GHRSST
Group for High Resolution Sea Surface Temperature

XIII Science Team Meeting
Tokyo, Japan

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EXECUTIVE SUMMARY

The Thirteenth Science Team Meeting (GHRSST–XIII) was held at the Hongo Campus of the University of Tokyo, Japan, from 4th-8th June, 2012. The Meeting was supported by the Japan Aerospace Exploration Agency (JAXA.) and the Japan Meteorological Agency (JMA), and the local arrangements were organized by Misako Kachi (JAXA) and Shiro Ishizaki (JMA). In total ~ 70 people participated in the meeting throughout the week. The format of the Science Team Meeting broadly followed that of prior meetings. The first day including succinct overviews of new satellites and summaries from many of the agencies that sponsor GHRSST activities. Tuesday was a brief Science Symposium, augmented by posters which were on display throughout most of the week. In addition to breakout sessions for the TAGs and WGs, an early evening session focused on VIIRS was led by Sasha Ignatov. The Friday morning Plenary Session included brief reports from the breakout sessions. All public presentations, reference and background documents can be accessed via the GHRSST web-site (http://www.ghrsst.org).

A new development this year is that the First CEOS SST Virtual Constellation meeting that was held in parallel with GHRSST–XIII. The **CEOS SST-VC** meeting was mainly focused on the Implementation Plan. It was highlighted how SST-VC could be of benefit for GHRSST: mainly via international linkage, and space agency support. It was stressed that the establishment of the CEOS SST VC would not change the way that GHRSST operates, which will remain at the initiative and direction of the Science Team members and following recommendations from the Working Groups and Technical Advisory Groups.

The reports of the break-out groups are given in the body of this report, and very brief summaries are presented here based on the presentations given during the Plenary Summary and Conclusion Session on the Friday morning:

ST-VAL, the Satellite Sea Surface Temperature Validation Working Group, discussed the 'cold tail' in satellite minus drifter discrepancies and reviewed the SSES common principles. Feedback to ESA CCI SST was provided, and support for a community multi-sensor matchup system (MMS) expressed.

IWWG, the Inlands Water Working Group, expressed a requirement for more in-situ data. Recommendations were discussed concerning orthorectification, land masking and cloud screening. Next Actions include clustering inland waters according to physical characteristics.

HL-TAG, the High Latitude Technical Advisory Group, discussed the results from the Bayesian classifier for cloud/ice/ocean classification, the performance of high latitude algorithms tested with the multi-sensor matchup system, and the user survey from ESA CCI showing increasing interest in ice surface temperatures. Future plans of HL-TAG include a 'Sea-Ice GMPE', and to treat operational sea ice products and climate data records separately.

AUS-TAG, the Applications and User Services Technical Advisory Group**,** addressed the question how users can be guided to their most appropriate L4 product. A template to accompany each L4 product has been drafted. Web-site development of a guidance document was discussed and planned for the next year.

The report of the **DVWG**, the Diurnal Variability Working Group, included an update on progress in the TWP+ project, the SPURS campaign as a potential new source of near-surface gradients, and on progress with Argo near-surface observations were presented. It is planned to make existing DW models readily available through the GHRSST web-page.

DAS-TAG, the Data Assembly and Systems Technical Advisory Group, discussed the review process for ingestion of new GHRSST data sets into the GDAC. Using the GDS2

checker, written in python, a review board will verify the meta-data information. Data providers are encouraged to use GDS2r4 (and note some minor issues as collected in the GDS2 Amendments tracker). Links with the CF metadata group will be maintained via Ed Armstrong.

EARWiG, the Estimation and Retrievals Working Group, identified priorities in developing metrics for algorithm comparison, improving cloud detection for infrared SST retrievals, and recognizing the critical need to provide calibration characterization for the purposes of CDRs/ECVs. For the latter, EARWiG suggested the CEOS SST-VC could help. A joint EARWiG/ST-VAL workshop was suggested.

IC-TAG, the Inter-Comparison Technical Advisory Group, discussed the importance of the recent AATSR loss on its data quality, on inter-comparison of ice information, and on how to compare feature resolution and to communicate to the users. All L4 producers are invited to participate in an OSSE-like comparison of L4 analysis methods, with the intention of publishing the results in a joint paper.

R2HA2, the Rescue & Reprocessing of Historical AVHRR Archives Working Group, reviewed progress and discussed the next steps to be taken. Progress had been made with acquisition of data from receiving stations and transcription to new media. The L1pCore format was presented, which will be finalized in R2HA2 and then circulated to the Science Team. For the next year, the focus on recovering data from Hawaii and Argentina will continue.

CDR-TAG, the Climate Data Records Technical Advisory Group discussed a Climate Dataset Evaluation Framework (CDEF). Various previous approaches have been analysed according to strengths and weaknesses, resulting in a general agreement that objectively comparable climate quality metrics will require a co-ordinated facility. Building upon the ESA CCI experience, it was noted that the multi-sensor match-up system is a powerful technique for evaluation, which the CDR-TAG suggests be developed as a community tool. The next step is to encourage tools to support CDR producers to supply comparable validation metrics.

During the **Advisory Council session** points discussed included: clarification of the link CEOS SST-VC and GHRSST; establishing a GDAC process to facilitate compliance to the GDAC acceptance procedure; recommendations on the preferred format of GHRSST meetings; and the continuation of the GHRSST Project office under ESA contract. Helen Beggs was elected as new AC chair 2012/2013.

Four new GHRSST Science Team members were nominated and subsequently elected: Alexander Ignatov, Simon Hook, Christo Whittle, and Werenfrid Wimmer.

Proposals for the next Science Team Meeting venue were presented: Woods Hole (to be hosted by Carol Anne Clayson), Santa Rosa (Chelle Gentemann) and Cape Town (Christo Whittle). A show-of-hands vote resulted in a tie between Woods Hole and Cape Town. An online poll was subsequently held with Woods Hole being selected for 2013. The 2014 Science Team Meeting will be held in Cape Town.

This was the last Science Team Meeting for Andrea Kaiser-Weiss who will be moving to the German Weather Service in late summer. She received thanks from the assembled group for her work as GHRSST Project Coordinator, and was wished well for her future career.

CHAPTER 1: AGENDA

GHRSST XIII AGENDA WITH LINKS TO DOCUMENTS

Sunday 3rd June	
14:00	GHRSST side meeting (informal): meet at the Main Gate (visitors' entrance) of Tokyo National Museum – Information available in *R2–Local Information* document, http://www.tnm.jp/modules/r_free_page/index.php?id=113&lang=en and http://www.tnm.jp/?lang=en
18:00	Informal get together: meet Misako Kachi and Shiro Ishizaki in lobby of Hotel Park Side Ueno. Full information in *R2–Local Information* document and http://www.parkside.co.jp/en/guide_ueno.html

Monday, 4th June		
09:00	Registration and Tea/Coffee	
Main Room		
	Plenary Session 1: ***Welcome and highlight talks***	***Chair:*** *Misako Kachi* ***Rapporteur:*** *Ken Casey*
09:30	Welcome from the ST Chair	Peter Minnett
09:45	Welcome and logistics	Misako Kachi
09:55	Welcome address from JAXA	Masanobu Shimada
10:05	Welcome address from JMA	Toshihiko Yano
10.15	GCOM – current status and its contribution to SST observations	Keizo Nakagawa
10:30	SST from VIIRS on the Suomi–NPP satellite	Peter Minnett
10.45	Summary of the Melbourne workshop	Helen Beggs
11:00	Tea/Coffee Break	
	Plenary Session 2: ***GHRSST components and major projects***	***Chair:*** *Chris Merchant* ***Rapporteur:*** *Shiro Ishizaki*
11:20	Report from the GPO	Andrea Kaiser–Weiss
11:30	Report on the Global Data Assembly Center (GDAC)	Ed Armstrong
11:40	Report from the GHRSST LTSRF at NODC	Kenneth Casey
11:50	ACSPO and monitoring tools	Sasha Ignatov
12:00	MyOcean/ MyOcean–2 RDAC progress report	Hervé Roquet
12:10	Report from the OSI–SAF RDAC	Pierre Le Borgne
12:20	Medspiration and SST Activities at IFREMER	Jean–François Piollé
12:30	Report from the Naval Oceanographic Office	Bruce McKenzie
12:40	Report from Australia– BLUElink and IMOS	Helen Beggs
12:50	MISST	Chelle Gentemann
13:00	Lunch	

Monday, 4th June *(continued)*		
	Plenary Session 3: News from Agencies	***Chair:*** *Peter Cornillon* ***Rapporteur:*** *Viva Banzon*
14:00	JAXA	Misako Kachi
14:15	JMA	Shiro Ishizaki
14:30	ESA	Olivier Arino
14:45	EUMETSAT	Anne O'Carroll
15:00	NOAA	Kenneth Casey
15:15	NASA	Andy Bingham
15:30	The GHRSST link to CEOS – an update on the CEOS SST Virtual Constellation	Kenneth Casey
15:45	Questions and comments	All
16:00	Tea/Coffee Break	
16:30	***Poster Session***	**MISST: Room 201/202**
18:00	**Ice–Breaker**	
18:30	**Poster session and Ice–breaker *(continued)***	**MISST *(continued)*: Room 201/202**
21:00	Close	

POSTERS

1.	Optimal Estimation Technique for SST from MTSAT–2	Yukio Kurihara
2.	Quasi–optimal assimilation of SST	Andrea Kaiser–Weiss
3.	Filling of Sea Ice Timeseries Gaps Using a Simple Data Assimilation Method – HL poster	Emma Fiedler
4.	Bias Correction in OSTIA in the Absence of AATSR Data	Jonah Roberts–Jones
5.	GMES Sentinel–3 Overview	Craig Donlon
6.	The Sentinel–3 Sea and Land Surface Temperature Radiometer (SLSTR)	Craig Donlon
7.	Fostering the Next Generation: Identifying And Filling The Gaps In Satellite Derived SST Data Tutorials	Pamela Michael
8.	Absolute Thermal SST Measurements over the Deepwater Horizon Oil Spill	William Emery
9.	Comparison of the IBI regional model and MSG/SEVIRI hourly Sea Surface Temperature fields	Françoise Orain

Tuesday, 5th June		
09:00	Registration and Tea/Coffee	
Main Room		
	Plenary Session 4: ***Users and Science Symposium***	
	Session 4.1: Climate and high latitude applications	***Chair:*** *Jorge Vazquez* ***Rapporteur:*** *Ed Armstrong*
09:30	Homogenisation of brightness temperatures between sensors to create stable SST for climate	Owen Embury
09:45	Continuity, independence and stability for AATSR/SLSTSR–based time series of SST	Christopher Merchant
10.00	An improved view of the Arctic SST during the summer of 2007	David Llewellyn–Jones
10.15	Multi–sensor satellite SST validation and bias adjustments in the Arctic Ocean	Jacob Høyer
10.30	Trends in the global SST front and gradient fields	Peter Cornillon
10.45	Discussion on SST in Climate Applications	All
11:00	Tea/Coffee Break	
	Session 4.2: Operational use in meteorology and marine applications	***Session Chair:*** *Gary Corlett* ***Rapporteur:*** *Werenfrid Wimmer*
11:20	Evaluation of assimilative SST forecasts in the Okinawa Trough and Gulf of Mexico	Charlie Barron
11:35	NGSST–O looking back to consider the future	Futoki Sakaida
11:50	Towards advanced use of SST in NWP model at JMA	Yuhei Takaya
12:05	Operational use of NWP outputs in SST retrieval methods: validation results	Pierre Le Borgne
12:20	Providing fishermen with daily high–resolution SST in the Kuroshio region	Xuhui Xie
12:35	An analysis of the SST gradients off the Peruvian coast: Sensitivity to resolution	Jorge Vazquez
12:50	Characterization of Agulhas Bank upwelling variability from MUR Blended SST and 1km MODIS Aqua Data	Christo Whittle
13:05	Lunch	

Tuesday, 5th June *(continued)*		
	Session 4.3: Error estimation and product development	***Chair:*** *Chelle Gentemann* ***Rapporteur:*** *Gary Wick*
14:00	In situ measurements of skin SST in the China Seas	Lei Guan
14:15	Quality control of SST observations from drifting buoys and ships on a per–platform basis	Christopher Atkinson
14:30	Error models for averages of binned SST observations based on small–scale and short–term variability estimates	Alexey Kaplan
14:45	The resolution capability of high–resolution SST analysis	Dudley Chelton
15:00	Global 1–Km SST: merging in situ measurements with multi–satellite observations	Yi Chao
15:15	Selecting a first guess SST as input to forward radiative transfer model	Korak Saha
15:30	NOAA NESDIS GHRSST operational SST products	Eileen Maturi
15:45	Replacement of AMSR with WindSat in the NOAA daily optimum interpolation microwave plus infrared product	Viva Banzon
16:00	Discussion	All
16:05	Tea/Coffee Break	
16:30	New ATSR full resolution L2P using the Arc processor	Owen Embury
16:45	EUMETSAT IASI SST	Anne O'Carroll
17:00	Discussion on session 4.2 and 4.3	All
	(A)ATSR Discussion	David Llewellyn–Jones
17:30	Close	
18:00–19:00	**Advisory Council Session – Room 203**	

Wednesday, 6th June		
09:00	Tea/Coffee	
Main Room		
	Plenary Session 5: ***New Instruments and Future Plans***	***Chair:*** *Peter Minnett* ***Rapporteur:*** *Jon Mittaz*
09:30	Logistic announcement	Misako Kachi
09:35	Status of NPP/VIIRS Sensor and SST	Sasha Ignatov
09:50	First year report on the COMS SST product	Chu–Yong Chung
10:05	The Sentinel–3 mission: Overview and Status	Craig Donlon
10:20	Discussion on co–ordination of GHRSST efforts	All
10:30	Tea/Coffee Break	
See following pages for full details of *Session 6: Parallel Breakout Sessions*		

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Parallel Breakout Sessions</td><td>Room 203</td></tr>
<tr><td></td><td>A.1: Main Room</td><td>A.2: Room 201/202</td><td rowspan="2">First CEOS–VC SST meeting</td></tr>
<tr><td>11:00</td><td>STVAL (Satellite Sea Surface Temperature Validation Working Group)

Chair: Gary Corlett
gkc1@leicester.ac.uk
☏ +44 116 252 5240
Rapporteur: Pierre LeBorgne
1. Update on SQUAM capabilities – Prasanjit Dash
2. The ‘cold tail’: How do we deal with this?
3. Common Quality levels for AVHRR
• Review of SSES Common Principles
• Can we converge?
4. ESA SST_CCI Product Validation Plan (PVP)
• Multi–sensor match–up system MMS
5. DBCP
6. And finally…
• AOB
• Argo as independent reference
• ST–VAL Membership/ToR</td><td>IWWG (Inland Waters Working Group)

Stand–in Chair: Robert Grumbine – Chair: Simon Hook
simon.j.hook@jpl.nasa.gov
☏ +44 818–354–0974
Rapporteur: TBD
• Lake Surface Water Temperature in the Operational OSTIA System – Jonah Robert–Jones</td></tr>
<tr><td>13:00–18:00</td><td colspan="3">Excursion and Team Building</td></tr>
<tr><td>18:30–20:30</td><td colspan="3">Conference Dinner</td></tr>
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<table>
<tr><th colspan="4">Thursday, 7th June</th></tr>
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<tr><td></td><td colspan="2">Session 6:
Parallel Breakout Sessions (continued)</td><td>Room 203</td></tr>
<tr><td></td><td>B.1: Main Room</td><td>B.2: Room 201/202</td><td rowspan="2">First CEOS–VC SST meeting
(continued)</td></tr>
<tr><td>09:00</td><td>HL–TAG (High Latitude Technical Advisory Group)
Report 2012
Chair: Jacob Høyer
jlh@dmi.dk,
☏ +1 45 39157203
Rapporteur: Bob Grumbine
• Agenda, Actions from Melbourne, future plans
• Improved cloud/ice/ocean classification – Chris Merchant
• HL SST algorithms – Jacob Høyer
• Update on the NCEP sea ice work – Bob Grumbine
• IST from AATSR – Gary Corlett
• Sea ice climatology from O&SI–SAF and ESA_CCI sea ice project – Jacob Høyer
• Discussion</td><td>AUS–TAG (Applications and User Services Technical Advisory Group) – Report 2012
Chair: Jorge Vazquez
jorge.vazquez@jpl.nasa.gov
☏ +1 818–354–6980
Rapporteur: Mike Chin
1. Which Data Sets should GHRSST advertise to climate users. How should these data sets be advertised: Andrea, Alexey
2. CEOS SST VC activities: Pam Michael, Kenneth Casey
3. Multi–Pager for users: Mike
4. Updating RDAC listings: Jorge
5. Review of "URD"
6. Vice–Chair</td></tr>
<tr><td>10:50</td><td colspan="3">Tea/Coffee Break</td></tr>
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<table>
<tr><th colspan="4">Thursday, 7th June (continued)</th></tr>
<tr><td></td><td colspan="2">Session 6:
Parallel Breakout Sessions (continued)</td><td>Room 203</td></tr>
<tr><td></td><td>C.1: Main Room</td><td>C.2: Room 201/202</td><td rowspan="2">First CEOS–VC SST meeting
(continued)</td></tr>
<tr><td>11:10</td><td>DVWG (Diurnal Variability Working Group) – Report 2012

Chair: Gary Wick
Gary.A.Wick@noaa.gov
☏ +1 303–497–6322
Rapporteur: Sandra Castro
• Agenda
• Update on TWP+ – Helen Beggs
• GOTM Modeling in the Mediterranean – Pierre LeBorgne
• Owen Embury
• Brief updates
- Argo near–surface observations
- Diurnal matchup database
- Diurnal warming analyses
• Discussion
- Provision of 6am/6pm SST for Aquarius salinity processing
- Other user requirements?
- Relationship to activities outside GHRSST
- Priorities and activities for the coming year
• Review of DVWG Action List
- Membership</td><td>DAS–TAG (Data Assembly and Systems Technical Advisory Group) – Report 2012
Chair: Ed Armstrong
Edward.M.Armstrong@jpl.nasa.gov
☏ +1 818–393–6710
Rapporteur: Jean–François Piollé
• Agenda
• Cloud computing and big data technology –Jean–François Piollé
• Demo of new tools and web services for GHRSST data – Ed Armstrong
• GDS 2 discussions including migration schedule and validation tools – Ed Armstrong</td></tr>
<tr><td>13:00</td><td colspan="3">Lunch</td></tr>
</table>

<table>
<tr><th colspan="5">Thursday, 7th June (continued)</th></tr>
<tr><td></td><td colspan="3">Session 6:
Parallel Breakout Sessions (continued)</td><td>Room 203</td></tr>
<tr><td></td><td>D.1: Main Room</td><td>D.2:Room 201/202</td><td>D.3: Room 001</td><td rowspan="2">First CEOS–VC SST meeting
(continued)</td></tr>
<tr><td>14:00</td><td>EARWiG (Estimation and Retrieval Working Group) –
Report 2012
Chair: Andy Harris
Andy.Harris@noaa.gov
☏ +1–301–763–8102 x169
Rapporteur: Owen Embury

• EARWiG Agenda and ToR – Andy Harris
• IR calibration – Jon Mittaz
• MW SST update – Chelle Gentemann
• Algorithm selection (Round Robin) Exercise in the ESA SST CCI – Christopher Merchant
• Conventional and incremental regression SST for AQUA and TERRA MODIS within ACSPO – Boris Petrenko
• GOES SST retrieval using total least square method – Prabhat Koner</td><td>IC–TAG (The Inter–Comparison Technical Advisory Group) –
Report 2012
Chair: Alexey Kaplan
alexeyk@ldeo.columbia.edu
☏ +1–845–365–8689
Rapporteur: Mike Chin

1. Introduction: recap of IC–TAG goals and ToR
2. Where do we stand and what are the pressing needs of the IC–TAG:
• Practical Outcomes of DSRII papers (parts 1 and 2) – brief summary – Discussion
• Uncertainty communication for the L4 products – brief summary Discussion
3. Presentations:
• Updates to the Uncertainty Estimates in the OSTIA System – Jonah Roberts–Jones
4. General discussion and plans for the next year</td><td>R2HA2–WG (Rescue & Reprocessing of Historical AVHRR Archives Working Group) – Report 2012
Chair: Peter Cornillon
pcornillon@gso.uri.edu ☏ +1 401–874–6283
Rapporteur: TBD

First step towards the definition of a common netCDF format for AVHRR HRPT l1 data – Hervé Roquet</td></tr>
<tr><td>16:00</td><td colspan="4">Tea/Coffee Break</td></tr>
</table>

Thursday, 7th June *(continued)*	
	Session 6: ***Parallel Breakout Sessions*** *(continued)*
	E.1 – Main Room
16:20	**CDR–TAG** *(Climate Data Records Technical Advisory Group)* – Report 2012 ***Chair:*** *Christopher Merchant* c.merchant@ed.ac.uk ☏ +44 (0)131 650 5097 ***Rapporteur:*** *Jon Mittaz* • Assessing climate data records – *Chris Merchant* • International Status Report • Use of METOP/AVHRR to fill the AATSR gap – *Pierre Le Borgne* • Bias correction without AATSR data – *Jonah Roberts–Jones*
18:20	Break
	F1 – Room 201/202
18:30– 20:30	**VIIRS working session** ***Chair:*** *Sasha Ignatov* alex.ignatov@noaa.gov ☏ +1–301–763–8102 x190 ***Rapporteur:*** *Bruce McKenzie* Introduction – round the room • why interested • suggested topics for discussion • adapt agenda to audience needs Preliminary agenda 1. VIIRS SST: Data availability/archival/distribution/formats – IDPS; ACSPO; NAVO; Miami 2. updates from JPSS Team members: Experience with VIIRS, Progress, Plans 1. OSI SAF 2. Miami 3. NAVO 4. NESDIS – real time demo of VIIRS products in SQUAM 3. NESDIS: official IDPS EDR SST product – Current design and proposed (re)design 1. currently, IDPS EDR reports skin and bulk SSTs (offset by 0.17K), and QFs for both. Propose to exclude bulk & bulk QFs, include reference SST 2. consensus QFs based on Miami/OSI SAF/IDPS QFs 3. consensus SST algorithms for day and night 4. current data formats – hdf4/5, no SSES; should reformat to GDS2? 4. discussion and wrap–up
20:30	Close

Friday, 8st June

08:45	Tea/Coffee	
Main Room		
	Plenary Session 7: ***Summary and Conclusion Session***	***Chair:*** *Peter Minnett* ***Rapporteur:*** *Andrea Kaiser–Weiss*
09:00	Report from the CEOS VC SST	Kenneth Casey
09:10	Report from STVAL breakout	Gary Corlett
09:20	Report from IWWG breakout	Robert Grumbine
09:30	Report from HL–TAG breakout	Jacob Høyer
09:40	Report from AUS–TAG breakout	Jorge Vazquez
09:50	Report from DVWG breakout	Gary Wick
10:00	Report from DAS–TAG breakout	Ed Armstrong
10:10	Report from EARWiG breakout	Andrew Harris
10:20	Report from IC–TAG breakout	Alexey Kaplan
10:30	Report from R2HA2 breakout	Peter Cornillon
10:40	Report from CDR–TAG breakout	Chris Merchant
10:50	Report from the Advisory Council	Misako Kachi
11:00	Tea/Coffee Break	
	Plenary Session 7 *(continued)*	
11:30	Changes to ST membership and G13 Actions	Andrea Kaiser–Weiss
11:40	Next meeting venue (Woods Hole/Cape Cod–US, Santa Rosa/CA–US, Cape Town–SA)	Peter Minnett
12:05	AOB	
12:15	Perspectives from the ST Chair	Peter Minnett
12:30	**Close of GHRSST XIII**	
13:00–17:00	**Side Meeting – Room 201/202**	

CHAPTER 2: MEETING SUMMARY

WELCOME NOTE

Welcome to Tokyo for the 13th GHRSST Science Team meeting!

This has been an eventful year with both positive and negative events. The end of the AATSR data stream with the demise of ESA's *Envisat* polar orbiter is a significant loss for the GHRSST community. While it is very unfortunate that the hoped–for overlap with the SLSTR on the European GMES Sentinel–3 will not happen, we should reflect that the ten years of high–quality measurements from AATSR, following on from the successful ASTR–1 and ATR–2 missions, has contributed two decades of very important measurements for many in GHRSST and the wider community. Similarly, the AMSR–E on *Aqua* failed last year, as the torque required to rotate the large antenna exceeded set bounds, but again, while losing the opportunity of overlap with the AMSR–2, it is remarkable that this and other instruments on the EOS satellites have served us excellently well beyond their planned lifetimes. The MODISs on *Terra* and *Aqua* continue to function well, and the outlook for the extended missions of these satellites is good.

On the positive side, the NASA–NOAA *Suomi–NPP* (National Polar–orbiting Partnership) satellite was launched on October 28, 2011, carrying the first VIIRS Visible Infrared Imager Radiometer Suite (VIIRS). This is the first in a series of visible and infrared imagers that will fly on the US satellites of the Joint Polar Satellite System (JPSS). The data from VIIRS is very clean and the derived SSTs show very little instrumental artifacts that one expects from the first of a new generation of spacecraft instruments.

Another very positive development was the successful launch of the first Japanese *GCOM–W* (Global Change Observation Mission 1st – Water "SHIZUKU") satellite on May 18, 2012. This satellite carries the AMSR–2 which will provide SST derived from microwave emission, and will thus continue the data stream from AMSR–E.

A successful GHRSST Joint Workshop on Tropical Warm Pool and High Latitude SST Issues was held at the Bureau of Meteorology Head Office, Melbourne, Australia, from 5 to 9 March 2012, and thanks are extended to Helen Beggs for organizing this and to the BoM for providing the logistical support that helped make the Workshop a success.

And so to this Science Team Meeting, the format of which will be familiar to many by following that of previous meetings. There are some evolving aspects: the first day includes some highlights, including brief overviews of the new satellites, and then summaries from many of the agencies that sponsor GHRSST activities. Tuesday is devoted to a Science Symposium, and to accommodate presentations covering a wide range of topics the presentations will be limited to 15 minutes. In addition to the oral sessions, there are a number of interesting posters which will be on display for most of the week. Following a plenary session on Wednesday morning dealing with New Instruments and Future Plans, the breakout sessions for the TAGs and WGs will continue through Thursday, which will end with an early evening session focused on VIIRS, led by Sasha Ignatov. The Friday morning Plenary Session will include brief reports from the breakout sessions. On Wednesday afternoon we will have a team building excursion, followed by the Conference Dinner. A further development this year is that the First CEOS SST Virtual Constellation meeting will be held in parallel with GHRSST–XIII, and there will be meetings of MISST–2 (Multi–Sensor Improved SST); MISST, amongst other things, provides the mechanism for several US investigators to participate in GHRSST.

GHRSST has been identified by several international groups as a model for other projects with international Science Teams and diverse interests and priorities. This recognition is a credit to you all.

The preparation for GHRSST–XIII has been a mammoth task, and thanks are due to Andrea and Silvia of the International Project Office, and to Misako Kachi and Shiro Ishizaki who have handled the local organization. And thanks are also due to JAXA and JMA for their sponsorship of this meeting.

The smooth running of GHRSST–XIII and of many behind–the–scenes activities that keep GHRSST moving forward is a credit to Andrea Kaiser–Weiss. She has been especially effective in helping me take over as Science Team Chair from Craig Donlon. It is therefore with deep gratitude that I thank Andrea for all she has done for GHRSST, and wish her every success in her new post in the German Weather Service (DWD) that she will take up in mid–August. I am sure I speak for all of you when I wish her well.

The success of GHRSST is based on the contributions of all of you, and I am confident that we will go from strength to strength. I look forward to a stimulating meeting, as indeed I hope you all do too.

Peter Minnett

(Chair of the GHRSST Science Team)

SESSION 1: OPENING PLENARY REPORT

Chair: Misako Kachi[(1)]; Rapporteur: Kenneth S. Casey[(2)]

(1) JAXA, Japan, Email: kachi.misako@jaxa.jp
(2) NOAA National Oceanographic Data Center, USA, Email: kenneth.casey@noaa.gov

ABSTRACT

The Opening Plenary, Session 1 of the 13th GHRSST Science Team meeting featured seven speakers, whose talks served to welcome the meeting participants and to set the overall stage for the meeting. The speakers and their key messages are summarized below.

Summary of Speakers and Topics

The seven speakers in Session 1 were as follows:

1. Welcome from the ST Chair – Peter Minnett
2. Welcome and logistics – Misako Kachi
3. Welcome address from JAXA – Masanobu Shimada
4. Welcome address from JMA – Toshihiko Yano
5. GCOM – current status and its contribution to SST observations – Keizo Nakagawa
6. SST from VIIRS on the Suomi–NPP satellite – Peter Minnett
7. Summary of the Melbourne workshop – Helen Beggs

Summary of Presentations

The highlights from each of the seven speakers are given below.

Welcome from the ST Chair – Peter Minnett

Peter Minnett, Chair of the GHRSST Science Team, opened the meeting with words of welcome and summarized both the "good and the bad" developments being addressed by the SST community today. On the bad side, the recent losses of the AATSR and AMSR–E sensors dealt serious blows to the quality of the available SST record. On the good side, the recent successful launches of the Suomi NPP satellite carrying VIIRS and the GCOM–W1 satellite carry AMSR2 marked great steps forward in the maintenance of the SST record from space. Dr. Minnett concluded his welcoming remarks with a review of the week's agenda.

Welcome and logistics – Misako Kachi

The next presentation was given by the local host of the meeting, Misako Kachi from JAXA. She provided the meeting logistics and welcoming remarks from JAXA.

Welcome address from JAXA – Masanobu Shimada

Next, Masanobu Shimada provided welcoming remarks from JAXA. In his presentation, he reminded the audience that despite the plethora of bad news on the TV these days, from power outages and economic stress to terrorism, global warming remains as perhaps the biggest issue we face, and that satellites play a key role in monitoring and understanding our global environment. He highlighted the launch of GCOM–W1 and pointed out the wonderful things to see and do in Tokyo if there is a chance to explore the city after the meeting.

Welcome address from JMA – Toshihiko Yano

In the next presentation, Toshihiko Yano provided a warm and cordial welcome on behalf of JMA, which looked forward to successful meeting. He highlighted the many and increasingly critical applications of high quality SST data, stressed JMA's commitment to SST data exchange, and wished the meeting participants a wonderful stay in Japan.

Current status and contributions to SST – Keizo Nakagawa

The GCOM Project Manager, Keizo Nakagawa, provided an excellent overview of the latest status and role that GCOM–W1 and the future C1 will play in the providing SST observations from space. He gave a technical status report that indicated the GCOM–W1 was in good condition and described the process by which the GCOM–W1 satellite is moving into its position in the A–train. He indicated that L1 products are planned to be open in January 2013 at: https://gcom–w1.jaxa.jp and that L2 products were planned for May 2013 after cal/val activities concluded. He also indicated that the plans were to release GHRSST formatted data at the same time and that the standard products are all in HDF–5. Following the status report on GCOM–W1, he also reviewed the GCOM–C1 status and that the engineering model tests for that satellite have been performed.

SST from VIIRS on the Suomi–NPP satellite – Peter Minnett

The GHRSST Science Team Chair, Peter Minnett, then provided a very positive overview of the quality of SST data from the newly launched VIIRS instrument. He pointed out that the Suomi NPP satellite was recently named after Professor Suomi from the University of Wisconsin, who was one of the founders of satellite meteorology. Dr. Minnett reviewed the quality assessments taking place at NOAA/STAR and by UMiami/RSMAS, which indicated that the SSTs were very "clean" and showing excellent qualitative aspects. Quantitatively, the initial comparisons with other SST products like OSTIA and the Daily OISST were very good, with mean differences near zero and standard deviations around 0.45K. Buoy comparisons were revealing standard deviations around 0.5K. He indicated that in summary the VIIRS instrument was well characterized so the at–launch performance is turning out to be very good. In addition, the early assessment of SST uncertainties is revealing systematic aspects of the uncertainties which imply that substantial improvements in accuracies can be made.

Summary of the Melbourne workshop – Helen Beggs

Dr. Helen Beggs from the Australian Bureau of Meteorology closed off Session 1 with a review of the Joint Workshop on Tropical Warm Pool and High Latitude SST Issues, held 5–9 March 2012. She reviewed the rationale for having tropical and high latitude groups together, showing how they share some common issues like prolonged cloud cover and relative poor in situ observations. The meeting highlighted that Arctic uncertainties were worse than Antarctic uncertainties, with higher humidity and higher air–sea temperature difference in the Arctic suggested as the complicating factor. The meeting also showed that diurnal warming in the Arctic was of order 4K, with Antarctic diurnal variations on the order 2K of possibly due to calmer winds speed in Arctic. She highlighted that the presence of four sea ice scientists at the meeting was very useful in better understanding the issues influencing SST. Some keep points from the tropical warm pool portion of the meeting include that SST diurnal variability is important for MJO, shallow clouds, and convection/precipitation, and that there is a TWP day/night variation in the ability to detect sub–pixel clouds. The meeting results stressed importance of using consistent SST retrieval algorithms for day and night and showed the effect of high water vapor conditions on day/night difference in SST algorithms. She closed the presentation with a description of the ship–based air–sea flux data available from IMOS and reviewed the aims and work plan of the TWP+ project (Tropical Warm Pool Diurnal Variability Project).

SESSION 2: GHRSST COMPONENTS AND MAJOR PROJECTS

Chair: Chris Merchant[(1)]; Rapporteur: Shiro Ishizaki[(2)]

(1) School of GeoSciences, University of Edinburgh, UK, Email: c.merchant@ed.ac.uk
(2) Japan Meteorological Agency, Tokyo, Japan, Email: s_ishizaki@met.kishou.go.jp

The notes below list the topics addressed in each presentation, with some comments on key points. For the details of what was presented under each topic, refer to the corresponding presentation, available on the GHRSST web site.

Report from GHRSST project office: Andrea Kaiser–Weiss

1. Highlighted role of GPO in overall GHRSST structure
2. Reviewed external representation
   - EUMETSAT Conference
   - GOVST–III
   - ESA–Solas Conference
   - Ocean Science conference
   - ESA Sentinel–3 Cal/Val Planning
   - Liege Colloquium on Ocean Dynamics
3. Reviewed the GHRSST web site
4. Reviewed GHRSST documents
   - User Guide
   - GDIP
   - Draft DPF
   - Draft Cal/Val plan
5. Reviewed future plan
   - Since Andrea is leaving GPO, ensuring a smooth transition is important.
6. Suggested by Craig Donlon: Put “user questions“ on JPL forum and encourage use of forum

Progress at GDAC: Ed Armstrong

1. Reviewed the Data Management and Archive System architecture
2. Now serving up 143 million files (+50% growth since GHRSST12)
3. Reviewed improved tools, service and metadata discovery
   - HITIDE
   - SOTO
   - THREDDS
   - LAS interface
   - OCSI
4. DMAS system makes GDAC–LTRSF interface much more robust
5. Concern: Data policy would be consistent with GDAC/PO.DAAC.
   - Discussion needed in Advisory Council meeting
   - High Number of L4 products
   - potentially confusing users
6. Encouraged: production of data in GDS–2
   - making better use of the GHRSST forum at JPL
7. Suggested by Bruce McKenzie: providing Brightness temperatures in L2P. There have long been divergent views regarding this.

Progress at LTRSF: Kenneth Casey

1. Reviewed current archives
   - Over 2million files and 48TB of volume
2. New service: Geoportal server
3. Reviewed Pathfinder SST
4. Reviewed questions/issues for GHRSST13
   - Haven't seen any GDS2.0 data yet
   - Climatologies in GDS2.0 format
   - GOCS intercomparison
   - Archive of ATSR–1/2 and AATSR L2P: data policy issue is to be resolved
5. Promoted RDACs to provide status for the GHRSST Homepage Dashboard

Progress at NESDIS: Sasha Ignatov

1. Reviewed ACSPO (Advanced Clear–Sky Processor for Oceans)
   - Using CRTM (Community Radiative Transfer Model)
   - Several products including SST
2. Reviewed SQUAM (SST Quality Monitor)
   - Future work: toward adding SST products and extend SQUAM function
3. Reviewed MICROS (Monitoring IR Clear–sky Radiances over Oceans for SST)
4. Reviewed iQUAM (in situ Quality Monitor)
   - "Wish List"

Progress at MyOcean RDAC: Hervé Roquet

1. Reviewed upgrade in OSTIA (November 2011)
   - inclusion of lake surface temperature (263 lakes)
   - use of new satellite SST sources (MSG, GOES–E)
   - use of new climatology
   - available in GDS V2 format
2. Reviewed transition of MyOcean to MyOcean2 (January 2012)
   - operational and R&D activities are funded until September 2014
   - SST and SIW TAC are merged into a single TAC
   - All L4 products available in GDS V2 format
   - new L3S products over the Mediterranean and the Black seas

Progress at OSI–SAF RDAC: Pierre Le Borgne

1. Reviewed OSI–SAF SST product using Geostationary satellites
   - all previous products have stopped
   - hourly MSG and GOES–E L3C SST are available (with 005deg.grid, GDS V2 formatted)
2. Reviewed OSI–SAF SST product using Polar orbit satellites
3. Reviewed R&D activities
   - SST bias correction
   - SST short scale variability (DW, surface velocity and validation of lake temperature)

Progress at IFREMER and Medspiration: Jean–François Piollé

1. Reviewed Medspiration/Odssea products
   - regional/global products
   - reprocessings

2. Reviewed GHRSST match–up database
3. Reviewed web service (Naiad)
4. Reviewed European GHRSST mirror
   - Mid–term archives for MyOcean: compressed NetCDF3 L2P
   - Long–term archives: Complete NetCDF4 L2P and OSI–SAF datasets
5. Concern: Facing data deluge
   - Increasing number of operational satellites and sensor spatial/temporal resolution
   - Can new big data and cloud computing technologies help with that?

Progress at Naval Oceanographic Office: Bruce McKenzie

1. Reviewed L2P Production
   - Global NOAA–18/19 and MetOp–A 9km; regional NOAA–19 2km
   - aerosoloptical depth data are included
   - brightness temperature
   - SST match–up database
2. Reviewed NAVOCEANO K10 Analysis
   - will be distributed in GDS V2.0 format
   - plan to update with Windsat, MSG, GOES–15 SST data
3. Reviewed VIIRS processing
   - receiving real–time VIIRS NPP data
   - producing NAVOCEANO VIIRS SST retrievals
   - will be provided in GDSV2 in Jan.2012

Progress at Bureau of Meteorology: Helen Beggs

1. Reviewed GHRSST format products
   - HRPT AVHRR skin SST (L2P, L3U, L3C, L3S) in GDS V2
   - MTSAT–1R/MTSAT–2 skin SST (L3U) in GDS V2
   - Global/regional foundation SST analysis (GAMSSA and RAMSSA) in GDS V1.7
   - L4 will be distributed in GDS V2
2. Reviewed other contributions to GHRSST
   - IMOS ship of opportunity SST
   - BLUElink Ensemble–based SST Global Reanalysis
   - Regional hourly and global 3–hourly skin SST analysis
   - Datasets for Tropical Warm Pool Diurnal Variability Study (TWP+)
3. Asked ST–VAL to discuss how to best exploit IMOS ship data

Report from MISST: Chelle Gentemann

1. Reviewed MISST objects
   - Research into satellite Cal/Val
   - Research into diurnal warming and cool skin modeling
   - Research into multi–satellite data fusion
   - Routine production of satellite SST data conforming to the GDS V2
   - Use of these advanced products to increase understanding of oceans and coasts
2. Reviewed NOAA progress
   - New L4 data (G1SST) to GDS V2.0
   - L2P AVHRR HRPT SST for the western Atlantic are processed and distributed
   - Assessing uncertainly in existing diurnal warming models
3. Reviewed issues faced this year

SESSION 3: NEWS FROM AGENCIES

Chair: Peter Cornillon[(1)]; Rapporteur: Viva Banzon[(2)]

(1) University of Rhode Island, Graduate School of Oceanography, Narragansett, RI, USA, Email: pcornillon@gso.uri.edu
(2) National Climatic Data Center NOAA/NESDIS, USA, Email: viva.banzon@noaa.gov

Six agencies (JAXA, JMA, ESA, EUMETSAT, NOAA, NASA) gave reports on recent developments and future activities. The content of the talks are available as Power points. Following the successful launch of GCOM–W1, JAXA provided details on the scheduled release of AMSR2 data, but access would require user registration. A question was asked whether this requirement would be waived, but the response was that this was unlikely because this JAXA policy applies to all data, not just AMSR2. Ishizaki, representing JMA, discussed a Level 4 product that incorporates WindSat. Beggs asked what WindSat latency was, and the response was 3–4 hours after acquisition. Barron asked if any comparisons were done against other satellites such as AVHRR on a subdaily (6 hourly) schedule. None had been done but it was suggested that comparisons against geostationary data might be a good avenue to pursue. O'Carroll, reporting for EUMETSAT, suggested an action item for GHRSST feedback on intercalibration products using MetOp/IASI as reference. Interested parties may contact her or Tim regarding the GSICS corrections. Ignatov asked what specific kind of feedback was sought, and the answer was just any information regarding L1 and L2 correction products compared against IASI/MetOp.

Speaking on behalf of NASA, Bingham focused on the PO.DAAC and put up for discussion some recommendations from its advisory User Working Group. One was that the PO.DAAC should work with GHRSST to ensure that metadata is clear and follows best practices. The other was that the data volume in the PO.DAAC was inflated and GHRSST was asked to provide guidance on how to reduce the number of Level 4 data. This question leads to a very animated discussion. Donlon said that the PO.DAAC should not depend on GHRSST to screen SST products. The spirit of GHRSST is to have many products so that users can choose. Gentemann, who is a member of the UWG, mentioned replication of archiving activities in NOAA and the problem of data inflation at the PODAAC.

This discussion was interrupted for the last scheduled talk on the CEOS–VC by Casey. Llewellyn–Jones asked how GHRSST became involved in CEOS since originally there was hesitation within GHRSST to pursue this course. The response was that CEOS–VC gives high level visibility and catches attention of managers. Alone, GHRSST is more effective at the scientist level. Llewellyn–Jones cautioned that this comes at a price of more work. Donlon replied that the VC team will do most of the work and only selected actions will cascade down.

The discussion session reverted back to the topic of level4 in the PODAAC. A point was made the UWG assessment was incorrect in that there are actually two problems. First, L4 data providers need to provide better product description to help the PODAAC provide user support and guidance. Secondly the different L4 products are designed to meet needs of different users, so there is no one best product but a more appropriate one for a given application. Arino suggested that increased awareness rather than reduced volume was needed. Resource limits to store and distribute data was not the main problem for the PODAAC, but manpower to answer user questions. The idea of GHRSST recommending metrics to pit one product against another was also not met favorably. Again, it was underlined that the variety of product exists for different purposes. Asking GHRSST to identify evaluation metrics may bias the choice towards a certain type of user. Finally, Minnett suggested that an action be made that the topic be continued in the AUS TAG, with onus on the data provider for a write up following a TBD template. The GPO will take on a coordinating role.

SESSION 4.1: CLIMATE AND HIGH LATITUDE APPLICATIONS

Chair: Jorge Vazquez[(1)]; Rapporteur: Ed Armstrong[(1)]

(1) Jet Propulsion Laboratory, California Institute of Technology, USA,
Emails: Jorge.Vazquez@jpl.nasa.gov and edward.armstrong@jpl.nasa.gov

Homogenization of brightness temperatures between sensors to create stable SST for climate – Owen Embury

- ARC homogenization (all ATSRs instruments)
- Requirements:
  - regional biases less than 0.1 degK
  - stability: 5 mk/year
  - sensor to sensor < .0K
- Issues
  - ATSR1 had increased operating temp affecting sensors
- ARC has 4 retrievals, dual and nadir
- Nadir retrievals are inferior
- Comparisons with buoys, lots of difference and biases
  - Nadir looks better?
- BT homogenization?
  - Using double differences: sensor to sensor, and sensor to simulations
  - Example double diff (AATSRsim – AATSRobs) – (ATSR2sim– ATSR2obs)
- Plots of double diffs for various channels for AATSR and ATSR2
  - Most are with 0.2 degC
- Approach: ignore 12 um channel
- Apply various biases to channels
- ATSR1–ATSR2 overlap: fewer match ups, issues with ATSR1 3.7 and 12 um channels 12um comparisons shows issues
  - Overall double differences on order of 0.2 degC
- With bias adjusts, the comparison curves to buoys is much better
- Double differences include correction for DW
- Overall ATSR–2 regional biases less than 0.1K!

Continuity, independence and stability for AATSR/SLSTSR–based time series of SST – Chris Merchant

- ARC strengths: independence
- How to bridge gap between SLSTR and AATSR, and retain independence?
- Bridge sensors: AVHRR on Metops and IASI
  - close to time of day of ARC
  - Overlaps: AATSR and AVHRR on Metop — 6 years
  - IASI
- Step one: link AATSR to AVHRR–A
  - Double matches of two sensors to common in situ reference
  - AVHRR–A BT made compatible with forward model and AATSR SSTs
- Cross references uses BT and skin SST
  - results is skin SST that AVHRR should have observed
  - Result in AVHRR BT that are consistent with AATSR BTs
- Step two: Stability measures uses IASI as stability reference
- Showed matchup plot. Large biases are apparent in both sensors (ARC and CMS)

- How stable is IASI–A?
  - Trends is 60 mk/Year, but could be artifact of retrieval algorithm that uses NWP
  - Need IASI in multi sensor matchup sensor
- AVHRR can also be used to assess stability
- Step 3: Stability validation
- Ship radiometry can link SST skin to SI standards
- Step 4: A volcano eruption would not be good
- Conclusion: there is a way forward to using Metop AVHRR and IASI to AATSR match ups

An improved view of the Arctic SST during the summer of 2007 – David L–Jones

- AKA: Results from ARC: SST Anomalies in the Arctic viewed by the ATSR sensors
- summer 2007: record loss of Arctic ice, large 6 degC SST anomaly
- Showed OSTIA SST anomaly plots
- ARC: similar to AVHRR Pathfinder for ATSR sensors. Involves universities, met office and hadley center
- ARC milestones
  - Stability of .03degC/decade in Tropics!
  - Bayesian cloud clearing an improvement over previous techniques
  - Future: lakes and land temps
- Showed monthly anomalies over 2004–2009
- 2007 anomalies are large signals in the time series record
- South warm winds in 2007 are hypothesized cause of ice loss and movement
- ARC for GHRSST?
  - Entire L2P archive will be available for the research community
  - Bridge to SLSTR record in future

Multi–sensor satellite SST validation and bias adjustments in the Arctic Ocean – Jacob Hoyer

- Arctic Ocean challenges: clouds, ice, atmospheric inversions, few in situ obs, darkness
- Study year is 2008
- Satellite sources:
  - SABIA is a database of in situ obs?
  - AVHRR, MODIS, AMSRE, AATSR L2P
- Showed examples of AMSRE and AVHRR biases, seasonally driven
- Spatial and temp aggregation
  - 5 day and 1/4 deg aggregation chosen
- AATSR and AVHRR GAC as reference: averaged together
- Showed example of spatial corrections fields
- L3 bias corrected data set: All sensors improved, especially MODIS
- L4 validation and impact
  - DMI_OI improves .2degC
  - Also improves using independent SST obs such as Ferry observations
- Lessons:
  - need to know error characteristics of individual sensors
  - Empirical Biased correlated with simulated bias
  - Approach reduces biases in L3/ and L4 data sets
  - Will be implemented operationally in myOcean L4 data sets

Trends in the global SST front and gradient fields Discussion on SST in Climate Applications – Peter Cornillon

- Study SST front changes due to warming, wind stress, cloud cover etc.
- Processed Pathfinder 5.2 globally for fronts. 0.35 deg resolution
- Also use 1991–2010 ARC data
- Processing 3x3 median filter
  - Sobel gradient operator and Cayula/Cornillon front detection
  - Cayula needs 32x32 window to do variance detection
- Day /night fields separated, Only 45N–45S looked at
- Data summed into 5x5 monthly cells, then summed over the entire world
- Showed global image of nighttime front probability. Top category is 4 % in coastal regions.
- Showed image of positive trend in SST front probability over 30 years
- One region showed 50 % increase
- Gradient magnitude
  - Showed plots of histogram of gradient magnitude for two period
  - But trend in gradient magnitude is decreasing!
  - AVHRR sensors seem to be degrading over time ARC data
  - ATSR gradient magnitude individually show increases
  - Front probabilities are inconclusive. Need to take advantage of hi res GHRSST datasets to look at these frontal issues!

Discussion

- Peter C: Did you look at orbital drift of AVHRR sensors?
- Chris M: trends in ARC due to noise in early sensors.
- David L–Jones: Heat content more important than SST for CDRs. Does Front detection distinguish eddies (to get at vertical mixing)? Not really.
- Dudley C: intensity for fronts decreasing while number of front increasing. Why?
- Craig: Issues: ARC database is now useful for climate studies, but what is the most efficient distribution method. Satellite Matchup database MMS need to be looked at.
- Jorge: GHRSST needs to educate the users on the availability of GHRSST data sets.

SESSION 4.2: OPERATIONAL USE IN METEOROLOGY AND MARINE APPLICATIONS

Chair: Gary Corlett[(1)]; Rapporteur: Werenfrid Wimmer[(2)]

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Evaluation of assimilative SST forecasts in the Okinawa Trough and Gulf of Mexico – C. Barron

The talk presented a Ocean Predication system and some improvements. The talk showed that there is a cool bias of 0.2K in the regions presented which might be due to missing heat flux adjustment / DV misrepresentation → want to use a foundation temperature product to investigate the issue.

Q: Harris: lines in scatter plots - are you worried about them (vertical lines look like digitization issue).

A: Only had a month to get this analysis done, might need to do some QA, was not relevant for the first draft of this study.

NGSST-O looking back to consider the future - F. Sakaida

NGSST-O stands for New Generation SST for open ocean (NGSST-O). It is and analysis product, produced daily, using AMSRE + MODIS, AVHRR 2003-2011 on 0.05 grid, SST resolution 0.15K (1byte). Based on Kawamura 2002, developed Guan and Kawamura 2004; continued operation for 10 years with no large gaps apart from the earthquake in March 2011.

Demonstration phase ended Oct.2011 -> Next step is a higher than daily temporal resolution and higher spatial effective resolution.

Q: Barron: Variability of AVHRR data in example eddy slide - why is the eddy disappearing? Advise look at source data.

A: Good example for using both AMSR and IR.

Towards advanced use of SST in NWP at JMA - Y. Takaya

JMA uses two operational SST: MGDSST – high res. 0.25deg, 1986 onwards; COBE SST – historic 1891 onwards, 1 deg. Planning to integrate weekly and monthly prediction systems, also will have hind casting possibility. Users always want higher resolution and longer period SST.

Future NWP will have an atmosphere ocean coupling; in the meantime skin SST is needed as interface temp. Important for fluxes, DV, calibration of sat, gas transfer (CO2 solubility depends on skin SST). Implement DV model (Takaya 2010 paper). Some issues with cool skin models, probably due to JMA spectral issues. Maybe update for direct assimilation for skin in the future?

High resolution and high frequency SST are essential for NWP (impacts are well recognized.)

Q: Beggs: Efforts similar at BOM (coupled model), good results, good to talk offline.

Operational use of NWP outputs in SST retrieval methods: validation results - P. Le Borgne

NWP outputs used to improve SST retrieval products. Work by OSISAF team and CMS showed two bias correction methods; a classic bias correction and a two/three channel optimal estimation method. The predicted / observed at day time correction over corrects and the night time correction underestimates the error. The OE (2, 3 channel) results are not quite as good as BC as BC uses smoothing of atmospheric correction. Operational BC has residual error depending on model TWVC, OE does not show this, but sensitive to true SST. OE SST uncertainty has effect on true SST sensitivity.

Q: Harris: No aerosol in model. Is the residual due to night time aerosol?

A: there is aerosol correction but not in this model.

Q: Sensitivity greater than 1 in QE, how is that possible?

A: relative to what is observed with operational

Providing fishermen with daily high resolution SST in the Kuroshio region - X. Xie

SST is useful in location of fishing grounds (promote economy of fishing operation). Why is daily high resolution SST needed? AVHRR - example of cloud contamination -> merged AMSRE and AVHRR product. Fishermen rely on bulk SST (in situ is measured at 3m). Use in situ to convert AMSRE to bulk than convert AVHRR to bulk. Analysis converted to isothermal maps (human drawn, to include frontal information and filter analysis artifacts) these maps are then send to the fishermen.

Q: Llewellyn-Jones: Interesting talk, what is the feedback from the fisherman? Expanding or contracting?

A: Good contact, also visit fisheries grounds.

Q: Llewellyn-Jones: When ATSR was launched British fishing industry was not interested in SST, because fishermen were doing too well anyway.

An analysis of the SST gradients off the Peruvian coast: Sensitivity to resolution - J. Vazquez

Why gradients of the Peruvian coast - fisheries and the Peruvian upwelling. A study of 2009 was conducted and the results are presented here. Gradients are estimated by a central difference method; also looked at upwelling scales. Higher mean gradients in REMSS and MUR than OSTIA and NCDC. Comparison with pathfinder and MODIS, more cloud free data in MODIS. Upwelling scale closest in MUR, OSTIA furthest; gradient highest at MUR. Annual cycle explains 30-40% of the variability. Want to extend the time series. SST validation also has to look at gradients validation not just SST.

Q: Casey: is this pathfinder 5.0?

A: Yes

Q: Chelton: Metric for the scale of upwelling, first peak in the upwelling, why not mean/median

A: Need to look into that, but upwelling scales seems to be consistent with other work and are not dependent on the Rossby radius of deformation, need to look at higher resolution SST to figure out.

Characterization of Agulhas Bank upwelling variability from MUR blended SST and 1 km MODIS Aqua data - C. Whittle

OceanSAfrica initiative. Needs integrated capability for observing and forecasting. Agulhas bank, better understanding of physical and biology (e.g. fisheries) models for productivity. Uses MUR SST. Looked and MODIS Aqua and Terra data. Upwelling index for region.

Q: Vazquez: MODIS data used highest quality?

A: No, used first three flags. Using only highest quality loses too much data.

Discussion

Ignatov: Is there a plan to have brightness temperature on the L2p AATSR dataset

Embury: Thinking about it, it is possible and should not be a problem. Are both nadir and forward BTs required?

Ignatov: Yes all BTs.

O'Carroll: It was considered to have the BT in the SLSTR L2P. at the moment only nadir BT; reason file size consideration.

Donlon: BT was considered as a quick check if cloud mask is ok.

Ignatov: BT also as part of L2P

Donlon: No, but all the BTs are available for SLSTR.

Gentemann: If some users want BT they could be in separate files.

Donlon: It should be flexible, so data providers can decide what to do.

Beggs: Wants some guidance if the AVHRR HRPT should have BT in L2P? File size might be an issue, no reprocessing planned, from now forward.

Ignatov: BT in L2P is very good. Especially for AATSR as it is more effort to implement it there.

Merchant: It needs to be seen if it's still relevant as no new AATSR data is coming through. Talk to Chris if you want to know more detail.

McKenzie: Navy NWP likes BT from now forward (Sentinel is a key one for BT) - important for radiance simulation.

Armstrong: Note that GDS says experimental variables are limited to 32 byte per pixel.

Cornillon: Solution might have to be two files.

Llewellyn-Jones: Few people who want it, some people would not like big files, it's quite a serious point. Need short document to explain the rationale for doing it:

ACTION - Bruce McKenzie: To draft a note on the requirements for incorporating BTs into L2p.

Cornillon: Data volume is issue – to BT in separate file is better.

Gentemann: Two files is the way to go.

Donlon: Different issue - that's what the experimental fields are for, otherwise point to the original L1b files.

Llewellyn-Jones: User survey good, but in context of user forum as Craig says, so data providers can take action with confidence.

Cornillon: Need to think carefully about a user symposium. Might be difficult to get people to come to just an SST symposium, might have to be at a physical ocean meeting.

Gentemann: User symposium at Santa Rosa User/ ST team had 80% overlap.

Minnett: There are too many meetings. A Scheme where a user symposium and ST meeting are together helps people not to have to travel less. Tuesday this week is mainly user related anyway.

Gentemann: Some people said Santa Rosa user meeting along with the ST meeting was too long.

Donlon: We need to show why we are doing what we are doing, so connection to user is important. 3 day User meeting is fine. How we want to take the meetings forward needs to have a proper strategy. Meeting format is important task.

Vazquez: In favor of having user symposium separate. Something like an IDL course / training session on GHRSST products is needed.

Gentemann: Web-seminar might be the way.

Minnett: Not sure what education is needed. For GradStudents ESA summer school could have a GHRSST session.

Donlon: might not be easy. Sentinels might be an opportunity. Ocean Colour does week long training courses.

Cornillon: Users are different for each member; might need targeted way to get your users.

Gentemann: For next generation copy IOCCG style?

Arino: Who are those users, can we make a list? Project office will lead on developing URD.

SESSION 4.3: ERROR ESTIMATION AND PRODUCT DEVELOPMENT

Chair: Chelle Gentemann[(1)]; Rapporteur: Gary Wick[(2)]

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"In situ measurements of skin SST in the China Sea" by Lei Guan, Kailin Zhang, and Zhimeng Yang

The Dong Fang Hong II research vessel has an ISAR deployed on the compass desk. It is accompanied by camera to look at sea state and camera to look at shutter. Data is written to a flash disk as data backup. Additional sensors measure shortwave radiation, longwave radiation, SST at 2m, and SST at 5 m. There have been 23 cruises since 2009 September. NOAA AVHRR from University Terra Scan system was collocated to the ISAR data, resulting in 449 matchups.

Questions: Sasha Ignatov: RMS at night larger than day, any explanation? Lei: not sure – need to check

"Quality control of SST observations from drifting buoys and ships on a per–platform basis" by Christopher Atkinson and Nick Rayner

Data (1995–2011) has existing team QC checks + a further check against reference of ARC or OSTIA vs ARC. Depth and time were adjusted to help account for diurnal heating. ARC clearly showed gross errors in drifting buoys. Only ~3% of buoys well sampled, so need spatially complete reference. OSTIA is not strictly independent. The validation data is compiled from collocation of in situ data to nearest grid from previous day, using only nighttime in situ data. The worst buoy failures detected by OSTIA and ARC, however, uncertainty in OSTIA fields in frontal regions has led to some false rejection of small segments of data. It is very important to not reject in situ data where reference is uncertain. A solution was found by using new OSTIA seasonal background error variance estimates to help prevent false rejection, which improved agreement with ARC QC outcomes. Validation: New QC reduces spread of biases and noise relative to OSTIA Ship QC is still being worked on, with new procedures for QC on platform by platform basis.

Questions: Craig Donlon: is QC internal to Met Office? Funding? Met Office funding. Shared with ESA CCI. Still improving.

Peter Minnett: Drifters that failed – anything common in design or construction? Any mechanism of failure? See one batch in 98/99. Nothing sensitive enough to see by type

"Error Models for Averages of Binned SST Observations Based on Small–Scale and Short–Term Variability Estimates" by Alexey Kaplan

There has been modest progress relative to last year. To study climate, it is necessary to have records from both historical in situ and modern satellite. There are problem with different coverage over time – not continuous time series on grid basis. The goal of this work is to find error of representation of climate field due to incomplete climate observation. Average value by grid, look at scatter. Can do much by sigma squared/N – not clear it would work for a while until get good number of samples. High resolution data can help pinpoint natural SST variability on small scales. Calculate background variability in 1x1 boxes. The pure STD pattern shows something missing: random component from Liz Kent/variograms. Need to take measurement error into account. If combine two estimates, Pathfinder plus Kent: To first order looked good.

Some regions of natural variability disappear in model. Issue of different number of obs between drifters/moored/ship. Drifters can dominate due to rapid sampling. Other months, all error could come from ship. Not satisfying behavior of error estimate. Requires more detail. Do daily binning of in situ data; separate by platform type and separate by day/night. Can then compare more closely. Daily 1 degree bins of Pathfinder day/night and compare with similarly averaged ICOADS data. (1996–2004). Where two platforms show same difference with Pathfinder – likely Pathfinder. Where different representation, likely in situ. Drifters better behavior than ships. Still some systematic biases need to be resolved.

Question: Helen: Work to 2004? Yes due to Pathfinder. Hopes to do more recent years with new Pathfinder. Helen curious to know if new data getting into GTS making improvements.

"The resolution capability of high resolution SST analyses" by Dudley Chelton, Richard W. Reynolds, Dimitris Menemenlis, Matthew Martin, Jonah Roberts–Jones

The primary need of L4 users is quantitative info about feature resolution capability of each SST analysis procedure. What is true resolution? There are 3 issues: (1) Many confuse grid spacing and feature resolution; (2) Resolution capability needs to be quantified individually for each analysis and each time and location; and (3) can push too hard and get bad stuff out.

It is impossible to get high resolution IR data in regions with cloud and results in sampling errors are bigger than measurement errors.

Approach is to experiment with synthetic data from ECCO–2 model. Sub sample data from model assumed as truth field. (full vs. reduced) Reduced due to missing data. Compare results from 2–stage OI and OSTIA. Examined Gulf Stream region and found that the spectrum of "true SST from ECCO–2. OSTIA full is more energetic than OI low–res, but less energetic than data. See tremendous reduction in spectral energy. When go to reduced data – Dick's produces energy that doesn't exist (OSTIA not change much).

Conclusion: synthetic data useful for quantifying resolution capability. Work here all assuming error free. This is work in progress. Believe should be applied to every global SST analysis to illustrate smoothing. Second stage of Dick still creating noise. OSTIA is superior analysis.

Questions: Craig: Say OSTIA is also 2–stage. Jonah, not really 2–stage, but 2 length scales.

Ken: Like idea of assessment. Important however not to use Pathfinder coverage – others have better cloud masking than Pathfinder. Use real sampling. Dudley – agree, should use real sampling.

Global 1–km SST (G1SST): Merging in situ measurements with multi–satellite observations Peggy Li, Zhijin Li, Benyang Tang, Quoc Vu

Motivation 1–km blended SST off CA coast. Looking for data for data assimilation. Decide to come up with own regional product. Since then extending to global, real–time (<24 hours), keep resolution as fine (1 km as possible). Use as much L2P satellite and in situ data as possible. Publishing validation statistics in real time. Website is http://sst.jpl.nasa.gov.

Current blending uses a 2Dvar data blending algorithm that includes data from MODIS, Metop AVHRR, AMSR, GOES… Windsat coming, and possibly AVHRR HRPT data from BoM in real time. 20% of in situ data reserved for independent validation. Typically around 0.1 K bias cold, rms around 0.7. There is a need for a consolidated black list. We understand the resolution / noise issue and are improving analysis by providing data availability flags that identify input data resolution. Next generation is 3–stage 2Dvar blending. Paper recently submitted. 3 sets of error covariance for low, medium, and high res. In process of implementing this work flow. Bias correction (still see cold bias).

Diurnal warming correction. Looking at feasibility of a 6 hour product and show 6 am/6 pm SST difference and impact on salinity. Publication targeted this calendar year

Questions: Andy Harris: How long take to run? Typically start 10/11 pm when more computer samples/data. Take about 10 hours end to end. Computers: 16 processor cluster

Alexey: How compute error? Look at some of model fields/ensembles – derive error covariance from there

"Selecting a first–guess sea surface temperature field as input to forward radiative transfer model" by Korak Saha, Alexander Ignatov, XingMing Liang and Prasanjit Dash

Selection of a first–guess SST depends on application. First guess is Reynolds daily M–O biases used for improve cloud detection. Evaluate first guess input filed into CRTM (just using nighttime data). M–O biases sensitive to first guess SST. Compare results using Reynolds/OSTIA. Differences more stable when OSTIA used as first guess. Contrast sharper in OSTIA. OSTIA long term time series seems more stable. STD SST L2–L4 biases also sensitive to first guess. Using L4–L2 biases rather than BTs M–O biases is more efficient.

Extended comparison to eleven more L4 SST fields. ACSPO L2 as a transfer standard.

7 months of L4–L2 data. Also looked at in situ but not show here. ACSPO data not assimilated so "independent". Conclusion: 11 different fields cross compared for use in ACSPO CRTM

3 bias metrics Temporal stability of mean bias; Average spatial STD, Temporal stability of spatial STD. During test period GMPE show best combination of all metrics. This consistent with Martin et al 2012. Plan to explore GMPE in ACSPO.

Questions: none.

"NOAA's Operational GHRSST Sea Surface Temperature Geostationary and Blended Products" by Eileen Maturi, Andy Harris, Jonathan Mittaz, John Sapper, Robert Potash, Krystal Repoff, Prabhat Koner, Prasanjit Dash, Yury Khai

Products include geostationary SST products: GOES–13 (East) GOES 15 west, MTSAT, MSG–2

2 Blended SST analysis products: Geo–polar blended SST analysis at 0.1 and 0.5 degree

Plans for nighttime only blended, diurnal warming estimates for all operational geostationary, diurnally corrected blended SST analysis. AMSR–2, New blended analysis with MW.

Geostationary products: Half hourly, hourly, 15 minutes. Improvements to Bayesian cloud mask. Hope to implement physical retrievals. Say will add diurnal warming estimates using NCEP fluxes and modified KC. Physical retrievals: reduces regional biases relative to regression based. Also improves trend. Geostationary GDS 2 will be produced when physical retrieval is operational and available end June. Two 11 km and 5 km blended SSTs. 5 km will be in GDS 2. Geo–polar blended, data adaptive correlation length scale. Validation monitoring also available for 5 km analysis. NOAA is doing nighttime only geo–polar blended reprocessed from September 2004 to present. Requested for coral reef products. Summary: Geo and blended. Improvements with physical retrieval and improved resolution.

Questions: none.

"Replacement of AMSR with Windsat in the MW+IR OISST" by V. F. Banzon and R. W. Reynolds

Problem: have a product with no continuity. Can something fill gap? What about Windsat? Can't just start, need to evaluate if provides data with same quality. Daily OISST analysis: 2 versions: AVHRR_only and AVHRR+AMSR. Both also add in situ and ice derived SST. Analyses using MW data only, also data without bias correction step, using Version 7 SST data from RSS. Different equator crossing times: AMSR at 1330, Windsat at 1800. Differences with respect to spatial gaps and L3 scan overlaps. AMSR gaps old data overwritten, windsat older data retained. Windsat data coverage: Less than AMSR but more than IR. Temporally less consistent than AMSR. More Windsat data missing early on. Look at on grid cell basis.

If look just at fields, look similar where have data at first look. Where start having gaps, windsat errors get larger. When don't do bias correction, see big difference. Say better to use Windsat as gap filer rather than combining MW obs. Conclusions: Consistent MW+ IR OISST can be made using AMSR followed by Windsat. Bias adjustments compensates for difference between Windsat and AMSR. Need consistent Windsat data – critical

Questions: Craig: Are we ever going to have consistent data record? Should build systems that presume no continuity. Viva say need is communicating how errors change as data come and go.

Chelle: not intended as operational data. NRL push data, but not check. Paul Chang adds another data stream.

"New ATSR Full Resolution L2P Using the ARC Processor", by Owen Embury, Chris Merchant, Hugh Kelliher, Nigel Houghton

ESA/NEODC multi–mission archive provides all (A)ATSR data in a common format and is source of AATSR L2P in LTSRF. ATSR reprocessing for climate: reproduced from L1b data. Available through website listed. No L2P or equivalent. Shows different results with operational vs ARC coefficients. See much improved results. AATSR L1b archive status is current version 2.0. Last reprocessed in 2008. Working on version 2.1. Latest version of processors and this will be used to generate L2P. Upgrades to processors: will give improvement on legacy SST retrieval: improved coefficients that will lead to 0 mean global bias but not remove regional biases. Better vis calibration. Fix known issues with cloud screen; nadir/forward view colocation and absolute nadir view geolocation. Within L2P will see switch to ERA0inteim for wind speed and sea ice. Ancillary data to include solar za, prob clear, systematic and unsystematic uncertainty (new uncertainty fields). Show improved cloud detection. Better removal of dust (through Bayesian). Also ice detection element.

Summary: multi–mission processing will add visible calibration and geolocation, new L2P

New L2p will be a significant improvement on current ATSR L2P SSTs: regional biases should be valuable for future reprocessing efforts.

Questions: Chris asks about other products coming from ARC. Owen show skipped slides.

Future products include Globol lakes.

Peter Cornillon: Ask about line in Saharan Dust Index. Owen hadn't looked in detail. Peter say was visible in previous L2P.

One other comment: was image with front. Is a cloud screening, cleaning up object that can help discriminate clouds from fronts.

"Sea surface temperatures from Metop–IASI" by Anne O'Carroll, T August, J Figa–Saldaña, T Hultberg, H Bonekamp, F Montagner

Developments in processing; core SST processing. Infrared atmospheric sounding interferometer. Designed for sounding but can get sst 3.62 to 15.5 microns, 2112 km swath edge, 12 km res at Nadir. Recent upgrades to processing: V 5 update to cloud detection. 5.2 again cloud test, latest cloud parameters but no impact on SST. L2p product is Core product but includes wind speed. As validation, IASI SST routinely collocated with OSI–SAF metop–avhrr drifting buoy data to create multi–sensor to use for SSES calculation. Regional analyses show cool bias. For regions identified as 100% cloud free, bias and STD decrease in many regions. Look specifically at arctic, again 3 way stats. Future plans: L2P core currently done at Eumetsat. OSI–SAF currently developing chain as well as validation chain. Products will be disseminated from OSI–SAF. SSES: using IASI L2 water vapor info. Based on IWV thresholds. Driest atm have highest quality level 5. 2 to 5 can be used. Will be updated for more consistency. Conclusion: Slight cool bias –0.36, std 0.35K to buoys. Residual cloud contam likely. Bias down to 0.2 if clear.

Metop–B launch planned for Aug 2012. SSES update planned

Future plans include new cloud detection, address slight angular dependency, include band 3 (shorter wavelength) in nighttime retrieval.

Questions: Ian Barton: possible to select IASI channel to match AVHRR to compare radiance/BT? Anne: say is something could do (hasn't)

Andy Harris: 0.14 error from 3–way analysis? Yes. Andy says never seen AVHRR that good. Anne says obs are qc'd and represent some of best quality.

ATSR Points DL–J

RSE special issue

How to get the data

Discussion:

Summary: There was first a discussion on including TB in L2P data. This generated much discussion both for and against the idea. It was suggested that the AC look at a 10–year plan and think about what community wants. Discussion then evolved into a proposal to hold a user symposium. This generated much discussion both for and against the idea. It was suggested that the AC look at whether a user symposium, webinar, or training session is necessary.

Chelle Gentemann: interesting session: much work on improving analysis

Sasha Ignatov: was going to ask Owen. Any plan to include BT in L2P? He would add to MICROS system. Owen say is possible. Sasha say consider this a user request. Owen: no problem, just slightly larger files.

Owen Embury: want both forward and nadir?

Sasha Ignatov: yes, 6. Sasha say wasn't possible for MODIS. Would also be nice to have as part of SLSTR.

Chelle Gentemann: has been discussion in past.

Anne O'Carroll: has been discussion of BT for SLSTR. At present just plans for Nadir.

Craig Donlon: based on practical issue. Gave idea of quality of cloud mask.

Sasha Ignatov: again say valuable for radiance monitoring.

Craig Donlon: SLSTR will be available as part of other products.

Sasha Ignatov: valuable to have in single product.

Chelle Gentemann: no need to have in same file.

Craig Donlon: Like as is:

Helen Beggs: would like guidance if her AVHRR L2P products would be more useful if did have BT. Would be lot of files going back. But could add if useful for going forward. How many users would want? Does add volume. Sasha: would really like for AATSR since new sensor. They are doing for AVHRR, others.

Chris Merchant: With regard to ATSR series. No ongoing data flow. Only access to full resolution cloud mask within Bayesian will be within L2P. Come to him to follow up.

Bruce McKenzie: key here is not older data. For navy weather prediction, more users that could add BT data to data would be useful. Bruce says Sentinel is what really would like in future. Great ned for all, but within weather prediction, going to radiance assimilation.

Ed Armstrong: limited to 32 bytes per pixel as in GDS.

Peter Minnett: solution implied is that could be 2 files. Chelle echo that could have 2nd file for those that really need.

David Llewellyn–Jones: had this discussion before. Always same way. A few that want it, a few would complain if too big. Unclear who really wants. Operational yes, but others just screwing around with retrievals. Request a user survey – always same way. Chelle say good idea, suggest Bruce take lead.

Craig Donlon: Discussion does keep coming up. Suggest 3 lines at AC tonight. Where want to be in 10 years. Hope group wants to operate in full/open exchange of BT. 2) Focus on CDR pushed by most anyone. BT goes with CDR. 3) Needs to be stronger user focus. Should be separate user symposium to attract users known and unknown.

Peter Cornillon: Having just downloaded 5 TB of ftp. If added fields, more productive if in separate files with pointer to second file. Chelle say agree. Help data distribution.

Craig Donlon: say that this in essence is pointing to L1B. Looking here for supplementing value. Is mechanism for 32 bytes. Should look to these, or point to original L1B files. Do right thing rather than driven by data management.

Chelle Gentemann: like idea of user survey: too big vs. useful information.

Craig Donlon: this then goes back to original task sharing. Version 1 is working now. What about 10 years, might look different. Regional/global task sharing back to Kawamura for political reasons. Need to have vision of looking forward. Computing moving toward cloud. Data there. Group should be on top of what happening in next 10 years.

David Llewellyn–Jones: agree idea of survey within context of a user symposium. Better audience, better argument to take to data providers.

Peter Cornillon: Think carefully about user symposium. Have had sessions previously. If user go to meeting will go to OS instead, not just SST group. May have trouble acting people.

Chelle Gentemann: say had good turnout in Santa Rosa, but strong overlap with GHRSST. Say perhaps better to have training session to reach out to younger group. Also problem with funds.

Peter Cornillon: he say he have particular interests. Not want to listen to biological interests.

Peter Minnett: say many here say too many meetings. Many a long way. Say model of symposium Wed–Fri, and then 3–day Monday – Wed GHRSST science team meeting. Chelle, 1 week about max.

Craig Donlon: This why he said separate: Need for strong user justification to ensure funding. GHRSST meetings long, yes, but good thing. Need working groups to do work before hand. Say plenary what keeps group going. Starting to see divisions between what groups doing. Need to again look forward.

Jorge Vazquez: in favor of separate symposium. If coupled, same people. Do need training session. Something like Webinar training and then user symposium somewhere down line.

Chelle Gentemann: did webinar with IOOS people. Went well. Got lot of feedback. Was painless way to communicate with other.

Peter Minnett: not sure what mean by education? Grad students or mature users? If grad school, ESA has sessions at ESRIN.

Craig Donlon: This would be hard (based on way courses set up). Maybe something around launch of Sentinel, but would likely still be cross Oceanography. Craig brings up IOCCG and detailed training courses.

Peter Cornillon: Clear that many different views of users. Need to target these people in their venues. E.g. OS.

Olivier Arino: Can we try to have a catalog of users that are not in the room. Way to see if is way to target them. Should have catalog.

Peter Cornillon: want to look at classes of users.

Chelle Gentemann: One of things thinking. DVWG have been some of best workshops. Working on problems. Useful. Would like to see something like this where emphasis on grad students.

Peter Minnett: say this coming back to ESRIN. Chelle: would get new and innovative research by throwing users together.

Peter Cornillon: Comment on focus of meetings. Are issues that need to be addressed with respect to SST. GHRSST meeting should focus on these issues rather than people getting up and saying what they doing. Minnett: Say based on abstracts. Perhaps need more abstracts on problems rather than solutions.

Craig Donlon: show example of what they did with Glob Current: User consultation meeting. Say was successful thing. Could be good for GHRSST but will take organization.

SESSION 5: NEW INSTRUMENTS AND FUTURE PLANS

Chair: Peter Minnett[(1)]; Rapporteur: Jon Mittaz[(2)]

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(2) University of Maryland, CICS, MD, USA, Email: Jon.Mittaz@noaa.gov

Status of NPP/VIRS sensor and SST by Sasha Ignatov

An introduction to NPP/JPSS was given detailing the roles of the different agencies and groups within the project. Some discussion of the setup of NPOES and JPSS was made including the relevant responsibilities between the US and Europe as well as details for the relevant contributions of private industry and government agencies in the development and production of the various products.

The JPSS team itself is drawn from people with expertise in MODIS and/or AVHRR processing and includes teams from NESDIS, University of Miami. NAVO and the OSI–SAF. Ocean color groups and the IDPS are also involved. Currently there are planned to be 4 global products from VIIRS.

Examples of imagery were then shown showing the improved level of detail available with the finer resolution of VIIRS. Raw swath data is banded at the edge of the swatch which can be removed by remapping and the VIIRS imagery (in terms of artifacts) seems similar to the MODIS imagery for both day and nighttime scenes. This includes the presence of low level striping seen when the color scale is stretched to a 2K range in both MODIS and VIIRS

In terms of the VIIRS SST two different SST schemes were shown, one from the ACSPO processing system and one produced by the IDPS. Both show some cold anomalies which is either due to poor cloud removal or to aerosol. In terms of the statistics the distribution of retrieved SST minus buoy data was close to Gaussian. In general the ACSPOS data had a lower bias and standard deviation than the IDPS retrievals, but the IDPS has a larger number of observations (by 30%). The IDPS also shows more cloud contamination in the daytime relative to the nighttime data. Currently work is being undertaken to make improvements to both the ACSPO and IDPS schemes.

MICROS results were then presented which showed a number of effects. One is the change due to changes in the lookup tables used for calibration. Apart from such effects looking at double difference results shows that VIIRS is essentially 'in–family' apart from a CRTM issue with a MODIS channel.

In terms of the release of the data, the sensor data record (SDR) has been declared Beta by CLASS. The IDPS data will be available in Sept. 2012 and ACPSO beta will also be available soon.

Q&A

The issue of problems with the VIIRS data was raised. Some processing (software) issues have occurred which have impacted the data. The issue of the striping was also raised and it was asked if the level of striping seen in the VIIRS data was expected. The JPSS team knew that this would occur was known about one year ago and was expected. It was also pointed out that the Bristol Channel was completely cloudy showing some minor issue with the cloud detection algorithm.

First year report on the COMS SST product by Chu–Yong Chung

The mission was introduced and will provide temperatures, ocean color and data to help with weather forecasts. The satellite was launched in June 2010 and became operational in April 2011. It is located at 128.2 degrees East and has 1km visible data and 4km infrared which is similar to MTSAT and the pre GOES–12 GOES Imager.

Operationally COMS takes a full disk every 3 hours, a northern hemisphere sector every 15 minutes and local area scans can also be done 8 times hour maximum. A range of different products is being produced.

In terms of the SST retrievals the MCSST algorithm is used with different coefficients for day and night. To begin coefficients based on simulated radiances was used and after 3 months the procedure was switched to using matchup data which are updated every three months. Quality checks are applied to the SST data to remove bad data due to clouds etc. The website enables access to 1 day, 5 day and 10 day SST maps.

In terms of buoy matchup collocations, matchup data was selected on the bases if a 5km distance limit and a 30 minute time window and for the period between April 20122 and January 2012. Preliminary results show that the data show a large bias and large RMSE, a lot of which can be ascribed to cloud detection issues. Updates to the cloud mask are being made and a problem with twilight cloud detection has already been address to remove an observed discontinuity in the cloud mask. Even with some improvements, however, the bias and RMSE still remain large (bias = –0.730 and RMSE=2.757) which though better than the original values are still large.

Q&A

The question of how to increase and improve the involvement of the Koreans in GHRSST was raised. It was pointed out that they had attended previous GHRSST meetings and there is support within Korea to support GHRSST. **ACTION**: to approach the Koreans to firm up the collaboration within GHRSST and Chu–Yong Chung suggested a contact person.

The Sentinel–3 mission. Overview and status by Craig Donlon

The Sentinel 3 mission is a large mission designed as a replacement for ENVISAT but with improved spatial and spectral coverage. It was noted that the nadir observations from SLSTR are offset to the west with an aim to minimize sun glint effects which has the potential to impact the SST retrieval algorithms. The equator crossing time will be 10am with a better than 4 day revisit time. Near real time data will be provided within a 3 hour window. It was hoped that there would be overlap with ENVISAT which is now longer possible. The SRFs are now available and can be obtained on request to Craig.

New elements of design were also discussed including the flip mirror (which has not been space qualified) which switches between the nadir and rear (oblique) views. Due to the flip mirror this then means that the calibration data (black bodies etc.) is available on alternate scan lines but the optical paths for oblique and nadir to the black bodies is the same as for the observations (something very important for accurate calibration). There is also a snorkel for outgassing. SLSTR also uses arrays of small detectors which may cause some issues at the swath edges.

Data access policies were then discussed and these are meant to be free and open, at least as far as Sentinel 3 and ESA is concerned. A license will be required to access the data. Data volumes will be large for raw data, and GHRSST L2P SSTs will be provided from inception.

Build in progress and it should be delivered by end of this year for testing an integration – full integration in 2012.

Q&A

A question was then asked about the image quality at the edge of the swath and whether any ray tracing has been undertaken and it was noted that this had been an issue with AATSR and is why the ATSR had a small swath to avoid this issue.

Answer: various things done including the use of small detector arrays and an example of the SWIR array was made which has 8 detectors. There has also been discussion of using some level of time domain averaging. Late last year lots of discussion regarding this and how exactly would it work since the pixels are messed up at the edge of the swath. Simulators were installed earlier this year but there is still a lot of work to be done. It was noted that the conical scan makes things more complex.

A question was then raised regarding the launch data. The official date is April 2014 but it shall not launch unless EC provides funds. ESA sates have built 6 Sentinels for 1.8 billion but a budget for operations is under threat at the moment – EC doesn't have legal way to pay for operations. Meeting this week to work it out.

A question was then asked as to what exactly a free and open access policy meant.

Answer: Free and open for ESA means you can request anything – they will endeavor to give access though you may have to pay some of the cost of delivery. For Sentinel there will be full and open access anyone has access worldwide under license which has been required through EC security issues. Licenses also go back to users and user feedback issues since you can know who has the data. And can show a return on the investment

A question was then asked regarding access to pre–launch data and it was noted that the transition from Level 0 to Level 1 is complex and will be a challenge. In principle it should be available but in practice it will be very difficult. However, in principle it should be available especially if you have something to offer in return. However, it will not be disseminated widely just as a practice constraint. Data is to be stored in the spacecraft coordinated database and the example of the SRFs was given which are stored in this database, though there have been some hiccups in making it work. It was pointed out that for long term climate data records the pre–launch data does need to be accessible to the wider community.

A question was then raised regarding the access of data through the ESA website and how slow it can be and the helpdesk can be unhelpful**. ACTION**: Chelle will send Craig her questions regarding this.

A further question regarding the licensing issue for data access was again raised and how it may be a barrier to people accessing the data. After some discussion it was pointed out that the system as designed already will put of SST in GHRSST 2.0 format and that this data will probably just be disseminated via standard GHRSST protocols**. ACTION**: Craig will check if this is the case. The lower level data (which have a large data volume) will be handled by data providers who will have licenses to produce the higher–level products. This is a slightly different model to what has gone before. If there are any comments they can be sent to Craig.

Discussion and co–ordination

A question was then raised regarding one of Sasha's point of having all the data in a single place. It was determined that what was meant was to have all the monitoring in one place, not the data. The data for VIIRS will be archived through standard archives such as NODC including the ACSPOS and IDPS versions.

ACTIONS (see text for context)

1. To approach the Koreans to firm up the collaboration within GHRSST and Chu–Yong Chung suggested a contact person.
2. Chelle will send Craig her questions regarding her issues with the ESA data access website
3. Craig will check if the ESA license requirement for access of data applied to GHRSST data from Sentinel–3

SESSION 6.A.1: STVAL BREAKOUT

Chair: Gary Corlett[(1)]; Rapporteur: Pierre Le Borgne[(2)]

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Email: Pierre.LeBorgne@meteo.fr

Introduction

The ST-VAL breakout took place on Wednesday 6th June 2012 from 11:00 to 13:00. The session covered:

- Update on SQUAM capabilities (Prasanjit Dash)
- Dealing with the 'cold tail' in satellite minus drifter discrepancies (and other outliers)
- Review of SSES Common Principles
- Common Quality levels for AVHRR
- ESA SST_CCI Product Validation Plan (PVP)
- Multi-sensor match-up system MMS
- DBCP HRSST
- Sensitivity to 'true' SST (Peter Cornillon)
- Argo as independent reference
- ST-VAL Membership/ToR

Update on SQUAM capabilities

Heterogeneity in Quality Level definition makes inter-comparison of L2 or L3 SST products difficult. This is inevitable as quality levels are per sensor. The group supports the SQUAM initiative as a very useful addition to the GHRSST toolbox.

Dealing with the 'cold tail' in satellite minus drifter discrepancies (and other outliers)

The issue of how to deal with the 'cold tail' (see figure below) was presented by Gary Corlett.

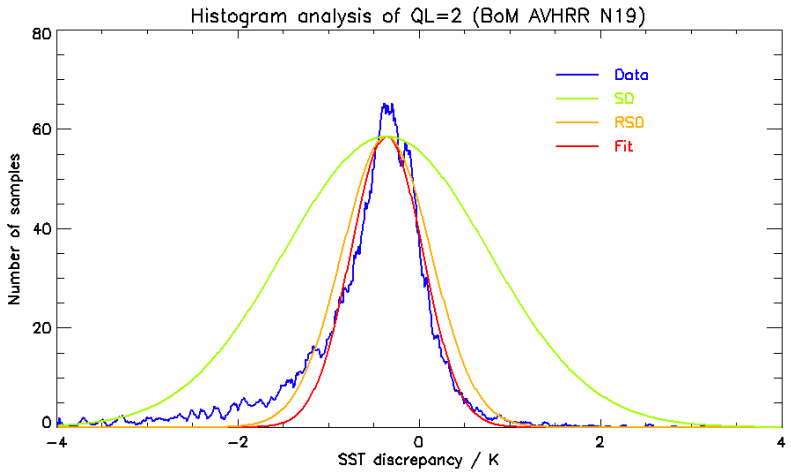

Figure 1: Example of cold tail from AVHRR match-up datset for QL=2 data from the BoM (from Gary Corlett).

The easy way to remove the tail is to improve the cloud mask itself; this is a particular challenge for EaRWiG. An alternate way to provide a better representation of the data is to use robust statistics (orange curve in Figure 1) instead of conventional statistics (green curve in Figure 1) as the conventional statistics do not represent the majority of the data when outliers are present. A further way is to fit a Gaussian function (red curve in Figure 1).

Other ways to deal with outliers are to use 3-sigma filtering. Peter Cornillon pointed out that this approach would not result in the correction distribution for a prefect dataset (i.e. no outliers) as you would be throwing away good data.

Producers (such as OSI SAF) consider that conventional stats reflect better the quality of the products than robust, and consequently should be the quantities included as SSES values. Sasha Ignatov noted that robust and conventional statistics are both informative.

It is not clear what users actually want so ST-VAL needs to discuss these issues with users before any decision is made to change from conventional to robust statistics.

Review of SSES Common Principles/Common Quality levels for AVHRR

The SSES common principles were reviewed and no changes were proposed. There is some confusion as to the purpose and definition of the quality level and SSES, so new users are advised to review the web pages or speak with the ST-VAL chair or co-chair for clarification. The number of levels (2 to 5) has been found quite adequate so far. Chelle Gentemann said she is willing to extend her levels up to 5 to better align the microwave levels with those from the infrared sensors.

ESA SST_CCI Product Validation Plan (PVP)

The ESA SST_CCI PVP is now available from the SST_CCI website (http://www.esa-sst-cci.org/). The project welcomes any feedback from ST-VAL and GHRSST on the document.

Multi-sensor match-up system (MMS)

The concept of the multi-sensor match-up system has been found to be extremely beneficial within the ESA SST_CCI project. Pierre Le Borgne said that the OSI-SAF will start a simplified operational system soon that will include IASI, METOP/AVHRR and (when appropriate) SLSTR. Boris Petrenko will use the SST_CCI MMS to do algorithm comparison studies for VIIRS. The MMS approach was endorsed by the group as the future way to build match-up databases. Gary Corlett noted that a description of the SST_CCI MMS system is available through the SST_CCI documentation (http://www.esa-sst-cci.org/).

DBCP HRSST

All groups were reminded that they are supposed to be evaluating the upgraded HRSST drifters. Pierre Le Borgne noted that this topic was discussed at the Melbourne workshop last March where it was shown the newly deployed buoys show poorer results than existing drifters.

Sensitivity to 'true' SST

Peter Cornillon showed an example of SST fronts with different values and distribution according to the data set used (see Figure 2).

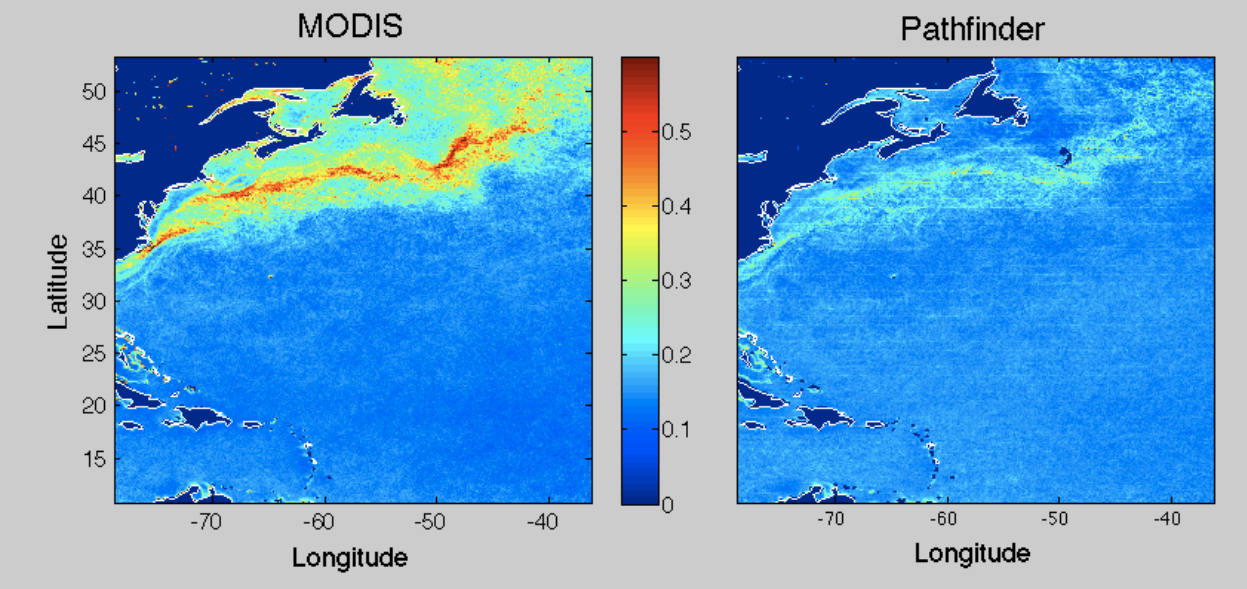

Figure 2: Comparison of (left) MODIS L3 and (right) Pathfinder L3 day time cloud free variance for 2008 (from Peter Cornillon).

An action has been defined to define a metric aiming to reflect the sensitivity to true SST of the various datasets.

Argo as independent reference

The decision taken in Edinburgh to use Argo data as an independent reference was revisited and the group agreed to continue to use Argo as an independent reference dataset for the next year.

ST-VAL Membership

Owen Embury has joined the ST-VAL group.

Actions

1. Peter Cornillon/Pierre Le Borgne (G-XIV)
    - Define metrics for evaluating sensitivity to 'true' SST (time, space)
2. Gary Corlett (End October 2012)
    - Draft position paper on statistical analysis methods for SST validation

SESSION 6.A.2: IWWG BREAKOUT

Stand–in Chair: Robert Grumbine *(1)*

(1) NOAA/NWS, USA, Email: Robert.grumbine@noaa.gov

Brief Updates:

- Jonah Robert–Jones – OSTIA Lake Surface Temperatures

Discussion:

Observations:

- Need more in situ data
    - Steinar Eastwood effort on inexpensive 4 depth platform for initial deployment in Sweden
    - Robert Grumbine effort for public participation, especially educational groups
- Inland Waters need not be at sea level
    - Importance of orthorectification for locations
    - Introduces variability in regression relationships
- Inland waters typically have complex coastlines
    - Challenge of locating satellite footprints which are free of land contamination
    - Area is not, therefore, a good indicator of which lakes are easiest to observe
    - Cloud clearing algorithms are more challenging
- Project noted which is completing assessment of inland water locations – data expected October 2012 (Olivier Arino)
- Lake climatologies are needed for some L4 approaches, and are scarce.

Recommendations:

- Use shoreline bounding curves and distance from shore for decision of whether observation is uncontaminated with land. E.g. GSHHS. Note: for sensors with variable footprint, this is less trivial.
- Sequence of inland waters should be first, those lakes which are 'easy' to get reliable retrievals for – insofar as agreement exists between listing of extant lake efforts (ARC/Chris Merchant, JPL/Simon Hook)
    1. ~150 lakes for which ARC was able to regularly get observations
    2. Then the ~100 lakes for which ARC could establish an observational climatology
    3. Then by order of greatest distance to shoreline first. N.b.: There are over 3000 inland waters which should be observable to some extent by AVHRR LAC coverage.
- Use mutually consistent land masks (e.g. Grumbine land mask generator)
- Producers of inland water temperatures should note whether they are using an algorithm tailored to that inland water, and if so, how it is tailored. Exact mechanism tbd.

Actions:

Document of generalized method for land mask generation, software available (Grumbine)

- Reconcile lists of most–manageable to less manageable inland waters (Hook, Merchant, Grumbine)
- Provide list of inland waters in order of distance to shore (Grumbine)
- Meet via telecon during interim before next GHRSST (Group)

SESSION 6.B.1: HL–TAG BREAKOUT

Chair: Jacob Høyer[1]; Rapporteur: Robert Grumbine[2]

(1) Danish Meteorological Institute, Copenhagen, Denmark, Email: jlh@dmi.dk
(2) NOAA/NWS, USA, Email: Robert.grumbine@noaa.gov

Introduction/Agenda

The report comprises the main activities during the High Latitude breakout meeting Thursday morning 9–10:50 at the GHRSST 13 science team meeting. The breakout session was split into two parts. The first part contained reports and scientific updates on high latitude issues, whereas the second part consisted of a discussion.

The agenda for the updates is given below:

- Chris Merchant/Steinar Eastwood/Claire Bulgin:
    - Improved cloud/ice/ocean classification
- Jacob Høyer:
    - HL SST algorithm developments within the ESA CCI project.
- Bob Grumbine:
    - Update on the NCEP sea ice work – http://polar.ncep.noaa.gov/seaice/demo/
- Gary Corlett::
    - IST from AATSR
- Jacob Høyer:
    - Sea ice climatology from O&SI–SAF and ESA_CCI sea ice project.

Updates

Some highlights given from the presentations were:

Chris Merchant

- Showed the results from a Bayesian classifier.
- It has been tested for AATSR and AVHRR using the Multi–sensor Match–up dataset developed within the ESA CCI project on sea ice.

Jacob Høyer

- The multisensory matchup dataset has been used for testing high latitude SST algorithms
- The performance of the CASSTA algorithm was tested against standard algorithms, such as the split window and the nonlinear algorithm, demonstrating that the CASSTA did not give improved SST retrievals, compared to the other algorithms
- Using regional derived algorithms instead of the global algorithms, was shown to reduce bias and decrease standard deviations.
- A North/South difference was found in the performance of the algorithms. All algorithms performed significantly better for the Southern Ocean than for the Arctic Ocean. This was

related to a much higher atmospheric variability in the Arctic, where inversions were also more frequent.

Bob Grumbine

- Presented an update of the NCEP sea ice analysis status.
- It was noted that it can be difficult to produce an operational sea ice product, since the microwave satellites are failing and getting old.
- There is a trade off between delivering a daily operational sea ice product and providing a consistent climate data record, which has been seen in an increase in the sea ice extent, relating to an artefact from changing satellite and algorithms.
- It was noted that the sea ice extent is a parameter that is sensitive to algorithm and satellite changes when looking at trends and changes. The sea ice extent is a much more stable parameter in this context

Gary Corlett

- Presented the ongoing work at University of Leicester related to developing an Arctic surface temperature product, including land and sea ice surface temperatures.
- They use the AATSR Reprocessing for Climate (ARC) dataset and the current work is concentrated on developing a classification algorithm.
- Inspections and preliminary results indicated that more development is needed before an actual surface temperature product can be validated.

Jacob Høyer

- The O&SI–SAF reanalysis is currently used for constructing a climatology and deriving trends
- Operational Metop–A ice surface temperature observations have been validated using radiometer observations and ship/buoy observations. A paper has been submitted on the results.
- The preliminary outcome from a user survey within the ESA CCI project on sea ice showed that surface temperatures are regarded as the 4th most important ice parameter, based upon 91 respondents.

Discussion

The discussion part included a review of the future plans for the HL–TAG group. Keywords are listed below:

- Sea Ice Analysis – needs?
- Sea ice ‘gmpe’ – Action for Bob Grumbine
- Sea Ice reanalysis products – summarize?
- Guidance requested on how/whether sea ice concentration analyses can be used for establishing Bayesian priors in detection/classification methods (Chris Merchant)
- Summary of methods for how sea ice is treated in L4 SST analyses? – recommendation to IC–TAG
- Land masks and comparison mentioned in passing.

A question was raised:

- Should ice surface temperature be part of GHRSST/HL–TAG? Terms of reference?
    - It was decided to take this together with the update of the terms of reference.

AOB:

Chris Merchant asked – are we really making progress in high latitude SST?

New Chair for HL–TAG

- Steiner Eastwood was nominated for new Chair. He was not present and declined the nomination due to work overload.
- It was therefore decided to swap between Bob and Jacob so that **Bob Grumbine is the new HL–TAG Chair and Jacob Høyer will be co–Chair**

Actions

Based upon the discussion, the following actions were agreed upon:

Action number	Content	Responsible	Status
1	Recommend to the IC tag that more focus should be put on the L4 performance in the Marginal Ice Zone (Jacob) CLOSED	Jacob Høyer	Closed
2	Set up a page with available Sea ice analysis at HL–TAG webpage	Jacob Høyer	Open
3	Develop a Sea ice GMPE–light	Bob Grumbine	Open
4	Update terms of reference	Jacob Høyer, all	open

SESSION 6.B.2: AUS–TAG BREAKOUT

Chair: Jorge Vazquez[(1)]; Rapporteur: Mike Chin[(1)]

(1) Jet Propulsion Laboratory, California Institute of Technology, USA,
Emails: Jorge.Vazquez@jpl.nasa.gov and mike.chin@jpl.nasa.gov

Agenda:

1. Review of AUS–TAG and accomplishments over past year. User symposium?

   Users Manual Completed

   Continued development of PO.DAAC tools and services in support of GHRSST activities

   Between the GDAC and the LTSRF the total number of users from 2006 to 2011 is 88,741. Total number of gigabytes served is 343,803 while the total number of files served is 143,355,862. More details on yearly trends, etc. may be found in the figures in the appendix.
2. Template for information from data providers
3. Which Data Sets should GHRSST advertise to climate users. How should these data sets be advertised: Andrea, Alexey
4. CEOS SST VC activities: Pam Michael, Kenneth. Casey.
5. Multi–Pager for users: Mike
6. Updating RDAC listings: Jorge
7. Review of "URD"
8. Vice–Chair

NOTES from session:

New Vice–Chair = Prasanjit Dash

Multi–pager webpage (link from www.ghrsst.org)

Aimed at new users: short tutorials rather than documents/manuals. Bring the data to users' hands before (or along with) the manuals.

Last year's effort covered only: L2P/L3/L4, GHRSST product lists at LTSRF & GDAC, netCDF software templates.

An expansion ("the multi–pager") that covers breath of GHRSST products/services (GMPE, MDB, SQUAM, and all subgroup activities) is proposed.

Better description of data sets, to answer: "Which data set should I use?"

Recommend each L4 product to have a description of intended use(s) and/or target application(s).

Preference for product list/table (resolution, spatial/temporal coverage, sensors, etc), rather than documentations. Examples are product lists at GDAC and LTSRF, but with potentially additional information such as status of production (active/inactive), date of last update/validation, etc.

Longer textual descriptions may be linked through the product table.

No clear decision was made on how best to move forward with the template concept.

SESSION 6.C.1: DVWG BREAKOUT

Chair: Gary Wick[(1)]; Rapporteur: Sandra Castro[(2)]

(1) NOAA Earth System Research Laboratory, USA, Email: Gary.A.Wick@noaa.gov
(2) University of Colorado, Boulder, USA, Email: sandrac@colorado.edu

The Diurnal Variability Working Group (DVWG) breakout session took place on the morning of 7 June. Planned agenda items included presentations by Helen Beggs, Pierre LeBorgne, and Owen Embury; brief updates on other progress and topics of interest; discussion of issues and activities; review of the action list; and review of membership including election of a co-chair. Since a large portion of the group had participated in the Melbourne joint workshop, the target of the session was providing updates on activities since the workshop and discussing future plans for the group and administrative issues.

Science Updates

Helen Beggs: Update on the GHRSST Tropical Warm Pool Diurnal Variability Project (TWP+).

Helen provided an update on progress made on the TWP+ project since the Melbourne joint workshop at which the project was one of the primary foci. She began by reviewing the two primary research projects underway and progress on tasks and data provision. Access to the data is open to interested participants. Data files and plots available through the common repository at the Australian Bureau of Meteorology (BoM) have been updated since the workshop and include additional diurnal warming model output fields in netCDF format. New TWP+ SST validation and diurnal variability frequency statistics were generated at the BoM. In particular Helen examined revised distributions of diurnal warming events observed by satellites after applying filters requiring a 2x2 array of pixels to be free from cloud and expanded land masks. For MTSAT-1R the 2x2 array was additionally required to be clear for the previous or following hour. The results, as reflected in Figure 1 below, showed a decrease in the number of the most extreme warming events compared with previous estimates. Diurnal warming estimates computed as day-night satellite SST differences and day-analysis SST differences were shown to be in better agreement before enabling improved coverage through use of the analyzed SST fields. Particularly interesting new diurnal warming estimates are available from the BLUE link high-res air-sea coupled model CLAM-R.

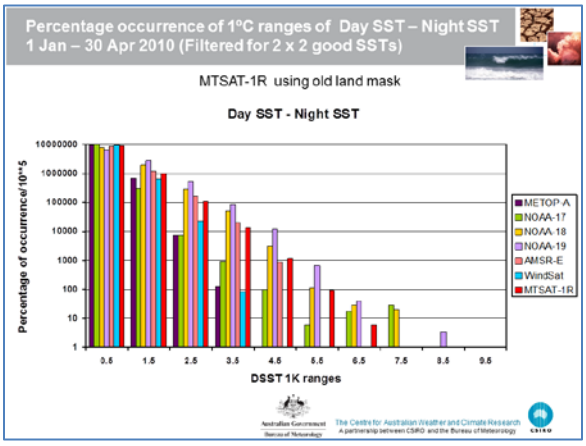

Figure 1: Distribution of satellite-derived diurnal warming estimates (from Helen Beggs).

Pierre LeBorgne: Comparisons between GOTM simulated, SATELLITE and BUOYS derived Diurnal Cycles in the Mediterranean Sea and Eastern Atlantic Ocean.

Pierre presented encouraging work-in-progress from the student Daniele Ciali comparing modeled diurnal warming in the ALADIN domain with observations from SEVIRI, drifting, and moored buoys over the period of April-September 2006. The work employed the GOTM model with the k-epsilon turbulence scheme and a customized vertical grid and forcing from ALADIN model fields. Average diurnal cycles were computed and compared for multiple regions within the domain considering events where the daily amplitude in both the modeled and observed data exceeded 0.5 K. Overall, the average modeled diurnal cycles were found to agree quite well with observations at multiple depths, particularly those from buoys as shown in Figure 2. Comparisons with SEVIRI-derived estimates were found to be better when only level 5 data were included. Tests also explored the impact of increasing the assumed wind stress in the comparisons against SEVIRI observations.

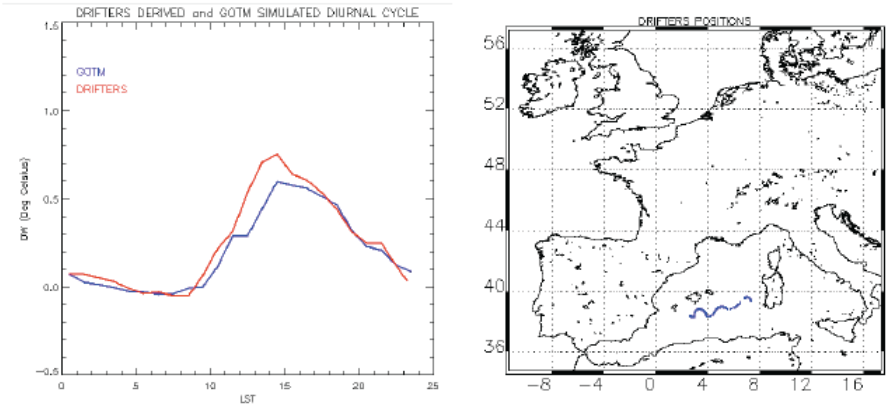

Figure 2: Comparison of simulated diurnal cycles from the GOTM model and buoy observations (from Pierre LeBorgne and Daniele Ciali).

Owen Embury: Diurnal Modeling in ARC/CCI

Based on a request by Chris Merchant, Owen Embury described how modeling of diurnal warming is being incorporated in the ARC and CCI projects. Skin and diurnal warming models are utilized to reference the satellite retrievals to a common time and depth. Forcing for the models is taken from ERA interim reanalysis data. Tests using different models provided feedback on model performance. The best results were observed when diurnal warming was estimated from the Kantha-Clayson model as implemented at the UK Met Office and skin layer effects were computed using the Fairall model. Overall, inclusion of the modeling was shown to result in improved matchup statistics for the projects' SST products.

Brief Updates

Evaluations of unpumped Argo near-surface temperature measurements are being conducted by Sandra Castro to assess their suitability for resolving diurnal warming events. Initial comparisons with collocated SEVIRI observations are quite positive.

Pierre LeBorgne described planned contributions of the OSI-SAF to the planned SPURS/Strasse campaign in August and September and again next year. The Salinity Processes in the Upper Ocean Regional Study or SPURS has a focus on salinity validation and is of relevance to the DVWG because

of the availability of a high number of new vertical profiles of temperature and salinity. The OSI-SAF will support the campaign by providing satellite datasets and constructing a dedicated diurnal warming validation dataset. The database, built around collocated SEVIRI observations, has been noted as a valuable new resource for the DVWG and its potential content has been discussed in previous e-mails and meetings. SPURS represents the first test of the database.

Discussion

Aquarius need for diurnal variability information

The DVWG was approached by representatives from the Aquarius mission with a request for information on 6 am – 6 pm SST differences to help determine if SST could be a factor in observed salinity retrieval differences. Chelle Gentemann spoke to work performed at Remote Sensing Systems demonstrating that the SST differences were minimal and the contribution to salinity small. It was agreed that no further action from the DVWG was required.

Provision of diurnal warming analyses

While the specific request from Aquarius was found to be unnecessary, provision of improved information on diurnal variability remains a key priority of the DVWG. Though construction of a diurnal warming analysis is not easy and is subject to important uncertainties, different communities would value some product from the group.

The availability of new and planned products of relevance was discussed. The Met Office is currently planning a variational assimilation diurnal variability analysis to accompany OSTIA. Planned operational availability is 2014. NOAA/NESDIS/STAR is planning to incorporate information on diurnal variability in their POES-GOES blended analysis. A diurnal warming model is also due to be included in the G1 SST product. Availability of modeled diurnal warming following the approach implemented by Peter Janssen at ECMWF was noted to be of special interest. Peter Cornillon, based on interest on the impact of diurnal warming on SST frontal features is constructing a database from SEVIRI observations he is willing to share.

Gary Wick proposed the establishment of a facility, loosely modeled on the GMPE concept, to demonstrate and compare diurnal warming analyses generated from different models and inputs. While significant interest was expressed, concerns were also voiced that the concept was premature. Much work will be required to define and create such a resource but it was identified as a target the group will strive for.

Administrative Actions

The action item list and membership list were not discussed in the breakout session due to lack of time. Through offline discussions, however, the action list for the DVWG was reviewed and several items were closed either due to completion or a desire to no longer pursue. A revised list was presented in the breakout session summary and a new item to make existing diurnal warming models readily available through web pages added. Formal election of a co-chair was conducted via e-mail following completion of the GHRSST meeting. Carol Anne Clayson was nominated and selected as co-chair. She will serve as co-chair of the group for the coming year with assumption of the chair position loosely targeted for the next GHRSST meeting.

SESSION 6.C.2: DAS–TAG BREAKOUT

Chair: Ed Armstrong[(1)]; Rapporteur: Jean–François Piollé[(2)]

(1) NASA Jet Propulsion Laboratory, Pasadena, CA, USA, Email: edward.armstrong@jpl.nasa.gov
(2) IFREMER, Brest, France, Email: Jean.Francois.Piolle@ifremer.fr

Attendees: Ed Armstrong (Chair), Jean Francois Piollé (co–Chair), Jorge Vazquez, Bruce McKenzie, Hervé Roquet, Christo Whittle Tim Nightingale, Ming Ji, Pam Michael.

DAS–TAG current members: Ed Armstrong (Chair), Jean-François Piollé (co–Chair), Bruce McKenzie, Hervé Roquet, Christo Whittle Tim Nightingale, Pam Michael, Dave Foley, Chelle Gentemann, Ted Habermann, Leon Majewski, Eileen Maturi, Kenneth Casey, Craig Donlon

The format of the breakout was as follows:

1. Review of last year activities
2. Presentation: *Cloud computing and big data technology* by Jean–François

evolving. GHRSST data management organizations should share cloud computing experiences. Should eventually be made part of a strategic plan for GHRSST.

3. Dataset review

Ed discussed the dataset review process for ingestion of new GHRSST datasets in GDAC.

Before only data and metadata DSD were provided, this is to be revised with a new 'roll out procedure'. This will require:

- No fatal errors are raised by python checker (warnings are allowed)
- A new data set product description must be provided to help users understand intended use of the data set and its limitations. A template will be provided similar to that proposed in the AUS–TAG.
    - This action responds to the GHRSST AC to redefine and improve the roll out process and improve the quality of the data set description.
    - Targeted user community for a product should be explained
    - Peer review publication for the datasets should be provided if possible

This procedure will be reviewed and verified for each dataset by a review board (3–4 people) for each dataset. The board will:

- Review each warning from the python checker(new variables, etc.) and providing recommendations
- Review the metadata template to be provided (AUS–TAG template): This will be a 4 pager to help user understand the dataset. This metadata file will be put online on ftp and exposed through link in metadata discovery system (for instrument, in L4, link to L2P provider)
- The suggested board will include Ed, JF, a NODC representative and any volunteer
- The board will be first permanent board and interact whenever a new datasets comes, meeting through telecon/WebEx

Following a question by NAVO, GDAC will continue filling additional variables in the short future

4. GDS2

There are still minor issues with GDS

- some variables are missing _FillValue, valid_min/max
- units is not always required
- grid_mappings attribute: there no example in GDS, so it is quite confusing and a risk of mistake for producers
- depth needs to be a optional attribute
- metadata_link must be lower case

5. CF metadata enhancement

- The CF metadata group is going to consolidate the metadata model for satellite
    - ⇨ standard name for individual bands
- Ed is monitoring the cf–satellite list and other people could be involved to
- Ed is also co–Chair of ESIP documentation activity (which CF is subset of)

6. QQCL

- QQCL stands for "quality quantity continuity latency": this is a set of metrics meant for assessing how good a data set and its services are. It helps assessing issues such as completeness, gaps, timeliness.
- PODAAC is investigating these metrics.

7. HITIDE

- This tool available at PODAAC is a level 2 subsetter (http://podaac–tools.jpl.nasa.gov/hitide/)
- Ed performed a demonstration of the tool with AMSRE, demonstrating subsetting, visualisation and extraction capabilities.

8. In situ data for GHRSST

- Question was raised if there is a need for a GHRSST format for in situ. It was suggested that first existing standards should be investigated (ARGO, OceanSites, NODC) and how they fit or should be upgraded to handle radiometric data for instance.

SESSION 6.D.1: EARWIG BREAKOUT

Chair: Andy Harris[(1)]; Vice–Chair and Rapporteur: Owen Embury[(2)]

(1) Earth System Science Interdisciplinary Center, University of Maryland, College Park, USA, Email: Andy.Harris@noaa.gov
(2) Department of GeoSciences, Edinburgh University, Scotland, UK, Email: owenembury@ed.ac.uk

1 BackgroundGHRSST's primary mission has focused on the characterization of uncertainty in existing products, combined with a unified data format to convey the relevant information to end–users. Actual algorithmic issues related to data products were initially eschewed by the GHRSST project, being regarded as the preserve of data providers. However, it became increasingly clear that scientists desired a forum for the sharing of ideas to overcome problems which were recurrent in one form or another in many SST products. Thus, the Estimation and Retrievals Working Group (EARWiG) was instituted with the express purpose of addressing issues relating to the retrieval of sea surface temperatures from radiances observed by satellite instruments.

It should be noted that EARWiG is intended not only as a focus but also a liaison with other national and international activities, such as the European Research Network for SST (ERNESST) and the recently formed NASA SST Science Team.

2 Presentations**IR Calibration for AVHRR and GOES** – Jon Mittaz

Pathfinder v6 SSTs show biases correlated with instrument temperature. Comparison of BTs against AATSR show that it is not a simple relationship, but it is possible to calculate an adjustment. This adjustment does reduce the observed trend in SST bias and improve the variability

GOES suffers from a mid–night black body calibration problem where the instrument heats up resulting in retrieval biases. This effect was largest in the 3.9 micron channel and was partially resolved with an operational fix; however problems remain and affect the other IR channels too. Data extracted from the space counts can be used to correct for the midnight BB problem for most of the year. This method does not work during the eclipse season and there may not be a solution to this.

Q. Does this affect MTSAT?

A. MTSAT2 will be affected as it uses the same design as GOES. In order to apply this correction method it is necessary to have access to raw count and calibration data.

- CEOS–VC SST may be a good channel to use to request the required data

Q. Are there and thermistors on the satellite (GOES) which can be used?

A. No. The problem is thought to be due to the sun–shield heating up, hence the need to use space counts as a proxy.

Q. Are the required AVHRR instrument temperatures available in the GAC data?

A. They are for the AVHRR/3 instruments, but not for the earlier instruments.

- May be able to get access through the R2HA2 work
- There was no operational requirement to archive L0. Although some centres did archive it, the data is now in an obsolete tape format and there is no longer hardware to read it.

2.2 Microwave SST – Chelle Gentemann

Version 7 of the RSS datasets are now available, the improvements include:

- Common version number across all instruments
- New water vapour continuum
- Rain algorithm modified
- New emissivity model
- Improved diurnal cycle

Version 7 data shows improved biases relative to drifting buoys than v5 did, especially at low wind speeds. RFI interference is a problem both through satellite TV signals reflected off the ocean and ground based sources such as naval exercises and oil rigs. The satellite based interference is easier to remove as the location of sources is known so the glint angle etc can be calculated.

Q. Are you worried about the apparent cold bias at high wind speed?

A. There are very few data points contributing to those bins so it is not a large problem. However, the cause is not fully understood yet and work continues

Q. As part of SST–CCI the AMSR–E SSTs were compared against ARC SSTs, this indicated that AMSR–E was much better than indicated in the SSES

A. Haven't had time to investigate this yet, however it is probably because the SSES were calculated with a 5–day window which is probably too short. In future hope the SSES may be calculated by feeding the instrument noise through the RTM and retrieval which should give a better estimate.

Q. Does this apply to other sensors?

A. The AATSR comparison was only performed for AMSR–E. However, the SSES were calculated the same way for all instruments so it is likely to be a common problem.

Q. Should users subtract the SSES bias from the L2P SSTs?

A. The SSTs in the product are the best estimate of the SST using AMSR–E, while the SSES bias is the bias relative to drifting buoys. The SSES bias can be subtracted if the users want a SST adjusted to match drifting buoys.

2.3 SST CCI algorithm selection – Chris Merchant

The SST CCI algorithm selection process was presented. It is intended to be a fair and objective comparison of algorithms with all teams external and internal having access to the same data, and a predefined set of comparison metrics. The approach proved to be very effective at comparing the different algorithms and identifying their particular strengths and weaknesses. One problem with the SST CCI approach is that it requires a single "winning" algorithm to be selected. In fact two competing algorithms had different strengths and weaknesses such that neither was a clear winner but that both could be improved by examining the differences.

The MMD/MMS was presented and EARWiG asked if it or something similar would be a useful tool.

Q. Is the lack of flexibility is comment on the SST CCI process rather than the MMS?

A. Yes!

Q. Could the MMS be improved by including model data too?

A. The MMS does include associated NWP etc. necessary for RT and DV modelling.

Q. Will the SST CCI MMD be supported as a "GHRSST" MMD?

A. The existing MMD exists for data 1991 through 2010, but there are currently no resources to update this. There is a proposal for an automated update system later under CCI, but this

would only include the instruments currently considered by SST CCI and not all instruments which would be of interest to GHRSST

Q. Are there any fields which you think you missed from the MMD?

A. Not at this stage. Some fields were intended to be included, but had to be missed from the original implementation; however, they have since been added by re–ingestion.

Q. How many people participated in the algorithm selection?

A. There were two external teams. A third team submitted several months after the deadline. There was interest from several other teams, but they were unable to provide submissions in time.

2.4 Incremental Regression for MODIS – Boris Petrenko

Presented work on the VIIRS algorithm development which used MODIS as a proxy. Two algorithms were compared: Conventional Regression (CR) and Incremental Regression (IncR). Both are NLSST formulations, but the IncR uses observation–model differences rather than just observed BTs. The use of obs–sim differences leads to a low signal to noise ratio so it is necessary to scale the coefficients, this scaling factor is chosen in order to maximize sensitivity to changes in true SST and minimize sensitivity to the prior SST. In comparison against drifting buoys, IncR always performs better and especially so for daytime matches. IncR can also return valid results for a larger range of VZA than other AVHRR/MODIS retrievals

Q. What is the reason for the reduced SD at the swath edge?

A. The plot in question was retrieval–OSTIA and the IncR retrieval is relying on the first guess more at the swath edge.

Tuning of the coefficients is a choice between sensitivity to true SST and reducing SD (increases sensitivity to prior SST)

Q. Use of 'advanced' retrieval methods (IncR, OE) may not improve global stats, but can give improved regional performance

A. Agree

Robust stats may be useful as they are less sensitive to outliers in reference dataset and/or cloud screening so reflect retrieval performance more.

Should see improvements in bias w.r.t. WV, latitude, VZA etc.

Q. Do you have a feel for the stability of the coefficients with time?

A. For CCI RRDP a fixed set of coefficients were produced for each instrument, and the retrieved SSTs appeared to be stable with time. Haven't looked at the variation of the coefficients themselves as more interested in producing stable SSTs

It is not only useful to have a good retrieval, but to understand why you have a good retrieval (*i.e.* may have two errors cancelling)

2.5 Geostationary SST retrieval – Prabhat Koner

Three retrieval algorithms for GOES–13 were shown: regression (REG), optimal estimation (OEM), modified total least squares (MTLS). In addition a new "Total Error" measure (*similar to Chi2?*) was suggested instead of using the usual bias, standard deviation metrics and SSES. When applied to GOES–13 data REG and OEM performed worse than the first guess, only MTLS actually retrieved better than the 1st guess.

Bias correction of the forward model was also covered. Including bias correction lead to a significant improvement for the OEM, but had little impact on MTLS. The bias corrections required for the 13 micron channel were very large which does not seem justifiable, however the same biases were seen in comparison of the forward model (CRTM) against a more accurate forward model (MODTRAN).

A new cloud detection scheme was developed which used additional channels and a neighbourhood comparison method. This resulted in a larger number of matchups being available at higher quality (reduced standard deviation and root mean square error) than via the Bayesian scheme as currently applied to NOAA geostationary data.

Q. MTLS uses the same equation as the Twomey–Tikhonov method. Is MTLS a standard name?

A. TLS is Total Least Squares, which is fairly standard. The formulation is similar to Twomey–Tikhonov and TLS is the method of choosing the regularization strength. It is "Modified", hence MTLS.

3 General Discussion

Should EARWiG adopt the MMD/MMS system and SST CCI PVP methods?

See SST CCI algorithm selection section

Need for standardized tools for working with MMD/similar datasets

Who can generate a "GHRSST MMD"?

How much of the ESA SST CCI code is available?

Standardized Metrics

We need standardized metrics so we can all produce comparable validation statistics (overlap with ST–VAL). This should be added as an EARWiG objective so we can start discussing it.

Calibration

Important to give feedback to providers via CEOS CalVal and SST–VC.

See IR Calibration for AVHRR/GOES and MTSAT question.

Cloud detection and QC flags

Work with ST–VAL to come up with recommended / standardised quality flags. Recommend best practices for cloud flagging and additional flagging etc.

- Complaint that different data providers use different quality_level definitions. *i.e.* some have 2 worst to 5 best while others have 2 best, *etc*.
- This is specified in GDS and providers should be encouraged to follow the specification

Was the Melbourne meeting useful for EARWiG?

It was felt that the meeting was more useful for HL and DV interests than general retrieval issues.

Future EARWiG meetings

ERNESST may have a meeting to discuss the use of NWP in SST retrievals next year in Lannion next summer. However, CMS is not really a suitable venue for a working EARWiG meeting due to access restrictions, *etc*... Edinburgh may be a better location.

A joint EARWiG / ST–VAL meeting was suggested.

NASA SST Science Team

Was the NASA SST ST informed about the GHSST meeting? In future ensure they are invited.

New co–Chair

Chris Merchant stepped down, and nominated Owen Embury as replacement. Chairman's note: this was approved during the EARWiG Breakout Report in the Plenary session on Friday.

4 EARWiG Priorities

The following priorities were identified during the breakout and in discussion with EARWiG members afterwards:

- Algorithm comparison
  - Mostly observe differences in Val/QC procedures
  - Need to standardize – determine what metrics to include
- Cloud detection for infrared SST retrievals
  - Needs a revisit, since it still seems to be a key factor in validation results
- Calibration
  - Critical for provision of CDRs/ECVs
  - Feedback to providers, apply "top–down" pressure to CEOS CalVal
  - Make use of SST–VC
- Radiative Transfer
  - Increasingly used in retrievals (NOAA, M–F, ESA_cci, NCEP)
  - Biases, bias correction, fast–forward model improvement, *etc*.

5 Summary

There has been a lot of activity in SST retrievals in the past year or so. New methods are yielding encouraging results. As mentioned above, the time is ripe for a workshop dedicated to the twin disciplines of retrieval science and validation – the latter because of the need for consistency in evaluating the various promising methods that are being developed. The Chairman will ensure that EARWiG activities are given sufficient airing at the next NASA SST Science Team meeting in Seattle (November, 2012).

SESSION 6.D.2: IC–TAG BREAKOUT

Chair: Alexey Kaplan[(1)]; Vice–Chair and Rapporteur: Toshio Michael Chin[(2)]

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(2) Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA,
Email: toshio.m.chin@jpl.nasa.gov

1. Terms of Reference and Membership

The breakout session started from a brief discussion of IC–TAG goals and Terms of Reference (ToR). The group saw no need to change them, in principal terms. However, the ToR specifically talk about GHRSST existing intercomparison (IC) systems for SST data sets: GMPE, L4–SQUAM, and HRDDS. The HRDDS system is currently dormant due to the departure of Dave Poulter and its future status is unclear.

ToR require the group "to regularly review the IC–TAG Chair/vice–Chair and membership." These issues have been reviewed, with the attention to the principle that IC–TAG should have representatives from active IC systems (GMPE, SQUAM) and all GHRSST L4 product providers among its members. The group has been chaired by Matt Martin for the last three years. Because of the change in his work duties in the U.K. Met Office, Matt has recently resigned from the group. Alexey Kaplan, who served as vice–Chair with M. Martin, became the new Chair, and Michael Chin had accepted an invitation to serve as vice–Chair. In addition to M. Chin, new members formally joining the group are Jonah Roberts–Jones (he will replace Matt Martin as representative of GMPE and OSTIA), Jorge Vazquez, Ed Armstrong, and Dudley Chelton. Removed from membership along with Martin were Emmanuelle Autret and Dave Poulter.

2. Main Accomplishments

Two seminal papers have been published in the last year (the work on them was done in the last two years), documenting the utility of GMPE and SQUAM systems:

- Martin, M., P. Dash, A. Ignatov, V. Banzon, H. Beggs, B. Brasnett, J.–F. Cayula, J. Cummings, C. Donlon, C. Gentemann, R. Grumbine, S. Ishizaki, E. Maturi, R. W. Reynolds, J. Roberts–Jones, **Group for High Resolution Sea Surface temperature (GHRSST) analysis fields inter–comparisons. Part 1: A GHRSST multi–product ensemble (GMPE)**, *Deep Sea Research Part II: Topical Studies in Oceanography*, Available online 2 May 2012, ISSN 0967–0645, 10.1016/j.dsr2.2012.04.013.
- Dash, P., A. Ignatov, M. Martin, C. Donlon, B. Brasnett, R. W. Reynolds, V. Banzon, H. Beggs, J.–F. Cayula, Y. Chao, R. Grumbine, E. Maturi, A. Harris, J. Mittaz, J. Sapper, T. M. Chin, J. Vazquez–Cuervo, E. M. Armstrong, C. Gentemann, J. Cummings, J.–F. Piollé, E. Autret, J. Roberts–Jones, S. Ishizaki, J. L. Høyer, D. Poulter, **Group for High Resolution Sea Surface Temperature (GHRSST) analysis fields inter–comparisons—Part 2: Near real time web–based level 4 SST Quality Monitor (L4–SQUAM)**, *Deep Sea Research Part II: Topical Studies in Oceanography*, Available online 17 April 2012, ISSN 0967–0645, 10.1016/j.dsr2.2012.04.002.

These papers have been under leadership and with major participation of IC–TAG members. The authors expressed special thanks to Jorge Vazquez, who served as a special editor of this DSR–II special issue and whose efforts were crucial for achieving the quality and success of this endeavor.

In addition to a generally useful thorough illustration of the IC systems and SST data sets provided by these papers, Tables 1–3 of Martin et al. (2012) and Table 1 of Dash et al. (2012) supersede previous IC–TAG efforts to provide comparative descriptions to GHRSST L4 data sets. These tables will be adopted for republishing in the IC–TAG area of the GHRSST website to finalize these efforts.

3. Discussions and New Action Items

Ice in L4 products. Jacob Høyer brought to the group's attention that currently there is not enough information and knowledge on when/if/how ice is getting incorporated into the SST fields of the L4 products. He also related the HL–TAG's request to develop statistics characterizing L4 performance in marginal ice zones. Prasanjit Dash noted that GMPE currently does not provide an ice mask (any information on presence of ice). *Action*: J. Høyer, J. Roberts–Jones, and P. Dash will discuss and evaluate what can be done realistically about ice information in L4 products

GMPE accuracy and source data sets. Helen Beggs initiated a discussion about (un)availability of the information on which products were actually used in the GMPE ensemble on a given date, which provided medians, etc. Such info is useful for product validation efforts, because the ensemble median SST field provided by the GMPE is known to be more accurate than the individual ensemble–member products (cf Martin et al., 2012). *Action*: H. Beggs, J. Roberts–Jones, and P. Dash will discuss what can be done about GMPE data source identification/presentation.

Impacts of AATSR loss on the L4 products. Prasanjit Dash related to the group that Sasha Ignatov noticed the recent increase in the spread between some L4 products and independent data in SQUAM. He suspected that this increase might be a manifestation of the AATSR data loss. It was noted that the decrease in accuracy of OSTIA as a result of the AATSR loss has been quantified and reported in the GHRSST Newsletters. P. Dash has agreed to investigate further and to try to document this phenomenon using SQUAM (*action item*). If successful, this SQUAM–based approach might become a useful tool for illustrating or evaluating the importance of individual data sources.

OSSE–like comparison of L4 analysis methods. Operation System Simulation Experience (OSSE) is a common approach to evaluate data assimilation systems using synthetic data. A similar approach has been used by Dudley Chelton and Dick Reynolds for evaluating feature resolution in the two–stage OI by Reynolds and in OSTIA (the latter in collaboration with J. Roberts–Jones and M. Martin) used to evaluate the various SST analysis methods used by the L4 data providers. In their work, the "true" SST field is taken to be a simulation from an ocean general circulation model (ECCO model runs were provided by D. Menemenlis of JPL). D. Chelton suggested this approach for a more general use in the IC–TAG. L4 data set producers who were present at the breakout session were enthusiastic about the suggestion. *Action:* D. Chelton and R. Reynolds will provide a brief description of the procedure. IC–TAG will invite all GHRSST L4 data set producers to participate. PO.DAAC will evaluate to what extent they will be able to aid and support this procedure (rewrite into L2P format and distribute the input data provided by D. Chelton and R. Reynolds; collect and make accessible the analysis results from L4 producers; run statistical analyses and intercomparison of the results). IC–TAG will coordinate the process.

4. Presentation

There was one formal presentation during the breakout session:

- Updates to the Uncertainty Estimates in the OSTIA System – Jonah Roberts–Jones

The talk described the new work on tuning OI parameters in the OSTIA system performed in the U.K. Met Office and was received by participants with interest and enthusiasm.

Appendices:

Term of Reference, IC–TAG

1. To coordinate existing inter–comparison activities for L4 analyses within GHRSST, including the GHRSST Multi–Product Ensemble (**GMPE**), and the comparison of L4 analyses and lower level data including the SST Quality Monitor (**SQUAM**) and the High Resolution Diagnostic Data Set (**HRDDS**).
2. To coordinate the development of the existing inter–comparison systems, including the **development of links between those systems**.
3. To **develop standardised metrics** for use in routine inter–comparison of L4 analyses, and advise on the content and form of automatic reports from the inter–comparison systems.
4. To **improve the documentation** of the inter–comparison systems, and to provide high–level information on the contributing L4 analysis systems.
5. To **promote the use of inter–comparison tools** for use by the other TAGs (e.g. Re–analysis TAG) where appropriate and make use of validation tools developed by other TAGs.
6. To **assess and improve the specification of error** in the L4 analyses.
7. To **regularly review** the IC–TAG Chair/vice–Chair and membership.

Revised Membership, IC–TAG (June 2012)

Viva Banzon, NOAA/NCDC, USA
Ian Barton, Australia
Helen Beggs, BoM, Australia
Bruce Brasnett, Canada
Mike Chin, JPL, USA (Vice–Chair)
Jim Cummings, NRL, USA
Prasanjit Dash (SQUAM), NESDIS, USA
Chelle Gentemann, RSS, USA
Robert Grumbine, NWS, USA
Jacob Høyer, DMI, Denmark
Alexander Ignatov (SQUAM), NESDIS, USA
Shiro Ishizaki, JMA, Japan
Alexey Kaplan, LDEO, USA (Chair)
Eileen Maturi, NOAA/OSPD, USA
Bruce McKenzie, NAVOCEANO, USA
Jean–François Piollé, IFREMER, France
Nick Rayner, Met Office Hadley Centre, UK
Richard Reynolds, NOAA/NCDC, USA
Martin Rutherford, Australia
Jonah Roberts–Jones (GMPE), Met Office, UK
Jorge Vasquez, JPL, USA
Ed Armstrong, JPL, USA
Dudley Chelton, OSU, USA

(Italic font identifies new members)

SESSION 6.D.3: R2HA2–WG BREAKOUT

Chair: Peter Cornillon[(1)]; Rapporteur: Hervé Roquet[(2)]

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(2) Centre de Météorologie Spatiale, Météo, France, Email: roquet@meteo.fr

1. Introduction

In GHRSST XII, the *Rescue and Reprocessing of Historical AVHRR Archives (R2HA2) Working Group* agreed on the need to define a common format for AVHRR HRPT and GAC data, that this format should be called L1p and that it should be stored in netCDF4. Hervé Roquet agreed to lead the effort to define this format. The group also expressed a desire to see work begin on the acquisition of data from a few AVHRR HRPT/LAC archive. Peter Cornillon agreed to lead this portion of the group's work.

2. R2HA2 membership/WG XIII attendees

The official members of the R2HA2 Working Group are:

- Peter Cornillon (Chair)
- Ed Armstrong
- Ken Casey
- Eileen Maturi
- Jon Mittaz
- Hervé Roquet (Vice–Chair)

Attending the GHRSST XIII R2HA2 Working Group Meeting were:

- Peter Cornillon (Chair)
- Jon Mittaz
- Hervé Roquet (Vice–Chair)
- Bob Evans

3. R2HA2 Working Group objectives

The objectives of the working group are to:

1. Identify historical archives[1] of AVHRR HRPT and LAC data.
2. Copy these archives to a central data repository.
3. Convert these data to a consistent L1P[2] format in netCDF4.
4. Reprocess these data in a consistent manner to GDS2.0 L2P and serve them via the GHRSST Regional/ Global Task Sharing Framework (R/GTS).

4. Necessary steps

In order to accomplish its objectives, the working group will:

1. Identify and locate historical archives (pre–2000) of AVHRR HRPT and LAC data.
2. Copy data from historical archives to a central location.

[1] The focus here will be on pre-2000 archives of HRPT and LAC data since a global 1km archive of MODIS data exists post-2000. However, post-2000 AHVRR HRPT and LAC data will be accepted if provided, they will simply not be the focus.
[2] L1P is a level 1 format that will defined by the R2HA2 explicitly for AVHRR HRPT and LAC data.

3. Identify a central assembly center(s) (CAC).
4. Define a format (L1P) in which the data are to be stored.
5. Define if/how contributions are to be stitched together at the CAC.
6. Determine how to handle navigation information.
7. Identify where the reprocessing is to be performed.
8. Define the SST algorithm to be used for reprocessing.
9. Determine how to perform the navigation.

5. Progress

Progress has been made in two areas over the past year:

- **Acquisition of data from receiving stations and the transcription of these data to new media**. Peter Cornillon presented a short summary of progress to date in identifying AVHRR HRPT/ LAC archives and in copying the data from these archives to more stable media. The status of data retrieval from three archives was discussed:

  - ***CMS receiving station, Lannion, France***
    CMS has been acquiring all HRPT passes visible from its receiving station in Lannion, France since 1992. The data have been stored in two formats. One, they call 'brut' (sounds like a type of champagne, but, in fact it is very close to the standard NOAA format) and the other is their internal format call 'fis'. We have copied all brut data to URI. These data date from 1996, fis data from 1993. The data are in good shape and waiting agreement on L1pCore (see the next section for a description of L1pCore).

  - ***Hawaiian receiving station***
    HRPT data were acquired from a receiving station maintained in Hawaii for a number of years. The data were archived on DAT tapes written with a Hewitt Packard computer running either a 10.xxx or 11.xxx operating system. Operation of the receiving station ceased a number of years ago but the DAT tapes were retained. A decision was made to discard these tapes. This was brought to our attention so the University of Rhode Island (URI) agreed to take possession of the tapes and to try and copy them to newer media. The transfer was effectuated in May 2012 and staff at URI immediately began trying to read the tapes. Unfortunately, they appear to be DDS2 compliant hence not compatible with the DAT drives available at URI. A request was made to the audience at GHRSST XIII for information on a DDS2 compatible DAT drive. Following the meeting several responses were provided. URI will follow up on these as needed. URI may require an HPUX 11.x machine as well. This will be determined once a DDS2 drive has been acquired.

  - ***Argentinian receiving station***
    The University of Miami acquired over 12,300 AVHRR HRPT passes from a receiving station in Argentina. These data were stored on 316 Sony optical disks and covered the period from July 1984 to September 1999. These data were going to be discarded so, as part of the *R2HA2* effort, URI agreed to attempt to copy these data from Sony optical drives to magnetic disks. Required for this effort is a Sony optical drive reader, a DEC computer, an interface board between the DEC machine and the optical drive reader and software capable of reading the data as written at UMiami. Although URI had all of these components each failed as they tried to read the data. Bummer.

- **Development of the L1p GHRSST format.** Hervé Roquet presented a first attempt at a L1p format. The structure that he proposed was based on the NOAA klm format[3] and software that he obtained from NCDC to reformat L1b data to netCDF[4].

6 Discussion ***Recover of receiving station data.*** This issue received little attention at the R2HA2 breakout. The primary conclusion was that the focus on recovering the UHawaii and Argentinian data continues. During and following the presentation of the R2HA2 breakout to GHRSST XIII interest from several GHRSST Science Team members was expressed in helping the R2HA2 Working Group recover data from other archives and potential sources of DDS2 compliant DAT drives were identified. Cornillon will follow–up on these.

- ***L1p.*** Finalization of this format consumed most of the breakout session. The following was agreed to:
  - A preliminary version of GHRSST L1p be developed and called L1pCore. This is viewed as a working format that will contain all data in the L1a or L1b data to be converted to L1p as well as other fields that are not likely to change in the future, such as clock corrections and precision ephemerides. A subsequent version of the format will be developed that will contain other information required for high quality SST retrievals such as information associated with the improved calibration being developed by Jonathan Mittaz and latitude, longitude fields developed from the precision ephemerides and spacecraft attitude information. This format will be called L1p. Both L1pCore and L1p will be made available to the community.
  - L1pCore will, with a few exceptions, mirror fields described in the L1b klm manual.
  - L1pCore fields fall in three classes
    - Basic telemetry fields. All of which will be captured
    - Fields added by the data provider; i.e., in the L1b product; e.g.
      - Calibration information.
      - Latitude, longitude fields.
  - Fields added to the L1a or L1b data stream, e.g.,
    - Year – this information is not in the telemetry stream.
    - Spacecraft ID – IDs recycled. We will add a unique GHRSST spacecraft ID.
    - Navy high precision ephemerides – available from UMiami.
    - Clock corrections – available from UMiami
    - A README variable documenting caveats with some of the variables.
  - Names of variables in the output file will be contracted names of variables in the NOAA klm documentation.
  - With the exception of the packing of data bits (10 bits on 10 bits, 10 bits in 32 bits…) data remains unaltered.
  - L1pCore will not contain GHRSST metadata required for other GHRSST products such as wind information, SSES, …

  Concerns were raised with regard to some of the decisions presented to GHRSST XIII participants in the R2HA2 Breakout summary. A complete draft of L1pCore will be presented first to the R2HA2 team and then to the GHRSST Science Team for comment.

7. Summary of action items

[3] http://www2.ncdc.noaa.gov/docs/klm/html/c8/s83133-1.htm
[4] http://www.ncdc.noaa.gov/oa/rsad/netcdf-access/index.php?name=sat2netcdf

Action: CMS data to be converted to L1pCore.

Responsible Party: Peter Cornillon

Action: Attempt to complete a system capable of reading the UHawaii DAT tapes and copy those that can be recovered to magnetic disk.

Responsible Party: Peter Cornillon

Action: Attempt to assemble the components needed to read the Argentinian Sony optical disks and copy these data to magnetic disk if successful.

Responsible Party: Peter Cornillon and Bob Evans.

Action: Write a letter to Olivier Arino requesting a copy of the EarthNet data set.

Responsible Party: Peter Cornillon

Action: E–mail Dominique Dagorne Dominique.Dagorne@ird.fr requesting a point of contact for the Peruvian data on DVD's that he mentioned to Cornillon at GHRSST XI.

Responsible Party: Peter Cornillon

Action: Discuss with Helen Beggs, the possibility of BOM converting their data to L1pCore.

Responsible Party: Peter Cornillon

Action: Contact Sergio Nunez (snunez@inpescal.cl) with regard to AVHRR HRPT holdings collected in Chile by the Instituto de Investigación Pesquera (http://www.inpesca.cl). These data date back to 1987.

Responsible Party: Peter Cornillon

Action: Contact Maria Angela Barbieri (angela.barbieri@ucv.cl) with regard to AVHRR HRPT holdings collected in Chile by the Escuela de Ciencias del Mar (http://www.ecm.ucv.cl/). These data date back to 1987.

Responsible Party: Peter Cornillon

Action: Contact Mauricio Arenas C. (teledeteccion@lts.udec.cl) with regard to AVHRR HRPT holdings collected in Chile by the Laboratorio de Teledeteccion. Universidad de Concepcion (http://www.lts.udec.cl/) Sr. Mauricio Arenas .These data date back to 1987.

Responsible Party: Peter Cornillon

Action: Write a draft plan – "here's what we want to do; here's how" – to include in communication with potential data providers

Responsible Party: Peter Cornillon

Action: Complete the definition of L1pCore. Hervé Roquet will mock up the L1pCore format that was decided on in GHRSST XIII. Mittaz and Evans will review the format. Roquet will then populate it for one of the NOAA 19 files in the CMS archive.

Responsible Party: Hervé Roquet, Jon Mittaz, Bob Evans,

Action: Code a transcription program for data in the Scripps format to L1pCore

Responsible Party: Peter Cornillon

Action: Code a transcription program for data in the CMS 'brut' data to L1pCore

Responsible Party: Peter Cornillon

SESSION 6.E.1: CDR–TAG BREAKOUT

Chair: Christopher Merchant[(1)]; Rapporteur: Jon Mittaz[(2)]

(1) School of GeoScience, University of Edinburgh, UK, Email: c.merchant@ed.ac.uk
(2) University of Maryland, MA, USA, Email: Jon.Mittaz@noaa.gov

The CDR–TAG exists within GHRSST to meet the need for long–term, stable and accurate SST data sets. The long–term stewardship of GHRSST data sets is part of this need, and has been addressed successfully within the RAN–TAG (the TAG that was replaced by the CDR–TAG in consultation with the GHRSST Science Team early in 2012). Meanwhile, it has become clear that no single "climate data record" of SST meets the needs of all users. It has been proposed that the CDR–TAG should determine which GHRSST data sets to accredit as official GHRSST CDRs. Given the variety of strengths of different data sets and of user requirements, this would seem to be both problematic and contentious.

As new Chair, therefore, Merchant proposed that the TAG should adopt the following term of reference (modified from that of RAN–TAG), which was agreed:

> To address the need for long–term, stable and accurate SST data sets
> — develop GHRSST consensus on requirements for products intended as CDRs
> — define a Climate Dataset Evaluation Framework
> — evaluate GHRSST datasets against this CDEF, maintain public list of result

The session at GHRSST therefore focused on what shape the CDEF should take. Merchant's starting propositions to the TAG were as follows:

- CDEF will comprise a means of providing substantive information about the climate–relevance of a given GHRSST data set
- the information needs to be adequately defined so that it is comparable by users between GHRSST data sets
- the CDR–TAG role will be to approve the information about the dataset, not accredit the data set itself
- we should use what exists in terms of templates for describing "climate" datasets – but innovate where what exists is inadequate

This approach is certainly a pragmatic first step. There was discussion about whether it is an adequate long–term end point. Merchant argued that we do not need to decide at present. Such a framework is a necessary step towards a full accreditation procedure. It is not a trivial ambition, although achievable, so the 3 year plan for the CDR–TAG is to create, test and operate a CDEF. At that point, we can reassess the desirability or otherwise of an accreditation procedure build on the CDEF.

Many precursor requirement lists, templates, and indices for describing and evaluating putative climate datasets were reviewed by Merchant in the CDR–TAG session. The slides are available on the GHRSST web site. The precursors were:

1. The existing RAN–TAG requirements
2. Slides for GHRSST 12, setting requirements such as being GDS2.0 compliant
3. GCOS (2010) guidelines for generation of data sets (GCOS–143)
4. GCOS climate monitoring principles
5. J Bates (NOAA–CDR programme) maturity index, various versions of
6. The WOAP (2011) proforma for an envisaged Global Observing Systems Information Center

7. The ESA SST Climate Change Initiative (SST CCI) User Requirements Document as material for a checklist
8. SST CCI algorithm selection metrics as described in the project's Product Validation Plan
9. the obs4MIPS briefing note template

TAG members commented in a balanced, well–informed way the strengths of weaknesses of these various templates/requirement documents. Some of the comments (no particular order):

- Some precursors emphasise "bureaucratic" status of a data set, while not engaging with quantitative climate quality aspects
- Where possible, we should adopt existing templates that data set producers already may have to provide – especially if this can be incorporated into metadata that anyone can interrogate for different purposes
- … but metadata can't replace documents
- May require a multi–level approach with a brief 1 page summary of the dataset and its strengths and weaknesses together with a more detailed summary for the interested user.
- Maturity index can be a good driver to improve documentation etc
- But a maturity index is very difficult to work adequately to cover all contexts yet still have meaningful content
- Need for more quantitative statements about climate quality
- "Customer ratings" system (like Amazon etc) could be included on GHRSST website

As a means of stimulate thought and discussion, Merchant distributed a 1 page briefing table on a fictitious SST CDR, and participants gave comments on the briefing. These were collected. The content is, for interest, shown below. Note: it was not a proposal for such a sheet, but a means of getting ideas.

Summary Assessment of [GHRSST Dataset] as a Climate Record

Status of assessment: [Producer's self assessment] / [CDR-TAG approved]
Dataset name and version: [SeaTempSat v3.5]
Lead Investigator and/or Agency: [C P Donnett, Ruritanian Bureau of Climate]
Principal strengths of data set: [High resolution with low noise, 18 year consistent record]
Principal recommended applications: [Coastal zone variability and change]

KEY DESCRIPTIVE FEATURES	INFORMATION
Period covered	3-12-1985 to 27-5-2013
Geographic range	Global (up to 87°N/S)
Spatial resolution	300 m
Temporal resolution	Daily coverage (95% of ocean with one or more observations in 24 h)
Valid data fraction	14% average (determined by cloud cover)
Data level / grid	Level 2 (as observed, not gridded, remapped or averaged)
Observation technology	Infra-red and visible multi-channel imager (Sea Temp Detector, STD)
Dependence on other data	Tied to surface XBT observations by regression
Type(s) of SST	SST-10 m (on average, actually sensitive to SST-skin)
Uncertainty info in product	Uncorrelated and correlated uncertainties given for every pixel

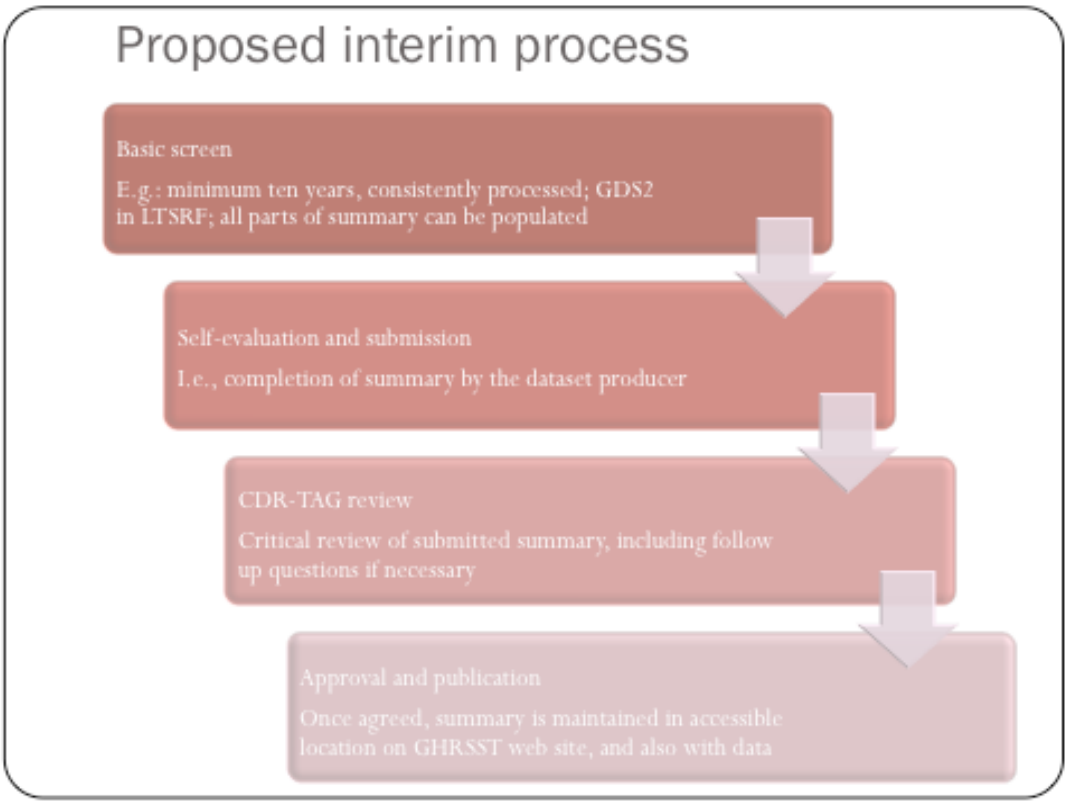
AVAILABILITY, DOC'N, FEEDBACK	
Data URL / ftp / DOI	http://www.seatempsat.rur/std http://www.ghrsst.org/ltsrf/std/
Primary peer reviewed reference	Donnett, C P, and Ignaplan, A K, 2013, The Sea Temp Detector Dataset, Rur. J Rem. Sens. (1) 1-12.
Source of technical documents	http://www.seatempsat.rur/std/docs
Dataset restrictions	None
Facility for user feedback	E-mail c.donnett@met.rur

MATURITY INDICES	SCORE (1 – 6)	COMMENTS
Software readiness	4	Some code changes expected
Metadata	6	Complete and stable metadata
Documentation	3	ATBD and peer-reviewed paper
Product validation	5	Discrepancies w.r.t. global buoys by indep. investigators
Public Access	6	In LTSRF
Utility	4	Showing positive impact in coastal zone studies

OTHER PRINCIPLES (GCOS)	COMMENTS
Detailed history	All instrument data and algorithm changes recorded and published
Diurnal cycle	Constant local time throughout
Timeliness of data	At LTSRF within 5 weeks

Certain obvious points had been omitted, and participants spotted these and suggested additions: these were: data volume information and SI traceability. The only aspect in the sample that was repeatedly questioned was the Maturity Index. The concern seemed to be how to achieve consistency of interpretation of the indices across different datasets. The short answer is that CDR–TAG scrutiny will be the mechanism, but this begs the question of how exactly to get the CDR–TAG to do this.

The interim process the CDR–TAG will develop in the next few years is illustrated in the next figure:



Merchant then raised the question of "how?" Rayner (email prior to meeting) had commented: "Whatever [evaluation criteria are] calculated need to be calculated consistently, if different CDRs are to be compared, so this does suggest a central comparison facility."

There was general agreement that this was correct, and that the GHRSST community should build such a facility. Precursors are the GHRSST High Resolution Diagnostic Dataset (not presently operational) and the SST CCI Multisensor Matchup System (presently covering only 1991 – 2010 and not all sensors). Merchant commented that the SST CCI experience does support having common–data metric comparisons (it worked well in the algorithm selection exercise, as reported in the EARWiG session). Moreover, the additional dimension of multi–sensor matches (in addition to common data) opens up the means to exploit multi–way statistical techniques and remove diurnal effects in comparisons. The system, as commented by Minnett, would need to allow different producers to upload their SST retrievals to the multi–sensor matchup system so that it is a system everyone can interact with.

The CDR–TAG therefore agreed to present the following objectives as GHRSST community objectives to the science team in plenary:

1. "A community multi–sensor match–up system should be developed in support of climate dataset evaluation"
2. "Tools should be developed to support CDR producers to supply comparable validation metrics"

CDR–TAG actions from GHRSST 12 were briefly reviewed.

The International Status Report (summary powerpoint slides of news from dataset producers) had been circulated shortly before the meeting and needs to be more fully updated.

ACTION all on dataset producers: Update the single slide on your data set in the International Status Report, send to Merchant.

ACTION on all dataset producers mentioned in the summary chart of L2P long–term datasets: verify you agree with status, and changes to Merchant.

The final portion of the CDR–TAG meeting was dedicated to the impact of the loss of AATSR from April 2012. This comprised a discussion by P Le Borgne and presentation by J Roberts–Jones. JRJ showed clear degradation in OSTIA O–B stats with patchier O–B fields. Use of Metop AVHRR as substitute reference can help, esp. with restriction to “best” data. In response the OSI–SAF will bring forward upgrade to Metop chain for NWP–based biased correction, which is welcome news in the circumstances. No NWP impact study as been undertaken on the loss, and this is to be encouraged.

Merchant proposed Jon Mittaz as vice–Chair, and this was approved the following day in plenary.

Merchant concluded the meeting, thanking everyone for their serious minded and constructive engagement. Since the proposed approach to develop a Climate Dataset Evaluation Framework was essentially agreed, the final action is:

ACTION CM / JM / GPO / CDR–TAG to draft v1 Climate Dataset Evaluation Framework.

SESSION 6.F.1: VIIRS BREAKOUT

Chair: Alexander Ignatov[(1)]; Rapporteur: Bruce McKenzie[(2)]

(1) NOAA/NESDIS, USA, Email: Alex.Ignatov@noaa.gov
(2) Naval Oceanographic Office, USA, Email: bruce.mckenzie@navy.mil

Attendees:

Sasha Ignatov	Bruce McKenzie	Ed Armstrong	Jorge Vazquez
Prasanjit Dash	Robert Evans	Prabhat Koner	Pierre Le Borgne
Eileen Maturi	Peter Minnett	Boris Petrenko	Herve Roquet
Christo Whittle	Chris Merchant	Shiro Ishizaki	

Introductions/Expectations:

JPL/PODAAC requests a timeline of when VIIRS SST data will be made available to the PODAAC. Christo Whittle would like to know how to get access to the data and Chris Merchant is hoping to better understand the future uses of VIIRS.

VIIRS SST – Data availability/archival/distribution/formats:

IDPS will make available the VIIRS SST EDR no earlier than August 2012 in HDF5 format. NAVO will create a bulk SST from VIIRS SDR data. Sample data in GDSV2.0 format will be provided in the Sept – Dec 2012 timeframe moving to an operational flow to the JPL/GDAC in the Jan – Mar 2013. NOAA will provide an ACSPO VIIRS SST in GDSV2.0 format in Nov–Dec 2012 time frame. It is up for discussion if users would like to receive the IDPS VIIRS SST EDR in L2P format. OSI SAF only plans to generate SST product for North–Atlantic Region (NAR). No global VIIRS production is planned. Ed Armstrong requested a one page write up on each of VIIRS SST products that are going to be distributed by the GDAC

Updates from JPSS team members:

OSI/SAF (Le Borgne) will produce a L3C VIIRS SST over NAR in GDSV2.0 in early 2013 at full resolution from their direct readout flow of data. The MAIA cloud mask has been adapted for VIIRS. This will be a prototype for their MetOp–B chain.

RSMAS (Minnett) shows the VIIRS data looks good when compared with other satellites and with Reynolds daily analysis. The matchup criteria are ± 0.5 hours and ± 2 pixels. VIIRS SST should make a reasonable CDR and would be improved with additional radiometers at sea. MAERI data is available to the public and RSMAS will distribute their MDB to Lannion. According to Evans, the M13 dual gain band has excessive temperatures at some scan lines and possibly high scan angles. Pierre questioned the reliability of BTs at large satellite zenith angles. Evans suggests limiting to angles less than 55°, beyond that it is much worse. The signal to noise ratio is good near nadir where there are 3 pixels combined into one then degrades when there are 2 combined and then is at its worse at higher angles where only 1 pixel is used. Ignatov mentioned that retrievals in ACSPO are done in full swath, and BTs are compared with RTM in full swath. RMS errors increase at slant geometries but biases seem to be relatively flat as a function of VZA. According to Ignatov it is still uncertain if it is the sensor or the algorithm causing issues. RSMAS is now using two sets of coefficients due to the 0.15K BT jumps seen with new LUTs introduced on 8 March 2012. Evans wonders who will do the CDR work to address LUT changes. The JPSS program should be included in these discussions and it should be noted that the benefits of reprocessing outweigh the costs. Minnett pointed out that VIIRS is ahead of MODIS. Ignatov mentioned that JPSS is a complex system, with SST team controlling only a part of it. The logistics of communicating are sometimes difficult, such as with the

creation and use of the VIIRS cloud mask, or algorithm change process. Evans discussed the use of the VIIRS DNB for cloud detection at night. Roquet expressed interest in this and Ignatov agreed to send Steve Miller's email address to him for further discussion.

NOAA (Ignatov) presented comparison of VIIRS vs AVHRR vs MODIS using an online demonstration of SQUAM.I It was noted that there was no ± in the IDPS view zenith angles. Using community consensus SST algorithms in VIIRS SST processing would facilitate product comparisons produced by various groups, and minimize problems down the road. We would like to draw on lessons learned from AVHRR. Le Borgne would like to see more testing done of VIIRS data before reaching a consensus. To implement changes in the VIIRS SST code for the beta release of the SST EDR a change request needs to be submitted in July of this year to get into version 6.3 of the code. Pierre and Herve questioned if bow–tie dropped lines are going to be taken care of. OSI SAF will take care of those by remapping product into L3c, but he questioned what those generating L2 or L2P products are planning to do.

NESDIS update on the official IDPS EDR SST product – current design and proposed redesign

Petrenko presented the results of his comparisons between various operational SST algorithms (IDPS, OSI SAF, MODIS, ACSPO, and NAVO) and looked at the effect of using Kelvin vs Celsius in NLSST using a MODIS SST matchup dataset. The OSI SAF algorithms provided consistently smaller biases and RMS, and more flat retrievals as a function of VZA both at day and night. Le Borgne would like to see these results using VIIRS and AVHRR data. Ignatov mentioned using the RRDP MMS system put together by Chris Merchant and Gary Corlett. Roquet pointed out that the best algorithm for one sensor may not always be best for another. Le Borgne said he will work with his algorithm and process two months of VIIRS data and will run it seasonally on the AVHRR MMS dataset.

Ignatov also would like to revisit and use community consensus QFs. He inquired about the OSI SAF QC methods. Le Borgne said he will document them informally by late July or August. Ignatov also recommended removing the bulk SST and bulk quality flags from the VIIRS SST EDR, as those are identical to skin except SSTs are displaced by 0.17K. This was agreed upon by all in attendance. The meeting adjourned at approximately 2030.

SESSION 7: SUMMARY AND CONCLUSIONS SESSION

Chair: Peter Minnett[(1)]; Rapporteur: Andrea Kaiser–Weiss[(2)]

(1) RSMAS, University of Miami, FL, USA, Email: pminnett@rsmas.miami.edu
(2) NCEO, University of Reading, UK,
now at: Deutscher Wetterdienst, Offenbach, Germany, Email: Andrea.Kaiser-Weiss@dwd.de

In Session 7, "Summary and conclusions", the CEOS SST VC meeting, all the 10 GHRSST TAG and WG breakout sessions, and the Advisory Council meeting were summarized in plenary. The Action List was shown and the next venue discussed. See the full session reports for more comprehensive information. Below, a few highlights were selected from each report.

The **CEOS SST-VC** meeting was mainly centered on the Implementation Plan. Ken Casey clarified the structure and interface of CEOS SST-VC with GHRSST. CEOS SST-VC activities were presented, and in the subsequent discussion it was highlighted how SST-VC could be of benefit for GHRSST: mainly via international linkage, and space agency support. It was stressed that the establishment of the CEOS SST VC would not change the way that GHRSST operates, which will remain at the initiative and direction of the Science Team members and following recommendations from the Working Groups and Technical Advisory Groups. By GHRSST being closely associated with the CEOS SST VC is has a voice that it would otherwise lack, especially by providing a conduit for recommendations to high levels within agencies and a mechanism to influence strategic decisions.

ST-VAL, the Satellite Sea Surface Temperature Validation Working Group, discussed the 'cold tail' in satellite minus drifter discrepancies and reviewed the SSES common principles. Feedback to ESA CCI SST was provided, and support for a community multi-sensor matchup system (MMS) expressed. Future ST-VAL plans include the definition of metrics for evaluating the sensitivity of observations to the true SST.

IWWG, the Inlands Water Working Group, expressed their need for more in-situ data. Recommendations were discussed concerning orthorectification, land masking and cloud screening. Next Actions include documenting methods and clustering inland waters according to physical characteristics.

HL-TAG, the High Latitude Technical Advisory Group, discussed the results from the Bayesian classifier for cloud/ice/ocean classification, the performance of high latitude algorithms tested with the multi-sensor matchup system, and the user survey from ESA CCI showing increasing interest in ice surface temperatures. Future plans of the HL-TAG group include a 'Sea-Ice GMPE' with the IC-TAG, and to treat operational sea ice products and climate data records separately. It was decided to consider including sea-ice temperature into the HL-ToR

AUS-TAG, the Applications and User Services Technical Advisory Group**,** addressed the question how users can be guided to their most appropriate L4 product. A template to accompany each L4 product has been drafted. Web-site development of the 'Multi-pager', following up from the 'In a hurry to use SST' – one-pager was discussed and planned for the next year.

In the report of the **DVWG**, the Diurnal Variability Working Group, an update on progress in the TWP+ project, the SPURS campaign as a potential new source of near-surface vertical information, and on progress with Argo near-surface observations were presented. Provision of diurnal warming analysis to users was discussed. It is planned to make existing DW models readily available through the GHRSST web-page.

DAS-TAG, the Data Assembly and Systems Technical Advisory Group, discussed the review process for ingestion of new GHRSST data sets into the GDAC. Using the GDS2 checker, written in python, a

review board will verify the meta-data information. Data providers are encouraged to use GDS2r4 (and note some minor issues as collected in the GDS2 Amendments tracker). Links with the CF metadata group will be maintained via Ed Armstrong. Meta-data for in-situ data have been discussed. New tools for sub-setting, visualization and extraction have been presented.

EARWiG, the Estimation and Retrievals Working Group, identified priorities in developing metrics for algorithm comparison, in improving cloud detection for infrared SST retrievals, and in recognizing the critical need to provide calibration characterization for the purposes of CDRs/ECVs. For the latter, EARWiG suggested that the CEOS SST-VC could help. A joint EARWiG/ST-VAL workshop was suggested.

IC-TAG, the Inter-Comparison Technical Advisory Group, discussed the importance of the recent AATSR loss on its data quality, on intercomparison of ice information, and on how to compare feature resolution and to communicate to the users. As priorities for the next year, feature resolution testing based on a synthetic data set is proposed. All L4 producers are invited to participate in an OSSE-like comparison of L4 analysis methods, with the intention of publishing the results in a joint paper.

R2HA2, the Rescue & Reprocessing of Historical AVHRR Archives Working Group, reviewed progress and discussed the next steps to be taken. Progress had been made with acquisition of data from receiving stations and transcription to new media. A L1pCore format has been presented, to be finalized in R2HA2 and then circulated to the Science Team. For the next year, the focus on recovering data from Hawaii and Argentina will continue. GHRSST XIII participants expressed interest in helping the R2HA2 to recover data from other sources.

CDR-TAG, the Climate Data Records Technical Advisory Group, moved from a background Data Processing Framework towards discussion of a Climate Dataset Evaluation Framework (CDEF). Various previous approaches have been analysed according to strengths and weaknesses, resulting in a general agreement that objectively comparable climate quality metrics will require a co-ordinated facility. Building upon the ESA CCI experience, it was noted that the multi-sensor match-up system is a powerful technique for evaluation, which the CDR-TAG suggests be developed as a community tool. An interim process was proposed. The next step is to encourage tools to support CDR producers to supply comparable validation metrics.

The **Advisory Council session** was summarized by Misako Kachi. Points discussed in the AC included: clarification of the link CEOS SST-VC and GHRSST; establishing a GDAC process to facilitate compliance to the GDAC acceptance procedure; recommendations on the preferred format of GHRSST meetings; and the continuation of the GHRSST Project office under ESA contract. Helen Beggs was elected as new AC chair 2012/2013.

Next, the **Actions** resulting from GHRSST XIII were shown and on-line review encouraged.

Four **new GHRSST Science Team members** were suggested: Alexander Ignatov, Simon Hook, Christo Whittle, and Werenfrid Wimmer. The elections of the new members and the re-election of first third of the 2011/2012 Science Team were performed by online poll after the meeting.

The **next meeting venue** was discussed, with suggestions for Woods Hole (Carol Anne Clayson), Santa Rosa (Chelle Gentemann) and Cape Town (Christo Whittle), also to be decided following an online poll.

Finally, Andrea Kaiser-Weiss received thanks for her work as GHRSST Project Coordinator, and was wished well for her future career in the German Weather Service.

CHAPTER 3: REPORTS AND SCIENTIFIC ABSTRACTS

R10 – MELBOURNE SUMMARY

Summary of the Joint Workshop of the DV–WG, HL–TAG, ST–VAL, and EARWiG on Tropical Warm Pool and High Latitude SST Issues

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The successful workshop was held at the Bureau of Meteorology Head Office, Melbourne, Australia, Monday 5th – Friday 9th March 2012. Thanks are due to the excellent organization of Helen Beggs (Joint Workshop organizer), Gary Wick (Chair of the DV–WG), Jacob Høyer (Chair of the HL–TAG), Gary Corlett (Chair of the ST–VAL), Andy Harris (Chair of EARWiG) and Chris Merchant (Chair of CDR–TAG).

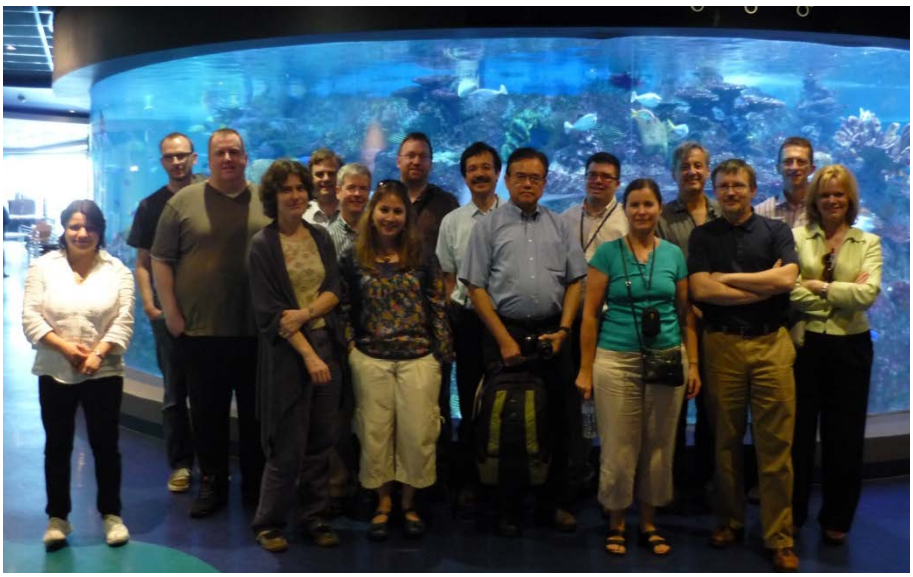
It was scientifically a very stimulating meeting**.** Two days of plenary sessions were followed by two days of collaboration on identified issues by sharing data, code and ideas, and a final day for drawing conclusions and for determining the next actions. The main contributions came from the GHRSST groups DVWG and HL–TAG, with cross–cutting input from EARWiG, ST–VAL and CDR–TAG.

The aim of the workshop was to achieve progress with the observed and modelled sea surface temperatures (SST) for two regions – the Tropical Warm Pool and high latitudes (particularly in the SH). The Tropical Warm Pool (TWP) region is located in the western tropical Pacific Ocean and the

eastern tropical Indian Ocean. Here the ocean shows the highest SST variation per unit area and is one of the most difficult areas to retrieve and validate SST. This is due to a combination of high water vapour amounts, large diurnal warming, frequent cloud cover reducing the amount of SST retrievals from infrared satellite sensors, island chains reducing the spatial coverage of SST from microwave satellite sensors, and a lack of quality *in situ* SST measurements. The High Latitudes (covering the Southern and Arctic Oceans) are challenging regions for measuring SST due to a combination of prolonged cloud cover, large atmospheric variability, variations in sea–ice cover, frontal regions causing high spatial and temporal variability in SST, and a lack of quality *in situ* SST observations for calibration and validation.

User Feedback: The plenary session started with three user talks covering model applications of SST for atmosphere–ocean coupling and flux estimation. The users stressed that diurnal variability is of importance in NWP at 1–15 day time scales (especially relevant for MJO, shallow clouds and convection) and that diurnal variability of SST has non–negligible effects for climate applications. The users want SST_{skin}, SST_{depth} and $SST_{foundation}$, plus preferably a good model of the diurnal cycle or, alternatively, enough data points to describe the DV profile. The users want to know the DV amplitude at reasonably resolved time and depth and need to know whether the wind fields used in DV modelling are consistent with their application. For matching DV model data to in situ and satellite SSTs, it was suggested that GHRSST evaluates the quality of DV models according to their diurnal warming probability distribution. Five talks were given on various diurnal warming models, followed by further user talks on boundary layer processes and enhanced ocean coupling, as well as radiance assimilation.

I**n–situ data** were discussed – in particular the potential value of different **Argo near–surface** measurements for verification of DV models, for verification of the foundation temperature and for verifying the stability of climate records. Further, the **upgraded drifting buoys** were discussed, and it was highlighted that applications might take into account the time of detachment of the drogue as this influences the depth of the drifter measurement. **Ship measurements,** especially the availability of cruise air–sea flux datasets were discussed. Possible opportunities for GHRSST in connection with Australia's new research vessel (*RV Investigator*) were presented (e.g. research cruises either into the TWP region or Southern Oceans 2014 and 2015, maybe in connection with other researchers such as the air–sea flux community).



Results of the TWP+ breakout session: The collection of available satellite data in the TWP+ project domain were discussed and extended. Current issues to discuss in EARWiG were identified. An analysis of satellite and buoy diurnal warming differences was linked to diurnal cycles in water vapour distribution and day/night variation in the efficiency of screening sub–pixel clouds. It was decided that the day–night differences of the various satellite instruments and algorithms should be compared, and that consistent SST retrieval algorithms should be employed for day and night in order to avoid the inclusion of implicit inter–algorithm retrieval biases. This way, after a quality assessment and filtering of outliers, MTSAT–1R, AVHRR, AMSR–E and other satellite SST data may be compared with the diurnal variability models in the TWP+ domain. In particular, MTSAT–1R SSTs were assessed for TWP+ applications and improvements suggested. Further analysis is required to ascertain the impact of SST algorithm sensitivity in high water vapour conditions on observed day/night SST differences. Several issues with the TWP+ data set (involving satellite SST and wave model outputs) were identified during and immediately following the workshop. NOAA has recently provided updates to the MTSAT processing code and BoM will reprocess the data ASAP. The TWP+ data set will be updated by the end of March 2012 and changes reported via the GHRSST TWP+ web page and email to the TWP+ collaborators.

The following models were discussed and initial TWP+ results presented: Gentemann (2003), Castro LUT, COARE, Wick modified KC, Zeng–Beljaars (ZB), ZB+T and KC with sea state. Additional DV models discussed for inclusion in TWP+ were POSH v2 and Janssen/ECMWF. Improved land masking was suggested to improve and increase coverage of the microwave measurements. The use of TWP–ICE and IMOS ship air–sea flux data sets were discussed in relation to validation of DV models and possible ingest into DV look–up tables. Chris Merchant presented a new method for testing DV models against day–night difference distributions in satellite SST. Additional direct comparisons of the different models for identified cases of extreme warming have been initiated by Gary Wick and Sandra Castro. Gary Corlett presented results showing the potential of using satellite in situ match–ups at multiple depths (e.g. comparing AATSR SST_{skin} to drifter $SST_{0.2m}$, GTMBA $SST_{1.0m}$ and Argo $SST_{3–5m}$) as a useful dataset for testing DV models.

Results of the High Latitude breakout session: The algorithms applied to High Latitudes were reviewed, and algorithm improvement work was initiated concerning the air–sea temperature difference which can be extreme in this region (particularly in the Arctic due to the proximity of

continental land masses and concomitant impact on atmospheric temperature & humidity structure), hard–to–spot sea ice and complex clouds with long shadows. The Multi–sensor Matchup Dataset (MMD), which has been developed in the ESA SST climate change initiative project, was demonstrated to be a useful tool for improvements of algorithms and for investigating the origin of the errors. The investigations showed a difference in the SST algorithm performance in the Arctic and Southern Oceans, where daytime Arctic Ocean SSTs have significantly higher uncertainties than daytime Southern Ocean SSTs. This can probably be attributed to differences in atmospheric conditions between hemispheres. The workshop provided new opportunities to build links to the sea–ice community, particularly to the in situ network. Collaborations have been initiated for sea ice analysis intercomparisons and consistency, ice surface temperature in–situ observations (AFIN and Antarctic AWS data), Southern Ocean SST trends and sea ice anomalies.

Summarized WG and TAG activities:

- DVWG is mining the TWP+ data set for improvements to diurnal warming models, and for analysing diurnal warming events as observed by different satellites.
- EARWiG investigated several ideas for IR algorithm improvements in both tropical and high latitude regions, discussed cloud detection, and the potential for MW improvements in connection with land masking.
- HL–TAG discussed the sea ice coverage, its trends and new in–situ measurements of sea ice temperature.
- ST–VAL investigated robust uncertainty estimation, discussed possibilities of homogenisation of quality levels across similar instruments (e.g. for each AVHRR product), and promoted the use of multi–sensor in–situ matchups.
- CDR–TAG has been exploring the information content of observed SST distributions.

The **Agenda of the workshop with links to the presentations** and the abstracts can be accessed via the GHRSST web–site: https://www.ghrsst.org/ghrsst–science/Meetings–and–workshops/.

R11 – STVAL REPORT

Gary Corlett *(1)*

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Introduction

The Sea Surface Temperature Validation Technical Advisory Group (ST-VAL TAG) is responsible for defining and providing the Single Sensor Error Statistics (SSES) for GHRSST L2P products. In addition the group looks at all aspects of the validation process.

The current challenges for the group are to:

- Ensure the SSES Common Principles are implemented across all L2P data sets without compromising the data quality of any one data set.
- Better understand all elements of the SST validation process is required, including reference data quality, match-ups limitations and the provision of meaningful uncertainty estimates to users.

Progress during the last year

The main ST-VAL activities in the last year were covered in the workshop hosted at the Australian Bureau of Meteorology in February 2012. The workshop itself was focused on the dual themes of Tropical Warm Pool and High Latitudes, and each environment presents particular challenges for retrieval of SST. The main ST-VAL activities are summarized in the workshop report (https://www.ghrsst.org/files/download.php?m=documents&f=120329165058–Melbourne2012Summary.pdf).

This meeting

An ST-VAL breakout will take place as part of the XIII GHRSST Science Team Meeting. The session will focus on methods to deal with the ‘cold tail’ observed in histograms of drifter-satellite discrepancies that can be attributed to cloud mask failures amongst others. In addition the session will cover the DBCP HRSST pilot project, the use of Argo as a reference dataset and will review the SSES common principles.

R13 – REPORT FROM THE GHRSST HIGH LATITUDE – TECHNICAL ADVISORY GROUP (HL–TAG)

Jacob Høyer *(1)*

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1. Introduction

The main focus of the HL–TAG group is:

- The validation of existing surface temperature and sea ice products in the high latitude
- The development of new products, e.g. in the Marginal Ice Zone (MIZ).
- Follow the diurnal warming at high latitudes and the development of SST and Sea ice in the high latitudes.

During the last year, a HL–TAG meeting was held in Melbourne in March 2012 in collaboration the Diurnal Variability Working Group (DV–WG), the SST validation (ST–VAL) and the EARWIG working groups.

2. Progress during the last year

Most of the progress in the HL–TAG group was reported at the Joint Workshop of the DV–WG, HL–TAG, ST–VAL, and EARWiG on Tropical Warm Pool and High Latitude SST Issues, which was held in Melbourne February/March, 2012.

The algorithms applied for High Latitudes were reviewed, and algorithm improvement work initiated (concerning air–sea temperature differences which can be extreme in this region, atmospheric inversion profiles, hard to spot sea ice and complex clouds with long shadows). The Multi–sensor Matchup Dataset (MMD) which has been developed in the ESA SST climate change initiative project was demonstrated to be a useful tool for improvements of algorithms and for investigating the origin of the errors.

The investigations showed a difference in the SST algorithm performance in the Arctic and Southern Oceans, where the daytime Arctic Ocean SST observations have significantly higher errors than the daytime Southern Ocean observations. This can probably be attributed to North/South differences in the atmospheric conditions. The atmospheric conditions (temperature and humidity) in the Arctic Ocean vary much more during the year than over the southern ocean and the differences in the air–sea temperature re significantly larger in the Arctic than in the Southern Ocean. In addition, atmospheric inversions are much more frequent in the Arctic than in the Southern Ocean.

Within the ESA climate change Initiative, regional high latitude algorithms (including the CASSTA and nonlinear algorithms) have been submitted to the Round Robin algorithm exercise. The algorithms are currently being evaluated by the project team and compared against the other submitted algorithms. The figure below shows that regionally tuned algorithms tend to have smaller biases and lower standard deviations than the globally tuned.

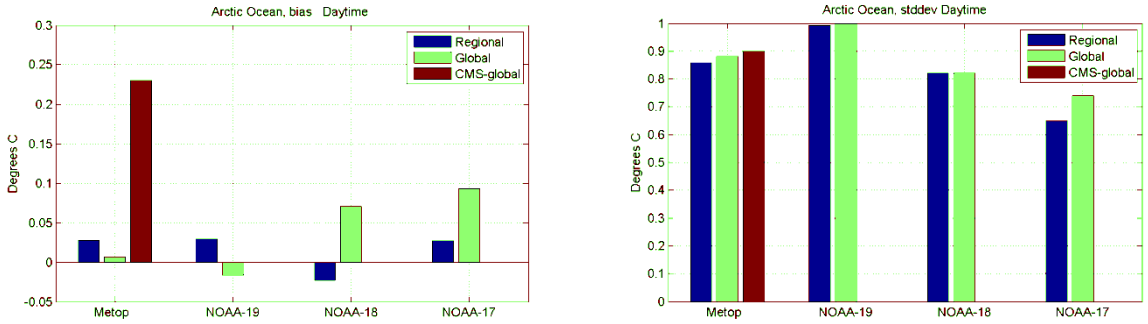

Figure1: Evaluation of the regional versus global algorithm performance for the Arctic Ocean Daytime observations. The results have been derived within the ESA Climate Change Initiative project, using the Multisensor Match–up dataset, created by the project. Left diagram is bias and right is standard deviation, compared to in situ observation. The results from the operational global (OSI–SAF) Metop_a algorithm (CMS–global) are included for reference.

The Melbourne workshop provided new opportunities to build links to the sea–ice community. James Screen from University of Melbourne reported on spurious effects in the NCEP sea ice area, due to the shift in the algorithm and the change of satellite sensors. This effect is also seen in the HADISST data set, which is very unfortunate since people are using this for climate change studies. It was decided to investigate these effects in the OSI–SAF sea ice reanalysis product, and we agreed that he should examine the data set for the same effects.

Petra Heil from Australia Antarctic division in Hobart presented the measurement program they are carrying out at the fast ice around Antarctica. It is a very interesting data set (AFIN and Antarctic AWS data) for cal/val of the satellite ice surface temperature products that will be developed for Antarctica within the OSI SAF CDOP–2.

Work was also initiated to investigate the relationship between sea ice and SST trends. Phil Reid reported a correlation between a decrease in sea ice and a positive SST anomaly, using Reynold OI SSTs. The SST trends were small, however, and work will be carried out to confirm the results using the AATSR.

R14 – REPORT ON THE APPLICATIONS AND USERS SERVICES TECHNICAL ADVISORY GROUP (AUS–TAG)

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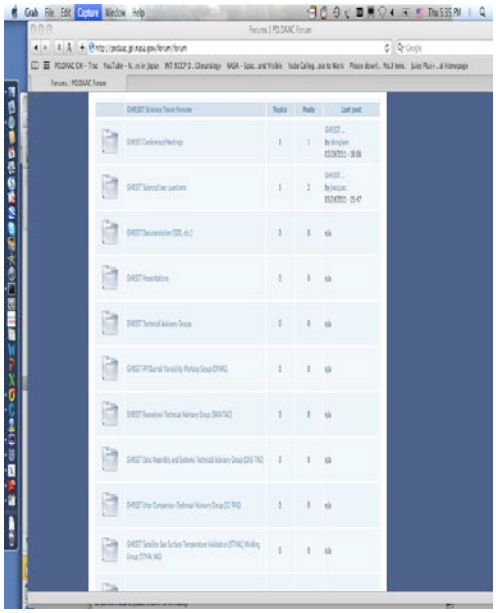
Version 1.5

ABSTRACT

Major accomplishments for the year 2011 were completion of the User's Manual and an initial version and review of the Users Requirement Document (URD). Work continued on the implementation of Tools and Services that included the Dataminer which allows for subsetting of MODIS Aqua, MODIS Terra, and AMSR–E GHRSST Level 2 Preprocessed data, implementation of the GHRSST forum, consolidation of AUS–TAG membership, and implementation of the "State of the Ocean" (SOTO) tool. Future plans include the implementation of the Live Access Server (LAS) to replace POET. The Dataminer tool will eventually transition to the PO.DAAC HITIDE tool which will incorporate Level 2 and Level 3 subsetting. The GHRSST forum continues in operation, but is underutilized. Discussion needs to be raised whether continuing to support the forum is worthwhile. All the tools have been implemented at the GDAC.

1. GHRSST Forum

A GHRSST Users forum has been setup. Individual groups have been setup based on the Technical Advisory Group and Science Team function. The forum and registration may be accessed at: http://podaac.jpl.nasa.gov/forum.



Currently though the forum is underutilized and future support needs to be discussed.

2. Accessing Data: Data Mining Tool

The PO.DAAC continues to support the dataminer subsetting tool which allows for spatial and temporal subsetting of GHRSST L2P data. MODIS Aqua and MODIS Terra data have been added to the available data sets. Thus, three GHRSST data sets are now available through the Dataminer and include MODIS Terra and Aqua and AMSR–E. An operational version is now available for testing at:

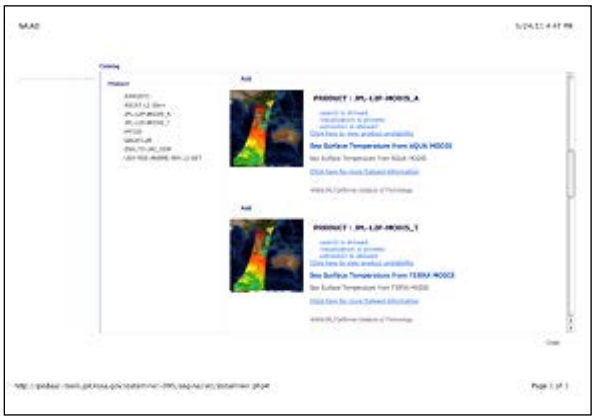
http://podaac–tools.jpl.nasa.gov/dataminer/aegina/src/dataminer.php

Dataminer is a web tool for searching and subsetting Level 2 (swath) data. It was developed originally by the French agency IFREMER (an upcoming collaboration is in the works), and modified at PO.DAAC.

An overview of the capabilities of this tool:

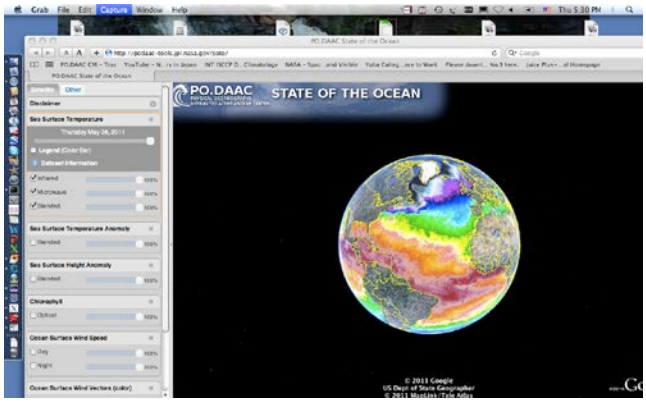
- Easily search for Level 2 (swath) data based on a spatial bounding box and time range
- Additionally filter your searches using basic statistical metadata collected from the original data (min, max, etc)
- Get an image preview of your search results before downloading the raw data, with a colorbar for reference
- Download the data in multiple formats (NetCDF3, HDF4, Image, KML)
- The data comes trimmed (subset) based on your space and time search criteria
- Save your search criteria and load it back up when you return (registration required)
- Access data both at PO.DAAC and at remote archives (AMSRE data from PO.DAAC and NODC, meaning the complete historical dataset is searchable across archives)
- Your data request is packaged into a tar file (tar.gz), and we send you an email to let you know when it's ready, and an http link to download it from our server

Currently two PO.DAAC data sets are available in the tool, GHRSST AMSRE REMSS L2P, and QuikSCAT L2B (25 km), MODIS Terra and Aqua L2P. A major component of this tool is the capability to subset data from the permanent storage site at the National Oceanographic Data Center (NODC). Whether the data is at NODC or the GDAC is transparent to the user.



3. Near real time visualization tool

The PO.DAAC continues to support a new visualization tool for viewing data in near real–time. The tool may be accessed at: http://podaac–tools.jpl.nasa.gov/soto/



Current data sets included WINDSAT, MODIS, and blended product as well

Additionally an anomaly product is available that uses SSTs from OSTIA and the Pathfinder 4km climatology. The tool allows for overlaying of data sets. Additionally in–situ is incorporated which can be overlaid with other SST data sets and/or winds and current data.

4. User's manual

A revised draft of the User's Manual has been reviewed. Changes have been implemented. The completed User's Manual may be accessed through the GHRSST project page: http://www.ghrsst.org/. Version 9 of the document can also be accessed directly through the GDAC at:

ftp://podaac.jpl.nasa.gov/oceantemperature/ghrsst/docs/

5. Quick start document

For those that are in a hurry to use SST data a quick start was developed and may be accessed through:

https://www.ghrsst.org/users–partners/quick–start/

6. GHRSST METRICS (GDAC+LTSRF)

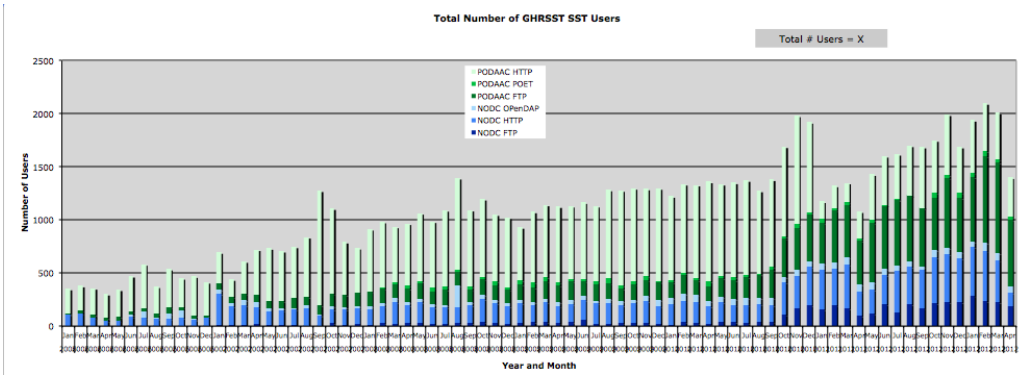
Between the GDAC and the LTSRF the total number of users from 2006 to 2011 is 88,741. Total number of gigabytes served is 343,803 while the total number of files served is 143,355,862. More details on yearly trends, etc. may be found in the figures in the appendix.

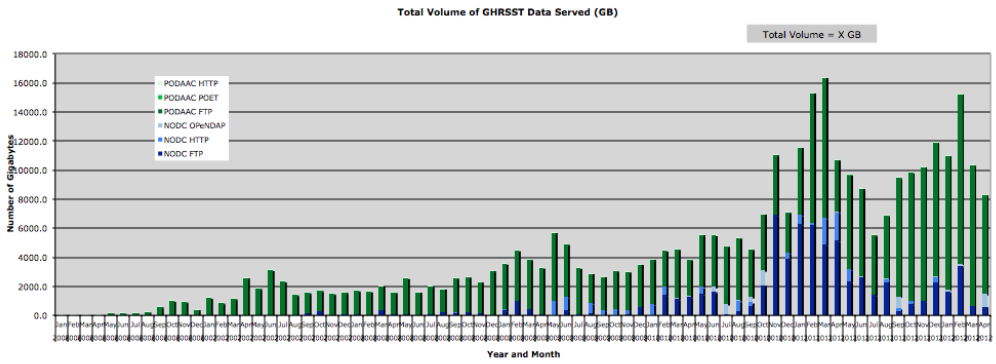
7. Conclusions

Users of GHRSST data continue to increase. With the emergence of the historically reanalyzed products, there has been a significant increase in using GHRSST data for scientific research. Near–real time capabilities continue to emerge, specifically in numerical weather forecasting and fisheries. New technologies, such as the dataminer, have been implemented which allow for temporal and spatial subsetting.

Challenges still remain which must be addressed for maximizing the use of GHRSST data. These include how to collect metrics on usage from such tools as the Dataminer and THREDDS. Future replacement of the popular POET Level 3 and Level 4 subsetter with LAS. Implementation of netcdf4 for use in THREDDS and OPenDAP. This is critical for distribution of high volume data sets such as global 1km Level 4 data. Additionally a dashboard concept needs to be developed where users can get near real time information on the status of data streams. Plans need to be formulated for both of the above.

APPENDIX: Figures GHRSST Users and Volume





R15 – REPORT FROM THE DIURNAL VARIABILITY WORKING GROUP (DVWG)

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ABSTRACT

This report summarizes the recent activities of the Diurnal Variability Working Group (DVWG) in the period between the GHRSST XII and XIII meetings and highlights our priority activities and goals. The overall focus of the DVWG is to provide the GHRSST community with critical science to enable the best possible characterization and estimation of diurnal warming in support of the creation of improved sea surface temperature (SST) products. Activities range from basic research to generation of analyses of diurnal warming.

1. Achievements

Two major focal points of the activities of the DVWG during the past year were a special session on temporal and spatial scales of SST variability co–Chaired by DVWG members at the 2012 Ocean Sciences Meeting in Salt Lake City, Utah, USA, and the GHRSST Joint Workshop on Tropical Warm Pool and High Latitude SST Issues hosted by H. Beggs in Melbourne, Australia. DVWG group members were also involved in meetings and activities associated with the NASA SST Science Team and European Research Network for Estimation from Space of Surface Temperature (ERNESST).

The activities of several GHRSST and DVWG members were presented at the Ocean Sciences Meeting. P. Minnett gave an invited overview talk on the components and sources of variability in SST. A. Kaiser–Weiss followed with a summary of GHRSST and discussion of the scales of SST variability observable in GHRSST data. A very unique set of observations of diurnal warming in the northern arctic from buoys was presented by Mike Steele from the Applied Physics Laboratory at the University of Washington, USA. Data from his Upper Temperature of the Ocean (UpTempO) thermistor string buoys deployed in the summertime north of Alaska showed observations of significant diurnal warming at multiple depths near the surface. The presentation generated good discussion and the observations provide great potential for additional validation of satellite observations and model products. Plans for an initial model comparison were developed with S. Castro. X. Zhu also gave a talk on her work with P. Minnett studying diurnal variability at multiple shallow coastal water sites. This work is exploring the different characteristics of diurnal warming at different sites and the ability of different classes of models to reproduce the observations.

Posters presented included contributions by C. Gentemann, S. Castro, G. Wick, and A. Bogdanoff, a student working with C. A. Clayson. C. Gentemann's work on the Spatial Variability of Diurnal Warming from Satellite Measurements of SST included comparisons of global maps of diurnal warming derived from satellite data with predictions from different models and parameterizations. The work of S. Castro and G. Wick included initial comparisons of models of different complexities with satellite–derived warming from the Tropical Warm Pool (TWP+) data set. The comparison suggested that the sensitivity of the predicted warming to the assumed solar absorption profile varies significantly between different diurnal warming models and the apparent optimal absorption model can be different for different warming models. Results presented by A. Bogdanoff incorporated a new revised parameterization of diurnal warming derived from a modified version of the Kantha–Clayson turbulence model.

The joint workshop on the TWP+ dataset began with three presentations from users which helped refine community requirements for information on diurnal warming. The users require information on the diurnal amplitude reasonably resolved in both time and depth, and would benefit from the availability of a good model of diurnal warming. The need was highlighted for information on whether

the wind speeds used in derivation of the diurnal warming are consistent with the users' applications. The presentations also demonstrated the importance of diurnal information on numerical weather prediction (NWP) and a non–negligible impact on climate applications.

Technical presentations highlighted the status of data products and model predictions within the TWP+ domain. Multiple analyses examined the quality and applicability of diurnal warming estimates derived from satellite SST products, particularly those from MTSAT–1R. Work during and after the workshop identified issues with some of the TWP+ SST products and suggested potential improvements, including use of a single retrieval algorithm during night and day for MTSAT–1R. Application of certain quality flags was also observed to mask larger diurnal warming events in the AMSR–E data. Development of a foundation SST product for the TWP+ domain was presented. Estimates of diurnal warming corresponding to the TWP+ data have been or are being derived for models including COARE, Zeng–Beljaars, Gentemann (2003), multiple versions of the Kantha–Clayson model, one of which includes sea state, and look–up tables derived from the Kantha–Clayson model. Future plans call for inclusion of POSH and GOTM.

Strategies were developed for intercomparison and validation of the various model–derived warming estimates using available TWP+ observations. C. Merchant will lead a new effort to evaluate the models based on their predicted distributions of diurnal warming amplitudes. This approach was motivated by the typical uncertainties in the MTSAT–1R observations. Additional direct comparisons of the different models for identified cases of extreme warming have been initiated by G. Wick and S. Castro. An example comparison is shown in Figure 1. G. Corlett presented results showing the potential of using satellite in situ match–ups at multiple depths as a useful dataset for testing diurnal variability models.

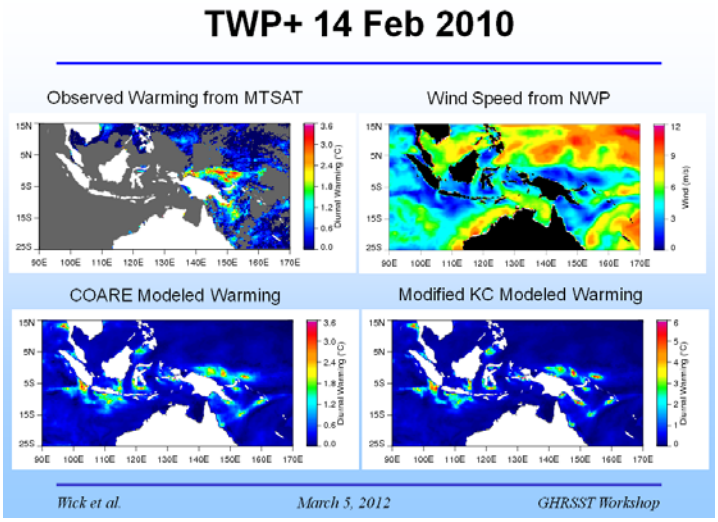

Figure 1: Sample comparison of modelled diurnal warming at 2 pm local time in the TWP+ domain with warming derived from observations from MTSAT–1R. Fluxes were obtained from the ACCESS–R model and predictions are shown for the COARE and Modified Kantha–Clayson models.

Through discussions at and following the joint workshop, efforts continue to facilitate improved access to Argo near–surface observations for validation of diurnal variability models. A. Kaiser–Weiss coordinated a response to the Argo steering team requesting the provision of unpumped near–surface data with as high as possible vertical resolution in addition to continuously pumped data as close to the surface as possible. While preliminary analyses suggest that the unpumped temperature observations have sufficient accuracy for analyses of diurnal variability, additional activities are underway within the DVWG to further justify the utility of these data.

SEVIRI data continues to be used extensively in studies of diurnal variability. Within the MyOcean ERNESST meeting on Small Scale SST Variability in Lannion, France in November, the diurnal signals from various MyOcean models were compared to buoy measurements and/or SEVIRI SSTs. While the initial results were partly contradictory, it is expected that methods and results will evolve and converge in the near future. Multiple activities at CNS in France are incorporating comparisons with observations from SEVIRI. Comparisons with drifter diurnal warming estimates over one year and the full SEVIRI disk have been conducted to understand the regional/seasonal differences between skin (SEVIRI) and 20cm depth (drifters) DW estimates. Example results shown in Figure 2 highlight differences in two distinct regions in the Atlantic. The comparisons also have suggested potential impacts of subpixel cloudiness on SEVIRI–based observations of larger diurnal warming events. Work in collaboration with S. Marullo is exploring differences between SEVIRI observations and simulated warming from the General Ocean Turbulence Model (GOTM) in the Mediterranean Sea and Eastern Atlantic. GOTM is being run on a 1 degree spatial grid with ALADIN heat and momentum fluxes using the K–epsilon turbulence scheme.

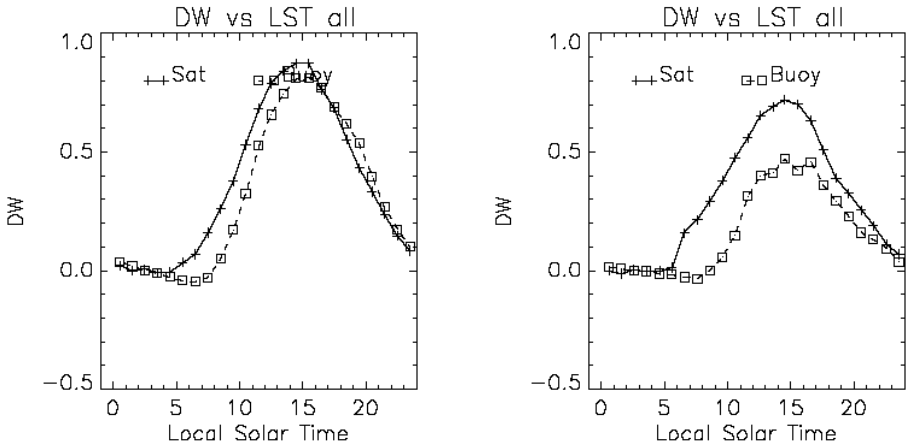

Figure 2: One year comparison: SEVIRI vs drifter DW estimates; left: Subtropical North Atlantic; right: Intertropical Atlantic. Courtesy P. LeBorgne.

The construction of a diurnal warming matchup database based on SEVIRI observations has been proposed by A. Marsouin and P. Le Borgne to facilitate ongoing and future studies. The primary inputs are to include:

- in situ SST measurements available on the GTS,
- workfiles of the OSI SAF processing chain for SST and radiative fluxes, and
- other NWP model outputs.

In situ measurements will be taken from both drifting and moored buoys. Preliminary lists of detailed contents were circulated in March and are currently being finalized. The work on this database is endorsed by the DVWG and is expected to be very valuable.

2. Priorities and Plans

The DVWG priorities are centered on providing the GHRSST community and users with improved estimates of diurnal warming both for individual satellite retrievals and on global grids to complement current foundation SST analyses. Significant progress has been made in improving the understanding and modeling of diurnal warming, and now it is important to apply these results to better convey diurnal warming estimates and associated uncertainties in a cohesive manner. Specific priorities include:

- Development, validation, and production of diurnal warming analyses
- Continued model development and evaluation
- Provision of guidance on recommended/consensus approaches

Despite the work to date in the DVWG, complete analyses of diurnal warming at multiple depths are still not broadly available. Multiple approaches have been developed and are in various stages of evaluation, but a standard GHRSST product is not yet available. The greatest priority of the group is to see this through to completion.

The launch of the NASA Aquarius mission has generated some specific new requests for information on diurnal variability. Related to the overpass time of the satellite, the Aquarius team is requesting the best possible estimates of the SST at 6 am and 6 pm local times for the processing of the salinity measurements as well as a climatology of the 6 pm – 6 am differences. Provision of this information will be a topic of discussion at GHRSST XIII.

To support creation of diurnal warming analyses and provision of information on the amount of diurnal warming present at specific times, model development and validation activities will continue. This work will include detailed assessments of uncertainty and formulation of guidance on the appropriateness of different models for different applications.

The activities of the DVWG are largely performed on a best–effort basis under broader support for SST related research activities. Few within the group have funding dedicated specifically to diurnal warming research. The group remains highly dedicated, but progress will remain constrained by available time and resources.

R16 – REPORT FROM THE ESTIMATION AND RETRIEVALS WORKING GROUP (EARWIG)

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Background

GHRSST's primary mission has focused on the characterization of uncertainty in existing products, combined with a unified data format to convey the relevant information to end–users. Actual algorithmic issues related to data products were initially eschewed by the GHRSST project, being regarded as the preserve of data providers. However, it became increasingly clear that scientists desired a forum for the sharing of ideas to overcome problems which were recurrent in one form or another in many SST products. Thus, the Estimation and Retrievals Working Group (EARWiG) was instituted with the express purpose of addressing issues relating to the retrieval of sea surface temperatures from radiances observed by satellite instruments.

It should be noted that EARWiG is intended not only as a focus but also a liaison with other national and international activities, such as the European Research Network for SST (ERNESST) and the recently formed NASA SST Science Team.

Activities

While retrievals–related activities had been ongoing for some time within the group, the EARWiG session at the XII GHRSST Science Team Meeting marked the beginning of more formal activities as a working group. The inaugural session was, rather gratifyingly, a standing–room only affair, and a number of novel approaches were presented and discussed. A summary of the presentations can be found on page 71 of the Proceedings.

https://www.ghrsst.org/files/download.php?m=documents&f=111114143724–Proceedings260911Final.pdf.

EARWiG also participated in a workshop hosted at the Australian Bureau of Meteorology in February 2012. The workshop itself was focused on the dual themes of Tropical Warm Pool and High Latitudes, and each environment presents particular challenges for retrieval of SST. The EARWiG findings are summarized in the workshop report.

https://www.ghrsst.org/files/download.php?m=documents&f=120329165058–Melbourne2012Summary.pdf.

Future

EARWiG will have session at the XIII GHRSST Science Team Meeting. Although retrieval of SST from microwave sensors is within the remit of EARWiG, there has been little discussion to date. With the recent successful launch of AMSR–2 on the GCOM–W1 platform, we will doubtless be hearing more about the challenges and opportunities in this area, irrespective of whether they are presented in the EARWiG breakout session.

R17 – REPORT FROM THE INTER–COMPARISON TECHNICAL ADVISORY GROUP (IC–TAG)

Alexey Kaplan[(1)], Matt Martin[(2)], Sasha Ignatov[(3)]

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1. Introduction

A large number of level 4 (L4) sea surface temperature (SST) analyses are produced by various institutes around the world, making use of the SST observations provided by the Global High Resolution SST (GHRSST) project. These are used by a number of groups including: numerical weather prediction centres; ocean forecasting groups; seasonal forecasting systems; climate monitoring and research groups. There is a requirement to develop international collaboration in this field in order to assess and inter–compare the different analyses, and to provide uncertainty estimates on both the analyses and observational products.

The GHRSST Inter–comparison Technical Advisory Group (IC–TAG) has been set–up in order to coordinate inter–comparison activities of L4 products within GHRSST, develop inter–comparison systems, improve the documentation of those systems and promote the use of inter–comparison tools for use by other TAGs where appropriate.

There are currently three systems contributing to the IC–TAG:

- The GHRSST Multi–Product Ensemble (**GMPE**) system (http://ghrsst–pp.metoffice.com/pages/latest_analysis/sst_monitor/daily/ens/index.html) which is run on a daily basis at the UK Met Office.
- The High Resolution Diagnostic Data–set (**HRDDS**) system (http://www.hrdds.net) which runs at the National Oceanography Centre, Southampton.
- The SST Quality Monitor (**SQUAM**) system (http://www.star.nesdis.noaa.gov/sod/sst/squam/) which runs at NOAA NESDIS.

The IC–TAG includes representatives from each of the L4 analyses producers which are contributing to GMPE, HRDDS and SQUAM, plus technical experts from the GMPE, HRDDS and SQUAM systems, and other colleagues interested in the intercomparison of the Level 4 data sets. For the most of the year since the GHRSST–XII Science Team Meeting, the IC–TAG has been chaired by Matt Martin, with Vice Chair Alexey Kaplan. As a manager of GMPE, Matt Martin also served as a GMPE technical expert on the IC–TAG. Because of the change in his job responsibilities in the U.K. Met Office, Martin is resigning his position on the IC–TAG by the time of GHRSST–XIII meeting. With Alexey Kaplan promoted the Chair position and Mike Chin having accepted the Vice–Chair responsibilities, the current IC–TAG membership becomes:

- Alexey Kaplan, Columbia University, USA (Chair)
- Emanuelle Autret, IFREMER, France
- Viva Banzon, NOAA/NCDC, USA
- Ian Barton, Australia
- Helen Beggs, BoM, Australia
- Bruce Brasnett, Canada
- Mike Chin, NASA JPL, USA (V–Chair)
- Jim Cummings, NRL, USA

- Prasanjit Dash, NOAA/NESDIS, USA
- Chelle Gentemann, RSS, USA
- Robert Grumbine, NOAA/NWS, USA
- Jacob Høyer, DMI, Denmark
- Alexander Ignatov (SQUAM), NOAA/NESDIS, USA
- Shiro Ishizaki, JMA, Japan
- Eileen Maturi, NOAA/OSPD, USA
- Matt Martin, Met Office, UK (GMPE) (former Chair)
- Bruce McKenzie, NAVOCEANO, USA
- Dave Poulter (HRDDS) NOCS, UK
- Jean–François Piollé, IFREMER, France
- Nick Rayner, Met Office Hadley Centre, UK
- Richard Reynolds, NOAA/NCDC, USA
- Martin Rutherford, Australia

2. Progress since the last GHRSST meeting

A two–part paper prepared under the leadership of the IC–TAG members has been published in a special issue of Deep–Sea Research II. The first part of the paper provides an overview of the L4 systems contributing to GMPE and SQUAM, presents an inter–comparison to independent data (near–surface Argo SST), investigations into the feature resolution of the products, and assesses the ensemble standard deviation as an estimate of error. The second part provides an overview of the SQUAM system and demonstrates the utility of typical inter–comparison and validation results.

Martin, M., P. Dash, A. Ignatov, V. Banzon, H. Beggs, B. Brasnett, J.–F. Cayula, J. Cummings, C. Donlon, C. Gentemann, R. Grumbine, S. Ishizaki, E. Maturi, R. W. Reynolds, J. Roberts–Jones, Group for High Resolution Sea Surface temperature (GHRSST) analysis fields inter–comparisons. Part 1: A GHRSST multi–product ensemble (GMPE), *Deep Sea Research Part II: Topical Studies in Oceanography*, Available online 2 May 2012, ISSN 0967–0645, 10.1016/j.dsr2.2012.04.013. (http://www.sciencedirect.com/science/article/pii/S0967064512000616)

Dash, P., A. Ignatov, M. Martin, C. Donlon, B. Brasnett, R. W. Reynolds, V. Banzon, H. Beggs, J.–F. Cayula, Y. Chao, R. Grumbine, E. Maturi, A. Harris, J. Mittaz, J. Sapper, T. M. Chin, J. Vazquez–Cuervo, E. M. Armstrong, C. Gentemann, J. Cummings, J.–F. Piollé, E. Autret, J. Roberts–Jones, S. Ishizaki, J. L. Høyer, D. Poulter, Group for High Resolution Sea Surface Temperature (GHRSST) analysis fields inter–comparisons—Part 2: Near real time web–based level 4 SST Quality Monitor (L4–SQUAM), *Deep Sea Research Part II: Topical Studies in Oceanography*, Available online 17 April 2012, ISSN 0967–0645, 10.1016/j.dsr2.2012.04.002. (http://www.sciencedirect.com/science/article/pii/S0967064512000501)

An overview of progress in the past year with the IC–TAG systems (GMPE and SQUAM) is provided below.

GMPE (Matt Martin)

The GMPE system (run on a daily basis at the UK Met Office) takes inputs from various analysis production centres on a routine basis and produces ensemble products. The analysis systems currently contributing to the GMPE system are:

1. OSTIA (Met Office, UK);
2. NAVO K10 (Naval Oceanographic Office, USA);
3. MGDSST (Japan Meteorological Agency, Japan);
4. RSS MW (Remote Sensing Systems, USA);

5. RSS MW+IR (Remote Sensing Systems, USA);
6. FNMOC (Fleet Numerical Meteorology and Oceanography Centre, USA);
7. NOAA AVHRR OI (National Oceanic and Atmospheric Administration, USA);
8. NOAA AVHRR/AMSR OI (National Oceanic and Atmospheric Administration, USA);
9. CMC (Meteorological Service of Canada);
10. GAMSSA (Bureau of Meteorology, Australia).

During the past year, the GMPE system has been contributing to the European MyOcean project (http://www.myocean.eu.org). Access to the GMPE data can be obtained by emailing the MyOcean service desk (servicedesk@myocean.eu.org). The data can be viewed interactively using a Web Map Service at http://data.ncof.co.uk:8080/ncWMS/godiva2.html. The anomalies of products from the ensemble median are used as a monitoring tool to highlight when particular analyses are outliers. For instance, the GMPE is used on a daily basis to monitor the OSTIA system.

Some of the developments to GMPE required for the analyses in the Martin et al. (2012) paper referenced above have been transferred into the main GMPE system. The GMPE files now include the following fields on a ¼ degree resolution grid:

- ensemble median;
- ensemble standard deviation;
- number of analyses contributing to the ensemble at each grid point;
- identifier for the analysis which is the median at each grid point;
- anomalies for each input analysis compared to the ensemble median;
- horizontal SST gradients for each input analysis and the ensemble median.

The new GMPE files are also now in GDS2.0 compliant format in netcdf4. The robustness of GMPE has been improved by running the system directly on the Met Office supercomputer.

SQUAM (Alexander Ignatov)

The SQUAM system continues to run daily at NOAA/NESDIS. It takes inputs from various Level 2, Level 3, and Level 4 SST products on a routine basis and generates summary consistency statistics. SQUAM contributes to the NESDIS and NCEP SST quality control efforts, and is NESDIS contribution to GHRSST Inter–Comparison Group Activities.

L2–SQUAM. The following global L2 products are currently displayed and updated (if updates are available) in the SQUAM system:

1. Medium resolution L2 AVHRR SST products (Global Area Coverage, 4km)
    - NESDIS heritage (Main Unit Task, MUT) low–resolution SST product from NOAA–16, –18, –19, and Metop–A
    - NESDIS operational Advanced Clear–Sky Processor for Oceans (ACSPO) SST product from NOAA–16, –18, –19, and Metop–A
    - NAVO operational Seatemp SST product from NOAA–18, –19, and Metop–A
2. High–resolution L2 SST products (1km and higher)
    - NESDIS ACSPO SST product from Metop–A FRAC 1km resolution data
    - O&SI SAF SST product from Metop–A FRAC 1km resolution data
    - MODIS ACSPO from Terra and Aqua
    - ACSPO NPP VIIRS
    - IDPS NPP VIIRS

L3–SQUAM. The only L3 product currently displayed in SQUAM is

1. Pathfinder AVHRR v5

L4–SQUAM. The following L4 products are currently displayed in SQUAM and updated in near–real time when updates are available:

1. NOAA AVHRR OI daily AVHRR–based
2. NOAA AVHRR_AMSRE OI daily AVHRR–based
3. RTG_SST_HR
4. RTG_SST_LR
5. NAVO K10
6. NESDIS POES–GOES
7. NASA JPL G1SST
8. OSTIA
9. OSTIA Reanalysis
10. CMC 0.2
11. GAMSSA 28km
12. NASA JPL MUR
13. ODYSSEA
14. GHRSST Median Product Ensemble

Web functionality has been updated to store the date of analyses and to facilitate cross–product comparisons.

Cross–comparisons of various L4 fields performed using L2 SQUAM product as a “transfer standard”. It is observed that the GMPE product best captures the spatial variability, and temporal stability in ACSPO L2, followed by CMC 0.2 and OSTIA products. A paper has been presented at the SPIE Conference, Baltimore, 25 April 2012: “Selecting a first guess SST as input to ACSPO” by Saha, Ignatov, Liang, and Dash http://spie.org/app/program/index.cfm?fuseaction=conferencedetail&conference_id=966891&event_id=957483&list=1

3. Further Plans

It was suggested at the previous GHRSST meetings that an effort be put into producing summary information about the various L4 products in GHRSST to inform users which product may be suitable for their application. While the collection of this information from the L4 producers was ongoing, the process had been superseded by the preparation of the inter–comparison papers listed above. Complete and well–organized summaries of individual L4 products have been published in the form of tables in these papers. These tables can and should be adapted for the presentation at the GHRSST website.

A number of issues have been raised over the past years with regard to the estimation of analysis error in the L4 products. A white paper is in preparation within the IC–TAG, aimed at summarizing the way error estimation is currently done with a view to improving and potentially attempting to standardise it.

R18 – REPORT FROM THE RESCUE & REPROCESSING OF HISTORICAL AVHRR ARCHIVES WORKING GROUP (R2HA2–WAG)

Peter Cornillon

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The R2HA2 has made progress in the following two areas:

1) Hervé Roquet has been working with other GHRSST members on a L1 GHRSST format for AVHRR HRPT and LAC data. His subgroup will present a proposal for this format at GHRSST XIII.

2) The University of Rhode Island has taken delivery of a large number of DAT tapes with the AHVRR HRPT archive collected at the University of Hawaii. We believe that this archive begins in the early 1980s. Staff at URI are now working to determine whether or not they are readable. The results thus far have not been encouraging. The condition of the tapes is unknown at this point as is the data density and format of data on the tape. We view this as a learning exercise to determine what is involved in recovering a dormant archive.

R19 – REPORT FROM THE CLIMATE DATA RECORD TECHNICAL ADVISORY GROUP (CDR–TAG)

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Executive Summary

The Climate Data Record Technical Advisory Group was formally instituted in April 2012 with the publication of its Terms of Reference, following a consultation period with the GHRSST Science Team. Its vision is to meet the world's needs for a comprehensive suite of trustworthy, long–term, and accurate SST data sets. Within GHRSST, the CDR–TAG will maintain a community consensus on the requirements that must be met by products intended to be Climate Data Records (CDRs), and elaborate these in practical detail within a Data Processing Framework (DPF).

1. Introduction

The Climate Data Record Technical Advisory Group was formally instituted in April 2012 with the publication of its Terms of Reference, following a consultation period with the GHRSST Science Team.

The CDR–TAG replaces the previous Reanalysis TAG in regards the aspect of SST records for climate within the GHRSST co–operative framework. The GHRSST Long Term Stewardship and Reanalysis Facility (LTSRF) now reports separately from CDR–TAG to the Science Team.

The CDR–TAG Terms of Reference are available at

https://www.ghrsst.org/files/download.php?m=documents&f=120430103725–CDRTAGToRv10.pdf

2. Background

It is widely appreciated that satellite datasets produced in near–real time, operational settings generally fail to provide the most highly accurate and consistent time series information possible. Experiences with the Advanced Very High Resolution Radiometer (AVHRR) sensor on board the NOAA polar orbiters illustrate this problem. Although real–time SST products have been derived for years from the AVHRR, discrete changes to the processing algorithms result in inconsistent time series unsuitable for use in longer term or climate studies. These problems were addressed by the AVHRR Pathfinder Project (Casey et al., 2010), which is now preparing its sixth major reprocessing (Pathfinder v6.0, RSMAS/NODC). Similarly, the ATSR Reprocessing for Climate (ARC) project addressed shortcomings in the operational ATSR–1, ATSR–2, and AATSR series. Other satellite sensors have similar reprocessing programs in place; SeaWiFS and MODIS/Terra have now completed several reprocessing cycles. Reprocessing efforts like these are required to attain the accuracies needed for climate and other long–term applications.

Based on experiences like these, the original GHRSST Science Team (then known as the GODAE High Resolution SST Pilot Project, or GHRSST–PP) initiated a Reanalysis Technical Advisory Group (RAN–TAG) whose goals were

- to produce delayed–mode products of higher accuracy and consistency than the real–time SSTs by taking advantage of additional delayed mode data streams and algorithms that cannot be used by the operational real time systems,
- to link the RAN products to longer–term in situ based SST analyses, and

- to enable a reprocessing capability so that future users of the data can easily reprocess or utilize the data.

As such, the RAN–TAG was as much about establishing a *data processing and management system* as it was about *creating SST products*. The RAN–TAG products would be suitable for use as climate data records, a guiding concept in environmental data management which dictates long–term accuracy and consistency (*e.g.* NRC, 2000). The original RAN–TAG began documenting its vision and goals during the first four GHRSST workshops and in 2004 published its first terms of reference (GHRSST–PP/19, 2004).

The RAN–TAG focused its initial efforts on

- establishing the Long Term Stewardship and Reanalysis Facility (LTSRF, http://ghrsst.nodc.noaa.gov) for GHRSST data at the US NODC,
- tracking and encouraging the reprocessing of individual sensor data streams and merged Level 4 (L4) products into GHRSST–compliant format, and bringing the climate SST community together for routine discussion, coordination, and communication.

Early ideas of establishing a central reprocessing and reanalysis center to create a single, RAN–TAG consensus climate data record or CDR were abandoned when the community realized that no consensus yet agreed on reprocessing or blending techniques and more importantly, that it was not possible to create a single, community–consensus product that would meet the needs of all climate–oriented users. The RAN–TAG refocused on improving the LTSRF archive and access services, publishing an annual International Status Report documenting the many GHRSST–related climate efforts that had been established around the world, implementing the GHRSST/GCOS SST Intercomparison Facility, and ultimately on defining and documenting a conceptual framework for the SST CDR, which detailed the need for a comprehensive suite of SST CDR products along dimensions of SST type, processing level, and space–time resolution (Figure 1, https://www.ghrsst.org/files/download.php?m=documents&f=R10–RAN_Meeting10_Report.doc). This conceptual framework establishes the basis for the present GHRSST CDR vision, goals, and strategies, and is summarized in the following section.

3. CDR–TAG Vision and Conceptual Framework

The CDR–TAG vision is to meet the world's needs for a comprehensive suite of trustworthy, long–term, and accurate SST data sets. This suite of products is illustrated as a collection of data sets in a conceptual framework with three dimensions.

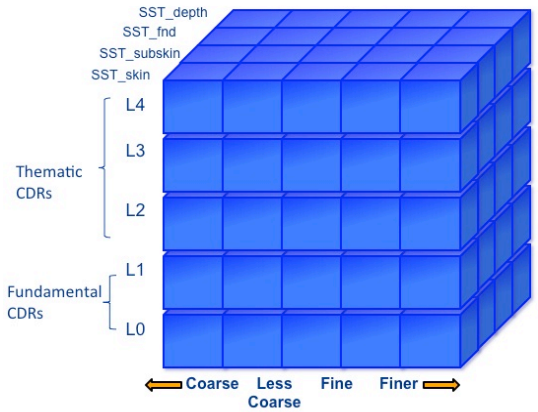

Figure 1: The SST Essential Climate Variable Conceptual Framework, defined by GHRSST in 2009.

The first of these dimensions represents the spatial–temporal resolution of the products, ranging from fine space time scales (sub–daily, order 1 km resolution) to coarse (monthly, order 1 degree resolution). Climate SST applications demand products with resolutions across this spectrum, so numerous products must be developed to meet those varying needs. Similarly, some applications require data at lower or higher processing levels, which is represented as the second dimension in the CDR product cube. For example, many applications require gap–free, gridded data (i.e., Level 4), but other applications cannot tolerate the smoothing or blending of data inherent in those Level 4 analysis systems. These applications may need Level 2 or Level 3 data. Developers of higher level data sets also need access to the lowest level data (Level 0 and 1) in order to build those products. Finally, the third dimension is necessary because different instruments systems actually measure different kinds of SST, including foundation SST, sub–skin SST, and skin SST. The differences in these values can be substantial and various applications are optimized to work with different SST types. Thus, the SST CDR conceptual framework consists of a suite of products working together to meet the widest possible range of climate–oriented SST applications.

4. Climate Data Record Technical Advisory Group: Terms of Reference

In the light of the above history and conceptual framework, the Terms of Reference for the CDR TAG have been agreed as follows.

4.1 CDR–TAG Responsibilities

Within the Group for High Resolution Sea Surface Temperature (GHRSST), the Climate Data Record Technical Advisory Group (CDR–TAG) accepts responsibilities addressing the need for long–term, stable and accurate SST data sets. The primary responsibilities are to:

1. Develop, regularly review and revise the GHRSST community consensus on the requirements that must be met by products intended to be Climate Data Records (CDRs).
2. Define, document, maintain and improve the CDR Data Processing Framework (DPF) in conjunction with the GCOS SST and Sea Ice Working Group and the CEOS Virtual Constellation for SST.
3. Evaluate GHRSST data sets that are proposed as CDRs against the DPF. Maintain the authoritative list of evaluation results, indicating which products are designated GHRSST CDRs.
4. Provide advice and guidance to the US NODC for operations of the LTSRF and GHRSST/GCOS SST Inter–comparison Facility.
5. Work in accordance with the current
    - GHRSST Data Specification (GDS 2.0, https://www.ghrsst.org/documents/q/category/gds–documents/operational/) and
    - GHRSST Development and Implementation Plan (GDIP, https://www.ghrsst.org/documents/q/category/ghrsst–strategy/),

    making recommendations for improvements to those documents as necessary.
6. Work with specific applications and users of CDRs to solicit and respond to feedback.
7. Provide regular reports on CDR–TAG activities and LTSRF operations at annual GHRSST meetings.
8. Provide scientific guidance to, and as appropriate, receive advice from, the GHRSST Science Team, RDACs, and GDAC on the scientific and technical issues associated with the implementation and operation of the CDR DPF.

9. Maintain CDR–TAG documents and information on the GHRSST web site (http://www.ghrsst.org), including at a minimum the:

    - Terms of Reference and Vision (this document)
    - membership list
    - name and contact information of the Chair
    - community consensus climate product requirements
    - data processing framework (DPF)
    - authoritative list of designated GHRSST CDR products.

4.2 CDR–TAG Membership

The CDR–TAG is open to all interested persons that attend meetings (in person or via teleconferencing), collaborate, and contribute positively to the CDR–TAG's remit. A membership list will be maintained by the Chair and GHRSST Project Office, based on active participation in the CDR–TAG. This list will be used for CDR–TAG mailings and can be checked at https://www.ghrsst.org/ghrsst–science/science–team–groups/cdr–tag/.

The CDR–TAG will be chaired by a member of the GHRSST Science Team. Other members do not need to be on the Science Team. The CDR–TAG Chair will be elected by simple majority vote of its members and will serve a 3–year term. Re–election to the Chair is permitted.

4.3 CDR–TAG Meetings

The CDR–TAG will meet once per year at GHRSST Science Team meetings and at other times as necessary. When possible, teleconferencing options will be provided for people who cannot attend in person. Meetings are open to members and non–members alike.

5. Forthcoming plans

The task for the CDR–TAG in the coming year is development of the Data Processing Framework (DPF) referred to above. This will be the basis on which SST products within the GHRSST system will be flagged to climate users as designated GHRSST CDR products. The DPF will therefore need thoughtful development, accounting for the need for rigour and transparency in the area of climate data while maintaining a pragmatic and open approach. Since GHRSST is now associated with the Committee for Earth Observing Satellites (CEOS), the CDR TAG will interact with the CEOS working group for climate via the GHRSST international project office. The European Space Agency (ESA) Climate Change Initiative, the US Climate Data Records programmes and the research community as a whole are generating new procedures and ideas in the areas, *inter alia,* of SST algorithms; product validation, CDR assessment and satellite (inter)calibration. This area will be a focus at the CDR–TAG session at GHRSST–13.

Annex: CDR–TAG Membership as of May 2012

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R20 – REPORT ON THE GLOBAL DATA ASSEMBLY CENTER (GDAC) AND THE DATA ASSEMBLY AND SYSTEMS TECHNICAL ADVISORY GROUP (DAS–TAG)

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ABSTRACT

In 2011–2012 the Global Data Assembly Center (GDAC) at NASA's Physical Oceanography Distributed Active Archive Center (PO.DAAC) continued its role as the primary clearinghouse and access node for operational GHRSST data streams, as well as its collaborative role with the NOAA Long Term Stewardship and Reanalysis Facility (LTSRF) for archiving. In our presentation we will report on our data management activities and infrastructure improvements since the last science team meeting in 2011. These include new web services for data subsetting, visualization, discovery and metadata. Specifically, the GDAC has implemented a new Level 2 sub setter known as HITIDE, a Live Access Server (LAS) for L3/L4 subsetting and visualization, a Google Earth interface to daily global sea surface temperature data, a THREDDS catalog of select GHRSST data collections and a metadata discovery service. We will also report on a recently implemented program set designed to check the validity of the netCDF4 GDS 2.0 data/metadata model for new GHRSST data sets as part of the DAS–TAG report. Finally we will summarize the expanding user and data statistics, and other metrics that we have collected over the last year demonstrating the broad user community and applications that the GHRSST project continues to serve via the GDAC distribution mechanisms.

1. Introduction

The GDAC serves as the key operational component for access and utility of GHRSST data products worldwide. Its primary mission is to ensure timely and transparent access to GHRSST data sets using a number of access protocols including FTP, OPeNDAP, THREDDS and other web services.

In this report the evolution and implementation of key enhancements to the overall GDAC architecture are documented. These are primarily improvements that have been made in the development of tools and services for GHRSST data subsetting, access, and metadata discovery. The PO.DAAC DMAS (data management and archiving system) that was reported on at the last meeting is now fully developed and in a sustaining mode. Final sections focus on GHRSST data usage statistics since 2011 and activities of the DAS–TAG.

2. New GHRSST data sets

Only a limited number of new GHRSST data sets were made available since the last report due primarily to finalization of the GDS v2r4 documentation and related activities (see DAS–TAG section). The new data sets were:

- GOES–15 L2P
- WinSat L2P_GRIDDED

3. Tools and Services

3.1 HITIDE

The HIgh–level Tool for Interactive Data Extraction (HITIDE) is a web–based interface facilitating the search, imaging, and extraction of select Level 2 "swath" data from the GHRSST archive. It currently supports AMSRE and MODIS L2P data sets. The current beta version of the tool is being made

available to the general public for review, and comments are encouraged. See: http://podaac–tools.jpl.nasa.gov/hitide

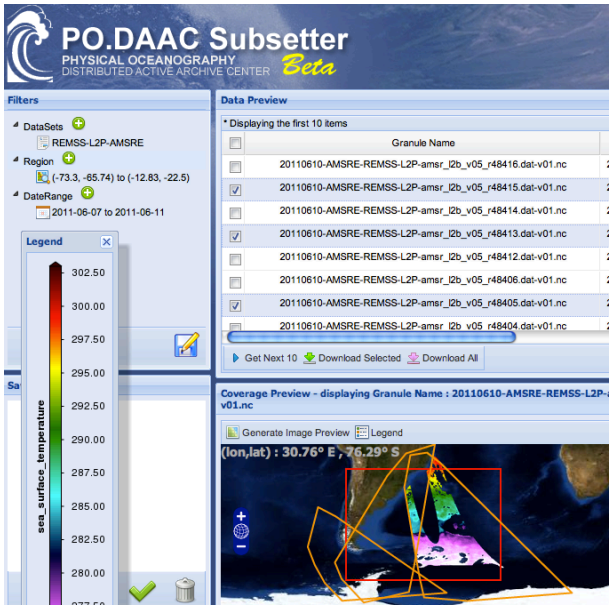

Figure 2: The HITIDE subsetting interface for Level 2 data showing a region of interest and some AMSR–E granules that met the search criteria.

3.2 SOTO

A Google Earth–based interface called State Of The Ocean (SOTO) has been implemented as a core visualization tool for the physical disciplines supported by the PO.DAAC including sea surface temperature. As shown in Figure 2, a user can globally visualize SST fields from the previous five days using GHRSST MODIS L2P, WindSat L2P, or G1SST L4, or some combination thereof including SST anomaly data. Other parameters including wind, SSH, ocean chlorophyll and ocean currents are also available. No specialized software other than a web browser and the Google Earth plug–in is required to run this system. SOTO can be accessed from: http://podaac–tools.jpl.nasa.gov/soto/

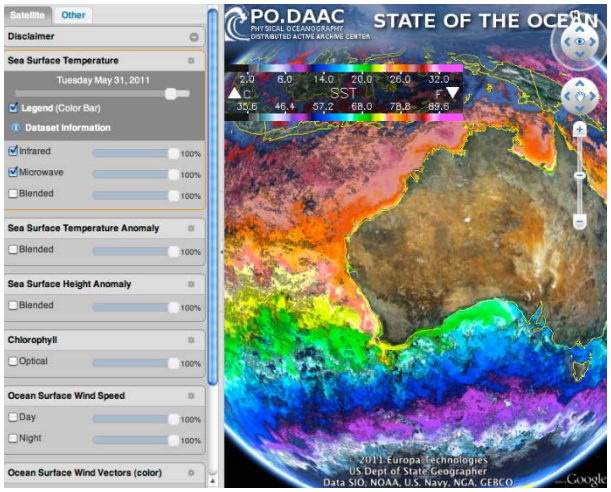

Figure 2: The SOTO Google Earth interface for GHRSST SST (and others).

3.3 THREDDS

The Unidata THREDDS (**Thematic Real–time Environmental Distributed Data Services**) Data Server is a web server that provides metadata and data access for scientific data sets, using OPenDAP, OGC WMS and WCS, HTTP, and other remote data access protocols. The PO.DAAC THREDDS Data Server (TDS) serves the contents of selected GHRSST data sets including Level 4 MUR, G1SST and AVHRR_OI, and AMSRE L2P_GRIDDED (L3). THREDDS provides a web catalog service that allows users to select data (granules) from a hierarchal tree that mirrors the PO.DAAC FTP site or predefined yearly virtual data sets (data aggregated by time) for subsetting or viewing through the provided data access service. More GHRSST data sets will be added in the future. See: http://podaac.jpl.nasa.gov/podaac_thredds

3.4 LAS

The Live Access Server (LAS) is a highly configurable web server designed to provide flexible access to gridded geo–referenced scientific data. It enables a user to: visualize data with on–the–fly graphics; request custom subsets of variables in a choice of file formats; access background reference material about the data (metadata); and compare (difference) variables from distributed locations. It is currently implemented for the GHRSST L4 AVHRR_OI data set while other L4 and L3 data sets will be added in the near future.

See: http://thredds.jpl.nasa.gov/las/getUI.do

3.5 User Forum

The GHRSST specific user forum established in 2011 (http://podaac.jpl.nasa.gov/forum/forum/32) continues to be available for collaborations among science team members, technical advisory groups and users.

4. Metadata and Discovery

The PO.DAAC has implemented the operational version of the Oceanographic Common Search Interface (OCSI) that was reported on at the last science team meeting. OCSI is a fast data discovery RESTful web service allowing user specified custom queries to return metadata at both the data set and granule level. It currently searches and delivers metadata on all data holdings within GHRSST and supports the ISO–19115–2 metadata specification from the version 2 GDS (Fig. 3). It also supports OpenSearch, GCMD, and FGDC output, with other metadata standards still being added. A typical use case could entail using OpenSearch to find a specific data set shortname (e.g., OSDPD–L2P–MSG02) and then in turn using the shortname to return an ISO metadata record. An example query using this service can be found in Figure 4.

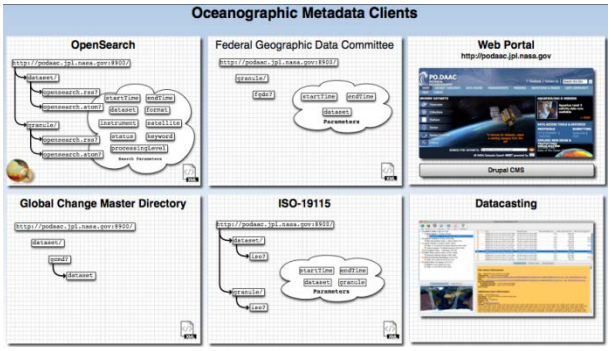

Figure 3: The web services of the Oceanographic Common Search Interface (OCSI) that interact with the PO.DAAC data set inventory.

To retrieve the ISO 19115 record for data set with shortname "OSDPD-L2P-MSG02":

```
% curl -X GET
"http://podaac.jpl.nasa.gov:8890/ws/metadata/data
set?format=iso&shortName=OSDPD-L2P-MSG02"
```

From the perspective of GHRSST data set metadata, the PO.DAAC completed a major metadata quality improvement project at the end of summer 2011. This effort focused on improving the accuracy, consistency and completeness of metadata data set descriptions and other attributes for all 61 GHRSST data sets.

The PO.DAAC continues to be active in providing GHRSST metadata to the NASA's Earth Observing System Clearinghouse (ECHO), a metadata search interface to all NASA earth science data holdings at the granule level. These data sets and granules are available for search through the ECHO Reverb interface.

5. GDAC data metrics

Data distribution metrics were not available at the time of publication. They will be presented at the GDAC oral report at the 13th GHRSST Science Team meeting.

6. DAS–TAG

The Data Assembly and Systems Technical Advisory Group (DAS–TAG) was active in conducting a small post–GHRSST–12 mini review to resolve some final changes in the GDS version2 specification for granule metadata. The GDSv2r4 was formally finalized on 6 Nov 2011, although other minor details and discrepancies were recently discovered that will be dealt with at the upcoming meeting.

A python–based GDSv2 netCDF4 format checker was developed and released to the GHRSST community. This program was designed as a software authentication tool to validate the data and metadata structure of any GHRSST granule to ensure consistency across all data sets built to the GDS2 specification.

7. Conclusion

The Global Data Assembly Center continues to meet its requirements to distribute increasing numbers of GHRSST data sets and volumes, foster data discovery, maintain meaningful metadata records, implement robust data stewardship practices, and provide data utilization tools and web services. GHRSST datastreams can now leverage off a large array of new subsetting, visualization, data discovery, and metadata services supporting the concept that leading edge research is fostered with a strong foundation of sound data management principles and infrastructure. The GDAC is committed to maintaining GHRSST data for all users in conjunction with the NOAA Longterm Stewardship and Reanalysis Facility well into the future.

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R21 – REPORT FOR THE GHRSST LONG TERM STEWARDSHIP AND REANALYSIS FACILITY (LTSRF)

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EXECUTIVE SUMMARY

The Group for High Resolution Sea Surface Temperature (GHRSST) Long Term Stewardship and Reanalysis Facility (LTSRF) has made numerous achievements since the 12th Science Team meeting in Edinburgh, Scotland, in June of 2011. Since that meeting, Chairmanship of the Reanalysis Technical Advisory Group (RAN–TAG) has passed to Chris Merchant and the group has been renamed as the Climate Data Record TAG, and so no longer will be reported on by NODC. This report will now focus only on LTSRF activities. First, automated archive operations at the GHRSST at NOAA's National Oceanographic Data Center (NODC) have been successfully maintained, with archive volumes growing from 34 terabytes in May of 2011 to over 46 terabytes in May of 2012. The number of GHRSST netCDF files jumped from approximately 1,650,000 to 2,154,000, and the number of archival information packages (data from one sensor or analysis system for one day) increased from about 67,000 to 82,000. On a daily basis, the rate of files ingested to the LTSRF varied much more than in past years, varying from as little as 400/day to over 1200/day. The data volumes also varied widely, from around 12 GB/day to over 35 GB/day. The NODC Live Access Server (LAS) has been updated and currently serves 13 aggregated GHRSST L4 products. All GHRSST products have also been added to NODC's Geoportal Server, which improves discovery and access to the GHRSST data.

The SST intercomparison facility at the LTSRF, built in association with the Global Climate Observing System (GCOS) SST and Sea Ice Working Group, continues to operate and one new common–input analysis was added to the system. In addition, all three of the common–input analysis products (for both of the pilot study's analysis periods) were reformatted to the GHRSST–compatible GCOS data cube structure and added to the NODC LAS.

Since the last meeting, the LTSRF team at NODC has released Version 5.2 of the AVHRR Pathfinder L3C dataset, in a nearly 100%–compliant GDS2 format. NODC has also been an active leader in the international SST community, and with ESA has established the new CEOS SST Virtual Constellation, which provides GHRSST with a direct link to the principals of the space agencies that operate the world's SST–capable platforms and sensors.

User accesses continued to be monitored as they have every year since LTSRF operations began in 2006: calendar year 2012 is on pace to see a 284% increase in terms of numbers of files served, and a 112% increase in the number of users compared to calendar year 2011. Data volumes being served are on pace to decrease substantially this year, likely due to a substantial increase in the use of OPeNDAP and its subsetting capabilities to access the data. Details and additional information on all of these accomplishments are provided in this report.

1. INTRODUCTION

1.1 Background

Since the inception of the GODAE High Resolution Sea Surface Temperature (SST) Pilot Project (GHRSST–PP), the GHRSST–PP Science Team worked to ensure that all products created through the international collaboration were archived and made freely accessible to all. The result of this focus

was a Regional/Global Task Sharing (R/GTS) framework, consisting of Regional Data Assembly Centers (RDACs) that produe data and send it to a Global Data Assembly Center (GDAC), which serves the data for 30 days before sending it to a Long Term Stewardship and Reanalysis Facility (LTSRF). The US National Oceanographic Data Center (NODC) serves as the LTSRF within the R/GTS, with the first products being archived and served in 2006.

In 2008 the GHRSST–PP evolved into the Group for High Resolution SST (GHRSST) program, taking on the new name as the overall GODAE project came to a close. NODC continues to serve as the LTSRF under GHRSST, and archive operations have been successfully performed to this day. Since the 12th GHRSST Science Team meeting in June of 2011, Chairmanship of the Reanalysis Technical Advisory Group (RAN–TAG) has passed to Chris Merchant from Kenneth Casey of NODC, so this report will now focus solely on the activities of the LTSRF.

1.2 Period of Report and Document Organization

This document describes the current status of the GHRSST LTSRF with a focus on its activities since the 12th GHRSST Science Team meeting, held in Edinburgh, Scotland in June, 2011. The year since that meeting has been a productive one for both GHRSST and the LTSRF. The remainder of this document covers four key areas of activity:

- GHRSST Long Term Stewardship and Reanalysis Facility (LTSRF) archive operations
- GHRSST/Global Climate Observing System (GCOS) intercomparison facility
- Active Archive Efforts at the NODC LTSRF
- Climate Data Record Developments at NODC

A summary and look forward, plus three appendices close off the report with listings of LTSRF Operational Messages (Annex 1), LTSRF News Messages (Annex 2), and LTSRF Automated Status Messages (Annex 3).

2. OPERATIONS OF THE LONG TERM STEWARDSHIP AND REANALYSIS FACILITY

2.1 Operational Reliability

The LTSRF (http://ghrsst.nodc.noaa.gov) at NOAA's National Oceanographic Data Center (NODC) has successfully continued operations over the last year. Automatic data archiving and access to existing archived data was maintained, with only brief periods of unavailability throughout the year. Annex 1 lists all LTSRF Operational Messages between June of 2011 and May of 2012. While it was not posted to the LTSRF Operational Messages feed, the LTSRF did experiene one extended outage due to a building–wide electrical issue, lasting approximately 36 hours from 22–23 March, 2012. NODC's failover systems picked up the GHRSST data streams, and no files were lost. Public access to the GHRSST archive was re–established the afternoon of 23 March 2012.

2.2 Operational Data Streams

The LTSRF is currently acquiring, or has acquired, on a daily basis from the GDAC a total of 54 GHRSST L2P, L2P_GRIDDED, "L3P" (a non–standard hybrid format briefly in use during the GDS2 development process), and L4 products. These products are listed in Table 1 below.

In addition, an archive process is being established for a new RDAC from the Rutherford Appleton Lab (RAL), which provided a series of L2P data for the ATSR–1, ATSR–2, and AATSR sensors on LTO tapes. These tapes include roughly a Terabyte of data. Progress on archiving these data through a specialized process has recently be renewed, following a change of staff at the LTSRF. Since this (A)ATSR series is not yet archived, it does not appear in the table below.

GHRSST Products in the LTSRF

RDAC	Product	Product Level	Start Date (YYYYMMDD)	Stop Date (YYYYMMDD)	GDS Version	Grid / Pixel Size	Metadata	Access
ABOM	GAMSSA_28km	L4	20080824	ongoing	1.6	28 km	xml html	TDS OPeNDAP FTP HTTP
	RAMSSA_09km	L4	20080401	ongoing	1.6	9 km	xml html	TDS OPeNDAP FTP HTTP
DMI	DMI_OI	L4	20070604	ongoing	1.6	3 km	xml html	TDS OPeNDAP FTP HTTP
EUR	AMSRE	L2P	20050131	20070226	1.6	25 km	xml html	TDS OPeNDAP FTP HTTP
	ATS_NR_2P	L2P	20050315	20090929	1.6	1 km	xml html	TDS OPeNDAP FTP HTTP
	AVHRR16_G	L2P	20050131	20060814	1.6	8.8 km	xml html	TDS OPeNDAP FTP HTTP
	AVHRR16_L	L2P	20050201	20051026	1.6	2.2 km	xml html	TDS OPeNDAP FTP HTTP
	AVHRR17_G	L2P	20050131	20070226	1.6	8.8 km	xml html	TDS OPeNDAP FTP HTTP

	AVHRR17_L	L2P	20050131	20070226	1.6	2.2 km	xml html	TDS OPeNDAP FTP HTTP
	NAR16_SST	L2P	20050131	20051122	1.6	2 km	xml html	TDS OPeNDAP FTP HTTP
	NAR17_SST	L2P	20050131	20100322	1.6	2 km	xml html	TDS OPeNDAP FTP HTTP
	NAR18_SST	L2P	20051124	ongoing	1.6	2 km	xml html	TDS OPeNDAP FTP HTTP
	SEVIRI_SST	L2P	20050131	ongoing	1.6	0.1 deg	xml html	TDS OPeNDAP FTP HTTP
	TMI	L2P	20050131	20070227	1.6	25 km	xml html	TDS OPeNDAP FTP HTTP
	AVHRR_NOAA_19	L3P	20091210	ongoing	1.7	2 km	xml html	TDS OPeNDAP FTP HTTP
	AVHRR_NOAA_METOP_A	L3P	20090901	ongoing	1.7	0.05 deg	xml html	TDS OPeNDAP FTP HTTP
	ODYSSEA GAL	L4	20080123	20081215	1.6	2 km	xml html	TDS OPeNDAP FTP HTTP
	ODYSSEA GLOB	L4	20071001	20091207	1.6	6 km	xml html	TDS OPeNDAP FTP HTTP
	ODYSSEA MED	L4	20050426	20100103	1.6	2 km	xml html	TDS OPeNDAP FTP HTTP

	ODYSSEA NWE	L4	20080123	20100103	1.6	2 km	xml html	TDS OPeNDAP FTP HTTP
JPL	MODIS_A	L2P	20060630	ongoing	1.6	1 km	xml html	TDS OPeNDAP FTP HTTP
	MODIS_T	L2P	20061001	ongoing	1.6	1 km	xml html	TDS OPeNDAP FTP HTTP
	MUR	L4	20030618	ongoing	1.7	0.011 deg	xml html	TDS OPeNDAP FTP HTTP
	RTO_SST_Ad	L4	20101230	ongoing	1.7	1 km	xml html	TDS OPeNDAP FTP HTTP
	RTO_SST_An	L4	20101230	ongoing	1.7	1 km	xml html	TDS OPeNDAP FTP HTTP
	RTO_SST_Td	L4	20101230	ongoing	1.7	1 km	xml html	TDS OPeNDAP FTP HTTP
	RTO_SST_Tn	L4	20101230	ongoing	1.7	1 km	xml html	TDS OPeNDAP FTP HTTP
JPL_OUROCEAN	G1SST	L4	20100609	ongoing	1.7	1 km	xml html	TDS OPeNDAP FTP HTTP
NAVO	AVHRR17_G	L2P	20060621	20090706	1.6	8.8 km	xml html	TDS OPeNDAP FTP HTTP
	AVHRR17_L	L2P	20060621	20080916	1.6	2.2 km	xml html	TDS OPeNDAP FTP HTTP

	AVHRR18_G	L2P	20060125	ongoing	1.6	8.8 km	xml html	TDS OPeNDAP FTP HTTP
	AVHRR18_L	L2P	20060125	20090909	1.6	2.2 km	xml html	TDS OPeNDAP FTP HTTP
	AVHRRMTA_G	L2P	20070926	ongoing	1.6	9 km	xml html	TDS OPeNDAP FTP HTTP
	K10_SST	L4	20080401	ongoing	1.6	10 km	xml html	TDS OPeNDAP FTP HTTP
	AVHRR19_G	L2P	20091005	ongoing	1.7	9 km	xml html	TDS OPeNDAP FTP HTTP
	AVHRR19_L	L2P	20091005	ongoing	1.7	2.2 km	xml html	TDS OPeNDAP FTP HTTP
NCDC	AVHRR_AMSR_OI	L4	20020601	20110903	1.6	0.25 deg	xml html	TDS OPeNDAP FTP HTTP
	AVHRR_OI	L4	19810901	ongoing	1.6	0.25 deg	xml html	TDS OPeNDAP FTP HTTP
NEODAAS	AVHRR17_L	L2P	20080902	20100722	1.6	1.1 km	xml html	TDS OPeNDAP FTP HTTP
	AVHRR18_L	L2P	20080726	20090818	1.6	1.1 km	xml html	TDS OPeNDAP FTP HTTP
	AVHRR19_L	L2P	20091003	ongoing	1.6	1.1 km	xml html	TDS OPeNDAP FTP HTTP

OSDPD	GOES11	L2P	20061222	20111206	1.6	6 km	xml html	TDS OPeNDAP FTP HTTP
	GOES12	L2P	20061222	20100414	1.6	6 km	xml html	TDS OPeNDAP FTP HTTP
	GOES13	L2P	20100621	ongoing	1.7	2.5 x 4 km	xml html	TDS OPeNDAP FTP HTTP
	MSG02	L2P	20091122	ongoing	1.7	3 km	xml html	TDS OPeNDAP FTP HTTP
	MTSAT1R	L2P	20091122	20101222	1.7	4 km	xml html	TDS OPeNDAP FTP HTTP
	MTSAT_2	L2P	20110928	ongoing	1.7	4 km	xml html	TDS OPeNDAP FTP HTTP
REMSS	AMSRE	L2P	20020601	20111005	1.6	25 km	xml html	TDS OPeNDAP FTP HTTP
	TMI	L2P	19980101	ongoing	1.6	25 km	xml html	TDS OPeNDAP FTP HTTP
	AMSRE	L2P_GRIDDED	20020601	20110806	1.6	25 km	xml html	TDS OPeNDAP FTP HTTP
	TMI	L2P_GRIDDED	19980101	ongoing	1.6	25 km	xml html	TDS OPeNDAP FTP HTTP
	mw_ir_OI	L4	20050821	ongoing	1.6	9 km	xml html	TDS OPeNDAP FTP HTTP

UKMO	OSTIA	L4	20060401	ongoing	1.6	6 km	xml html	TDS OPeNDAP FTP HTTP
UPA	ATS_NR_2P	L2P	20090324	ongoing	1.6	1 km	xml html	TDS OPeNDAP FTP HTTP

Table 1: Summary of GHRSST data products in the NODC LTSRF. The ODYSSEA data sets indicated by an asterisk (*) remain in the archive but their ongoing production remains on hold. The European RDAC (EUR) expected this stoppage to last only a few months but it has continued for more than a year.

RDAC Codes and Acknowledgements	
ABOM	Australian Bureau of Meteorology, Australia
DMI	Danish Meteorological Institute, Denmark
EUR	Medspiration Project, Europe
JPL	NASA Jet Propulsion Laboratory, Ocean Biology Processing Group and University of Miami, USA
JPL_OUROCEAN	NASA Jet Propulsion Laboratory, The OurOcean Team
NAVO	Naval Oceanographic Office, USA
NCDC	NOAA National Climatic Data Center, USA
NEODAAS	NERC Earth Observation Data Acquisition and Analysis Service, United Kingdom
OSDPD	NOAA Office of Satellite Data Processing and Distribution, USA
REMSS	Remote Sensing Systems, Inc., USA
UKMO	UK Meteorological Office, United Kingdom
UPA	UK Multi–Mission Product Archive Facility, United Kingdom

Table 2: RDAC codes and acknowledgements.

2.3 Archive Metrics

Together, these L2P, L2P_GRIDDED, L3, and L4 files occupy over 46 terabytes (compressed, estimated 92 terabytes uncompressed) of disk space, and consist of approximately 2,154,000 netCDF data files, an increase from 34 terabytes and 1,650,000 files at the time of last year's report. Current temporal coverage varies for each product line, with the earliest dataset available back to 1981 (though the majority do not begin until 2005–2007).

The following four figures illustrate the growth of the LTSRF archive. Figures 1 and 2 show the daily rates of GHRSST data in terms of volumes and numbers of netCDF files, respectively. Figures 3 and 4 show the cumulative growth of the archive in terms of volumes and numbers of netCDF files,

respectively. These graphics are generated automatically each day and posted to the LTSRF web site. On a daily basis, the rate of files ingested to the LTSRF varied much more than in past years, varying from as little as 400/day to over 1200/day. The data volumes also varied widely, from around 12 GB/day to over 35 GB/day.

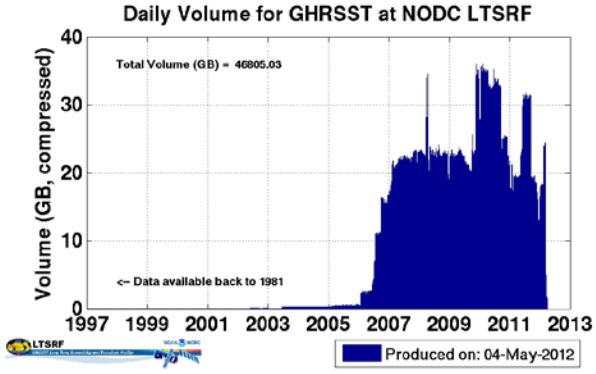


Figure 1: Volume in gigabytes arriving in the LTSRF each day.

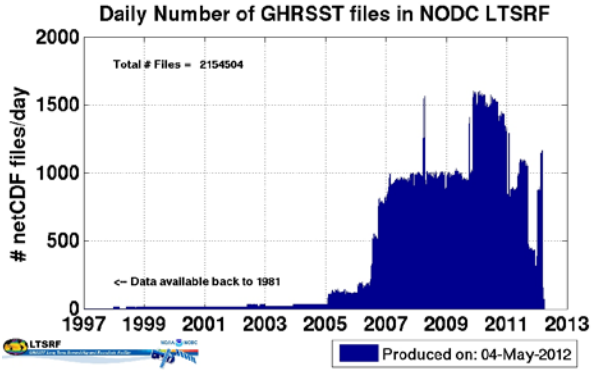


Figure 2: Number of netCDF files arriving in the LTSRF each day.

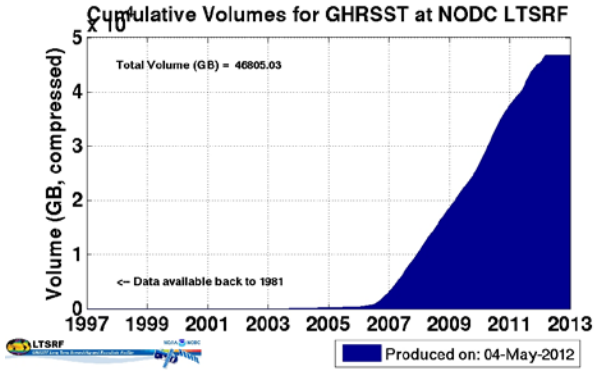


Figure 3: Cumulative volume in gigabytes in the LTSRF.

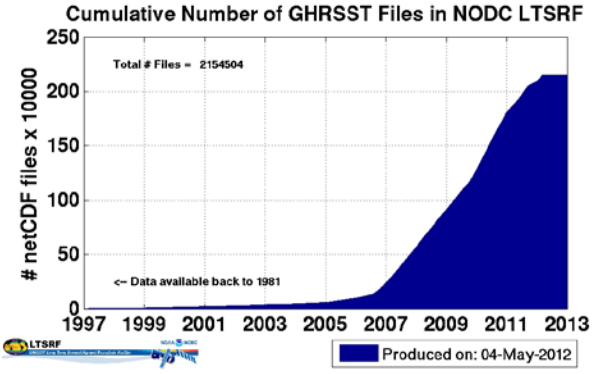


Figure 4: Cumulative number of netCDF files in the LTSRF.

The data are grouped in the archive system in Archival Information Packages (AIPs, also known as NODC "accessions"), or logical groupings of data. For GHRSST, an AIP is defined as the data from a single sensor (or analysis system and region), from a given RDAC, for a particular date. For example, all of the approximately 288 netCDF data files (and corresponding metadata files) from MODIS Aqua, produced by the JPL RDAC for 01 January 2007 are grouped into a single NODC accession. As of 15 June 2010, there were 59,982 GHRSST AIPs in the formal NODC archive systems. As of 09 June 2011, there were 67,511. As of 04 May 2012, there were 82,260. The growth of the number of AIPs in the GHRSST archive is shown below in Figure 5. Like the previous four figures, this graphic is also updated automatically daily and posted to the LTSRF web site.

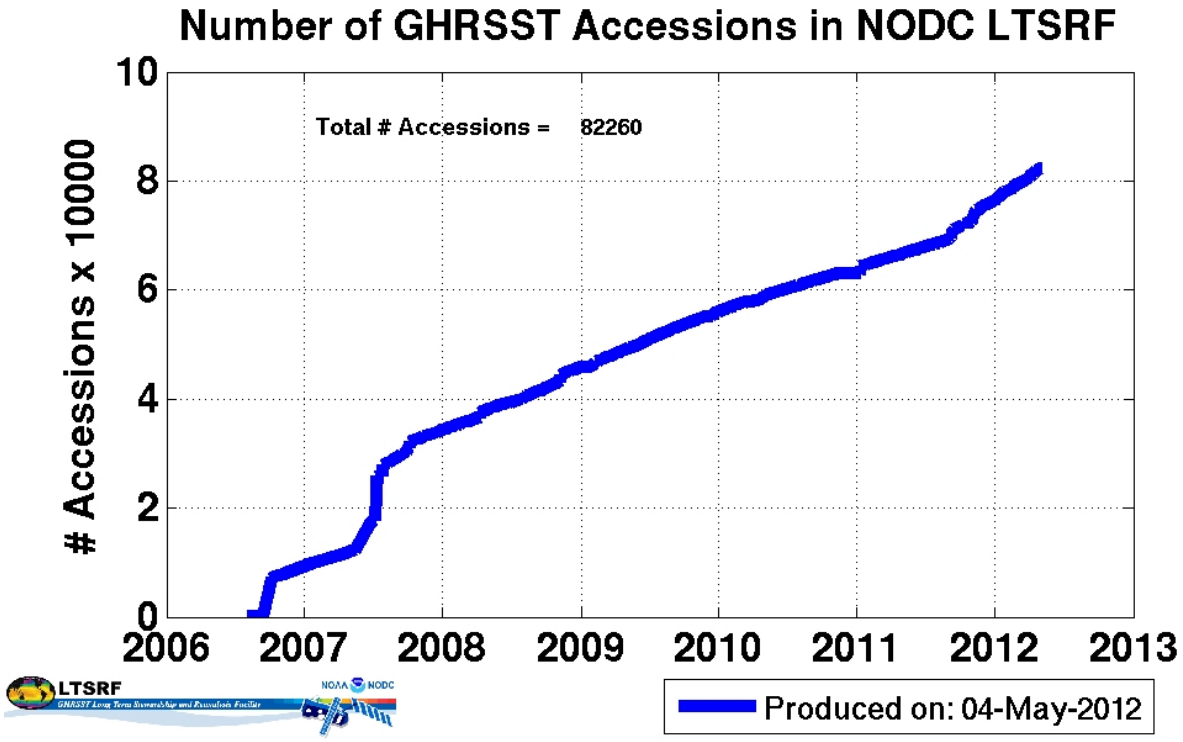


Figure 5: Growth in the number of accessions, or Archival Information Packages, in the LTSRF.

2.4 Operational Reporting

In addition to the automated graphics that are generated and posted to the LTSRF site on a daily basis, the LTSRF also maintains 3 Really Simple Syndication (RSS) feeds. The first feed is manually updated as necessary, providing LTSRF Operational Messages (http://ghrsst.nodc.noaa.gov/LTSRF_OpMessages.xml) as demonstrated in Annex 1. The second syndication is a news feed for noteworthy items of interest to users of the LTSRF (http://ghrsst.nodc.noaa.gov/ghrsst_news_rss.xml). This feed is updated manually as needed, and Annex 2 lists the news items posted since the 12th Science Team meeting. The third feed conforms to the GHRSST draft specification on automated status reporting. This syndication provides automatically generated messages on a daily basis, which assess the current state of the LTSRF–GDAC connection based on the number of AIPs generated each day (http://ghrsst.nodc.noaa.gov/LTSRF_OpStatus.xml). Annex 3 displays a recent set of these automated messages.

2.5 Archive Access Metrics

The number of users, files served, and data volumes served continue to be monitored. Figure 6 (a, b, and c) summarizes the statistics since logs have been recorded at the LTSRF in June 2006.

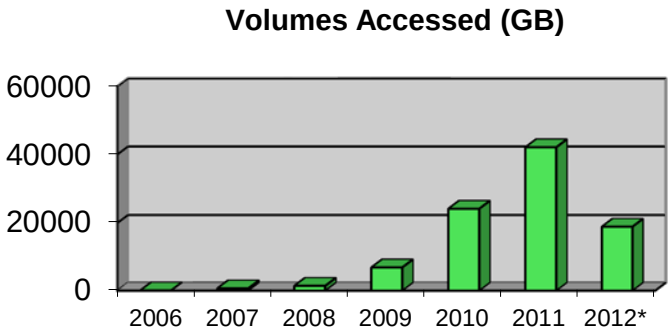


Figure 6a: Volumes of GHRSST data accessed at the NODC LTSRF (in gigabytes). 2012 numbers are projected based on Jan–April numbers.

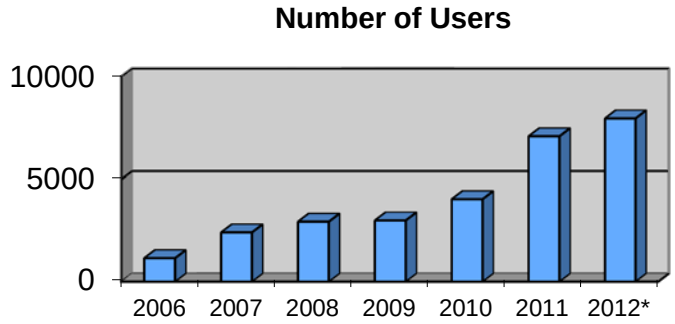


Figure 6b: Number of users of GHRSST data at the NODC LTSRF (based on unique IP addresses). 2012 numbers are projected based on Jan–April numbers.

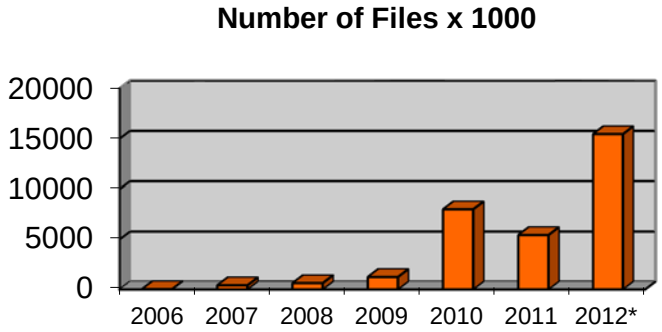


***Figure 6c:** Number of GHRSST data files accessed at the NODC LTSRF. 2012 numbers are projected based on Jan–April numbers.*

The general trend toward increasing number of netCDF files being accessed from the LTSRF continued. In 2006, 85 files were transferred per day on average over FTP, HTTP, and OPeNDAP services. That number grew to 1130 per day in 2007, 1734 in 2008, and 3413 in 2009. For 2010, 21,956 files per day were transferred with a huge spike in number of files being accessed via

OPeNDAP. In 2011 the files/day rate fell to 14,896 but for 2012 is projected (based on Jan–Apr numbers) to jump to 42,332 files/day.

The volume rates fluctuated when compared to past years, going from 0.2 GB/day in 2006 to 1.8 GB/day in 2007, 3.9 GB/day in 2008, and 19 GB/day in 2009. For 2010, 66 GB/day were transferred and for 2011, 115 GB/day were accessed. In 2012, the volumes transferred are projected (based on Jan–Apr numbers) to fall to 52 GB/day. This potential decrease in data volumes served in 2012 is likely due to a dramatic rise in the number of files being served via OPeNDAP. With the OPeNDAP services, users can subset and download only the portion of a file that is of interest to them, thus resulting in a large reduction in the data volume served. With FTP services, the entire file must be downloaded.

2.6 Adjudication of Anomalous Data Packages

The NODC LTSRF has received over the course of the years of GHRSST operation a fairly large number of data packages that did not exactly meet the documented processes and specifications. A major effort begun last year to rectify the lingering issues with these anomalous collections of GHRSST data acquired from the GDAC was continued this year. These anomalies can generally be placed into three categories: (1) data files received with incorrect or ambiguous associated metadata; (2) data files received for a previously–received archive information package for which there is no clear indication of whether they should replace the previous package, be added to it, replace only some portion of the existing package, or some combination of these; and (3) data files received that used the GDS 1 file name convention incorrectly, typically using the GDS version portion of the file name inappropriately as a file version.

This ongoing effort involves extensive collaboration with the GDAC and individual RDACs. The process resulted in enhancements to the LTSRF procedures to account for these anomalous data packages. Between October of 2011 and May of 2012, 583 of 816 Archival Information Packages had been adjudicated and processed into the archive (100 GB of 630 GB), marking good progress toward resolving the overall anomalous data package problem. However, at the time of writing of this report, a large amount of new and revised data packages are being received from the GDAC which appear to have problems and may need special handling. These packages are missing FGDC control files or have multiple control files and will require extra effort to archive. More detail on these emerging issues will be provided in next year's report.

3. Updates to the GHRSST/GCOS SST Intercomparison Facility

In 2008, in conjunction with the Global Climate Observing System (GCOS) SST/Sea Ice Working Group, the LTSRF established an intercomparison facility for different L4 SST analysis products and historical SST reconstruction datasets. Data cubes, intercomparison diagnostics, and browse graphics are available for all of these datasets in standard formats, including GDS–compliant netCDF. A complete list of products currently included in the intercomparison framework appears in Table 1 below. Satellite era products are available on a one–degree weekly basis, while historical area data sets are available on monthly, five–degree grids. These data sets are also available through NODC's LAS. Figure 7 shows an example of a user–generated Hovmoller diagram from the LAS, showing the 1983 and 1987 El Niño events.

Table 3: GHRSST/GCOS SST Intercomparison Products available at the intercomparison site.

Data Set Name	Satellite Era (1981 – 2007)	Historical Era (1850 – 2008)	In LAS
AVHRR Pathfinder Version 5	**X**		**Y**
Operational AVHRR	**X**		**Y**
NOAA Optimum Interpolation (OI) Version 2	**X**		**Y**
NOAA Daily ¼–degree OI Version 1	**X**		**Y**
Hadley Centre SST V2	**X**	**X**	**Y**
Hadley Centre Sea Ice and SST (HadISST) V1	**X**	**X**	**Y**
NOAA Extended Reconstruction Version 3	**X**	**X**	**Y**
Kaplan Reconstructed	**X**	**X**	**Y**
International COADS Version 2.4		**X**	**Y**
COBE Analysis		**X**	**Y**

Since its implementation, several additions and improvements have been made to the facility, which is available at http://ghrsst.nodc.noaa.gov/intercomp.html. This year, another analysis product was received as part of a GCOS experiment testing several reanalysis systems using a common input data set, and the available data sets were reformatted to the GHRSST compatible data cubes and added to the NODC Live Access Server (LAS) (Table 4).

Table 4: Summary status on the progress of the GCOS common–input reanalysis experiment.

Common–Input Reanalysis Product	Received	Reformatted	Metrics Computed	In LAS
Hadley Centre Sea Ice and SST (HadISST)	N	N	N	N
Kaplan Reconstructed	**Y**	**Y**	N	**Y**
National Oceanography Centre Reanalysis	N	N	N	N
COBE Analysis	**Y**	**Y**	N	**Y**
NOAA Extended Reconstruction SST	**Y**	**Y**	N	**Y**

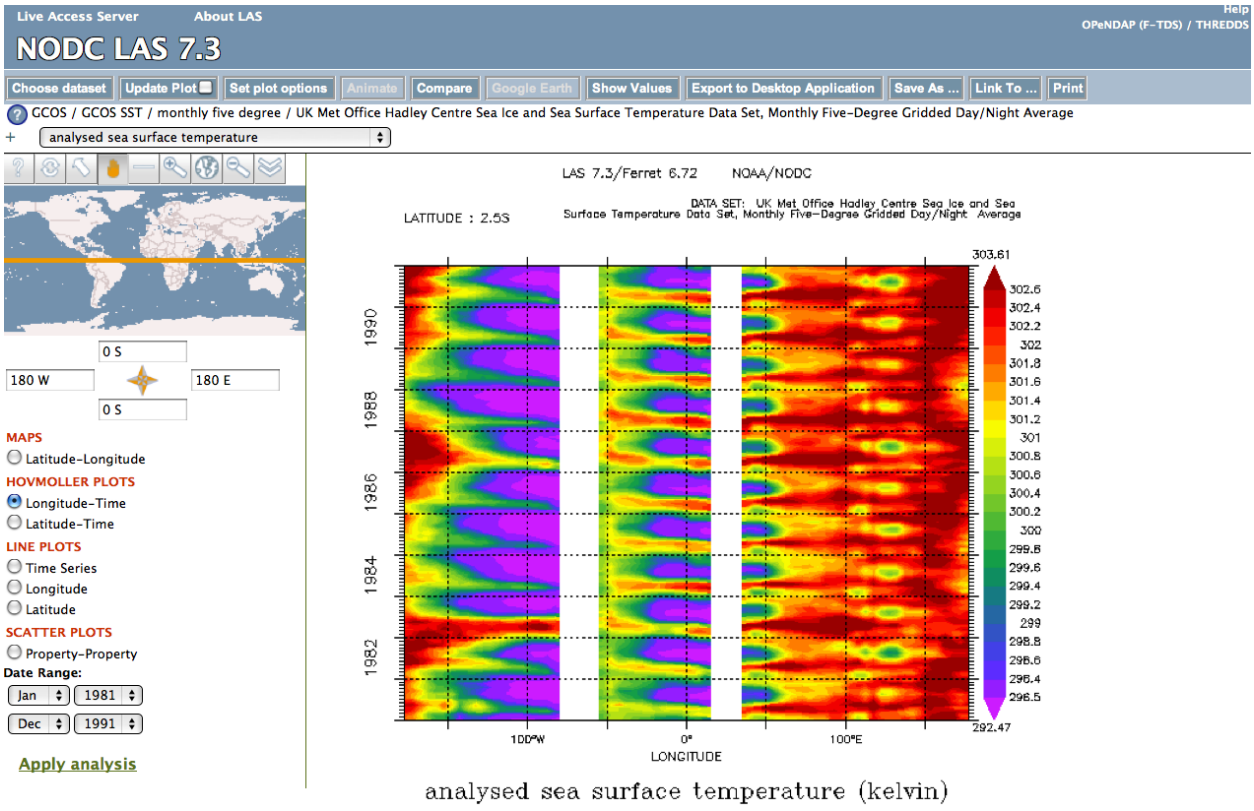


Figure 7: Example Hovmoller plot across the equator for 1981–1991, generated using the NODC LAS for the UKMO Hadley Centre Sea Ice and Sea Surface Temperature product. The 1983 and 1987 El Nino periods are evident.

4. Active Archive Efforts at NODC LTSRF

Active archive efforts that commenced in 2008 continued this year, with annual reviews of GHRSST version 1 product metadata and feedback provided to RDACs on inconsistencies and issues with their products. With the final approval of the new GHRSST Data Specification Version 2 (GDS2) in the fall of 2010, NODC staff are also actively working to prepare ISO 19115–2 metadata for all GHRSST products.

Browse graphic images continue to be created, but need to be added for several of the newest GHRSST products entering the LTSRF and work remains to include them in the actual archive packages. The process of generating a browse graphic forces the LTSRF archive to confirm and verify the contents of every package of data arriving into the archive. Currently, a PNG browse graphic is automatically generated for every L2P, L2P_GRIDDED and L4 data file arriving at the LTSRF. An accompanying KML wrapper is also generated, which allows the PNG graphic to be viewable in Google Earth. An example for the L2P AMSR–E product from Remote Sensing Systems is shown below in Figure 8.

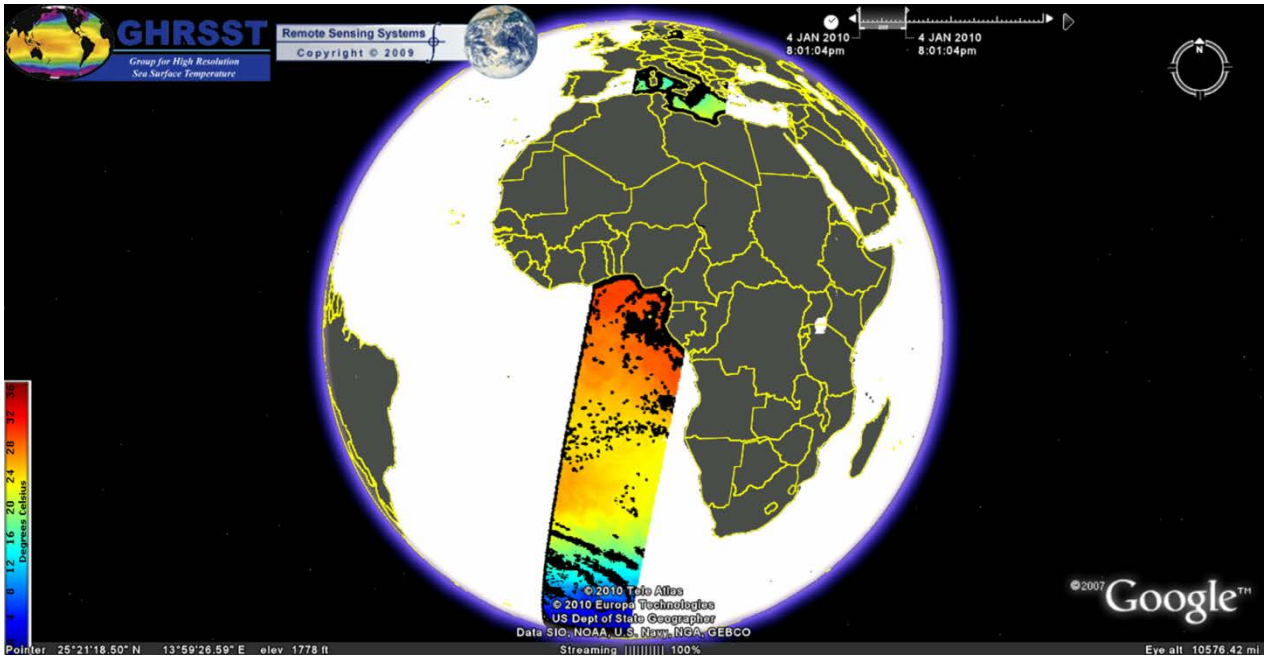


Figure 8: Example L2P REMSS AMSR–E browse graphic in Google Earth browser.

In addition to quality assurance, browse graphics increase the discoverability of GHRSST data holdings at the LTSRF. Users can quickly see the differences in spatiotemporal coverage and resolution among the various GHRSST products, helping them to choose which product is the best for their particular application. Increasing the discoverability of and access to GHRSST data continues to be a major focus of the NODC LTSRF. In addition to HTTP and FTP, GHRSST data continue to be made available online from the LTSRF using the Data Access Protocol (DAP) via OPeNDAP's Hyrax server, and through the DAP, Web Coverage Service (WCS), and Web Mapping Service (WMS) via Unidata's THREDDS Data Server (TDS). Virtual aggregations making the gridded GHRSST products appear as single, 3–dimensional "cubes" of data in space and time instead of a discrete collection of 2–dimensional slices were made available through the NODC LAS this year (http://data.nodc.noaa.gov/las). The collection–level metadata records generated by NODC for each GHRSST product are accessible via Google searches and are also published to Geospatial One Stop (http://www.geodata.gov) and Data.gov (http://data.gov).

The biggest step forward in discoverability of GHRSST data in the past year has been the inclusion of all GHRSST products in NODC's new Geoportal Server, which provides both human– and machine–based discovery interfaces. See http://data.nodc.noaa.gov/geoportal for more information. All GHRSST products are in the Geoportal, including an integrated view of all of the data access mechanisms available for each data set, thumbnail graphics, and extensive metadata. Users can also now search for and find GHRSST data directly from any OpenSearch or CS–W client as well, without needing to come to the LTSRF web site.

5. Climate Data Record Developments at NODC

A major step forward for the AVHRR Pathfinder SST effort was made with the public release and archive of the AVHRR Pathfinder Version 5.2 (PFV5.2) dataset in September of 2011 (http://Pathfinder.nodc.noaa.gov), following a public review and comment period in May of 2011. This new version of Pathfinder is available in L3C format is nearly 100% compliant with the GDS 2 specifications (it is missing only the pixel–by–pixel time specification and the SSES bias/standard deviations) and is a signifant stepping stone on the way to the future Pathfinder Version 6, which will

include L2P, L3–uncollated (L3U), and L3–collated (L3C) products generated using a new and improved coefficient scheme. The new PFV5.2 is available for 1981–2010 and work is underway to include 2011–2012 data.

6. Summary and Look Forward

The past year has been a highly active one for the GHRSST LTSRF at the US NODC. The large data management system has been maintained and improved, following on the progress of previous years. Preparations for the receipt of GDS2 data at the LTSRF have been made, and it is anticpated that the new GHRSST standards will further enhance the usability of the GHRSST collection for climate–related applications. Growing numbers of users continue to access more and more GHRSST data every year, and an increase in the use of interopable OPeNDAP access mechanisms is underway. The GHRSST LTSRF archive continiues to improve its level of quality–assurance of the data as it flows into the archive and is working with providing RDACs to remedy problems that are found. The coming year looks even more promising, with longer time series of data being made available to a wider range of users in GHRSST GDS2 format. Improvements to the SST intercomparison facilty for understanding key differences in the available data continue including dyanmic subsetting and analysis through the NODC LAS. Next year, specifying a new Data Production Framework (DPF) for the SST Essential Climate Variable will be a priority for the NODC LTSRF, working with the GHRSST Climate Data Record Technical Advisory Group and the CEOS Virtual Constellation for SST (which Kenneth Casey co–Chairs). Finally, work on making GHRSST products more easily used by the archive user community, both now and in the future, will continue.

Annex 1: Listing of Operational Messages, June 2011 – May 2012

No operational messages were issuesd during this period.

Annex 2: Listing of LTSRF RSS News Messages, June 2011 – May 2012

2011–09–09: NODC Announces the Release of AVHRR Pathfinder Version 5.2 in GDS2 Format!
September 9, 2011 9:00 AM

The NOAA National Oceanographic Data Center (NODC) is pleased to release the AVHRR Pathfinder Version 5.2 (PFV52) sea surface temperature data set. This new version of Pathfinder includes substantial updates to the data format, content, and metadata. While previous versions of Pathfinder, including V5.0 and V5.0, were in HDF–SDS format, the new Version 5.2 is in CF–compliant netCDF–4, conforming to the GHRSST Data Specification Version 2 (GDS2.0). See http://Pathfinder.nodc.noaa.gov for more information.

2011–08–29: GHRSST Newsletter No. 4 for August 2011 available
August 29, 2011 9:00 AM

The fourth monthly GHRSST newsletter is now available through the GHRSST Project Office website at https://www.ghrsst.org/documents/q/category/newsletters/. The newsletter features a summary of the 12th GHRSST Science Team meeting, including announcements of new Science Team members and the new GHRSST Science Team Chair.

2011–06–20: GHRSST Announces New Science Team Chair
June 20, 2011 9:00 AM

Professor Peter Minnett has been elected by the Science Team as the new GHRSST Science Team Chair, taking over from Craig Donlon on 1st July 2011. To read his statement, visit https://www.ghrsst.org/news/q/date/2011/06/20/new–ghrsst–science–team–Chair/.

2011–06–16: Session on CF Standards Extensions for Remote Sensing Data to be held at summer ESIP meeting
June 16, 2011 9:00 AM
A session on "CF Standards Extensions for Remote Sensing Data" will be held at the Summer ESIP Federation Meeting in Santa Fe, NM (tentatively set for 1:30–3:00pm local time, 14 July 2011). The two main topics are: 1) Standard descriptions of spectral bands and 2) Swath/orbital geometry representation. Other topics can also be accommodated. The ESIP Federation includes a wide range of stakeholders involved with remote sensing data. Meeting web site: http://wiki.esipfed.org/index.php/Summer_2011_Meeting. A dial–in number for remote access can also be set up if there is sufficient interest. For more information, contact robert.g.raskin@jpl.nasa.gov.

Annex 3: Recent LTSRF RSS Automated Operational Status Messages

2012–05–03: Ingested 63 new AIPs into NODC LTSRF – Status Green

GHRSST archival status is "Green": 63 out of an expected 29 new Archival Information Packages (AIPs) were added today to the LTSRF archive at NODC. An AIP contains one day of data from one RDAC for one sensor or blended product. An AIP is also known as an NODC "accession". Read more…

2012–05–02: Ingested 0 new AIPs into NODC LTSRF – Status Red

GHRSST archival status is "Red": 0 out of an expected 29 new Archival Information Packages (AIPs) were added today to the LTSRF archive at NODC. An AIP contains one day of data from one RDAC for one sensor or blended product. An AIP is also known as an NODC "accession". Read more…

2012–05–01: Ingested 0 new AIPs into NODC LTSRF – Status Red

GHRSST archival status is "Red": 0 out of an expected 29 new Archival Information Packages (AIPs) were added today to the LTSRF archive at NODC. An AIP contains one day of data from one RDAC for one sensor or blended product. An AIP is also known as an NODC "accession". Read more…

2012–05–01: Ingested 4 updated AIPs into NODC LTSRF

4 Archival Information Packages (AIPs) were updated today at the LTSRF archive at NODC. An AIP contains one day of data from one RDAC for one sensor or blended product. An AIP is also known as an NODC "accession". Read more…

2012–04–30: Ingested 0 new AIPs into NODC LTSRF – Status Red

GHRSST archival status is "Red": 0 out of an expected 29 new Archival Information Packages (AIPs) were added today to the LTSRF archive at NODC. An AIP contains one day of data from one RDAC for one sensor or blended product. An AIP is also known as an NODC "accession". Read more…

2012–04–29: Ingested 78 new AIPs into NODC LTSRF – Status Green

GHRSST archival status is "Green": 78 out of an expected 29 new Archival Information Packages (AIPs) were added today to the LTSRF archive at NODC. An AIP contains one day of data from one RDAC for one sensor or blended product. An AIP is also known as an NODC "accession". Read more…

R22 – REPORT OF THE GHRSST PROJECT OFFICE

Andrea K. Kaiser–Weiss

National Centre for Earth Observation, Dept of Meteorology, The University of Reading, UK,
(now at: Deutscher Wetterdienst, Offenbach, Germany, Email: Andrea.Kaiser-Weiss@dwd.de)

The GHRSST International Project Office (GPO) continued in 2011/2012 coordination and development of GHRSST, according to its Statement of Work (SoW). The tasks of the GPO comprise the support of the GHRSST Science Team, running of the GHRSST web–site, communication internally and externally, and document development like the User Requirement Document (URD), the GHRSST Data Processing Specification (GDS), the GHRSST calibration and validation plan, and the GHRSST ECV Data Processing Framework (DPF), as well as the organisation of the annual GHRSST Science Team meetings.

1. Internal support to GHRSST

The GPO had been active in supporting the GHRSST Science Team, the GHRSST Working Groups (WGs) and Technical Advisory Groups (TAGs) with respect to communication and coordination. The GPO discussed and worked on documents describing the optimal linkage via CEOS–VC SST.

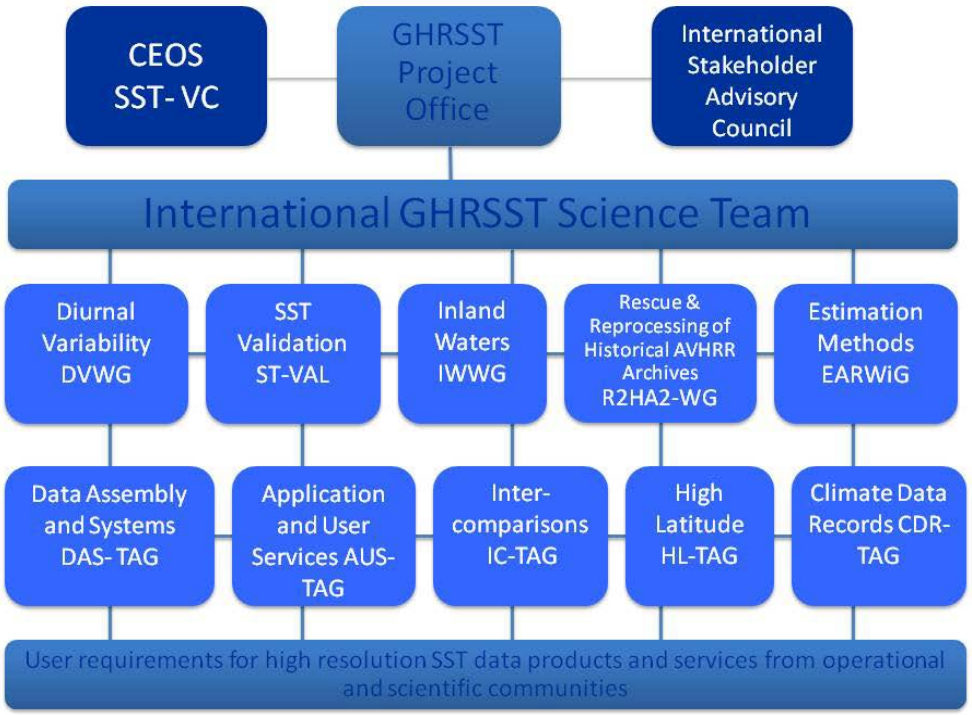


Figure1: Organisation of GHRSS 2012, its Project Office and the linkage to the CEOS SST–VC.

The Science Team – Practical Guidelines have been developed in collaboration with the Science Team Chair and input from the Science Team, and implemented.

2. External Representation

Users: A special focus this year was communication with climate data users. Effort went in an introduction of users to both definitions of SST and guidance to the GHRSST data products. Further, the user needs in connection with salinity data were explored.

International linkage: The GPO participated in the development of the implementation plan of CEOS–VC SST.

GHRSST presentations at conferences: In the last year, Andrea Kaiser–Weiss represented GHRSST at:

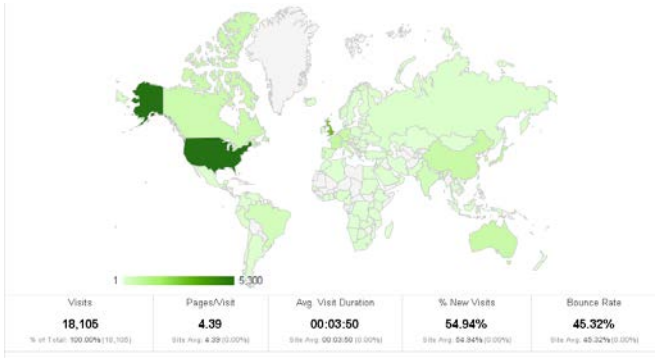
- EUMETSAT Conference, September 2011, Oslo
- GODAE OceanView annual meeting GOVST–III, November 2011, Paris
- ESA–Solas Conference, November 2011, Frascati
- Ocean Science Conference, February 2012, Salt Lake City
- ESA Sentinel–3 Calibration and Validation Planning Meeting, March 2012, Frascati
- 44th Liege Colloquium on Ocean Dynamics, May 2012, Liege

3. Internal support to GHRSST

Communication of the GPO with GHRSST Science Team members are in the order of 1000 emails per quarter. Weekly telecons with the Science Team Chair ensured priorities of the GPO are in accordance with the GHRSST Science Team. The GPO put effort into fulfilling the ESA contact according to the Statement of Work schedule. More than 50 News items and several operational announcements have been sent via the GHRSST mailing list, and 4 Quarterly Newsletters were published.

4. Website

Since the GHRSST XII, continued improvements were done to the web–site with its 280+ sub–pages. Content was updated according to the developments in the Science Team. New developments on user related documents on the website include: A Quick–start**,** the follow–up **"**Multi–pager" (in work) and the SST definition discussion document. New webpages have been created on: GHRSST related projects and Community links. New collection of Strategy documents, including the GHRSST Development and Implementation Plan (GDIP), and the ST Practical Guidelines.



	Country/Territory	Visits	Pages/Visit	Avg. Visit Duration	% New Visits	Bounce Rate
1.	United States	5,300	3.13	00:02:29	61.38%	53.34%
2.	United Kingdom	3,062	9.52	00:07:29	34.06%	29.13%
3.	Japan	914	3.78	00:03:53	42.67%	39.93%
4.	France	788	3.77	00:02:30	52.41%	37.82%
5.	Australia	691	3.15	00:03:06	51.23%	46.45%
6.	China	666	3.23	00:04:23	58.11%	43.69%
7.	Germany	647	3.87	00:03:06	52.86%	42.50%
8.	Canada	581	3.56	00:03:51	53.18%	47.33%
9.	South Korea	558	5.89	00:10:31	32.97%	28.14%
10.	Italy	479	3.81	00:03:06	62.42%	35.49%
11.	India	382	2.25	00:01:53	86.13%	54.19%
12.	Brazil	353	3.67	00:04:12	55.81%	48.46%
13.	Spain	243	3.21	00:02:46	72.84%	52.26%
14.	Netherlands	217	3.87	00:02:00	48.39%	44.24%
15.	Portugal	201	4.07	00:04:09	49.25%	48.26%
16.	Norway	192	2.70	00:01:19	41.15%	48.96%
17.	Belgium	137	2.65	00:01:54	60.58%	48.91%
18.	Denmark	133	3.92	00:03:31	33.83%	36.09%
19.	Russia	128	2.28	00:01:35	65.62%	54.69%
20.	Switzerland	119	3.52	00:02:37	57.14%	42.86%
21.	South Africa	116	6.30	00:04:04	68.97%	35.34%
22.	Peru	113	4.47	00:04:01	66.37%	39.82%
23.	(not set)	108	1.56	00:00:23	93.52%	75.93%
24.	Taiwan	98	3.50	00:02:36	61.22%	48.98%
25.	Ukraine	93	1.44	00:01:59	35.48%	80.65%

Figure2: Continued interest in the GHRSST web–site ***www.ghrsst.org*** *with growing global coverage as monitored with google statistics.*

GHRSST related meetings and workshop documents are collected at: https://www.ghrsst.org/ghrsst–science/Meetings–and–workshops/. The Proceedings of GHRSST XII (Edinburgh, 2011) were published, and the presentations were uploaded and linked to the Agenda, and the Edinburgh Actions followed up during the year . Likewise, the presentations of the Melbourne workshop had been linked to the Agenda and uploaded. https://www.ghrsst.org/ghrsst–science/Meetings–and–workshops/workshop–on–tropical–warm–pool–and–high–latitude–issues/.

5. Documents

The User Requirement Document (URD) has been compiled by the GPO based on interaction with SST data users, the Science Team, and especially AUS–TAG. An updated version of the User Guide was published this year. The GHRSST Development and Implementation Plan (GDIP) has been put together this year for the first time, in collaboration with the Science Team Chair and many members of the Science Team. Updates will be done according to needs. The GPO also tracks the GDS2 amendments, published the GDS2r4 and RDAC plans for GDS2 transition (in collaboration with DAS–TAG). A draft document describing the GHRSST Calibration and Validation activities has been prepared for ST–VAL and a draft ECV Data Processing Framework (DPF) for CDR–TAG.

6. GPO Actions

No	Action	Owner	Date Due	Status
G12–02	GPO to collect all data links form G12 presentations and put these onto GHRSST Web page.	GPO	End of July	done
G12–05	Arrange ECMWF data transfer via JPL to GHRSST producers.	GPO, All producers requesting ECMWF	July 15th 2011	done

No	Action	Owner	Date Due	Status
G12–13	a link on GHRSST web page to the new GHRSST PODAAC main page	GPO	Jul–11	done
G12–15	GPO to send a letter to FNMOC thanking them for contributions	GPO	Jul–11	pending
G12–17	GPO to discuss what Space Agencies need to be reported on the web site (e.g., What's new, Newsletters, Breakthroughs and well cited publications (Based on P. Hacker Request).	GPO	GHRSST meetings	regular
G12–18	GPO to work with the SMOS and Aquarius Science Teams to ensure that GHRSST is collaborating in the most appropriate manner.	GPO	Jul–11	Done
G12–20	GPO to add a link to Jannsen Tech note on Waves and DV @ ECMWF on GHRSST web page	GPO	Jul–11	Newsletter 7
G12–21	GDAC and MyOcean to agree on the reporting of user statistics (e.g., % url by country etc) from GDAC to MyOcean.	GPO, H Roquet, M Gierach	Sep–11	closed
G12–22	Once ACTION G12–21 is closed, MyOcean to make products available to GDAC	GPO, H Roquet, M Gierach	Sep–11	In work
G12–23	H Roquet to confirm MyOcean agreement to ACTION G12–21 and G12–22 to GPO before initiating these actions	H. Roquet, GPO	Sep–11	closed
G12–24	GPO to discuss with IOCCG on what steps/activities can be taken to improve coordination between SST and OCR	GPO, and Chair of IOCCG – D. Antoine	Dec–11	regular
G12–25	AUS–TAG to organise some shared discussions at specific times on specific topics (~1 hour)	AUS–TAG, GPO		Done with forum
G12–31	GPO to publish a web page and What's new item on new DBCP buoys improvements	GPO	August	Done
G12–32	GPO to work with M Martin to investigate how MyOcean FOAM model 1 day forecast SST's (with DV) over 0–10m depths could be provided to the GHRSST community to as a pilot DVHAC.	M Martin	Jul–11	Pending
G12–35	GPO to advise ST where the new buoys are and how to access them (code)	GPO	August	Done

No	Action	Owner	Date Due	Status
G12–41	GPO to arrange formal communication of GHRSST statement to ARGO–ST and seek feedback	GPO	Melbourne meeting	Done
G12–42	GPO to implement the reviewed and endorsed updates to GDS2.0 (revisions)	GPO	End 2012	Done
G12–44	GPO to communicate the revisions to GDS2.0 to GHRSST community in the most appropriate manner	GPO	End of 2012	Done
G12–46	GPO and RDAC to work together to ensure that communications when a newGDS2.0 data set comes on line – users need to be pro–actively informed (need a list of users)	GPO	ongoing	Done
G12–55	Incorporate quick–start one–pager on Web–site, with example figures	GPO	Sep–11	Done
G12–64	Webpage for Global Network for Shipborne Radiometers	GPO	To report at GHSST–13	Done
G12–98	***ACTION AC/12–03*****:** GPO and GDAC to set up a GHRSST forum/chatroom to capture user feedback on GDS 2.0 transition issues.	Andrea Kaiser–Weiss and Jorge Vazquez	September	Done
G12–99	***ACTION AC/12–04*****:** GPO to develop a web page on transition to GDS2.0 on the GHRSST website and promote the information.	GPO	September	Done
G12–101	***ACTION AC/12–06:*** GPO to initiate a survey of what remapping tools are available and used in GHRSST (GPO).	GPO	September	Pending

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R23 – NOAA NESDIS – GHRSST OPERATIONAL SST PRODUCTS

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ABSTRACT

The National Oceanic and Atmospheric Administration's (NOAA) office of National Environmental Satellite Data and Services (NESDIS) generates operational geostationary Level–2P (L2P) products in GHRSST GDS2.0 format and a blended geostationary and polar orbiting Level 4 SST analysis to satisfy the requirements of the GHRSST users. NOAA provides full L2P SST products for GOES E/W as part of its operational processing. The L2P products are derived from ½–hourly GOES–East & West North & South sectors in native satellite projection and include the full L2P ancillary fields. NOAA provides full L2P SST products for MTSAT–2 and MSG–2 as part of routine operations. For MTSAT–2 the L2P product is produced every hour in native satellite projection whereas for MSG–2 the L2P product is produced every 15 minutes. Both the MTSAT–2 and MSG–2 L2P products contain the full L2P ancillary field as required by the GSD2.0 format.

Operational SST retrievals from NOAA's GOES and POES satellites are used to produce an operational daily global, high resolution 11km SST Analysis in GSD1.7 format. A new operational daily global, high resolution 5km SST Analysis in GSD2.0 format is available.

Within the next year the following operational products will be available: 1) diurnal warming estimates will be included in all the operational geostationary L2P products; 2) operational daily global 5km SST analysis for nighttime only and diurnally corrected will be available in GHRSST L4.

Future plans include the incorporation of the AMSR–2 SSTs into the daily global 5km SST analysis suite of products.

R24 – MYOCEAN/MYOCEAN–2 RDAC PROGRESS REPORT

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ABSTRACT

The MyOcean project, which was funded by the European Union for a 3 year period (2009–2012), included the development and operations of a Thematic Assembly Centre for satellite SST products (SST TAC), providing near real–time global and regional L3 and L4 products, derived from GHRSST L2P SST sources, and also a global SST re–analysis over the 1985–2007 period, based on the OSTIA system. MyOcean–2 is the follow–on project, funded by the European Union, and was kicked–off on 1st of April 2012 for a 30 month duration. The SST TAC development, production and validation activities will continue during MyOcean–2 in the framework of the OSI TAC, which includes now activities related to satellite–derived Sea Ice, Wind and SST products.

1. Introduction

MyOcean was an EU–funded project, which was kicked–off in April 2009 for a 3 year duration. Its main objective was to transition into operations and operate the first GMES Marine Core Services. Its architecture was based on seven ocean Monitoring and Forecast Centres (MFCs), covering the Global Ocean, the Mediterranean Sea, the Black Sea, the Arctic Ocean, the Baltic Sea, the Atlantic North West Shelves and the Iberian plateau, on five data Thematic Assembly Centres (TACs) for in–situ observations and satellite SST, Ocean Colour, Surface Topography and Sea Ice products, and on a centralised information system and service desk for delivering products and services.

The SST TAC was a significant European contribution to the GHRSST, in the following areas:

- near real–time processing and delivery of global and regional L3/L4 SST products,
- near real–time processing and delivery of GMPE products,
- global SST re–analysis (OSTIA),
- systematic building and/or collection of Match–up Data Bases, and continuous quality monitoring of input L2P SST sources.

The MyOcean development and production activities, as well as services are now continuing in the framework of a new EU–funded project, MyOcean–2, running from April 2012 up to September 2014. The production architecture, based on MFCs and TACs, is very similar. However, the management has been optimized by merging the former SST TAC and Sea Ice and Wind TAC into a single entity, called the OSI TAC, and coordinated by Met.no.

In this paper we present some highlights of the MyOcean SST TAC achievements of the since GHRSST XII, and give an overview of the planned developments related to satellite SST products in MyOcean–2.

Figure 1: Home page of the MyOcean web portal www.myocean.eu

2. Main achievements since GHRSST XII

2.1 Research and development activities

Many NWP users of the UK Met Office's OSTIA global SST analysis have requested that information about Lake Surface Water Temperature (LSWT) be included in the product. This has therefore been developed ready for V2 of MyOcean. The lake mask used in OSTIA is that defined by the ESA/University of Edinburgh ARCLake Project (http://www.geos.ed.ac.uk/arclake/) and includes lakes with a surface area greater than 500 km2, plus an additional 10 lakes, giving a total of 263 lakes. The ARCLake climatology has been used to initialise the LSWTs in OSTIA, and during the relaxation to climatology step during the OSTIA assimilation procedure. Table 1 shows the error statistics of OSTIA LSWTs from a run in September 2011. Although there are many different satellite data types used in OSTIA, statistics are shown here from only the data types which are currently providing lake information, namely the in situ data, NOAA–18 AVHRR, MetOp–A AVHRR and AATSR instruments.

Observation type	Observation minus Background Mean Error	Observation minus Background RMS Error	Observation minus Climatology Mean Error	Observation minus Climatology RMS Error
Global				
In situ	-0.18	1.20	-0.95	2.30
AATSR	0.08	0.79	-0.12	1.39
MetOp AVHRR	0.15	0.95	-0.08	1.44
NOAA AVHRR	0.21	0.64	-0.05	1.41
Great Lakes				
In situ	-0.21	1.23	-1.09	2.38
AATSR	0.28	0.90	-0.71	1.66
MetOp AVHRR	0.23	1.05	-0.52	1.64
NOAA AVHRR	0.30	0.64	-0.91	1.67
Lake Baikal				
In situ	-	-	-	-
AATSR	-0.15	0.84	-1.61	2.04
MetOp AVHRR	-0.09	0.83	-1.10	1.59
NOAA AVHRR	0.21	0.78	-0.69	1.32
Lake Victoria				
In situ	-	-	-	-
AATSR	0.09	0.49	0.32	0.49
MetOp AVHRR	-0.10	0.49	0.14	0.49
NOAA AVHRR	-0.10	0.32	0.01	0.31

Table 1: Global and regional statistics for Lake Surface Water Temperatures in OSTIA, computed globally and for three case studies, from 2 September to 5 October 2011. A dash (–) indicates that there is not enough data to produce statistics.

The Arctic Ocean is a region with persistent cloud cover and extreme atmospheric conditions, which results in elevated satellite SST errors in this region. Inter–sensor bias corrections will therefore be particular valuable here, but a bias correction method based on the only AATSR data does not work well in this region. There is thus a need for a multi–sensor bias correction approach within the high latitude satellite SST observations to improve the quality of the satellite SST observations and to improve the results when used within the operational MyOcean SST TAC analysis scheme for high latitudes running at DMI and Met.no. A bias correction method that used the combined AATSR and NAVO–GAC fields as a reference has been developed at DMI in cooperation with Météo–France, to correct the biases of the AMSR–E, MetOp–A and MODIS SST products at high latitude. The impact of the bias correction method on the Arctic SST analysis scheme used in the MyOcean SST TAC in shown in Table 2.

Product: SST Arctic level 4	Nmatch	Bias (OI – in situ)	Standard deviation	RMS
Reference	128990	–0.28	0.61	0.67
Bias corrected	129089	–0.04	0.54	0.55

Table 2: Validation statistics using independent drifting buoy observations in 2008 for reference and test (bias corrected) runs performed with the Arctic SST analysis scheme used in MyOcean SST TAC.

2.2 SST TAC products upgrades

All the SST TAC near real–time global and regional L4 SST products have been upgraded to be GDS V2 compliant for V2 of MyOcean (January 2012). The horizontal resolution of the regional SST analysis over the Baltic Sea, processed at DMI, has been improved from 0.03° to 0.02°. OSTIA has also been upgraded to take into account new satellite SST sources (new MSG/SEVIRI and GOES–East SST products from EUMETSAT OSI SAF, MetOp–A/IASI SST products from EUMETSAT, and NOAA–19/AVHRR SST products from NAVOCEANO), and to use a new SST climatology derived from the OSTIA re–analysis.

New near real–time L3S SST products at 0.01° over the Mediterranean Sea and the Black Sea, processed at CNR, have been added to the SST TAC products catalogue for V2.

3. Plans in MyOcean–2

3.1 Research and development activities

At UK Met Office, research and development activities during MyOcean–2 will mainly focus on:

- the transition of the OSTIA analysis system from an Optimal Interpolation scheme to a variational assimilation scheme
- the development of a global high resolution analysis system of the SST diurnal cycle, to complement the daily OSTIA foundation SST analysis

At Météo–France, research and development activities during MyOcean–2 will mainly focus on:

- the development of a new inter–sensor bias correction method based on an EOF technique, in cooperation with the AGO–GHER group (University of Liège)
- the development of a three–hourly regional SST analysis over European Seas at very high resolution

In all OSI TAC SST Production Units, a significant part of the research and development activities will be also devoted to the continuous improvement of the OSI TAC SST products.

3.2 OSI TAC SST products upgrades

In 2012, all the remaining GDS V1.7 OSI TAC SST products will evolve towards GDS V2 in netCDF4, and the horizontal resolution of the regional SST analysis over the Arctic Ocean, processed at Met.no, will be improved from 0.05° to 0.03°. During MyOcean–2, new available satellite SST sources will be taken into account when available (NPP/VIIRS, MetOp–B/AVHRR, S–3A/SLSTR…).

A regional SST re–analysis (1985–2011) over the Arctic region will be performed at DMI, using (A)ATSR ARC and AVHRR Pathfinder 5.2 satellite SST data, as well as ICOADS in–situ measurements.

4. References

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R25 – REPORT FROM EUMETSAT AND OSI–SAF

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ABSTRACT

This report overviews the work performed at EUMETSAT and the OSI–SAF over the period mid–2011 to mid–2012 covering geostationary SST products, polar–orbiting SST products (including Metop–AVHRR, high–latitude, and VIIRS products), and an update on SSTs from IASI.

1. Introduction

The mid 2011–mid 2012 period has been characterized by:

I) The upgraded OSI SAF geostationary SST and radiative flux chain being fully operational (CMS, August 2011).
II) The development of a VIIRS SST chain over the NAR area (CMS, spring 2012).
III) The production of composite multisensor SST product over High Latitudes (met.no, January 2012).

IASI L2Pcore SSTs have been continued to be supplied in GDS V2.0 format as a demonstrational product, available via ftp from the EUMETSAT data centre since March 2011. The SSTs are those contained within the operational EUMETSAT IASI L2 Product Processing Facility (PPF) product, available from EUMETSAT since April 2008. The IASI SST L2Pcore contains skin SSTs, flags, quality information and SSES plus an auxiliary wind–speed field, but no further auxiliary data.

2. Geostationary SST products

The new geostationary SST products have been validated over more than one year. Results are stable and most regional biases have been removed (See Figure 1) by the bias correction method (LeBorgne et al, 2011). The validation results over one year are presented in Table 1.

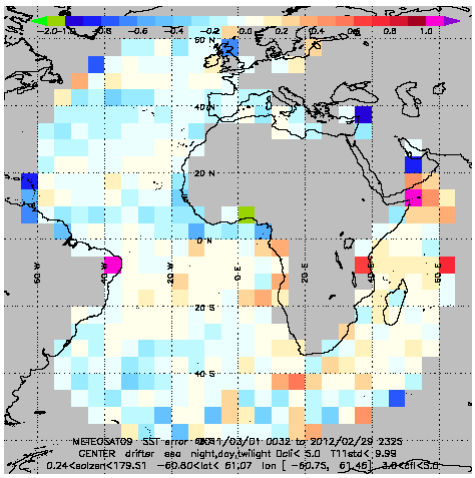

Figure 1: Mean METEOSAT–9 yearly bias.

	GOES–13 (night)	METEOSAT–9 (night)	METEOSAT–9 (day)	Global METOP (night)	Global METOP (day)
δ (K)	–0.16	–0.07	–0.02	–0.07	0.07
σ (K)	0.52	0.57	0.57	0.45	0.56

Table 1: OSI–SAF global METOP and geostationary derived SST validation results from May 2011 till May 2012

The nighttime GOES–13, daytime and nighttime METEOSAT–9 validation statistics are rather similar. The hourly SST products at 0.05° resolution are now distributed in GDSV2 compliant L3C format through the IFREMER server. The distribution of the old products stopped on the 15th of March 2011. Saharan Dust Index experimental products have been made available in near real time since March 2012 through the IFREMER server.

3. Polar orbiter SST

Global METOP/AVHRR

Global AVHRR SST validation results have been stable during the period (Table 1 and Figure 2), in spite one unique algorithm is used over the globe (distinct by night and day) without using NWP outputs. The switch to GDSV2 compliant format will be done in phase with the change from METOP–A (present) to METOP–B in Autumn 2012.

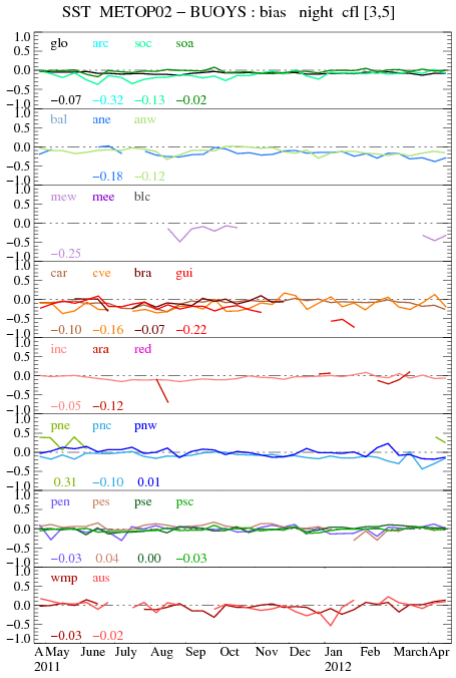

Figure 2: Global METOP yearly regional biases.

High Latitude products

In January 2012 the OSI SAF started to distribute a separate 12 hourly L3 SST products for the Atlantic High Latitudes, based on AVHRR data. This product combines all available AVHRR data from NOAA–18, NOAA–19 and METOP–A received locally at Norwegian Meteorological Institute and

through the EUMETSAT retransmission service EARS. The product is presented on a 5km polar stereographic projection, in HDF5 and GRIB format. Starting this summer, the product will also be provided on GHRSST L3 NetCDF format.

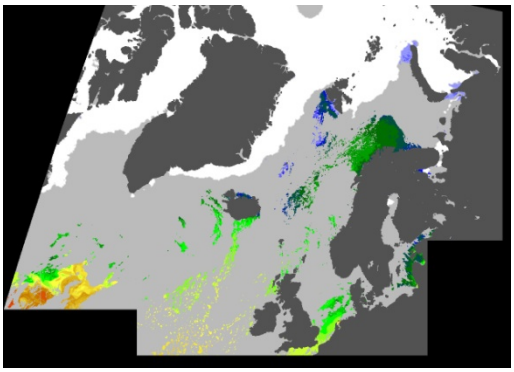

Figure 3: AVHRR derived multisatellite SST12 hour composite over High Latitude Atlantic on the 26th of April 2012

VIIRS derived SST

A VIIRS SST chain is under construction at OSI–SAF/CMS, aiming to produce twice daily SST fields over the NAR (North Atlantic Regional) area. Figure 4 shows a recent example of SST field in satellite projection off Tunisia, produced by the OSI–SAF prototype chain. The white (missing) lines result from the trimming of overlapping scans at large scanning angles. The VIIRS derived SST products are expected operational in early 2013.

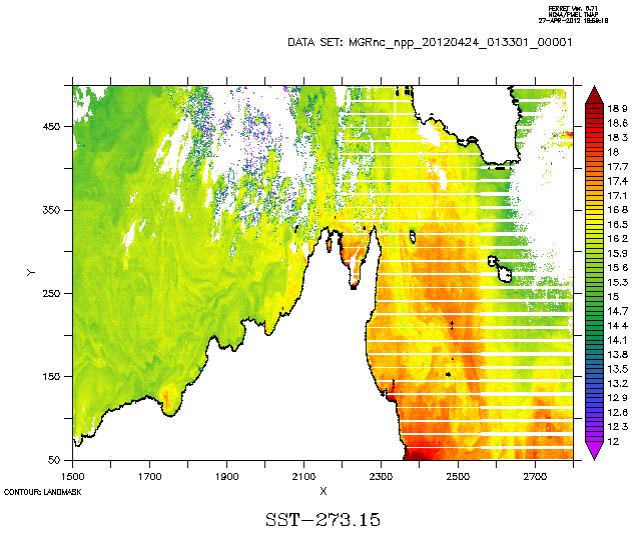

Figure 4: VIIRS derived SST off Tunisia by the OSI–SAF prototype chain on the 24th of April 2012

4. IASI SST products

The IASI L2 PPF was upgraded on the 28th February 2012 as v5.3. The upgrade affected the cloud parameters and not the SST retrieval. A new cloud detection based on artificial neural networks is currently being monitored, since October 2011. Its use is being finalised and is expected to be used operationally soon. Reprocessing of the IASI L1c is planned for 2013 and will begin after the commissioning of Metop–B is complete. Reprocessing of IASI L2 will follow afterwards.

Validation results over the period April 2011 to March 2012 give the night–time IASI minus buoy mean difference to be –0.36K (standard deviation 0.35K). AVHRR minus IASI SST statistics for the same period and sample of 786 collocations covering quality levels 2 to 5, give a bias of 0.37K and a standard deviation of 0.31K. The global standard deviation of errors, using AVHRR observations with quality level 2 and above, are 0.28K (IASI), 0.14K (AVHRR), and 0.22K (drifting buoys). Figure 5 shows the monthly standard deviation of errors for IASI, AVHRR and drifting buoys over the period April 2011 to March 2012.

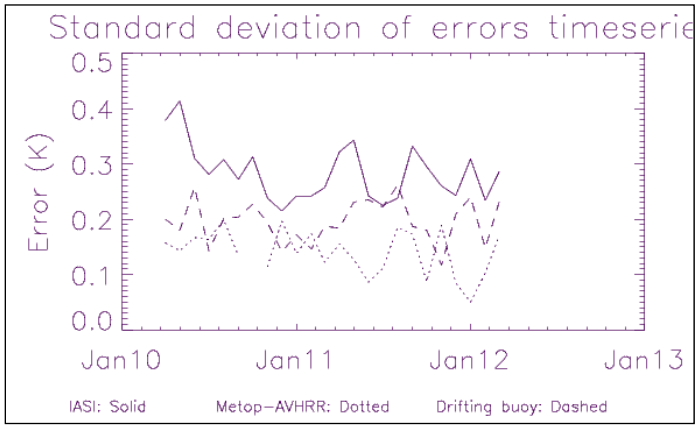

Figure 5: Monthly time–series of IASI, AVHRR and drifting buoy uncertainties over the period April 2011 to March 2012

Within the Continuous Development and Operations Phase 2 of the OSI–SAF a full IASI L2P SST will be produced based on the IASI L2Pcore SST from EUMETSAT central facilities and the addition of the extra auxiliary data needed (e.g. aerosol, ice).

5. Conclusion

More information is available on the OSI–SAF website http://www.osi–saf.org.

6. References

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R26 – MEDSPIRATION AND SST ACTIVITIES AT IFREMER

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ABSTRACT

A large effort and infrastructure at Ifremer/CERSAT are dedicated to the archiving and processing of GHRSST datasets, in particular in support to projects such as Medspiration, MyOcean or OSI SAF. In the frame of Medspiration, founded by ESA, we deliver long time series of multi–sensor high resolution SST maps over predefined regional areas, based on user requirements expressed to ESA. They are processed through the ODYSSEA inter–calibration and analysis chain, which also delivers global scale products, using all available GHRSST L2P. For this reason, and to perform SST maps reprocessing or to develop multi–sensor and multi–variate data fusion applications, we maintain a comprehensive long–term archive of GHRSST L2P/L3P data, building on top of it open and added–value services such as satellite to in situ match–up databases, data search and extraction (Naiad dataminer) and remote processing capabilities through cloud computing technology.

1. Medspiration

The **Medspiration** Project is a European initiative, funded by ESA (in the frame of DUE program), to combine sea surface temperature (SST) data measured independently by several different satellite systems into a set of data products that represent the best measure of SST, presented in a form that can be assimilated into ocean forecasting models or used for various kinds of application. It has pioneered the implementation of operational services for SST following GHRSST project recommendation and standards.

Medspiration is releasing its latest **line of high resolution regional SST maps** over several predefined areas, namely **Mediterranean sea**, **Brazil**, **South–Africa** and **Great Barrier Reef** in Australia. These products have been available and updated on a daily basis for more than two years now, new sensors being added to the merging process.

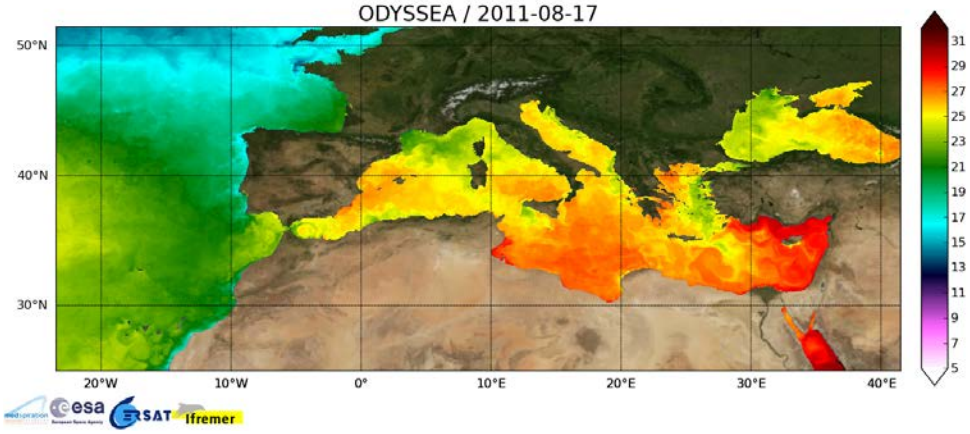

Figure 1: Medspiration multi–sensor 2km analysis (L4)

In the past year, a full reprocessing over Medspiration era (2006 to today) of the Mediterranean product has been undertaken and is expected to complete in June 2012. We plan to extend this series back to 2002 by the end of this year making available a 10 year long time series.

Information and data access are available on Medspiration pages: http://www.medspiration.org

2. Odyssea global analysis

The Odyssea processing chain was designed for the fusion, inter–calibration and optimal interpolation of multi–sensor SST data. This is the chain used for the production of Medspiration regional analyses. It is also used to deliver global 10 km resolution multi–sensor L3 (supercollated and L4 products) and available routinely in near real time (refer to http://cersat.ifremer.fr/News/Products–informations/ODYSSEA–SST–Products for access details). In the last months, a similar reprocessing as for the Mediterranean Sea was started and will be completed by June.

3. GHRSST Satellite/In situ Match–up Database

The GHRSST in situ to satellite match–up database for sea surface temperature was developed in the context of Medspiration project. It is a unique tool to assess the quality of the satellite SST observations and estimate the respective sensor specific errors. The CERSAT continues to produce and to host for GHRSST community the available satellite to in situ match–ups. The match–ups are either processed at CERSAT or directly provided by another institution. They are ingested into a common database, and the content of this database is daily exported to NetCDF4 format and available through ftp (ftp://ftp.ifremer.fr/ifremer/cersat/projects/myocean/sst–tac/matchups/).

Currently, we produce match–ups from drifting buoys, ship or Argo floats measurements delivered by CORIOLIS data center for the following swath products: AATSR, AMSRE, TMI, GOES–11, AVHRR18/19 GAC, AVHRR19 LAC. We also host match–ups provided by OSI SAF for AVHRR/METOP–A, SEVIRI and GOES–13.

4. European Long–Term SST Archive

Initially for the needs of MyOcean project and the production of regional and global SST analyses, Ifremer maintains an online mirror of a large selection of GHRSST data collections. To optimize both storage and download performances, all files have been converted to NetCDF4, using its internal compression ability. Some datasets previously not compliant to GHRSST format, such as the complete series of Atlantic GOES (2001–2012) and SEVIRI (2002–2012) hourly 5km products, have been converted to GDS format too, complementing the newly available OSI SAF similar operational products, and added to this archive.

This archive is openly accessible through ftp on–demand to any users (request access to CERSAT Help Desk: fpaf@ifremer.fr).

The demonstration platform used to set–up this archive is based on a combination of Big Data and cloud computing technologies to offer to users co–located data collection and processing capabilities at the same facility. The deluge of SST historical and newly acquired data, together with the limited network bandwidth or end–user's local storage capacity hamper large–scale analysis and revisiting of swath full resolution data. It is our ambition to demonstrate that today's technologies are changing the shape of long–term data centers and the way scientists make use of the data. The CERSAT archives now permits – on mutual agreements – users to also locally process the data through a custom virtual machine.

5. User–friendly access

We are continuing our efforts to provide advanced tools for the search, discovery, graphical display and data extraction of GHRSST products.

In particular, the Naiad datamining tool (http://www.naiad.fr) is being operated to provide such functionalities for GHRSST swath products, including so far AATSR, AVHRR on METOP, AVHRR19 LAC, MODIS on AQUA. A new capability implemented recently is the WMS access to these L2P data. The Naiad web service queries can be also now be easily scripted for automatic data selection requests. The new online storage capability described above will allow soon access to the complete archive through Naiad datamining tool.

Another new application, Calypso (http://www.ifremer.fr/calypso) provides display and graphical feature extraction (time series, sections, hovmoller, ...) for a set of GHRSST L3 and L4 products (geostationary products, supercollated and analyses produced for MyOcean). This new application is now being interfaced with Naiad tool to provide integrated access to any GHRSST product level.

R28 – REPORT TO GHRSST13 FROM AUSTRALIA – BLUELINK AND IMOS

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ABSTRACT

Since June 2011 there have been a number of new and updated sea surface temperature (SST) products released by the Australian Bureau of Meteorology with support from the Bluelink Project and the Integrated Marine Observing System (IMOS). In addition to the operational regional and global SST analyses (RAMSSA and GAMSSA) contributed to the GHRSST Global Data Assembly Centre (GDAC) and the GHRSST Multi–Product Ensemble Project, the Bureau is also producing High Resolution Picture Transmission (HRPT) AVHRR SST in GDS v2.0 L2P, L3U, L3C and L3S formats which we intend to supply to the GDAC before December 2012. Other new products produced by the Bureau which may be of interest to the GHRSST community are the Bluelink Ensemble–based SST (BESST) reanalyses, reprocessed MTSAT–1R and MTSAT–2 skin SST GDS v2.0 L3U files and validation–quality, near real–time SSTdepth data from sixteen ships of opportunity. This report summarises the advances made in the research and development of new SST products by Bluelink and IMOS from 1 June 2011 to 1 June 2012 and plans for the coming year.

1. Introduction

For the past nine years, the Australian Government, through the Australian Bureau of Meteorology (Bureau, http://www.bom.gov.au), Royal Australian Navy and CSIRO have contributed to Bluelink Ocean forecasting Australia (Brassington et al., 2007; http://www.bom.gov.au/bluelink), a project to deliver ocean forecasts for the Australian region. Bluelink includes ocean model, analysis and assimilation systems, and provides timely information and forecasts on oceans around Australia. Phases I and II of the project have completed and Phase III has commenced and will run until June 2014. Operational high resolution (0.1° horizontal resolution) ocean analyses and forecasts are available as maps from http://www.bom.gov.au/bluelink and netCDF files from http://godae.bom.gov.au.

One of the aims of Bluelink has been to provide the best possible SST products for ingest into and validation of research and operational Numerical Weather Prediction (NWP), ocean and atmosphere–ocean coupled models. To this end it was decided at the commencement of Bluelink I to align with many of the goals of the Group for High Resolution SST (GHRSST: http://www.ghrsst.org) and modify the Bureau's existing operational SST analysis and direct broadcast Advanced Very High Resolution Radiometer (AVHRR) SST processing systems to produce a range of products in GHRSST formats containing uncertainty estimates for each SST value. These satellite SST products have been produced in various GHRSST file formats ranging from geolocated SST from one satellite to gridded SST from multiple satellites (L2P, L3U, L3C, L3S and L4 – see Casey et al., 2011) at various spatial and temporal resolutions designed for a wide range of research and operational applications (Beggs, 2010, Beggs et al., 2011a).

Commencing in 2007, the Bluelink support for development of GHRSST products has been strongly augmented by funding from the Integrated Marine Observing System (IMOS, http://www.imos.org.au), a nation–wide collaborative program designed to observe the oceans around Australia, running until June 2013.

The main Bluelink and IMOS contribution to GHRSST is through an Australian Regional Data Assembly Centre (RDAC) system based at the Bureau of Meteorology, delivering the following types of GHRSST data products:

- MTSAT–1R and MTSAT–2 hourly, 1/20° resolution, SST L3U (gridded, single scene) files (Section 3)
- Locally received High Resolution Picture Transmission (HRPT) Advanced Very High Resolution Radiometer (AVHRR) SST L2P (geolocated, single swath), L3U (gridded, single swath), L3C (gridded, single sensor) and L3S (gridded, multiple sensor) files (Section 4)
- L4 (gridded, gap–free) files from "RAMSSA", the operational, daily, 1/12° resolution, SST analysis over the region 20°N to 70°S, 60°E to 170°W (Section 5), and the operational, global, daily, 1/4° resolution SST analysis system ("GAMSSA") (Section 6).

Other SST–related contributions include:

- Quality assured *in situ* SST available via the GTS and IMOS Ocean Portal in near real–time from vessels of the Australian Volunteer Observing Fleet (AVOF) fitted with Automatic Weather Stations and other ships of opportunity and research vessels in the Australian region (Section 2)
- Quality assured meteorological, SSTdepth and calculated air–sea flux data available via the IMOS Ocean Portal (http://imos.aodn.org.au/webportal) from three research vessels in the Australian region (http://imos.org.au/airseaflux.html)
- Quality assured *in situ* meteorological, SSTdepth and calculated air–sea flux data available via the IMOS ocean portal in near real–time from a Southern Ocean mooring (http://imos.org.au/sofs.html)
- Ten years of global, daily, 1/10º resolution, Bluelink Ensemble–based SST (BESST) re–analyses (Section 7)
- Regional hourly and Global 3–hourly skin SST analyses in a GHRSST L4–like format ("RAMSSA_skin" and "GAMSSA_skin": Beggs et al. 2009 and Beggs et al., 2011b) – available from http://godae.bom.gov.au
- Evaluating the use of hourly RAMSSA_skin SSTs in the data assimilation cycle of the Bureau of Meteorology's regional ACCESS NWP system (Puri et al., 2010). (It is hoped that the use of realistic diurnally varying SSTs will have a positive impact on the quality control of satellite radiance observations, and therefore on forecast skill. Work so far has been focussed on addressing the technical issues that arise in using the hourly SST fields in the ACCESS assimilation cycle.)
- Testing the effect of including a sub–daily skin SST upon ACCESS NWP boundary layer fluxes and the associated sensitivity of atmospheric processes, particularly during intense rainfall events in Australia
- Provision of in situ and satellite SST and NWP and wave model forecasts for the GHRSST Tropical Warm Pool Diurnal Variability (TWP+) Project (https://www.ghrsst.org/ghrsst–science/science–team–groups/dv–wg/twp/) and TWP+ research contributions (see https://www.ghrsst.org/files/download.php?m=documents&f=120227143525–GHRSSTJointWorkshopMelbourneAbstractsv12.pdf).

2. SST from Ships of Opportunity

Typically, SST observations from engine intake sensors on volunteer observing ships (VOS) in the Australian region are significantly noisier than those obtained from drifting buoys. Until recently, the more accurate SST observations from Australian research vessels have been difficult to access in a timely manner in consistent formats. Therefore, prior to 2010, Ship SST observations in the Australian region have not been used for near real–time validation of satellite SST observations. From 2008, the IMOS Project has enabled accurate, quality controlled, SST data to be supplied in near real–time (within 24 hours) from VOS, passenger ferries and research vessels in the Australian region.

Table 1: Details of IMOS Ship SST Data Available Via the GTS and IMOS Ocean Portal

Vessel	Callsign	Data Start	SST Sensor
RV Southern Surveyor	VLHJ	4 Feb 2008	SBE 3
RV L'Astrolabe	FHZI	30 Dec 2008	SBE 38
RSV Aurora Australis	VNAA	12 Oct 2008	SBE 38
PV SeaFlyte (Rottnest Is Ferry)	VHW5167	30 Apr 2008	SBE 38
PV Fantasea One (Whitsunday Ferry)	VJQ7467	5 Nov 2008	AD590
PV Spirit of Tasmania II (Bass Strait Ferry)	VNSZ	10 Dec 2008	SBE 48
MV Portland	VNAH	20 Jun 2009	SBE 48
MV Stadacona	C6FS9	10 Aug 2009	SBE 48
MV Highland Chief	VROB	30 Sep 2009	SBE 48
MV Iron Yandi	VNVR	10 Feb 2010	SBE 48
PV Pacific Sun	9HA2479	12 Dec 2010	SBE 48
RV Solander	VMQ9273	5 Dec 2010	SBE 38
RV Cape Ferguson	VNCF	5 Dec 2010	SBE 38
RV Tangaroa	ZMFR	27 Apr 2011	SBE 38
MV Pacific Celebes	VRZN9	15 Nov 2011	Aanderaa 4050
RV Linnaeus	VHW6500	22 Dec 2011	SBE 38

As part of IMOS, the Bureau of Meteorology (Bureau) has instrumented six vessels of the Australian Volunteer Observing Fleet with hull temperature sensors (Sea Bird SBE 48), supplying high–quality bulk SST observations every hour. There are also two passenger ferries reporting one minute averaged SST measurements for CSIRO Marine and Atmospheric Research (Rottnest Island ferry) and the Australian Institute of Marine Science (Whitsunday Island to Hook Reef ferry). In addition, there are near real–time, one minute averaged SST and salinity data streams available from seven research vessels (RV Southern Surveyor, RSV Aurora Australis, RV L'Astrolabe, RV Solander, RV Cape Ferguson, RV Tangaroa and RV Linnaeus). In total, sixteen vessels have contributed near real–time data to IMOS (Table 1 and Figure 1).

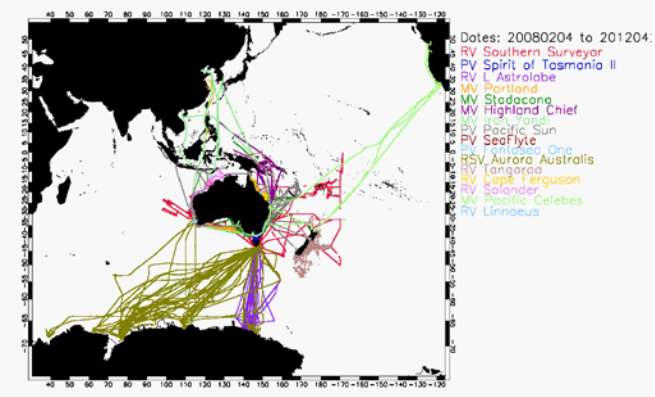


Figure 1: Locations of all IMOS QC'd ship SST observations to 26 April 2012 from 16 vessels.

All SST data are quality assured (Beggs et al., 2012) and placed in real–time on the Global Telecommunications System (GTS) as either SHIP or TRACKOB reports. The quality controlled (QC'd) SST data are also available in netCDF format with QC flags and metadata via the IMOS ocean data portal (http://imos.aodn.org.au/webportal) or directly from http://opendap–tpac.arcs.org.au/thredds/catalog/IMOS/SOOP/SOOP–SST/, http://opendap–tpac.arcs.org.au/thredds/catalog/IMOS/SOOP/SOOP–ASF/catalog.html or http://opendap–tpac.arcs.org.au/thredds/catalog/IMOS/SOOP/SOOP–TRV/catalog.html.

Comparisons between AATSR, AVHRR, buoy and IMOS ship SST observations indicate that at least twelve of the IMOS ship data streams, including all those from hull temperature sensors have comparable errors to those obtained from drifting buoys (Beggs et al. 2012 and Section 4). In waters with little or no coverage by buoys, satellite SST validation and bias–correction should be improved by using IMOS ship SST observations in addition to available drifting buoy SST data.

The IMOS ship SST data has been used in real–time SST analysis systems (including RAMSSA and GAMSSA) and for validation of satellite SST, SST analyses and ocean models (Beggs et al., 2012).

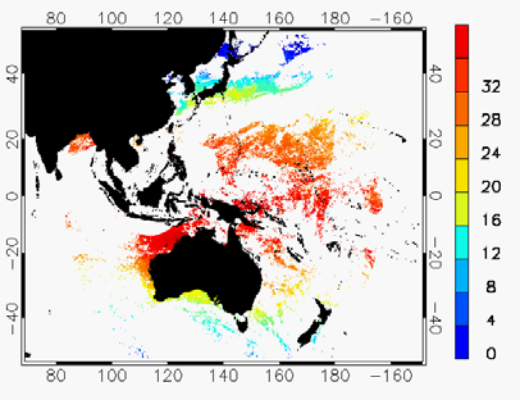
3. Geostationary MTSAT–1R/MTSAT–2 skin SST

Geostationary satellites provide measurements of skin SST over the same scene every 15 to 60 minutes, particularly useful for the study of diurnal warming of the surface ocean. Between June 2005 and June 2006 the Bureau received data from JAXA's geostationary MTSAT–1R satellite in HiRID format. In June 2006 the Bureau upgraded its satellite reception hardware to be capable of receiving MTSAT–1R data in HRIT format (10–bit). Results from the match–up database demonstrated that the HiRID data received by the Bureau was not of sufficient quality to obtain an accurate SSTskin retrieval due to the degraded signal. Since mid–2007, the Bureau has routinely generated SSTskin products from the Japanese geostationary satellite, MTSAT–1R (and later MTSAT–2), using the NOAA–developed Geostationary Satellite Derived Sea Surface Temperature Processing System (Maturi et al., 2008). The original version of the software (v1) installed at the Bureau in 2007 was modified to accept locally generated NWP fields and further modified to output GHRSST formatted, single scene L2P and gridded L3U files. A match–up database system was developed to determine the difference between satellite retrievals and *in situ* measurements from drifting buoys. In May 2010 the Bureau's MTSAT–1R SST processing system was further upgraded to version 3 (v3) to incorporate a physical retrieval methodology and University of Edinburgh/NOAA Baysean cloud clearing, following a visit by Jon Mittaz and Andy Harris from NOAA/University of Maryland. During early 2011 the processing system was updated to version 4 (v4) to use regression against drifting buoy SST rather than physical retrieval to convert from brightness temperatures to SST.

The standard deviation (when compared to drifting buoys) for day–time HRIT data with a quality level 5, using the 11 and 12 μm channels, collected during 1 January to 30 April 2009 was 0.7°C for the version 4 system. The corresponding standard deviation for night–time HRIT data, which also incorporates the 3.75 μm channel, was 0.5°C. The mean bias for both day and night SST retrievals was around 0.05°C.

In December 2009 the Bureau's NWP system was upgraded to use the UK Unified Model. The upgrade has resulted in improved accuracy of the NWP forecasts along with increases in the vertical, spatial and temporal resolution of the NWP fields (Puri et al., 2010). These changes necessitated an upgrade of the MTSAT–1R system to handle the new ACCESS–G NWP output data format. The v4 MTSAT–1R SSTskin 0.05° x 0.05° gridded, single scene L3U files (Figure 2) back to June 2006 are available via ftp://aodaac2–cbr.act.csiro.au/imos/GHRSST/L3U/ABOM–L3U_GHRSST–SSTskin–MTSAT_1R/.

(a)



(b)

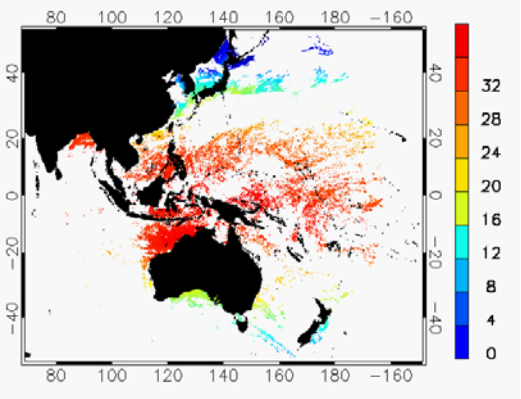


Figure 2: An example of the output from the v4 MTSAT–1R processing system of L3U SSTskin for (a) 0530 UT (day) and (b) 1630 UT (night) on 10 April 2009. SST is plotted for cloud–free pixels (quality level = 3 to 5).

On 1 July 2010, MTSAT–1R HRIT transmission was replaced with MTSAT–2 data. Following a visit by Jon Mittaz in March 2012, the MTSAT–2 processing code was upgraded to version 5 (v5) to incorporate recent NOAA enhancements. The Bureau currently produces real–time experimental v5 SSTskin L3U files from MTSAT–2. The real–time and reprocessed v5 MTSAT–2 files should be available via the IMOS OPeNDAP and FTP servers by December 2012.

4. Locally Received AVHRR SST

The highest resolution (1.1 km) data from AVHRR sensors on the NOAA polar–orbiting meteorological satellites can only be obtained through receiving direct broadcast HRPT data from the satellite as this data is not stored onboard. In Australia HRPT data is received by a consortium of agencies (Bureau of Meteorology, WASTAC, AIMS and CSIRO) at groundstations located in Darwin, Townsville, Melbourne, Hobart, Perth and Alice Springs and in Antarctica at Casey and Davis Stations. As part of the IMOS Project the Bureau of Meteorology, in collaboration with CSIRO Marine and Atmospheric Research, is stitching this raw data and producing real–time, HRPT AVHRR SSTskin data (Paltoglou et al., 2010) from operational NOAA polar–orbiting satellites in the GHRSST GDS v2.0 L2P, L3U, L3C and L3S formats (Casey et al., 2011).

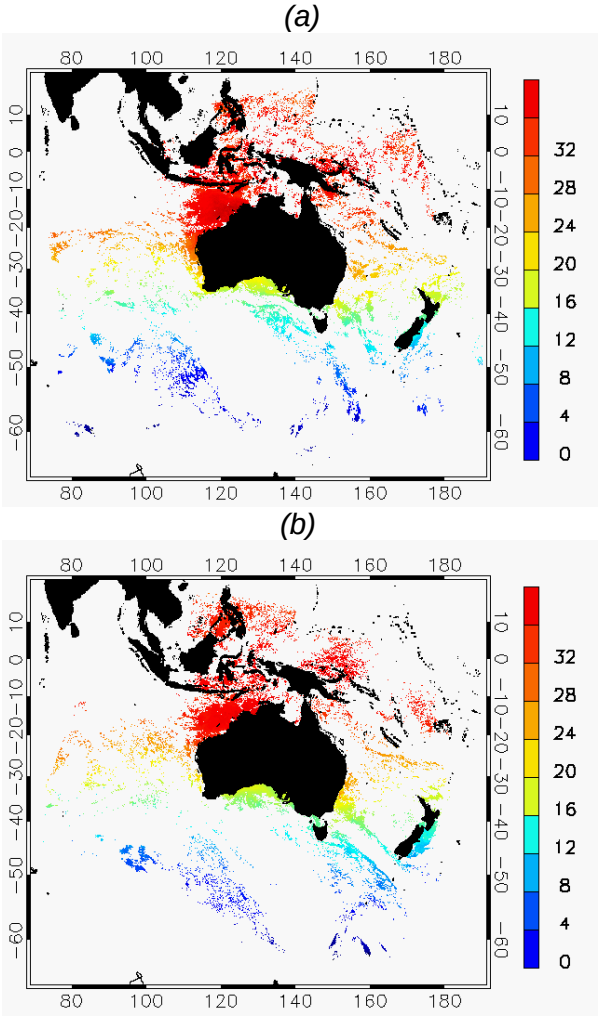


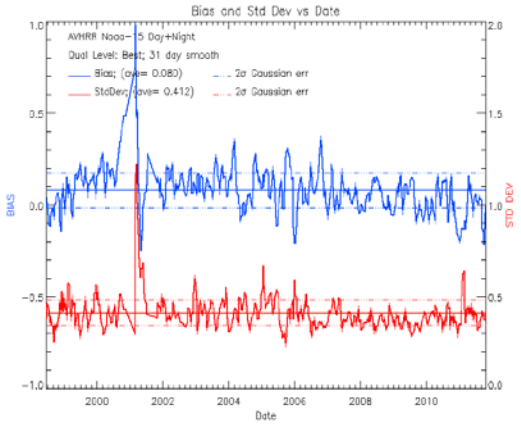
Figure 3: Example of 1–day (a) day (~1330 LT) and (b) night (~0130 LT) 0.02° x 0.02° L3C SSTskin from NOAA–18 HRPT AVHRR SST data for 10 April 2009. SST is plotted for cloud–free pixels (quality level = 3 to 5).

In addition to the 1.1 km resolution HRPT AVHRR SSTskin values and other mandatory fields such as 10m wind speed, land mask and sea ice concentration, the single swath, geolocated, L2P files contain bias and standard deviation estimates for each SST value (Single Sensor Error Statistics – SSES) based on match–ups with *in situ* drifting buoy SST data from the GTS. These SSESs are a function of the estimated proximity to cloud, satellite zenith angle and whether day or night, with daytime defined as sun zenith angle < 100º.

Each L2P file is gridded to a cylindrical equidistant projection (0.02° latitude x 0.02° longitude) over the region 70ºE to 190ºE, 70ºS to 20ºN to form a GDS v2.0 format L3U file (Casey et al., 2011). These L3U files are in turn combined to form single sensor (one and three night/day) L3C and Multiple sensor (one, three and six night/day) L3S composite 0.02° x 0.02° resolution HRPT AVHRR SSTskin files in GHRSST GDS v2.0 formats (Casey et al., 2011) over the region 70ºE to 190ºE, 70ºS to 20ºN (e.g. Figure 3). In order to convert individual geolocated SST values in L2P files to gridded composite SST in L3U, L3C or L3S files, the highest quality level SST values from one swath are averaged over each grid cell, and SST values from the same grid cell from multiple swaths are weighted by 1/(standard deviation)^2. No SST values are used which either have a solar zenith angle between 85º and 100º, or are 10ºC below the corresponding SST analysis (RAMSSA or GAMSSA), or have quality level below the threshold (currently 2), or satellite zenith angle > 68º.

The IMOS HRPT AVHRR SSTskin data from NOAA–15, 17, 18 and 19 satellites are very stable over time (Figure 4). Recent improvements to NOAA–15 HRPT AVHRR SST calibration and processing means NOAA–15 SSTs are still currently useful, although exhibiting larger standard deviation for day and night matches with drifting buoy SST for quality level 5 (best) (0.41ºC) compared with those from NOAA–17, 18 or 19 (0.31ºC, 0.33ºC and 0.31ºC, respectively) (Figure 4). To obtain match–up statistics the SSTs at drifting buoy depths (20–30 cm) were converted to a skin SST at ~10 µm depth by subtracting 0.17ºC to account for the cool skin. The data were considered matched if within ± 2 hours and collocated within the same ~1 km pixel.

(a)



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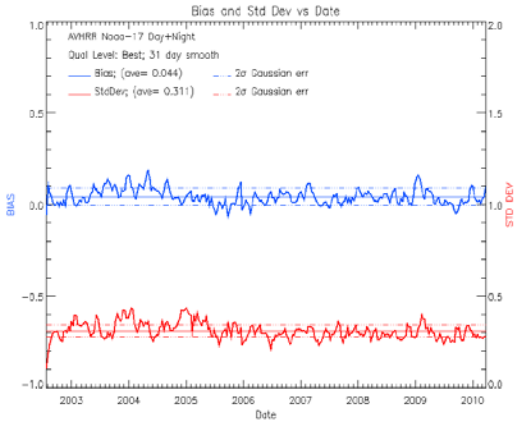

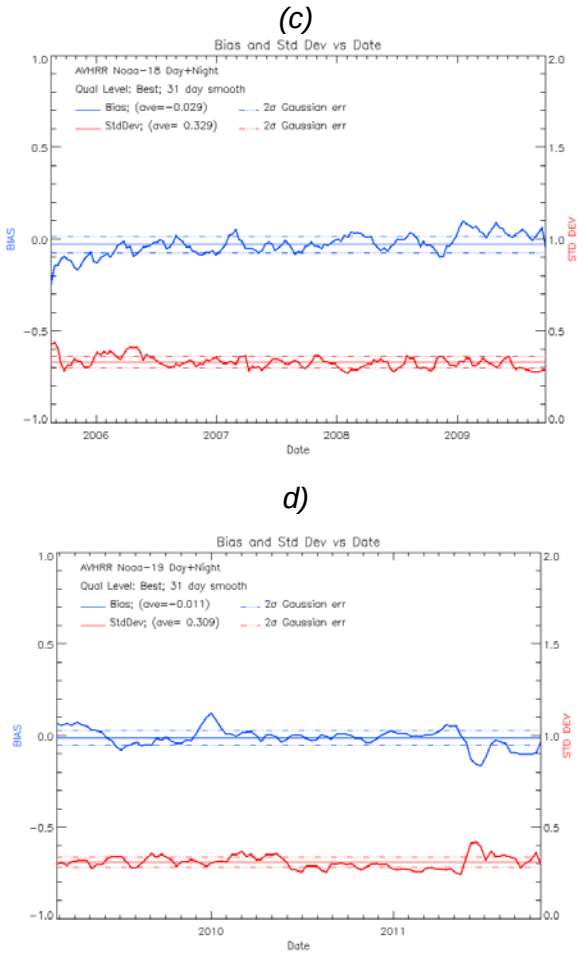

Figure 4: Bias (blue) and standard deviation (red) of matches between the day+night quality level 5 IMOS HRPT AVHRR SSTskin from (a) NOAA–15, (b) NOAA–17, (c) NOAA–18 and (d) NOAA–19 and drifting buoy SSTdepth (converted to SSTskin by subtracting 0.17ºC).

The relatively high accuracy in the IMOS AVHRR SST data has been achieved by implementing new CLAVR–based cloud clearing algorithms, implementing new brightness temperature to SST transforms with new day–time terms including latitude and higher order, and using regional, QC'd drifting buoy SST observations for the regression (Paltoglou et al., 2010).

Table 2 gives the mean and standard deviation of quality level 5 IMOS night–time, 1 km resolution, NOAA–18 AVHRR SST minus SST data from IMOS and non–IMOS ships and drifting buoys over the region 70°E to 190°E, 20°N to 70°S, during 1 December 2008 to 1 June 2011 (Beggs et al., 2012). In order to largely remove the effects of the cool skin and diurnal stratification through the water column from the match–ups, the satellite SSTskin observations were converted to SSTsubskin by adding 0.17ºC then both these and the SSTdepth in situ observations were converted to foundation SST (SSTfnd) by removing observations where NWP winds were < 6 m/s during the day and < 2 m/s at night.

Existing raw, archived, high–resolution HRPT AVHRR data from all operational NOAA polar–orbiting satellites over the Australian region back to 1992 will be progressively reprocessed into SSTskin L2P, L3U, L3C and L3S and made available to GHRSST and IMOS by June 2013. Currently, HRPT AVHRR SSTskin GDS v2.0 L2P and L3U files from NOAA–15, 16, 17, 18 and 19 (back to 1998) are

available from the IMOS FTP server (ftp://aodaac2–cbr.act.csiro.au/imos/GHRSST/) with L3C available back to 2009 and L3S files (from NOAA–15, 17, 18 and 19) available back to 2002. Maps of HRPT AVHRR L3C SSTskin are available from the IMOS Ocean Portal under Satellite Remote Sensing (http://imos.aodn.org.au/webportal/).

Table 2: Mean and Standard Deviation of Night–time quality level 5 AVHRR SSTfnd from NOAA–18 minus In Situ SSTfnd.

In Situ Data Stream	Number of Matchups	Mean (K)	Standard Deviation (K)
RV Southern Surveyor	132	–0.02	0.24
RV L'Astrolabe	28	–0.03	0.22
RSV Aurora Australis	135	–0.03	0.26
PV SeaFlyte	20	–0.20	0.71
PV Spirit of Tasmania II	830	–0.01	0.29
MV Portland	153	0.12	0.36
MV Highland Chief	167	–0.03	0.34
MV Stadacona	388	0.03	0.42
MV Iron Yandi	102	–0.01	0.31
PV Pacific Sun	106	0.04	0.26
RV Tangaroa	9	0.09	0.21
Non–IMOS Ships	1440	–0.07	1.46
IMOS Ships	1858	0.02	0.33
Drifting Buoys	7528	0.05	0.31

The IMOS AVHRR L2P products are being ingested into several SST analysis systems (Bureau's RAMSSA, GAMSSA, JPL OurOcean's G1SST and Medspiration's ODYSSEA Great Barrier Reef analysis). The L3C products are being used in the GHRSST TWP+ experiment (https://www.ghrsst.org/ghrsst–science/science–team–groups/dv–wg/twp/). The L3S products are used in the real–time mapping of meso–scale ocean currents in the Australian region (http://oceancurrent.imos.org.au/) and within the Bureau for upgrades to the ReefTemp coral bleaching prediction Project (http://www.cmar.csiro.au/remotesensing/reeftemp/web/).

Future work for the period to June 2013 will include:

- Testing the calibration of HRPT AVHRR SST over the Southern Ocean by validating against new IMOS SST data (e.g. ships, Argo, seals)
- *Providing real–time HRPT AVHRR SSTskin L2P and L3U files from Davis and Casey Antarctic stations*
- Investigating the best method for combining SST data using AVHRR sensors of widely varying accuracy into multi–sensor, composite L3S files in order to optimise spatial coverage and minimise uncertainty
- *Providing reprocessed (back to 1992) HRPT AVHRR SSTskin L2P, L3U, L3C and L3S files incorporating Australian and Antarctic data via IMOS and the GHRSST GDAC – all ready providing real–time files from Australian ground stations via IMOS and Bureau OPeNDAP servers*

5. RAMSSA – Regional Australian Multi–Sensor SST Analysis

A real–time, high–resolution, Regional Australian Multi–Sensor Sea surface temperature Analysis (RAMSSA) system has been developed at the Australian Bureau of Meteorology as part of the Bluelink Ocean Forecasting Australia project. The pre–existing operational, 1/4° resolution, regional SST analysis system (Smith et al., 1999) has been modified to produce 1/12° resolution, daily SST analyses over the Australian region (20°N – 70°S, 60°E – 170°W) (Figure 5).

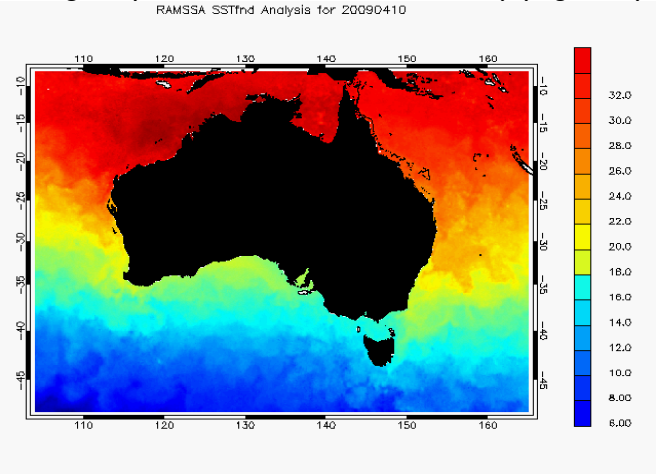

Figure 5: An example of the RAMSSA v1.2 daily regional 1/12° resolution SST analysis for 10 April 2009.

The high–resolution analysis system combines SST data from infrared (AVHRR and AATSR) and microwave (AMSR–E/WindSat) sensors on polar–orbiting satellites with in situ (ship and buoy) measurements to produce daily foundation SST estimates (SSTfnd), largely free of nocturnal cooling and diurnal warming effects. To produce foundation SST estimates, input data is filtered depending on the corresponding regional NWP surface wind speed and day/night. The method used to produce the pre–operational ("Gamma Test") and v1.0 RAMSSA products is described in detail in Beggs (2007). The RAMSSA v1.0 system became operational on 13 June 2007, was upgraded to v1.1 on 26 October 2007 (system modified to reduce "speckliness" in analyses), v1.2 on 10 June 2008 (incorporating the NAVOCEANO GHRSST GAC AVHRR L2P SST products), v1.3 on 9 April 2009 (incorporating the NAVOCEANO 1/120° land/sea mask), v1.4 on 1 September 2009 (replacing the LAPS NWP winds with those from ACCESS–R) and v1.5 on 25 March 2012 (when REMSS WindSat L2P–gridded, IMOS HRPT AVHRR L2P and NAVOCEANO NOAA–19 GAC AVHRR L2P were added, resulting in ~0.1ºC decrease in RMS of observations minus the previous day's RAMSSA). REMSS AMSR–E L2P stopped being ingested on 10 October 2011 and ESA AATSR L2 SST on 12 April 2012. The various data streams that have been used to form each daily RAMSSA analysis are listed in each L4 file header. See Beggs et al. (2011d) for details of the v1.1 to v1.4 methodology and comparisons with other GHRSST L4 analyses. By ~0300 UT each day, the operational analyses of the previous day's observations can be downloaded as GDS v1.7 netCDF L4 files from the GHRSST GDAC (via ftp://podaac–ftp.jpl.nasa.gov/allData/ghrsst/data/L4/AUS/ABOM/RAMSSA_09km/). Archived RAMSSA L4 files back to 12 June 2006 are available from http://godae.bom.gov.au/ and back to 1 April 2008 from the GHRSST Long–Term Stewardship Facility at NODC (ftp://ftp.nodc.noaa.gov/pub/data.nodc/ghrsst/L4/AUS/ABOM/RAMSSA_09km/).

The RAMSSA analyses are used in real–time as the boundary condition for the Bureau's regional numerical weather prediction models (ACCESS–R, ACCESS–A and ACCESS–C) and to validate the Bluelink operational ocean model (OceanMAPS2) SST (2.5m) forecasts/analyses. They are used

experimentally in regional skin SST analyses (Beggs et al., 2009b) and the GHRSST TWP+ experiment.

Future work on RAMSSA in 2012/2013 will include investigating the blending of planned satellite SST GHRSST L2P files from MTSAT–2, AMSR–2 and VIIRS.

6. GAMSSA – Global Australian Multi–Sensor SST Analysis

A real–time Global Australian Multi–Sensor Sea surface temperature Analysis (GAMSSA) system was developed at the Australian Bureau of Meteorology as part of the Bluelink project. The operational, RAMSSA 1/12° resolution, regional SST analysis system (Beggs, 2007; Beggs et al., 2011d) was modified to produce 1/4° resolution, daily global foundation SST analyses (Beggs, 2008; Zhong and Beggs, 2008) (Figure 6).

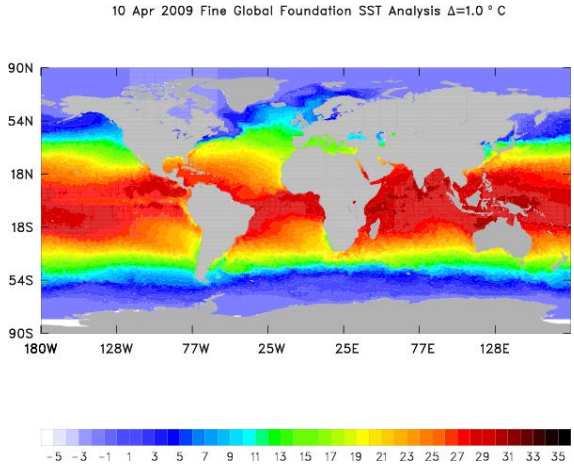

Figure 6: An example of the GAMSSA v1.1 daily global 1/4° resolution SSTfnd analysis for 10 April 2009.

The GAMSSA system blends infrared and microwave SST from radiometers on polar–orbiting satellites with *in situ* ship and buoy SSTs from the GTS. To produce foundation SST estimates, input data are filtered depending on the corresponding global NWP surface wind speed and day/night.

The GAMSSA v1.0 system started Alpha testing at the Bureau on 6 December 2007, Beta testing on 4 May 2008, and became operational on 2 October 2008. The system was upgraded to v1.1 on 9 April 2009 (incorporating the NAVOCEANO 1/120° land/sea mask) and v1.2 on 1 September 2009 (replacing the GASP NWP winds with ACCESS–G winds). On 25 March 2012 the operational GAMSSA SST analysis system switched to using the following new SST data streams:

(i) REMSS WindSat L2P–gridded SSTsubskin

(ii) IMOS HRPT AVHRR L2P SSTskin from NOAA–18 and NOAA–19

(iii) NAVOCEANO GAC AVHRR SSTblend from NOAA–19

In addition to the previously ingested data streams: NAVO GAC AVHRR (NOAA–18) L2P, BoM Legacy HRPT AVHRR L2 SST (NOAA–18), ESA AATSR Meteo Product L2 SST and in situ SSTs (ships and buoys).

By 0330 UT each day, the operational analyses of the previous day's observations can be downloaded as GDS v1.7 L4 files from the GHRSST GDAC (via ftp://podaac–ftp.jpl.nasa.gov/allData/ghrsst/data/L4/GLOB/ABOM/GAMSSA_28km/). Archived GAMSSA L4 files back to 23 July 2008 are available from http://godae.bom.gov.au/ and back to 24 August 2008 from

the GHRSST Long–Term Stewardship Facility at NODC (ftp://ftp.nodc.noaa.gov/pub/data.nodc/ghrsst/L4/GLOB/ABOM/GAMSSA_28km/).

Since 10 March 2009, GAMSSA analyses have contributed as one of 11 global SST analyses to the GHRSST Multi–Product Ensemble (GMPE: Martin et al., 2012) and Analysis Intercomparison Project (http://ghrsst–pp.metoffice.com/pages/latest_analysis/sst_monitor/daily/ens/index.html). During 2010, the GAMSSA SSTfnd analyses contributed the third highest percentage of SST values to the GMPE median SST (10.3%) compared with the Canadian Meteorological Centre (CMC) 0.2º SSTfnd analysis (12.9%) and Met Office OSTIA SSTfnd analysis (12.3%) (Martin et al., 2012). Global match–ups with independent SST observations from Argo floats indicate that during 2010 GAMSSA had a standard deviation of 0.49ºC compared with 0.46ºC from CMC and OSTIA analyses (Martin et al., 2012). Although globally GAMSSA was on average only 0.03°C colder than Argo SST during 2010, it was on average 0.13°C warmer than Argo SST over the Southern Ocean (Matthew Martin, pers. com., 2011).

Hovmöller diagrams of L4 minus L4 analyse produced by the NOAA SST Quality Monitor (L4–SQUAM: http://www.star.nesdis.noaa.gov/sod/sst/squam/L4/index.html) show that GAMSSA SSTfnd is on average between 0°C and 0.5°C warmer than the GMPE daily SSTblend analysis over the Southern Ocean (Dash et al., 2012). It has been shown that the AVHRR and AMSR–E L2P SST data streams ingested into GAMSSA are on average biased warm by between 0°C and 0.3°C south of 40°S between 60°E and 170°W (Beggs et al., 2011d).

The GAMSSA analyses are used in real–time as the boundary condition for the Bureau's global NWP model (ACCESS–G: Puri et al., 2010) based on the Met Office's Unified Model. They are also used to initialise the Bureau's seasonal forecast model (POAMA 2.0: http://poama.bom.gov.au).

Future work on GAMSSA in 2011/2012 will include testing the blending of planned GHRSST L2P SST products from VIIRS, AMSR–2 and MTSAT–2.

7. BESST – Bluelink Ensemble–based SST Analysis

As part of Bluelink III, CSIRO has produced daily, 3–daily and 5–daily, 1/10° resolution, near–global reanalyses of satellite sea–surface temperature observations using ensemble optimal interpolation (EnOI) and the Bluelink Ocean Data Analysis System (BODAS: Oke et al. 2008). Analyses cover the period 2000 to 2010. EnOI is a computationally inexpensive method that uses an ensemble of anomaly fields that are constructed from a model simulation to produce spatially inhomogeneous, anisotropic, time–invariant estimates of the system's background error covariance. Traditional OI–methods, such as used to produce RAMSSA and GAMSSA, typically use isotropic Gaussian functions to quantify the background error covariance. The model–based approach implicitly includes modes and structures that are dynamically meaningful, with long length–scales in the direction of the mean flow, and short length–scales across topographic boundaries, islands, etc. A pilot L4–like global SST analysis has been produced using this method using AMSR–E L2P, NAVOCEANO GAC AVHRR L2P and Pathfinder (v5) L2 as inputs. Globally–averaged RMS mis–fits with in situ SST (0–10m) observations from Argo indicate the performance of the EnOI–based analyses is similar to GAMSSA and Reynolds AVHRR+AMSR–E L4 optimal interpolation SST analyses (Figure 7). An evaluation of the sensitivity of the EnOI–based approach to the formulation of the ensemble and to different data inputs is underway.

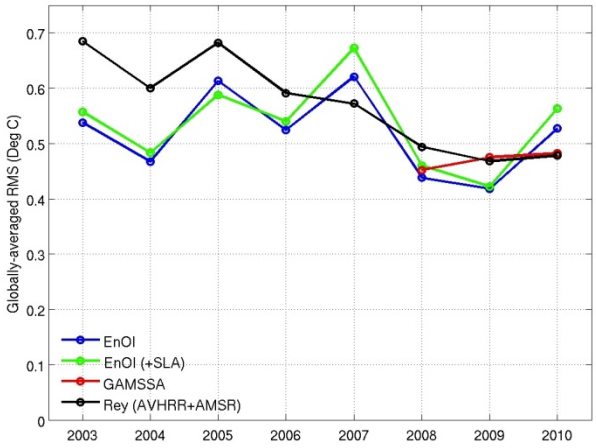

Figure 7: Globally–averaged RMS mis–fits with Argo (T between 0–10m) for the 3–day EnOI SST, GAMSSA SSTfnd and Reynolds AVHRR+AMSR–E SSTblend analyses. Two EnOI–based results are shown: a univariate application, using only SST data as input; and a multivariate approach, using SST+SLA data as input.

8. Future Plans for Bluelink and IMOS SST Products (2012–2013)

8.1 SST Products

As part of the next phase of the IMOS and Bluelink–III Projects (June 2012 – June 2013), the Bureau of Meteorology aims to:

Provide reprocessed (back to 1992) HRPT AVHRR SSTskin L2P, L3U, L3C and L3S files incorporating Australian and **Antarctic** data via IMOS and the GHRSST GDAC – all ready providing real–time files from Australian ground stations via IMOS and Bureau OPeNDAP servers

Provide real–time HRPT AVHRR SSTskin L2P, L3U and L3C files from Davis and Casey Antarctic stations

Provide real–time and reprocessed hourly, 0.05º x 0.05º gridded, MTSAT–2 SSTskin L3U files to IMOS

Equip two additional SOOP vessels with hull temperature sensors and data loggers and provide real–time, quality assured ship SST data streams from these vessels to the GTS and IMOS

Upgrade operational RAMSSA and GAMSSA to incorporate new GHRSST L2P data streams as they become available

8.2 SST–related Research

Over the coming year the Bureau of Meteorology in collaboration with CSIRO Marine and Atmospheric Research and GHRSST Diurnal Variability Working Group plan to:

Evaluate hourly RAMSSA_skin SSTskin analyses for quality control of satellite sounder data being assimilated into ACCESS–R NWP analyses

Evaluate the effect of using a sub–daily skin SST (rather than a persisted foundation SST) as the boundary condition for ACCESS–R NWP forecasts – particularly on forecasting intense rainfall events over Australia

Investigate using the CLAM air–sea coupled model to predict diurnal warming events over the Tropical Warm Pool (TWP) and the impact on weather forecasting

Using the TWP+ satellite SST data set (AVHRR, AMSR–E, WindSat and MTSAT–1R) and ACCESS–R winds, quantify the frequency and extent of diurnal warming events over the TWP

Continue evaluating the Bluelink EnOI SST analyses and determine if a joint SST+SLA EnOI SST analysis is superior to an SST–only EnOI analysis.

9. Acknowledgments

The work was supported by both the Bluelink Ocean Forecasting Australia Project (a joint project between the Royal Australian Navy, CSIRO Marine and Atmospheric Research and the Australian Bureau of Meteorology) and the Integrated Marine Observing System (an initiative of the Australian Government being conducted as part of the National Collaborative Research Infrastructure Strategy and the Super Science Initiative).

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10.1 Links to Web Pages, OPeNDAP and FTP Servers

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Bluelink Ocean Forecasting Australia Project Web Site: http://www.bom.gov.au/bluelink/

Bluelink SST Products Research Web Page:

http://www.cawcr.gov.au/projects/SST/SST_external.html

Bureau of Meteorology GODAE OPeNDAP Server: http://godae.bom.gov.au

Bureau of Meteorology Seasonal Forecast Model (POAMA) Web Site: http://poama.bom.gov.au.

Bureau of Meteorology Web Site: http://www.bom.gov.au

Group for High Resolution SST (GHRSST) Web Site: http://www.ghrsst.org

GHRSST Global Data Assembly Centre Web Page: http://ghrsst.jpl.nasa.gov

GHRSST Long–Term Stewardship Facility at NODC Web Site: http://ghrsst.nodc.noaa.gov/

GHRSST Multi–Product Ensemble (GMPE) and Analysis Intercomparison Project Web Page: http://ghrsst–pp.metoffice.com/pages/latest_analysis/sst_monitor/daily/ens/index.html

GHRSST Tropical Warm Pool Diurnal Variability (TWP+) Project Web Page: https://www.ghrsst.org/ghrsst–science/science–team–groups/dv–wg/twp/

Integrated Marine Observing System (IMOS) Web Site: http://www.imos.org.au

IMOS GHRSST SST Products Web Page: http://imos.org.au/sstproducts.html

IMOS Ocean Data Portal: http://imos.aodn.org.au/webportal

IMOS Remote Sensing Data Web Page: http://imos.org.au/srs_data.html

IMOS Remote Sensing FTP Server for GHRSST data: ftp://aodaac2–cbr.act.csiro.au/imos/GHRSST

IMOS Research Vessel Air–Sea Fluxes web page: http://imos.org.au/airseaflux.html

IMOS Research Vessel Meteorological, SST and Flux Data OPeNDAP site:

http://opendap–tpac.arcs.org.au/thredds/dodsC/IMOS/SOOP/SOOP–ASF/catalog.html

IMOS Ship of Opportunity SST web page: http://imos.org.au/sst.html

IMOS Ship of Opportunity SST Data OPeNDAP site: http://opendap–tpac.arcs.org.au/thredds/dodsC/IMOS/SOOP/SOOP–SST/

IMOS Southern Ocean Flux Station Web Page:

http://imos.org.au/sofs.html

IMOS Tropical Research Vessel Data OPeNDAP site: http://opendap–tpac.arcs.org.au/thredds/catalog/IMOS/SOOP/SOOP–TRV/catalog.html

NOAA/NESDIS SST Quality Monitor Site (SQUAM): http://www.star.nesdis.noaa.gov/sod/sst/squam/index.html

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R29 – MULTI–SENSOR IMPROVED SEA–SURFACE TEMPERATURE (MISST) FOR IOOS

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Sea Surface Temperature (SST) is vital to coastal and marine spatial planning, global weather prediction, climate change studies, search and rescue, and ecosystem based management. SST is derived from measurements taken by numerous satellites carrying infrared and microwave radiometers, and measured from moored buoys, drifting buoys, and ships. This project focuses on completing research to improve the quality of the satellite SSTs from existing and new sensors, produce multi–sensor blended gap–free SSTs from US and international datasets, and successfully broaden the use of these products within specifically targeting coastal applications and the Integrated Ocean Observing System (IOOS).

The objectives of this project are to (1) improve and continue generation of satellite SST data and SST analyses in the IOOS DMAC and CF compliant Group for High Resolution Sea Surface Temperature (GHRSST) Data Specification GDS format; (2) distribute and archive these data; and (3) use this improved SST data in applications, many specifically targeted for the Integrated Ocean Observing System (IOOS).

In the full proposal, each task has been assigned to one or more partners. This partnership consists of 28 scientists from industry, academia, and government with wide ranging experience spanning the initial calibration of satellite sensors, development of SST algorithms, assessment of SST uncertainties, production of NRT satellite data, research into data fusion methodologies and the production of blended data sets, research into diurnal warming and the cool skin effect which both affect satellite SST measurements, and applications that utilize SSTs.

Progress on the proposed work and current status will be presented.

R30 – REPORT TO GHTSST XIII FROM JAXA

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ABSTRACT

Recent Japan Aerospace Exploration Agency (JAXA) activities are summarized and reported.

In 4 October 2011, AMSR–E halted its observation on orbit, and data distribution has stopped since then. JAXA has released new version of AMSR–E standard products since September 2011. Reprocessing of Level 1 product will be completed in May 2012. We also released new long–term sea ice concentration data set from 1978 to 2010 merging multi–microwave imagers.

AMSR2 onboard the GCOM–W1 satellite is scheduled to be launched in 18 May 2012 (JST) from Tanegashima Space Center, Japan. GCOM–C1, which carrying SGLI instrument, is currently scheduled to be launched in Japanese Fiscal Year of 2015.

JAXA operates its GHRSST server to distribute AMSR–E SST product in near–real–time. Currently we're working on update of the GDS format version from 1.6 to 2.0. In addition to JAXA developed instruments, we have received data of the Visible Infrared Scanner (VIRS) on the Tropical Rainfall Measuring Mission (TRMM) satellite from NASA, and Windsat from NOAA. We have applied our SST algorithm to those instruments to produce SST products. Binary data is already distributed and GDS V2.0 format is in preparation.

1. Introduction

JAXA developed the Ocean Color and Temperature Scanner (OCTS) as optical imagers to observe SST onboard the Advanced Earth Observing Satellite (ADEOS) operated from 1996 to 1997, the Global Imager (GLI) onboard the Advanced Earth Observing Satellite–II (ADEOS–II) operated from 2002 to 2003, and is developing the Second generation Global Imager (SGLI), which will be carried by the first generation of the Global Change Observation Mission (GCOM) – Climate (GCOM–C1) scheduled to be launched in Japanese Fiscal Year (JFY) of 2015.

JAXA also developed the Advanced Microwave Scanning Radiometer (AMSR) as passive microwave imagers to observe SST, onboard the ADEOS–II, AMSR for EOS (AMSR–E) onboard NASA's EOS Aqua satellite, which has been operating since 2002, and is developing AMSR2, which will be carried the first generation of the GCOM – Water (GCOM–W1). C–band (6.9GHz/7.2GHz) channels on AMSR, AMSR–E and AMSR2 are indispensable for retrieving global sea surface temperature and soil moisture. All–weather and frequent measurements enables analyses of rapid changes of SST.

JAXA Earth Observation Research Center (EORC) has been operating the JAXA GHRSST server to distribute GLI, AMSR and AMSR–E SST data to GHRSST community. To access the server, please send a request e–mail to ghrsst@ jaxa.jp. Current data format is GDS v1.6, but will be updated to GDS v2.0 soon.

2. Current status of JAXA missions

2.1 AMSR–E observation halted and algorithm version up

AMSR–E was launched in May 4, 2002, and halted its observation in 4 October 2011. Since the end of August 2011, the continuous increase of relatively large antenna rotation friction was detected twice, thus JAXA has been monitoring condition. At 0658UTC in 4 October 2011, the AMSR–E reached its limit to maintain the rotation speed necessary for regular observations (40rpm,) and the

radiometer automatically halted its observation and rotation. Since AMSR–E hardware (both sensor and control) is expected in healthy condition except for its large friction with antenna rotation, and cross–calibration between AMSR–E and AMSR2 is very important, JAXA prepared a recovery plan with engineers and NASA. Those are; observation without rotation (done); trial run–up to 4rpm; and further discussion for cross–calibration with AMSR2.

Just before the run–down of AMSR–E, JAXA released new version of AMSR–E standard products in 28 September 2011. AMSR–E Level 1 product is version–up from Version 2 to Version 3, and Level 2 from Version 6 to Version 7. Currently, JAXA is reprocessing data of past period. Change in Level 1 algorithm is modification of program in geometric correction. Sea Surface Temperature standard algorithm, which is developed by Dr. Akira Shibata (JAXA, current affiliation is Japan Meteorological Institute since April 2012,) is also updated. Major medications are to improve correction method of year–to–year and orbital variation, and removal of some effects by Radio Frequency Interference.

Since April 2012, JAXA has released new products called JAXA Long–term Sea Ice Concentration Data Set (Figure 1), which includes 33–year sea ice concentration data using SMMR, SSM/I, AMSR–E and Windsat brightness temperature to retrieve and analyze sea ice concentration from 1978 to 2010 (http://kuroshio.eorc.jaxa.jp/JASMES/climate/index.html).

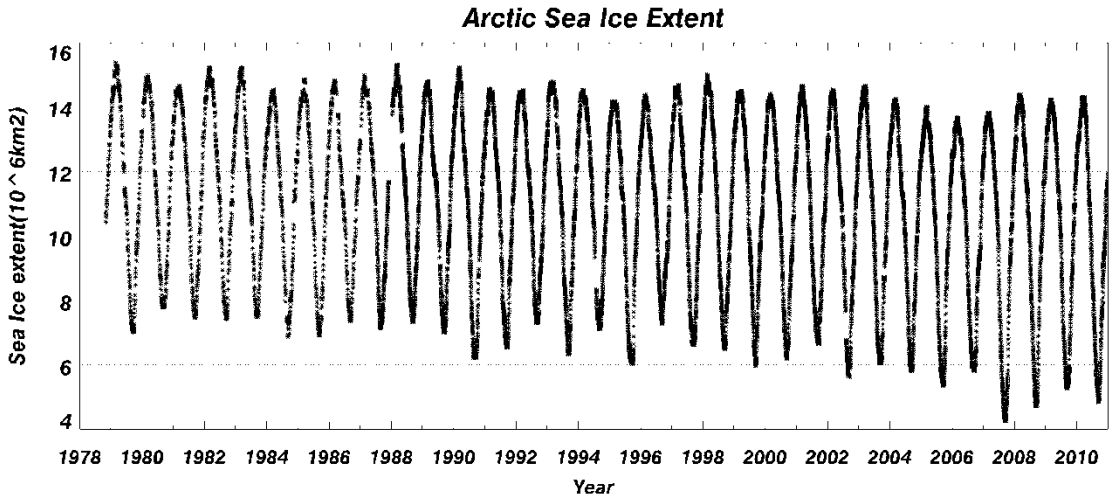

Figure 1: Arctic sea ice extent trend from 1978 to 2010 by JAXA Long–term Sea Ice Concentration Data Set.

2.2 AMSR2 on GCOM–W1 satellite

AMSR2 onboard the GCOM–W1 satellite is multi–frequency, total–power microwave radiometer system with dual polarization channels for all frequency bands. The instrument is a successor of AMSR and AMSR–E. The frequency bands include 6.925, 7.3, 10.65, 18.7, 23.8, 36.5, and 89.0–GHz. GCOM–W1 is scheduled to be launched around 0139JST 18 May 2012.

Standard products of AMSR2 will be distributed through new GCOM–W1 Data Distribution Service system (http://gcom–w1.jaxa.jp) as well as AMSR–E and AMSR standard products, which are already available through that web site.

JAXA plans to deliver AMSR2 data to GCOM–W1 principal investigators (PI) and user agencies, which have agreement with JAXA, for calibration/validation purposes as internal distribution when initial check out phase is completed. Level 1 product will be distributed about 3–month after launch, and Level 2 and 3 products 4–month after launch. To general researchers, JAXA will distribute

products when calibration/validation phase is completed. Level 1 product will be distributed 8–month after launch, and Level 2 and 3 products 12–month after the launch.

2.3 SGLI on GCOM–C1 satellite

SGLI is a versatile, general purpose optical and infrared radiometer system covering the wavelength region from near ultraviolet to infrared. SGLI system consists of two components; SGLI–VNR (Visible & Near infrared push–broom Radiometer); and SGLI–IRS (shortwave & thermal InfraRed Scanner) to optimize optics for each wavelength range. Two major new features are added to SGLI, they are 250 m spatial resolution for 11 channels and polarization/multidirectional observation capabilities. The GCOM–C1 satellite is currently scheduled to be launched in Japanese Fiscal Year of 2015.

The 250m resolution data of SGLI–VNR will enable to detect more fine structure in the coastal area such as river outflows, regional blooms, and small currents SST and ocean color products derived from SGLI will provide additional information to AMSR2 SST.

The engineering model (EM) tests for GCOM–C1 satellite have been performed, and the system Critical Design Review (CDR) will be planned in autumn 2012.

3. Current status of JAXA GHRSST server

3.1 Transfer to GDS2.0

JAXA GHRSST server currently distributes AMSR–E near–real–time L2P data in GDS v1.6 format following instruction by GHRSST Data Processing Specification.

Since autumn 2010, we have been working on update of GDS format version to v2.0 following GHRSST instructions. Since AMSR–E Level 1 Version 3 product has been released in September 2011, and reprocessing of whole period data will be completed in May 2012, we plan to process AMSR–E SST data in GDS v2.0 format after completion of reprocessing.

3.2 Addition of VIRS SST

The SST products by the Visible Infrared Scanner (VIRS) onboard the Tropical Rainfall Measuring Mission (TRMM) satellite is also under preparation to upload to JAXA GHRSST server with GDS format. We completed program to produce VIRS SST in GDS v2.0 format except wind speed field, which cannot be obtained from the VIRS instrument itself and need objective analysis data such as ECMWF. Currently we're waiting to receive ECMWF wind speed data.

3.3 Addition of Windsat SST

After observation halt of AMSR–E, we started to prepare production of Windsat SST data in GDS v2.0 format. SST algorithm for NOAA's Windsat satellite was based on that for AMSR–E, and has been developed and tested since 2008. Latest version of JAXA's Windsat SST binary products has been distributed to some operational users of AMSR–E SST, including the Japan Meteorological Agency (JMA), since November 2012.

We completed program to produce Windsat SST in GDS v2.0 format except sea ice and wind speed fields, which need inputs from other Windsat products processed at EORC in different system. We plan to release Windsat SST in FDS v2.0 format during this year.

3.4 Preparation for AMSR2 SST

AMSR2 SST in GDS v2.0 format will be distributed 12–month after the launch – same as Level 2 standard product. We're preparing program to convert data from HDF5 to GDS v2.0.

4. Activities and Plan for 2012–2016

Currently, we're planning following activities during 2012 and 2016 as shown in Table 1.

Table 1: List of JAXA activities and plans

Year	Activities and plans
2012	Release of Long–term Sea Ice product. Launch of GCOM–W1 satellite. Complete reprocessing of AMSR–E Level 1 standard product. Release of AMSR–E SST in GDS v2.0 format. Addition of VIRS SST and Windsat SST to JAXA GHRSST server. Release of AMSR2 L1 standard product to collaborative users 3–month after launch. Release of AMSR2 SST standard product to collaborative users 4–month after launch.
2013	Update and release of AMSR2 L1 standard product to general users 8–month after launch. Update and release of AMSR2 SST standard product to general users 12–month after launch. Addition of AMSR2 SST to JAXA GHRSST server. Apply AMSR2 algorithm to AMSR–E data to produce continuous data set. Consideration of extension of AMSR2 SST algorithm to other satellite microwave imagers (TBD).
2014	Update of AMSR2 SST algorithm (TBD).
2015	Launch of GCOM–C1 satellite (TBD). Release of SGLI data products (TBD). Addition of SGLI SST to JAXA GHRSST server (TBD).
2016 or later	Launch of GCOM–W2 satellite (TBD).

5. Conclusion

Activities and plans of JAXA are described. Japanese GHRSST members, JAXA, JMA and Tohoku University, are working closely and sharing information regarding satellite instruments and SST data each other.

JAXA GHRSST server has been operating, and continues updating in order to meet requirements from the GHRSST science team. In addition to JAXA instruments, we're extending algorithm to non–JAXA instruments such as VIRS and Windsat. Satellite–based SST data from future missions such as AMSR2 on GCOM–W1 and SGLI on GCOM–C1 will also be distributed to the community.

R31 – REPORT TO GHRSST13 FROM JMA.

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ABSTRACT

After the 12th GHRSST–PP Science Team Meeting, AQUA/AMSR–E SST was excluded from global daily sea surface temperature (MGDSST), and other satellite SST observations were incorporated to MGDSST analysis. In order to improve MTSAT SST, Meteorological Satellite Center (MSC)/JMA developed new processing system for MTSAT SST.

1. Introduction

Office of Marine Prediction (OMP)/ JMA developed a SST analysis system to generate global daily SST data (Merged satellite and in–situ data Global Daily Sea Surface Temperature: MGDSST) in 2004. This SST analysis system produces 1/4°resolution, daily global SST analysis, using both satellite and in–situ SST observation. As an analysis scheme, the MGDSST analysis adopts optimal interpolation (OI) method which considered not only spatial correlation but also temporal correlation. JMA started to implement operational (real–time) analysis of the MGDSST in 2005 using GAC AVHRR SST (NOAA–15 and NOAA16) provided by NOAA, and AQUA/AMSR–E SST by JAXA. By 03UTC each day, the operational analysis of the previous day's (real–time analysis) is available through the NEAR–GOOS Regional Real Time Data Base (RRTDB: http://goos.kishou.go.jp/ registration is required prior to use). The MGDSST analysis contributes to the GHRSST Multi–Product Ensemble (GMPE) median SST.

The MGDSST is used for the regional ocean data assimilation system (Multivariate Ocean Variational Estimation system / Meteorological Research Institute Community Ocean Model for the Western North Pacific: MOVE/MRI.COM–WNP; Usui *et al.* (2006)), in which the MGDSST is used as observation data. MOVE/MRI.COM–WNP well reproduces the ocean states in the seas around Japan and provides better prediction of current and temperature field for one month.The MGDSST is also used as a lower boundary condition in the numerical weather prediction models.

Because the OI method applied in the MGDSST analysis considers temporal correlation, this method requires the observation data after the target day in order to produce the more appropriate analysis. On the other hand, long term, consistent time series of the SST analysis is needed for climate research. For these reason, OMP/JMA implemented reanalysis of the MGDSST from 1985 to 2004 using AVHRR Pathfinder Version 5 SST. After 2005, OMP/JMA reprocesses the observation data to generate the MGDSST data (delayed analysis) in operation with about 5–month delay using GAC AVHRR SST and AQUA/AMSR–E SST. The MGDSST reproduces global SST field well, although high–frequency SST variation is underestimated (Iwasaki *et al*., 2008).

After geostationary satellite MTSAT–1R was launched, Meteorological Satellite Center (MSC) /JMA had generated several types of products, including SST, using observation of MTSAT–1R. In 2009, in order to reduce biases of the MTSAT–1R SST, MSC and OMP/JMA developed new processing system for MTSAT–1R SST based on a method of Maturi *et al.*, (2008). These SST products are included in Monthly Report of Meteorological Satellite Center (CD–ROM; see, http://mscweb.kishou.go.jp/product/library/report/index.htm). After MTSAT–2 was in operation, MSC/JMA started to generate SST product using MTSAT–2 observations instead of MTSAT–1R.

2. Current Status of the MGDSST Analysis

Since October 2011, AQUA/AMSR–E SST was excluded from MGDSST analysis due to completion of its observation. In June 2012, SST observed by MetOp–A/AVHRR (HRPT data) was incorporated to the operational (real–time) analysis of MGDSST. Currently, OMP/JMA uses AVHRR SST (NOAA–18, NOAA–19 and MetOp–A) in order to generate operational MGDSST data. These data are provided by NOAA/NESDIS for Global ocean (GAC data), as well as locally received by MSC/JMA for the western North Pacific (HRPT data).

In the first half of 2012, OMP/JMA implemented reanalysis of the MGDSST from 1982 to 1985 using AVHRR Pathfinder Version 5.2 SST. OMP/JMA now has 30–years (1982–2011) time series of reprocessed SST analysis.

3. Current Status of the MTSAT SST Product

SSTs from MTSAT–1R and MTSAT–2 observations show a good performance for monitoring ocean states. But additional efforts to reduce biases are required for incorporating to SST analysis, since the current method produces MTSAT SSTs with large negative biases in the areas where satellite zenith angles are larger than 50 degrees. MSC/JMA developed a new method for producing MTSAT SSTs using one–dimensional Variational (1DVAR) technique (Kurihara, 2012). The new method includes single layer radiative transfer calculation in order to take into account effects of water vapor absorption and sea surface emissivity.

4. Future Plan

1. It is a highly prioritized issue to incorporate SST observed by microwave radiometer into the operational SST analysis. OMP/JMA plan to use WindSat SST provided by JAXA for MGDSST analysis.
2. OMP/JMA plan to implement reanalysis of MGDSST for the period after 1985 using AVHRR Pathfinder Version 5.2 SST.
3. The new method which improves SST retrieved from MTSAT observation will be applied to operational systems by the end of 2012. How to incorporate new version of the MTSAT SST into SST analysis will be discussed.
4. JMA is preparing *Himawari* 8/9, successor of MTSAT, to be launched in 2014 and 2016 respectively.
5. In collaboration with NWP division of JMA, OMP/JMA discusses about a design of a next generation SST analysis system. In this discussion, requirements from SST users (e.g. NWP group), new satellites (e.g. GCOM–W2, HIMAWARI–8) and progresses in developing analysis scheme will be considered in order to develop the new analysis system.
6. Developing a system to create and deliver MGDSST files of NetCDF version based on GDS–2.0 format is one of the issues to be discussed in these years.

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R32 – ESA CONTRIBUTIONS TO GHRSST

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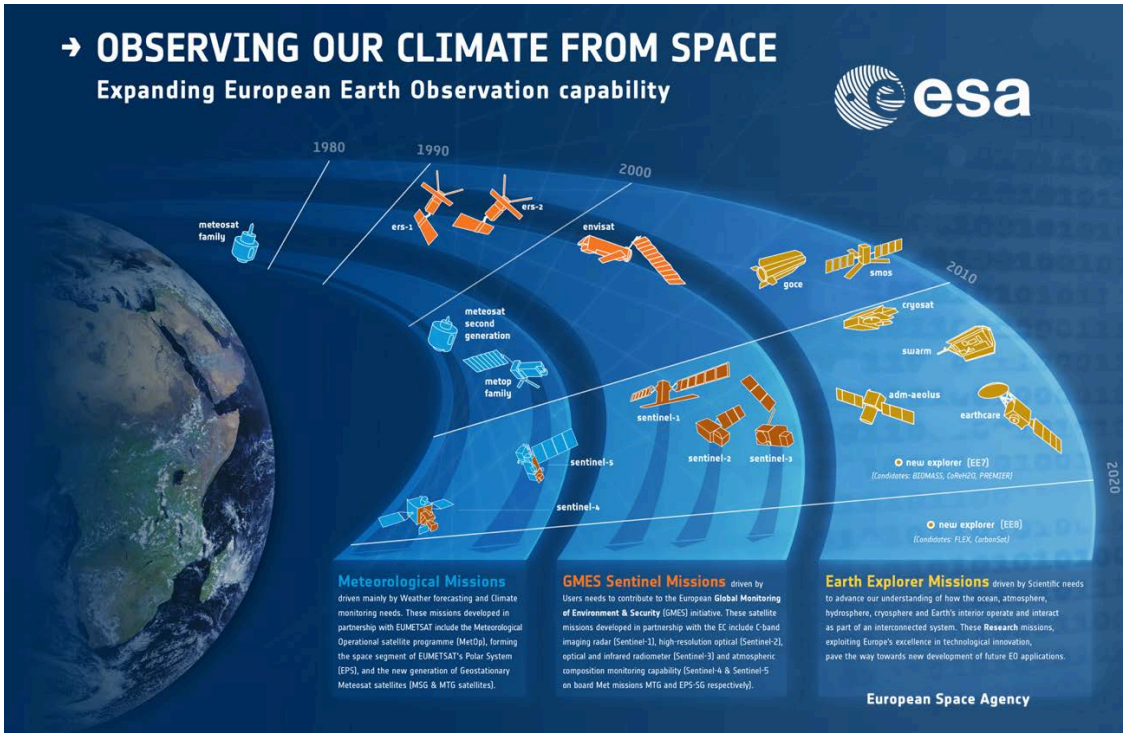
ABSTRACT

The European Space Agency (ESA) has supported the activities of GHRSST for over 10 years and continues to do so in a variety of ways today. This paper provides a summary of current and future ESA activities that contribute to the operation and development of GHRSST. The coordination of international SST activities is a challenging yet profitable investment and ESA remains committed to GHRSST activities. GHRSST helps drive technology developments at ESA to deliver the next generation of satellite SST capability. ESA urges GHRSST improve its relationship with a broad spectrum of users, remain a user–led organization that actively nurtures a strong and productive dialog with users – not just from the scientific and operational communities – but from the end user community – the new users that GHRSST does not yet know.

1. Introduction

ESA has been dedicated to observing Earth from space ever since the launch of its first Meteosat meteorological satellite in 1977. Following the success of this first mission, the subsequent series of Meteosat satellites, ERS–1, ERS–2 and Envisat have been providing us with a wealth of valuable data about Earth, its climate and changing environment. ESA is committed to continue exploring our planet to better understand the Earth system and its processes, especially within the context of global change. As part of this effort, GHRSST is assisting the application of contemporary and historical ESA data and helping to define the next generation of instruments and spacecraft to deliver reference quality SST from space.



ESA's Living Planet Programme comprises a science and research element, which includes the Earth Explorer missions, and an Earth Watch element, which is designed to facilitate the delivery of Earth observation data for use in operational services. Earth Watch includes the well–established meteorological missions with the European Organisation for the Exploitation of Meteorological Satellites (Eumetsat). The Earth Explorer missions are designed to address key scientific challenges identified by the science community whilst demonstrating breakthrough technology in observing techniques. Involving the science community right from the beginning in the definition of new missions and introducing a peer–reviewed selection process ensures that a resulting mission is developed efficiently and provides the exact data required by the user. In addition, the GMES (Global Monitoring for Environment and Security) Sentinel missions, which form part of the GMES Space Component, will collect robust, long–term climate–relevant datasets. Together with other satellites, their combined data archives will be used to produce Essential Climate Variables for climate monitoring, modelling and prediction. This approach gives Europe an excellent opportunity for international cooperation, both within the wide scientific domain and also in the technological development of new missions.

2. The success of ENVISAT AATSR

Just weeks after celebrating its tenth year in orbit, communication with the Envisat satellite was suddenly lost on 8 April. Two potential double–failure scenarios are currently still being investigated:

- a double failure in the power subsystem (most likely) or
- a double failure in Central Communication Unit plus a Safe Mode Failure

The Anomaly Review Board will continue its attempts and analysis with a final conclusion will be provided in July. Following detailed investigations the chances of recovering Envisat are extremely low and the end of Envisat satellite operations was declared on the 9th May 2012. For GHRSST, this marks the end of AATSR operations. AATSR, the only dual–view infrared imager on orbit providing precision SST and has made a significant contribution to GHRSST. The impact of its loss is only just emerging (e.g., see the paper on OSTIA performance degradation by Roberts–Jones et al presented at this meeting). The outstanding performance of Envisat over the last decade led many to believe that it would be active for years to come, at least until the launch of the follow–on Sentinel missions. However, Envisat had already operated for double its planned lifetime. Envisat provided crucial Earth observation data not only to GHRSST but to scientists and many environmental services.

Nevertheless, the historical archive of ENVISAT AATSR is a legacy that will, together with the ATSR–1 and ATSR–2 data sets, provide a precision SSTskin data set from 1992 – 2012. Reprocessing of ATSR–1, ATSR–2 & AATSR datasets up to and including L2P products is planned for 2012 including

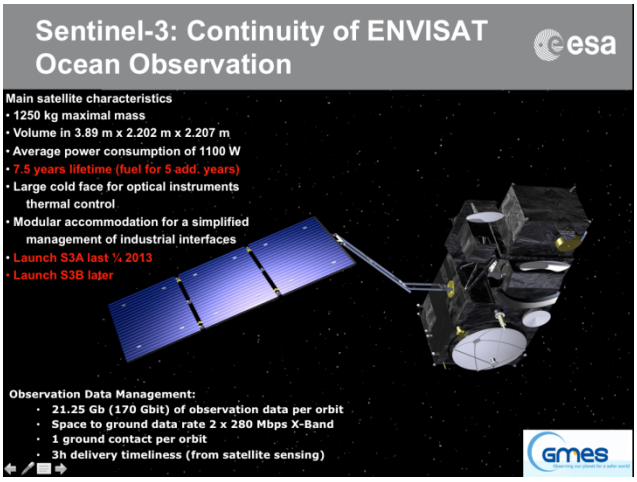
- New L2P processor aligned with ARC will run from reprocessed (A)ATSR L1B data includes improved:
    - Absolute geolocation accuracy (to one pixel)
    - Colocation accuracy
    - Improved, consistent visible channel calibration
    - Improved cloud clearing (within current scheme)
- New L2P processor will then add the following benefits:
    - Improved SST retrieval
    - Better cloud screening

The complete archive of (A)ATSR data will be available in 2012 Q4 through the ftp and MERCI access for full exploitation by GHRSST.

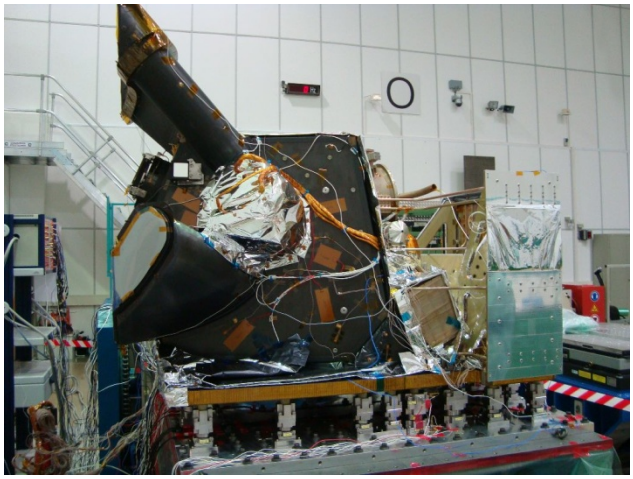
3. GMES Sentinel–3 SLSTR

Now with the end of Envisat's mission, the launch of the upcoming GMES Sentinel satellites, particularly Sentinel–3 which carries the AATSR replacement – the Sea and Land surface temperature Radiometer (SLSTR) has become even more urgent to ensure the continuity of data to GHRSST and other users. SLSTR has been developed to measure SST and Land Surface Temperature with an equivalent baseline performance to ENVISAT A/ATSR. The activities of GHRSST that have demonstrated the necessity of a dual–view high–accuract SST satellite instrument have been important inputs to the definition of the baseline SLSTR design requirements. The SLSTR instrument has been developed with GHRSST requirements clearly in mind that maintains the fundamental concepts and elements of the original ATSR design while addressing some of the notable shortfalls. Improvements include:

- Increased number of spectral bands from 7 to 9 (new bands at 1.3 and 2.2um) for better Ci Cloud detection. All AATSR bands will remain.
- Increased spatial resolution for VIS and SWIR channels (0.5 km @ nadir, TIR 1 km @nadir)
- Two–point on–board blackbody calibration system complemented by a VISCAL.
- Along track scanning with increased swath:
  oblique swath to 740 km
  nadir swath to 1400 km
- 100% overlap with the Sentinel–3 Ocean and Land Colour Imager (OLCI)
- Improved coverage < 4 days global ocean (practically ~ 2 days)
- Dedicated Active Fire channels
- Better timeliness: 3 hours NRT Level 1/2 products
- GHRSST L2P products form Mission conception.



Overview of the Sentinel–3 Spacecraft



The Sentinel–3 Sea and Land Surface Temperature STM.

Sentinel–3A is expected for launch in April 2014 (Sentinel–3B no earlier than 2015) resulting in a significant dual–view IR imager gap due to the failure of ENVISAT. Efforts within the GHRSST and other communities are urgently required to "bridge the gap" between ENVISAT AATSR and Sentinel–

3 SLSTR – one approach will make full use of METOP AVHRR and IASI instruments together with in situ ship–mounted radiometers and other high–accuracy in situ data.

The Sentinel–3 S3 satellite CDR closed–out in Nov–2011 and both Sentinel–3 A & B units are under development. The SLSTR Subsystem AIT is in full progress and will deliver to instrument in Summer/Autumn 2012 for instrument integration and testing. SLSTR Instrument calibration and subsequent delivery targeted for 1st quarter 2013. A full description of the Sentinel–3 mission is available in Donlon et al (2012) and a detailed overview of the SLSTR design in Coppo et al (2010). See also the paper presented at this meeting by Donlon et al describing the SLSTR instrument and Sentinel–3 mission.

4. ESA Support to GHRSST

In addition to satellite data, ESA supports GHRSST through a variety of political, infrastructure, application and science initiatives including:

www.esa.int and earth.esa.int (Satellite data Archives)
www.esa.int/due (Data User Element Application Programme)
due.esrin.esa.int/stse/ (Support to Science Element Science Programme)
www.esa–cci.org (ESA Climate Change Initiative)
www.ceos.org (CEOS SST–Virtual Constellation)

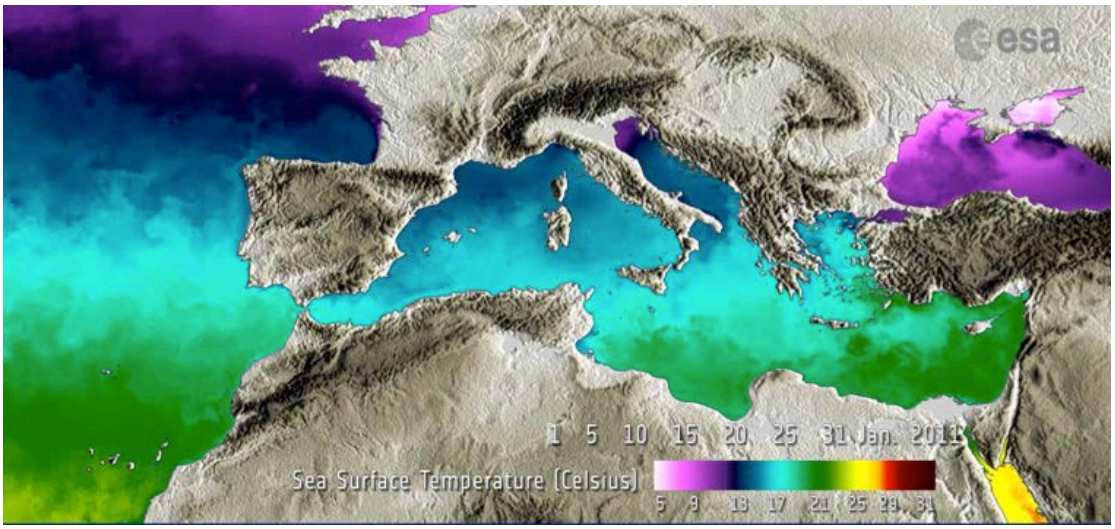
Specific ESA Projects that contribute directly or benefit from GHRSST include:

www.ghrsst.org (Operational and management of the GHRSST Project Office)
www.medspiration.org (Founding GHRSST SST project – still operating today)
www.microwat.org (New satellite mission concepts for passive microwave imagers)
www.globwave.info (Ocean Waves)
www.coastcolour.info (Case–II Ocean Colour)
www.storm–surge.info (Storm Surges)
www.oceanflux–ghg.org/ (Ocean Carbon Flux)
http://polarlow.met.no/stars/ (Polar Low Research and development)
SST_cci – the SST component of the ESA Climate Change Initiative

In addition, funding and support is/has been provided to host GHRSST Science Team meetings, review of GHRSST documentation and the publication of GHRSST documentation.

5. ESA DUE Medspiration

The Medspiration Project is a European initiative, funded by ESA (in the frame of DUE program), to combine sea surface temperature (SST) data measured independently by several different satellite systems into a set of data products that represent the best measure of SST. The Medspiration project started in 2004 and has been delivering a full range of innovative products and services for sea surface temperature (SST), in the context of GHRSST framework for which it was the first operational node. It pioneered the implementation of operational services for SST following GHRSST project recommendation and standards. Medspiration products provide data in the GHRSST GDS form that can be assimilated into ocean forecasting models or used for various kinds of application. Some of the former Medspiration products are now been natively produced under the umbrella of other agencies (including ESA,EUMETSAT,...) or projects (e.g. GMES MyOcean) demonstrating the successful transition from R&D to operations and the success of the GHRSST approach. Today, Medspiration is still improving and delivering new products focusing on the development of high–resolution gap–free maps of SST.



Medspiration is now releasing a new line of high–resolution regional SST maps over several predefined areas, namely Mediterranean sea, Brazil, South–Africa and Great Barrier Reef in Australia. These products are now available and updated on a daily basis, and a full reprocessing over Medspiration era (2005 to today) will occur for the Mediterranean Sea product.

See http://projets.ifremer.fr/cersat/Information/Projects/MEDSPIRATION2 for more details.

6. New SST Instrument concepts

An ESA Support to Science Element (STSE) study called Microwat has been contracted by Astrium SAS. The Study is exploring a future mission concept that responds to the needs of GHRSST passive microwave SST. The study has consolidated scientific requirements and performed a preliminary analysis of different observational principles (real aperture conical scanner, 1D and 2D synthetic aperture) and concepts to measure contemporaneously high–resolution SST and Ocean Vector Winds (OVW). An optimal mission concept has been defined and elaborated that will provide contemporaneous 10 km real aperture SST and 12 km real aperture OVW over the global ocean including coastal and ice infested areas.

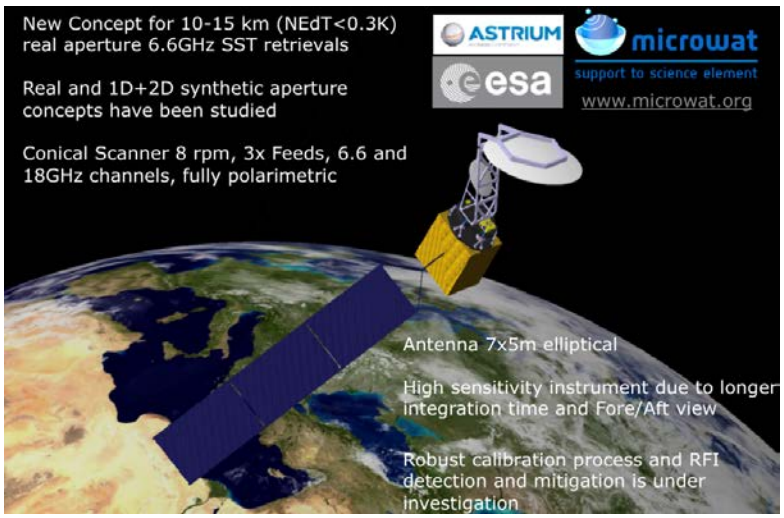


Figure 1: Overview of the ESA Microwat Mission concept to provide contemporaneous SST and OVW at high–resolution (10–15 km real aperture).

Following trade–off analyses, the Microwat concept is a conically scanning multi–frequency passive microwave radiometer using a large (7 x 5 m) rotating elliptical antenna. 3 feeds are used to reduce the antenna rotation rate (essential to manage momentum compensation) and increase the dwell time (and thus NEdT) of the instrument. 6.6 and 18. GHz channels are baseline with optional channels at higher frequencies. The mission uses on–board RFI filtering (in both time and frequency domains) with a direct secondary chain to provide all unfiltered data on–ground. Calibration is based on the use of new Active Cold Loads and noise diode together with external targets.

Follow on studies are now investigating advanced momentum compensation, 1D–pushbroom approaches and alternative interferometric solutions. See http://wwww.microwat.org for more information.

7. Future Activities

Priority GHRSST activities in the coming year include the development of Sentinel–3 SLSTR, continuity of the GHRSST Project Office, evolution and maintenance of the Medspiration Project, full exploitation of GHRSST data and services, contribution of the reprocessed (A)ATSR reprocessed data set, preparation of future projects related to SST (e.g. ESA GlobCurrent that will exploit SST data sets for ocean surface current data sets in synergy with other satellite data (e.g. altimetry, gravimetry, SAR, ocean colour, in situ data, glitter patterns) and the development of a Group for Surface High–resolution Ocean Currents – G–SHOC, see http://cersat.ifremer.fr/News/GlobCurrent–2012 for more information), amongst others.

8. Conclusions

The coordination of a international SST activities is a challenging yet profitable investment and ESA remains committed to GHRSST activities that are: user driven, breed new and innovative applications, conduct innovative science that deliver outcomes. Through these activities, GHRSST helps drive technology developments at ESA to deliver the next generation of satellite SST capability. ESA urges GHRSST to improve its relationship with a broad spectrum of users, remain a user–led organization that actively nurtures a strong and productive dialog with users – not just from the scientific and operational communities – but from the end user community – the new users that GHRSST does not yet know.

9. References

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R33 – EUMETSAT SUPPORT TO GHRSST

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ABSTRACT

The main purpose of the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) is to deliver operational weather and climate–related satellite data, images and products throughout all day and year. EUMETSAT also has commitments to operational oceanography and atmospheric composition monitoring. Activities over the next twenty years include the continuation of the Mandatory Programmes (MSG, EPS) and future (MTG, EPS–SG), which all include ocean observations of SST and sea surface winds. Metop–B is due for launch on 23rd May 2012, with the MSG–3 launch planned for 19th June 2012.

EUMETSAT is participating in GMES Sentinel–3, where EUMETSAT will operate the satellite and will serve the marine user community.

EUMETSAT supervises and coordinates its Satellite Application Facility (SAF) network. There are currently eight SAFs. The EUMETSAT Ocean and Sea–ice SAF is lead by Meteo–France with a consortium of institutes from EUMETSAT member states, and provides reliable and timely operational services related to meteorology, oceanography and the marine environment. The OSI–SAF Continuous Development and Operations Phase 2 began in March 2012.

The continuation of the EUMETSAT Ocean Surface Topography Mapping optional programme (Jason–3 and beyond) will contribute an uninterrupted sea level rise monitoring data set. Work towards access to relevant data from third–parties with the preparation of agreements with ISRO and SOA, will give EUMETSAT access to an enhanced ocean products catalogue. Reprocessing plans at EUMETSAT will also be discussed.

R34 – AN UPDATE ON THE CEOS SST VIRTUAL CONSTELLATION

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ABSTRACT

The first CEOS Sea Surface Temperature Virtual Constellation (SST–VC) meeting will take place 6–7th June 2012 in room 203 at Sanjo Conference Hall, the University of Tokyo – Hongo Campus, Tokyo, Japan, kindly hosted by JAXA. At this inaugural meeting, we will consolidate planning and activities for the coming year and agree on a short report to the CEOS Strategic Implementation Team (SIT) Chair at the close of the meeting. The SST–VC proposal and Implementation plan, both approved by CEOS and the SIT since the last GHRSST Science Team meeting, will form the backbone of the meeting. In particular, understanding how the SST–VC shall be used to pilot activities for the SST CDR together with the CEOS Working Group on Climate and GHRSST is an important aspect of the meeting. The agenda will also include an overview of the CEOS SST–VC; status updates and selection of leads for the elements of its implementation plan; discussion on representatives to monitor issues in CEOS Working Groups, other VC's, and the SIT; and identification of the date and location of the next meeting. All GHRSST Science Team Meeting attendees are welcome to attend the SST–VC meeting and your support is requested as we now implement our new CEOS Virtual Constellation.

QUALITY CONTROL OF SST OBSERVATIONS FROM DRIFTING BUOYS AND SHIPS ON A PER–PLATFORM BASIS

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ABSTRACT

A comparison of Sea Surface Temperature (SST) observations from drifting buoys and ships with high quality SST estimates from the (A)ATSR Re–processing for Climate (ARC) project reveals frequent large errors in individual *in–situ* platform records. Quality control procedures are developed whereby SST observations from an *in–situ* platform are 'tracked' through comparison with some reference SST to identify and reduce these errors. For drifting buoys, bad observations at the start and end of a record, and records that are persistently biased or noisy, are rejected. For ships, blocks of data that are biased or noisy within a record are rejected. From 1996–2010, only 3% of drifting buoy records are found to be well tracked over their lifetime using ARC as a reference. Quality control outcomes from this subset are used to validate those generated using the Met Office Operational Sea surface Temperature and sea Ice Analysis (OSTIA) as a reference. All drifting buoy and ship records (1996–2010) are subsequently quality controlled using OSTIA and an attempt is made to improve outcomes by incorporating OSTIA SST uncertainty estimates. Following quality control, the differences between SST measurements from drifting buoys and ARC, and drifting buoys and Argo floats, are reduced.

REPLACEMENT OF AMSR WITH WINDSAT IN THE NOAA DAILY OPTIMUM INTERPOLATION MICROWAVE PLUS INFRARED PRODUCT

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ABSTRACT

One of the NOAA Daily Optimum interpolation sea surface temperature (DOISST) products combines infrared (IR) and microwave (MW) data from AVHRR and AMSR, respectively. When AMSR–E ceased functioning in October 2011, the AVHRR+AMSR DOISST production was put on hold. Since then, MW–derived SSTs from WindSat have become available. A comparison of AMSR and WindSAT–only DOISST for 2010 suggest that WindSat can be used to continue the MW+IR DOISST series beyond October 2011. WindSat has large time gaps in the early part of the record but availability has improved in the recent period. Furthermore the equatorial crossing times differ. The local time ascending node is 13:30 for AMSR and 18:00 for WindSat, which correspond to different points of the diurnal warming cycle. The bias adjustment step is able to compensate for this. Examples are shown of the OISST products with and without bias correction for each MW satellite.

1. Introduction

The National Climatic Data Center produces daily optimally interpolated sea surface temperature (SST) analyses or DOISST, herein, on a ¼ degree grid by combining in situ and satellite data (Reynolds et al., 2007). One type of DOISST is operationally produced daily and uses infrared (IR) satellite data from the Advanced Very High Resolution Radiometer (AVHRR). This paper is concerned with the second DOISST that uses AVHRR and microwave (MW) satellite data from the Advanced Microwave Scanning Radiometer (AMSR). This second product is also known as AVHRR+AMSR and is available from June 2002 until October 2011, when the AMSR instrument on MODIS–AQUA stopped functioning properly.

Recently, Remote Sensing Systems (RSS) has started distributing SST data from another MW sensor, the WindSat Polarimetric Radiometer (or WSAT; see http://ssmi.com for details). The outstanding question is whether SSTs from WSAT, that has a different design and equatorial crossing time from AMSR, can be used to make a MW+IR DOISST product to continue the time series initiated using AVHRR+AMSR, until AMSR2 data becomes available. WSAT SSTs match up well with buoy data (Gentemann et al., 2011), but the viewing geometry results in slightly less spatial coverage than AMSR (Fig. 1). The local time ascending node is at 13:30 for AMSR and at 18:00 for WSAT. Where scans overlap, RSS makes the daily composite by overwriting older data for AMSR, but retains older data for WSAT.

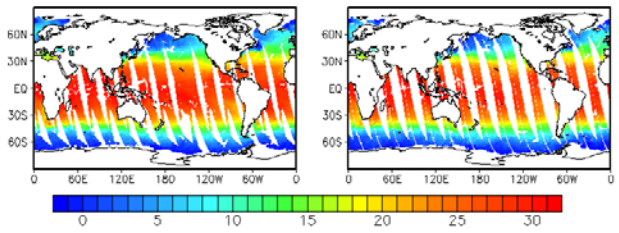

Figure 1: Ascending a) AMSR and b) WindSat L2P data for 21 March 2010 show differences in sun glint pattern and width of interorbital gaps

To establish whether data from the two MW can be used to produce a climate–quality time series, this work compares DOISST fields generated using only AMSR and only WSAT for 2010, the most recent period that a full year's data are available for both instruments. The importance of bias correction to in situ data is also examined.

2. Data and Methods

Buoys and ship SSTs from International Comprehensive Ocean and Atmosphere dataset (ICOADS release 2.5) were used. AMSR and WSAT L2P SST fields were obtained from the MISST website. The OI methodology used, including computation of anomalies, is described in Reynolds et al. (2007), with version 2 updates (Reynolds, 2009). An uncorrected DOISST set was generated by skipping the bias adjustment step. For evaluations, averages and standard deviations were computed.

3. Results

The WSAT DOISST analyses (or WOI) show spatial patterns that are similar to the corresponding AMSR DOISST fields (or AOI), as exemplified by the anomaly mean and standard deviation for March 2010 (Fig. 2a–d). The two averages differ by at most 0.2 C, except in some high latitude areas (Fig. 2e). The WSAT standard deviation is slightly higher (Fig. 2f) because of more spatial and temporal gaps. There are more occurrences of missing orbits for WSAT, especially in the early years. For 2010 which is the focus of this study, 12 entire days are missing in contrast to 2 for AMSR.

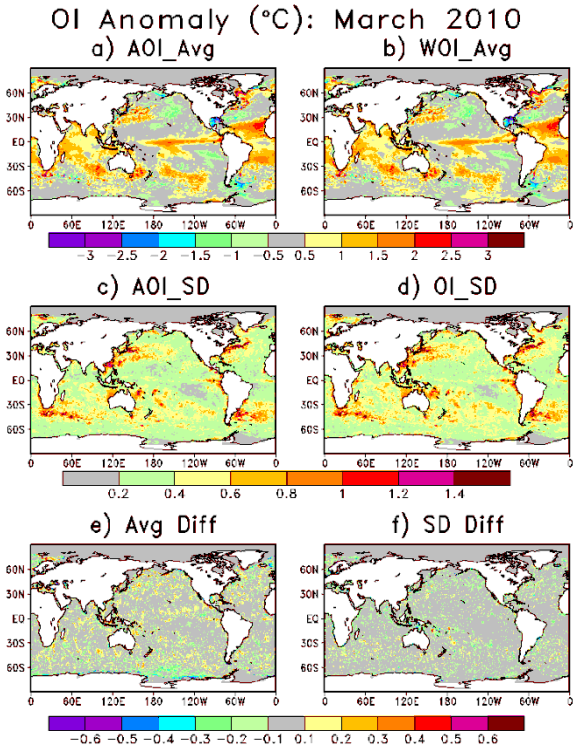

Figure 2: Average DOISST anomaly in March 2010: a) AMSR and b) WSAT. Corresponding standard deviations: c) AMSR and d) WSAT. Difference (AMSR minus WindSAT) of: e) the two averages and f) standard deviations.

Using the standard DOISST methodology that includes bias adjustment, the zonally averaged difference between AMSR and WSAT OISST fields is at most +/–0.1 (Fig. 3). Without the bias adjustment, then the average difference between MW analyses can exceed 0.2 K, and this may vary

seasonally. From 20 to 50 °S, the uncorrected fields differ most in spring and fall. In the Northern mid–latitudes, the greatest difference occurs in boreal summer. The difference is also observed in the tropics, but is smaller.

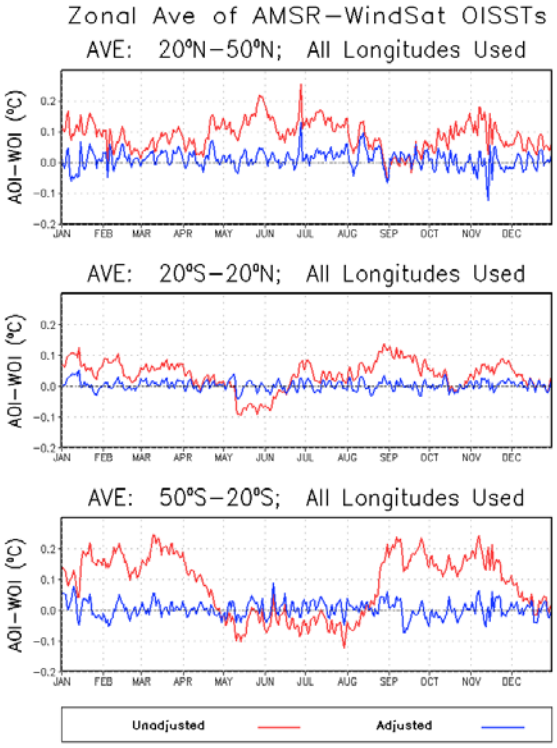

Figure 3: Zonal averages of the difference between AMSR–based (AOI) and WSAT–based (WOI) DOISST with and without the bias adjustment step.

4. Conclusion

For all of 2010, the AMSR and WSAT DOISST fields differed by < 0.1 K on average. This consistency can be attributed to bias adjustment of SSTs prior to interpolation. Thus, a MW+IR DOISST can be generated using AMSR until its demise, followed by WSAT. In high latitudes the MW analyses are less consistent due to lack of in situ data.

5. References

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EVALUATION OF ASSIMILATIVE SST FORECASTS IN THE OKINAWA TROUGH AND GULF OF MEXICO

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ABSTRACT

Regional ocean models assimilate a variety of sea surface temperature (SST) observations to bring their analyses and forecasts into agreement with measured conditions. We examine the skill of forecasts from the Naval Coastal Ocean Model (NCOM) implemented in the Okinawa Trough and Gulf of Mexico. Each of these is guided by satellite and in situ observations using three–dimensional variational assimilation (3DVAR) through the Navy Coupled Ocean Data Assimilation System (NCODA). The impact including various satellite data streams is evaluated by comparing model analyses and forecasts to unassimilated ship and buoy observations.

1. Introduction

Satellite measurements of sea surface temperature (SST) provide one of the most important data streams supporting real time ocean analyses and forecasts. Before including a new SST data stream within an operational data–assimilating forecast system, it must be demonstrated the inclusion has an overall positive impact. Use of more data does not guarantee improved analyses and forecasts. The impact of observations from a particular platform are a function of measurement accuracy, data distribution and uncertainty relative to other observing systems, timeliness, and representativeness for scales and processes resolved by the assimilative system. These impacts vary by time and location and may be positive or negative. Evaluation of products relative to independent in situ observations provides a basis for assessing the impact of various data sources as well as other errors within the forecast systems.

This article focuses on selected evaluations from two regions, the Okinawa Trough (17–34°N,118–134°E) as a region of interest to our Japanese hosts of the GHRSST XIII meeting and the Gulf of Mexico (18–31°N,79–98°W) as the IOOS regions closest to the workplace of the authors. Assimilation and nowcast analyses employ the Navy Coupled Ocean Data Assimilation System (NCODA; Cummings, 2005); forecasts are generated by systems linking NCODA with regional implementations of the Navy Coastal Ocean Model (NCOM; Barron et al., 2006). The models in both have 3 km horizontal grid spacing, use Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) fluxes on the upper boundary, and receive initial (start of experiment) and boundary conditions from the operational global ocean model GOFS 2.6. The SST level 2 data assimilated in these studies is provided by NAVOCEANO and introduced into NCODA via its OCNQC process. Daytime and nighttime SST are assimilated via 3DVAR in a 24–hour update cycle using a first guess from the prior day's NCOM forecast. Section 1 examines the addition of AMSR–E in the Okinawa Trough, while section 2 considers AVHRR and GOES in the Gulf of Mexico. The conclusion extends consideration of diurnal variations and plans for continuing work.

2. AMSR–E in the Okinawa Trough

Ocean model case studies over 2008–2009 in the Okinawa Trough compared cycling NCOM/NCODA systems assimilating altimetry, in situ profiles, and satellite AVHRR SST. Surface drifter and ship observations were withheld to serve as an independent comparison. The data were assimilated using

a first guess at the appropriate time (FGAT) approach to account for temporal variability in the background. The experimental case additionally assimilated SST from AMSR–E while the control did not. Results in Table 1 indicate that inclusion of AMSR–E slightly increased mean bias while slightly reducing RMS error. As AMSR–E is masked near the coast to avoid land contamination of the microwave signal, the statistics in Table 2 are selected using ~330K matchups at least 50 km from land. RMS and bias errors are smaller but continue to show larger bias with smaller RMS error when AMSR–E is assimilated. In both sets of matchups, similarities between analysis and forecast bias and RMS errors show no indications of significant model drift. Work into additional operational bias corrections for the AMSR–E data was suspended when AMSR–E stopped transmitting observations on 10 October 2011.

	Regional NCODA/NCOM (Okinawa Trough), All SST						
	Simulation	AMSR SST Assimilated			AMSR SST Not–Assimilated		
		R	Bias (°C)	RMS (°C)	R	Bias (°C)	RMS (°C)
2008	NCODA Analysis	0.95	0.16	0.99 🟢	0.95	0.05 🟢	1.00
	NCOM 24 Hr Fcst	0.94	0.13	1.01 🟢	0.94	0.04 🟢	1.04
	NCOM 48 Hr Fcst	0.94	0.08	1.04 🟢	0.94	–0.01 🟢	1.07
2009	NCODA Analysis	0.96	0.09	0.93 🟢	0.96	0.00 🟢	0.96
	NCOM 24 Hr Fcst	0.95	0.10	0.99 🟢	0.95	0.01 🟢	1.02
	NCOM 48 Hr Fcst	0.95	0.06	1.02 🟢	0.95	–0.02 🟢	1.05

Table 1: Statistics associated with ~400K matchups between independent analyses and forecasts in the Okinawa Trough and independent in situ observations (OCNQC ship/buoy). Green circles indicate the case with smaller errors.

	Regional NCODA/NCOM (Okinawa Trough), SST > 50 km from Land						
	Simulation	AMSR SST Assimilated			AMSR SST Not–Assimilated		
		R	Bias (°C)	RMS (°C)	R	Bias (°C)	RMS (°C)
2008	NCODA Analysis	0.94	0.16	0.94 🟢	0.94	0.04 🟢	0.96
	NCOM 24 Hr Fcst	0.94	0.13	0.97 🟢	0.94	0.02 🟢	0.99
	NCOM 48 Hr Fcst	0.94	0.08	0.99 🟢	0.93	–0.03 🟢	1.02
2009	NCODA Analysis	0.96	0.09	0.89 🟢	0.96	–0.02 🟢	0.92

	Regional NCODA/NCOM (Okinawa Trough), SST > 50 km from Land					
	Simulation	AMSR SST Assimilated			AMSR SST Not–Assimilated		
		R	Bias (°C)	RMS (°C)	R	Bias (°C)	RMS (°C)
	NCOM 24 Hr Fcst	0.95	0.08	0.94 ●	0.95	–0.02 ●	0.98
	NCOM 48 Hr Fcst	0.95	0.04 ●	0.98 ●	0.95	–0.05	1.01

Table 2: Statistics associated with matchups between independent analyses and forecasts in the Okinawa Trough and independent in situ observations (OCNQC ship/buoy). Green circles indicate the case with smaller errors. Matchups are restricted to at least 50 km from land.

3. GOES in the Gulf of Mexico

Two sources of SST observations are considered in the Gulf of Mexico study: polar–orbiting NOAA AVHRR SST in both its global (GAC) and local (LAC) area coverage, and geostationary GOES SST. The spatial representativeness of these GAC, LAC and GOES measurements is nominally 2.2, 8.8 and 4 km, respectively, as shown in the examples of figure 1. The 30–minute sampling frequency of the GOES observations enables much better coverage than is available from the nominally 12–hour interval between ascending and descending AVHRR swaths.

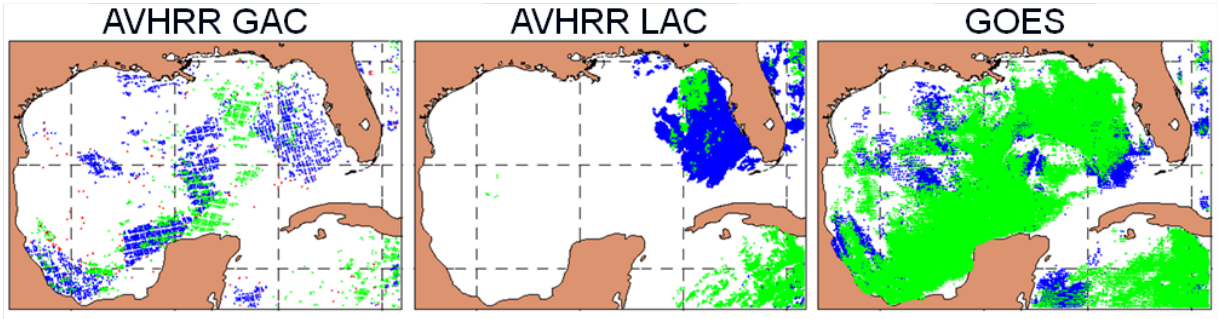

Figure 1: GAC, LAC, and GOES coverage in the Gulf of Mexico on 15 January 2010. Green and blue points indicate day–time and night–time measurements, respectively.

Three NCOM simulations are used to evaluate introduction of GOES into the standard AVHRR–centric input stream of satellite observations. The control case assimilates NOAA AVHRR SST (GAC and LAC), a second case replaces the AVHRR stream with GOES, and a third case assimilates both AVHRR and GOES. All cases additionally assimilate altimeter and in situ profiles but reserve the surface ship and buoy observations for independent validation. FGAT was not used in the Gulf of Mexico cases. The three simulations are initiated from a common 01 December 2009 initial condition regridded from GOFS 2.6. Annual statistics over 2011 (Table 3) show SST bias is <0.1°C warm with RMS error <0.9°C. The differences in bias are mixed, but the RMS errors indicate a preference for the combined data streams. More notable than the differences among the cases is the degradation over the forecast, with the forecast bias about 0.25°C colder than the slightly warm analysis bias. RMS error increases by 0.1°C.

Table heading	AVHRR only	GOES only	GOES + AVHRR
Bias °C (model – observation)			
nowcast	0.07	0.05	0.07
forecast	–0.20	–0.23	–0.21
RMS error °C			
nowcast	0.84	0.88	0.83
forecast	0.96	0.99	0.95

Table 3: Statistics associated with 364336 matchups between Gulf of Mexico SST NCODA analyses, 72–hour NCOM forecasts, and independent surface observations.

4. Conclusion

A seasonal breakdown of the matchups by local time of day provides additional insight into the forecast cold bias. Winter 2010–2011 (Figure 2) and summer 2011 (Figure 3) errors are largest in magnitude during midday to late afternoon. Bias is coolest in late afternoon, suggesting an underestimation of diurnal warming. In addition, biases are near zero in winter but 0.2–0.8°C cool in summer. A possible source of these discrepancies is a low bias in the incoming solar radiation. A 6–hour update cycle or FGAT approach using GOES observations might reduce analysis errors but would be unable to address the forecast bias; 3DVAR assimilation addresses errors in the initial state. A 4DVAR approach that jointly mitigates errors in the initial state and boundary conditions holds more promise in these cases. Alternatively, other methods have been developed to calibrate or adjust surface forcing according to satellite measurements of the terms in the bulk heat flux formulation. Work at NRL is progressing along these avenues in addition to continuing work on incorporating the GHRSST data streams into the Navy ocean forecast systems.

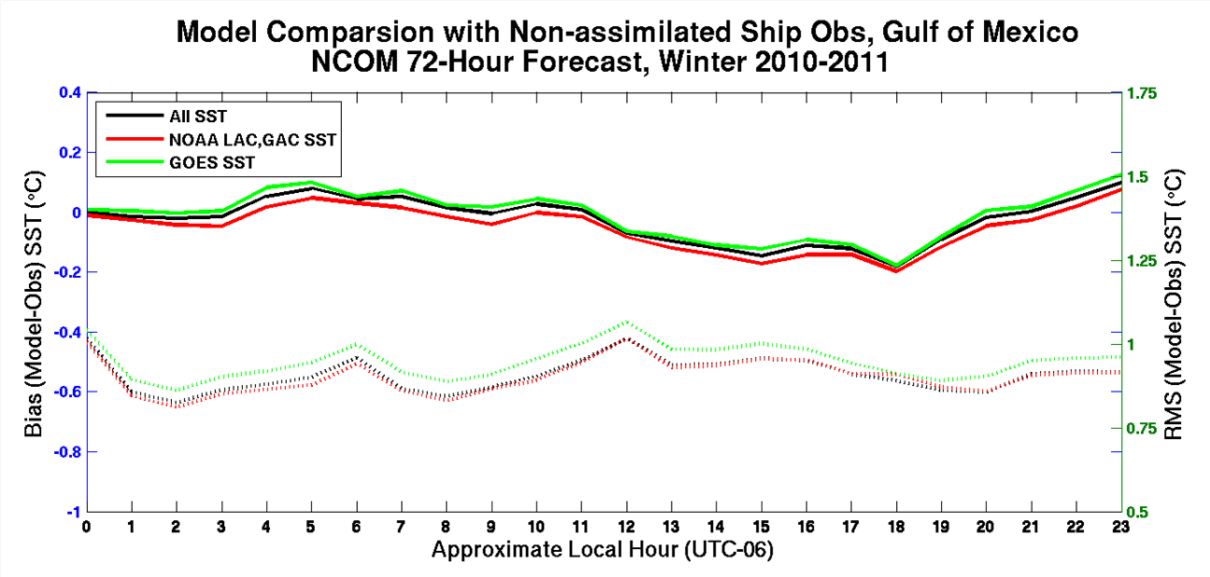

Figure 2: Winter (2010–2011) matchups binned by hour between observations and tau 48–72 forecasts. Bias (RMS error) is shown by solid (dashed) lines with the scale on the left (right).

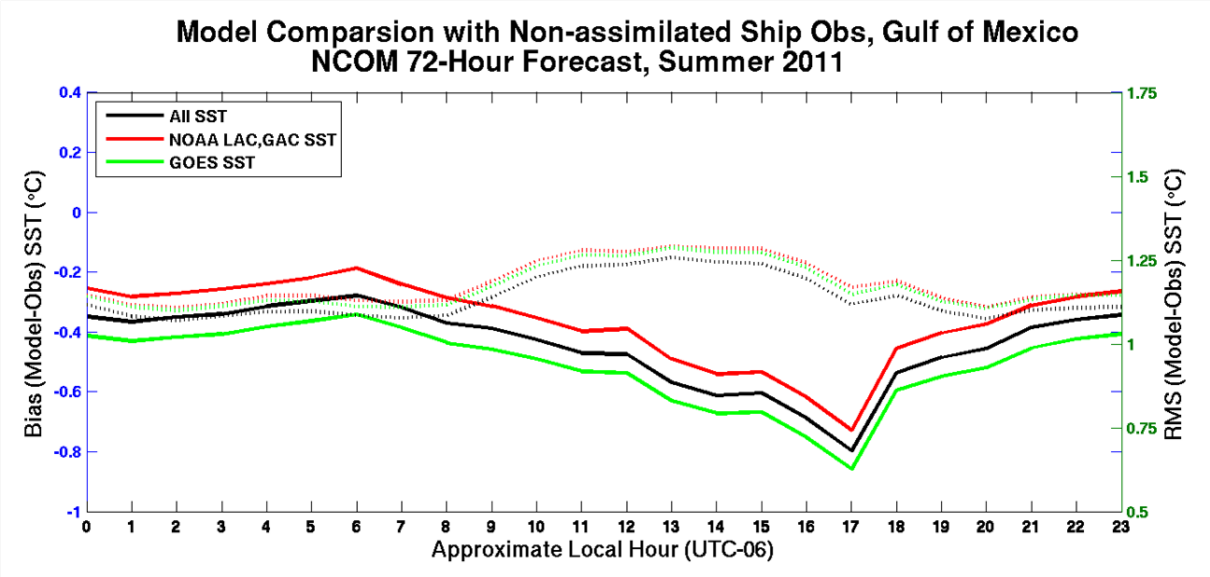

Figure 3: As in figure 2 for summer 2011.

5. References

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UPDATE ON THE GHRSST TROPICAL WARM POOL DIURNAL VARIABILITY (TWP+) PROJECT

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ABSTRACT

Diurnal variations of the sea surface temperature (SST) have important implications for accurate satellite–based SST retrievals and modulation of the air–sea heat flux. An ocean region experiencing particularly high diurnal warming (exceeding 5°C over small spatial/time scales under low wind speed and high solar radiation conditions) is the Tropical Warm Pool (TWP). The "Tropical Warm Pool" is the mass of ocean water located in the western Pacific Ocean and eastern Indian Ocean which exhibits the highest water temperatures over the largest expanse of the Earth's surface. This climatically important region experiences frequent heavy rainfall, strong atmospheric heating, weak mean winds with highly intermittent westerly wind bursts and is of particular importance in the generation of tropical cyclones. It was therefore considered by the Group for High Resolution SST (GHRSST) Diurnal Variability Working Group to be an ideal region to use for a coordinated study of diurnal warming observations and models.

A new comprehensive dataset, the TWP+, has been compiled by the Australian Bureau of Meteorology (Bureau) in collaboration with the Group for High Resolution SST (GHRSST), Australian Integrated Marine Observing System (IMOS), Météo–France, University of Edinburgh (UoE) and Remote Sensing Systems (REMSS) for the study of diurnal variability over the Tropical Warm Pool region. The TWP+ data set comprises satellite and *in situ* SST observations and high–resolution model forecasts of ocean/atmospheric parameters at the ocean surface over the region 25°S to 15°N, 90°E to 170°E for the periods 1 January to 30 April 2009 and 1 January to 30 April 2010. The data set contains gridded satellite skin (~10 μm depth) SST data from infrared radiometers on polar–orbiting and geostationary satellites (AATSR on EnviSat, AVHRR on NOAA–17, NOAA–18, NOAA–19 and METOP–A, Imager on MTSAT–1R), gridded subskin (~1 mm depth) SST from microwave radiometers (AMSR–E and WindSat) on the Aqua and Coriolis satellites, along with SST observations ranging in depth from 20 cm to several metres from drifting and moored buoys and ships. Other SST products included are a gridded, daily, composite of "foundation" (pre–dawn) SST using night–time MTSAT–1R

skin SST data averaged over the hours 10 pm to 11 pm and 4 am to 5 am Local Time and a gridded, daily, gap–free analysis of satellite and *in* situ SST approximating a foundation SST (RAMSSA). Forecast products included in TWP+ are the Bureau's hourly, 0.375° resolution, ACCESS–R Numerical Weather Prediction forecasts of surface parameters (short–wave and long–wave flux, friction velocity, sensible and latent heat flux, wind stress, accumulated precipitation, winds, pressure, air temperature and humidity) and the Bureau's AUSWAM 12–hourly, 0.5º resolution forecast of sea state parameters (significant wave height and direction, wind speed and direction and peak wave period).

All TWP+ data are available to project collaborators in netCDF format from the Bureau of Meteorology OPeNDAP server. Contact h.beggs@bom.gov.au for access. The TWP+ data are currently being used to quantify diurnal warming events and test diurnal variation (DV) models as part of the GHRSST Tropical Warm Pool Diurnal Variability (TWP+) Project. Further information about the project can be found at https://www.ghrsst.org/ghrsst–science/science–team–groups/dv–wg/twp/.

Leon Majewski is responding to TWP+ user comments regarding the v1 MTSAT–1R SST TWP+ data set (produced using separate day/night algorithms) and aims to contribute a consistent day/night two channel MTSAT–1R SST L3 to TWP+ by the end of May 2012.

The DV models currently being investigated using the TWP+ data set are: Gentemann et al. (2003) (Gentemann03), Castro Look–Up Table (Castro LUT), COARE (Fairall et al, 1996), Wick–modified Kantha–Clayson (Wick–KC: Wick et al, 2002), Zeng–Beljaars (ZB: Zeng and Beljaars, 2005), modified version of ZB with the change in the stability function after Takaya et al. (2010) (ZB+T), Generalized Ocean Turbulence Model (GOTM: Burchard et al., 1999) and Kantha–Clayson with sea state (KC + sea state). Helen Beggs, Sandra Castro, Gary Wick and Michael Brunke have used the Gentermann03, Castro LUT, COARE, Wick–KC, ZB, ZB+T and GOTM models to produce gridded netCDF files of either SSTskin – SSTfnd, SSTskin, SSTsubskin and/or SSTdepth over the TWP+ domain and 1 January to 30 April 2010 period. The models used ACCESS–R fluxes and RAMSSA and/or MTSAT–1R SSTfnd estimates as inputs.

The presentation will report on the current status of the TWP+ data set and DV model outputs, and summarise TWP+ results reported during the recent GHRSST Joint Workshop on Tropical Warm Pool and High Latitude Issues, Melbourne, 5–9 March 2012 (https://www.ghrsst.org/ghrsst–science/Meetings–and–workshops/) and obtained subsequently. In particular, it will cover results of validation of both the in situ and satellite SST TWP+ data sets, and their use in quantifying the frequency, amplitude and spatial coverage of diurnal warming events over the TWP+ domain.

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GLOBAL 1–KM SEA SURFACE TEMPERATURE (G1SST): MERGING IN SITU MEASUREMENTS WITH MULTI–SATELLITE OBSERVATIONS

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ABSTRACT

A global 1–km Sea Surface Temperature (G1SST) product is produced in near real–time merging *in situ* measurements with multi–satellite observations. The G1SST data are distributed by the GHRSST Global Data Assembly Center (GDAC) as a Level 4 (L4) data product. This talk/poster will describe the input data sets, including infrared (IR) sensors on both polar–orbiting satellites (e.g., AVHRR, METOP, MODIS) and geostationary satellites (e.g., GOES, MTSAT, SEVIRI) as well as microwave sensors (e.g., TMI), the blending methodology and the validation results. Plans to further improve G1SST will be discussed.

1. Introduction

Sea surface temperature (SST) is a key oceanographic parameter and increasingly being used operationally for research (e.g., studies of eddies, fronts, upwelling, and biological productivity) as well as practical applications (e.g., maritime safety, military operations, ecosystem assessment, fisheries support and tourism). SST is also a key parameter to better understand and predict interactions between the ocean and atmosphere. The quality of the atmospheric forecasting systems depends significantly on the accuracy of the SST being prescribed as the boundary condition.

Although there are many *in situ* measurements of SST from moored and drifting buoys and ships, a truly global coverage is only obtainable from a blended analysis incorporating satellite borne observations. Each SST sensor and platform has its own strengths and weaknesses. The production of an accurate SST is dependent on use of multiple data types, accounting for the individual measurement characteristics, maintaining as much of the information in the observations as possible, and minimizing the “noise” introduced during the blending and interpolation process.

This talk/poster describes a global 1–km SST (G1SST) that is produced daily in near real–time.

2. Input SST Data Sets

Table 1 describes the satellite SST data that are used in the blending process.

Name of Sensor and/or Satellite	Sensor type	Resolution (km)	Typical time data becomes available (US Pacific Time)	Typical number of files per day	Typical size of download per day
TMI	Microwave	25	Next day 5pm to the third day	15	30 MB
AMSR–E* (before Oct. 2011)	Microwave	25	Same day 12am to the 5th day	23	65 MB
AVHRR17_L	Infrared	2.2	Same day 2am to the third day 3am	7	390 MB

Name of Sensor and/or Satellite	Sensor type	Resolution (km)	Typical time data becomes available (US Pacific Time)	Typical number of files per day	Typical size of download per day
AVHRR19_L	Infrared	2.2	Previous day 6pm to the same day 10am	9	550 MB
METOP	Infrared	3	Previous day 6pm to same day 7pm	480	2 GB
GOES11	Infrared	6	Previous day 9pm to the same day 10pm	80	2.6 GB
GOES12	Infrared	6	Previous day 10pm to the next day 11am	90	2.8 GB
MTSAT	Infrared	4	Previous day 5pm to same day 6pm	24	1.2 GB
SEVIRI	Infrared	6	Same day 11pm to the next day 3pm	9	13 MB
MODIS–T	Infrared	1–2	Same day 2am to the 6th day	300	6 GB
MODIS–A	Infrared	1–2	Same day 9am to the 6th day	300	6 GB
AATSR* (before April 2012)	Infrared	1–2	Same day 6pm to the third day	13	200 MB

Table 1: The L2P data sets used to produce G1SST and their major characteristics.

In addition to satellite SST data, we are also using *in situ* SST measurements in the blending process. On the daily basis, there are about 10,000 *in situ* SST measurements. In order to reserve some independent data for validation, we use 80% of the *in situ* SST measurements randomly selected over the world ocean to produce the blended G1SST product, while the rest of the 20% in situ SST measurements are used as the independent data to validate the blended product.

3. Results

The SST data from in situ platforms and multiple satellites are blended to produce the G1SST product. The blending method is based on the 2–dimensional variational (2DVAR) algorithm as described in Chao et al. (2009). A typical daily image from the G1SST blended SST product is shown in Figure 1. The white color represents those areas where there is no 1–km satellite data available during that particular 24–hour period. The gap–free data are also produced and distributed with those white areas filled in with the extrapolated data from the 1–km data in the surrounding areas.

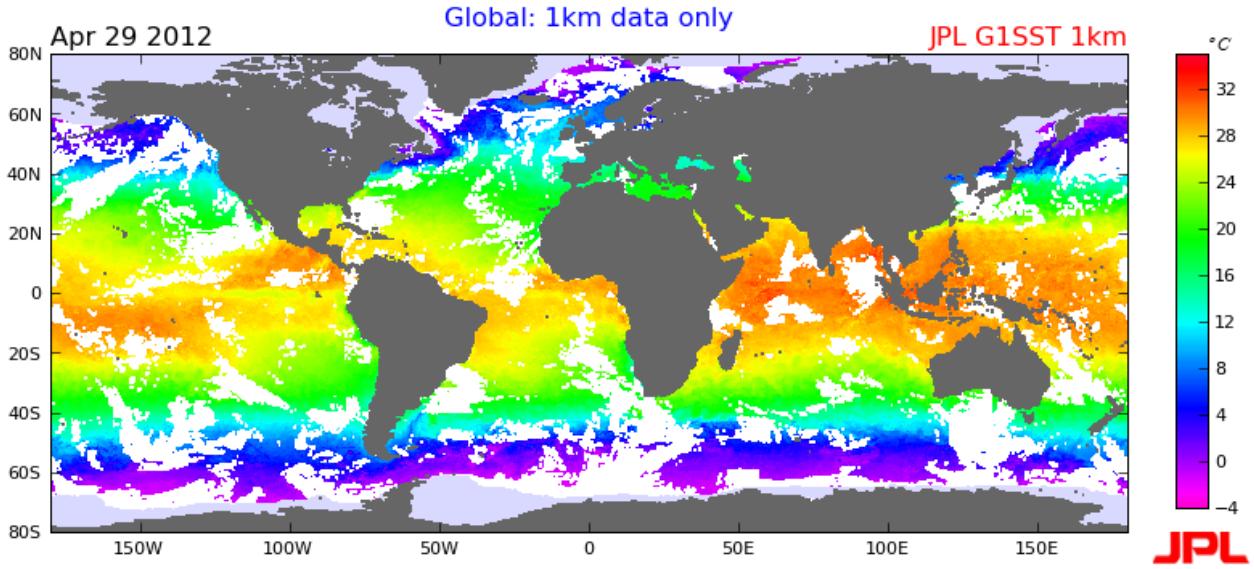

Figure 1: G1SST daily blended SST image on 29 April 2012 blending both in situ measurements and multiple satellite observations.

The G1SST blended SST product is produced daily in near real–time (defined as no more than 24 hours behind real–time). Both images and the digital data are distributed from the G1SST web site (http://ourocean.jpl.nasa.gov/SST) as well as the GHRSST GDAC maintained by the JPL PODAAC (ftp://podaac.jpl.nasa.gov/allData/ghrsst/data/L4/GLOB/JPL_OUROCEAN/G1SST/).

On the daily basis, the G1SST blended SST product is validated against the independent *in situ* SST measurements, which are randomly selected from 20% of the total *in situ* SST measurements during the 24–hour period. On 29 April 2012, a total of 2672 independent *in situ* SST measurements are used to produce the typical validation image as displayed on the G1SST web site (Figure 2). In general, the G1SST product has a very small bias and a RMS error of about 0.7^{o}C.

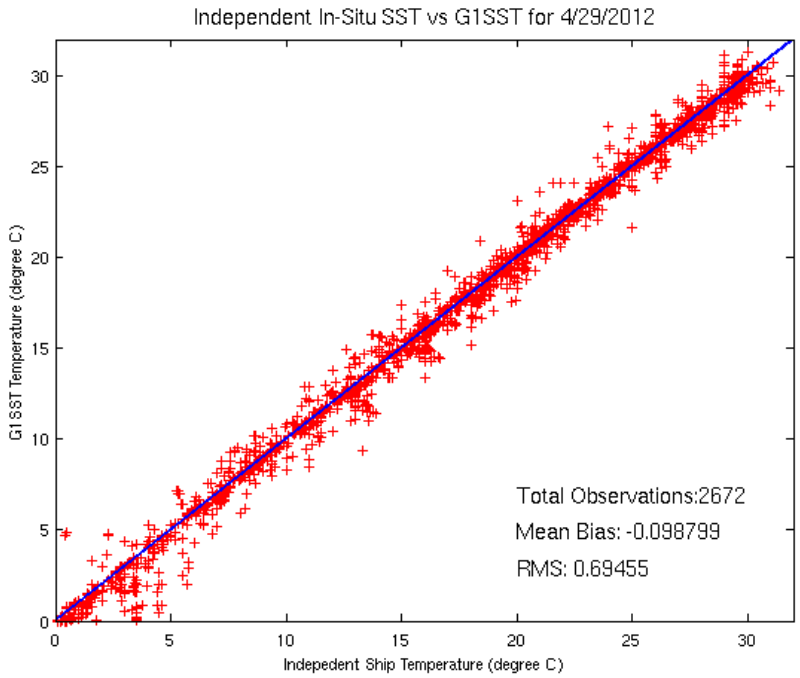

Figure 2: Scatter plot comparing the G1SST daily blended SST with the independent in situ SST measurement on 29 April 2012.

4. Future Work

While the AMSR–E and AATSR sensors stopped providing data, we are planning to add the microwave SST data from WindSat in the near future. The Visible Infrared Imager Radiometer Suite (VIIRS) onboard NASA's newest Earth–observing satellite, NPP, acquired its first measurements on Nov. 21, 2011. We plan to include the VIIRS data as they become available. Using the 2DVAR algorithm, we are in the process of producing three blended SST products at 25–, 5–, and 1–km sequentially so that three sets of error covariance and the associated de–correlation scale can be applied. We also plan to apply the diurnal warming correction as recommended by the GHRSST diurnal warming working group.

5. References

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THE RESOLUTION CAPABILITY OF HIGH–RESOLUTION SST ANALYSES

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ABSTRACT

High–resolution SST analyses generated as part of the GHRSST Project produce global SST fields on grids with resolutions ranging from 1/4° down to 1/20°. These SST analyses are often misinterpreted, both by the producers and by users, as having a feature resolution equal to the grid resolution. Such resolution is clearly not achievable with reliability during periods of persistent cloudiness. The resolution capability of a given SST analysis product can be quantified from the wavenumber spectrum computed from the analysis SST fields and from the wavenumber coherence spectrum between the analysis SST fields and the true SST fields. In practice, however, the true SST fields are not known, in part because of noise in the satellite–based measurements, but primarily because of the inability to obtain high–resolution satellite infrared measurements under cloudy conditions.

The problem of not knowing the true SST is circumvented in the analysis presented here by treating the SST fields from the ECCO–2 model as if they are the true SST. These model SST fields are then subsampled at the times and locations of actual satellite infrared and microwave measurements to produce simulated satellite data. These simulated satellite data are then used as input to the OI procedures of two different GHRSST SST analysis products to assess their resolution capabilities: 1) The NOAA/NCDC 1/4° daily OI analysis; and 2) the 1/20° daily OSTIA analysis.

It is found that the SST fields produced by the OSTIA analysis procedure are smoother than those produced by the NCDC analysis produce. The simulated satellite measurements of SST are thus more heavily filtered spatially by OSTIA than by NCDC. However, some of the small–scale SST variability that is produced under cloudy conditions by the NCDC analysis procedure is fictitious. It thus becomes apparent that an SST analysis can be pushed beyond the resolution capability of the data when and where high–resolution satellite measurements are sparse. The fractional coverage of high–resolution measurements provides a useful metric for assessing when and where small–scale variability in an SST analysis can be considered reliable. It is shown that the coverage must exceed about 50% in order to achieve a squared coherence of 0.5 between the SST analysis and the true SST on wavelength scales between 25 and 50 km.

FIRST YEAR REPORT ON THE COMS SST PRODUCT

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ABSTRACT

South Korean first geostationary multi–purpose satellite COMS was launched on June, 2010. COMS observation data began to be distributed officially from April, 2011. Sixteen baseline meteorological products have been generated from the same time including sea surface temperature. NMSC/KMA evaluated the accuracy and performance of these products and tried to improve them. This presentation is to provide information of COMS SST algorithm and the first year validation report compared with buoy data.

1. Introduction

COMS (Communication, Ocean, and Meteorological Satellite) is the first geostationary multi–purpose satellite of South Korea which has three missions – communication experiment, ocean color monitoring orbit, and meteorological observation from the geostationary orbit. COMS has 5 channel meteorological imager similar to MTSAT and GOES. It was successfully launched in 27th June, 2010, and was located at 128.2°E above the Equator. After the in–orbit test procedures, COMS meteorological observation data began to be broadcast from 1st April, 2011.

From COMS measured data, sixteen meteorological parameters are operationally produced using CMDPS (COMS Meteorological Data Processing System) system. CMDPS products consist of cloud detection, cloud information, cloud top temperature and height, sea surface temperature, land surface temperature, rainfall intensity, fog, yellow dust detection, aerosol optical depth, snow/sea ice detection, upper tropospheric humidity, total precipitable water, insolation, outgoing longwave radiation, clear sky radiance and atmospheric motion vector. COMS products are provided via NMSC/KMA (National Meteorological Satellite Center / Korea Meteorological Administration) website (http://nmsc.kma.go.kr). NMSC evaluated error characteristics and quality of these products for the first year period and this paper present these results.

2. COMS SST algorithm

MCSST (Multi–Channel Sea Surface Temperature, McClain et al., 1985) method is selected as a main algorithm to generate COMS SST (KMA, 2009). Equation of MSCCT is as follows,

$$SST = a_1 T_{IR1} + a_2(T_{IR1} - T_{IR2}) + a_3(T_{IR1} - T_{IR2})(\sec\theta - 1) + a_4$$

here, a1, a2, a3, and a4 are SST retrieval coefficients,

TIR1 and TIR2 are brightness temperature of IR1 and IR2 channels,

and θ is satellite zenith angle.

In COMS algorithm, different SST regression coefficients are utilized at daytime and nighttime. Targeted area of SST producing is Full Disk.

At the beginning, NMSC applied pre–launch algorithm coefficients which are acquired from MODTRAN radiative transfer model simulation using COMS SRF(Spectral Response Function). But it is founded that SST generated from pre–launch coefficients tends to have warm bias, around 1°C and 2.5°C RMSE. So we updated SST algorithm every 3 month by comparison with buoy SST data. Figure 1 shows the scatter plot for COMS and buoy collocation dataset (from April 2010 to January 2011) used in generating regression coefficients.

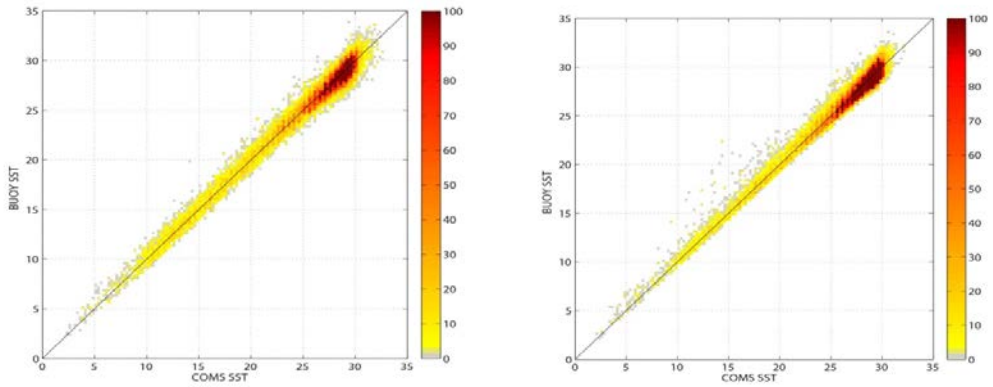

Figure 1: Comparison of (a) daytime, (b) nighttime COMS SST and buoy SST for coefficients estimation between April 2011 and January 2012 (Unit: degree Celsius). The yellow to red colors denote the number of collocation data.

3. Validation

COMS SST was validated in comparison with buoy SST. Spatial and temporal window are 5 km and 30 minutes, respectively, around buoy measuring location and time when making validation collocation dataset. Examples of validation results (on September and December, 2011) are showing in Figure 2, and monthly validation scores are given in Table 1. As shown in Figure 2 and Table 1, COMS first year preliminary validation results showed SST had about 1.5°C negative bias and 3.0°C RMSE through whole 10 months' time period.

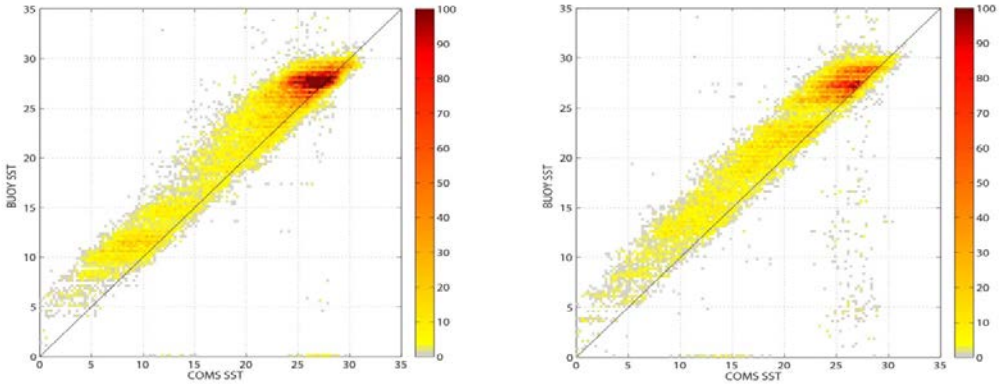

Figure 2: COMS SST validation results by monthly SST compared with buoy at (a) September and (b) December, 2011 (Unit: degree Celsius).

Year	2011									2012
Mon	Apr.	May	Jun.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.
Bias	–1.337	–1.726	–1.667	–1.665	–1.792	–1.680	–1.330	–1.600	–1.753	–1.714
RMSE	3.614	3.006	3.094	2.848	2.741	2.767	3.609	3.381	3.128	3.119
CC	0.870	0.934	0.929	0.932	0.953	0.940	0.858	0.887	0.912	0.911

Table 1: First year validation results on COMS SST compared with buoy data.

As a reference, NMSC compared COMS SST with NGSST. Figure 3 is the image example of COMS SST, NGSST, difference map and scatter plots between COMS SST and NGSST on 5th August, 2011.

It is clear that negative bias and large RMSE are caused from cloud contamination. Under–detection especially in cloud edge should be solved.

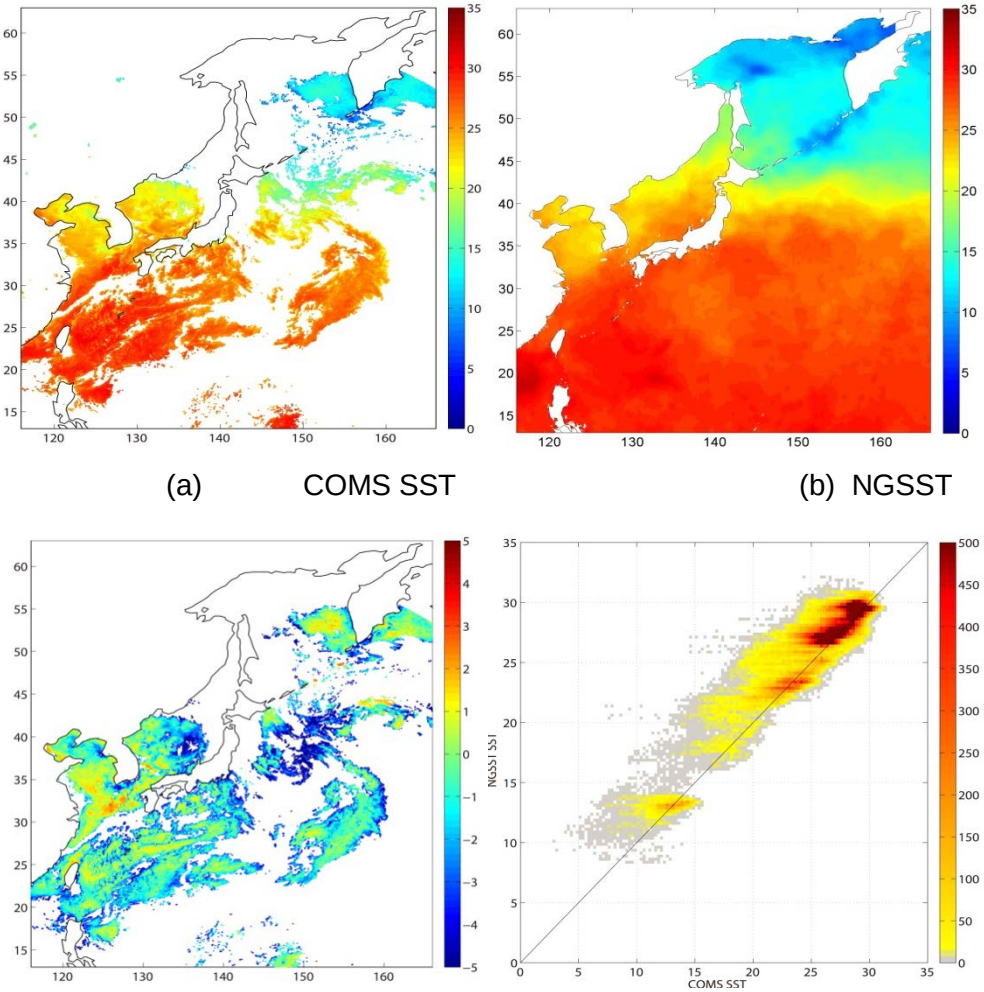

Figure 3: SST comparison on Aug, 5th, 2011 by (a) COMS SST, (b) NGSST, (c) COMS SST – NGSST, and (d) scatter plot. Bias, CC, and RMSE between two datasets are –0.934, 0.933, and 1.765, respectively.

4. Future Plans

NMSC plans to add the additional cloud screening tests for SST retrieval, such as strong spatial uniformity test. In 2011, NMSC will concentrate on the regional optimization for Korean peninsula and vicinity region, and also begin to study composite method with NOAA AVHRR SST and other microwave based SST for regional NWP model application.

5. References

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TRENDS IN THE GLOBAL SST FRONT AND GRADIENT FIELDS

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ABSTRACT

In this presentation we examine the change in front probability and in the distribution of gradients in global fields of AVHRR (Pathfinder) and ATSR (ARC) sea surface temperature. Fronts were identified with the Cayula/Cornillon Single Image Edge Detection (SIED) algorithm and gradients with a simple Sobel gradient operator. The Pathfinder (v5.2) fields are available at approximately 4km resolution and date from 1981. The ARC fields are available at 1/10°, approximately 11 km, and date from 1991. The data for each day in both data sets are separated into nighttime and daytime fields. Preliminary results of the global Pathfinder time series suggest an increase in front probability of 17% for nighttime fields and 13% for daytime fields while the mean gradient magnitude has decreased by about 5% over the same 29 year period; i.e., a shift from strong to weak gradients. There are however some problems apparent in the data raising the question as to whether these changes are a result of instrument artifacts or represent a change in the small scale structure of the global SST fields. In order to address this question, we analyze the ARC data using the same processing algorithms that were used with the Pathfinder data. In this presentation we will discuss the results of this analysis in the context of the Pathfinder results.

NEWER ADDITIONS & TECHNICAL UPDATES TO SQUAM SINCE GHRSST–XII

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ABSTRACT

With ever increasing volume of different level–2 (L2), level–3 (L3) and level–4 (L4) SST products available from different agencies, a major challenge lies in their cross–evaluation and validation against a consistent reference dataset, in a timely manner, and reporting their summary statistics to the community online. Towards this end, the SST Quality Monitor (SQUAM) was established at NOAA NESDIS in 2007.

The monitor comprises three main modules: L2–, L3–, and L4– SQUAM. Currently, L2–SQUAM analyzes five global AVHRR products from NESDIS, NAVOCEANO, and O&SI SAF; L3–SQUAM reports Pathfinder v5.0 SSTs; and L4–SQUAM monitors and cross–compares fourteen products from various countries. These results were presented in earlier GHRSST meetings.

With the advent of newer sensors and generation of newer datasets, SQUAM is continuously evolving to account for these newer products. For example, recently NPP VIIRS and Terra/Aqua MODIS SSTs generated by the NESDIS ACSPO were included in High Resolution (HR) module of L2–SQUAM and work is underway to include the NGST IDPS VIIRS in the same module. In the L4–SQUAM, the JPL MUR data was partly included to provide a quick feedback and will be fully implemented in the next version. L4–SQUAM was also recently documented, along with GMPE, in a two part publication currently in press in a DSR–II special issue. In addition to these data additions, SQUAM graphic user interface was also modified for enhanced user experience.

The presentation will brief on the newer data additions and technical updates with a short online demo, which will help the SQUAM users to navigate later on their own.

THE SENTINEL–3 MISSION: OVERVIEW AND STATUS

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1. Introduction

Global Monitoring for Environment and Security (GMES) is a joint initiative of the European Commission (EC) and European Space Agency (ESA), which aims at achieving an autonomous and operational Earth observation capacity. GMES marks the transition from R&D oriented efforts in earth observation towards operational services. The development of the space infrastructure i.e. the GMES "space segment" for the provision of Earth remote sensing data is led by ESA partly in cooperation with EUMETSAT. Two Sentinel–3 satellites are in development with the second satellite expected approximately 18 months after the first. The overall service duration is planned to be 20 years with several satellites. Currently, the launch of the first Sentienl–3 satellite is planned in 2014. This paper describes the Sentinel–3 Mission and reports its current status.

2. Mission Objectives

Sentinel–3 is an operational mission in high–inclination, low earth orbit for the provision of observational data to marine and land monitoring services [4]. These services include the generation of sea, ice and land surface altimetry products, the generation of land and ocean colour products, the generation of sea and land surface temperature products, and the generation of vegetation products. Full performance will be achieved with a constellation of two identical satellites, separated by 180 degrees in the same orbital plane. This configuration is driven by (i) trade–off between ocean and land coverage requirements and (ii) operational constraints.

The operational character of the mission implies a high level of availability of the data products and fast delivery time, which have been important design drivers for the mission. The Sentinel–3 spacecraft accommodates two large optical instruments – the Ocean and Land Colour Instrument (OLCI) with 21 spectral channels from 0.4 to 1.0μm, and the Sea and Land Surface Temperature Radiometer instrument (SLSTR) with 9 spectral channels from 0.5μm to 13μm in nadir and oblique view directions [1], and a topography payload [2] consisting of a SAR Radar Altimeter (SRAL) and a Microwave Radiometer (MWR) plus a suite of instruments for precise orbit determination (POD). These instruments will ensure the continuation of important data streams established with ESA's ERS and ENVISAT satellites.

The Sentinel–3 mission objectives can be summarized as:

- to provide Ocean and Land colour (reflectance) data, at least at the level of the ENVISAT Medium Resolution Imaging Spectrometer (MERIS) instrument,
- to provide Sea and Land surface temperature measurements, at least at the level of quality of the Advanced Along–track Scanning Radiometer (AATSR) instrument,
- to continue and extend the current set of altimetry measurements at least at the level of quality of the ENVISAT Radar Altimeter (RA).

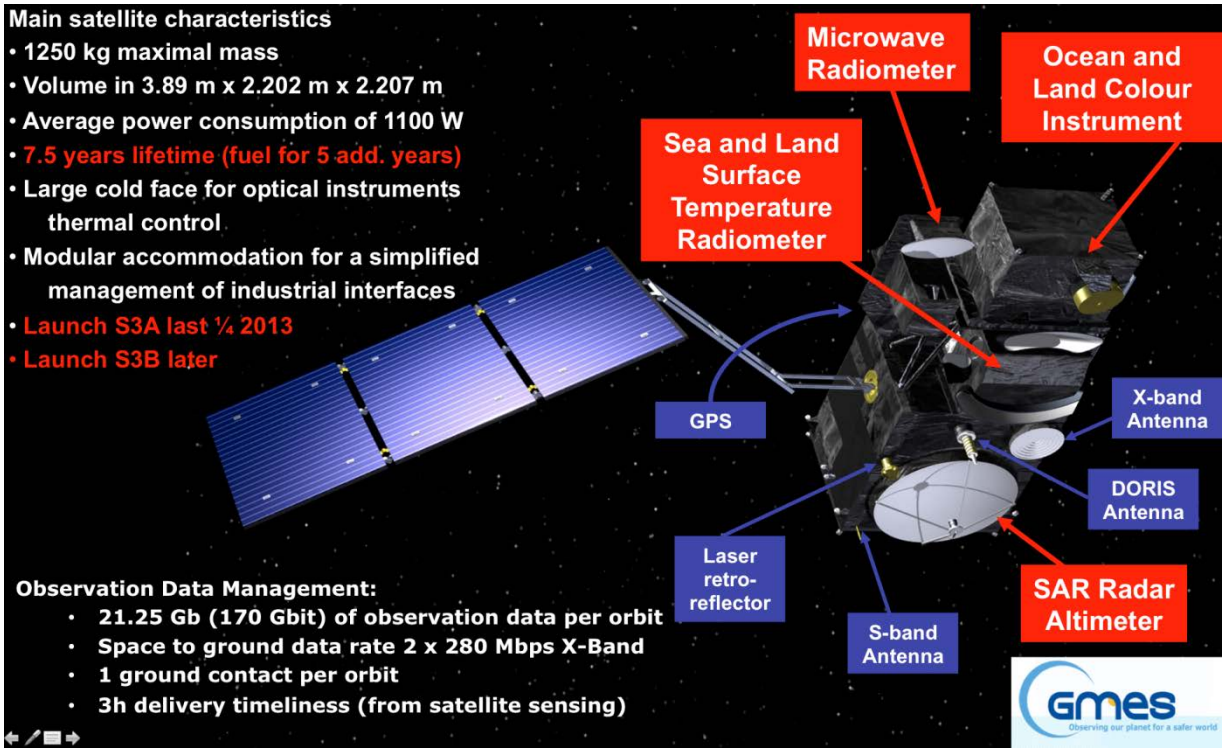

Figure 1: Overview of the Sentinel–3 Mission: satellite and payload.

3. Topography Payload

The dual–frequency (C/Ku–band) nadir looking radar altimeter SRAL performs range measurements over different types of surfaces. Range measurements are sampled with the Ku–band frequency and the C–band observations are mainly used to correct for ionosphere effects. The instrument includes several measurement modes, calibration modes and support modes. The two measurement modes are a low–resolution (LRM) mode and enhanced synthetic aperture radar (SAR) mode. Each measurement mode can be operated either in closed–loop tracking for which the echo is tracked autonomously or in open–loop tracking where the tracking parameters over the targeted surface are derived in real time based on information provided by the onboard precise orbit determination package and the a–priori knowledge of the surface elevation (DEM) stored on board.

The microwave radiometer observations are used to correct the delay of the radar altimeter signal due to the water vapor contained in the Earths atmosphere. It operates at 23.8 GHz and 36.5 GHz covering a bandwidth of 200 MHz in each channel. The radiometer employs a single offset reflector of 60 cm in diameter and two separate feeds for the two channels. Calibration is achieved through a dedicated horn antenna pointing at the cold sky.

The POD package includes a high precision dual frequency GPS receiver, a Laser Retro Reflector and a DORIS instrument.

4. Optical Payload

The primary mission objective of the optical payload is to ensure the continuation of the successful ENVISAT observations of MERIS for ocean colour and land cover and AATSR for sea surface temperature. In addition, due to the overlapping field of view from both optical sensors, new applications will emerge from the combined exploitation of all spectral channels. The combination of

the orbit and the extended instrument swaths for two spacecraft flying simultaneously achieve full ocean coverage within 1.9 days, considering OLCI sun–glint, but not clouds. Land surfaces are covered in just 1.1 days by the common swath of both sensors.

The Ocean and Land Colour Instrument (OLCI) is a push–broom imaging spectrometer, with 5 camera modules to cover the complete field–of–view (FOV) spanning over 68.6 deg. across the satellite track. The design is similar to ENVISAT MERIS with additional and modified spectral channels, different camera arrangements and simplified on–board processing. All data are acquired with a resolution of 300 m at the sub–satellite point.

The Sea and Land Surface Temperature Radiometer (SLSTR), based on ENVISAT's AATSR, is designed to observe ocean and land surface temperatures with an accuracy of better than 0.2 K at a spatial resolution of 1 km. This requires the observation of a given zone using a nadir and an along track view (dual view), with different observation angles. On SLSTR, this is achieved by the implementation of two separate scan mechanisms, providing a large near–nadir swath (~1400 km) and a smaller backwards–looking swath (~750 km). SLSTR accommodates 9 channels, 3 in the visible and near infrared range, 3 in the short–wave infrared range, 1 in mid–infrared range and 2 in the thermal infrared range. The two additional dedicated channels allow fire detection.

5. Data Products

5.1. OLCI Products

The product definition for OLCI follow the heritage from corresponding MERIS products on ENVISAT plus several new parameters on Level 2 to consider new community requirements for Ocean colour data. The first product level 1b for OLCI will be top of atmosphere radiance values.

At Level 2 the product portfolio includes – for water surfaces – water leaving radiances, Chlorophyll–A and Total Suspended Matter estimates as well as several other products – see [3] for a full list of core products. For land surfaces the MERIS Global Vegetation index will be continued in addition to terrestrial chlorophyll estimates – see [3] for a full list of core products.

5.2. SLSTR Products

The Level 1b product combines the top of atmosphere observations of the all 9 spectral channels expressed as radiances for the solar bands, i.e. S1 – S3, and brightness temperature values for the thermal channels S4 – S9.

At Level 2 the products include for water surface high precision estimates of sea surface temperatures as operational continuation of the A(A)TSR instrument series on ERS and ENVISAT. Surface temperature values are also provided for land surfaces in addition to detect and assess fire event with an estimate of Fire Radiative Power. See [3] for a full list of core products.

5.3. Synergy Products

As OLCI and SLSTR provide total overlap for their viewing geometries it is possible to define a new synergy product combing measurements from both instruments. This product, defined as "Level 1c" will include accurate instrument–to–instrument co–registration information allowing the user to work with all spectral channels as provided by one "virtual" instrument and with a choice for an arbitrary output grid. On Level 2 this product will be the basis for products like land surface reflectance and aerosol estimates and opens the door for future synergy products for e.g. coastal applications. See [3] for a full list of core products.

5.4. Altimetry Products

The altimeter product will include the classical surface elevation values both with Ku– and C–band measurements together with the echo waveform data from Level 1 to allow wave height and wind speed estimates. Different tracking algorithms will be used for specific surfaces like coastal regions, sea ice, ice sheets interior and inland water bodies. See [3] for a full list of core products. All altimetry products will be delivered as Near–Real–Time within 3 hours after acquisition with an orbit estimate from the GNSS and DORIS receiver. STC and NTC products will be based on improved orbit estimates with complementary information from DORIS and the laser reflector.

6. Conclusion and Mission Status

GMES Sentinel–3 is a series of operational satellites that will guarantee access to an uninterrupted flow of robust global data products. Together with the other Sentinels, this mission will fulfill the monitoring needs of the GMES marine and land services and climate research communities. The improved design of the topography and the optical payload and the corresponding data products will allow a data continuity the next decade.

Sentinel–3 A & B units are now in development and the S3 satellite CDR was successfully closed in November 2011. SLSTR Subsystem AIT is in full progress and will deliver to instrument in Summer/Autumn 2012 for instrument integration and testing. SLSTR Instrument calibration and subsequent delivery targeted for 1st quarter 2013. Cal/Val and in–orbit verification plans for commissioning phase are now being defined and an S3 Validation team call is expected in late 2012 (this will be an International call). ESA is coordinating the development of the ground segment and flight operations with EUMETSAT who will operate the satellite and manage the marine component of the ground segment. ESA will be the operator of the Sentinel–3 land Mission. Sentinel operations will be funded by the European Commission although final funding of mission operations is not yet finalized. With respect to GHRSST, SLSTR SSTskin L2P will be available from the start of mission operations. The launch of the Sentinel–3A is currently foreseen for Apr 2014

7. References

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HOMOGENISATION OF BRIGHTNESS TEMPERATURES BETWEEN SENSORS TO CREATE STABLE SST FOR CLIMATE

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ABSTRACT

Well established climate monitoring principles highlight the need to exploit the overlap periods to homogenise retrieval products across a series of sensors. This presentation describes how this step has been done within the ATSR Reprocessing for Climate project.

When considering SST time series, an obvious approach is to attempt bias correction of SST. This would usually be done by calculating the relative bias between the sensors during the overlap period on some spatio–temporal scale, and assuming that this relationship can be propagated forward through the mission.

An alternative approach was used in the ARC, and will be used also in the ESA SST Climate Change Initiative (CCI) project. This is to perform the inter–satellite bias adjustments in Brightness Temperature (BT) space before the SST retrieval. In this approach, expected BT differences are calculated by radiative transfer accounting for known instrument differences, and remaining BT differences are viewed as relative biases to be empirically corrected. The biases are parameterised as a function of atmospheric state, which has advantages that we will present.

This method has been applied to the coefficient–based SST retrieval used in the ARC project to homogenise the satellite data record across the three ATSR sensors. It is not an automatic procedure, since choices need to be made based on detailed understanding of the instruments involved, and these steps in the case of ARC will be discussed.

NEW ATSR FULL RESOLUTION L2P USING THE ARC PROCESSOR

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ABSTRACT

As part of the ATSR Reanalysis for Climate (ARC) project, which completed last year, improved algorithms for ATSR SST retrieval and cloud detection were developed. These provide significant improvements compared to the previous operational algorithms: more ocean is correctly flagged as clear, while the rate of large SST biases from unscreened cloud is reduced; and SST retrievals are more consistent between sensors and different channel combinations, showing biases <0.1 K for all regions of the global oceans.

The output from the ARC project was an archive of daily L3 SSTs (gridded at 0.1 degree resolution); however, as a reprocessing activity, ARC had no capability to provide near real time (NRT), nor full resolution (L2P) products.

In co–ordination with the current upgrade of the operational AATSR processing chain, a new project will adapt ARC software to create a new L2P processor, which will become the operational processor after some parallel operations. This will allow users of the L2P data streams to benefit from the algorithms developed for the ARC project. In particular this should benefit L4 analysis such as the Operational SST and Sea Ice Analysis (OSTIA) which use the AATSR L2P as their reference SST field.

The same software will also be used at the NERC Earth Observation Data Centre (NEODC) for reprocessing of the ESA/NEODC (A)ATSR Multi–mission Archive such that a complete dataset of ARC–based L2P files will be available for all three ATSR instruments.

The progress on the ARC L2P will be presented, along with the fit between this project and other activities on the ATSR archive datasets.

ABSOLUTE THERMAL SST MEASUREMENTS OVER THE DEEPWATER HORIZON OIL SPILL

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ABSTRACT

Rapid assessment and continuous monitoring was critical to addressing the changing conditions in the response to the Deepwater Horizon Oil Spill. Airborne, satellite, ship–borne, and underwater sensors were all used with data being assimilated as actionable reports. To assist with the recovery effort and evaluate the utility of new sensors for oil spill response, Ball Aerospace sent a team of scientists and engineers to the Gulf in July 2010. The team deployed on a Twin Otter aircraft with a suite of sensors including a thermal imaging radiometer, ultra–violet to visible hyperspectral imaging radiometer, and a visible high dynamic range context imager. All three sensors were operated at the same time with overlapping fields of view to assist with targeting and characterization of the oil. The ultra–violet and thermal imaging capabilities demonstrated were unique when compared with other airborne sensors flown over the spill. The use of these varying data sets allow for cross comparison which provides determination of false signals as well as characterization of the properties of oil on the water. Absolute calibration and validation of these sensors is needed to enable comparisons of temporally separated data sets and provide accurate information to response personnel. Both optical and SAR satellite images were examined for the Gulf of Mexico oil spill. In the optical spectral range imagery from the WorldView 2 satellite operated by DigitalGlobe was utilized while SAR imagery was collected by the TerraSAR–X, COSMOSkyMed (also X–band) and the ENVISAT Advanced SAR (ASAR, C–band). This combination of optical and radar imagery proved very useful in being able to map oil features on the surface of the Gulf of Mexico. Results of the thermal measurements are presented along with a discussion of the other sensor data used to eliminate false signals including UV–Vis hyperspectral and satellite SAR and multispectral data.

LAKE SURFACE WATER TEMPERATURE IN THE OPERATIONAL OSTIA SYSTEM

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1. Introduction

Operational analyses of Lake Surface Water Temperature (LSWT) have many potential uses including improvement of Numerical Weather Prediction (NWP) models on regional scales. On 24 November 2011, LSWT was included in the L4 UK Met Office Operational Sea Surface Temperature (SST) and Sea Ice Analysis product, OSTIA, for 248 lakes globally. Prior to this, the Caspian Sea was the only lake included in the OSTIA land mask. The LSWT is included as part of the SST field and, similarly, is a foundation temperature on a $1/20^{o}$ grid.

2. Methodology

A full description of the OSTIA system is provided in Donlon et al. (2012). The OSTIA LSWT analysis method used here is the same as that for the SST, so factors such as error covariances and length scales have not been optimised for lakes. However, this method provides a starting point for future development work.

LSWT data is routinely available as part of GHRSST L2P SST products used in OSTIA (MetOp and NOAA AVHRR, IASI, plus AATSR until the recent failure of Envisat). This LSWT data is based on SST retrieval algorithms and does not include any lake–specific processing. This introduces errors into the retrievals owing to factors such as:

- The use of cloud–clearing schemes optimised for oceans
- The elevation and continental location of lakes, which affect atmospheric thickness, water vapour column and aerosol corrections
- Uncorrected surface emissivity (salinity dependent)

Other factors which also contribute to errors in LSWT analyses include sparse observations, particularly in cloudy regions, and coastal contamination. However, these observations are currently the only near–real–time satellite observations of lakes available. In–situ data for lakes are also available, through the Global Telecommunication System (GTS). Over 80% of these in–situ data are located in the North American Great Lakes (from ship and moored buoy platforms).

A skin effect of a similar magnitude and variability to that found in oceans is also observed in lakes (see Fiedler et al., 2012 and references therein for details) so, similar to the OSTIA SST analysis, only data from nighttime or where the wind speed was greater than 6 m s^{-1} are used.

The OSTIA land/lake mask is that defined by the ESA ARCLake project at the University of Edinburgh (MacCallum and Merchant, 2011). This mask has been adopted for practical reasons since the ARCLake climatology has been used in the OSTIA LSWT processing for the relaxation of the background field step. The ARCLake mask includes lakes with a surface area greater than 500 km^2, plus an additional 10 lakes. 248 lakes of the full ARCLake 263 have been included in the OSTIA mask, as climatological information is not available for all of the lakes.

3. Accuracy of OSTIA LSWT analysis

An assessment of the accuracy of the OSTIA LSWT analysis was conducted using a delayed–mode run for June/July/August 2009, using in situ, AATSR, MetOp AVHRR, and NOAA–18 AVHRR LSWT

observations. Nighttime AATSR data from the ESA/Univ. Edinburgh ARCLake LSWT dataset (MacCallum and Merchant, 2011) were used to validate the OSTIA LSWT analysis. The ARCLake observations are produced using retrievals with lake–specific coefficients, a cloud–clearing scheme designed for lakes, and a salinity dependent emissivity, which make this dataset the best available global satellite observations of lake surface temperature. The difference in the retrieval algorithms used means the ARCLake AATSR observations can be considered independent from the AATSR observations assimilated into OSTIA.

	OSTIA–ARCobs		**ARCclim–ARCobs**		**Mean daily num. ARCobs**
Location	**Mean Error (K)**	**RMS Error (K)**	**Mean Error (K)**	**RMS Error (K)**	
Global	0.65	1.31	0.00	1.78	4453
Great Lakes	1.31	1.78	0.45	2.13	822
Lake Victoria	0.40	0.44	0.08	0.29	137
Lake Baikal	1.83	2.76	1.21	2.11	140

Table 1: OSTIA LSWT minus ARCLake observations and ARCLake climatology minus ARCLake observations for June/July/August 2009.

Statistics averaged over the three month period are summarised in table 1 and demonstrate that OSTIA has a global accuracy of 1.31 K and a bias (mean error) of 0.65 K. It should be noted that, as OSTIA is a foundation temperature and ARCLake is a skin temperature, the bias includes a cool skin effect of ~0.2 K (MacCallum and Merchant, 2011) so will be smaller than this value implies. However, the bias is still larger than ideal and indicates the OSTIA bias correction (which uses AATSR and in situ data) could be improved, for example by using the ARCLake processing for the AATSR data. For the near–real–time operational OSTIA system, the loss of data from the AATSR instrument aboard the Envisat satellite means that only in situ data are currently being used in the OSTIA bias correction scheme.

Generally, the RMS error for OSTIA minus ARCLake observations is better (lower) than for the ARCLake climatology minus ARCLake observations. This demonstrates that, overall, OSTIA is more accurate than climatology at capturing the day–to–day variations in global lake surface temperatures. The threshold accuracy requirement of the OSTIA SST analysis is 0.8 K (with a target of 0.5 K). 1.31 K for LSWT does not meet this requirement, but the results indicate that use of the analysis would remain an improvement over using climatology. The accuracy of the OSTIA LSWT analysis is poorer than for the SST (at 0.55 K, Donlon et. al, 2012). This result is expected owing to the use of retrieval algorithms and analysis techniques optimised for SST and not LSWT.

Therefore, it follows that large lakes at elevations near to sea level would be expected to give the best results as they approximate the seas the retrieval algorithms are designed for. Figure 1(a) indicates that LSWT analyses for lakes with surface areas greater than 3000 km^2 (blue squares) and elevations below 2500 m (black dots) generally have a positive bias. The LSWT for higher altitude, smaller lakes may contain compensating errors, thus reducing the bias. Figure 1(a) indicates higher altitude lakes (above 2500 m, red triangles) are likely to have a negative bias, where the bias of this group of lakes is statistically significantly different at the 0.05 level to lakes at lower elevations.

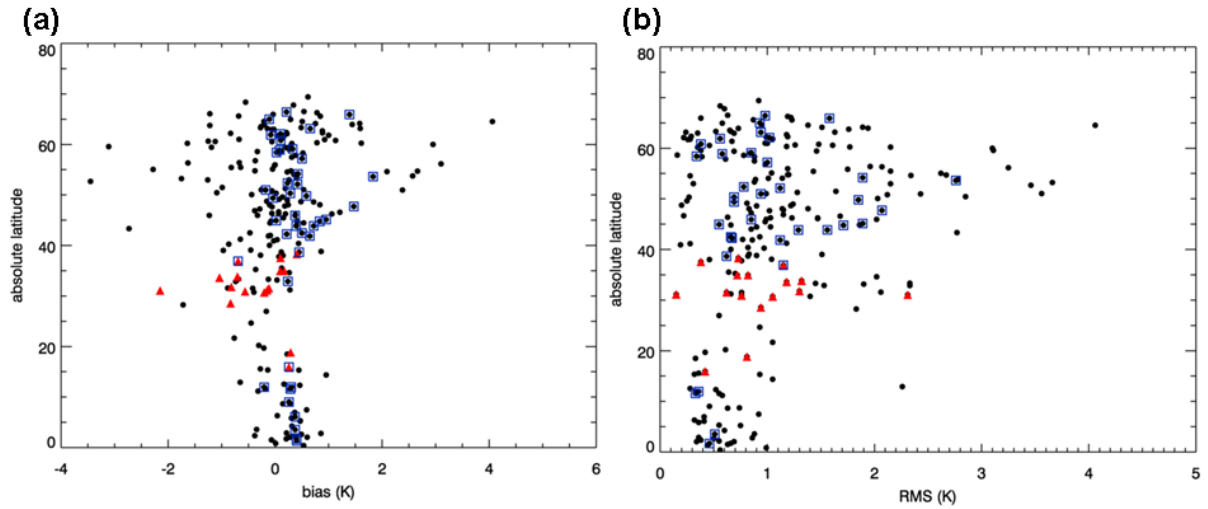

Figure 1: OSTIA LSWT analysis minus ARCLake nighttime observations (a) bias, (b) RMS error. JJA 2009 average, with absolute latitude (disregarding hemisphere). Each point represents a lake.

red triangle = elevation >2500 m
black dot = elevation <=2500 m
blue square = surface area also >3000 km^2

Figure 1(b) illustrates there is also a statistically significant difference between the RMS of lakes with latitudes above 30° (1.41 K) and below 30° (0.74 K); a relationship which is not found for the bias (figure 1(a)). Lakes located at latitudes below 30° are known to have smaller temperature cycles (see Fiedler et al., 2012, and references therein), meaning it is easier to capture their temperature variability in an analysis. There is little obvious relationship between RMS error and lake area or elevation (figure 1(b)). In addition, no relationships were found for the RMS error and bias with lake depth or volume. It was found, as might be expected, that a greater number of daily observations generally contributed to a smaller RMS error for a lake, independent of the size of that lake.

The metadata used (area, elevation, depth etc.) was collated by the ARCLake project (thanks to Stuart MacCallum for providing the data).

4. Summary and Conclusions

- LSWT included in operational OSTIA product on 24 November 2011 for 248 lakes
- LSWT analysis produced in same way as SST analysis, using in situ and GHRSST L2P satellite data
- Retrievals are optimised for SST so some inaccuracies when used for LSWT, but the only near–real–time satellite data source available
- Accuracy of OSTIA LSWT for JJA 2009 assessed against independent observations (ARCLake). Positive bias (~0.2 K) expected due to skin–bulk difference
- OSTIA LSWT has global accuracy of 1.31 K (RMS error) and bias of 0.65 K (OSTIA minus ARCLake, including skin–bulk error of ~0.2 K)
- OSTIA LSWT improvement over use of climatology to capture day–to–day variation in global lake temperatures

- Analyses for lakes which approximate seas (large, low elevation), and are therefore expected to produce best results, generally have positive biases
- Analyses for lakes within 30° of equator and with greater number of observations are more accurate (lower RMS errors)
- More detailed analysis available in Fiedler et al. (2012), including detailed case studies of particular lakes

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FILLING OF SEA ICE TIMESERIES GAPS USING A SIMPLE DATA ASSIMILATION METHOD

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ABSTRACT

The OSI–SAF global sea ice concentration reprocessing dataset will be used as the sea ice data source for the planned ESA SST CCI (Climate Change Initiative) reanalysis using the UK Met Office Operational SST and Ice Analysis (OSTIA) system. There are gaps in the daily OSI–SAF dataset resulting from lack of available data or rejection of poor quality data through our own quality control procedures. Using a simple data assimilation method, a new ice concentration field for each day of the gap is produced using ice concentration and error information provided in available OSI–SAF files at the start and end of each gap. The validity of this method is demonstrated through successful recreation of ice concentration fields for which data is available.

IN SITU MEASUREMENTS OF SKIN SST IN THE CHINA SEAS

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ABSTRACT

Sea Surface temperature (SST) is an essential indicator for climate change. High accuracy and stability of the satellite SST products are required for long–term climate data records of global SST. It is important to routinely collect in situ SST measurements for the evaluation and improvement of the quality of satellite SST products. The infrared SST autonomous radiometer (ISAR), made by the University of Southampton, has been deployed on the research vessel Dong Fang Hong II of Ocean University of China since September 2009. The R/V Dong Fang Hong II operates mainly in the China Seas including Bohai Sea, the Yellow Sea, the East China Sea and the South China Sea, for about 300 days per year. The skin SST measurements were collected during 18 cruises in the China Seas from 2009 to 2011. The satellite SST products are compared with shipboard measurements of skin SST. The results will be presented and discussed.

MULTI–SENSOR SATELLITE SST VALIDATION AND BIAS ADJUSTMENTS IN THE ARCTIC OCEAN

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ABSTRACT

The extreme atmospheric and oceanographic conditions in the Arctic Ocean result in elevated errors on satellite sea surface temperature (SST) observations in this region, compared to other regions of the global ocean.

The use of one satellite sensor, such as the AATSR, as a reference against which the other products can be referenced, does not work optimally in the Arctic Ocean. The presentation will therefore focus upon a new technique to perform a high latitude multi–sensor bias adjustment of satellite sea surface temperature. The technique is tested using 6 of the most widely used global satellite products from Infrared (AATSR, AVHRR and Modis) and Microwave (AMSR–E) sensors and has been derived taking into account the detailed error characteristics of each of the satellite products.

A test data set has been constructed for one year and the impact of the multi–sensor adjustment method has been assessed against independent in situ observations. In addition, examples will be shown on the bias correction fields obtained for Metop–A and simulated bias correction fields obtained using Numerical Weather Prediction output and radiative transfer modelling.

The improvement of using the new bias corrected fields in an Arctic Level 4 analysis will also be demonstrated through the use of the operational DMI Optimal Interpolation data processing system, which is similar to the operational Arctic level 4 SST product delivered in the MyOcean SST TAC.

1. Introduction

Sea surface temperature observed from satellite is one of the key variables in the present global observing system and is fundamental for understanding the fluxes and interactions between the atmosphere and oceans. The Arctic Ocean is a region with persistent cloud cover and extreme atmospheric conditions, which results in elevated satellite SST errors in this region. Inter–sensor bias corrections will therefore be particular valuable here, but the single sensor (AATSR on ENVISAT) bias correction method does not optimally in this region.

There is thus a need for a multi–sensor bias correction approach within the high latitude satellite SST observations to improve the quality of the satellite SST observations and to improve the results when assimilated into hydrodynamical models with assimilation schemes requiring bias free observations. The objective of this work is to validate satellite observations and develop a new multisensor bias correction method to be used within the operational MyOcean SST level 4 production schemes at DMI and Met.no.

The specific objectives pursued within this project were:

Development of a new multi–sensor bias correction method

Perform error characterization of individual and collated products

Creation of complete maps of SST and difference fields with error estimation.

2. Observations

The satellite fields data from the DMI Level 4 processing system (ARC_0.05) have been used to verify the results obtained using the SABIA data set (see e.g. LeBorgne, 2011a,b) and to test improvements on the operational Level 4 setup for the MyOcean Arctic region. The DMI L4 data covers the entire Arctic region in a 0.05 degrees spatial resolution and is called ARC_0.05. An example of the coverage of the product is seen in Figure 1:

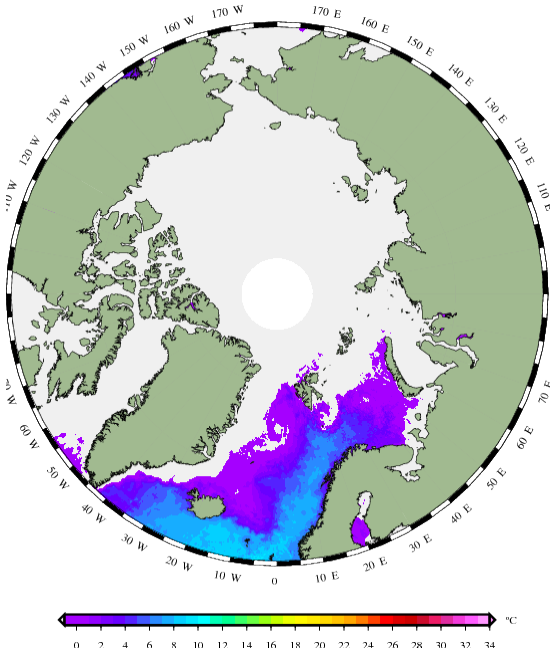


Figure 1: The area covered by the DMI level 4 SST product for the Arctic region. The area is identical to the MyOcean SST product for the Arctic.

Daily fields are obtained from the operational setup, covering the period from January 20th 2008 to December 31st 2008. The ARC_0.05 pre–processing produces one daily level 3 SST file per sensor from averages of the available Level 2 satellite observations from 21.00 to 07.00 local solar time.

The satellite products are listed in Table 1:

Product name	Data provider	Satellite	Sensor	Observation technique	Data grid (km)
NAVO–GAC	Naval Oceanographic Office, USA	NOAA 18	AVHRR	IR	9
AATSR	ESA/UK–MM–PAF	ENVISAT	AATSR	IR	1
Metop–A	EUMETSAT/OSI–SAF/Meteo France	Metop–A	AVHRR	IR	~5
MODIS	NASA/JPL/OBPG/RSMAS	Aqua	MODIS	IR	1
MODIST	NASA/JPL/OBPG/RSMAS	Terra	MODIS	IR	1
AMSR–E	Remote Sensing Systems	Aqua	AMSR–E	MW	25

Table 1: Characteristics of the infrared (IR) and microwave (MW) satellite observations used in the study. See (Høyer at al., 2012) for more details on the data providers.

The in situ observations applied in this project consist of drifting buoy observations obtained from the GTS system. These data are not included in any of the OI products and can therefore be used throughout the project as an independent validation data set.

An initial validation of these products were carried out, where the level 2 observations were compared against in situ observations (Høyer et al., 2012) indicating that the NAVO–GAC and AATSR products have the lowest errors in the Arctic Ocean, whereas the Modis Aqua/Terra, Metop–A and AMSR–E all have significantly higher errors.

The operational ARC_0.05 level 3 products were also validated against in situ observations from drifting buoys. Two examples of the mean biases throughout the year are shown in Figure 2.

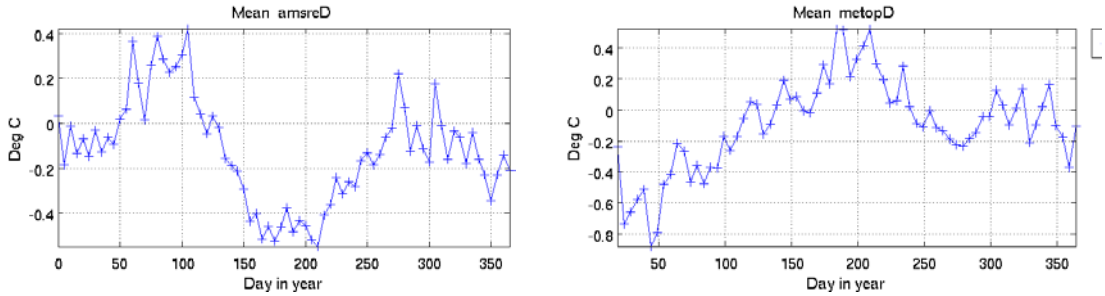


Figure 2: Validation statistics (ARC_0.05 fields – in situ) for descending AMSR–E fields (left) and Metop–A Daytime observations (right). A minimum number of 15 match–ups have been required before calculating the statistics.

The bias variations throughout year 2008 are significant, ranging from –0.5 to 0.4 K for Metop–A and from –0.5 to 0.4 K for AMSR–E

3. Bias adjustment method

Based upon the validation and error characterization results, it was decided to proceed with a bias correction method that used the combined AATSR and NAVO–GAC fields as a reference field to derive the biases for the AMSR–E, Metop–A and Modis products.

The bias correction method is explained in detail in Høyer, 2011. The main steps in the bias correction are listed below:

- Aggregate single sensor fields in 0.05 degrees resolution with a 5 day window
- Average all the aggregated fields into coarse (0.25 degrees) grid
- Obtain one reference field from averaging coarse grid AATSR and NAVO–GAC
- Calculate difference between coarse grid AMSR–E/Metop–A field/Modis and AATSR/NAVO–GAC:
    - Separate bias fields for AMSR–E ascending and descending
    - Separate bias fields for Metop–A nighttime and daytime
    - One field for Modis Aqua and one for Modis Terra
- Correct the AMSR–E/Metop–A/Modis data in two ways.
    - **Constant:** Subtract the constant bias for the high resolution (0.05 deg) field
    - **2–Dim:**
        - Interpolate the bias field to high resolution (0.05 deg) for all grid points
        - Smooth the bias field with appropriate spatial scales.
        - Subtract the spatial bias field from the high resolution aggregated single sensor fields

- **Outcome:** two corrected files per day per sensor (AMSR–E ascending/descending and Metop–A day/night) and one file per day per sensor for the Modis products.

Due to the orbit configuration, the AMSR–E ascending product contained very few observations within 21 and 7.00 local solar time. This product will therefore not be considered in the validation and impact assessment.

Size of Corrections:

An example of the constant bias correction that has been applied to the ascending and descending (or day and night) fields are shown in the figure below for 5 days aggregated fields.

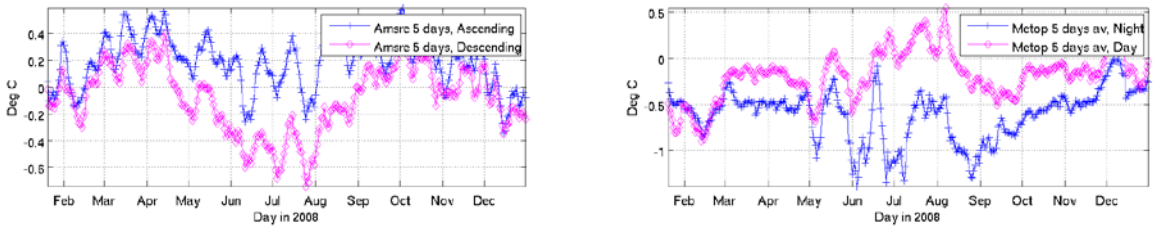
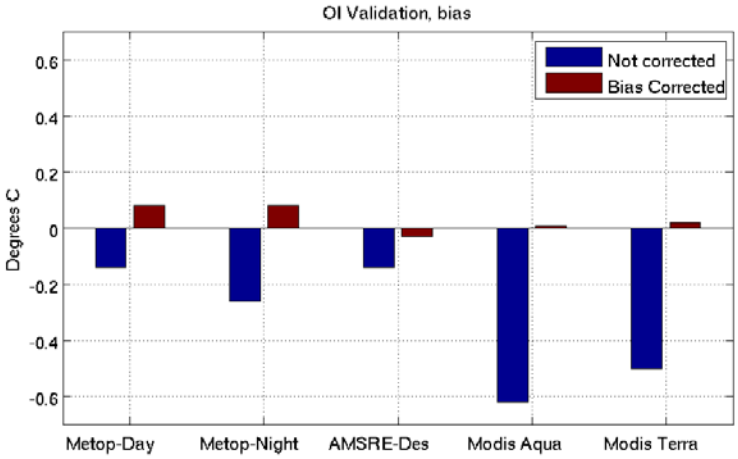


Figure 3: Bias derived from 5 days aggregated ascending/descending AMSR–E (left) and day/night Metop–A (right) observations.

From a comparison with the validation results in Figure 2, it is evident that the satellite derived biases are correlated with the biases derived against in situ observations.

The spatially constant bias was validated along with the spatially varying results for. Using these spatially varying bias correction fields resulted in all cases in better performance than the constant bias correction. The results presented here are thus obtained using a 2–D bias correction field with a spatial smoothing over 100x50 grid points with resolution 0.05 degrees. For more details on the validation results, see (Høyer, 2011).

The effect of bias correcting the level 3 fields in Figure 4, where the corrected and uncorrected fields have been validated against in situ observations.



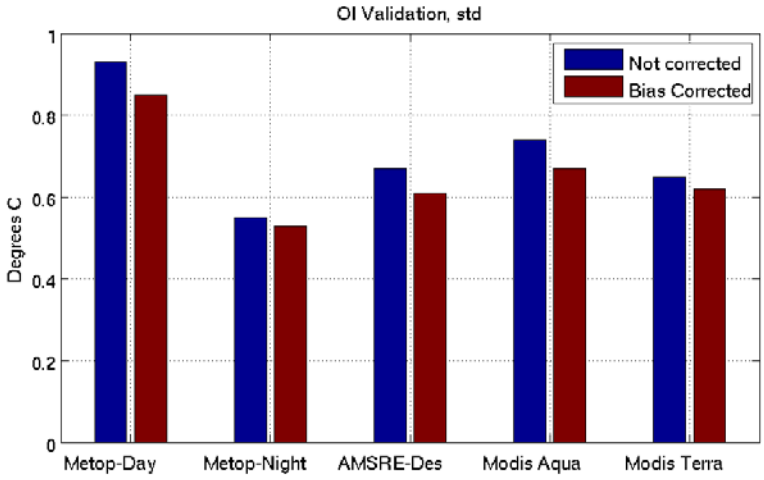


Figure 4: Overall bias (top) and standard deviation (lower) for the uncorrected and corrected products, validated against independent drifting buoys throughout the year 2008. The bias correction applied is a spatial 2–D daily field, smoothed bias over 100x50 grid points.

As seen from the figure above, the bias correction method is very efficient in removing constant biases throughout the year. Even the Modis products with large negative biases are reduced to insignificant biases. In addition, the standard deviations are also improved for all the products.

An example of the validation statistics throughout the year 2008 is shown in figure 6 for the AMSR–E descending orbit observations

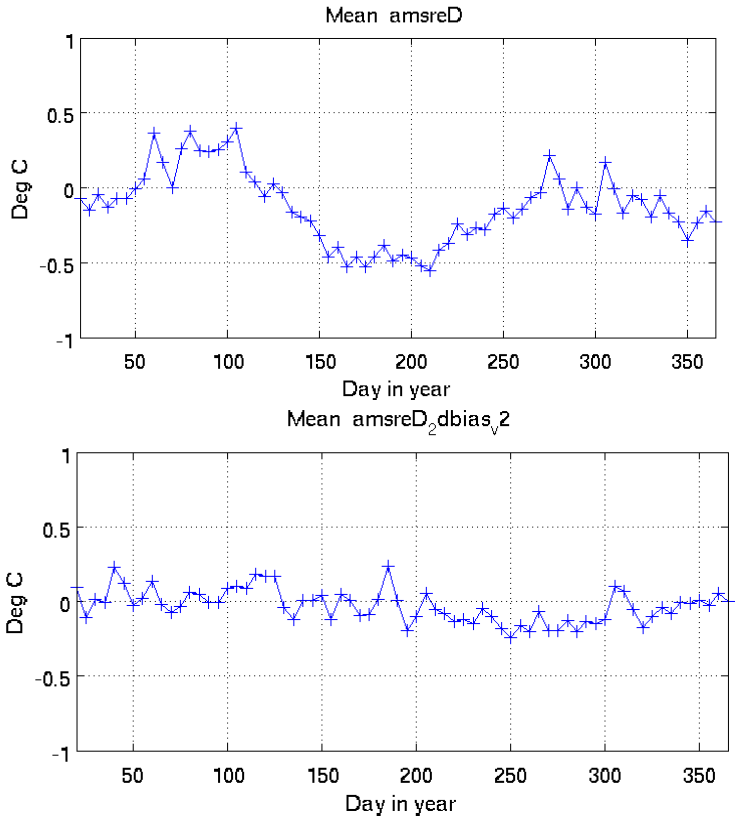


Figure 5: Mean bias of the AMSR–E descending field before (upper) and after (lower) bias correction.

The results from the AMSR–E bias correction are encouraging. The bias correction value is relatively constant from day to day and shows the well known pattern with positive values in spring and negative in summer. Validated against in situ observations, we see a clear improvement in the performance of the bias corrected results with a reduced and much more constant bias throughout the year.

The validation results for the Interpolated level 4 analysis confirm the improvements seen from the validation of the individual products. The table below shows a significant improvement in the level 4 product when the using the bias corrected satellite products.

SST Arctic level 4	Nmatch	Bias, oC (OI – in situ)	Standard deviation	RMS
No bias correction	128990	–0.28	0.61	0.67
Bias corrected	129089	–0.04	0.54	0.55

Table 1: Validation results for the level 4 analysis with or without bias corrections applied.

4. Conclusion

The results from the project demonstrate that a new multi–sensor bias correction method has been developed for the Arctic region. The validation against independent in situ observations from drifting buoys for year 2008 confirmed that the bias correction method, based upon AATSR and NAVO–GAC observations efficiently reduces the bias and standard deviations on the level 3 pre–processed satellite products from METOP–A, AMSR–E, Modis Aqua and Modis Terra. A significant improvement in the bias of the level 4 optimal interpolation scheme for the Arctic Ocean was seen when the bias corrected level 3 products were used as input instead of the uncorrected fields. The improvements are seen both in the overall statistics for the full period but the method also minimized the period with persistent negative biases that existed during the summer period in the reference run.

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HIGH LATITUDE SST ALGORITHMS FOR AVHRRS DERIVED USING A MULTI–SENSOR MATCH–UP DATABASE

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ABSTRACT

The traditional global SST algorithms have elevated errors in the high latitudes, compared to the low– and mid–latitudes. A significant seasonal bias variation is e.g. found in the Arctic Ocean for the Metop–A, with a positive bias of 0.4 degrees during summer. In addition, it has been shown by Vincent et al., 2008a, b that very simple algorithms can perform significantly better than traditional global algorithms under extreme conditions in the North Water open Polynya. With these indications of elevated high latitude biases, there is thus a need for investigating the effects of using simple algorithms like CASSTA or regionally derived algorithms with specific coefficients for the Arctic Ocean and the Southern Ocean. A multi–sensor matchup database has been developed within ESA CCI project. This database has been used on AVHRRs from 2006 to 2010 to test the standard algorithms against the simple CASSTA algorithm in the Arctic and Southern Ocean. It is shown that the simple CASSTA algorithm does not improve the retrievals for the high latitudes, except for very extreme dry conditions. The MMD is also used to examine the north/south difference in the algorithm performance and the effect of using regionally versus globally derived coefficients. The results indicate that there is a distinct difference in the algorithm performance in the Arctic and the Southern Ocean. The traditional algorithms are able to estimate the SST in the Southern Ocean significantly better than in the Arctic Ocean. The reasons for the differences are probably related to the differences in atmospheric conditions and example will be presented on the main differences.The effect of deriving global versus regional coefficients is mostly seen on the daytime results, where daytime biases are reduced for the regionally derived coefficients compared to the globally derived. Furthermore, the standard deviations are slightly lower on the regional products.

STATUS OF NPP/VIIRS SENSOR AND SST

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ABSTRACT

The Suomi National Polar–orbiting Partnership (NPP) satellite was launched on 28 October 2011. It is a bridge mission towards the Joint Polar Satellite System (JPSS), which is the US contribution to the next generation polar–orbiting operational environmental satellite system that will be coordinated with EUMETSAT. The Visible/Infrared Imager/Radiometer Suite (VIIRS) is one of five instruments onboard NPP. It builds on MODIS heritage, and provides high radiometric accuracy and spatial resolution multispectral imagery. For the infrared bands, Earth, Black Body, Space View counts, and Telemetry are reported in the Raw Data Records (RDR; L1a), from which Sensor Data Records (SDR; L1b) are generated. From SDRs, a wide range of Environmental Data Records (EDRs; L2) are produced, for ocean, land, atmosphere and cryosphere.

Processing of NPP data is performed by the Interface Data Processing Segment (IDPS) developed by a private contractor, Raytheon. Algorithms have been developed by another private contractor, Northrop Grumman Aerospace Systems (NGAS), and algorithm responsibility is currently being transitioned to the NOAA/NESDIS Center for Satellite Applications and Research (STAR). STAR works closely with U. Miami/RSMAS, the Naval Oceanographic Office (NAVO; D. May and B. McKenzie), NGAS, and the OSI SAF, on a wide range of Algorithm and Cal/Val activities, including verification of the performance of SDRs, cloud mask, and the SST algorithm, to ensure a high quality SST product.

The VIIRS Nadir Door opened and first solar reflectance images were collected on 21 November 2011. Cryoradiator doors opened on 18 January 2012. After several days, the focal plane cooled down, and nominal quality thermal imagery was acquired. The SST Team commenced analyses of VIIRS radiances and SSTs on 23 January 2012. On 5 April 2012, the SDR Team held a review, where it was concluded that VIIRS radiometric performance, geolocation, and band–to–band co–registration are of sufficient quality for the VIIRS SDR product to be designated a "beta". This means that VIIRS SDR data are now approved for free and open distribution to users, via NOAA CLASS, for evaluation and feedback. Please be aware, that SDRs may still have errors, and their use for scientific analyses and applications is recommended only with extreme caution.

A Cal/Val Meeting was held in Washington, DC from 17–18 April 2012, focusing on performance of VIIRS SDRs, Cloud Mask (VCM), and EDRs. The SDRs were determined to be of sufficient quality for EDR production. The VCM needs improvement before it can be declared "beta", and following this, the SST atmospheric correction coefficients will likely need to be recalculated. Subsequent analyses

will determine if the SSTs can be designated "beta". It is expected that IDPS SST may reach "beta" status by approximately August 2012, following formal VCM and SST "beta" reviews. Following "beta" the data will be "provisional" and then "calibrated".

In addition to the IDPS SST product, NOAA/STAR, U. Miami, NAVO and OSI SAF are either generating their own global SST products from VIIRS SDRs, or are planning on doing so in the future. In particular, the Advanced Clear–Sky Processor for Oceans (ACSPO) SST product is generated at STAR, using the heritage NOAA cloud masking and SST algorithms, which have been operational with AVHRR since May 2008. ACSPO has been also tested with MODIS Terra and Aqua data. Currently, it runs at STAR in near–real time, and generates a global L2 SST product in hdf4 format (not L2P yet).

Performance of the IDPS and ACSPO VIIRS SSTs is monitored in the SST Quality Monitor (SQUAM) page, www.star.nesdis.noaa.gov/sod/sst/squam/HR/ against several L4 products and *in situ* data. Other products monitored include two AVHRR FRAC SSTs (produced by ACSPO and OSI SAF), and two ACSPO MODIS SSTs (from Terra and Aqua). Work is underway to add MO(Y)D28 MODIS products in SQUAM, to allow cross–evaluation of various high–resolution SST products for stability, continuity, accuracy and cross–platform consistency. Quality controlled *in situ* data used in SQUAM come from another online near–real time system, the *in situ* Quality Monitor (*i*Quam; http://www.star.nesdis.noaa.gov/sod/sst/iquam/). Additionally, the performance of the VIIRS clear–sky ocean brightness temperatures in the SST bands M12 (3.7µm), M15 (11µm), and M16 (12µm) is monitored in the Monitoring of IR Clear–sky Radiances over Oceans for SST (MICROS) page www.star.nesdis.noaa.gov/sod/sst/squam/HR/ against Community Radiative Transfer Model (CRTM) simulated BTs, checking them for stability, continuity, accuracy and cross–platform consistency.

All indications so far are that the VIIRS is a good sensor for SST. As of this writing, the VIIRS cloud mask (VCM) in the standard IDPS product remains suboptimal, especially during the daytime. Work is underway with the VCM Team to improve the cloud mask.

GLOBAL CHANGE OBSERVATION MISSION (GCOM) CURRENT STATUS AND ITS CONTRIBUTION TO SST OBSERVATION

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The Global Change Observation Mission (GCOM) consists of two polar orbiting satellite systems, GCOM–W (Water) and GCOM–C (Climate), and three generations to achieve global and long–term monitoring of the Earth. GCOM–W1, the first satellite of the GCOM–W series, is scheduled for launch in May 2012. The satellite system is already at the Tanegashima Space Center and all the final preparations are being steadily implemented. On October 4, 2011, the Advanced Microwave Scanning Radiometer for the Earth Observing System (AMSR–E) halted its observation due to the increase of antenna rotation torque. Although all the efforts are being made to resume the AMSR–E observation, early initiation of the observation by AMSR2 on GCOM–W1 is highly desired. Development of the first satellite of the GCOM–C series, GCOM–C1, is also underway. The Second–generation Global Imager (SGLI) is the mission instrument on GCOM–C1. SGLI has several new features: 250 m spatial resolution for most of the visible channels, 250/500 m resolution for thermal channels, and polarization/multidirectional observation capability. AMSR2 and SGLI will contribute to the SST monitoring in different ways. AMSR2 will provide unique cloud–through and thus frequent SST observations but with coarse spatial resolution. On the other hands, SGLI will observe small scale SST features together with the ocean color information, particularly around coastal areas by utilizing the 250 m resolution for both thermal and visible channels. Authors believe that these features are also beneficial for creating the blending SST products.

QUASI–OPTIMAL ASSIMILATION OF SST

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Retrieval of physical parameters such as Sea Surface Temperature (SST) from satellite observations (such as brightness temperatures in the observing channels) requires some assumptions on the state of the atmosphere, and often also about the parameter of interest as well. The so–called ”state vector” comprises all the variables needed to describe the state, and is denoted

atmospheric water vapour, aerosol and temperature profiles. The data providers could provide the QOA transformed retrieval, together with the relevant row of the transformed averaging kernel to allow quasi–optimal assimilation.

If SST retrievals are used as a boundary condition for ocean models, or if the aim is to produce an L3 or L4 product (gridded maps of SST), the problem can be simplified by including the influence of the atmospheric part of the state vector into the error term. We consider each single observation for a certain time and location separately. Let the first parameter of the model state be SST, followed by the atmospheric parameters

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ERROR MODELS FOR AVERAGES OF BINNED SST OBSERVATIONS BASED ON SMALL–SCALE AND SHORT–TERM VARIABILITY ESTIMATES

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ABSTRACT

SST observations from the International Comprehensive Ocean–Atmosphere Data Set were binned on the regular 1°x1^{o}x1day spatiotemporal grid, separately for day and night observations and for different platform types (ships, drifters, moorings). Basic statistics characterizing each bin (mean, standard deviation, number of observations) were computed and stored, thus providing essentially an L3 product for the in situ data. These products were compared with the L3 products based on day and night AVHRR SST data sets (Pathfinder SST) and interpreted in the context of theoretical error estimates that were obtained using maps of SST variability and the number of observations in each bin, with an assumption that errors in individual observations are independent from each other. The separation of data sets before binning by a platform type and day/night observational time resulted in improved modelling of their errors. A similar approach, but taking into account a temporal autocorrelation of the SST, is used for modelling the error in temporal averages. Finally, an approach based on empirical orthogonal functions of small–scale variability is used for an efficient description of covariance between observations in the same gridbox. Verified error estimates of SST observations are used for presenting the error of the L3 products, which in turn are useful as conservative error estimates for the characterization of the related L4 products.

GOES SST RETRIEVAL USING TOTAL LEAST SQUARE METHOD

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There are many ambiguities involved in skin/subskin SST retrieval from satellite observations. With only five channels in the day (including visible channel) and four channels at night, the GOES Imager is unable to retrieve all of the multiple unknowns which affect the basic retrieval of SST. Thus, a number of assumptions are made as a truth (of sorts), and variability of the retrievals are attributed to only a few parameters, which may be the cause of only part of the variability. On one hand, the number of unknowns may easily be reduced if, for example, we opt for a regression–based SST retrieval using top–of–atmosphere radiances, but the regression coefficients do not contain a deep physical meaning of the problem and still have a mean prior state embedded in them. Regression coefficients may be calculated based on the bulk SST data, either from in situ buoy measurements data or even a L4 SST product and the retrieval produces a SST representative of bulk temperature – itself a significant scientific ambiguity. On the other hand, inversion of the full radiative transfer is time–consuming and subject to the uncertainties of the input parameters. Available tools for the forward modeling (fast RTM) may be one of the prime sources of error in the physical skin/subskin SST retrieval from the GOES Imager. The choice of the inversion method also plays an important role in such retrieval. This work addresses a number of these issues relating to the application of physical retrieval methodologies to the inversion problem.

OPTIMAL ESTIMATION TECHNIQUE FOR SST FROM MTSAT–2

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ABSTRACT

MSC/JMA operationally retrieves Sea Surface Temperatures (SSTs) from MTSAT–2 radiance observations of the 10.8 and 12 micron channels. The retrieval algorithm is based on empirical method comparing between the satellite observations and buoy's SST observations. To enhance the SST product, a One–Dimensional Variational (1DVAR) method is planned to be introduced. To take into account effects of the sea surface emissivity, which varies with the emission angle and the surface wind speed, and the absorption of water vapour in atmosphere on the MTSAT–2 radiance observations, single–layer radiative transfer calculation is used. Sea surface emissivity is calculated by using the Isotropic Gaussian (IG) model. Analysis parameters are SST, layer temperature and layer water vapour absorption coefficient. Background values and errors are set from a look up table (LUT), which is pre–generated by using MTSAT–2 brightness temperatures and buoy's SST data of one year from July 2010 to June 2011. As for the observation errors of MTSAT–2 radiance data, values corresponding to 0.2 K brightness temperature errors are used. For validation, SST calculation by using the new algorithm was examined for the cases of July and August in 2011 and January and February in 2012, and compared with buoy SST measurements. To evaluate the new algorithm's performance excluding the effect of cloud screening error, statistics are calculated by using the match–up data within 50% from the median. Mean differences and standard deviations are –0.31 K and 0.29 K in July and August, and +0.21 K and 0.30 K in January and February.

1. Introduction

MSC/JMA has operationally retrieved SSTs from infrared imageries by geostationary satellites (GEO) since GMS–5 launched in July 2005. Current SSTs are retrieved from MTSAT–2 which has been operational since July 2010. For the SST algorithm, formally the MCSST method (McClain et. al, 1985) and currently algorithm for GOES–8/9 (Maturi et. al, 2008) are used. These methods are regression equation based techniques and coefficients are generated using a match–up data set of analyzed surface temperature and simulated radiances of 10.8 and 12 micron channel. Radiances are calculated from the surface temperature and atmospheric profiles in outcomes of JMA NWP using a radiative transfer model MODTRAN4. Retrieved SSTs have negative biases which increase with the increase of the satellite zenith angle and exceed –1 K out of about 60 degrees. To improve SST products from MTSAT–2, a new optimal estimation technique has been developed at MSC. For advanced corrections of the atmospheric attenuations, 1DVAR method is adopted. MSC is planning to implement the new algorithm into the process of the operational retrieval of SST from the MTSAT–2 infrared imageries. In this paper, outline of the algorithm (Section 2), results by applying the algorithm to data from MTSAT–2 (Section 3), and conclusion (Section 4) are presented.

2. Algorithm

1DVAR method is applied to the calculation of SSTs from the infrared radiances of 10.8 micron and 12.0 micron channels of MTSAT–2. SST is calculated by minimizing the cost function

$$J(\mathbf{x}) = (\mathbf{x} - \mathbf{x}_0)^T \mathbf{B}^{-1} (\mathbf{x} - \mathbf{x}_0) + (H(\mathbf{x}) - \mathbf{y}_0)^T \mathbf{R}^{-1} (H(\mathbf{x}) - \mathbf{y}_0), \qquad (1)$$

where $\boldsymbol{x}$ and $\boldsymbol{x_0}$ are the variable vector and its background value vector, $\boldsymbol{y_0}$ is the satellite observation vector, $\boldsymbol{B}$ is the error covariance matrix of background value vector, $\boldsymbol{R}$ is the error covariance matrix of satellite observation vector and $H(\boldsymbol{x})$ is a forward operator. The symbol 'T' represents the transpose of a vector and the symbol '–1' denotes the inverse of a matrix. $\boldsymbol{x}$, $\boldsymbol{y_0}$ and $H(\boldsymbol{x})$ are defined by

$$\mathbf{x} = \begin{pmatrix} T_s \\ T_a \\ U_{H_2O} \end{pmatrix}, \tag{2}$$

$$\mathbf{y}_0 = \begin{pmatrix} I^{obs}_{10.8} \\ I^{obs}_{12.0} \end{pmatrix} \tag{3}$$

and

$$H(\mathbf{x}) = \begin{pmatrix} I_{10.8}(\mathbf{x}) \\ I_{12.0}(\mathbf{x}) \end{pmatrix}, \tag{4}$$

where T_s, T_a and U_{H2O} are SST, mean air temperature and a variable relating to water vapor (see 2.3), $I^{obs}_{10.8}$ and $I^{obs}_{12.0}$ are the observed radiances from the 10.8 micron and 12.0 micron channels and $I_{10.8}(\boldsymbol{x})$ and $I_{12.0}(\boldsymbol{x})$ are radiances expected to be observed under the atmospheric and sea surface condition given by $\boldsymbol{x}$. $I_r(\boldsymbol{x})$ (r = 10.8, 12.0) is calculated using

$$I_r(\mathbf{x}) = \varepsilon_r B_r(T_s)\tau_r + (1. - \tau_r)B_r(T_a), \tag{5}$$

where $\boldsymbol{\varepsilon_r}$ is the sea surface emissivity, B_r is a sensor Planck function and τ_r is the atmospheric transmittance. Sensor Planck function is an approximation function which takes into account the spectral response of each channel and calculate radiance corresponding to given brightness temperature.

2.1 Sea Surface Emissivity

For the calculation of sea surface emissivity, the Isotropic Gaussian (IG) model with the Surface–emitted Surface–reflected (SESR) emission (Masuda, 2006) is used. In the IG–SESR model, emissivity is expressed as a function of emission angle, sea surface wind speed and radiation wave length. For reflectance by the sea surface, single reflectance is assumed. Figure 1 shows emissivity calculated with the IG–SESR model.

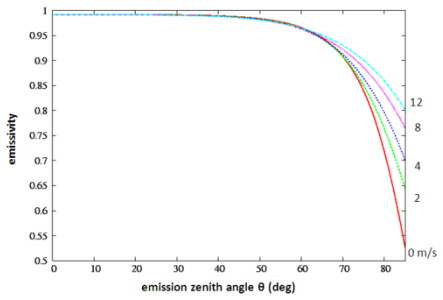

Figure 1: Emissivity of the infrared radiation with 10.8 micron wave length as a function of emission zenith angle (degree) and surface wind speed calculated with IG–SESR model. Numbers on the right of each plots show wind speed (m/s).

2.2 Atmospheric transmittance

For the calculation of atmospheric transmittance, water vapor absorption is only taken into account. According to Roberts (Roberts et. al 1976), transmittance is calculated by the following equations

$$\tau_r = e^{-\sigma_{H_2O} L}, \tag{6}$$

$$\sigma_{H_2O} = C(\lambda, T_a) W_{H_2O} [P_{H_2O} + \gamma (P - P_{H_2O})] \tag{7}$$

and

$$C(\lambda, T_a) = C^0(\lambda) exp[T_0 (\frac{1}{T_a} - \frac{1}{296})], \tag{8}$$

where σ_{H2O} is absorption coefficient of water vapor, L is radiation path length, T_a is air temperature, W_{H2O} is the total amount of water vapor, P and P_{H2O} are atmospheric pressure and partial water vapor pressure, and T_0 and γ are constants. To cut down the total number of variables, a new parameter U_{H2O} defined by (9) is introduced.

$$U_{H_2O} = W_{H_2O} [P_{H_2O} + \gamma (P - P_{H_2O})] L \tag{9}$$

Then transmittance can be calculated from T_a and U_{H2O} using

$$\tau_r = e^{-C(\lambda, T_a) U_{H_2O}}. \tag{10}$$

2.3 Background values

The background values of SST, T_a, U_{H2O} and their statistics are calculated from a match–up data set of satellite data, buoy SST and surface wind speed. Surface wind speeds are calculated from surface wind vectors forecasted by JMA NWP. The match–up data set is generated using annual observations and JMA NWP outputs from July 2010 to June 2011. Total number of the match–ups is 4,242,175. T_a and U_{H2O} are calculated from the radiances of 10.8 and 12.0 micron channel and buoy SST by solving a simultaneous equation of (5). Buoy SST and derived T_a and U_{H2O} are gathered into 3–dimensional bins with a bin interval of 1 K for brightness temperature corresponding to radiance of 10.8 micron channel, 0.1 K for the difference of brightness temperature (10.8 micron minus 12.0 micron) and 1 degree for the satellite zenith angle. Then bin–averaged SSTs, T_a and U_{H2O} are compiled into a look up table (LUT). Standard deviation of each background value in each bin is also compiled as uncertainty of the value. For the uncertainty of MTSAT–2 data, radiance corresponding to the brightness temperature of 0.2 K is used.

3. Results

MTSAT–2 SSTs are retrieved by applying the new algorithm to the MTSAT–2 imageries for July and August in 2011 and for January and February in 2012. For cloud screening, CLAVR based tests are adopted. Surface wind speed which is required to calculate sea surface emissivity is calculated from the surface wind vector forecasted by JMA NWP. For the algorithm to minimize the cost function (1), conjugate minimization method is used. SST calculated for each cloud free infrared imagery pixels are gathered into bins with an interval of 0.04 degree for both latitudinal and longitudinal. The maximum SST in each bin is selected as the MTSAT–2 SST for the corresponding grid. Because significant biases are found in midnight imageries by MTSAT–2, MTSAT–2 SST is not calculated from 15 UTC to 17 UTC.

3.1 Comparison with buoy data

MTSAT–2 SSTs are compared with buoy SSTs. Locations of buoys are shown in Figure 2, correspondence between MTSAT–2 SST and buoy SST is shown in Figure 3.

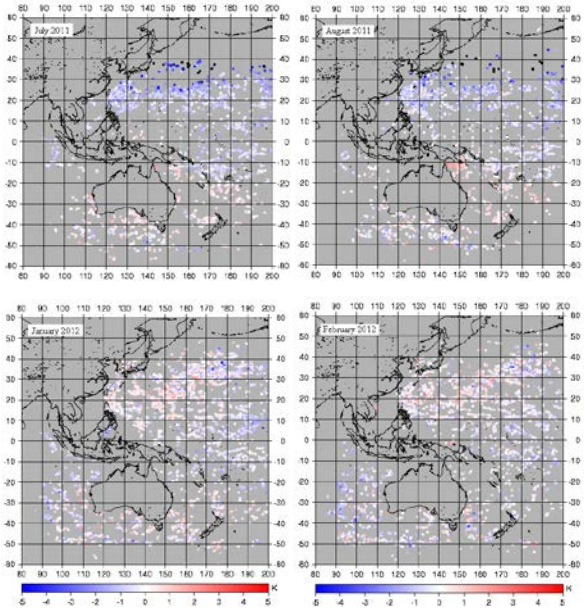

Figure 2: Spatial distribution of buoys. Colors of plots show the difference between MTSAT–2 and buoy in July 2011 (upper left), August 2011 (upper right), January 2012 (lower left) and February 2012 (lower right).

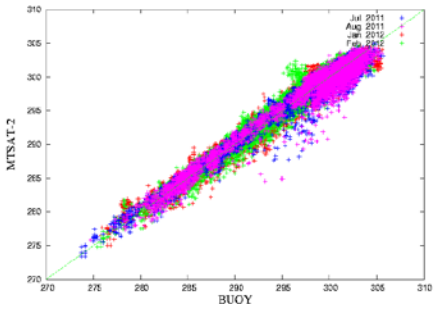

Figure 3: MTSAT–2 SST (y axis) against buoy SST (x axis).

To reduce cloud screening errors and evaluate the effect of the algorithm, robust statistics technique is adopted. Statistics, root mean square difference (RMSD), bias and standard deviation (STD) are calculated from the 50 % of match–ups centered at the median. Robust statistics are shown in Table 1 and Figure 4. STD is 0.29 K in summer (July and August in 2011) and 0.30 K in winter (January and February in 2012). Biases in summer and in winter are –0.31 K and +0.21 K. For the reasons of these biases, background states which are empirically calculated from match–ups and/or seasonal calibration (MIttaz et. al, 1999) are possible.

	N	RMSD (K)	BIAS (K)	STD (K)
July	26106	0.43	–0.32	0.28

	N	RMSD (K)	BIAS (K)	STD (K)
August	21757	0.41	–0.29	0.29
July–August	47863	0.42	–0.31	0.29

	N	RMSD (K)	BIAS (K)	STD (K)
January	37058	0.35	+0.18	0.30
February	31910	0.38	+0.24	0.30
January–February	68968	0.36	+0.21	0.30

Table 1: Robust statistics of MTSAT–2 SST by comparing with buoy measurements (MTSAT–2 minus buoy) for July and August in 2011 (top) and for January and February in 2012 (bottom).

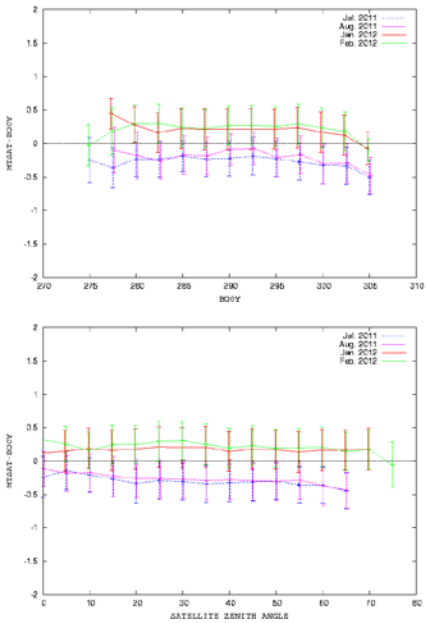

Figure 4: Robust bias (MTSAT–2 minus buoy) and STD as a function of buoy SST (top) and those as a function of satellite zenith angle (bottom).

3.2 Comparison with MGDSST

MTSAT–2 SSTs are also compared with the MGDSSTs by JMA. Spatial distributions of monthly mean differences (no robust average of MTSAT–2 minus MGD) are shown in ***Figure 5***. Mean differences

are smaller in winter than in summer. Mean differences are generally between –0.5 K and +0.5 K in January. In summer, large negative differences exceeding –1.0 K are found around cloud masks in the northern Pacific. These differences may be caused by cloud screening error. In the mean time, positive differences dominate southern Pacific and those exceeding +0.5 K are found between Australia and New Guinea. Positive error can be occurred by dry air condition than normal. For the reason of those differences north of Australia, dry air condition is possible too.

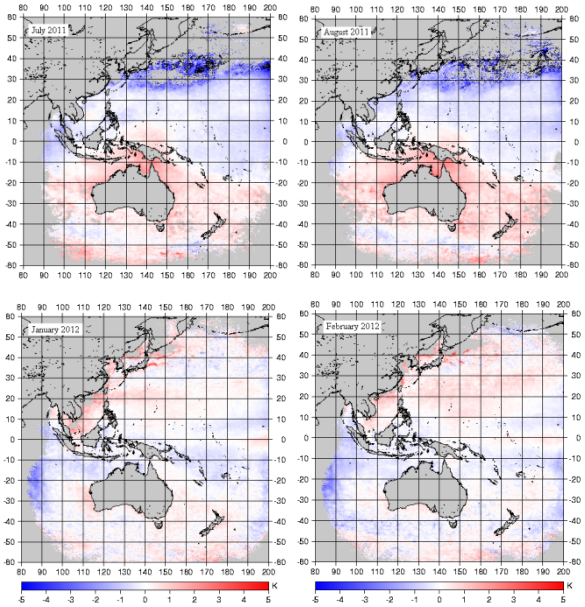

Figure 5: Monthly averaged difference between MTSAT–2 SST and MGDSST (MTSAT–2 minus MGD) in July 2011 (upper left), August 2011 (upper right), January 2012 (lower left) and February 2012 (lower right).

4. Conclusion

1DVAR method is adopted for the SST retrieval from infrared radiance imageries of the 10.8 and 12.0 micron channels of MTSAT–2. For the forward operator, the atmospheric single layer infrared radiative transfer calculation is introduced. In the calculation of radiance, sea surface emissivity is estimated from the satellite zenith angle and the sea surface wind speed by JMA NWP using the IG–SESR model. For the calculation of atmospheric transmittance, water vapor absorption is only taken into account and a new parameter relating to water vapor is installed. Transmittance is calculated from this parameter and atmospheric temperature. Background values and their uncertainties are calculated from the match–up data set of MTSAT–2 imageries, buoy SST measurements and wind speeds forecasted by JMA NWP from July 2010 to June 2011 and compiled into a look up table (LUT).

New algorithm is applied to the MTSAT–2 imageries for July and August in 2011 and January and February in 2012. MTSAT–2 SSTs are compared with buoy data. Robust bias and STD are –0.31 K and 0.29 K in summer (July and August in 2011) and +0.21 K and 0.30 K in winter (January and February in 2012).

Results are also compared with MGDSSTs by JMA. Monthly mean differences from MGDSST are generally smaller in winter than in summer. Differences are generally between –0.5 and +0.5 K in winter. In the meantime, large negative differences are found around cloud masks in the northern Pacific and large positive differences are found north of Australia in summer. As for negative differences, cloud screening errors are possible for their reasons. Regarding positive errors, they may be caused by dry air condition.

Except seasonal bias problem and cloud screening errors, SSTs are successfully retrieved from MTSAT–2 infrared imageries with the new algorithm. MSC/JMA is planning to introduce this algorithm to the operational retrieval of SSTs from infrared imageries by MTSAT–2 in the near future, and it will also be applied to the imageries from MTSAT–1R.

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SST FROM NPP/VIIRS: STATUS AT OSI–SAF

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The OSI–SAF at Météo–France/Centre de Météorologie Spatiale (CMS) is committed to derive SST products over the North Atlantic Regional (NAR) area. CMS has been receiving routinely NPP data in direct read–out since April 2012. A VIIRS dedicated cloud mask has been defined as an adaptation of the MAIA mask already used in the OSI–SAF for METOP or NOAA/AVHRR processing.

A daytime (NLC) and a nighttime (T37_1) algorithm have been derived from simulated brightness temperatures and are used on a routine basis since the end of April 2012.

NLC: $SST = (a + b\,S_\theta)\,T_{11} + (c + d\,T_s\text{clim} + e\,S_\theta)\,(T_{11} - T_{12}) + f\,S_\theta + g$ (1)

T37_1: $SST = (a + b\,S_\theta)\,T_{37} + (c + d\,S_\theta)\,(T_{11} - T_{12}) + e\,S_\theta + f$ (2)

where: $T_S\text{clim}$ = first guess climatologic SST and $S_\theta = 1/\cos(\theta) - 1$

The processing chain as well as the preliminary control results will be briefly presented.

OPERATIONAL USE OF NWP OUTPUTS IN SST RETRIEVAL METHODS: VALIDATION RESULTS

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ABSTRACT

New methods based on using Brightness Temperature (BT) Simulations derived by applying a fast radiative transfer model on Numerical Weather Prediction (NWP) profiles are progressively implemented at Centre de Météorologie Spatiale (CMS). These methods are either bias correction (BC) methods (LeBorgne et a, 2011) or Optimal Estimations (OE) methods (Merchant et al, 2008). They have been implemented at CMS with various levels of maturity:

SST from geostationary satellites (MSG and GOES–E) are now calculated operationally in the framework of the EUMETSAT/OSI–SAF by using ECMWF outputs in a BC method. OE methods using two (11 and 12 micron) or three (8.7, 11 and 12 micron) channels have been also implemented experimentally on a routine basis.

SST from polar orbiters: an experimental chain has been developed to process global METOP/AVHRR. BT are simulated using ECMWF profiles and used in a BC method . The new NPP/VIIRS operational chain will also use BT simulations in a BC method.

The validation results from these operational or experimental chains will be presented and discussed.

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AN IMPROVED VIEW OF THE ARCTIC SST DURING THE SUMMER OF 2007

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ABSTRACT

The 20–year near–continuous ATSR SST time–series has recently been refined and re–processed by a consortium led by C Merchant and including the University of Edinburgh, the University of Leicester and the UK Met Office, who have developed the ARC (ATSR Re–processing for Climate) SST data–set. The excellent quality of the ARC data allows many oceanic phenomena and processes to be re–examined with greatly improved clarity. An example of this is provided by the exceptionally high SST anomalies that were observed in the Arctic regions by the AATSR Space sensor in the summer of 2007.

The main features of the ARC data–set will be summarised and the SST data collected over the Arctic Ocean in 2007 will be shown and compared to equivalent data from preceding and following summers. These data show very clearly the extent, spatial structure, variability and intensity of the high SST values experienced in 2007. Likely reasons for the anomalies and their possible implications will be briefly discussed.

THE EUROPEAN SPACE AGENCY CLIMATE CHANGE INITIATIVE FOR SEA SURFACE TEMPERATURE

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In August 2010, the European Space Agency (ESA) kicked–off the Sea Surface Temperature (SST) project within its Climate Change Initiative (CCI). The author is Science Leader on this three project, which involves many partners within the Group for High Resolution SST (GHRSST) and is designed to work closely with GHRSST (both as a community of scientists, and as a framework for SST product development).

The CCI overall in its present phase requires team to prototype systems for a dozen satellite–driven Essential Climate Variables (ECVs) and to generate products demonstrating their outputs. In the case of the SST CCI products, the approach is to build on (i) the Along Track Scanning Radiometer (ATSR) Reprocessing for Climate (ARC) project, (ii) a National Centre for Earth Observation (NCEO) project applying ARC techniques to Advanced Very High Resolution Radiometers (AVHRRs), and (iii) the ability to interface to the Ocean and Sea Ice Satellite Application Facility (OSI–SAF) operations at Centre de Météorologie Spatiale (CMS).

The key data outputs from SST CCI will be:

- "climate–quality' time series of skin and depth SST estimates from ATSR and AVHRR observations, for 1991 – 2010
- demonstration of skin SST observation and analysis using ATSR, AVHRR, the Spinning Enhanced Visible and Infra–Red Imager (SEVIRI), and the Advanced Microwave Scanning Radiometer – E (AMSRE–E), for a six month period in 2011/2012
- an extensive multi–sensor match–up dataset (MMD)

For SST as an ECV, accuracy, stability and consistency are key attributes of the products. The SST retrieval approach is to be defined in the light of an 'algorithm competition', referred to as the 'Round Robin'. The Round Robin will be based on data sets created for the purpose as appropriate extracts from the MMD, and will be designed to give a fair, blind comparison of the performance of different possible algorithms against several metrics for an SST climate data record. We strongly encourage scientists outside of the project to contribute competitor algorithms to the Round Robin. The details of this will be presented within the Estimations and Retrievals Working Group meeting at GHRSST 12 (Thursday).

The SST CCI project by June 2011 will have:

- Undertaken a significant User Requirements consultation
- Specified its planned products in detail
- Collected data for and defined the MMD and extracts for the Round Robin Data Package
- Started internal work on SST algorithm development

In the conference presentation, these activities will be reviewed in turn.

AN ANALYSIS OF THE "BATES MATURITY INDEX" FOR CLIMATE DATA RECORDS IN RELATION TO SST

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ABSTRACT

Bates and Barkstrom published in 2006 an index for assessing the maturity of climate data records. In response to an action from GHRSST–12, this presentation will review the index's relevance to GHRSST and the Climate Data Record TAG. The index combines the status of a dataset across several factors, ranging from uncertainty information provided, to publication status and documentation. The matrix inevitably embodies particular values and approaches, not all of which fit comfortably with GHRSST TAG/WG recommendations. These issues will be reviewed, and a way forward proposed.

CONTINUITY, INDEPENDENCE AND STABILITY FOR AATSR/SLSTR–BASED TIMESERIES OF SEA SURFACE TEMPERATURE

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ABSTRACT

A 20 year time series of sea surface temperature (SST) has been created from the Along–Track Scanning Radiometer (ATSR) series sensors, that is apparently stable to the order of 5 mK/yr while being essentially independent of in situ SST observations. How is this record to be continued into the era of the successor series of dual–view instruments, the Sea and Land Surface Temperature Radiometers (SLSTRs)? Assuming that the minimum useful 6 months of AATSR/SLSTR overlap will not be achieved, continuity will need to be achieved with a single–view sensor subject to several requirements. A review suggests considering the Advanced Very High Resolution Radiometers (AVHRRs) on the MetOp–A platforms as a primary candidate for a bridging data stream. This paper discusses this possibility, as follows. Why MetOp–A AVHRR? How would independence from in situ SST be preserved with such an option? How might stability be monitored and controlled? How would the bridging achieved be validated and traceable? And what is the likelihood of success in such an endeavour?

1. Introduction

The sea surface temperature (SST) time series from the Along Track Scanning Radiometer (ATSR) Reprocessing for Climate (ARC) SST project is available from www.neodc.rl.ac.uk. This 20 year record appears to be highly stable, to provide both skin and (via a modeled adjustment) depth SST, to be globally accurate (magnitude of mean discrepancy against drifting buoys less than 0.1 K in all regions) and is essentially independent of in situ observations (Embury et al., 2012a; Embury et al., 2012b, Embury and Merchant, 2012).

This issue of independence is important in the context of climate change. Given the high stakes for society associated with concerns about anthropogenic climate change, it is important that climate data are trustworthy and broadly perceived to be robust. Agreement within uncertainties between two independent records for a given component of the climate, especially if based on fundamentally different estimation/measurement techniques, provides a high degree of confidence that no significant systematic effect was disregarded and uncertainties were not underestimated. In short, it is good evidence for the validity of both records.

The ARC project obtained an essentially satellite–based SST record for 1991 – 2010, and the time series is being extended to the latest AATSR observations within ESA's Climate Change Initiative for SST (SST CCI). The SST record is based inversion based on physical modeling of the relationship between observations and SST. The ATSR–series instruments appear to have been extremely stable sensors, AATSR (the third and last) in particular.

It is possible that AATSR will not overlap with the next dual–view two–point calibrated sensor, the SLSTR. Indeed, by the time of GHRSST–13, it may even be certain. But the need for robust evidence on the evolution of the climate will not disappear, and gives a strong motivation to consideration of how to bridge any gap in a way that maximizes the homogeneity of the record (minimizes artefacts across the transition between sensors) and achieves adequate levels of stability, as comparable as possible to those obtained using the AATSRs. That is the topic of this paper.

2. Candidate sensors for continuity

Within the ARC SST record, the primary observations are skin SSTs at the instantaneous time of observation. In addition, depth SSTs are estimated which do two things: adjust for skin to ~20 cm depth differences in SSTs; adjust (in the case of AATSR) to an (approximately) 10.30 or 22.30 h observation time, to avoid aliasing of the diurnal cycle into the long–term record at the transition between ATSR–2 and AATSR (the latter being on a platform with a 10.00 / 22.00 h overpass, half and hour earlier than the previous two missions).

In looking for a sensor to bridge any AATSR / SLSTR gap, therefore, we look for:

- overlap with AATSR (data from. say, 2011 or earlier)
- likely overlap with SLSTR (data up to, roughly, end 2015 or later)
- similar observational technology, i.e., thermal window channels and ~1 km (although inevitably single view)
- satellite overpass time within an hour of 10.30 / 22.30 h
- known or assessable stability

The Metop–A AVHRR fits well with the overlap considerations. Although its current nominal end of life is end 2013, EUMETSAT will aim to continue the mission until commissioning of Metop–C to ensure redundancy (subject to various caveats on instrument performance and resources). This implies continuation until 2016, if possible. MODIS on Terra is also in a suitable orbit, but is already (in 2012) 13 years into its remarkable mission, and so continuation for a further 3 to 4 years cannot be taken for granted.

3. Preserving independence

AVHRRs are traditionally empirically tuned to drifting buoy SSTs by regression on matched satellite–in situ observations. Météo–France define Metop–A AVHRR retrievals by radiative transfer modeling to define coefficients, followed by adjustment of the offset coefficient, again by empirical comparison with selected drifting buoys. Neither is an independent procedure.

In the ARC project, baseline retrieval coefficients were defined for each sensor using line–by–line radiative transfer. Inter–sensor and inter–algorithm biases of SST were generally within 0.1 K on this basis. In order to homogenize the data set and improve stability, adjustments were made to retrieval coefficients based on inconsistencies of brightness temperature between sensors. The details are relatively complex (and yet to be published) – see Figure 1 for a summary.

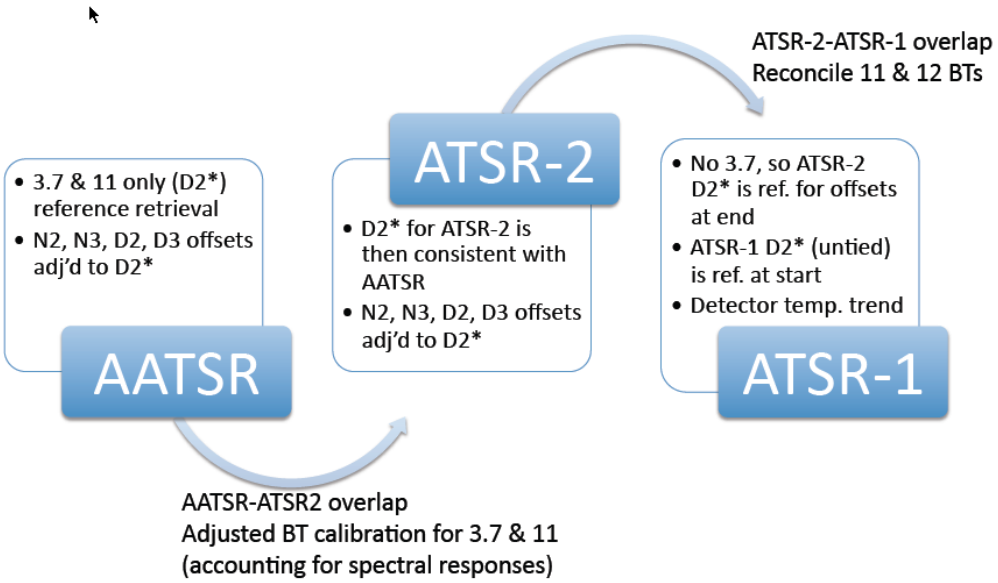

Figure 1: Homogenisation procedure using multi–sensor matches (no in situ) to reconcile ATSR SST time series in the ARC project.

In essence, the calibration of all the ARC SSTs is tied to the calibration of the 3.7 and 11 um brightness temperatures of AATSR, which appear to be extremely well calibrated and well simulated channels. For clarity: the tuning between algorithms and sensors was done at the L1b level (brightness temperatures were compared, although SST coefficients were then adjusted to compensate for discrepancies) and involved no in situ data.

A similar procedure can therefore be applied to Metop–A AVHRR, using AATSR–AVHRR matches. A multi–sensor matchup database (MMDB) has been prototyped in the SST CCI project in part because of the need to do this sort of homogenization of calibration at brightness temperature level. From the MMDB, a multi–sensor match–up data set (MMD) for a particular study can be extracted, that includes the reflectance, infra–red, and auxiliary files (such as numerical weather prediction fields interpolated to the matches) necessary for homogenizing brightness temperatures using ARC methods. However, there is no fully automated procedure here. Knowledge of the instruments involved and so degree of judgment is involved in the detailed decisions about how the observations are most legitimately to be reconciled.

Lastly, we note that Metop–B is due for imminent launch at time of writing (May 2012). This introduces some redundancy in to the above bridging strategy.

4. Stability

Stability is the degree to which there is no trend artefact in the SST timeseries, i.e., the degree to which any existing bias in observations is constant in time. It has units of K/yr for SST and brightness temperatures and is unusually an uncertainty: i.e., the actual drift in observation/SST bias is unknown (if we knew it independently, we'd correct for it), but the 1–sigma magnitude can be constrained from the trend in discrepancy against some independent, stable reference point. In ARC, de–seasonalised discrepancies relative to Global Tropical Moored Buoy Arrays had trends that were statistically within about 5 mK/year of zero.

Let's assume that Metop–A (perhaps with Metop–B) provides a bridging data stream of 1 km SST observations in the TIR that overlaps with AATSR and, in the future, SLSTR. Given the precedent achieved with the ATSRs in the ARC project, we also assume that inter–sensor matches are adequate to "tie" Metop AVHRR to the AATSR calibration with high precision. One sensor in a series is taken to be the "absolute" reference to which others are successively tied, so let's also assume we continue to use AATSR 3.7 and 11 um channels as the benchmark. Were we confident that Metop AVHRR had been adequately stable across any AATSR / SLSTR gap period, the strategy would be therefore to tie SLSTR to Metop AVHRR, in order to be homogenized indirectly through to AATSR.

The stability of the Metop AVHRR(s) then becomes very important. It cannot be assumed that these instruments will deliver 5 mK/yr stability over. In this connection, the fact that the Infrared Atmospheric Sounder Interferometer is also present on the same platform may provide an additional capability to monitor and control Metop AVHRR stability.

IASI / AATSR comparisons show high mutual stability (Figure 2). IASI / AVHRR clear–sky comparisons should be able to put a strong constraint on the AVHRR stability. Having redundancy with Metop–B will also help this: Metop–A AVHRR BTs can be assessed for stability not only against IASI on Metop–A, but with respect to Metop–B AVHRR and IASI, using a multi–sensor matchup approach.

Metop–A AVHRR comparisons with IASI have been made by Mittaz et al. (2011). These show the AVHRR 11 and 12 channels to be stable to within 0.05 K on time scale of a few years relative to IASI (Figure 3), provided the Mittaz calibration is used. This is not as stable as the IASI–AATSR comparison, but the ability to do co–incident matches of the AVHRR and IASI means that instabilities in the former should in principle be able to be modeled over time, and thus the stability of the ultimate SSTs can be improved.

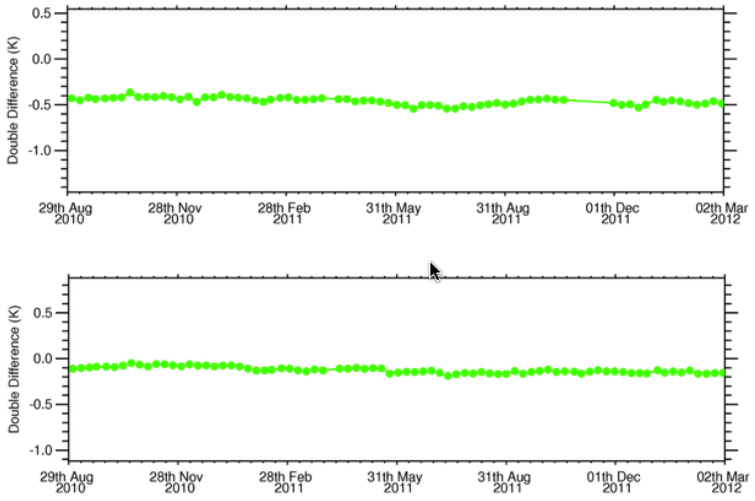

Figure 2: Double–difference assessment of stability between Metop–A IASI and AATSR. Top: IASI channel 8007 (~3.7 um) and AATSR 3.7 um channel. Bottom: IASI channel 1133 (~11 um) and AATSR 11 um. The procedure is to the daily differences between IASI and radiative transfer simulations for clear–sky observations for form a difference, and then do the same thing for AATSR relative to radiative transfer simulations. The double difference (the difference of these two daily differences) should then take out variations due to model effects. Since the channels are not identical, the mean of the double difference is not directly informative. Any trend in the double difference may arise instability in either instrument, or NWP drift effects that happen differentially to affect bias in radiative transfer simulations. The double difference trend is therefore an upper bound to the stability of either sensor. Plot provided by Global Space–based Inter–Calibration System – http://gsics.wmo.int (R Saunders, T Hewison); created under EUMETSAT contract.

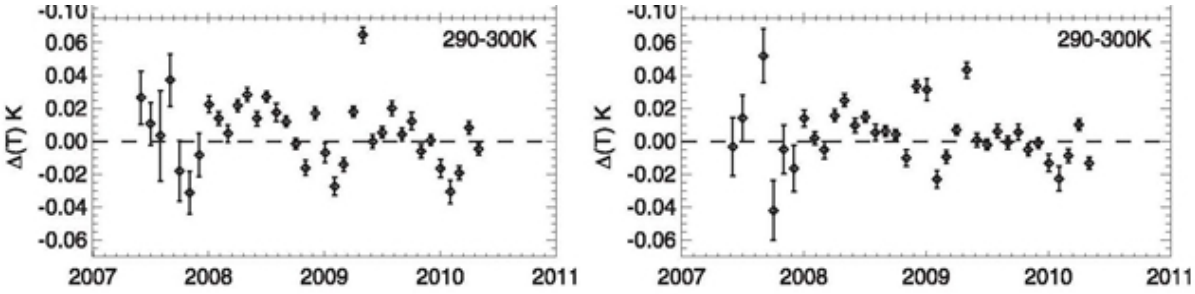

Figure 3: Metop–A AVHRR brightness temperatures using Mittaz and Harris (2011) calibration (left, 11 um; right, 12 um) compared to co–incident IASI observations, integrated over the AVHRR spectral response functions. Extracted from Mittaz and Harris (2011) (permission requested from American Meteorological Society).

5. Validation and traceability

Bridging / homogenisation strategies in general aim for:

- the maximum achievable homogeneity (minimum artefacts in SST across the sensor transitions for all regions globally)

and in the case of continuing the ARC SST record forward, in addition:

- continuation of 'climate quality' levels of long–term stability (changes in absolute bias <5 mK/year)
- continuation of the independence of into the Sentinel era

For any transition between sensors in a homogenized satellite data record, there needs to be validation (in a wide sense) of the homogenization.

In regions where a sufficient number of distinct drifting buoys can be matched to AATSR, AVHRR and SLSTR over (say) a two year period either side of any AATSR/SLSTR gap, the regional SST–depth biases of both should be able to be constrained to <0.1 K. Based on ARC experience, this will probably be the case for most of the global ocean. However, because the temperature stability of the drifting buoy ensemble is essentially unknown, this alone is not adequate to assess the long term stability of the satellite CDR.

In addition, we expect the growing Argo network can also be used as a SST depth reference to integrate the ARC/Sentinel climate data record with the historical SST record such as HadSST3 from drifters, moorings and ships. Argo measurements are thought to be more accurate than drifting buoys, so that fewer matches are required to establish a robust bias of AATSR/SLSTR SST–depth relative to Argo than to drifting buoys. However, the deeper depth of measurement introduces more geophysical variability into the comparison. Argo calibration (or perhaps a subset of it) may also be traceable to SI and have a controlled; more work needs to be done to establish the facts in this regard, but it may be that this network can be used in conjunction with GTMBA to give a constraint on the stability of the satellite record from AATSR to SLSTR.

Comparisons of AATSR and SLSTR to in situ radiometers give traceability to SI of the core skin retrievals of the satellite. This allows the retrieved SSTs to be declared to be compatible to the SI temperature scale and compatible with each other to some level of precision – this is traceability to a standard reference. The practical significance of this depends on the degree of precision with which satellite–SI agreement can be established. This cannot be better than the uncertainty of the in situ radiometry and is likely to be less precise because of the limitations of sampling of satellite–

radiometer matches. To ensure the best possible AATSR–to–SLSTR traceability, the geographical and seasonal sampling of available radiometric matches made for the final years of AATSR should be broadly replicated for the early years of SLSTR, and continued in between, so that the bridging sensor can also be included. (Explanation for this requirement: SST biases are region and season–dependent, and these dependencies cannot be assumed to be the same for AATSR, AVHRR and SLSTR. Thus, radiometric matches that are not consistent in this regard would have an additional component of uncertainty when used for AATSR–SLSTR comparison.) The observations for any given region should also ideally be undertaken with consistent in situ radiometers, to minimise differences in the trace to the standard reference arising from technological differences.

6. Risks

No mission is guaranteed, and the satellite SST constellation will not necessarily provide the means to continue an independent ARC–based satellite SST record forward to the Sentinel era. However, the strategy discussed here of using Metop AVHRRs has a degree of redundancy (once Metop–B is safely commissioned). The homogenization and MMD approaches have some precedent, and should be achievable, assuming adequate resources are found to do the detailed work.

The dual view sensors have a much higher degree of tolerance (robustness) to atmospheric aerosol than single view sensors. On a global scale, the risk is a major volcanic eruption and elevated stratospheric aerosol. There is approximately a 1/30 chance of such an event per year. Thus, the chances of such an event during an AATSR/SLSTR gap are small but not negligible.

For a single–view two–channel retrieval, an aerosol robust algorithm is not possible, and SST retrieval would need to rely on external aerosol information heavily. For a single–view three–channel retrieval including the 3.7 um, aerosol robustness is possible in principle, if the brightness temperature impacts of the aerosol are well known for all three channels. A characterization of the aerosol effects on AVHRR brightness temperatures might be possible from IASI spectra, constrained by Mie theory modeling of the volcanic aerosol layer. Nonetheless, if there is a Pinatubo–like event, this would be a considerable challenge to bridge between AATSR and SLSTR with an independent satellite SST.

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ALGORITHM SELECTION (ROUND ROBIN) EXERCISE IN THE ESA CLIMATE CHANGE INITIATIVE FOR SEA SURFACE TEMPERATURE (SST CCI)

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ABSTRACT

At the GHRSST–12 meeting (2011) the ESA SST CCI protocol for an inter–comparison and selection of SST retrieval algorithms was presented. This exercise ran between September 2011 and March 2012. “Competing” SST algorithms were trained / tested on common data available to all participants. Participants then derived SST retrievals for a common independent set of cases (the “selection set”) with no access to corresponding validation data (‘blind’ submission of results). This ensures (i) participating algorithms are compared on the same data, so that comparisons are not confounded by differing validation data characteristics, and (ii) tuned algorithms are compared on a statistically independent set of cases, and therefore have no “overfitting” advantage in comparison with other algorithms. The experiences of the participants in the exercise will be described. Algorithm selection will depend on the performance of the algorithms on pre–defined metrics. The results for these metrics and comparisons will be presented and discussed.

FOSTERING THE NEXT GENERATION: IDENTIFYING AND FILLING THE GAPS IN SATELLITE DERIVED SST DATA TUTORIALS

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ABSTRACT

To address user needs, the newly implemented Sea Surface Temperature Virtual Constellation (SST–VC) in the Committee on Earth Observation Satellites (CEOS) supports the GHRSST AUS–TAG assessment of the gaps in currently available tutorials on how to use satellite derived SST data. The current results indicate that both adolescents and adults could benefit from tutorials introducing the concept of 'skin', differences between microwave and infrared radiometers, basic orientation mechanics and data set selection. Adult materials could additionally explore more technical topics, including uncertainty, diurnal variability, and data resolution versus grid / pixel resolution. Before developing new materials, GHRSST & the CEOS SST–VC are seeking feedback from users regarding their needs and requirements.

1. Introduction

The Group for High Resolution Sea Surface Temperature (GHRSST) provides a variety of products to a broad range of users with diverse needs. These users have voiced their desire for a more comprehensive suite of instructions (hereafter 'tutorial packages') on how to utilize the materials GHRSST creates. In light of their shared investment in user satisfaction and comprehension, the CEOS SST–VC is promoting the work of the GHRSST AUS–TAG to develop a more comprehensive and effective set of tutorial packages. Specifically, integral components of the SST–VC implementation plan include;

1. encourage the identification and assessment of existing materials
2. promote the development of new materials filling identified gaps

2. Status of Assessment

We reviewed 49 tutorial packages and assessed their characteristics in five categories (Table1a–c):

1. audience: young users, professional users, if learning standards were present
2. applied context: ocean forecasting, weather forecasting, climate and seasonal forecasting, research and development, travel and tourism, daily use
3. essential skills: data set selection, import data, select a region, change color, change numeric properties
4. technical understanding of satellite data, including an introduction to: skin, microwave or infrared radiometers, polar orbiting or geostationary operational environmental satellites, algorithms applied to the data, orientation mechanics, uncertainty
5. tutorial requirements: what data sets were used, if a program needed to be downloaded, name of program used.

We then performed a gap analysis and sorted these by target age–group. A "gap" is defined when the topic in question was absent from ≥70% of the tutorial packages (Figure 1).

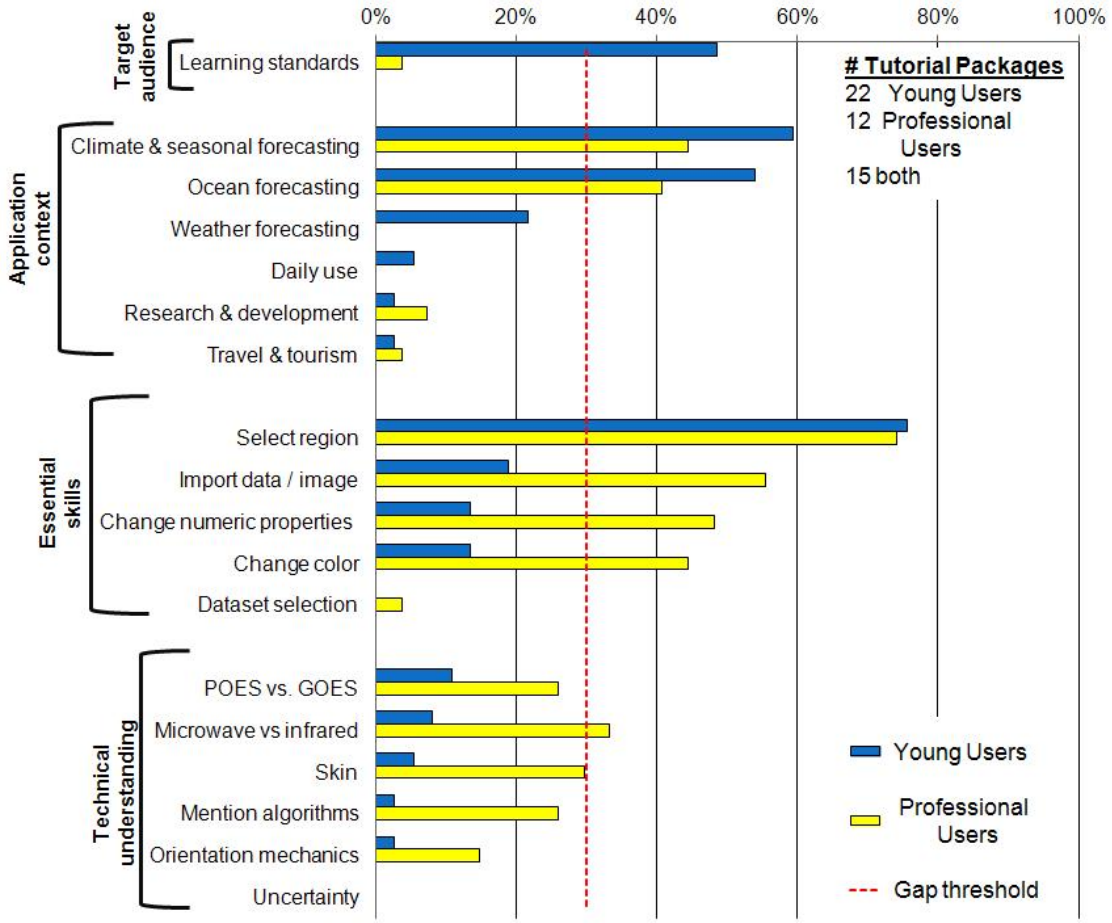

Figure 1: Percent of tutorial packages including assessment criteria by target audience. Not all criteria are shown in this figure.

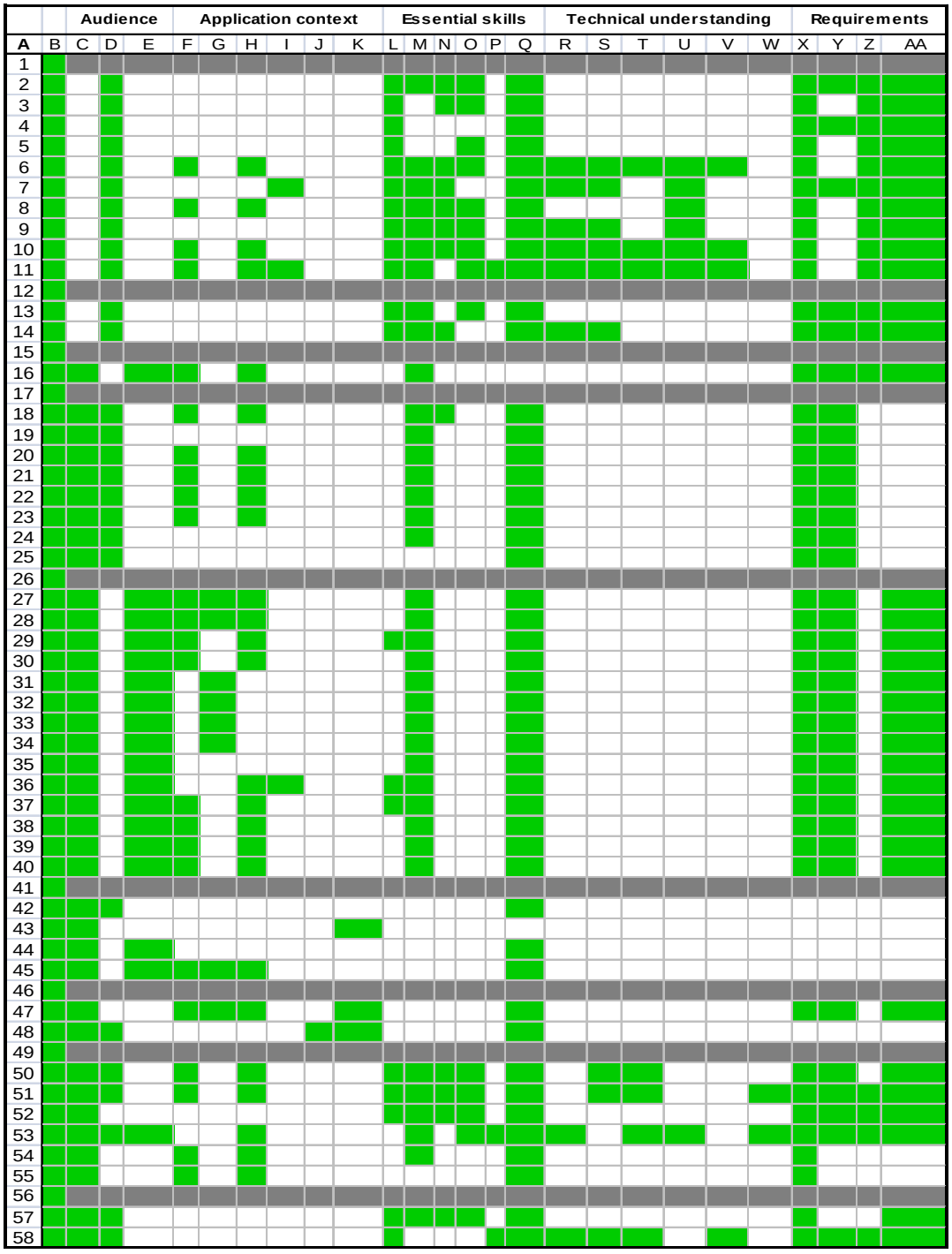

*Table 1a: Gap analysis for individual tutorial packages. White = absence of criterion, green = presence of criterion. Tutorial package #5 (column A) did not use SST data but was included as the lesson was applicable to SST data. Names of columns and rows in Tables1b and 1c, respectively. These results should be interpreted as a conservative assessment of the information in each tutorial package. If you have a discrepancy or question, please contact **pam.michael@noaa.gov** or **kenneth.casey@noaa.gov***

Table 1b: Names of columns (criterion) in Table 1a.

	Organization / tutorial package names
1	**Bilko**
2	Introductory materials
3	Mini-Lesson 1: Geometric correction of an AVHRR image
4	6: Opening binary flat files int Bilko
5	7: Using flag code images
6	calcluating thermal stress and predicting coral bleaching
7	exploring output from the National Centre for Ocean Forcasting (NCOF) Forcasting Ocean Assimilation Model (FOAM)
8	DevCo Cast Lessons = 1 a. b. c. of three downloadable
9	EAMNet Lessons = 2
10	Envisat Lessons = 5: Excluded: Internal waves (L2) 2, 3, 4, 5, 6
11	Applications of remote sensing to fisheries management = 7
12	**OceanTeacher**
13	Marine GIS Applications, Incl. ArcGIS & Spatial Analyst
14	Marine Data Literacy: Operational Oceanography: Synoptic Views of the Sea (2012) : 9.2, 8.2 & 5.4
15	**Node**
16	El Niño
17	**NASA**
18	Introduction to Ocean Color and Sea Surface Temperature Data from Satellites
19	Major Boundary Currents
20	Upwelling and Phytoplankton Productivity
21	Interannual Variability
22	Seasonal Variability
23	The Southern Ocean
24	LOCUS Tutorial Research Project 5: Sea Surface Temperature versus Chlorophyll Scatter Plots, Part I
25	LOCUS Tutorial Research Project 6: Sea Surface Temperature versus Chlorophyll Scatter Plots, Part II: Where in the World (Ocean)?
26	**My NASA Data** (combined with NASA in assessment)
27	Ocean currents and Sea Surface Temperature
28	Coral Bleaching in the Caribbean
29	Sea Surface Temperature Trends of the Gulf Stream
30	Ocean impacts of an El Niño event
31	Hurricane Frequency and Intensity
32	Hurricane Research
33	Hurricanes: An Environment of Concern
34	Hurricanes as Heat Engines (Inquiry version link)
35	Fostering Geospatial Thinking: Space to Earth: Earth to Space (SEES)
36	Evidence of Change Near the Arctic Circle
37	Phytoplankton in the Gulf of Maine
38	Comparing Graphs of Temperature and Radiation
39	Comparing the effects of El Niño and La Niña
40	El Niño Lesson
41	**COSEENow**
42	San Francisco State U, Ocean Circulation, Part IIB (Investigating atmospheric circulation and surface currents---other satellite imagery)
43	Jellies a drift
44	Seasonality in the Ocean
45	Ships, Ocean, and Satellites (S.O.S.)
46	**COOLProjects: Rutgers marine & costal sciences**
47	Earth Science Project: Create an ocean weather forcast
48	COOLRoom: Sailor's and Boater's help: How to read Sea surface temperature images
49	**Assorted**
50	University of New Hampshire: Hands-on Tutorial on How to Access and Work with Remote Sensing Images Using ImageJ
51	Scientific & Educational Endeavors (SEE): Computer lab exercises and Instructor's Guide for use with NASA Image2000: Exploring oceanography using satellite data
52	Eyes in the Sky II: G K-12, NASA Comparing Geospatial Tools
53	SEES: Center for Costal and Physical Oceanography, Old Dominion Univeristy, OVERspace Summer Institute June 21-24: Draft of classroom activities using Data with ImageJ
54	NOAA: Coral Reef Watch: Satellites & Bleaching
55	The Oceanography Society: Hands-On Oceanography: Coral Reef Watch: A classroom activity using satellite sea surface temperatures to predict coral bleaching
56	**GHRSST**
57	User guide to displaying GHRSST data using ESRI ArcGIS: Incl. ArcGIS & Spatial Analyst
58	QuickStart GHRSST One Pager

Letter	Criterion
A	Organization tutorial package
B	Web address
C	Young Users
D	Professional Users
E	Learning standards
F	Ocean forecasting
G	Weather forecasting
H	Climate & Seasonal Forecasting
I	Research & development
J	Travel & tourism
K	Daily Use
L	Import / image
M	Select region
N	Change color
O	Change # properties
P	Dataset selection
Q	Notes
R	Skin
S	MW vs IR
T	GOES vs POES
U	Mention of algorithm
V	Orientation mechanics
W	Uncertenty
X	Stated satellite source of data
Y	More information on data used
Z	Required program download?
AA	Name of program

Table 1c: Names of rows (tutorial packages) in Table 1a.

3. Conclusion

Our gap analysis highlighted significant shortcomings in the technical understanding of satellite data and tutorials applied under a weather forecasting, research and development, travel and tourism, or daily use context across age–groups (Figure 1, Table 1a). Specifically, these results suggest that the focus of new training materials for both adults and adolescents should describe the concept of 'skin', differences between microwave and infrared radiometers, basic orientation mechanics and data set selection. Adult materials could additionally explore more technical topics, including uncertainty, diurnal variability, and data resolution versus grid / pixel resolution. The authors are seeking feedback from users on this assessment to ensure that new training materials are relevant, address user needs, and succeed in enabling the future generation of data users.

SEA–SURFACE TEMPERATURES FROM THE VISIBLE/INFRARED IMAGER RADIOMETER SUITE (VIIRS) ON THE SUOMI–NPP SATELLITE

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ABSTRACT

The Visible/Infrared Imager Radiometer Suite (VIIRS) on the recently–launched NASA *Suomi–NPP* satellite is the first of a series of imaging radiometers that will replace the long–running series of Advanced Very High Resolution Radiometers (AVHRRs) on the NOAA polar–orbiting meteorological satellites. The VIIRS will be flown on the NOAA satellites of the Joint Polar Satellite System (JPSS), and benefits from several instrument components that have been developed from heritage instruments, including MODIS (MODerate–resolution Imaging Spectroradiometer) and SeaWiFs (Sea–viewing Wide Field–of–view Sensor). The components include a rotating telescope fore–optics, from SeaWiFS, and calibration targets and procedures, and multiple detectors per spectral band, from MODIS. In the infrared, VIIRS has four bands in atmospheric transmission windows which were selected for the accurate retrieval of skin Sea–Surface Temperature (SST). The atmospheric correction algorithms are based on those of the heritage instruments, and follow the tried–and–tested Non–Linear SST (NLSST) formulation. The cool–down of the infrared focal planes of VIIRS began in late January 2012, and examination showed the infrared data to be very clean with instrumental artifacts, which were a severe problem with the *Terra* MODIS, being essentially absent. The presentation will provide an overview of the VIIRS instrument and provide examples of the SST fields with an initial assessment of the accuracies of the SST uncertainties. An outline of plans for rigorous validation of the SSTs will be given.

EUMETSAT IASI SST

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ABSTRACT

IASI L2Pcore SSTs have been continued to be supplied in GDS V2.0 format as a demonstrational product, available via ftp from the EUMETSAT data centre. The SSTs are those contained within the operational EUMETSAT IASI L2 Product Processing Facility (PPF) product, available from EUMETSAT since April 2008. The IASI SST L2Pcore contains skin SSTs, flags, quality information and SSES plus an auxiliary wind–speed field, but no further auxiliary data. A summary of recent developments in the IASI L2 PPF will be given, together with some recent validation results.

Within the Continuous Development and Operations Phase 2 of the EUMETSAT Ocean and Sea–Ice Satellite Application Facility (OSI–SAF) a full IASI L2P SST will be produced based on the IASI L2Pcore SST produced at EUMETSAT central facilities and the addition of the extra auxiliary data needed (e.g. aerosol, ice). Therefore plans towards the transition to an OSI–SAF IASI L2P will be described.

COMPARISON OF THE IBI REGIONAL MODEL AND MSG/SEVIRI HOURLY SEA SURFACE TEMPERATURE FIELDS

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Operational Ocean models are now delivering fine resolution and short time scale outputs (every 1 hour). Sea Surface Temperature (SST) is one of those results, that could be compared with satellite derived SST. Hourly SST fields have been derived from the Spinning Enhanced Visible and Infra–Red Imager (SEVIRI) onboard Meteosat Second Generation (MSG). They have been produced operationally by the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT) Ocean and Sea Ice Satellite Application Facility (OSI–SAF) at Météo–France/Centre de Météorologie Spatiale (CMS) in Lannion (see [*EUMETSAT*, 2011]). The MSG/SEVIRI SST fields are thus in principle adapted to this objective. There are however various issues to consider such as:

distinct definition of SST in satellite or ocean model products

difference in projection or resolution

cloudiness that masks frequently and may contaminate IR derived satellite SSTs

In this study we use the Ireland–Biscay–Iberia (IBI) Regional Operational Oceanographic System SST outputs [*Cailleau et al., 2011*]. These temperatures are hourly fields representative of the first meter depth of the ocean. The IBI area covers the North–East Atlantic from 26 N to 65 N and from 20 W to 15 W. The IBI SST have been compared to the MSG/SEVIRI experimental hourly SST provided on a 0.05° regular grid (60 S–60 N, 100 W–45 E) in summer 2009. This presentation will describe the global comparison results and discuss in particular the restitution of diurnal warming by the ocean model compared to hourly satellite data.

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IMPLEMENTATION OF CONVENTIONAL AND INCREMENTAL REGRESSION SST ALGORITHMS FOR AQUA AND TERRA MODIS WITHIN ACSPO

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ABSTRACT

Presently, regression algorithms [1] remain the mainstream technique for SST retrieval from satellite infrared measurements. Several recent studies [2–5], however, have revealed an essential dependency of regression SST uncertainty on observational conditions and explored an alternative approach to SST retrieval, which adopts the first guess SST from analysis fields (such as OSTIA or Reynolds) and retrieves increments, or deviations, in SST from its first guess. This "incremental" approach was shown to provide more uniform accuracy of SST retrieval within a wide range of observational conditions, compared with the conventional regression (CR). As a part of preparations to the Geostationary Operational Environmental Satellites–R (GOES–R) Advanced Baseline Imager (ABI) mission, the Incremental Regression (IncR) algorithm was developed within the Advanced Clear–Sky Processor for Oceans (ACSPO) [6] and showed a superior performance over several other known SST algorithms [5,7]. Recently, the ACSPO was used for SST retrieval from data of the Moderate Resolution Imaging Spectroradiometer (MODIS) flown on *Aqua* and *Terra* satellites. This presentation reports results of development and validation of the CR and IncR SST algorithms for MODIS within ACSPO. The IncR significantly improves the performance of the daytime two–channel CR; in particular, it reduces the dependency of SST retrieval errors on view zenith angle. For the three–channel nighttime algorithms, the performances of the IncR and CR are comparable. The ACSPO CR and IncR algorithms are also compared with the standard MODIS SST algorithm, MOD28 and MYD28. A special attention is paid to the IncR implementation issues, such as correction for biases in observed minus simulated BTs and scaling of IncR coefficients.

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CLOUD COMPUTING AND BIG DATA TECHNOLOGIES FOR GHRSST

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ABSTRACT

Within the next decade, past, actual and future satellite Earth Observation (EO) missions, extended in situ networks and super–computer simulations will continue to accumulate huge volume of data at an increasingly growing resolution. **Facing streams of data pouring from space and simulations dictates that tools and methods must be engaged** to leverage such a wealth and to better link the past and/or near real–time complementary observing and modeling system elements. **This can only be achieved with dedicated infrastructures** to dynamically process massive information and to perform retrospective–analyses which will be essential key instruments for breakthroughs, and to stimulate multidisciplinary Earth system research and applications in marine and climate sciences.

This is also a major issue to be considered in GHRSST, SST being one of the most sampled parameters for the ocean with increasing frequency and resolution. What is the point of building massive archiving centers if it is impossible for users to transfer, store or process these data because of the huge volumes involved?

Processing capabilities associated with online massive storage is a way to go to cope with this challenge. Instead of bringing the data to users, users are encouraged to bring their processing to the data archive. This requires new infrastructure developments on data center side, at a limited cost. In the meantime, the necessary overhead by user to remotely deploy processings and analyses must be limited and seamless. '**Big Data'** technologies, virtualization and dynamic allocation of resources as provided by **cloud computing**, and supported by big web companies (search engines, social networks,...) can be of help for Science too.

This talk will attempt to give an overview of these upcoming **challenges** and **existing technologies**, based on a demonstration platform (Nephelae) implemented at Ifremer/CERSAT.

UPDATES TO THE UNCERTAINTY ESTIMATES IN THE OSTIA SYSTEM

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ABSTRACT

The UK Met Office Operational SST and sea Ice Analysis (OSTIA) system generates a daily combined foundation SST and sea ice concentration product on a 1/20° (~6 km) grid. The system assimilates infra–red and microwave satellite SST observations in addition to in–situ observations. All input data is passed through an automatic quality control system and a bias correction on selected satellites using the in–situ and AATSR data as a reference is carried out. OSTIA then uses a multi–scale optimal interpolation scheme to assimilate observations onto a first guess field provided by the previous analysis with a relaxation to climatology. The sea ice concentration is obtained from the EUMETSAT OSI–SAF daily ice concentration product.

The weight given to an observation in the SST assimilation scheme is dependent on both the observation and background error covariances. These error covariances have been estimated within the ESA CCI project using output from the 23 year OSTIA reanalysis. The two–component background error variances and the correlation length scales associated with these errors have been calculated. Spatially varying observation errors for the in–situ observations have also been estimated which differ across the in–situ observation platform types.

A brief overview of the OSTIA system will be presented together with the method used to estimate the error covariances. The resulting estimates and how they were implemented within the OSTIA system will be described. An assessment of the impact of these updates on the OSTIA SST analysis fields will also be presented.

BIAS CORRECTION IN OSTIA IN THE ABSENCE OF AATSR DATA

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ABSTRACT

The UK Met Office Operational SST and sea Ice Analysis (OSTIA) system generates a daily combined foundation SST and sea ice concentration product on a 1/20° (~6 km) grid. The system assimilates infra–red and microwave satellite SST observations in addition to in–situ observations. All input data is passed through an automatic quality control system and a bias correction on selected satellites is carried out. OSTIA then uses a multi–scale optimal interpolation scheme to assimilate observations onto a first guess field provided by the previous analysis with a relaxation to climatology. The sea ice concentration is obtained from the EUMETSAT OSI–SAF daily ice concentration product.

Prior to the loss of communications with the ENVISAT satellite in April 2012 the AATSR data were used as a reference dataset in addition to the in–situ observations in the bias correction of the other satellite data types. Alternative bias correction methodologies will be shown and their impact on the OSTIA SST analysis will be assessed. A brief overview of the old OSTIA bias correction scheme will be presented together with a description of the new bias correction techniques considered. Results from the assessments of trial runs will be shown validating both the bias correction fields themselves and the accuracy of the SST analysis derived using them.

SELECTING A FIRST–GUESS SEA SURFACE TEMPERATURE FIELD AS INPUT TO FORWARD RADIATIVE TRANSFER MODEL

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ABSTRACT

Advanced Clear–Sky Processor for Oceans (ACSPO) developed at National Environmental Satellite, Data, and Information Service (NESDIS) provides observed top–of–atmosphere clear–sky brightness temperatures (BT) in AVHRR channels 3B (3.7), 4 (11) and 5 (12 *μm*) along with the sea surface temperatures (SST) retrieved from these BTs as a level 2 (L2) product. Additionally, ACSPO provides the corresponding modeled BTs simulated with the Community Radiative Transfer Model (CRTM), using first–guess Level 4 (L4) SST and numerical weather prediction upper air fields as inputs. Currently, Reynolds daily 0.25º optimum interpolation SST (OISST) and National Centers for Environmental Prediction Global Forecast System (NCEP–GFS) 6–hourly 1º data are used. The simulated BTs are used for detecting clouds, retrieving physical SSTs, monitoring sensor performance and validating CRTM. Accuracy of simulated BTs is critical for all these ACSPO applications. This paper tests eleven different gap–free gridded L4 SSTs for their potential use as first–guess fields in ACSPO to improve accuracy of simulated BTs. The ultimate measure of L4 appropriateness is improved consistency between the measured and simulated BTs. As a first step towards this objective, in this study, we have chosen to check for consistency between various L4 products and the ACSPO L2 SSTs. This approach does not require expensive CRTM calculations, and SST consistency was shown earlier to be representative and equivalent to the BT consistency. The metrics employed in L4 comparisons, include the global spatial bias and variance of the L4–L2 SST differences, and their temporal stability. Also, the effect of L4 fields on the corresponding satellite–to–satellite double–differences calculated using L4 fields as a 'transfer standard' is examined. Several L4 products show better consistency with ACSPO L2 SST, including the GHRSST Median Product Ensemble (GMPE), Canadian Meteorological Centre analysis (CMC–0.2º) and UK Met Office Operational SST & Sea Ice Analysis (UKMO OSTIA). These L4 SSTs will be explored as input to CRTM simulations in the future versions of ACSPO.

TOWARDS ADVANCED USE OF SST IN NWP MODEL AT JAPAN METEOROLOGICAL AGENCY

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ABSTRACT

Real–time sea–surface temperature (SST) analysis is essential for the numerical weather/climate prediction at operational weather services. This talk introduces current usage of SST products in numerical weather prediction (NWP) systems at the Japan Meteorological Agency (JMA). In addition, on–going development of skin SST schemes in a NWP model is also presented. The preliminary validations with skin SST schemes in a JMA atmospheric model show encouraging results although further re–tuning of other parameterizations in the atmospheric model is needed for implementation of the skin SST schemes in the operational system.

1. Operational usage of SST products in NWP systems at JMA

JMA has two operational SST products. One is MGDSST, which is a high–resolution SST analysis (0.25 deg.) using satellite observations (Sakurai et al. 2005). MGDSST is used in the high–resolution operational NWP systems (e.g., global spectral model with the resolution of 20 km etc.). The other is COBE–SST (COBE–SST; Ishii et al. 2005), which is a low–resolution SST analysis (1 deg.) using in–situ observations only. The COBE–SST is a historical SST product (1891–present) suitable for applications that require a long–term analysis. For instance, reanalysis and seasonal forecasts use COBE–SST since they require SST analysis of a long period roughly 30 years and more. Specifications and usages of operational SST products at JMA are summarized in Figure 1. JMA plans to integrate weekly and monthly ensemble prediction systems (EPSs), which are currently operated in independent systems. On the course of integration of weekly and monthly ensemble prediction systems, we will use MGDSST for the integrated system including hindcasts. This implementation needs extension of an analysis period of MGDSST back to 1981. Upgrade of horizontal resolution of the monthly EPS would be benefited by using high–resolution SST analysis.

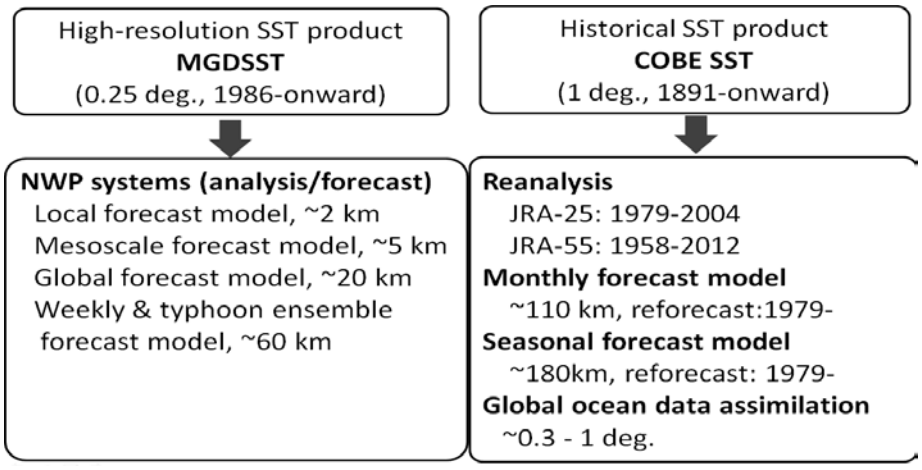

Figure 1: Usages of SST products in NWP systems at the Japan Meteorological Agency

2. Skin SST schemes

The skin SST effects (e.g., Donlon et al. 2002) on atmospheric variability has been recognized by observational and modeling studies. It is pointed out that the diurnal variation of SST influences atmospheric variability such as the Madden–Julian Oscillation (MJO) through ocean–surface interaction. Since the skin effects exist in nature and have impact on the atmosphere, the skin effects should be taken into account in NWP models for better representation of the ocean–atmosphere interaction. Nevertheless it has not been treated in operational NWP models at many national weather services. Recently the European Centre for Medium–Range Weather Forecasts (ECMWF) has introduced the simple skin SST scheme to its operational forecast model (Zeng and Beljaars, 2005; Takaya et al. 2010).

We are attempting to include the cool skin (Fairall et al. 1996) and warm skin (Takaya et al. 2010; Zeng and Beljaars, 2005) schemes in the JMA's global spectral model (JMA–GSM). This implementation potentially improves the atmosphere–ocean interaction in the NWP model. This development has been done together with development of a new surface boundary layer scheme (COARE3.0, Fairall et al. 2003). Only preliminary tests and some diagnostics are shown here as the combined revision has not given satisfactory results in prediction skill yet.

3. Experimental setting and Results

The performance of the warm skin SST scheme is validated in Takaya et al. (2010). The paper shows that the diurnal SST variation of the scheme is in good agreement with satellite estimates and in–situ buoy observations. Here we performed consecutive 10–day integrations during the TOGA–COARE period. The model used is a low–resolution global atmospheric model with the same configuration as the JMA monthly EPS (resolution: TL159L60, ~110 km).

Figure 2a shows a time–series of observed temperature at 0.45–m depth from a WHOI IMET buoy at 1° 45' S, 156° E. It is seen that there are periods with high and low diurnal SST variability corresponding to atmospheric intra–seasonal variability in the tropics (cf. Bernie et al. 2005). Figure 2b shows time–series of observed and simulated diurnal SST amplitude (DSA) near the buoy location. It is found that the model reproduces the small (large) DSA during a period A (B). Figures 3a and 3b show spatial maps of 10–day mean DSA during periods A and B, respectively. The NOAA outgoing longwave radiation (OLR) analysis shows that active (suppressed) convections were prevailed over the eastern tropical Pacific during periods A (B). On contrary, the DSA in the tropical Indian Ocean during the period A is larger than that during the period B. This may be related to less active convection during the period A than the period B (Figures 3c and 3d). These results suggest that the air–sea interaction through the diurnal SST variability is represented in the JMA model to some extent. The inclusion of the diurnal SST variability in NWP models would potentially give better atmospheric intra–seasonal variability (Vitart et al. 2007, Woolnogh et al. 2007). We continue our attempt to implement the skin SST scheme with re–tuning of other relevant processes.

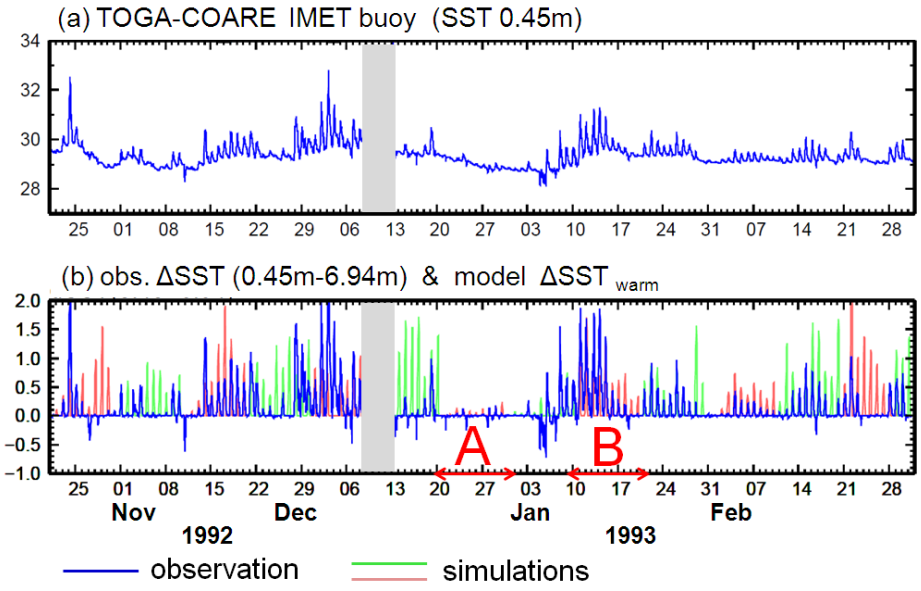

Figure 2: (a) Time–series of observed temperature [o C] at 0.45–m depth from a WHOI IMET buoy at 1o 45' S, 156o E. (b) Time–series of observed and simulated diurnal SST amplitude (DSA) [o C] near the buoy location.

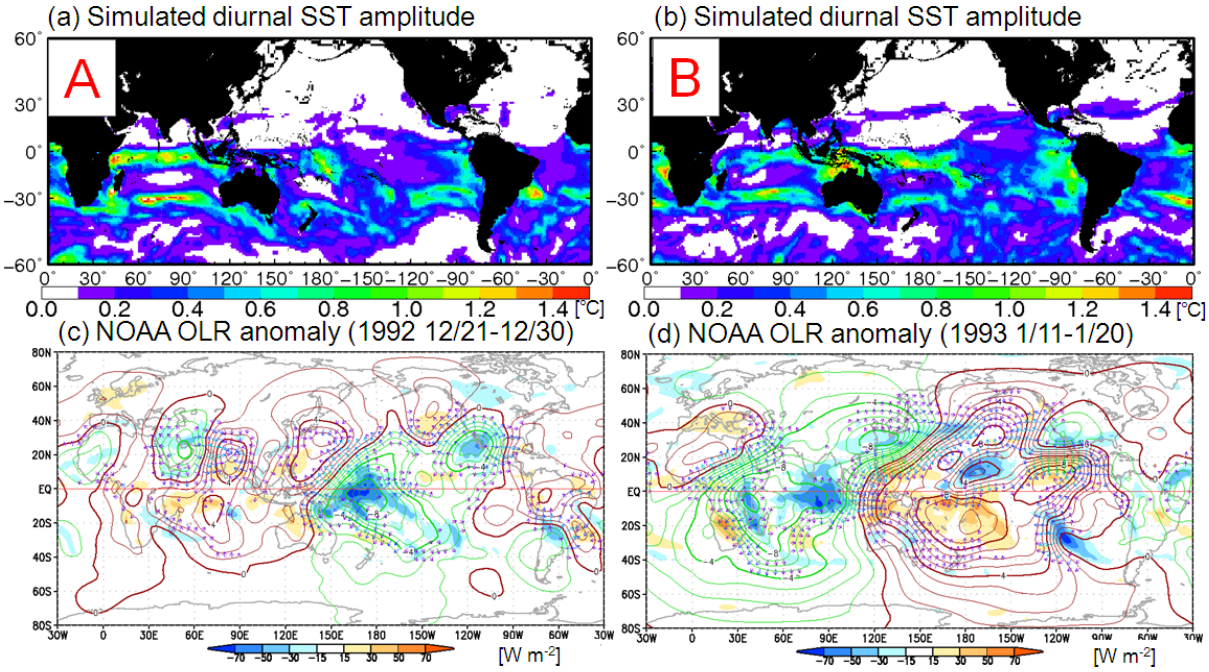

Figure 3: Simulated DSA [oC] during (a) Period A and (b) Period B. Corresponding anomalies of NOAA OLR analysis during (c) Period A and (d) Period B. Colors indicate OLR anomalies to 1981–2010 climatology. Contours indicate velocity potential anomalies at 200 hPa.

Two formulations of a cool skin SST effect (Fairall et al. 1996, Artale et al. 2002) are diagnosed as well. The cool skin departure is roughly expressed as a function of 10–m wind. Donlon et al. (2002) and Minnett et al. (2011) present relationship between cool skin departure and 10–m wind speed based on ship–based spectroradiometric measurements. Figure 4 is a plot of simulated cool skin temperature departures and measured estimates in a function of 10–m wind. It is found that the Fairall scheme matches relatively well in moderate wind speed. On the other hand, both of Fairall and Artale schemes simulate smaller cool skin SST departure in high–wind conditions (> 10 m s^{-1}) with the JMA model.

The reason should be investigated in more details. The disagreement of the Artale scheme between 10 and 15 m/s may be due to formulation of the thickness formulation adopted the scheme (Figure 1 in Tu and Tsuang. 2005).

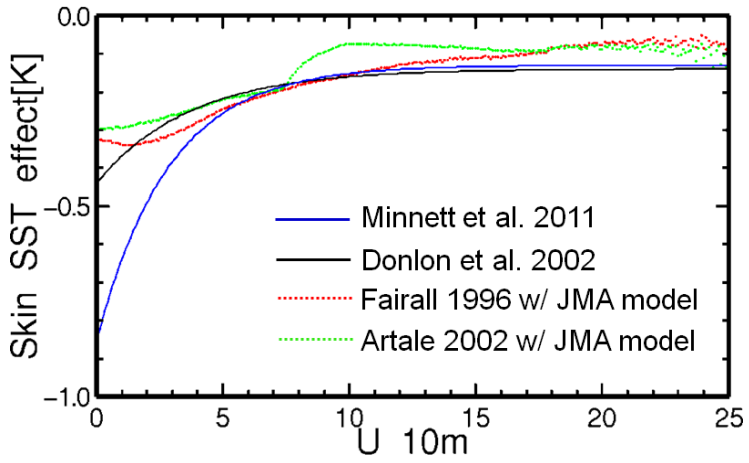

Figure 4: Cool skin temperature departure [oC] with respect to 10–m wind speed [m s–1]. Simulated results with Faiall et al. 1996 scheme (red dotted line), Artale et al. 2002 scheme (green dotted line), and estimates from Minnett et al. 2011 (blue solid line), Donlon et al. 2002 (black solid line) are plotted.

4. Concluding remarks

The new skin SST schemes are tested in accordance with the new surface boundary layer scheme. The preliminary results for the TOGA–COARE case imply its positive role in simulating atmospheric intra–seasonal variability. Validations with two cool skin SST formulations suggest that the Fairall scheme is one of our options, however the scheme underestimates the cool skin effect in high wind conditions. Further evaluation and improvement of skin SST schemes would be desired. The diurnal skin SST analysis from GHRSST projects would be certainly great help for advancing skin SST parameterization.

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AN ANALYSIS OF SST GRADIENTS OFF THE PERUVIAN COAST: SENSITIVITY TO RESOLUTION

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ABSTRACT

The Peruvian Coastal Upwelling System (PCUS) is one of the most productive fisheries in the world and yet the less documented in terms of physical processes. The upwelling region off Peru exhibits a rich spatial variability associated with changes in the magnitude and location of frontal structures, potentially having a strong impact on biology. Here, SST gradients from four different data sets, NCDC, REMSS, OSTIA, and MUR are compared in two test areas off the PCUS: Païta (5°S) and Pisco (14°S). The focus is on the benefit in going to higher–resolution for documenting characteristics of the upwelling dynamics (i.e. upscaling scale, diffusion process, seasonal to decadal variability). In both areas SST gradients derived from the MUR data set show greater magnitudes, as well as a larger seasonal cycle. Off Pisco the seasonal cycle of 2 °C/100km in MUR is twice as large as those derived from the lower resolution data sets. All data sets exhibit a seasonal cycle that peaks in late Austral summer and early fall. Hovmuller diagrams calculated at 5.5S, 10.5S, and 14.5S show clearly defined offshore maxima in the cross–shore gradients for all the data sets. All four date sets show similar large–scale structures associated with the Peruvian Upwelling. Sub–sampled MUR 1km data at the 25km, 9km, and 4km resolutions compare well in magnitude and phase with the lower resolution products. Agreement in gradient magnitude between the lower resolution data sets and the MUR sub–subsampled at their respective resolutions implies that the pixel–to–pixel analysis noise in MUR is at a similar level as the other data sets. At the decadal scales preliminary results indicate that using the Pathfinder V5.0 data leads to identification of higher spatial scales along the coast than seen in the lower resolution data sets.

CHARACTERIZATION OF AGULHAS BANK UPWELLING VARIABILITY FROM MULTISCALE ULTRAHIGH RESOLUTION (MUR) BLENDED SEA SURFACE TEMPERATURE AND 1KM MODIS AQUA DATA

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ABSTRACT

South of Africa the Agulhas Bank forms a roughly triangular–shaped, broad extension of the continental shelf, ranging from Cape Point in the west to East London 800km further along at its eastward extreme. It is a complex oceanic region influenced by coastal upwelling processes typical of the Benguela Upwelling System, as well as shelf–edge dynamic upwelling resulting from the variable presence of the Agulhas Current. During summer intermittent easterly winds drive coastal upwelling at several promontories along the South African southern coast. On the eastern Agulhas Bank divergent upwelling is observed as the Agulhas Current follows the edge of a widening continental shelf. Further southward intermittent, intense shear–edge eddies, driven by a meandering Agulhas Current, upwell cold water in their cores which may be advected onto the Agulhas Bank. A subsurface ridge of cool water, extending along the 100 m isobath, appears to be a quasi–permanent feature of the large scale thermal structure along the eastern and central Agulhas Bank during spring and summer. These upwelling processes promote high primary production at preferred locations on the Agulhas Bank. Consequently the Agulhas Bank provides both a spawning ground and nursery area, and is the centre of abundance of numerous commercially exploitable species. The mesoscale surface signatures associated with these upwelling events are readily observed on sea surface temperature and chlorophyll–a concentration images. An analysis of the large scale climatology and variability of sea surface temperature (SST) and surface chlorophyll on the Agulhas Bank has previously been performed using 4.5km AVHRR and SeaWiFS data, but this study did not address variability on shorter space and time scales. Cloud–free high resolution SST data from the Multiscale Ultrahigh Resolution (MUR) blended product presents the opportunity for a detailed analysis of upwelling at the event scale, thereby allowing for the identification of upwelling contributions from various locales on the Agulhas Bank. MODIS Aqua 1km data provide coincident SST and chlorophyll–a data that not only serves to confirm the quality of the blended product, but also allows for the characterization of the chlorophyll response to upwelling events.

APPLICATION OF DAILY SEA SURFACE TEMPERATURE IN FISHERIES AND ITS DATA PROCESSING

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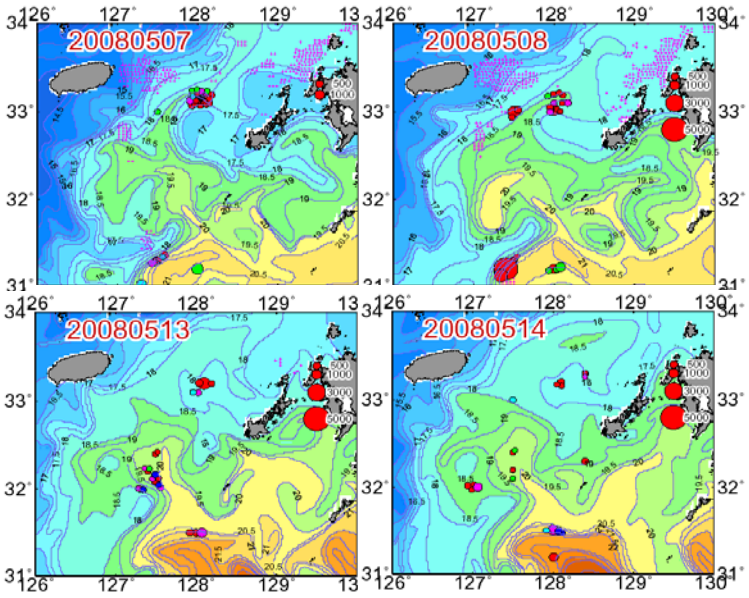
ABSTRACT

As the powerful tool for observation ocean information from space, Satellite remote sensing Satellite has been widely applied in fishery for nearly 30 years in Japan. The satellite observations, sea surface temperature (SST), has been extensively used to predict effective fishing grounds, will be introduced, including how to blend several satellite data, and fisheries analysis case will be demonstrated.

In the outer layer, SST is an important oceanographic factor to help in locating fishing grounds of Pelagic Fisheries. In order to provide fishermen with daily high–resolution SST, a method for obtaining daily SST with per 1/40° grid is presented and discussed. For this purpose, infrared radiometers (AVHRR) SST, which is a temperature of skin SST roughly at depth of 10μm, is very valuable due to its high ground resolution of 1.1km, but the status obscured by clouds often leads to a blank SST distribution. Microwave radiometer (AMSR–E) SST, which is a temperature of sub skin SST about at depth of 1mm, has advantages of observation capability through clouds, thereby provides an uninterrupted view of ocean, but it also has weaknesses such as a poor resolution of 27km. In fact, fishing ground analysis needs in situ SST measurement from ship or buoy, which sample the bulk SST at around 0.5~3m depth, but actually in situ SST is always has a sparsely distribution. To overcome this disadvantage, firstly, we developed a device that is installed on fishing boat, by this instrument we can collect as much as in situ SSTs in real time. Accordingly, in order to converting sub skin SST to bulk SST, we prepare a daily composite AMSR–E SST from SSTs collected in the past 3 days, the quality controlled in situ SSTs are compared with the AMSR–E SSTs, and the differences are used to calibrate all the AMSR–E SSTs. Finally, we prepare a daily composite AVHRR SST from SSTs collected in the past 5 days. If a SST is lacking, this SST can be interpolated from available SSTs at surrounding grids. Average temperature difference and standard deviation between composite SSTs and the latter two SSTs are calculated. In order to select high–quality SSTs, composite SSTs with a temperature difference two times larger than the standard deviation are eliminated. At the same time, all selected composite SSTs are corrected by the average temperature difference. These procedures of selecting and correcting SSTs are reiterated until the standard deviation of the temperature difference becomes smaller than 0.5°C. Selecting high–quality composite SSTs, however, results in a lack of data at some grids. Accordingly, they are interpolated or extrapolated from those at the nearest grids. The composite SSTs are finally corrected by means of the temperature difference obtained.



Left Figure: the character of fishing grounds in Tsushima Warm Current. (Round mark is the fishing grounds of Trachurus japonicus, Scomber japonicus, Houttuynyellowtail, Skipjack tuna, + mark is the position of Squid fishing boat)

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APPENDICES

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