GHRSST

Group for High Resolution Sea Surface Temperature

PROCEEDINGS OF THE GHRSST XI SCIENCE TEAM MEETING

Hotel Plaza del Bosque, Lima, Peru

21st June –25th June 2010

Hosted by: IMARPE

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Photograph on front page *(from left to right)*:

Front row:	*Robert Evans, Alexey Kaplan, Tim Liu, Jorge Vazquez, Sara Purça*
Second row:	*Viva Banzon, Nick Rayner, Tess Brandon, Craig Donlon, Christopher Jeffrey, Daniel Valla*
Third row:	*Shiro Ishizaki, Ed Armstrong, Gary Wick, David Meldrum, Richard Reynolds*
Fourth row:	*Pierre Le Borgne, Jean-François Piolle, Ken Casey, Ioanna Karagali, Ian Barton, Anne O'Carroll, Yi Chao*
Fifth row:	*Sandra Castro, Participant, Matt Martin, Andy Bingham, Steinar Eastwood, David Poulter, Werenfrid Wimmer, Jacob Høyer, Tim Nightingale, Peter Cornillon, Peter Minnett*

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Edited by:

A. Kaiser-Weiss
GHRSST Project Office

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INTRODUCTION

Craig Donlon, GHRSST Science Team Chair

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Introduction

This report provides a record of the proceedings at the 11th GHRSST Science Team meeting, held at the Hotel del Bosque, Lima Peru Monday 21st June – Friday 25th June 2010. The meeting was attended by over 40 representatives from the International SST community including scientific, operational and user communities. Each delegate brings a message or an SST problem and takes back an answer from the GHRSST International Science Team based on discussions and consensus agreements. The strength and success of GHRSST lies in the ability of the talented individuals working within GHRSST, who often represent their employers, their Nation and their user community, to debate an issue and reach a satisfactory compromise. This allows the international community to benefit through confident consensus decision making, sharing of SST data, and sharing of knowledge in a manner that delivers progress towards better SST products and services for all.

The 11th GHRSST meeting provided an important opportunity to critically review where the GHRSST activity must focus its effort for the future benefit of the stakeholders that have invested in the project to date. A key focus for the meeting was the review and sign off the GDS 2.0 before final editing and external review. This has been an immense amount of work from many people over the last 12 months and I would like to thank all of those involved for their incredible dedication and attention to detail. The GDS-2.0 marks an important development for a more stable, more inclusive GHRSST framework allowing the teams to focus on Science and User applications rather than technical coordination.

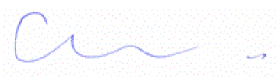
A new development for a CEOS SST Virtual Constellation has been initiated to enhance the relationship between space agencies and the SST user/producer community. This will benefit GHRSST through better international recognition and allow GHRSST to feed back developments and issues to the space agencies that ultimately provide data and capability. As we move forward into the next generation of satellite systems and instruments GHRSST will work together with the SST-VC to help ensure a balanced and cost effective SST constellation is developed and maintained with science and operational users fully involved in the process.

Most importantly, a new GHRSST Project Office Coordinator, Dr Andrea Kaiser-Weiss (at the University of Reading) has been appointed to manage and develop the GHRSST International Project Office that is so important for the daily operation of GHRSST. On behalf of the GHRSST Science Team, I would like to welcome Andrea to the GHRSST fold and to wish her success in managing and developing GHRSST over the next 3 years. Andrea can expect to receive the full backing and cooperation from the Science Team as she helps shape the future of GHRSST.

The 11th GHRSST meeting format was biased toward *plenary discussion* using keynote talks to identify issues complemented with poster sessions and dedicated breakout discussions for each GHRSST TAG/WG. Breakout groups were used to focus the attention of world expertise within the GHRSST TAG and WG to critically review the GDS 2.0 documentation and develop their own work plans for the coming year. As members of the international Science Team of GHRSST we all have an obligation to serve the RDAC and GDAC projects with a clear roadmap, based on our collective scientific judgment and consensus opinion to guide and nurture a globally integrated and sustainable high resolution SST operational system for the benefit of all. I am confident in the activities and progress made by WG and TAG and would like to thank each of these groups for the excellent work that they do – often without public knowledge: these are the groups that shake and move GHRSST to ensure the flow of high quality data for science and operations. WG/TAG Chairs have a significant role in coordinating activities to ensure a successful outcome and can often be found working late into the night in different parts of the world making "SST for all" a daily reality. The proceedings from the 11th GHRSST Science Team workshop show how the GHRSST Science Team continues to innovate and develop the next generation SST data products and services.

On behalf of the GHRSST Science Team I would like to take this opportunity to thank Sara Purça and the IMARPE team for all of their help and support in Hosting and preparing this workshop. Thanks also to all the sponsors and you, the participants, who make these important events possible.

Dr. Craig Donlon



(Chair of the GHRSST Science Team)

CHAPTER 1

PROJECTS AND GROUPS REPORTS

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REPORT ON THE GLOBAL DATA ASSEMBLY CENTER (GDAC) TO THE 11th GHRSST SCIENCE TEAM MEETING

Edward M. Armstrong[(1)], Andrew Bingham, Jorge Vazquez, Charles Thompson, Thomas Huang, Chris Finch

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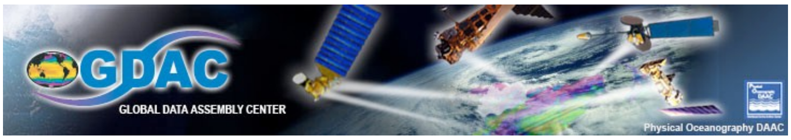


ABSTRACT

In 2009/2010 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.

The GDAC has continued to grow with more data and users served, evolved with new infrastructure implementation and data access capabilities as well as provided expertise in GHRSST data management and product development.

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 products using a number of access protocols including FTP and OPeNDAP.

In this report we first describe key new improvements and evolution developments to the overall GDAC architecture. This includes implementation of the new PO.DAAC DMAS (data management and archiving system) that was reported on at the last meeting. Further sections are devoted to new products, and the development of tools and services for L2P subsetting and access. The metadata section documents how the GDAC has been actively providing metadata and fostering discovery for GHRSST products, and helping to guide the development of an ISO-based metadata model. The last section details the GHRSST data usage statistics since 2009.

2. GDAC integration and evolution

The original GDAC data interfaces to GHRSST data producers, data consumers and data archive (LTSRF) were designed and implemented over 5 years ago, and as reported at the last Science Team meeting, a new PO.DAAC data management architecture, DMAS (data management and archiving system) has now been implemented for all GHRSST data streams. This new architecture has several improvements including scalability to handle increasing volumes of data ingest and dissemination.

In addition to aforementioned ingest and dissemination capabilities, further DMAS functions included metadata registry into an upgraded Master Metadata Repository (MMR) in an Oracle database in conjunction with its web-based search and discover interface, FGDC metadata generation and implementation of the NODC interfaces for GHRSST data transfer for archiving, ingest data latency tracking and distribution metric capturing and other enhanced operator functions. DMAS also assumes data management roles of the MODIS L2P RDAC including L2P ancillary filling.

In 2009/2010, the PO.DAAC DMAS system has completed four major incremental deliveries that have been deployed operationally at PO.DAAC. These incremental releases included enhancements to address capabilities identified in the above paragraphs. This year DMAS also received many good reviews at AGU, ESDIS, and ESIP Federation conferences and workshops. As shown in Figure 1 and 2, DMAS is a multi-mission data system that offers data ingestion, validation, catalog, archive, and distribution capabilities. GHRSST data are being handled operationally by DMAS since June 2009.

Figure 1. The top-level DMAS system architecture view

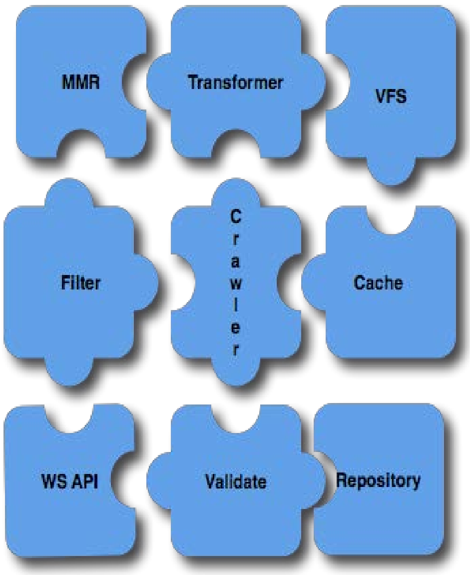


Figure 2. Components of the data handler to process GHRSST data

3. New Products

The GDAC has continued to support the ingestion of new L2P, L3 and L4 products. Some of these include the imminent distribution of ultrahigh resolution (UHR) regional to global Level 4 products including the:

- North America 1 km MODIS/ AMSRE RTO
- G1SST 1 km Global OI
- MEaSURES Multisensor (MUR) North America 1 km retrospective

Other L2P and L3 products include:

- METOP_A L2P
- METOP_A L3C
- MTSAT-1R L2P
- AVHRR19_L, _G L2P

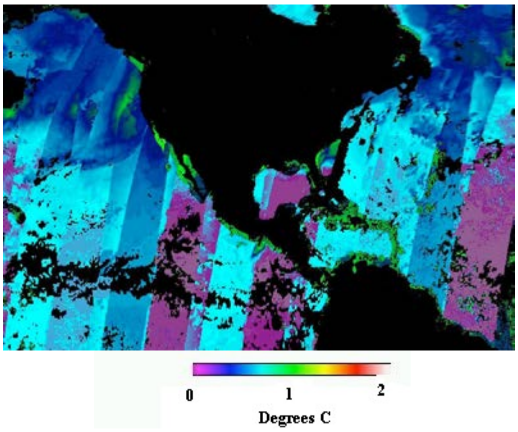


Figure 3. Example error map (analysis_error) for the L4 UHRSST RTO product, 14 Nov 2009

4. Tools and Services

NAIAD (Enhanced Satellite Archive Dataminer) is a software system consisting of a set of web services for data search, imaging and extraction, a virtual tile database, back-end processing for imaging and extraction, and a web-based client (Dataminer) for executing these services. It was developed originally by the French agency Ifremer, and elements have been modified at PO.DAAC for use in supporting GHRSST L2P datastreams.

The core of the NAIAD system is the “virtual tile” database. Each swath data granule is tiled, or divided into regions (typically representing 500kmx500km). The spatial and temporal data associated with each data region is stored inside of a tile, as well as that region’s statistical properties. Dividing the data granules into tiles enables searches at a sub-file level for swath data, something not possible using file-level metadata. The system also uses the tile information to obtain slices of data for imaging or extraction, instead of having to download the entire granule before processing.

PO.DAAC has recently released a fully functional beta version of Dataminer to the ocean community (http://podaac-tools.jpl.nasa.gov/dataminer). In its current form the tool allows search and extraction of GHRSST AMSR-E L2P and QuikSCAT swath data (both from PO.DAAC and NODC) and is being extended to support all GHRSST L2P data products by the end of Summer 2010. Any Level 2 products both local and remote that are accessible via OPeNDAP can be part of a Dataminer search with relatively small effort. Dataminer's GUI sits on top of search and extraction SOAP web services that can be called directly as well, providing for machine-to-machine interfaces and automation (e.g., subscriptions).

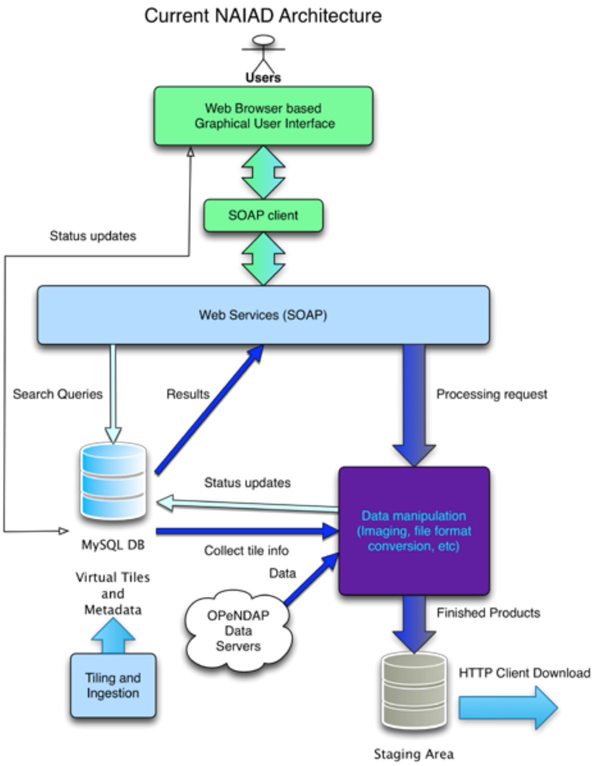


Figure 4. Overall NAIAD architecture

Enhancements expected to be developed during the remaining portion of the year include the creation of RESTful analogs of the current SOAP services and automatic notification of incoming data product files through the use of Datacasting feeds. The Dataminer GUI will also be modified to include a Google Earth data selection mechanism to augment the current interface. Users will be able to select regions using the traditional bounding box available in the current version of Dataminer or by manipulating the Google Earth display to make selections based upon event hurricane, oil spills, El Niño) or common regions (Southern Ocean, Pacific Ocean, Atlantic Ocean).

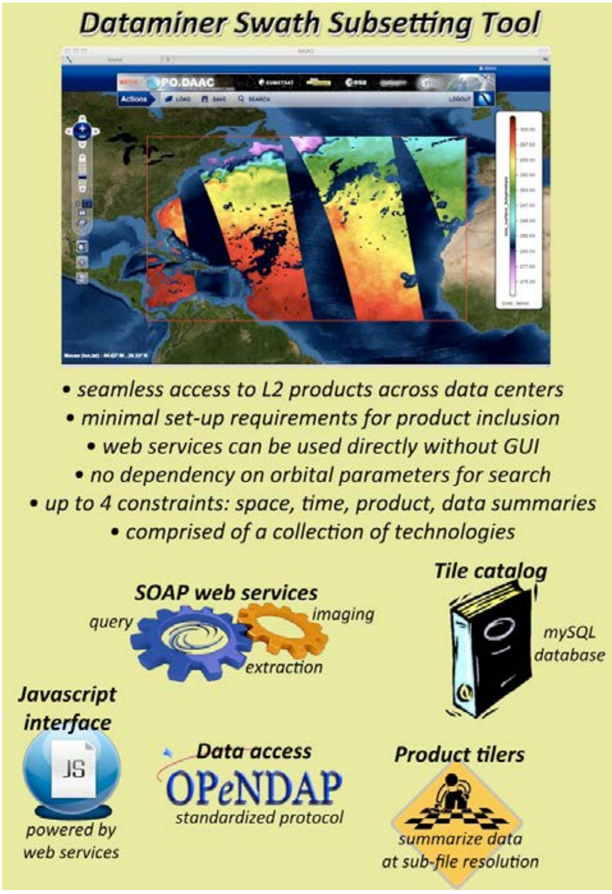


Figure 5. The features and components of the NAIAD/Dataminer system.

5. Metadata and Discovery

The GDAC has collaborated with the NOAA National Geophysical Data Center (NGDC) and National Oceanographic Data Center (NODC) to produce a new GHRSST metadata model for GHRSST data products. The GHRSST GDS 2.0 Metadata Specification uses ISO 19115-2 format specifications and is a substantial change from the existing GHRSST metadata model. Currently, there are three types of existing GHRSST metadata. The Data Set Descriptions (DSD) include metadata that provides an overall description of a GHRSST product, including discovery and distribution. The File Records (FR) contain metadata that describe a single data file or granule including is spatial and temporal bounds. Both of these types of metadata are written as XML into files that are separate from the satellite netCDF records.Finally there is metadata that is included in the GHRSST data files, which are written in netCDF. All three types of metadata are considered in the initial GHRSST 2.0 Metadata Model.

An ISO metadata model is made up of a set of containers (also referred to as classes or objects) that contain metadata elements or other objects that, in turn, contain other elements or objects. In our implementation we use the ISO 19115-2 (part 2) specification that contains the remote sensing extensions designed for describing remote sensing data and gridded dataset. The root element in our model is the MI_Metadata object (Fig. 6). It contains twelve major classes that document various aspects of the resource being described including both collection and granule level metadata captured in a single XML file. Detailed information on the new metadata model and an example XML record for an AMSRE L2P data file can be found in the GDS 2.0 Metadata Specification document on the GHRSST web site (http://www.ghrsst.org).

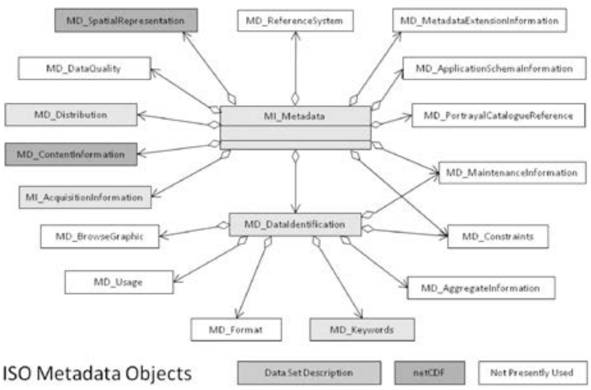
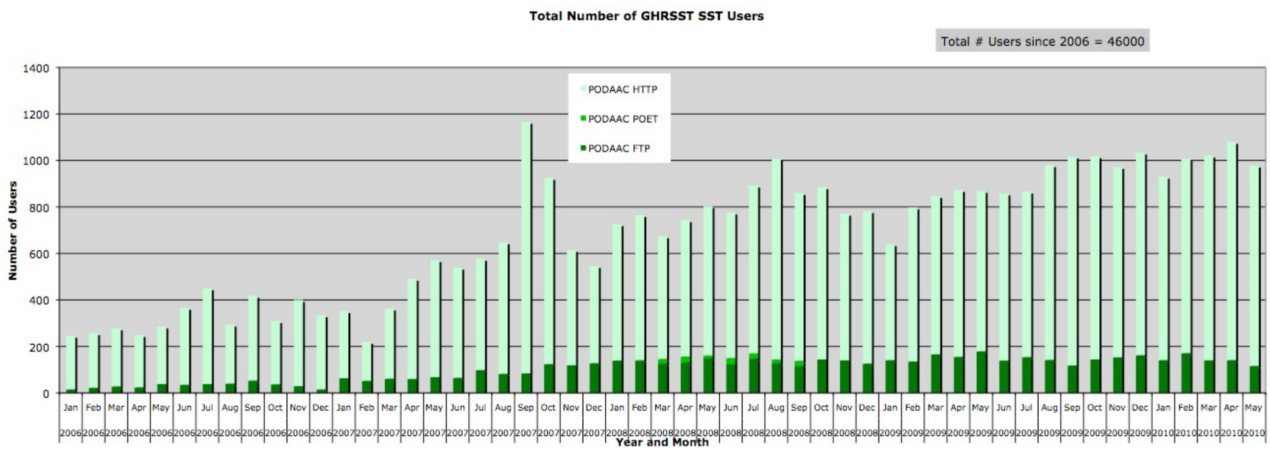


Figure 6. Proposed ISO-19115-2 objects for the GDS 2.0 metadata specification

The PO.DAAC has also been 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. Currently, ECHO contains 32 GHRSST data sets with more than 270,000 granules. These data sets and granules are available for search through the ECHO WIST interface (https://wist.echo.nasa.gov/api/), which now has a GHRSST topic keyword under the OCEAN discipline in the user interface. The metadata at ECHO for these data sets are currently updated weekly. The remaining 14 GHRSST data sets will be added to ECHO in the near future.

6. GDAC data metrics

The following figures are representative summaries for the data volume (compressed) and number of users of GHRSST data from the GDAC since early 2006. The GDAC continues to average around 2.5 TB for data distributed per month. More enhanced statistics will be reported at the June 2010 Science Team meeting.



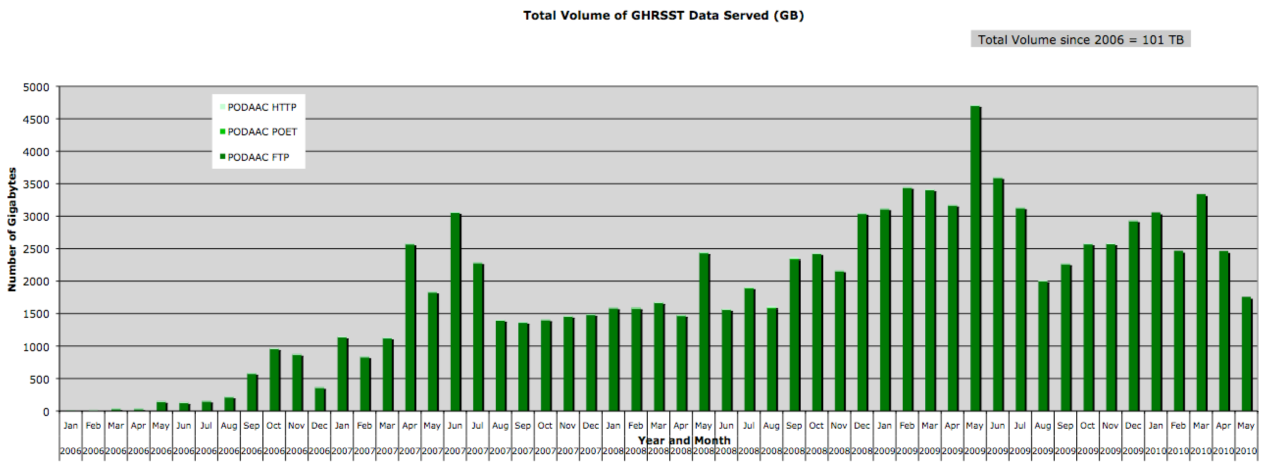


Figure 7 and 8. GDAC user and data distribution (compressed volume) summaries.

7. Conclusion

The Global Data Assembly Center (GDAC) continues to meet its requirements to distribute increasing numbers of GHRSST products and volumes, foster data discovery, maintain good metadata records and data stewardship, and build new data utilization tools. GHRSST datastreams can now leverage off an improved and scalable data management system that has recently been put into place at the PO.DAAC as well as new subsetting tools and infrastructure. N ASA has recognized the importance of GHRSST data (with several proposal calls emphasizing these products) while supporting the concept that leading edge research cannot be fostered without strong data management principles and intrastructure. The GDAC has committed to maintaining GHRSST data for all users in conjunction with the NOAA Longterm Stewardship and Reanalysis Facility well into the future.

OSI SAF ACTIVITIES AT MF/CMS BETWEEN GHRSST X AND GHRSST XI

P. Le Borgne[(1)], G. Legendre, A. Marsouin, S. Péré, S. Philippe, H. Roquet, MF/CMS

OSI-SAF/Metéo France, Email: leborgne@meteo.fr

1. Development of a new geostationary chain

A new geostationary chain has been developed and is now under preoperational testing. The operational delivery of its product should start before the end of 2010.

SST are now derived from MSG every 15 minutes and from GOES-E every 30 minutes, and then synthesised into hourly products. These hourly products will be delivered as L3C (collated) over 0.05° resolution grids from 60° N to 60° S: the longitude range is 60°W to 60°E for MSG and 135°W to 15° W for GOES-E.

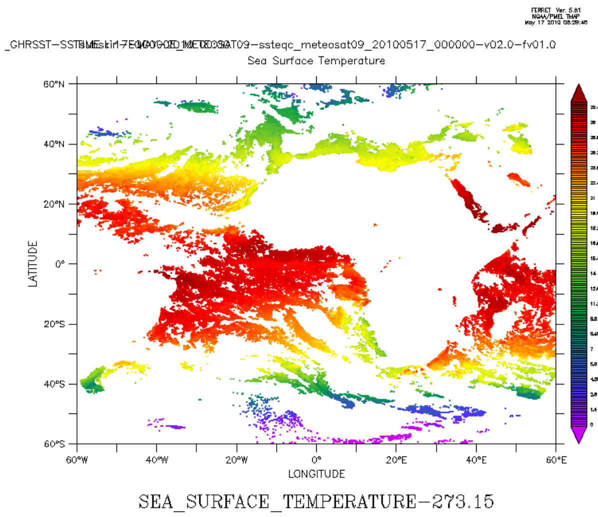
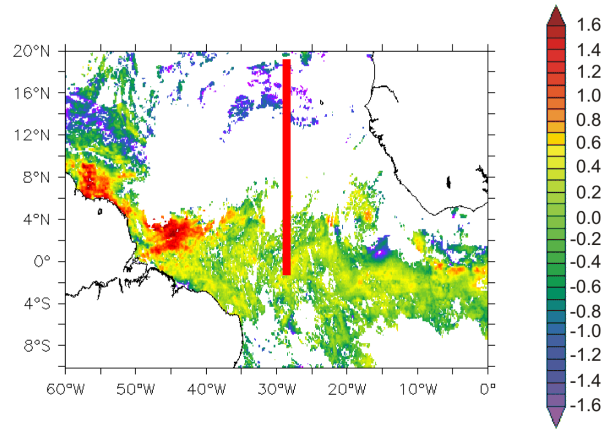


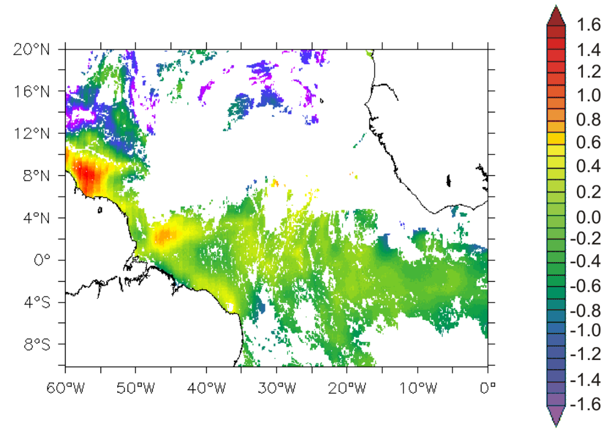
Figure 1: SEVIRI derived SST on the 17th of May 2010 at 0000 UTC.

2. Development of a prototype geostationary chain using NWP outputs

Multi spectral algorithms show regional biases that have been difficult to correct. A prototype geostationary chain has been implemented to use the NWP model outputs (atmospheric profiles) to derive SST from Optimal Estimation (Merchant et al., 2009) or correct the SST multispectral calculations according to the local atmospheric conditions (Le Borgne et al, 2010). These approaches are efficient in correcting the regional biases and will be applied operationally.



(a)



(b)

Figure 2: Inter-tropical Atlantic on the 29th of August 2009 at 0000 UTC.
(a): difference between operational SST and OSTIA; (b): error simulated by using ECMWF profiles.

3. Analysis of the impact of the Eyjafjöll eruption on the North Atlantic AVHRR derived SST

The impact of the Eyjafjöll eruption (14th of April) on the AVHRR derived SST fields has been investigated from the 15th till the 19th of April. Various scenes from the OSI SAF NAR (North Atlantic Regional) product have been analysed. The errors we observed are produced on the margins of dense ash clouds or by thin ash clouds (Figure 3). They are related to relatively low values of T11-T12, but not low enough to be detected by the cloud mask. The examples we have studied show that the eruption related errors are small in amplitude and limited in geographical extension. The validation results on MDB confirm the relatively small impact of the eruption (Figure 4).

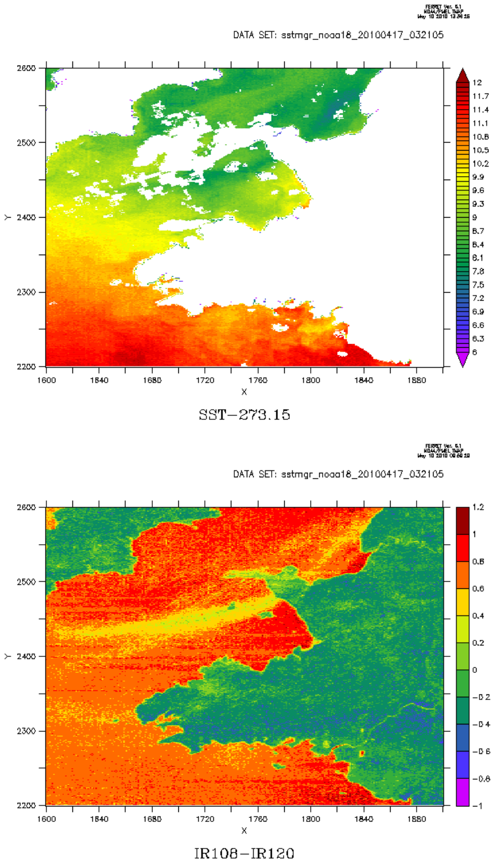


Figure 3: NOAA-18 over the Channel on the 17th of April at 0321 UTC: SST and T11-T12 (from LeBorgne & Péré, 2010)

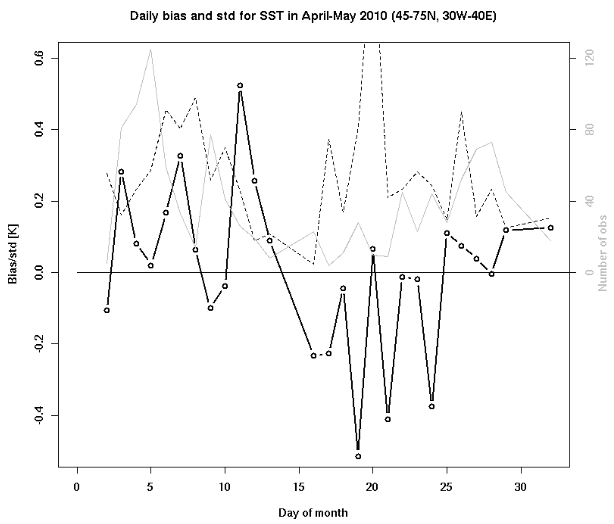


Figure 4. Daily METOP SST validation results (from S. Eastwood, met.no)

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1. Merchant,C.J, P. le Borgne, H. Roquet and A. Marsouin, 2009 , "Sea surface temperature from a geostationary satellite by optimal estimation", *Remote Sensing of Environment*, 113 (2), p.445-457
2. Le Borgne, P., Roquet, H. and C.J. Merchant, 2010, Estimation of sea surface temperature from the Spinning Enhanced Visible and Infra Red Imager, improved using numerical weather prediction, accepted, *Remote Sensing of Environment*
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MyOcean SST TAC activities between GHRSST X and GHRSST XI

Météo-France, Met Office, Ifremer, Met.no, DMI, CNR, NOCS

4. Research and development

At Ifremer, as part of development of the new ODYSSEA processing chain, a new inter-calibration method using all available sensors instead of relying on the sole AATSR has been implemented and tested. A priori information for the analysis scheme have also been improved.

At the Met Office, a system to produce a 20-year high resolution, global, daily reanalysis using the OSTIA system has been developed. The satellite SST (Pathfinder AVHRR and re-processed (A)ATSR) data and in situ (from the ICOADS database) data inputs for this reanalysis have been accessed and decisions made about the quality flags to be used. Re-processed sea-ice concentration data produced by the EUMETSAT OSI-SAF have also been accessed. A one-year period was used as a test-bed to develop the reanalysis system to ingest these various data sources, and results compared with the operational OSTIA system. Aspects relating to the consistency between the sea-ice concentration and high-latitude SSTs are being investigated. A preliminary version of the full reanalysis is now being produced and assessed.

At CNR, new merging procedures to build the internal super-collated L3 used as input for the CNR L4 chains have been developed and validated. The space-time interpolation (L4) algorithm implemented at CNR is able to ingest a single value of SST per pixel and per day, combining several days. In order to avoid artefacts in the super-collated data, a bias adjustment procedure is applied to L3 data before merging. The scientific validation of different merging algorithms has been performed analysing some of the metrics suggested by GHRSST (SST gradients and increments) and comparing satellite estimates and drifting buoys measurements.

5. Technical upgrades

At Météo-France/CMS, the operational robustness of the production chain for L3 collated and super-collated satellite SST products has been improved (implementation of a back-up server, definition of operational procedures in case of failure).

The archiving and processing platform at Ifremer has been consolidated and upgraded, adding redundancy and fault tolerance to the existing platform. New hardware has been deployed, based on virtual servers in order for software to run on any server and to quickly replace a failing server. Ingestion and dissemination storages spaces have been duplicated (master and backup) in order to maximize availability of the data and offer backup in case of any failure. All processing and data flow management chains are duplicated on at least two servers.

At the Met Office, the GHRSST Multi-Product Ensemble (GMPE) product resolution has been increased from 1/2º to 1/4º in line with the MyOcean product specification and following-on from recommendations made by the GHRSST Science Team. Contributions to the GHRSST Data Specification (GDSV2.0) have also been made, including production of a new document describing the GMPE product as well as contributions to the L4 specification document.

At CNR, the processing chain for the production of L4 satellite SST products at 0.01° horizontal resolution over the Mediterranean and Black Sea has been developed and is running pre-operationally. Additional development activities were performed, to produce super-collated L3 products over the Mediterranean and Black Sea according to the GHRSST Data Specification (GDSV2.0).

6. Quality control and validation

At Météo-France/CMS, a daily Quality Control of the SST TAC input data (satellite and in-situ measurements) started in autumn 2009. This activity is based on Match-up Data Bases, built at Ifremer or collected by Ifremer in near real-time and transformed into a common NetCDF format. Ifremer has also developed web-based tools to exploit these MDBs. Ten-daily and monthly statistics are computed for each L2P data source over geographical areas, defined and agreed by the MyOcean Consortium, and are displayed on the SST TAC validation web site managed by Ifremer. Météo-France/CMS is also using these MDBs to identify drifting buoy SST measurements considered as dubious, and, after cross-checking, to report its findings to JCOMM OPS.

The SST TAC L3 and L4 producers have also agreed on common quality statistics which will be computed daily and monthly over the agreed geographical areas, and displayed on the SST TAC validation web site:

- L3 (daily) : number of SST values per confidence level, mean and standard deviation of the departures from a climatology
- L4 (daily) : mean and standard deviation of the analysis increments
- L3 and L4 (monthly) : mean and standard deviation of the departures from buoy SST measurements

REPORT TO GHRSST 11 FROM AUSTRALIA – BLUELINK AND IMOS

Helen Beggs[1], Leon Majewski[2], George Paltoglou[1], Eric Schulz[1], Ian Barton[3] and Ruslan Verein[1]

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13 August 2010

ABSTRACT

Since the 10th GHRSST-PP Science Team Meeting there have been a number of exciting new sea surface temperature (SST) products developed at the Australian Bureau of Meteorology supported by 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 single sensor HRPT AVHRR SST in preliminary GDS v2.0 L2P/L3C formats which we intend to supply to the GDAC once the GDS v2.0 is ratified. Other products routinely produced by the Bureau which may be of interest to the GHRSST community are the experimental regional and global skin SST analyses (RAMSSA_skin and GAMSSA_skin), operational MTSAT-1R skin SST GDS v2.0 L2P/L3U files, operational 14-day "Mosaic" HRPT AVHRR SST composite product in GHRSST-L3 format and validation-quality, real-time bulk SST data from ten ships of opportunity and a meteorological mooring in the Southern Ocean, augmented with one Southern Ocean cruise of radiometer skin SST data. The Bureau has also commenced assimilating NAVOCEANO GAC AVHRR L2P SST into its operational ocean prediction system, OceanMAPS. This report summarises the advances made in the research and development of new SST products by BLUElink> and IMOS from 1 June 2009 to 1 June 2010.

1. Introduction

For the past seven 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 is about to commence and will run until 2013. 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.

Commencing in 2007, the BLUElink> support for the Group for High Resolution SST (GHRSST) 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:

- Locally received High Resolution Picture Transmission (HRPT) Advanced Very High Resolution Radiometer (AVHRR) SST single swath L2P and single sensor, composite L3C files (Beggs et al., 2009a)
- L4 files from "RAMSSA", the operational, daily, 1/12° resolution, SST analysis over the region 20°N to 70°S, 60°E to 170°W (Beggs, 2007; Beggs et al., 2010a), and the operational, global, daily, 1/4° resolution SST analysis system ("GAMSSA") (Zhong and Beggs, 2008; Beggs, 2008)

Other contributions include:

- High quality *in situ* SST available via the GTS in real time from vessels of the Australian Volunteer Observing Fleet (AVOF) fitted with Automatic Weather Stations and other ships of opportunity in the Australian region (Beggs et al., 2009b; Beggs et al., 2010b)
- High quality *in situ* meteorological and SST available via the IMOS ocean portal in near real-time from a Southern Ocean mooring (http://imos.org.au/sofs.html)
- Radiometer skin SST data collected on a Southern Ocean research cruise during March 2010

- NOAA/BoM collaboration on MTSAT-1R SST calibration/validation and processing
- Regional hourly and Global 3-hourly skin SST analyses in a GHRSST L4-like format ("RAMSSA_skin" and "GAMSSA_skin")
- Provision of satellite and numerical weather prediction (NWP) model data for the GHRSST Diurnal Variability Working Group study of SST diurnal variation models over the Western Pacific Tropical Warm Pool (TWP+)

2. SST from Ships of Opportunity

Typically, SST observations from the ships of opportunity program (SOOP) in the Australian region are either of uncertain accuracy or difficult to access in a timely manner, and have therefore 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 SOOPs 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

As part of IMOS, the Bureau of Meteorology (Bureau) has instrumented five vessels of the Australian Volunteer Observing Fleet with hull-mounted 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 data streams available from three research vessels (RV Southern Surveyor, RSV Aurora Australis and RV L'Astrolabe). In total, ten vessels contribute near real-time data to IMOS (Table 1 and Figure 1).

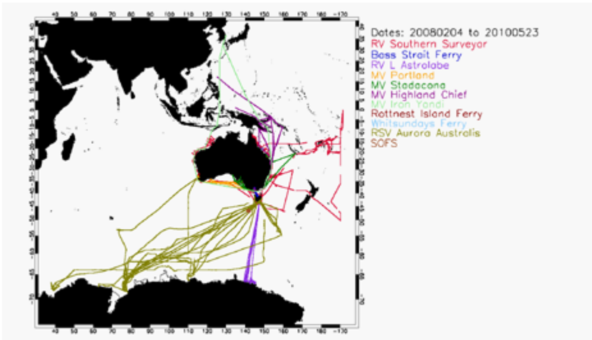


Figure 1. *Locations of IMOS QC'd ship SST observations to 23 May 2010 from 10 vessels.*

All SST data are quality assured (Beggs et al., 2009b) and placed in real-time on the Global Telecommunications System (GTS). 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/dodsC/IMOS/SOOP/SOOP-SST/ and http://opendap-tpac.arcs.org.au/thredds/dodsC/IMOS/SOOP/SOOP-ASF/catalog.html.

Initial comparisons between AATSR, AVHRR, buoy and IMOS ship SST observations indicate that several of the IMOS ship data streams have comparable errors to those obtained from drifting buoys (Section 5 and Beggs et al., 2010b). In waters with little or no coverage by buoys, AVHRR SST calibration, validation and bias-correction will be improved by using IMOS ship SST observations in addition to available drifting buoy SST data.

3. SST and Meteorological Data from the Southern Ocean Mooring

The Southern Ocean Flux Station (SOFS) mooring is tasked with building a climate record in the Southern Ocean (see http://imos.org.au/sofs.html). This will be achieved by observing and understanding the air-sea interactions and surface forcing in the Sub-Antarctic Zone, approximately 350 nautical miles southwest of Tasmania (46.75ºS, 142ºE) (see Figure 1). SOFS is an OceanSITES reference station with World Meteorological Organisation station number 58450. SOFS provides accurate measurements in the top 200 m of the ocean of meteorology, sea temperature and photosynthetically active radiation. The buoy was deployed on 17 March, 2010 at 11:09 (UTC) from the RV Southern Surveyor in 4624 m water depth. The SOFS mooring is equipped with two Air-Sea Interaction METeorology (ASIMET) systems, along with Iridium modems. ASIMET data are hourly averaged and are transmitted every four hours. The timestamp for each data record associated with the mean data values is taken as being at the end of averaging period. Each data transmission includes the following parameters: water temperature and conductivity, eastward and northward wind speed components, air temperature, relative humidity, atmospheric pressure, downward short and long wave radiation and precipitation. Quality controlled, netCDF data from the mooring is available in near real-time via http://opendap-tpac.arcs.org.au/thredds/catalog/IMOS/ABOS/ASFS/SOFS/ .

A DAR011 radiometer was operated on the RV Southern Surveyor during the SOFS mooring deployment cruise in March 2010. *In situ* skin SST observations of useable quality were obtained during 16, 17, 19 and 20 March 2010 (e.g. Figure 2). The DAR011 SSTskin standard deviation within each of the one-hour periods shown in Figure 2 was approximately 0.1 to 0.2°C, with DAR011 SSTskin – Buoy SST1m of 0.01 ± 0.07°C, DAR011 – ship SST6m of 0.01 ± 0.08°C, indicating no cool skin or diurnal warming. The 10 m winds were always above 5 m/s for the study period shown, indicating well mixed surface ocean layer.

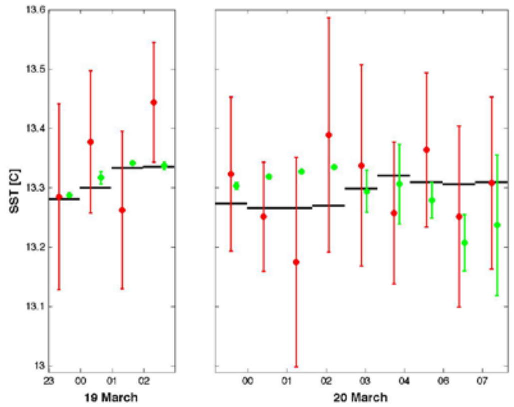


Figure 2. *An example of the one hourly averaged SST data (± 1 standard deviation) from the RV Southern Surveyor cruise during 19 and 20 March 2010. The DAR011 SSTskin observations are shown in red, SST6m observations from the SBE 3 sensor on the ship in green and the SST1m observations from SBE 37 sensor on the SOFS mooring in black.*

ASCII files of the radiometer SSTskin data can be obtained from Eric Schulz (e.schulz@bom.gov.au).

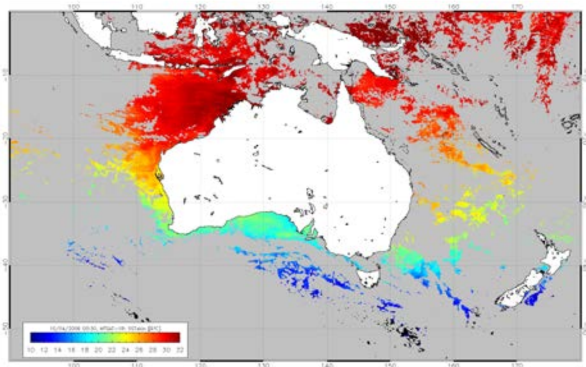
4. Geostationary MTSAT-1R skin SST

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. Since mid-2007, the Bureau has routinely generated SSTskin products from the Japanese geostationary satellite, MTSAT-1R, using the NOAA-developed Geostationary Satellite Derived Sea Surface Temperature Processing System (Maturi et al., 2008). The version of the software (v1) running at the Bureau was modified to accept locally generated NWP fields and further modified to output GHRSST formatted, single scene L2P 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, following a visit by Jon Mittaz and Andy Harris from NOAA/University of Maryland. The system was also tested with two weeks of raw data obtained during 2009 from MTSAT-2.

Between June 2005 and June 2006 the Bureau received data from MTSAT-1R 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. The monthly averaged RMSE (when compared to drifting buoys) for day-time HRIT data with a quality level > 3, using the 11 and 12 μm channels, collected during December 2008 was 0.8°C for the version 1 system. The corresponding RMSE for night-time HRIT data, which also incorporates the 3.75 μm channel, was 0.5°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 NWP forecasts along with increases in the vertical, spatial and temporal resolution of the NWP fields. These changes necessitate an upgrade of the MTSAT-1R system to handle the new ACCESS-G NWP output data format. By December 2010, v3 MTSAT-1R SSTskin 0.05° x 0.05° gridded, single scene L3U files (Figure 3) back to June 2006 are expected to be made available to Australian researchers via the IMOS Australian Ocean Distributed Archive and Access Centre (AO-DAAC - see http://imos.org.au/srs_data.html). In July 2010, MTSAT-1R HRIT transmission will be replaced with MTSAT-2 data and the Bureau will then produce real-time SSTskin L2P/L3U files from MTSAT-2.

(a)



(b)

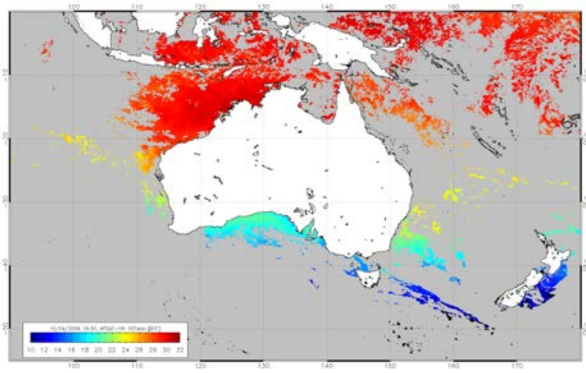
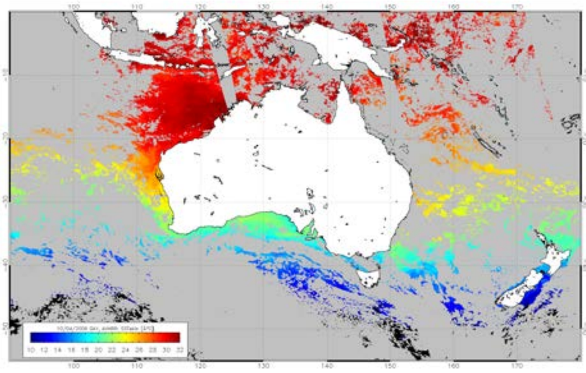


Figure 3. *An example of the output from the v3 MTSAT-1R processing system of skin SST for (a) 0530 UT (day) and (b) 1630 UT (night) on 10 April 2009. SST is plotted for cloud-free pixels (quality level = 3 to 5).*

5. Locally Received AVHRR SST

The highest resolution (1.1 km) data from AVHRR sensors on the NOAA polar-orbiting meterological 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 c onsortium 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 from operational NOAA polar-orbiting satellites in the GHRSST GDS v2.0 L2P and L3C formats (Casey et al., 2010). These GDS v2.0 files for NOAA-17, 18 and 19 are available through the IMOS FTP server (ftp://aodaac2-cbr.act.csiro.au/imos/) and will be available through the GHRSST GDAC (http://ghrsst.jpl.nasa.gov) and the Bureau's OPeNDAP server (http://godae.bom.gov.au) once the GDS v2.0 format has been released later in 2010. In addition to the 1.1 km resolution HRPT AVHRR SSTskin values and other mandatory fields, these L2P files contain bias and standard deviation estimates based on match-ups with *in situ* drifting buoy SST data from the GTS, and 3-hourly forecasts of averaged 10 m winds from the Bureau's legacy GASP Global NWP model up to 30 June 2010 and the ACCESS-G NWP model (Bureau of Meteorology Operations Bulletin 80 http://web.bom.gov.au/nob/nmoc/stan/opsbull/) after that date.

(a)



(b)

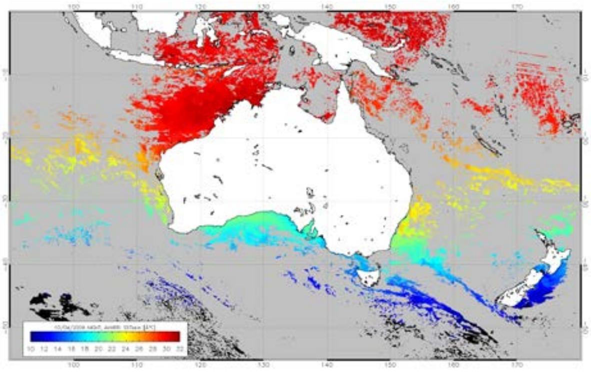


Figure 4. *Example of (a) day (~1330 LT) and (b) night (~0130 LT) 0.02°x 0.02° L3C composites from locally received NOAA-18 AVHRR SST data for 10 April 2009. SST is plotted for cloud-free pixels (quality level = 3 to 5).*

Single sensor (single night/day) composite HRPT AVHRR SST files have been produced in GHRSST GDS v2.0 L3C format (Casey et al., 2010) over a cylindrical equidistant projection (0.02° latitude x 0.02° longitude (Figure 4). Existing raw, archived, high-resolution HRPT AVHRR data from all operational NOAA polar-orbiting satellites over the Australian region back to 1996 will be progressively reprocessed into SSTskin L2P/L3C and be available to GHRSST and IMOS by June 2011.

The new IMOS HRPT AVHRR L2P SSTs exhibit nearly half the error of the Bureau's pre-existing HRPT AVHRR level 2 SST data from NOAA-17 and NOAA-18 satellites, with standard deviations compared with drifting buoys during nighttime of 0.23 to 0.27°C for NOAA-17, 18 and 19, and during daytime of 0.34 to 0.37°C. This significant improvement in accuracy has been achieved by implementing new CLAVR-based cloud clearing algorithms, implementing new BT 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. The SSTs at drifting buoy depths (20-30 cm) are converted to a skin SST at ~10 μm depth by subtracting 0.17ºC to account for the cool skin. Table 2 gives the mean and standard deviation of quality level 5 IMOS nighttime, 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 June 2008 to 23 May 2010. The data are considered matched if within ± 2 hours and collocated within the same ~1 km pixel.

Table 2. *Mean and Standard Deviation of Nighttime AVHRR SST from NOAA-18 minus In Situ SST.*

In Situ Data Stream	Number of Matchups	Mean (K)	Standard Deviation (K)
RV Southern Surveyor	72	0.02	0.19
RV L'Astrolabe	21	-0.02	0.24
RSV Aurora Australis	88	-0.09	0.26
PV SeaFlyte	13	-0.12	0.28
PV Spirit of Tasmania II	359	0.00	0.29
MV Portland	46	0.12	0.22
MV Highland Chief	34	0.02	0.22
MV Stadacona	104	0.02	0.39
MV Iron Yandi	13	-0.04	0.22
Non-IMOS Ships	1095	-0.10	1.55
Drifting Buoys	2922	0.03	0.25

Multiple sensor, composite HRPT AVHRR SST files from all operational NOAA polar-orbiters have also been produced in GHRSST-L3 netCDF format from the Bureau's legacy 14-day weighted mean, AVHRR Mosaic (Figure 5). The data has been reformatted to a cylindrical equidistant projection (0.01° latitude x 0.01° longitude) over the region 8°S to 48°S, 104°E to 165°E, and is currently available back to 1 January 2001 from IMOS via http://imos.org.au/srs_data.html.
For further details on the new AVHRR L2P and single-sensor L3C products see Beggs et al. (2009a), and for the legacy 14-day "Mosaic" L3P product see Rea (2004).

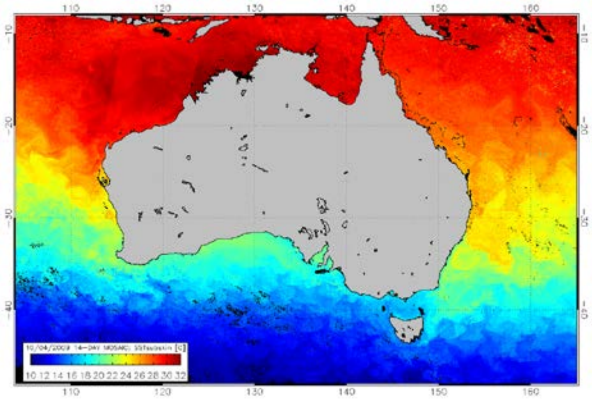


Figure 5. *Example of the Bureau's legacy 14-day "Mosaic" SST produced from locally received NOAA-17 and NOAA-18 AVHRR data for the period 28 March to 10 April 2009.*

6. 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 6).

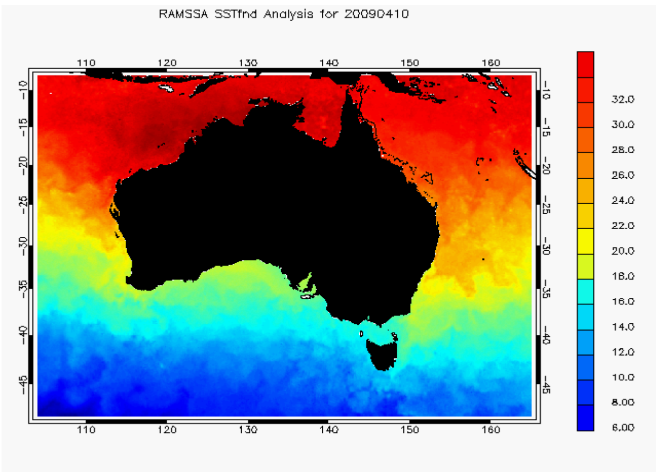


Figure 6. *An example of the RAMSSA v1.2 daily regional 1/12° resolution SST analysis for 10 April 2009, plotted over the 14-day Mosaic domain for comparison with Figure 5.*

The high-resolution analysis system combines SST data from infrared (AVHRR and AATSR) and microwave (AMSR-E) sensors on polar-orbiting satellites with in situ 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) and v1.4 on 1 September 2009 (replacing the LAPS NWP winds with those from ACCESS-R). See Beggs et al. (2010a) for details of the v1.1 to v1.4 methodology. Reprocessed RAMSSA v1.1 files are available on request back to 1 October 2006. By ~0400 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 hosted by PO.DAAC (via ftp://podaac.jpl.nasa.gov/pub/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 (http://ghrsst.nodc.noaa.gov/).

The RAMSSA analyses are used in real-time as the boundary condition for the Bureau's regional numerical weather prediction models (LAPS 0.375, MesoLAPS, TCLAPS, ACCESS-R, ACCESS-A and ACCESS-C) and to validate the BLUElink> operational ocean model (OceanMAPS) SST5m forecast/analyses.

Over the period 1 October 2007 to 31 March 2008 and region 60°E to 180°E, 20°N to 65°S, the RAMSSA v1.1 1/12° SSTfnd analyses exhibited mean(Analysed SSTfnd(date) – Buoy SSTfnd(date+1)) of 0.03 ± 0.42°C, comparable with the Met Office 0.05° resolution daily SSTfnd analysis, OSTIA (-0.05 ± 0.39°C). Over this same period, RAMSSA v1.1 agreed more closely with Ifremer's ODYSSEA and Met Office' OSTIA SSTfnd analyses than with other GHRSST microwave and infrared blended L4 analyses such as NCDC's AVHRR+AMSR-E SSTblend or Remote Sensing System's MW+IR SSTfnd analyses, with mean(RAMSSA SSTfnd – ODYSSEA SSTfnd) of -0.02 ± 0.40°C and mean(RAMSSA SSTfnd – OSTIA SSTfnd) of 0.10 ± 0.35°C. The major differences between RAMSSA and these other foundation SST analyses relate to RAMSSA's method for creating super-observations and assigning weights to the various input data streams, and Ifremer and the Met Office analysis systems' bias-correction of all satellite input data using SST data from the AATSR. The lack of bias-correction of data input into RAMSSA has minimal effect north of 40°S where RAMSSA is on average within ±0.07°C of other multi-sensor SST analyses. South of 40°S, RAMSSA is on average 0.09°C to 0.25°C warmer than the four bias-corrected, GHRSST-L4 analyses studied, due to systematic biases over this region in the calibration of the satellite SST data streams used for RAMSSA.

Future work on RAMSSA in 2010/2011 will include investigating the blending of satellite SST GHRSST L2P files available through Eumetsat (1 km ATS_NR__2P AATSR SSTskin) and IMOS (1 km HRPT AVHRR SSTskin and 4 km MTSAT-1R SSTskin).

7. GAMSSA – Global Australian Multi-Sensor SST Analysis

A real-time Global Australian Multi-Sensor Sea surface temperature Analysis (GAMSSA) system has been 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., 2010a) has been modified to produce 1/4° resolution, daily global foundation SST analyses (Beggs, 2008; Zhong and Beggs, 2008) (Figure 7).

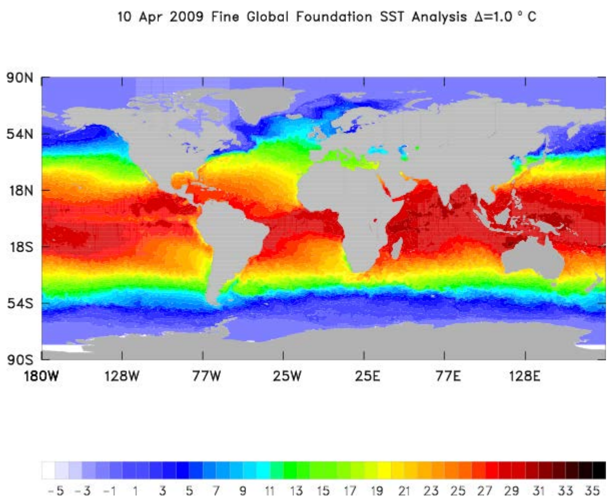


Figure 7. *An example of the GAMSSA v1.1 daily global 1/4° resolution SSTfnd analysis for 10 April 2009.*

The GAMSSA v1.0 system blends NAVOCEANO's GAC 9.9 km x 4.4 km resolution AVHRR L2P SST data (NOAA-18 and METOP-A), European Space Agency's 0.17° AATSR skin SST Meteo Product (EnviSat), Remote Sensing System's 25 km resolution AMSR-E L2P sub-skin SSTs (Aqua) and *in situ* bulk SSTs from the GTS. To produce foundation SST estimates, input data is 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). By 0500 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 hosted by PO.DAAC (via ftp://podaac.jpl.nasa.gov/pub/GHRSST/data/L4/GLOB/ABOM/GAMSSA_28km/). Archived RAMSSA 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 (http://ghrsst.nodc.noaa.gov/).

The GAMSSA analyses are used in real-time as the boundary condition for the Bureau's new global NWP model (ACCESS-G) based on the Met Office's Unified Model.

Over the period 20 May to 30 August 2008, the GAMSSA v1.0 1/4° SSTfnd analyses exhibited mean(Analysed SSTfnd (date) – Buoy SSTfnd (date+1)) of -0.04 ± 0.50°C globally, comparable with the Met Office 0.05° resolution daily SSTfnd analysis, OSTIA, over the same region and period (OSTIA SSTfnd - Buoy SSTfnd = -0.07 ± 0.44°C) and with lower error than NCDC's AVHRR+AMSR-E 0.25° resolution daily SSTblend analysis (NCDC SSTfnd - Buoy SSTfnd = -0.03 ± 0.64°C). GAMSSA v1.0 agreed more closely with Met Office' OSTIA SSTfnd analyses than with other GHRSST microwave and infrared blended L4 analyses (NCDC SSTblend and ODYSSEA SSTfnd) over this same period, with mean(GAMSSA SSTfnd – OSTIA SSTfnd) of 0.07 ± 0.46°C.

The GAMSSA analyses have contributed to the GHRSST Multi-Product Ensemble (GMPE) and Analysis Intercomparison Project (http://www.ghrsst.org/Todays-global-SST.html) since 10 March 2009. These daily intercomparisons produced by the Met Office (see http://ghrsst-pp.metoffice.com/pages/latest_analysis/sst_monitor/daily/ens/index.html) show that GAMSSA SSTfnd is consistently warmer than the GMPE daily SSTblend analysis over the Southern Ocean. For the period 1 June 2008 to 30 June 2009, the GAMSSA analyses were on average slightly warm compared to independent drifting buoys south of 40°S, with mean(Analysed SSTfnd (date) – Buoy SSTfnd (date+1)) of 0.05 ± 0.48°C. It would therefore appear that the satellite observations over the Southern Ocean going into GAMSSA are overall warmer compared with those going into other analyses contributing to GMPE. Validation of satellite SST observations and analyses over the Southern Ocean will be a priority at the Bureau.

Future work on GAMSSA in 2010/2011 will include investigating the blending of new GHRSST L2P SST products 1 km AATSR SSTskin, 1 km HRPT AVHRR SSTskin and 4 km MTSAT-1R SSTskin.

8. Global and Regional Skin SST Analyses (GAMSSA_skin and RAMSSA_skin)

An experimental, regional, hourly, 1/12° resolution, skin SST analysis ("RAMSSA_skin" – Figure 8(a) and 9(a)) and global, 3-hourly, 1/4° resolution, skin SST analysis ("GAMSSA_skin" – Figure 8(b) and 9(b)) have been developed at the Bureau of Meteorology as part of the BLUElink-II Project. Both skin analyses are formed by adding a simple, empirically based estimate of ΔSST at that time to the daily RAMSSA SSTfnd or GAMSSA SSTfnd analysis. That is,

RAMSSA_skin SSTskin = RAMSSA SSTfnd + ΔSST – 0.2°C

and

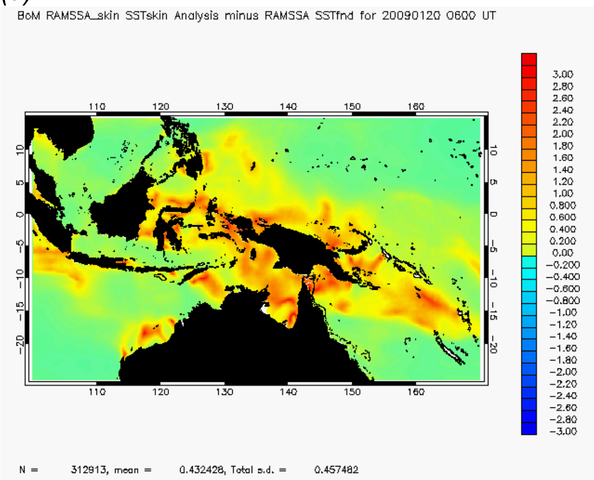
GAMSSA_skin SSTskin = GAMSSA SSTfnd + ΔSST – 0.2°C,

where ΔSST = SSTsubskin – SSTfnd, calculated from a simple algorithm developed by Chelle Gentemann, based on geostationary SEVIRI SSTsubskin and AMSR-E surface wind data (Gentemann et al., 2003). No allowance is made in this empirical ΔSST model for cloud or net heat flux, although it accounts for the daily variation of incoming solar radiation by calculating the solar zenith angle and using the mean value of the solar constant for 1978 to 1998 calculated to 1366.22 Wm^2 (see http://remotesensing.oma.be/RadiometryPapers/article2.html). The maximum range of the ΔSST model is 0 to 3°C.

A constant 0.2°C is used to transform the SSTsubskin estimate to SSTskin following the SEVIRI skin to subskin constant 0.2°C adjustment (OSI-SAF Project Team, 2006). For RAMSSA_skin, the inputs to the ΔSST algorithm are mean hourly, 0.375º resolution, 10 m winds from the Bureau's ACCESS-R regional NWP 24 hour forecasts. For GAMSSA_skin, the mean 3-hourly, 1.25º lon x 0.833º lat resolution, 10 m winds from the Bureau's ACCESS-G global NWP 24 hour forecasts are used.

Both RAMSSA_skin and GAMSSA_skin have been validated against the 1 km resolution AATSR SSTskin L2P product available from GHRSST (http://ghrsst.nodc.noaa.gov/). For the period 1-31 January 2009, RAMSSA_skin – AATSR SSTskin = 0.14 ± 0.38ºC. For the same period, GAMSSA_skin – AATSR SSTskin = 0.10 ± 0.38ºC. These are encouragingly low errors and indicate that Chelle Gentemann's simple empirical model in conjunction with ACCESS-R and ACCESS-G forecast winds should be useful in predicting diurnal warming in all but the most extreme cases (ΔSST > 3°C).

(a)



(b)

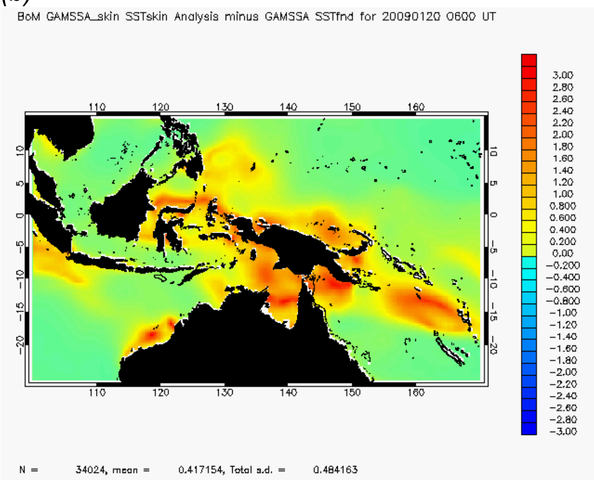
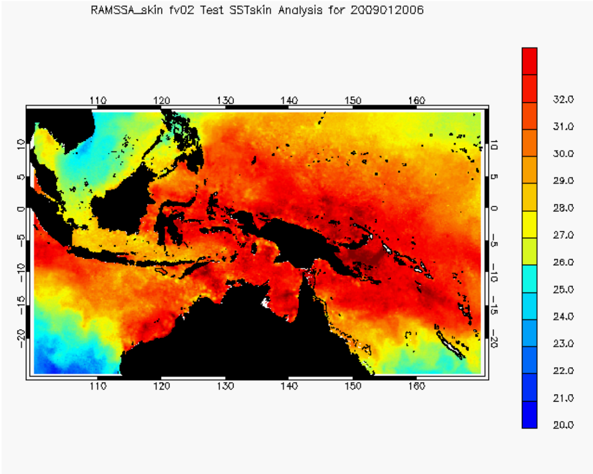


Figure 8. *(a) RAMSSA_skin SSTskin – RAMSSA SSTfnd and (b) GAMSSA_skin SSTskin – GAMSSA SSTfnd analyses plotted over the region 25°S to 15°N, 100°E to 170°E, for 20 January 2009 at 0600 UTC (1500 LT at 135ºE).*

(a)



(b)

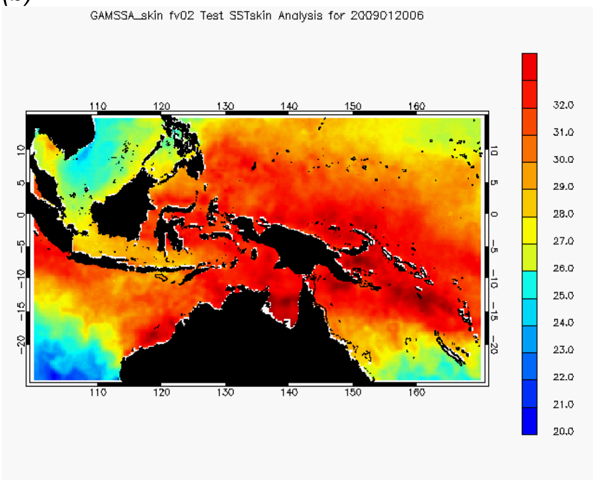


Figure 9. *(a) RAMSSA_skin and (b) GAMSSA_skin SSTskin analyses, plotted over the region 25°S to 15°N, 100°E to 170°E, for 20 January 2009 at 0600 UTC (~1330 LT at 110ºE and 1500 LT at 135ºE).*

Comparison with MODIS composite SSTskin and MTSAT-1R hourly SSTskin indicates that RAMSSA_skin analyses capture diurnal warming maxima quite effectively where there are clear skies but night-time (pre-dawn) minima are too warm by up to +3°C (Beggs et al., 2009c), due to the equator crossing times of the satellites contributing SST data to the RAMSSA SSTfnd analyses being several hours before local sunrise, the "foundation" time. These polar orbiters (NOAA-17, NOAA-18, NOAA-19, METOP-A, EnviSat and Aqua) have nighttime equator crossing times between 9 - 11 pm and 1 - 2 am local time. Luckily, this should not adversely affect using RAMSSA_skin for quality control of satellite sounder observations assimilated into the Bureau's new NWP models as all satellites used for ACCESS NWP models have equator crossing times of around 10 pm and 1:30 am, not close to dawn. It is anticipated that in 2010 the Bureau will test the efficacy of using the RAMSSA_skin and GAMSSA_skin analyses for quality control of satellite data assimilated into the new ACCESS NWP models.

Hourly RAMSSA_skin analyses are available over the domain 65ºE to 185ºE, 15ºN to 65ºS, back to 1 October 2008, in a GHRSST L4 format similar to RAMSSA (contact h.beggs@bom.gov.au). Likewise, the 3-hourly, global, GAMSSA_skin analyses are available in the same format back to 1 June 2008.

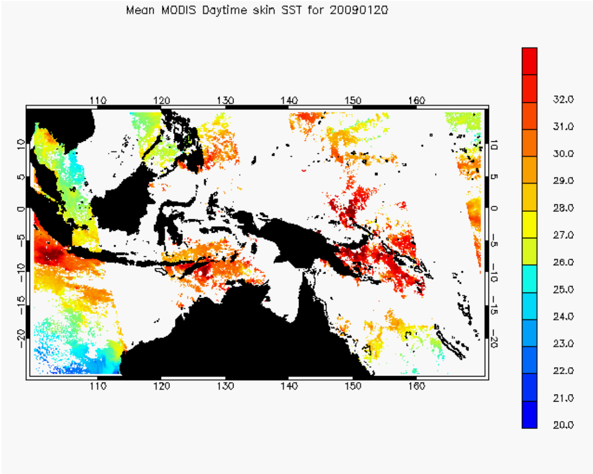
9. Tropical Warm Pool Diurnal Variability Experiment (TWP+)

The Tropical Warm Pool (TWP) north of Australia is one of the most difficult areas of the ocean to measure sea surface temperature (SST). This is due to a combination of high diurnal warming (possibly up to 6°C over small spatial/time scales – Figure 10), frequent cloud cover reducing the amount of SST observations from infrared satellite sensors, and island chains reducing the spatial coverage of SST measurements from microwave satellite sensors.

During 2009 and 2010, the Bureau of Meteorology in collaboration with Météo-France compiled a data set of satellite SST data (from v3 MTSAT-1R and METOP-A), RAMSSA SSTfnd analyses and the Australian hourly, 0.375° resolution, LAPS NWP forecasts over the "TWP+" region (25°S to 15°N, 90°E to 170°E) for the period 1 January to 30 April 2009.

Each satellite product has been regridded onto a common grid over the TWP+ domain with resolution of 0.025º for METOP-A and 0.05º (MTSAT-1R and RAMSSA). The LAPS NWP surface wind and flux fields have been left on their original 0.375º grid. This "TWP+" data set will be used by members of the GHRSST Diurnal Variability Working Group to test their diurnal warming models over the Western Pacific Tropical Warm Pool region. The TWP+ data set is available via the Bureau's OPeNDAP server and will be advertised by end of June 2010 on the GHRSST web site. Contact h.beggs@bom.gov.au for access details.

(a)



(b)

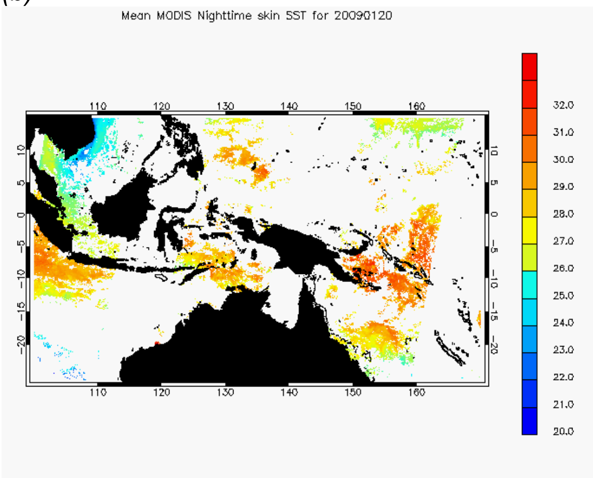


Figure 10. *Composite maps of ~4 km skin SST from the MODIS infrared sensor on the Aqua satellite for 20 January 2009 during the (a) day (~1330 LT) and (b) night (~0130 LT) over the TWP+ domain.*

10. Use of GHRSST L2P in BLUElink> Ocean Forecasting

From mid-February 2010, GHRSST NAVOCEANO 9 km x 4 km resolution, Global Area Coverage (GAC) AVHRR L2P files from NOAA-18 and METOP-A have been incorporated as an additional SST data stream assimilated into the BLUElink> operational ocean model, OceanMAPS. The GAC AVHRR L2P data complement the previously assimilated 25 km resolution AMSR-E SST data. Using GAC AVHRR together with AMSR-E improves spatial coverage, particularly within 75 km of coasts, with GAC AVHRR adding increased resolution (Andreu-Burillo *et al*., 2010). Assimilating both AMSR-E and AVHRR SSTfnd products results in OceanMAPS SST5m analyses closer to buoy observations compared with assimilating AMSR-E and AVHRR SST separately.

11. Future Plans for BLUElink> and IMOS SST Products (2010-2011)

As part of the next phase of the IMOS and BLUElink-III Projects (June 2010 – June 2011), the Bureau of Meteorology aims to:

- Provide real-time HRPT AVHRR SSTskin L2P and single-sensor L3C files via IMOS (June 2010) and the GHRSST GDAC (December 2010), and reprocessed L2P/L3C back to 1996 (June 2011)
- Provide real-time and reprocessed (back to June 2006) hourly, 0.05º x 0.05º gridded, MTSAT-1R SSTskin L2P/L3U files to IMOS (December 2010)
- Provide real-time, hourly, 0.05º x 0.05º gridded, MTSAT-2 SSTskin L3U files to IMOS once MTSAT-2 replaces MTSAT-1R transmissions in July 2010
- Equip an additional AVOF vessel with a hull-contact temperature sensor and add real-time, quality assured ship SST data streams from this vessel plus the New Zealand research vessel RV Tangaroa (December 2010)
- Upgrade RAMSSA and GAMSSA to incorporate new IMOS L2P data streams for enhanced accuracy (HRPT AVHRR and MTSAT-1R) and L2P data from AATSR (June 2011)
- The ACCESS NWP data assimilation team at the Bureau will test RAMSSA_skin and GAMSSA_skin SSTskin analyses in the new regional and global NWP analysis systems (ACCESS-R and ACCESS-G) for the quality control of satellite sounder data over the ocean (December 2010)
- Depending on the outcome of Phase I of the TWP+ experiment, the Bureau may provide operational, hourly, 0.375º resolution, ACCESS-R surface wind and flux fields over the TWP+ domain for a period after 1 January 2010 for input into diurnal variation models.

12. 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.

13. References

13.1 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/

Bureau of Meteorology GODAE OPeNDAP Server: http://godae.bom.gov.au

Bureau of Meteorology Operations Bulletin 80: http://web.bom.gov.au/nob/nmoc/stan/opsbull

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://www.ghrsst.org/Todays-global-SST.html. Near real-time comparisons of global SST analyses are available from http://ghrsst-pp.metoffice.com/pages/latest_analysis/sst_monitor/daily/ens/index.html

Integrated Marine Observing System (IMOS) Web Site: http://www.imos.org.au

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 Data FTP Server: ftp://aodaac2-cbr.act.csiro.au/imos/

IMOS Ship of Opportunity SST Data OPeNDAP site: http://opendap-tpac.arcs.org.au/thredds/dodsC/IMOS/SOOP/SOOP-SST/

IMOS Ship of Opportunity Meteorological, SST and Flux Data OPeNDAP site:

http://opendap-tpac.arcs.org.au/thredds/dodsC/IMOS/SOOP/SOOP-ASF/catalog.html

IMOS Southern Ocean Flux Station Web Page: http://imos.org.au/sofs.html

IMOS Southern Ocean Flux Station data OPeNDAP portal: http://opendap-tpac.arcs.org.au/thredds/catalog/IMOS/ABOS/ASFS/SOFS/

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Beggs Helen (2007) A High-Resolution Blended Sea Surface Temperature Analysis over the Australian Region, *BMRC Research Report*, *Bureau of Meteorology*, *Melbourne, Australia, 43 pp.* http://www.bom.gov.au/bmrc/pubs/researchreports/RR130.pdf

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Beggs, H., R. Verein, H. Kippo, M. Underwood, I. Barton, C. Steinberg, E. Schulz, R. Hibbins, A. Thomas and G. Ball (2009b). Enhancing Ship of Opportunity Sea Surface Temperature Observations in the Australian Region, GHRSST 2009 International Users Symposium Conference Proceedings, Santa Rosa, USA, pp. 147-150. http://imos.org.au/soopdoc.html

Beggs, Helen, Chelle Gentemann and Peter Steinle (2009c) Real-time skin sea surface temperature analyses for quality control of data assimilated into NWP models, *extended abstract, The Fifth WMO International Symposium on Data Assimilation of Observations in Meteorology, Oceanography and Hydrology, Melbourne, Australia, 5-9 October 2009.*

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REPORT ON THE APPLICATIONS AND USERS SERVICES TECHNICAL ADVISORY GROUP

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ABSTRACT

Data usage for all GHRSST SST products has increased significantly from 2009 through 2010. The type of users has also diversified as the reanalysis component of GHRSST continues to provide historical data that is allowing for increased scientific use.

The first GHRSST Users Symposium in 2009 in Santa Rosa, California was a huge success. Included in this report as an appendix is both the overall summary and rapporteur notes from each session. As a result of the symposium it was decided to form the Applications and User Services Technical Advisory Group (AUS-TAG). A draft of the Terms of Reference is included as an appendix to this report. The second User Symposium in Lima, Peru will focus on South American Users and build on the success of Santa Rosa.

1. INTRODUCTION

Last year, as part of the GHRSST X meeting in Santa Rosa, California, the decision was made to officially form the Applications and User Services Technical Advisory Group (AUS-TAG). The rationale was that a coordinated effort was needed to guide the Application and Users Services of the GHRSST project. J. Vazquez was asked and agreed to chair the group with Ted Haberman as co-chair. Two major action items emerged from that meeting.

1) A draft of the Terms of Reference (TOR)
2) The AUS-TAG was tasked with the responsibility for maintaining the Users Guide for the GHRSST project.

A draft of the TOR is included as part of this report in the Appendix. The AUS-TAG was also charged with overseeing the implementation of new technology that could facilitate the distribution of GHRSST data. A major component of that has been implementing software that can allow for subsetting in time and space of different GHRSST data sets. The Global Data Assembly Center, in collaboration with IFREMER, has installed software (NAIDS) that allows for subsetting.

The rest of the AUS-TAG report is organized as follows: section 2 discusses the implementation of new technology focusing on the data mining tool, section 3 summaries the user statistics and type of access, section 4 gives an overview of the type of broad range applications of the data. Because this is the first report from the AUS-TAG, three appendices are included, the Terms of Reference (TOR), summary of the first GHRSST User Symposium in Santa Rosa, California, and the unedited raporteur notes from the symposium.

2. ACCESSING DATA: NEW DATA MINING TOOL

New technology has been implemented at the PO.DAAC that allows for spatial and temporal subsetting of GHRSST L2P data. A beta version is available for public release at:

http://podaac-tools.jpl.nasa.gov/dataminer/

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). As mentioned above, you can search the full archive of AMSRE, as well as the full archive of QuikSCAT data.

More datasets will be added in the near future.

3. USER STATISTICS

Since 2006 dramatic increases in the usage and distribution of GHRSST data have occurred. Both the GDAC/PODAAC and LTSRF/NODC maintain statistics on data users, volume of data distributed, and number of files distributed.

Figure 1 shows the number of users from 2006-2010 (present) and the total.

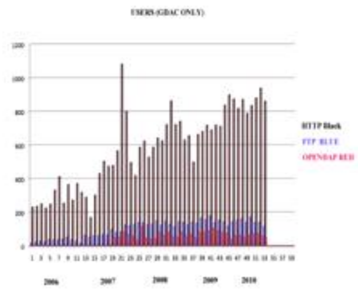

Figure 1: Users from 2006 to April 2010 broken down by data access.

Figure 1 shows example of user statistics broken down by FTP, HTTP, and OPeNDAP. Total number of users between the GDAC and the LTSRF has been approximately 47000, with a significant number of users accessing information or downloading data via HTTP.

4. EXAMPLES OF USER APPLICATIONS: NEAR REAL TIME AND HISTORICAL

In near real time usage JPL is collaborating with SPoRT to implement SSTs in numerical weather forecasting. Below is an example of a MODIS-Aqua 1km composite for November of 2009 for the area that covers both the Atlantic and Pacific Coasts of North America.

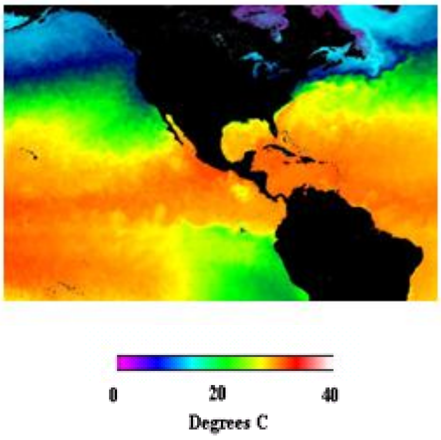

Figure 2: Example RTO composite for November 2009.

Additionally JPL is also producing a beta version of the MEaSUREs Multivariate Ultra High Resolution (MUR) SST data set that is currently being used in several applications. An example of this data is seen below for October of 2008.

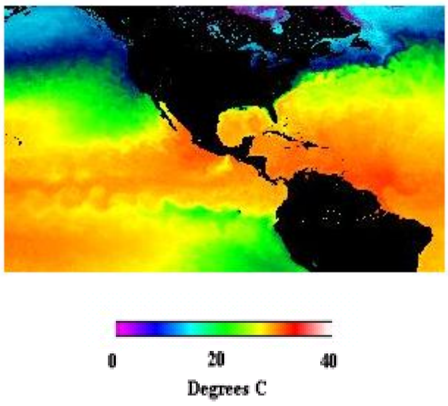

Figure 3: MEaSURES (MUR) analysis for November 2008

Edward Armstrong, in collaboration with USC, is creating frontal probability maps for use in fisheries. Figures 4 and 5 show the differences of using higher resolution SST.

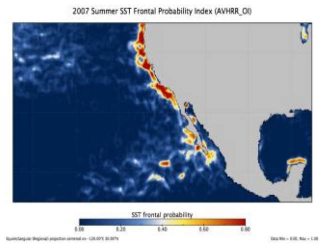

Figure 4: Probability Map Using AVHRR_OI (25km)

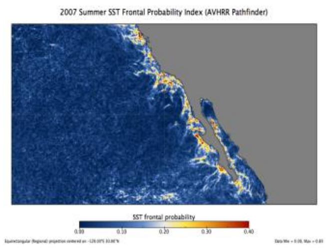

Figure 5: Probability Map Using Pathfinder (4km)

Several examples of the type of usage of GHRSST data are listed below:

- Tagging of Pacific Predators (TOPP) program needed monthly SST data for 2002-2006
- Eric Hackert of the Earth System Science Interdisciplinary Center at the University of Maryland used the NCDC Daily OI for assimilating SST into a tropical ocean/coupled model.
- Suzanne Dickinson of the University of Washington Applied Physics Laboratory, as part of CLIMODE, is working with a group to try and find the best SST and air temperature to compute decent turbulent fluxes over the Gulf Stream, eventually expanding to global flux calculation. She said "your GHRSST .nc files are very user friendly. They can easily be converted to Matlab format, which is always our end product."
- Peter Yaukey of the University of New Orleans was in need of daily sea surface temperature, not smoothed by averaging with adjacent dates, for his research in tropical cyclogenesis.
- Dierdre Byrne of the University of Maine wanted to know about GHRSST's accessibility through OPeNDAP (before it actually was accessible through OPeNDAP again). Her husband was responding to a NASA RFP which specifically mentioned GHRSST products. Ken introduced her to the GMPE and HR-DDS.
- Katrien Quisthoudt of Vrije Universiteit in Brussel, Belgium used the Daily OI (AVHRR oly) for research on mangroves
- Nadya Vinogradova of Atmospheric and Environmental Research, Inc. needed L2P SST for the last decade (MW or infrared) as part of the ECCO-GODAE modeling and assimilation experiment.
- Sunanda, a research fellow at the Indian National Centre for Ocean Information Services (INCOIS) in Hyderabad, India, was working on a thesis entitled "merging multiplatform SST." He wants to generate a product that could be a contribution to GHRSST from India. He's working with AVHRR and MODIS data, as well as TMI and in-situ data, and wants to know where to start. We pointed him at the GDS documentation for guidance.
- Jim Meacham, a Business Development Manager from Signal Systems Corporation, was doing Navy Anti-Submarine Warfare acoustic signal processing work, and aiding NAVAIR with advanced distributed sonar buoy field systems concepts. He requested 1km SST with a high update frequency for the Far East. These would be used to track sonobuoys instead of GPS by correlating sonobuoy temperature sensor readings with near-real-time SST.
- Jaime Fernandez used ODYSSEA data for sport-fishing along the Portuguese coast.

The MUR product development at JPL also shows usage that is relevant to the need of high resolution SST.

Some applications of the Multivariate Ultra_High Resolution (MUR) SST: 1. Figure 6 below shows "mid-summer cooling" where average SST from June and September 2008 is subtracted from the monthly average SST of July 2008, showing that mid-summer SST around Central America (both the Pacific and Atlantic) is actually cooler than late spring or early autumn. This is a prevailing phenomena, and JPL scientists are starting to look at its correlation with "mid-summer drought" condition, which is an especially intense drying over this region in summer predicted by a multi-model ensemble.

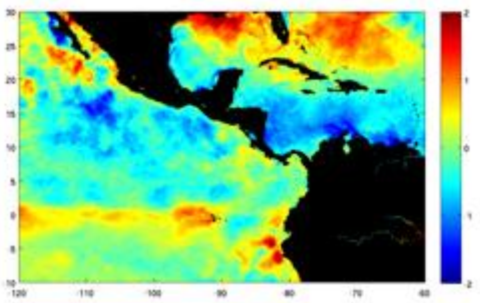

Figure 6: SST anomaly for July of 2008

A beta data set of the MUR can be found at:

ftp://mariana.jpl.nasa.gov/mur_sst/tmchin/images/amami0/

Scientists at the University of Delaware are using model outputs, drifter trajectories, and high-resolution SST maps to locate the Kuroshio Current north of Okinawa for cross-validation study. Drifter trajectories often show sub-grid scale vortices, which may be correlated with the small scale structures in SST maps.

5. 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 NAIDS, have been implemented which allow for temporal and spatial subsetting. The first GHRSST User's Symposium in Santa Rosa, California was a success (see appendix) and will be followed up with a second symposium in Lima, Peru.

Challenges still remain which must be addressed for maximizing the use of GHRSST data. These include efficient subsetting tools, data aggregation, and flexibility in data formats.

APPENDIX I: Terms of Reference

Terms of Reference

Applications and User Services Technical Advisory Group (AUS-TAG) for the Group for High Resolution Sea Surface Temperature

Version 0.5

The Applications and User Services Technical Advisory Group (AUS-TAG) of the Group for High Resolution Sea Surface Temperature (GHRSST) was formed at the 10th meeting of the GHRSST Science Team (GHRSST-ST) in Santa Rosa California, June 1-5, 2009. The GHRSST-ST voted to form the group as a result of the need to consolidate and facilitate better communications for user's and application's support within the GHRSST science and user community.

RESPONSIBILITIES

- Manage all aspects of the GHRSST User Manual.
    - This includes overseeing all new versions, providing periodic reviews, as deemed necessary by the science team, and maintaining the latest version to the user community
- Maintain and develop methods for data discovery within the GHRSST R/GTS.
    - This includes making recommendations to the science team on new technologies that could improve data access and usability. Will also work closely with the data management technical advisory group in the implementation of these new technologies.
- Actively solicit (using acceptable outreach tools, workshops, symposia, brochures etc) catalog and publish GHRSST user feedback in order that the groups within GHRSST may act on feedback.
- Help coordinate and facilitate GHRSST users symposium, as deemed appropriate by the GHRSST-ST. This does not include chairing the event. Such chairs will be appointed in coordination with the GHRSST-ST Science Chair.
- Develop new methods of user documentation
    - This will include working closely with and facilitating communication between the different technical advisory groups, such as the Diurnal Variability, Inter-comparisons technical advisory group and others.

MEMBERSHIP

Chair and Vice-Chair of the AUS-TAG shall be appointed by the GHRSST-ST. Term of chairmanship is at the discretion of the GHRSST-ST and will be reviewed periodically by the GHRSST-ST and science chair. Membership of the AUS-TAG shall be done on volunteer basis, appointed by the chair and co-chair, or by the

GHRSST-ST. There will be no limits on the term of membership

APPENDIX II: Final Report on the International GHRSST User's Symposium May 28-29, 2009, Santa Rosa, California

SUMMARY OF SYMPOSIUM FROM SANTA ROSA, MAY 2009 (NOTES).

Eric Lindstrom voiced strong praise for the symposium. Several highlights from the symposium are listed below.

Diversification of GHRSST users

- Operational „'Heavies'' still here. These include organizations such as the UK Met Office and NAVOCEANO.
- Ocean Scientists now developing high resolution for use in coastal zones

Emerging focus on using the GHRSST data historically.

Reanalysis efforts critical for increasing science usage.

GHRSST is providing a stable system that is delivering

Quality data products that are useful are being developed across a wide spectrum.

L2P and L4 products arebing widely used

Uncertainty estimates are being used

Services (GDAC, LTSRF, RDAC, GMPE, HRDDS) are

being used more and more

There is an obvious need to improve uncertainty estimates

Statistics from GDAC and LTSRF show exponential increase in users, volume served and files delivered since 2006.

GHRSST User Base is increasing and diversifying

- We need to recognize that the Users within GHRSST are changing. Users now include:

Coral Reef studies becoming a potential highly visible use.

Coastal applications very strong

Air-sea interaction, fluxes

Ocean circulation, processes, dynamics, and coupling to

Atmosphere, coral reefs, detection of eddies, frontal studies,

Rossby Wave detection, upwelling

People are learning about GHRSST and are excited about the potential

It has taken time to generate an archive of products for use

Takes time for groups to look at data

Takes more time for groups and people to trust products and services

Question? How can we reduce the time between learning about products and usage? What I would call user latency?

Documentation? Handholding?

GHRSST needs more coordinated Applications User Support (AUS).

Handholding can be labor and cost-ineffective.

Impossible for one or two people to be experts on all the products. How do we coordinate documentation?

Groups are looking critically at GHRSST data in automated systems

But feedback and communications between these groups is not good

Need to provide a means to keep people talking. face to face meetings can't be replaced with telecons, emails, etc. This seems especially true with respect to documentation issues.

Validation efforts need to be more coordinated using different data sets, including buoy's, but also using innovative techniques such as those by SQUAM and inter-comparisons of Level 4 products (GMPE).

Independent data sets need to be defined.

How to handle biases between data sets still an ongoing issue.

Inter-comparisons group under GHRSST?

People are using ancillary fields
People want more Diurnal information and diurnal information is being used
Error statistics very important and being used now in many applications, including data assimilation

Want better and more consistent error estimates with
Documentation is becoming more critical

Reanalysis and long time series clearly becoming important.

Different components of the reanalysis include the following:

L4
L2P
GMPE
HRDDS
Funding for historical processing efforts in EU for the
(Environmental Climate Variable) ECV. A major missing component is the historical reprocessing of MODIS data into the GHRSST L2P format.

Clearly there are issues of education and outreach to users.

Issues were raised about targeting this community for the next User Symposium.
Conclusion was that this needs to be done thoughtfully.
Needs of education community are different.
Browse capability, search and discovery major issues
for this community.

SST at High Latitudes and sea ice

Several people have requested Lake Temperatures.
The largest issue here is the uncertainty of these temperatures.
One example is the Great Lakes Observing System (GLOS/IOOS Regional Association) could benefit greatly from GHRSST products.
Major question arising is whether we need a validation effort for Lakes

Level 4 Products

L4 analysis products may be misleading users in terms of resolution
Need proper and careful descriptions for users with examples.
AATSR provides a good reference field for many of these analysis.
Need to study and develop correlation terms and error covariance
functions
Need better docs for users in simple language
This is a huge issue especially as reanalysis efforts kick in and more L4 products become available. Example, how do I use the single sensor error statistics? How do I handle the Diurnal Variability?

Issue of defining which is the best data set still very complicated. How do the GDAC and LTSRF handle this? There is no “best” data set. What information needs to be communicated to the user for decision making.
Problem is that it is clear there is no one “best” data set.
How do we manage all of these data sets to help users choose the one that’s
just right?
Going back to point that one or two people cannot be expert on all of
these data sets. How de we handle this within the context of the AUS?
Eric Lindstrom’s and Zdenka Willis comments indicate we need to
increase Science and Applications beyond our power operational base.
Reanalysis efforts should increase science usage. Science and IOOS
communities stressed.
Groups in EU (ERNESST) and USA (USA SST Science Team) are being convened GHRSST. How do we get more international involvement? South America? China?

Future Symposiums

What are the next steps?
Symposiums continue at every GHRSST science team meeting?
Symposium on separate dates and/or locations from the Science Team Meeting?
Longer meeting? Shorter Meeting?
More Posters? Should we target specific International Partners.
Who should lead future symposiums (Users, etc.)

APPENDIX III: GHRSST User Symposium, 2009, Santa Rosa, California, Session Notes

SESSION 1

– Kenneth Casey

– National Oceanographic Data Center

– Email : ken.casey@noaa.gov

GHRSST International Users Symposium

28-29 May 2009

Santa Rosa, CA, USA

Hyatt Vineyard Creek Hotel

Session 1: Invited Talks:

1. Introductions by Chelle Gentemann
2. Craig Donlon, Introduction to the GHRSST Project
    a. Provided brief history of GHRSST
    b. Stressed need for high res by showing AATSR image n Gulf of Lyon
    c. Provided overview of GHRSST requirements and approach
    d. Gave overview of the GHRSST product suite, including examples of L2P, L3, and L4 data
    e. Mentioned briefy, GMPE, HR-DDS, MDB, RAN and GCOS intercomparisons
    f. Described the R/GTS Framework
    g. Showed last year's data transfer statistics
    h. Invited the User Symposium to provide input to the Science Team
    i. Summarized
3. Eric Lindstrom, NASA GHRSST Science
    a. Mentioned the diverse set of interest groups for SST present here
    b. Concerned about the climate record for SST, operational users, use of SST in surface fluxes, and other marine applications
    c. NASA is trying to work internationally with the other agencies through GHRSST, which is the "unifying force" for SST
    d. As a coordination mechanism, GHRSST has been second to none
    e. However, Eric sees GHRSST as only the beginning
    f. SST is almost unique and interesting because it is one of those things that NASA has taken for granted for 20 years, and it is the one that has gone from operations back to research!
    g. Increasing use of research satellites in operations
    h. So, we have to have a new paradigm other than the one-way trip from research to operations.
    i. Eric sees the next decade as seeing a big push from the research community to get us to a new high level of SST product
    j. From his NASA physical oceanography perspective:
        i. would like to see more research enabled from the new generation of SST products
        ii. would like to see the science users be able to feed back into the quality of the SST products
    k. Should focus much more scientific attention on the uncertainty estimates for SST - This should be a focus of not just the GHRSST Science Team but also a newly forming NASA SST Science Team
    l. This parameter-based team would focus on the error budget for SST, to help ensure the climate data record. The error budget would be the rallying point for this team
    m. A meeting in Rhode Island in November will follow up on this idea
    n. Sees a time scale of many years, and hopes this effort will help generate new resources for SST science
    o. The decadal challenge ahead should be to "beat down the error budget" and take advantage of what GHRSST has done
    p. Wants to see GHRSST broaden to take in a wider range of scientific issues, both in the US and in Europe
4. Zdenka Willis, IOOS Use of GHRSST
    a. Introduction and overview of GHRSST followed by a challenge
    b. Talked about the "team sport" aspect of US IOOS
    c. Coastal component and Global component
    d. National contribution to GOOS => GEOSS
    e. Transitioned from congressional earmarks to competitively based selections
    f. Has focused on the DMAC component, not so much on the Modeling and Analysis/Observing Systems
    g. Stressed the challenge of selling the importance of data management, which is not easy to see or understand (like an observing system is)
    h. 25-40% of NOAA forecaster time is spent finding data and reformatting it for their needs
    i. Gave overview of the Data Integration Framework (DIF), highlighting it as a risk-reduction pilot effort. Focus on a handful of variables, addressing some aspects of the overall DMAC.
    j. Some successes: SOS services, regional implementation of the DIF, documentation, collaborations with interagency/GEOSS
    k. Listed the four example applications: Coastal inundation, harmful algal bloom forecasts, hurricane intensity forecasts, and integrated ecosystem assessments

l. Gave example from Humboldt Bay oyster production: the aquaculture farmer she was with yesterday said what he needs more than anything is extremely high resolution SST and chl-a observations so he can arrange his seeding schedules to maximize oyster survival/crop yield
m. Issued invitation from IOOS to GHRSST:
    i. Given that GHRSST serves ocean data, GHRSST uses standards used by IOOS (DAP+CF+netCDF), that GHRSST architecture aligns with IOOS conceptual architecture…
    ii. We invite GHRSST to be recognized as an IOOS data provider (agree to mutual data sharing principles, reciprocal links/logos)

5. Wolfgang Lengert, AATSR Exploitation Plan (AEP)
    a. Overview:
        i. How to exploit jointly the (A)ATSR mission (scientist - funding bodies – operational users)
        ii. Exploitation Plan – Exploitation Board
        iii. What's missing & next steps
    b. Exploitation Management Tool is missing
        i. For funding bodes (easily identify activities that meet their objectives)
        ii. For scientists (identify research gaps, shopping list)
        iii. For operational users (to see what science has matured)
        iv. In summary: An attractive tool for all (A)ATSR players providing transparency on the full (A)ATSR exploitation life cycle and encouraging the synergetic use of resources (money and intelligence) was missing.
    c. AEP – contains 6 volumes, <u>including an SST Products and Applications Volume</u>. Here is the list of volumes:
        i. Volume 1: (A)ATSR project overview
        ii. Volume 2: Projects which have requested (A)ATSR data
        iii. Volume 3: Peer reviewed (A)ATSR Exploitation
        iv. Volume 4: SST Products and their Applications
        v. Volume 5: LST Products and their Applications
        vi. Volume 6: Aerosol and Cloud Products and their Applications
    d. Showed a diagram of the ATSR series – Product quality, scientific evaluation, and product validation framework
    e. Stressed the importance of quality to ESA, and how the ATSR series is being improved
    f. Gave (A)RC project as an example.
    g. Described the AEP Board
        i. composed of the funding bodies behind the ATSR series (DECC, ESA, CSIRO, NEC). Also the funders of exploitation of the data (DEFRA, etc., and the ATSR PI team)
        ii. Objective is to act on behalf of the ATSR funding partners <u>to exercise appropriate and effective leadership in the evolution of ASTR exploitation</u>
    h. What's missing from the AEB
        i. Make the board more international
        ii. Get ToR approved
        iii. Communicate new way of working in collaboration across funders, scientists, and operations (GHRSST is a good example of a success here he states)
    i. Summarized with:
        i. The (A)ATSR mission is more than only easy & free data access.
        ii. The AEP ensures Transparency & Openness throughout the Exploitation life cycle
        iii. With the new Exploitation management structure everybody can contribute to the mission and the same time take benefit for his work

6. Guenole Guvel, for Hans Bonnekamp, EUMETSAT
    a. Overview:
        i. EUMETSAT in the GHRSST
        ii. Satellite Application Facility plans
        iii. Future Programs and missions (MTG, Post-EPS, Sentinel-3 ..)
        iv. Recent Altimetry developments
        v. Climate monitoring
        vi. CEOS Virtual Constellations
    b. Stressed EUMETSAT as a key L2P and L3 GHRSST data provider via OSI-SAF
    c. Pointed out that the SAFs will be continued. Current phase runs through 2012, next phases is 2012-2017 and is based on the Meteosat Third Generation (MTG) program
    d. Gave some details on the MTG program (two platforms, beginning around 2016, three-axis stabilized)
        i. Full Disk High Spectral Resolution Imagery (FDHSI) – 8 thermal channels at 2 km resolution
        ii. High Spatial Resolution Fast Imagery- Local scales with 2 thermal channels at 1 km resolution

         iii. InfraRed Sounder – like IASI, full disk at 4 km
      e. Then talked about the EUMETSAT Polar System
         i. VIS/IR Imaging Mission (VII, follow on to Metop AVHRR)
         ii. Dual View Radiometry (DVR, Sentinel-3 follow on to AATSR)
         iii. Microwave Imaging Mission (MWI, AMSR-E follow-on, BUT: EUMETSAT to ensure awareness that Europe is relying on other missions to provide measurements at 6.9 and 10 GHz for all weather SST and heavy precipitation - namely NPOESS MIS and GCOM-W AMSR missions, following the decision to de-scope of the 10 GHz from the MWI mission.)
         iv. EUMETSAT to operate Sentinel-3 based on agreement with ESA
      f. Talked only briefly about Jason-2
      g. Talked about Generating climate products, addressed through:
         i. Archive reprocessing
         ii. SAF climate monitoring
         iii. ECV generation in near real time
      h. Proposed that perhaps GHRSST Advisory Council could serve as the lead for a GCOS Virtual Constellation for SST
7. Kenneth S. Casey, for Margarita Gregg, National Oceanographic Data Center Stewardship of GHRSST and Related Data
      a. (I gave this talk, so have no notes for it!)
      b. (but basically I showed a summary of NODC's role in GHRSST, archive statistics, GCOS Intercomparison work, and other related datasets like our archive of the World Ocean Database, Argo floats, etc.)
8. Olivier Arino, ESA Climate Change Initiative
      a. Proposing to play a key role in providing climate change information – observations, data, and analyses
      b. Doing it within the international framework (UNFCC, GCOS, GEOSS)
      c. Objectives: To realize the full potential of the long-term global Earth Observation archives that ESA together with its Member states have established over the last thirty years, as a significant and timely contribution to the ECV databases required by United Nations Framework Convention on Climate Change (UNFCCC).
      d. New element of existing Earthwatch ESA Programme, 6 year duration (2009-2014) with 75 MEuro budget
      e. Gave a list of prioritization criteria:
         i. Significance of response to GCOS requirements and to scientific priorities of international climate research and modelling communities
         ii. Availability and accessibility of suitable long time-series of adequately stable, calibrated satellite observations from which to constitute FCDRs & derive ECVs
         iii. Relative importance, uniqueness and complementarity of ESA EO missions data in the context of the coordinated international response to GCOS
         iv. Maturity of the methodology & algorithms related to one or more ECVs
         v. Capitalizing on established European excellence in generating and delivering high quality global EO data products
         vi. Effective engagement of complementary scientific expertise, and technical capabilities from participating states, to achieve a coherent European effort for GCOS, by efficient use of resources available to CCI
         vii. Prospects for transiting capabilities developed under CCI to an operational context for future regular updating and continuous availability of ECVs
      f. ESA CCI will focus on ECV development based on other L1B/L2 products
      g. Gave a lot of information on how the CCI program will be managed (through open competitions, etc.) and how it will incorporate scientific and user feedback
      h. Showed a graph going back to 1991 of all the satellites to be used, but it will go back to 1981 for SST

GHRSST USER symposium
Session 3 and 3a Rapporteur notes

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SESSION 3

Jorge Vazquez: Overview of data access GDAC and LTSRF

Missed talk due to conference call that ran long.

Martin Rutherford: Processing and displaying GHRSST data using ESRI ArcGIS Desktop - Royal Australian Navy Perspective.

The Royal Australian Navy is using GHRSST data to satisfy requirements for safety (eg., the level of personal protection required on deck), freedom of maneuver (SST gradients as a proxy for currents), tactical operations, and model validation. They are displaying the data through GIS and web services because of the rich toolset for processing and display, the interoperability, and the mandate of the Australian defense force. Examples were presented of the loading and display of L4 and L2 data. The L2 processing is more complicated since it is not inherently in raster format. Basic processing is keystroke intensive, but scripts can be constructed (using Model Builder) end eventually published and run as a cron job.

Dimitris Menemenlis questioned on the relationship between SST gradients and currents. Martin replied that the approaches were related to exercises around Australia and were worked up in the 60's. Another comment suggested that there has been other work exploring the connection between SST and currents. Helen Beggs questioned if L3 data were also to be included. Martin replied that all GHRSST data would be considered but there were some issues whether data would be exported externally outside the Navy.

Dave Poulter: New HR-DDS User Services

Website is http://www.hrdds.net, development was originally performed through the Medspiration project. The talk considered two portions: An introduction to the HR-DDS and planned new features. The HR-DDS is an interactive web based system to analyze GHRSST data. Data are extracted from distributed sites and subsets are made available in a common format. The content is loaded into fast database containing additional ancillary data such as on waves. Multiple dynamic visualization, manipulation, and statistical calculations are possible facilitating data intercomparison and identification of possible data problems. The system now contains about 5 years of data plus climatology. Results and original data can be downloaded.

New features under development include a Wave HR-DDS from GlobWave using common format L2p wave data, pixies, and a regional diagnostic data set. Pixies are automatic reporting features that he broke into 3 classes ranging from information on data availability (class 1), to regular delivery of content based on some specified criteria (class 2) to some detailed report (class 3). The regional diagnostic data set will be a lower resolution product over a broader region. The regions are not preselected and users can select a desired lat/lon range.

Dick Reynolds commented that it would be useful to have some alarm clock or "butt-kick" email when any product differed significantly from the overall ensemble.

Tess Bandon: Working with the GHRSST data format: Experiences of the GCOS SST/SI Intercomparison Working Group.

NODC hosts and SST intercomparison facility which she describes from the point of view as a GHRSST user. The talk considered the backround of the intercomparison framework, methodology, and user reports. The goal of the GCOS SST intercomparisons are to understand differences between different analyses and use this understanding to link present satellite data with historical in situ based data. A major effort was expended to reformat to some standard format – the GHRSST L4 data specification was used. The data has fewer ancillary requirements but led to a potential inconsistency in the error fields due to the different content of the various data sets. The structure includes data cubes at weekly one-degree and monthly 5-degree resolution in netCDFand Matlab. Web access statistics were presented based on content, file type, number of requests, and organization.

Tess Brandon described anecdotes on working with GHRSST data. Input was largely on file formats. Users almost all use whatever lying around but prefer formats tied to the tools they normally work with. Some requests were for formatted text due to the steep learning curve for working with netCDF. NetCDF was slightly favored over Matlab but not by much. She also received requests for data in data cubes tying the different data sets together.

Break

SESSION 3A. GHRSST DATA VALIDATION

Richard Reynolds: Comparison of Daily SST analyses for 2007-2008 by Reynolds and Chelton

His study considered 6 analyses based on global data for 2007-2008 (his AVHRR only, AMSR+AVHRR, NCODA, RSS, RTG hi-res, OSTIA). He first showed preliminary differences between daily fields in the analyses and differences in the gradients. The analyses were shown to have different levels of representing small scale features/smoothness. He highlighted the potential issue in representing small scale features if there is a chance that the data is not there every day and advised that one shouldn't do high resolution analysis without high resolution data. He next showed zonal wave number spectra highlighting the different spectral energy in the products. He then compared the analyses with buoy data illustrating product biases and rms by region and averaged over a month. Issues related to high rms differences for the RSS product in the Gulf Stream and the RTG analysis in the Aleutians were highlighted. In the Aleutians the RTG showed a large negative bias in the winter of 07 perhaps due to poor inclusion of sea ice information.

His summary points included: RSS appears too noisy, especially in the tropics; the RTG analysis is too smooth with a 2007 winter cold bias; NCODA and, to a lesser extent, OSTIA are tuned to the buoy data; MW can lower resolution of data. Regarding grid spacing vs. resolution, small scales can't persist in the absence of data and one must degrade the analysis resolution to the MW resolution until IR data return. His current analysis is a low resolution analysis and he then proposed adding a second stage to get higher resolution from 1-10 km. High resolution IR data could be added on top of a stable low resolution analysis from MW and low resolution IR data. He proposed that such an approach could be computationally more efficient.

Arthur Mariano questioned whether he used equal weighting of the MW and IR data and Reynolds replied that he did.

Alexey Kaplan: Gridded SST data sets: How to choose a “right” one?

The talk centered on how to advise users about selecting an appropriate product for their application given the large number of different high-resolution analyses. He highlighted that while having a systematic intercomparison is important, it is important to look at individual users for their problems. He compared the OSTIA, RSS, and Daily OI from NCDC showing the pairwise mean differences and standard deviations. Some regions showed systematic biases but he was more interested in the random differences. There is a relationship of the differences to wind speed/stress in the tropics (smaller stress corresponds to smaller differences between the products while larger stress corresponds to larger differences) but more needs to be done to explain scatter. Other knowledge can be gained by tracing differences back to the original data entering the analysis – some differences can be seen related to sampling of the in situ data. He further highlighted differences between the effective resolution of features in the analyses to their nominal grid resolution.

His final recommendation was that users should select data that has minimum acceptable resolution – the data should be only as fine as is absolutely necessary.

Ed Armstrong: GHRSST Level 4 product comparisons in coastal regions.

Ed presented the results from a pilot project validating L4 products in coastal regions against in situ data for June 2007 – June 2008. The products included the NCDC AVHRR-only and AVHRR+AMSR analyses, OSTIA, and RSS. Three regions were considered with high frontal probability: the Gulf Stream, Gulf of Mexico, and along the US West Coast. Biases and standard deviations relative to buoys were shown for each region. In general larger RMS differences were observed in the coastal regions (on order of 0.5 K but up to 1 K) highlighting the difficulty in working in these regions. Errors were larger in the Gulf Stream than in the Gulf of Mexico; OSTIA performed best overall in the Gulf of Mexico. Restriction of data to nighttime only showed no regular reduction in bias or standard deviation as expected leading him to question whether the foundation analyses were really representative of the foundation temperature. Finally he highlighted the difficulty of using buoy data for independent validation since the data are used in some analyses and recommended that providers document what buoys are used in their analysis.

Future work is to include more L4 products as well as seasonal and interannual comparisons. A new data tool now has been developed to perform this L4 validation on the fly.

Mike Chin: Validation of ultra-high resolution (1 km) SST analysis

The product is a daily analysis at 1-2 km resolution for the Gulf of Mexico and western Atlantic (from 15 deg. N) and includes both real-time (faster) and retrospective (more accurate) output. Both will be delivered through the PODAAC. The analysis uses MODIS and AMSR-E data and both inputs are validated against fixed buoy and independent AATSR data. The analysis technique is Multi resolution variational analysis (MRVA) used for both single sensor and multi-sensor analysis. This technique has the advantage that it can do interpolation over large gaps while preserving high resolution data. Comparisons were shown relative to both buoys and AATSR satellite swaths. If single sensor biases in the input products are removed, there is a reduction in the analysis bias with respect to the buoys but not always a reduction of the analysis rms. Performing the analysis does result in lower bias and rms than in the individual inputs. His summary further highlighted the usefulness of the bias values and emphasized that the multi-sensor combination consistently improves agreement with buoys and the AATSR.

Chris Merchant: ATSR Re-analysis for Climate (ARC) (in place of Nick Rayner)

The primary project goal is to construct an independent record of SST over the period from August 1991 to December 2009. The project has been running for 3.5 years and has 1 year to go. Many other products have some tie to buoy data and the AATSR record may be one of the few that can be independent. The recent period is one of big ocean change, but the observing system has also been changing with a different distribution of observations – this emphasizes the value of an independent record with consistent sampling. The project contains 3 elements: cloud detection, retrieval, and adjustments. This talk focuses on cloud detection which is as important or more important as retrieval. The improved SADIST and alternative Bayesian approach were compared. Using an identical retrieval technique, significant differences were seen in the standard deviation of the nadir-dual look differences for the SADIST and Bayesian approaches. Use of the Bayesian approach also provided improved coverage as persistant flagging of cold water in SADIST was improved.

On the retrieval, improved coefficients are being used but this entails many steps and could be a talk on its own. A problem exists with the AATSR 12 micron spectral response function but processing cannot wait and the channel will need to be excluded. A retrieval using the 3.7 and 11 micron channels is being developed and all retrievals using 12 micron data will be referenced to this dual 3.7/11 approach. Median differences and robust standard deviations with respect to drifting buoys were shown highlighting improvements through the steps from the operational approach to inclusion of the Bayesian methodology and ARC coefficients.

The product will contain adjustments from skin SST to drifter depth using skin and diurnal model (implying abandonment of the foundation concept). The project is almost at the stage where the SST is verified within the consortium. There will be synthesis of the verification results and then a final adjustment to give SST v1. The product will include a 0.1 degree, spatially complete 3-day composite. Comments on the product were requested from the meeting.

Craig Donlon questioned why the move to drifter depth from foundation. Chris replied that this approach is more consistent with the past climate analysis and that the foundation temperature is not an observed quantity.

Karen Veal: A comparison of AMSR-E and AATSR SST time series.

The focus of this investigation is to determine if the difference between using an IR clear-sky only SST product and an all-sky MW product has any significant impact on the global mean SST time series. The study utilizes AMSR-E data for the MW product and AATSR for the IR product, both averaged to a 5-degree grid. The AATSR product is the version 2 (first common processed, not ARC) product. Only nighttime data are used. Anomalies are computed to the Reynolds OI climatology. Daily differences between the products were considered first. Since the AMSR-E observation is later than AATSR it could potentially be cooler, but since the AMSR-E is representative of the subskin temperature it might also be warmer. Daily differences were generally small but there were some regions of differences where there are persistent clouds. Latitude banding was also observed. Time series of the monthly averaged global SST anomaly were also compared showing general agreement and similar features. Constructing a cloud-cleared AMSR-E product from AATSR showed a very small difference from the all-sky product at the 5 deg average (all-sky ~0.02 K less than cloud cleared). Further comparison against AVHRR and the HadSST2 again suggested that AMSR-E and AATSR were similar.

She concluded that the AMSR-E and AATSR are in good agreement considering the 3.5 hour difference in measurement time and different sampling. Differences are likely related to unfiltered clouds. There does appear to be seasonal component to the difference – possibly due to skin/subskin changes. Ultimately, neglecting cloudy data does not appear to have a large effect on the SST time series on a 5 degree grid. In the future they plan to consider regional studies and look at cloud liquid water as a proxy for cloud cover.

Alec Bogdanoff: Calculation of SST using a Forward Radiative Transfer Model Approach

For background Alec noted that empirically based retrievals are biased to areas where in situ data exist and he desired to obtain more confidence in regions with little in situ data using a minimal computing approach. They utilize RTTOV as a fast radiative transfer model (RTM) plus a neural net. From the MDB provided by Pierre LeBorgne they used 100,000 randomly selected nighttime collocations (this is not optimum and they will go back to explore the distribution). Using inputs of NWP (ECMWF) and the brightness temperatures they obtained better results compared to multiple linear regression. The neural network (NN) emulated the OSI-SAF algorithm and the further question is whether the NN can emulate a full RTM. The NN emulation of the RTTOV Jacobian in general did well for not being optimized. He concluded that as a first guess the neural network does an exceptionally good job with inclusion of the RTM increasing the accuracy of the modeled approach.

Dave Poulter questioned if he was familiar with recent work on a Gaussian processor. Alec responded that he had just learned of this. R. Reynolds questioned if you want to hold back some buoys and Alec replied that he had.

End of Presentations

Jorge Vazquez then offered closing remarks for the day extended thanks to Frank Wentz and RSS for sponsoring the symposium and to the OSI-SAF. He further acknowledged Chelle Gentemann for doing all of the heavy lifting in preparation for the event.

REPORT ON THE DATA ASSEMBLY AND SYSTEMS (DAS-TAG) FOR THE GHRSST XI MEETING IN LIMA, PERU.

Andrew Bingham and Ed Armstrong

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ABSTRACT

Consensus at last GHRSST meeting (Santa Rosa, CA) to merge

- GDS-TAG (Gentemann)
- DM-TAG (Vazquez)
- XML-TAG (Armstrong)

Oversee the development and implementation of the GHRSST Data Processing Specification (GDS)

- Data product specifications (L2P, L3 & L4)
- Data system specifications (RDAC, GDAC, LTRSF interfaces, common data management practices)
- Common user interfaces for data discovery and access
- Coordinate GDS reviews and get buy-in from the stakeholders

1. Progress since last meeting

A GDS2 draft version has been produced and has been made available on the web

- Special thanks to Book Captains (& Chelle, Ken, Craig)

Technical content is largely correct

- Special thanks to Book Captains (& Chelle, Ken, Craig)
- GDS2.0 review and endorsement shall focus on this aspect at this meeting

Editorial consistency and how to publish the document is not agreed

- We need to agree how to do this.

GPO will then edit up a document and organise an external review. We can then publish a final version.

GRSST AC requested an external review following GDS-2.0 acceptance by ST

2. General observations

Motherhood docs:

- User guide needs more tailoring to the science users

Product Specifications (L2p, L3, L4)

- Discrepancies between Tables 6.1 (product summary) & 8.1 (variable summary)
- L3 document has formatting issues
- Need to ensue proper cross-referencing (particular with conventions document)
- Check acronyms & abbreviations lists

System Specifications

- No MDB document
- HRDDS document status?
- Need ICD

3. Issues that need resolving

- Do we need a single volume GDS document or are we happy with these many different documents with repeating information?
- Are we happy with slightly inconsistent styles to the various documents?
- NetCDF 3 or 4?
- How do we put the GDS under revision control?
- How shall we organize the external review?
- How do we implement and integrate the ISO-19115 metadata records?
- How do we ensure data discovery/retrieval is backward compatible with GDS 1.x?

4. GDS2 External Review

GDS

GDS-2.0 REVIEW TERMS OF REFERENCE

The aim of the GDS-2.0 External Review is to verify the technical content, completeness and fitness for purpose of the GDS-2.0 documentation prior to GDS-2.0 implementation.

The objectives of the review are:

- To verify and endorse as fit for purpose the GHRSST GDS-2.0 **product definitions and technical formats**;
- To verify and endorse as fit for purpose the **Technical content** of GHRSST GDS-2.0 documents;
- The **format, completeness, consistency and accuracy of final GDS-2.0 documentation**;

GPO to organise this as soon as possible

5. Membership of the DAS-TAG

The DAS-TAG is chaired by Andrew Bingham, with Vice Chair Ed Armstrong

Current members of the DAS-TAG include:
Ted Habermann, Jean-Francois Piolle, Dave Poulter, Leon Majewski, Ken Casey, Chelle Gentemann, Tess Brandon, Gary Wick, Craig Donlon, Jorge Vazquez, Dave Foley.

REPORT ON ACTIVITIES OF THE DIURNAL VARIABILITY WORKING GROUP

Compiled by **Chris Merchant**

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1. Introduction

The Diurnal Variability Working Group (DVWG) has not met in the interval between GHRSST X and GHRSST XI. DVWG members have been involved in relevant activities in relation to links with the Data Buoy Co-operation Panel (DBCP), US and Euro Argo teams (both these activities joint with the GHRSST ST- VAL TAG), a Met Office National Centre for Ocean Forecasting workshop on Ocean-Atmosphere coupling, the European Research Network for Estimation from Space of Surface Temperature (ERNESST), in connection with the GHRSST High Latitude WG, and the US Interim Sea Surface Temperature Science Team (ISSTST). Rather than give a series of meeting reports, the developments across these fora are described thematically below. In addition, research progress by individual WG members is mentioned.

2. Drifting Buoys

Interaction with the DBCP has steadily increased since GHRSST IX. In September 2009, Merchant attended the DBCP on behalf of the DVWG and ST-VAL and presented a talk co-authored by Gary Corlett on “Use of Drifting Buoy SST in Remote Sensing”. Key points made were:

1. There is increasing demand for high-accuracy high-resolution SST, and progress in satellite SST is delivering improving accuracy
2. In some cases, satellite SST uncertainties are comparable to or less than drifting buoy uncertainties (~0.2 K) and much sub-daily SST variability
3. Thus, present drifting buoy SST accuracy is now a practical limitation for remote sensing
4. Residuals against in situ are markedly affected by in situ calibration and precision – e.g., are markedly smaller when we compare against Argo 4 m SST depth
5. Improvement in accuracy and precision to 0.05 K would greatly assist further developments in satellite SST, and is technically feasible, at a cost, for drifting buoy technology
6. Need to consider in-situ/satellite as a joint system, and increase co-operation and mutual quality control within that system

The DBCP were very positive about this increasing co-operation, and in particular Etienne Charpentier and David Meldrum are looking to frame a pilot study of high-accuracy drifter deployments to establish the benefits, within the DBCP context.

Finally, a reminder of the GHRSST recommendations on drifting buoys, plus an additional requirement that is necessary should high-accuracy deployments become routine in future:

GHRSST recommendations agreed in 2008 + 1

(1) Make hourly reporting universal
(2) Report design depth in calm water to ±5 cm
(3) Report of geographical location to ±0.5 km or better
(4) SST accuracy to ±0.05 K or better, resolve 0.01 K
(5) Use NetCDF CF-1.3
(6) Report of the time of SST measurement to ±5 minutes
(7) No requirement to report on or close to integer hours

(8) (Extra) Report estimate of absolute accuracy

Figure 1: GHRSST recommendations on drifting buoys from 2008, plus (number 8) an additional requirement that will be necessary if some drifting buoy deployments are made with higher accuracy temperature sensors in future (we will need to know which drifters are the high accuracy ones).

3. Argo profiling floats

On receipt of a request from the US Argo Science Team, the following statement, led by the ST-VAL and DVWG on behalf of the GHRSST Science Team, was considered at the international Argo co-ordination meeting (March 2010).

> Requirements for Argo near surface measurements
>
> Group for High Resolution Sea Surface Temperature (GHRSST) Science Team: (lead: Validation and Diurnal Variability working groups)
>
> NASA Interim Sea Surface Temperature Science Team

European Research Network for Estimation from Space of Surface Temperature (ERNESST).

The production of advanced SST datasets using multiple satellite SSTs[1] and in situ data sets requires improved models of the ocean's sub-daily variability and improved error estimates for SST retrievals. The diurnal cycle of the ocean can include formation of near-surface warm layers that are warmer than measurements at depth, typically by 0 to 2 K, with warm layers >5 K readily observable from space[2]. Since satellite SSTs measure this diurnally warmed skin and sub- skin layer, proper analysis of SSTs measured at different times of day requires an estimate of the diurnal cycle and its uncertainty.

The development of an improved understanding of the upper-ocean variability is essential to improving accuracy of near-surface models. Some physics-based and empirical models provide estimates of the depth-dependency of diurnal stratification, and these need testing against more comprehensive observations than are presently available.

With growing evidence of the relevance of the ocean diurnal cycle to the behaviour of the coupled atmosphere-ocean system[3], the trend is towards representing near-surface (upper ~10 m) processes explicitly in numerical models. These efforts will create demand for more observations of relevance.

Improved knowledge of variability in near-surface thermal structure will also help to improve SST retrieval. Some satellite SST retrieval and satellite SST validation methods include comparison to in situ data. It is increasingly clear that the comparison of a satellite skin or sub- skin measurement of SST to an in situ measurement at 0.1 to 5 m depth needs to be made in the light of the near-surface thermal structure that may be present.

To support all this, there is a need for routine, distributed observations of upper ocean temperature profiles, to quantify the characteristics of stratification in the near surface with good vertical resolution. A modified operation of the Argo profilers that supports vertically resolved SST in the upper ~10 m of the ocean will significantly address this need.

It is necessary to consider the question of space-time sampling. The limiting factors here are that for Argo as presently configured:
- sampling is only fortnightly;
- sampling is not phased with respect to local time

These factors would tend to mean that the rate of accumulation of observations displaying diurnal stratification may be slow. Under the current sampling regime, the average modified Argo float would likely measure a significant diurnal thermocline only a few times per year (depending on location). Nonetheless, the statistical picture of near-surface stratification that will emerge will be immensely valuable for the purposes mentioned above. Argo is a completely unique opportunity to get near-global coverage.

We also note that:
Sampling strategies could in principle be devised that are more favourable for diurnal variability research (e.g., surfacing at a useful local time; repeat near-surface profiles over several hours; etc), taking advantage of Iridium technology in particular.
Stratification from near-surface salinity variation is also relevant to sub-daily SST variability (as well as to satellite sea-surface salinity validation). Enhanced instrumentation can achieve such measurements for additional cost.
Effort will be required to understand and interpret near-surface profiles with respect to surface effects and to design effective post-processing strategies.
This document states no requirements on these issues, but notes that discussion involving the Argo and satellite SST communities should be pursued.

In the long-term, the modified Argo floats may:

1. Provide, in the long run, a global 'climatology' of near-surface SST-depth for model development and improved satellite – in situ SST comparisons
2. Provide insight into the temporal and spatial variability of upper ocean stratification
3. Provide profiles in high latitudes in regions typically not sampled well by autonomous CTD
4. Casts from ships-of-opportunity.
5. Provide a resource for the ocean modeling community to study DV and help parameterize DV
6. in mixed layer/coupled model systems
4. Provide the basis for further development of the Argo and GOOS systems for air-sea interaction
5. Provide a systematic reference for relating satellite SSTs to SST-depth and/or foundation SST

Given this potential, the GHRSST ST-VAL, GHRSST DVWG, GHRSST Science Team, NASA Interim SST Science Team, and ERNESST support the proposed trials of high resolution SST profiles in the upper ocean.

Technical requirements for Argo temperature profiles relevant to near-surface stratification /diurnal variability (additional to standard profile requirements):

Vertical resolution:
Goal: 10 cm sampling in upper 3 m with ability to respond to a gradient of 0.1 K cm−1; 50 cm sampling below 3 m
Useful: 0.5 m sampling in upper 3 m; 1 m sampling below 3 m

Depth range:
Must capture top ~10 m with high reliability, implying conservative approach to the start of near-surface data collection, e.g., from above 14 m.

Accuracy of depth estimate (viewed as crucial):
Goal: 2.5 cm in upper 3 m; 10 cm down to 10 m
Useful: 10 cm in upper 3 m; 15 cm down to 10 m

Accuracy of SST
Maintain SST accuracy requirements of rest of profile in near surface

---

[1] E.g., datasets that meet requirements for sea surface temperature for climate in GCOS (2006), GCOS-107 (WMO/TD No. 1338).
[2] Merchant, et al (2008), Geophys. Res. Lett., 35, L04601, doi:10.1029/2007GL033071; Gentemann, et al., (2008), Geophys. Res. Lett, 35, L22602, doi:10.1029/2008GL035730.
[3] E.g., Klingman et al. (2008), J. Climate, 21, 6119-6140, doi :10.1175/2008JCLI2329.1

Meanwhile, JAMSTEC (Japan) has deployed 6 iridium Argo floats that sample the top 10 m at 1 m intervals, although they are constrained to rise at times around dawn. The Met Office are assessing unpumped near-surface measurements from their deployments and will have a recommendation about their utility for the European Argo Users Workshop (June 2010).

4. “Tropical Warm Pool +”experiment

Beggs has continued to develop and implement an intensive data collection to support understanding of diurnal variability in the tropics. This is a follow-on initiative inspired by the previous effort (“ALADIN+”) focussed on the W Mediterranean and European Shelf Seas. At time of writing, data collection is well underway with the following TWP+ data sets available from the Bureau's
OPeNDAP server (http://godae.bom.gov.au) in a common netCDF format similar
to that for ALADIN+:

* IMOS MTSAT-1R hourly SSTskin derived using NOAA's latest physical retrieval method (gridded to 0.05 deg)
* BoM RAMSSA SSTfnd analyses (regridded to 0.05 deg from 1/12 deg)
* BoM hourly, 0.375 deg, LAPS NWP forecasts of winds and surface fluxes (from 12-hourly model runs)
* Meteo-France METOP-A AVHRR "subskin" SST (regridded to 0.025 deg)

Please contact h.beggs@bom.gov.au to organise password-protected access to the TWP+ files. The TWP+ data sets will doubtless support some interesting diurnal variability science. Andy Harris has started testing the ingestion of the LAPS forecast surface fields into his Modified Kantha-Clayson DV Model.

5. High latitude diurnal variability

Eastwood, Poulter and Le Borgne have continued their analysis of large diurnal warming events at high latitudes, with examples diurnal variability exceeding 2 K identified in both the high Arctic and in sheltered areas around the coast of Antarctica.

6. Diurnal Variability Analysis

Le Borgne and Filipiak have specified experimental hourly diurnal variability fields to be derived in the context of an pre-operational processing chain to be implemented for the Spinning Enhanced Visible and Infra-Red Imager (SEVIRI). These comprise the (gappy) SEVIRI SSTs, a data-driven diurnal cycle estimate (interpolation of SEVIRI data) and an NWP-driven diurnal cycle estimate (parameterisation based on past SEVIRI observations). This will support research into the analysis of diurnal variability (where high frequency SST observations are available).

7. Diurnal Warming Model Intercomparison

Wick and Castro have initiated computations for a detailed intercomparison of the behavior and accuracy of multiple numerical models of diurnal warming. The comparison involves multiple participants of the DVWG using a framework established at the Rome DVWG meeting. Model performance will be compared for several idealized forcing conditions and then validated against a compilation of diurnal warming observations from research cruises. Initial results were presented at the 2010 Ocean Sciences Meeting in Portland, Oregon in February.

8. FinalNote

This is the last report compiled by me as DVWG chair, although I will continue to be an interested member of the DVWG. My confident prediction is that Gary Wick, who succeeds me in the role, will gain immense satisfaction from working with such an enthusiastic and bright collection of colleagues – as have I.

Chris Merchant

REPORT FROM THE HIGH LATITUDE TAG TO THE 11TH GHRSST SCIENCE TEAM MEETING

Prepared on the behalf of the HL-TAG group by **Jacob L. Hoeyer**

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Email: jlh@dmi.dk

1. Introduction

The HL-TAG was formed at the GHRSST 10 science team meeting in Santa Rosa in 2009. It was proposed to the science team to turn the Ice-TAG into a high latitude TAG (HL-TAG). This was accepted by the science team.

It was agreed that the HL-TAG should focus upon:

- 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.

A first HL-TAG meeting was held in March 2010 in Copenhagen. The minutes from the meeting and presentations can be found at the HL-TAG page (http://www.ghrsst.org/High-Latitude-Technical-Advisory-Group-(HL-TAG).html). The meeting was collocated with a MyOcean SST TAC meeting. Unfortunately only Europeans were able to come to the meeting due to tight travel schedules and budget limitations in the US and Australia.

The HL-TAG group photo from the 1st meeting in Copenhagen in March, 2010.

The focus during the meeting was on the issues mentioned above together with a discussion and identification of the challenges in the high latitudes regarding satellite SST and sea ice. The main activities in the group the last year have been related to:

- L2P Algorithm retrievals in the high latitudes
- Ice and cloud detection
- Diurnal warming at high latitudes

2. L2P retrieval and validation

Validation studies have shown that the Metop_A SST data processed by CMS had a positive bias of up to 0.5 degrees in the summer. Pierre LeBorgne has looked into the split window algorithm performance in relation to atmospheric profiles.

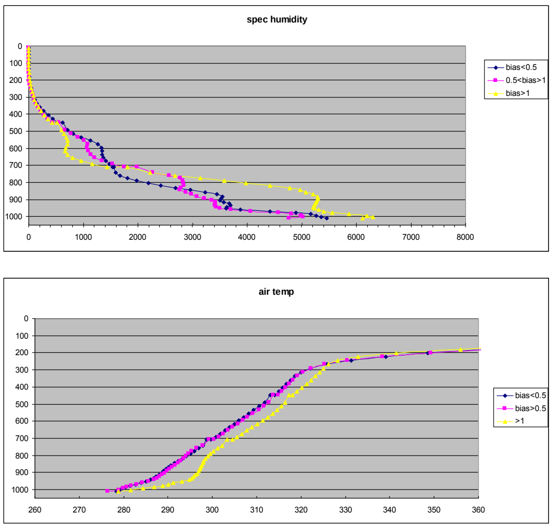

Figure 1: Hirlam atmospheric profiles corresponding to bias < 0.5 (blue) 0.5< bias< 1 (pink) and bias > 1 (yellow) in summer 2008. Top: water vapour; Bottom: temperature (LeBorgne & Péré 2010)

The positive errors of the split window algorithms have been analysed with the HIRLAM atmospheric profiles. They are likely induced by anomalous profiles (relatively moist and warm lower layers). See presentation at the Copenhagen HL TAG meeting Copenhagen, 17 March 2010: Split window algorithm High Latitude issues (LeBorgne, P. and Péré, S.)

Jacob Hoeyer has performed validation activities in the Arctic Ocean including 7 different GHRSST L2P satellite products for the Arctic Ocean

(AATSR, OSI-SAF NAR, METOP_A, MODIS AQUA, MODIS TERRA, AMSRE, NAVOCEANO-GAC), north of 60 Deg N. The results showed a large difference between the different producers and the meaning of the quality flags, see the figure below.

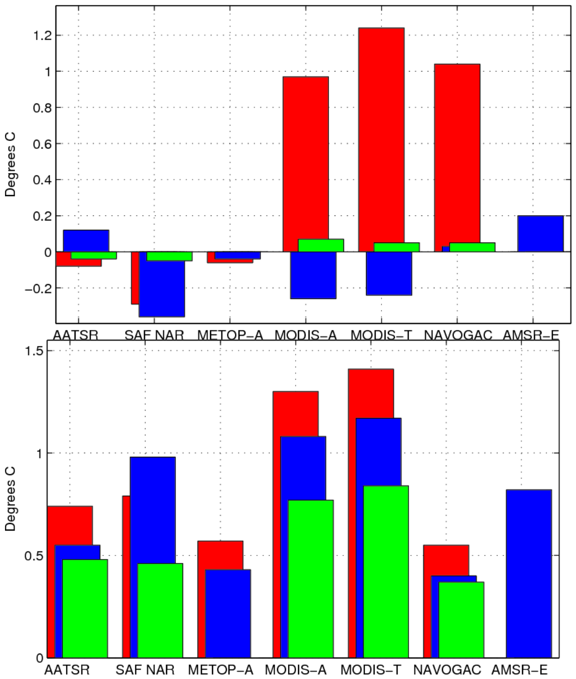

Figure 2: Bias (Top) and standard deviation (Bottom) from a 5 months validation. Red, blue and green indicate proximity confidence levels of 3, 4 and 5, respectively. Note that the SSES biases have been applied to all products.

The Modis products (sst4) showed very large biases for quality flags (proximity confidence) 3 and 4, whereas the biases were lower for quality flag 5. Error statistics grouped as distance from the ice edge showed the Metop_A to perform very well, no quality level 5 was found for Metop_A data in this region.

Helen Begg and her group from BOM is currently carrying out a reprocessing of all archived HRPT from the DAVIS and Casey stations at Antarctica. They use improved algorithms obtained from drifting buoys and the IMOS ship observations, which have shown to of very good quality.

Within the HL-TAG, there is also a focus upon how the HRDDS system from David Poulter can be used for the high latitudes. At present the HRDDS system is not designed for high latitudes, where all sites have to be equal-rectangular grids in degrees. Future upgrades may solve this issue. The HL-TAG group recommended that more ice products (OSI SAF and MyOcean high resolution) should be included in the HRDDS system. It was agreed in the HL-TAG group that the HRDDS should be used for validation of the satellite products, not to improve upon the products.

The gathering of in situ observations to validate the satellite products is a crucial point that has been discussed within the HL-TAG. Steinar Eastwood has demonstrated that the amount of the drifting buoy observations in the Arctic Ocean will decrease rapidly in the coming years, due to the ending of the Norwegian Poleward project. Contacts have been made with the IABP international arctic buoy program, which will have a meeting in Oslo.

3. Ice and clouds

New products:

Within the European projects Damocles and MyOcean, new ice surface temperatures products have emerged. DMI has implemented the CASSTA algorithm to perform real time processing of the Metop_A 1 km observations. The algorithm provides surface temperatures for the sea ice, the marginal ice zone and the open ocean in the high latitudes. The first results look promising. A first validation of the IST products against air temperature observations from buoys in the high arctic, showed biases of about 1 degree and standard deviations of about 2 degrees. Complementary work at DMI focus upon combined thermodynamic and sea ice microwave emission model, to characterize the satellite observations of ice surface temperatures in the microwave during the winter season.

Detection and masking

The detection and masking of clouds and ice is an essential part of high latitude SST processing. OSI-SAF is currently performing a Bayesian approach at daytime to give probabilistic. Other SST producers do, however, not use a very sophisticated detection and masking method. The HL-TAG group agreed that transparency was needed for the users on how the producers were treating the observations in waters with ice.

4. Diurnal warming

The number of examples of diurnal warming at high latitudes have increased in the recent year and regions where DW occurs now include the Nordic Seas, Barents Sea in the North and McKenzie Bay in the south. Below is shown an example from the McKenzie Bay from Pierre LeBorgne and his group.

A “diurnal warming watch” has been established during the Antarctic summer 2009-2010 and the results are progressively being analysed: Cases of several K have been identified, but less frequently than in the Arctic.

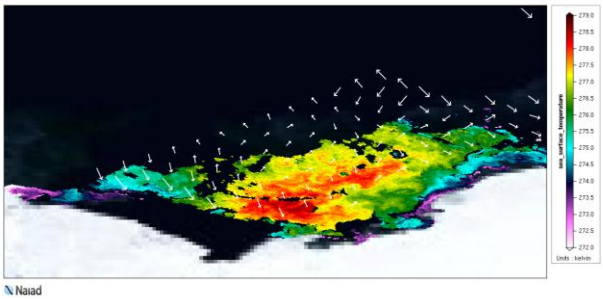

Figure 3: Warm spot in the McKenzie bay on the 08/01/10 at 0125 UTC , observed by METOP/AVHRR (SST) and ASCAT (wind) through IFREMER/NAIAD (LeBorgne, Péré & Piollé, 2010)

5. Discussion within HL-TAG

During the meeting in Copenhagen several issues were discussed in the HL-TAG. They are listed below:

What do the users want ?

Challenge:

New products are emerging covering the zone with mixed ice and waters. The HL-TAG group debated what the users want in terms of surface temperature values (sea surface temperature, ice surface temperature or radiometric surface temperature).

Solution:

The HL-TAG recommend that a user survey is carried out, to determine what the users want. The ESA CCI project on SST will deal with user surveys and it might be an opportunity to get the user requirements for this area.

Performance of SST products

Challenge:

The performance of the satellite observations in the high latitudes are questionable due to the lack of in situ observations, and SSES provided with the data are not applicable.

Solution:

The HL-TAG recommend to perform a triple collocation of the AATSR, the METOP_A and the AMSRE SST products, assuming that the errors on these products are independent. In that way the errors can be assessed without using in situ observations and compared with the SSES'. A data set (SABIA) covering 4 months in 2008 with all the L2P data and in situ observations on the same grid will facilitate these investigations.

Improve usage of SST products in high latitudes

Challenge:

Many products come with no information about the SST treatment in the vicinity of the ice, which limits the usage of the SST products for the high latitudes,

Solution:

The HL-TAG will take action towards writing specifications/recommendations for the SST producers for high latitude products. The aim is not to impose requirements within GHRSST, but to encourage the SST producers to follow the specifications to enlarge the quality and usage of the products in the high latitudes.

Need for in situ observations in the high latitudes

Challenge:

The amount of in situ data in the high latitudes are critical to validate and improve the products, but limited

Solution:

The HL-TAG decided to try and get an overview of the data already available, and to follow the discussions in the IABP to see whether collaboration can result in more data.

Improve ice and cloud treatment

Challenge:

The detection of clouds and the separation from ice during night time and twilight is a challenging task that should be addressed. The ice detection and masking in the L2P processing is an issue that is performed very differently from one producer to the next and not very transparent to the users

Solution:

The HL-TAG decided to make a survey and ask the SST L2P producers on how they treat the presence of ice in their SST processing chain.

Finally, The HL-TAG group has put forward a set of prioritized tasks that the group think are important issues that need work.

- Inter-comparisons (three matches) of satellites in high Arctic as a way of assessing relative biases and standard deviations using the extended Wasparc data set SABIA.
- Pre-draft of new specifications for Arctic products for discussion at Lima
- Transition zone temperature definition and validation

REPORT ON THE INTER-COMPARISON TECHNICAL ADVISORY GROUP (IC-TAG) FOR THE GHRSST XI MEETING IN LIMA, PERU.

Matt Martin

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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; 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.

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.

At the previous GHRSST meeting (GHRSST X), the IC-TAG was initiated by expanding the previous GMPE-TAG. The Terms of Reference which were agreed at that meeting are:

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 (e.g. pixies from the HRDDS).
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.

The IC-TAG should include 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.

2. Progress since the last GHRSST meeting

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. RTG_SST_HR (National Centers for Environmental Prediction, USA);
3. NAVO K10 (Naval Oceanographic Office, USA);
4. MGDSST (Japan Meteorological Agency, Japan);
5. RSS MW (Remote Sensing Systems, USA);
6. RSS MW+IR (Remote Sensing Systems, USA);
7. FNMOC (Fleet Numerical Meteorology and Oceanography Centre, USA);
8. NOAA AVHRR OI (National Oceanic and Atmospheric Administration, USA);
9. CMC (Meteorological Service of Canada);
10. ODYSSEA (Ifremer, France);
11. 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). For that project, the horizontal resolution of the ensemble products (median and standard deviation) was increased to ¼°. 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, a screen-shot of which is shown in Figure 1. 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.

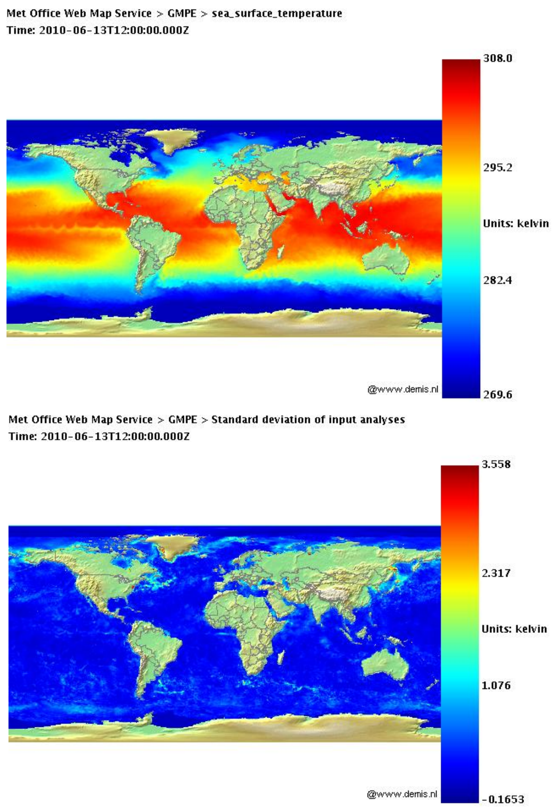

Figure 1. Screen shot of the Web Map Service showing GMPE ensemble median SSTs and ensemble standard deviations.

HRDDS

The HRDDS system allows interactive analysis of many satellite, in situ and model environmental data sets and is available from www.hrdds.net. A separate report on the HRDDS will be made for the GHRSST XI meeting.

SQUAM (Alexander Ignatov)

The SQUAM system runs daily at NOAA/NESDIS. It takes inputs from various Level 2 and Level 4 SST products on a routine basis and generates summary consistency statistics.

The following global L2 products are currently processed in the SQUAM system:

1. NESDIS heritage (Main Unit Task, MUT) low-resolution SST product (from NOAA-16, -17, -18, -19, and Metop-A Global Area Coverage 4km resolution data)
2. NESDIS newly developed (Advanced Clear-Sky Processor for Oceans, ACSPO) high-resolution SST product (from NOAA-16, -17, -18, -19, and Metop-A from Global Area Coverage 4km resolution data)
3. NESDIS ACSPO SST product from Metop-A FRAC 1km resolution data
4. O&SI SAF SST product from Metop-A FRAC 1km resolution data
5. NAVO Seatemp SST product from NOAA-14, -15, -16, -17, -18, -19, and Metop-A

The following L4 products are currently processed in SQUAM

1. NOAA AVHRR OI daily AVHRR-based (NOAA, USA);
2. NOAA AVHRR OI daily AVHRR+AMSRE-based (NOAA, USA);
3. OSTIA (Met Office, UK);
4. RTG_SST_HR (National Centers for Environmental Prediction, USA);
5. RTG_SST_LR (National Centers for Environmental Prediction, USA);
6. ODYSSEA (Ifremer, France);

During the past year, the SQUAM system has been contributing to the NESDIS and NCEP SST quality control efforts. Description of the SQUAM system is found at http://www.star.nesdis.noaa.gov/sod/sst/squam/index.html.

Membership of the IC-TAG

The IC-TAG is chaired by Matt Martin, with Vice Chair Alexey Kaplan.

Current members of the IC-TAG include:

Emmanuelle Autret, Ian Barton, Helen Beggs, Bruce Brasnett, Jim Cummings, Chelle Gentemann, Jacob Hoyer, Alexander Ignatov, Eileen Maturi, Bruce McKenzie, David Poulter, Jean-Francois Piolle, Dick Reynolds, Martin Rutherford.

11TH MEETING REPORT FOR THE REANALYSIS TECHNICAL ADVISORY GROUP (RAN-TAG) AND THE LONG TERM STEWARDSHIP AND REANALYSIS FACILITY (LTSRF)

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1 Introduction

1.1 Background

Since the inception of the GODAE High Resolution Sea Surface Temperature (SST) Pilot Project (GHRSST-PP), it has been 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. With this knowledge, the GHRSST-PP Science Team initiated the Reanalysis (RAN) program whose goals are to produce delayed-mode products of higher accuracy and consistency than the real-time SSTs by taking advantage of additional delayed mode data that cannot be used by the operational real time system, to link the RAN products to existing longer-term SST analyses, and to enable a reprocessing capability so that future users of the data can reprocess or utilize the data. As such, the GHRSST RAN is as much about establishing a *data processing and management system* as it is about *creating SST products*.

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. In this new context, the GHRSST RAN Technical Advisory Group (RAN-TAG) remains the formal GHRSST body that is responsible for the scientific and operational methods and algorithms used to generate delayed-mode GHRSST data products. The delayed mode products will be suitable for use as climate data records, an important concept in environmental data management, which dictates long-term accuracy and consistency (*e.g.* NRC, 2000). Target accuracies for GHRSST reanalysis products are on the order of 0.3 K absolute and 0.1 K relative, with a temporal stability requirement of 0.01 K/decade. These ambitious targets may not be strictly achievable given current satellite sensor technologies but they provide demanding and rigorous goals which push the RAN-TAG to continually search for and implement improvements to the data sets.

1.2 Period of Report and Document Organization

This document describes the current status of the GHRSST RAN-TAG with a focus on its activities since the 10th GHRSST Science Team meeting, held in Santa Rosa, California, USA from 28 May - 05 June of 2009. The year since that meeting has been a productive one for both GHRSST and the RAN-TAG as well. 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 enhancements
- Active Archive Efforts at the NODC LTSRF
- Reanalysis product developments

Several appendices close off the report with listing of LTSRF Operational Messages (Annex 1), LTSRF News Messages (Annex 2), LTSRF Automated Status Messages (Annex 3), and current members of the RAN-TAG (Annex 4).

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 May of 2009 and May of 2010.

2.2 Operational Data Streams

The LTSRF is currently acquiring on a daily basis from the GDAC all GHRSST L2P and L2P_GRIDDED files greater than 30 days old from the following sensors. New data streams in the last year are shown in bold face:

- AATSR (**switched from EUR to UPA as contributing RDAC**)

- AMSR-E
- AVHRR-16, (no longer active but are still available in the archive)
- AVHRR-17, AVHRR-18 (GAC and LAC/HRPT)
- GOES-11 and GOES-12
- MODIS Aqua and Terra
- SEVIRI
- TMI
- AVHRR on MetOp-A
- AVHRR-18 HRPT (for European seas)
- **AVHRR-19 HRPT (over NW Europe and Arctic)**

In addition, twelve L4 analysis products are currently being received via the GDAC from several Regional Data Assembly Centers (RDACs) and archived:

- European (EUR): 2.2km Mediterranean L4 SST (using ODYSSEA system)*
- UK Met Office (UKMO): OSTIA 5.6 km Global OSTIA L4 SST
- EUR: ODYSSEA 10 km Global L4 SST*
- EUR: ODYSSEA 0.02º Galapagos Region L4 SST*
- EUR: ODYSSEA 0.02º North-Western European Shelves Region L4 SST*
- National Climatic Data Center (NCDC): AVHRR_AMSR_OI 25 km Global L4 SST
- NCDC: AVHRR_OI 25 km Global L4 SST
- Remote Sensing Systems (REMSS): 9 km Global mw_ir_OI L4 SST
- Danish Meteorological Institute (DMI): 0.03º North Sea-Baltic Sea Region L4 SST
- Australian Bureau of Meterorology (ABOM): BLUElink Regional Australian Multi

Sensor SST Analysis (RAMSSA)

- ABOM: BLUElink Global 28 km Australian Multi-Sensor SST Analysis (GAMSSA)
- US Naval Oceanographic Office (NAVO): Global 0.10 degree L4 Analysis (K10)

* IFREMER, the RDAC for the ODYSSEA line of products, has temporarily halted production of all ODYSSEA products in order to update their processing system for more secure and sustained production into the future. IFREMER expects this stoppage to last only a few months.

2.3 Archive Metrics

Together, these L2P, L2P_GRIDDED, and L4 files occupy over 28 terabytes (compressed, estimated 56 terabytes uncompressed) of disk space, and consist of approximately 1,350,000 netCDF data files, an increase from 20 terabytes and 1,00,000 files at the time of last year's report. Current temporal coverage varies for each product line, with the earliest dataset available back to the beginning of 1981 (though the majority do not begin until 2005-2007).

The following four figures illustrate the growth of the LTSRF archive holdings. 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. These graphs indicate about 1000 netCDF files occupying between 20 and 25 gigabytes (compressed, about 50 gigabytes uncompressed) arrive at the NODC LTSRF each day.

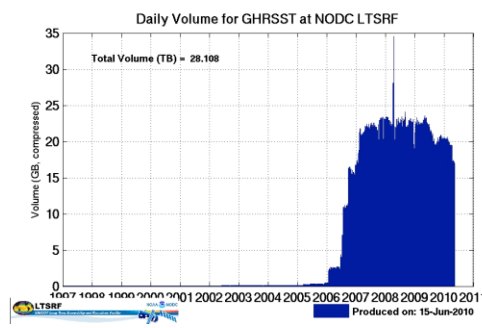

Figure 1: Volume in gigabytes arriving in the LTSRF each day.

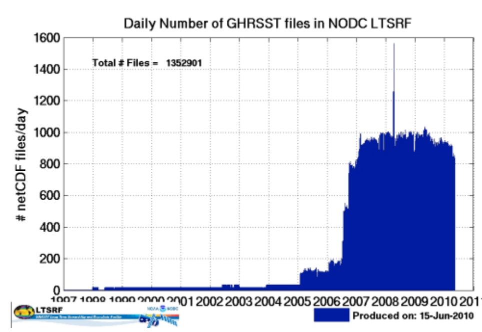

Figure 2: Number of netCDF files arriving in the LTSRF each day.

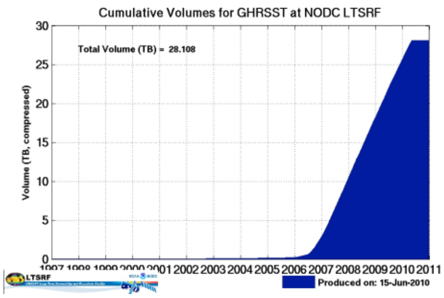

Figure 3: Cumulative volume in gigabytes in the LTSRF.

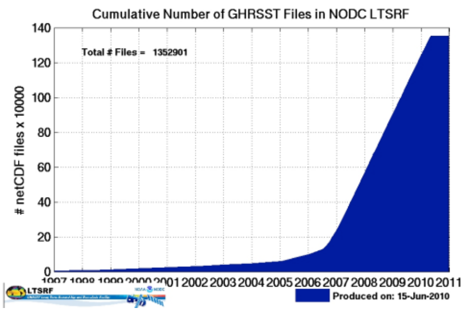

Figure 4: Cumulative number of netCDF files in the LTSRF.

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 23 May 2009, there were 49,747 GHRSST AIPs in the formal NODC archive systems. As of 15 June 2010, there were 59,982. 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 generated automatically daily and posted to the LTSRF web site.

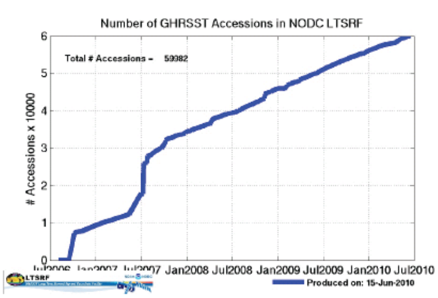

Figure 5: Growth in the number of accessions, or Archival Information Packages, in the LTSRF.

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 10th 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. An example of the XML source for one of the status messages is shown here for reference:

```
<item>
<title>2008-05-15: Ingested 52 new
AIPs into NODC LTSRF - Status
Green</title>

<description>GHRSST archival status
is "Green": 52 new out of an
expected 26 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".</description>
<pubDate>Thu, 15 May 2008 21:26:08
GMT</pubDate>
<ghrsst:status>Green</ghrsst:status
>
<ghrsst:AIP_count>52</ghrsst:AIP_co
unt>
<ghrsst:AIP_expected>26</ghrsst:AIP
_expected>
<media:thumbnail
url="http://ghrsst.nodc.noaa.gov/im
g/led-green.gif" width="16"
height="16" />
<guid isPermaLink="false">ghrsst-
archive-20080515</guid>
</item>
```

2.5 Archive Access Metrics

The number of users accessing GHRSST data from the LTSRF continues to increase. Figure 6 (a, b, and c) summarizes the statistics since logs have been recorded at the LTSRF in June 2006.

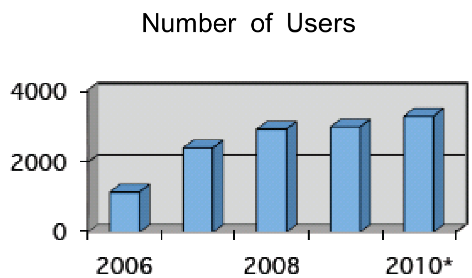

Figure 6a: Number of users of GHRSST data at the NODC LTSRF (based on unique IP addresses). 2010 numbers are projected based on Jan- May numbers.

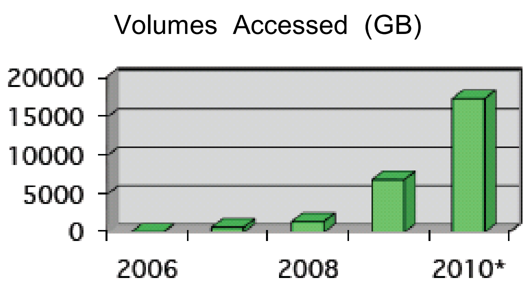

Figure 6b: Volumes of GHRSST data accessed at the NODC LTSRF (in gigabytes). 2010 numbers are projected based on Jan-May numbers.

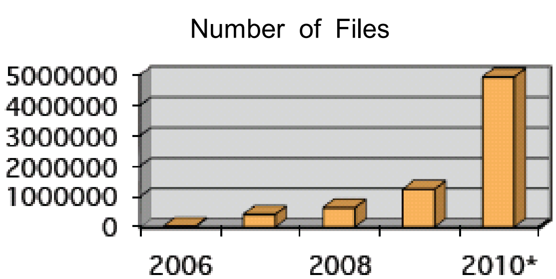

Figure 6c: Number of GHRSST data files accessed at the NODC LTSRF. 2010 numbers are projected based on Jan-May numbers.

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.

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

Table 1: GHRSST/GCOS SST Intercomparison Products available at the intercomparison site.

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, an artifact in the monthly Pathfinder and Daily OI SST fields was identified, and all affected data and browse graphic files were reprocessed and replaced online with the corrected versions. Also, global maps of linear trend were calculated for the historical GCOS datasets and included as standard diagnostics in the online intercomparison facility (Figure 7). These diagnostics were highlighted along with others during an oral presentation on the intercomparison facility given at the 2010 American Society for Limnology and Oceanography (ASLO) Ocean Sciences meeting in Portland, Oregon.

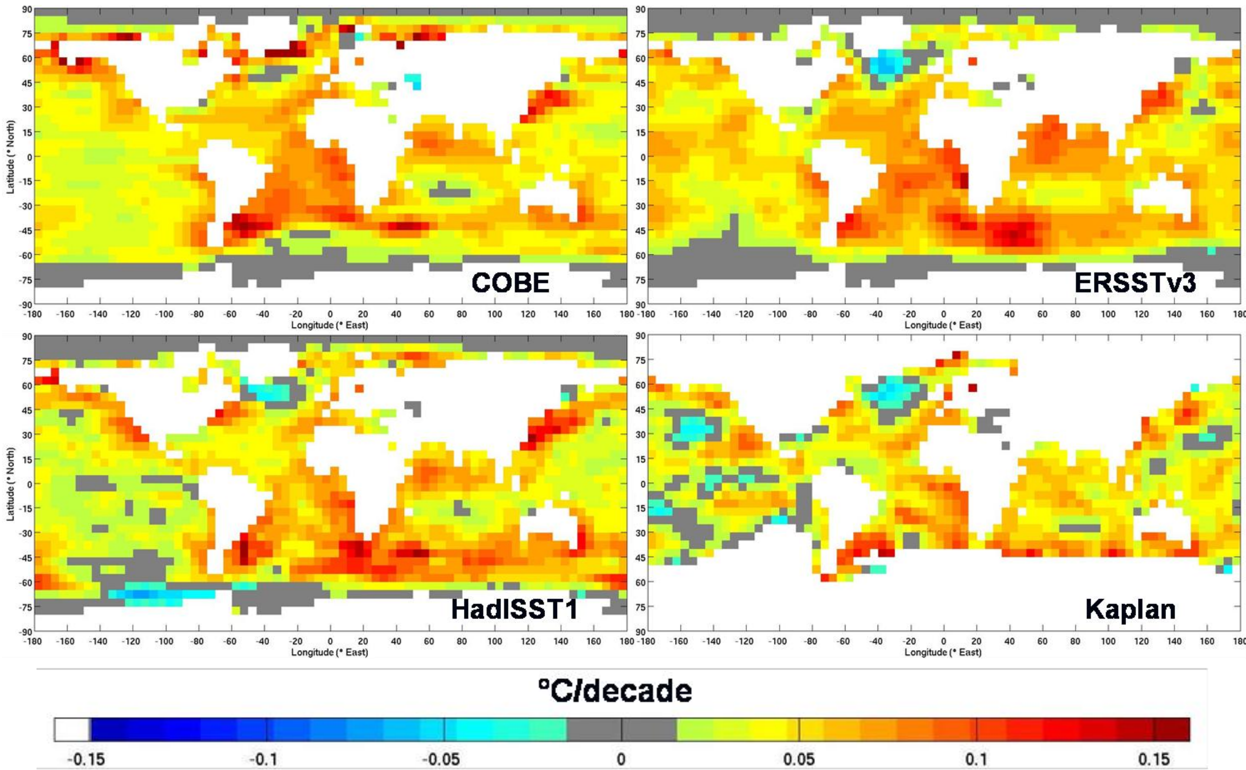

Figure 7: Linear trends calculated for four historical GCOS SST analyses for 1891-2006. Spatial patterns of linear trend are similar for all four analyses, though the COBE and ERSSTv3 analyses show uniformly more warming.

4 Active Archive Efforts at NODC LTSRF

In late 2008 the NODC LTSRF began a process to comprehensively quality-assure all of the GHRSST archive holdings. The first step in this process was to write and test a system capable of reading any GHRSST file. This step found problems in several of the GHRSST products, including incorrect grids, lack of required sea ice information, and problems with the SST scales and offsets. In all cases, the producing RDACs were notified of the inconsistencies.

The second step was to initiate an annual review of the Data Set Description (DSD) and File Record (FR) metadata associated with each of the GHRSST products. For the second year running, the NODC LTSRF coordinated updates with the RDACs, and the NODC staff transferred the new metadata to the GHRSST GDAC at JPL for integration with the overall data management system.

The third step was to begin directly using the GHRSST data in scientific applications. This first-hand experience with the data is an important way to develop and document its quality and usefulness, and it contributes to the long-term preservation of the information. This effort continued over the past year through one such study, which uses numerous GHRSST L4 products in conjunction with other satellite-based inputs to calculate air-sea heat fluxes. Although satellite-based fluxes remain limited by retrievals of air temperature and humidity, comparisons of fluxes produced at the NODC LTSRF with other flux products highlight the suitability of GHRSST L4 analyses for use in such calculations. More recently, GHRSST L2P products are being used to assess the impact of temporal and spatial resolution and instrument type on the calculation of air-sea heat fluxes.

A fourth step has been added this year, involving the creation of a browse graphic image for every GHRSST netCDF file. 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.

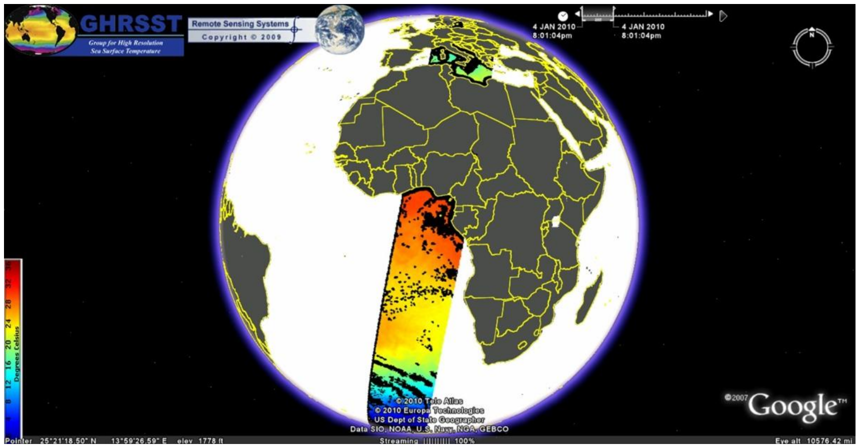

Figure 8: Example L2P REMSS AMSR-E browse graphic in Google Earth browser

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 was another major focus of the NODC LTSRF over the past year. In addition to HTTP and FTP, GHRSST data are now 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 are being experimented with now and will be make available to users by the end of June 2010. These virtual aggregations also span the NODC LTSRF and JPL GDAC holdings, making all of the data appear to the user as a single, complete collection. NODC staff have also generated collection-level metadata records for each GHRSST product that are published to NODC's Web Accessible Folder, which makes all of the NODC LTSRF GHRSST data holdings discoverable through simple text searches from any web browser using search engines like Google.

5 Reanalysis Product Developments

Significant progress has been made since the last Science Team meeting in the development of reanalysis SST products, both single sensor and merged. Demand for these more accurate, consistent, and longer-term products continues to grow, with users ranging from fisheries scientists to numerical modelers interested in longer data sets than the GHRSST forward-mode operational data streams can provide. Requests for data have sky-rocketed at the LTSRF, providing clear evidence that users need more and longer SST data sets to achieve a range of societal benefits.

First, the AVHRR Pathfinder effort has made significant strides forward in the last year. The Pathfinder Version 5 time series now spans 1981-2009 and includes a new set of SST climatologies. Progress also continues with implementing Version 6 in the SeaDAS environment at NODC. Nearly all required modules are in place, and the focus is now on the overall workflow management and ensuring the output files are compliant with the developing GDS 2 specifications. Pathfinder Version 6 will include L2P, L3-uncollated (L3U), and L3-collated (L3C) products. One year of Pathfinder Version 6 is expected to be available by 01 October 2010, with the remaining data made available later in 2011. Work to reprocess HRPT data from the AVHRR series is also underway at the Australian Bureau of Meteorology and the University of Rhode Island.

Second, L4 reanalysis products continue to be developed. An effort at the Danish Meteorological Institue (DMI) has commenced to create an L4 reanalysis product for the Arctic and Greenland waters around Nuuk. This work uses Pathfinder and the (A)ATSR Reanalysis for Climate data and will span 1985-present. April 2011 is the anticpated data the product will become available. In addition, a global 1-km resolution analysis product known as G1SST is being produced by JPL. G1SST is a real-time, merged L4 SST product using 16 satellite sensors and in situ measurements, and plans to develop a reanalysis component for data prior to May of 2009 are underway. Improvements to the existing NCDC 1/4° Daily OISST (Reynolds et al., 2007) are also underway, with the goal of creating a higher resolution daily OI with1-10 km spatial resolution. This work will use the 1/4° daily AMSR+AVHRR OI from the current day and a strongly damped high resolution analysis from the previous day as a first guess, and will utilize infrared observations from AVHRR and MODIS only. This product will initially span June 2002 – present.

Third, work to provide a reformatted (A)ATSR archive in L2P core with uncertainty estimates is now complete. This ESA-sponsored effort has resulted in what is known as the Version 2.0 (A)ATSR data set and discussions are now underway to ingest these data into the LTSRF. This reformatted dataset will also be provided to the GHRSST/GCOS SST intercomparison facility by the University of Leicester.

Finally, a major step forward was also just announced this month as part of the ESA Climate Change Initiative (CCI), which is formally known as the Global Monitoring of Essential Climate Variables. The CCI goal is to provide an adequate, comprehensive, and timely response to the extremely challenging set of requirements for (highly stable) long-term satellite-based products for climate, that have been addressed to Space Agencies via GCOS and CEOS. As part of the CCI program, a dedicated activity for the SST Essential Climate Variable (ECV) has been developed. The SST ECV component of CCI, known as "sst_cci", will deliver:

- **A new 20 year leading SST record** (fundamental climate data record and merged products) based on synergy between complementary satellite data sets together with comprehensive uncertainty estimations
- **New Techniques** including advanced retrievals, cloud/ice/aerosol flagging and associated uncertainties, data merging and analysis systems, match up databases, verification and validation analyses and protocols
- **A new SST ECV processing system** (prototype & specification for an operational system) to be implemented in future CCI activities
- **A better stronger SST ECV community** through continuous user interactions and feedback between SST climate users and modelers.

The project, led by Dr Chris Merchant at the University of Edinburgh and supported by a European consortium is set to start on 01 August 2010 and has a budget of €1.8M over a 3 year period.

6 Summary and Look Forward

The past year has been a highly active one for GHRSST reanalysis and the LTSRF. The large data management system has been maintained and improved, and progress made toward creating high resolution, multi-sensor reanalysis products. RAN-TAG inputs to the developing GDS-2 specifications have been made, and it is anticipated that the new GHRSST standards will further enhance the usability of the GHRSST collection for climate-related applications. New data streams have entered the archives, and growing numbers of users are accessing more and more GHRSST data. The GHRSST LTSRF archive is now doing significant work to quality-assure 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 format from projects like ARC and Pathfinder. Improvements to the SST intercomparison facility for understanding key differences in the available data continue to be made. Next year, supporting the creation of long-term reanalysis products will continue to be a high priority for the RAN-TAG, and efforts will continue to make GHRSST products more easily used by the archive user community. As always, and above all else, international collaboration will continue to be the means by which the ambitious goals of GHRSST Reanalysis will be achieved.

7 References

1. NRC (2000). Ensuring the climate record from the NPP and NPOESS meteorological satellites, NAP, 71 pp.
2. Reynolds, R.W., T.M. Smith, C. Liu, D.B. Chelton, K.S. Casey, and M.G. Schlax (2007). Daily high-resolution blended analyses for sea surface temperature, *Journal of Climate*, vol. 20.

Annex 1: Listing of Operational Messages, May 2009 – May 2010

2009-12-28: NODC Archives fully operational
Scheduled maintenance on the NODC Archive system has been successfully completed. All GHRSST data which has been acquired during the maintenance period will be ingested over the next few days. Thank you for your patience.

2009-12-26: NODC Archives undergoing maintenance
The NODC Archive system is undergoing scheduled maintenance. Various database and software improvements are being rolled out over the next few days. In the meantime, the LTSRF continues to acquire GHRSST data which will be ingested once the Archive maintenance has been completed. Thank you for your patience.

2009-12-14: Network issues resolved, LTSRF resuming operations
Network issues that had been interfering with the acquisition of GHRSST data from JPL have been resolved. Additional issues with incomplete metadata for AVHRR17_L data sets are being investigated. All other GHRSST data sets are being ingested normally. Thank you for your patience.

2009-12-09: Network issues interfering with acquisition of GHRSST data
Network issues have been interfering with the acquisition of GHRSST data from JPL. The connection has been unexpectedly slow and thus we have been unable to keep up with the regular flow of data. Network engineers are looking into the trouble in hopes of determining the cause of the slowness. Thank you for your patience.

Annex 2: Listing of LTSRF RSS News Messages, May 2008 – May 2009

2010-03-24: IFREMER temporarily halts production of ODYSSEA products IFREMER, the Regional Data Assembly Center for the ODYSSEA line of products, has temporarily stopped production of all ODYSSEA products in order to update their processing system for more secure and sustained production into the future. IFREMER expects production to resume again in two months, at which point another news alert will be published on this news feed. This stoppage affects all GHRSST L4 ODYSSEA products, including the regional products for the Galapagos, Mediterranean, and Northwestern European shelf regions, as well as the global ODYSSEA product.

2009-12-22: GHRSST Archive Adds L2P AVHRR19 LAC Data from NEODAAS
The GHRSST Long Term Stewardship and Reanalysis Facility archive added a new Level 2P 1km Local Area Coverage (LAC) sea surface temperature product from the AVHRR on board the NOAA-19 satellite. The product is generated by the Natural Environment Research Council (NERC) Earth Observation Data Acquisition and Analysis Service (NEODAAS). Other GHRSST products from NEODAAS include AVHRR LAC sea surface temperature from NOAA-17 and NOAA-18. Daily data for this product is available in forward mode beginning with day 277 of 2009.

2009-07-27: LTSRF OPeNDAP services back online!
The GHRSST Long Term Stewardship and Reanalysis Facility is happy to announce that OPeNDAP services are once again publicly available from our web site. To access GHRSST data via OPeNDAP, go to http://data.nodc.noaa.gov/opendap/ghrsst. All GHRSST data continue to be available via FTP and HTTP access as well.

2009-07-16: GHRSST Archive Adds L2P AATSR data from UPA
The GHRSST Long Term Stewardship and Reanalysis Facility archive added a new Level 2P 1km SSTskin product from the AATSR instrument on board ENVISAT. The product is generated by the UK Processing and Archive Centre (UPA) and is intended to replace the original European product generated by Medspiration. Daily data is available in forward mode beginning with day 83 of 2009.

Annex 3: Recent LTSRF RSS Automated Operational Status Messages

2010-06-14: Ingested 42 new AIPs into NODC LTSRF - Status Green
June 14, 2010 3:15 PM
GHRSST archival status is "Green": 42 new out of an expected 29 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".

2010-06-13: Ingested 0 new AIPs into NODC LTSRF - Status Red
June 13, 2010 7:59 PM
GHRSST archival status is "Red": 0 new out of an expected 29 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".

2010-06-12: Ingested 42 new AIPs into NODC LTSRF - Status Green
June 12, 2010 3:15 PM
GHRSST archival status is "Green": 42 new out of an expected 29 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".

2010-06-11: Ingested 0 new AIPs into NODC LTSRF - Status Red
June 11, 2010 7:59 PM
GHRSST archival status is "Red": 0 new out of an expected 29 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".

2010-06-10: Ingested 42 new AIPs into NODC LTSRF - Status Green
June 10, 2010 3:15 PM
GHRSST archival status is "Green": 42 new out of an expected 29 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".

2010-06-09: Ingested 0 new AIPs into NODC LTSRF - Status Red
June 9, 2010 7:59 PM
GHRSST archival status is "Red": 0 new out of an expected 29 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".

2010-06-08: Ingested 42 new AIPs into NODC LTSRF - Status Green
June 8, 2010 3:15 PM
GHRSST archival status is "Green": 42 new out of an expected
29 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".

Annex 4: RAN-TAG Membership

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REPORT FROM THE ST-VAL TAG TO THE 11TH GHRSST SCIENCE TEAM MEETING LIMA, 21ST JUNE 2010

Edited on behalf of ST-VAL by **Gary Corlett**

University of Leicester, UK, Email: gkc1@leicester.ac.uk

1. 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 group has not met as a whole in the interval between GHRSST X and GHRSST XI, but several European based members attended a meeting organised by MF/CMS in Lannion as a combined ST-VAL/MyOcean SST validation meeting. Minutes of this meeting can be found on the web at http://www.geos.ed.ac.uk/ernesst/STVAL_minutes_Jan2010.pdf.

- **Successes**
  - The main success of the ST-VAL group was to agree a set of Common Principles for
  - SSES at GHRSST X. The objectives of the common principles are to provide more
  - Uniform uncertainty estimated for users.

- **Challenges and proposed solutions**
  - The main challenge for the STVAL group is to now ensure these Common Principles are implemented across all L2P data sets without compromising the data quality of any one
  - data set. The current solution for this challenge is for all L2P providers to assess how these Common Principles would impact their SSES schemes and to identify those principles that required further refinement. Progress towards this challenge is reported in this report.
  - A better understanding of 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. The solution to this challenge is to engage more with reference data providers and to develop novel methods for deriving uncertainty budgets. Progress towards this challenge is reported in this report.

- **Issues for science team**
  - The main issues that require the attention of the GHRSST Science Team at GHRSST XI are:
    - ***The skin to depth adjustment***: Should we use 0.17 K, 0.2 K, the Donlon model or some other adjustment scheme?
    - ***Modelled uncertainty estimates***: As we move towards more advanced retrieval schemes we can use the retrieval diagnostics to refine our uncertainty budget. How should these be included in the L2P files?
    - ***A reference data set***: We need to create a high quality reference data that do not get used for algorithm development and are used solely for validation of L2P and higher data products. Can we get algorithm developers and analysis producers to agree to this?

2. Activities since GHRSST X

The STVAL group has supported the DVWG in two specific GHRSST activities since GHRSST X. These are an increased interaction with the DBCP and a request to the Argo programme to provide upper ocean profiles. Chris Merchant attended the DBCP meeting in September 2009 on behalf of the DVWG and STVAL and gave a talk on “Use of Drifting Buoy SST in Remote Sensing”. The objective of the talk was to demonstrate that current drifting buoy SST accuracy is now a practical limitation for remote sensing of SST, and an improvement in accuracy and precision to 0.05 K would greatly assist future developments. The DBCP were very positive about this increasing co-operation, and in particular Etienne Charpentier and David Meldrum are looking to frame a pilot study of high-accuracy drifter deployments to establish the benefits, within the DBCP context. David Meldrum will be in attendance at GHRSST XI for further discussion with the GHRSST Science Team.

A statement on the benefits of upper ocean profiles, led by the DVWG and STVAL on behalf of the GHRSST Science Team, was considered at the international Argo co-ordination meeting (March 2010).

The statement reviewed the scientific benefit of such profiles and concluded with a set of technical requirements on vertical resolution, total depth and SST accuracy for the Argo project to consider. In addition, Gary Corlett presented the case for upper ocean profiles to the UK Argo User's Workshop and subsequently has been invited, along with Chris Merchant, to make a presentation and the European Argo Users' meeting in July 2010. Further details on both these topics are provided in the DVWG report for this meeting (R19).

The rest of this section summarises a selection of specific activities that L2P providers have carried out between GHRSST X and GHRSST XI.

AATSR (G. Corlett, O Embury, C Merchant)

No changes have been made to the operational SSES scheme, which conforms to most of the SSES Common Principles. Updates to the operational SST retrieval coefficients are currently being evaluated, which, along with other proposed updates to the AATSR processing chain, will require a new SSES scheme. These updates are likely to be implemented in September 2010.

The Envisat satellite that hosts AATSR is undergoing a change in orbit height in late 2010. This is required to extend the lifetime of the satellite towards the end of 2013. There is not expected to be any change in AATSR performance and updated SSES will not be required. However, during the satellite manoeuvre there will be no science data produced from ay of the instruments, so this means there will be no AATSR data for the period from 22nd October 2010 to 2nd November 2010. Data should be available again from 3rd November but its quality may not be optimal and should be used with care. At the moment we expect normal data delivery and quality to resume in January 2011. However, every effort will be made to ensure the AATSR data are optimal as soon as possible after 2nd November 2010.

Several specific validation activities have been carried out looking at issues relating to drifting and moored buoy data and validation in general. These include (with two expanded examples):

- An assessment of drifter location information
- The quality of individual buoys
- An initial validation of the Version 3.0 ATSR series (ATSR-2 and AATSR only)
- Diurnal heating rates: Minnett (1991) showed that spatial separation between satellite and in situ of ~ 10 km and time separations of ~ 2 hours can introduce RMS errors of ~ 0.2 K into satellite validation. Recent results (Embury et al., 2010) confirm these findings and demonstrate that, in fact, the errors associated with the time component have a significant systematic part that can be compensated for. This is important where the distribution of satellite-buoy time difference is asymmetrical or where the satellite observation time is near the peak or trough of the diurnal SST cycle. The effect of the time separation on retrieval bias is shown in Figure 1. There is a cooling trend of 0.015 K/hour affecting night-time matches and a warming trend of 0.058 K/hour during the day.

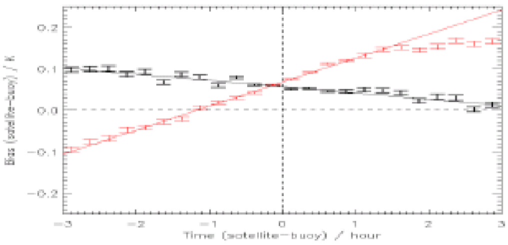

Figure 1: AATSR D2 SST-0.2m retrieval bias as a function of satellite-buoy time difference for daytime (red) and night-time (black) matches. Solid lines show linear best fit to data (only using time differences < 1.5 h for day time matches). [From Embury et al., 2010].

- Demonstrating the benefits of using SST-4m from Argo for validating SST-skin
- Long-term validation issues: An important aspect of any validation activity is to use new knowledge to improve the assessment of historical data. As an example, we consider the validation of the entire ATSR Version 2.0 dataset from 1991 to date as a single dataset. In particular, the relative stability of the dataset over time requires careful assessment as it is arguably more important than the absolute accuracy as any residual bias can be adjusted if it is stable.

Figure 2 shows the bias and uncertainty for night time D3 and day time D2 ATSR Version 2.0 SSTs compared to drifting buoys with no consideration for skin to depth or diurnal variability corrections. The large gap in the left hand plots is due to the failure of the ATSR-1 3.7 micron channel in May 1992, which meant no D3 retrievals after that date. Each point represents an average over one month.

We can see two important features in Figure 2. First, there is a notable variation in bias throughout the record, particularly in the early part of the mission, which is more pronounced in the day time data than at night. Second, there is a notable change in the standard deviation over time, with a much smaller change in the robust standard deviation over time. To investigate these affects, the stability of the drifting buoy record was investigated.

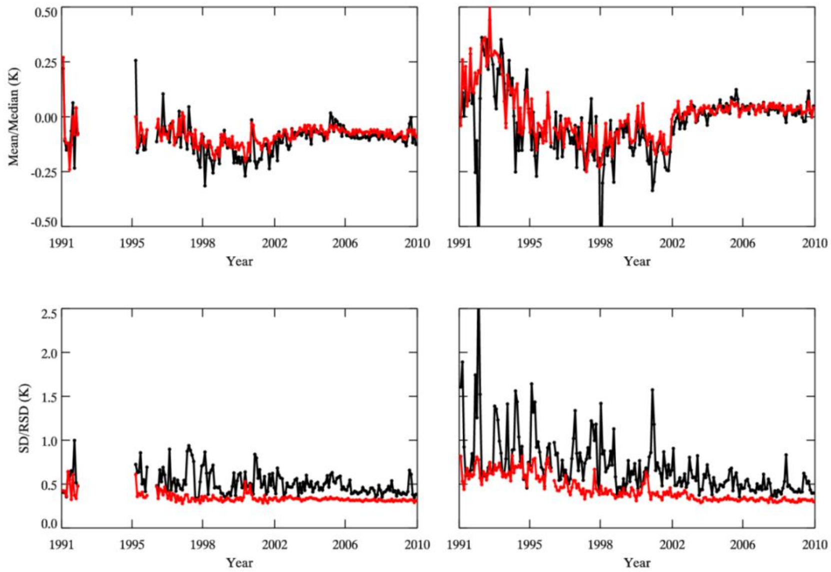

Figure 2: Bias (upper plot, mean in black and median in red) and uncertainty (lower plot, standard deviation in black and robust standard deviation in red) for night time D3 (left hand plots) and day time D2 (right hand plots) ATSR SSTs compared to drifting buoys.

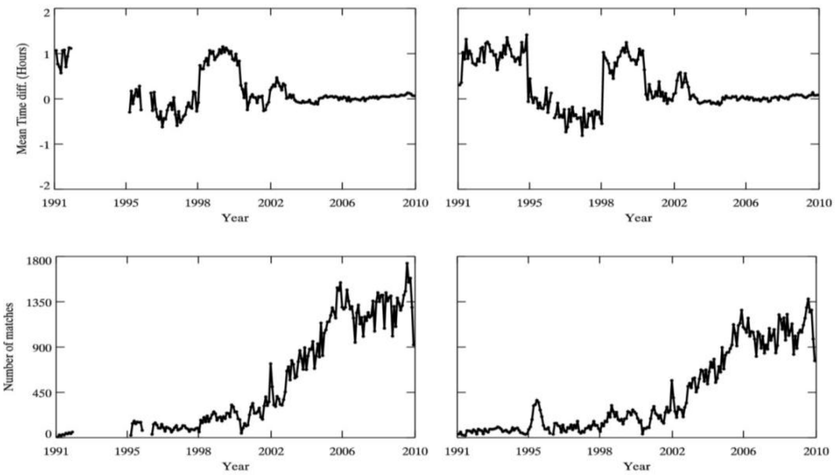

Figure 3: Mean time difference (upper plot) and the total number of match-ups per time interval (lower plot) for night time D3 (left hand plots) and day time D2 (right hand plots) ATSR SSTs compared to drifting buoys

Figure 3 shows the mean time difference and the total number of match-ups per time interval for night time D3 and day time D2 ATSR Version 2.0 SSTs compared to drifting buoys. The time interval is the same Figure 2 and is one month. Here we see two major issues with the drifting buoy data. First, the average time difference between the ATSR and drifting buoy observations has not remained constant throughout the ATSR mission. Consequently, both measurements will be subjected to larger variations over time arising from diurnal heating of the upper ocean by the Sun. Second, the coverage of the drifting buoy, which is excellent during the AATSR mission, is not satisfactory prior to the AATSR mission both temporally (total number of buoys in the ocean) or spatially (total number of buoys in any one region).

Therefore, it is highly likely that much of the observed variation in bias and uncertainty seen when comparing the entire ATSR to drifting buoys is simply due to changes in the drifting buoy record. Consequently, a more robust methodology is required to better account for thermal skin and diurnal heating effects before an uncertainty budget can be determined for the ATSR mission as a whole. This conclusion will be applicable to all long-term SST records.

MF/CMS (P.Le Borgne, A. Marsouin, S. Péré, H. Roquet)

- An automatic blacklisting of erroneous buoy measurements has been defined and implemented at CMS; it is now operational (Figure 4).

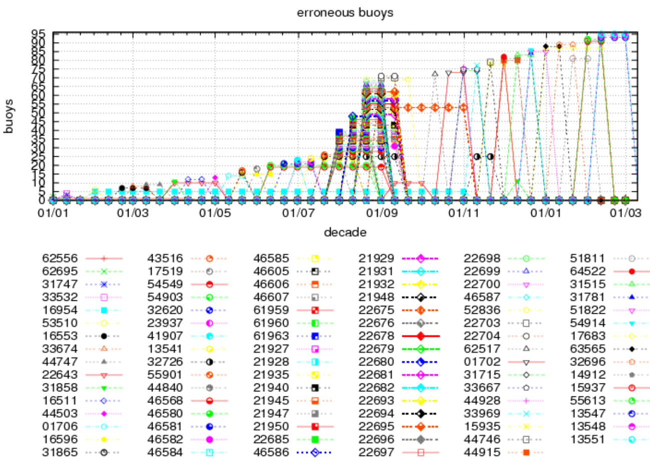

Figure 4: list of erroneous buoys detected at MF/CMS since 01/01/2009

- A set of validation areas (Figure 5), defined for users, has been also proposed during the MyOceanValidation Lisbon meeting (14-15th April) and should be adopted soon.

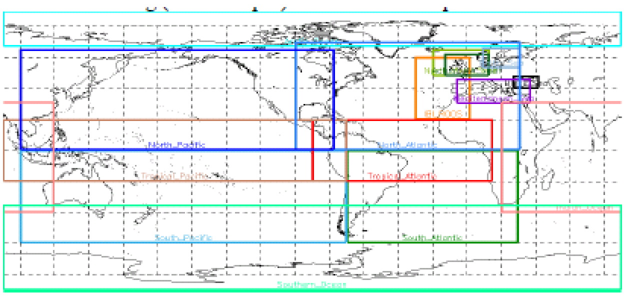

Figure 5: The SST validation areas proposed within MyOcean

- MyOcean also decided to use the AATSR L3 dataset to validate all their SST products.

EUMETSAT (Anne O'Carroll)

- Surface temperature is already produced operationally as part of the current EUMETSAT Infrared Atmospheric Sounding Interferometer (IASI) L2 processing. Within the last 6 months work has been done at EUMETSAT towards producing the IASI SSTs in GHRSST L2P format.
- IASI L2Pcore is now being produced daily as an experimental product at EUMETSAT since the end of March 2010. The product contains skin SST, SSES, quality levels and flags. These SSTs are being routinely monitored and the SSES LUT will be finalised after 6 months worth of data has been evaluated. The final step to produce the full L2P product including auxiliary data will follow, with production taking place either at EUMETSAT or the OSI-SAF.
- An SSES scheme has been developed to stratify IASI SST with the water vapour profiles contained with the IASI L2 product. Quality levels 2 to 5 have been assigned according to IASI integrated water vapour, with thresholds determined using climatology and AVHRR L3 SSTs over the period November 2008. In order to assess the SSES to be assigned per quality level, the IASI SSTs are routinely collocated with the OSI-SAF METOP/AVHRR in situ MDB. The matchup criteria collocates to a distance less than 12km nadir between IASI and AVHRR SSTs; the AVHRR and IASI SST time difference must be within 1 hour (the OSI-SAF drifting buoy to AVHRR time criterion is +-3 hours); only drifting buoys are used; and only night-time IASI observations over sea are used in order to reduce diurnal variations. In addition, the criteria imposed whilst calculating the SSES bias and standard deviations for each quality level between the IASI and drifting buoy SSTs are: the addition of 0.17K to the IASI skin SSTs to enable direct comparison with buoy sub-skin SSTs; buoy SSTs are checked to be within 8K of climatology; only AVHRR L3P confidence flags greater than 3 are used; the standard deviation of AVHRR SSTs over the IASI footprint should be less than 0.3K; 3-sigma statistics are used in the calculations; and only SSTs greater than 271.3K are included in the analyses.
- Figure 6 shows the range of quality levels determined for IASI SST on 1st November 2008. Table 1 shows the IASI SSES bias and standard deviation for each quality level, determined from data for 1st-30th November 2008. This LUT will be updated when 6 months worth of data has been analysed before the product is made operational

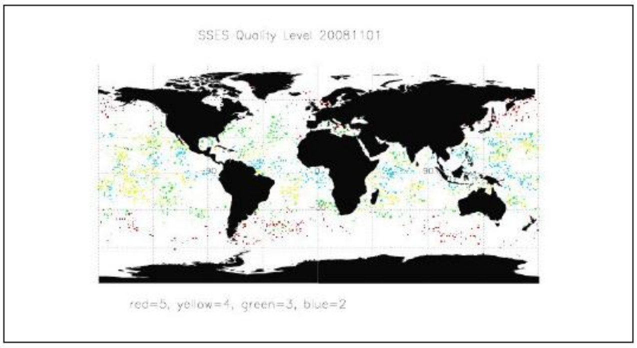

Figure 6: SSES quality levels for 1st November 2008

Quality level	SSES_bias (K)	SSES_standard_deviation (K)
2	-0.23	1.92
3	-0.55	0.70
4	-0.43	0.46
5	-0.25	0.39

Table 1: IASI SSES bias and standard deviation 1-30th November 2008

MODIS/AVHRR PATHFINDER (Bob Evans)

- We are working of providing a uniform approach for all AVHRR (Pathfinder) SST SSES using the same approach, and code, as we use for MODIS. Thus the Version 6, our next generation Pathfinder, will be L2P, have SSES in the Hypercube mode, and deliver a skin SST.
- The MODIS brightness temperatures have been re-calibrated by the NASA MODIS Calibration Support Team (MCST), using their 'Collection 6' calibration approach. We are working with the NASA Goddard Ocean Biology Processing Group (OPBG) to create a Collection 6 Match-up database for the Terra and Aqua MODIS sensors.
- The OBPG has extracted all Terra observations corresponding to ~2km space match and within +/- 30 minutes satellite overpass. They are nearly finished with the corresponding Aqua extractions. We have collated the Terra satellite extractions with the corresponding in situ data with separate databases for buoy and radiometer in situ obs. The Terra Match-ups have been used to derive Collection 6 SST retrieval coefficients and these in turn are being analyzed to determine residual temporal, cross-scan, and mirror side corrections.
- Following completion of determining the complete SST retrieval process, the uncertainly Hypercubes for bias and standard deviation will be extracted. The SST determination for both AVHRR and MODIS will use the LATBAND formulation where 20 degree wide overlapping zonal bands define the applicable coefficient range and the coefficients are determined in monthly sets (12 groups) and the same coefficient sets are used for all years for a given sensor. This approach has yielded equivalent performance for AVHRR and MODIS in the 11, 12 um band with a std. dev. of order 0.38 globally.
- At present the Hypercubes will be discrete which will result in boundary discontinuities. We have submitted a proposal to NASA to support developing a Hypercube that will provide continuous estimates of uncertainty for the dimensions of temperature, 11-12 um brightness temperature difference and satellite zenith angle. The remaining dimensions of month, latitude band, quality level and day/night will remain discrete.

NAVO (Bruce McKenzie)

- NAVO provides a bias and standard deviation as required, and uses quality levels 3-5 only. Each quality level is clearly defined in documentation but not in the product. Future work would be to add it into the L2P NetCDF header.
- The derivation of the quality indicator and SSES are documented and available to users, and the reference data set is surface drifters, which are quality controlled during the match-up process.
- TAO/TRITON and PIRATA match-ups are also produced but no regional statistics are provided. The current match-up criteria are 4 hours and 25 km for both the LAC 2 km and GAC 9 km AVHRR SST retrievals. Potential refinement of these criteria is currently being investigated.
- NAVO currently provide daytime SSES from day time data and are not free form diurnal variability. This is because their daytime algorithm coefficients are regressed from daytime match- ups and so estimating uncertainty on these algorithms on nighttime match-ups would produce erroneous results. NAVO are currently considering ways to implementing an operational method to flag retrievals that might be impacted by diurnal variability.

NOAA/NESIDS (A. Ignatov)

- Currently provides SST Quality Monitor (SQUAM). The objectives of the SQUAM are to:

- Monitor NESDIS operational AVHRR SST products in NRT for stability, self- consistency, cross-platform & cross-product consistency
- Evaluate satellite SST products daily in global domain, against global L4 fields (Reynolds, RTG, OSTIA, ODYSSEA)
- Quickly identify anomalies & facilitate product diagnostics (*e.g.*, due to sensor malfunction, cloud mask, or SST algorithm)

- New additions to SQAUM include:
    - Worked with NCEP to add NRT inter-comparison of daily L4 SSTs: *http://www.star.nesdis.noaa.gov/sod/sst/squam/L4/*
        - Two Reynolds (AVHRR-only and AVHRR+AMSR)
        - Two RTG (low and high-resolution)
        - OSTIA
        - ODYSSEA
    - Collaborated with NAVOCEANO to include SEATEMP GAC SSTs: *http://www.star.nesdis.noaa.gov/sod/sst/squam/NAVO/*
        - Platform/sensor: AVHRRs onboard NOAA-14 through 19,MetOp-A
        - Time: 2000 – recent
    - MetOp-A AVHRR ~1km FRAC SST products were added: *http://www.star.nesdis.noaa.gov/sod/sst/squam/FRAC/*
        - NESDIS: ACSPO FRAC
        - Worked with O&SI SAF (MGR SST)
- Future plans:
    - Add two more L2 SST products to SQUAM
        - Pathfinder & MODIS
    - Reconcile AVHRR SSTs (different agencies, platforms, day-night):
        - Improve AVHRR sensor calibration (NESDIS)
        - Account for diurnal cycle (e.g., Gentemann model)
        - Improve SST products (cloud screening, SST algorithms)
    - Add K10 & GHRSST GMPE to L4-SQUAM
        - Work with L4 producers to reconcile different L4s and satellite SSTs

3. Membership of STVAL

The current members of the STVAL group are:

Sandra Castro, Jean-Francois Cayula, Gary Corlett, Prasanjit Dash, Steinar Eastwood, Bob Evans, Chelle Gentemann, Andy Harris, Jacob Hoeyer, Alexander Ignatov, Alexy Kaplan, Pierre Le Borgne, Leon Majewski, Bruce McKenzie, Peter Minnett, Jon Mittaz, Chris Mutlow, Anne O'Carroll, Jean-Francois Piollé, Igor Tomazic, Werenfrid Wimmer and Feng Xu.

Members of the in situ QC sub-group are:

Emmanuelle Autret, Steinar Eastwood, Jacob Hoeyer, Pierre Le Borgne, Leon Majewski, Matt Martin, Bruce McKenzie and Sonia Péré.

4. References

1 Embury, O., Merchant, C.J., and Corlett, G.K., 2010. A Reprocessing for Climate of Sea Surface Temperature from the Along-Track Scanning Radiometers: Preliminary validation, accounting for skin and diurnal variability effects, Remote Sensing of the Environment ATSR Special Issue, submitted.

2 Minnett, P. J., 1991. Consequences of sea surface temperature variability on the validation and applications of satellite measurements. Journal of Geophysical Research 96 (C10), 18475–18489.

CHAPTER 2

SCIENTIFIC ABSTRACTS

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THE COLD BIAS IN THE EXTENDED RECONSTRUCTION OF SEA SURFACE TEMPERATURE ANALYSIS INTRODUCED BY THE INCLUSION OF PATHFINDER V5 DATA

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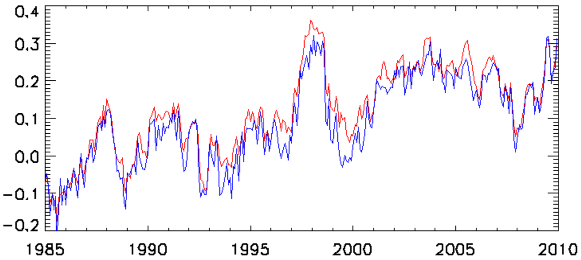
ABSTRACT

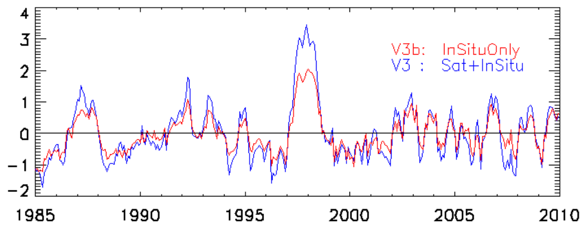
The current version of the Extended Reconstruction of Sea Surface Temperature product, called ERSSTv3b, is based on in situ data. A previous version v3 included satellite data (AVHRR Pathfinder V5 for 1985-2005; operational Navy AVHRR from 2006 onwards) but a spatially and temporally varying cold bias was detected. The v3 product is now maintained only internally as a diagnostic tool. Examination of the v3b-v3 difference shows the high latitude satellite bias can be significantly reduced with the planned use of a latitudinal band approach in the upcoming Pathfinder V6 algorithm. However, issues like orbit drift and sensor aging may still remain, and will require a re-examination of instrument calibration. Temporal and spatial variability in buoy data distribution impacts Pathfinder coefficient retrieval, but may also introduce a warm bias to ERSST.

1. INTRODUCTION

The Extended Reconstruction Sea Surface Temperature (ERSST) analysis is produced monthly on a 2°-grid by the National Climatic Data Center (NCDC/NOAA) to support global climate assessments. The ERSST uses historical *in situ* sea surface temperatures (SST) from the International Comprehensive Ocean-Atmosphere dataset (ICOADS, release 2.4), with marine monthly observation updates. Due to sparse data, the reconstruction is possible only beginning in 1854. Previously, Smith *et al.* (2008) presented ERSST version 3 or v3, characterized by three main improvements: inclusion of satellite data (AVHRR Pathfinder SST version 5 from 1985-2005; operational Navy SST from 2006 onward) as an input, optimized analysis settings based on comparisons with simulations, and better handling of sea ice conditions. In the most recent ERSST version 3b, satellite data were removed from the analysis because inconsistencies were found relative to previous *in situ* only results. On average, the two analyses (v3 and v3b) were not significantly different (Fig. 1). However, v3 was generally biased towards cooler values and produced differences in rankings of warmest year, etc. relative to v3b (Fig. 1a-b). Depending on differences in data coverage between satellite and *in situ* data, computed climate indices could also differ (Fig. 1b). Although superceded by v3b, ERSST v3 is maintained internally at NCDC. Here, the v3-v3b differences are examined in greater detail to understand the nature of the satellite cool bias, and evaluate planned changes in the AVHRR Pathfinder algorithm from the current version 5 to the new version 6.



a)



b)

Figure 1. a) Monthly average ERSST anomaly (60°N-60°S) computed relative to 1971-2000 baseline and b) NINO1+2 index. Colors indicate ERSST version.

2. ERSST PROCESSING

The ERSST analysis is summarized by the flowchart (Fig. 2). Details can be found in Smith *et al.* (2008). The difference between the two version (v3 and v3b) is the use of satellite data in the former. Note that data from each source is gridded separately then combined using weights that reflect their variance characteristics. Thus, nighttime satellite data has the most impact when data from all sources are present.

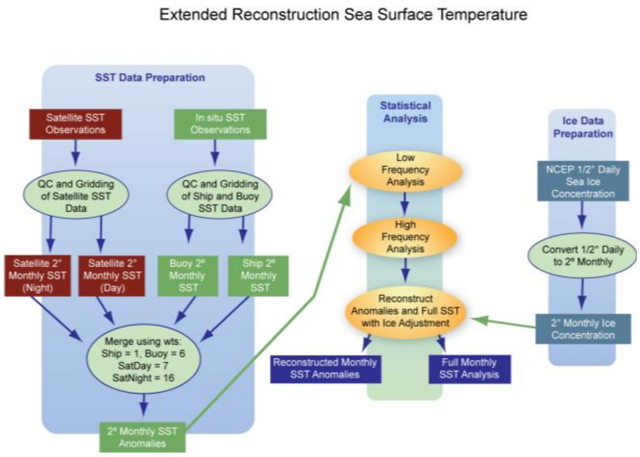


Figure 2. ERSST processing flowchart. Version3 uses satellite data (red boxes) while Version 3b does not.

3. COOL BIAS PATTERNS

A distinct temporal trend in the global v3-v3b difference appear to coincide with the change in instrument (NOAA-xx) that was used to generate the Pathfinder version 5 SST dataset, with the difference becoming increasingly negative over time for the older design (NOAA 9, 11,14; Fig. 3). These satellites were used far beyond their 2-year expected service lifetimes, with poor characterization of the degrading onboard calibration systems. All three had a positive orbital drift of at least 3.0 minutes/month. In contrast, NOAA 16, 17 and 18 are a more modern design, with orbit drifts of 1.9, -0.1, and -0.6 minutes per month, respectively.

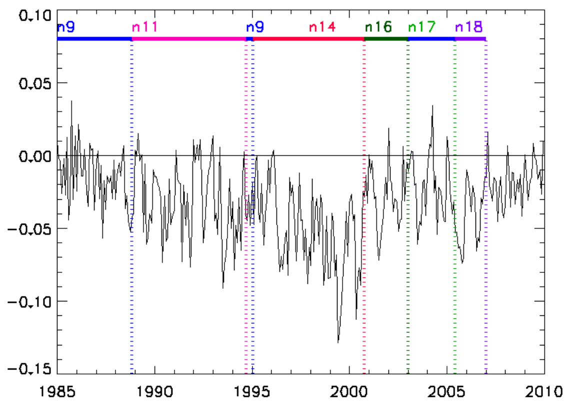


Figure 3. Average difference between ERSST v3 and v3b, globally. In color, time span of data from different NOAA instruments used in Pathfinder version5(an input to ERSST v3but not v3b)

The v3-v3b difference also exhibits as latitudinally varying seasonal pattern (Fig. 3), with a much cooler bias at high latitudes, particularly in the Southern Hemisphere.

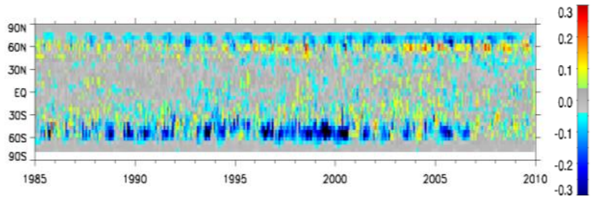


Figure 4. Latitudinal average (every 5°) of ERSST v3-vb over time.

Pathfinder version 5 uses only two coefficients (tropical-temperate and temperate-polar), that are applied to both hemispheres. Since the algorithm coefficients are computed from nighttime buoy data, the distribution and availbility of buoy data may bias the retrievals. As shown in Fig. 5a-b, mooring data is mostly limited to the northern hemisphere, and drifter data can be sparse in the vicinity of 60° S and beyond, with a clear seasonality in data availability.

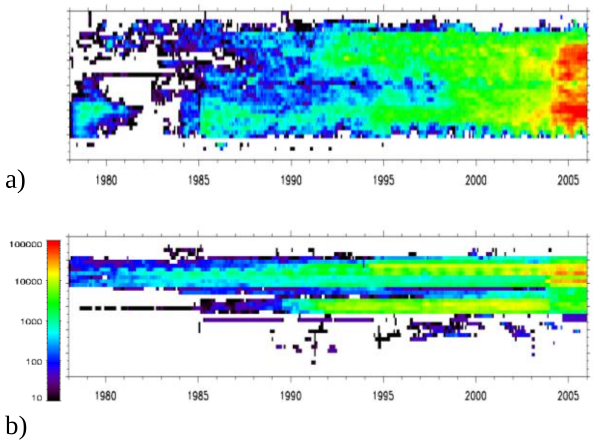


Figure 5. Number of observations from a) drifting buoys and b)moored buoys over time averaged by latitude

In Pathfinder version 6, the seasonal spatial bias in Fig. 4 is expected to be minimized with the use of coefficients that vary by latitudinal band. Tests with NOAA 18 suggest that the error will be reduced (Fig. 6). The latitudinal bands takes into account the global atmospheric circulation regimes and thus, seasonal shifts in water vapor conditions. Still, the lack of buoy data in the early satellite period may limit the effectiveness of this approach. The use of ship data may be required to obtain algorithm coefficients.

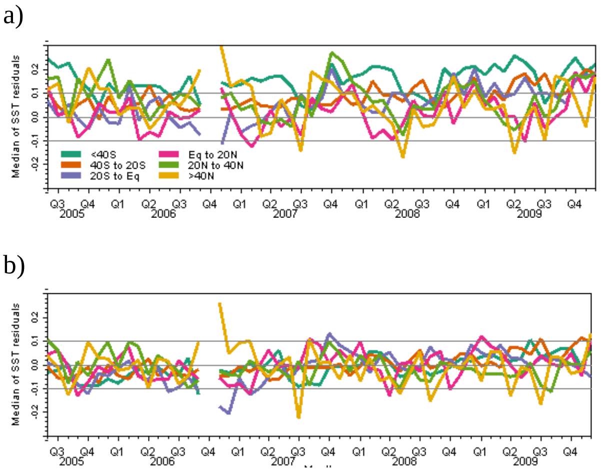


Figure 6. SST monthly median residuals from a NOAA 18 validation dataset (buoy data subset is kept separate from that used to compute coefficients): a) version 5 and b) version6

Some attention should also be paid to *in situ* data. The dominance of buoy data over ships as a source of SST data has increased from the 1970's to the present. Ship and moored buoys tend report at regular intervals daily (Fig. 7a-b). Drifting buoys have a less homogeneous data collection schedule since they rely on the ARGOS system on polar-orbiting satellites (Fig. 7c).

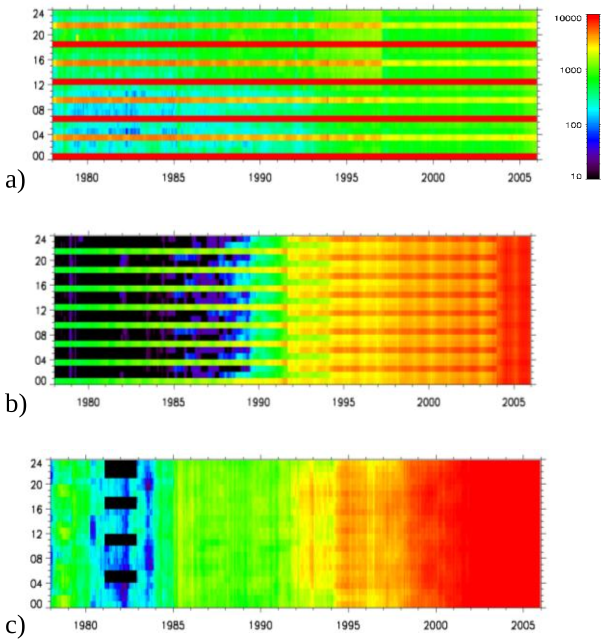


Figure 7. Number of observations at each UTC hour (y-axis) from a) ships, b) drifting buoys and c) moored buoys

When the data distribution is plotted in terms of solar hour (Fig. 8), then the uneven distribution of drifter measurements over the diurnal cycle becomes evident. Daytime measurements are affected by diurnal heating at low wind conditions. Thus, depending on the relative amount of daytime measurements, *in situ* only analyses can be biased warm. This issue remains to be better understood, but the point is that biases can also be present in the *in situ* dataset.

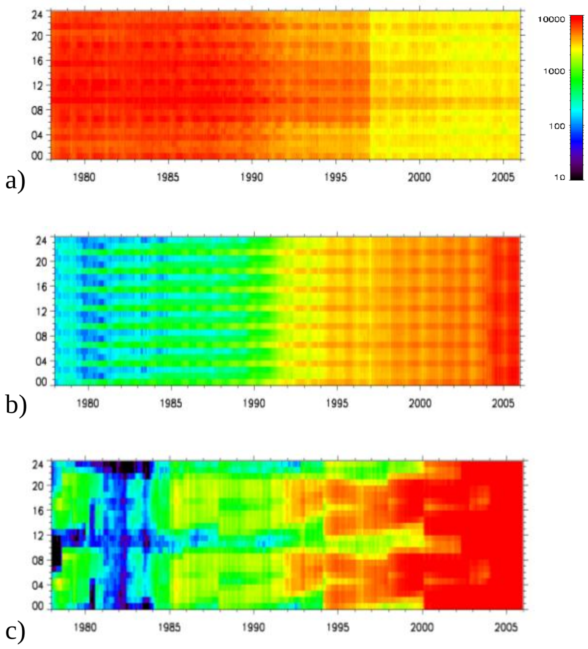


Figure 8. Number of observations at each solar hour (y-axis) from a) ships, b) drifting buoys and c) moored buoys

4. CONCLUSIONS

The use of the latitudinal band approach in the upcoming Pathfinder version 6 is expected to reduce the seasonal and temporal variability in the AVHRR time series. But it remains to be seen if the divergence between v3 and v3b will be resolved. Variability in buoy data distribution affects the accuracy of the satellite algorithm (and hence ERSST v3), as well as the *in situ* only ERSST analysis (v3b).

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A GLOBAL 1-KM SEA SURFACE TEMPERATURE PRODUCT BLENDING SATELLITE AND IN SITU OBSERVATIONS

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ABSTRACT

A global Sea Surface Temperature (SST) data set at 1-km (also known as ultra-high resolution) is produced daily and distributed to the research and application communities. The input SST data sets are derived from the Global High-Resolution Sea Surface Temperature (GHRSST) L2P products with a spatial resolution ranging from 1-km to 25-km. In situ SST measurements are also used to blend with these satellite SST data sets with a goal to produce a blended data at the highest possible resolution (i.e., 1-km). We have developed a multi-scale two-dimensional variational (MS-2DVAR) blending algorithm, which is characterized by inhomogeneous and anisotropic background error covariance specifically developed for regional applications. As part of the data distribution, we are providing a gap-free data as well as data flags describing the data coverage and quality. Both images and digital data can be accessed from http://ourocean.jpl.nasa.gov/SST. A subset interface is provided to produce regional images over any part of the world ocean. Our blended global SST can be visualized using Google Earth, and the digital data are distributed by the OpenDAP/THREDDS server.

REMOTE VERSUS LOCAL FORCING OF INTERANNUAL SST ANOMALIES OFF THE COAST OF PERU (1981-2008): CONTRASTING COLD TONGUE EL NIÑO WITH MODOKI EL NIÑO CONDITIONS.

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ABSTRACT

The Peru marine ecosystem undergoes drastic changes at interannual timescales due to the El Niño phenomenon which brings warm and poorly oxygenated waters near the coast. Concomitantly, during El Niño events, along-shore winds tend to become upwelling favourable, which may result in opposite effect on the ecosystems. Understanding the relative role of local and remote forcing during El Niño event is thus a major concern for prediction and resources management purpose.

Here we take advantage of the extended high-resolution satellite SST data set provided by the GRHSST to investigate interannual SST variability along the coast of Peru. The processing of the data allowed recollecting information on the regional variability at a monthly resolution and at a 4km resolution over 1981-2008, a period which encompasses two major Cold Tongue El Niño events. Satellite data are first compared to *in situ* data from IMARPE, which indicates a very good agreement between both data sets. Oceanic Reanalysis (SODA) and a variety of wind products (ERS, QuickSCAT and downscaled products from the NCEP Reanalysis) are then used to document respectively the remote equatorial forcing in the form of equatorial Kelvin waves and the local wind stress forcing and associated Ekman transport. A tentative composite analysis is proposed in order to categorize the effect of Cold Tongue EL Niño and Modoki EL Niño on coastal upwelling and associated SST front.

ESTIMATION AND VALIDATION OF THE PERUVIAN SEA SURFACE TEMPERATURE USING NOAA - AVHRR AND IN-SITU DATA WITH PACHA-RICAJ SOFTWARE

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ABSTRACT

The purpose of this work is to estimate and validate the SST from AVHRR/3 images. The study area is 0 to 20 °S latitude and 100 to 70 °W longitude. The raw images have been obtained from the CLASS corresponding to Level-1b format (LAC and GAC). The in-situ SST data were measured in three periods: (1) October 1 to November 13, 2002, (2) March 1 to April 5, 2007 and (3) March 1 to April 5, 2008 from IMARPE. The image processing software "Pacha-Ricaj" was used for the calibration, cloud filtering (thresholds and Great Rapid Algorithm to Surround Areas technique), Split-Windows SST, geometrical correction, monthly averages, digital filters, histograms, validation of results.

1. Introduction

Currently, the SST fields in the Peruvian sea are obtained of the following sources: interpolation the SST data measured in-situ by campaigns in ships (IMARPE), the results of numerical models (IMARPE, IGP) and from the data received by the image receiving station AVHRR/3 IMARPE. The Peruvian scientific institutions such as SENAMHI, IMARPE, IGP, HIDRONAV, frequently used for analysis of SST data provided by NOAA's TAO project, for the detection, understanding and prediction of the phenomena's El Niño. The purpose of this work is to estimate and validate the sea surface temperature (SST) from thermal infrared channels proportionate by the sensor AVHRR/3 on-board of the NOAA satellites 16, 18 and METOP-2. In this context, this work will provide the Peruvian scientific community a new alternative source of satellite data, to estimate the daily SST with a spatial resolution of 1 km (1).

2. Satellite Data

2.1 AVHRR data

In this work was used the AVHRR/3 images provided by the NOAA-16, NOAA-18 and Metop-2 satellites, in the periods 2002, 2007 and 2008. Satellite images were obtained from the CLASS (http://www.class.noaa.gov), in original format, with Level 1b processing level (packed format of 10 bits per pixel). The data type for METOP-2 is FRAC (Full Resolution Area Coverage) of 1 km spatial resolution and data type of the NOAA 16 and 18 satellites is LAC (Local Area Coverage) and GAC (Global Area Coverage) with 1 and 4 km spatial resolution, respectively (5).

2.2 In-Situ SST

The "in situ“ SST measures have been carried out by the IMARPE, through three campaigns cruises in period October 01 to November 13, 2002; March 01 to April 05, 2007 and March 01 to April , 05 2008. A total of 1058 records have been posted for the period 2002, 574 records for the period 2007 and 1004 records for the period 2008. With this information has been possible to obtain the coefficients of the MCSST equation for NOAA-16, NOAA-18 and METOP-2 satellites.

2.3 SST MODIS

The L2_LAC_SST MODIS product is used to validate the results; this product provides daily estimates of the temperature Sea Surface with 1 km spatial resolution. The format of data files is HDF (Hierarchical Data Format). This data is currently distributed through the Ocean Color web site, http://oceancolor.gsfc.nasa.gov, or created using the program SEADAS (SeaWiFS Data Analysis System, http://oceancolor.gsfc.nasa.gov/seadas/). Additionally, in the process of filtering clouds of the MODIS SST images (L2_LAC_SST) have used the MOD35_L2 (Level 1B MODIS Cloud Mask and Spectral Test Results) product, distributed free through the http ://modis.gsfc.nasa.gov/data/).

3. Methodology

To achieve the objectives of this study, the methodology is shows on the figure 1.

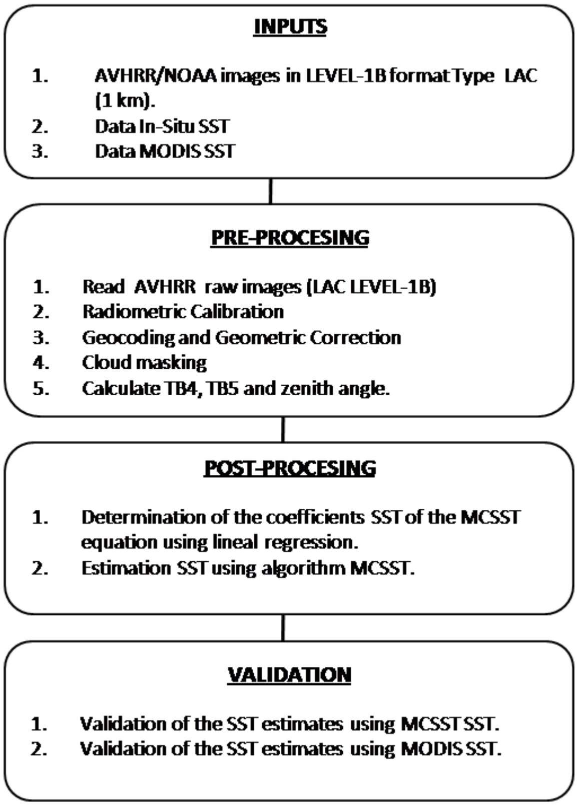

Figure 1 - Methodology diagram

4. PACHA RICAJ – Image Processing Software

The Pacha-Ricaj image processing software has been entirely developed at the Remote Sensing of Laboratory (LABTEL) at San Marcos University (UNMSM). It has been implemented with the processes of calibration, filtering of clouds (Cloud Masking using threshold and GRASA methods), SST estimation, geometric correction, compute of monthly averages of SST, digital filters, histograms, validation of results, etc (see figure 2,3,and 4) (see 2,3,4,5,6,7). The Pacha-Ricaj software provides advantages significant over other commercial software, which can perform the same tasks for pre and post processing, since we can improve or integrate new algorithms for estimating the SST and other geophysical parameters that can be recovered from AVHRR/3 data (1).

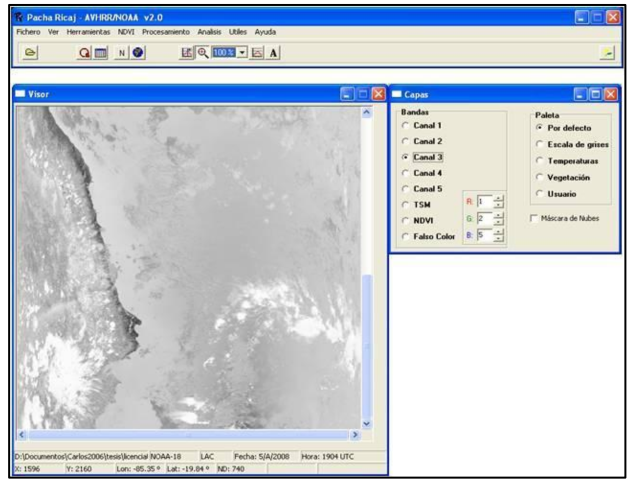

Figure 2 - Pacha Ricaj software

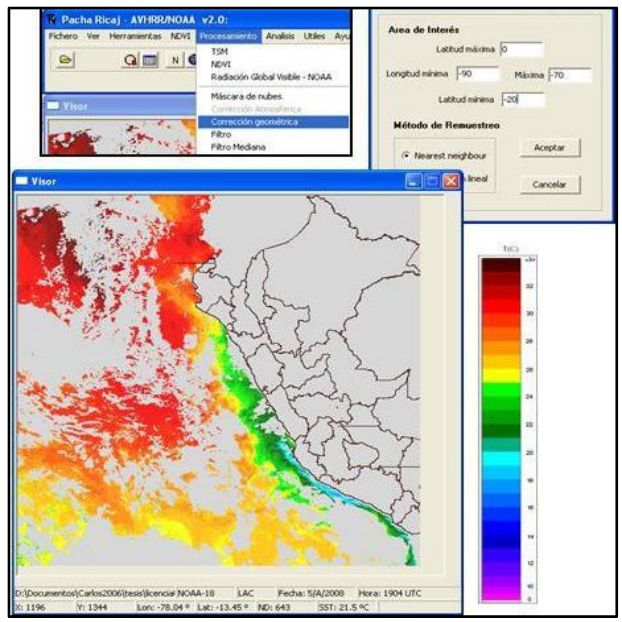

Figure 3 - AVHRR-LAC geometric correction.

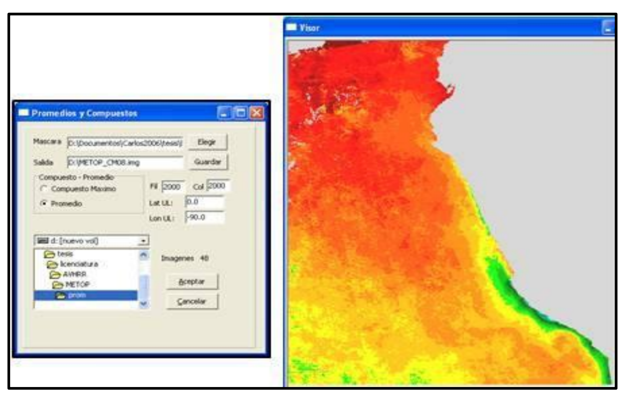

Figure 4 – The monthly average SST image (AVHRR/NOAA-18)

5. Results

5.1 The Split-Windows Algorithm for the Peruvian Sea

MCSST for AVHRR/3 NOAA-16 (5 and 6)

$$\mathbf{MCSST = 0.889 \times T_4 + 2.152 \times (T_4 - T_5) + 1.340 \times (Sec\theta - 1) \times (T_4 - T_5) - 241.504}$$

Regression Coefficient: $R^2 = 0.921$ (see Figure 5).

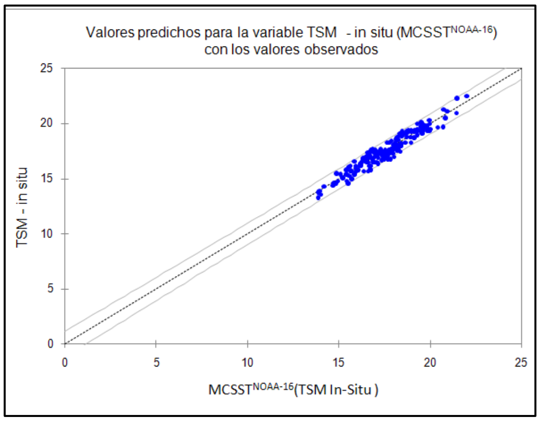

Figure 5 - Scatter Plot of SST in-situ vs SST-NOAA

MCSST for AVHRR/3 NOAA-16/METOP-2

$$\mathbf{MCSST = 1.038 \times T_4 + 3.862 \times (T_4 - T_5) + 3.016 \times (Sec\theta - 1) \times (T_4 - T_5) - 285.544}$$

Regresión Coeficiente, $R^2 = 0.914$ (see Figure 6).

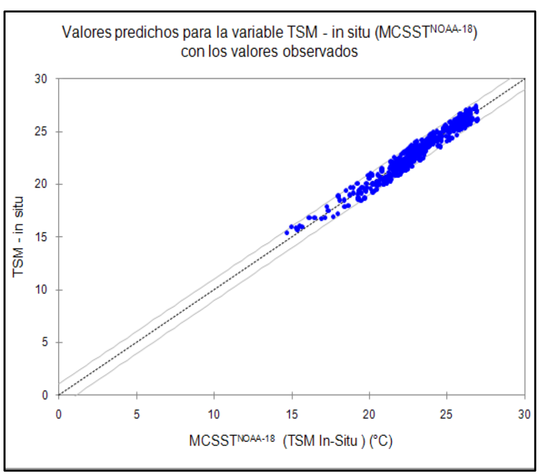

Figure 6 - Scatter Plot of SST in-situ vs MCSST-

5.2 Validation

For validating of the results were used SST from MODIS database. To NOAA-18 its obtain a bias of -1.40 °C, a correlation coefficient of 0.87 and a RMSD of 1.67 °C. To METOP-2 gives a bias of -0.97 °C, a correlation coefficient 0.94 and a RMSD of 1.15°C (see Figure 7 and 8).

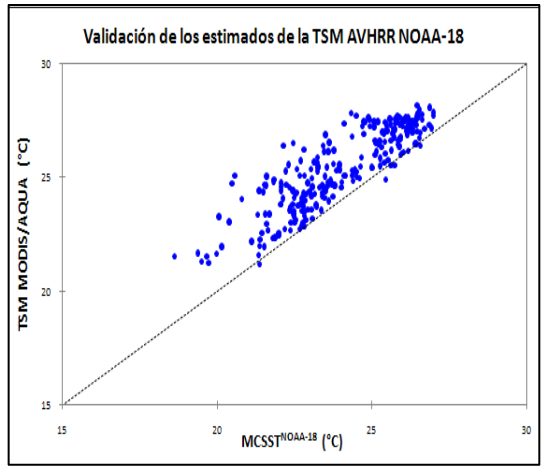

Figure 7 - Scatter Plot of SST - MODIS vs SST-NOAA

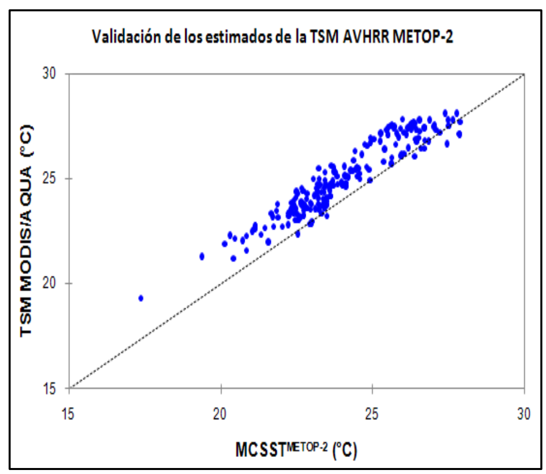

Figure 8 - Scatter Plot of SST-MODIS vs SST-METOP

Conclusions

- The coefficients of the equation MCSST daytime, have been obtained by linear regression between SST In-Situ measures and satellite measurements. The results of the linear regression R^2 values are 0.921, 0.956 and 0.914 with a confidence level of 95% for the NOAA-16, NOAA-18 and METOP-2 respectively

- The validation of the results for the NOAA-18 gives a systematic error (BIAS) of -1.40°C, a correlation coefficient r = 0. 87 and RMSD of 1.67°C and for the METOP-2 an error of bias(BIAS) of -0.97 °C, a correlation coefficient r = 0.94 and a RMSD of 1.15°C.
- It has developed the "Pacha-Ricaj“ image processing software, which has been implemented THE algorithms: calibration, filtering of clouds, SST estimation, geometric correction, compute of monthly averages, filters digital histograms, validation of results.

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USE OF SST IN ANCHOVY STUDIES IN PERUVIAN COAST

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ABSTRACT The Peruvian anchovy (*Engraulis ringens)* is one of the fishing resources of more abundance to world, near 6 million tons are extracted annually, is the second source of devises for to the country, when warm events happen like ¨El Niño¨ or ¨La Niña¨ change all the distribution and biomass.

The monitored of anchovy fishing areas for the industrial fishing fleet of purse seiner in the Peruvian coast (3º to 18ºS), is analyzed in relation to the information of Sea Surface Temperature (SST) coming from the radiometer AVHRR of the Marine Institute HRPT station for a space resolution of 1,1 km2 during the period 2008-2009, using information of total industrial fleet (650 vessels) using the satellite system ARGOS.

The evolution of the environmental conditions allows us to identify the preference of this resource for waters with temperatures from 16º to 20º associated to the cold coastal waters of the Peruvian Coastal Current, in summer the anchovy goes toward the coast near 20 to 30 mn, in winter we can find anchovy up the 120 to 150 miles of the coast.

The movement of the industrial fleet is associated to the change of the environmental conditions, which is monitory with satellites images of SST and the system ARGOS.

USE OF GHRSST PRODUCTS FOR THE IDENTIFICATION AND MONITORING OF CHINOOK SALMON HABITAT

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ABSTRACT

The stocks of Central California Chinook salmon (*Oncorhynchus tshawytscha*) suffered catastrophic collapses in 2008 and 2009; as a result, both the recreational and commercial fisheries were closed for both of those years. The salmon fishery of the central California coast represents a revenue of about US $70 M per annum, and is also an iconic part of life for the citizens, including the Native American tribes who have fishing rights by treaty. Chinook are anadromous fish, spending the early part of their life in rivers, migrating into the ocean for 2-3 years, then returning to their nascent river to spawn. In an effort to understand the conditions experienced during their oceanic phase, over 400 electronic tags recording temperature and depth every minute were deployed on Salmon caught during fishing season. The 60 returned tags provided a wealth of information regarding dive behavior as well as a strong preference for a certain temperature range. By integrating the data from electronic tags with a similar environmental product, either remotely sensed from satellite, or generated with an oceanic model, their oceanic habitat may be monitored, providing a tool that may used towards the responsible and sustainable management of the fishery. The blended microwave/infrared sea surface temperature (SST) product made by Remote Sensing Systems Inc. (Santa Rosa, CA,USA), has been chosen for this work. These daily, 9km global products provide the resolution of the meso-scale features and upwelling shadows along the coastline. The recreational and commercial fisheries are highly regulated, with frequent closures in discrete, narrow bands that divide up the coast into management regions. The data are acquired from NASA's Jet Propulsion Laboratory, and served via a Thematic Real-time Distributed Data System server at the NOAA Pacific Fisheries Environmental Laboratory. SST values are transformed to a "Potential Habitat Utilization Index", that is then made available to managers. The switch to the RSS SST product has allowed us to resolve temporal and spatial patterns that are elevant to both the behavior of the fish and the management of the fishery.

DIURNAL WARMING IN THE NORTH SEA AND BALTIC SEA

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ABSTRACT

An extensive data set is used to identify areas of the North Sea and the Baltic Sea where diurnal warming events may frequently occur. Data recorded from the S.E.V.IR.I. instrument, on board the MSG (Meteosat Second Generation) satellites, consist of hourly measurements of SST for the period of June 2004 until October 2009. Night-time reference fields generated from the S.E.V.IR.I. dataset, were utilized in order to compute the hourly SST anomaly fields of each day. Diurnal warming exceeding 2 [K], occurring most frequently at 15:00 local solar time, was identified during the spring and summer months of every year, starting as early as March and reaching maximum observations in June and July. Areas where diurnal warming was most frequently observed include the Baltic sea along with the west coast of Denmark and the Danish straits. Most frequently observed maximum values were approximately 2.1 [K], occurring at 15:00 local solar time, while 25% of the maximum anomalies recorded were larger than 3 [K]. Single large scale events were identified mainly in the west coast of Denmark, with anomalies reaching up to 6 [K], with the corresponding wind fields indicating wind speeds lower than 3 [m/s].

1. Introduction

A significant percentage of the incoming solar radiation is absorbed by the few top meters of the ocean surface, thus increasing its temperature in a manner that depends on the daily solar cycle. Lack of wind prevents mixing of the water column, thus leading to the creation of a thermal layer on the top of the water column where the temperature is higher when compared with the one bellow and above. This phenomenon may typically start around 10:00 and last until 18:00 local solar time. It may temporarily affect air-sea interactions by altering the heat and gas fluxes, atmospheric circulation and the height of the atmospheric boundary layer. Hence, it is important because it complicates the assimilation of SST by ocean and atmospheric models, the derivation of atmospheric correction algorithms for satellite radiometers and SST data merging. Therefore, as mentioned in (1) "Identification of diurnal warming events across the global ocean is required in order to improve our understanding of their spatial and temporal variability as well as their impact at daily, monthly, seasonal, annual and multi-annual time scales".

In this paper we present results obtained using data from the S.E.V.IR.I. (Spinning Enhanced Visible Infrared Imager) instrument on board the MSG (Meteosat Second Generation) satellites. The instrument is characterized by high spatial resolution and high sampling frequency, but is bounded by cloud coverage. Being in geostationary orbit, the North Sea and Baltic Sea are observed by the sensor, with a resolution of 6-9 km. Thus, the aim is to contribute at the ongoing research field regarding the diurnal variability of SST, by using an extensive dataset in order to resolve the magnitude, extend and frequency of this phenomenon in the North and Baltic Seas.

2. Methodology

S.E.V.IR.I. data were provided by CMS, for the period April 2004 to October 2009. The domain of interest was a rectangular extended from 48^o to 60^o North and from 10^o West to 30^o East. Night-time reference fields were generated from the S.E.V.IR.I. dataset. Only quality 5 pixels were considered. For every point and every calendar day, the local sunrise time was computed. The last local pre-dawn value of every cell was utilized to generate the validation fields. These served as test subjects to ensure that the night-time reference fields would not include any local warming. Night-time reference fields were generated based on three different parameters, i.e. number of days prior and after the given day, night-time interval and quality flags. Different datasets were generated for a test period (April-December 2006). Anomalies were estimated defined as the difference between validation fields and reference fields. Results were compared in terms of mean values and standard deviations along with data availability. Finally, the night-time reference fields were generated for every calendar day, using the temperature fields between 00:00 and 03:00 of the three calendar days prior and after the given day, accounting only for pixels flagged with qualities 3, 4 & 5. All times refer to local time for any given location. The daily night-time reference fields were subtracted from the hourly, day-time S.E.V.IR.I. measurements. Anomaly fields were created for local times between 08:00 and 20:00. Thus, for every day we computed the frequency of observation for anomalies larger than 1, 2 and 3 [K], the local time of occurrence, the maximum anomalies observed along with the time of occurrence. Spatial patterns were identified using the "nearest neighbour" technique. Clusters of more than 5 neighbouring grid cells recording anomalies have been identified as large events.

3. Results

The S.E.V.IR.I data availability for the quality 5 flag is shown in Figure 1. Only measurements taken between 08:00 and 20:00 local time have been taken into account in this case. The spatial distribution of diurnal warming exceeding 2 degrees is shown in Figure 2, as the amount of recorded hourly measurements.

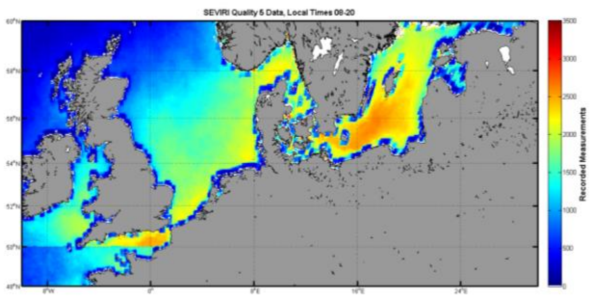

Figure 1. Number of hourly measurements between 06/2004 and 10/2009, with quality 5 flag between 08:00 and 20:00 (local time).

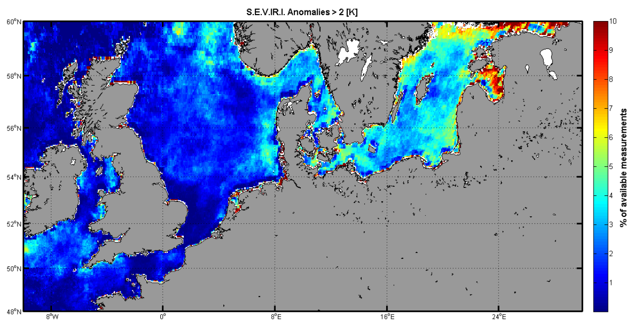

Figure 2. Percentage of hourly measurements between 06/2004 and 10/2009, when anomalies are greater than 2 [K] between 08:00 and 20:00 (local time).

Most warming events in the areas of interest did not exceed 2.1 degrees and occurred at 15:00 local time, followed by 16:00 and 14:00. Nonetheless, 25 % of the events exceeded 3 degrees and lasted more than 3 hours, with 5 % lasting more than 7 hours. Monthly distributions indicated that June and July are the prime months for diurnal warming larger than 2 [K], followed by May and August. Analysis of scatterometer sea winds, retrieved from QuikSCAT, indicated that the areas of frequent low wind speeds (< 3 m/s) coincided well with the areas of frequent warming. The annual distribution of 10 years of QuikSCAT winds indicated very low wind speeds typically in July, June, May and August.

Table 1. Size of large warming events in km^2, based on anomalies larger than 2 [K].

Percentage	**25%**	**5%**	**2.5%**
Events >	230 km^2	1050 km^2	1860 km^2

4. Conclusion

This study has shown that diurnal warming of the sea surface occurs in relatively high latitudes (more than 50 N), during the spring and summer months. Measurements from an infrared radiometer are limited by cloud coverage therefore data availability regulated our knowledge about the frequency of such events. The areas of most frequently observed events coincide well with areas of frequently observed low winds. These were areas of generally complex coastal morphology and high water turbidity, with the Baltic exhibiting significantly more diurnal warming than the North Sea. Given the fact that the night-time reference fields hold an important role in the definition of day-time warming, an extended sensitivity analysis has been performed the results of which are not included here. Nonetheless, the qualitative results were similar independent of the night-time field used to estimate the daily anomalies. On average, anomalies more than 2 [K] were frequently recorded, while anomalies of 6 [K] were also observed. Local time varied from 14:00 to 16:00 hours, with maximum number of cases being recorded at 15:00 (local times).

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USE OF NWP PROFILES IN THE NEW MSG/SEVIRI SST CHAIN

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ABSTRACT

A new SST chain for geostationary satellites has been defined within the EUMETSAT OSI-SAF. A prototype has been developed and has been producing routinely SST fields over the MSG SEVIRI globe at full resolution every 15 minutes since early 2009. New cloud mask control principles have been adopted, and the algorithms have been revisited. In particular we propose to use forecast atmospheric profiles and a radiative transfer model to simulate the algorithmic errors of the classical multi-spectral algorithms. We show that the simulated errors, used as correction terms, reduce significantly the regional biases of the NL algorithm as well as the standard deviation of the differences with drifting buoy measurements. An Optimal Estimation (OE) method will be also experimented.

1. Introduction

Regional and seasonal biases have been detected in the SEVIRI derived SST fields by comparisons with drifter measurements (1) and with SST estimates from sensors such as the Advanced Microwave Scanning Radiometer (AMSR-E) or the Advanced Along Track Scanning Radiometer (AATSR) (2). These biases are clearly due to limitations of the non linear (NL) split window algorithm used operationally by the OSI-SAF.

Through the example of SEVIRI, the objective of this presentation is to show that multi-spectral algorithm errors can be simulated and corrected using the European Centre for Medium-range Weather Forecasting (ECMWF) forecast atmospheric profiles. The next section describes the experiment that has been defined at CMS to investigate this use. In section 3 we present a simple method based on simulated brightness temperatures (BTs) to predict the NL algorithm errors and we demonstrate its efficiency to improve the SEVIRI derived SST validation results. In section 4, we illustrate through a few examples the relationship between NL errors and atmospheric water vapour profiles.

2. The SEVIRI prototype chain

CMS has been running a prototype chain since the beginning of 2009 for studying the combined use of SEVIRI BTs and the ECMWF forecast profiles to improve the SEVIRI derived SST calculations. The prototype processing is done in near-real time, to be as close as possible to operational conditions and uses 3-hourly short lead-time atmospheric forecasts (6, 9, 15 and 18 hour forecasts) from ECMWF, initialized from the analyses at 0000 h and 1200 h UTC every day.The radiative transfer computations, based on the Radiative Transfer for TIROS Operational Vertical Sounder model version 9 (RTTOV-9), use a limited number of vertical levels from the model (15 levels at 1000, 950, 925, 900, 850, 800, 700, 600, 500, 400, 300, 250, 200, 150 and 100 hPa), due to limitations of the operational near-real time dissemination of ECMWF products to Météo-France.

A 0.1° resolution grid has been defined from 60°S to 60°N and 60°W to 60°E, to which all satellite observations and forecast fields are remapped or interpolated.

The prototype chain includes the following steps:

- Calculation of simulated clear-sky SEVIRI IR BTs in channels. This is done every 3 hours (0000, 0300 UTC,..), by applying RTTOV-9 to forecast model outputs (profiles of temperature and specific humidity).
- Remapping of the actual SEVIRI IR BTs and operational SST for the same hours
- Bias adjustment of the simulated BTs by a 20 day rolling average of the observation-simulation differences at 0000 UTC, averaged in 2.5 ° boxes.
- For the 0000 UTC data, estimates of SST are derived from an optimal estimation (OE) technique (1) and expected errors of the NL SST algorithm are calculated (see below).

The prototype has been routinely operated in its present version since February 2009 using MSG (Meteosat-9) data. In the remaining of the text, all calculations have been made using the 0000 UTC SEVIRI data, corresponding to night time conditions.

3. Correction to NL algorithm

The NL algorithm is described by the following equation:

$$SST = (a + b\, S_{\square})\; T_{11} + (c + d\, T_{CLI} + e\, S_{\square})\, (T_{11} - T_{12}) + f\, S_{\square} + g \qquad (1)$$

where T_{11} and T_{12} are the BTs at 10.8 and 12.0 μm, respectively. T_{CLI} is a climatological SST value. a, b, c, d, f and g ar e coefficients determined from brightness temperature simulations on a radiosonde profile database, with the offset coefficient corrected relative to buoy measurements.

In the present SEVIRI experiment, the error intrinsic to the algorithm has been determined on the simulated BTs as follows: the NL SST is calculated from the 10.8 and 12.0 μm corrected simulated BTs using equation (1); the retrieved NL SST is compared to the true SST value used in the simulation, i.e. the input SST based on OSTIA used as the surface temperature in the simulations. The difference between the simulated retrieved NL SST and t he input SST is then the simulated algorithmic error. The simulated errors have been calculated in routine mode since the 2^{nd} of February 2009. The patterns observed on t hese errors are in general similar to those observed on the SEVIRI-minus OSTIA SST differences . Although OSTIA SST cannot be considered as a perfect truth, the SEVIRI minus OSTIA SST difference can be c onsidered as a r easonable approximation of a systematic error field.

To assess the ability of the model simulated errors to represent actual errors, SEVIRI minus OSTIA SST differences and corresponding simulated errors for each day at 0000 UTC have been averaged on a monthly basis. Figure 1 shows the monthly field in July, representing an extreme case of the errors in the SEVIRI field of view, smoothed over 25x25 pixel (2.5°) boxes to show the main features of the fields.

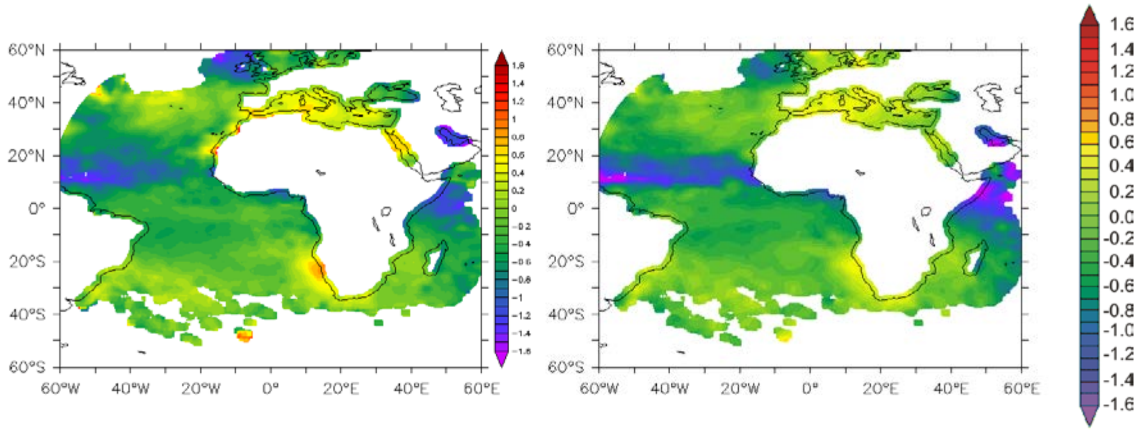

Figure 1: Mean observed SEVIRI-OSTIA differences (left panel) and simulated errors (right panel) at 0000 UTC July 2009

The observed "errors" and the simulated ones are in general in agreement and c an be s orted into 3 categories:

- The main negative bias appears in the equatorial band.
- The Angola/Namibia and North West African positive anomalies are present in both fields and are relatively static with respect to season.
- The diffuse positive bias across the Mediterranean represents the mean signature of positive anomalies rapidly moving from West to East.
- The sub-polar positive anomalies at 45° South or North, quite often masked by clouds, but may peak at several degrees off Newfoundland, or in the southern Atlantic.

Forecast fields often show discrepancies with the truth when considered over short time and s pace scales. It was thus necessary to assess the ability of the simulated error to improve the SEVIRI OSTIA comparison results when applied on hourly SEVIRI data. The bias and standard deviation have thus been calculated for every case at 0000 UTC from February till October, and t he results before and after having applied the simulated error as a correction term are shown in Figure 2. This figure shows that biases and standard deviation are significantly reduced after correction.

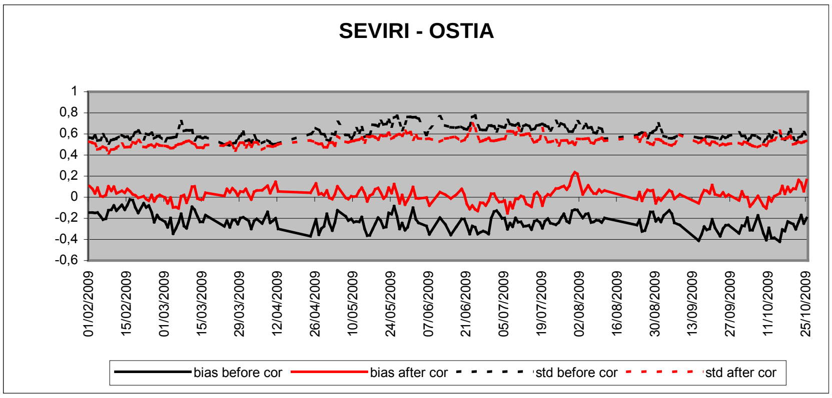

Figure 2: Hourly (0000 UTC) SEVIRI –OSTIA mean difference and standard deviation before and after having applied the simulated error as a correction

As mentioned already, OSTIA is not a perfect reference, in consequence the method has been also evaluated against buoy measurements from February till October 2009. Biases and standard deviation determined in 10° latitude bins from the daily MDB are displayed in Figure 3. This figure shows how this correction corrects for the latitude dependency of bias. A negative bias remains in the corrected field north of 50°N. It corresponds to large zenith angle and may be indicative of cloud induced problems that are not corrected for by the simulated errors.

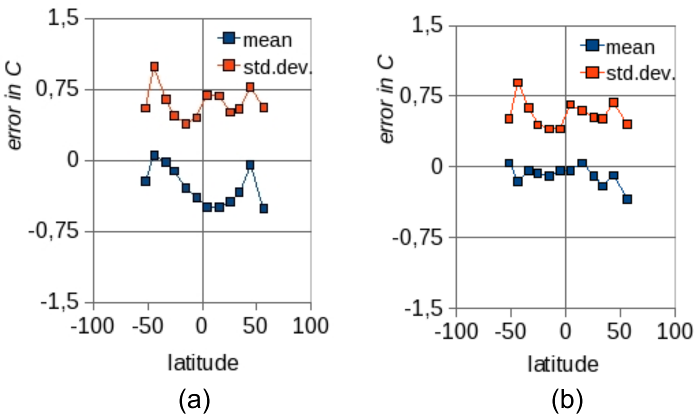

Figure 3: Error at 0000 UTC in 10 degree latitude bins for (a) the operational algorithm; (b) operational algorithm with correction

4. Profiles and NL errors

The link between profiles and errors was first investigated in (3) using radiosonde profiles. The objective of this section is to illustrate the use of NWP model profiles through a case on the 29th of August 2009 in the equatorial region corresponding to the inter-tropical negative errors. The study has been limited to the water vapour profile effect and the impact of the temperature profiles deserves a complementary investigation.

Figure 4 shows a zoom over the inter-tropical Atlantic on the 29th of August 2009. This situation corresponds to about the northernmost location of the inter-tropical negative bias. The negative errors are located north of 10°N, mostly north of the thickest cloud band of the Inter –Tropical Convergence Zone (ITCZ). The simulated errors fit in general with the differences between the operational SST and OSTIA, with simulated positive anomalies likely underestimated off the Brazilian coast. Two points have been selected along 28°W to analyze profiles corresponding to large negative or to small errors:

A) 18.15°N: large negative error (-1.7 K) relatively dry atmosphere (39 kg m^{-2})

B) 7.95°N: small error (+0.4 K), relatively moist atmosphere (41 kg m^{-2})

A and B are located north and south of the ITCZ, respectively.

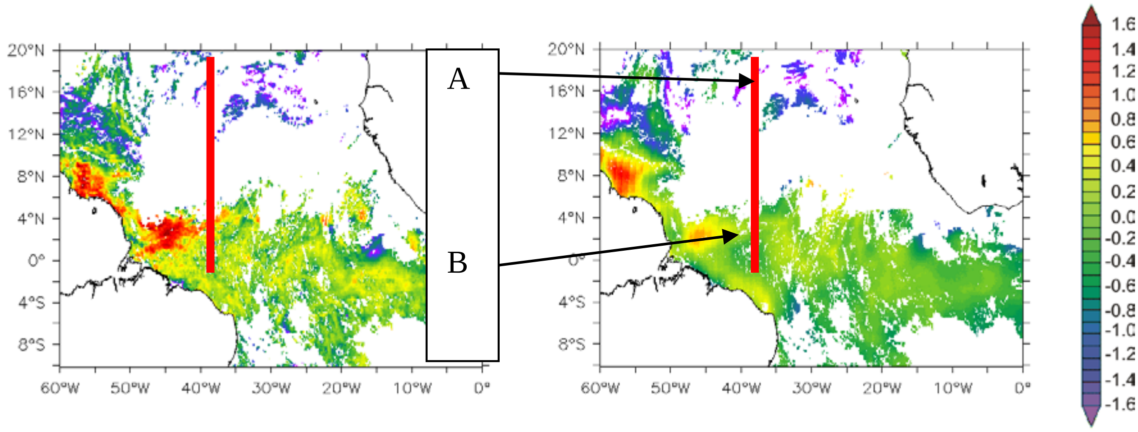

Figure 4: Inter-tropical Atlantic on the 29th of August 2009 at 0000 UTC. (a): difference between operational SST and OSTIA; (b): simulated error.

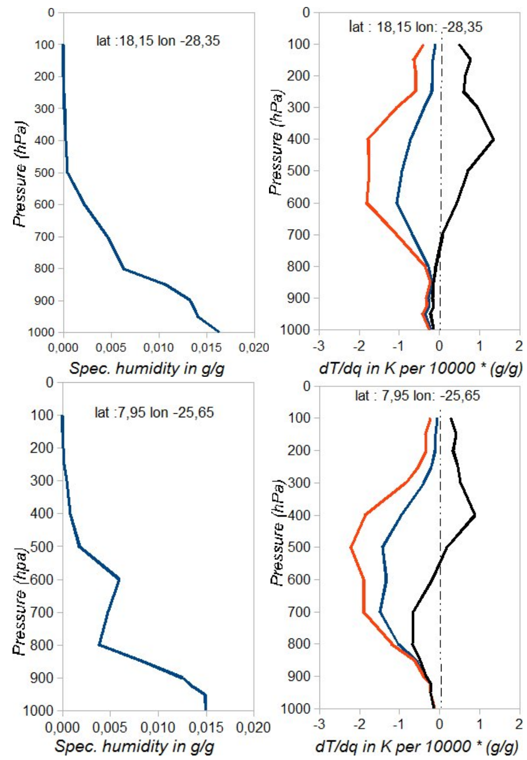

Figure 5: Profiles in A (top) and B (bottom) . Left panel: Specific humidity profiles; right panel: Jacobian profiles (red line: dT_{12}/dq; blue line: dT_{11}/dq; black line dSST/dq).

The profiles in A and B are displayed in Figure 5, left columns. The profiles of the Jacobians d(T)/d(q) have been also displayed in Figure 5, right columns, where T is the 11 or 12 μm BT and q is the specific humidity at the forecast pressure levels. The d(SST)/d(q) profiles have been determined by applying equation (1) to $d(T_{11})/d(q)$ and $d(T_{12})/d(q)$ at each profile level, resulting in equation (2).

$$d(SST)/d(q) = (a + b\, S_{\square})\ d(T_{11})/d(q) + (c + d\, T_{CLI} + e\, S_{\square})\ (d(T_{11})/d(q) - d(T_{12})/d(q)) \qquad (2)$$

The d(SST)/d(q) profiles show a neutral water vapour (WV) point which altitude varies from 800 hPa (North of the ITCZ) to 500 to 700 hPa (south of the ITCZ). Above this point, an excess of humidity leads to positive errors (d(SST)/d(q) > 0), and conversely a dry atmosphere leads to negative errors. Below the neutral WV point an increase of humidity leads to negative errors. The negative errors in A are likely to have been induced by large humidity values in the lower layers, whereas profile B shows a dry layer at 800 hPa and a moist layer at 600 hPa. This moist layer corresponds in altitude to the local neutral WV point altitude and thus has minimal effect on the error.

5. Conclusion

The errors of a split window non linear algorithm can be simulated using forecast profiles produced by the ECMWF NWP model. The level of accuracy of these simulated errors is sufficient to use them as a corrective term to the SST produced from the SEVIRI BTs using this algorithm. A study over several months in the SEVIRI field of view has demonstrated that this correction method reduces the regional bias regularly observed on SEVIRI SST results between 0° and 20°N. The standard deviation of the validation results obtained by comparison with drifter measurements is also reduced. This is not a trivial outcome, since NWP outputs show often small scale discrepancies with the truth and an increase of the standard deviation could have well been observed instead. This aspect of the study is considered as positive and this correction method will be implemented in the operational OSI-SAF SEVIRI SST chain.

Since it is possible to simulate the essential of the errors of a multispectral algorithm with NWP model outputs, they offer the possibility of understanding the origin of these errors by analyzing water vapour and Jacobian profiles. Profiles affect errors in a large variety of altitude-dependent ways, explaining the relative lack of efficacy of corrections based on integrated water vapour content in characterization of multi-spectral SST errors. This also challenges the use of a reduced state vector comprising only SST and integrated water vapour content in optimal estimation (OE) techniques. In this text, the emphasis has been put on the spatial and vertical distribution of the water vapour, which is the main factor determining the algorithm errors; it would be useful to investigate also the role of the temperature profiles. In a future study at CMS we will generalize this analysis to a larger range of situations where algorithmic errors have been identified as likely to be significant (over the Warm Pool, Arctic Seas, etc…) by addressing the case of global observations by METOP/AVHRR.

Acknowledgements

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SEA SURFACE TEMPERATURE COMPOSITE OF HURRICANES

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ABSTRACT

We rarely have good maps of sea surface temperature (SST) in a tropical cyclone (hurricane), but SST is of critical importance to the characterization, understanding, and prediction of the genesis and intensification of hurricanes. Moorings and drifters give only point measurements of opportunity. Wide-swath spacebased radiometers may be the best way to look at the surface structure of a hurrican and its oceanic influence and feedback. Hurricane is a hostile environment even for remote sensing. Clouds form veils to infrared sensors. Heavy rain and breaking wave with water spray may also hinder observations. Over eight years of coincident SST from infrared radiometers (Advanced Very High Resolution Radiometer (AVHRR) and Moderate-Resolution Imaging Spectroradiometer (MODIS)) and microwave radiometers (Tropical Rain Measuring Mission (TRMM) Microwave Imager (TMI) and Advanced Microwave Scanning Radiometer-Earth Observing System (AMSR-E) over global oceans have been analyzed. It is a large data ensemble to form statistical significant subsets. The differences among these data sets in azimuth asymmetry are examined. The study shows the advantages of spatial resolution and spectral diversity of AMSR-E over TMI, and the cloud penetrating capability of microwave sensors over infrared sensors in revealing the SST characteristics. The SST asymmetry is being related to the asymmetry of surface wind divergence, angular momentum, temperature profile, rain profile, and cloud parameters to understand the ocean-atmosphere coupling in a hurricane.

THE EFFECT OF SEA SURFACE TEMPERATURE ON WIND/STRESS RETRIEVAL

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Wind is air in motion. Ocean surface stress is the turbulent transfer of momentum between the ocean and the atmosphere. While the general public knows and feels the wind, very few people know what is stress. Even for oceanographers, their concept on stress distribution is largely derived from their knowledge of wind because there was no large-scale stress measurement over ocean until the launch of radars into space. The two parameters are put together in the title because they have been closely associated with each other. Stress is closely related to wind but not solely driven by wind. Stress depends also directly on ocean parameters such as surface current and temperature, which drive wind shear and instability that generate turbulence. (Liu et al., 2010)

Spacebased radar, including scatterometer, altimeter, and synthetic aperture radar send microwave to the ocean surface and measure the backscatter power from surface roughness caused by small waves. The retrieval of wind or stress is affected by sea surface temperature (SST) in several ways, one is the stability of the near surface atmospheric layer and the others are viscosity and surface tension that affects capillary waves. There is a long history of studies relating radar wind errors to SST, starting with the observation of sharp jumps of radar return across temperature front of the Gulf Stream but without such sharp gradient in the mean wind aloft (e.g. Weissman et al. 1980). Vigorous studies of the difference in winds derived from spacebased sensor and in situ measurements started with Liu (1984). He separated the interrelated effects of wind speed, atmospheric stability and SST, using multivariate regression. By removing the independent effects of stability and wind speed, he showed that the difference between collocated satellite and in situ wind measurement 'wind error' in the 90 days of Seasat scattometer data have slight SST dependence, mostly at low wind speed and the dependence agree with the postulation of the capillary wave spectra on viscosity by Lleonart and Blackman (1980). The effect of surface tension could be neglected because it changes only 5% compared with the 50% change in viscosity over the same temperature range. Freilich (1986) show similar results using data from the scatterometer on European Remote Sensing Satellite (ERS). Using ERS data, Ebuchi (1997) attribute the 'wind error' to viscosity and Quilfen et al. (1998) show the annual cycle of the 'error' which may by related to the cycle in SST.

There was a sharp increase in studies of the relation between scatterometer measurement and SST with the availability of QuikSCAT data. When the first Quick Scatterometer (QuikSCAT) data came back in 1999, the science team was surprised to see that the scatterometer signal in the equatorial Pacific propagates westward with the ocean temperature front of the tropical instability waves in the area where we expected to see steady trade winds (e.g. Liu et al 2000; Chelton et al 2001). Since then, the spatial coherence between scatterometer measurements and SST has been observed over many locations and under various atmospheric conditions, e.g., over the Kuroshio Extension and Kuroshio (e.g. Liu et al. 2007; Liu and Xie, 2008), over the circumpolar current, Indian Ocean, in the East China Sea during winter cold air outbreak (Xie et al., 2002), over the Gulf Stream Ring (Park and Cornillon, 2002), and over typhoon wake (Lin et al., 2003). Following traditional paths to study atmospheric boundary layer processes, many scientists were quick to postulate explanations of the wind and SST correlation, based on boundary layer height change, pressure gradient force, secondary flow, cloud entrainment, and organized convection, but none of these is generally applicable to the ubiquitous correlation. Misinterpreting stress measured by the scatterometer as wind is the cause of the confusions. Stress must be spatially coherent with SST and ocean current, which create buoyancy and wind shear. As pointed out by Liu et al. (2007) and Liu and Xie (2008), at small turbulence scales at the surface, factors that affect atmospheric boundary layer dynamics (wind), such as Coriolis force, pressure gradient force, baroclinicity, cloud entrainment, etc., are not important. That is why the spatial coherence is ubiquitous, found under all kinds of atmospheric circulations.

For all practical purposes, our knowledge of τ is derived from winds (U) at a reference height through a drag coefficient C_D, which was empirically determined as a constant or a function of wind speed. Liu et al. (1979) first proposed a parameterization method of stress, which is equivalent to a C_D including the stability effects and molecular constraints at the interface, by solving the flux-profile relation in the surface layer, where the vertical gradient of stress is negligible:

$$\frac{U-U_s}{U_*} = 2.5(\ln\frac{z}{z_0} - \psi_U) = \frac{1}{\sqrt{C_D}}\,, \qquad (1)$$

where U_s is the surface current, $U_* = (\tau/\rho)^{1/2}$ is the frictional velocity, z_o is the roughness length, and ψ_u is a function of the stability parameter, which is the ratio of buoyancy to shear production of turbulence. An alternative to using the neutral C_D is to express z_o as a function of U_*. Neglecting ψ_u (neutral stability) and U_s, U will be equal to an equivalent neutral wind U_N, the geophysical product of the scatteroemter. Although the atmosphere is believed to be near neutral over most ocean area, exact neutral stability (ψ_u=0) is rare, and to compute U_N from conventional wind measurements of U, the stability effect has to be removed. While the relation between stress and actual wind depends on stability, Un has a one-to-one relation with stress and is stress in wind dimension. The stability effect on the difference between wind and stress, in the form of the difference between U_N and U, is governed by the ψ_u,

$$\delta U = U_N - U = 2.5 U_* \psi_u \qquad (2)$$

Liu et al. (2010) computed δU at 10 m averaged over a three years period, for January and July. This distribution of the stability effect on wind speed follows closely the distribution of sea-air temperature difference. Because atmospheric temperature variations have larger scale than oceanic temperature variations, the buoyancy-generated turbulence should have strong spatial correlation with SST at small scales.

Stability and viscosity have opposite effects on wind derived from scatterometers, but the stability effect is much larger than the viscosity effect. Whether one use wind measurement to derive stress or use stress measurement to infer wind, SST variation is important. The push for higher resolution of SST and wind/stress products should go hand-in-hand. SST plays an important role not only in wind retrieval, but also in retrieving the core parameters in water and carbon cycles in the ocean.

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PRELIMINARY ASSESSMENT OF A 20-YEAR REANALYSIS USING OSTIA

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ABSTRACT

The Operational SST and sea Ice Analysis (OSTIA) has been running operationally at the UK Met Office since November 2006. The output is a daily global coverage 1/20° (~6km) combined SST and sea ice concentration product based on measurements from several satellite and in situ SST data sets. OSTIA uses SST data in the common format developed by GHRSST and makes use of the uncertainty estimates and auxiliary fields as part of the quality control and analysis procedure. Satellite derived sea ice products from the EUMETSAT Ocean and Sea Ice Satellite application Facility (OSI-SAF) provide sea ice concentration and edge data to the analysis system. After quality control of the SST observations, a bias correction is performed using AATSR data as a key component. To provide the final SST analysis, a multi-scale optimal interpolation is performed using the previous analysis as the basis for a first guess field.

A reanalysis system, based on OSTIA, is being developed as part of the MyOcean European project. This reanalysis uses Pathfinder AVHRR data (version 5), version 2.0 re-processed ATSR data in L2P format (obtained from the NEODC, http://www.neodc.rl.ac.uk), in situ SST data from the International Comprehensive Ocean-Atmosphere Data Set (ICOADS), and a re-processed version of the SMMR and SSM/I sea-ice concentration data produced by the EUMETSAT OSI-SAF. A preliminary run of this reanalysis system has been carried out between 1985 and 2006. An overview of the reanalysis system will be presented, with some initial assessment of results.

THE DATA BUOY CO-OPERATION PANEL (DBCP) AND ITS ROLE WITHIN GHRSST

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ABSTRACT

The DBCP was formed in the mid 80's to address the serious concerns surrounding the quality, quantity and timeliness of data being collected from the newly deployed fleets of satellite-tracked surface drifters. Over time these issues have largely been resolved and a global population of more than 1300 drifters now routinely reports good quality surface pressure and SST data via the GTS, overseen by a full-time Technical Coordinator based in Toulouse. In the last few years the DBCP has turned some of its attention to a number of pilot projects with the aim of evaluating new technologies that might in due course transition to operational use, and has tried to strengthen its links with other observing system groups, from both the *in situ* and remote sensing communities. In the case of GHRSST, the DBCP is anxious to fully understand the needs for high resolution SST and to work with GHRSST in helping to equip the future drifter fleet with sensors that meet its requirements. An initial practical step would be to jointly develop a pilot project that demonstrates the benefits that accrue for high resolution *in situ* SST in one particular ocean area.

OVERVIEW OF IASI L2P AND DEVELOPMENT OF SSES

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ABSTRACT

The IASI L2 Product Processing Facility (PPF) at EUMETSAT has retrieved surface skin temperature over land and sea since April 2008. The data are available via EUMETCast together with vertical temperature and humidity profiles. Work has been on-going at EUMETSAT to produce the IASI SST data in GHRSST L2P format. Validation results show that the IASI SSTs are of good quality. The results are presented with a description of the work involved to produce the Single Sensor Error Statistics.

1. Introduction

Skin sea surface temperature is supplied within the current EUMETSAT MetOp Infra-red Atmospheric Sounding Interferometer (IASI) L2 product and has previously been validated against AATSR SST and ECMWF fields to have a cool bias of around 0.3K and root mean square of 0.7K [1]. In order for the use of IASI SSTs to be maximised by a wide range of users, work is being done towards producing IASI SST in GHRSST L2P format. A Single Sensor Error Statistic (SSES) scheme has been developed for the IASI SSTs based on water vapour profiles contained within the IASI L2 product. An experimental L2Pcore product containing SST, SSES, and quality levels has been produced at EUMETSAT since March 2010 and is currently under evaluation.

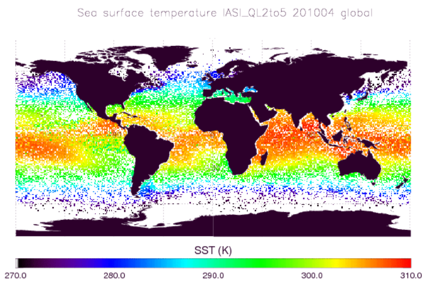

Figure 1. IASI L2Pcore SST April 2010.

In this paper we present an overview of the IASI SSES scheme, show some validation results, and describe future progress towards the availability of the full IASI L2P product. Figure 1 shows a global plot of the IASI L2Pcore SST for April 2010.

2. IASI L2P Single Sensor Error Statistics

The SSES scheme developed for IASI SST observations uses integrated water vapour derived from the IASI water vapour profiles contained in the IASI L2. A major error contribution on SST retrievals is the amount of water vapour in the atmosphere [2]. IASI is uniquely placed to utilise this information to gain information on the observational errors.

To investigate possible relationships between IASI water vapour profiles and the quality of the SST retrieval, differences between IASI and climatology SST (NSIPP monthly climatology, [3]) were compared to integrated water vapour (IWV). IWV was calculated by integrating the IASI water vapour profiles (kg/kg), with pressure level information. Figure 2 shows a plot of IASI-climatology SST versus IWV. SSTs with the smallest biases and error bars occur at the lower water vapours. The largest deviations are where IWV is less the 0.5 is due to two observations where the climatology is reporting an ice surface temperature, whilst the IASI SST measures a sea temperature.

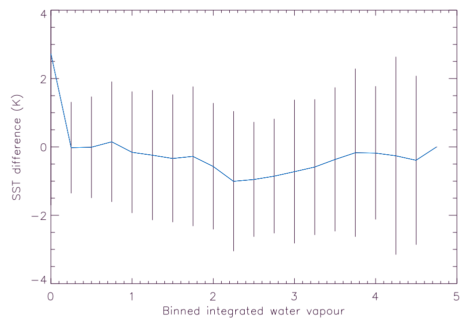

Figure 2. IASI minus climatology SST differences versus IASI integrated water vapour 1/11/2008.

Thresholds have been determined from figure 2 to give quality levels ranging from 2 (worst) to 5 (best). The thresholds have been applied to METOP/AVHRR level 3 data.

Figure 3 shows the global spread of quality levels from 2 to 5 for IASI L2Pcore data from April 2010. The quality levels are seen to represent different water vapour regimes, which follow different error characteristics.

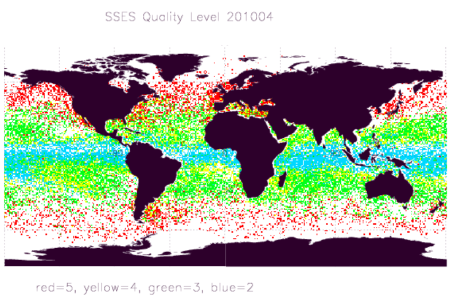

Figure 3. IASI L2P core SSES quality levels for April 2010

3. Validation

IASI L2P SSTs have been collocated to the OSI-SAF Metop/AVHRR MDB creating a IASI MDB (IMDB), from April to June 2010. The dataset has been used to calculate the SSES for each quality level using the criteria: night-time drifting buoys only; IASI SST +-3hours of drifting buoys; distance within 12km nadir. The statistics are given in table 1 indicating that the standard deviations for quality levels 3 to 5 are around 0.45K. For all quality levels the mean IASI – buoy difference is -0.33K, standard deviation 0.50K. As the IMDB is populated further more stringent collocation criteria will be applied to derive the SSES, when 6 months worth of data has been gathered.

Table 1. Statistics of IASI L2P core MDB per quality level for 1/4/10 to 9/6/10 (787 collocations)

Quality level	SSES bias (K)	SSES stdev (K)
2	-0.27	0.70
3	-0.38	0.45
4	-0.33	0.45
5	-0.23	0.46

Figure 4 shows a global map of IASI minus drifting buoy differences for April 2010. The largest deviations are in regions typically affected by aerosol such as off the West African coast and the Arabian Sea. Additionally, some occasional red points are observed which are likely to be due to residual cloud contamination causing cool IASI SSTs.

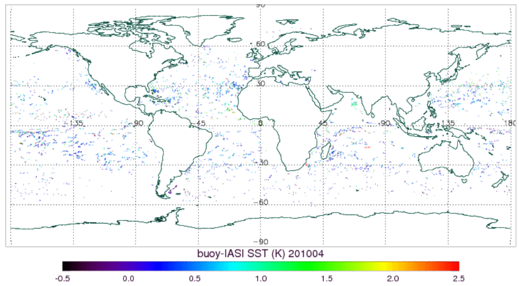

Figure 4. Global map IASI minus drifting buoy SST for April 2010.

4. Conclusion and way-forward

IASI L2Pcore SST have been produced routinely at EUMETSAT since March 2010. Comparisons against AATSR give mean differences of around 0.4K, standard deviations 0.3-0.4K. An IMDB is routinely produced using collocations with OSI-SAF Metop/AVHRR MDB. The analysis of 6 months worth of IMDB to finalise the SSES will be complete by Autumn 2010. The production of the full IASI L2P will come later, perhaps within the OSI-SAF.

Retrieval scheme improvements and additions to the cloud detection scheme are currently under development for the IASI L2 surface temperature product. Other considerations for updates to the IASI L2Pcore are: to look at error budget from L2 uncertainties with Optimal Estimation retrievals; aerosol flagging in combination with L2; and the inclusion of water vapour information in L2P extra fields.

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HIGH RESOLUTION AVHRR SST IN PERUVIAN COAST

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ABSTRACT

High-resolution images of the Advanced Very High Resolution Radiometer (AVHRR) sensor were processed to calculate sea surface temperature (SST) of Peruvian sea, the data have been collected by the High Resolution Picture Transmission (HRPT) receive station that is located en Lima (Peru). The data are been collected from November 1998 until September 2008. The algorithm used to calculate the sea surface temperature is Linear Multi Channel Sea Surface Temperature (MCSST Day Split Window Algorithm) which was developed by National Oceanic and Atmospheric Administration (NOAA), these images have a spatial resolution of 1.1 km. The Advanced Very High Resolution Radiometer images allowed knowing in real-time, information about the ocean thermals conditions and the space variability of the processes occurring there, such as eddies, blooms, thermal fronts and also monitoring great oceanographic events like El Niño.

1. INTRODUCTION

The Instituto del Mar del Peru (IMARPE), has as one of its objectives the study of the physical environment of the ocean, which is done through evaluation oceanographic cruises and the use of remote sensing technology. Being the last of these, which allows real-time information of ocean conditions and macro-scale with high spatial and temporal resolution.

The temperature of the waters in the tropical central and west Pacific Ocean has been linked to the Southern Oscillation Index and the onset and persistence of the El Niño phenomenon (Cane et al., 1986).

In November 1998, after the disaster caused by the presence of El Niño 97-98 in Peru and especially in the fisheries sector, the IMARPE acquired an image receiving station (HRPT), in order to have information in real time of the thermal conditions of the Peruvian sea and for the monitoring of weather events like El Nino – La Niña.

The use of AVHRR images is primarily intended for data collection and images of sea surface temperature, which is important for many oceanographic applications, fishing, weather prediction models and also for monitoring global climate change.

On the other hand, it is known that the sea surface temperature has a strong influence on the spatial distribution of marine species. The SST information is collected in Peru by in situ observations through research oceanographic cruises, oceanographic buoys and by fixed meteorological stations in harbours. However, this information is seasonal and with low temporary coverage which does not allow daily, continuous monitoring and real-time, like the satellite images

This paper presents the estimation of the Peruvian sea surface temperature from AVHRR satellite images, the processing done from the configuration of the HRPT receiving station, the programming of the images to receive, the algorithm used to calculate SST and final visualization

Due to the high cloud cover featuring the Peruvian coast during much of the year for this work the best images were processed for the months of spring and summer.

2. AVHRR AND HRPT SYSTEM OVERVIEW

The AVHRR five channel scanning radiometer is sensitive in the visible and near-infrared, and the infrared 'window' regions. This instrument was be carried through NOAA-J (14); NOAA-K, L and M (15, 16, and 17) and will have a similar instrument with six channels and other improvements. AVHRR data are broadcast for reception by ground stations and also tape-recorded onboard the spacecraft for readout at the Fairbanks and Wallops Command Data Acquisition stations. These data can be recorded in 1.1-km resolution (the basic resolution of the AVHRR instrument) or at 4 km resolution;

the swath width is >2600 km. The stored high resolution (1.1-km) imagery is known as Local Area Coverage (LAC). Owing to the large number of data bits, only about 11+ minutes of LAC can be accommodated on a single recorder. In contrast, 115 minutes of the lower resolution (4-km) imagery, called Global Area Coverage (GAC), can be stored on a recorder, enough to cover an entire 102 minute orbit of data. (P. Rao et al 1990).

NOAA-K, L and M (NOAA-15 onwards) carry an enhanced version of the AVHRR scanner. It has six channels (three visible and three infra-red) but, for compatibility at receiving stations, only five are transmitted. Channel 3 is the visible channel during the daytime and the infra-red channel at nighttime, although sometimes it is infra-red during the day too for fire detection. Additionally, the visible channels have been modified with a dual slope for calibration to give greater sensitivity at low light levels. (P Rao et al 1990).

The HRPT station, allows receiving and processing images in real time of meteorological satellites of the National Oceanic and Atmospheric Administration (NOAA), which receives radio transmissions from the L-band satellite, amplifies, converts, demodulates and digitizes the signal radio on HRPT raw data. It also, saves the data in HRP digital format on the computer.

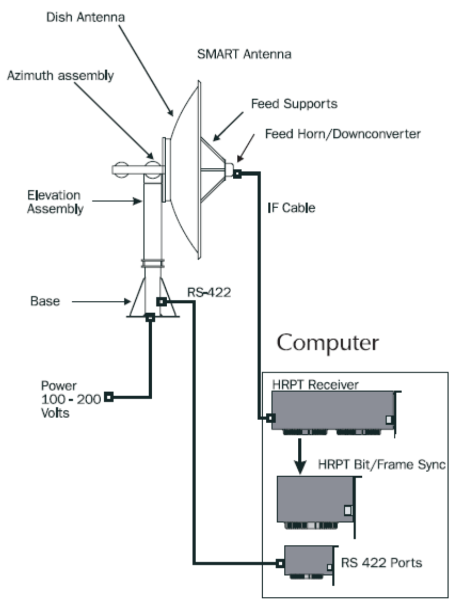


Figure 1. Diagram of the HRPT system.

A schematic diagram of the HRPT receiving system is showed (Figure 1), which HRPT antenna uses a tracking system in azimuth and elevation through a satellite dish mounted and incorporates a power supply and a microprocessor on a pedestal base providing a fully autonomous tracking antenna. The HRPT interfaces with the computer via an RS-422 communications port, and performs satellite tracking and antenna-control tasks internally. This design frees the HRPT station's computer to process the satellite data as it is received. (HRPT station guide)

HRPT station consists of a receiving antenna, a GPS, a frequency demodulator and an IBM computer, which allow real-time reception up to 9 images per day in the study area. (Figure 2).

Figure 2. IMARPE HRPT system.

The high resolution (1.1km) from AVHRR images, allows to make researching and monitoring of environmental ocean conditions in micro and macro scale. The SST is the main variable studied due to the high importance in the development of big events like El Niño. Moreover, these images can show information cloudiness, snow, soil conditions and vegetation, forest fires, ocean color, water vapor, clouds temperature and pollution in large areas. The data source and characteristics of the AVHRR sensor is summarized in Table 1.

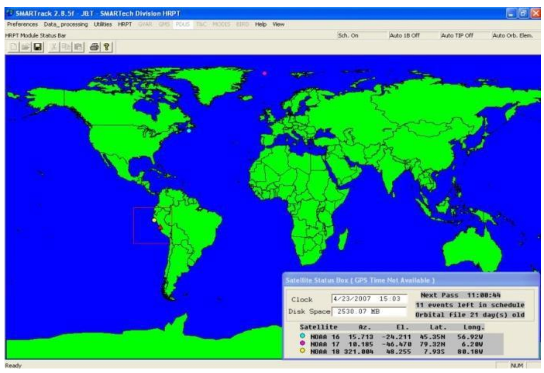
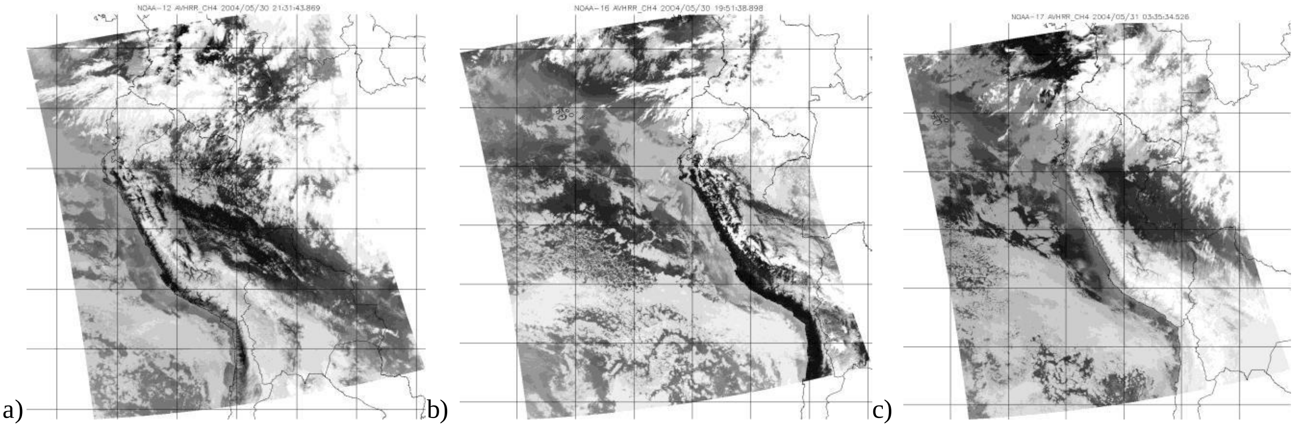


Figure 3. SMARTrack software.

The reception of NOAA satellite images and the calculation of the SST are performed with the

Table 1. AVHRR sensor.

Sensor (Satellites)	Sensor	Spatial Resolution	Data Source	Study Area	# Bands	wavelength
AVHRR-HRPT (NOAA 12, 14, 15, 16, 17 & 18)	Visible Infrared (5 bandas)	1.1km	Remote Sensing Laboratory IMARPE	Peruvian Sea (1°-25°LS / 68°-100°LO)	1	0.58 - 0.68
					2	0.725 - 1.00
					3	1.58 – 3.93
					4	10.30 - 11.30
					5	11.50 - 12.50



a) b) c)

Figura 4. Raw images a) NOAA 12 AVHRR CH4 2004/05/30 21:31 b) NOAA 16 AVHRR CH4 2004/05/30 19:51 y c) NOAA 17 AVHRR CH4 2004/05/3103135

SMATrack program (Figure 3). For the selection of the best images is taken into account that the orbit of the satellite, meets the criteria of minimum elevation angle and free cloud coverage.

3. DATA PROCESSING

The AVHRR sensor measures radiance from the earth in five bands or channels. Satellite estimates of SST's are made by converting the radiance measured in the infrared channels to brightness temperature and then using a multichannel technique to calculate SST.

The HRPT receive station of IMARPE has data since November 1998 to September 2007 of NOAA 12, 14, 15, 16, 17 and 18. During this time, HRPT station stopped receiving information during some periods, due mainly to failures in the mechanical system of the antenna. However, it has long periods of uninterrupted reception.

The Peruvian coast is a region characterized by high cloudiness for the most part of the year, especially during fall, winter and some spring days as can be seen in Figure 4. The processing of the estimation of the SST begins with the selection of the best images storaged on the Pc. (Figure 5).

Then, the calibration of thermal bands 3, 4 and 5 was performed using the SMARTrack, this is an automatic process of the program. Once the image is calibrated, the surface temperature of the sea is calculated.

The MCSST - Day Split Window algorithm was used to calculate the sea surface temperature which use the last 3 bands of the AVHRR sensor and some constant coefficients in an equation, in order to obtain pixels values in degrees centigrade of sea surface temperature from the radiance data (Mc Clain et al 1985). For SST estimation the most common algorithms used are those supplied by NOAA called the multichannel MCSST, the "crossed-product" CPSST, and the nonlinear NLSST, (J. Barton, 1995).

SMARTrack includes algorithms developed by the Coastal Observation Program of NOAA (NOAA Coast Watch Program).

MCSST Algorithm - Day Split Window used in the processing of the SST is:

$$SST = (A1*T4) + A2*(T4-T5) + A3 * (T4-T5) * (\sec(sate\_Angle) - 1) + A4$$

Where:
sate_Angle = satellite zenith angle.
A1, A2, A3 and A4 = NOAA constant coefficients.

T4 and T5 = correspond to the values of brightness temperature in band 4 and 5 of the AVHRR sensor.
Nomenclature in the equation of the algorithms:
* Secz is the secant of the satellite zenith angle (Radians) That is (1.0/cos (satz)).
* = Solar zenith angle Solza
* Satz = satellite zenith angle

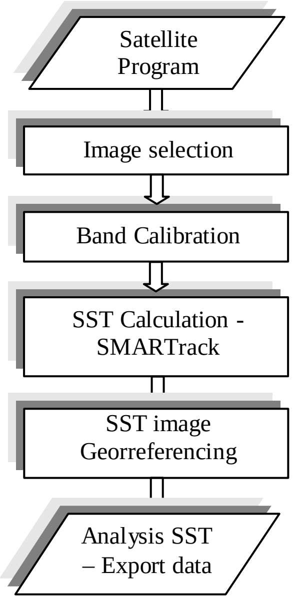


Figure 5. SST diagram processing

During the process of estimating SST, the SMARTrack creates a mask for clouds and automatically assigns digital values of zero to one (0-1) to these pixels. With the SST pixels values calculated, the process of georeferencing was performed for the study area based on a Mercator projection system and WGS 84 datum.

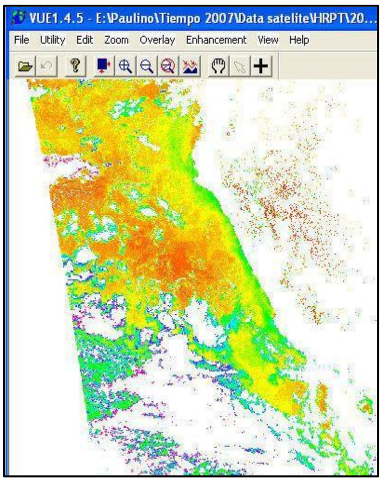


Figure 6. SST Image

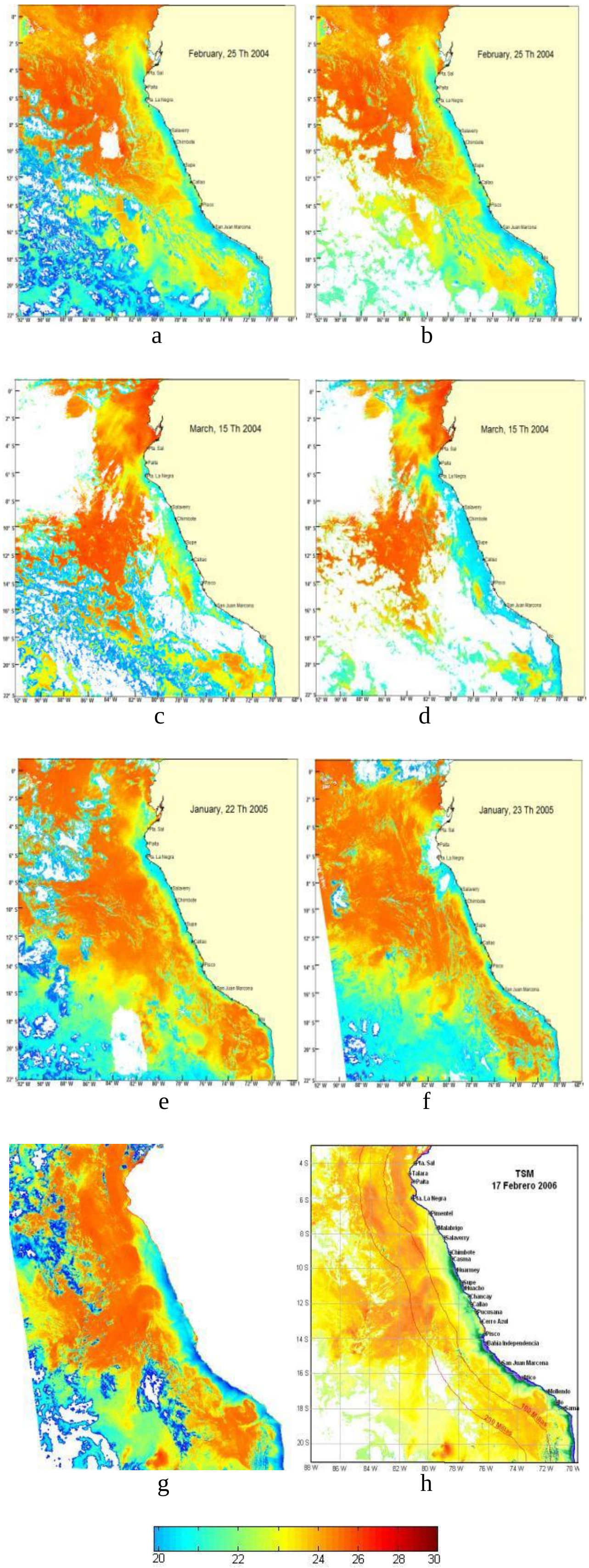


Figure 7. SST 25 Feb 2004, without mask (a) with mask (b); SST 15 Mar 2005, without mask (c) with mask (d); SST 22 y 23 Ene 2005 without cloud mask (e y f); SST 17 Feb 2006, without cloud mask (g) with mask (h).

In the SMARTviewer window from SMARTrack menu the SST image is displayed in greyscale. SMARTviewer allows to create a color palette assigning one color for each value of SST, wit the aim of a quickly and adequate interpretation. (Figure 6).

These pixel values calculated SST can be exported in ASCII format (latitude, longitude, SST), for the use in GIS software.

4. DATA ANALYSIS

From the processed data is possible to observe that the SST showed a high variability along the Peruvian coast, especially in areas near the coast.

One of the most important troubles is the cloud cover across the study region. SMARTrack allows to create a mask for clouds, but this is not totally effective as shown in the images (Figure 7 - left side). The SST pixel values in the image are blended with pixel values of clouds, which are easily identifiable in the images..

For best viewing in the estimation of SST has made a reclassification of digital values corresponding to the clouds of the data matrix. Similarly been removed noise pixels, yielding better results as shown in Figure 7 (right side).

The variability of ocean currents, wind direction, the upwelling, the Coriolis force, and other variables, allows the formation of ocean structures such as eddies and thermal fronts. (Figure 8).

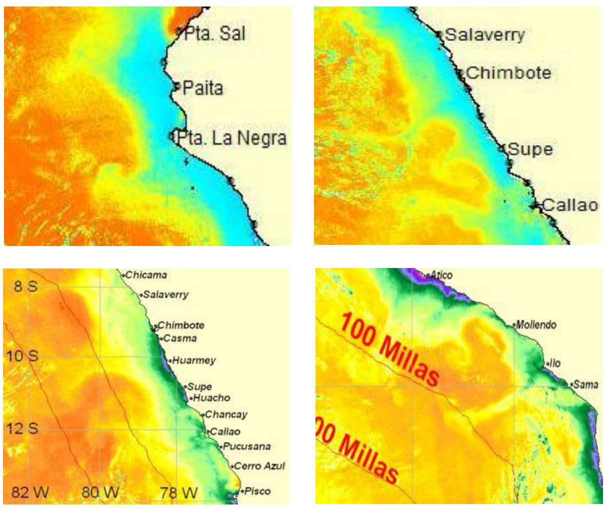


Figure 8. Ocean structures in Peruvian waters

5. CONCLUSIONS

The sea surface temperature of the AVHRR is a good source for the detection of oceanic formations as eddies and thermal fronts. However, the presence of clouds along the Peruvian coast and inadequate concealment algorithm for the cloud hampers the calculation of the TSM

AVHRR images are useful for predicting weather and climate events of macro scale as El Niño, and to monitor events in coastal areas.

The SST is an important variable in the analysis of resource-environment relationships, the calculated SSTs can be exported in ASCII or matrix and processed in other programs.

It is important to update the algorithms used for the calculation of TSM, and to improve the method of masking the clouds.

This paper is a preliminary study, in the future it will be Focus in Develop the validation of the processed data for Longer Time Periods with in situ observations.

This paper is a preliminary study, in the future it will be focused in develop the validation of the processed data for longer time periods with in situ observations.

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Currents variability on the northern Patagonia continental shelf

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ABSTRACT

The Patagonia continental shelf break is one of the most productive regions in the World Ocean. We report in-situ observations of currents and temperature taken on the outer edge of the continental shelf at two locations near 44°S (A) and 41°S (B). Shelf waters and waters from the western boundary of the Malvinas Current are found from simultaneous observations of temperature and salinity at (A). These observations suggest relatively intense upwelling events, with isotherms, isohalines and isopycnals rising at a rate of ~30 m/5 days for several days. One of these events was followed by a relatively intense and vertically coherent on-shore flow at all levels. This type of events may generate the nutrients flux towards the surface necessary to sustain the growth of phytoplankton in the outer shelf.

Our aim is to estimate the contribution of horizontal advection of temperature in causing these sharp temperature drops observed at the mooring sites. To this end, we plan to combine satellite derived sea surface temperature and current observations. We are currently evaluating high resolution (1km) MODIS, microwave and analyzed multisensor SST data.

1. Introduction

The elevated phytoplankton biomass observed in the Patagonia continental shelf sustains a variety of species including cephalopods, fish, and marine birds and mammals and contributes to large rates of CO_2 absorption from the atmosphere[1-2]. The biological production depends on the flux of micro and macronutrients to the fotic zone, which is enhanced near tidal fronts and the shelf break region. Given that the Malvinas Current (MC) is a major source of macronutrients along the shelf eastern boundary, we propose to test the hypothesis that horizontal advection can produce a nutrient flux from the Malvinas Current into the outer shelf by evaluating the different terms of the heat equation,

$$\partial T/\partial t + V \cdot \nabla_H T + w\, \partial T/\partial z + Q = 0, \qquad (1)$$

where T is the temperature, V is the horizontal velocity, w is the vertical velocity and Q is the heat flux exchanged with the atmosphere.

In this paper we briefly discuss the feasibility of calculating horizontal advection (second term of the heat equation) using different sea surface temperature (SST) products. In the section that follows the data are described. We then discussed the SST field derived from different products; this discussion is then followed by a preliminary analysis of zonal SST gradients. This paper ends with a summary of conclusions and future work.

2. Instruments and data

In-situ observations of currents and temperature were taken on the outer edge of the continental shelf at two locations, (A) and (B), between October and December 2005 and September 2006 and March 2007, respectively. Current velocity has been estimated between 0-80m depths over vertical ranges of 20m and between 85-175m depths over vertical ranges of 30m using a buoy-mounted acoustic *doppler* profiler (ADCP).

Five SST products have been used in order to estimate the zonal temperature gradient at the mooring zone, as described in table 1.

Table 1: SST products used to estimate SST zonal gradients

SST Product	Spatial resolution
MODIS (AQUA)	1km
AVHRR Pathfinder (v. 5)	4km
AMSR-E	0.25º
GHRSST AVHRR L4 OI SST	0.25º
GHRSST L4 AVHRR + AMSR OI	0.25º

3. SST fields and zonal gradients

As a preliminary analysis of the datasets, daily averaged SSTs and *in-situ* data at 1m depth at (A) were compared (Figure 1). Significant correlation at a 95% confidence level was found for all products (not shown).

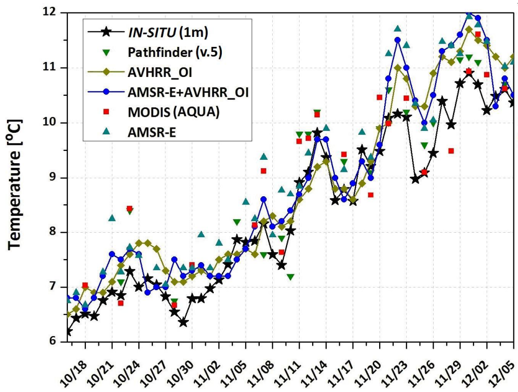

Figure 1: In-situ temperature time series at 1m depth and SSTs at the mooring place (A)

Daily averaged difference between each SST product and *in-situ* temperature was then computed. It was on average 0.5 ºC warmer for the first part of the record and rose up to 1 °C near the end (early summer, Figure 2),.

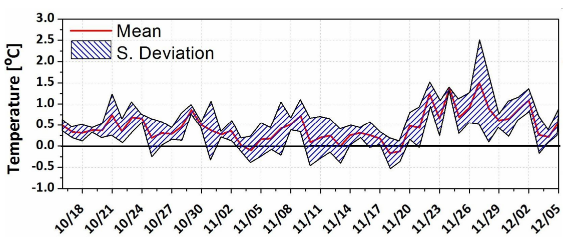

Figure 2: Averaged differences between daily SSTs and in-situ *temperature means at 1m. SSTs are on average 0.5 ºC warmer; the difference increases towards the beginning of summer.*

As a first approach to estimating SST gradients, necessary to estimate the advective term in eq. 1, daily SST fields were analyzed along zonal transects located at the same latitude as the buoy. If compared with *in-situ* data at 1m depth level, low-resolution products appear to overestimate SST within the MC core, thus filtering some of its cold features (Figure 3).

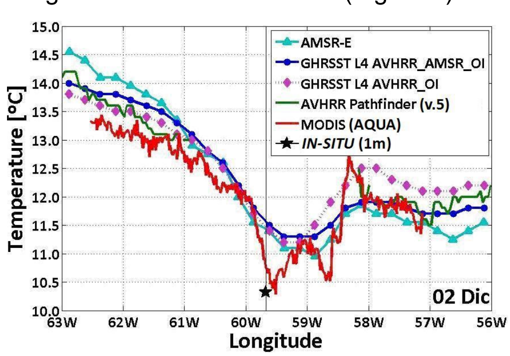

Figure 3: SSTs zonal transects. Compared to in-situ *temperature, low resolution products filter cold features inside Malvinas Current core, between 60W and 58W.*

Finally, zonal SST gradient estimates taking different spatial scales were computed at (A). For a spatial scale of 100km or less, substantial differences were found, depending on the product resolution (Figure 4).

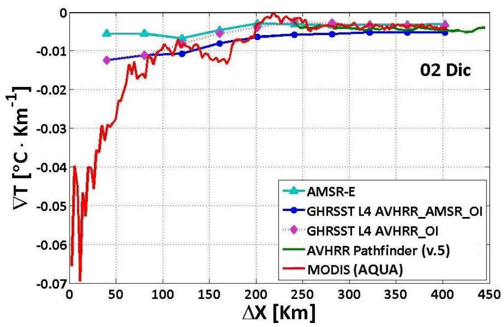

Figure 4: Example zonal SST gradients centered at (A) for different spatial scales. Values derived from high resolution products differ from those calculated from low resolution products.

4. Conclusion and future work

All SST products show good correlation with *in-situ* temperature at 1m, with differences that range from 0.5 ºC for the first part of the record to 1 ºC in the later period. Malvinas Current structure is best described with high resolution SST products. Zonal SST gradients calculated with low resolution products over scales lower than 75 km differ significantly from those computed with high resolution products. Therefore, when calculating the horizontal advection terms, further analysis will be necessary in order to determine which spatial scales best represent features that cause the observed local temperature changes in this area. Future tasks include additional comparison with *in-situ* data and evaluation of vertical advection, heat fluxes and eddy diffusivity terms.

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TOOLS TO ACCESS AND DISPLAY GHRSST DATA: (1) THE NAIAD DATAMINER FOR SATELLITE DATA

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ABSTRACT

The NAIAD dataminer is a web tool for searching and subsetting Level 2 (swath) data. It was developed originally by the French agency Ifremer and is now a joint effort between Ifremer and PO.DAAC. Two instances of the system, in beta version, are hosted at both site (http://www.ifremer.fr/naiad for Ifremer, http://podaac-tools.jpl.nasa.gov/dataminer for PO.DAAC), each one presenting their own datasets – including GHRSST data – but many more datasets will be added in the next few months.

Here is 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 tarball (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.

TOOLS TO ACCESS AND DISPLAY GHRSST DATA: (2) THE MATCHUP DATABASE INTERFACE

Jean-François Piollé and Sylvain Herledan

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ABSTRACT

The calibration and validation of the GHRSST satellite SST relies strongly on satellite to in situ matchup databases (MDB). Such MDBs have been implemented by many product providers or in the context of GHRSST project itself (such as the Medspiration MDBs).

Ifremer has defined and implemented a common framework to host at single place and in a common way all available MDBs (that producers wish to share). Unified services have been built on top of this format such as data subsetting and extraction to netCDF format and a user-friendly interactive web interface (http://www.ifremer.fr/matchupdb/) – developed using FLEX/Flash language – to visualize, analyse and qualify the match-up database content through various displays and statistical estimators.

HIGH RESOLUTION DAILY SEA SURFACE TEMPERATURE ANALYSES

Richard W. Reynolds [(1)], Dudley B. Chelton [(2)] and Thomas M. Smith [(3)]

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ABSTRACT

A two-stage high and low resolution sea surface temperature analysis is presented. The high resolution analysis is computed on a 4.4 km grid using infrared (IR) data. The first guess for the analysis is a low resolution analysis on a 25 km grid using combined microwave (MW) and IR plus a damped high resolution IR-only analysis from the previous day. Thus, the high resolution analysis features will only be present when there are high resolution data.

1. Introduction

The number of sea surface temperature (SST) analyses has increased in recent years along with an increase in the number of satellite instruments. Many of these analyses are part of the Group for High-Resolution Sea Surface Temperature (GHRSST) (1). Comparisons of SST analyses reported in (2) have shown that if the analysis procedure attempts to resolve very small features in the SST field, there may be insufficient high-resolution data during cloudy periods, thus resulting in noise in the SST analysis. If the smoothing in the analysis procedure is too large, the SST fields will be unnecessarily smooth.

To avoid analyses that may be too noisy or too smooth, a two stage analysis procedure is presented. In the first stage, a low resolution SST analysis is produced based on combined microwave (MW) and infrared (IR) data as described in (3). In the second stage, a high-resolution analysis is produced with a finer grid spacing using only the available IR data; MW and in situ data are not used directly in the high-resolution analysis.

2. High Resolution Analysis

The analysis procedure is outlined in figure 1. The low resolution daily analysis (shown in blue) has already been completed using optimum interpolation (OI) on a 25 km spatial grid using infrared Advanced Very High Resolution Radiometer (AVHRR) and microwave Advanced Microwave Scanning Radiometer (AMSR) satellite data (2). Both the AVHRR and AMSR data were averaged onto the 25 km spatial grid before the analysis is carried out.

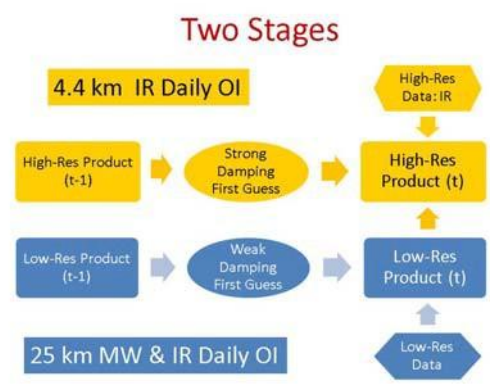

Figure 1. Schematic of high (yellow) and low (blue) resolution OI Processing

The high resolution analysis (shown schematically in yellow in figure 1) uses Pathfinder AVHRR data averaged onto a 4.4 km grid. The first guess, F(x,t), at spatial location, x, and time, t, is a combination of the low resolution analysis, L(x,t), and the damped difference between the high resolution analysis, H(x,t-1), and the low resolution analysis at the previous time, t-1, and is defined as

$$F(x,t) = L(x,t) + D(x) [H(x,t-1) - L(x,t-1)]$$

Here D(x) is the damping factor. This factor was estimated as the lag-1 autocorrelation of the „modified' data increment defined as [A(x,t) - L(x,t)] where A(x,t) is the field of the high resolution

AVHRR satellite data. The data increment is termed „modified' because it ignores the impact of the [H(x,t-1) - L(x,t-1)] term. Damping is needed because small-scale features generally have shorter time scales than large-scale features.

The damping factor, D(x), was computed for daily daytime and nighttime AVHRR data and low resolution analyses for 2003. The spatially smoothed average result is shown in Figure 2. The results show that the damping is low (< 0.3) in the tropics and highest in middle latitudes reaching a maximum just above 0.6. Thus, high resolution data will be strongly damped in the tropics but will persist in middle latitudes.

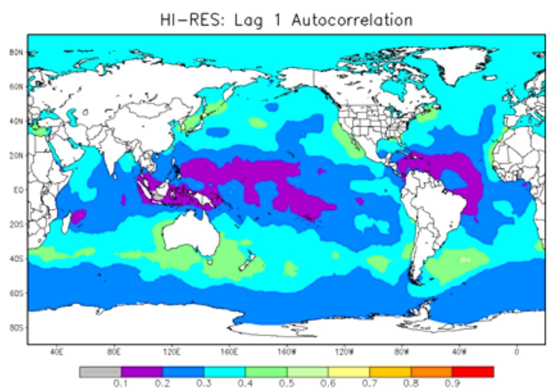

Figure 2. Lag-1 autocorrelation of the high resolution data increments.

Before computing the OI it is necessary to define the spatial error correlations, C(x), and noise-to-signal variance ratio, N(x). For the low-resolution analysis these are defined in (2). When the method described in (2) was applied to the high resolution data, the results were noisy because of large gaps in the high resolution data. Other statistical computations showed that parameter changes from low to high resolution can be expressed as

$$C_H(x) = C_L(x) / R$$
$$N_H(x) = N_L(x) \; R$$

Here the subscripts H and L stand for high and low resolution and R is a factor which ranges from 1 to G_L/G_H where G_L=25 km and G_H=4.4 km are the spatial grid scales, hence G_L/G_H=5.68 and $1 \le R \le 5.68$. The value of R is determined by the correlations between the low and high resolution grid noise. For R > 1, the high resolution error correlation decreases over the low resolution value while the noise-to-signal ratio increases. The factor, R, was determined by experimentation. A value of R = 5.68/2 = 2.84 was selected as producing a good balance between resolution and noise. The resulting high resolution error correlations are shown in figure 3 for the zonal (top) and meridional directions. Note that the correlation scales range from the 10-20 km in the Gulf Stream region to above 60 km in the tropics.

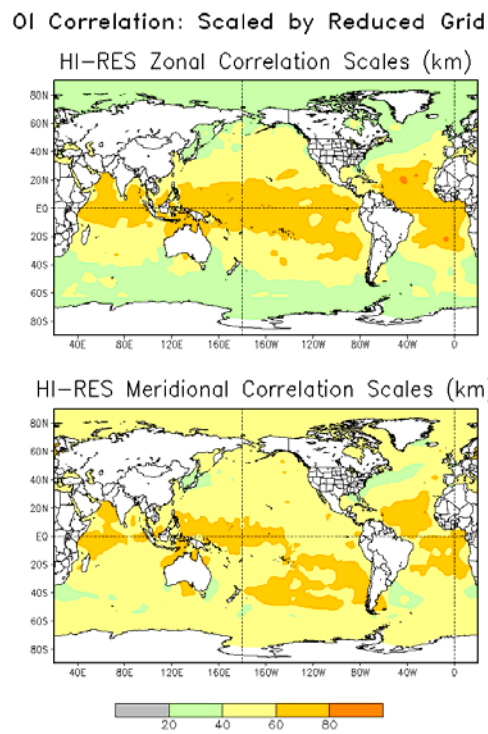

Figure 3. Zonal and meridional error correlation scales used in the high resolution analysis. The smallest scales are in the western boundary current regions; the largest are in the tropics.

3. Results

The high resolution analysis was run from June 2002 through the end of 2006. The results showed some noise using Pathfinder's highest quality control (flag=7). Examination of the data showed cold pixels in regions with clouds suggesting some cloud contamination. To reduce the impact of the noise, medians were computed using 3 days of data over a 3 by 3 spatial grid. Observations were discarded in any grid box if the absolute difference between the grid value and its associated median were greater than 1°C.

An example of the difference between the high and low resolution analyses with and without the median filter is shown in figure 4 for December 7, 2002 for the western tropical Pacific. The analysis without the median filter (top panel) shows cold pixels with largest values south of the equator near 145°E. These extremes disappear in the analysis with the median filter.

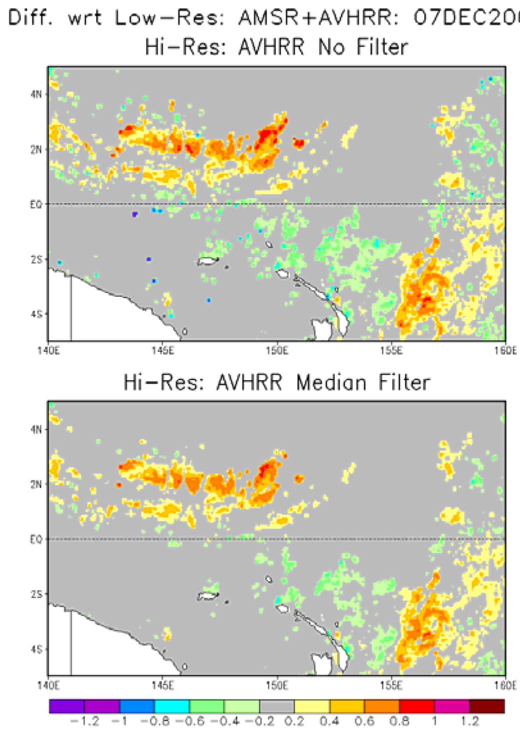

Figure 4. Difference between the high and low resolution analyses for December 7, 2002. The high resolution data are processed without (top) and with (bottom) median filtering.

In regions with persistent cloud cover, there will be no high-resolution data. Thus, differences between the high and low resolution analyses will disappear in regions with persistent cloud cover. This is clearly illustrated in maps of the monthly RMS difference between the high resolution (with median filter) and the low resolution analysis. Examples are shown in figure 5 for January and July 2003. The figure shows small differences in cloudy areas such as in the Gulf Stream region in January 2003, off the west coast of South America in July 2003 and along the Intertropical Convergence Zone (ITCZ) in both months. The spatial resolution of the high resolution analysis clearly will change with time. Thus, for example, the Gulf Stream will be better resolved in July than January.

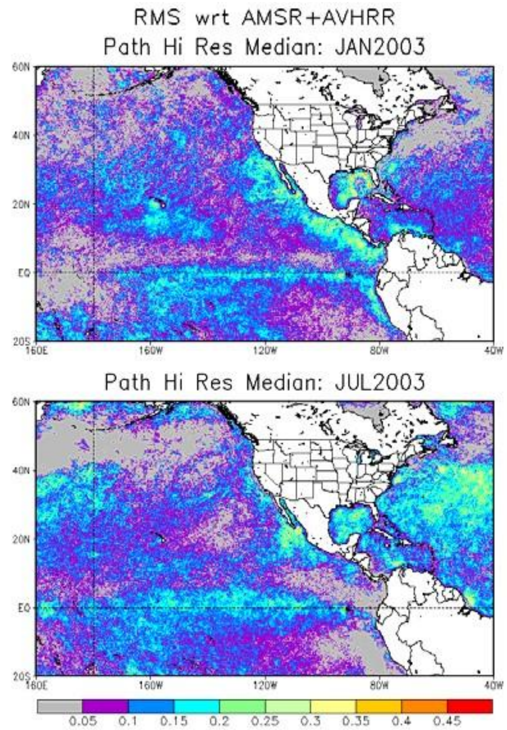

Figure 5. RMS monthly difference between the high (with median filtering) and low resolution analyses for January (top) and July (bottom) 2003.

An example of the high and low resolution analyses is show in the Gulf Stream for 26 August 2003 in Figure 6. The figure shows that the Gulf Stream gradients along the 27°C isotherm are sharper in the high resolution analysis between the coast and roughly 70°W. Also the 28°C isotherm shows more detail south of this gradient. However, north of 40°N there are very few high resolution data and, hence, little difference between the two analyses.

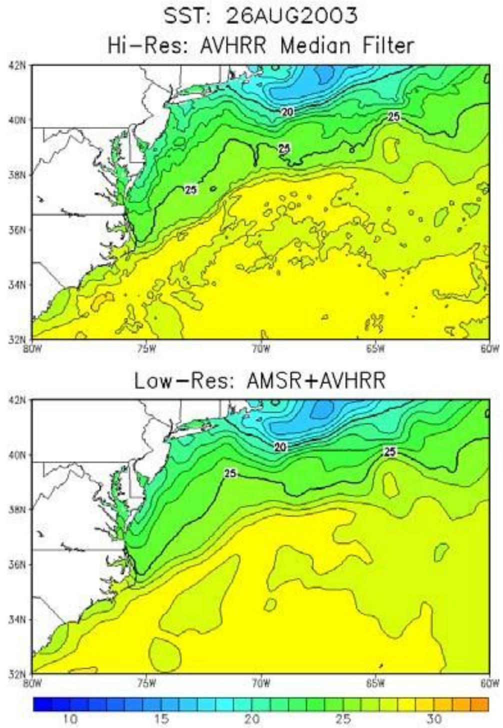

Figure 6. High (top) and low (bottom) resolution SST analyses for 26 August 2003. Contours are 1°C.

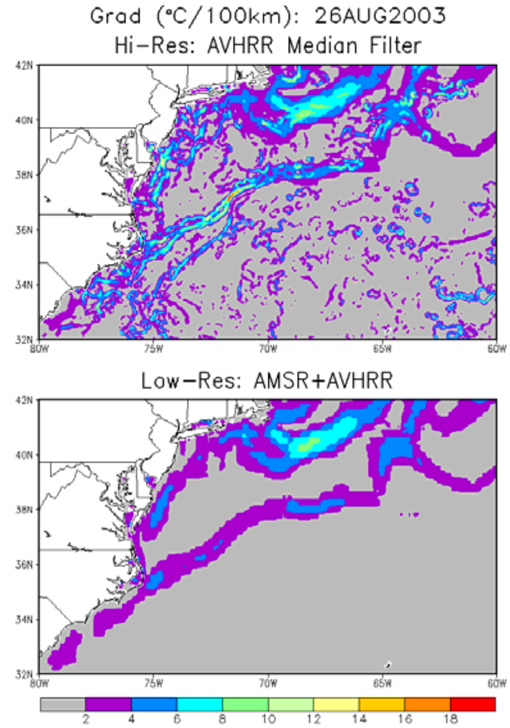

Figure 7. Magnitude of the gradient of the high (top) and low (bottom) resolution SST analyses for 26 August 2003.

The change in resolution from low to high resolution is shown more dramatically in the magnitude of the gradient. This magnitude is shown in figure 7 for the same region and day as shown in figure 6. Here the gradient exceeds 14°C/100 km in the high resolution analysis near 38°N and 71°W but is less than half that magnitude in the low resolution analysis. In addition there are other small features south of 36°N which only occur in the high resolution analysis. However, as expected the two gradients are very similar north of 40°N.

4. Conclusion

The high resolution analysis shows promise of producing realistic high resolution features when data are available. However, further work is needed to improve the median filter and the first guess and the OI parameters.

5. References

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3. Reynolds, R. W., and D. B. Chelton, “Comparisons of daily sea surface temperature analyses for 2007-08”, *J. Climate,* in press, 2010.

A COMPARISON OF SSTS OFF THE PERUVIAN COAST USING GHRSST DATA AND NASA'S ECCO2 MODEL: ASSESSMENT OF MIXED LAYER DEPTHS AND UPWELLING

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ABSTRACT

Eastern Boundary Upwelling Coastal Regions (EBUCR) contain the worlds most productive fisheries. These regions have a direct impact on climate through the net cooling effect associated with the presence of low level clouds and the relationship with major upwelling events. This is a major source of uncertainty in current climate models. Thus an accurate understanding of the dynamics in the EBUR is critical for climate modeling and forecasting. A critical issue for understanding the dynamics is the formation of the mixed layer depth (MLD) associated with the seasonal variability. This is a motivating factor for directly comparing results from NASA's Estimating the Circulation and Climate of the Ocean Phase II (ECCO2) model and SSTs from NASA's Advanced Microwave Scanning Radiometer (AMSR-E) Earth Observing System.

Direct comparisons between derived SSTs from the ECCO2 model (ESST) and AMSR-E (ASST) indicate, that off the Peruvian Coast, the ASSTs can be cooler than the ECCO2 by 1°C. It was hypothesized that these biases and differences could be due to an underestimate of the MLD in the ECCO2.

MLDs were then derived from both ARGO data and the ECCO2 model in an area off the Peruvian Coast between 10S to 2N and 90W to 80W. Overall, during times of strong upwelling off Peru, ESSTs derived MLDS were deeper than those derived from ASSTs, indicative of a possible underestimation of the seasonal upwelling off the Peruvian Coast. Results will be presented that assess the strength of the upwelling represented in the ECCO2 model compared to actual data.

SEASONAL AND MONTHLY VARIABILITY OF GRADIENT SEA SURFACE TEMPERATURE OFF PERU

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Email: avicuna@geomapconsult.com

ABSTRACT

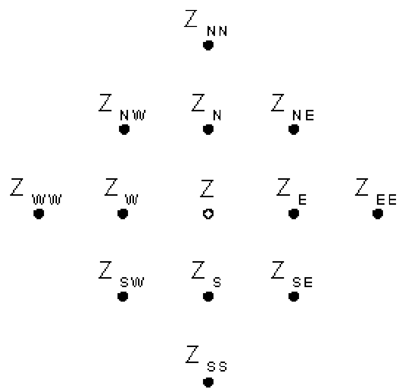
In general, the ocean presents regions of temperature and other variables relatively uniform, separated by transitions in which the gradients are strongest. Ocean fronts are relatively more turbulent areas, and vertical movement more intense, which is associated with an increased flow of nutrients to the illuminated area and, consequently, are generally associated with higher biological activity. With information from the Group for High Resolution Sea Surface Temperature (GHRSST), were mapped seasonal and monthly gradient of sea surface temperature (SST) off the coast of Peru. Data were obtained from the NOAA Optimum Interpolation 1/4 Degree Daily Sea Surface Temperature Analysis (Reynolds et al. 2007), which uses data from the sensors Advanced Very High Resolution Radiometer (AVHRR) and Advanced Microwave Scanning Radiometer (AMSR), also includes *in situ* data of ships and buoys, as well as technical adjustment to satellite bias with respect *in situ* data. This type of information has a spatial resolution of 0.25° and daily temporal resolution. The present is restricted to 2003-2009 years, because the AMSR start from

mid 2002, the advantage of using this sensor is that coverage is not limited by the presence of clouds. First, I was built the grid of the SST for the area between 0°-20° S and 90°W-70° W, then applied the following equation for the detection of thermal gradient:

$$\|g\| \approx \sqrt{\left(\frac{Z_E - Z_W}{2\Delta x}\right)^2 + \left(\frac{Z_N - Z_S}{2\Delta y}\right)^2}$$

Where:

$\|g\|$: Thermal gradient of the cell at position Z
Z_E : SST in the neighboring cell Z_E.
Z_W : SST in the neighboring cell Z_W.
Z_N : SST in the neighboring cell Z_N.
Z_S : SST in the neighboring cell Z_S



New grids are constructed with data from the previous procedure and makes an monthly and seasonal average using data for the seven years of study. As a result, the maps show monthly and seasonal: summer (JanFebMar), autumn (AprilMayJune), winter (JulyAugustSeptember) and spring (OctoberNovemberDec).

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CHAPTER 3

BREAKOUT SESSIONS SUMMARIES

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AUS-TAG BREAKOUT SESSION REPORT

Jorge Vazquez[(1)], Mike Chin[(1)]

(1) Jet Propulsion Laboratory, California Institute of Technology, 2800 Oak Grove, Pasadena, CA 91109, Email: jorge.vazquez@jpl.nasa.gov
(2)

The terms of reference were approved as laid out at the previous GHRSST Meeting in Santa Rosa, California. D iscussion points raised were as follows:

Issue 1: Users Manual

- The work by Chris Jeffery appreciated. The remaining task to finish the manual will now be lead by Jorge Vazquez and Andrea Andrea Kaiser-Weiss (per DAS-TAG).
- The scope of the current Users Manual is too large. It was recommended that it Ishould focus on GHRSST *file access & reading*.
- A (very) short document "quick-start guide" *separate* from GDS Users Manual is needed.

Issue 2: Technical Needs

- There needs to be implemented a time aggregation of files so users can just download one f ile. Eg: With modis there are approximately over 250 files/day. This makes it very difficult for users to access the data. Several centers have implemented this technology.
- GHRSST should have the capability to deliver SST animations.
- Technically managing large volumes of data still difficult.
- Implement Google Earth but still an issue with changing color bars as one zooms in.
- Recommendation: Should we standardize color bars, etc.
- There are inconsistencies in L2P land-masks.
- Recommendation: Should *GHRSST standardize land-masks?*
- There is still the issue with lat-lon values in some L2P files containing "bad/missing" fill-values.
- Recommendation: *GHRSST should require all (lat,lon) values in L2P files to be legitimate**.***
- Multiple files per day created with some GHRSST products. Users would want "hours" information in the file-name.
- *GHRSST file-naming will be modified (per DAS-TAG)* ***in GDSV2.0.***

AUS-TAG Recommendations

•GHRSST to write a ***"quick-start guide"*** in addition to GDS Users Guide to facilitate access by novice users (Mike Chin & Jorge Vazquez)

•GHRSST to allow ***hours*** as extension of the date field in the file name(s).

•GHRSST to require every sample point to have a legitimate location, i.e., ***no "bad/missing" lon-lat values***.

•GHRSST to consider standardized landmask and/or colorbar, as well as a single file delivery of regional SST timeseries.

DAS-TAG BREAKOUT SESSION REPORT

Andrew Bingham[(1)] (Chair), Ed Armstrong[(1)] (co-Chair/Rapporteur), Dave Foley (Rapporteur)

[(1)] NASA PO.DAAC/GDAC, Jet Propulsion Laboratory, Pasadena, CA 91109, USA

Emails: andrew.bingham@jpl.nasa.gov and earmstro@mail.jpl.nasa.gov

Overview

Consensus at 10th GHRSST Science Team meeting (Santa Rosa, CA) to form the Data Assembly & Systems Technical Advisory Group (DAS-TAG), by merging and disbanding:

- GDS-TAG (Gentemann)
- DM-TAG (Vazquez)
- XML-TAG (Armstrong)

The purpose of the DAS-TAG is to oversee the development and implementation of the GHRSST Data Processing Specification (GDS), specifically:

- Oversee the data product specifications (L2P, L3 & L4);
- Oversee data system specifications (RDAC, GDAC, LTRSF interfaces, common data management practices);
- Ensure common user interfaces for data discovery and access;
- Coordinate (with the GHRSST Project Office) GDS reviews and get buy-in from the stakeholders;
- Review requirements proposed by the GHRSST TAGs, Working Groups and Science Team and levy on the implementation systems (RDAC's, GDAC and LTSRF).

DAS-TAG Membership

Chairs: Andrew Bingham & Ed Armstrong

Members: Tess Brandon, Ken Casey, Craig Donlon, Dave Foley, Chelle Gentemann, Ted Habermann, Leon Majewski, Jean-Francois Piolle, Dave Poulter, Gary Wick, Jorge Vazquez.

DAS-TAG Breakout Session Discussion Points

The DAS-TAG breakout session occurred between 2°– 6pm on Tues 22nd June.

1. GDS 2.0 document layout

[Issue]: No consensus on how to combine and publish the different GDS2.0 sections produced by the Book Captains.

[**Consensus**] GDS2.0 will consist of three documents: GDS 2.0 Technical Specification, User Manual and Interface Control Document.

[**Action**] GDS 2.0 Technical Specification will be compiled by Donlon & Casey and will contain the following sections:

- Overview
- Conventions
- L2P specification
- L3 specification
- L4 specification
- GMPE specification
- Metadata specification

[**Action**] The User Manual will be compiled by Andrea at the GHRSST Project Office.

[**Action**] The ICD will contain information for i) submitting data into the GHRSST framework ii) reporting problems within the GHRSST framework and iii) reporting metrics. This document will be compiled by Bingham & Brandon.

2. GDS 2.0 version control

[**Issue**] No process for version control

[**Consensus**] Once GDS 2.0 is complete, the GHRSST Project office will take ownership of the documents and place under version control.

[**Action**] Andrea will make GDS 2.0 documents available on web site. Recommend a folder for current operational version and development versions.

3. GDS 2.0 external review

[**Issue**]: unclear what process GHRSST was to follow for getting buy-in from the stakeholders.

[**Consensus**]: The DAS-TAG members agreed to the approach laid-out by Donlon in the document "Procedure for External Review of the GHRSST Data Specification version 2.0"

We agreed to aim for having GDS 2.0 ready for review by Sept 31th, 2010.

4. netCDF 3 or 4?

[**Issue**] Need to decide if netCDF-4 is the **required** format for GDS 2.0.

[**Concern**] Raised by Piolle that IFREMER would not be able to support netCDF-4 until they have buy-in from their user communities.

[**Consensus**] It was agreed to state that netCDF-4 was the **preferred** format with GDS2.0. Products may be made available in netCDF3, which will be described as 'temporarily acceptable'.

The GDS2.0 will observe that acceptance of netCDF3 will be withdrawn at some point in the future (Date TBD at GHRSST 12). At which point netCDF-4 will be the **required** format.

GDS2.0 products entering the GDAC in netCDF4 format will not be required to provide MMR-FR files. Products in netCDF3 will still require MMR-FR files

[**Action**] A small report detailing the benefits of netCDF4 for GHRSST will be made available on the GHRSST website (Poulter)

5. ISO-19115 implementation

[**Issue**] Unclear how ISO-19115 would be implemented as part of GDS 2.0.

[**Consensus**] Ed presented work carried out in collaboration with Ted Habermann. The GDAC will produce ISO 19115-2 records for every granule. GDAC will add both dataset-level and granule-level metadata into the ISO record. Will use metadata provided in current DSD records. After adopting GD2.0, RDACs will be required to provide dataset level metadata in ISO format (a simple reformat of the current DSD).

6. Metrics

[**Issue**] This is a recurring action item created from several previous GHRSST meetings.

[**Consensus**] RDACs, GDAC and LTRSF need to provide monthly metrics to the GHRSST Project Office. These shall be published as RSS feeds for the Project Office to easily collect and analyze.

[**Action**] Casey and Bingham to create the specification for the Metrics RSS feed and publish in the ICD.

[**Action**] Bingham to contact ESDIS and investigate if GHRSST could leverage EMS services.

7. Operational issues

[**Issue**] The GDAC reported operational interfaces issues with Remote Sensing Systems (spamming the GDAC with 120+ versions of the same granule), the LTRSF also reported data quality issues observed in several datasets from various RDACs, and Users reported missing data. Request for a system to collect and track issues that would be available to users AND a procedure for communicating problems to the RDACs.

[**Action**] The DAS-TAG Chair (Bingham) to contact REMSS and request they change the operational interface.

[**Action**] The Project Office to include an issue tracking system to be implemented as part of the new web site.

8. MDBs

[**Issue**] No MDB in GDS 2.0

[**Consensus**] IFREMER's myOcean is the official GHRSST MDB

[**Action**] Add a description of the MDB to User Manual (Vazquez/Project Office)

[**Action**] Describe the process and specification for about updating the MDB in the ICD (Bingham)

9. Filename convention

[**Issue**] Request from the Application & Users TAG to include a timestamp in the filename convention.

[**Consensus – mostly**] Every GHRSST data file will contain information in the file name indicative of the measurement time of the data contained within the file. This information will be represented as YYYYMMDDTHHMMSS at the beginning of each file name.

Time will be represented in the following ways:

L2P – the start time of the first measurement point in the file

L3 & L4 – the mid-point of the measurement range.

[**For the record**] Ken Casey is opposed to adding time to the filename on the grounds that the proposed filename was a result of over 2 years of deliberation in which numerous "use cases" were examined and the

[**Action**] Update the Conventions section of GDS2.0 to reflect the new file name (Donlon)

DVWG BREAKOUT SESSION REPORT

G. Wick, S. Castro, P. Minnett, P. Le Borgne, I. Barton (H. Beggs), Ioanna Karagali, B. Evans, Daniel Valla (Argentina), A. O'Carroll, G. Corlett, Yi Chau (JPL), Steiner, J. Vasquez, C. Jeffrey

1. Updates:

Up till now focus has been in science behind DV. We are at a point that we might want to revisit Alice Mendett's model.

Pierre: DW Analysis:

At CMS working on 3 a spects: Seviri and polar orbiters. With SEviri you cannot go up that 60N. The high latitudes are very important, hence the polar orbiters to complement seviri.

Want a DW product from Seviri by 2011. Aim to provide uncontaminated-dw daytime data for Foundation analysis

2. Hourly analysis (L4 + DW)

Use Seviri (GEOS) + LEOS (frequent orbit, consist can be used together)

DT+ obs sst – reference (the reference is the problem). How do you cope with cloudiness

Do time Interpol of seviri obs. B y using previous night seviri, use cooling rate to reconstruct (interpolate) the time series of DW. There are spatial structures, but that was a dead end. No simple inference structure for spatial interpolation

0,05 deg res. Net CDF

vbls:

Reference, DT, confidence flag on 5-level scale (like the SST: 5: when it has been observed or interpolated, etc), Nb cases in day (where) provisional, std of calculations (TBD)

Seviri DW product

Model: DT + confidence

Product will include model outputs

Question: What is the adequate content of the product: Hourly? Daily? Real time? 2-hours from measurements, not end of day?

With Steiner: Using Polar orbiters;

What is the reference?

Prototype will be implemented early 2011

Next steps: Combining GEOS and LEOS and USE of NWP outputs

Reference should be consistent with the daytime values. Same satellite is the lesson learn. Found another problem: Fronts: strong displacement of cold water (15 deg vs 18 in background). Introduces artifacts. N ever sure of the reference because of advection issues and interpolation issues. In the North: bias corrections in the individual sensors (polar orbiter, MODIS, AVHRR), and has to be done for the reference as well.

How does this methodology can be a dapted to GOES? No objection to be used with MTSAT. For Goes-east no 12 mu channel. N o sufficient information to compute SST.

Could we tried to incorporate MODIS, AVHRR?

Bring the Indians and their GEO? Some progress with the ocean color group. Request from GHRSST to approach the Indians about sharing their GEO?

Purely polar approach?

How about using a model for first guess and iterate with data obs? Not practical for operations, but might be useful for theoretical analysis.

Where are the documents or progress reports from previous meetings? Reporting documentation made available to the GHRSST community.

Establish a website where we can put all the papers/models approaches, documentation in common place? Who do you address your questions to it?

Steiner:

Diurnal Warming in the Arctic:

WAPARC: June-July 2008 data: L2P, GHRSS, NWP fields for the arctic. Regridding at 2 deg, 67 North

DW: METOP SST – Reference. E xtreme events aligned with the wind minimum conditions from ECMWF of the order of 3-5 deg K. P olar orbiter based reference (5 day average of nighttime MODIS+METOP+ AATSR). T ime series of all available satellites for a f ixed point in the warming streak. Insolation at ToA at 75N is ~500 W/m2. Data observed from multiple polar orbiter satellites and moorings.

Using Pierre reference analysis, maps of distribution of significant evens (> 1 deg), they often occur in shallow waters and coastal regions. Some few in open seas. For all occurrences look at scatterometer winds and for 90% of cases, the events correspond to winds< 5 m/s. They don't know what happens with the 10% of events that happen at higher winds?

Do simple model to study the evolution of the warming to found how temperature changes with time

Any correlation with optical properties? Take the SST over warm events and compare with the MODIS K490 product. No apparent indication of any correlation with water turbidity. Foundation sst in the summer, you need to wait for nighttime in the summer…

Rules of Guideness or Indicators for corrections that can be implemented by users? Things to be aware? Wind speeds, for instance. Probability distribution of Chris' model. A lso document the test areas (Australia, Arctic, Tropical conditons (Minnett) and the Med). Need a catalog through the website.

Peter Minnett:

New student. DW in very shallow waters, coral reef. With reflectivity.

Led model RI number for convective instability and mixing at night.

Coral observing network (Caribbean and B ahamas) with CTD with 2m, below and 1m.

Intermediate depths. Full forcing for diurnal heating. Posh model with bottom.

Barrier reef (20 self-recording stations). Modeling so far retains heating into the evening. 3d model addressed with a 1-d model. Hard to get the coral reef topography. What to identify conditions when 1d model gives good representation. S olar absorption: compare the 9-band with hydrolight (sophisticated absorption model develop for ocean color apps). Don't have the right parameters. Need to guess some of the hydrolight parameters. Tidal conditions are affected by river outflow.

Bleaching not necessarily caused by prolonged events but also by 2-hours of diurnal events.

Gary Corlett:

Initial ARC validation:

Skin and diurnal correction needed to build CDR.

Core model (Sarah Millongton) and K-C to correct fro DW,

Skin to subskin:0.2, 2, 2.5 output dephs

Think the 0.2 is the drifter depth. GTMBA depth 1.0 me? Should we have agreed depths?

Skin-drifter ARC D@: if only correct for subskin).1 deg (ignoring DW correction).

Need to get the buoy depth right at the low winds.

Very accurate skin and subskin data set for model evaluation.

THEY INTERPOLATE FROM NWP FIELDS

Residual warming corrections plots Bias vs. time functions to be applied directly to the retrievals.

Correction is working but computation lay expensive. Residual warming and cooling rates add variance and can add to bias validation.

Issue: get the depth right!!! (Bias due to depths)

3. DVWG-GDS2 issues:

L2P products: Insolation was a core field. SSI dropped from core fields (useless). Wind field is very useful for filtering/detect DW. It has to be present. Wind has to be obtained from somewhere else and sample to your data. A lot of trouble. Scheptical of using L2p winds for estimation.

Use a DT analysis for a proxy for DW (diff SST provided and US NAVY analysis?).

Seviri DW product will be provided separate (not embedded). Would people want it to embedded the DW analysis?

Modis included a DW analysis based on REYNOLDS. But based on AMSR looks very good. Useful. T aking modis as an ex ample, there is a resistance to make the product any bigger. Better separate.

EOS products. O ne suggestion never accepted: work with the people that produces NWP fields: remove one degree of uncertainty by interpolating by producing an optimized wind field for the polar orbiters at the time of the overpass. N eed to work with the modeling community. H ave a standard NWP field that looks at 10:30 and the overpass in the afternoon. L2P has to provide some wind field, convenient for the users. E CMWF winds? B e careful every time you add a field to the L2p. Add time in processing time. More practical to have ancillary data set somewhere else. Big gap btn L2P and general users.

Up to the providers to embed or not the extra fields for DW.

L4: definitely should have DW embedded.

Time resolution and depth requirements?

Argo can provide the resolution needed at the surface? Crucial data set. Proposal to NASA? Essential. Need to follow-up with the DBCP and Argo communities?

Depth for buoys and modeling/assimilation communities:

-foundation analysis, temporal info on 3 target depths: skin, drifter depth, and 1m?

0.2m depth would be from modeling.

Write to “Dive-option view” for requirements (action for Gary)

Steve Raiser (modified Argo floats). Official endorsement to the funding agencies with the need for more of this modified Argo floats? Accuracy is not degraded (G. Corlett). It could be used as negotiation point. Hard to convince argo to do changes. Need money to produce/deploy some of this. The salinity campaign for Aquarious (subtropical Atlantic could be a test bed for modified argo sst. Important campaign for this group. Intercalibration of MW and IR. Very important for this group.

SPURS.JPL.NASA.gov with information.

More on analysis, methods, and uncertainty?

Jpoint NASA/ERNNEST meeting on DW?

-Estimates of DW and associated uncertainty remain experimental fields. Only 3 experimental fields allowed and we are taking 2?

3. Priorities

4. Future Workshop

HL-TAG BREAKOUT SESSION REPORT

Jacob L. Høyer[(1)], Bob Grumbine[(2)] Steinar Eastwood[(3)]

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ABSTRACT

During the GHRSST 11 science team meeting, the High Latitude Technical advisory Group (HL-TAG) held a breakout session for the scientists interested in SST observations at high latitudes and issues related to the detection of sea ice.

1. Introduction

The meeting was a follow up meeting from the HL-TAG intersession meeting in Copenhagen in March 2010. The topics for the meeting are given in the list below:

- GDS 2.0 review related to high latitudes
- In situ observation overview
- L2P ice treatment survey
- DW in Antarctica

2. GDS 2.0 review related to high latitudes

The GDS2.0 documents were reviewed and discussed during the meeting, paying special attention to the high latitude issues, such as the treatment and t ransparency of the sea ice in the L2P, L3 and L4 SST products.

The variable field sea_ice_fraction in the L2P data specifications was discussed and it was agreed that despite the focus on the sea ice concentration, the ice edge products can also be included as a 0 percent ice cover or 100 percent ice cover. At the moment, the sea ice is only required for the pixels with valid SST observations. The group can see the advantage of having sea ice in all pixels. However, to save space for the files, this is more relevant when L2P and L3 files are in netcdf4 format. The HL_TAG recommended to put the sea ice in an optional field.

To Increase the transparency of the sea ice detection, it was suggested to add an attribute field (possible a table) to account for

- Use unmodified
- Use multiple ice sources (not modified)
- modified ice information using onboard sensors

It was suggested to leave it to the producers when and where they will modify their ice information.

The variable sea_ice_fraction_dtime_from_sst was considered to be overkill, considering the nature of the sea ice products. Instead, it was suggested to give the times and source (daily/weekly) in the attribute. If multiple sources are used, list them in the attributes.

The issues discussed for the L2P were also applicable for the L3, since all the sea ice information is carried through.

Regarding the GDS2.0 specifications for the L4, it was recommended to include the sea_ice_fraction_error as an optional field. This requires that the sea ice products comes with error estimates, which they presently do not.

3. Sea ice survey

The HL-TAG organized a survey to all GHRSST L2P producers to better understand how they handle the issue of sea ice in their production chains. The survey was send to 9 producers, and 6 answers were received from:

NAVO (Bruce McKenzie)	AVHRR
JAXA (Misako Katchi)	AMSR-E
PML (Peter Miller)	AVHRR HRPT
MODIS (Peter Minnett)	MODIS A/T
OSI SAF (Pierre LeBorgne)	METOP AVHRR
ARC (Chris Merchant)	ATSR-1,2, AATSR

The questions concerned: External sea ice data source, inclusion of masking retrieval procedures, additional specific tests in addition to the cloud mask, day/night/twilight differences, validation of sea ice masking, treatment of sea ice over lakes and plans to produce ice surface temperatures (IST).

The outcome of the full survey will be p ut on t he web under the HL-TAG webpage. Some of the main conclusions are listed below:

- Many producers use sea ice mask from PMW
- Some producers have identified ice tests within their cloud mask system
- Only OSI-SAF has additional ice mask step in addition to cloud mask
- If a gl obal cloud mask is used, we recommend that additional instrument tests are performed (twilight issues)
- Very limited documented validation of the performance of the ice masking
- No specific plans to include Ice Surface Temperature in the production chains

4. Scientific presentations

A presentation was given on the diurnal warming (DW) events in the Antarctic by Pierre LeBorgne. DW events of several degrees were found in the Antarctic. The events are less frequent than in the Arctic, occur mostly in sheltered bays and good agreement was found between AVHRR/METOP, MODIS/A and MODIS/T.

Steinar Eastwood has participated in an International Arctic Buoy Deployment meeting in Oslo and reported about the plans for the coming summer. It was clear that most of the deployment are on i ce and only a few in the open waters. There is thus a need for more observations in the Arctic.

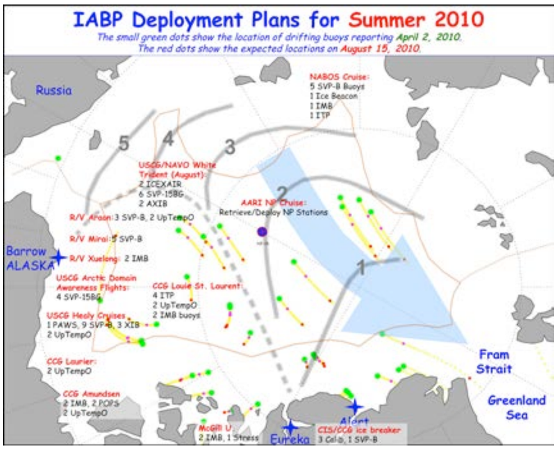

Figure: Buoy deployment plans in the Arctic Ocean during summer 2010.

5. Conclusion

The major conclusions and recommendations from the breakout session is given below:

GDS 2.0:

In general the HL-TAG supports the GDS2.0 specifications and only minor comments to treatment of sea ice w ere passed on t o the science team.

Sea ice treatment

HL-TAG encourages the producers to validate the L2P products in the vicinity of the sea ice regions (MIZ). It was recommended that the L2P producers to have onboard instrument sea ice detection. To compare different sea ice products, it was recommended to produce a sea ice GMPE/SUQAM

In situ observations:

HL-TAG will produce a summary of the in situ observations available for validating high latitude SST observations.

HL-TAG recommends more observations in the high latitudes (buoys and radiometer).

Preliminary plans were discussed about a joint HL-TAG, DV-TAG and STVAL-TAG intersession meeting in February 2011. Information can be found at: http://www.ghrsst.org/High-Latitude-Technical-Advisory-Group-(HL-TAG).html.

INTER-COMPARISON TECHNICAL ADVISORY GROUP (IC-TAG) BREAKOUT SESSION REPORT

Matt Martin (Chair)[(1)], Alexy Kaplan (Vice-Chair)[(2)], Dave Poulter (Rapporteur)[(3)]

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1 Summary

Matters arising

The terms of reference for the TAG were reviewed and accepted without change. The TAG welcomed Nick Rayner (UK Met Office), Viva Banzon (NCDC) and Robert Grumbine (NOAA) as new members and extended an invitation to Shiro Ishizaki (JMA) to join.

Requested changes to the GDS2.0

The proposed GDS2.0 specification was reviewed in the context of the terms of reference, after discussion the TAG requests the following changes to the document:

1) The Met.no and UPA should be added to the code table of data providers (as METNO and U PA). The entry 'NOCS' should replaced with 'NOC'.
2) Presently the GDS2.0 defines **sea_ice_fraction** as a decimal fraction in L4 products and an integer percentage in L2 files. These definitions should be homogenised in the form of a fraction.
3) The GMPE specification should allow for the inclusion of the version number of the source products entering the comparison.
4) The GMPE field **std** should be renamed to **standard_deviation**.
5) The GMPE product should add a v ariable **anomaly_field** describing the difference between each product and the GMPE median. This will require the creation of an additional dimension within the GMPE product.
6) Comments on t he L4 and G MPE document were supplied by Nick Rayner separately.

Observations on GDS2.0

The following are observations made on the GDS2.0, they are not recommendations of the TAG:

1) It was noted that data providers must endeavour to ensure that the netCDF variable attributes **_FillValue**, **valid_max**, and **valid_min** are stored with the same type as the variable field they are representing. Whilst this is not a strict requirement in CF, it is known to break some netCDF readers not followed.
2) It was noted that in the case of floating point variables, setting the **_FillValue** to the minimum possible value of a f loating point can cause a segmentation fault when changing platforms. For this reason this practice should be avoided.

Sea Ice

A detailed discussion regarding sea ice occurred. Providers of L4 pr oducts are requested to investigate including **sea_ice_fraction_uncertainty** as an optional field.

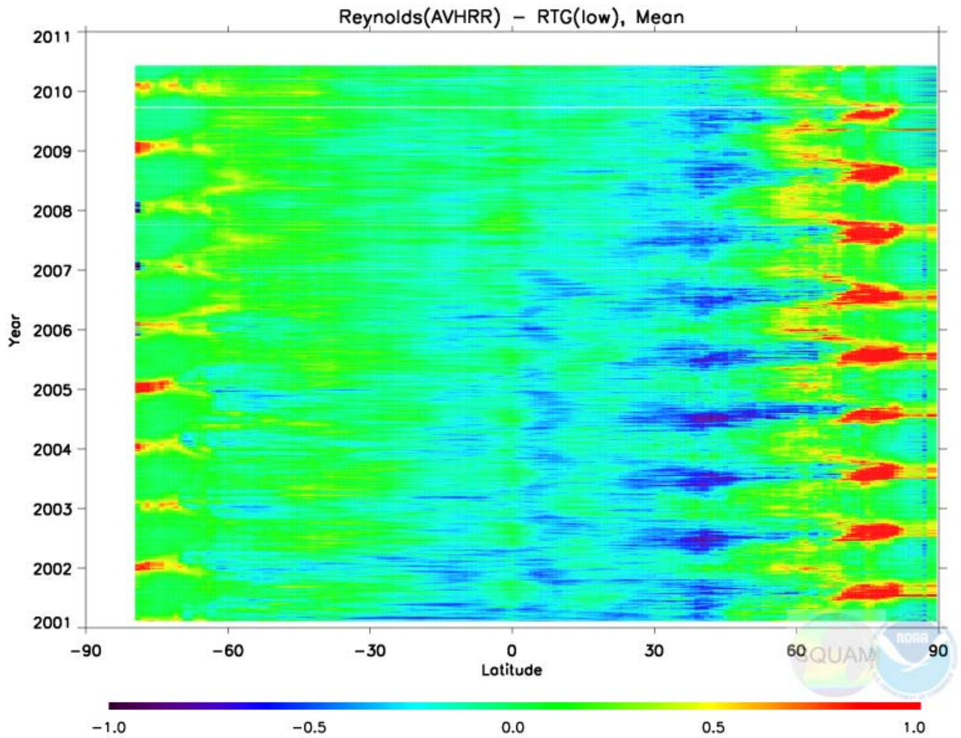
At present some L4 pr oducts provide an SST value where surface ice concentration is 100%; for some products this SST is a valid under ice temperature and for others it is know to be a simple interpolation. There is no mechanism in the L4 product specification to relate this information. However, the SST analysis error estimate could be used as a mechanism for indicating this.

2 Presentations made

Robert Grumbine, NOAA

Grumbine presented the talk **Cross-monitoring of L4 SST fields in the SST Quality Monitor (SQUAM).** He described the history of the SQAM system and demonstrated the ability of the SQUAM system to inter-compare L4 pr oducts. The impressive system is available via the link *http://www.star.nesdis.noaa.gov/sod/sst/squam/L4/*

The SQUAM system allows for the creation of maps, timeseries, statistics, histograms and Hovmuller plots of L4 comparisons. At present both 'Reynolds' products, RTG, OSTIA and ODYSSEA.



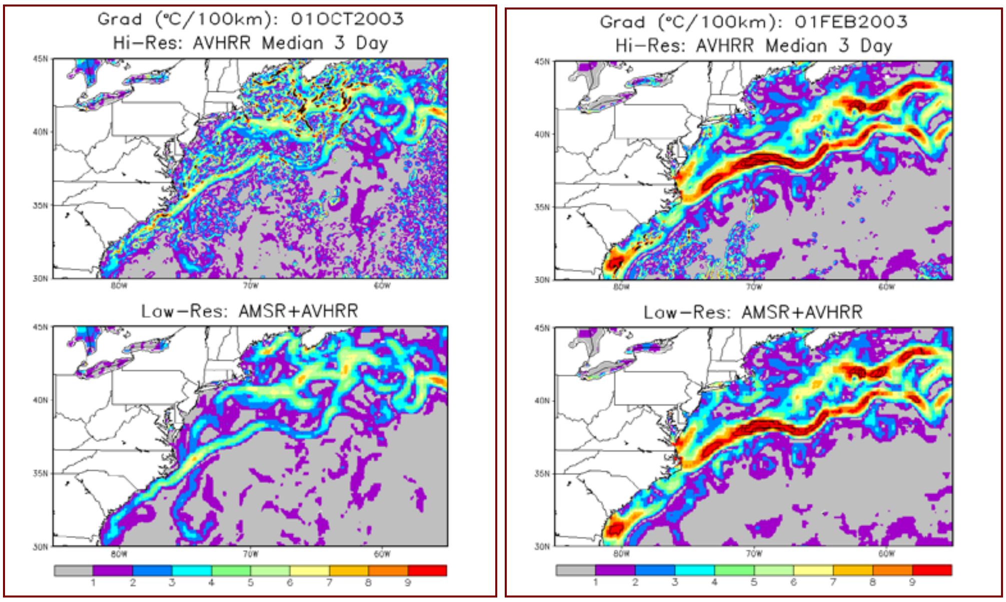
The SQUAM system will soon include K10 and NCODA. It was shown that much of the variability in the high latitudes is down to confusion between ice masks. A discussion ensued relating to the ways in which the SQUAM, GMPE and DDS systems could be integrated.

Dave Poulter, National Oceanography Center

Poulter briefly demonstrated the availability of KML output from maps produced by the GDDS system. A discussion then occurred over what demonstration 'class 2 pixies' should be demonstrated. It was agreed that simple event driven warnings should be basis of the initial system.

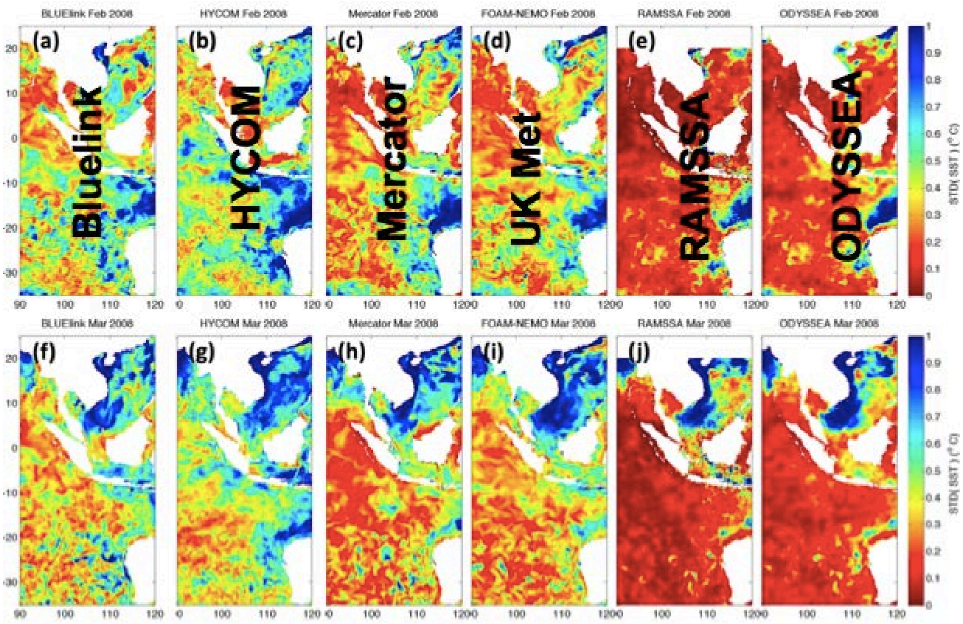
Dick Reynolds, NCDC

Reynolds resented the development of a two-stage SST analysis product, highlighting the use of a median filter to remove cloud contamination in Pathfinder V5, and also the volume of missing data in high gradient regions. Reynolds showed that in the two-stage processing, the high resolution analysis resolution is only improved when high resolution data are available.



Alexy Kaplan, NCDC

Kaplan presented the results from the GODAE model SST inter-comparison. Highlighting situations from the area north of Australia where mesoscale features where incorrectly forecast in all available models. This was shown to be an error in the statistics used in the intercomparison for calculation of the GHRSST data (e.g. variance instead of standard deviation).The use of Taylor diagrams was shown to be useful a nd was strongly encouraged.



Future work

A discussion on prioritisation of future work was held, with the main subjects being:

- Developing links between IC-TAG systems
- Use of independent data to assess L4 analyses
- Relationship with external groups including GCOS SST inter-comparison and GODAE OceanView.

A number of actions came out of these discussions, listed below, which will address these areas for improvements.

3 Action list

ACTION Fred Wimmer: Investigate and attempt to extend ISAR comparison to as many of the GHRSST L4 products as possible.

ACTION Matt Martin: Provide a s ummary document detailing the main aspect of each L4 product, especially including the meaning of SST in the presence of sea ice for each L4 product.

ACTION Matt Martin: Investigate performing regular inter-comparison of GMPE and ARGO data. It is suggested to use only night time data and perform comparisons over 10 days.

ACTION Dave Poulter: Investigate inclusion of GCOS inter-comparison products in the GDDS, report back to GXII.

ACTION Dave Poulter: Ingest model SST fields into the HRDDS, starting with FOAM in the first instance.

ACTION Dave Poulter: Investigate possibility of including ICOADS reports into the DDS system.

ACTION Dave Poulter: Include GHRSST L3 products and regional L4 products in the GDDS.

ACTION Dave Poulter: Once GDDS is ingesting in real time develop a c lass 2 pi xie to email providers when their analysis product exceeds a threshold difference from the GMPE median.

ACTION Dave Poulter: Develop dynamic masking for the GDDS prototyping analysis for regions with specific features. Specifically one of; the marginal ice zone, the Saharan dust influence zone, areas with diurnal variability or areas with no MW or no IR data input.

ACTION Dave Poulter: Introduce linking of analysis on the DDS to comparable analysis on the GMPE website. The DDS pages should allow users to 'see what GMPE says about this'.

ACTION Dave Poulter: Contact Sasha Ignatov to investigate mechanisms for linking analysis on the GDDS to comparable analysis on the SQUAM system.

REANALYSIS TECHNICAL ADVISORY GROUP BREAKOUT SESSION

Kenneth S. Casey[(1)], Tess Brandon[(1)], Nick Rayner[(2)]

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1. Introduction

The three main goals of the Reanalysis Technical Advisory Group (RAN-TAG) breakout session were to (i) review the current status and future plans of reanalysis activities; (ii) perform a review of the GDS 2.0; and (iii) identify the priority actions for the coming years.

2. Status Report

The first goal of the RAN-TAG breakout session was to collect and publish an authoritative status report, documenting the current state and future plans of the international SST reanalysis community. Twenty-one projects were summarized in an easy-to-understand and consistent format; these summaries will be made available on the GHRSST and LTSRF websites following the meeting.

Historical and *in situ* Activities:

Kaplan Historical analysis (Kaplan et al., LDEO): Currently generating an ensemble of possible realizations as a new means for capturing uncertainty in historical SST analyses. Collaborating with Alicia Karspeck at NCAR; analyses will be produced and served on the web.

ERSSTv3b (Banzon, NCDC): Blending of Pathfinder and *in situ* observations in the Extended Reconstruction SST highlights issues with Pathfinder V5; for this reason, satellite data has been removed from the most recent version (3b).

HadSST3 (Rayner, UKMO): Bias adjustments have been developed to create a homogeneous record of SST changes since 1850, HadSST3, with an ensemble of possible realizations.

Level 1 Activities:

AVHRR HRPT/LAC Reprocessing (Cornillon, URI): Plan to gather historical AVHRR HRPT/LAC archives to a central point and convert them to a consistent format. Met last year in Santa Rosa and started the process, but not much progress since then. People expressed interest and a few more archives have been identified. It is not clear in some cases how much metadata from Level 1a and 1b (which arrives via the downlink) has been saved. The metadata is needed to reprocess the data.

Level 2 and 3 Activities:

AVHRR Pathfinder SST (Casey, NODC): AVHRR Pathfinder V6 production system is under development. A lot of improvements have been made to the processing and algorithm in addition to GHRSST compliance, including latitude band coefficient derivation to remove artifacts seen in V5. Pathfinder V6 will produce L2P, L3U, and L3C daily ascending and descending files, with planned improvements to data access. Goal is to have one year available by October 2010 and the rest by October 2011.

Correcting Pathfinder V5 Biases (Saunders and Millington, UKMO): Using ATSR series and TOMS aerosol information, providing adjustments for the whole Pathfinder AVHRR period, using direct matchups between AVHRR and ATSR, when possible, and adjustments at same overpass times before 1991.

(The group discussed the origin of the consistent relative negative bias in Pathfinder AVHRR. This is thought to be due to either cloud contamination (NODC) or to a consequence of the tuning of the algorithm to drifting buoys with a northern hemisphere bias in sampling (NCDC), which introduces a seasonally varying bias to the SST. It is hoped that Pathfinder V6 will not have this problem, although it would be interesting to resolve it for v5, as it has been used in various products.)

MODIS SST Improvements (Evans, RSMAS): Work on VIIRS SST, MODIS and Pathfinder clearly linked now e.g. work done on MODIS applied in Pathfinder SeaDAS environment. MODIS collection 6 and hypercubes to be completed soon, moving to a continuous function approach rather than discreet look-up tables.

ATSR V2 (Corlett, U. of Leicester): In creating ATSR version 2, historical problems were found in the archive and it took longer to produce the data set than expected. It is in L2P format and will be put into the GDAC and LTSRF soon.

ATSR Reprocessing for Climate (Merchant, U. of Edinburgh): ATSR Reanalysis for Climate retrieves SST by column water vapour, not by latitude band (ATSR-2 and AATSR have been completed so far). It uses different cloud screening (Bayesian) from version 2. SST from ARC is colder than version 2 for ATSR-2. ARC is 0.1 degree and not currently planned to put into L2P.

IMOS HRPT AVHRR SST (Beggs via Casey, ABOM): L2P and L3C reprocessing produced in GDS 2.0 format. Data is available back to 1996.

Level 4 Activities:

Multi-sensor Ultra High Resolution (Chin, JPL): SST analysis using wavelets. Currently, one year's worth of 1km data has been produced, but this currently only covers North and parts of South America. Planning to use various validation sources, e.g. ATSR and Denmark *in situ*.

MGDSST Reanalysis (Ishizaki, JMA): Plan to process MGDSST analysis back to 1981. Discussing ways to get into GDAC and LTSRF.

Mediterranean and Black Sea Reanalysis (Nardelli via Poulter, CNR): Generating 1km ultra high resolution product around Italy with promising results, but exploring issues with correlation lengths. Product estimated to be available for testing in September.

OSI-SAF Sea Ice Concentration (Eastwood, DMI): Reanalysis was finished in January 2010 and reviewed through EUMETSAT review procedures. Daily products from SMMR and SSM/I. L3 format on polar stero and EASE grid, with dynamical tie points and error estimates for each data point. Discussing resources with EUTMETSAT to update beyond 2007 and routinely thereafter. Monthly updates will be available in 2012.

OSTIA Reanalysis (Martin, UKMO): Produced a preliminary version of the OSTIA reanalysis for 25 years using Pathfinder v5 and ATSR v2, ICOADS and OSI SAF sea ice. Investigating aspects in the ATSR-1 period. This is a MyOcean product, but would like to provide for GHRSST. Next version will be available end of 2010.

DOISSTv2 (Reynolds, CICSS-NC): No new updates but production continues daily.

DOISST "Two-Stage" High Resolution (Reynolds, NCDC/retired): Daily two-stage OI builds on the Daily OI processing to add 4km analysis from AVHRR Pathfinder v5. June 2002-Dec 2006 done; issues found with Pathfinder v5.

G1SST (Chao, JPL): G1SST analysis supports real time operations in coastal areas. One year's reanalysis is being providing to PO.DAAC. It takes 7-8 hours to process one day of data and clusters need to be purchased to produce a longer reanalysis. If there is interest, please discuss with NASA management. The MUR product is retrospective and G1SST is a real time product.

DMI L4 Reanalysis (Hϕyer, DMI): Arctic reanalysis using Pathfinder v5 and ARC data. Could work on test year of data from v6 to see differences. Available March/April 2011.

POES-GOES Blended Analysis (Harris, OSDPD): POES-GOES blended analysis is an operational product only, but if funding was identified, could consider a retrospective analysis.

Data Tool and Intercomparison Activities

GCOS SST Intercomparison Facility (Brandon, NODC): Linear trend maps for historical products have been added to the facility. Fixed bug in some of the monthly satellite fields.

GHRSST L4 *in situ* matchup validation (Armstrong, JPL): ATSR L2P matchups used for validation purposes; to provide validation for L4 products

In general, the availability of reformatted and/or reprocessed data in GHRSST formats and archives from all possible satellite sensors is becoming almost complete. The group asked whether there was any progress on SEVIRI and GOES East and West reprocessing.

The group also identified a few gaps in the activity reporting. These include reprocessing of IASI L2P data back to April of 2008; reprocessing of SEVIRI L2P by OSI-SAF, and GOES and MT-SAT reprocessing by OSDPD. An L4 analysis from Canada was also identified for tracking. The RAN-TAG solicited summaries for these activities and will include them with the 21 others on the GHRSST and LTSRF websites once received.

Overall, GHRSST reanalysis activities are progressing extremely well, with efforts underway, completed, or planned for the reprocessing of every major sensor providing L2P SST.

3. GDS 2.0 Review

The second goal of the RAN-TAG breakout session was to evaluate and make recommendations regarding the GDS 2.0, with an emphasis on the L3 and L4 product specification documents. Several members shared positive comments about the overall GDS 2.0. Both the

Pathfinder Version 6 and the GCOS SST Intercomparison projects have begun using the new specifications and have not experienced any problems.

Two questions regarding the new specifications were addressed. Discussions clarified that delayed-mode data sets will also need to conform to the GDS 2.0. An example of a unique data set – an adjusted reanalysis data set that has been standardized to a local time – was posed as a test to the new specifications. Discussions led to the conclusion that the GDS 2.0 is flexible enough to accommodate such a data set.

Finally, the TAG discussed an issue regarding the use of the term “target accuracy” in a table in the L4 product specification document. The GDS needs to define what this term means, in terms of what the reference data set is. Information in this table is explained in more detail in various places throughout the GDS, so an action was given to the authors of the GDS to create a small section in the overview of the GDS giving some justification and detail on these requirements for reference throughout the GDS.

4. Prioritized List of Actions

The third goal of the breakout session was to develop a prioritized list of actions for the coming years. In preparation for the meeting, the Chair solicited input on priority actions from members. During the breakout session, the group reviewed this input and ranked the actions according to popularity by show of hands. While there was no rigorous structure to the ranking method, the following list shows the top priority actions for the RAN-TAG in the coming year:

1. Begin production of Pathfinder Version 6, 1981-near present, in GHRSST L2 and L3 format, for GAC and available LAC/HRPT
2. Fix the calibration of AVHRR and AMSR-E to remove latitudinal and other biases before reprocessing of data sets
3. Create MODIS retrospective data in GHRSST format
4. Complete ARC science for ATSR-1 to AATSR
5. Assign proposed HadSST3 *in situ* bias adjustments on a per-observation basis to allow incorporation into GHRSST reanalysis products
6. Test and possibly integrate improved AVHRR Brightness Temperatures and/or physical retrieval methods into Pathfinder Version 6
7. Create GOES retrospective data in GHRSST format
8. Improve data discovery and access mechanisms at GDAC and LTSRF – Live Access Server and THREDDS Catalogs
9. Investigate the stability and robustness of the reanalysis products in the Marginal Ice Zone
10. Incorporate ICOADS v2.5 observations into GHRSST reanalysis products
11. Complete GCOS SST Intercomparison pilot study: (i) generate SST analyses using common quality-controlled input data from UKMO; and (ii) incorporate analyses into intercomparison framework and evaluate results
12. Explore NIST traceability for SST Climate Data Records
13. Undertake a graphics face-lift for the entire GCOS Intercomparison site

Additional actions brought up during the breakout were also discussed. These include the generation of a comprehensive “picture book” from the graphics on the GCOS Intercomparison website, and a thorough global evaluation of sea ice algorithms and products, as well as a thorough assessment of associated uncertainties.

5. Terms of Reference and Membership

The TAG also performed an annual review of its Terms of Reference and membership. When the TAG was first created, these Terms of Reference were laid out with the intention that the group would implement a consensus processing system to create the official RAN-TAG L4 SST product. However, it quickly became clear that such a consensus did not exist. Currently there are several L4 SST products generated as part of GHRSST, each using a different processing system. It also quickly became clear that there was a strong need to establish more historical L2P inputs. Based on this review, the chair of the RAN-TAG accepted an action to update the Terms of Reference to reflect the more "modern" RAN-TAG vision, and will distribute the updated Terms to the group for review and approval.

The group also reviewed its membership. Mike Chin, Steinar Eastwood, Alexey Kaplan, Matt Martin and Eileen Maturi were added as new members, with invitations for membership also extended to Jonah Roberts-Jones, Chris Merchant and Bruno Buongiorno Nardelli (these last three were not present to confirm and will be contacted via email by the RAN-TAG chair). No current members were removed from the RAN-TAG as a result of this review.

Finally, the RAN-TAG approved Ken Casey to continue on as Chair for another year, but will consider other names for nomination at next year's meeting.

6. Summary of Action Items

Action: Update Terms of Reference and RAN-TAG Member list
Responsible Party: Ken Casey

Action: Write a section in the GDS 2.0 overview document, providing appropriate text and making reference to other documents in the GDS that explain the meaning of the information in Table 5-1 in the L4 product specification document (e.g. “target accuracy”)
Responsible Party: Ken Casey, Craig Donlon

Action: Recommend the creation of an HRPT Working Group under the RAN-TAG, chaired by Peter Cornillon
Responsible Party: RAN-TAG

Action: Document biases observed in the GCOS SST Intercomparison Facility
Responsible Party: GCOS SST Working Group

Action: Submit to Ken Casey a 1-slide summary of current and planned efforts within MyOcean to reprocess SEVIRI L2P
Responsible Party: Pierre LeBorgne

Action: Submit to Ken Casey a 1-slide summary of current and planned efforts by OSDPD to reprocess GOES and MT-SAT L2P
Responsible Party: Andy Harris, Eileen Maturi

Action: Submit to Ken Casey a 1-slide summary of current and planned efforts by EUMETSAT to reprocess IASI data into L2P
Responsible Party: Anne O’Carroll

ST-VAL BREAKOUT REPORT

Gary Corlett

Leicester University, UK, *Email: gkc1@leicester.ac.uk*

Gary Corlett (GC) gave a short introduction to the session summarising the objectives. These were to obtain:

- Feedback on data buoy usage within GHRSST for DBCP
  - Define priority regions of interest
- Progress towards implementation of GDS 2.0 SSES
  - What are the remaining issues/problems

The session was split into two topics:

1. Data buoy usage in GHRSST
2. GDS 2.0 SSES

1. Data buoy usage in GHRSST

GC presented an overview of the Data Buoy Cooperation Panel (DBCP) and its potential interactions with GHRSST on behalf of David Meldrum who was delayed on route to the meeting. The main issue to be addressed was which area would GHRSST recommend for a pilot project high resolution drifter deployment? A general discussion concluded high latitudes, the tropical Atlantic or the western Pacific as the current areas of high priority. The highest priority would be Southern high latitudes.

Several participants then presented their current procedures for obtaining and quality controlling buoy data. Summaries were made by ATSR, NOAA-NESDIS, NAVOCEANO, CMS/OSI-SAF and the Bureau of Meteorology. This was followed by a summary from Nick Rayner (NR) on using ARC data to QC historical buoy data.

It was clear that nearly all groups obtain their data via the GTS data but that we have markedly different QC approaches and probably QC results. Bob Evans (BE) said that MODIS uses data from NAVOCEANO but they apply extra QC steps (BE to summarise). Gary Wick uses similar approach to CMS/OSI-SAF for QC of buoy data for research purposes.

BE said that Bill Emery has submitted a paper on biases between different drifting buoy manufacturers. This meant that it is hard to quantify on regional biases as there is a regional distribution in buoys from different manufacturers.

The group recognised the current difficulties in separating the performance of the buoy from the performance of algorithm, something that is facilitated by multi-way match-ups to assist. GC reminded the group that all groups had committed to provide their MDBs to MyOcean to be merged into the MyOcean MDB for exactly this reason.

The group supported the idea of a controlled inter-comparison of drifting and moored buoys.

BE suggested that all groups should be quality controlling data from moored buoys as well as drifting buoys if they do not do so already.

Viva Banzon (VB) asked if the group felt that the current drifting buoy coverage was suitable or whether additional buoys would be useful. VB suggested reading a paper from NOAA on this topic (Zhang et al, 2006) that had already attempted to answer this question. The group could not answer this question but would add it to its work plan. Possible regions where more buoys would be useful include the upwelling zones. However, as these are heavy fished national economic zones they may be better dealt with by radiometer deployments on ships.

NR noted that a lot of buoy operators are reusing the same WMO ID several times, which makes it hard to track individual buoys. The current regulations should be verified with JCOMMOPS. Also, the group should look to see how much drifting buoy data is available that has not made it onto the GTS. NR suggested looking at the new release of ICOADS (version 2.5) to see if non-GTS data is included.

Two immediate actions arose from the discussion on data buoys:

1. Pierre Le Borgne: To add Bob Evans, Nick Rayner, Dick Reynolds and Gary Wick to the MF buoy blacklist mailing list
2. Bob Evans: To provide details of extra QC steps done to buoy data prior to ingestion into MODIS MDB.

The work plan for the next year should include:

- The exchange of buoy black lists between groups
- An investigation of the impact of varying QC approaches

- Separate NRT activities/requirements from offline/CDR requirements.
- Include moored buoys to QC procedures if not already done so
- Assess current buoy coverage and identify areas where additional data are needed for SSES.
- Consult widely with buoy providers to identify non-GTS historical data, starting with latest ICOADS release.

The group makes the following suggestions (recommendations) relating to data buoys:

1. DBCP/JCOMM should carry out a controlled buoy inter-comparison
2. L2P producers should use multi-sensor matches as a minimum for rejecting bad buoys
3. DBCP/JCOMM should ensure all buoys have unique IDs.
4. DBCP/JCOMM should target Southern high latitudes for a pilot project deployment for high resolution drifters.

2. GDS 2.0 SSES

GC gave a host introduction to GDS 2.0 SSES. GDS 2.0 SSES must:

- Comprise bias and standard deviation relative to agreed reference source
- Be supported by a quality level
- Be defined according to the SSES Common Principles
    - These will be maintained on GHRSST website
- Be documented and traceable
    - L2P providers must provide documentation on their schemes to be maintained on GHRSST website

Only one of the common principles agreed at GHRSST X was refined, relating to skin to sub-skin conversion for L2P products that contains SST-skin. The current text of "A common skin to sub-skin adjustment of 0.17 K should be used" does not consider retrieval schemes that include the skin to sub-skin adjustment as part of the atmospheric correction. The revised text for this principle is

- L2P producers that provide SST-skin should use as a minimum a constant offset of 0.17 K to adjust SST-skin to SST-sub-skin for SSES production. If sufficiently accurate wind-speed data is available then L2P producers are encouraged to allow for the wind speed dependence of the skin to sub-skin adjustment.

Several participants then presented their progress in adopting the SSES common principles and providing GDS 2.0 compatible SSES. Summaries were made for ATSR, IASI, NAVOCEANO, CMS/OSI-SAF, MODIS and the Bureau of Meteorology.

In general the group felt that good progress was being made towards providing uniform SSES across all products, albeit that some minor incompatibilities with the SSES common principles remain. Further iterations and refinements would be sought over the next year.

The issue of documentation is still a concern and will be a high priority item over the next year. In addition the group felt that the project would benefit if all SSES schemes were peer-reviewed. BE noted that a paper on the MODIS hypercube was currently in review. This paper extends on an earlier hypercube-type approach from Castro et al (2008).

The group discussed the possibility of a combined IASI/AVHRR retrieval. Pierre LeBorgne (PLB) said there were no plans for this at the moment but a common MDB now exists so that AVHRR biases can be investigated using IASI atmospheric profiles.

Two other issues were raised and discussed relating to SSES. These were

1. Jacob Hoeyer pointed out that large regions of the oceans (such as the Baltic Sea) have little if any drifters so how can users we assured that SSES are valid in these regions? GC said that currently producers have to rely on finding match-ups in other regions that have similar retrieval conditions. Although this is not ideal it is all that can be done until we increase the drifter coverage in these locations.
2. Anne O'Carroll pointed out that retrieval algorithms for future sensors will be able to use Level 1B uncertainties and have much better defined retrieval errors. How should these be incorporated into SSES and L2P? GC said that currently the SSES must be given in relation to drifting buoys. However, alternate satellite-only uncertainty estimates could be added as experimental fields. It was felt that users would not accept data that only had a satellite-derived uncertainty estimate.

No immediate actions arose from the discussion on SSES.

The work plan for the next year should include:

- Provision of documentation for the website and user manual
- Continued refinement and adoption of the SSES common principles
- Peer-review of SSES schemes

No suggestions (recommendations) arose from the discussion on SSES.

3. Next meeting

The session was concluded with a discussion regarding a inter-GHRSST ST-VAL meeting. The group recognised the overlap in personnel with both the DVWG and HL-TAG and so a combined meeting of all three groups will be sought in February 2011.

4. References

1. Castro, S. L., G. A. Wick, D. L. Jackson, and W. J. Emery, 2008. Error characterization of infrared and microwave satellite sea surface temperature products for merging and analysis, J. Geophys. Res., 113, C03010, doi:10.1029/2006JC003829.
2. Zhang, H-M., R. W. Reynolds and T. M. Smith, 2006. Adequacy of the In Situ Observing System in the Satellite Era for Climate SST, Journal of Atmospheric and Oceanic Technology, 23, 107-120
3. Gary Corlett & Pierre Le Borgne (24th June 2010).

RESCUE & REPROCESSING OF HISTORICAL AVHRR ARCHIVES (R2HA2) BREAKOUT TERMS OF REFERENCE

Peter Cornillon

University of Rhode Island, USA, Email: pcornillon@gso.iro.edu

The objective of the Working Group for the Rescue & Reprocessing of Historical AVHRR Archives is to:

- Identify historical archives of AVHRR HRPT and LAC data,
- Copy these archives to a central data repository,
- Convert the data to a consistent L1x data format, and
- Reprocess these data to L2P.

In order to accomplish this, the Working Group will:

- Identify historical archives of AVHRR HRPT and LAC data - Regional Data Providers (RDPs),
- Identify a central assembly center(s) (CAC),
- Define a format in which the data the are to be stored,
- Define if/how contributions are to be stitched together - to be done at the CAC,
- Identify where the reprocessing is to be performed, and
- Define the SST algorithm to be used to reprocess.

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CHAPTER 4

MEETING SUMMARY

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Summary of the 11th GHRSST Science Team Workshop (G11)

Craig Donlon, GHRSST Science Team Chair

ESA, The Netherlands, Email: craig.donlon@esa.int

Donlon began with a detailed review of Actions outstanding and initiated at the Workshop. 9 actions remained from the 9th ST workshop, 8 actions remained from the G10 workshop and 70 new actions were raised at the 11th Workshop. Each action was reviewed and target dates set for completion as reported in https://www.ghrsst.org/files/download.php?m=documents&f=G11-Actions-agreed-in-plenary-2010-06-25.pdf. Donlon thanked the teams for their activities and dedication to GHRSST and urged all Science Team members to focus on closing all outstanding and new actions in good time to ensure the smooth running and further development of GHRSST in support of user applications.

Donlon then began a review of the Lima meeting starting with a summary of the objectives set at the start of the meeting. He noted that GHRSST continues to provide a stable system that is delivering quality data products that are useful to a variety of international operational and scientific users. The product line now includes consensus L2P L3*x* and L4 products provided by a variety of producers and for all of the major SST satellite sensors. The fact that GHRSST uncertainty estimates are now being criticised and used shows that GHRSST has an active user community and that there is more to be done to accommodate the standing user requirement for better uncertainty estimates with each satellite measurement.

The R/GTS services (GDAC, LTSRF, RDAC, GMPE, HRDDS, MDB) are also being used more and more and statistics shown at the meeting show significantly increased user numbers, volumes of served data and files delivered since 2006. New initiatives (e.g. development and coordination of AVHRR LAC “global” data sets) show that the GHRSST Science Team is alive and is addressing issues that require international collaboration. Working together to solve such problems is at the core of the GHRSST activity.

Donlon then presented example user statistics reported at the meeting by PO.DAAC, The Royal Australian Navy and the University of Hawai’i which underlined the importance of a “stable and credible” GHRSST system and Science Team. The GHRSST responsibility to its user community is a serious issue and must be at the forefront of the Science Team focus. Donlon noted the advice from the GHRSST Advisory Council Chair:

> *“There are now more users than ever before and the AC advised that care was needed to serve this user community well.”*

Against this backdrop, Donlon explained that GHRSST needs to strive towards excellent and up-to-date documentation, products and services that are maintained in place and are continually reviewed to endure that they remain useful to the GHRSST user community. This is even more important now that GDS-2.0 has been effectively agreed and will be in place in the coming months. Furthermore, the tools surrounding GHRSST (e.g., NAIAD and dataminer at IFREMER and JPL, NOAA SQUAM. MetOffice GMPE, NOC HRDDS, various WMS and DataCasting applications) must strive to maximise their utility to help users access and make full and proper use of GHRSST products and services. The fact that these tools continue to be developed and maintained demonstrates their usefulness.

Donlon then turned to address the various working groups (WG) and technical advisory groups (TAG) within GHRSST. All of the groups are functioning well and are now quite mature, working on specific problems and issues with full user engagement. All groups have ‘local’ activities that are pushing GHRSST and it is in the WG and TAG that GHRSST ‘gets the work done’. Donlon thanked all of the TAG and WG chairs and their members for their continued involvement, support and excellent outputs and hoped that the work in the coming inter-sessional period would keep international collaboration strong. In particular, Donlon noted the significant development of ERNESST and the NASA SST-ST and was pleased to see that these important groups were building GHRSST into their plans. In summary, GHRSST remains healthy and as dynamic as it ever was, with a firm foundation in user needs.

Donlon then reviewed the proposed terms of reference for a new working group: The Rescue &

Reprocessing of Historical AVHRR Archives (R2HA2-WG) Working Group. These were endorsed by the science Team as follows:

The objectives of the Working Group are to:

- Identify historical archives of AVHRR HRPT and LAC data,
- Copy these archives to a central data repository,
- Convert the data to a consistent L1x data format, and
- Reprocess these data to L2P.

In order to accomplish this, the Working Group shall:

- Identify historical archives of AVHRR HRPT and LAC data - Regional Data Providers (RDPs),
- Identify a central assembly center(s) (CAC),
- Define a format in which the data the are to be stored,
- Define if/how contributions are to be stitched together - to be done at the CAC,
- Identify where the reprocessing is to be performed, and
- Define the SST algorithm to be used to reprocess.

Membership is Open and P Cornillon was elected as Chair to the group.

Donlon explained that significant progress had been made at the 11th ST meeting towards a final version of GDS2.0. A revised and simplified GDS document structure had been agreed in which only 3 volumes would be produced: The GHRSST Technical Specification (TS), the GHRSST Interface Control Document (ICD) and a User Manual (UM). All 'Showstopper' issues regarding the netCDF version and conventions for filenames had been agreed through discussion, compromise and consensus at the meeting and the technical content had been endorsed by the GHRSST AC. Te next steps involved assembling a final version of the GDS2.0 and submitting this to an external review procedure, as endorsed by the GHRSST AC. In order to accomplish this in a timely manner (and address the urgent concern of some projects that urgently required the GDS-2.0 for implementation), Donlon noted that the GDS-2.0 shall be available by 9th July 2010 and the GDS 2.0 Review shall be complete by September 30th 2010. This means that all **inputs to the GDS-2.0 will be CLOSED on 1st July 2010** and after this point, the document would be revised based on a formal external process and DAS-TAG review. Donlon made clear that this was a formal process and has strict deadlines in order for the review to be successful. He urged the Science Team to provide all inputs and changes to GDS-2.0 **as soon as possible and this is a tight schedule.** Donlon thanked the teams involved for their significant efforts and inputs so far noting that the final push to complete the work would be challenging to all involved.

Turning then to the CEOS SST Virtual Constellation proposal, Donlon recalled that an initial proposal has been developed and is available at https://www.ghrsst.org/files/download.php?m=documents&f=CEOS-SST-VC-Pre-Proposal-to-SIT-Iss-1-Rev-6-FINAL.doc, and requested the ST to review the documents and suggest changes as soon as possible. It was expected that following the endorsement of the GHRSST ST of the main elements of the proposal, a complete draft will be developed and submitted to CEOS at the next Strategic Implementation Team (SIT) meeting in early 2011. After this, if successful, the SST-VC would be developed into a full proposal of activities with GHRSST as the implementation body for the SST-VC. The final form of the initial proposal will be developed by C. Donlon and K. Casey in the coming months.

Donlon then urged the GHRSST Science Team to consider the presentation made by D. Meldrum on behalf of the Data Buoy Cooperation Panel (DBCP) to improve SST measurements in support of better satellite SST. This was a significant opportunity for GHRSST to help evolve the ocean observing system in a positive and synergistic manner in order to improve the quality of SST products. Donlon urges the Science Team to contact Meldrum to enable the proposed joint DBCP-GHRSST Pilot project. The proposal was available at http://www.ghrsst.org/modules/documents/documents/draft-DBCP-GHRSST-PP-proposal-v1.0.doc

Donlon then reviewed the GHRSST Science Team membership. S. Eastwood (Met.no, Norway) was proposed and admitted to the Science team. The following Chairs for WG and TAG were agreed:

- DAS-TAG: Bingham, Armstrong and Piolle
- IC-TAG: Martin and Kaplan
- HL-TAG: Hoeyer and Grumbine
- RAN-TAG: Casey and Rayner (Replacement requested)
- AUS-TAG: Vazquez and Chin
- ST-VAL: Corlett and LeBorgne

- DV-WG: Wick and Castro
- EM-WG: Harris and Merchant
- R2HA2-WG: Cornillon

Following some discussion and debate it was agreed that the 12th GHRSST Science Team Meeting (G12) will be held at the University of Edinburgh, Scotland, Mon 27th June – Fri 1st July 2011. Donlon thanked Chris Merchant for arranging the organization of the workshop and urged all science team members to help Chris in the planning and organization where they could.

Donlon then thanked all at IMARPE for organising the Meeting and specifically Jorge Brousset (President of IMARPE), Renato Guevara (Scientific Director of IMARPE), and Godofredo Cañote (Executive Director). Donlon noted the excellent support and organization of Dr Sara Purça at IMARPE supported by Jorge Vazquez. Their dedication made the GHRSST 11th ST meeting truly remarkable. Donlon then thanked all sponsors of the meeting including IRD, CONCYTEC, NOAA, NASA, US-Navy, NOPP, EUMETSAT and ESA, and others. Finally, Donlon thanked the GHRSST Science team for continuing to support GHRSST and wished all a safe trip home.

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APPENDICES

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Appendix I: Agenda for the GHRSST 11th Science Team Meeting

Sunday, 20th June 2010

Time	Agenda item	Session leaders
18:30	Informal dinner for those who are Interested In going out In Lima and catching up on the SST gossip. Meet In the Plaza del Bosque Hotel Foyer.	

Monday, 21st June 2010

Time	Agenda item	Session leaders
08:15	**Registration & Coffee Location Paz Soldan meeting room on the 9th floor**	
Plenary session in the Paz Soldan meeting room on the 9th floor		
08:45	**Welcome and logistics:** Sara Purca	**Chair: C Donlon Rapporteur: K Casey**
08:50	**Welcome address from the President of IMARPE:** Admiral Jorge Brusset.	
09:00	**Review of 11th ST meeting Agenda:** Craig Donlon	
09:05	**Report from the GHRSST Science Team Chair** • Overview of the GHRSST project status, priorities and aims of the Workshop. • Expected Outputs from this workshop	
09:30	• Review action items since the 10th GHRSST Science Team Meeting	
10:00	Coffee	
Session 1. R/GTS Components: Reports to the GHRSST Science Team		
10:20	**Europe report (MyOcean)**: Pierre LeBorgne	**Chair: C Donlon Rapporteur: K Casey**
10:50	**Australia report:** Ian Barton	
11:10	**USA report (MISST):** Peter Minnett	
11:30	**GHRSST GDS-TAG Report:** Kenneth S Casey/Chelle Gentemann/Craig Donlon	
11:50	**High Resolution Diagnostic Data Set (HR-DDS) Report**: David Poulter	
12:10	**Global Data Assembly Centre (GDAC) report and PO.DAAC report**: Ed Armstong	
12:30	**Long-Term Stewardship and Re-analysis Facility (LTSRF) and Reanalysis TAG (RAN-TAG) report :** Kenneth S Casey and Nick rayner	
12:50	Lunch	
14:00	**Diurnal Variability Technical Advisory Group (DV-WG) report:** Chris Merchant (Gary Corlett)	**Chair: C Donlon Rapporteur: K Casey**
14:20	**SSES/Validation working group (STVAL) report:** Pierre LeBorgne & Gary Corlett	
14:40	**GHRSST Inter-comparison TAG (IC-TAG) Report:** Matthew Martin	
15:00	**GHRSST High Latitude TAG (HL-TAG) Report:** Jacob Hoeyer	
15:30	Tea	
16:00	**GHRSST Data Assembly and Systems TAG (DAS-TAG) Report:** Andrew Bingham	**Chair: C Donlon Rapporteur: K Casey**
16:20	**GHRSST AUS-TAG report:** Jorge Vazquez	
16:40	**The importance of SST for accurate wind speed retrievals from scatterometer measurements**: Tim Lui	
17:00	**Preliminary assessment of a 20-year reanalysis using OSTIA:** Matthew Martin, Jonah Roberts-Jones, Emma Fiedler	
17:20	**Open discussion and identification of key issues to address, Breakout group preparations and logistics**: Craig Donlon/ Sara Purca	
18:00	**Close**	
18:30	**Icebreaker in the Terraza on the 9th floor of the Plaza del Bosque Hotel.**	

Tuesday, 22nd June 2010

GDS 2.0 Breakout group draft agendas

Final agendas will be provided by the breakout group session leaders at the session

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BG-1: Inter-comparaison TAG (IC-TAG) GDS 2.0 discussion
The main aims of the breakout session are:
1. To review the GDS2.0 documentation, particularly for L4 and for GMPE.
2. To review L4 inter-comparison work over the past year in the form of presentations.
3. To make recommendations for improved L4 inter-comparison work over the coming year.

Preliminary agenda:
08:45 - 09:00: Introduction.
09:00 - 09:45: Review of GDS2.0 documentation
10:00 - 10:30: Presentations of L4 inter-comparison work.
10:30 - 10:45: Discussion on priorities for future inter-comparison work and wrap-up.
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BG-2: Diurnal Variability WG (DV-WG)) GDS 2.0 discussion

Preliminary agenda:

1) Brief updates on recent and ongoing activities
2) Review of GDS2.0 issues relevant to diurnal warming
- definitions of any DV fields
- broader group comments and recommendations
3) Discussion of any new priority activities
4) Planning for next DVWG workshop
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BG-3: Reanalysis Project (RAN-TAG)
The main goals of the session are:
1. Collect updates on the SST reanalysis/reprocessing activities from around the world.
2. GDS 2 Review.
3. Identify priority efforts for the coming year(s).

preliminary agenda (circulated to RAN-TAG)
11:00 - 11:15: Introductory Remarks (Casey)
11:15 - 11:30: Global Reanalysis: Current Status Summary (Goal 1, Casey)
11:30 - 12:30: Summary of GDS-2 Concerns and Discussion (Goal 2, Brandon)
12:30 - 12:45: GHRSST Reanalysis Priority List of Actions (Goal 3, Rayner)
12:45 - 13:00: Wrap-Up and Way Forward (Casey)
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BG-4: Estimation And Retrievals Working Group (EARWiG)) GDS 2.0 discussion

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BG-5: SSES and Validation working group (ST-VAL)) GDS 2.0 discussion

Preliminary agenda:

14:00 Introduction and objectives for session (G Corlett)
14:10 The Data Buoy Co-operation Panel (DBCP) and its role within GHRSST (D Meldrum)
14:30 Summary of current buoy data acquisition and quality control procedures (All)
15:00 GDS2.0 SSES overview (G Corlett)
15:15 GDS2.0 SSES discussion and feedback (All)
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BG-6: High Latitude TAG (HL-TAG)) GDS 2.0 discussion

Preliminary agenda:

16.30 - 16.45: Introduction
16.45 - 17-15: GDS2.0 documentation with special focus upon the GDS2.0 issues related to presence of ice in the marginal ice zone
17.15 - 17.45: Review of the current status in the high latitude work regarding L2, L4, Diurnal warming, collection of in situ observations, etc.
17.45 - 18.00: Identification and priority of high latitude issues and recommendations for future work
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<td>
BG-7: Data Assembly and Systems TAG (DAS-TAG)) GDS 2.0 discussion

Preliminary agenda:

- Review DAS-TAG Charter (Bingham) (10 mins)
- Status of GDS2.0 and Review Feedback (90 mins)
- Overview (Robinson) (5 mins)
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BG-8: Applications and User Services TAG (AUS-TAG)) GDS 2.0 discussion

Preliminary agenda: the results of this session will be used to be set requirements that can be implemented to improve user accessibility to GHRSST data.

1. Overview of Current Users by type: operational
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- Conventions (Casey) (5 mins) - User Manual (Jeffery/Vazquez) (10 mins) - L2P Specification (Donlon) (10 mins) - L3 Specification (Le Borgne) (10 mins) - L4 Specification (Gentemann) (5 mins) - HRDSS Specification (Poulter) (5 mins) - GMPE Specification (Martin) (10 mins) - Metadata Specification (Armstrong) (15 mins) - Discussions (15 min) - GDS 2.0 Implementation Plan (Bingham) (20 mins) - Discussions on the next step with GDS2.0 If we run out of time, we will continue the discussion in the evening.	(applications) versus research. This can be a somewhat artificial boundary, but we need to start somewhere. All 2. Lessons learned from Users Symposium: Santa Rosa and Lima Jorge 3. Overview of current Users Manual (GDSV2.0) and Terms of Reference for AUS-TAG: Chris Jeffries 4. Review of examples of usage of GHRSST data by users: again operational versus research All 5. Bases on discussions from 1-3 what are the issues (from a user perspective) to working with the data. Subsetting? Data Aggregation? All 6. Requirements document: Can we come up with a requirements that can be handed over to the DAS-TAG `for implementation based on user needs, etc.

Tuesday, 22nd June 2010

Time	Agenda item		Session leaders
Session 2. Parallel breakout sessions 1 in the Paz Soldan meeting room on the 9th floor			
08:30	**Introduction to the GDS-2.0 and breakout session overview:** C Donlon/K Casey/C Gentemann		
Parallel session			
08:45	**BG-1: Inter-comparison Technical Advisory Group GDS-2.0 review** **Chair:** Matthew Martin (Matthew.martin@metoffice.gov.uk) **Rapporteur:** Ian Barton Please contact the Chair to arrange a presentation	**BG-2: Diurnal Variability Technical Advisory Group (DV-TAG) GDS-2.0 review** **Chair:** Gary Wick (gary.wick@noaa.gov) **Rapporteur:** Sandra Castro Please contact the Chair to arrange a presentation	**Breakout Groups-1**
10:45	**Coffee**		
Parallel session			
11:00	**BG-3: Reanalysis Project Technical Advisory Group (RAN-TAG) GDS-2.0 review** **Chair:** Ken Casey (kenneth.casey@noaa.gov) **Rapporteur:** Nick Rayner/ Tess Brandon Please contact the Chair to arrange a presentation	**BG-4: Estimation And Retrievals Working Group (EARWiG)GDS-2.0 review** CANCELLED	**Breakout Groups-1**
13:00	**Lunch**		
Session 3. Parallel breakout sessions 2 in the Paz Soldan meeting room on the 9th floor			
Parallel session			
14:00	**BG-5 SSES-Validation Technical Advisory Group (ST-VAL TAG) GDS-2.0 review** **Chair:** Pierre Le Borgne (Pierre.Leborgne@meteo.fr) **Rapporteur:** Gary Corlett Please contact the Chair to arrange a presentation	**BG-7 Data Assembly and Systems TAG (DAS-TAG) GDS-2.0 review** **Chair** Andrew Bingham (andrew.bingham@jpl.nasa.gov) **Rapporteur:** Ed Armstrong Please contact the Chair to arrange a presentation	**Breakout Groups-2**
16:00	**Tea**		
Parallel session			

<table>
<tr><td>16:30</td><td>BG-6: High Latitude TAG (HL-TAG) GDS-2.0 review

Chair: Jacob Hoeyer (jlh@dmi.dk)
Rapporteur: Bob Grumbine
Please contact the Chair to arrange a presentation</td><td>BG-8 Applications and User Services TAG (AUS-TAG) GDS-2.0 review

Chair Jorge Vazquez (jorge.vazquez@jpl.nasa.gov)
Rapporteur: Mike Chin
Please contact the Chair to arrange a presentation</td><td>Breakout Groups-3</td></tr>
<tr><td>18:00</td><td colspan="3">Close</td></tr>
<tr><td>18:00-19:30</td><td colspan="3">Poster Session and informal discussion. Location: Terraza Paz Soldan Room
1. Satellite sea surface temperature validation in coastal and near coastal regimes: Edward Armstrong, Jorge Vazquez, Toshio Chin, Gregg Foti, Gary Jedolvec
2. Estimation and Validation of the Peruvian Sea Surface Temperature using imagery from AVHRR/NOAA and in situ data with Pacha Ricaj Software: José Carlos Eche Llenque, Joel Rojas Acuña y Edward Alburqueque Salazar
3. A Comparison of SSTs off the Peruvian Coast using GHRSST data and NASA's: Jorge Vazquez, Holger Brix, Dimitris Menemenlis
4. Daily anomalies of high resolution sea surface temperature of Eastern Tropical Pacific: Alfredo Vicuña
5. The Data Buoy Co-operation Panel (DBCP) and its role within GHRSST: David Meldrum
6. Satellite Oceanic Observatory Atlas: D. Dagorne, H. Demarcq, Carlos Paulino</td></tr>
</table>

Wednesday, 23rd June 2009

<table>
<tr><th>Time</th><th>Agenda item</th><th>Session leaders</th></tr>
<tr><td colspan="3">Session 4. Parallel breakout sessions 3 in the Paz Soldan meeting room on the 9th floor</td></tr>
<tr><td colspan="3">Parallel session</td></tr>
<tr><td>09:00</td><td>Open sessions and working Lunch for TAG and WG discussions:
• Consolidation of issues raised during breakouts
• Writing Reports and update of GDS

This session is provided to allow time for GHRSST Science Team and meeting participants to work through issues within small groups and prepare text for GDS2.0 and the plenary reports due on Friday morning.

Please make wise and sensible use of the time provided.</td><td>Breakout Groups-4</td></tr>
<tr><td>10:30</td><td colspan="2">Coffee</td></tr>
<tr><td>11:00</td><td>Open sessions and working Lunch for TAG and WG discussions: (cont.)
• Consolidation of issues raised during breakouts
• Writing Reports and update of GDS</td><td>Breakout Groups-4</td></tr>
<tr><td>12:30</td><td colspan="2">Informal discussion excursion. The point of departure will be the Hotel Plaza del Bosque at 12:30 pm. We will visit the ancient constructions (200 years BP) near to Lima: Pachacamac Sanctuary. This site have fifteen main temples, the most important is The Sun temple, and the Woman house (Acllahuasi). We strongly recommend you take sport shoes and water. We will spend almost 2 hours.

http://pachacamac.perucultural.org.pe/parav.htm

After that, we return to the "Dama Juana" Restaurant, it is located in a centric tourist and entertainment center in Miraflores, Lima. In the restaurant we will take a "Dinner creole-buffet show". The dinner show includes: Seven native dances from Peruvian main geographical region. The show begin at 8:30 pm.

http://ladamajuana.com.pe/#

The total cost will be 50 USD (14 USD for transport and 36 USD for Restaurant). For

reservations please send an e-mail to Sara Purca:spurca@imarpe.pe</td></tr>
</table>

Thursday, 24th June 2009

Time	Agenda item	Session leaders
Session 5: User Symposium in the Paz Soldan meeting room on the 9th floor		
08:40	**Welcome and overview:** Sara Purca and Jorge Vazquez	**Chair:** Jorge Vazquez **Rapporteur:** C Donlon Programmatic
09:00	**Spatial and temporal variability of SST variogram model:** Emanuelle Autret and Pierre Tandeo	
09:20	**The SST Error Budget ISSTST:** Peter Cornillon	
09:40	**Major Revisions to SST processing in NCEP:** Robert Grumbine, William Gemmill, Bert Katz, Xu Li, Diane Stokes	
10:00	**A Global 1-km Sea Surface Temperature Product Blending Satellite and In Situ Observations:** Yi Chao, Peggy Li, Zhijin Li, Benyang Tang, Quoc	
10:20	Coffee	
11:00	**Overview of IASI L2P including development of SSES:** Anne O'Carroll and Thomas August	**Chair:** Sara Purca **Rapporteur:** Jorge Vazquez Products
11:20	**Use of NWP profiles in the new SEVIRI SST chain:** Pierre LE BORGNE, Gérard Legendre, Anne Marsouin, Hervé Roquet, Chris Merchant	
11:40	**High Resolution Daily Sea Surface Temperature Analyses**: Richard W. Reynolds, Dudley B. Chelton and Thomas M. Smith	
12:00	**Sea Surface Temperature Composite of Hurricanes:** Tim Liu, Wenqing Tang	
12:20	Lunch	
14:00	**Remote versus local forcing of interannual SST anomalies off the coast of Peru (1981-2008): contrasting Cold Tongue El Niño with Modoki El Niño conditions:** B. Dewitte, S. Purca, J. Vazquez, D. Correa and K. Goubanova	**Chair:** Jorge Vazquez **Rapporteur:** C Donlon Applications
14:20	**Use of SST in anchovy studies in Peruvian coast:** Luis Escudero Herrera, Victoria Rivera	
14:40	**High resolution AVHRR SST in the Peruvian coast:** Carlos Paulino Rojas, Luis Escudero H.	
15:00	**Submesoscale frontal activity in the Peruvian upwelling region from high-resolution SST and Chlorophyll satellite dataset:** Hervé Demarcq, Sara Purca, Daniel Quispe, Victoria Rivera, Carlos Paulino, Alexis Chaigneau , Luis Escudero	
15:20	**A preliminary investigation of the cold bias in the Extended reconstruction of Sea Surface Temperature analysis introduced by the inclusion of pathfinder** V. F. Banzon, R. H. Evans, R. W. Reynolds, T. M. Smith	
15:40	Tea	
16:00	**SST Diurnal Warming in the North Sea and Baltic Sea**: Ioanna Karagali,Jacob L. Høyer	**Chair:** Sara Purca **Rapporteur:** Jorge Vazquez Science
16:20	**Currents variability on the northern Patagonia continental shelf** Daniel Valla	
16:40	**Sea Surface Temperature from the new Operational GMES Sentinel-3 Satellite:** Craig Donlon	
17:00	**Naiad tools to access and analyse GHRSST data**: J F Piolle	
17:20	**Use of GHRSST Products for the Identification and Monitoring of Chinook Salmon Habitat along the California Coast:** Dave Foley	
17:40	Close	
18:00-19:30	GHRSST Advisory Council meeting, Location in the Hotel Plaza del Bosque Hotel TBC (All issues to be passed to the Chair: I Barton by midday 24/06/2010)	
20:00	Wine reception on the Terraza, 9th floor of the Plaza del Bosque Hotel.	

Friday, 25th June 2009

Time	Agenda item	Session leaders
Session 7: Reports from Breakout sessions in the Paz Soldan meeting room on the 9th floor		
08:20	**Report from the GHRSST Advisory Council meeting:** I Barton	**Chair: Craig Donlon Rapporteur: Ian Barton**
08:40	**Report from ST-VAL breakout:** Gary Corlett	
09:00	**Report from IC-TAG breakout:** Mathew Martin	
09:20	**Report from HL-TAG breakout:** Jacob Hoeyer	
09:40	**Report from RAN-TAG breakout:** Ken Casey	
10:00	**Coffee**	
10:30	**Report from DAS-TAG breakout:** Andy Bingham	**Chair: Craig Donlon Rapporteur: Ian Barton**
10:50	**Report from AUS-TAG breakout:** Jorge Vazquez	
11:10	**Report from DV-WG breakout:** Gary Wick	
11:30	**Discussion on the future of EARWiG:** Craig Donlon	
11:40	**Open discussion C Donlon**	
12:20	**Lunch**	
Session 9: Final discussion, Wrap up session and close in the Paz Soldan meeting room on the 9th floor		
14:00	**Review of Action list from the 11th GHRSST Science Team Meeting**	**Chair: C Donlon Rapporteur: Ken Casey**
15:30	**1. Summary of workshop** **2. Preparation of proceedings: Chair & Rapporteur inputs** **3. Science Team Membership (New nominations and resignations to be passed to the Science Team Chair by Thursday 24th June)** **4. Next meeting location and dates** **5. AOB** **6. Thank you and close of meeting**	
16:00	**Close**	

Appendix II: Action list resulting from the 11th GHRSST Science Team meeting (June 2010)

The following actions were reviewed and agreed in plenary by the GHRSST Science Team which are based on the reports made by session Rapporteurs and the GHRSST-PO on the 25th June 2010, Lima, Peru

Last update: C. Donlon 2010-06-25

No	Action	Owner	Date Due	Status
G9-4	RDACs to organise regional user meetings and report user feedback at the next ST meeting	AUS-TAG	To report at the next ST meeting	Open
G9-6	The OSI-SAF/IFREMER/RSMAS/URI will plan the development of an open source L2P re-gridding tool.	D Poulter (mostly completed)	Report to next ST meeting	Open
G9-10	Dave Poulter to develop a simple user questionnaire requesting HR-DDS requirements and circulate via email to all at the meeting. Collated feedback to be published on the HRDDS site.	D. Poulter	To report at the next ST meeting	Open
G9-14	Provide link to new high resolution pathfinder derived coldest climatology and other climatology data sets via web pages www.GHRSST-PP.org web page. The mean climatology derived from pathfinder is available under ftp://eftp.ifremer.fr/odysseav2/glob/climatology/ The minimum climatology is still not available.	Le Borgne, GHRSST-PO	To report at the next ST meeting	Open
G9-15	Request Andy Bingham to contact all GHRSST Science Team and request them to consider being a ***MetricsCaster*** for GHRSST Metrics. Done for GDS 2.0	Bingham, Barton, Corlett	To report at the next ST meeting	Open
G9-17	All ST members to send references of GHRSST relevant papers to the GHRSST-PO for inclusion in the Scientific References list on the GHRSST-PP.org web site.	ALL + GPO	On-Going	Open
G9-25	Set up at least one DivHAC to implement a DV method and fill fields in a manner similar to SSES. Alternative approach developed at G11	Gentemann, Le Borgne	Report at G12	Open
G9-27	GHRSST-PO to arrange for a refresh and update of the GHRSST web site to focus on a user perspective (rather than the current pages which are focused toward the GHRSST project perspective). (Some branding done and top level pages changed)	GHRSST-PO	To report at the next ST meeting	Open
G9-38	A small informal group will coordinate the implementation of GHRSST metrics bearing in mind the need for a Metrics Dashboard. A plan has been developed at G11	GPO with DAS-TAG	To report at the next ST meeting	Open
G10-3	GHRSST will work together with IOOS so that GHRSST becomes a recognised IOOS data	Casey	To report at the next ST	Open

	provider. Immediate requirement is to develop and publish a manual for IOOS users describing how to obtain and use GHRSST data. Attended IOOS meetings and promoted GHRSST		meeting	
G10-14	Define and agree on the most sensible error estimate for L4 data products and provide inputs to GHRSST and L4 producers.	IC-TAG, (Martin/Kaplan)	Report at G12	Open
G10-18	Prototype the generation of animation embedded within RSS feeds as part of the DDS system Nearly there with this example in July 2010	Poulter	To report at the next ST meeting	Open
G10-33	OSTIA and GMPE should include lake surface water temperatures. How will this be done? Work with Discussion group led by Bob Grumbine on this issue (Action **G9-30)**	IC-TAG	To report at the next ST meeting	Open
G10-34	Should HR-DDS, R-DDS, SQAM etc include lake surface temperatures Work with Discussion group led by Bob Grumbine on this issue (Action **G9-30)** DDS includes these when provided – 8 DDS sites over lakes	IC-TAG	To report at the next ST meeting	Open
G10-42	Develop MMR user guide Needs to be added to user guide	AUS-TAG (Armstrong)	To report at the next ST meeting	Open
G10-43	All WG and TAG to include periodic review of ST chairs and membership as part of the ToR. Please update ToR accordingly and pass back to GPO.	Chairs of WG and TAG	Annually	Open
G10-46	EARWiG to review and prioritise issues for Lake Surface Temperature Retrieval. EARWiG to organise itself better.	EARWiG (Harris)	Report at G12	Open
G11-1	Keep GHRSST ST informed about AATSR activities during the ENVISAT de-orbit manoeuvres planned in fall 2010. Communicate via GHRSST web site and send information via e-mail.	ST-VAL (Gary Corlett)	As required	Open
G11-2	DAS-TAG to investigate the optimized use of netCDF 4 within GHRSST. A small report detailing the benefits of netCDF4 for GHRSST will be made available on the GHRSST website.	DAS-TAG (Poulter, Bingham)	Report at next ST meeting	Open
G11-3	DAS-TAG to remind RDACs on the procedures for file exchange within the R/GTS to minimise problems when multiple but identical files are sent to the GDAC,	DAS-TAG (Bingham)	July 2010	Open
G11-4	GHRSST ST to review IFREMER NAIAD and NASA JPL Dataminer and report back to GDAC and IFREMER respectively.	ST, GPO	Report at next ST meeting	Open
G11-5	Bingham to provide link to 'good' SST colour bar for use on WMS/Gearth to GHRSST	Bingham	End of July 2010	Open
G11-6	Add links to the GHRSST web site to Martin Rutherfords WMS systems http://www.metoc.gov.au	GPO	End 2010	Open

G11-7	Add the investigation of retrieval methods for SST in the high latitudes to EARWiG Activities.	EARWiG (Harris)	End of 2010	Open
G11-8	Provide more information regarding the specification of target error s pecs for L 4 and insert into GDS-2.0	RAN-TAG (Casey)	July 9th 2010	Open
G11-9	Send Alan Beljaars paper to Bob Grumbine on troposphere impacts of SST.	Donlon	End of July 2010	Open
G11-10	LSWT-WG to explore the generation of land masks using GMT tool	LSWT-WG (Grumbine)	Report to G12	Open
G11-11	Matt Martin to pass netCDF code writer from UKMO to NWS to generate NWS GHRSST L4 products.	Martin	End of July 2010	Open
G11-12	GPO to publish UKMO netCDF code writer on the GHRST web site.	GPO/Martin	End of 2010	Open
G11-13	G1 analysis to be sent as a gridded at ¼ degree L4 product for GMPE if required.	IC-TAG (Chao)	End of 2010	Open
G11-14	IC-TAG to look at including G1 analys is in GMPE.	IC-TAG (Martin)	End of 2010	Open
G11-15	G1 L4 team to collaborate with STVAL an d provide feedback of SSES quality	Chao, ST-VAL (Corlett)	Report at G12	Open
G11-16	ST to look at EUM ETSAT IASI L2Pcore products and pass comments to Ann e O'Carroll	ST	End of 2010	Open
G11-17	GHRSST to present an overview of GHRSS T activities and requirements for upgraded drifting buoys and at DBCP meeting in fall 2010.	GPO with ST-VAL	DBCP meeting 2010	Open
G11-18	DBCP to a rrange for buoys to be sent for deployment in Peruvian waters.	Purca/Meldrum	Report at G12	Open
G11-19	Vazquez to follow up with IMARPE HRPT receiving station and assist to act as a GHRSST RDAC.	Vazquez/Purca/ Escudero	Report at G12	Open
G11-20	Provide gradient analysis to and fronts from GOES to Demarq.	Cornillon/Demarq	Report at G12	Open
G11-21	Add web link to GHRSST MDB site on GDAC http://www.ifremer.fr/matchupdb	Armstrong	End of July 2010	Open
G11-22	Add web link to GHRSST MDB site on GHRSST web site http://www.ifremer.fr/matchupdb	GPO	End of 2010	Open
G11-23	MDB curators requested to provide a c opy of their MDB to JF Piolle so that they can be included in the GHRSST MDB	ST-VAL	Report at G12	Open
G11-24	ST to review the Joint DBCP-GHRSST draft proposal to upgrade 50-100 drifting buoys for satellite SST work (available at http://www.ghrsst.org/modules/documents/documents/draft-DBCP-GHRSST-PP-proposal-v1.0.doc) Please send reviews to GPO via email.	ALL ST	End of July 2010	Open
G11-25	ST to review the draft CEOS SST-VC proposal (available at http://www.ghrsst.org/modules/documents/documents/CEOS-SST-VC-ProposalToSIT-v3_0_KSC.doc) Please send reviews to GPO via email.	ST	End of July 2010	Open
G11-26	L2P data providers to consider participating in the ESA CCI Round Robin Algorithm inter-	ST (Merchant)	End of 2010	Open

	comparison			
G11-27	EARWiG Chair to re-organise EARWiG activities (ToR, Membership, Activities, link to ERNESST, NASA SST-ST and ESA CCI activities, link to G11-10, G10-46)	Harris/Merchant	Report at G12	Open
G11-28	Add Evans, Rayner, Reynolds and Wick to Meteo France drifting buoy blacklist communication list.	ST-VAL (LeBorgne)	End of July 2010	Open
G11-29	Bob Evans to circulate further details describing the extra QC done on MODIS SST.	ST-VAL	End of July 2010	Open
G11-30	ST-VAL to update the SSES descriptions and common principles on the GHRSST web site.	ST-VAL	Report at G12	Open
G11-31	ST-VAL to update the description of how to use GHRSST SSES for users in the User manual.	ST-VAL/AUS-TAG	Report at G12	Open
G11-32	ST-VAL to encourage publication of SS ES schemes in peer reviewed journal papers.	ST-VAL	Report at G12	Open
G11-33	ST-VAL to plan an inter-meeting between ST-VAL, DV-WG, and HL-TAG during the G11/G12 inter-sessional period	ST-VAL, DV-WG, HL-TAG	Report at G12	Open
G11-34	Dave Poulter to submit PhD by G12 meeting.	Poulter	Report at G12	Open
G11-35	sea_ice_fraction is different in L2 and L4 files. Recommend that these are made c onsistent sea_ice_fraction in GDS-2.0.	Donlon/Casey	ASAP	Open
G11-36	Investigate and attempt to exte nd ISAR comparison to as many of the GHRSST L4 products as possible. Requires Poulter to put many L4 into HRDDS.	IC-TAG (Wimmer, Poulter)	Report at G12	Open
G11-37	Provide a summary document detailing the meaning of SST for each L4 product. Th is should be linked to the L4 and GMPE products in GDS-2.0 using an attribute that points a URL to the GPO web site with these descriptions.	IC-TAG (Martin)	Report at G12	Open
G11-38	Investigate performing regular inter-comparison of GMPE and ARGO data. It is suggested to use only night time data and perform comparisons over 10 days.	IC-TAG (Martin)	Report at G12	Open
G11-39	Investigate inclusion of GCOS inter-comparison products in the Global Diagnostic Data Set (G-DDS).	IC-TAG (Poulter)	Report at G12	Open
G11-40	Investigate possibility of including ICOADS reports into the DDS system.	IC-TAG (Poulter)	Report at G12	Open
G11-41	Include GHRSST L3 products and regional L4 products in the GDDS.	IC-TAG (Poulter)	Report at G12	Open
G11-42	Once G-DDS is in gesting GHRSST L4 in real time, develop a class 2 pixie to email providers when their analysis product exceeds a threshold difference from the GMPE median.	IC-TAG (Poulter)	Report at G12	Open
G11-43	Develop dynamic masking for the G-DDS prototyping analysis for regions with specific features. Specifically (i) one of the marginal ice zones, (ii) the Saharan dust influence zone, (iii) areas with diurnal variability and (iv) areas with no MW or no IR data input.	IC-TAG (Poulter)	Report at G12	Open
G11-44	Introduce linking of analysis on the DDS to comparable analysis on the GMPE website. The DDS pages should allow users to 's ee shat GMPE says about this'	IC-TAG (Poulter)	Report at G12	Open

G11-45	Add an attribute to sea_ice_fraction variable called sea_ice_treatment with Values: use unmodified use multiple ice sources modified ice information using external sensors HL-TAG to provide text for GDS 2.0.	HL-TAG (Hoeyer) Donlon/Casey	1st July 2010	Open
G11-46	For L4 HL-TAG recommends the use of sea_ice_fraction_error_estimate if available in an optional field as best practice. HL-TAG to provide text for L4 document.	HL-TAG (Hoeyer) Donlon/Casey	1st July 2010	Open
G11-47	HL-TAG to review and report on benefits and issues related to the inclusion of Ice Surface Temperature (IST) in GDS.	HL-TAG (Hoeyer)	Report to G12	Open
G11-48	Update RAN-TAG ToR with Modern Vision and membership list.	RAN-TAG (Casey)	Report to G12	Open
G11-49	Publish RAN-TAG status report on GHRSST Web site	RAN-TAG (Casey)	Report to G12	Open
G11-50	Send RAN-TAG status report template to LeBorgne (MSG SEVIRI), O'Caroll (IASI), Vazquez (MODIS), and Bruce Brasnett (CMC L4)	RAN-TAG (Casey)	ASAP	Open
G11-51	Add section in GDS explaining targets for stability and bias with respect to long term in situ reference data sets.	RAN-TAG (Casey)	ASAP	Open
G11-52	DAS-TAG to define a process for RDAC to update ISO information (DSD)	DAS-TAG (Bingham)	Report at G12	Open
G11-53	GDAC will add both dataset and granule level metadata to ISO metadata record as part of ISO-19115-2 implementation for GDS-2.0	DAS-TAG (Bingham)	Report at G12	Open
G11-54	GPO will make GDS 2.0 documents available on web site. DAS-TAG recommends a separate folder to hold the current operational version and a folder to hold development versions.	GPO (Donlon)	July 9th 2010	Open
G11-55	The MDB Centre (called a Matchup Database Centre MDBC) should now be included as part of the GHRST R/GTS system. Update the R/GTS framework ICD to reflect this change.	DAS-TAG (Bingham)	Report at G12	Open
G11-56	Update the R/GTS framework graphics figure to include the MDBC.	GPO (Donlon)	Report at G12	Open
G11-57	GDS 2.0 Technical Specification will be compiled by Donlon & Casey and will contain the following sections: • Overview • Conventions • L2P specification • L3 specification • L4 specification • GMPE specification • Metadata specification	DAS-TAG (Donlon Casey)	July 9th 2010	Open
G11-58	The GHRSST User Manual will be revised, compiled and maintained by the AUS-TAG	AUS-TAG	Report at G12	Open
G11-59	The GHRSST ICD will contain information for i) submitting data into the GHRSST framework	DAS-TAG (Bingham & Brandon)	July 9th 2010	Open

	ii) reporting problems within the GHRSST framework and iii) reporting metrics. This document will be compiled by Bingham & Brandon			
G11-60	Create the specification for the Metrics RSS feed and publish in the ICD Bring all other Metrics actions here if possible)	DAS-TAG (Casey and Bingham)	Report at G12	Open
G11-61	Bingham to contact ESDIS and investigate if GHRSST could leverage EMS services.	DAS-TAG (Bingham)	ASAP	Open
G11-62	The DAS-TAG Chair (Bingham) to contact REMSS and request they change the operational interface.	DAS-TAG (Bingham)	ASAP	Open
G11-63	The Project Office to include an GHRSST User issue tracking system to be implemented as part of the new web site.	GPO	Report at G12	Open
G11-64	Add a description of the GHRSST MDB to the GHRSST User Manual	DAS-TAG (Vazquez/Project Office/Piolle)	Report at G12	Open
G11-65	Describe the process and specification for submitting and updating the MDB in the GHRSST ICD.	DAS-TAG (Piolle)	9th July 2010	Open
G11-66	Develop a quick start guide for users using GHRSST products.	AUS-TAG (Chin/Vazquez)	End of 2010	Open
G11-67	DV-WG shall review and update web presence on the GHRSST web pages and elsewhere.	DV-WG (Wick) and GPO	Report at G12	Open
G11-68	GPO to attend the GODAE Ocean View (GOV) meeting and present progress in GHRSST. Action to query GOV at this meeting on user requirements for DV information. GHRSST proposes to provide hourly DV information for SSTskin, SST0.2 and SST1.0.	DV-WG (Wick, Kaiser-Weiss)	Report at G12	Open
G11-69	UNESCO Bilko image processing software to be added and promoted on GHRSST and GDAC web pages (http://www.bilko.org)	GPO (Donlon, Armstrong)	Report at G12	Open
G11-70	GPO to revise (based on ST inputs) the Joint DBCP-GHRSST draft proposal to upgrade 50-100 drifting buoys for satellite SST work. Revised proposal returned to Meldrum for comment.	GPO	End of 2010	Open

Last updated: C Donlon, 25th June 2010.

Appendix III: Report of the GHRSST Advisory Council

Report of meeting 24th June 2010

The Advisory Council (AC) of the Group for High Resolution Sea Surface Temperature (GHRSST) took place at the Hotel Plaza del Bosque, Lima, Peru, during the 11th Science Team Meeting. It was held on Thursday 24th June, 2010, commencing at 18:30.

Present

Ian Barton (CSIRO/BoM) Chair
K. Casey (NOAA/NODC)
A. O'Carrol (EUMETSAT)
S. Ishizaki (JAXA/JMA)
J-F Piolle (MyOcean)
P. LeBorgne (EUMETSAT OSI-SAF)
M. Martin (MetOffice UK)
B. Grumbine (NOAA/NWS)
J. Vazquez (NASA JPL PO.DAAC)
G. Corlett (Medspiration)

1. Welcome & review of agenda

Ian Barton (AC Chair) welcomed the members of the Advisory Council. Craig Donlon acted as secretary. A tour de table introduced members of the AC present. Craig Donlon asked for the Data Buoy Co-operation Panel (DBCP) joint proposal for upgraded drifting buoys to be added as an agenda item. This could be discussed under point 9. Hence, the following agenda was adopted for 10th GHRSST Science Team Advisory Council (AC)

1. Welcome and round table introductions
2. Apologies for absence
3. Appointment of Secretary for the session
4. Review and adoption of Agenda (any Other business to be raised here to allow Chair to plan the meeting)
5. Review of actions from last meeting
6. Review of GHRSST AC Terms of Reference
7. Status of GHRSST and Matters arising for the project (Discussion)
8. Status of GDS 2.0 and actions required
9. Any other Business
10. Review of Actions
11. Close

The agenda items form the section headings of this report.

2. Apologies for absence.

The Chair had received apologies for absence from the following people:

I Robinson, H. Beggs, H. Bonekamp, E. Lindstrom, C. Gentemann, M. Katchi, W. Lengert, N. Houghton and A Kaiser-Weiss.

3. Review of actions from last meeting (Minutes in Appendix 2)

The report of the 10th GHRSST Science Team Advisory Council (AC) was accepted with no further comments. An update the status of outstanding actions was then given by the Craig Donlon as follows:

Action AC/10/01: *Stand-in GPO coordinator (Craig Donlon) will develop a Terms of Reference for the GDS2.0 review and circulate to AC for approval*.
Action Closed and it was agreed to discuss the SST-VC proposal under item 7. The AC expressed thanks to C. Donlon.

Action AC/10/02: *To provide the AC with an example of CEOS VC proposal (H. Bonekamp)*
Action closed. The AC expressed thanks to Hans Bonekamp.

Action AC/10/03: *To draft a proposal to CEOS SIT for GHRSST acting as SST VC, and circulate it within AC (C. Donlon)*
Action Closed and it was agreed to discuss the SST-VC proposal under item 7. The AC expressed thanks to C. Donlon.

4. Review of GHRSST AC Terms of Reference

The Chair presented the GHRSST AC Terms of Reference (ToR) and noted that these had not changed since inception in 2006. The Chair invited the AC to review and comment on the AC ToR. K. Casey noted that the AC ToR should be updated to reflect the change from GHRSST Pilot Project (GHRSST-PP) to GHRSST now that the pilot project had finished. No other changes were discussed.

Action AC/11/01: *Stand in GHRSST Project Office (GPO) to revised the AC ToR to reflect change from GHRSST-PP to GHRSST. Action Closed and revised ToR provided as Appendix 1.*

The Chair then reviewed the GHRSST AC Membership noting that the original membership list included representatives from each GHRSST Regional Data Assembly Centre (RDAC), the Global Data assembly Centre (GDAC) and Long- Term Stewardship and Reanalysis Facility (LTSRF). Later Space Agencies were invited to join the GHRSST AC. The current list of AC members was now somewhat confusing and a review was required to clarify the role and purpose of each member. The chair noted that a small group of 10 people would be ideal. Grumbine noted that 12 people should be the maximum number of people serving on the GHRSST AC in order to facilitate its functionality and decision making capacity.

Casey noted that clarity on the representation of NOAA was required. The Chair suggested that it should be the Agency who is responsible for nominating the most appropriate person for the AC. Casey explained that in the case of NOAA, the LTSRF (NOAA/NODC) is important but the other arms of NOAA also need to be in attendance. Grumbine agreed and further explained that NOAA is very large organization and the specific concerns of one arm of the organization are not necessarily the same as that from other parts.

Following further discussion it was **agreed** that the following constitutes the GHRSST AC Membership fro 2010/11:

1. Helen Beggs (CSIRO/BLUElink/IMOS/BoM, Australia)
2. Ken Casey: (NOAA NESDIS/LTSRF)
3. Herve Roquet: (MyOcean project)
4. Chelle Gentemann (Remote Sensing Systems)
5. Jorge Vazquez: (NASA PO.DAAC/GDAC)
6. Misako Kachi: (JAXA)
7. Wolfgang Lengert: (ESA)
8. Peter Hacker: (NASA)
9. Hans Bonekamp: (EUMETSAT)
10. Pierre LeBorgne: (OSI-SAF/Meteo France)
11. Matt Martin: (GMPE/Met Office)
12. Jacob Hoeyer (Danish Meteorological Office)
13. Bob Grumbine (NOAA NWS NCEP)
14. Craig Donlon: (Ex-officio as Chair of the GHRSST Science Team)
15. Andrea Kaiser-Weiss (Ex Officio, GPO)

AC/11/14: *Hoeyer to invite Peter Hacker to join the GHRSST Advisory Council to represent NASA.*

Status of GHRSST and Matters arising for the project (Discussion)
Craig Donlon gave a verbal overview of the key developments in the GHRSST Project as reported in the GPO Report to the GHRSST Science Team (G11) document provided as an input to the GHRSST-XI meeting. Donlon noted the development of a draft proposal to the Committee for Earth Observing Satellites (CEOS) Strategic Implementation Team (SIT) for a Victual Constellation for SST (SST-VC). This required review by the AC. A summary overview of the draft SST-VC proposal was given by the GHRSST ST Chair and the following action agreed by the AC:

AC/11/13: *(Donlon and Casey) A draft SST-VC proposal to CEOS to be circulated to AC for comment prior to the next CEOS SIT submission later this year. Comments should be returned to Donlon no later than July 15th 2010*

Donlon explained the successful development of a renewed contract from ESA (and National Centre fro Earth Observation, UK) to continue the GPO which has now relocated to the University of Reading UK. Dr Andrea Kaiser-Weiss had been successfully recruited to the GPO and is expected to start her Duties on 1st August 2010 subject to accepting an employment Contract with the University.

A draft version of the GDS-2.0 had been successfully developed and had been reviewed by the GHRSST ST during the GHRSST-XI session. It was expected that the GDS-2.0 would be endorsed by the AC and the GHRSST ST subject to the changes and updates presented and agreed at the GHRSST-XI meeting.

Finally Donlon noted that the GHRSST web site had been maintained on a best effort basis.

Donlon explained that GHRSST was operating well with a clear increase in the number of users accessing GHRSST products using an increasingly diverse set of GHRSST interfaces and tools. Donlon expressed concern that GHRSST was now reaching a critical point as the user base was large and was now depending on successful long-term coordination of SST data products and services for SST under the GHRSST Regional/Global Task Sharing (R/GTS) framework. Furthermore, more products and services had been reported at the GHRSST-XI meeting highlighting the rapid but welcome growth of GHRSST.

The Chair noted that there are now more users than ever before and advised the AC that care was needed to serve this user community well.

Several members of the AC felt that better outreach to China and Japan is required in order to help coordinate SST activities in those countries that have upcoming and extensive satellite launches. The AC **requested** the GPO to take steps to increase collaboration with China and Japan.

Ken Casey noted that the GDAC had complained that some RDAC's were not fully compliant with GHRSST procedures and format protocols and standards. RDAC compliance was becoming a large issue for the data management operations at GDAC and LTSRF now that large volumes of data are passing through the GHRSST system. The AC **requested** that RDACS should take necessary steps to conform to the GDS specifications and R/GTS framework procedures in order to maintain efficiency. Ken Casey and JF Piolle explained that the GHRSST GDS-2.0 Interface Control Document should be used to clarify these issues.

Jorge Vazquez asked if there are any issues for GHRSST due to the creation of other SST groups that were emerging (e.g. ER NESST and the NASA SST-ST). Donlon explained that the NASA SST-ST provided a way for NASA to fund SST research and participation in GHRSST. This was viewed as beneficial and the AC **welcomed** the development of the NASA SST-ST noting that GHRSST should be pro-active in working effectively with the new team.

Donlon expressed concern that the GHRSST EARWiG had failed to take up responsibility for coordination of SST Estimation and Retrievals that were the focus of these groups.

Pierre LeBorgne described the role and status of the European Research Network for SST (ERNESST) which had been set up based on a need to increase European coordination of SST activities. ERNESST emerged from discussions across institutions (MyOcean, OSISAF, ESA) and was responding to a need for the EU groups to be fully informed on SST activities to reduce duplication of activity and recruit new people into SST activities. LeBorgne noted that ERNESST was not a small closed circle but an open network for information exchange. A first informal meeting had been held at GHRSST-X (Santa Rosa) and a follow up formal meeting had been held in Reading UK. The priority for ERNESST was to now advertise what is happening in the community in order to address a lack of structure and funding fro SST. The next ERNESST meeting will be held in Cordoba, Spain in early September with the theme "Getting Organized" with an aim to prepare a proposal to the EC for a network of excellence. The AC **urged** GHRSST ST members to attend the ERNEST and SST-WG meetings if possible.

The Chair asked if the NOPP structure and funding for GHRSST still exits (i.e. MISST funding). Casey said that it was expected that NOPP funding for a MISST follow activity might be advertised toward the end of 2010. The AC **welcomed** this development noting that MISST was considered a great success by the GHRSST and wider communities involved in SST activities.

8. Status of GDS 2.

Donlon reported that a draft GDS-2.0 document had been prepared and the GHRSST ST had been given a 4 week period to review and comment on the document content and structure. Many comments had been received and were being collated by the relevant BookCaptains and DAS-TAG.

LeBorgne noted that the EUMETSAT OSI-SAF had an urgent need for the GDS-2.0 document that had been incorporated into upgrade plans for processing chains this year. JF Piolle explained that the European GMES MyOcean project SST-Thematic Assembly Centre (SST-TAC) also had an urgent need for the GDS-2.0. Donlon further noted that the Australian RDAC (BoM) also had requested that the GDS-2.0 be published as soon as possible.

Ken Casey gave a summary review of activities related to the development and status of the GDS 2.0. Some key issues regarding the version of netCDF format to use (v3 or v4) had been resolved (both shall be admissible). A change of document structure had been recommended by the GHRSST DAS-TAG that consisted of a Single Technical manual containing GHRSST product specifications supported by a GHRSST Interface Control Document and a User Manual. Several omissions and errors had been noted by the ST and these would be included in a revised version of the GDS-2.0. The AC **welcomed** these developments and the AC **urged** the GDS Book Captains to complete the GDS as soon as possible. Casey explained that the team was now reformatting this document although this would not be ready for presentation to the ST tomorrow. Donlon said that he believed a full version of the GDS 2 could be available in the new format within a couple of weeks (early July 2010).

The AC **endorsed** the GDS-2.0 and proposed new structure, subject to resolution of all suggested changes proposed by the GHRSST ST prior to and during the GHRSST-XI meeting. Furthermore the AC noted the urgency required by RDACS waiting to use the GDS-2.0 and therefore the AC **requested** the Book Captains to expedite the final editing process.

Donlon then presented a proposed process for external review of the GDS Technical specifications. The process was extensively discussed and it was **agreed** that the process would be as follows:

1. The GHRSST ST prepares the GDS-2.0 and submits this to the GPO
2. The GPO puts the GDS-2.0 under revision control.
3. The GPO passes the GDS-2.0 to the DAS-TAG for internal review.
4. The DAS-TAG review and revise the GDS-2.0
5. The GPO prepares and conducts an external review of the GDS-2.0 according to an agreed review process.
6. The DAS-TAG addresses the review item discrepancies (RIDs) and updates the GDS-2.0.
7. A GDS-2.0 Board is convened to complete the review and update process.
8. The GPO publishes the gDS-2.0 in its final form.

The AC **requested** that the review process should be conducted in a manner that is effective but efficient in terms of time delay. It was agreed that the GDS- v2.0 shall be available for review by the 9th July 2010.

AC/11/02: *Casey and Donlon to have a complete GDS-2.0 Technical specification document available for review Friday 9th July 2010.*

Following discussion on the question of the GDS-2.0 review the AC **agreed** that the AC shall appoint 3-5 people to review the GDS-2.0. The following people shall be invited by the GPO to conduct a technical review of the GDS-2.0:

Dave Foley (NOAA)
A representative from EUMETSAT
A representative from ESA
A representative from NASA
S. Ishizaki (JAXA/JMA)
A representative from the Met Office UK
Tim Pugh (BoM)

AC/11/03: *Casey to invite Dave Foley to review GDS-2.0. CLOSED*
AC/11/04: *O'Carroll to provide a name from EUMETSAT for the external review of GDS-2.0 as soon as possible*.
AC/11/05: *Mat Martin to provide a name from UKMO for the external review of GDS-2.0 as soon as possible*.
AC/11/06: *Donlon to ask Tim Pugh (BoM) to review GDS-2 ASAP*
AC/11/07: *Jorge Vazquez provide a name from NASA for the external review of GDS-2.0 as soon as possible.*
AC/11/08: *Donlon provide a name from ESA for the external review of GDS-2.0 as soon as possible*.

The AC then discussed appointing members to the GDS-2.0 Review board that will be responsible for vetting RIDs and resolving disputes and issues arising from the Review procedure. The following people were appointed to the GDS-2.0 Review Board:

JF Piolle, Ed Armstrong, Tess Brandon, Anne O'Carrol, Andy Bingham

AC/11/09: *GPO to invite JF Piolle, Ed Armstrong, Tess Brandon, Anne O'Carrol, Andy Bingham to serve on GDS 2.0 board. CLOSED*

The AC then reviewed the proposed GDS-2.0 review procedure which was revised to include review dates. The AC requested the GPO to update the procedure and circulate this to all parties concerned in preparation for the GDS- 2.0 review. The AC **agreed** that the GDS-2.0 Technical Specification shall be available for review by 9th July 2010.

AC/11/10: *Donlon to update the draft GDS2.0 review procedure including agreed dates and names of board members and the review panel and circulate the procedure to all concerned as soon as possible (no later than 9th July 2010)*

9. AOB:

Donlon noted that David Meldrum from the Data Buoy cooperation Panel (DBCP) had attended the GHRSST-XI meeting in order to develop a better relationship with GHRSST which was considered a significant user of drifting buoys. Meldrum had presented a proposition to prepare a joint pilot project to upgrade 50-100 existing drifting buoys to report hourly, provide an increase in position information and higher accuracy and resolution SST sensors. Meldrum had prepared a draft proposal and submitted this to the Science Team Chair. The AC **requested** that the proposal be reviewed by Gary Corlett (ST-VAL), J Hoeyer (HL-TAG) Anne O'Carrol, P. Le Borgne, Gary wick (DW-WG) and returned to Meldrum for final endorsement.

AC/11/11: *Donlon to circulate draft DBCP-GHRSST proposal to Gary Corlett (ST-VAL), J Hoeyer (HL-TAG) Anne O'Carrol, P. Le Borgne, Gary wick (DW-WG) requesting comments and update by mid July 2010*.

The AC noted that GHRSST should be represented at the upcoming DBCP meeting in Scotland October 2010. The AC **requested** the GPO coordinator to present the GHRSST project to the DBCP.

AC/11/12: *AC requests GPO to present GHRSST at DBCP meeting including the proposed DBCP-GHRSST pilot project*. CLOSED

The chair then called for volunteers to chair the AC in the coming inter-sessional period. Jacob Hoeyer agreed to chair the GHRSST AC for the 2010/11 period and was duly appointed.

The outgoing chair thanked the AC for their participation and wished the incoming chair success in the coming year.

The meeting closed at 20:15 on 24th June 2010

List of Actions arising

Action AC/11/01: *Stand in GHRSST Project Office (GPO) to revised the AC ToR to reflect change from GHRSST-PP to GHRSST. (CLOSED)*

AC/11/02: *Casey and Donlon to have a complete GDS-2.0 Technical specification document available for review Friday 9th July 2010.*

AC/11/03: *Casey to invite Dave Foley to review GDS-2.0. (CLOSED)*

AC/11/04: *O'Carroll to provide a name from EUMETSAT for the external review of GDS-2.0 as soon as possible*.

AC/11/05: *Mat Martin to provide a name from UKMO for the external review of GDS-2.0 as soon as possible*.

AC/11/06: *Donlon to ask Tim Pugh (BoM) to review GDS-2 ASAP (CLOSED)*

AC/11/07: *Jorge Vazquez provide a name from NASA for the external review of GDS-2.0 as soon as possible.*

AC/11/08: *Donlon provide a name from ESA for the external review of GDS-2.0 as soon as possible*.

AC/11/09: *GPO to invite JF Piolle, Ed Armstrong, Tess Brandon, Anne O'Carrol, Andy Bingham to serve on GDS 2.0 board. CLOSED*

AC/11/10: *Donlon to update the draft GDS2.0 review procedure including agreed dates and names of board members and the review panel and circulate the procedure to all concerned as soon as possible (no later than 9th July 2010) (proposal circulated 24/06/10)*

AC/11/11: *Donlon to circulate draft DBCP-GHRSST proposal to Gary Corelett (ST-VAL), J Hoeyer (HL-TAG) Anne O'Carrol, P. Le Borgne, Gary wick (DW-WG) requesting comments and update by mid July 2010. (proposal circulated 24/06/10)*

AC/11/12: *AC requests GPO to present GHRSST at DBCP meeting including the proposed DBCP-GHRSST pilot project*. CLOSED

AC/11/13: *(Donlon and Casey) A draft SST-VC proposal to CEOS to be circulated to AC for comment prior to the next CEOS SIT submission later this year. Comments should be returned to Donlon no later than July 15th 2010.* (proposal circulated 24/06/10)

AC/11/14: *Hoeyer (AC-Chair) to invite Peter Hacker to join the GHRSST Advisory Council to represent NASA.*

Appendix-1 Revised Terms of Reference for the GHRSST Advisory Council

Last updated: 2010-06-24

The GHRSST Advisory Council (AC) provides a formal interface between the GHRSST Science Team and to key stakeholders of GHRSST activities. The following terms of reference have been established by the AC.

TERMS OF REFERENCE:

1. To provide support and advice to the GHRSST Project Office (GPO), and to assist the GPO in the determination of policy decisions.
2. To encourage full participation of partners for the benefit of all.
3. To monitor and oversee the performance of GHRSST, the GPO, and the contributions and requirements of GHRSST partners.
4. To mediate on conflicts and disputes to ensure that GHRSST proceeds in a timely and mutually-beneficial manner.
5. To respond to feedback and issues raised by the user community.

AC LOGISTICS

- The AC shall meet once per year and when possible this meeting shall be co-located with the annual GHRSST Science Team meeting.
- The Chair of this meeting shall rotate each year between the key stakeholder agencies. The Chair is responsible for coordinating and running the AC meeting with support from the GPO.

- A Secretary shall be appointed for each AC meeting who shall take minutes of the meeting.
- The Secretary and Chair shall provide a summary report of the AC
    - meeting that shall be presented to the GHRSST Science Team.
- A written report shall be provided as a record of each AC meeting and posted on the GHRSST public web site.
- The written report shall be circulated to Stakeholder agencies.
- Alternate members shall be nominated by the AC member and the AC Chair shall be informed.

GHRSST AC MEMBERSHIP

Members may appoint alternates to stand in at the meeting as required. Only named members or alternates may vote.

The AC may be attended by other Science Team members with no voting rights.

Last updated 2010-06-24

1. Helen Beggs (CSIRO/BLUElink/IMOS/BoM, Australia)
2. Ken Casey: (NOAA NESDIS/LTSRF)
3. Herve Roquet: (MyOcean project)
4. Chelle Gentemann (Remote Sensing Systems)
5. Jorge Vazquez: (NASA PO.DAAC/GDAC)
6. Misako Kachi: (JAXA)
7. Nigel Houghton: (ESA)
8. Peter Hacker: (NASA)
9. Hans Bonekamp: (EUMETSAT)
10. Pierre LeBorgne: (OSI-SAF/Meteo France)
11. Matt Martin: (GMPE/Met Office)
12. Jacob Hoeyer (Danish Meteorological Office)
13. Bob Grumbine (NOAA NWS NCEP)
14. Craig Donlon: (Ex-officio as Chair of the GHRSST Science Team)
15. Andrea Kaiser-Weiss (Ex Officio, GPO)

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Appendix IV

A Joint DBCP-GHRSST Pilot Project to Upgrade Elements of the Global Drifting Buoy Fleet to Allow the Reporting of Higher Resolution SST and Position.

Document Management			
Reference:	DBCP-GHRSST-PilotProject-proposal-ver1.0-rev1.0		
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Date of issue:	Sunday, 11 July 2010		
Document type:	Microsoft Word 2008		
BookCaptain:	Craig Donlon (craig.donlon@esa.int) and David Meldrum (David.Meldrum@sams.ac.uk)		
Author:	The Group for High Resolution Sea surface Temperature Science Team		
Master File Location:	URL to location of online resource: **Approved version:** http://www.ghrsst.org/documents.htm?parent=832		

Please reference this document as:
DBCP-GHRSST (2010), Proposal for a Joint DBCP-GHRSST Pilot Project to Upgrade Elements of the Global Drifting Buoy Fleet to Allow the Reporting of Higher Resolution SST and Position available from the GHRSST International Project Office, http://www.ghrsst.org

A Joint DBCP-GHRSST Pilot Project to Upgrade Elements of the Global Drifting Buoy Fleet to Allow the Reporting of Higher Resolution SST and Position.

Table of Contents

1. Background

The quality of satellite SST retrievals depends critically on the availability on high quality *in situ* SST datasets. Further progress with improving retrievals is currently limited by the accuracy and resolution of the *in situ* observing systems [Bitterman and Hansen, 1993; Donlon et al, 2002; Corelett et al, 2006], the most useful component of which is the global fleet of approx 1500 surface drifters coordinated by the IOC/WMO Data Buoy Co-operation Panel (DBCP). These currently report SST on to the GTS with a resolution of 0.1K (an inherent limitation of GTS BUOY code), and an accuracy no better than 0.2K [O' Caroll et al. 2008]. For most of the fleet, location is computed by the Argos satellite system used for data transmission, yielding km-scale accuracies. The accuracy, and therefore usefulness of in situ SSTdepth data is, in addition to the behaviour of the deployment platform (buoy design, ship etc.), critically dependent on adequate knowledge of sensor calibration stability and drift.

Improved resolution and accuracy of drifter SST and location would allow progress with satellite SST retrievals to be maintained for relatively little outlay. Additional applications include:

1. Accurate validation of satellite SST retrievals,
2. Monitoring of in situ SST for climate change research and development complementing satellite measurements,
3. Bias correction of satellite SST data used in operational global SST analysis systems and Numerical Ocean Prediction (NOP) and weather (NWP) systems (e.g Zhang al. 2009).
4. Monitoring surface ocean currents that may be used to characterise the surface ocean dynamics feeding in to appropriate uncertainty estimates for any satellite to drifter match-up process.
5. to assist in the assimilation of in situ measurements in ocean models

This would address the expressed goals of many agencies involved in weather and climate forecasting, including NOAA-OCO, NASA, ESA, EUMETSAT, JAXA, E-SURFMAR, the WMO and national weather and ocean services.

2. Objectives

The aim is to upgrade 50-100 standard drifters, already being procured by operational agencies, to report higher resolution and accuracy SST and location at hourly intervals. The project will also develop procedures to improve pre- and post-deployment SST sensor calibration, improve sensor installation leading to problems of sensor warming (Emery et al, 2001) and address the lack of metadata describing the depth of observation (Donlon et al, 2002). This approach avoids the costs of having to purchase complete drifters specifically for the project, and allows the benefits of HRSST to be evaluated and become apparent prior to a more extensive operational rollout.

The specification expressed and endorsed by the International Group for High Resolution SST (GHRSST, Donlon et al 2007) Science Team at the 11th GHRSST Science Team meeting, Lima, Peru (21-25th June 2010) is as follows:

Variable	**Accuracy**	**Resolution**	**Drift**
SST	0.05K	0.01K	0.01K/decade[1]
Location	0.5km	0.5km	
Obs time	5 mins	5 mins	

[1] The GHRSST Reanalysis Technical Advisory group (RAN-TAG), in its implementation plan, established: "Target accuracies for SST are on the order of 0.3 K absolute and 0.1 K relative, with a temporal stability requirement of 0.01 K/decade."

The data will be reported in BUFR code on the GTS in near real time. Additionally, the sensor type(s), estimated accuracy and sensor design depth will be reported in metadata. Delayed-mode datasets will be made available in NetCDF format.

3. Implementation plan

- The DBCP will be approached to endorse the creation of a joint DBCP-GHRSST Pilot Project of limited duration to equip more than 50 standard drifters with enhanced SST, GPS and Iridium communications. The DBCP is already aware of the concept and is certain to be fully supportive, and to allocate some of its own funds to the project;

- A science steering team will be created, drawing on DBCP and GHRSST Science Team membership, including DBCP members from the buoy manufacturing community;

- An action plan will be agreed for immediate implementation. This will be likely to include the following actions:

    - Identify operational agencies willing to include HRSST-upgraded drifters in their procurement and deployment schedules. Likely agencies would include NOAA-OCO and E-SURFMAR;
    - Identify a suitable SST sensor;
    - Agree a deployment strategy in terms of ocean area and timing;
    - Identify buoy manufacturers willing to participate in the project and agree a nominal upgrade cost and calibration schedule;
    - Identify a suitable operational agency to receive, process and distribute drifter messages received via Iridium. Likely agencies would include CLS / Service Argos, NOAA-NDBC and Météo France, all of which are capable of inserting BUFR messages on to the GTS;
    - Identify a suitable organisation to collect, manage and disburse project funds on behalf of the DBCP and GHRSST. One candidate would be the Scottish Association for Marine Science, which already manages the funds for other DBCP pilot projects;
    - Authorise the expenditure of project funds on drifter upgrades;
    - Request the DBCP Technical Coordinator to publicise the project and associated data on the DBCP and GHRSST websites (www.jcommops.org/dbcp and www.ghrsst.org);
    - Report regularly to the DBCP, GHRSST and funding agencies;
    - Review progress and make changes to the implementation plan as necessary.

4. Cost estimates

The cost of adding HRSST, GPS and Iridium communications is estimated as approx $1k per drifter, compared to an outright purchase price of approx $4k. In addition to being cost-effective, the approach is also low-risk in that the GPS and Iridium elements have already been fully evaluated [ref] and are now used operationally by agencies such as E-SURFMAR.

5. Support sought

A total of at least **$100k** is believed to be necessary to ensure an adequate number of deployments and to assist the travel of steering team members to relevant meetings. The DBCP is likely to contribute approx $20k over three years from its own Trust Fund. Similar or greater levels of support (**$20-30k**) are sought from other potential participants.

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7. Further information

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APPENDIX V

A CEOS CONSTELLATION FOR SEA SURFACE TEMPERATURE (SST-VC)

Initial Proposal: December 2010

By

Craig Donlon (ESA), and Kenneth S Casey (NOAA)

DOCUMENT MANAGEMENT

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CHANGE LOG

Reason for change	Issue	Revision	Date
Release of first complete Draft for comment	1	0	11th July 2010
Comments from Science Team and proposed members of the SST-VC (EUMETSAT, JAXA, NOAA, NASA, ESA)	1	1	17th June 2010
Revisions following feedback from CEOS SIT- WG and GHRSST.	1	2	1st October 2010
Revision following discussions prior to CEOS plenary	1	3	7th October 2010
Final revision following discussions prior to SIT meeting in 2011	1	4	30th November 2010
Added section on Costs following Review by K Sawyer (NOAA)	1	5	7th December 2010
Removal of GEO task descriptions in order to keep the initial proposal short	1	6	14th December 2010

THE CEOS CONSTELLATION FOR SEA SURFACE TEMPERATURE (SST-VC)

Draft Initial Proposal: December 2010

Craig Donlon (ESA) and Kenneth S Casey (NOAA)

Executive Summary

The key space segment capabilities providing Sea Surface Temperature (SST) measurements are extensive and are used by a large number of international Agencies. So far, several CEOS Agencies have invested a considerable amount of resources in activities related to SST, sometimes without full optimization. An ***actual*** SST in-flight constellation does exist but could be optimised further through:

- Better use of ENVISAT AATSR and the Sentinel-3 SLSTR reference sensors within the constellation,
- Long-term continuity of passive microwave SST data,
- Better and homogeneous SST products and services to users,
- Improved collaboration within the Constellation,
- Improved coordination, consolidation and development of the collective EO SST capability,
- Improved SST products, homogenization of products, services and product dissemination with better user engagement.

Since 2000, significant development has taken place through the activities of the Group for High Resolution SST (GHRSST) in these areas.

This document is a pre-proposal for a CEOS Sea Surface Temperature Virtual Constellation (SST-VC) to address this situation. It is proposed to implement a CEOS SST-VC using the existing Group for High Resolution Sea Surface Temperature (GHRSST, see http://www.ghrsst.org) as the implementation mechanism. The proposed SST-VC will:

- **Strengthen CEOS Agency SST activities** and i**mprove coordination, consolidation and development** of the collective EO SST capability through better synergy and communication in a global framework to **encourage wider participation of all Agencies**,
- **Improve SST products**, **services, interoperability, data access and data dissemination** building on the strengths of CEOS Agencies with better user engagement,
- **Avoid duplication of existing coordination activities** and provide CEOS Agencies with **value for money** by capitalising on the already committed investments made to GHRSST and allow a **rapid spin up of SST-VC** activities.

The mature GHRSST structures have developed and evolved as the CEOS VC concepts have developed themselves serving over 50,000 users that have accessed SST products in near real time, accessing over 60 million files amounting to 120 Tb of information. GHRSST has an origination structure that has both fixed and flexible components allowing it to respond effectively and efficiently to new and emerging challenges. GHRSST, through its extensive international coordination activities, has often been cited as a model for other VCs. In fact the GHRSST Management Advisory structure has developed with the proposed CEOS SST-VC clearly in mind. In this context, the current implementation of GHRSST already provides an SST-VC function but is not formally connected to CEOS.

This pre-proposal has been fully endorsed by the GHRSST Science Team at the 11th GHRSST Science team Meeting, Lima Peru, 21-25th June 2010.

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1. MISSION STATEMENT AND ANTICIPATED OUTCOMES.

In support of the Group on Earth Observations (GEO) objectives and as a space component of the Global Earth Observation System of Systems (GEOSS), the Committee on Earth Observation Satellites (CEOS, see http://www.ceos.org/) has developed the concept of virtual, space-based "CEOS Constellations for GEO". CEOS Virtual Constellations (VCs) exist for Ocean Surface Vector Wind, Ocean Colour Radiometry, Ocean Surface Topography, Atmospheric Composition, Land Surface Imaging, and Precipitation.

CEOS Agencies recognize Virtual Constellations as a means to better address space-based Earth observation needs on a global basis – without eroding the independence of individual agencies. CEOS recognizes that national/regional observing requirements will continue to dominate space agency spending and that any grand design for implementation of global observing systems will always be dependent on individual agency funding priorities.

So far, several CEOS Agencies have invested a considerable amount of resources in activities related to sea surface temperature (SST), sometimes without full optimization. This document is an Initial proposal for a CEOS Virtual Constellation for Sea Surface Temperature (SST-VC) to address :

- Better use of ENVISAT AATSR and the Sentinel-3 SLSTR reference sensors within the constellation,
- Long-term continuity of passive microwave SST data,
- Better and homogeneous SST products and services to users,
- Improved collaboration within the Constellation,
- Improved coordination, consolidation and development of the collective EO SST capability,
- Improved SST products, homogenization of products, services and product dissemination with better user engagement.

The key space segment capabilities applicable to a SST-VC are shown in Table 2 (page 15). Assuming that most or all of the sensors listed are successfully launched the potential impediments to success are:

(1) Lack of timely access to and sharing of data, including Level-1 and higher product satellite data;
(2) Lack of developing and sharing in-situ data bases, and derived products of sufficient quality to use for calibrating and validating satellite data products;
(3) Difficulty of sustaining projects for coordination of data products and user feedback across satellite sensors to support global and regional scientific data products;
(4) Limited outreach, education and development of new SST practitioners.

CEOS can help avoid these impediments by encouraging member Agencies to promote timely access to and sharing of data, through better cooperation to establish appropriate linkages required to overcome impediments (2) and (3) and to support focused activities to address (4) as listed above.

In the last decade, satellite Agencies, science, operational user/producer and SST practitioner communities have come together within the Group for High Resolution SST (GHRSST) to create a new framework for generation, delivery and application of improved common format high-resolution (~1-10 km) satellite SST datasets for the benefit of society. The GHRSST data system is a mature, robust, and highly reliable near real time data system known as the GHRSST Regional/Global Task Sharing framework (R/GTS) and has operated in NRT since 2006. It consists of distributed Regional Data Assembly Centers (RDACs) around the world which submit their data to a Global Data Assembly Center (GDAC) maintained at the NASA Jet Propulsion Laboratory Physical Oceanography Distributed Active Archive Center (JPL PO.DAAC), where all the data are available for 30 days. After that they are transferred to the GHRSST Long Term Stewardship and Reanalysis Facility (LTSRF) at the U.S. National

Oceanographic Data Center (NODC) for long term preservation and distribution. The extensive user base includes many operational meteorological services, the scientific community, industry and Government. Since the R/GTS has operated, statistics show over 50,000 users have accessed the R/GTS in NRT, accessing over 60 million files amounting to 120 Tb of information.

The GHRSST structures (Figure 1) have developed and evolved as the CEOS VC concepts have developed themselves. GHRSST has an origination structure that has both fixed and flexible components allowing it to respond effectively and efficiently to new and emerging challenges. GHRSST has often been cited as a model for other VC and the current implementation of GHRSST already provides an SST-VC function. The purpose of the CEOS SST-VC proposal presented here is not to duplicate or to replace the activities of GHRSST but rather, to ensure effective communication and coordination between CEOS Agencies on issues related to SST using GHRSST as the 'implementation' of the CEOS SST-VC.

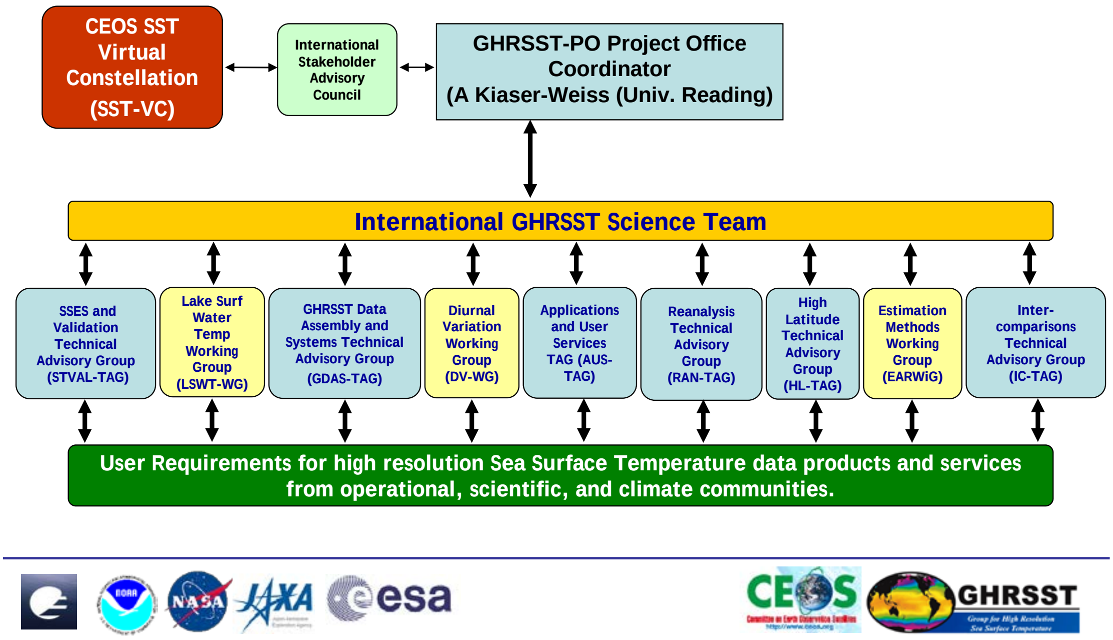

Figure 1. Currently active GHRSST structures and proposed interface to the SST-VC. Standing Technical Advisory Groups (TAG) and task oriented Working Groups (WG) are highlighted.

GHRSST functions internationally based on national and Agency support that today amounts to approximately $25M over a period of nearly 10 years. GHRSST processes and services, implemented via many CEOS Agencies and National infrastructures, support on a daily basis, in near real time, the continued development and management of critical SST datasets and have attained a significant level of operational maturity. This maturity now calls for a formal relationship with CEOS, which coordinates the activities of Agencies for the sustained cost-effective collection of the satellite measurements on which GHRSST bases its work. It is proposed that this formalism be expressed as a CEOS SST Virtual Constellation (SST-VC).

Our proposed approach will:

- Strengthen CEOS Agency SST activities through better synergy and communication;
- Encourage wider CEOS Agency participation in SST related activities;
- Encourage better SST product and service interoperability building on the strengths of CEOS Agencies;
- Facilitate better data access and product applications by CEOS Agencies;
- Provide CEOS Agencies with value for money by capitalising on the already committed investments made to GHRSST;
- Avoid duplication of coordinating activities; and
- Allow a rapid spin up of SST-VC activities.

2. PROPOSED ACTIVITIES FOR THE SST-VC

The proposed SST-VC shall support the coordination consolidation and further development of satellite SST capability, products, user feedback and education/outreach activities using the recognized and well established GHRSST as the prime coordination mechanism. Initially SST-VC group members will be those represented at the GHRSST Advisory Council and Science Team together with those working for the Agencies and in the core processing of the products. The emphasis on this structure is to reduce redundancy between the successful and functioning work of GHRSST (as an implementer of the SST-VC coordination) and the SST-VC (representing the activities of the Agencies).

11 Key actions and activities are proposed for the SST Virtual Constellation (SST-VC):

ID	Action	Activity	GEO/CEOS link	Measure	Status
1	**Minimise duplication of existing activities.** Act as a conduit for feedback between CEOS and the international SST science and operational community at all levels by formal reporting of SST-VC activities to CEOS SIT.	Maintain a close dialogue between GHRSST and CEOS agencies by reporting GHRSST, GEO and CEOS activities regularly to CEOS-SIT.	AR-09-02 (GEOSS) AR-09-03 (GOOS & GOS) DA-06-01 (Data sharing) DA-09-01 (Data management) DA-09-02 (Data integration) DA-09-03 (Global data sets) CB-09-03 (Capacity building) US-09-01 (User engagement) CL-06-01 (Climate records) CL-09-01 (Env. Inf. for Decisions) CL-09-02 (Implementing GCOS) EC-09-01 (Ecosystem monitoring) EC-09-02 (Ecosystem vulnerability) Many SBA activities	Reports prepared and presented to SIT.	Initiated through SST-VC proposal.
2	**Development and optimization of the SST constellation** Advocate and promote the development and optimization (reduced redundancy and improved continuity and overlap among missions) of a virtual constellation of satellites (defined in Table 2) that satisfy key ongoing GEOSS and	Develop a paper describing an optimised constellation for SST building on the feedback from the GHRSST Regional/Global task Sharing (R/GTS), Users and Agencies. Contribute to the CEOS response to the 2010 GCOS Implementation Plan. Please note that this response	DA-09-02 (Data integration) DA-09-03 (Global data sets) CL-06-01 (Climate records) CL-09-02b (Implementing GCOS) Many SBA activities	Paper prepared and presented to CEOS. Peer reviewed journal paper prepared and submitted to Journal	Initiated by SST/GHRSST Ocean Obs 09 White Paper.

	GCOS requirements for SST measurements based on international consensus[1] that shall build on the strengths of each CEOS Agency to sustain an effective constellation	is prepared in the context of the			
3	**Develop and implement metrics for SST services, products and users.** Develop a and implement processes, based on an agreed set of metrics, that ensure the SST Constellation will satisfy the relevant community needs making full use of existing statements of requirements	Continue to develop and maintain an International GHRSST User Requirements document for an SST constellation.	AR-09-02 (GEOSS) AR-09-03 (GOS & GOS) DA-06-01 (Data sharing) DA-09-01 (Data management) DA-09-03 (Global data sets) CL-06-01 (Climate records) GCOS SST ECV Many SBA activities	GHRSST URD updated annually by GHRSST Project Office	URD in place
4	**Coordinate consensus SST reference documents.** Coordinate the GHRSST Data Specification (GDS[2]) document for the benefit of CEOS Agencies and GEOSS tasked with implementing GHRSST recommendations (e.g., formalism, feedback and reviews)	Maintain the GDS documentation for the benefit of CEOS agencies	AR-09-02 (GEOSS) AR-09-03 (GOS & GOS) DA-06-01 (Data sharing) DA-09-01 (Data management) DA-09-02 (Data integration) Many SBA activities	GDS Documentation reviewed and under revision control.	GDS reviewed internationally and v2.0 in place and under CVS.
5	**Encourage timely access to products.** Foster and encourage timely access to CEOS agency satellite SST data products in GHRSST GDS-2.0 format	Continue to liaise with data providers within the GHRSST R/GTS especially agencies that are not well connected	AR-09-02 (GEOSS) AR-09-03 (GOS & GOS) DA-06-01 (Data sharing) DA-09-01 (Data management) Many SBA activities	Develop new collaborations with CEOS agencies under the GHRSST R/GTS	On-going.
6	**Develop and improve satellite SST Essential Climate Variable.** Foster the development, improvement, production and wide application of CEOS agency satellite SST Essential Climate Variable (ECV) satellite data products for climate applications and services.	Continue to coordinate the international efforts for re-analysis of SST products (e.g. NOAA, NASA, JAXA, EUMETSAT and ESA CCI, activities, GCOS SST/SI Working group, GOOS, OOPC) to minimise duplication and maximise international partnerships.	AR-09-02 (GEOSS) AR-09-03 (GOS & GOS) DA-06-01 (Data sharing) DA-09-01 (Data management) DA-09-02 (Data integration) DA-09-03 (Global data sets) CL-06-01 (Climate records) CL-09-02b (Implementing	Develop active collaborations between Agency activities for the SST ECV.	On-going

[1] Donlon, C. J., K. S Casey, C. Gentemann, P. LeBorgne, I. S. Robinson, R. W Reynolds, C. Merchant, D. Llewellyn-Jones, P. J. Minnett, J. F. Piolle, P. Cornillon, N. Rayner, T. Brandon, J. Vazquez, E. Armstrong, H. Beggs, I. Barton, G. Wick, S. Castro, J. Hoeyer, D. May, O. Arino, D. J. Poulter, R. Evans, C. T. Mutlow, A. W. Bingham and A. Harris, Successes and Challenges for the Modern Sea Surface Temperature Observing System, in *Proceedings of OceanObs'09: Sustained Ocean Observations and Information for Society (Vol. 1), Venice, Italy, 21-25 September 2009, Hall, J., Harrison, D.E. & Stammer, D., Eds., ESA Publication WPP-306*. White paper available from http://www.ghrsst.org/modules/documents/documents/OO-ModernEraSST-v3.0.pdf and http://www.oceanobs09.net/blog/?p=227

[2] The GDS is the Detailed Processing Model used by the GHRSST data producers and has now matured to a v2.0 based on 6 years of sustained activity. Details are available at http://www.ghrsst.org/documents.htm?parent=50

		Coordinate CEOS implementation actions through GCOS Action O7 [IP-04 O9]: "provision of best possible SST fields".	GCOS) GCOS Action O7 [IP-04 O9] Many SBA activities		
7	**Improve EO SST calibration, inter-calibration and validation.** In partnership with data providers and the international science community, improve calibration, inter-calibration and validation of each satellite system contributing to the VC, including the definition and implementation of appropriate near-real-time uncertainty estimates for CEOS agency satellite SST data products working within the framework of CEOS QA4EO	Develop QA4EO processes and implement these within the GHRSST R/GTS.	AR-09-02 (GEOSS) AR-09-03 (GOS & GOS) DA-06-01 (Data sharing) DA-09-01 (Data management) DA-09-02 (Data integration) DA-09-03 (Global data sets) CL-06-01 (Climate records) GCOS SST ECV Many SBA activities	Install QA4EO processes into GHRSST R/GTS and products	In progress
8	**Improve user feedback to CEOS Agencies.** In partnership with data providers, coordinate SST user feedback for the benefit of CEOS Agencies	Actively seek user feedback at GHRSST user consultations/symposia on an annual basis	AR-09-02 (GEOSS) AR-09-03 (GOS & GOS) DA-06-01 (Data sharing) CL-06-01 (Climate records) GCOS SST ECV Many SBA activities	Conduct an annual user assessment for SST products at the GHRSST Science Team Meeting	On-going
9	**Develop training activities for satellite SST practitioners.** Develop and implement specific development and training activities to foster a next generation of satellite SST practitioners	Develop training materials and support international workshops (e.g., ESA Summer schools, GHRSST training workshop) using existing tools and products to promote a new generation of SST practitioners	CB-09-03 (Institutional Capacity) Many SBA activities	Number of training events and resources supported and/or made available through SST-VC activities	New activity building on existing capabilities.
10	**Liaise with the other virtual constellations** Liaise with the other virtual constellations (e.g., Ocean Vector Winds, Ocean Surface Topography, Ocean Colour Radiometry) to enable cross-fertilization among the communities and to create synergy	Attend other VC meetings to better coordinate activities and synergies	AR-09-02 (GEOSS) AR-09-03 (GOS & GOS) DA-06-01 (Data sharing) DA-09-01 (Data management) DA-09-02 (Data integration) DA-09-03 (Global data sets) CL-06-01 (Climate records) GCOS SST ECV Many SBA activities	Useful collaboration established across VC	New Activity
11	**Prepare an Implementation Plan, to be approved by CEOS.**	Prepare plan, review plan with GHRSST community and submit to CEOS		Submit plan to CEOS	New Activity

2.1. CLIMATE REQUIREMENTS ADDRESSED

The GCOS[3] requirements for the SST Essential Climate Variable are as follows:

> *A climate quality blended analysis SST product that provides a measure of the SST at depth that makes use of in situ, satellite infra red and satellite passive microwave SST measurements*

GCOS requires blended SST analyses generated from satellite sensors and satellite data sets in the form of Fundamental Climate Data Records (FCDR) underpinning Essential Climate Variables (ECV) of appropriate infrared and microwave imagery capable of supporting climate accuracy global analyses with the target specification set out in Table 1

Table 1. GCOS Target Requirements for SST ECV[3]

GCOS Target Requirements for the SST ECV	
Accuracy	0.25 K
Spatial resolution	1 km, particularly in the coastal zone
Temporal resolution	Three hour observing cycle to minimise impact on product stability.
Stability	0.1 K[4]
Spatial coverage	Global
Additional requirements for satellite data	An (A)ATSR class of instrument with high accuracy and high temporal stability is required to link other passive microwave and infrared satellite data derived from sensors aboard satellites in low-earth, polar and geostationary orbit. Continue reprocessing satellite data for providing a homogenous global SST climate data record, in particular from AVHRR and the (A)ATSR series, from 1981 and 1991, respectively, to 2010. Additional reprocessing of the AVHRR time series. Maintain the high frequency observations sufficient to resolve diurnal variability, provided by geostationary instruments, together with more limited coverage AATSR-class capability. Improve in situ observations for use in calibration and validation as well as cloud and aerosol characterization including data from: the global array of surface drifting buoys, Volunteer Observing ships (VOS) and VOSClim subset of them, and time series mooring sites (tropical moored buoys and OceanSites reference array) and appropriate ship borne surface-viewing radiometers.

International consensus target requirements derived by the GHRSST Reanalysis Technical Advisory Group (RAN-TAG) for long term satellite SST records have been set as: 0.01K/decade stability, 0.3K absolute accuracy, 0.1K relative. These requirements provide a

[3] Systematic Observation Requirements for Satellite-based Products for Climate: Supplemental Details to the satellite-based component of the "Implementation Plan for the Global Observing System for Climate in support of the UNFCCC (GCOS-92)", GCOS-107, September 2006 (WMO/TD No.1338) Available online at http://www.wmo.int/pages/prog/gcos/index.php

[4] Climate change has already been detected using the surface network (IPCC, 2007). SST data sets for model verification and climate monitoring are now needed, which require long term stability and a small observational error in any calculated trend (studies of processes may have less stringent requirements). Stability requirements, as expressed by GCOS, are marginal: the current expected signal is a global warming of ~0.05 K/decade [RD-1] which ideally requires an SST stability of 0.02 K/decade for model verification (certainly 0.1K/decade is marginal).

Target (long term goal) requirement set that is extremely challenging to (a) meet using satellite infrastructure (b) even if satellite data were able to achieve these specifications, the current in situ infrastructure is not capable of validating such products because it is itself insufficiently stable or accurate. The GHRSST RAN-TAG is intimately connected to CEOS Agency activities underway for SST ECV development and production.

3. GEO Requirements Addressed.

This is a preliminary list of GEO requirements that will be more fully described in the final proposal.

SST is a variable that has implications for many GEO Climate, Weather, Ecosystem and Agriculture Societal Benefit Areas (SBA) Tasks: e.g. aquaculture, fisheries, ocean prediction and monitoring, search and rescue, ecosystem monitoring, climate and seasonal prediction. The priority SBA Tasks that will be addressed by the SST-VC will be developed in a full proposal building on existing activities and collaborations. Tasks that could benefit from SST and related to ocean forecasting, weather forecasting or climate forecasting include:

- CL-06-01a "A Climate Record for Assessing Variability and Change"
- CL-06-01b Extending the Record of Climate Variability at Global Scale
- CL-09-01a "Towards Enhanced Climate, Weather, Water and Environmental Prediction"
- CL-09-02 "Accelerating the Implementation of the Global Climate Observing System"
- CL-09-02a "Key Observations for Climate"
- CL-09-02b "Key Climate Data from Satellite Systems" CEOS response to the GCOS requirements
- CL-09-03a "Integrated Global Carbon Observation (IGCO)"
- CL-09-03c "GHG monitoring from space".
- EC-09-01a "Ecosystem Classification and Mapping"
- EC-09-01c Regional Networks for Ecosystem
- EC-09-02a Impact of Tourism on Environmental and Socio-Economic Activities
- EC-09-02c Vulnerability of Sea Basins

The transverse Tasks from the GEO 2009 -2011 Work Plan that are most relevant to the activities of the proposed SST-VC are listed below.

- AR-09-02: Interoperable Systems for GEOSS
- AR-09-03: Advocating for Sustained Observing Systems
- DA-06-01: GEOSS Data Sharing Principles
- DA-09-01: Data Management
- DA-09-02: Data Integration and Analysis
- DA-09-03: Global Data Sets
- US-09-01: User Engagement
- CL-06-01: A Climate Record for Assessing Variability and Change
- CB-09-03: Building Institutional Capacity to Use Earth Observations

4. Programmes of Direct Relevance to GEO

This is a preliminary and incomplete list of cooperation that will be more fully described in the final proposal.

- NASA JPL Physical Oceanography Distributed Active Archive Center (PO.DAAC) GHRSST GDAC services for SST (http://ghrsst.jpl.nasa.gov/)
- NOAA National Oceanographic Data Center (NODC) Long Term Stewardship and Reanalysis Facility for GHRSST SST (http://ghrsst.nodc.noaa.gov)
- EUMETSAT Ocean and Sea Ice Application facility (OSI-SAF http://www.osi-saf.org/) and EUMETSAT Central Facilities.
- JAXA data server for GHRSST (http://sharaku.eorc.jaxa.jp/ADEOS2/ghrsst/)

- European Space Agency Climate Change Initiative (CCI http://earth.eo.esa.int/workshops/esa_cci/intro.html)
- NASA SST Science Team (http://depts.washington.edu/uwconf/sst2010/)
- GODAE Ocean View (http://www.godae.org/oceanview.html)
- NOAA GOES-R project (http://www.goes-r.gov/)
- Global Monitoring for Environment and Security (GMES) Marine Core Service (http://www.myocean.eu.org/)
- Australian Integrated Marine Observing System (IMOS) Project (http://imos.org.au/)
- All services and projects within the scope of GHRSST (http://www.ghrsst.org)

We anticipate that other groups will be part of the SST-VC activities.

5. DESCRIPTION AND TIMELINES OF CURRENT AND FUTURE SATELLITE PROGRAMMES

Table 2 summarises current and future satellite programs from 1991 to 2025 that include instruments capable of measuring SST.

Table 2. Key space segment capabilities for SST 1981-2025

Mission Name Short	Launch Date	End of Life (EOL) Date	Mission Status	Mission Instruments
Meteosat series	20 November 1993	31 January 2021	Currently being flown	MVIRI: 6, 7 SEVIRI: 8, 9, 10, 11
ERS series	1991	31 December 2011	Currently being flown	ATST-1 and ATSR-2
POES series	01 May 1981	01 March 2016	Currently being flown	AVHRR/2: 7,9, 11, 14 AVHRR/3: 15, 16, 17, 18, 19
TRMM	28 November 1997	?	Currently being flown	TMI, VIRS
INSAT series	03 April 1999	10 April 2013	Currently being flown	VHRR: 2E, 3A
OCEANSAT series	26 May 1999	31 December 2009	Currently being flown	MSMR: 1
Terra	18 December 1999	30 September 2011	Currently being flown	MODIS
GOES series	03 May 2000	01 January 2028	Currently being flown	ABI: R, S Imager: 11, 12, 13, O, P Sounder: 11, 12, 13, O, P
NMP series	21 November 2000	30 September 2011	Currently being flown	ALI: 1 Hyperion: 1
Envisat	01 March 2002	31 December 2013	Currently being flown	AATSR
Aqua	04 May 2002	30 September 2011	Currently being flown	AIRS, AMSR-E, MODIS
FY-1 series	15 May 2002	31 December 2009	Currently being flown	MVISR (10 channels): 1D
Coriolis/Windsat	06 January 2003	?	Currently being flown	Windsat
KALPANA-1	12 September 2002	09 December 2012	Currently being flown	VHRR
FY-2 series	19 October 2004	31 December 2016	Currently being flown	IVISSR (FY-2): 2C, 2D, 2E, 2F
MTSAT series	26 February 2005	28 June 2015	Currently being flown	IMAGER/MTSAT-2: 2 JAMI/MTSAT-1R: 1R
EPS series	19 October 2006	01 December 2021	Currently being flown	AVHRR/3: 1, 2, 3 HIRS/4: 1, 2 IASI: 1, 2, 3
HY-1 series	11 April 2007	01 January 2013	Currently being flown	COCTS: B, C, D
FY-3 series	27 May 2008	31 December 2024	Currently being flown	IRAS: 3A, 3B, 3C, 3D, 3E, 3F, 3G MVIRS: 3F, 3G VIRR: 3A, 3B, 3C, 3D, 3E, 3F, 3G

Meteor series	18 September 2009	31 December 2015	Currently being flown	IKFS-2: N2 MSU-MR: N1, N2 MTVZA: N1, N2
COMS series	23 June 2010 (?)	01 November 2016	Approved	MI: 1
GOMS/ELECTRO series	31 December 2009	31 December 2021	Approved	MSU-GS: N1, N2, N3
HY-2 series	01 January 2010	01 January 2011	Planned	RAD: A
SAC series	22 May 2010	22 May 2015	Approved	NIRST: D/Aquarius
NPP	01 September 2011	02 June 2015	Approved	VIIRS
GCOM series	01 February 2012	01 February 2025	Approved	AMSR-2: W1, W2, W3
Sentinel-3 series	01 August 2013	01 July 2026	Approved	SLSTR: A, B, C
FY-4 series	31 December 2012	31 December 2024	Planned	MCSI: O/A, O/B, O/C, O/D, O/E
GCOM-C series	January 2014	January 202027	Approved	SGLI: C1, C2, C3
JPSS series	31 January 2013	01 January 2027	Approved	MIS: 2, 3, 4 VIIRS: 1, 2, 3, 4
MTG-I (imaging) series	15 December 2016	15 December 2037	Approved	FCI: 1, 2, 3, 4

6. PROPOSED MEMBERS

GHRSST membership includes representatives from CEOS and other government agencies as well as scientists and others representing scientific and operational user communities. GHRSST working groups generally consist of scientists. However, we propose that the leads for the SST-VC come from implementing organizations; specifically those individuals from space and other government agencies representing their governments on GHRSST. To date, the following GHRSST members have confirmed that their agency will participate in the SST-VC:

1. Kenneth S. Casey, National Oceanic and Atmospheric Administration (NOAA), USA
2. Craig Donlon, European Space Agency (ESA), Netherlands
3. Hans Bonekamp, European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), Germany
4. Andrew Bingham, Jet Propulsion Laboratory, National Aeronautics and Space Administration (NASA), USA
5. Misako Kachi, Japan Aerospace Exploration Agency (JAXA), Japan
6. David Llewellyn-Jones, University of Leicester, United Kingdom
7. Ian Barton, CSIRO Australia
8. Jacob Hoeyer, Danish Meteorological Office, Denmark
9. Helen Beggs, Bureau of Meteorology, Melbourne, Australia

We anticipate that others will join as well and additions to this list will be made in due course. This group would form the leadership of the SST-VC supported as *ad hoc* members by the GHRSST Chair (currently Dr. Craig Donlon). Our plan is to select 2 from the leadership group to serve as the co-chairs with a rotation every 2-3 years.

7. SCHEDULE

Assuming that the initial proposal is approved at SIT-2011, the SST-VC leadership group will begin to prepare a Study Report. The goal would be to have a final version of the Study Report for submission to SIT following the next GHRSST annual meeting to be held at Edinburgh, Scotland, June 27 – July 1st 2011.

8. COSTS

The cost of ***establishing*** the SST-VC constellation is minimal given the commitments already made to GHRSST (approximately $25M over a period of nearly 10 years). In terms of ***operating*** the SST-VC the following resources are in hand:

- ESA continues to fund the GHRSST International Project Office until 2013,
- NASA funds the GDAC and NASA SST-Science Team activities,
- NOAA funds the GHRSST LTSRF,
- EUMETSAT funds the OSI-SAF contributions to GHRSST,
- JAXA funds their activities within GHRSST,
- Additional funds contribute from National agencies supporting the activities of the SST-VC (via GHRSST),
- GHRSST international Science Team meetings provide an obvious annual focal point for the SST-VC. Traditionally, costs associated with hosting the GHRSST meetings are met by *sponsorship* with travel and subsistence costs covered at National level (except for students where sponsorship is required).

In terms of ***developing*** the SST-VC, additional CEOS support will be required to support specific SST-VC activities including: development and publication of promotional and educational materials (web pages, course materials); organization and hosting of SST-VC training workshops; attendance of CEOS meetings and other specific meetings as required by the activities of the SST-VC.

END OF DOCUMENT

Proceedings of GHRSST XI Science Team Meeting (G11) - Lima 2010

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Appendix VI: Attendance List for the GHRSST 11th Science Team Meeting

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