GHRSST-PP

GODAE High Resolution Sea Surface Temperature Pilot Project

Report of the 8th GODAE High Resolution SST Pilot Project Science Team Meeting.

Bureau of Meteorology Head Office, 700 Collins St, Docklands, Melbourne, Australia,

Monday 14 May to Friday 18 May, 2007

GHRSST-PP Report: GHRSST-35, 2007

Sponsored by:

GODAE Global Ocean Data Assimilation Experiment · NASA · CSIRO Marine Research · Australian Government Bureau of Meteorology · Met Office · NOAA · esa

Report of the 8th GODAE High Resolution SST Pilot Science Team Meeting

Bureau of Meteorology Head Office, 700 Collins St, Docklands, Melbourne, Australia

Monday 14 May to Friday 18 May, 2007

Compiled by Craig Donlon and the GHRSST-PP International Science Team

Published by the International GHRSST-PP Project Office
Met Office Hadley Centre
Met Office,
Fitzroy Road, Exeter, EX3 1PB
United Kingdom

E-mail: craig.donlon@metoffice.gov.uk
Tel: +44 (0)1392 886622
Fax: +44 (0)1392 885681

The GHRSST-PP International Science Team (2007/08)

Craig Donlon	Chair; Hadley Centre, Met Office, United Kingdom
Andrew Bingham	JPL, PO.DAAC, USA
Andrew Harris	NOAA/NESDIS ORA, USA
Bill Emery	University of Colorado, USA
Bob Evans	University of Miami, USA
Chelle Gentemann	Remote Sensing Systems, USA
Chris Merchant	University of Edinburgh, United Kingdom
Chris Mutlow	Rutherford Appleton Laboratory, United Kingdom
David Llewellyn-Jones	University of Leicester, United Kingdom
David Poulter	National Oceanography Centre, United Kingdom
Doug May	Naval Oceanographic Office, USA
Ed Armstrong	JPL PO.DAAC, USA
Gary Wick	NOAA ETL, USA
Helen Beggs	Bureau of Meteorology, Australia
Hiroshi Kawamura	Tohoku University/JAXA, Japan
Ian Barton	CSIRO Marine, Australia
Ian Robinson	National Oceanography Centre, United Kingdom
Jean François Piollé	IFREMER, Brest, France
Jorge Vasquez	JPL PO.DAAC, USA
Ken Casey	NOAA/NESDIS NODC, USA
Nick Rayner	Hadley Centre, Met Office, United Kingdom
Olivier Arino	European Space Agency
Peter Cornillion	University of Rhode Island
Peter Minnett	University of Miami, USA
Pierre LeBorgne	Meteo France/O&SI SAF, France
Richard Reynolds	NOAA NCDC, USA

Printed in England, 30th April 2008.

Document change record

Author	Modification	Issue	Ref.	Date
C J Donlon	Original	1.0	DRAFT	25th July 2007
C J Donlon	Revised	1.1	DRAFT	10th August 2007
C J Donlon	Revised	1.2	DRAFT	16th November 2007
C J Donlon	Final version	2.0	Final	10th January 2008
C J Donlon	Correction	2.1	Final	14th April 2008
C J Donlon	Updated DV-breakout report	2.2	Final	9th May 2008

Table of Contents

1 Introduction

This report provides a comprehensive review of the presentations, discussion and outcomes of the 8th GHRSST-PP Science Team meeting. These annual events are the highlights of the 'SST year' and provide all concerned with an opportunity to review the health of the GHRSST-PP, exchange the latest scientific ideas and results, plan for future collaborative activities and help ensure that the international SST user community requirements are met today and in the future through coordination of international activities. This year we have the largest attendance list to date which provides a metric of the growing awareness and interest in the GHRSST-PP.

I am proud to say that the progress made by the GHRSST-PP project community since the seventh Science Team meeting in 2006 has been an outstanding achievement to all involved. For the GHRSST-PP International Project Office it is a busy but exciting time as the office continues to guide, support and promote the international activities of the GHRSST-PP on the road to sustainable products and services for the SST user community. A baseline GHRSST-PP regional/global task sharing (R/GTS) framework is now operational and user uptake of GHRSST-PP products and services has begun: The GHRSST-PP regional projects have developed, implemented and now operate a GHRSST-PP Global Data Analysis Centre (GDAC) served by several Regional Data Assembly Centres (RDAC); a supporting operation is in preparation in the European Region; a Long Term Stewardship and Reanalysis Facility (LTSRF) has been developed to archive all GHRSST-PP data products and there has been significant progress towards a satellite era reanalysis program. This shifts the emphasis within the GHRSST-PP from a technical implementation towards maintaining and coordinating international activities that serve a growing and a demanding user community with real time operational data feeds of SST products and delayed mode SST Climate Data Records through re-analysis.

The primary responsibility placed on the GHRSST-PP and the Science Team by our user community is to coordinate the transition of our activities from a pilot project into sustained operations. Transition of R&D systems with associated user communities requires suitable transition planning in order to maintain services. Part of this work includes working toward internationally accepted and viable Interface Control Documents (ICD) and Service Level Agreements (SLA) between GHRSST-PP Operators. The GHRSST-PP systems also require careful refinement based on user feedback and the collective experience gained by the GHRSST-PP community over the last 5 years. A major challenge is to develop a GDS-v2.0 within the next 12 months that should include: full descriptions of gridded products (L3P); revised metadata frameworks: operational system messaging including comprehensive error and metrics; better more homogeneous and well described SSES, definition and provision of new data sets (e.g., METOP, MTSAT); a full revision of L4 and L2P data sets; Sea Ice (concentration and extent) and SST in the marginal ice zone; implementation of improved schemes to account for diurnal variability in a way that provides users with a useful and error-bound product using other data sets in synergy (e.g., Ocean Colour and NWP outputs); and improved ancillary data tuned to individual sensors.

The aim of the eighth Science Team meeting was to review progress made within the GHRSST-PP since the last Science Team meeting and prioritise coordination of the GHRSST-PP distributed applications and activities for the next inter-sessional period. As members of the GHRSST-PP international Science Team all delegates 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. The meeting format was once again biased toward *plenary discussion* with keynote talks to identify key issues. This format has worked exceptionally well during previous GHRSST-PP workshops and many delegates came well prepared with slides, questions and practical solutions that can be incorporated into GHRSST-PP plans and specifications**.** In addition, parallel session breakout groups were used to focus the attention of world expertise on particular issues.

On behalf of the GHRSST-PP Science Team I would like to take this opportunity to thank Helen Beggs and the Australian Bureau of Meteorology team for all of their help and support in preparing the workshop. Thanks also to all the sponsors and participants who make these important events possible. Finally, it is with a warm heart that I thank each of you for your contributions, support and dedication to the GHRSST-PP and your company in Melbourne throughout the productive and stimulating workshop.

Craig Donlon
(Director of the GHRSST-PP International Project Office,
Met Office, Exeter United Kingdom)

Delegates attending the 8th GHRSST-PP Science Team Meeting, Bureau of Meteorology, Melbourne Australia 2007.

2 Introduction Session

Following a welcome from Helen Beggs and a review of safety, evacuation and logistical information, Beggs invited Neville Smith (Chief Scientist, Bureau of Meteorology Research Centre (BRMC), Australia) to formerly welcome the GHRSST-PP Science Team to the BRMC and open the meeting.

2.1 Opening and welcome address, *N. Smith, BRMC, Australia.*

Neville Smith welcomed the GHRSST-PP Science Team to the BRMC and remarked that despite a long running relationship with GHRSST-PP this was the first GHRSST-PP meeting that he had managed to attend. There were some faces that Smith recognised at the meeting that were also present at the initial GODAE meeting in 2001 hosted by the European Commission Joint Research Centre (JRC), Ispra, Italy where the basis for a GHRSST-PP was established. Smith remarked that as during his time as Chair of the International GODAE Steering Team (IGST), watching GHRSST-PP has been like watching a lucky and dedicated child grow and credit is due to all in the project. GHRSST-PP has become a tool to develop and nurture the science and application of SST which have all developed under the GHRSST-PP Science Team coordination.

Smith recalled the agenda followed at the Ispra meeting where much effort was given to debating the issue of bulk SST *vs.* SkinSST and the associated ATSR *vs.* NOAA AVHRR retrieval processes; issues of geostationary and new ‘all weather’ Microwave SST; in situ buoys and radiometers for validation; cloud clearing and the need for better blending techniques. Today all of these issues are now seen as normal and part of everyday life in the SST community. At Ispra there were 30 scientists and it is clear from this meeting alone that numbers have grown enormously since then. At the start of GHRSST-PP it there really was not a community to push the science of SST (bar a few notable exceptions) and the scientific consensus of the time thought that SST was ‘a done deal’; satellite measurements and associated validation and quality control was considered mature and more than adequate for all applications. Smith noted that we have learned that the satellite data have many issues to deal with if systematic, accurate and timely SST data are to be provided for the present and next generation of forecasting systems and for climate.

Four main themes were followed at the Ispra meeting: Testing of data sources concepts (now the Diagnostic Data Set), data assembly (now the Regional/Global Task Sharing (R/GTS) framework), inter-comparisons (now emerging within GHRSST-PP multi-product ensemble) and data assimilation (in partnership with GODAE). Assimilation systems have been slow to adapt and use GHRSST-PP data even though it should be a mainstream activity. Part of the reason is that it takes time to develop the confidence of the users in operational and R&D communities and while this has grown from modest beginnings, there are still huge challenges in both technological and scientific areas. These significant challenges were apparent at the Ispra meeting and raised concern that strong leadership was required if a GHRSST-PP was to be successful. Bill Emery, Ian Barton and Ian Robinson were tasked to advise on potential candidates for the job and suggested Craig Donlon who, together with an excellent Science Team have together made GHRSST-PP the success that it is.

Smith was pleased to report that in Australia the BLUELink> project has successfully developed a strong community for SST and all aspects of ocean forecasting. The associated integrated marine observation structures now being developed are the largest infrastructure initiative in Australia and while these are better times now than ever before, the infrastructure is not completely ideal – especially in the future as satellite systems have a chequered and often uncertain future. In this respect, there remains much to be done by GHRSST-PP and other similar groups.

Smith remains proud of the GHRSST-PP and noted that perhaps his biggest failure was loosing the argument over the GHRSST-PP acronym. Today, GHRSST-PP is well recognised by IOC and WMO, it is still making excellent progress and the GHRSST-PP data sets are well known. Most importantly, the community of GHRSST-PP has tremendous respect. The future challenges remain exciting and direct and Smith recommended that the GHRSST-PP should consider the application of its products in the widest possible manner. A particular challenge is to integrate GHRSST-PP products into climate data sets (fluxes, SST Climate Data Records) and to help drive uncertainties down.

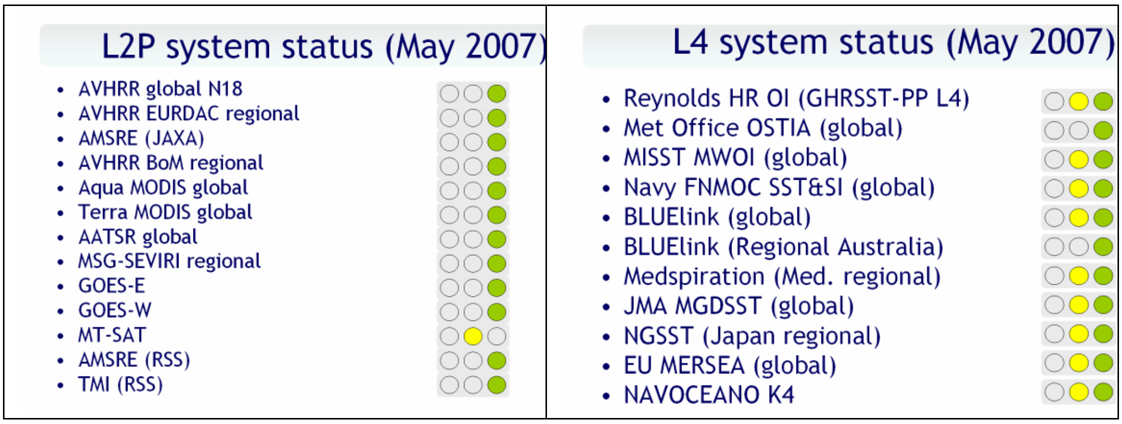
Smith concluded noting that it is pleasure to welcome everyone, old friends and new faces, to the GHRSST-PP meting and hoped that the meeting will be a great success. Finally Smith invited everyone to a welcome cocktail sponsored by the BRMC later that evening which he planned to attend in a more informal manner.

2.2 Report from the GHRSST-PP International project Office: Overview of the GHRSST-PP project status, priorities and aims of the Workshop, *C Donlon GHRSSTPP International Project Office, UK.*

Donlon thanked Neville Smith for his excellent introduction and welcomed the Science Team to the 8th GHRSST-PP Science Team meeting (the 'G8' meeting). He began by thanking the Bureau of Meteorology (BoM) Research Centre (BMRC) for hosting this meeting (and for funding the icebreaker reception planned for the evening), the BoM Space Based Observations section for co-funding the meeting, to the BRMC staff for preparing so well and supporting registration and events including Meryl Wiseman, Margaret Hughes, Val Jemmeson, Sussana Casso, Tim Pugh and Helen Beggs.

Donlon then gave a summary overview of the GHRSST-PP status noting that progress had been excellent and that there was far too much to review in a short introduction. The GHRSST-PP Regional/Global Task Sharing Framework (R/GTS, see Figure 2.2.2a) was now well established and is governed by the GHRSST-PP data Processing Specification (GDS) with functional projects underway for each of the main elements of the project. These include:

- Many Regional Data Assembly Centres (RDAC) providing regional and global coverage L2P and L4 products as shown in Figure 2.2.1.
- The High-resolution diagnostic data set system (HRDDS, see http://www.hrdds.net),
- The GHRSST-PP Match-up Database (MDB, see http://www.medspiration.org/tools/mdb),
- The Global Data Assembly Centre (GCAC, see http://ghrsst.jpl.nasa.gov),
- The Long-term Stewardship and Re-analysis Facility (LTSRF, see http://ghrsst.nodc.noaa.gov),
- The Master Metadata Repository (MMR, see http://ghrsst.jpl.nasa.gov/sdata_search.html).



(a) (b)

Figure 2.2.1 (a) Status of GHRSST-PP L2P data sets May 2007 and (b) status of L4 data sets May 2007.

Donlon explained that a considerable effort was underway in the European area to develop a Marine Core Service for operational oceanography, to be funded by the European Commission (EC) and European Space Agency (ESA). This is part of the EU Global Monitoring for Environment and Security (GMES) initiative and includes the development of a sustained space observing system (the new ESA Sentinel series) and core data product services. A project proposal and large consortium led by Mercator Ocean (see http://www.mercator-ocean.fr) is developing 'MyOcean' which will deliver regular and systematic reference information (processed data and value-added products) on the state of the oceans and regional seas at the resolution required by users for the global and European regional seas.

Within the MyOcean project a Sea surface Temperature Thematic Assembly Centre (SST-TAC) will be developed and operated which will implement a GHRSST-PP system in a complementary manner to the JPL GDAC implementation. The EU SST-TAC will manage the transition of Medspiration, MERSEA and GHRSST-PP in Europe to sustained operational system. The MyOcean project is expected to start in 2008 with a €35Million EC contribution matched by participants giving a €90M total budget.

(a)

(b)

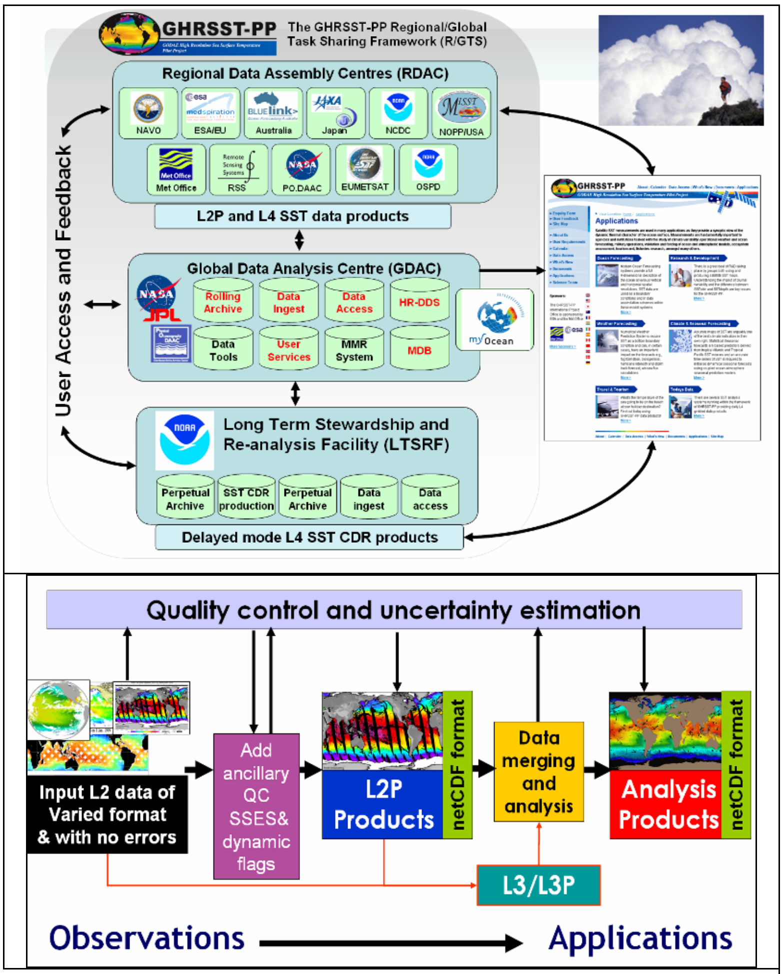


Figure 2.2.2 (a) The GHRSST-PP Regional/Global Task Sharing Framework (R/GTS) and (b) the General strategy for the GHRSST-PP showing the proposed introduction of L3/L3P data products.

Donlon then reminded the ST of the GHRSST-PP strategy for developing the next generation of SST and sea ice data products (Moving Observations to Applications) as shown in Figure 2.2.2b. The basic strategy was now recognised as a useful way to develop the GHRSST-PP but was lacking in certain areas in particular the growing user need for Level-3 (L3 and L3P variant) regular gridded products and the desire for access to brightness temperature (BT) information (radiances, L1b or L1P). An excellent discussion over the past few months had taken place via e-mail to establish the requirements and scope of a GHRSST-PP L3/L3P products which concluded that there is a clear demand for L3P type products and that there are many potential benefits users and producers alike particularly for L4 production centres, for validation and for easy web-based data access. The G8 provided an excellent opportunity for the ST to agree by consensus a way forward and to scope out in some detail the specification and rules required by the GDS to manage the international production of L3/L3P and if necessary L1b radiance type products. In summary, Donlon noted that the GHRSST-PP development and implementation was moving forward. Furthermore there was considerable activity and new resources within the R/GTS implementation framework to help it transition into a sustained system

Several key applications that had emerged since the last meeting were then highlighted. Collaboration with the Group on Earth Observation (GEO) has been set up to promote the use of ensemble based techniques and earth observation data sets. GHRSST-PP has taken the lead for a dedicated GEO action in this respect and is actively promoting the use of ensemble SST analyses. Nicholas Kilingaman has applied the OSTIA data set (see http://ghrsst-pp.metoffice.com/pages/latest_analysis/ostia.html) to help understand Indian Monsoon breaks. Using the HadAM3 atmospheric model forced with ensembles of the high-resolution OSTIA SSTs. Results show that time-evolving precipitation structures are completely different and much more coherent when using high-resolution SST's when compared to runs forced with conventional coarse resolution NCEP or coupled model outputs. A pdf presentation is available from the GHRSST-PP web site http://www.ghrsst-pp.org/modules/documents/documents/klingaman-met_office_presentation_s07.pdf).

Other applications (to be presented more fully during the G8 meeting) included potential contributions to the Australian Great Barrier Reef/Coral Bleaching community as part of the ReefTemp project (see http://www.cmar.csiro.au/remotesensing/gbrmpa/ReefTemp_application.htm) that needs better re-analysis and climatological SST data sets at high resolution. ReefTemp is interested in working with climatological data that considers estimates of climate change for planning purposes. Jeff Maynard will present a comprehensive overview of the needs for ReefTemp at the G8 on Tuesday.

Significant advances have been made as part of the BLUELink> reanalysis project (BRAN) which assimilates both SST and altimeter SSH data. The full impact of the observations is only realised when both SST and SSH data sets are assimilated which has led to an acceleration of SST activities. Hurricane prediction re-analysis runs conducted by the MISST project and for a more limited number of cases at and Met Office have shown that high resolution microwave SST's do have an impact in some cases. Although there was no significant difference in the track forecast errors overall, there were areas where the use of the GHRSST-PP SST analyses resulted in significantly improved hurricane track forecasts. See presentation by Chelle Gentemann. SST is a key GCOS Essential Climate Data Record and top of NASA's list which underscored the importance of the GHRSST-PP reanalysis program (RAN) and several activities to bring the RAN effort closer to producing a first GHRSST-PP CDR have taken place since the last GHRSST-PP ST meeting. Ken Casey reviewed the RAN and its activities in a dedicated session later in the week.

Helping the GHRSST-PP application and user community as part of the GHRSST-PP Applications and User Services (AUS) has been a key focus for all projects in the GHRSST-PP. A new GHRSST-PP web site has been developed with a full dynamic Wiki style web site content management system. All Science Team members can log in and edit/change/add information to the site. Each WG/TAG has a dedicated page for their activities that can include applications, demos and information pages. A Simple Project Management tool has been installed to assist in monitoring and managing general projects/activities within the web space. A fully functional calendar that can carry event information has been implemented as requested by the Science Team at the 7th ST meeting, and electronic document library and events registration system has also been installed. The GHRST-PO has invested considerable time, effort and funding to develop and prepare the web system which now allows content to be managed by the Science Team more effectively. It remains for the ST to log in to the system and update their pages with appropriate and timely content. Other web sites (notably the LTSRF and the GDAC) have adopted a similar look and feel to the GHRSST-PP main page in order to ensure continuity between sites.

A new data use tutorial paper prepared by Ken Casey is available as an on-line resource at the LTSRF and has been linked on the GHRSST-PP main pages. Several ST members suggested that the data access pages on the main GHRSST-PP web site should be upgraded and revised. Donlon concluded that for many people ranging from casual users to GHRSST-PP funding managers, the web sites are the main tool they use to discover what is current in the GHRSST-PP and it is in all of our interests to ensure that they all provide good looking and up-to-date systems that demonstrate progress and provide useful information about GHRSST-PP.

Donlon then discussed the need for further research and development within the GHRSST-PP to establish accurate single sensor error statistics (SSES). For many users, SSES are one of the main benefits to using GHRSST-PP data sets but so far, only very basic SSES have been developed for some sensors (including AATSR, MODIS, GOES, SEVIRI, AMSRE, TMI). Accurate SSES are at the very heart of the GHRSST-PP but they are extremely difficult to derive, maintain and validate within a real-time system such as the R/GTS. There is clearly a need to homogenise the definitions of SSES so that they are easily understood and are effective when applied by the end user community. Donlon explained that it is recognised that SSES are all different but there is a need to keep working toward a common scale/definition of 'Quality' as agreed at the G7 meeting. At present there are various definitions/approaches to SSES nomenclature and symbology (hypercube, proximity_confidence, microwave SSES) that must be rationalised. Donlon noted that this was a priority area for the GHRSST-PP ST during this meeting. In particular GHRSST-PP should document SSES and their derivation, continue to improve SSES procedures, provide user support for SSES and their application and try to homogenise SSES (as far as practically possible) as part of the GDSv2.0 documentation.

The issue of diurnal variability and the use of ocean colour information to help develop new diurnal variability parameterizations and applications were then discussed. The MODIS RDAC system is providing example Ocean Colour data information within experimental L2P product fields (see Figure 2.2.3) following discussions at the 7th GHRSST-PP Science Team meeting. There is also a growing user requirement for combined ocean colour and SST products (as discussed at the Joint ESA Medspiration/Globcolour user consultation workshops, and as noted by the NASA Ocean Biology Processing Group) to which GHRSST-PP needs to respond.

Ocean Colour (OC) data are clearly needed for complete Diurnal Variability studies as they can provide information that helps define the solar absorption profile in the upper ocean. OC is also an independent tracer for surface current and structures (fronts, eddies, upwelling etc) which can be used as part of L4 system verification (this requires a global high resolution OC data set). OC can be helpful in marginal ice zone and, can provide information on excess atmospheric aerosol load impacting IR sensors (AOD type of ***dynamic_indicator***).

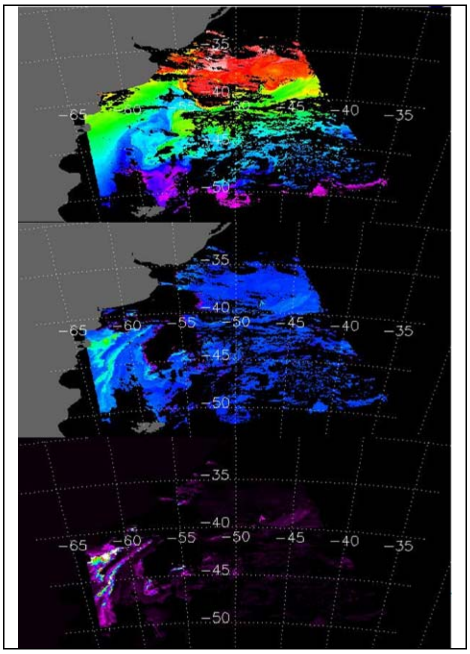


Figure 2.2.3 MODIS L2P granule showing (top) SST, (middle) Kd(490) and (bottom) Chlorophyll-*a* within L2P experimental fields.

Donlon suggested that the ST consider if GHRSST-PP needs to have an Ocean Colour RDAC to develop appropriate ancillary field products (e.g., the NASA OBPG and GlobColour projects which both have sent representatives to the G8). Clearly there is an action to work towards integrating appropriate OC data products (e.g., $Kd_{(490)}$, Chl-*a*, Z_{hl}) from various providers for dedicated GHRSST-PP specific applications (e.g. as part of the DV-WG and emerging L4 GMPE work) into the R/GTS system and as part of GDS v2.0. Specifically, the GHRSST-PP science Team needs to agree on which OC products (e.g., $Kd_{(490)}$, Chl-*a*, Z_{hl}) are of most benefit to the GHRSST-PP and how should they be included within existing L2P/L4 processing schemes and the R/GTS itself?

The need to stabilise a GHRSST-PP product line before starting the development of GDSv2.0 and USA GDAC to EU-SST-TAC interface definitions were raised by Donlon as a priority actions for the GHRSST-PP ST at this meeting. There are many loose ends to tie up including netCDF versions, CF-1.0 GHRSST-PP specifications, sftp, ftp, THREDDS, OPeNDAP, POET interfaces etc. All of these R/GTS interfaces and agreements need to be documented within the GHRSST-PP (possibly as interface control documents (ICD), Service Level Agreements (SLAs)) GDS v2.0 documentation.

This meeting provided a great opportunity to start working on Service and data management issues (particularly as 5 representatives from PO.DAAC/JPL were present at the meeting and many from the EU MyOcean Consortium implementing the SST-TAC). The GDS (and internal ICD/SLA's) provides the basis for metrics to assess the GHRSST-PP so that establishing formal agreements and relationships (GDAC<>GDAC<>RDAC<>L2 Providers) within the R/GTS is a priority action for the meeting. One way to take these ideas forward is to develop a GHRSST-PP Metrics/Operations Dashboard that can be shared by all of the GHRSST-PP teams. This would help to establish a better awareness of who is doing what within the NRT R/GTS at any one time and help build confidence in the GHRSST-PP systems (see Figure 2.2.4)

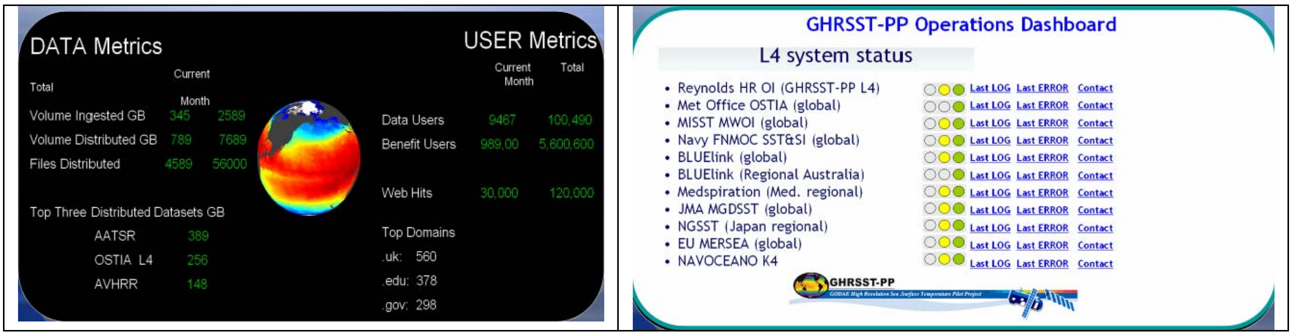


Figure 2.2.4 Mock up of a potential implementation for a GHRSST-PP Metrics Dashboard system that would communicate by RSS in NRT informing people of the status of each R/GTS component

Donlon suggested that a small working group should be established to make a note of 'GDS-2.0' issues throughout the meeting and to report back in plenary later on during the meeting. This suggestion eventually resulted in a dedicated session for GDSv2.0 issues to be discussed and Donlon requested that the ToR for the GDS-TAG are reviewed as soon as possible to get the GDSv2.0 moving; there are only ~12 months before the GDS is essentially 'locked in' with MyOcean project. NASA GDAC teams want to begin the process immediately and we need a GDAC to SST-TAC talking session to bottom out how we will run the systems in the most efficient manner. The most important priority for the GHRST-PP ST is the definition and publication of the GDS v2.0 building on what we have done so far. This should include revision of the following key elements:

- L2P, L3/L3P, L4 format and content specification including rule base and reference data sets and SSES definitions.
- A new system for the exchange of NRT operational messages and error logs,
- Specification of a Metrics/system Dashboard (see Figure 2.2.4)
- ICD's/SLA's and documentation of data agreements in force (respect your users….)
- MMR upgrades ISO 19115 (Metadata model revision)
- User help utilities and AUS requirements
- Better QC systems (MDB and HR-DDS)
- Proper documentation of the HR-DDS and user driven HRDDS services
- MDB (Data model revision) and proper documentation of the MDB and user driven MDB services
- System validation
- Product validation
- Data policy

To achieve such an ambitious document in a relatively short period of time will require a concerted effort by a dedicated team (a 'GDS Squad') that will be tasked with the overall responsibility to manage sections of the GDS documentation. This should be established by the end of the G8 meeting.

Donlon explained that the GHRSST-PP was now in the process of moving to a more sustained system and that in the future the Pilot Project will need to end. GODAE is set to end in 2008 and the GHRSST-PP will at that point need to decide which international organisation it is best affiliated with (a dedicated talk later in the week will be given to explore various options). The GHRSST-PP was progressing well and had now implemented a viable and useful R/GTS system that had an increasing user base depending on its products and services ranging from operational systems, university and research laboratories to public users. While there are many issues facing the continuity of SST sensors (particularly for the NPOESS CMIS/MIS now that this had been dropped from the NPOESS C3 satellite) and that other gaps for precision IR data sets (AATSR through to Sentinel-3), the GHRSST-PP had much to do to build the case so that such gaps should not occur in the future. In terms of this G8 Science Team meeting, Donlon set the following priorities for the ST to resolve:

- G8 Priority 1: Write the GDS v2.0 in a draft version by the end of 2007. This needs to be specified building on what GHRSST-PP has implemented so far but consider also the future sustainability of the data sets and services.
- G8 priority 2: Define L3/L3P data sets for GDS2.0.
- G8 Priority 3: Improve the Application and User Services of GHRSST-PP.
- G8 Priority 4: Document and continue to improve SSES procedures, provide user support and try to bring SSES together in GDS2.0.
- G8 Priority 5: Work towards integrating appropriate ocean colour products (e.g., $Kd_{(490)}$, Chl-*a*, Z_{hl}) suitable for use by DV-WG, L4 GPME into the R/GTS system and GDS v2.0.
- G8 Priority 6: Establish formal agreements and relationships where and when appropriate (e.g., GDAC<>GDAC<>RDAC<>L2 Providers) within the R/GTS.
- G8 Priority 7: Develop a concerted RAN data processing and analysis activity (now that data collection is in place at the LTSRF).
- G8 Priority 8: Encourage and develop MDB and HRDDS user led applications.
- G8 Priority 9: Implement a common GHRSST-PP metrics dashboard/operational messaging interface system (RSS syndication? email? Other?).
- G8 Priority 10: Decide on a preferred home for GHRSST-PP once GODAE has ended in 2008.

2.3 Review action items since the 7th GHRSST-PP Science Team Meeting

Donlon recalled the action list form the 7th GHRSST-PP Science Team Meeting and reviewed each action together with the GHRSST-PP Science Team. Of the 86 actions raised in Boulder, 26 were carried over into the 2007/08 inter-sessional period. These are listed in Appendix IV. This was considered great progress and a significant achievement for all involved.

3 Session on R/GTS Components: Reports to the GHRSST-PP Science Team

3.1 USA Multi-Instrument SST (MISST) National Ocean Partnership Program (NOPP) report, *C. Gentemann, Remote Sensing Systems, USA.*

Gentemann explained that the Multi-sensor Improved Sea Surface Temperature (MISST) project has two parts that address two distinct aims: Part 1 focuses on producing an improved sea surface temperature (SST) product through the combination of observations from complementary infrared (IR) and microwave (MW) sensors. Part 2 focuses on demonstrating the impact of improved multi-sensor SST products on operational ocean models, numerical weather prediction, and tropical cyclone intensity forecasting. To produce multi-sensor improved SSTs and successfully and assess the impact of these products, five project tasks have been identified:

1) Computation of sensor-specific observational error characteristics (SSES) required for optimal application and data fusion techniques.
2) Parameterization of IR and MW retrieval differences, with consideration of diurnal warming and cool-skin effects required for multi-sensor blending.
3) Production and dissemination of sensor-specific SST products with associated retrieval confidence, standard deviation (STD), and diurnal warming estimates to the application user community.
4) Production and dissemination of improved multi-sensor high-resolution skin and bulk SST analyses to demonstrate and optimize utility in operational applications.
5) Targeted impact assessment of the SST analyses on hurricane intensity forecasting, numerical data assimilation by ocean models (both national and within GODAE), numerical weather prediction, and operational ocean forecast models.

The main tasks during the first two and a half years of the MISST project period have focussed on the development of error estimates for each sensor (SSES), initial production of SST data with SSES, develop methodologies for estimating diurnal warming and for calculating skin and bulk temperatures differences. The MISST project is now entering the impact assessment phase and will continue to develop impact studies with a wide variety of international and national partners.

The MISST project has now successfully developed nine L2P/L2Pc data sets including ancillary fields as described in Table 3.1.1. A large part of the MISST work has been devoted to proper specification of SSES for each L2P stream that are typically specified as time/space varying Look-up tables (LUT). Considerable progress has been made in this area and feedback from user applications is so far encouraging.

Table 3.1.1 L2P data sets developed within the framework of the MISST project.

Responsible Agency	MISST L2P/L2Pc data set
NAVOCEANO	NOAA-18
NAVOCEANO	NOAA-17
RSS	TMI orbital swath and gridded product
RSS	AMSR-E orbital swath and gridded product
NOAA	GOES-East
NOAA	GOES-West
NOAA/BoM	MTSAT (in preparation)
JPL GDAC / OBPG / RSMAS	MODIS Terra
JPL GDAC/ OBPG / RSMAS	MODIS AQUA

A particular concern is how to adequately account for diurnal variability (DV) in L2P data sets as most groups running L4 analysis systems need to know what data are likely to be contaminated by DV signals. Furthermore, providing accurate SSESW requires that DV is explicitly accounted for or removed form the SSES analysis data set. MISST has conducted an extensive R&D program to explore parameterisations and models of DV that can be tailored for application in a NRT processing environment that provides DV estimates for L2P data sets. As DV is global, and currently GHRSST-PP does not have a global array of geostationary SST sensors on-line, MISST has used complementary constellations of polar orbiting and low-earth orbit sensors that can sample SST at different points in a DV cycle (see Figure 3.1.1).

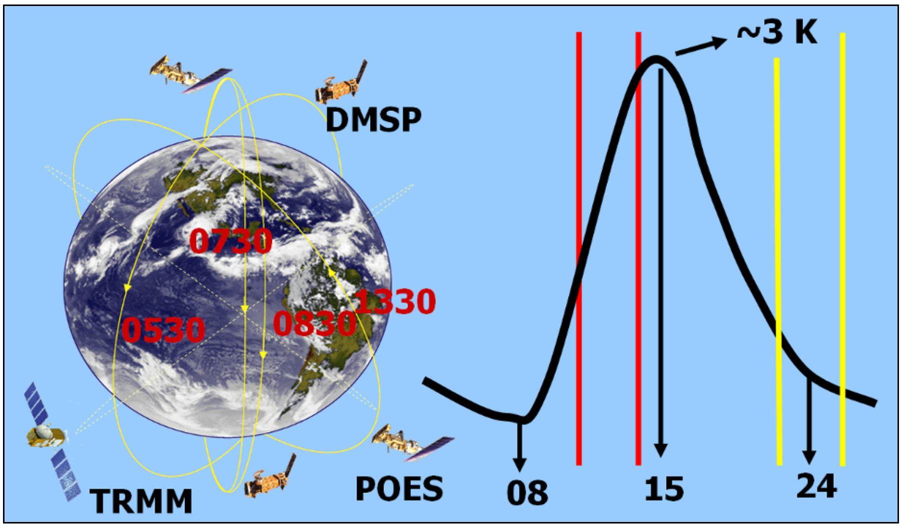
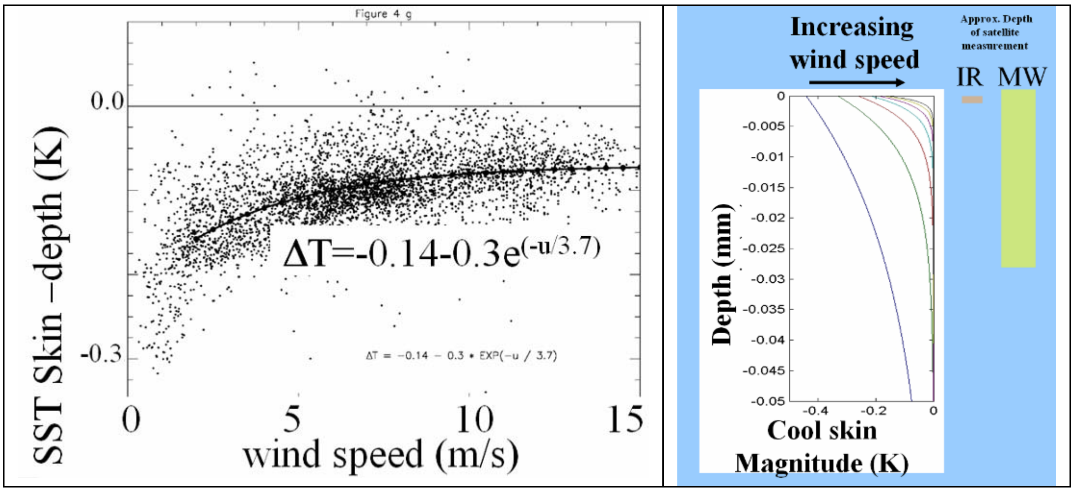


Figure 3.1.1 Schematic diagram showing constellation of SST sensors having different equatorial crossing times and the nominal location of each overpass plotted on a representative DV signal over a 24 hour period.

SSES are also required to consider SST skin and SSTdepth variability which requires a full understanding and characterisation of Skin-depth SST (ΔT) differences. A ΔT parameterisation updating Donlon et al. (2002) with additional high-wind speed (>15 ms^{-2}) data from new cruises is being used to provide an estimate of cool skin and DV as part of MISST L2P data sets. Further work looking at the depth of the skin/sub-skin layer and temperature profile is also been completed (see Figure 3.1.2).



(a) (b)

Figure 3.1.2 (a) Updated MISST parameterisation for ΔT as a function of Wind Speed following Donlon et al. (2002). (b) Effective depth and cool skin magnitude of surface skin and sub-skin layers (e-folding depth of IR and MW sensor penetration is shown schematically.

The MISST teams have also developed several L4 global analysis products with various combinations of infrared and microwave input data, bias correction schemes, spatial resolution and compensation for diurnal variability (see Table 3.1.2). All MISST L4 data sets are available at the GHRSST-PP GDAC in L4 format. See http://www.misst.org for full details.

MISST L4 data are being used in a variety of applications trials to asses the impact of MISST SST products and services. Several studies are targeted on hurricane intensity forecasting, ocean forecasting and NWP forecasting. The work has focussed on three main issues:

- *Do merged SSTs improve assimilation of AMSU radiances?*

- *Are L2P errors useful?*
- *Do multiple satellite SSTs improve NOGAPS forecasts?*

Table 3.1.2 Data servers and general description/links to MISST L4 data products

Server	Type[1]	Sensors used	Resolution	Link	Link
RSS	MW	TMI	~25 km	Images	Data
RSS	MW	AMSR-E	~25 km	Images	Data
RSS	MW	TMI+AMSR-E	~25 km	Images	Data
RSS	IR+MW	MODIS+TMI+AMSR-E	~9 km	Images	Data
FNMOC	IR	AVHRR	~9 km	-	Data
FNMOC	IR+MW	AVHRR+AMSR-E	~55 km	-	Data
NOAA	IR	AVHRRs (POES+GOES)	~11 km	Images	-

Initial Hurricane studies suggest that although there was no significant difference in the track forecast errors overall when using MISST products, there were areas where the use of the MISST SST analyses resulted in significantly improved NOGAPS TC track forecasts (see Figure 3.1.3). Further work is being carried out by Mark DeMaria (NOAA Hurricane Prediction Center) who is evaluating the utility of MISST merged SSTs in the Statistical Hurricane Intensity Prediction Scheme (SHIPS) forecasting system. The impact of microwave SST's capable of revealing cool upwelling regions associated with hurricane activity is particularly important as shown in the Geneveve/Faousto case. In these situations, when a following storm crosses over the cold wake of a previous storm, MISST SST's reduce Hurricane intensity errors and also (to a lesser degree) the track error. Another impact study by Joe Cione (NOAA Hurricane Research Division) is evaluating MISST merged SST in a developmental of a new hurricane prediction algorithm (the inner-core SST algorithm) which is discussed later in this meeting report.

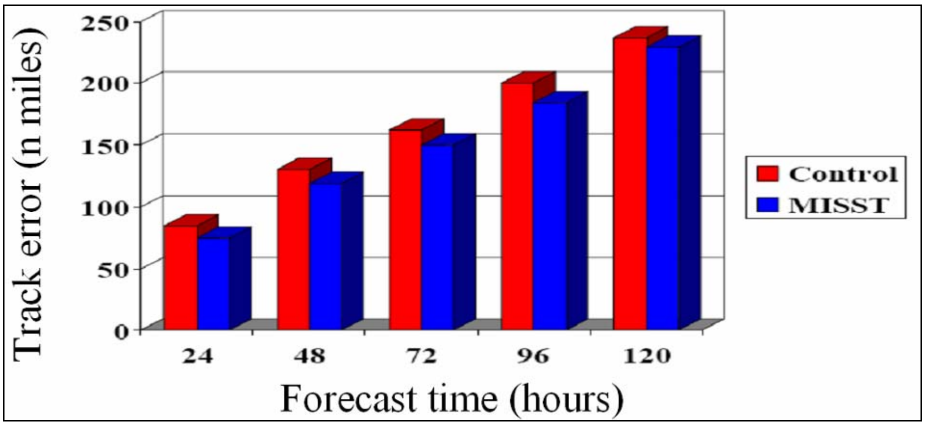


Figure 3.1.3 NOGAPS tropical Cyclone forecast error (n miles) for eastern North Pacific Hurricanes Jova and Kenneth. The number of forecasts was 54, 50, 46, 42, and 38 for the 24-h, 48-h, 72-h and 120-h forecasts respectively.

Ming Ji, Director of the NCEP Ocean Prediction Center (OPC) at NOAA has agreed to run several impact studies using MISST SST data. The OPC issues 109 daily operational marine forecast products including surface analysis and up to five-day lead time forecasts of ocean surface winds and wave heights for offshore regions. OPC forecasts serve commercial shipping, commercial and recreational fishing communities, and many other public-good applications to protect life and properties. However, OPC does not yet have an operational SST analysis or forecast products and the MISST project is helping OPC develop an appreciation of the issues, strengths and weaknesses of various data-driven SST analysis systems and outputs.

MISST SST's are also being used as part of research efforts to look at the ocean-atmosphere exchange of into CO_2 and associated fluxes which can be affected by SST. Significant DV reduces the CO_2 uptake by Ocean and in some cases can change the direction of the flux. This work is on-going.

---

[1] RSS = Remote Sensing Systems
FNMOC = Fleet Numerical Meteorology and Oceanography Center
NOAA = National Oceanic & Atmospheric Administration
MW = MicroWave: day + night; through cloud
IR = InfraRed: day + night

MISST has a dedicated web site (http://www.misst.org) which carries all information related to the project including access to data, reports and an overview of the project. The latest addition shows Google earth kml files for the MISST MW+IR 9km products. Gentemann stressed the need for GHRSST-PP applications to work effectively with Google earth to help users make the most of new data visualisation technologies by providing kml files for all analyses. Some discussion on the use of Google earth revealed issues related to scaling of data sets and the inability of Google Earth to adequately control dynamic images.

Ken Casey was keen to find out when MISST L4 products will be available at the GDAC (and then the LTSRF). Gentemann replied that L4 production code was available and data were already going to the GDAC – the main issue was providing an update to the older data that were processed in a different format but this is now in hand and should be completed soon. Andy Harris was keen to discover what is the impact of DV was in terms of data coverage and accuracy? Gentemann noted that day/night differences are ~0.2K (warmer than daytime) with some persistent DV in certain regions however sampling of DV features was poor unless a geostationary platform was available so global estimates of DV are not currently robust. Gentemann noted the new hourly '*Aladdin*' data set containing SEVIRI data set created by the DV-WG is very accurate and near perfect for DV studies. Comparisons of daytime SEVIRI to nighttime data show signals of ~0.4-0.5K – accounting for such features can decrease the [SSES] errors by ~0.1K.

3.2 European Space Agency (EAS) Medspiration project report, *J-F Piollé, IFREMER, France.*

Piollé explained that Medspiration (http://www.medspiration.org) is a project supported by the European Space Agency (ESA) as part of its Data Utilisation Envelope (DUE) programme. Commencing in 2004 it has served as the GHRSST Regional Data Assembly Centre (RDAC) for Europe. Since June 2005 it has continuously produced real time SST L2P products from the Advanced Along Track Scanning Radiometer (AATSR), Meteosat Second Generation (MSG) geostationary Spinning Enhanced Visible and Infra-red Imager (SEVIRI), and from the NAR SST datasets produced by the EUMETSAT Ocean and Sea Ice Satellite Applications Facility (OSI-SAF) from AVHRR on NOAA 16, 17 and 18, over European Seas and the N. Atlantic (see Figure 3.2.1). Initially it also produced L2P files of SST over the European area from Remote Sensing Systems TMI and AMSR-E SST products, as well as L2P versions of NAVOCEANO AVHRR LAC and GAC products over the European area. From December 2005 it extended the scope of the AATSR L2P data products to global coverage. Overall, during the whole of 2006 about 30,000 L2P files were created, made available to users, deposited in the GHRSST GDAC and archived in the GHRSST long-term stewardship system.

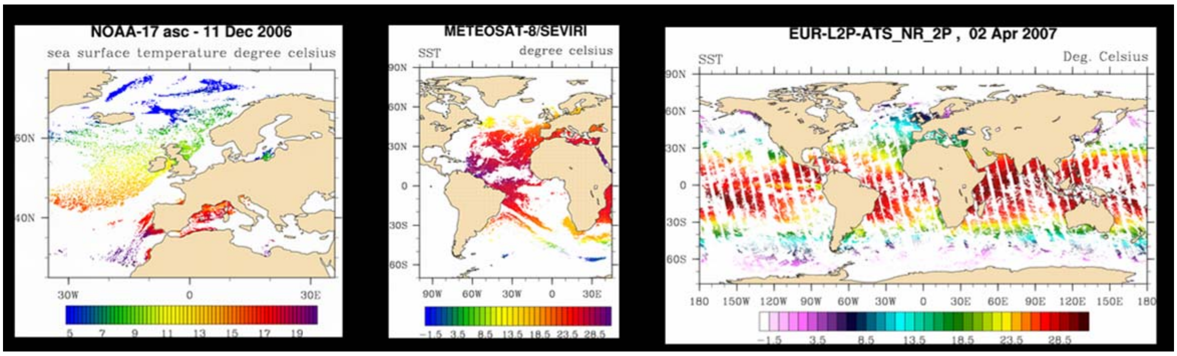


Figure 3.2.1 L2P products routinely generated by Medspiration. (a) Regional AVHRR North Atlantic Region (NAR), (b) MSG-SEVIRI Atlantic regional (every 3 hours) and (c) global daily ENVISAT AATSR.

Medspiration also began producing from June 2005 a merged, multi-sensor daily SST analysis (L4) product for the Mediterranean Sea at a resolution of 2 km. To this was added from 2nd Feb 1996 onwards a NW. European Shelf Seas daily analysis product. A total of more than 620 L4 products were produced in 2006.

Piolle presented a series of production and data usage statistics which are reproduced in Figure 3.2.3. These statistics show that Medspiration as managed to attain high levels of operational throughput and service and is being taken up by a growing user community.

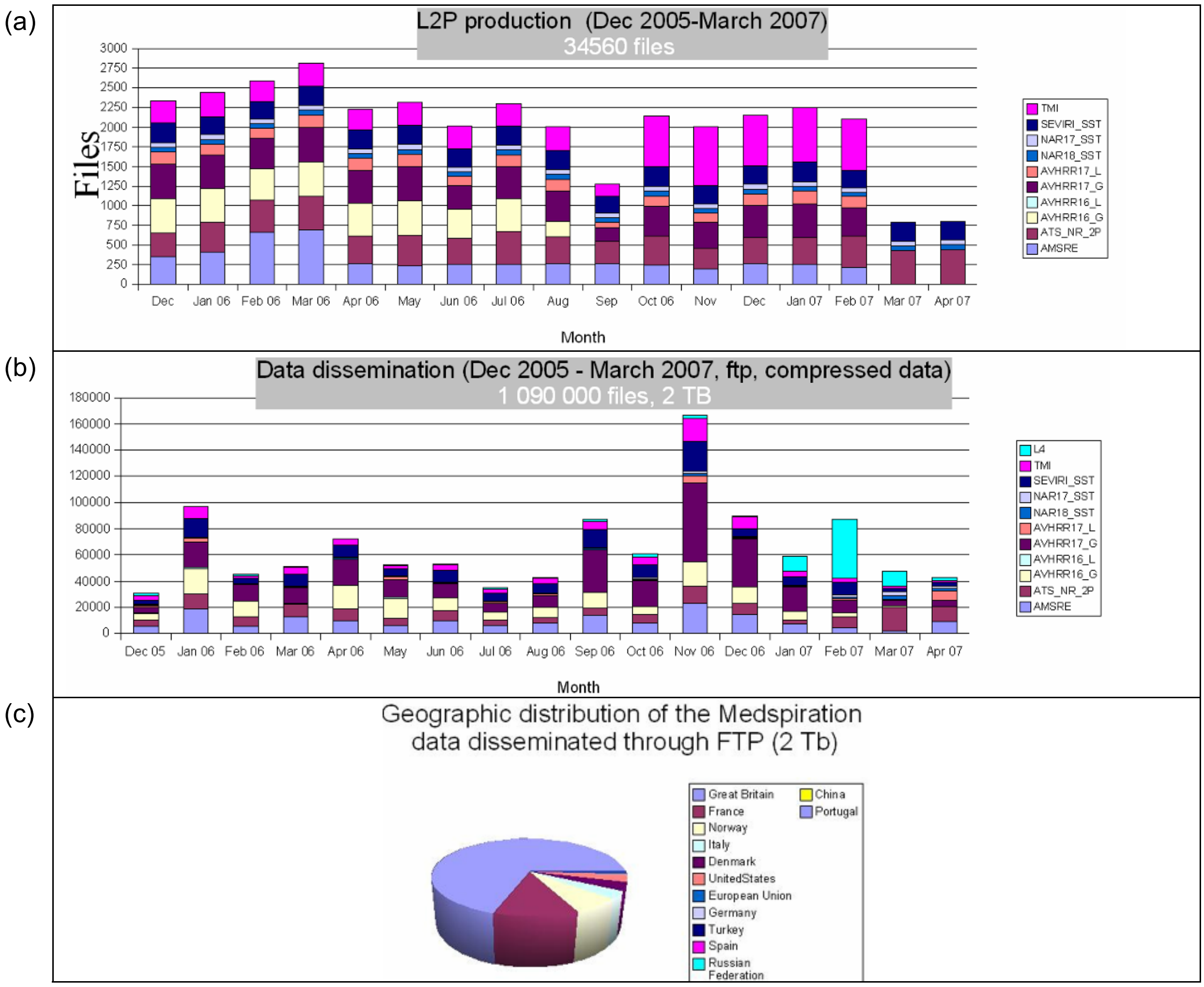


Figure 3.2.3 Production and usage statistics for the Medspiration project. (a) L2P file production (b) data dissemination by file type (c) geographic distribution of products via IFREMER ftp server.

3.2.1 New Developments since the 7th GHRSST Science Team Meeting

During the last year a number of modifications have been made to the Medspiration Service.

- Following discussions at the GHRSST 7th Annual Science Team meeting, which identified that the confidence values attached to AATSR L2P data were too severe, successive modifications were made to the definition of the SSES and confidence values on 5th June, 9th August and 21st September, 2006 (see http://www.medspiration.org/news/index.html). Moreover, research is underway within Medspiration, involving the AATSR Validation Scientist, to produce a new approach to SSES definition for AATSR data. This uses the difference between nadir and dual view SST products as a basis for setting the confidence value and hence stratifying the error estimates. This is fully reported in the presentation of Gary Corlett.
- From 9th January 2007, the L4 SST maps of Mediterranean and NW European Shelf Seas have been made available to users through Google visualisation. An example is shown in Figure 3.2.2.
- From 9th January 2007, access to the Medspiration Match-up database (MDB) held at IFREMER, has been available through a new web interface developed within the scope of the ESA Medspiration contract. This is reached through the main Medspiration website (http://www.medspiration.org). Web form for extraction tools and pre-extracted files (netCDF) are available at the MDB web page.
- From 27th Feb, 2007, the Medspiration provision of Atlantic area L2P products based on TMI, AMSR-E and AVHRR GAC and LAC from NAVOCEANO were terminated. This decision was made at a User Consultation meeting and execution followed a five-week warning period to users. The reason for this action was that a superior service of these products globally is now provided by RSS and NAVOCEANO and these data are all available through the GDAC. It was in the interests of users to move them to the better products.
- During the year, the high resolution diagnostic data set (HR-DDS) has been steadily developed at NOCS. Additional functionality has been incorporated to meet the needs of producers of L2 data,

producers of L4 analyses, those assimilating SST data into ocean forecasting models and SST users in general. The HR-DDS facilitates the comparison of different SST datasets and incorporates all L2 and L4 products produced by Medspiration, plus some others. This activity extends beyond the scope of Medspiration. The HR-DDS is accessible through http://www.hrdds.net and is fully reported in the presentation of David Poulter.

- Medspiration opened up a new L4-UHR experimental product in the Pacific Ocean region S.W. of Costa Rica including the Galapagos and Coco Islands. This was done during March as a demonstration, related to ESA's DIVERSITY project. An example is shown in Figure 3.2.2(c).

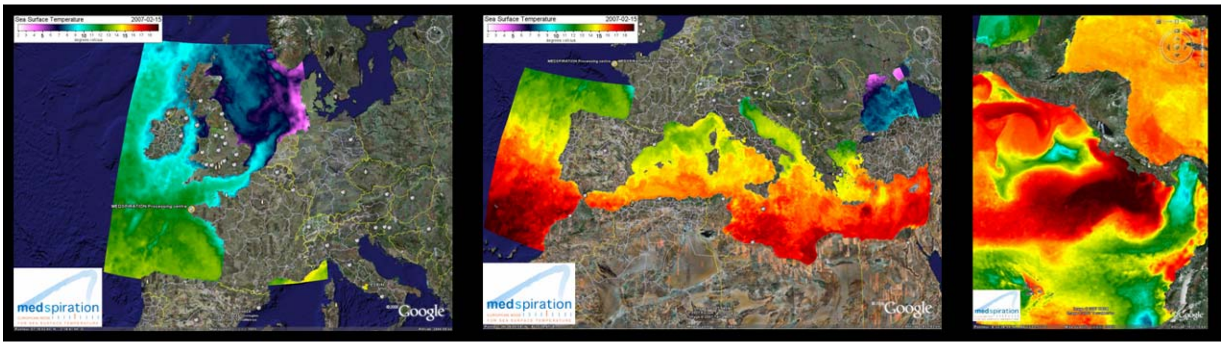


Figure 3.2.1. Example of Google Earth output of L4 data product. (a) NW European shelf region (since January 2006), (b) Mediterranean Sea (since June 2005) and (c) Galapagos/Coco islands (since March 2007 as part of the ESA DIVERSITY program).

3.2.2 User Feedback

Medspiration User Consultation Meetings were held on 1st June 2006 at CNR-ISAC in Rome and on 4-6 Dec 2006 at Villefranche-sur-Mer in France. These meetings allowed users of Medspiration products to report on their experiences. Highlights of these presentations include:

- A new global daily SST analysis (OSTIA) has been developed at UK Met Office, based on Medspiration and GHRSST L2P inputs which is now running daily at the Met Office (see later presentation on Mathew Martin, UK).
- Confirmation that the AATSR L2P data are robust against corruption by Saharan dust. This enabled new methods for bias adjustment of AVHRR and SEVIRI L2P data in relation to AATSR as a basis for new MERSEA SST analysis products (see later presentation of Emannuelle Autret, France).
- The routine use of Medspiration L2P data in the Italian Mediterranean Forecasting System (MFS) model. The use of L2P data for improving the MFS SST 4km analysis product, to be used operationally in future by the Mediterranean Ocean Observing Network (MOON.
- A report by JPL PO.DAAC showed widespread use of Medspiration data accessed through the GDAC.
- The use of Medspiration data in research by the US MISST project.
- The Danish Meteorological Institute (DMI) rely on Medspiration L2P input for:
  - Daily Baltic & North Sea SST analysis product, used by the operational high resolution NWP system,
  - Experimental assimilation into a 3-D ocean model using a simplified Kalman filter,
  - A specialist L4 analysis product for ocean regions following the progress of a high profile round-the-world Danish educational expedition,
  - The operational HYCOM ocean forecasting model using relaxation to the analysis product as shown in the presentation by Jacob Hoeyer (Denmark).
- UK Met Office report that assimilation of Medspiration L2P has been shown to reduce the standard deviation of errors in the FOAM ocean forecasting model, both at the surface and to 600 m depth. The Met Office based last year's winter long term forecast on Atlantic upper ocean temperatures and SST including OSTIA, based in part on L2P inputs.
- Reports of various applications in coastal oceanography that are benefiting from the new L4 SST analyses, including those produced by Medspiration and others derived from Medspiration L2P inputs.
- A number of German newspapers used the Medspiration UHR-L4 analyses to inform their holidaymaking readers about Mediterranean SST during summer 2006.
- An agreement with the French TV5 world Channel to provide SST's focussing on specific areas throughout the EU has been reached.
- IFREMER are making extensive use of the Medspiration outputs within the NAUSICAA browser

system which has more than 300 registered users (coastal stations, Halieuths…). The system uses multiple predefined areas including the Med Sea, Bay of Biscay, Channel/North Sea, Europe western shelves. L4 SST analyses and inter-comparisons (see Emmanuelle Autret's talk) are also provided here. Access can be obtained using one of several browsers focusing on different geographical areas, depending on our users interest or the projects in which IFREMER is involved. The available datasets and their respective historical depth may vary for each browser. New browsers will be added in the future. See the following for more details:

- North-West Europe (http://www.ifremer.fr/nausicaa/marcoast/index.htm)
- Bay of Biscay (http://www.ifremer.fr/nausicaa/gascogne/index.htm)
- Channel/North Sea (http://www.ifremer.fr/nausicaa/roses/index.htm)
- Gulf of Lion and Corsica (http://www.ifremer.fr/nausicaa/medit/index.htm)

3.2.3 Anticipated European developments

The European Union is developing a new activity for providing operational environmental data to meet the needs of government (EC and National), operational users, commercial users and the general public. It is known as Global Monitoring for Environment and Security (GMES).

- Members of the Medspiration team have been active in helping the EC to define the Marine Core Services, which is the ocean element of GMES. They communicated the recommendation of the GHRSST Science Team that there is a strong international requirement to sustain the provision of a high-quality, stable SST sensor of the ATSR class, which has a dual view capability. This advice has been heeded, and such a sensor is planned for the payload of the Sentinel-3 series of satellites which will serve the needs of operational ocean monitoring from 2012.
- A proposal is being prepared within the GMES funding opportunities to transition the Medspiration project into a SST Thematic Assembly Centre (TAC) within the GMES Marine Core Services. It is proposed that the SST TAC should maintain the core functionality of the Medspiration project in respect of ensuring that there is a continuing European contribution to GHRSST of a European RDAC. In addition it is intended to strengthen this input by seeking to provide some of the services of a GDAC to complement JPL and introduce the operational security of moderate redundancy.

Meanwhile the Medspiration team seeks additional support to maintain its current service until such time as the MCS and SST TAC are established, probably in the first half of 2008.

Piolle then discussed the complementarity between ocean colour and SST in the context of interaction with the ESA GlobCOLOUR project. GlobCOLOUR has been designed to follow the model of the GHRST-PP except for Ocean Colour. There has already been an extensive interchange of ideas and information for the combination of SST and OC data and associated tools during the Joint meeting in Villefranche, France, (December 2006) and soon in Oslo (end 2007). Of particular note were the synergies investigated (e.g. HR-DDS system, diurnal variability…). These ideas will be taken up within the EU GMES Marine Core Services projects and developed further in the context of ocean forecasting systems and diurnal variability over the coming 18 months.

Finally, Piolle noted that a new questionnaire had been developed to solicit user feedback on the performance and application of Medspiration and its products. Piolle encouraged all at the meeting to fill in the questionnaire (which was very small and to the point) in order to feedback this information in to the project and the developing SST-TAC system. The questionnaire is on the Medspiration Web site at http://www.medspiration.org with a link from the main page to the news section. The GHRSST-PO agreed to make sure a link was present on the main GHRSST-PP site to the Medspiration questionnaire.

3.3 Ocean Forecasting Australia BLUElink> project report, *H. Beggs, BRMC, Australia.*

For the past four years, the Australian Government, through the Australian Bureau of Meteorology (BoM), Royal Australian Navy and CSIRO have contributed to BLUElink> Ocean forecasting Australia, a project to deliver ocean forecasts for the Australian region. BLUELink> aims to develop ocean model, analysis and assimilation systems, and provide timely information and forecasts on oceans around Australia. The project will also produce both behind real-time analysed and now-cast surface and subsurface fields. Phase I of the project has just completed and Phase II has commenced and will run until 2010. The main BLUElink> contribution to the GHRSST-PP will be through an Australian RDAC system based at the Australian Bureau of Meteorology, delivering the following types of

GHRSST-PP data products:

- Locally received HRPT AVHRR SST L2P (Rea, 2004), DDS and possibly L3P files
- Match-up Data Base (MDB) files comprising high quality in situ SST available via the GTS in real time from vessels of the Australian Volunteer Observing Fleet fitted with Automatic Weather Stations
- L4 files from the new 1/12° resolution regional SST analysis system (Beggs, 2007) over the region 20°N to 70°S, 60°E to 170°W, and the current BoM operational global weekly 1° resolution and operational regional daily 1/4° resolution SST analysis systems (Smith et al., 1999).
- Ian Barton's team at CSIRO Marine and Atmospheric Research (CMAR), in collaboration with the Australian Institute for Marine Science (AIMS) will contribute MDB records of in situ temperature data from the Rottnest Island, Fantasea (Whitsunday Island to Hook Reef) and Heron Island ferries off the coast of Australia.

3.3.1 Production of geostationary MTSAT-1R skin SST at BoM

In May 2007 Andy Harris, Jon Mittaz and Eileen Maturi from NOAA visited the Bureau of Meteorology to port their code for processing raw HRIT data from MTSAT-1R to skin SSTs (based on their GOES SST radiative transfer method system) onto BoM systems. The BoM Space Based Observations Section currently receives raw HRIT MTSAT-1R data. Just prior to the G8 meeting, a successful implementation of the NOAA code on a BoM research machine was completed and generated the images in Figure 3.3.1 below. BoM will in the coming months port the code to an operational machine for routine processing.

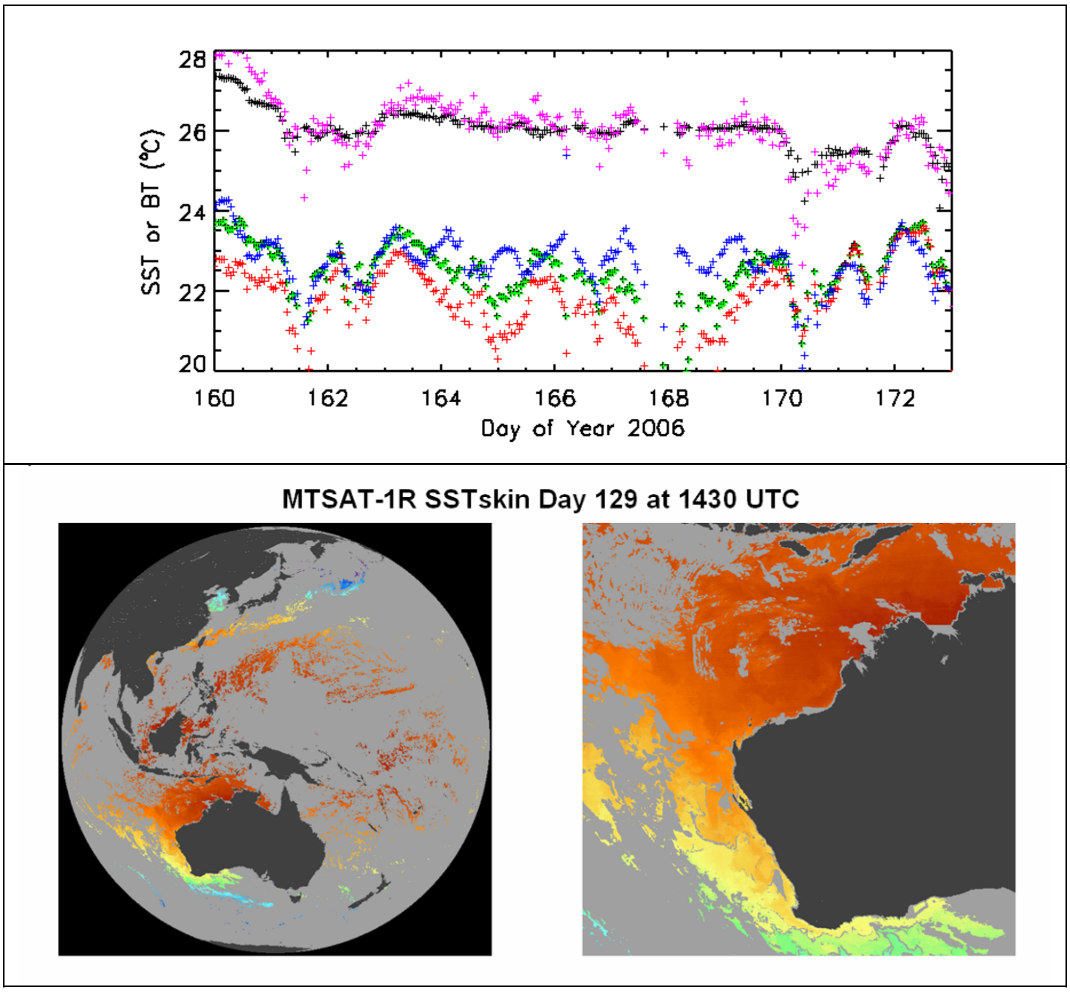


Figure 3.3.1 Top panel: MTSAT brightness temperatures (3.7 µm blue, 11 µm green, and 12 µm red) and MTSAT-derived SST (magenta) at the ship location plotted with the thermosalinograph measurements of SST (black). Bottom panel shows MT-SAT SST's for Day 129@1430 using NOAA code base run at BoM installed prior to the GHRSST-PP meeting.

Ian Barton (CSIRO Marine and Atmospheric Research) has completed an evaluation of SST derived from MTSAT-1R, comparing it with thermosalinograph SST measurements from a three week cruise of the RV *Southern Surveyor* off the north-west coast of Australia in June 2006 (Figure 3.3.1). The brightness temperatures have been used to derive an SST estimate using an algorithm that is based on that used to analyse GOES-9 geostationary data. A constant offset has been added to the algorithm to ensure that there is no average bias to the comparisons with the thermosalinograph SST measurements. The standard deviation between the MTSAT-1R and thermosalinograph SSTs is 0.48°C, which is considered an acceptable value. However, there appear to be some calibration problems for the 11 and 12 μm channels. A better knowledge for the filter function of the infrared channels would assist in further analyses. An operational SST algorithm would also assist a better understanding of the calibration issues. At this stage there appears to be no impediment to using the MTSAT-1R HRIT data to derive skin SSTs based on the NOAA GOES skin SST physical retrieval method.

3.3.2 MDB from Volunteer Observing Ships (VOS)

There are currently eight vessels carrying automatic weather stations (AWS) that participate in the Australian Volunteer Observing Fleet (AVOF) program and soon to be more. Their routes include the Southern Ocean, coastal Australia (Queensland to South Australia), Bass Strait, North Pacific Ocean and the Tasman Sea (see Figure 3.3.2). There are also two passenger ferries that are currently taking some SST measurements and other ferries and research vessels are also under consideration by AIMS for SST measurements. Integrated Marine Observing System (IMOS) funding from 2007 to 2011 has been obtained to contribute to the purchase, installation, calibration, maintenance, ongoing quality control and data management of sea surface temperature (SST) sensors on these existing and future vessels in the Australian region (11 to a projected 14 in total).

On the AVOF vessels, regularly tested, hull-mounted temperature sensors will supply high-quality bulk SST data fed into current AWS data management systems and broadcast via satellite back to Australia every three hours. The SST data shall be quality assured, placed on the GTS and fed into the BoM near real-time satellite SST data validation system. The SST data shall also be made immediately available and archived for use by the research community. Radiometers and thermosalinographs operated by AIMS and CMAR on ferries will supply high-quality skin and bulk SST data in near real-time. All the *in situ* SST data will be available to GHRSST-PP as (Match-up Data Base) MDB files.

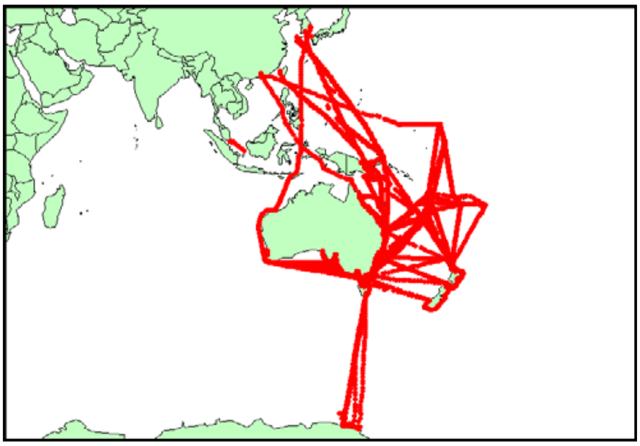


Figure 3.3.2. Cruise tracks during 2005 for the 8 vessels in the Australian Volunteer Observing Fleet installed with Automatic Weather Stations.

This IMOS VOS SST project will significantly improve the validation of remotely sensed SST measurements over the Australian region and also benefit research into diurnal warming of the surface ocean and other research applications such as climate models, air-sea gas exchange and air-sea heat exchange which require accurate in situ measurements of bulk SST. The Whitsunday ferry also carries an infrared radiometer allowing skin-bulk SST comparisons and research into air-sea interactions.

3.3.3 AVHRR L2P, L3P and DDS

In collaboration with Ian Barton's remote sensing team at CMAR and through funding provided by IMOS, BoM will contribute L2P and DDS data sets of locally received HRPT AVHRR SST at approximately 1 m depth (SST1m) from operational NOAA polar-orbiting satellites by July 2008, and a SSTskin HRPT AVHRR L2P product by the end of 2009. Each DDS will contain HRPT AVHRR SST data over a specified time interval, remapped onto a 0.01° x 0.01° latitude-longitude grid over the recommended DDS area of 2° x 2° over areas where there are also high quality in situ SST data. CMAR is currently producing DDS files from AVHRR and AATSR SST data. These data sets could feed into the GHRSST-PP HRDDS system but further work is required to establish data format and data transfer protocols between the HRDDS and CMAR.

Recruitment will commence shortly for a dedicated remote sensing scientist to convert existing BoM and CMAR HRPT AVHRR SST processing systems to produce GHRSST-PP format L2P files from stitching raw HRPT AVHRR data from L-band ground-stations at Townsville, Darwin, Alice Springs, Perth, Melbourne and Hobart. In September 2005 BoM successfully ingested AVHRR data into CAPS (Common AVHRR Processing System developed by CSIRO with BoM involvement) and produced output files of SST using the CSIRO SST algorithm. Input is an ASDA (Australian Satellite Data Archive) file and output is a McIDAS area file. It is planned to use CAPS to produce the netCDF format SST data required for a BoM AVHRR L2P data product for GHRSST-PP. In addition to the HRPT 1.1 km AVHRR SST1m values and other mandatory fields, these L2P files will contain bias and standard deviation estimates based on match-ups with in situ SST data from the GTS, and hourly forecasts of instantaneous short-wave solar radiation and instantaneous 10 m winds from the BoM LAPS NWP model (Puri et al., 1998). Existing raw, archived, high-resolution HRPT AVHRR data from the NOAA polar-orbiting satellites over the Australian region back to at least 1989 will be reprocessed into SST L2P (both skin and bulk) and also made available to GHRSST-PP.

There is also the possibility of BoM converting its existing running 15-day composite mosaic of HRPT AVHRR bulk SST to a new GHRSST-PP L3P product and providing these to the GHRSST-PP. This real-time, daily, ~1.5 km resolution mosaic in a Mercator projection gives the highest weight to the previous day's data and uses a weighted average to include previous days' observations in each grid cell. The Bureau has files back to 1995. The product is described in http://www.bom.gov.au/sat/SST/sst.shtml.

3.3.4 High Resolution Regional SST Analyses

As part of the BLUElink> Ocean Forecasting Australia project, the Australian Bureau of Meteorology has modified its existing operational optimal interpolation SST analysis system (Smith et al., 1999, http://www.bom.gov.au/marine/sst.shtml) to produce 1/12° resolution, daily SST analyses over the Australian region (20°N - 70°S, 60°E - 170°W) (Figure 3.3.3). The aim of the BLUElink> regional high resolution SST analysis system is to resolve SST features at ~10 km over the Australian region at a temporal resolution of one day. An analysis grid of 1/12° (~9 km) has initially been chosen, with a background correlation length scale of 20 km, an observation correlation length scale of 12 km and observation correlation time scale of 0.5 days for all input observations.

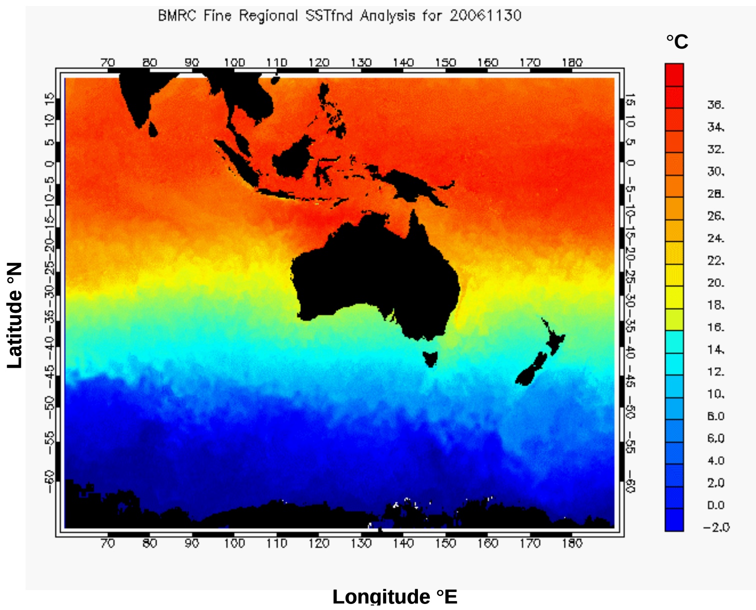


Figure 3.3.3. An example of the BLUElink> daily regional 1/12° resolution SSTfnd analysis for 30 November 2006.

The new BLUElink> 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 (SSTfnd) estimates, largely free of nocturnal cooling and diurnal warming effects. The method used in blending these data streams is described in detail in Beggs (2007) and the data format in Beggs and Pugh (2007). By ~02:30 UT each day, the pre-operational test analyses of the previous day's observations can be downloaded as GDS v1.7 L4 files from http://godae.bom.gov.au/ for research purposes. It is expected that these files will be made available to the GHRSST-PP Global Assembly Centre (GDAC) hosted by PO.DAAC and the GHRSST-PP Long-Term Stewardship Facility at NODC shortly. The BLUElink> Regional High-Resolution SST analysis system is expected to become operational around May 2007 as part of the BoM NWP suite.

The pre-operational test analysis system blends the BoM 1.1 km resolution HRPT SST1m data stream from AVHRR (NOAA-17 and 18), averaged over 8 x 8 pixels, with the NESDIS GAC 9.9 km x 4.4 km resolution AVHRR SST1m data (NOAA-17 and 18), 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. In order to produce a foundation SST estimate, the AATSR skin SST data stream is converted to foundation SST using the Donlon et al. (2002) skin to sub-skin temperature conversion algorithms. These empirically-derived algorithms apply a small correction for the cool-skin effect depending on surface wind speed, and filter out SST values suspected to be affected by diurnal warming by excluding cases which have experienced recent surface wind speeds of below 6 ms^{-1} during the day and less than 2 ms^{-1} during the night. Wind data used are the 0.375° horizontal resolution, hourly, instantaneous 10 m winds derived from the BoM Limited Area Prediction System (LAPS) NWP forecasts (Puri et al., 1998). The remaining satellite and in situ sub-skin and bulk SST data streams are similarly filtered to remove suspected diurnal warming events using calculated times for sunrise and sunset at the measurement location, LAPS forecast winds and the same wind speed thresholds as applied to the AATSR data. It appears that although filtering satellite SST using Donlon et al (2002) day/night wind speed thresholds slightly reduces RMS error (cf buoy SSTs), in the resulting OI analysis of satellite and *in situ* SSTs, when all *in situ* SSTs are withheld from the analysis, filtering on wind speed increases the RMS error of the analysis. Beggs noted that there is a clear need to find a way of accounting for diurnal variation rather than filtering out low wind speed SST observations.

The BoM univariate statistical (optimal) interpolation analysis system (SIANAL) requires all input observations to have zero relative bias. In order to achieve this, the AATSR Meteo skin SSTs and L2P AMSR-E sub-skin SSTs have known biases with respect to *in situ* bulk SSTs removed prior to ingestion into the analysis. A bias correction is not currently applied to the GAC and HRPT AVHRR SSTfnd estimates from NOAA-17 or NOAA-18. A BoM study of satellite SSTfnd to buoy SSTfnd comparisons over the Australian analysis region (20°N - 70°S, 60°E - 170°W) has shown that average monthly biases between AVHRR foundation SST estimates are small (≤ 0.1°C) compared with foundation SST estimates from drifting and moored buoys (Beggs, 2007).

The estimated observation standard deviation errors input into the OI analysis system provide the system with the weight to give each observation in the analysis relative to other observations and the background field. These observation errors are a combination of instrument error and representativeness errors (both spatial and temporal). The representativeness errors must be estimated over the target field, in this case chosen to be the analysis spatial resolution (1/12°) and temporal resolution (24 hours). For the pre-operational test BLUElink> analysis system, observation standard deviation errors have initially been estimated for each satellite data stream by using a month of match-ups (1 – 30 November 2006) between foundation SSTs from the various input satellite data streams and buoy foundation SSTs (Beggs, 2007). The standard deviation of all matches over a month is considered to be an effective estimate of the total relative standard deviation error between estimates of SSTfnd from the particular satellite and buoy SSTfnd. The error estimate incorporates instrument errors from each type of sensor, spatial representativeness error over the satellite data resolution, and temporal representativeness error over the analysis period (in this case 24 hours). All estimated observation standard deviation errors used in the analysis are automatically recorded in the header of each analysis L4 netCDF file (Beggs and Pugh, 2007).

Future work on the BLUElink> regional foundation SST analysis will include investigating the blending of satellite SST "L2P" files newly available through the GHRSST Pilot Project (including NAVOCEANO 9.9 km x 4.4 km GAC AVHRR SST1m, 1 km MODIS SSTskin, 1 km ATS_NR__2P AATSR SSTskin and future 5 km MTSAT-1R SSTskin products). The blending of MODIS and/or MTSAT-1R SST data may enable the analysis resolution to be reduced to around 1/20°. Other improvements to the analyses will include further tuning of the correlation length scales, improvement of SST at high latitudes by ingesting daily 10 km resolution Ocean and Sea Ice Satellite Application Facility (OSI-SAF) sea-ice analyses (http://saf.met.no/), automation of the calculation and ingestion of monthly error estimates for each data stream and improvement of the land mask used to resolve coastlines. In collaboration with Gary Corlett (University of Leicester), the removal of bias from the AATSR Meteo Product skin SSTs will be automated.

3.3.5 Future Plans for BLUElink> High-Resolution L4 SST Products (2007-2010)

As part of the next phase of the BLUElink> Project (2007-2010), the Bureau of Meteorology aims to provide the following SST analysis products:

1. Operational daily, regional foundation SST analyses (L4) at between 5 km and 10 km spatial resolution
2. Trial six-hourly, regional, skin SST analyses at between 5 km and 10 km spatial resolution
3. Trial, daily, global, foundation SST analyses at ~20 km spatial resolution

CMAR will also evaluate existing techniques aimed at accounting for diurnal variability in satellite estimates of SST. BoM will research applying these techniques to provide 6-hourly, regional, skin temperature analyses using optimum data blending techniques.

In order to produce regional skin SST analyses in addition to the foundation SST analyses developed for BLUElink-I, BoM will develop local SST coefficients for AVHRR by regressing brightness temperatures from these infrared radiometers against SSTs obtained from Envisat's AATSR radiometer. BoM will produce real-time, daily, global, foundation SST OI analyses at around 20 km spatial resolution, which will be a blend of global infrared and microwave satellite L2P SST data streams, following similar blending methods as used for the regional SST analysis. The proposed method for producing regional skin and foundation SST analyses and a global foundation SST analysis is presented in Figure 3.3.4.

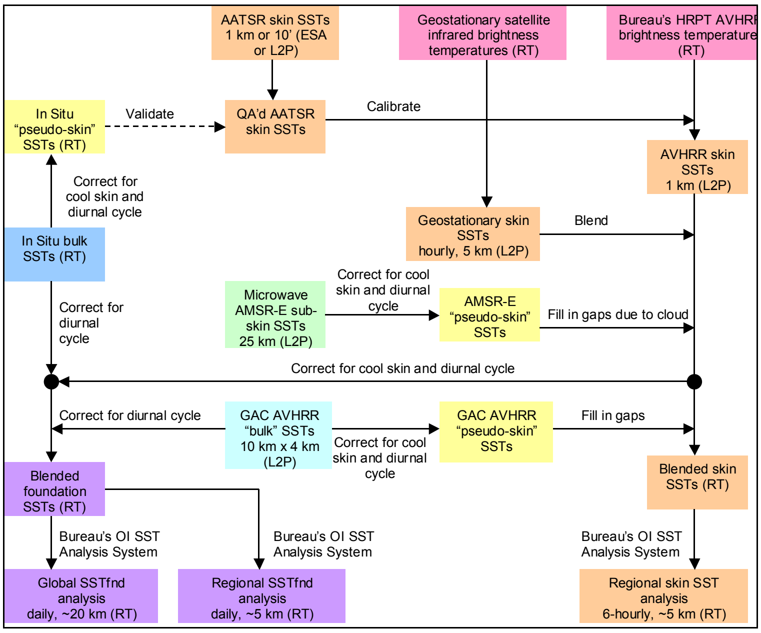


Figure 3.3.4. Proposed blending method for the next phase of the BLUElink> Real-Time High Resolution SST Analysis System

3.3.6 References

Australian Bureau of Meteorology GODAE data products (including GHRSST-PP L4) OPeNDAP portal: http://godae.bom.gov.au

Australian Bureau of Meteorology Operational SST Analysis Web Page: http://www.bom.gov.au/marine/sst.shtml

Australian Bureau of Meteorology Space Based Observations Section SST Products Web Page: http://www.bom.gov.au/sat/SST/sst.shtml

Beggs, Helen (2007) A High-Resolution Blended Sea Surface Temperature Analysis over the Australian Region, *Submitted as a BMRC Research Report*. (http://www.bom.gov.au/bmrc/ocean/BLUElink/SST/Bureau_HR_Regional_SST_Analysis_vg1.0.pdf)

Beggs H. and T. Pugh (2007) Format Specification for the Australian Bureau of Meteorology's SST Analysis L4 files, *BMRC Web Document*, 12pp. (http://www.bom.gov.au/bmrc/ocean/BLUElink/SST/BLUElink_L4_file_format_v3.pdf)

BLUElink> Ocean Forecasting Australia Project Web Site: http://www.bom.gov.au/oceanography/projects/BLUElink/

Donlon, C. J., P. Minnett, C. Gentemann, T. J. Nightingale, I. J. Barton, B. Ward and J. Murray (2002) Towards improved validation of satellite sea surface skin temperature measurements for Climate Research, *J. Climate*, **15**, No. 4, 353-369.

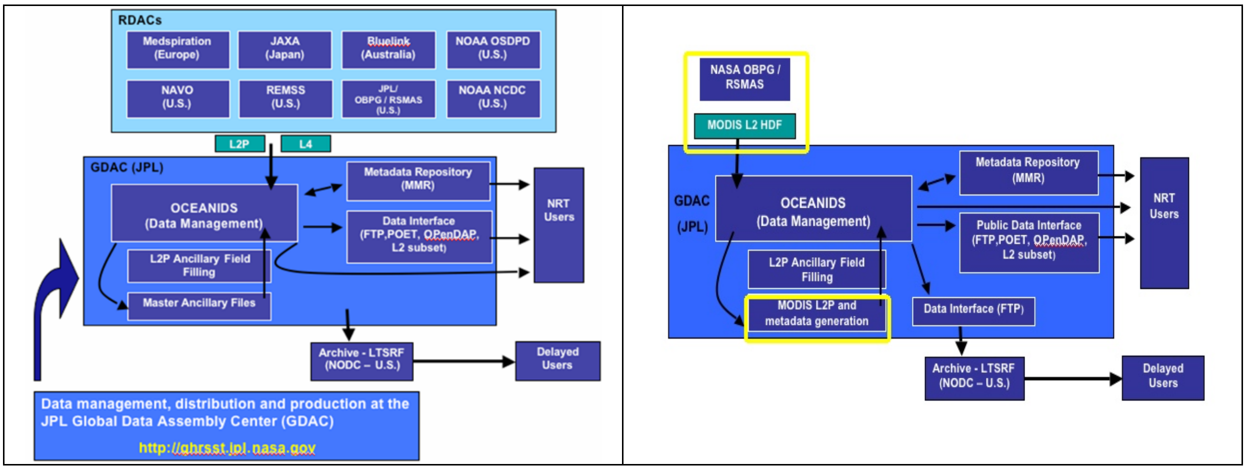
Puri, K., Dietachmayer, G., Mills, G.A., Davidson, N.E., Bowen, R.A. and Logan, L.W. (1998) The new BMRC Limited Area Prediction System, LAPS, *Aust. Met. Mag*., **47**, 203-233.

Rea A. (2004) Recent improvements to the NOAA AVHRR SST product at the Australian Bureau of Meteorology. (http://www.bom.gov.au/bmrc/ocean/BLUElink/SST/5th_GHRSST-PP_Workshop_Paper-Anthony_Rea.doc)

Smith N. S., B. Ebert and G. Warren (1999) The Bureau of Meteorology SST Analysis System, An informal paper produced as background for the OOPC/AOPC Workshop on SST Analyses for Climate, International Research Institute, LDEO, Palisades NY USA, Nov 10-12, 1998. (http://www.bom.gov.au/bmrc/ocean/BLUElink/SST/The_Bureau_of_Meteorology_SST_analysis_system.doc)

3.4 USA Global Data Assembly Centre report, *E. Armstrong, PO.DAAC, JPL, USA.*

Armstrong explained that there had been considerable activity at the PO.DAAC GHRSST-PP GDAC since the last GHRSST-PP Science Team Meeting (March 2006, Boulder, Colorado, USA). Figure 3.4.1(a) shows a schematic diagram showing the current general architecture of the GDAC system which is focussed on the JPL OCEANIDS system. Several new RDAC's (JAXA, BLUELink>, NCDC, NOAA-OSPD) have been brought on-line (i.e., full product conformance has been established and delivery is accompanied by full MMR metadata records). An operational 'sweep' service has also been established with the NOAA-NODC LTSRF and all data are swept off the JPL GDAC rolling store to the LTSRF after 30 days residence. The system is functioning well as a prototype.



(a) (b)

Figure 3.4.1 (a) General architecture of the GHRSST-PP GDAC system operating at the JPL PO.DAAC. (b) Modified flow for MODIS data sets within the GDAC/JPL architecture.

New data streams added since 2006 include the Met Office OSTIA L4, Aqua/Terra MODIS L2P, GOES 11/12 L2P, AMSRE and TMI L2P_GRIDDED and actively assisting NCDC, JAXA, BLUELlink> with GHRSST product quality control and format prior to full operational ingest. The GDAC team has also dealt with a number of operational anomalies including REMSS metadata preparation and delivery. The GDAC has increased robustness with LTSRF data/metadata exchange and not a single byte of data has been dropped in operations.

A considerable effort has been invested since the 6th GHRSST-PP Science Team meeting (Met Office, UK) to prepare MODIS L2P 1 km global data streams. This has been done in collaboration with the NASA Goddard Ocean Biology Production Group (OBPG) and the University of Miami (RSMAS). MODIS Aqua L2P data were available in June 2006 and Terra in September 2006. Figure 3.4.1(b) shows the modified GDAC architecture developed to handle the extremely large MODIS data files. In addition to SST, MODIS L2P data sets are the only GHRSST-PP products containing experimental ocean colour measurements. Furthermore, MODIS night-time SST's are derived using mid-IR (4.0µm) spectral channel data. The resulting products are large (6 Gb/day) but are split into a large number of daily granules (288/day) to allow for efficient sub-setting. A "refined" MODIS L2 data stream is also acquired with a 10 day lag. FNMOC and ECMWF ancillary data are used within the MODIS products and the whole MODIS L2P processing system is exists in prototype form running on a dedicated Linux cluster. Two modes for filling ancillary products are used in the system:

- A near real time system using forecast fields and
- A refined 10 day lag based on the latest analysis fields. The delayed mode data streams overwrite NRT data at 10 days.

The system will be further refined in the coming 12 month period as more experience is gained. The creation of 1km MODIS high resolution SST data streams in real time is a considerable achievement and the GDAC team are looking forward to users pulling data for their applications. Armstrong suggested that a concerted effort by the Science Team to use the MODIS data streams was now required.

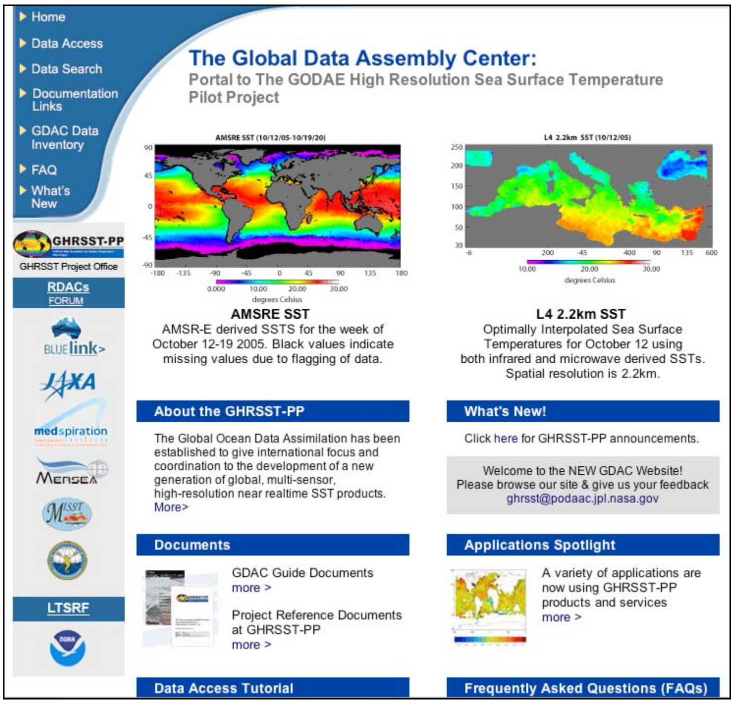


Figure 3.4.2 New look and feel web page for the GHRSST-PP GDAC

The GDAC has also redeveloped the web interface to the GHRSST-PP pages in keeping with elements of the main GHRSST-PP project web space. L4 read software (in K&R 'C' language and IDL) has been developed and placed on to on the GDAC web space for users with links to the GHRSST-PP site. In the future, Web based Forums for RDAC discussions will be developed to encourage application of GHRSST-PP data holdings within the GDAC.

3.4.1 GDAC redesign and development

The JPL PO.DAAC is currently undergoing extensive redesign that will provide more operational capability and better inter-operability. The main design element is to have a large distributed system including a full replacement to the prototype OCEANIDS system and the GHRSST-PP MMR. The current goal is to have a web based interface and supporting architecture in place later in 2007 with all GHRSST-PP GDAC activities and services integrated into the redesign. Currently GDAC is using POET and NERIEDs which will both be redeveloped with Near Real Time interfaces to be fully integrated as clients to the Product Server Support system. OpenDAP use will be expanded and extended on PO.DAAC as part of the Support subsystem.

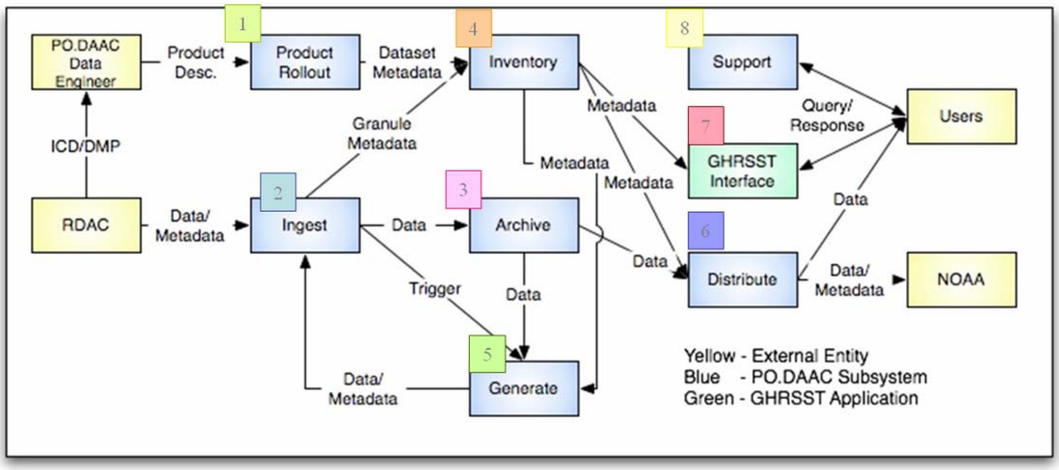


Figure 3.4.3 Proposed re-design of the PO.DAAC interface for the GHRSST-PP and GDAC

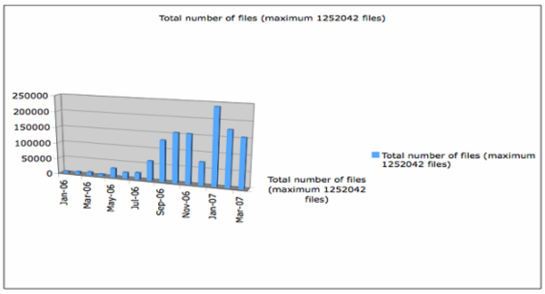
The GDAC website will be integrated with the PO.DAAC site after modification to query the PO.DAAC database within the Inventory subsystem. User support will be provided by the Support subsystem (PropWeb ©, http://www.pcaonline.com), which is available on PO.DAAC. Integrated metrics and reporting with PO.DAAC EMS reporting will be able to provide reports to RDACs, NASA and NOAA based on the Nettracker © http://www.unica.com/ metrics tools for tracking input and output of products too all DAACs.

3.4.2 GDAC data ingest and data serving statistics

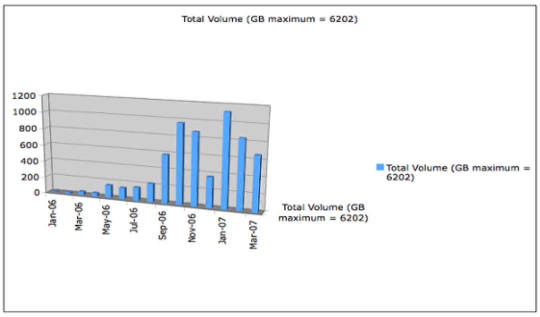
Testing of the new system should begin in early 2008. The PO.DAAC teams are aware that there is an urgent need to interact with the emerging European SST-TAC plans to ensure a sensible development plan. As a consequence of the redesign, new funding will come from operations budgets rather than the current R&D budget. This is an excellent example of GHRSST-PP reaching maturity and transitioning from a pilot-project to a sustainable system.

Product	Mean latency (hrs)	Std Dev (hrs)
EUR-L2P-ATS_NR_2P	6.9	2.5
EUR-L2P-SEVIRI_SST	4.6	1.9
NAVO-L2P-AVHRR18_G	2.9	1.7
NAVO-L2P-AVHRR18_L	3.1	1.7
REMSS-L2P-AMSRE:RT (delay)	6.1 (140)	1.9 (17)
OSDPD-L2P-GOES11	4.2	1.2
JPL-L2P-MODIS_T	7.4	1.8

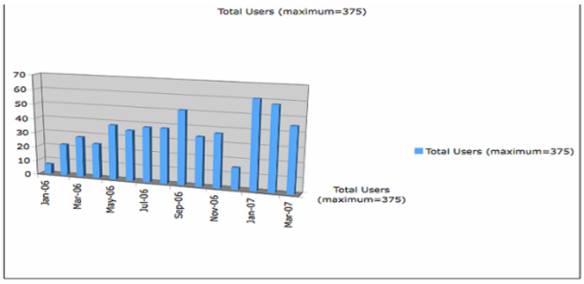
(a)



(b)



(c)



(d)

Figure 3.4.4 Data production and usage statistics for the GHRSST-PP GDAC system (May 2005 to March 2007). (a) latency statistics for various data sets, (b) total number of files ingested, (c) total volume of files and (d) total number of users.

Armstrong then reported production and user statistics for the GDAC system as shown in Figure 3.4.4. Statistics were developed for the period May 2005 to March 2007. The total number of files ingested was close to 1.2 million having a volume of ~6.5 terabytes. On average, the GDAC ingests up to 28 gigabytes per day. The main operational power users of the GDAC are:

- NAVO
- UK Met Office
- NASA JPL
- Canada Meteorological Agency
- Danish Meteorological Agency

The statistics report shows that huge amounts of data have been distributed by the GDAC with a few significant jumps (related to the inclusion of global AATSR and MODIS and inclusion of GOES data). Armstrong explained that the PO.DAAC were really geared up for increases in user applications (user pull) whereas what actually happened over the last few months has been a tremendous increase in the data ingest. There are several issues regarding general operations that still need to be addressed mostly related to data stream latency issues: the EU-RDAC are not meeting the 6 hour metric, MODIS L2P data are late and RSS L2P/L4 are also late.

3.4.3 GDAC applications report

Several key user applications working with the GHRSST-PP GDAC data streams and services were then summarised. US regional users for climate, weather and ecosystem studies at federal or state agencies, non profit organizations, universities are now using the GDAC. The NASA short-term prediction and research centre (SPORT) is one user that supports infusion of observations, data assimilation and modelling research into NWS forecast operations and decision making at the regional and local level. SPORT are using the UK Met Office OSTIA product for modelling and forecasting activities for the US Gulf and North Atlantic regions. Daily images of various SST data sets are available at: http://weather.msfc.nasa.gov/sport/sstAnimation/. The GDAC has received very favourable feedback on the GHRSST-PP project and GDAC services so far.

Linkages to the modelling community are also being established with the Estimation of the Circulation and Climate of the Ocean (ECCO2) group. The GDAC and GHRSST-PP capitalize on the results and expertise of ECCO2 which is lead by Liming Li at JPL. ECCO2 has the following GHRSST-PP goals:

1. use GHRSST products to improve model estimates of air-sea interaction and circulation
2. provide user feedback to GHRSST toward improving products
3. develop increased understanding of processes affecting SST small scale variability and high frequency

A report will be given on ECCO2-GHRSST-PP progress at the next GHRSST-PP science Team Meeting. Current work is focussed on understanding the impact of small scale variability and high frequency SST's. Armstrong showed comparisons of data using EOF and spectral analysis that can be used to look for peaks in the model SST power spectrum associated with diurnal variability.

The Asia Pacific Natural Hazards and Vulnerabilities Atlas (APNHVA) has pledged their support to prepare and disseminate gridded GHRSST data via the APNHVA. The Atlas is published both as Asia Pacific basin-wide and Hawaiian Island regional service to support disaster community applications for preparedness, mitigation, response and recovery activities. The user community includes the Hawaii State Civil Defense, FEMA, NOAA, UN agencies, Thailand's National Disaster Warning Center and Vietnam's Disaster Management Committee. Further information can be found at http://www.pdc.org.

The PO.DAAC has been working on several applications that use GHRSST-PP data products. A new Event Viewer providing a web interface to remote sensing product "events" for scientific use. The current system is focused on hurricanes and typhoons providing a new generation high resolution winds from QuikSCAT and uses OSTIA L4 and NCDC L4 as SST source. It is expected that in the future, it will be tuned for other "events".

Collaborations between Google Earth and ESRI are working towards near real time earth remote sensing data from oceans, atmosphere and land within the Google Earth environment for public consumption. ESRI tools and services are used extensively to support science and Government management systems and GHRSST products are well situated to support these activities because of our information management infrastructure.

JPL is also working on a new Datacasting activity (taking a lead from PodCasting, see http://datacasting.jpl.nasa.gov/). The basic model is to use an RSS-like feed for satellite data streams allowing clients to subscribe to a data feed. Such a system will be "aware" of new data as soon as it is available and the provider can package a feed with metadata that consumer can filter on (e.g., location, cloud free pixels etc.). Datacasting is now being prototyped on GHRSST L2P data.

Armstrong concluded with four main areas that the PODAAC GDAC team will be focussing on in the next 12 months which are

- Integration of GHRSST-PP GDAC within the PO.DAAC redesign
- Development of the Datacasting system using GHRST-PP data
- Introduction of new L2P sub-setting tools at GDAC
- Bringing historical MODIS L2P and other data streams up to date and into the GHRSST-PP GDAC system
- Effective coordination with the emerging EU SST-TAC system.

3.5 GOES-SST RDAC project, *E. Maturi, A. Harris and J. Mittaz, NOAA/OSPD, USA.*

Maturi began with a summary of GOES L2P activities that have successfully completed at the NOAA-OSPD. GOES-E and GOES-W L2P data sets are now being delivered to the GHRSST-PP community via ftp from ftp://gp16.ssd.nesdis.noaa.gov/pub/goessst/L2P/ every 3 hours. The basic processing system has been developed by Andy Harris and John Mittaz over the last 12 months. A full format L2P data set has been implemented in which products are derived from ½-hourly GOES-East & West North & South sectors in native satellite projection. The aerosol ancillary field is derived from the NESDIS operational daily aerosol optical depth analysis, and values are sampled to each GOES retrieval on a nearest-neighbour basis. The "age of observation" value that is available with the analysis is also included – in this case the range may extend to several days rather than the 24 hours. Meteorological ancillary fields are derived from the NCEP Global Forecast System forecast fields and bi-linearly interpolated to the SST retrieval location. Surface solar irradiance is derived from the 3-hr average for the period in which the SST observation was made. Wind speeds are interpolated in time to the satellite overpass time. The “proximity confidence” is actually the Bayesian probability of clear-sky, with a range from 0.95 to 1 in steps of 0.0002 as described by Harris at the 6th GHRSST-PP Science Team meeting. The total GOES product set generates ~24 Gb /day uncompressed (~8Gb/day compressed). A typical example GOES-12 product is shown in Figure 3.5.1.

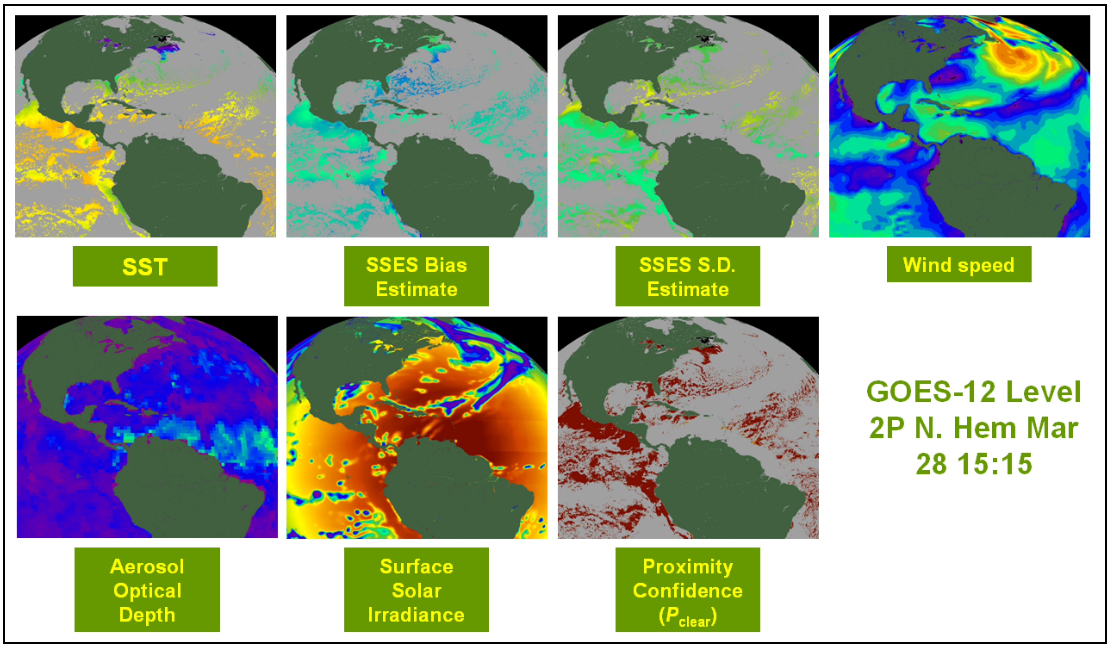


Figure 3.5.1 Example GOES-12 L2P product for the northern hemisphere on 28th May @ 15:15 2007. The key L2P ancillary fields are shown together with the SST.

Each GOES L2P netCDF product file has 22 parameters for each pixel:
SST

- Time, Latitude, Longitude
- Satellite Zenith Angle
- Aerosol Optical Depth
- Surface Solar Irradiance
- Wind Speed
- Uncertainty estimates (bias and S.D.)
- Proximity Confidence Value
- QC flags (including cloud and land)
- Ice concentration
- Deviation from analysis SST
- Temporal coincidences of ancillary data (c.f. SST observation)
- Source codes for ancillary data
- Probability of clear-sky (optional field)

The GOES team are using SSES to provide additional information that cannot be calculated from L2P ancillary data based on the assumption is that retrieval bias depends on clear-sky transmittance (calculated from NCEP CRTM) and the air-sea temperature difference (currently NCEP only).The SSES calculation assumes that sensitivity to Air-Sea Temperature Difference (ASTD) increases with decreasing atmospheric transmittance and that the Derived_Bias = offset + gradient $\times$ ASTD for different satellite τ11. Post-corrected σ is estimated as a function of transmittance only and SSES is typically different for sensor/day/night. Further verification and validation work is in progress to establish the reliability of the method. The team has also included a probability of cloud clearing as part of the L2P experimental fields which will be studied in the coming months. Future work includes a correction for radiance bias, improved calibration and cloud priors and development of a full physical SST retrieval. Maturi noted that NOAA OSPD is now collaborating with BoM to develop an MTSAT 1R L2P product based on the same processing code. In addition, collaborations with India are now developing that may result in establishing coverage over the Indian Ocean for geostationary platforms in the next 12 months.

A discussion on the format of GOES L2P ancillary data streams concluded that GOES L2P compression ratios could be improved significantly if only those ancillary data corresponding to valid SST observations were included in the L2P file (which is the approach taken by all other L2P data providers). Harris noted that due to the probabilistic basis for some fields (probability of cloud clearing) not all fields could be treated in this way but recognised that this approach could help the user community with data volumes. The OSPD team agreed to consider the suggestions of the GHRSST-PP Science team in this respect.

3.6 **Global Processing of MODIS for Operational SST, Ocean Color, and GHRSST,** *B. Franz, OBPG, NASA-Goddard, USA.*

The Ocean Biology Processing Group (OBPG) at Goddard Space Flight Center is the NASA Project tasked with the processing and distribution of global sea surface temperature (SST) and ocean colour products derived from the MODerate-resolution Imaging Spectroradiometer (MODIS). The OBPG is also responsible for the calibration, processing, and distribution of global ocean colour products from the Sea-viewing Wide-Field Sensor (SeaWiFS) and the processing and distribution of Aquarius sea surface salinity (once launched and operational), and serves as the Product Evaluation and Test Element (PEATE) for ocean colour on the National Polar-orbiting Operational Environmental Satellite System (NPOESS) Preparatory Project's (NPP) Visible/Infrared Imager/Radiometer Suite (VIIRS). For MODIS, the OBPG produces a set of standard operational products at Level-1A through Level-3 (global, see Figure 3.6.1), for both ocean colour and SST, that are distributed through the ocean color web (http://oceancolor.gsfc.nasa.gov) and also form the basis of value-added MODIS data distribution services such as the Goddard DAACS' Giovani system, JPL PO.DAAC's POET, and the European Space Agency's GlobColour Project.

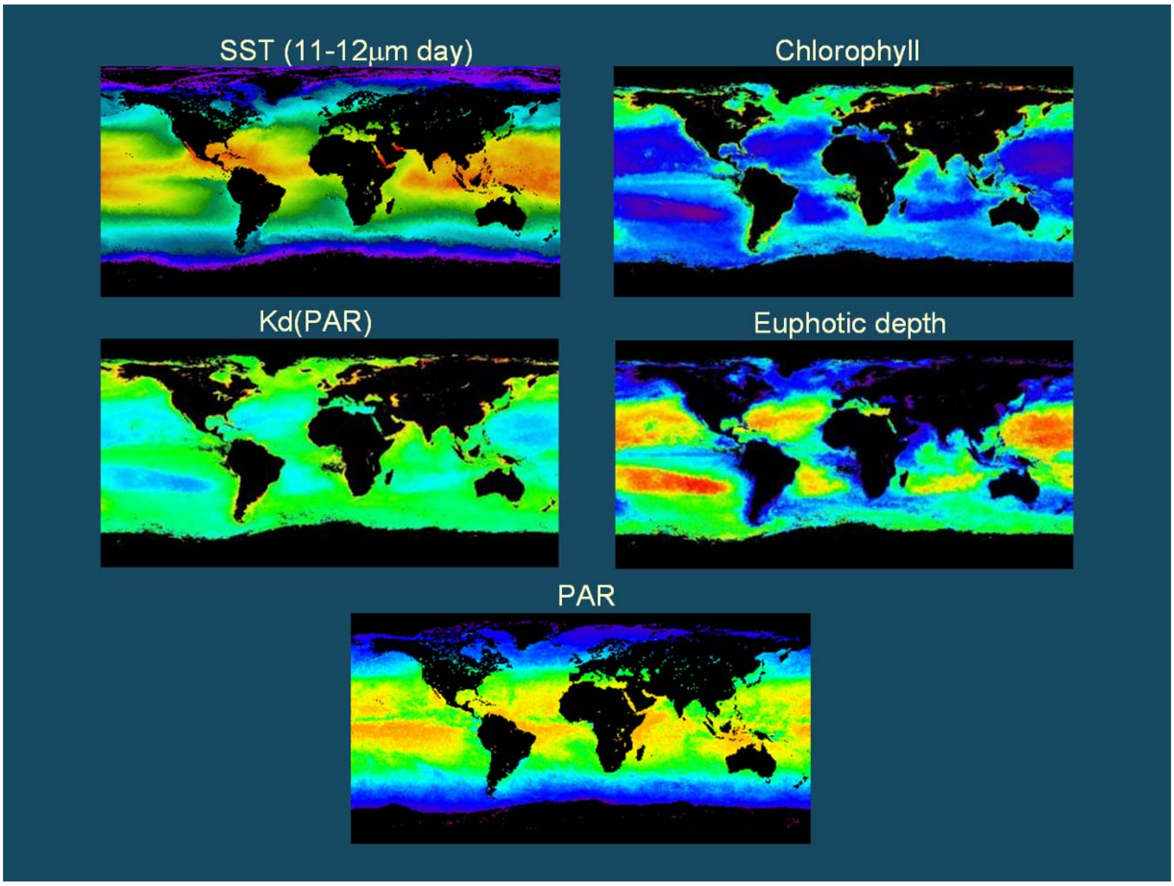


Figure 3.6.1 'Operational' L3 composite image data sets of SST and ocean colour produced by the OBPG from the MODIS sensor.

For GHRSST, the OBPG provides an alternate set of Level-2 SST products that incorporate additional information, such as sensor-specific error statistics (SSES) specific to GHRSST. The GHRSST files are distributed to the PO.DAAC, which serves as the regional data assembly centre (RDAC) for MODIS L2P products.

This report is focused on the large-scale processing of ocean products for MODIS, both operational and GHRSST-specific, within the OBPG, including processing and product changes since the last GHRSST meeting in Boulder and future plans to merge the two data streams. It should be noted that, for MODIS SST, the OBPG only provides software development, processing, and distribution. Responsibility for the SST algorithm and quality assessment rests with P. Minnett, R. Evans, and K. Kilpatrick at the University of Miami.

3.6.1 Standard Operational MODIS SST Products

The operational MODIS ocean products produced by the OBPG include Level-2 (swath oriented, native 1-km^2 resolution) files, as well as globally binned and mapped Level-3 products at approximately 4 and 9 km^2 resolution. All products are generated in Hierarchical Data Format (HDF). Geophysical parameters include daytime ocean colour (water-leaving radiances, chlorophyll-a concentration, diffuse attenuation, aerosol type and concentration), as well as daytime and night-time SST derived from the 11-12µm channels of MODIS, and night-time SST derived from the 4µm channels. These products are produced in near real-time from MODIS data acquired from both the Terra and Aqua spacecraft of NASA's Earth Observing System (EOS).

The OBPG has been producing the operational SST products for MODIS in near real-time (3-6 hours from observation to distribution) since 2005. In 2006, the entire Aqua mission (July 2002 to present) was reprocessed with the latest MODIS calibration and SST algorithm coefficients. In April 2007, the OBPG completed a full reprocessing of the MODIS/Terra mission dataset for SST (February 1999 to present). This latest milestone represents a completion of the transition of MODIS SST processing and distribution responsibilities to the OBPG.

3.6.2 GHRSST-specific Products

In October 2005, the OBPG began producing a secondary set of Level-2 products from MODIS/Terra and MODIS/Aqua specifically for GHRSST. This unfunded effort was implemented in parallel to the operational processing stream to allow for rapid evolution of the GHRSST file content during the early phase of development, without impact to standard operational processing or existing MODIS SST users, as shown in Figure 3.6.2. The basic format remains HDF, and software and algorithms are identical to that used for operational processing, but for GHRSST the OBPG adds the SSES field based on the algorithm and tables developed by the University of Miami. The GHRSST-specific products produced by the OBPG are made available via rolling ftp archive to the RDAC at NASA JPL, where they are converted to netCDF format and merged with additional meta-data and ancillary fields to form the MODIS GHRSST L2P products.

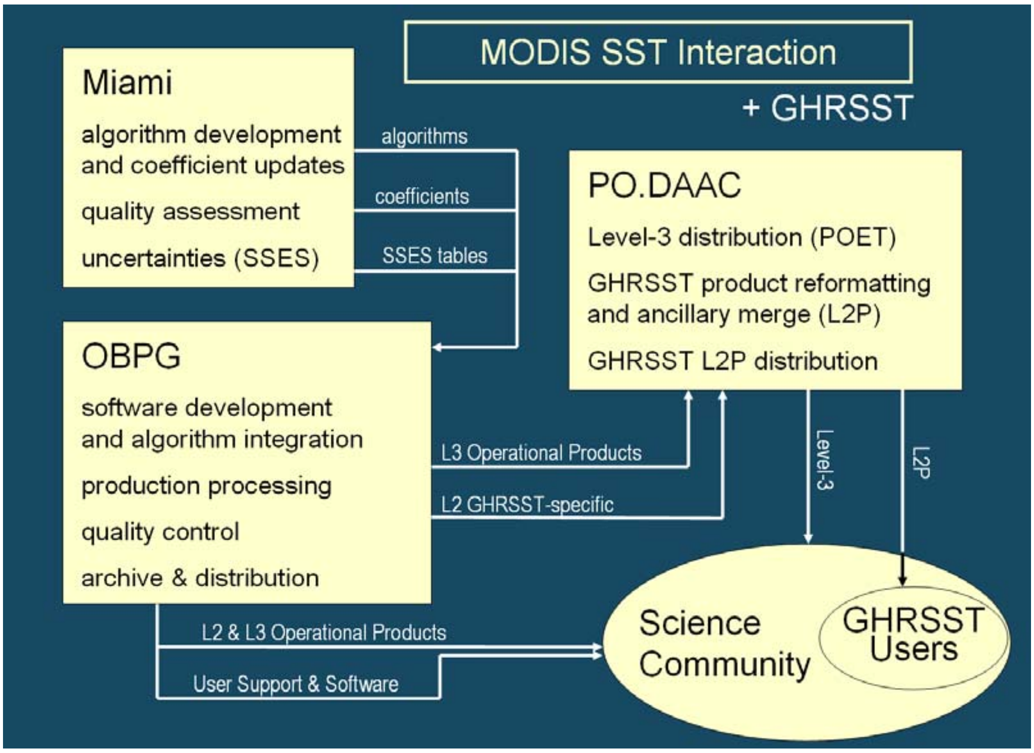


Figure 3.6.2 MODIS SST-Interactions and responsibilities between OBPG, JPL and the University of Miami for GHRSST-PP.

Following discussions at the March 2006 GHRSST meeting in Boulder, the OBPG made some changes to the GHRSST-specific file content to reduce file size and enhance product value. These changes, which were made operational prior to the culmination of the meeting, included addition of the ocean colour chlorophyll-a (Ca) parameter along with the 11-12μm SST in the daytime GHRSST files, with the night-time files providing both the 11-12μm SST and the 4μm SST fields. The RDAC incorporates these Ca and 4μm SST parameters as experimental fields (i.e., in addition to the basic SST and auxiliary data sets) in the daytime and night-time L2P products, respectively with an associated increase in file size and complexity form a user perspective. Recently, the University of Miami provided an update to the SSES tables based on a hypercube approach in 7 dimensions (SST level (day or night, season, view zenith, brightness temperature difference, latitude, quality level). This change was incorporated into the GHRSST processing stream in late April 2007.

3.6.3 Data Latency Analysis

The OBPG has no operational requirement to provide near real-time support for MODIS, but every effort is made to provide the data products for both ocean colour and SST in a timely manner. All products are first produced in a quick-look mode, using best available ancillary inputs (wind speed etc.) and spacecraft orbit and pointing knowledge. This is followed 3-4 days later by a refined processing when higher quality ancillary information is available. An analysis of the most recent 30 days of GHRSST-specific quick-look products showed that median latency from time of observation to time of availability on our ftp site was 4.05 hours for Terra and 4.48 hours for Aqua, with a typical spread of 3-6 hours (Figures 3.6.3 and Figure 3.6.4). Longer delays can occur when granules are dropped at the NOAA near real-time processing element (NRTPE) due to packet loss or corruption, thus requiring OBPG failover to the EOS Data Operations System (EDOS). The EDOS system ensures completeness of down-linked granules, but with approximately 9 hours delay. These fail-over events are more common for Terra (Figure 3.6.3).

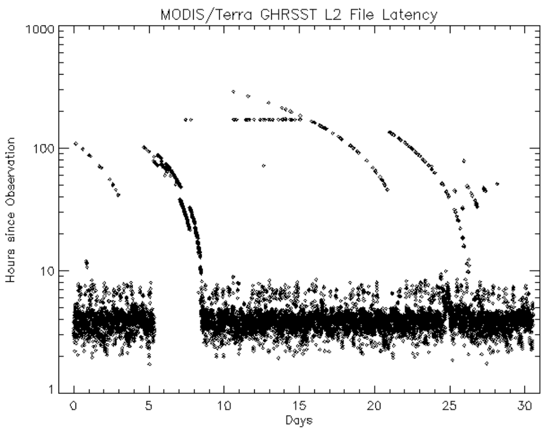


Figure 3.6.3 MODIS/Terra Level-2 GHRSST products, time of observation to time of availability, last 30 days.

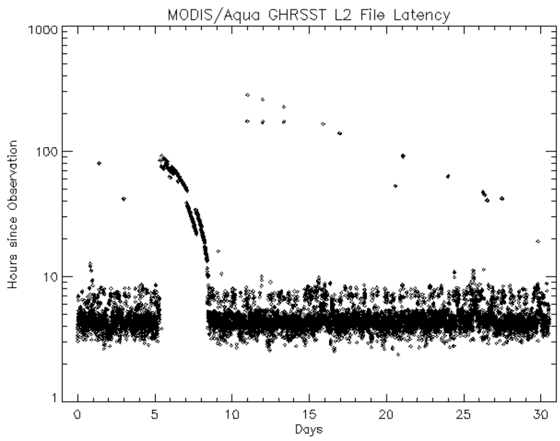


Figure 3.6.4 MODIS/Aqua Level-2 GHRSST products, time of observation to time of availability, last 30 days.

3.6.4 Future Plans

The OBPG periodically reprocesses the entire ocean colour and SST product suites to incorporate sensor calibration and product algorithm updates. It is anticipated that a full reprocessing of the operational MODIS/Terra and MODIS/Aqua SST products will be performed in late 2007 (which may result in a loss of historical experimental fields). At that time, it is likely that the SSES fields will be incorporated into the operational SST Level-2 and L3 products (in GHRSST-PP format), thereby eliminating the need for a GHRSST-specific processing stream. In addition to the reduction in processing and disk storage costs, the advantage of this merger is that GHRSST-compatible Level-2 products will be available online for the entire mission lifespan. The disadvantage is that any future, GHRSST-specific algorithm or content changes (including experimental fields) will not be as readily introduced into the operational processing stream. As such, it is critical that the GHRSST community is in agreement on the desired content of the MODIS Level-2 SST products. For example, is Ca the best product to enhance the utility of daytime SST, or would another product such as spectrally integrated diffuse attenuation, K(PAR) or Zhl (depth of the 'heated layer'), be more relevant?

Furthermore, given that the typical coverage form a NRT data stream of ocean colour observations is significantly different form that of SST (due to impacts such as sun glint, see Figure 3.6.5), use of multi-day ocean colour composites may be more useful for applications such as diurnal variability studies as fields are more complete. The OBPG requires clarification and guidance as to which ocean colour data streams should be included with MODIS L2P data sets. In this respect, the timely development of a stable GDS v2.0 is extremely important.
An action was raised on the DV-WG, the main 'user' of ocean colour fields, to consider the best fields to add to MODIS data although several DV-WG members noted that there was insufficient effort and resource available to properly address these issues in a systematic manner.

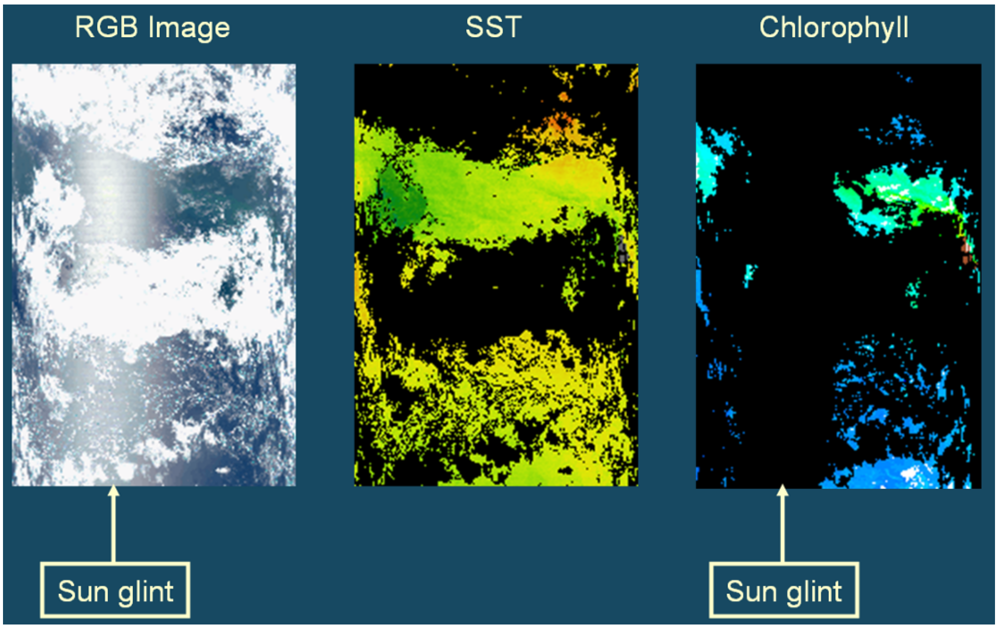


Figure 3.6.5 Retrieval differences between SST and ocean colour products complicating the combination of SST and ocean colour data sets.

The OBPG processing software can produce a multitude of geophysical parameters, most of which are considered experimental and thus not included in any operational products. Instead, the processing capability is distributed to the research community through a software and analysis package called SeaDAS. The GHRSST community may wish to investigate available options through SeaDAS or suggest new products that may be more useful for SST analysis and models.

Franz summarised by reminding the GHRSST-PP Science Team that the OBPG currently produces the Level-2 MODIS data for input to the GHRSST RDAC and the operational Level-2 and Level-3 SST and Ocean Color products for general distribution (including to 3rd-party distributors such as POET, Giovanni, and GlobColor). They plan to merge the two Level-2 SST streams to a common Level-2 HDF format in the next reprocessing (2007) in order to remove any overlap in product content between operational SST and OC products (e.g., chlorophyll, Kd(490)). The GHRSST ST (diurnal variability working group) should if possible recommend the incorporation of alternative OC products which better complement SST.

3.7 Reanalysis Technical Advisory Group (RAN-TAG) report, *K. Casey, NOAA/NODC, USA.*

The GODAE High Resolution Sea Surface Temperature Pilot Project (GHRSST-PP) Reanalysis Technical Advisory Group (RAN-TAG) has made several key achievements since the 7th Science Team meting in Boulder, 27-31 March 2006. First and foremost of these accomplishments is the completion of the fully automated ingest, archive, and access system for all GHRSST data at the Long Term Stewardship and Reanalysis Facility (LTSRF) at NOAA's National Oceanographic Data Centre (NODC), and its population with a large quantity of data. The LTSRF is now archiving on a daily basis all GHRSST L2P, L2P_GRIDDED, and L4 products that have been processed at the Global Data Assembly Centre at the NASA Physical Oceanography Distributed Active Archive Centre (PO.DAAC). Second, a new L4 global, multi-platform, optimally interpolated reanalysis SST dataset is now being produced at NOAA's National Climatic Data Centre with daily, 25 km, resolution and progress made on a daily, 5 km reanalysis product by the Met Office, UK. Finally, significant work by members of the

RAN-TAG has been conducted, aimed at generating broader community knowledge and use of the GHRSST products.

While much of the initial focus of the GODAE High Resolution Sea Surface Temperature (SST) Pilot Project (GHRSST-PP) has been the development of real-time SST products, it is widely appreciated that satellite datasets produced in such 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 a 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 streams 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 easily 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*. The GHRSST-PP RAN Technical Advisory Group (RAN-TAG) is the formal GHRSST-PP body that is responsible for the scientific and operational methods and algorithms used to generate delayed-mode GHRSST-PP data products. Current (open) membership includes

- Ken Casey
- Ed Armstrong
- Jorge Vazquez
- Craig Donlon
- Hiroshi Kawamura
- Gilles Larnicol
- David Llewellyn-Jones
- Nick Rayner
- Gary Wick
- Dick Reynolds
- Bill Emery
- Helen Beggs
- Gary Corlett

The team has been particularly active this year promoting the GHRSST-PP and associated RAN at the following meetings:

- NOAA-NASA Satellites in Ecosystem-based Management Workshop (Monterey, May 2006)
- NOAA Office of Climate Observations Review (Silver Spring, May 2006)
- Summer ASLO (Victoria, Jun. 2006)
- GODAE Symposium (Beijing, Oct. 2006)
- Medspiration-GlobCOLOUR Joint User Consultation (Villefranche-sur-mer, Dec. 2006)
- NOAA-NFRDI Data Panel (Busan, Feb. 2007)
- GlobCOLOUR (Exeter, Mar. 2007)
- Director, China NODC (Silver Spring, Apr. 2007)
- Upcoming:
    - AGU Joint Assembly (dedicated CDR from space session) (Acapulco, May 2007)
    - NOAA CoastWatch (Annapolis, Jun. 2007)

The delayed mode products will be suitable for use as climate data records, an emerging 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 to strive for.

Casey described the current status of the GHRSST RAN-TAG with a focus on its activities since the 7th GHRSST Science Team meeting, held in Boulder, Colorado, USA from 27-31 March of 2006. The year since that meeting has been a productive one for GHRSST in general and for the RAN-TAG as well. The remainder of this document covers three key areas of RAN-TAG activity:

- Establishment and population of the GHRSST Long Term Stewardship and Reanalysis Facility (LTSRF) at NOAA's NODC
- Reanalysis product developments
- Reanalysis Data Access and Application efforts

3.7.1 Establishment and Population of the Long Term Stewardship and Reanalysis Facility

The establishment of the LTSRF (http://ghrsst.nodc.noaa.gov) and its population with substantial quantities of GHRSST data marked an important milestone in the year since the last Science Team meeting. This effort to insure proper preservation and description of the GHRSST data streams is a critical first step on the way to creating more accurate GHRSST reanalysis products.

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:

- AATSR
- AMSR-E
- AVHRR-16, AVHRR-17, AVHRR-18 (GAC and LAC/HRPT)
- GOES-11 and GOES-12
- MODIS Aqua and Terra
- SEVIRI
- TMI

In addition, two L4 analysis products are currently being received and archived:

- European RDAC 2.2km Mediterranean L4 SST
- UK Met Office OSTIA 5.6 km Global OSTIA L4 SST

Together, these L2P, L2P_GRIDDED, and L4 files occupy over 2.5 terabytes (compressed, ~50 terabytes uncompressed) of disk space, and consist of over 170,000 netCDF data files. Current temporal coverage varies for each product line, with the earliest datasets available back to the beginning of 2005. The data are grouped in the archive system as NODC "accessions", or logical groupings of data. For GHRSST, an accession 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 FR metadata files) from MODIS Aqua, produced by the JPL RDAC for 01 January 2007 are grouped into a single NODC accession. As of 26 March 2007 there are 11,176 GHRSST accessions in the formal NODC archive systems.

Figure 3.7.1 illustrates the growth of the LTSRF archive holdings since the beginning of 2005, when the first GHRSST products became available. 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.

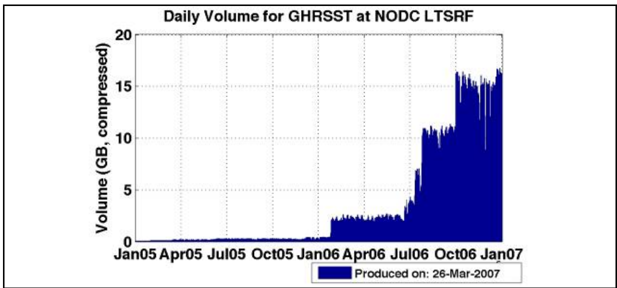


Figure 3.7.1a Volume in gigabytes arriving in the LTSRF each day.

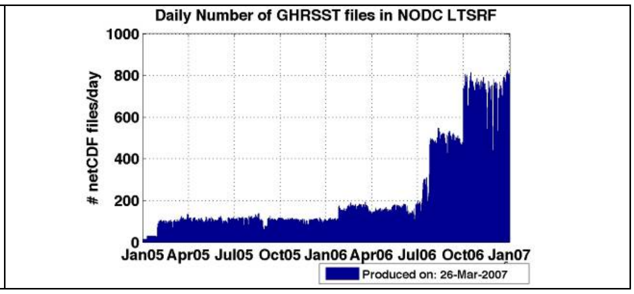


Figure 3.7.1b Number of netCDF files arriving in the LTSRF each day.

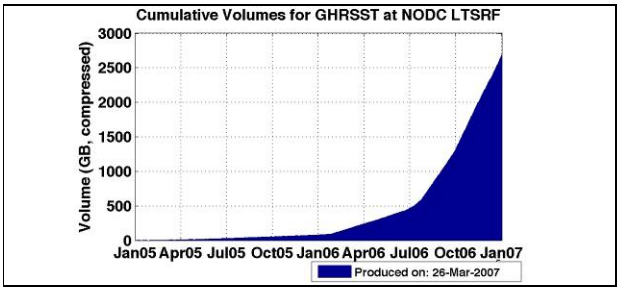


Figure 3.7.1c Cumulative volume in gigabytes in the LTSRF.

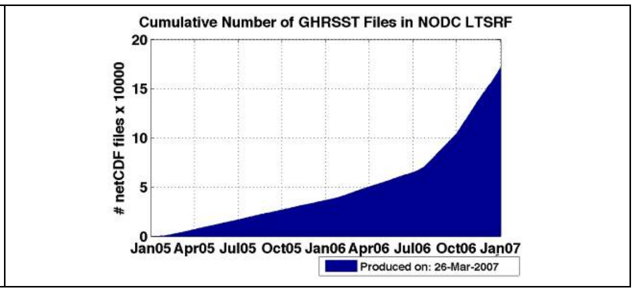


Figure 3.7.1d Cumulative number of netCDF files in the LTSRF.

These graphs indicate that approximately 800 netCDF files occupying about 16 gigabytes of disk space (compressed, about 320 gigabytes uncompressed) are arriving at the NODC LTSRF each day. Data are automatically acquired on a daily basis from the GDAC with a 30-day delay from observation to archive. All products are available online via FTP, HTTP, and OPeNDAP. All data is searchable via NODC Ocean Archive System - http://www.nodc.noaa.gov/cgi-bin/search/prod/accessionsView.pl/pref with extensive metadata in both FGDC and original DIF formats. Table 3.1.7 provides a summary table of data access statistics for the LTSRF based on access type and shows a significant increase in data access.

Table 3.7.1 Data access statistics at the LTSRF based on unique IP addresses showing a roughly 50% increase over 2006 by May 2007. The LTSRF is on track for 300% increase by end of 2007. Total access is ~1/6 of Pathfinder access in 2006, but on par with Pathfinder for 2007.

Method	2006	Jan-Apr 2007
FTP	24	48
HTTP	568	708
OPeNDAP	57	169
Totals	649	925

In order to facilitate the application of GHRSST-PP archive data and to minimise the number of user enquiries regarding use of GHRSST-PP data a Matlab reader and data access tutorial that also includes information explaining how to read GHRSST-PP data into ArcGIS has been developed and placed on-line at the GHRST-PP and LTSRF web sites. Casey requested assistance to 'beta-test' the tutorial and feedback any issues or suggestions. Martin Rutherford agreed to test LTSRF access and application of LTSRF data sets.

There was some discussion regarding the use of OPeNDAP techno logy and several ST members wanted to know if the technology was reliable particularly outside of the USA and given that NODC has had to close its OPeNDAP server because of security issues. Casey replied that NODC rely on OPeNDAP a lot although security, bandwidth and data chunking on netCDF3.0 issues are still problematic. Orders of magnitude improvement in data access are gained when chunking data and netCDF 4.0 (which allows chunking of data in the same way as HDF) should help considerably in this respect.

While substantial progress has been made, future development of the LTSRF and its stewardship capabilities is needed in three keys areas. The first is a robust and preferably automated way to manage new versions of data already held in the archives. This problem is surprisingly non-trivial as many permutations exist, and current GHRSST metadata is inadequate to handling new versions in an automated fashion. The second area is to develop a more robust "rich inventory" system that examines incoming granules of GHRSST data, calculates various statistics, and puts the results in a searchable database for quality control and more content-specific search capabilities. The third area is complete the initial build of an inter-comparison capability for different L4 SST analysis products and historical SST reconstruction datasets. This work is being done in conjunction with the Global Climate Observing System (GCOS) SST/Sea Ice Working Group. Little progress has been made since last year, though activity has once again resumed in just the last few weeks. This capability will also facilitate the development of a GHRSST ensemble mean SST product, which will enable better understanding of the differing analysis techniques.

3.7.2 Reanalysis Product Developments

Progress has been made since the last Science Team meeting in the development of reanalysis SST products. Demand for these more accurate, consistent, and longer-term products is very high, with users ranging from fisheries scientists to numerical modellers interested in longer data sets than the GHRSST forward-mode operational data streams can provide.

The first is the work of Richard W. Reynolds, Thomas M. Smith, Chunying Liu, Dudley B. Chelton, Kenneth S. Casey, and Michael G. Schlax, to create a set of daily, 25 km resolution optimally-interpolated SST products going back to 1985, using AVHRR Pathfinder Version 5 data when available (1985-2005), operational AVHRR data for 2006 onwards, and AMSR-E as well. Two sets of analyses have been created, one with AMSR-E and one without, going back to 1985 but they have not yet been fully converted to GHRSST L4 format with the required metadata. This work has been submitted for publication in *Journal of Climate*. The data are also currently available from the NOAA National Climatic Data Centre web site (http://www.ncdc.noaa.gov) but not yet through the GHRSST data management infrastructure.

Work has also begun by John Stark and Craig Donlon to produce a retrospective Operational Sea Surface Temperature and Sea Ice Analysis (OSTIA) product at the Met Office, UK. The forward-mode

OSTIA product is already part of the GHRSST system, but the retrospective product will go backward in time using reprocessed inputs like AVHRR Pathfinder when available. Discussions have been held between NODC and the Met Office and the acquisition of the currently available Pathfinder data will begin shortly.

In addition to the above efforts aimed at producing retrospective reanalyses, progress has also been made in single sensor reprocessing efforts whose goals are to provide better inputs to the reanalysis systems. One of these involves European efforts to provide a rapidly-reformatted (A)ATSR archive in L2P core with uncertainty estimates in early 2008, as well as a longer term reprocessing effort called the (A)ATSR Reanalysis for Climate (ARC). This project is led by Chris Merchant of the University of Edinburgh and will deliver an improved (A)ATSR series in L2P core in 2010. The other effort involves NODC and University of Miami's work to transition the AVHRR Pathfinder processing system to NODC and to migrate it into the SeaDAS environment. This work is well underway and NODC's goal is to have an initial capability to produce Pathfinder version 5 data in SeaDAS by October 1, 2007. Once that initial capability is established, work will begin to enable the creation of Pathfinder data in L2P core.

Progress was also made in the past year through the submission of a large NASA proposal to the "MEaSUREs" RFP. This proposed project is a partnership between Kenneth Casey at NODC, Bob Evans at University of Miami/RSMAS, Rick Stumpf at NOAA/National Ocean Services, and Ed Armstrong at NASA PO.DAAC, and is led by Peter Cornillon at URI/GSO. The project will attempt to

- Process the entire retrospective MODIS and AVHRR archives available at the Ocean Biology Processing Group (OBPG), the University of Rhode Island (URI) and University of Miami/RSMAS to full resolution GHRSST L2P core fields.
- Acquire at the GHRSST LTSRF the complete (A)ATSR L2P core data set from the European Union and to produce L3 high resolution SST data products on a 4 km and a 1 km global, equal-angle grid for AVHRR, MODIS, and (A)ATSR sensors.
- Produce a merged L4 high resolution SST climate data record from the MODIS, AVHRR and (A)ATSR L3P data sets on both 4 km and 1 km global, equal-angle grids.

Other developments include a new formal connection with the Group on Earth Observations (GEO Task DA-06-03), to facilitate the wider use of ensemble averaging techniques for SST data records.

3.7.3 Reanalysis Data Access and Application Efforts

The RAN-TAG and staff at the LTSRF have also begun efforts to enable easier and broader use of all GHRSST products. These efforts have taken various forms and are of growing importance owing to the growing awareness and number of users of GHRSST products. Progress made includes:

- Numerous presentations and discussion at venues around the world, including the US, China, Republic of Korea, France, and the UK
- Outreach efforts through the NOAA Public Affairs and official NOAA Press Releases (e.g., http://www.noaanews.noaa.gov/stories2007/s2780.htm on GHRSST's LTSRF)
- Responding to a growing number of user services requests
- Draft Matlab readers for GHRSST L2P and L4 files - http://ghrsst.nodc.noaa.gov/documents/GHRSST_matlab.zip
- The development of the first of a series of GHRSST data access tutorials - http://ghrsst.nodc.noaa.gov/documents/GHRSST_DataAccess_Mar2007.pdf

3.7.4 Summary and Look Forward

The past year has been a highly active one for GHRSST reanalysis. A large data management system has been developed, and progress made toward creating high resolution, multi-sensor reanalysis products. The coming year promises to be even more active, with a renewed interest in establishing an effective SST inter-comparison facility and work at the LTSRF to provide long term stewardship to a growing number of L2P and L4 products. Supporting the creation of long-term reanalysis products will again be the high priority for the RAN-TAG, and more effort will be expended in making GHRSST products more easily used by the archive user community. Above all, international collaboration will continue to be the means by which the ambitious goals of GHRSST Reanalysis will be achieved.

3.7.5 References

NRC (2000). Ensuring the climate record from the NPP and NPOESS meteorological satellites, NAP, 71 pp.

3.8 Status and application of the HR-DDS, *D. Poulter, NOCS, UK.*

The GHRSST-PP High Resolution Diagnostic Data Set (HR-DDS) is a real time archive of GHRSST-PP L2P and L4 data sets collected at ~150 globally distributed locations. These data are dynamically analysed using a web interface (see http://medserve.noc.soton.ac.uk/mydds/sst/) to look at temporal and spatial differences between the input satellite data sets. The HRDDS also includes SST climatology, ocean model SST data sets and L4 analysis systems and is used to investigate the quality and representivity of these data sets. Input data are typically provided on different grids and the HRDDS system first re-samples these data onto a common 0.05 x 0.05° latitude x longitude grid. At the same time statistics for each HRDDS granule (HRDDS site) are derived and stored in a relational database for further use by the system and visualisation service. The HRDDS provides three levels of visualisation:

1. Time series line plot of SST data from satellite, model, L4 data sets and climatology for a given HRDDS site
2. Spatial plot of these data
3. Difference maps and other statistics related to a given data set at a specific site.

Example plots from the HRDDS system are shown in Figure 3.8.1

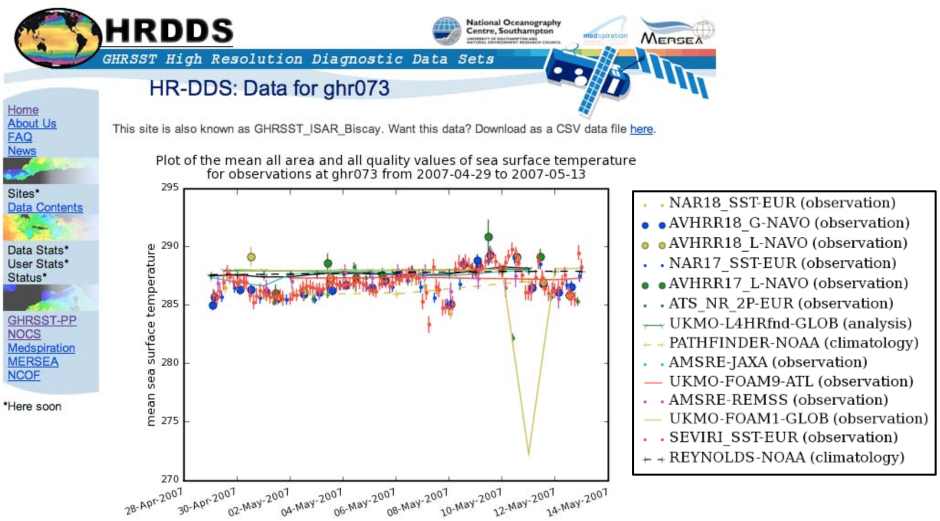


Figure 3.8.1(a) Screenshot of the HRDDS time series display showing how the HRDDS reveals problematic data sets.

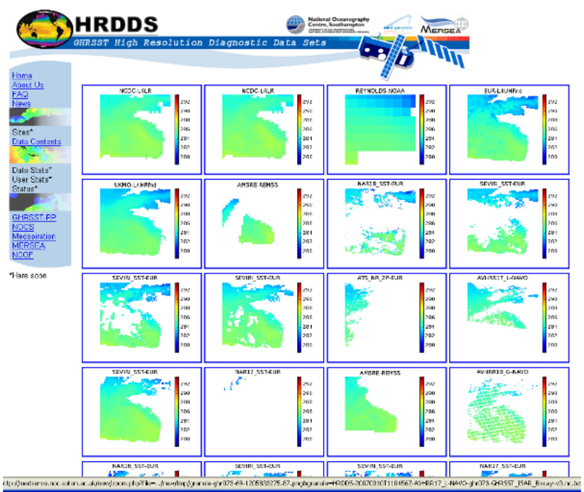


Figure 3.8.1(b) Screenshot of the HRDDS spatial visualisation.

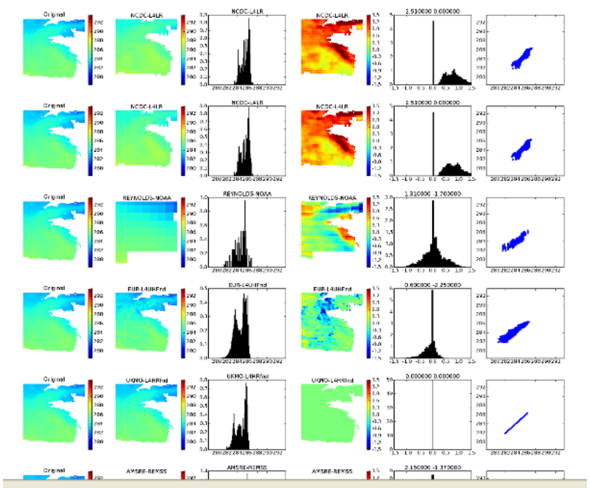


Figure 3.8.1(c) Screenshot of the HRDDS inter-comparison.

Major work has been undertaken on the HR-DDS since G7 and third complete redesign has recently concluded. The system is now capable of analysing and ingesting many new sources of data, including for the first time in situ observations and non GHRSST format data. Initial work towards integration with the ESA-GlobColour project and collaborative research within the UK National Centre for Ocean Forecasting (NCOF) is already underway.

The HRDDS provides a very easy way to visualise GHRSST-PP data sets and study how they interact with each other. The present system has the capability to define up to ~1200 sites although it is not likely that such a large number of sites are required. Each HRDDS site is colour coded according to a specific category: red sites are guaranteed to have operational in situ observations within the site (normally at the centre of the area); purple sites are enclosed areas (lakes etc), yellow sites are coded as special areas of request. Special sites include some of those that cover areas where in situ observations are collected by dedicated Volunteer Observing Ship (VOS) systems such as the ISAR-Ferrybox project in Europe, Several transects made by Ferry in Australia and the Royal Caribbean M-AERI project in the Caribbean. Blue sites are those areas matched with GlobColour project.

The recent redesign of the HRDDS back end system includes a scaleable architecture, far better graphics system, more statistical analysis functions and a new look and style. The system can now take in L2Pc, L2P and non GHRSST-PP data sets, climatology data sets (providing a future aspect to the HRDDS) and other ancillary fields. Several dedicated machines including a spare backup machine to provide complete redundancy are used by the system One particular new feature is the ability to use the SSES provided within each L2P data file and to plot these us pas error bars on the HRDDS system pages. Bias corrections appear to be quite poor and the HRDDS shows up weaknesses in the SSES. In order to refine the way in which the HRDDS system calculates statistics of a given site, ‘centre area only’ statistics using a 5x5 grid average is provided which helps understand differences between data sets when large cloudy areas are present.

Following some discussion, the Science Team noted that there is a need to use the HRDDS to derive numerical values and statistics in a more automated manner. The DDS web interface is good for browsing but applications based on the data sets are also required. Poulter noted that the HRDDS granule data files are available and could be used for this by individual users. However, the Science Team urged Poulter to discuss the options and requirements of different groups for interfaces and applications using the HRDDS system. Dave Poulter was tasked by the Science Team to develop a simple user questionnaire requesting HR-DDS requirements and circulate to all at the meeting.

3.9 The GHRSST-PP MDB system: Status and Plans, *J. F. Piollé, IFREMER, France.*

Piolle provided a summary of the motivation for the GHRSST-PP Matchup Database (MDB) system noting that the original idea for a common shared MDB system was to have a data resource that everyone working in GHRSST-PP could use to validate satellite SST data. Having a common shared resource means that different groups would at least start the validation process from a common set of data which is not the case today. Currently, each group maintains its own [different] set of MDB data QC’d by different rules and thus including different data. This is for historical and political reasons but given this situation, it is not really possible to compare different SSES derivations or validation results as each database uses different QC and data content. The GHRSST-PP MDB should help to provide a better validation framework that will also deliver a scale of economy (1 database that everyone agrees with compared to many different systems) and if we all start form the best common set of data then the assumptions made in the analysis during the validation process are fair.

Piolle noted that the GDS specifies the MDB data records and the matchup process for satellite and in situ data. A first version of the GHRSST-P MDB has been constructed at Ifremer in the frame of Medspiration project (Figure 3.93.), with support by ESA, making available online (through both a web interface and netCDF files) more than 2 years (2005 to today) of match-ups (about 2.8 million observations). However the content has so far been restricted to the Medspiration data for satellite observations and the IFREMER Coriolis database for in situ observations, which is a severe limitation to the scope of this tool. The GMES Marine Core Service should take over the operation and extension of this MDB starting from 2008 and aims to include all GHRSST datasets. Despite limited resources improvement of the MDB is required to take advantage of existing datasets, practices and experiences in other systems in order to bridge this gap and progress toward a single common GHRSST MDB. Piolle presented a roadmap to achieve this objective:

- Addition of new in situ SST sources into Coriolis database, in order to improve the completeness of this reference database and allow match-ups derived from a wider variety of in situ data sources,
- Merging of existing MDBs into the central GHRSST MDB (historical data and/or new GHRSST datasets),
- Develop and test rules for match-up criteria, quality control and confidence estimation,
- Develop tools to add relevant ancillary data to SST observations,
- Describe and develop ways for other partners to contribute to the GHRSST MDB

This presentation will focused on what has been achieved so far, review updates of the GDS specification and provide suggestions and plans to meet these goals.

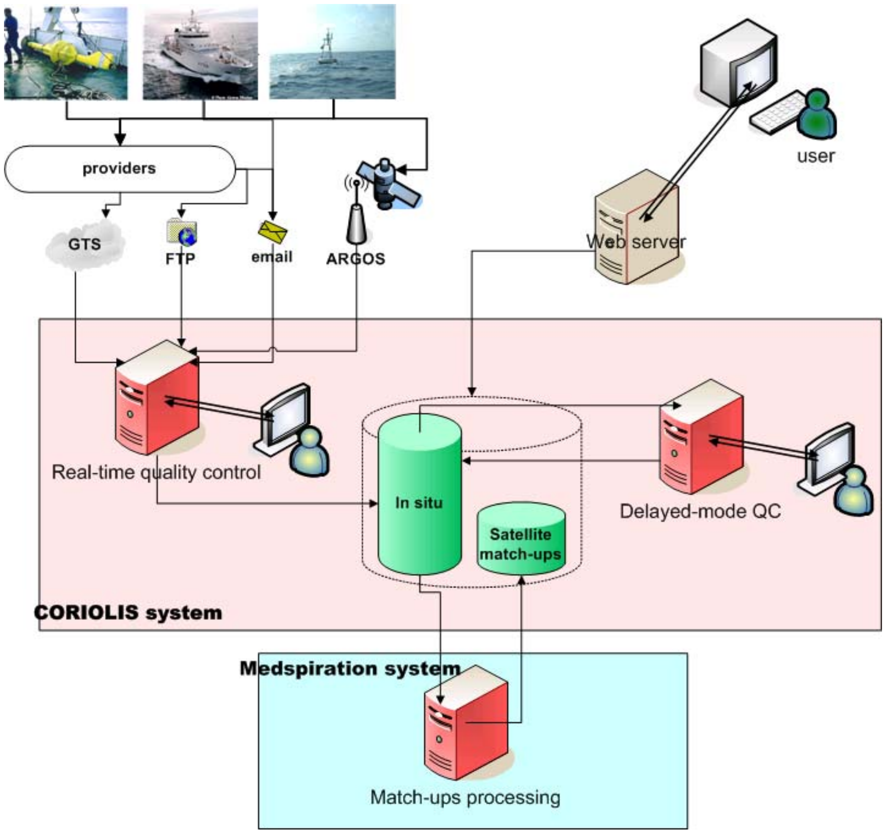


Figure 3.9.1 Summary Schematic diagram showing the prototype GHRSST-PP Matchup Database system implemented at IFREMER France.

Piolle explained that the MDB has been a challenge and the system is not yet in a stable or complete state. Why is this? Is it a resource issue? A practical issue? A political issue? It is clear that at present, most providers don't want a centralised database but how can we continue and strengthen the effort? New interfaces to the MDB have been set up with data available in NetCDF format from http://www.medspiration.org/tools/mdb/preextraction.html. In addition, a flexible multi-criteria extraction interface (to ascii/netcdf) is provided at http://www.medspiration.org/tools/mdb/consultation/. This has been a significant effort by Medspiration team and funding by ESA to provide open access to all users And will be a major item of the upcoming European GMES Thematic Assembly Center (TAC) for SST (2008-2011)

Piolle noted that applications of the MDB cover many elements of the GHRSST-PP from L2P SSES moniotoring to Re-analysis and feedback to the data providers. There is a need to develop the MDB user community to feedback on the specification and content of the MDB system. This community should be able to access to the MDB in a simple manner and obtain data sets with more homogeneity to help understand quality of validation results as the MDB data will have the same QC and processing rules applied. Ancillary data can be added to the matchup bringing additional flexibility and the potential to add other sensor specific or climatological databases. Piolle noted that this was a huge task and we need to be sure we have users and we meet their requirements. A questionnaire was prepared and sent out to the Science Team to explore the user requirements which is presented in

Table 3.9.1 below.

Currently we only data form Medspiration and the Coriolis in situ database which is not sufficiently flexible. In addition, we need the content to be expanded to other file formats especially L1 (brightness temperature) information. Two strategies were discussed to achieve this aim:

1. The current Medspiration setup is a central Napoleonic structure all processed the same way and same inputs. Can then compute independent SSES information. Benefit of optimal consistency of content. But high cost of management and processing. Also limited content as we can only use L2P and Coriolis data.
2. To use the MDB data from other providers noting that only limited control in terms of QC will be possible but, we may have more diverse data. (sometimes less data). This approach is easier to manage as it is basically just formatting of input data. The main inconvenience is an inconsistent database as different MDB's have very different content, supporting information and ancillary data.

Piolle concluded that the MDB is a delayed mode activity and will form a core input to the GHRSST-PP RAN effort and is targeted to verify the SSES provided by data providers. For wider R&D efforts, users are referred to the L2P data providers MDB which is typically much richer in content.

Questionnaire

Are you a L2 or L2P data provider	Most of them but not all of them (who seems to find it more painfull to have to do it)
Do you compute your own L2 or L2P match-ups	All L2/L2P providers
If you compute your own match-ups, how frequently do you update them	L2/L2P providers => daily Research => monthly
Do you need L2 or L2P match-ups? If it is not for the validation of your own L2 or L2P products, for which purpose?	Some providers express need for double check/confirmation of their own SSES estimation Others : SSES estimation, sensor characteriztion, data merging => need for ancillary data
If your compute match-ups, are you ready to make them available to everybody ?	Most of them Some L2/L2P providers can not (need to compute match-ups in this case)
Do you mind putting a copy of your MDB at the GHRSST MDB (with proper acknowledgement/credits/…) in addition to any other access you may provide	Those that make them available agree on duplication at GHRSST MDB (though it may not be the purpose of GHRSST MDB if we seek complete independancy!!)
Do you expect the GHRSST MDB to compute match-ups from your L2P datasets (from its own in situ data stream) or just store your own match-ups and no others?	Question was ambiguous It was about creating independant match-ups at GHRSST level (not using the L2/L2P providers match-ups) **Strongly related to objectives/independance level sought for GHRSST MDB**
What service do you expect from the GHRSST MDB? A single access to the match-ups for all L2P datastreams? Homegeneous format ? More information associated with the match-ups (ancillary data,…)? Finding SSES for each L2P dataset? Search and extraction tools? Some intercomparison tools (such as the graphical display of the HR-DDS systems, plots, maps,…)?	**Credible and independant evaluation of L2Ps** **Single access point, format, match-up criteria** Search/subsetting/extraction tools Access to specific buoys/cruises Integration with HR-DDS system Some requirements contradictory with minimal goal of MDB (which is to provide independant SSES)

Table 3.9.1 MDB questionnaire and results developed by the IFRMER MDB team

Piolle explained that based on this user review and considering the applications noted previously, the GHRSST MDB will be redesigned for more flexibility in terms of its content to allow other data streams to be used rather than just the Coriolis system. The need to for the central MDB to compute match-ups from L2P and in situ data will be maintained (depending on available computing resources) with match-ups delivered periodically in netCDF format (and online from web interface) to allow SSES checking and inter-comparison with homogeneous content. L2/L2P providers are encouraged to complete the datasets with whatever information they have (brightness temperature,…) prior to ingestion within the MDB system. A general overview of the new system is given in Figure 3.9.2.

With this GHRSST MDB redesign the MDB will provide a more complete and comprehensive system for wider use. GDS2.0 should be updated to reflect the changes proposed here.

The Following actions were raised:

- Set up a revised MDB system for user verification of GHRSST-PP data products as part of the R/GTS and GMPE.
- Revise the MDB section in GDS-v2.0 (Piolle, GHRSST-PO, Poulter)
- How can the HRDDS and MDB systems merge? Discus this at the SSES session (Piolle,

GHRSST-PO, Poulter)

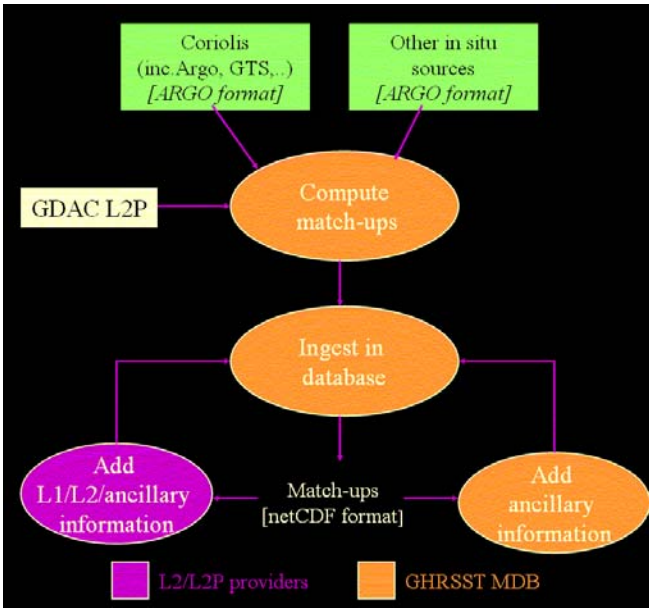


Figure 3.9.2. General overview of a revised and more flexible GHRSST-PP MDB system that includes other matchup database systems targeted to SSES verification.

3.10 Data Management Technical Advisory Group (DM-TAG) report, *J. Vazquez, PO.DAAC, JPL, USA.*

The main accomplishments of the DM-TAG include:

- Revision of GDS-1.7
  - Level 4 specifications
  - Level 2P specifications
- Discussion on Level 3 specifications (led by Ken Casey) and based on Pierre LeBorgne's document.
- Addition of "Data Access Tutorial" written by Ken Casey. Accessible through both LSTRF and GDAC web sites.
- Formation of SSES working group
- Discussions regarding a GHRSST-PP Data Policy Draft Document

With the cooperation of members of the Data Management Technical Group (DM-TAG) a review occurred of the GHRSST-PP Data Processing Specification GDS (Version 1 revision 1.7) document. This review included both the Level 2P and Level 4 formatted products. Several issues were discussed and agreed upon by the DM-TAG. They included;

1) Inclusion of the DT-analysis in the L2P formatted data sets. The discussion arose as to whether the requirement for the DT_analysis field should be included in the L2P fields. The consensus was that the DT_analysis should be included in the delayed mode L2P data sets but not in the L2P_core real time products. One option discussed was that a decision be made as to which analysis was going to be used as the "reference analysis". The DT_analysis would not be filled until this reference field was available for the previous day. One possibility discussed is that the DT_analysis be filled in at the GDAC, to make sure the same reference field is used.
2) Second issue discussed was the convention to be used for L2P_gridded fields. Consensus arose that the gridding resolution for any L2P product should be sensor dependent. It need not be specified in the GDS explicitly. Following the convention set by Remote Sensing Systems the naming convention for L2P gridded files would look like the following:

   20070203-AMSRE-REMSS-L2P_GRIDDED_25-amsre_20070203v5-v01.nc.

   In this example 25 equals the resolution of the product in kilometers. It should be indicated that in the file naming convention for L2P_GRIDDED files that the resolution in the file name is in km. For example, two L2P_GRIDDED products are available now, one for TMI and one for

AMSRE. Here is what one looks like:

3) Another issue raised was with respect to defining the time information for level 4 files. These issues were resolved and incorporated into both the L2P convention and L4 convention.

A new GHRSST-PP data applications tutorial has been developed by Ken Casey and is available at http://ghrsst.nodc.noaa.gov/accessdata.html in pdf or ppt format. This tutorial should greatly assist users in where to find GHRSST-PP data at the GDAC and the LTSRF together with the use of tools that help search for specific data sets of interest.

Considerable discussion has taken place within the DM-TAQG regarding the development of appropriate Level-3 gridded data sets which has been particularly useful in developing appropriate terminology and language for the L3 data sets. Several issues remain including specification of content, filename conventions, L3P collated and super-collated approaches etc. Some of this will be covered in the presentation and discussions of Pierre LeBorgne based on the MERSEA L3P developments. It is expected that the L3/L3P discussions will develop throughout the meeting.

Several discussions with Steve Hankin on netCDF CF convention specifications driven by GHRSST (led by Edward Armstrong) have been initiated. Issues raised by Steve Hankin include:

- No explicit standard for GHRSST-PP codes in CF and incorporation of swath data. One goal of the meeting is to write a report to Steve Hankin on needs of GHRSST with respect to CF standards. Donlon noted that discussions with the CF convention group directly was required.
- Ed Armstrong had a discussion with CF developers to add time_offset to COARDS attributes for clarification.

It was agreed that the GHRSST-PO should follow up with Ed Armstrong on the CF issues as soon as possible.

Vazquez noted that current plans at PO.DAAC included the integration of the GHRSST-PP GDAC into PODAAC full operations. Official letter endorsing the integration of the GDAC into the Physical Oceanography Distributed Active Archive Center (PO.DAAC). Endorsement came from the PO.DAAC User Working Group (UWG). A GHRSST-PP data policy should also be explored as the PO.DAAC has implemented new Data Acceptance Procedures which should be compatible with GHRSST data policy. A draft GHRSST data policy document has been written in collaboration with DM-TAG members and led by Ken Casey. The main elements of the data policy include:

1. Providers should agree to provide all data and metadata in a free and open manner to the GDAC
2. Agree to allow all data and metadata to be provided by the LTSRF in a free and open manner in perpetuity.
3. Routinely review and report to the chair of the DM-TAG on data and metadata compliance to the current version of the GHRSST Data Specification (GDS) using the *GHRSST Data Compliance Checker* and *GHRSST Metadata Compliance Checker*.
4. Annually review and report to the chairs of DM-TAG and RAN-TAG with anticipated data streams and data volume rates for the coming year.
5. DM-TAG and RAN-TAG will provide the results of the above review and report to the GDAC(s) for their planning and support preparation.
6. Bring all existing product streams into compliance within 6 months of issuance of new versions of the GDS.
7. Routinely monitor product quality and completeness and report any anomalies to the GDAC, LTRSF, and GHRSST Project Office.

This needs to be further discussed and agreed by the Science Team following further discussion and iterations.

The DM-TAG noted that a NASA ROSES proposal call has been released that calls for

> *"Proposals are that characterize and/or reduce uncertainties in these data products, utilize prototype products to constrain ocean general-circulation models or interact directly with the GHRSST project to prepare for exploitation of data"*

The USA GHRSST-PP user base is expected to increase as a consequence of this call and in particular, the collaboration between modellers and oceanographers

The DM-TAG has formed a small sub-group dedicated to the development and formulation of a Single Sensor Error Characteristics (SSES) Working Group (led by Pierre LeBorgne). The SSES-WG membership includes;

- Robert Evans
- Gary Cortlett
- Gary Wick
- Peter Minnett
- Bryan Franz
- Doug May
- Chelle Gentermann
- John Stark
- Jorge Vazquez

The initial questions proposed for discussion include:

- Are SSES exclusively defined against buoys measurements
- if so how to make a partition of the MDB?
- Any alternative to use the confidence levels to partition the MDB?
- How to define the confidence levels?
- Can we agree on a range of errors per confidence level?

The following actions were raised on the DM-TAG chair:

- Check and finalise the SSES group membership and Terms of Reference
- Prepare appropriate user support material in time for BAMS publication (All)

3.11 Data Processing Specification Technical Advisory Group (GDS-TAG) report, *J. Vazquez, PO.DAAC, JPL, USA.*

The GHRSST-PP Data Processing Specification (GDS) represents a consensus opinion of the GHRSST-PP community of how to pursue the optimal combination of satellite and in situ data streams within a globally distributed operational system to provide a new generation of global coverage SST data products. It is managed by a dedicated GDS Technical Advisory Group (the GDS-TAG) overseen by the GHRSST-PP Science Team. GDS Editorial control is maintained by the GHRSST-PO and the current version of the GDS is version 1.7 which has the following components which are available on-line at http://www.ghrsst-pp.org :

- GDS Part I: Introduction and rationale for the GDS (Owner: GHRSST-PO)
- GDS Part II: L2P format and processing specification (Owner: GDS-TAG, Vazquez)
- GDS Part III: L4 format and processing specification (Owner: GDS-TAG, Vazquez)
- GDS Part IV: HR-DDS system description and interface control document (inc. formats and operations) (Owner: GDS-TAG, D Poulter/I. Robinson)
- GDS Part V: MDB system description and interface control document (inc. formats and operations) (Owner: GDS-TAG, J-F Piolle)
- GDS Part VI: MMR system description and interface control document (inc. formats and operations (Owner: GDS-TAG, E. Armstrong)
- GDS Part VII: GDAC system description and interface control document (inc. formats and operations) (Owner: J. Vazquez/H. Roquet/J-F Piolle)
- GDS Part VIII: LTSRF system description interface control document (inc. formats and operations) (Owner: K Casey)
- GDS Appendix I: Data description tables (Satellite, in situ, model, Owner: GHRSST-PO/K Casey)
- GDS Appendix II: GDAC/LTSRF code tables (Accession codes, formal names etc) (Owner: K Casey)
- GDS Appendix III: Reference data sets for L2P/L4 processing (Owner: GHRSST-PO)

GDSv1.7 is an interim version of the GDS and the next significant upgrade of the GDS will be to version 2.0 which will build on the technical experience within the GHRSST-PP so far and user feedback from the RDAC and GDAC systems around the world. GDSv2.0 will include the following upgrades:

- L3P format, content and production rules including QC procedures
- Homogenous SSES (where possible)
- Operational monitoring of all GDAC and RDAC systems within the R/GTS framework
- Homogenised and improved QC
- Operational validation and verification procedures and systems
- New Governance
- Improved standards based metadata, search and lookup and data access

The GDS-TAG ToR and membership was reviewed (mandatory before starting the process of writing GDSv2.0). The current ToR and membership for the GDS-TAG is as follows:

GODAE High Resolution SST (GHRSST) Data Processing technical advisory group (GDS-TAG) TERMS OF REFERENCE (June 2005)

PREAMBLE

The GODAE high resolution sea surface temperature pilot project (GHRSST-PP) has been established to give international focus and coordination to the development of a new generation of global, multi-sensor, high-resolution, SST products. The most promising way to realize a new generation of SST data products is to combine observations from complementary infrared (IR) and passive microwave (PM) satellite sensors on polar-orbiting and geostationary platforms together with quality controlled in situ observations from ships and buoys. Each of these measurement types has unique benefits but individual limitations and innovative but robust data merging strategies and methods have to be developed that optimise the resolution, coverage, accuracy and temporal characteristics of diverse input data.

Table. 1 : GHRSST-PP data product specification.

Characteristic	Merged SST	Analyzed SST	Reanalyzed SST
Grid Size	Better than 10 km	Better than 10 km	Better than 10 km
Temporal resolution	6 hours	12 hours	6 hours
Delivery timescale	Real time	Real time	7-60 days following data reception
Accuracy	< 0.5 K absolute 0.1 K relative	< 0.5 K absolute) 0.1 K relative	< 0.3 K absolute (target), 0.1 K relative
Error statistics	rms. and bias for each input data stream at every grid point	rms. and bias for each output grid point (no input data statistics are retained)	rms. and bias for each output grid point (no input data statistics are retained)
Coverage	Regional (Best effort Global)	Global, (Regional extracted)	Global
SSTskin product	Yes	Yes	Yes
SSTsub-skin product	Yes	Yes	Yes
SSTfnd product	Yes	Yes	Yes
Cloud mask	For each input data set	Yes	Yes
Confidence data	No	Yes (sea ice information, diurnal warming mask, quality flags)	Yes (sea ice information, diurnal warming mask, quality flags)
Nominal product format	Hdf/GRIB/NetCDF	Hdf/GRIB/NetCDF	Hdf/GRIB/NetCDF

The GHRSST-PP convened a Workshop in May 2002 to formalise the GHRSST-PP Implementation Plan. At this meeting the specifications of GHRSST-PP data products was agreed. Three types of primary GHRSST-PP SST demonstration products will be produced in real time at GHRSST-PP Regional Data Assembly Centres (RDAC) and Global Data Analysis Centres (GDAC): L2P (native swath), L3P (gridded) observational products and L4 Merged Analysed products. A summary of GHRSST-PP data products is provided in Table 1. The GHRSST-PP Data Processing Specification (GDS) component of the GHRSST-PP refers to the operational methodology that will be used to deliver the data products described above. The GDS is expected to evolve as new research results become available and will be coordinated by the GDS-TAG answering to the GHRSST-PP Science Team. The following Terms of Reference have been agreed for the GDS-TAG:

1. Based on the conclusions GHRSST-PP Workshops, working groups and technical advisory groups, develop a consensus methodology that can be implemented within RDAC and GDAC providing global coverage SSTskin, SSTsub-skin and SSTfnd observations, merged and analysed data products according to the specification in Table 1,
2. Work with specific applications of GHRSST-PP data products and act on any feedback,

3. Review and assess proposals for improvements to the GDS methodology and decide if and how such improvements should be incorporated into the operational GDS;
4. Provide scientific guidance to, and as appropriate, receive advice from, the GHRSST-PP Science Team on the scientific and technical issues associated with the implementation and operation of the GDS and on the use of GHRSST-PP products by GODAE and other users;
5. Provide regular reports on progress to the GHRSST-PP Science Team,
6. Maintain and update the GHRSST-PP Data Processing Specification (GDS) for use by all actors in the GHRSST-PP.

GDS technical advisory group (June 2005)

Jorge Vazquez (Chair: JPL/GDAC, jv@podaac.jpl.nasa.gov)
Gary Wick (NOAA, USA: Data merging expert:gary.a.wick@noaa.gov)
Hiroshi Kawamura (Tohoku University/NASDA EORC; Japan, NGSST: kamu@ocean.caos.tohoku.ac.jp)
Pierre le Borgne (SAF, Meteo France: Operational high-resolution products: Pierre.leborgne@meteo.fr)
Chelle Gentemann (RSS, USA, Microwave satellite SST: gentemann@remss.com)
Doug May (NAVO, USA. Operational global SST production from AVHRR: mayd@navo.navy.mil)
Craig Donlon (GHRSST-PO: craig.Donlon@metoffice.gov.uk)
Andy Harris (NOAA, USA: Radiative transfer based retrievals: andy.harris@noaa.gov)
Ed Armstrong (JPJ, PODAAC, data archive: ed@seaeddy.jpl.nasa.gov)

The GDS-TAG chair noted that following a review of the GDS-1.7 very few changes were called for. The main suggestion was to simplify the GDS document so that it was easier to use. It was agreed that this should be a priority for GDS-v2.0.

Several technical issues were discussed as follows:

- The GDS-2.0 should decide on using either signed and unsigned bytes otherwise the users will be very confused because netCDF doesn't have signed and unsigned attributes. The group noted that new libraries seem to have fixed this issue but it will take some time before all users have upgraded to the latest libraries.
- A decision was made to keep DT_analysis in delayed mode products, but not necessarily in the L2P_core as this tended to affect timeliness of products.
- It was agreed that descriptions of experimental fields should be added to GDS-v2.0
- A review of the rejection and confidence words in L2P data sets are required
- A full specification of L3P file content should be developed based on the L3 and L3P collated and super-collated file specification proposed by the MERSEA team. It was agreed that GDS-v2.0 should be backwards compatible with GDS-v1.7
- It was agreed that the time tag for L4 analysis fields are defined as: The value should be chosen to most closely represent the time at which the analysis is valid. This may be the mid-point of the nominal time window for observations from which the analysis has been derived, but is dependent on the L4 analysis system. Essentially L4 time should be defined as the reference time of the analysis, and should be the beginning of the nominal time window for observations from which the analysis represents.

Vazquez noted that the production of a GDS-v2.0 was a challenge and would require much more discussion before it can be finalized. GDS-v2.0 should be a much simpler document to assist teams using the material in the most optimal manner. Vazquez concluded that a technical GDS is required for the teams working with GHRSST-PP data production and a user manual is required for teams applying these data products. At present the GDS tries to be both.

3.12 **Diurnal Variability Technical Advisory Group (DV-WG) report,** *C. Merchant, University of Edinburgh, UK.*

At GHRSST-7, the Diurnal Variability Working Group agreed that a series of focussed workshops was needed to stimulate the collaborative experiments required to make progress on the question of diurnal variability in sea surface temperature, at both a fundamental level and as it applies to the techniques that will be used within GHRSST. The first workshop was hosted by Ifremer (Brest, France) in November 2006, and the second will take place in Key Largo, FL, at the end of March 2007. This report describes the outcomes of the Brest meeting (whose participants are listed as authors to this abstract), and will be supplemented in the verbal report at GHRSST-8 by the outcomes from the Key Largo meeting.

The objectives of the workshop were to conceive and initiate collaborative work:

- To confront a range of DV models (some new) with diverse data (some new)
- To diagnose the relative contributions to error in model-data comparisons (distinguish limitations of models from limitations of available forcing)
- To begin experiments in "L4" analysis (accounting for DV in SST analysis)
- To establish partnerships in which DV models, data, and techniques are freely shared for mutual benefit

The DVWG is responsible to GHRSST for recommending a DV model for "L2P" production (to generate a DV estimate for instantaneous SST observations where auxiliary fields permit) and for recommending methods for L4 analysis (analysis of SST observations account for differences in foundation and (sub)skin SSTs). Believing that it is in the latter context that the most fruitful scientific progress can be made at present, the DVWG is focussing initially on L4 methods.

The workshop began by reviewing the work already undertaken on diurnal variability (DV) by working group members. Meeting notes are available on the working group Twiki at https://arc.geos.ed.ac.uk/bin/view/DV/WgMeetingBrestNov2006 by registering with Mark Filipiak (mjf@staffmail.ed.ac.uk), so the details will not be reviewed item by item. The themes that emerged are:

- The variety of spatial scales of the phenomenon. In situ observations (cruises, profilers) indicate major three-dimensional variability in DV amplitudes over short (<<1 km) horizontal scales. Satellite observations, in particular from SEVIRI, show coherent DV structure on 10 – 1000 km scales. This has immediate implications for models of DV (whether physical or statistical): since those available are essentially one dimensional, they clearly cannot capture the nature of the <<1 km observed variability; do they – can they – represent the >1 km scale average DV relevant to satellite observations? This question motivates the objective of confronting models with diverse data.
- The unresolved origin of DV spatial variability at 10 to 100 km scales, this range being between the small scales (wind gusts, Langmuir circulations, etc) and the apparent atmospheric length scales (away from coasts) of synoptic weather systems, as represented in numerical weather prediction (NWP) fields (e.g., ECMWF, NCEP). This links to the question of the fitness-for-purpose (or otherwise) of NWP wind stress for predicting or estimating DV.
- The variety of models available or under development within the working group from statistical (satellite-based, both microwave and infrared SSTs), to semi-empirical (Zeng & Beljaars [2006], PWP modified with DV-like thermocline patterns), to turbulence closure (Kantha-Clayson, General Ocean Turbulence Model (GOTM)). This should provide a powerful set of tools for understanding the problem.
- The need to quantify (i) the additional information content and (ii) the benefit of bias-reduction that DV estimation will bring to L4 SST analysis. It is not clear a priori how to do this, but the involvement of centres undertaking (operational) analysis is essential to progress here

In the light of these discussions, we prioritized a number of projects to develop further and initiate work on during day two, working in small groups. These were:

- Exploration of fundamental limits of NWP and microwave wind fields as forcing fields for DV models (whether statistical or physical). The group identified an "experiment", the basis of which is a co-ordinated data set including: ALADIN winds and fluxes (0.1 deg resolution); ECMWF winds and fluxes (1.25 deg resolution); satellite winds (nearest available surface wind retrieval), fluxes (SEVIRI irradiance retrievals) and SSTs (SEVIRI, 0.1 deg resolution). The first phase was to compile this rich data set ("ALADIN+") onto a common grid and time step for further analysis: this was completed by the start of March, and the investigative comparisons of the data have started (and will feature in the Key Largo workshop).
- Satellite and in situ horizontal variability of DV: focus on Bay of Biscay (since the ALADIN+ data covers the Bay of Biscay where autonomous radiometric observations are made with the ISAR from National Oceanography Centre Southampton).
- Controlled comparisons of physical DV models and sensitivity to model and input parameters,

using standardised scenarios run by various group members with different models.

- Satellite v. in situ comparisons: GOES-8 SST v. M-AERI; SEVIRI SST v. CIRIMS. Buoy-SEVIRI matches stratified by NWP water vapour will be used to look for atmospheric effects in SEVIRI DV estimates.
- Data sharing. In addition to the Medspiration match-up database and NAUSICAA visualisation tools, Ifremer have agreed to collect and host data sets generated by the DVWG.
- Experiments in the OSTIA SST analysis system, comparing analyses generated using SEVIRI only as input, with different strategies for accounting for DV (reject dubious, reject where error in DV estimate is above a threshold, always use DV and combine optimally using estimated DV error).

At the time of writing, these projects are in progress, and preliminary results will be reported in the Key Largo meeting, and subsequently at GHRSST-8.

Merchant noted that the aim of the DV group was to have a DV model for L2P and also for L4 products that can be used when these data seta re applied and to refine SSES estimates as appropriate. The modelling activities described above are the tools that are used to help get at this target. There is also a resolution dependence (noted in a recent paper by Brian Ward using his profiling float which is going in/out of the DV)

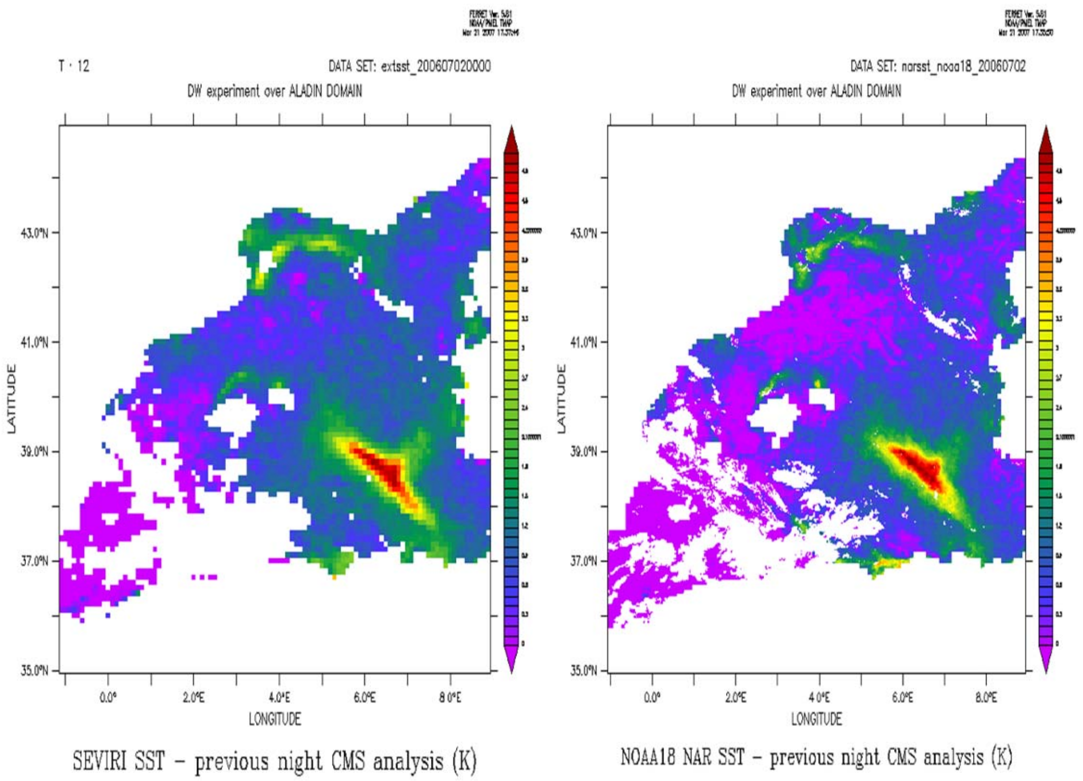


Figure 3.12.1 Diurnal variability signals measured using (a) gridded SEVIRI 10km data and (b) AVHRR (NOAA18) 1km data referenced to the previous L4 SSTfnd computed at CMS.

Figure 3.12.1 shows that the 1km scale AVHRR DV is much smoother than the 10km SEVIRI data which is interesting given the length scales of wind field are larger and smaller that the AVHRR image. There is a clear need to understand the scale of DV and bring models and data together so that “full” and “fast” models can be correctly matched and empirical models correctly fitted. IF particular importance to the DV-WG is how limited are DV calculations when using the NWP and other data (MW winds)? An action was raised on the GHRSST-PO to try and establish access to NWP winds from a number of centres that can be used to study differences and their impact on DV modelling (and therefore the usefulness of including winds within the L2P files themselves). Target centres include NWP UKMO, NRL, BoM.

Finally, the Science Team requested that the DV-Chair provide summary papers describing the proceedings of the DV-WG meetings as part of the GHRSST-PP web site (and not just the University of Edinburgh TWIKI site) as this was a GHRSST-PP WG and progress reports should be available to project managers particularly as NASA have funded applications of GHRSST-PP and diurnal variability.

3.13 GHRSST-PP Sea Ice Working Group (SI-WG) report: *P. Minnett, RSMAS, University of Miami USA.*

There are three specific focus areas/issues associated with the accurate retrieval of sea surface temperature (SST) at high latitudes using infrared radiometry:

1. The discrimination between ice-free and ice-covered water at the resolution (temporal and spatial) of the GHRSST SST retrieval schemes.
2. The discrimination between ice-free and ice-covered water at the resolution (temporal and spatial) of the GHRSST SST global analyses schemes.
3. The accurate correction of the effects of the atmosphere on the infrared radiation as it propagates from the sea surface to the satellite radiometer.

Detecting ice-free water

Within GHRSST, the requirements for an ice mask are spatial resolution of 1, 4 or 10 km with a six hourly update. While polar orbiters with suitable sensors map polar regions sufficiently frequently for the temporal requirement to be met (or nearly met), the spatial requirement, can not be currently met using microwave radiometry, which is the conventional technique for mapping sea-ice. However, the ice-mask requirement for SST does not require the retrieval of ice properties, but merely identification of the presence of ice in particular infrared pixels. This is very analogous to the identification of cloud, and the same techniques can be used to identify ice as are used to identify cloud.

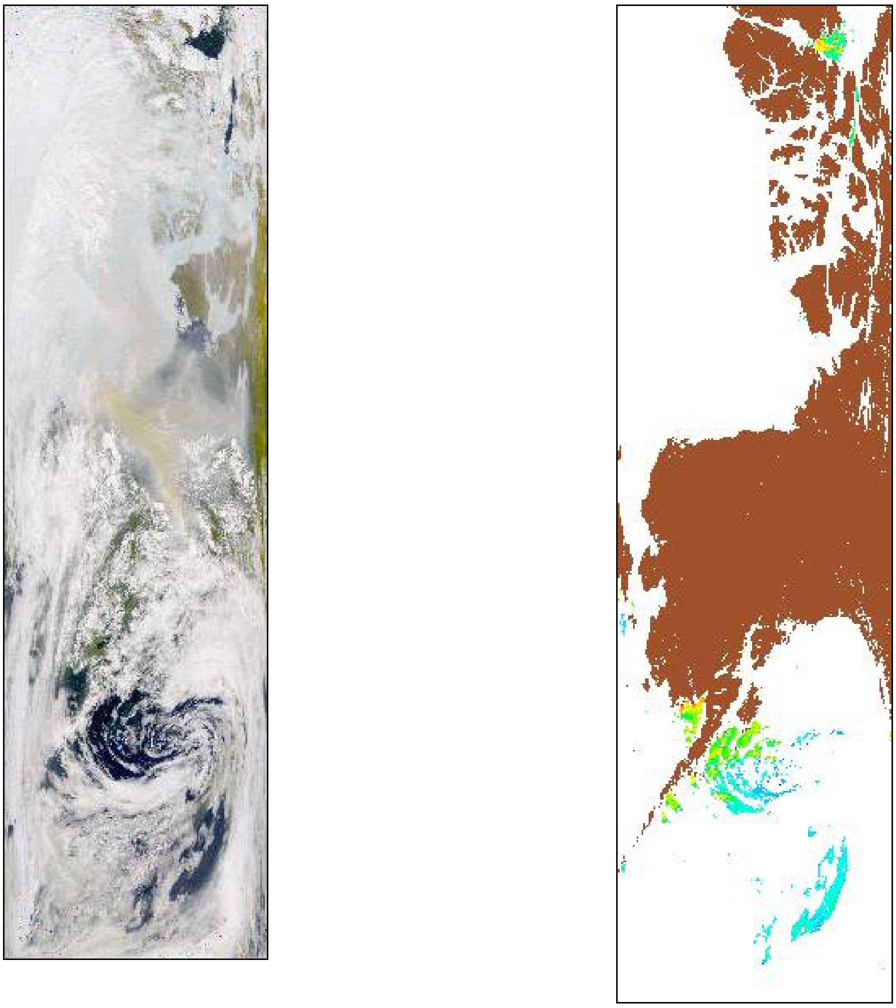


Figure 3.13.1. An example of cloud and ice cover at high latitudes. The swath is from MODIS and shows a "true color" image (left) and cloud-ice mask (right) based on a visible reflectance test. White is cloud and ice, and brown is a land mask; other colours represent open ware under cloud-free skies.

For IR SST retrievals, during the day, reflected sunlight provides a powerful mechanism for identifying open, cloud-free water. Figure 3.13.1 shows part of a MODIS swath extending from the northern

Pacific Ocean to the northwest coast of Greenland. Areas of open water are clearly identifiable in the "true color" image to the right, even though the discrimination between cloud and ice cover may not be straightforward. The image to the right shows the result of application of cloud-mask tests to these data and indicates a qualitatively successful outcome. Those areas identified by eye in the image on the left are deemed to be cloud and ice-free in the image to the right.

During the polar night the problem of identifying ice becomes more difficult, but a simple temperature threshold test might be adequate. Surface temperature retrievals from spacecraft infrared radiometers below –01.8°C, the freezing point of sea water, can be classified as ice cover. However, this is prone to miss-classification as a) there is noise, perhaps systemic, in the satellite-derived surface temperature so that ice-free retrievals could fall below the threshold, and ice-covered pixels fall above the threshold; b) when melting, sea ice, especially if covered by snow, may remain frozen at temperatures above the threshold. In these cases, microwave retrievals of ice cover may have a role to play, even though they lack the high spatial resolution.

For MW SST retrievals, side-lobe contamination from the microwave emission from sea ice prevents accurate SST measurements within several pixels of the ice edge. The large emissivity contrast between ice and open water means the contamination of the MW SST retrievals by sub-pixel ice can be severe. This emissivity contrast means, however, that microwave radiometers are able to determine the presence of sea ice at a higher spatial resolution than the SST retrieval in both day and night conditions. The microwave ice retrieval has difficulties distinguishing sea ice in conditions that include high cloud and/or rain.

Atmospheric Correction

The polar atmosphere is generally very dry and cold, and is an extreme in terms of the climatological distribution of atmospheric properties. As such it represents an anomalous set of conditions for routine atmospheric correction algorithms that are used to retrieve SST from infrared brightness temperatures measured from Polar Orbiting Satellites. It is expected, therefore, that systemic retrieval errors in the derived SSTs will result when they are obtained using standard atmospheric correction algorithms optimized for the global range of atmospheric variability (e.g. McClain et al, 1985). Such bias errors, usually resulting in an erroneously warm SST, are routinely observed and can be greater than 1K.

Recent work using AVHRR brightness temperature measurement collocated with ship-based radiometric skin SST measurements have shown that a simple, single channel retrieval algorithm (CASSTA - Composite Arctic Sea Surface Temperature Algorithm) can produce satisfactory accuracy in the measurement of skin SST and Ice Surface Temperature (IST; Key et al, 1997) (Vincent et al., 2007a, b). Figure 3.13.2 shows the residual SST errors using the new algorithm compared to the standard multi-channel retrieval; the reference measurements are those of the Marine-Atmospheric Emitted Radiance Interferometer (M-AERI; Minnett et al, 2001).

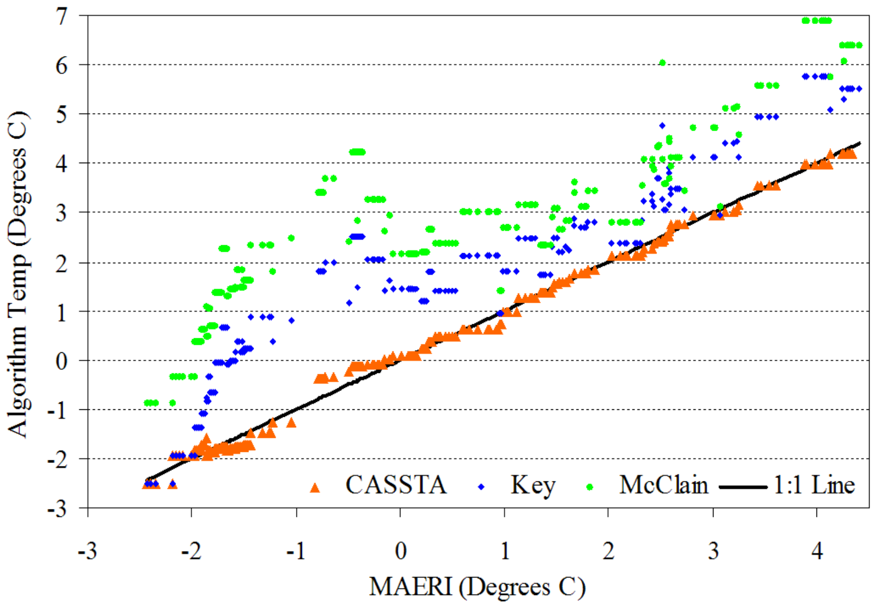


Figure 3.13.2. M-AERI ground truth data is compared to CASSTA, McClain SST (1985) and Key IST (Key at al, 1997) estimates. A significant gain in accuracy is evident with CASSTA, which closely follows the 1:1 line. (From Vincent et al, 2007a).

The explanation for the poor performance of the multi-channel approach is the loss of the correlation between the brightness temperatures measured at 10.5 and 11.5 µm with the atmospheric water vapor that occurs in very dry atmospheres. The brightness temperature differences, at the heart of the assumptions behind all multi-channel atmospheric correction algorithms, do not provide the appropriate information necessary to correct for the effects of the intervening atmosphere. A single-channel algorithm appears to be more appropriate.

Air-sea temperature differences

As with atmospheric water vapour, the air-sea temperature difference in polar regions manifests values that are seldom seen elsewhere over the oceans. Very large values are possible for off-ice airflow (Figure 3). The air-sea temperature difference is important in introducing uncertainties in the retrieved SSTs as it is closely related to the temperature difference between the ocean surface and the atmospheric gases that modify the infrared radiation on its passage to the satellite radiometer. Although less important than in moist atmospheres, the wide range of air-sea temperature differences encountered in polar regions introduce a source of uncertainty in the SST retrievals. It is not clear that the single-channel SST algorithms can account for such variability.

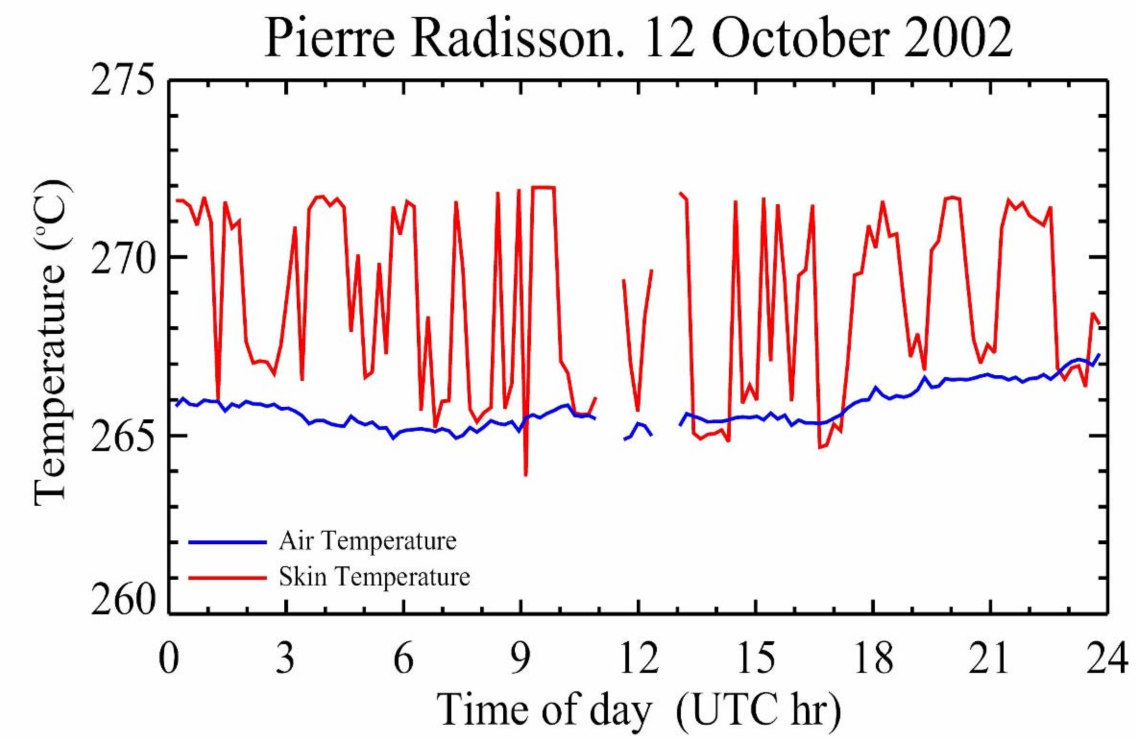


Figure 3.13.3. Air temperatures and surface skin temperatures measured by an M-AERI on the Pierre Radisson in the Amundsen Gulf of the Beaufort Sea. Very large air-sea temperature differences are found in the vicinity of the ice.

Conclusions

While presenting particular problems to the accuracy of SST retrievals in the infrared, high latitude conditions can be addressed by applying standard approaches for cloud screening to the need for discriminating between open water and ice cover, and very simple algorithms have been shown to function well in correcting for the effects of the polar atmosphere.

Validation of these approaches is hampered by the difficulties in obtaining accurate in situ measurements, which are only achievable by using instrumentation on ice-breaking research vessels.

References

Key, J. R., J. B. Collins, C. Fowler, and R. S. Stone, 1997: High-latitude surface temperature estimates from thermal satellite data. Remote Sensing of Environment, 61, 302-309.

McClain, E., Pichel, W., and Walton, C., 1985. Comparative Performance of AVHRR-based multichannel sea surface temperatures. Journal of Geophysical Research, 90: 11587-11601

Minnett, P. J., R. O. Knuteson, F. A. Best, B. J. Osborne, J. A. Hanafin, and O. B. Brown, 2001: The

Marine-Atmospheric Emitted Radiance Interferometer (M-AERI), a high-accuracy, sea-going infrared spectroradiometer. Journal of Atmospheric and Oceanic Technology, 18, 994-1013.

Vincent, R. F., R. F. Marsden, P. J. Minnett, K. A. M. Creber, and J. R. Buckley, 2007a: Arctic Waters and Marginal Ice Zones: Part 1- A Composite Arctic Sea Surface Temperature Algorithm using Satellite Thermal Data. In preparation.

Vincent, R. F., R. F. Marsden, P. J. Minnett, and J. R. Buckley, 2007b: Arctic Waters and Marginal Ice Zones: Part 2 - An Investigation of Arctic Atmospheric Infrared Absorption for AVHRR Sea Surface Temperature Estimates. In preparation.

3.14 Report from the XML working group, *E. Armstrong, PO.DAAC, JPL, USA.*

GHRSST-PP has in the last year successfully demonstrated coupling metadata with data production, archive, transfer and storage systems through the exchange of metadata between RDACs, the GDAC and the LTSRF as well as using databases to publish metadata "on the fly." Future implications of the ISO 19115 metadata model for the GHRSST-PP will be presented. ISO 19115 is becoming widely adopted as the international standard for geographic metadata. The newly-christened North American Profile (NAP) of ISO 19115 is being studied by NOAA and the FGDC, and both agencies will likely replace or adapt their current metadata standards or profiles to conform to the NAP. The potential adoption of a new metadata model has important ramifications for all components of GHRSST-PP.

The GHRSST-PP Metadata model is based on NASA DIF where an RDAC provides granule File Record (FR) metadata which is then collated and attached to a Data Set Description (DSD) co-maintained by Project Office, GDAC and RDAC. All metadata are inventoried in MMR at the GDAC. XSL translation tools to convert GHRSST metadata (in MMR) to FGDC for a daily collection of granules of one product stored at Longterm Stewardship and Reanalysis Center have been developed at the GDAC and tested.

The ISO 19115: *2003 Geographic information – Metadata* is a new international standard for describing geospatial metadata and has extensions of CSDGM (FGDC). It defines a set of core variables (see Table 3.14.1) which can be extended via “profiles”. It supports other languages and adds a Topic Category with 19 standardized subject categories to facilitate data discovery. The format is UML/XML and ISO 19139 is the XML schema for this standard. The GHRSST-PP Mapping is generally OK to the new standard.

Dataset title	Spatial representation type
Dataset reference date	Reference system
Dataset responsible party	Lineage statement
Geographic location	On-line resource
Dataset language	Metadata file identifier
Dataset character set	Metadata standard name
Dataset topic category	Metadata standard version
Spatial resolution	Metadata language
Abstract	Metadata character set
Distribution format	**Metadata point of contact**
Additional extent info (vert / temp)	**Metadata date stamp**

Table 3.14.1 ISO 19115 core metadata elements. Mandatory fields are shown in bold

The ISO metadata standard (ISO 19115) provides a set of Core metadata elements that must occur in every national profile/implementation. Most of these elements either map to existing CSDGM metadata elements or represent properties of the data that can be determined and populated using a data integrated metadata tool. *Topic Category* is the only mandatory element of the ISO core metadata set that requires new information that cannot be directly captured from the data. Metadata creators are encouraged to include one or more of these Topic Categories in their existing CSDGM metadata Theme_Keywords. If the Topic Categories are included, the CSDGM2ISO metadata translator can identify and insert the Topic Category into the output ISO metadata record. Also, if the metadata is published via geodata.gov, the portal will notify the Channel Steward of the corresponding Data Community (at this point only the first Topic Category provided will be used but multiple Topic Categories will be used, i.e. notifications will be made, in the future).

Armstrong concluded by noting that GHRSST-PP should begin to move as soon as possible to ISO 19115 standards and a community profile for GHRSST-PP should be established as soon as possible. The following action was raised on the XML-WG:

- **Explore the application of the ISO-19115 International Marine Community Profile as the basis for GHRSST-PP MMR data (contact: Greg Reid)**

3.15 Report on plans for an follow on-activities to Medspiration, *C. Donlon, Met Office, UK.*

The MyOcean project has been initiated by the European Union to provide a European Marine Core Service (MCS) as part of the Global Monitoring for Environment and Security (GMES) program which aims to consolidate investments made within operational oceanography (MERSEA, Medspiration, etc) and provide a pan-European operational oceanography system. The resulting system should develop synergy and be stronger than its component parts to deliver core data products and services for the benefit of the Euopean Member States and their own services, their marine related Inter-governmental agreements that are currently and projected to be in place, the European Union and its services, and other commercial/research downstream services. The project is a 3 year initiative starting in 2008-2010 coordinated by Mercator Ocean, France.

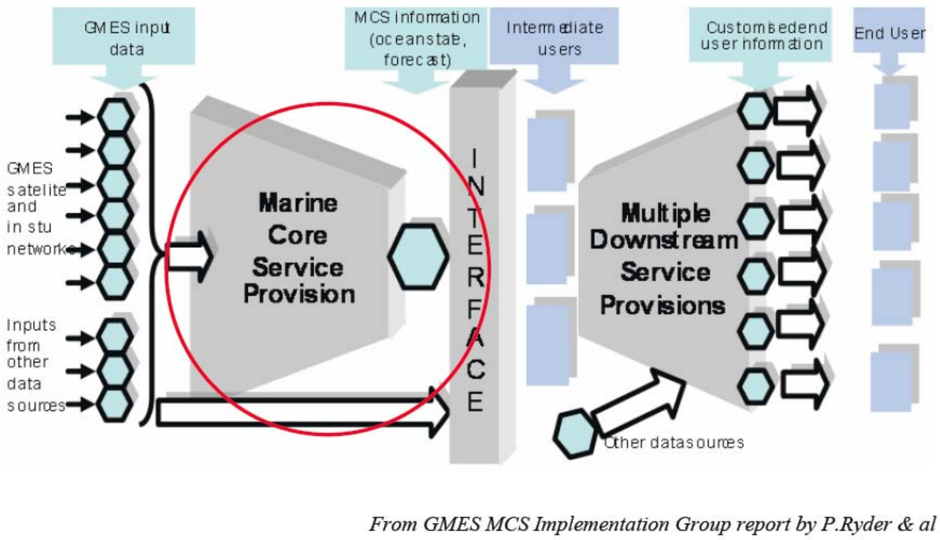


Figure 3.15.1 A summary of the GMES Marine Core Service identifying input data, marine core services, downstream services, and data flows.

The MyOcean project will provide a set of common denominator ‘core' data for all users in the marine sector including that required by applications in climate, the marine environment, seasonal prediction and weather forecasting, offshore activities, maritime transport and safety, fisheries, research and, the general public. In particular, MyOcean will deliver regular and systematic reference information (processed data, elaborated products) on the state of the global oceans and regional seas at the resolution required by intermediate users & downstream service providers, of known quality and accuracy. Hindcast, Nowcast, Forecast□Data, Assimilation and Models will be brought together in the MyOcean project to ensure a pan European operational capacity for ocean monitoring and forecasting will be integrated. Figure 3.15.2 provides a schedule of activities for the implementation of the MyOcean project starting in 2008 noting that two qualified and validated versions of the distributed MyOcean system will be delivered by 2011.

Within the MyOcean project, European GHRSST-PP activities will be consolidated to provide a European Thematic Assembly Centre providing GHRSST-PP Services.

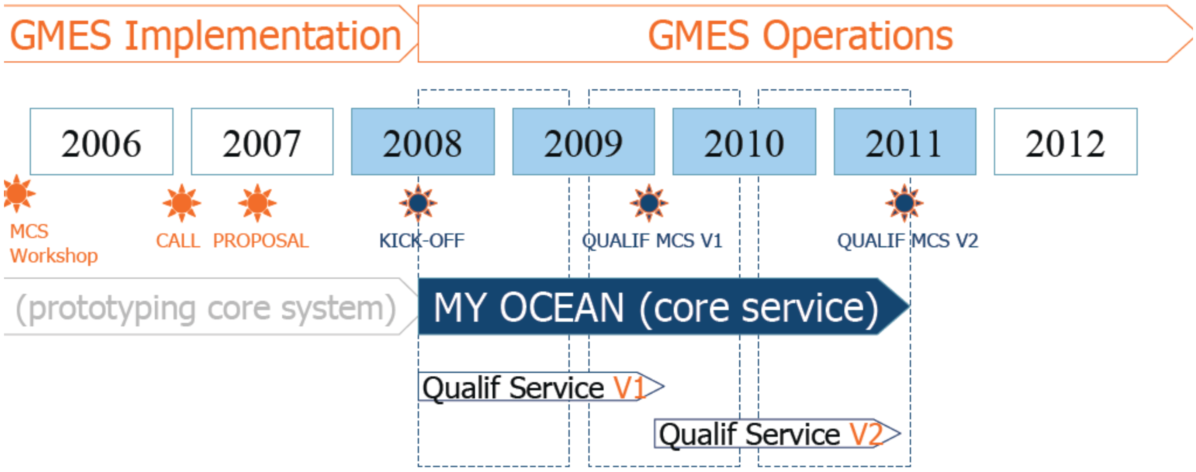


Figure 3.15.2 Schedule for implementation of the MyOcean Project.

The SST-TAC will deliver comprehensive SST products suitable for use by ocean and atmospheric assimilation systems within the MyOcean/GMES framework as well as for the GHRSST-PP. Products will be derived using a combination satellite and in situ observations according to GHRSST-PP standards. The SST-TAC will establish economies of scale by integration and consolidation of ESA Medspiration and EC MERSEA SST activities. It builds on and contributes to the Regional/Global Task Sharing (R/GTS) framework GHRSST which provides a mature international collaboration dedicated to the provision of SST data products and services pioneered by European investments over the last 5 years. The SST-TAC will ensure there is no interruption of service to existing users of Medspiration and MERSEA SST data products.

The SST-TAC system consists of a series of sub-systems with operational heritage within the ESA Medspiration project, the EUMETSAT OSI-SAF and the GHRSST-PP. A schematic diagram of the V2.0 SST-TAC components (at T0+36) is provided in Figure 3.15.3

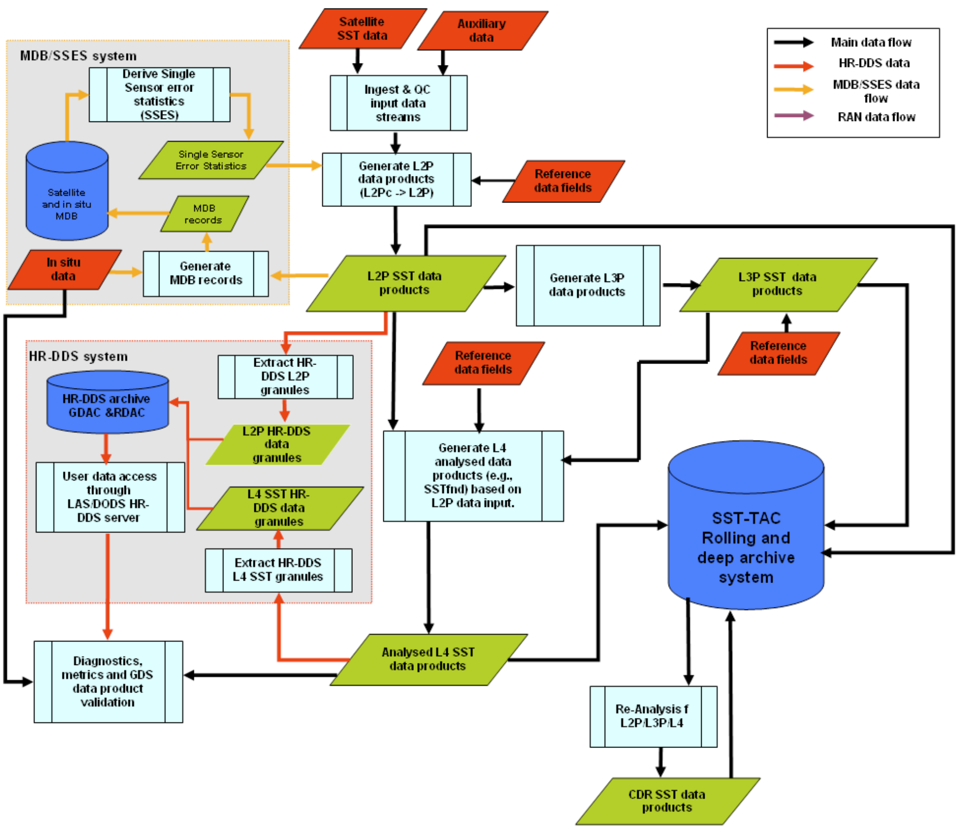


Figure 3.15.3. Functional diagram showing production within the MyOcean SST-TAC.

Note that the SST-TAC is distinct from any activity within the EUMETSAT OSI-SAF, ESA Medspiration and GHRSST-PP. EUMETSAT OSI-SAF and ESA are expected to provide fully formed GHRSST L2P data sets to the SST –TAC. The role of the SST-TAC is to apply thee data, quality control them, bring oin additional international data streams and to develop marine core SST products for use in the MyOCean/MCS and within the GHRST-PP.

The SST-TAC will interface to ESA, EUMETSAT OSI-SAF, NASA, JAXA and the USA GHRSST-PP Global Data Assembly Centre and secure the regular timely delivery of global and regional high resolution SST observational data products (L2P and L3P) for use within the Marine Core Service. These data will be quality controlled on a regular basis using on-line and database tools including the High Resolution Diagnostic Data Set (HRDDS) and Matchup Database (MDB) systems developed in the framework of Medspiration/GHRSST-PP. The MDB will be populated in NRT for all satellite sensors using in situ observations. MDB data will be analyses on a regular (at least 6 month and using where possible real-time web systems) basis to assure that the Single Sensor Error Statistics (SSES) provided by the L2P/L3P data providers are of sufficient quality and consistency for use within the MyOcean System. The HRDDS will be configured to send automatic email based alerts should significant quality control thresholds be exceeded.

L4 analysis systems will be used to provide high-resolution SSTfnd analyses for the Global and European areas. Global systems will operate in a mutual backup configuration. Specific analyses for the Baltic Sea, Arctic Ocean Mediterranean, NW Shelves and NE Atlantic will also be provided. The SST-TAC will undertake daily inter-comparisons between L4 analysis products as a European contribution to the GHRSST-PP Multi-Product Ensemble (GMPE) project (also a GEO Action DA-06-03). Global, regional and local tools will be used to monitor the performance of the L4 analyses using international reference standards provided by the SST-TAC (e.g., GMPE median ensemble) to assure the quality of SST-TAC L4 outputs. Sensor bias fields will also be provided in order to assist regional groups in bias correction of satellite data and as part of the GMPE activities.

Global and Mediterranean SST-anomaly products will be provided on a daily basis using the OSTIA and CNR systems. Re-analysis products will be produced using the global OSTIA L4 system covering a 20 year period based on ESA, NOAA and NASA input satellite data sets and Met Office in situ data.

TAC-SST Main Challenges

The main challenge for the SST-TAC is to maintain, evolve and sustain pre-existing systems developed within the context of the GHRSST-PP, MERSEA and Medspiration. The main technical and scientific challenge for the SST-TAC is to specify, monitor and deliver accurate error uncertainties for individual satellite data streams (based on MDB activities) used within the SST-TAC and to integrate these data in the most appropriate manner using the next generation of L4 analysis systems. The main operational challenges are to ensure the timely availability of complete and accurate SST products by proper pull through and integration of existing capability and to develop comprehensive interaction with MFC systems and users. The main technological challenge for the SST-TAC is the day-to-day integration of SST activities, maintenance of standards based verification, quality control and monitoring systems that ensure the SST-TAC is an efficient and robust system.

3.16 Role and selection of a New GDS-2.0 Working Group for the duration of the meeting

The GDS-2.0 Working group were requested by the GHRSST-PP science Team to:

1. During the 8th GHRSST-PP Science Team identify issues that need to be resolved by the development of the GDSv2.0.
2. Bearing in mind the discussions at the GHRSST-PP 8th ST Workshop, propose a simple plan of action for development and production of the GDS v2.0 to be completed by the start of 2008
3. Present a summary report of findings to the GHRSST-PP science Team at the end of the 8th Science Team Workshop.

The following terms of reference was agreed for the GHRSST-PP Data Processing Specification Working Group:

Terms of Reference for a GDS-2.0 Working group

Preamble

The GHRSST-PP data Processing Specification (GDS) v1.7 has been developed by the GHRSST-PP science Team over the past 5 years and was recently reviewed by the GDS Technical Advisory Group (GDS-TAG). The GDS is now composed of distinct sections written as separate documents. There is a need to transition the GDS v1.7 into a GDS-v2.0 which captures the following basic elements:

- Full descriptions of L2P data streams including input/output definition, QC and formatting of products,
- Full description gridded products (L3P) including input/output definition, QC and formatting of products,
- Revised metadata frameworks for netCDF and the MMR system as appropriate,
- Operational system messaging including comprehensive error and service metrics,
- Better more homogeneous and well described SSES,
- Definition and provision of new data sets (e.g., METOP, MTSAT),
- A full revision of L4 and L2P data set content and format based on user feedback and commitments,
- Better focus of Sea Ice (concentration and extent) and SST in the marginal ice zone,
- Implementation of improved schemes to account for diurnal variability in a way that provides users with a useful and error-bound product using other data sets in synergy (e.g., Ocean Colour and NWP outputs),
- Improved ancillary data and dynamic flags tuned to individual satellite sensors,
- Implementation, operation and validation of the HR-DDS system,
- Implementation, operation and validation of the MDB system,
- Implementation, operation and validation of generic RDAC systems,
- Implementation, operation and validation of generic GDAC systems,
- Implementation, operation and validation of generic LTSRF systems.

Other issues not covered by this list should be considered by the team as appropriate to the vision of GDS-v2.0.

Composition:

1 Chair
6 members (or more as required)

4 Session 2. Application/development of new data streams/products

This session was dedicated to an overview of new and on-going applications of the GHRST-PP data sets and services. In summary the session included the following:

- Peter Oke described work with the Ocean Forecasting Australia Model, OFAM, using the BLUElink Ocean Data Analysis System (BODAS) to assimilate ocean observations in a dynamically consistent manner. Evaluations of the Global Ocean Observing System (GOOS) components show that all contribute to reanalysis skill: SST is particularly useful in coastal waters, altimetry over eddies and Argo and XBT measurements everywhere.
- Gary Brassington described ways GHRSST-PP data could be used by GODAE. GHRSST-PP SSTs in Ocean Model Analysis and Prediction System (OceanMAPS) forecasts remove surface biases, and modify surface currents and sub-surface structure. High quality SSTs will be critical for the upcoming gap in altimetry observations.
- Joe Cione described the use of SSTs to predict maximum hurricane intensities with the simple Statistical Hurricane Intensity Prediction Scheme (SHIPS). SHIPS forecasts using Reynolds 111km weekly SST analyses show greater skill than existing hurricane models and these are improved further with GHRSST-PP daily 25km AMSR-E SSTs.
- Coral bleaching is caused by the accumulation of thermal stress. Jeff Maynard introduced ReefTemp, a project to improve resolution and predictive skill for coral stress in the Australasian region over existing NOAA products, based on 4km composites of AVHRR data. Shorter-term (~10 year) and higher resolution rolling mean climatologies are needed, the former as corals acclimatise to warmer conditions. Coral reef bleaching reference climatologies are a specialized dataset and it seems that the coral reef community is best placed to generate them. GHRSST can best contribute to this effort by supplying accurate, well-characterized SSTs (i.e. L2P) for the coral reef regions.
- Olvier Arino outlined ESA's support to GHRSST-PP and the forthcoming GMES Sentinel-3 programme. ESA has supported the GHRSST project office for three years now and plans to continue for a further three years. Olivier discussed the synergies between GlobCOLOUR and GHRSST-PP and the opportunities for GlobCOLOUR to learn from the GHRSST-PP experience. GMES will provide European independence for its observational needs. The Sentinel-3 satellite series has four core missions: SSH, ocean color, land cover, and SST and will operate for twenty years, starting in 2012. GHRSST-PP drove the science requirement for the SLSTR sensor, a dual-view wider-swath instrument drawing on ATSR heritage.
- Jean-François Piollé introduced the NAIAD multi-satellite data portal. Often, quite large datasets, such as L2P products, must be downloaded in order to extract small amounts of information. NAIAD provides rich search, subsetting and regridding and visualization tools to reduce the data size and can even add collocated auxiliary data "on-the-fly" before distribution to users by OpenDAP.
- Météo-France/CMS generates full resolution 1km, near-Atlantic regional 2km and global gridded 5km SST products from the METOP AVHRR. All are available in L2P format within a few hours of acquisition. Pierre Le Borgne described the processing chain and the implementation of the cloud mask and confidence level indicator. The product is validated against a match-up database compiled daily from buoy and ship measurements. The processor is complete and operational deliveries will commence in June 2007.
- Ed Armstrong (for Andy Bingham) demonstrated a datacasting system being developed at JPL. Data requests are filtered at the datacast server using rich metadata associated with the data files and broadcast over an RSS feed to datacast clients. Ed is looking for users to test both the server and client programs.
- John Le Marshall described the generation of physically-based SST analyses at the Joint Center for Satellite Data Assimilation. The NCEP GSI scheme is about to become operational and uses radiance data and products from as many as 50 different instruments. The SST analysis is performed at the start of the GSI run and currently uses AVHRR cloud-cleared radiances but recent tests using selected AIRS window channels enable SST and emissivity to be retrieved simultaneously. More accurate skin SSTs are required to improve the accuracy of near-surface sounding for humidity and water vapour. The inclusion of hyperspectral radiances from AIRS gives forecast improvements equivalent to several years of development effort.
- Some users found aspects GHRSST-PP of data difficult to interpret, including distinctions

between, and the best choice of data type (L2P, L3, L4) for their applications, the meaning of different SST types (foundation, skin…), product error bars and data gaps.

- In summary, the user community for GHRSST products is growing. The requirements are diverse, ranging from radiance data to L4 analyses. There are also innovative data mining/distribution tools and services being developed which have great potential to improve user access to GHRSST products.

4.1 On the relative importance of SST, Argo and altimetry for an ocean reanalysis, P. Oke, CSIRO, Australia.

OKE began noting that he was an SST user that is very grateful to the GHRSST-PP because his group is doing new things as a consequence of GHRSST-PP. The BLUElink Ocean forecasting Australia model is based on the MOM 4 code configured with a variable grid resolution focussed on the Australian region. The system is eddy-resolving around Australia having a 10 m vertical resolution to 200 m depth with surface flux forcing based on ECMWF (for reanalyses). The Data Assimilation system (called the BLUElink Ocean Data Assimilation System, *BODAS*) is an ensemble OI approach with model-generated covariance's and a like least squares fitting to model-based anomalies. A 72-member ensemble of model anomalies from a 10-year run has been used within the multivariate assimilation system which assimilates observations of SLA, SST, in situ T and S for this work. The BLUElink Reanalysis (BRAN1.5) covers the period 1/2003 – 6/2006 which is forced with ECMWF forecast fluxes. The system assimilates observations once per week including SLA from Jason, Envisat and GFO (T/P with-held) and AMSR-E SST. T and S from Argo and the ENACT database are also assimilated.

Oke showed plots of sea level height and SST which show that the BRAN is basically a good interpolator of the observations in a dynamically consistent manner (2003-2006). However a more quantitative assessment suggests that the time series rms. error for sea level anomaly and SST is lower over the Australian Region and the model never reaches the analyses values. The SST gets to within 0.7K and the seasonal cycle is OK but there are some issues to deal with. Oke explained that it is only when altimeter data and SST data are assimilated together that a good result is obtained. The role of SST in BRAN is thus extremely important

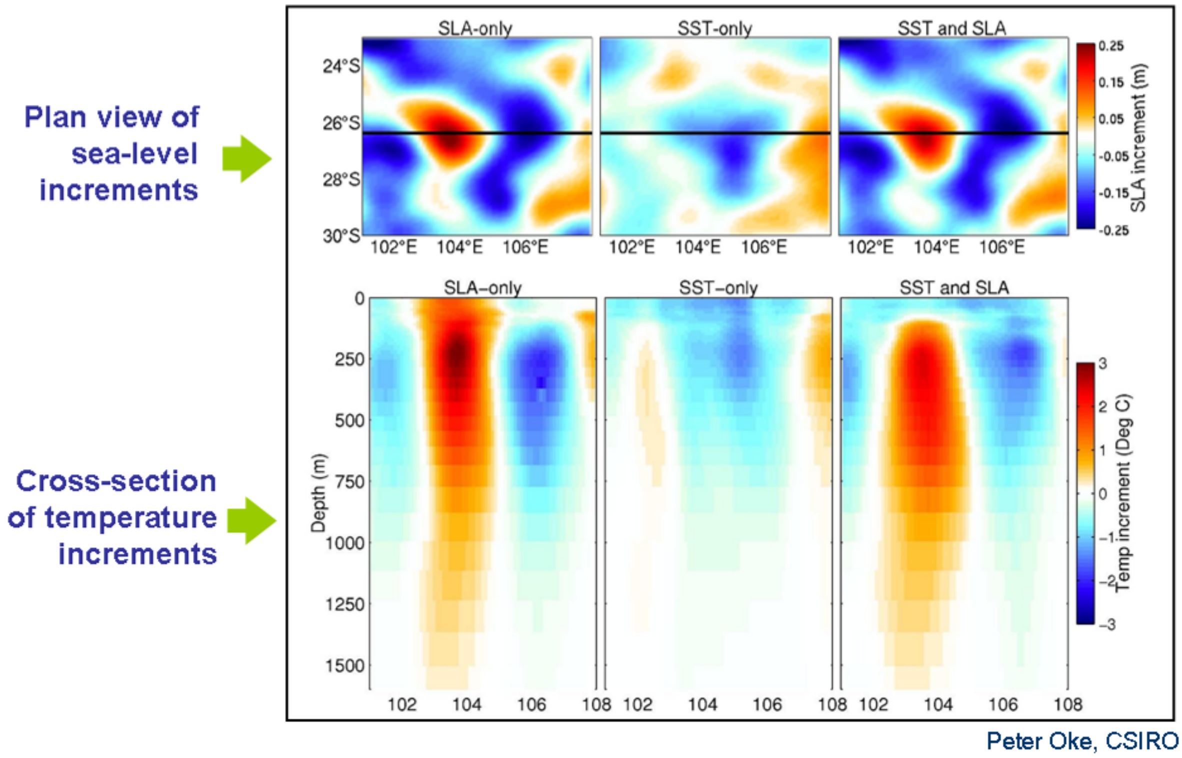


Figure 4.1.1 Increments associated with different data assimilation configurations of the MOM-4 BRAN system. Top panel shows plan view of sea level increments and bottom panel the cross section of temperature increments. Left panels show SLA assimilation only, centre panel SST only and right hand panel both SST and SLA.

Figure 4.1.1 shows the results of data assimilation experiments using the BRAN 1.5 system. The bottom panel shows that both SLA and SST are required to generate a realistic result at the surface using the BRAN system. Oke explained that several data withholding experiments (SLA, ARGO, GHRSST-) were performed using the BRAN system which suggest that errors at the surface and depth are to be expected if SST is not assimilated by the system. Based on this result, the SST work within BLUElink has now been accelerated to improve both the operational short term prediction system and the BRAN.

Oke concluded by noting the need for a user guide to help select the best types of GHRSST-PP data for the BLUElink applications (skin, depth, foundation?). Should analyses or observations be used? Following some discussion, the Science team recommended that the BRAN system assimilate observational products rather than L4 analysis (to minimise errors in the DA system). OKE noted that the BRAN 1.5 needed a long time series of data (Pathfinder/Reynolds type for 20+ years) and wondered when this would be available form GHRSST-PP at high resolution. The Science Team noted that the RAN project was currently working on this data set but it was unlikely to emerge in a usable format before 2010. The following action was raised on the GHRSST-PP RAN Chair and Peter OKE:

- **How can the BRAN be used to greatest effect within the GHRSST-PP RAN effort**?

4.2 BLUElink> toward merging GHRSST and GODAE for sea surface temperature forecasting, *G. Brassington, T. Pugh, H. Beggs and P. Oke, BRMC/CSIRO, Australia.*

Brrassington started by noting that this talk complement that of Peter Oke talk as the same basic modelling structure and DA system is shared. From the BLUElink perspective there are many pathways for use of GHRSST-PP data including:

- GHRSST => GODAE: for the validation of GODAE products
- GHRSST => NWP => GODAE: for improved analysed surface fluxes
- GHRSST => GODAE <=> NWP for SST: assimilation and improved analysed and forecast currents and forecast SST
- GHRSST => GODAE <=> WAM <=> NW: for improved forecast currents for wave refraction
- GHRSST => BRAN <=> GODAE: reanalysed SST and feedback on GODAE system design
- GHRSST => MCC => GODAE: to fill the data gap in altimetry

Brassington noted that in particular, GHRSST-PP/GODAE SST improves current forecasts, is required in its own right (squalls & afternoon convection), is needed by RAN as it is critical to development of the ocean forecasting system where the reanalysis is the benchmark for tuning the end to end system. SST can also offer a bridge for the potential gap in altimetry through use of maximum cross correlation products derived from high resolution SST's. However there are several impediments to progress including difficulties with satellite biases, diurnal variability, resolution of GODAE models and GHRSST-PP data sets (should be the same but the models are not quite there yet), uncertainties in dynamic interpolation (using NWP systems which are complex tools that are not optimised for tracking impacts of SST due to resolution issues and NWP indexes) etc. However, Brassington noted that it is a good strategy to use high resolution SST's in GODAE models and great progress has been made.

The BLUElink system is now in a transition as the BoM moves to the Met Office Unified Model (UM) code base. The BoM has now 'fast tracked' SST due to the results of Peter Oke (SST matters) and Bradssingtoin gave a case study of a monster eddy in the East Australian Current (EAC) where the inclusion of SST assimilation fixed a warm bias problem. Surface currents were also improved shown using drifter data. The real advance is to incorporate actual (GHRSST) SSTs rather than relax back to climatology (as has been traditionally done. The SST assimilation has removed surface biases, improved the assimilation of altimeter data and as SST is adjusting the steric height effect it also modifies the surface current. However the Limitad area system currently reports only negligible impacts although the impacts (via heatflux signals) are difficult to ascribe. It is much better to look at the atmospheric boundary layer heights

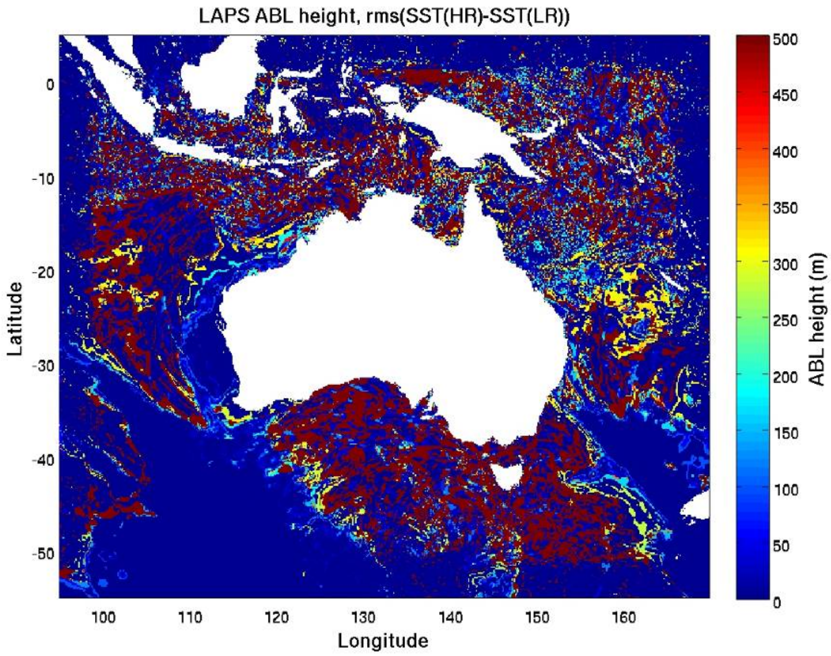


Figure 4.2.1 Difference in LAPS Atmospheric Boundary Layer Height rms meters between high and low resolution SST boundary forcing.

BLUElink has demonstrated the advantage of GHRSST products to an ocean re-analysis

(a) Removes obvious biases
(b) Multi-variate does modify the sub-surface structure (Oke)
(c) Modifies near surface currents, quantitative improvement and indications of skill over persistence

Positive impact has accelerated implementation of SST systems into OceanMAPSv1.0 where these results have translated to removal of bias. The availability of GHRSST products made this feasible with particularly good impacts from AMSR-E 25km resolution which matches OFAM and coverage. The potential microwave SST data gap is a concern.

Brassington concluded with a list of user requirements for the GHRST-PP Science Team:
The BoM OceanMAPS requires (ideally):

- L2P or L3P foundation for direct assimilation
- L4 foundation and skin for validation with uncertainty estimates
- Error bars - normalised
- Full Documentation (not available from GHRSST-PP yet)
- Timeliness (Real-time to 10 days behind)
- Want real time data and out to 10 days currently at 0.1° but up to 1/16° local resolution
- Diurnal model (model foundation to skin) from a reverse engineering perspective in NWP applications
- Minimum Data gaps

The BLUElink reanalysis (BRAN) system requires from GHRSST-PP:

- Reanalysed L2P or L3P for 20 years

Brassington thanked GHRSST-PP and concluded that the GHRSST-PP community was serving the NWP and ocean forecasting community well and helping make some activities feasible for the first time at BoM.

4.3 The Sensitivity of the Statistical Hurricane Intensity Prediction Scheme (SHIPS) to Sea Surface Temperature, *J. Cione, National Hurricane Centre, Miami, USA.*

Joe Cione began with an overview of hurricane predictions and their steady improvement over the last 20 years in terms of intensity and track noting that there was still some way to go yet and this was the motivation to work with the GHRSST-PP MISST project. Since 2007 the NHC have run the Weather

Research and Forecasting (WRF) Model i a next-generation mesocale numerical weather prediction system designed to serve both operational forecasting and atmospheric research needs. It features multiple dynamical cores, a 3-dimensional variational (3DVAR) data assimilation system, and a software architecture allowing for computational parallelism and system extensibility. WRF is suitable for a broad spectrum of applications across scales ranging from meters to thousands of kilometers. In addition the NCEP/GFDL hurricane model (a 3-D dynamical model) with coupled ocean is also used at the NHC. Two statistical systems are also run including:

- The Statistical Hurricane Intensity Prediction Scheme (SHIPS) which is a statistical regression model with input from SST analyses and global model forecasts
- SHIFOR which is Simple statistical model with climatology and persistence input *(baseline for comparison)*

The SHIPS regression model is based on 1982-2006 sample recently upgraded to include for 2007 version. There are 18 basic predictors based on atmospheric from GFS forecast fields, Reynold's weekly 111km SST, cloud top structure from GOES, climatology and persistence and empirical decay rate once storm is over land. The SST is sued in the SHIPS model to provide an upper bound on maximum winds. The SHIPS SST predictor is the intensification "potential" which is shown in Figure 4.3.2 as the difference between black curve and current intensity.

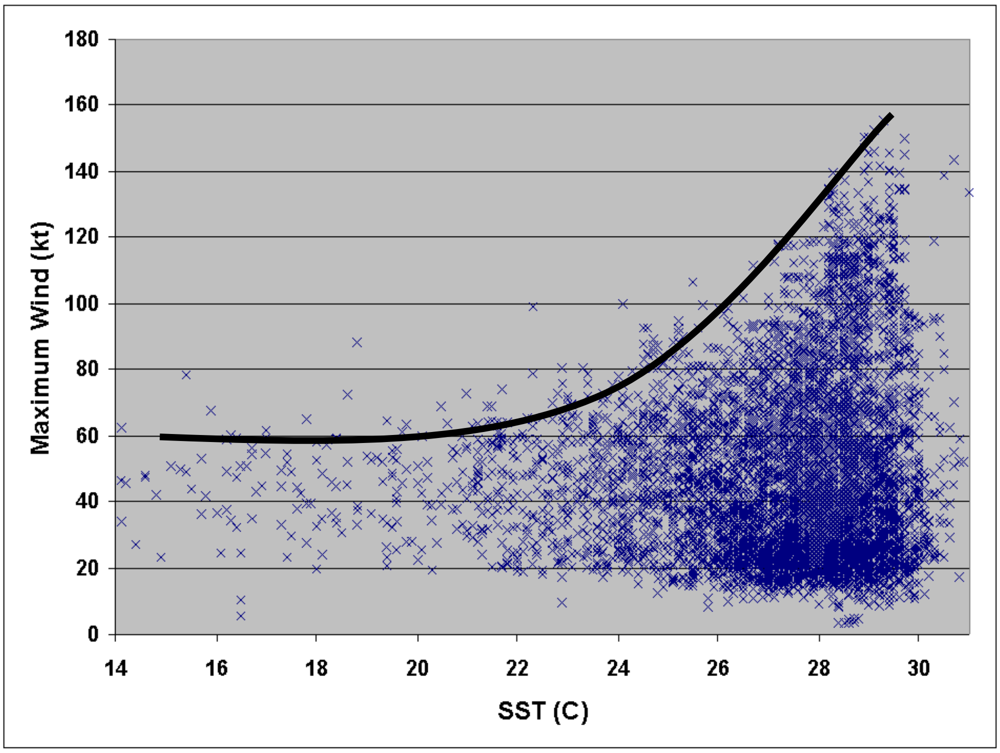


Figure 4.3.1 Reynolds weekly SST vs Maximum Wind speed in the Atlantic Ocean- 1982-2005. Black line shows the SHIPS SST predictor (intensification "potential").

Note that SST potential is the most important term for the 3 day SHIPS forecast. The SST potential is averaged along the forecast track of the storm. The SST potential term is most important at nearly all of the forecast times in SHIPS. The vertical shear in the atmosphere is also important but secondary to the SST potential.

Cione ran several sensitivity studies using the SHIPS model for the 2004-2006 seasons in the Atlantic and E Pacific. Four tests were conducted as follows:

- Reynold's weekly 111km SST, hurricane-induced, inner-core *(eyewall)* SST cooling algorithm not used (*control)*
- TMI/AMSR-E microwave 25km 'foundation' (diurnal bias removed) daily SST, no storm-induced cooling
- Reynold's weekly 111km SST, storm-induced cooling included (Atlantic only)
- Microwave SST, storm-induced cooling included (Atlantic only)

In addition, a tropical cyclone (TC) Inner-Core SST Algorithm for SHIPS has been developed. Currently, SHIPS uses 'pre-storm', ambient SSTs obtained from weekly 111km resolution Reynolds analyses. As such, SHIPS is unable to account for any storm-induced ocean cooling that occurs within the high wind inner-core environment. Furthermore the 'SST potential term', is defined in SHIPS as:

SST Potential = MPI(fn of SST only) - TC intensity

and as previously shown, the SST potential term is a highly significant predictor (R~.65) in the statistical model. Therefore even modest improvements to SST may result in significant improvements in SHIPS intensity forecasts. However there is a problem in that routine observation of the inner-core hurricane ocean environment is often impractical and in many cases impossible. Recent multi-hurricane observations (1975-2002) from Cione and Uhlhorn (2003), have provided an improved representation of inner-core (<60km) SST conditions. Using storm-specific information in conjunction with ambient and inner core SST observations from the 33 TC events documented in Cione and Uhlhorn (2003) an algorithm to predict hurricane inner core SST was developed as a function of (ambient SST,TC lat, TC speed) as shown in Figure 4.3.2.

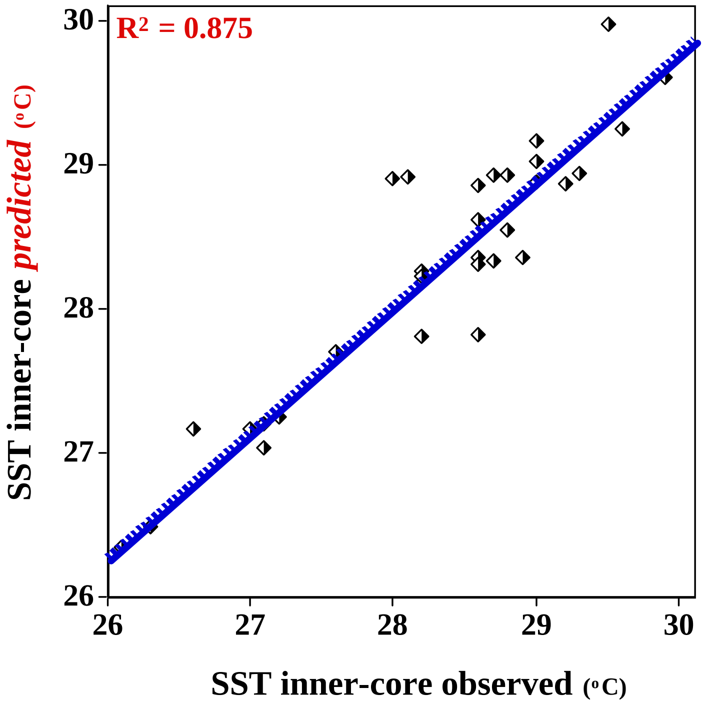


Figure 4.3.2 Scatter plot of in-situ SST vs. predicted inner-core SST [using the hurricane inner-core SST cooling algorithm developed from the 23-hurricane (1975-2002) sample from Cione and Uhlhorn (2003)]. SST is given in °C.

The TMI/AMSR-E Microwave 25km 'Foundation' (diurnal bias removed) Daily SST impact on Hurricane Intensity Forecasts was positive in the Atlantic with respect to neutral impact in east Pacific as shown in Figure 4.3.3(A). Previous studies by Chelle Gentemann from earlier years showed opposite result (improvement in east Pacific, neutral in the Atlantic). The Impact of daily microwave SST is for cases of storms crossing tracks of previous storms. Atlantic was unusually active in 2004-2006, and east Pacific was unusually inactive. This may explain the difference from previous results.

However, the impact of the Hurricane Inner-Core SST Cooling Algorithm on Hurricane Intensity Forecasts is much greater. SST cooling with Reynolds SST improves forecasts by almost 5% at the short forecast periods (see Figure 4.3.3(b)). Additional improvement at the longer forecasts is obtained from including both the SST cooling and microwave SSTs. The current operational SHIPS forecast has included the SST cooling since 2005, so that gain is being realized operationally. Addition gain appears to be possible by including a better SST analysis.

Cione concluded that overall improving the SST (that the storm 'sees') improves the forecast. The daily microwave SST analysis improved the Atlantic SHIPS intensity forecasts for the 2004-2006 Independent sample. A positive to neutral impact was found for the east Pacific. The very active 2004-

2005 Atlantic season, quiet east Pacific seasons may explain these results as previous studies showed positive impact in the east Pacific, neutral in the Atlantic. However, the SST cooling algorithm improved the Atlantic SHIPS forecasts for all periods and an additional gain at 72-120 hr was found by including SST cooling and microwave SSTs. The Cione SST cooling algorithm (V 1.0) is now being used operationally (since 2005) by NHC. Further work includes operationally testing 'new' SST analyses (Reynolds AVHRR/AMSR-E 25km daily SST) and using a Cione inner-core SST cooling algorithm V 2.0 (now under construction)

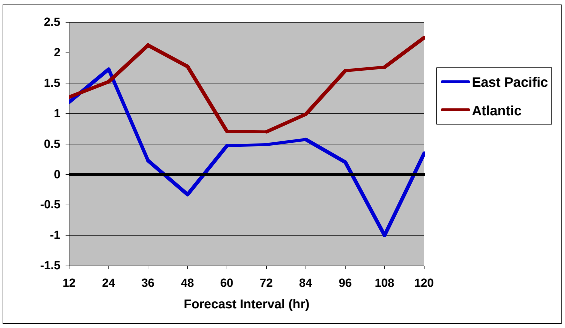


Figure 4.3.3(a) Impact of TMI/AMSR-E Microwave 25km 'Foundation' (diurnal bias removed) Daily SST on Hurricane Intensity Forecasts. % Improvement after replacing weekly Reynolds SST with daily microwave analyses.

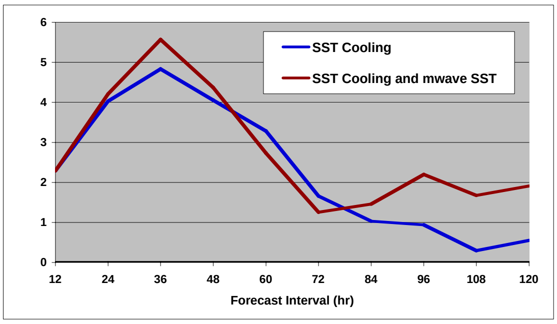


Figure 4.3.3(b) Impact of Hurricane Inner-Core SST Cooling Algorithm on Hurricane Intensity Forecasts. % Improvement after including storm-induced SST cooling algorithm (% Improvement after including SST cooling algorithm & microwave SSTs) (Atlantic Cases Only)

4.4 ReefTemp – An improved tool to nowcast coral bleaching risk in the Great Barrier Reef Marine Park and the need for detailed climatology analyses, *J. Maynard and P. Turner, BoM/CSIRO, Australia.*

Maynard began by explaining Coral bleaching using photographs of a healthy reef in the Southern Great Barrier Reef (GBR) and the impact of a bleaching event 2-3 weeksw later where 30-40% mortality had occurred as shown in Figure 4.4.1.

Figure 4.4.1(a) A healthy reef in the Southern Great Barrier Reef

Figure 4.4.1(b) 2-3 weeks later after a bleaching event whith 30AwgTH2Z-40% mortality.

Maynard explained that ReefTemp (see http://www.cmar.csiro.au/remotesensing/gbrmpa/ReefTemp.htm) is a mapping product that provides information on coral bleaching risk for the Great Barrier Reef region. It is a collaborative project between CSIRO Marine and Atmospheric Research, the Great Barrier Reef Marine Park Authority and the Bureau of Meteorology. Part of the Reef Temp project includes climate change projections for the Great Barrier Reef and the increased frequency and severity of mass coral bleaching events. ReefTemp produces high-resolution now-casts of bleaching risk and provides an improved ability to monitor heat stress in the Great Barrier Reef.

NOAA early warning products (degree heating days, heating rate and SST anomaly) have been need to deal with a global community of users and provide good baselines and guidance at lower spatial and temporal scales. However climate change is a distinct problem where we might expect some bleaching every year (see Figure 4.4.2). By 2025 temperatures may prohibit the sustainability of coral reefs due to continued bleaching every year.

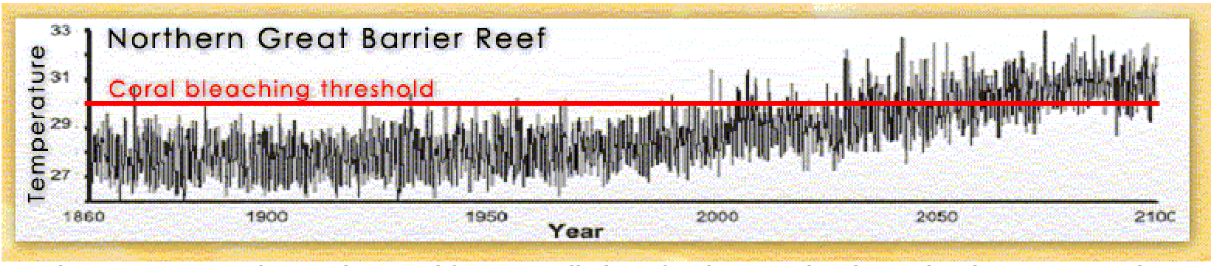


Figure 4.4.2. SST observations and future predictions for the great barrier region (Courtesy: Janice Lough, AIMS)

There are areas where much improvement could be made to help coral reef management using SST observations. To begin with there is a need to know where bleaching has been most severe and where such severe events are expected to become more frequent in the future. The former requires better resolution of data whereas the latter requires better climate predictions.

It is clear that SST vary dramatically over small areas and at the km scale Reef Temp needs help. Pathfinder data sets at 4km are not sufficient and 1km data sets are required in an easy to handle format. Ideally, a daily hotspot map and a multi-index product approach to look for the look for the reef locations that are under stress with better monitoring tools is required. Can stresses at 4km be correlated to bleaching severity? (4km too big).

Helen Beggs and Anthony Rea have developed 15day SST mosaic maps that can be used with climatology to provide a customised indicator of bleaching risk analysis running at 2km. Such products can be visualised through Google earth based on 4 different ways to describe the stresses on the reef. The degree heating days product works best and using Google Earth it is relatively straightforward to search for the reefs under stress. Maynard suggested that better collaboration between ReefTemp, Anthony Rea and Helen Beggs could help to improve products to Reeftemp.

Maynard then discussed the use of short term (10 years +) SST climatologies noting that there were few high resolution climatologies available. Ideally a high resolution (2km or better SST climatology would be ideal. This needs to be used to verify GBR SST forecast from the climate models used to give the signal providing products to help determine where we will expect bleaching effects. Given this information, teams can begin to work towards mitigating other stresses.

Maynard concluded that better SST maps will lead to:

- Improved understanding of the climatic conditions conducive to bleaching
- Fine-tuned monitoring efforts and allocation of resources
- Raised awareness in community monitoring groups
- Communications outlets to scientific community and public
- Further contribution to science

The Science team noted that the GHRSST-PP reanalysis effort and the HRDDS were ideally suited to help Maynard and the Reef Temp team. The following actions were raised:

- Jeff Maynard, Helen Beggs, Dave Poulter, Ken Casey and Anthony Rea should meet to discuss how best to use GHRSST-PP data within Reef Temp
- Dave Poulter and Jeff Maynard to liaise on the application of the HRDDS within Reef Teamp and possibly work towards a short paper.
- Ken Casey: Add the ReefTemp application to the GHRSST-PP RAN project user requirement document.

4.5 Future plans of ESA for GHRSST-PP, *O. Arino, ESA, Italy.*

Arino explained that in 2002 during the first GHRSST-PP meeting in Tokyo ESA offered to support an international project office to0 coordinate the GHJRST-PP and to initiate a European project called Medspiration in support of the GHRSST-PP initiative. Since that time several other projects have been initiated within ESA modelled on the GHRSST-PP-Medspiration successes (waves, Ocean Colour, ice etc). ESA does not see GHRSST-PO as a single project office but rather a tactical strategy to support offices that themselves coordinate the application and development of different satellite sensors of ESA sentinels and other missions (ERS, ENVISAT). Through the project offices ESA has a better interaction with the scientific and operational communities.

In 2007 the contract to the GHRSST-PO was reviewed. The GHRSST-PO has performed well strengthening the scientific collaboration and access to data across the international community. ESA has now agreed to continue to support the GHRSST-PO for the next 3 years (until 2009) at a minimum.

Within Medspiration (explained by JF Piolle) data production and delivery was initiated for 2 years. Future data provision fro AATSR and Sentinel-3 ATSR-4 will be similar based on GHRSST-PP methods. Within Medspiration several new L4 abalysis areas have been opened including the Galapogos area for marine biodiversity studies (Ocean Colour and SST and Currents). The Medspiration as worked hard to improve the SSES for ENVISAT AATSR and for outreach to the general public. ESA are now discussing the use of SST's by television companies (e.g., TV5 monde) as part of a developing service.

Arino then noted that Medspiration continuity is assured and ESA will extend the service until November 2008, for AATSR L2P. At this point the EU Marine Core Service MyOcean project (see Donlon presentation earlier) will manage L2P data sets provided by ESA. ESA therefore plan to continue the provision of L2P until the end of ENVISAT.

For Medspiration a user consultation meeting has been held every year to guide the project. At each meeting, users are4 encouraged to make statements regarding the usefulness and issues when using Medspiration projects providing valuable user feedback to the project. The Next User Consultation meeting will be in Oslo (November) and run in parallel with the ESA GlobColour User Consultation. ESA are particularly keen to see better interaction between the GlobColour and Medspiration projects particularly for diurnal variability, long term climatologies, HRDDS sites, calibration and validation work and applications using both SST and ocean colour data.

Arino then discussed ESA's plans for the development of a series of operational satellites for the EU GMES program called the Sentinels.

- Sentinel-1 will be a SAR RADAR system
- Sentinel-2 will provide SPOT Landsat type imagery
- Sentinel-3 will provide ocean data including continuity of the AATSR, MERIS and Altimetry

During the operational definition phase, the Sentinel-3 system took the GHRSST-PP as a main requirement. The current system architecture will operate 2 Senbtinel-3 satellites for 20 years (many satellites). ESA is developing a ground segment to deliver products in L2P format. The Sentinle-3 will carry an Improved AATSR (ATSR-4) having a dual view capability at the swath centre and an additional wide swath of 1500km. Several processing chains will be developed and implemented to achieve the following data delivery schedule:

- L2P within 3h of measurement at the satellite with a 1km FoV

The main characteristics of the Sentinel-3 SST and Land Surface Temperature Radiometer include a basic heritage from AATSR, dual-view (nadir and backward) required for aerosol corrections:

    - Nadir swath >74° (1300 km min up to 1800 km)
    - Dual view swath 49° 750 km
    - Nadir swath covering the ocean colour instrument (OLCI) swath
- 9 spectral bands:
    - Visible : 555 – 659 - 859 nm
    - SWIR : 1.38 – 1.61 – 2.25 µm
    - TIR : 3.74 – 10.85 – 12 µm
- One IR channel used for co-registration with OLCI

The Scan geometery of the instrument is shown in Figure 4.5.1.

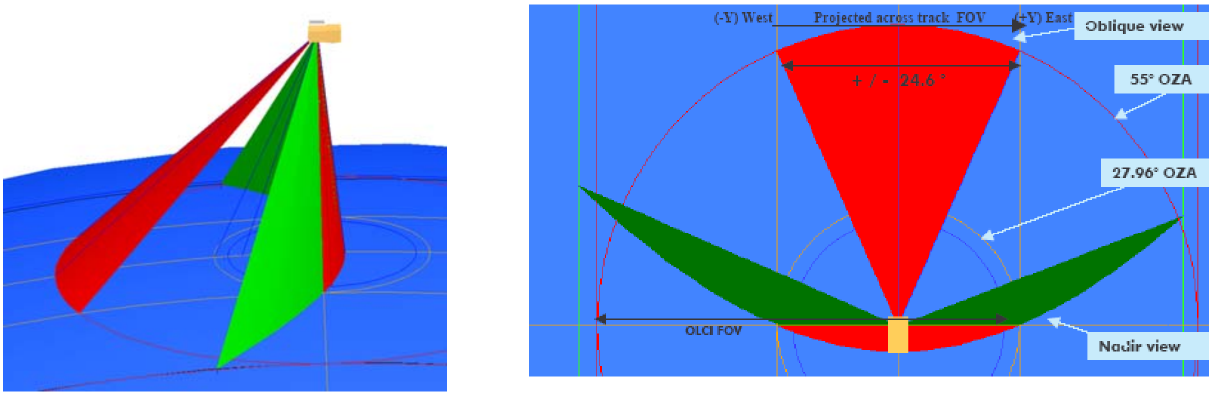


Figure 4.5.1 Proposed Scan geometry for the Sentinel-3 ATSR-4 instrument (SLSTR)

The Sentinel-3 is planned for launch in 2012 and the first system is now being built. In this way, ESA will continue to support the GHRSST-PP and the provision of AATSR class data into the future.
The Science Team were pleased to hear the report of Arino and requested that an information page describing the Sentinel-3 ATRSR-4 system should be developed as part of the GHRSST-PP web site. The following action was raised on the GHRSST-PO:

- ACTION: Develop a summary set of pages for the GHRSST-PP web site outlining plans for new Sentinel-3 satellite and ATSR-4 instrument being developed by ESA.

4.6 NAIAD : a new advanced system to access satellite data, *J. F. Piollé, IFREMER, France.*

A great effort has been undertaken by GHRSST project in order to provide an homogeneous access to satellite sea surface temperature data, relying on common specification and technologies for metadata, data content, format (NetCDF) and access (ftp, OpenDAP). This effort, while making the life of users much easier and the development of applications requiring and merging these data streams, is still to be strengthened (as raised in several GHRSST workshops) when considering the optimization of the data flow: full resolution swath data (L2P) are still very voluminous, bandwidth consuming and complicate to manage, due to their sampling pattern, especially when focusing on very regional areas. It is of high interest for applications and users to download only the relevant data for their need, filtering out for instance cloud contaminated images or out-of-boundary swath sections.

The Naiad system is highly powerful and open framework for the dissemination of voluminous multi-parameter swath data, developed by IFREMER, and supported by ESA and EUMETSAT, that will be used in the frame of the Ocean & Sea-Ice SAF, of the European GDAC and many other contexts. It provides unique features such as multi-criteria data search, sub-setting, re-gridding, visualization and automatic generation and dissemination of customized products directly to users and is based on existing standards (OpenDAP). It greatly facilitates the implementation of advanced data mining applications.

NAIAD provides a framework to access satellite data and advanced search capabilities to massive archive. NAIAD was developed to help manage users need to access only a small subset of global satellite data over a small area for example, at a river estuary, over a storm or over a Gulf Stream eddy. Normally to do this work requires many hours of processing satellite data to a common format, re-gridding to a common resolution, to then relate these data in time and place and to finally visualise the results. Furthermore, to overlay and use ship tracks or other in situ data requires powerful GIS capabilities that are expensive and often tailored to land based activities. NAIAD uses a powerful and large database and the principle of “process once, uses many times” to help users gain access to small focussed sub-sets of very diverse data. NAIAD uses metadata describing the information content within a file to link information from one sensor to another (e.g., SST and Microwave roughness) and other data sets

The NAIAD system objectives are developed to try to address these issues and in addition, to provide a way to data-mine a large image database as a generic processing system and the archive for OSI-SAF and GMES MyOcean systems. Tools are provided for data-mining using a library for easy access to data where collocation and time series data extractions are automatically handled by the system. Only the subset of data that is useful to the user will be extracted for further activities without accessing the whole file. Piolle explained the use of multiple sources of satellite data for oil spill identification that can help limit false positives based on the use of SST, OC and surface wind speeds (see Figure 4.6.1).

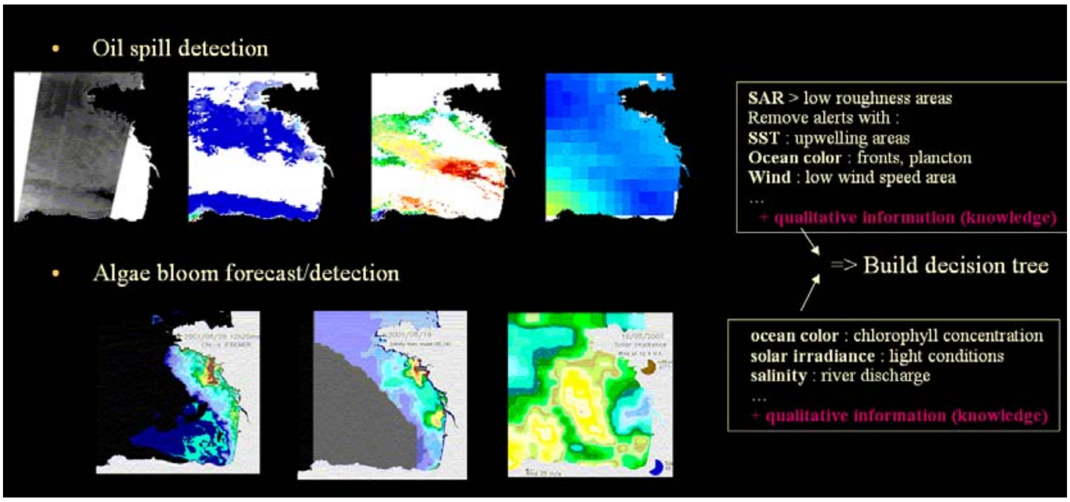


Figure 4.6.1 Use of NAIAD to work with data describing oil slicks including SAR, SST, OC and surface wind speed data.

The System relates different spatial, content and temporal attributes ton each other using virtual variable definitions that can themselves be searched by the system. This allows a very high level description of features to be established that relates image and other database objects to each other. The main features of the NAIAD system are:

- Multi-satellite data portal
- Data discovery, search, extraction (NetCDF, GeoTIFF,…), visualization
- Remote or local access to data (OpenDAP) open (source code, architecture), scalable (load balancing, distributed system) and extensible (plugins, specialization)

More advanced features include

- Information compression
- Complex content-oriented queries
- Co-location
- Virtual variables
- Product customization
- Client API to access information content for user application (atlas, datamining,…) based on a high-level client library (vs low-level libraries such as OpenDAP)

Advanced metadata description allow the data sets to be split into small tile entities or aggregation tiles. The system is open and scale-able to address varied processing loads that can also be distributed and extendable using plugins. Advanced data 'compression;' based on (for example) average values linked to full resolution tiles is used to enhance the speed of searches and discover tools. The system can then register data related to events (e.g. storms). The same principles can be applied to in situ data which can also have the same type of metadata with tiles and with model output. In this way NAIAD can integrate many types of data in the framework. Figure 4.6.2 shows a set of example NAIAD screens.

The first operational version of NAIAD is expected in September 2007 which will include a web interface and a direct access low level query system using a web interface system. The team are currently working on an Atlas of Stormwatch (indexing scatterometer data for storms and hurricanes). The Stormwatch application will use full swath data and will include a storm identification algorithm.

Following some discussion regarding the application of NAIAD within the GHRSST-PP it was suggested that a link between NAIAD and the GHRSST-PP GDAC should be established on the GHRSST-PP web portal. The utility of NAIAD within the GHRSST-PP for data-mini g diurnal variability events, tracking eddy systems, western boundary currents, hurricane systems and clod wakes, etc was obvious and the GHRSST-PP Science Team urged the full use of NAIAD as a tool for applications requiring GHRSST-PP data.

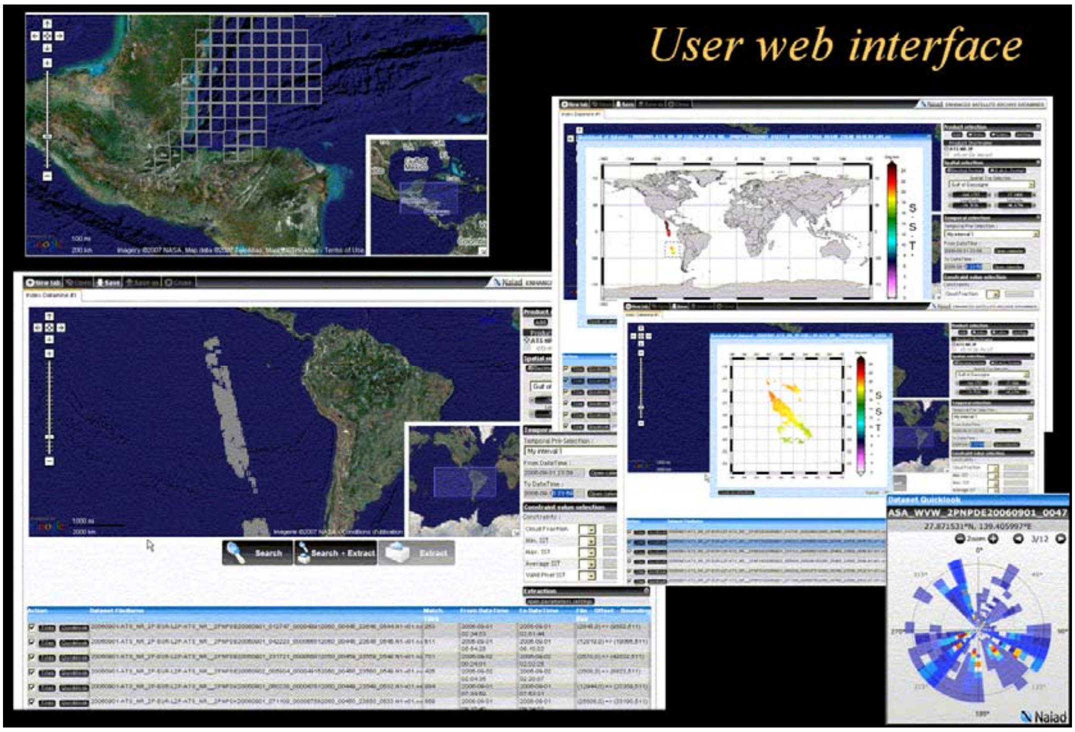


Figure 4.6.2 Example screenshots from the NAIADF system developed by IFREMER to visualisae extensive satellite data hboldings.

4.7 METOP/AVHRR derived SST products, *P. LeBorgne, Meteo France, France.*

LeBorgne presented an overview of the METOP processing chain, products, the validation methods and preliminary results since the successful launch of the METOP satellite carrying an AVHRR/3 instrument. The main characteristics of data are a 1km, 2km and 0.05° gridded product set. LeBorgne explained that there is an issue between the format specification of L2P and the timeliness requirements where the DT_analysis field is resulting in delays to the L2P product. In this case, the OSI-SAF now produces a self contained L2P core product without external fields which is updated to L2P once DT-Analysis is available.

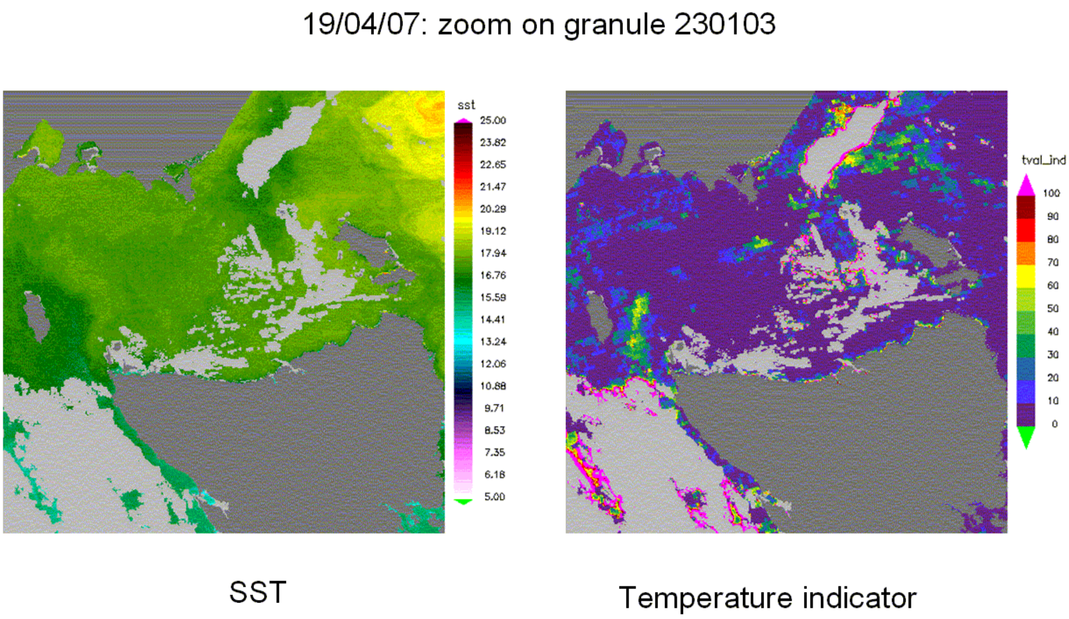


Figure 4.7.1 (a) SST image obtained from the METOP AVHRR on 19/04/07: zoom on granule 230103 (b) corresponding indicator mask for (a)

LeBorgne explained the METOPO AVHRR processing chain at Meteo France which includes a Climatology check, cloud clearing, tests against a minimum SST Climatology, Ice edge tests, aerosol tests and a cloud mask control. Then an SST retrieval is made including NWP and aerosol bias correction, a set of data confidence levels are defined and assigned to each pixel in the image data set. Both L2P and GRIB2 data sets are produced as part of the operational chain.

The METOP AVHRR algorithms are derived from radiative transfer modelling and return an SST-subskin value using a classical 3 channel algorithm (3.7µm) at night. The METOP processing chain makes use of indicators (value 0=clear sky to 100=cloudy) to assist in defining a good cloud mask. This indicator also use inputs form other indicators used by the processor including a gradient indicator, an aerosol indicator and an ice indicator. An example of the METOP AVHRR indicator is given in Figure 4.7.1. Such an approach allows an overview of all errors and problems in the data set in an homogeneous framework. However more work is required to understand and refine the mask based on the complex nature of dust in the Mediterranean Sea (for example).

The team have derived GHRSST-PP confidence levels based on a 2 axis system the SST algorithm and the 0-100 indicator scale (this is a very different approach than that taken for SEVIRI). This means that the confidence level categories can be established in 2D space (as shown in Figure 4.7.2).

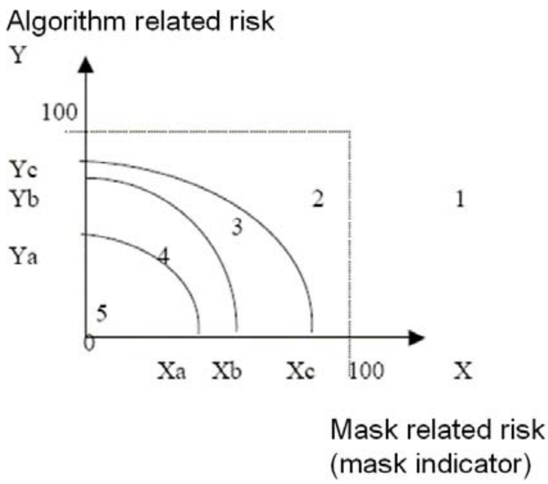


Figure 4.7.2 Confidence level definition used by the METOP AVHRR processing chain at the EUMETSAT OSI-SAF. The confidence level is set based on the error risk associated with the SST algorithm and the combined mask indicator.

In the two axis confidence level definition each line in the plane is an iso-error line. An example of a confidence level map derived using the above approach and corresponding SST values are given in Figure 4.7.3.

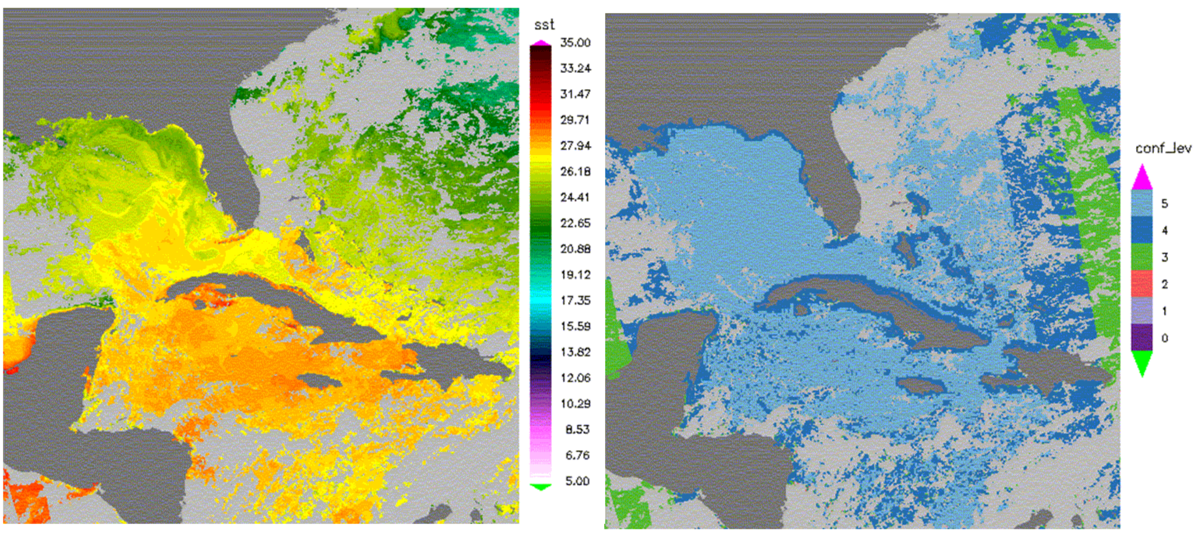


Figure 4.7.3 (a) METOP cloud cleared SST map and (b) corresponding L2P confidence (quality) level for each pixel.

LeBorgne then discussed the derivation of SSES and validation statistics for METOP AVHRR. Buoy and ship measurements collected on the GTS are used as the basis for his work which are collocated to satellite data extracted in 21x21 pixel boxes centred on the buoy measurement (corresponding to the GHRSST-PP MDB approach. In general there is a negative bias at high latitudes especially at night time bias. The validation shows that there is some skill in the mask indicator and there is skill in the definition of confidence levels. One aspect that is required is the introduction of a correction for atmospheric dust contamination based on the SEVIRI Saharan Dust Index (SDI). However, many other regional biases could be introduced by this approach and further work is required.

LeBorgne concluded that

- The EUMETSAT OSI-SAF METOIP AVHRR production chain is ready and delivering L2P core data sets.
- The inclusion of DT_analysis in L2P core is not compatible with timeliness requirements for METOP using the current configuration and DT_analysis has been dropped from the L2Pc.
- Preliminary validation results are nominal and need further work.
- In June 2007 it is planned to start routine delivery of data products to IFREMER in an experimental mode
- In September 2007 a preoperational delivery to IFREMER will start
- This chain will be used to process NAR data in 2008 and SEVIRI data in 2009

The Science team noted the developments at the OSIO-SAF and were pleased to see EUMETSAT adopt the L2P specification for METOP operations. The number of files and data volumes generated by the METOP AVHRR in 1km mode is impressive. Jim Cummings was keen to establish if the processing chain had thought to use the NAAPS system. LeBorgne noted that this was the intention but noted that while the relationship between SEVIRI and NAAPS was good this might not be the case for the METOP AVHRR. Further discussion focussed on the use of a coldest climatology as a fundamental QC threshold check as this could result in the rejection of anomalous (but true) data – particularly in the marginal sea ice zone.

The Science Team suggested that OSI-SAF could make their coldest climatology data set available via web pages for the group to use in normal operations. A second request to LeBorgne to inform the GHRSST-PP Science Team on progress with METOIP SST's at OSI-SAF was made.

4.8 Utilization of Earth Science Datacasting by the GHRSST Project, *A. Bingham, R. Deen, K. Hussey, T. Stough, S. McCleese, A. Cervantes, JPL, USA.*

Bingham began with an overview of the Datacasting metaphor noting that just like podcasting for the iPod where the content is music and videos using the Apple iTunes software, datacasting is the same idea but using satellite data. Table 4.8.1 summarises the podcasting and datacasting metaphors. The main aim is to get at earth system data on a subscription basis and to have this fed to a system but only the data that you actually want to use for a given purpose.

Table 4.8.1 Podcasting and Datacasting metaphor

Podcasting	Datacasting
Search for and subscribe to music or video feeds using iTunes	Search for and subscribe to Earth Science data feeds using the Datacasting client
Download all files as they become available	Download only relevant files, as they become available (filtering)
Manage files in iTunes	Manage files in the Datacasting client
Listen to music file or watch video	Visualize data in the client and/or Google Earth
Upload to ipod	Ingest data into a science analysis tool

Datacasting is a Really Simple Syndication (RSS see http://en.wikipedia.org/wiki/Rss) based technology for distributing Earth Science data. Providers of the data publish the availability of files through a web-feed, along with relevant ancillary information pertinent to Earth Science data (e.g., file format, data collection methods and data content). Users subscribe to the feeds with the Datacasting Feed Reader, which enables them to list and interrogate the feeds for identification and download of the files for further analysis. Figure 4.8.1 summarises the main elements of the Datacasting system configuration. A set of tools and software is available for setting up Datacasting feeds at http://datacasting.jpl.nasa.gov/

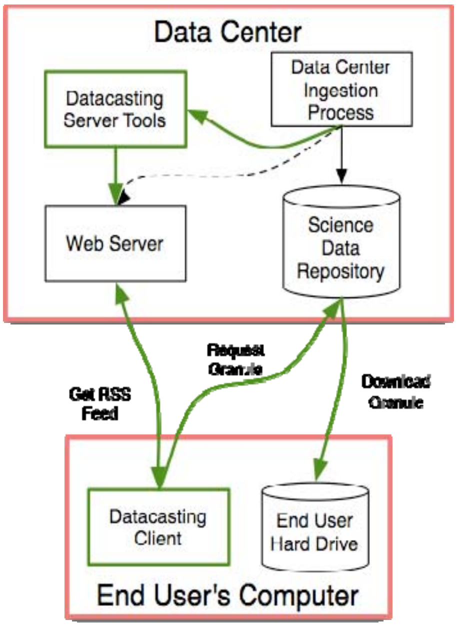


Figure 4.8.1 Datacasting system configuration. Data provider creates XML feeds and provides access to files using the Datacasting server software. Users subscribe and download relevant files using the Datacasting client software

Datacasting feeds are specified using XML, which conform to the RSS specification with additional extensions that are relevant to Earth Science data. These Datacasting extensions contain elements (tags) that describe the data collection (e.g., location in time and space, sensor and measurement retrievals), the file formats (based on ESML, this allows for files to be read and displayed in the Datacasting Feed Reader) and custom elements. Custom elements enable data providers to define metadata that are unique to their Datacasting feed. For example, adding a custom element that quantifies the percentage cloud free pixels in a image enables users to quickly select images which have few clouds. A custom element consists of a definition which can either be of a type float, integer, string, Boolean, region or time. This facility provides a data management tool for data (just as iTunes provides a music management tool for your music).

A powerful addition to the Datacasting Feed Reader is that of filtering, written in Java and available at http://datacasting.jpl.nasa.gov/, which gives users the ability to precisely identify the files that are relevant to a particular need. By building filters that make comparisons with information contained within a feed, users are able to construct lists of relevant files and have these files downloaded automatically. For example, a user might subscribe to a Datacasting feed that contains information about global coverage L2P files produced by GHRSST-PP, but they may only be interested in data that contain data over the Gulf of Mexico. The user would therefore construct a filter that lists only the files that have been tagged in the Datacasting feed to contain data related to the Gulf of Mexico and imaged within a bounding box. The user could further refine the filter to show only the files where the SST exceeds a specific magnitude or within a certain distance of an active hurricane.

The types of filters a user can build are solely dependent on the richness of information tagged in the web-feed. The hope is that through the Datacasting forum, users are able to make recommendations to data providers on the information that ought to be contained within a feed and also promote the uptake of standard metadata conventions and taxonomies, and thereby enable filtering across multiple feeds. In addition to filtering, a Datacasting Feed Reader will have the ability to read files that have been downloaded and display the data. The intent is to give users the capability to quickly analyze the data and further decide if it is useful or not. For more in depth investigations, users would use their usual tools to perform analyses on the downloaded data.

The GHRSST-PP Science Team were keen to see GHRSST-PP data as a foundation data set for testing datacasting noting that these data were easy to use, carry a well specified and stable format and are relatively easy to interpret. The following actions were raised during discussions:

- Andy Bingham was asked to contact each RDAC/GDAC to consider setting up facilities to become a GHRSST-PP datacaster.
- It was agreed that a basic historical GHRSST-PP data should be set up so at the LTSRF so that datacasting can be tested on these historical (and develop the appropriate RSS interfaces at NODC)
- Once in place the GHRSST-PP Science Team should test the datacasting facility and feedback to Andy Bingham their thoughts and comments.
- Andy Bingham was asked to help define appropriate RSS feeds forward for a GHRSST-PP Metrics Dashboard.

4.9 Calculating sea surface temperature, emissivity and atmospheric state using hyper-spectral radiances: J. Le Marshall, W. L. Smith and J. Jung, Bom Australia, JCSDA, USA.

LeMarshal started by explaining the mission and vision of the Joint Centre for Satellite Data Assimilation (JCSDA) in the United States:

- Mission: Accelerate and improve the quantitative use of research and operational satellite data in weather. ocean, climate and environmental analysis and prediction models
- Vision: A weather, ocean, climate and environmental analysis and prediction community empowered to effectively assimilate increasing amounts of advanced satellite observations and to effectively use the integrated observations of the GEOSS

Operational centres in the US want to maintain close relationships with operational data centres and to try and share the large workload of processing satellite data and developing advanced data assimilation codes to accelerate the use of satellite observations in operations. The task is huge as the JCSDA is trying to use the full database of the GEOSS which includes~ 50 instruments and 5 orders of Magnitude increase in data volumes over the last 10 years. Instruments are first prioritised in terms of overall potential value to the JCSDA and then component parts of the centre are tasked with work activities. At present NWP uses 30-40 instruments as simultaneous input to the DA scheme. The Centre is now staring to assimilate new high resolution data in local and global domains. For GHRSST-PP one system of interest is solving for air temperature and humidity but develops a skin SST as a by-product.

The Centre has also established a new community radiative transfer model (CRTM) with a very active community which is keen to link to projects like GHRSST-PP. In particular, the use of hyper spectral radiances within the CRTM has been developed and AIRS hyper spectral data assimilation started in 2005. Uses 281 channels from the AIRS system (clouds removed and optimised channel weights established). The data are extremely large and are thinned before use. Improved Physically based SST retrieval analysis at NCEP

Progress includes the merging of SST physical retrieval code into GSI which is provided to NCEP marine branch for operational use. An extensive diagnostic study on the diurnal variation signals within in situ and satellite observations, SST retrievals, SST analysis and associated air-sea fluxes (NCEP GFS product) shows the SST diurnal variation needs to be addressed to improve the SST analysis product. 7-day 6-hourly SST analysis has been produced with GSI, after a new analysis variable, in situ and AVHRR data were introduced into GSI. Figure 4.9.1 shows the main results form this work.
The advantage of the analysis framework at the JCSDA is that you have all the data there ready to go. However, there are still lots of development work to be done and LeMarshal noted that GHRSST-PP should get involved and use the framework to demonstrate the usefulness of the GHRSST-PP data sets.

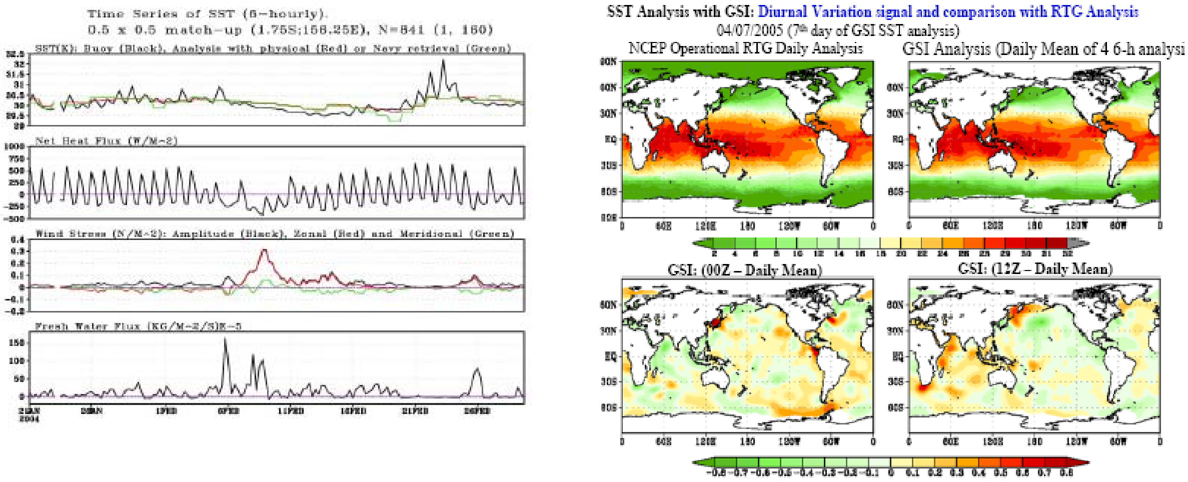


Figure 4.9.1 (left) Time series of SST showing the importance of diurnal variability which is not seen in any SST analysis (top panel). (right) Comparison between the new GSI diurnal variation SST analysis to NCEP RTG and increment fields (lower panel).

LeMarshal then explained that to use AIRS data close to the surface the emissivity of the surface must be known well: a good emissivity model within the system is fundamental to accurate retrievals. Several infrared sea surface emissivity models are available that have been tested with in situ interferometer data. LeMarshal explained that there is a need to bias correct AIRS radiances to fit with the other radiances raising concerns about the quality of the emissivity models. The approach taken was to tune the emissivity using the Skin Temperature and use AIRS to measure the emissivity. Only very high quality data were used in the analysis of emissivity together with the 3rd generation of the model for clear sky cases. The SSTskin was then varied and the minimum variance on emissivity was established which was then feed that back into the system. GOES SSTskin temperatures were used for independent verification. The basic results look good and agree well with matchups to buoys.

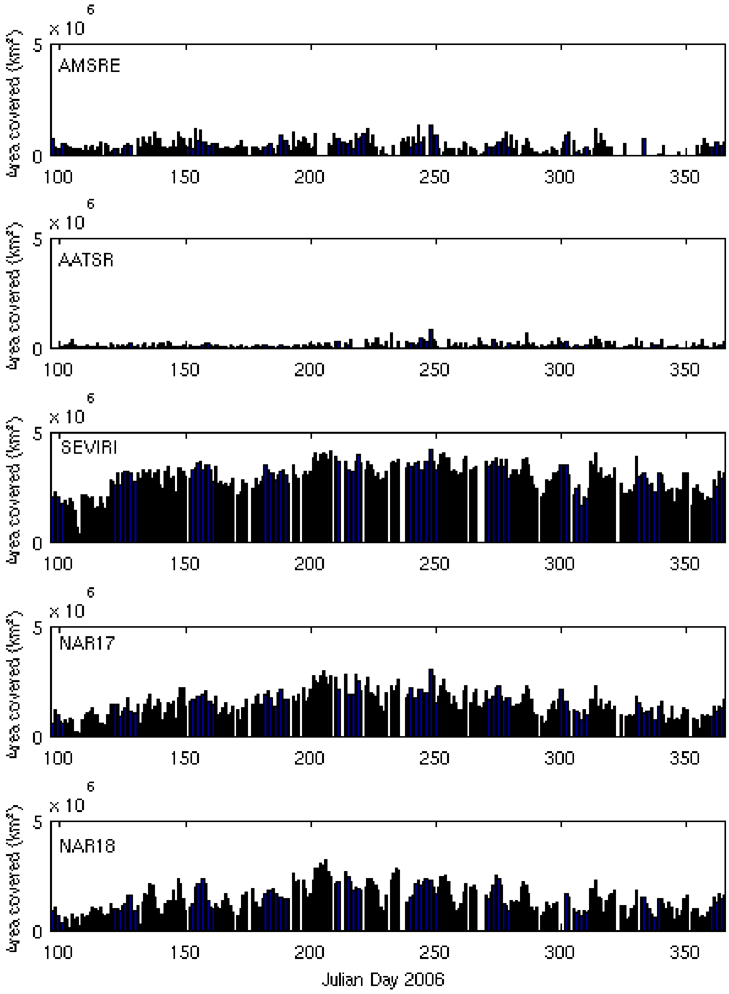
LeMarshal concluded that the JCSDA is working hard to develop new DA systems for satellite data streams and is now starting to look at SST and the GHRSST-PP data sets. The introduction of AIRS data has improved the forecast greatly although the modelling of emissivity required to extract the full value from AIRS radiances has been tricky. There is lots of potential for using data for SST and for calculating SST as a model output at the JCSDA.
The following actions were established following some discussion on how GHRSST-PP can get involved with the JCSDA (primarily via the US Navy links at present):

- **The GHRSST-PP should establish better links with the JCDA teams (LeMarshal, Barton, Donlon)**
- **Eileen Maturi and John LeMarshal agreed to explore the availability of Windsat SST data for GHRSST-PP**
- **Eileen Maturi and John LeMarshal agreed to explore the availability of AIRS SST data for GHRSST-PP**
- **Eileen Maturi and John Le Marshal agreed to explore the availability of JCSDA SSTskin outputs for GHRSST-PP multi-product ensemble comparisons**

4.10 **Assessment of one year of Medspiration L4 SST Products,** *J. Tournadre, IFREMER, France.*

An assessment the Medspiration L4 SST fields was presented by Jean Tournadre. These have been produced in a consistent fashion since January 2006 into daily, 2km-resolution files using night-time measurements from most of the available satellite radiometers (both infrared and microwave). Because of the rapid sampling possible from geostationary orbit, the basis of the L4 analyses is the SEVIRI fields. The L4 products are Optimally Interpolated L2P fields having a nominal time of 00:00 T-1.

Medspiration now has 1 year of data and can start to analyse the time series data properly. Tournadre showed a movie of wind vectors and SST in the Gulf of Lions during a strong Mistral wind event at the beginning of August 2006. This event cooled down the French Riviera by more than 5K and is a good demonstration that the L4 Medspiration system is working in general. Tournadre then decomposed the input L2P data sets used by the analysis (Figure 4.10.1). SEVIRI has the largest temporal and spatial coverage and constitutes the base of the L4 analysis even if the number of samples /day is 10 times smaller than the AVHRR ones.



#

Figure 4.7.1 Area of the Medspiration L4 analysis system domain covered by observation type for 1 year in 2006.

Considering how the input L2P data within the L4 OA compare to each other Tournadre showed the difference between collated and L4 SST for April 2006. He concluded that:

- NAR17 (AVHRR17) no bias (first choice in data selection after AATSR)
- Large biases for NAR18
- Strong regional biases for SEVIRI
- AATSR strong local biases (not enough samples)
- Strong temporal and spatial variability of inter-sensor biases e.g. or July 2006 from –0.5 to 0.5K which are especially strong in upwelling regions.

The regional biases are partially due to the SST local variability and are related to strong surface SST gradients. Most of the problems we encountered during this year of operation are related to large biases between sensors (sometimes more than 1.5K). as shown in Figure 4.7.2 These biases are highly variable in time and space. Improvement of the L4 fields can only come from an improvement of the inter-calibration of sensors.

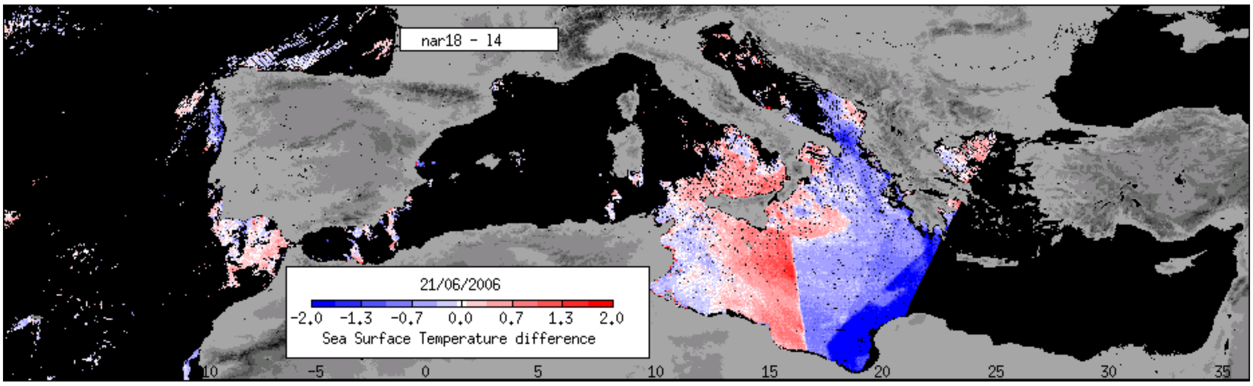


Figure 4.10.2 Difference between NAR18 and the previous Medspiration L4 reference on 21/06/2006 showing strong regional biases in L2P input data sets.

Tournadre then considered the geophysical applications that require L4 analysis time series data sets in the Mediterranean. Preliminary analyses of the L4 SST have comprised comparisons of the times series in the different basins and the responses to strong wind forcing events such as the Mistral in the Gulf of Lions. Such Mistral events changes the energy cascade for 1-2 months and affects the mesoscale activity in the region and seems to propagate to the central Mediterranean. The seasonal signature in the SST amplitude (see Figure 4.10.3) shows marked regional variations with the largest amplitudes being found in the western basin (except for the Alboran Sea) and the northern Aegean and Adriatic Seas. The areas with largest seasonal amplitudes tend to have their maximum temperature earlier in the year, in early August, compared to other regions which peak in early September (eastern Mediterranean) or even later (eastern Atlantic). Spectral analyses of spatial variations have shown differences between the eastern and western basins. Spectral analyses reveals a spectral peak of the SEVIRI 10km data which needs to be addressed (SEVIRI provides the base data to the L4 system). The SEVIRI data have also been analyzed to give L4 fields at 3-hourly intervals which have permitted a study of the amplitude of diurnal warming the Medspiration area.

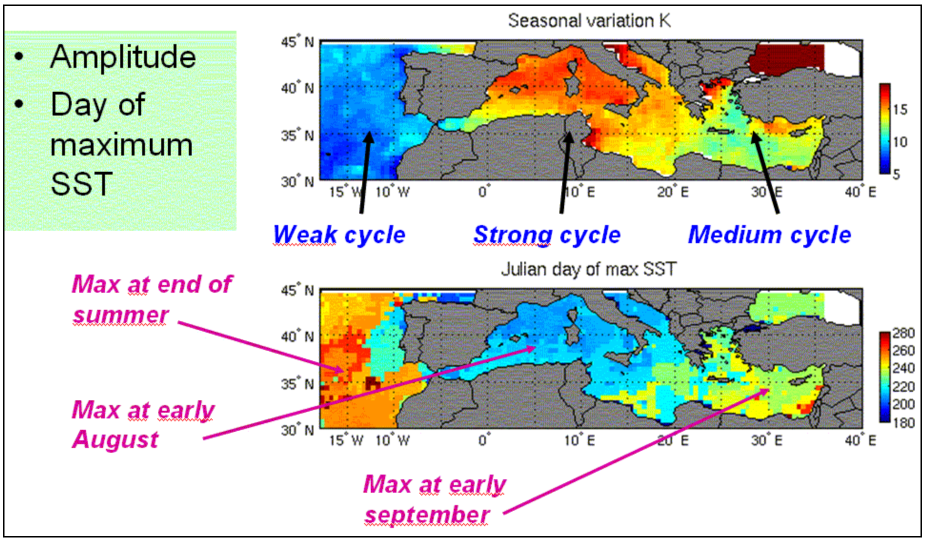


Figure 4.10.3 Seasonal cycles (top SST amplitude, bottom, day of maximum SST) of SST in the Mediterranean Sea based on 1 year (2006) of Medspiration L4 outputs.

Tournadre concluded that the Medspiration L4 system provides a good data base to study the evolution and variability of SST at fine temporal and spatial scales but has limitations that are mostly related to the quality and sampling of input L2P data. The limitations need to be properly described so that users are aware of them and can consider their impact on a particular application. The Medspiration L4 needs to define a new technique to deal with inter-sensor calibration biases that are not presently well captured by the SSES provided with each data set.

4.11 Dust selection and correction for MODIS 4µm SST: A brief progress report, *B. Evans, RMSAS University of Miami, USA.*

Bob Evans presented some early results showing significant improvement in the accuracy of MODIS Aqua night-time 4µm SST retrievals in the area of the Saharan Dust outflow over the tropical North

Atlantic. The current SST 4um algorithm provides a distinct improvement over standard 11µm split window which has significant aerosol biases when compared to AMSRE SST's. Dust aerosol effect on the 4µm SST is to cool the retrieved SST4 by up to 1K while the corresponding 11µm SST is cooled up to 3K. A new algorithm has been developed to minimise the impact of aerosol dust on SST retrieval. The approach uses a scaled difference in the brightness temperatures measured in the 3.75 and 3.95 µm channels of MODIS. This correction is applied to the 4µm SST retrievals, based on the 3.95 and 4.05µm measurements, when heavy dust loading has been detected. The tests have been conducted using MODIS data from Aqua with the AMSR-E microwave SSTs being used as a reference field (see Figure 4.11.1). The MODIS IR and AMSRE MW SST's are contemporaneous as they are flown on the same platform which is a particular strength of the Aqua satellite configuration. The GHRSST-PP should make more use of this capability. The correction is scaled by the type of dust present – course or fine mode. The corrections are empirically based and require rigorous testing, but indicate a promising approach to the retrieval of night-time SST from MODIS measurements in areas contaminated by terrigenous dust.

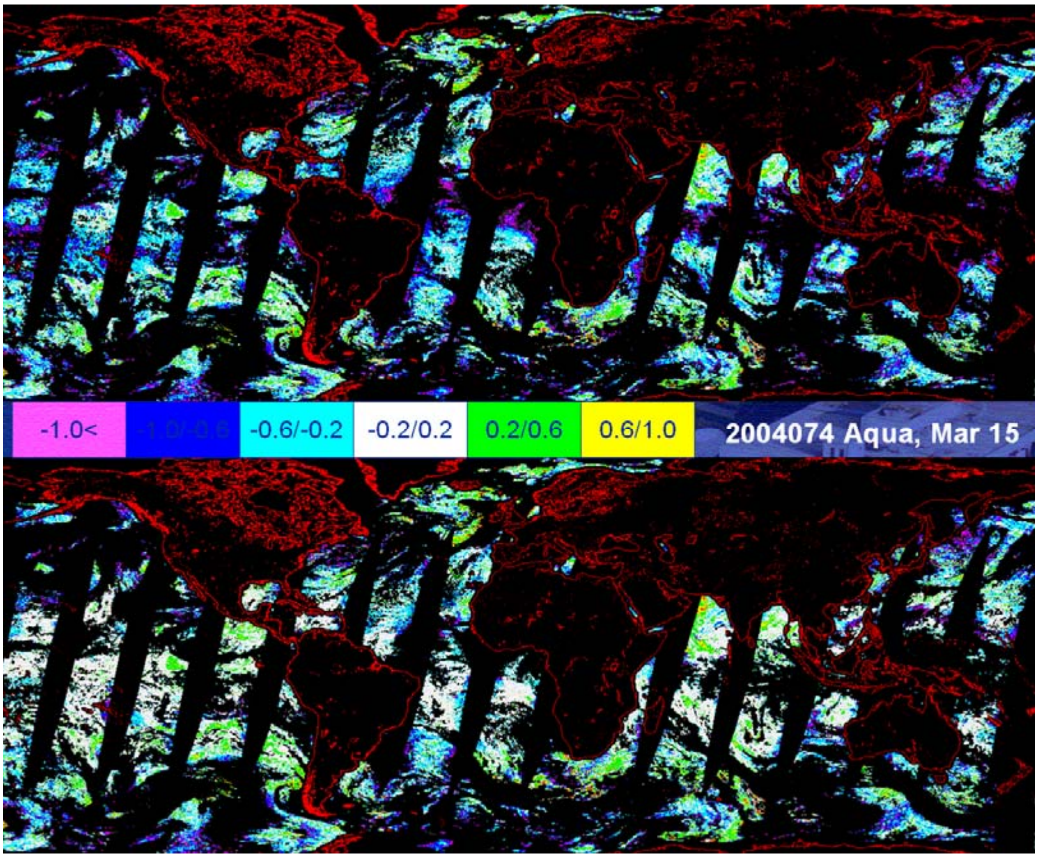


Figure 4.11.1 Top panel: MODIS Aqua SST4µm SST retrieval minus near contemporaneous AMSRE SST Lower panel: MODIS Aqua SST4µm dust corrected SST retrieval minus near contemporaneous AMSRE SST

The Science Team discussed this result noting the similarity to the SEVIRI Saharan Dust Index (SDA) corrections developed at the EUMETSAT OSI-SAF. The MODIS SST team were encouraged to work more closely with the SEVIRI OSI-SAF team on the impact of Saharan Aerosols on IR SST retrievals.

4.12 A reanalysis of sea ice concentration from the SMMR and SSM/I Passive Microwave Records, *S. Andersen and J. Hoeyer, Danish Meteorological Institute, Denmark.*

Jacob Hoeyer presented "Reanalysis of Sea Ice Concentration from the SMMR and SSM/I Records." This study is directed at improving the time series of sea-ice measurements to produce consistent time series, including uncertainty estimates. Present sea ice concentration time series products are extremely simple and contain little to no meta data and uncertainty information. Products are based on level 3 satellite radiances which preclude detailed scrutiny and satellite inter-comparison. A number of products exist but there is currently no consensus on relative merits or best practices. Following EUMETSAT OSISAF activities to reprocess the SSM/I time series, a workshop was held at NSIDC in

March 2007 to:

- Exchange views and results
- Review and adapt OSISAF plans
- Define a shared state of the art, traceable data set including the SMMR time series (1978-1987)

The project is an extension to existing OSISAF plans to reanalyse the SSM/I record (1987 to present). The entire level-1 data set was purchased from Remote Sensing Systems by EUMETSAT for use in the SAF network. Cooperation with NSIDC includes extension with SMMR back to 1978 and more importantly the definition of a consensus data set that may help address above deficiencies.

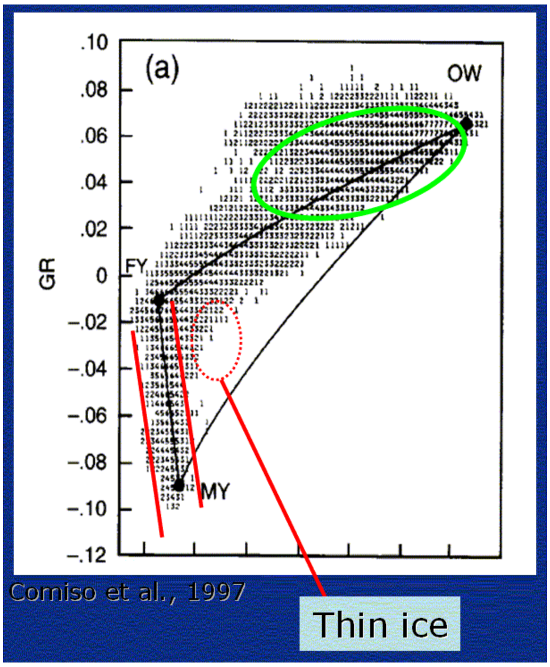


Figure 4.12.1 The main error sources in ice concentration products. The figure illustrates the clustering of microwave observations into a linear feature for sea ice (First Year and Multi Year in the Arctic or type A and B in the Antarctic).

Figure 4.12.1 upper right is the Open Water cluster and a good deal of the observations that do not fall inside the triangle are due to atmospheric contamination (wind roughening of the sea surface, water vapour and cloud). These result in spurious non-zero sea ice concentrations over open water. Conversely the scatter around the ”ice line” is a measure of the uncertainty of the sea ice reference emissivities (tie points). Mixing of footprints refers to the fact that the 19 GHz channels have a footprint of 69x43 km, whereas the 37 GHz has 37x28 km. Simple combination of these channels results in error. Sensor noise can be shown by a Monte Carlo like method to be lower than 2%. However, most errors depend on the ice concentration and with atmospheric errors (largest over open water) much due to the high emissivity of sea ice).

A total of eight ice concentration retrieval algorithms have been studied, and three have been selected for implementation in the scheme. These are referred to as the Bristol algorithm, which is good at high ice concentration, the TUD (Technical University of Denmark) algorithm, which provides high spatial resolution, and the NASA Bootstrap algorithm, which functions well at low ice concentrations. These were selected by comparisons of test cases with high resolution images from SAR and AVHRR, and radiative transfer modelling driven by ECMWF ERA-40 data to determine sensitivities over oven water. The selection of algorithms has been based on a number of comparisons of many ice concentration algorithms. Such studies are relatively rare, usually only a few algorithms are taken into account. Several methods were used:

- Over sea ice: Comparison to reference data (SAR and VIS/IR), analysis of algorithm variability and tie point uncertainty (to be revisited)
- Over open water: The reference is known = 0%, so algorithm intercomparison is easy. Furthermore, radiative transfer models are accurate and allow reliable modelling of errors.
- Over the marginal ice: studies suggest that the coarse resolution is the main limiting factor and so algorithms are more equally affected.

For low concentration and open water: The Bootstrap algorithm, which has the lowest sensitivity to atmospheric effects. For high concentration sea ice: The Bristol and the TUD algorithms are better. The latter uses 85 GHz information, which has higher resolution but only available since 1991. Bristol is therefore the baseline and TUD will be computed when possible.

At low ice concentrations atmospheric errors are important, but as the ice concentrations increase, uncertainties in emissivity dominate. The tie points for the algorithms were determined with error bars which propagate through the algorithms to give uncertainty estimates in the retrieved ice concentrations. The tie points were dynamically determined to reconcile the differences between sensors and also the natural seasonal and inter-annual variations in the ice signatures. The products of the reanalyses will be Level 2 fields – with one file per orbit - and two daily Level 3 fields for the polar regions, in the EASE grid, for each sensor. This joint reanalysis project is scheduled to start in June 2007, with preliminary SSM/I data sets ready in September 2007, followed one month later by the SMMR retrievals. The final data sets are planned to be released in March 2008.

5 Session 3 Diurnal Variability

5.1 Diurnal variability introduction (see DV-WG report): *C. Merchant*

Merchant introduced the session noting that a new mini agenda had been developed together with the DV-WG members to link the DV session to the GHRSST-PP breakout group. The main issues for the DV-WG are:

- Understanding how to improve L4 analyses by accounting for DV
- Resourcing DV studies
- Use of opacity fields;
- Discovery and use of new data sets
- Central or distributed DV estimation;
- Communications (TWIKI, meetings, GHRSST-PP web pages etc);
- ALADIN+ data set and its revision

Merchant presented several example DV data sets where different satellite data sets are used to consider the spatial and temporal variability of DV events based on differences from a previous L4 analysis field. For comparison NWP wind speeds are also shown. Figure 5.1.1 shows several DV events based on MODIS, AMSER-E SEVIRI, NWP (ECMWF) wind speed. Clearly seen are large DV magnitudes in excess of 3K over substantial areas of the ocean that correspond to low surface wind speeds. The character of each satellite data set is slightly different in terms of spatial resolution and the time at which the data were obtained. However, when observations are matched and co-located the results form each sensor are consistent in terms of DV magnitude. The largest DV magnitude was in excess of 6°C measured by the MSG-1 SEVIRI instrument in the North Sea.

Merchant then reviewed the progress of actions raised at the second DV-WG meeting held in Key Largo 28-30 March 2007 attended by 11 international participants. The group has developed an hourly high resolution data set (called ALADIN+) for the detailed study of Diurnal variability, a DV model inter-comparison project, the collection of dedicated in situ observations for the investigation of DV and verification of model predictions, conducted a review of foundation temperature definitions, a number of experiments have been conducted to test the application of DV tools and techniques in operational/large scale SST analysis systems, and an inter-comparison of NWP wind speeds has been discussed. Summary outcomes from this meeting and several other DV-WG meetings are available at https://arc.geos.ed.ac.uk/bin/view/DV/WgMeetingBrestNov2006.

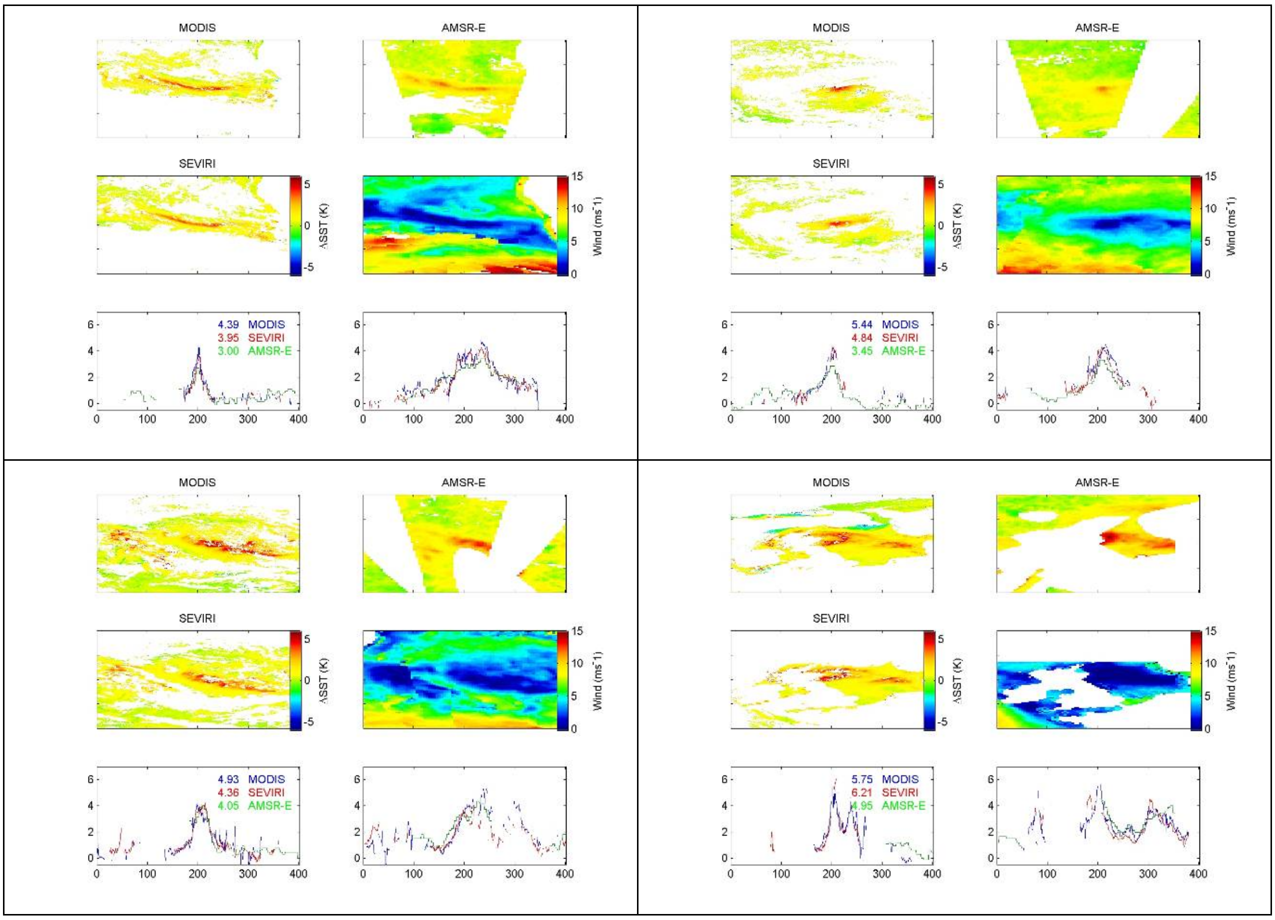


Figure 5.1.1 Several diurnal variability events captured by different satellite SST data sets referenced to a previous L4 analysis product. NWP wind speeds are also shown and the lower panel shows a transect (km) of observed diurnal variability magnitude (°C) for each sensor. The maximum amplitude is shown in colour.

5.2 In situ observations of diurnal warming in the skin layer, *C. L. Gentemann and P. J. Minnett, RSMAS, University of Miami, USA.*

Gentemann began with an assessment of what the SST measured from a satellite instrument represent as diurnal variability may significantly impact satellite measurements depending on the local environmental conditions and time of day. Figure 5.2.1 shows a schematic diagram of an idealised diurnal SST signal during a 24 hour period. Within this time window, satellite observations are obtained at 05:30 07:30, 08:30 and 13:30 (equator crossing times) leading to significant aliasing of diurnal variability. This has significant implications for the construction of climate data records.

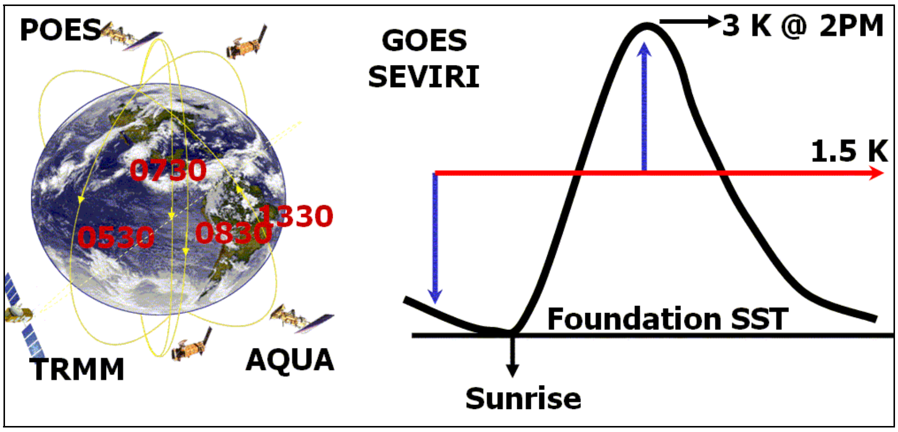


Figure 5.2.1 Schematic diagram showing the local equator crossing time of several SST measuring satellite instruments. The sampling of satellite data (excepting geostationary satellite instrument such as GOEAS and SEVIRI) within a typical diurnal signal leads to significant differences between satellite observations at the same location.

Gentemann noted that the diurnal temperature builds from the foundation temperature each day and but timing and amplitude of peak DV varies from day to day and place to place. There are few measurements of diurnal warming at the air-sea interface and most research / model development use in situ observations at depth or extrapolated from 0.5m or 1.0 m to the ocean surface. Figure 5.2.2 presents research cruise observations of DV derived from the M-AERKI interferometer which measures the SSTskin referenced to a trailing thermistor at 10cm depth. For 72 days during a cruise in the Gulf of California peak DV exceeded 4K.

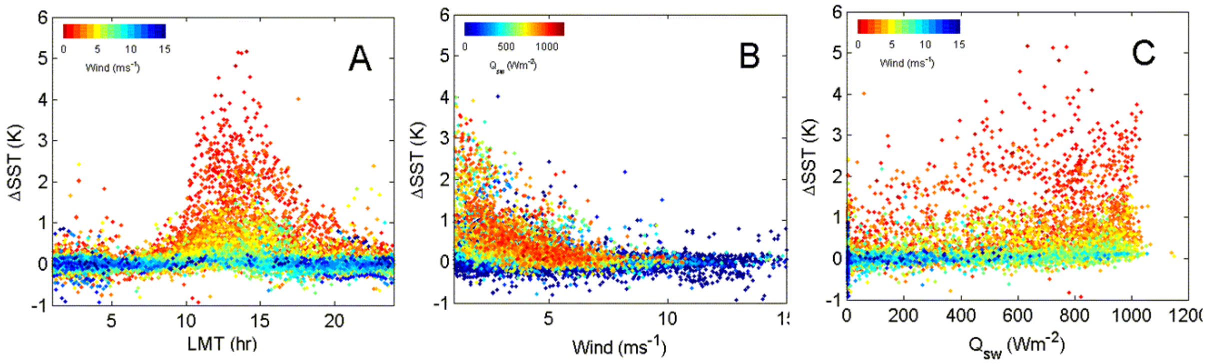


Figure 5.2.2 In situ interferometer measurements of diurnal variability from measurements made byu the M-AERI instrument made during a cruise aboard the R/V Melville in the Gulf of California DV measurements. 72 days with diurnal warming which was > 4 K. The peak warming is not at peak insolation times.

Gentemann then explained that this data set is extremely useful for developing and testing models and parameterizations of DV. Gentemann has been working with the Price-Weller (PWP) and Fairall 1996 version which derive DV and the Depth of the warm layer. Surface inputs are contained within the model which is simple to run. Static stability and mixed layer stability are enforced, but not shear layer instability. Once incoming (solar and LW) heat flux exceeds the outgoing heat flux (sensible, latent, LW radiation, the diurnal warm layer forms a separate layer within the mixed layer. Surface inputs of heat and momentum are confined within this layer. Using the 1D heat & equation of state Gentemann determines the diurnal heating at the surface. The model requires that the bulk Ri to be 0.65, to determine the depth of the warm layer. Structured dimensionless temperature profiles within the warm layer can then be derived See Figure 5.9.3). The aim of the work is to develop a model to replicate the data. The basic Fairall model has been modified to include a 9-band absorption system together with dissipation of heat and momentum. The dissipation values have been determined from M-AERI data. The model is called Profiles of Surface Heating (POSH).

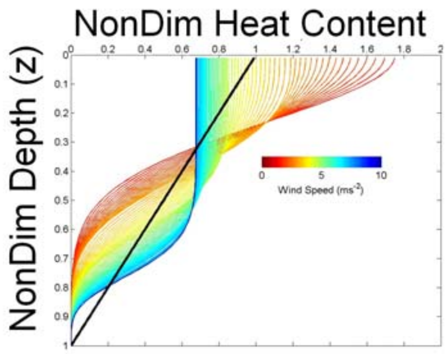


Figure 5.2.3 Dimensionless profiles of diurnal variability (as a function of heat content)used by the POSH model.

Figure 5.2.4 shows a comparison between several models and parameterisations of diurnal variability forced with high resolution cruise data sets. Observations are shown in blue (M-AERI SSTskin and 10cm SSTdepth observations).Only the POSH model is able to capture the variability seen in the observations. Shown below is the depth f the heated layer presented as a profile at regular time-steps showing the penetration of the warming over time and its variability.

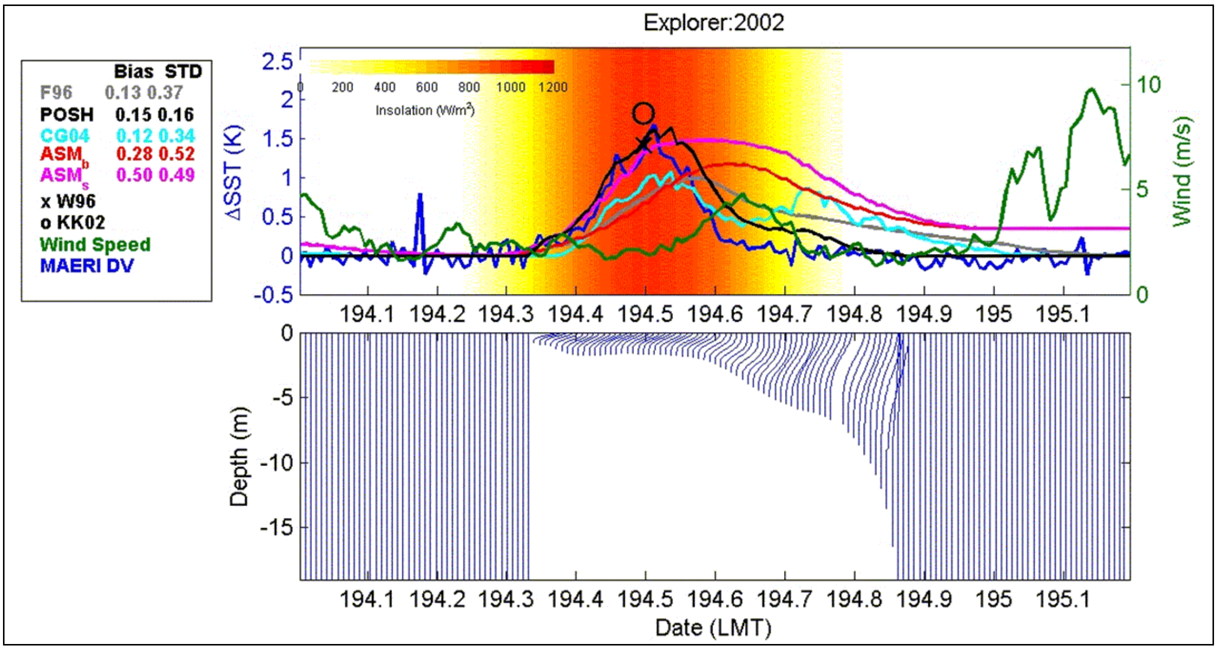


Figure 5.2.4 Time series of diurnal variability predicted using various parameterisations together with observations. Solar insolation is shown as graduated shading. Lower panel shows the predicted profile of warming derived from the POSH model.

Gentemann concluded that

- The variability in warming and total daily heat available from the surface are not well represented by a single point such as the Kawai and Kawamura 2002 or Kawamura 1996 models.
- The Gentemann2004 (CG04) model has largest errors in the late afternoon or evening when there is a sudden drop in wind speed. Diurnal warming is then over estimated by CG04 model
- The Fairall 1996 (F96) model is too small and tends to overestimate warming in afternoon (due to the accumulation of heat)
- POSH model responds rapidly to the onset of warming and decreases realistically in afternoon. Additionally model returns information on warming profile within the warm layer
- Accuracy of CG04 model indicates that it is useful, especially for polar orbiters w/ 2AM/PM local equator crossing time while POSH more useful for geo-stationary satellites, understanding of intra-day variability, and vertical structure.

The new POSH model has least error of several models compared to 72 days of M-AERI DV and provides vertical structure of diurnal warm layer. POSH should be able to resolve large DV events better by integration of surface heat and momentum fluxes and further work will be completed in the coming months lo look at this issue.

5.3 The GHRSST-PP ALADIN DV database, *P. LeBorgne, Meteo France, France.*

LeBorgne explained that in order to study diurnal variability the GHRSST-PP DV-WG had decided to set up a dedicated data resource of high space and time resolution satellite and NWP model output data. The database domain is 35N-55N; 11W_17^{E} at a resolution of 0.1° latitude x longitude as shown in Figure 5.3.1.

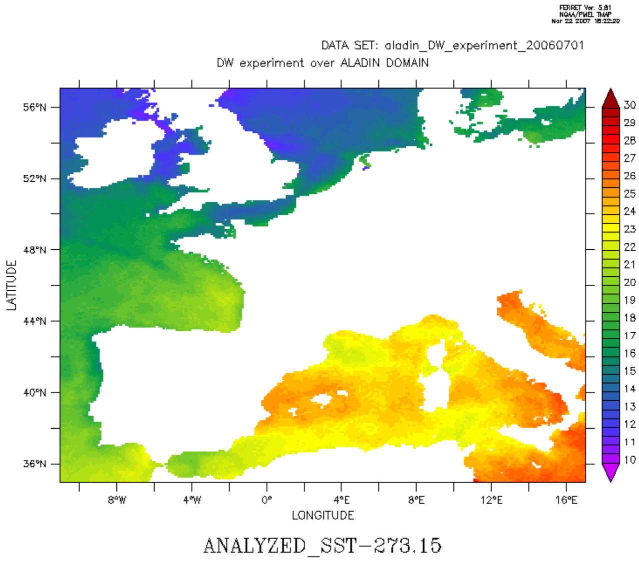


Figure 5.3.1 Domain of the Aladin+ Diurnal variability database

The database contains daily data files for a 6 month period starting from the 1st April till the 30th September 2006 including the following hourly variables

- ALADIN NWP outputs (U_wind, V_wind, net_ssi, net_dli, latent_heat, sensible_heat)
- ECMWF outputs (as above excepta t synopotic times 0,6,12,18hrs Z)
- microwave wind (speed, time, origin)
- dt_analysis (DT, error)
- reference SST
- MSG derived radiative fluxes (ssi, dli)
- MSG derived Saharan Dust Index (sdi)

The Meteo France ALADIN NWP model outputs have been available in this database have been provided by Météo-France on request of the Director of the GHRSST-PP Project Office (Craig Donlon) and are restricted to research activities within the GHRSST-PP. Access to the database is available though: ftp://ftp.ifremer.fr/ifremer/cersat/projects/ghrsst-dvwg/aladin-dw/. LeBorgne presented examples of the ALADIN+ data base fields and discussed their strengths and limitations (see Figure 5.3.2). Several wind speed data sets (instantaneous from satellite and integrated from NWP model) and Surface Solar Irradiance (SSI) data sets are particularly useful to understand the relative merits of each data type in diurnal variability research. It is not yet clear if instantaneous or integrated forcing is most appropriate. Also included in the data set is the Saharan Dust Index (SDI) which is still in development but is providing a useful improvement compared to the SST algorithms prior to the SDI. Biases for SEVIRI (seasonal components) are generally very low.

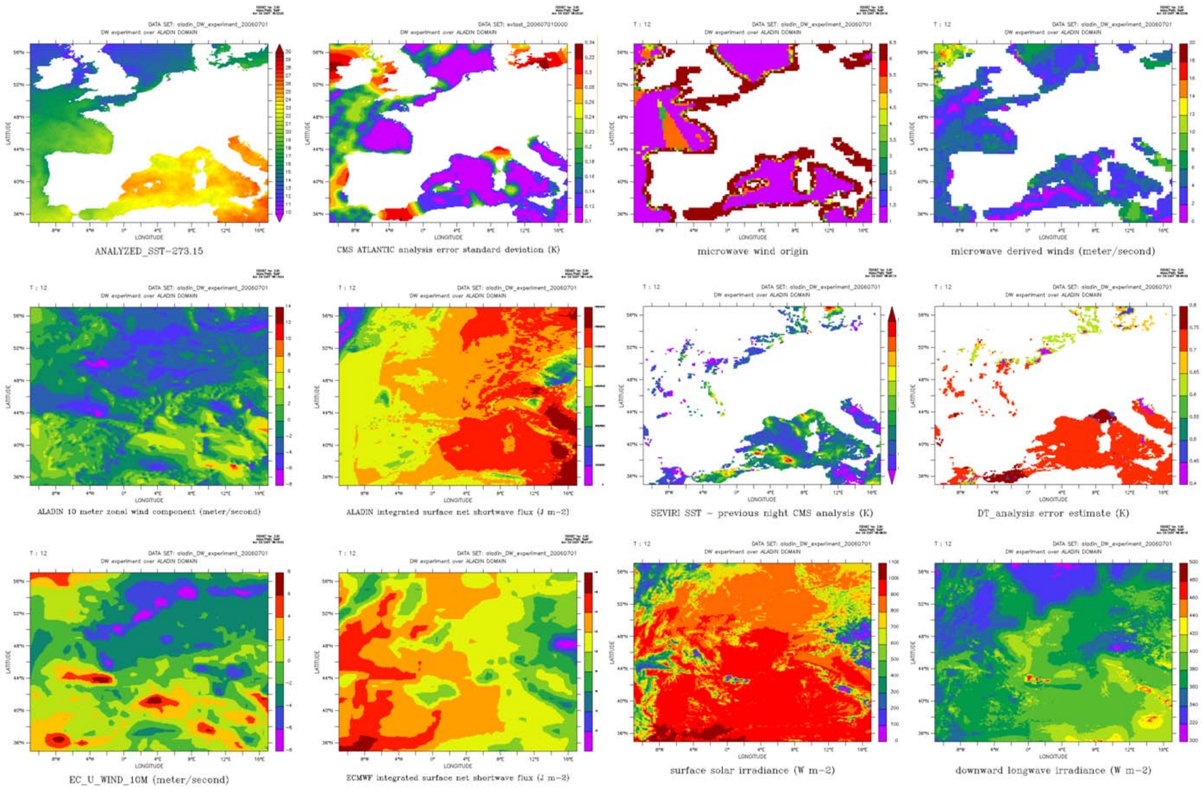
LeBorgne noted that the team want to analyse the database for the variation of DV in relation tyo all of the variables included in the data set particularly at low wind speeds. The NWP and fine grid scale of the baseline grid used in Aladin (0.1°) allows the investigation of very fine scale at low wind speeds (as seen in Figure 5.1.1.). A key observation is that moving from high to low resolution SST grids the a different peak warming signal is recorded the higher the spatial resolution the higher the peak warming signal.

LeBorgne concluded that there are limitations and strengths to the ALADIN+ DV database but that this was more than just a first step and the database is proving to be extremely useful. Over the coming months it is expected that more work will be done using the database and results presented at the next DV-WG meeting (planned for the AGU conference in March 2008) and at the GHRSST-PP ST meeting.

Following this presentation, the following actions were raised during discussions:

- The DV-WG should provide more content to the GHRSST-PP Web site on diurnal variability and the Aladin Database as there were such good results to report.
- The DV-WG should aim to link the university of Edinburgh web site to the GHRSST-PP web site for DV-WG activities' and ensure that reports from the International DV meetings are

prepared and circulated to the Science Team.



METEO FRANCE
Toujours un temps d'avance

Figure 5.3.2 Example fields within the ALADIN+ database Top L – to Bottom Right Analysed SST, Analysis Error, microwave wind field origin flag, microwave derived wind speed, NWP 10m zonal winds, integrated SSI (NWP), SEVIRI SST minus previous night SST analysis, DT_analysis error estimate, ECMWF 10m wind speed, ECMWF integrated SSI, SSI from SEVIRI, DLI (SEVIRI derived).

6 Session 4: Parallel Breakout groups (1)

BG-1: Data management

The Data Management Breakout Session focussed on a wide and open discussion of the major challenges facing the GHRSST-PP. The session was well attended including GHRSST-PP Science Team members and data management specialists from the BoM. The following key issues were discussed during the Data Management breakout session.

1) **Documentation.** There was general consensus that the level of GHRSST-PP documentation is low. A new set of revised and updated documentation needs to be developed from both a user and a producer perspective. Documentation should include not just technical recipes and formats but appropriate science documentation (or clear links to such documentation). GHRSST-PP should set up a review procedure to check that the documentation is useful and properly prepared and maintained. One clear request was to provide documentation that explains how to obtain GHRSST-PP data files.
2) **Use of Brightness Temperatures (BT).** Several members of the SST community have requested access to L1b brightness temperatures in L2P and other GHRSST-PP data products. The group noted that in principle, this is not a major technical problem but more of a political and data volume issue. BT data are useful for the AATSR data files and NAVOCEANO consider 11µm BT essential to understand the quality of SST retrievals. Others want to use the complete BT data set for radiance assimilation work. The group considered the idea of a L1P data set which would be the GHRSST-PP L1b data set holding all BT's in a common gridded netCDF data set. This was considered a useful approach so long as sufficient groups requested the data set to justify its production. At present only a few users are keen to access and use such a product. Furthermore, there will be political and data volume issues to consider. The group suggested a way foreword was to define an L1P product as part of the GDWS-v2.0 and to e3ncourage data providers to adopt that product specification in the future.
3) **The GHRSST-PP Matchup Database (MDB).** The group spent some time discussing the MDB system and how it related to the GDAC in terms of data content and responsibility. The MDB was evolving as a European component and given the large number of data records it was ,felt that the MDB does not need to have a strong interaction with the GDAC system. The MDB can be a stand alone system that needs further R&D to mature and to be properly recognised as the GHRSST-~Pp reference data set. It was agreed that the MDB should be described in the GDS-v2.0 but be a more flexible system in terms of the data content and extensibility of the database. This implies a more heterogeneous database (as described by JF Piolle) but this would make the system more useful in the long term. Clearly a minimum 'core' set of data must be specified in order to make the database meaningful and the current GDS-1.7 documentation was sufficient to start that process.
4) **SSES development and verification.** The group noted that SSES were the responsibility of a L2P data provider. However, in a real time system SSES must be monitored for quality using simple but effective tools as well as periodically updated in a re-analysis mode. The group noted that these were two related but distinct user requirements (SSES monitoring in NRT and SSES delayed mode production) that both relied on the MDB to do their task. Should the we MDB be split into a real time component and a reanalysis component? The conclusion reached stated that L2P data providers should maintain a database that is highly specialised to a given satellite sensor to generate the SSES in the first place and the role of the NRT MDB service is to check the consistency and quality of the provided SSES. For the Reanalysis, a separate database is really required that is based on the L2P data providers definitive SSES database. The GHRSST-PP MDB can be used as a backup but often, delayed mode processing of NRT SST data streams means that a completely different SSES is applied to the delayed mode data. As long as the GHRSST-PP MDB can store several versions of the same data this should not be a problem. One option discussed was to split the MDB development into two phases (NRT and RAN). The MDB will be delivered by the EU MyOcean Marine Core Service Project.
5) **Interfaces.** NetCDF CF-1.0 (moving to v1.1) forms the basis for GHRSST-PP data interfaces. There is a need in GDS v2.0 to integrate the currently separate metadata feeds (MMR feeds) into the netCDF headers. This would be done accorsing to the new ISO 19115 metadata geospatial standards. This would be a much clearner implementation of the GHRSST-PP than the current one with many small files that are not hard linked to each other.

6) **How will EUR-GDAC interface with LSTRF**. As the EU develop the MyOcean project there is an opportunity for JPL and IFREMER to strengthen the GDAC service (the MDB will be in the EU, the MMR will be in the USA and the LTSRF will be common to both). Some data policy issues must be clarified in the next 18 months in the EU particularly the GMES data policy regarding the redistribution of data sets. The group was not in a position to comment on these issues as they were evolving. A decision to follow up at the next GHRSST-PP ST meeting was made. However, it was clear that interfaces to the LTSRF must be established to allow both the USA and EU DAACS to interface to the LTSRF – particularly with the introduction of GDS-v2.0. Donlon noted that the MyOcean project is not likely to start before the mid-end 2008 and there will be time to plan the system in late 2008. It was agreed that the basic idea is to have a GDAC on both continents that are hooked up in near real time to each other to provide a backup and regional services (EU will be in multiple languages whereas the USA is only in English). Finally there was some discussion on the need to review the need for registration and any policy relating to this.

BG-2: Diurnal Variability Working Group

The diurnal variability (DV) breakout session was comprised of two short presentations and discussions on topics including

- objectives for creation of a L4 DV analysis
- use of opacity fields in diurnal warming estimates
- new data sets for additional diurnal warming studies, and
- methods for producing L2P DV estimates.

The first presentation was by Sam Lavender on how ocean colour products might potentially assist in diurnal warming estimates. The group was elected to explore this issue further, the first step being inclusion of ocean colour products in the ALADIN+ data set (see section 5.3 of these proceedings). Following this up at the subsequent DVWG in Edinburgh (September 2007), it was shown that this was a fruitful approach for identifying and quantifying the links between colour and diurnal variability (Merchant et al, 2008).

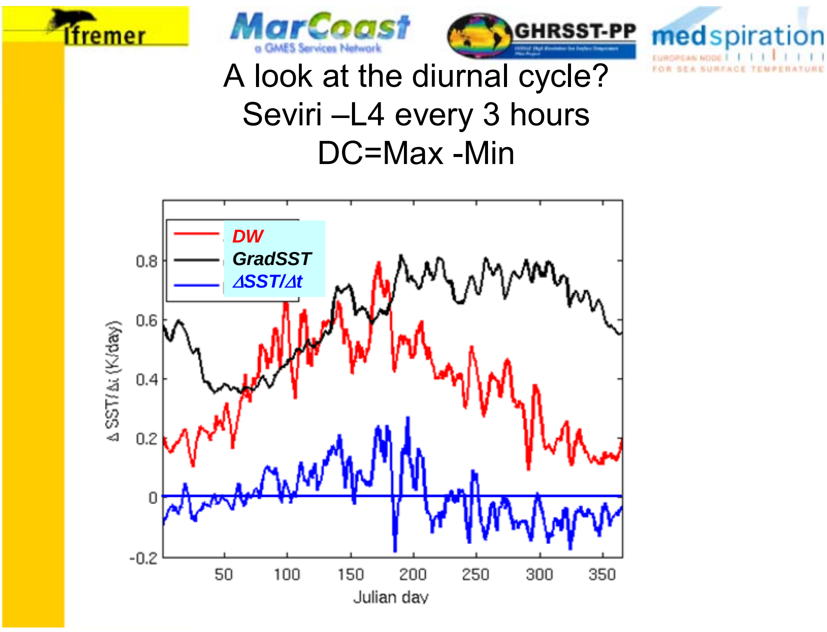


Figure BG-2.1. Diurnal warming and daily change in foundation temperature observed using SEVIRI 3-hourly SSTs and an L4 foundation SST analysis. DW is peak diurnal wamring amplitude from SEVIRI. Delta-SST/delta-T is the daily rate of change in foundation temperature.

The second presentation was by Jean Tournadre who examined use of L4 fields as a basis to analyze diurnal warming in individual satellite data. Specific results included counts of days with warming in excess of specified thresholds. A key factor highlighted in the talk was the issue of how to treat the foundation temperature in the presence of cooling at night and other seasonal changes. This point was illustrated by Figure BG-2.1, in which there is seen to be a seasonal relationship between daily change in foundation temperature (delta-SST/delta-T) and peak amplitude of diurnal variation (DW). This is not a surprise – the heat involved in diurnal warming is more-or-less the same heat that warms the mixed layer during spring and summer, for example – but this analysis was a very useful confirmation of the inter-relationship from a real analysis.

In the discussion portion of the session, the first question posed was what sort of L4 DV analysis was desired. A baseline proposal was to analyze foundation temperature plus an hourly estimate of the evolution of the skin temperature relative to the foundation. (This was generally agreed to be preferable to analyzing the more transient skin temperature.) Under this concept, the diurnal warming at the surface is

$$\Delta T_{DV} = SST_{skin} - \Delta T_{skin-effect} - SST_{foundation}$$

where the skin effect looks to be well constrained (at least at for low insolation) as a function of wind speed – see Figure BG-2.2 contributed by Chelle Gentemann. The concept of L4 analysis comprising foundation SST plus hourly skin estimation was later ratified at the Edinburgh meeting of the DVWG in September 2007. It was noted that both model and observational estimates (with complex and variable errors) of the skin-foundation difference may be available at irregular times during the day (dependent on cloud cover, for example), and that how actually to achieve an hourly L4 analysis is a major research question; nonetheless, the DVWG feels the challenge is tractable and indeed, significant progress towards this is underway.

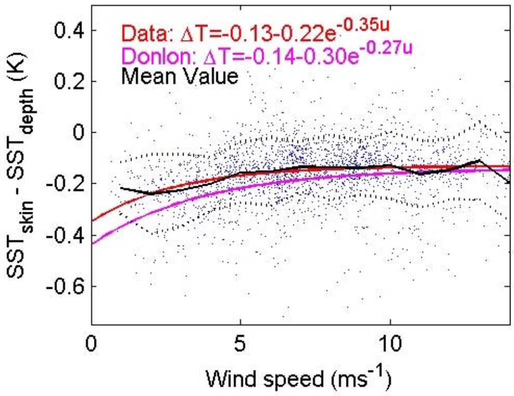


Figure BG-2.2. The (night-time) skin effect as estimated by the difference, M-AERI SST_{skin} minus TSG SST_{depth}, as a function of wind speed. The least-squares fit to the data is shown in red, the mean and standard deviation of the data, calculated at 1 ms^{-1} intervals, are respectively shown by the black solid and dotted lines.

Part of the challenge is that the "classical" diurnal warming curves (smooth, with a 2pm or 3pm peak, obtained by averaging over many observed cycles) describe only a minority of real cases, since sub-daily wind variability is a major control on hourly time scales. This is illustrated, for example, by the distribution of peak times, from Chelle Gentemann, in Figure BG-2.3. It is based on 72 days with diurnal warming identified from a data set of M-AERI cruises. The peak warming is distributed throughout the day and early evening.

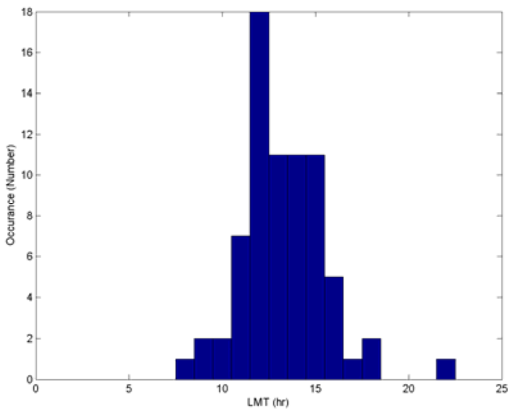


Figure BG-2.3. Histogram showing distribution of the daily maximum diurnal warming local mean time for 72 days with diurnal warming.

Possibilities for generating new composite data sets (with geostationary SST observations and high resolution numerical weather prediction (NWP) fields similar to the existing combination of SEVIRI and ALADIN data) for added diurnal warming studies were considered next. While products based on GOES observations are subject to potential satellite calibration and channel availability issues, the group decided to further explore opportunities particularly for the Gulf of Mexico region. Initial discussions were targeted to include the ALADIN group and Jim Cummings.

Regarding the L2P DV estimates, the group discussed whether computation should be centralized or left to individual L2P providers (see Figure BG-2.4). A centralized approach would simplify matters for L2 providers, use a single model and allow for a more complicated approach. A distributed approach could provide for a beneficial diversity of approaches but models might be constrained to be simpler. Issues on timeliness and burdens on the GDAC were discussed but no clear consensus was reached – partly because these issues interact with the question of the recommended method to be used.

Alternative practical strategies

- Centralized DV estimation
  - \+ uniformity across L2P
  - \+ updateable
  - \+ tolerant of complex DV model (L4)
  - \+ easy for L2P producers
- Requires operational centre

- Distributed DV estimation
  - \+ diversity of approach
  - – duplication of effort
  - – needs simple DV model
  - – extra investment by producers
- No need for new centre of activity

Figure BG-2.4. Summary of advantages (+) and disadvantages (-) of alternative practical strategies for DV estimation within GHRSST.

Final activities included a review of actions for the DVWG and agreement that the next group meeting would be held in Edinburgh in September 2007, just prior to the joint Eumetsat/Am Met Soc meeting. A further DVWG meeting took place in March 2008.

REFERENCES

Merchant, C. J., M. J. Filipiak, P. Le Borgne, H. Roquet, E. Autret, J.-F. Piolle, and S. Lavender (2008), Diurnal warm-layer events in the western Mediterranean and European shelf seas, Geophys. Res. Lett., 35, L04601, doi:10.1029/2007GL033071.

7 Session 5: Sensors and Single Sensor Error Statistic (SSES) formulations

7.1 Introduction, *P. LeBorgne, Meteo France, France.*

LeBorgne began with a review of the aim for Single Sensor Error Statistics (SSES) which is to:

> *Provide the users with the best estimate of the error (bias and standard deviation) associated with any delivered SST value*

To date there have been several schemes that are loosely coordinated through the GDS v1.5 but these are varied and mean different things to different people,. GHRSST-PP needs to focus on generating a consensus on the way forward for SSES. For example, what is the SSES referenced to? When a user applies the SSES to L2P observations do they generate an SSTskin or an SSTsub-skin? In the case of the AATSR and MODIS it should be an SSTskin and for all others an SSTsub-skin.

In terms of SSES methods SSES are nearly all derived from a matchup data base of varied quality and construction (i.e. all different). SSES developers need to be mindful of generating meaningful statistics at the cost of loosing regional or local details for significant errors (although this is largely a function of limitations in MDB sampling of the entire error space). The main issues are related to how the MDB is partitioned. The GDS v1.5 suggested that partition should be made according to the proximity_confidence values although this was just a first approach and several other schemes also exist including:

- according to proximity confidence (GDS-v1.5) as in the case of AATSR, SEVIRI, METOP teams
- as a hypercube developed and used by the MODIS/MISST team
- based on 11 µm transmittance as used by the GOES team
- using a confidence scale based on the cloud mask used by NAVOCEANO
- by calculation using environmental conditions (wind, SST etc) as developed by REMSS.

Figure 7.1.1 shows a table of current SSES for a variety of L2P data streams classified according to proximity_confidence values. Highlighted are the exceptions for GDS-v1.5 which suggest that more discussion is required to understand what each value is supposed to mean.

	Proximity Values found	SSES vs pcv	0	1	2	3	4	5	6
AATSR	0-5	Fix.	Na	Na	0.19 *0.60*	0.19 *0.30*	0.19 *0.30*	0.19 *0.30*	Na
AVHRR/G	3-5	Var.	Na	Na	Na	-0.35 *1.5*	0.24 *0.76*	0.01 *0.42*	Na
GOES-11		Var.	Na	Na	0.18 *0.58*	0.19 *0.58*	0.19 *0.58*	0.26 *0.59*	
MODIS	2-5	Var. for 4 & 5	Na	Na	-17.8 *15.8*	-1.75 *1.85*	0.04 *0.65*	-0.09 *0.35*	Na
SEVIRI	1-5	Fix.	Na	Na	-0.30 *0.64*	-0.02 *0.60*	-0.01 *0.40*	0.04 *0.38*	Na
METOP (night)	1-5	Fix.	Na	Na	-0.60 *0.73*	-0.37 *0.72*	-0.1 *0.47*	0.01 *0.31*	Na
AMSRE	1-4	Var.	Na	0.08 *0.74*	0.06 *0.78*	Na	0.07 *0.74*	Na	Na

Figure 7.1.1 Present status of SSES for different L2P data streams in relation to confidence values (valid for May 2007).

LeBorne noted that all groups use a confidence scale of values 0-6 (within the framework of GHRSST-PP although no-one uses a confidence value of 6 (cool_skin). Confidence value 2 data sometimes include errors and sometimes not indicating a divergence of interpretation for this particular confidence value definition. For the case of AMSRE there are clear differences as the SSES logic is different and there is no clear relationship between confidence and errors. GOES 11 there appears to be no hierarchy in the errors values as a function of proximity confidence. For the EU sensors there is a continuous distribution of errors which acknowledges that SST assigned confidence values of 2 include potentially useable data (depending on the application) but with significant issues. Clearly there is a need for each of the SSES groups to agree on a commonly understood set of definitions for SSES: what they mean, what the reference is, how they should be applied, what the quality scale is etc.

LeBorgne noted that some issues are quite detailed and will required close collaboration for example SSES groups should eventually reach agreement on what constitutes a valid matchup between satellite and in situ data within an MDB. Should drifters and moored buoys be used together with ships and ARGO floats? Can L4 analyses or other satellite data (e.g., AATSR) be used as a reference for the match up? At present and with only a prototype GHRSST-PP central MDB system this remains a challenge.

Part of this challenge can be met by developing consensus documentation on the SSES and how they are used by each group. This is also required by the user community in order to work with the SSES in the first place. The group agreed that there is no need for uniformity but there is a need for documentation.

LeBorgne noted that there is a need to agree on a common scale and how errors relate to the confidence_value (or Quality) scale. At present there is no single agreement on this issues as some groups have decreasing errors with decreasing quality scale values and others the opposite! We should aim for some homogeneity and agree on a common quality scale. The group agreed the need for a quality scale and the need to present and educate the user community to use the common SSES scale.

Leborgne concluded with a summary outline of the session which should include a summary of the SSES schemes used by various groups to review of the present practices followed by a plenary discussion. The following groups were asked to provide a short summary of their SSES scheme.

- MODIS (B. Evans)
- GOES (A. Harris)
- NAVOCEANO (D. May)
- REMSS (C. Gentemann)
- AATSR (G. Corlett)
- EUMETSAT (P. Le Borgne)

7.2 Improving the SSES inputs to AATSR L2P Products, *G. Corlett, University of Leicester, UK.*

Corlett began with a summary description of the ENVISAT AATSR noting the dual view, stable cooled detectors, 2-point blackbody calibratio0n, 500km swath and 1km Field of View. The SST retrieval algorithms used by the SSTSR are developed as SSTskin outputs using radiative transfer simulations and within these algorithms the 3.7µm channel dominates retrievals when it is used (3 channel). Four Possible Retrievals are available from the AATSR:

- Nadir 2-channel **N2**
- Nadir 3-channel **N3**
- Dual 2-channel **D2**
- Dual 3-channel **D3**

Corlett noted that the current SSES scheme used by AATSR is based on AVHRR proximity_confidence_value (PCV) approach (distance to cloud, minimum climatology) as shown in Figure 7.2.1 and described in the GDS-v1.5. While this is a sensible first approach it is not really applicable to the AATSR for a variety of reasons.

The GDS-v1.5 SSES scheme based on heritage of nadir-view only IR sensors (AVHRR, SEVIRI) in which it is assumed that cloud contamination (either sub0-pixel or cloud that failed to be flagged in the cloud clearing algorithm) is biggest source of error. Cloud in a nadir view will appear at a lower brightness temperature than the surface and thus gives lower estimate of surface SST. An obvious test is then to compare the proximity of pixel [i,j] to the nearest flagged cloud and compute the difference in SST from a minimum SST climatology. Results are stratified by IPCV on a scale of 0 (bad) to 5 (excellent) giving an estimate of contamination. Statistical errors can then be assigned based on an MDB .where the IPCV value is used to stratify the MDB for a finite period.

Threshold values for DT_min, (K)>				
> IPCVThres1	3 (Suspect)	3 (Suspect)	5 (Excellent)	
< IPCVThres1	2 (Bad)	2 (Bad)	4 (Acceptable)	
> IPCVThres2	1 (Cloudy)	2 (Bad)	4 (Acceptable)	
< IPCVThres3	1 (Cloudy)	(Cloudy)	6 (Suspect, Cool skin, upwelling, riverine inputs etc.)	
	IPCV_D1 (close)	IPCV_D2 (near)	> IPCV_D2 (far)	Distance from nearest cloudy pixel (km)

Figure 7.1.1 The GDS-v1.5 Infrared_Proximity_Confidence_Value (IPCV) SSES description.

For AATSR this scheme does not exploit two important factors:

1) The dual-view means we have two goes at identifying cloud contamination; AATSR cloud screening is over cautious. In reality cloud contamination is small in AATSR, it is clear sky identified as cloud that is the problem!
2) The dual-view retrieval means that cloud in the forward view gives a ***warmer*** estimate of surface SST!

The outcome of the current SSES scheme is that during night-time data are mostly flagged bad by the test to climatology. Corlett proposed to update the SSES scheme for AATSR using dual-nadir SST differences to identify cloud (and aerosol) contamination based on the experience of AATSR and results from AATSR validation program. This should give improved uncertainty estimates for operational users compared to the *ad hoc* SSES values used for the AATSR at present.

The AATSR team have used the dual minus nadir SST difference as a way to detect for aerosols and cloud (or claerosol). In a normal atmosphere the distribution is normal but when claerosol is present the distribution has obvious tails. The team noted that these effects were related to the flight direction of the AATSR and also appeared at the edge of clouds as shown in Figure 7.1.2. In this image, the AATSR is flying from lower right to top left. The dual-nadir difference is cold (blue)on 1 side of cloud over large areas and warm on the other side with more speckle. The warm edge is due to forward view data being contaminated by cloud (note that the forward view has an effective FoV of 4km compared to a 1.1km FoV at nadir) and a clear nadir view. On the other side of the cloud back radiation from the cloud base is reflected at the sea surface into the nadir view causing an apparent warming. Thus the dual-nadir difference appears to offer the basis for a new AATSR SSES scheme

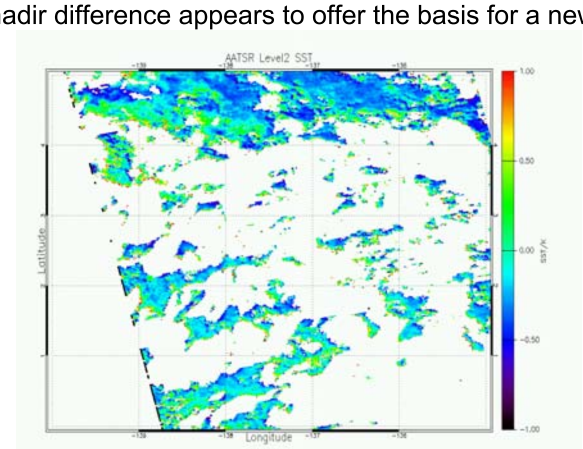


Figure 7.1.2 Example AATSR dual-nadir SST difference map showing the location of large differences is correlated with the location of cloud (shown as white) edges and the flight direction of AATSR (from bottom to top left.

A new set SSES scheme and values has been developed based on these results and a series of tests performed to look for improvements. Figure 7.1.3 shows a comparison of the old SSES scheme compared to the new SSES scheme. Clearly seen in this figure is a significant shift of values from the bad to good category (as expected as the AATSR cloud screening is over-cautious). The main conclusion is that the current PCF scheme is not looking at claerolsol and is not appropriate to AATSR.

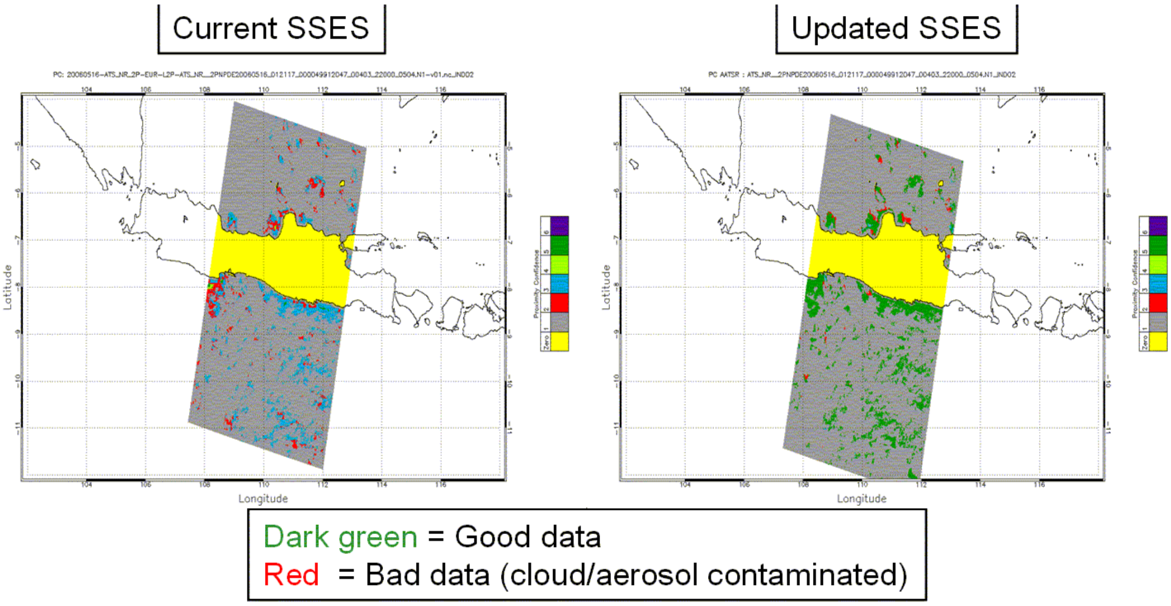


Figure 7.1.3. Updated AATSR SSES using D-N Differences (Day time) in Western Mediterranean. Note: Increase in good data (backed-up by validation); change in location of bad data

The new AATSR SSES scheme correctly picks out the edge of cloud effect and the PCF scheme is now much more representative. The new scheme uses a 3 sigma test with fitted distributions and thresholds and really only needs 3 confidence (quality) values (not 5). Coreltt noted that the scheme is not yet complete (still have static biases that do not take into variability and need regional estimates) and recommends that the nadir SST and the AATSR NR product confidence word is included in the AATSR L2P files as standard within the experimental fields.

Corlett concluded that a new SSES scheme has been developed for the AATSR although more work is required to refine the final numerical values used in the scheme. The next part of the work would be to data mine appropriate proximity confidence thresholds to use for the stratification of the AATSR MDB. However, issues remain above 60°N &S as little (no?) validation data are available to define an error statistic. Other issues to consider include the effect of wind and sea state on the SST in the 2 minutes between the nadir and forward views are made. Finally Corlett noted that there has been some resistance within the AATSR community to the inclusion/release of multiple SSTs (dual- nadir differences) and brightness temperatures for general use.

Some discussion on the quality of the various AATSR algorithms commenced. In particular, Corlett noted that the triple window daytime SST from AATSR was a very good SST and that there was more data available compared to the dual view data as the cloud screening was better in nadir only retrievals. The Science team were keen to see this data included in an L2P product and requested Corlett to develop an example plot showing dual and nadir 3 channel SSTs mixed together and to devise a flag system allowing users to select to use dual only, nadir only or both types of SST data.
Gary Corlett to produce and image set of N2 + N3+D2+D3 merged AATSR images to investigate best L2P GDS-v2.0 product (using experimental fields) to provide to users for review by ST using email

7.3 The MODIS Hypercube. *Bob Evans and Kay Kilpatrick, RSAM, University of Miami, USA.*

The MODIS SST hypercube is a multi-dimensional look up table of SST retrieval uncertainty, bias and standard deviation, determined from comprehensive analysis of the MODIS Match-up Data Base (MDB). The MDB includes contemporaneous, co-located satellite brightness temperature, in-situ buoy and radiometer SST, environmental 'observations' from analyzed model or satellite observed fields, satellite viewing geometry, time and location.

A series of quality tests is applied to each pixel during processing of the MDB data to identify cloud and dust aerosol contaminated retrievals and assign each pixel to one of several quality levels (0-3). After grouping MDB records by quality level the dataset is partitioned into a multi-dimensional array with the following 7 dimensions:

- time by season (4)
- latitude bands (5 steps in 20 degree from 60S to 60N)
- surface temperature (8 increments in 5 degree steps)
- satellite zenith angle (4 increments)
- brightness temperature difference as a proxy for water vapor (4 intervals for 4 um and 3 intervals for 11-12 mm SST)
- retrieved satellite SST quality level (2 intervals ql==0 and 1)
- day/night selection (2 intervals).

The bias (satellite-in situ) and standard deviation are then computed for each element. This hypercube look up table is then used during processing to predict the uncertainty bias and standard deviation of the retrieval. The scheme requires a large MDB having sufficient geographic, seasonal, and viewing geometry to capture statistical performance of both algorithm and sensor. At present the MDB's for MODIS are:

- TERRA 7+ years 2.6 million records
- AQUA 5+ years 2.4 million records

Unlike your stockbroker, the hypercube approach assumes that the past does predict future performance and that the types of errors can be classified and these characteristics remain relatively stable.

Determining partitions in the hypercube requires understanding of what drives retrieval performance and a good reference fields for exploring the relationships. The MDB contains 130 satellite, in situ and ancillary fields that are used to explore the SSES by recursive partitioning. Understanding algorithm strengths and weaknesses based on the following issues:

- The MODIS SSES are referenced to in situ bulk measurements but the MODIS instrument measures skin temperature.
- Diurnal heating effects means that the measurement of the error will behave differently at night versus day-- a natural split in the cube.
- Water vapor and aerosols can impact the uncertainty estimates for MODIS this is captured by proxy in the channel BT differences (dBT).
- The quantity and distribution of water vapor, type of aerosol change as a function of latitude and time of year. The relationship between dBT the SSES also changes as a function of scan angle and surface temperature.

Through recursive partitioning the dataset is split into smaller bins along the 7 dimensions while still retaining a sufficient number of records within a bin to produce stable and meaningful statistics (>50 records/bin). Some regions of the hypercube will always remain unpopulated generally when the bin is non-physical e.g. It's never 30 C @ 60N. Bins that contain insufficient records due to a lack of in situ buoy measurements (generally at high latitudes during winter months) are filled with the global SSES average as the default.

Evans concluded that the Hypercube approach will be further developed and the SSES schemes defined at this meeting (in terms of quality scale) will be followed by the MODISA team.

7.4 Three-way statistics for uncertainty estimation, *A. O'Carroll, Met Office, United Kingdom.*

Craig Donlon presented this work on behalf of Anne O'Carroll. The motivation of this work is to understand the absolute error associated with a satellite measurement using co-locations of three independent SST observation types to estimate the standard deviation of error on each observation type. The SST observations used included AATSR, in situ and AMSR-E data. The method assumes that the errors of each data source are not correlated and an attempt is made to validate this assumption at the end of the presentation. The approach could form the basis for a GHRSST-PP unified SSES scheme where all satellite data and in situ data are used to define absolute errors using multi-way statistics.

O'Carroll noted that there were significant differences between each of the data types used in the study. The AATSR SST data were derived from AATSR brightness temperature data provided on 1/6th degree resolution in near-real time converted to a 'bulk SST' using the Fairall (1996)scheme. Both moored and drifting buoys used, downloaded in near-real time from the GTS and quality controlled by in house tools were used. Finally ¼° AMSRE-SST spatial resolution sub-skin sea surface temperature data from remote sensing systems formed thje last data set.

AATSR SSTs have been routinely collocated to buoy SST observations on a weekly basis in near-real time since September 2002. In this study, the AATSR/buoy matchup database for 2003 was used. For each collocated AATSR/buoy matchup a corresponding AMSR-E SST matchup was found. Globally, differences between AATSR and AMSRE are less than 0.5K. However, at around 45ºN the AATSR SSTs are cooler than the AMSR-E SSTs by up to 2K; whilst at around 45ºS the AATSR SSTs are warmer than AMSRE SSTs by up to 2K which requires further investigation.

Daily differences were then calculated and an overall yearly mean of differences and standard deviations between:

- AATSR bulk D3n SST – AMSRE SST
- Buoy – AMSRE SST
- AATSR bulk D3n SST – buoy SST

Eight different experiments performed where certain observation and/or matchup criteria is varied to investigate whether the assumption that the errors are uncorrelated is valid which are summarised in Table 7.4.1

Table 7.1.4 Summary of 8 different observation matchup criteria between in situ, AMSRE and AATSR used in this study.

Expt	Region	AATSR/buoy matchup cutoff period (hrs)	Buoy type
1	Global	3	Moored & drifting
2	Global	3	Moored
3	Global	3	Drifting
4	Global	1	Moored & drifting
5	0º to 90ºN; 0º to 180ºW	3	Moored & drifting
6	90ºS to 0º; 0º to180ºE	3	Moored & drifting
7	As Expt 1, but AMSR-E SSTs interpolated to AATSR location		
8	As Expt 2, but AMSR-E SSTs interpolated to buoy location		

The theoretical basis for the analysis assumes uncorrelated errors. Let the error in observation Xi, of type I be expressed as

$$Xi = XT + bi + Ei$$

where XT is the true value of variable X, bi is the bias (mean error) in the observation and Ei is the random error in the observation. Assuming the errors in the 3 observation types are uncorrelated we can say that:

$$sd^2(a,b) = (\text{error in } a)^2 + (\text{error in } b)^2$$
$$sd^2(a,c) = (\text{error in } a)^2 + (\text{error in } c)^2$$
$$sd^2(b,c) = (\text{error in } b)^2 + (\text{error in } c)^2$$

therefore:

$$(\text{error in } a)^2 = \tfrac{1}{2}(sd(a,b)^2) + \tfrac{1}{2}(sd(a,c)^2) - \tfrac{1}{2}(sd(b,c)^2)$$

The analysis is actually more robust if more than 3 data types are available (3 is the minimum required). Sampling of the data is also important and the samples must be equal min all cases (i.e. all 3 observations must be available at the same time and location (to within acceptable limits).

The calculated error for each observation type (experiment 1) were computed as

AATSR bulk D3 SST = 0.16K
Buoy SST = 0.23K

AMSR-E SST = 0.42K

And similar trends were seen for the other experiments, ranging:
0.12K <= error in AATSR SST <= 0.16K
0.22K <= error in buoy SST <= 0.27K
0.42K <= error in AMSR-E SST <= 0.51K

O'Carrol concludes that Standard deviation for AATSR bulk (D3) SST observations very small at 0.16K, followed by 0.23K for buoys and 0.42K for AMSR-E SSTs. Varying the co-location criteria produces similar values of error throughout the experiments for each observation type. Based on this work, it is concluded that the assumption that the errors between AATSR, in situ and AMSRE used in this analysis are not correlated is valid.

Some discussion followed hit presentation which described a method that could be used for all satellite sensors within GHRSST-PP. This would require the GHRSST-PP MDB to be configured in such a way as to easily allow the extraction of 3, 4 and 5 way statistics for different sensor combinations. The MDB could, if sufficient data were available, be stratified according to quality levels and SSES derived for application in NRT. The Science Team concluded that the approach should be considered further and urged the development of the GHRSST-PP and its configuration for 3-way statistical error derivation.

8 Session 6: Parallel Breakout Groups (2)

8.1 Report from the Single Sensor Error Statistic (SSES) breakout group *(P.LeBorgne and H. Beggs)*

Single Sensor Error Statistics (SSES) include a bias and a standard deviation attached to each L2P data product SST value. SSES represent the L2P data provider's best estimate of the error associated with the delivered SST at a pixel level.

The main issues about the present status of the Single Sensor Error Statistics (SSES) are the following:

- SSES should be derived from a commonly agreed reference
- There is often a lack of documentation about the way SSES are determined as well as the way to use them
- There are inconsistencies between SSES and the associated the quality level (formerly proximity confidence level)

The first part of the session was dedicated to a review of the present practices, through short presentations as follows:

- MODIS (B. Evans)
- GOES (A. Harris)
- NAVOCEANO products (D. May)
- REMSS products (C. Gentemann)
- AATSR (G. Corlett)
- EUMETSAT products (P. Le Borgne)

Conclusions
The following conclusions were established following extensive discussion:

1) SSES must be derived using in situ buoy measurements as a reference. Currently GHRSST-PP MDB matchup criteria (derived from NAVOCEANO best practice) are +/- 25km and +/- 12 hours. It is expected that these broad limits would be treated as an absolute upper limit and in practice, more stringent matchup criteria are recommended.
2) There is some debate over which in situ data are blacklisted due to a variety of issues and should not be used. The group concluded that SST providers and users will exchange their "grey lists" of suspect buoy measurements (coordinated by GHRSST-PP office). Blacklists are available at the GHRSST-PP web site at http://www.ghrsst-pp.org/Quality-Control-In-situ-SST.html
3) For the AATSR, applying the SSES will preserve the skin definition of the provided SST (note that nthis may also apply to other satellite sensors including GOES and MODIS although it was not discussed during the breakout).
4) The Product User's Manual (which has been agreed during the 8th GHRSST meeting) will include a paragraph on SSES describing, for each dataset, the way they have been determined and recommendations for their application.
5) Due to confusion regarding the use of proximity confidence values and general lack of understanding between SSES producers of how and what scale SSES should follow, a new simplified 'Quality Level' scale was agreed. This will replace the Infrared Proximity Confidence Value (IPCV) and the Microwave Proximity Confidence Value (MWPCV) as a common single scale i.e. a user should not need to differentiate between infrared and microwave data sets to use the quality scale. The GHRSST-PP SSES Quality Scale was agreed as follows:

Quality level	0	1	2	3	4	5
Meaning	**Unprocessed:** e.g., Land, no data, side lobe contamination etc.	**Not usable:** Cloudy, rainfall detected,	**Bad data:** SST present but recommended for Qualitative use only	**Suspect data:** Follow producer recommendations if using this data (could be OK)	**Acceptable data:** OK for quantitative use	**Excellent data:** OK for quantitative use

In practice this means that REMSS for AMSRE and TMI and PODAAC for MODIS will have to reorganize their quality levels as follows:

- REMSS: the present MWPCV 3 and 4 should now become Quality Level 4 and 5
- PODAAC: the present IPCV 2 should become Quality level 1
- The AATSR system is being redefined by G. Corlett, who will provide IFREMER with the agreed quality level scale
- The NOAA/GOES system is somewhat different from the others so it may take some time for them to converge.

6) It was agreed that SSES error values must be consistent with the quality levels, showing increasing errors with decreasing quality. In practice this applies to Quality levels 2,3,4 and 5 only.

Outstanding items
The breakout group could not reach a consensus on the following issues which remain open:

- Should we impose a maximum delay between the time of the matchups used to derive the SSES and the time of the pixels on which the SSES will be applied?
- Would the user need a continuous distribution of SSES throughout the quality scale rather than discrete values as it is often the case at present?
- Would we define a precise range of SSES per quality level, as a metric applicable to the SSES?
- For one given sensor (e.g. AVHRR) it should be possible to converge towards consistent methods.

8.2 GHRSST-PP Data Processing Specification TAG Breakout Group report *(J. Vazquez and C Donlon)*

This breakout session was dedicated to gaining abetter understanding of the content, format and schedule for the production of the GHRSST-PP Data Processing Specification (GDS) v2.0. The current version of the GDS revision was 1.7 (a slightly modified version of GDSv1.6 following review in 2006. However, as the GHSST-PP has gained more experience and has obtained more user feedback on products, and as the users request new products sets such as gridded ‘L3P’ data and ‘radiance’ L1P data sets a significant upgrade of the GDS is required. This will be embodied in the GDS-2.0 and will require significant upgrade of tools for the user community and a planned introduction to the GHRSST-PP community to realise its full content. Conversely the GHRSST-PP now needs to upgrade SSES definitions and other definitions that have developed significantly.

Discussions during the GHRSST-PP 9th Science Team meeting so far focussed the GDS-TAG breakout on the following issues and conclusions.

1. The need to recognise the user requirement for brightness temperatures in the L2P data sets. User requests have indicated that Channel BT’s are becoming essential for the next generation of radiance assimilation systems and it is clear that GHRSST-PP must recognise the need for L1P type products i.e. the GHRSST-PP equivalent of a L1b satellite data product. However, the group noted that this is a very difficult project as each space agency spends a considerable amount of time preparing file formats for each mission. It was agreed that where possible L2P data files should include channel brightness temperatures and that any L1P data file would be extremely simple and include just a standard GHRESST-PP header, grid specifications followed by the channel BT’s (i.e., no additional fields). Users should be in any case directed to the data providers for more information on the L1P data files. In conclusion it was agreed that (a) a L1P specification could be written for the GDS2.0 and (b) that channel brightness temperatures/reflectance’s could be incorporated into L2P data files as part of the optional/Experimental fields (see 2 below)
2. The need to provide more flexibility to the L2P experimental fields. It was agreed to increase the byte allocation for each pixel in the experimental fields and also to rename these to Optional fields. The ***optional field size*** is clearly too small to accommodate the incorporation of channel BT’s in the current L2P specification. It is suggested that the size of the optional field is increased (or made flexible) to accommodate channel radiances. ?the group agreed on a figure of 18 bytes (noting the large MODIS or IASI requirement). The description and content of these bytes needs to be specified in appropriate file level documentation and metadata within both the file and the GDS-2.0.
3. The need to define ISO 19115 geospatial metadata for the GHRSST-PP product and

incorporate this into product headers. As data management practices have developed a consensus on the use of IOSOI 19115 geospatial metadata has emerged in the community. GHRSST-PP should try to base its metadata on the ISO 19115 standard in GDS-2.0. In addition it was agreed that MMR records should no longer be produced in GDS-v2.0 but instead all GHRSST-PP metadata relating to a file should be included in its file header (applies to L1P, L2P, L2Pc, L3, L3P and L4 data files). This development implies a reprocessing of historical GHRSST-PP data sets.

4. That the MDB needs to be revised to accommodate more diverse input data sets (other MDB's). Issues raised by JF Piolle regarding the MDB mean that in its present format, the MDB is difficult to extend and develop due to restrictions of the IFREMER CORIOLIS database. The breakout agreed that the MDB should be re-developed according ton the outliner provided by Piolle. A minimum set of MDB core fields for each data entry and interfaces to the MDB should be specified. The MDB should be designed to include and QC other MDB data sets already developed in order to present a homogeneous data set for GHRSST-PP SSES checking and production (based on multi-way statistics for example).
5. That GHRSST-PP is a distributed system linked across many data centres even in the archive. The discussion notes that the LTSRF and the GDAC were playing a unifying role within the GHRSDST-PP Regional/Global Task Sharing Framework and that this should be continued. Development in the EU for an EU-GDAC should be complementary to that already in existence and all efforts should be made to prevent competing systems being developed. The best way to assure this is through proper interface specifications and adequate data policy agreements. The latter require significant work at the GHRSST-PP level and at the space agency level (particularly in the EU). The group agreed that any GHRSST-PP data policy should encourage the free and open exchange of data with respect to the rights of individual data providers. The breakout was not able to take these discussions further.
6. That the GHRSST-PP L2P core (L2Pc) data sets and flow is required by operational teams. Some teams (OSI-SAF) have noted that the use of DT_analysis in L2Pc data products is having a negative impact on timeliness statistics and have requested that DT_analysis is not considered part of L2Pc (but will be a mandatory part of full L2P). The discussion concluded that L2Pc is more clearly defined as a satellite record (i.e., the DT_analysis is a value added field). The L2P full is more clearly defined as a value added product which includes the L2P data set of value-added ancillary records.
7. That GHRSST-PP should encourage the development and provision of fully formed L2P data sets in all cases noting that L2Pc is only a precursor to the L2P. It was agreed that L2P [full] is the main product that GHRSST-PP wants RDACs to provide.
8. It was agreed that SSES schemes need to be documented and rationalised to a common Quality Level Scale following the discussions led by P.LeBorgne. A common Quality Level Scale will be adopted as defined by the SSES working group.
9. It was agreed that the GDS documentation should be simplified and complemented by a user manual.
10. Should netCDF4 be used as the GDS_V2.0 standard? Discussions on the netCDF3.0/4.0 issues were extensive. Backwards compatibility between the libraries is essential. The GDS-TAG request that the netCDF community accommodate the requirements of GHRSST-PP for (a) bzip2 and chunking and (b) forwards compatibility (i.e. netCDF 3.0 readers can read netCDF 4.0 data). Peter Cornillon agreed to check these issues and report back to the GDS-TAG.
11. There was no clear consensus on the inclusion of ocean colour data as standard ancillary fields to L2P or L4 data products even though some data providers (MODIS) were already providing ocean colour data products. The breakout encouraged the GHRSST-PP to continue to explore the use of ocean colour data (e.g., using the HRDDS) as an aid to understanding diurnal variability and to try and reach a consensus on the inclusion of ocean colour data within GHRSST-PP data products prior to the drafting of the GDS-2.0

A schedule for the production of a draft GDSV2.0 was discussed in order to have the draft in place by the end of 2007. The following Science Team members were considered to be part of the GDS_V2.0 writing committee:

- Ken Casey
- Edward Armstrong
- Jorge Vazquez
- Craig Donlon
- Chelle Gentemann

- Jean-Francois Piolle
- Peter Cornillon
- Doug May and Bruce Mackenzie

The structure of the GDS-2.0 was then discussed. The discussion concluded that

1. The GDS should be a technical document reduced ion size and scope for the current edition having only a short introduction. The main purpose of this document is as a reference to develop and read GHRSST-PP data files. Where possible, generic content (i.e. common headers) should be specified in the GDS. Ideally the GDS should be a pdf and html document with hyperlinks maintained at the GHRSST-PP web site.
2. A User document/manual should also be provided which is separate from the GDS. This should be a simple document at high level in order to gain user support. However, the Guide should be capable of providing advanced information for complex applications. A separate section for each GHRSST-PP data product is required in the User Manual.

9 Session 7: L4 Analyses

9.1 Introduction: L4 Key Issues facing the GHRSST-PP, *J. Cummings, NRL, USA.*

Cummings began by explaining that the basis for the GHRSST-PP L4 metrics is a document prepared by Christain LeProvost which appeared in Proceedings of 1st GODAE Symposia "En Route to GODAE" 13-15 June 2002 Biarritz, France. The GODAE validation philosophy is built on the following basic principles:

- **Consistency:** verifying that system outputs are consistent with the current knowledge of the ocean circulation.
- **Quality:** based on direct comparison with available observations.
- **Performance:** aimed at evaluating the effectiveness of the systems in terms of the assimilation and use of the observing systems.
- **Benefit:** end-user assessment of product quality for use in applications.

Cummings noted that the last principle is hard to realise in practice and remains a challenge for GODAE and for GHRSST-PP. The methodologies required to deliver metrics have been classified into four classes of Metrics.

- **Class 1 Metrics: comparisons of analyzed fields:** instantaneous or time means (interpolation to a standard grid?)
- **Class 2 Metrics: comparisons to independent observations:** moorings, drifting buoys, VOS, remotely sensed SST
- **Class 3 Metrics: derived physical quantities:** balances and temporal evolution of analyzed SST fields with other variables (surface radiation, sea ice, wind, altimeter SSH, others?)
- **Class 4 Metrics: performance of the analysis system:** statistical measures of analysis quality and skill compared to observations (assimilated or not); formal error estimates, covariance consistency, performance measures

Class 1, 2, and 3 metrics allow the consistency and quality of each L4 analysis system to be deduced. whereas class 4 metrics address the performance of the system. The benefit is assessed using all classes of metrics, but it is likely new metrics will need to be defined by user groups based on applications and user consultation. Cummings suggested that the main GHRSST-PP L4 **variables to consider included** SST, SST variability in both space and time and, SST gradients. Other variables could be used in a more advanced approach (a phase II).

Cummings then reviewed the characteristics of GHRSST-PP Global and Regional L4 analysis data sets as shown in Table 9.1.1.

Table 9.1.1(a) Characteristics of GHRSST-PP Global L4 data sets

Source	Name	Resolution	Update Interval	Data Used
NCEP	Reynolds V2.0	0.25 deg	Daily	AVHRR GAC, AMSR-E, In Situ
JMA	MGDSST	0.25 deg	Daily	AVHRR GAC, AMSR-E
NOAA	RTG	1/12 deg	Daily	AVHRR GAC, In Situ
Met Office	OSTIA	1/20 deg	Daily	All Data Sources
FNMOC and NAVOCEANO	GHRSST	9 km	6-hours	AVHRR GAC/LAC, AMSR-E, AATSR, In Situ
RSS	MWOI	0.25	Daily	MODIS, AMSR-E, TMI

Table 9.1.1(b) Characteristics of GHRSST-PP Regional L4 data sets

Source	Name	Resolution	Update Interval	Data Used
ESA	Medspiration	2 km	Daily	AVHRR GAC/LAC, AATSR, AMSR-E, MSG
Tohoku Univ.	NGSST	0.05 deg	Daily	AVHRR LAC, MODIS, AMSR-E
BoM	BLUELink>	1/12 deg	Daily	AVHRR GAC/LAC, AATSR, AMSR-E

FNMOC and NAVOCEANO	Various Regional Names	~3-5 km	Daily	AVHRR GAC/LAC, AMSR-E, AATSR, GOES, MSG, In Situ

Cummings explained that all inter-comparisons should be done at the highest grid resolution which was currently the Met Office OSTIA 1/20° grid globally and for the regional systems, Medspiration uses a 2km grid . Products use differing blends of input data (AATSR only used by a few, AVHRR used by all, GOES by some but not all). In addition, the changes of SST and how they are captured by an analysis system using data form a 24 hour or even a 12 hour window is a problem are these products unrealistic? Can GHRSST-PP define the physical metrics to monitor and measure the time evolution of the SST and L4 systems? The performance of the analysis system should be a key metric using observations and formal error estimates and if appropriate other performance metrics.

Cummings then raised the issue of sea ice which is critical to the quality and performance of a L4 analysis system. Should the GHRSST-PP measure the performance of ice inputs (which are largely complete products requiring no activity other than remapping within GHRSST-PP)? The group noted that it was important to use sea ice data as part of the L4 Metrics. Cummings then listed the reasons why GHRSST L4 products might differ from each other as follows:
i

- Inaccuracies in the statistics used to parameterize the analysis: observation errors are assumed to be SSES, but differences will exist in the correlation scales, representation errors, and background errors are all
- Different components of the SST observing systems that are used by each analysis including timeliness of the observations available at the analysis time (generally OK), space/time resolution and geographical extent of the analysis itself
- Differences in the pre-processing of the observations including data thinning algorithms (formation of super-obs), application of sensor specific bias and diurnal warming corrections and differences in the quality control acceptance/rejection decisions of each system
- Use of different variables that constrain SST (e.g. sea ice, flow)
- Special case of dynamical forecast model first guess vs. persistence analysis first guess whi9ch was discussed as an option but open to debate.

Cummings explained that due to these differences, it is important that the group realise that GHRSST L4 Metrics may not be available or apply in all cases. A better way forward is to design and implement a carefully controlled experiment which demands a considerable amount of investment and may not be feasible at this stage and Cumming concluded that the group is better off with simple inter-comparisons at this stage.

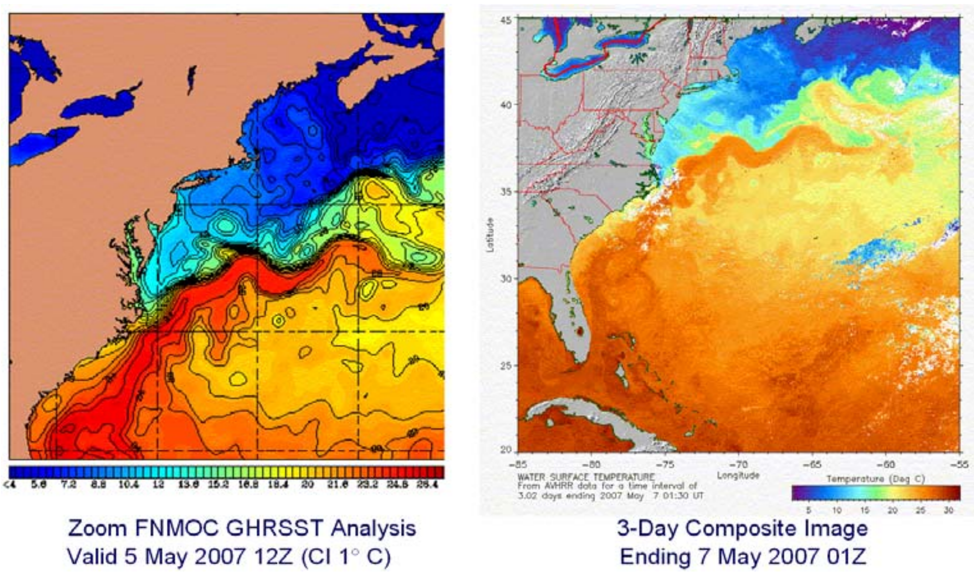


Figure 9.1.1 Example Class 2 metrics for L4 system validation using L4 outputs (left) and L3 observation composite data in the East Coast US region.

Cummings then presented a set of metrics noting that there were no Class 1 metrics to show (although the HRDDS system provides a class-1 metric for the outputs. For an example class 2 metric A validation of the L4 output against composite imagery can be used. Figure 9.1.1 shows the global FNMOC GHRSST analysis and a 3 day composite of AVHRR data. In both panels the outputs capture Gulf Stream meanders and frontal eddies, warm core rings, warm water intrusions south of the stream, and development of large cyclonic ring near 62°W with considerably more detail in the L3 composite image. Cummings noted that this is an excellent reason for GHRSST-PP do develop and maintain L3 products.

Computing spatial gradients provide a useful way to study the information content of L4 outputs and Cummings cited the excellent developments at the MERSEA web pages (see http://www.mersea.eu.org/Satellite/sst_validation_l4_glob_oi.html) which are reproduced in Figure 9.1.2 below for the Tropical Pacific Regions.

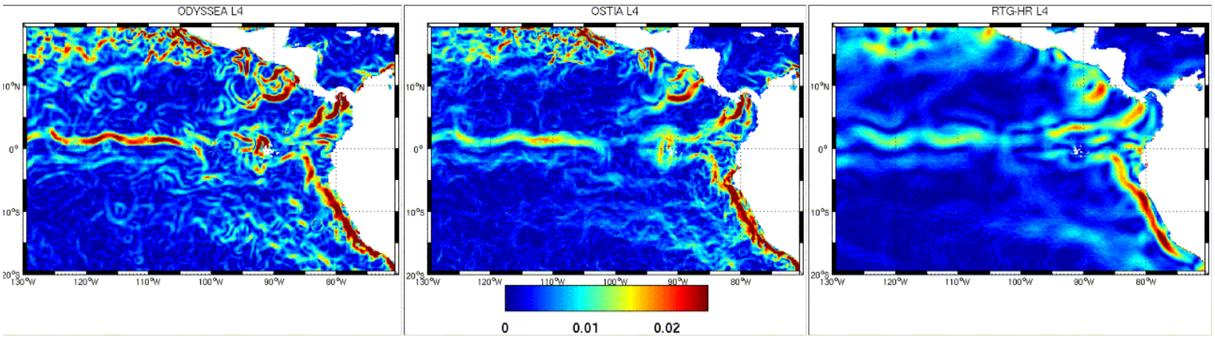


Figure 9.1.2 Gradient analyses of L4 SST analyses outputs from (a) MERSEA ODYSSEA, (b) Met Office OSTIA and (c) NCEP RTG SST analyses for 1st April 2008. See http://www.mersea.eu.org/Satellite/sst_validation_l4_glob_oi.html for more details.

Cummings noted that while gradients are a good way to look at structure there is a need to know what are the expected gradients are in specific areas if we are to compare gradients properly including issues of computation and agreed units (°C km^{-2}). Furthermore, decisions as to a refere4nce data set and specification of what represents reality need to be taken. This is difficult as L3 composite data are not ideal for gradient computation and L2P data are often too sparse to compute useful gradients due to cloud cover.

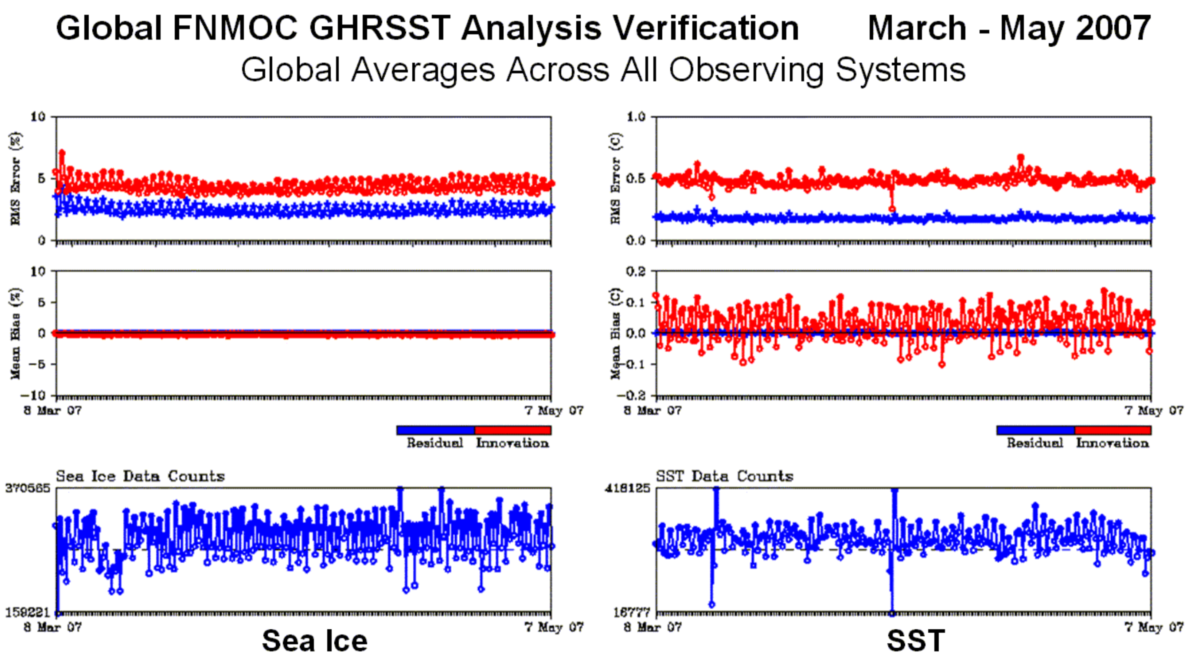


Figure 9.1.3 Class 4 metrics (Bias, rms) computed at FNMOC for sea ice and SST analyses March-May 2007. Counts provides the number of data used in the analysis.

Class 4 metrics were then discussed using examples computed at FNMOC shown in Figure 9.1.3. Running global averages are maintained of residual and innovation observation-background errors. A reduction in error from innovations to the residuals is required for skillful analysis and analysis residuals are expected to be zero. More work needs to be done in this approach to stratify these statistics as a function of location and observing system for more useful outputs. The stratification could be defined by the GHRSST teams. Cummings noted that using class-4 metrics a global 0.1K diurnal variability signal is seen highlighting the need for better DV work.

Cummings then explained that there are more costly and complex methods that can be used to investigate the consistency of the covariance's using the Jmin statistic that provides a way of describing the matrices used. Ideally, Jmin should be computed for all observing systems at each update cycle and used to monitor the quality of SSES from the data providers and stratified by location to look at observing system biases. However, several people noted that computing Jmin for their analysis was quite expensive (more costly than the analysis itself in some cases) which limited the potential for such work. Nevertheless, a time-bound experimental period could be used to test the utility of Jmin for all L4 systems. Cummings noted that computation of formal error estimates was yet another approach but as for Jmin, computation was costly. But this approach provides quantitative measure of accuracy and significance and allows direct inter-comparison of L4 products and L4 products with observations. Cummings suggested that the group could run Jmin and formal error estimates for a 2 month period as a test and in parallel considers options to simplify the formal estimate.

Finally the need to consider Analysis Performance Estimates was noted as an important consideration for L4 inter-comparison work (e.g. autocorrelations of residuals, fit background field to data, compute residuals, look at the spatial correlation which should be close to zero if good) as used by the meteorological agencies.

The following actions were raised during the presentation:

- **ACTION: The ST request that the Jmin and other formal error estimates (complex or simple version) are computed by each L4 centre for 2 months or more (ideally 1 year)**
- **ACTION: The group should explore if background error fields can be shared.**
- **ACTION: A 24 hr composite of SST with extracted frontal data should be prepared for L4 comparisons in L3 format (E. Maturi).**
- **ACTION: (Cummings and other) a definition and common vocabulary of the various terms used in used by L4 production systems is required (GHRSST-PO)**
- **ACTION: (Cummings and GHRSST-PO) use the GHRSST-PP web site as a front end to a framework of L4 inter-comparisons (GMPE)**
- **ACTION: Put GODAE Metrics document on the GHRSST-PP web page (GHRSST-PO)**
- **ACTION agree a metrics grid for global and regional domains (currently we have recommendations to use 6.5km (OSTIA) and 2km (Medspiration et al)).**
- **ACTION: Update web with all GHRSST-PP analyses and the inputs based on Cummings L4 regional and global L4 systems table. This should be checked for completeness and accuracy**
- **ACTION: The L4 data providers should develop sharing of QC outputs from the analyses systems.**
- **ACTION: The L4 group should develop and test the use of an ocean model based first guess and inter-comparisons of the outputs.**
- **ACTION: The L4 group need L3P style composite data for metrics and this should be a formal request for L3 Products within GHRSST-PP.**

9.2 SST L4 analysis at DMI using GHRSST-PP data, *J. Hoeyer, Danish Meteorological Institute, Denmark.*

Hoeyer began with a summary of an SST analysis system for the Baltic Sea and North Sea based on optimal interpolation which has been operational for 4 years. The system uses local covariance, in x.y and time and considers multiplatform data inputs with satellite dependent error estimates. Only night-time data are used in the analysis (to limit diurnal variability impacts) and bias corrections to satellite data are based on in situ comparisons. Data ingested include O&SI-SAF, AVHRR 2 km, AATSR 1 km, (AMSR-E) and the current spatial resolution is 0.03 degrees latitude x longitude. The accuracy of the output products is ~0.7°C. Figure 9.2.1(a) shows a plot of the domain foir the analysis.

The need for regional covariance estimates especially in the coastal zone was highlighted and Hoeyer noted that the DMI system uses spatial correlations of ±50 km in x and y, averaged for 100x100 km bins. Figure 9.2.1(b) shows the covariance estimates used with contour intervals 0.1.

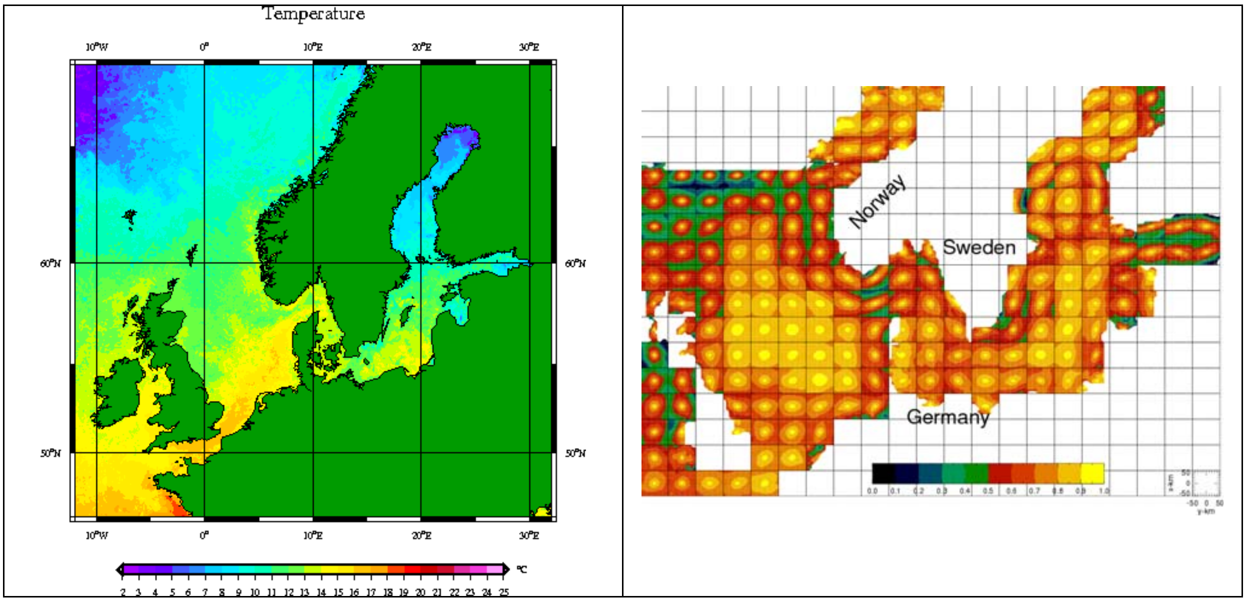


Figure 9.2.1 (a) Spatial domain of the DMI Baltic Sea/ North Sea regional SST analysis system. (b) Regional covariance estimates for the analysis.

A new adaptive OI scheme was required and has been developed to support the round the world Danish expedition, Galathea 3 Aug. 2006 to April 2007. The cruise track taken by the expedition is shown in Figure 9.2.2.

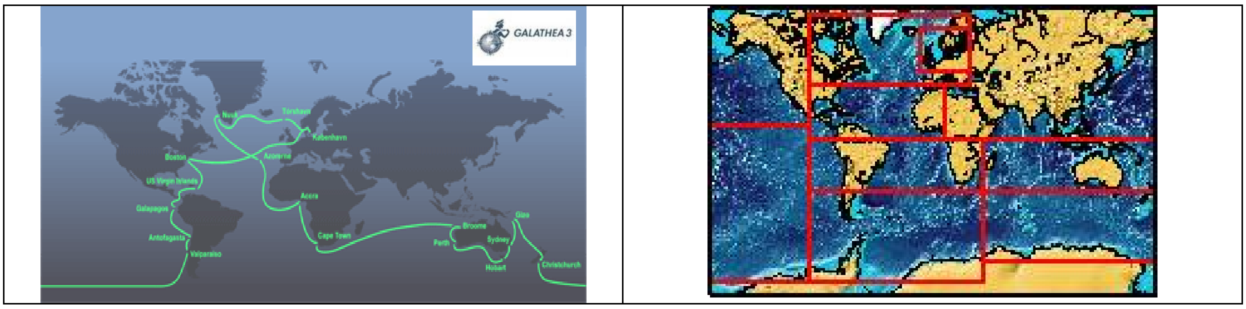


Figure 9.2.2 Cruise track taken by the Danish round the world expedition, Galathea 3 Aug. 2006 to April 2007. Right hand panel shows high resolution window areas set up for the SST analysis at DMI.

A, high resolution 0.05 degrees analysis has been made to cover the cruise track and onboard research is guided by SST fields. The focus area is the Greenland waters based on the OSI-SAF and GHRSST data (ATSR, AVHRR, AMSR-E, TMI, SEVIRI 5km, MODIS. Few microwave data re used due to the proximity of land and side-lobe contamination problems. A driver for the new system was a strong requirement to have a very easy set up in new areas (see Figure 9.2.2), and to include individual satellite errors from in situ comparisons. The system was designed for weekly reruns to include delayed mode data. Results from the analysis are available at http://www.satelliteeye.dk/databank.htm including Google Earth output and an archive. Data are also assimilated into BSH-CMOD for North Sea/Baltic Sea and HYCOM model for the North Atlantic

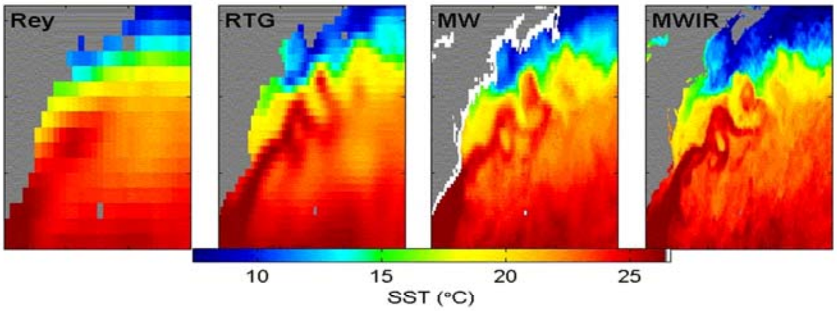
A new test was performed using AATSR data as a bias correction reference data field for all other satellite data inputs. The pre-computed AATSR bias correction fields from METEO-FRANCE were downloaded and used in this work. The investigation included a test and reference run in the North Atlantic at 0.05° spatial resolution using only night-time observations and a single SST input field per day. Data used included AATSR, SAF NAR 17 (-18), NAVO LAC 17+18, NAVO GAC 17+18, SEVIRI 5 km, GOES 5 km. The analysis used bias corrections where significant quality degradation was evident otherwise the bias was set to zero over a test period: Feb 2007 -> May 2007. Geostationary data were only used < 50°N and all corrections were applied to retrieve SSTsubskin observations. The experiment concluded that the spatial statistics are very similar for test and reference run (not using AATSR data as a reference) although temporal statistics may show real differences and further work was required to definitively say that AATSR improves this particular system

Hoeyer then concluded by noting the role of DMI in the EU MyOcean project in which a full Arctic domain SST OI system will be set up in partnership with Met.no having special emphasis on the Nordic Seas, Greenland waters (DMI) and around Svalbard and the Barents Sea (Met.no). This is a challenging area to work in with L4 SST analysis (at 0.05°) due to the presence of ice to ice edges, with temporally dependent statistics along with changing ice extent. Particular work will be performed looking at SST in the marginal ice zone, the use of ice temperature retrievals from other systems within MyOcean. Data will be delivered to GHRSST-PP GDAC and DDS in netCDF format according to GHRSST-PP specifications. Finally Hoeyer suggested that the GHRSST-PP needs to agree a new format for exchange of L4 data sets for inter-comparison (to be considered by GMPE?) and that a defined land mask that all group must be agreed.

- **ACTION: (Hoeyer) Put up Galithea-3 story on the GHRSST-PP web site**
- **ACTION: (Hoeyer) Provide L4 Outputs in GHRSST L4 format.**

9.3 Global 9 km OI SSTs – lessons learned from MODIS/AMSR-E/TMI blending, *C. Gentemann, Remote Sensing Systems, USA.*

Gentemann noted that a number of new global L4 SST products have been developed within the MISST project which have different spatial scales as shown in Figure 9.3.1. Processing is performed on 4 processors in a Master/3 slave configuration.



Reynolds	RTG	RSS MW	RSS MW+IR
Weekly	Daily	Daily	Daily
100km	50km	25km	9km
AVHRR	AVHRR	AMSRE TMI	MODIS AMSRE&TMI

Figure 9.3.1 Different L4 SST analysis outputs in the Gulf Stream region highlighting the impact of using high resolution data sets and analysis systems.

The newest system using both microwave and infrared data from the EoS Aqua platform shows the advantage it gives to the detail within the analysis especially in the coastal regions. Gentemnann then looked at the stability of the outputs. An example of biases in the IR SST record due to atmospheric aerosols was shown as a time series of the global average of SST from a number of data products. Spurious cooling events due to volcanic eruptions in 1982 and 1991 are clearly seen in the IR-derived MCSST. These biases are absent in the Reynolds SST because it is constrained by *in situ* measurements. The microwave channels used for SST retrieval are not affected by aerosols, and hence MW SSTs will be useful in inferring small temperature changes in the Earth's climate.

The method of removing large-scale regional biases and time drifts from the IR SST is similar to the Pathfinder method, but instead using the MW SST rather than *in situ*. There will be three satellite microwave radiometers in operation during 2001-2003 (TMI on TRMM, AMSR-E on Aqua, and AMSR on ADEOS-2). In 2 days, complete global coverage will be obtained, and one can construction a 2-day global map of microwave SST retrievals at a 50-km resolution. The IR SST retrievals can be sub-sampled to 50 km and compared with the microwave results.

The inevitable question is whether the MW SST can be trusted as an absolute reference to remove biases in the IR SST. Past satellite microwave radiometers (including TMI) have experienced small calibration problems on orbit. However for the most part, these calibration problems have been correctable using post-launch calibration methods, leading to extremely reliable inter-annual and decadal time series. Two notable examples of this are the MSU air temperature time series from 1979-2000 [*Spencer and Christy*, 1990] and the SSM/I water vapor time series from 1987-2000 [*Wentz and Schabel,* 2000]. MISST is indeed placing a very high confidence on the microwave technology, but we think this is justified by past experience.

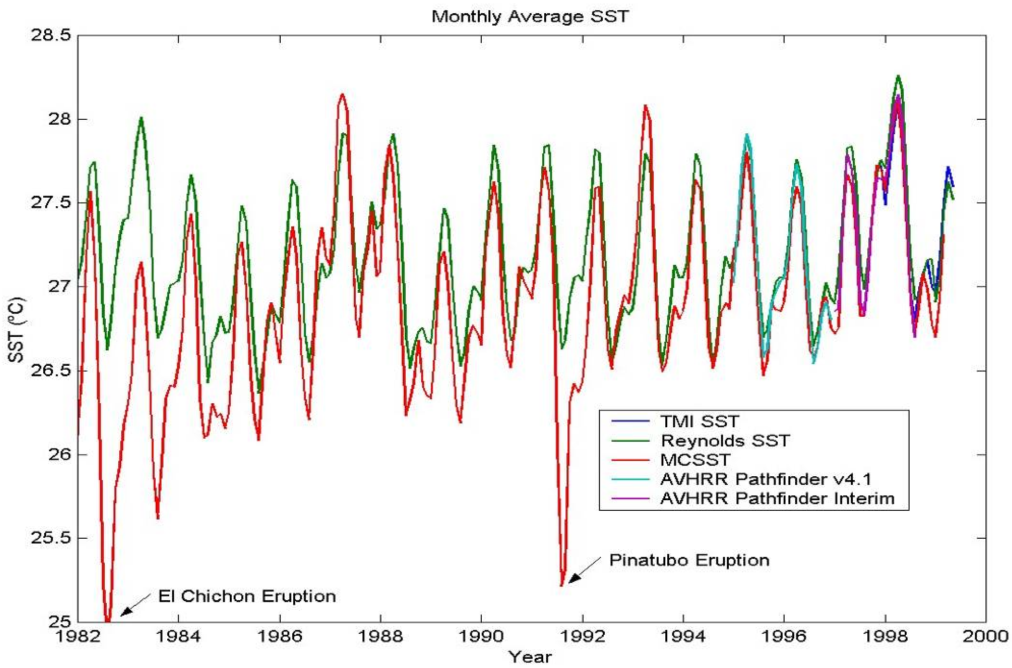


Figure 9.3.2 Monthly average L4 SST outputs from a variety of systems 1982-2000.

Gentemann noted that the challenge to the GHRSST-PP community when using satellite data is to improve long-term stability of the data sets rain, sidelobe contamination , cloud impacts , sunglint, on a sensor-by-sensor basis which is why MISST has focussed on uncertainty estimation. Pre-processing of observations is essential and use of wind speeds (NWP and satellite) helps in understanding the impacts of diurnal variability but it is alone not enough. This is especially the case given the different spatial characteristics of infrared and microwave satellite data. For example, for MODIS SSTs, AMSR-E SSTs are used in the analysis and can supply AMSR-E wind speed data. However, MODIS has a wider swath and retrieves near land. The approach taken is to look for any AMSRE wind within 100km of land/MODIS SST or use NWP winds. More work is required.

Gentemann then explained that diurnal variability adjustment schemes are necessary in order to make use of all data obtained in the daytime. Within MISST, parameterization of IR and MW retrieval differences, with consideration of diurnal warming and cool-skin effects required for multi-sensor blending. The current activities include the testing and use of a new diurnal variability model called POSH. Diurnal variability adjustments are implemented in the pre-processing step of the analysis
Gentemann explained that problems remain using an example in the Mediterranean Sea where MW winds and NWP problems lead to distinct discontinuities with the data.

Gentemann then showed a series of joint probability density functions (jpdf) for MODIS – AMSRE data sets which reveal problems with the differences at both low & high wind speed water vapour and SST as shown in Figure 9.3.3. Wind speed dependencies could be related to emissivity/surface roughness issues. More work is in progress but the daytime data looks better than night-time (low SST biasing). Wind bias in opposite direction than expected skin-bulk relationship. Jpdf''s show low vapor biasing and correlations with water vapour only in night-time data suggest a new approach is required as the Ch4-5 diffs have no skill in the infrared.

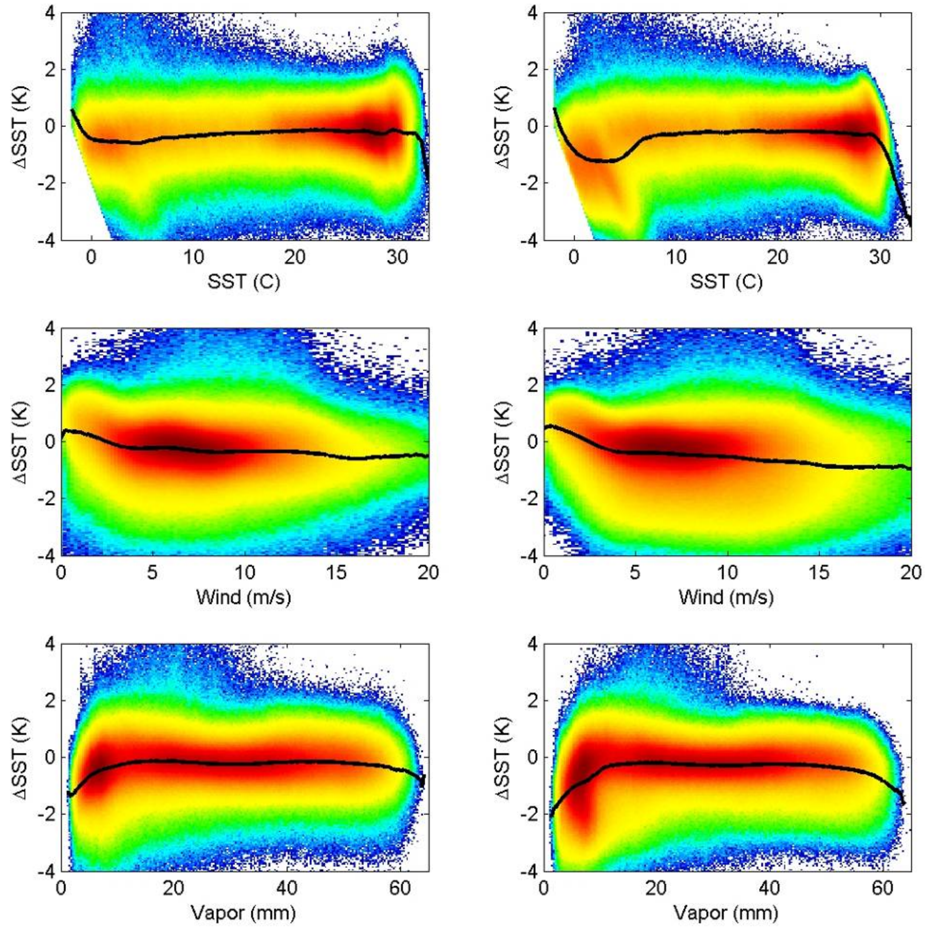


Figure 9.3.3 Joint probability density functions for AMSRE (left) and MODIS AQUA (right) for SST, wind speed and total column water vapour.

The impact of regional biases was then highlighted and Gentemann noted that there is a need to account for regional differences due to unexplained algorithm errors in MW and IR SSTs. One approach to look at the impacts was to calculate 20-day average difference, smooth and then subtract from IR data sets although this was acknowledged as a simplistic approach.

Some time was dedicated to validation efforts that used Reynolds OI data as a validation reference standard. This is a different process to validating L4 outputs than the traditional approach using independent (withheld) in situ data – particularly as the Reynolds data is used in the calibration routines of the AMSRE data sets used by the Analysis. However it servers as a useful cross check confirming that the new analysis (compared to Reynolds) has a global rms. of 0.65K. Following discussions it was agreed that there is a need to establish regional validation areas.

Finally Gentemann presented a new high-resolution data set being developed at Remote Sensing Systems for Sea ice noting that current sea ice data products suffer from many problems. A comparison using MODIS visible imagery clearly showed significant ice free regions that were classified as ice in operational outputs from OSI-SAF and NASATEAM algorithms. More work is required to address these issues in the satellite sea ice community.

- **ACTION: (LeBorgne) To discuss and agree regional definitions for validation areas**
- **ACTION: (Gentemann) to provide L4 data and AMSRE data in L2Pc and L4 format.**

9.4 Status of POES-GOES SST analysis, *E. Maturi, NOAA/OSPD, USA.*

Harris explained that a new L4 system and daily product has been developed from an extensive accumulation of POES-GEAS initialization data. Analysis can be generated every 3 to 6 hours and the production software has been adapted to use different spatial resolutions (11km and 5km). The project has involved the effort of many people including contributions form the UK. The system objective is to develop estimation scheme for combining multi-satellite retrievals of sea surface temperature into a single analysis and to apply complementary SST datasets available from polar orbiters, geostationary IR and microwave sensors. The system uses the computing power available to implement this estimation scheme.

The basic methodology includes:

- Initial guess of SST background field
- Initial guess of SST variability
- Observations with well-characterised errors
- Definition of relationship between observational datasets (*i.e.* assume one or more bias terms which are spatially correlated)
- Data Quality Control
- Daily SST Update
- Data Error Characterization
- Correlation Map
- Boundaries of Ocean Basins
- Derived Correlation Length Scale

The output is characterised as Daily blended SST analysis at 1/10°grid spacing using a equal-angle projection. The original output is MATLAB binary format which has now been converted to HDF. Harris noted that in addition, images of the data will also be generated and selected 5-km regions can be generated as special data sets as required. Several example animations were shown including Tropical Instability Waves in the Pacific Ocean and in the Gulf Stream region.

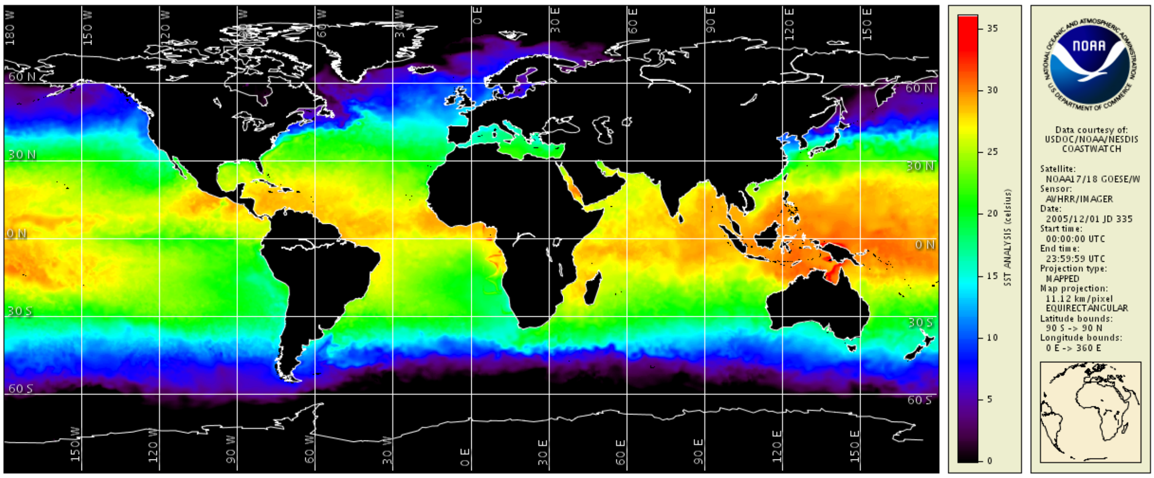


Figure 9.4.1 Example NOAA-NESDIS blended POES-GOES global SST output for 2005-12-01.

The outputs are evaluated against the RTG_SST ½°×½° resolution (also planning validation against 1/12°×1/12°) operational NCEP product, the ¼°×¼° daily OI (with and without MW) and screening out bad SST data prior to analysis and using microwave SST (AMSR-E) or other independent data. The team will also perform a traditional *in situ* data *e.g.* buoys with all results and outputs available at an ftp web site.

In summary, a pre-operational L4 SST product has been developed at NOAA/NESDIS using NOAA-17/18 SST and GOES-11/12 SST as inputs. The validation process will begin this summer with NCEP/Ocean Prediction Center, CoastWatch Regional Managers and the GHRSST-PP. The operational product is expected in January 2008. Future plans include using SST retrievals from non-NOAA satellites in particular microwave *e.g.* AMSR-E, WindSat, develop the moist useful community in the coastal zone and NESDIS will analyze all satellite SST datasets using this methodology to produce a single "best estimate" global analysis

- **ACTION: (Maturi) Provide information on the application of the data sets and other users of GOES-POES OI.**
- **ACTION: (Harris) Provide global outputs for inclusion in the L4 metrics and GMPE experiments once operational (January 2008.**

9.5 The OSTIA analyses at the Met Office, *M. Martin, J. Stark, M.*

McCulloch and C. Donlon, Met Office, United Kingdom.

Martin began with a summary of the Met Office Operational SST and Sea Ice analysis (OSTIA) system which produces a gaily 1/20° (~5.6km) global SST analysis using optimal interpolation (persistence based). OSTIA provides an analysis of the 'foundation' SST [pre-dawn or below the diurnal warm layer] using a blend of data sources including satellite (microwave & IR) GHRSST data products and in situ data. OSTIA uses the sea ice analysis performed by EUMETSAT OSI-SAF (met.no / DMI) and is now running daily, operationally (since mid December 2006). All data are sent to GDAC and LTSRF including all associated MMR metadata. A web page has been set up for direct access to the OTIA system and documentation at http://ghrsst-pp.metoffice.com/pages/latest_analysis/ostia.html.

Martin gave an overview of the OSTIA system architecture which is summarised as follows

- Data is obtained from various sources and is converted from the GHRSST format into BUFR format. This is done because the Met Office's Meteorological Data Base (Met DB) takes BUFR inputs. The data is therefore stored in a central Met Office observations database.
- The quality control and observation processing system then extracts the required data and performs a check of the data against a background field.
- It also flags any observations which might have been affected by diurnal warming, as explained on the next slide.
- A bias estimation procedure is then undertaken using in situ SST observations and ENVISAT AATSR satellite data.
- The OI analysis is then calculated using two background error correlation scales with spatially varying error variances.
- A daily SST analysis output is then generated according to GHRSST-PP L4 specification
- The analysis is then slowly relaxed to climatology and used as a background for the next cycle.

Martin explained that considerable effort is spent to ensure that the observations used by OSTIA are properly pre-processed and quality controlled. This includes rejection all observations with non-zeo reject flag in the L2P GHRSST data and rejection of 'daytime' observations with 'low' wind speed to reduce diurnally warmed data. The criteria used are Daytime: whether the sun is above the horizon. And Low wind speed: < 6 m/s. All skin temperature measurements are adjusted to 'SSTdepth' (including AATSR) ad a background check is performed against previous analysis (Bayesian). This uses background error and observation error to estimate probability of gross error (PGE). If PGE is large the observation is rejected. The system then assigns an error estimate using the error value supplied in the GHRSST product L2P SSES. The bias value supplied with the data is subtracted from observation value.

In addition to processing satellite data, OSTIA also uses in situ observations. The system ingests moored and drifting buoy & ship data via GTS and assigns error estimates to data based on type and station code where background errors are added from static 2D fields. Martin then reviewed the input data sources to the OSTIA system using plots and images.

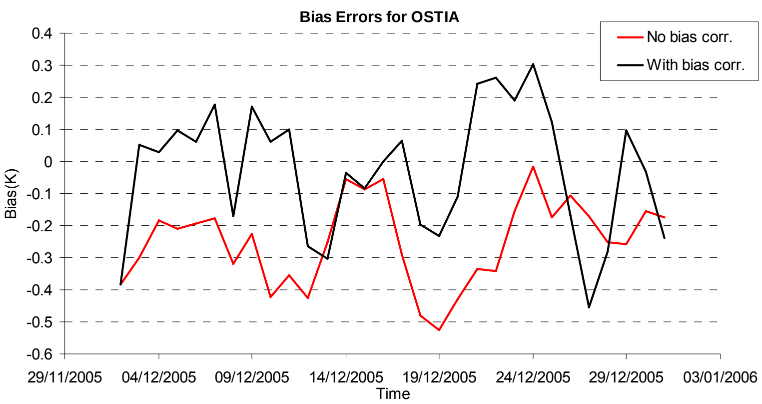


Figure 9.5.1 OSTIA bias errors in the Mediterranean Sea shown for November 2005-January 2006 using AATSR and without AATSR data. Mean bias without AATSR is -0.25K and the mean bias when using AATSR is -0.03K.

The bias correction scheme used by OSTIA is based on a reference set of observations made up of the in situ data and the AATSR data. Matchups with other data types are then found with search radius of 25km and valid within 12 hours. The differences between all of the matchup data are then calculated and a 2D analysis is performed with 700km correlation scales (in SOAR function). This results in a field of biases for each of the data types. This bias is then removed from the observations and used in the analysis. Martin then used the Mediterranean Sea as an example noting that this region generally has some of the strongest biases. He showed the impact of the bias correction scheme on the mean background errors vs in situ data for a one month period in December 2005. This demonstrated that without the bias correction there are on average 0.25 degrees bias whereas with the bias correction the bias is very close to zero on average as shown in Figure 9.5.1.

Martin noted that validation using a global comparison of in situ observations with the background field from the previous analysis (shown in Figure 9.5.2) shows very good performance with RMS errors (shown in solid line) less than 0.6K and mean bias errors (shown in thin solid line) less than 0.1K. In this plot it should be noted that the AATSR skin correction was implemented in towards end of period, and in fact the biases are now even smaller than shown.

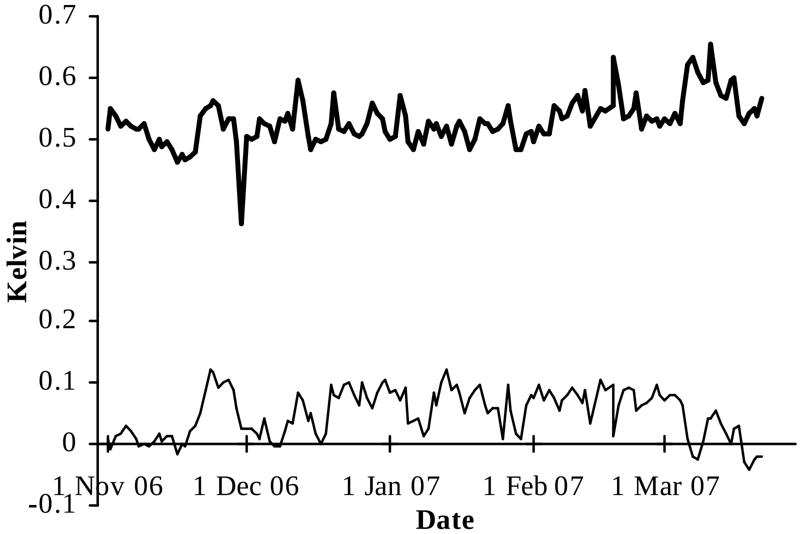


Figure 9.5.2 Validation results for the OSTIA SST analysis (global) using observations minus background, November 2006-March 2007

Martin then explained that small trials using OSTIA SST in Met Office NWP models have now begun using a case study using a 5-day forecast of Hurricane Rita (20 – 25 September ’05) which shows promise as the storm low pressure centre is shifted toward the observed track when using OSTIA rather than NWP SSTs. In addition there has been interest from ECMWF and olther national, met services as potential users.

Martin then moved on to discuss the application of GHRSST-PP data within the Met Office Forecasting Ocean Assimilation Model (FOAM) system which is an operational ocean forecasting system for the deep ocean. It also runs daily in the operational suite of the Met Office and assimilates data including Argo, altimeter SSH, SST and sea ice concentration. The model component is currently based on the ocean model used in the Hadley Centre climate models and we are currently transitioning it to use the NEMO ocean model. FOAM produces an analysis and 5 day forecast each day and is forced by 6 hourly surface fluxes from the Met Office’s NWP system. Various resolution models are run, including a 1 degree global model, a 1/3 degree model of the north Atlantic and Arctic and a 1/9th degree model of the north Atlantic. Until recently, there was only a coarse resolution 2.5 degree product assimilated into FOAM, although there was also the in situ data. The plan is to move to use GHRSST data (although as an interim the system is currently assimilating a 50km/100km NESDIS product). The OSTIA system was based on the analysis system used by FOAM – an OI scheme. However, the bias correction scheme used in OSTIA is not currently used by FOAM. The SST analysis produced at the surface is applied at all model depths which are within the mixed layer, as determined by the model. The increments are applied to the model using IAU which applies the increments as a constant forcing to the model during the forecast to avoid generating spurious gravity waves.

Two integrations of the FOAM north Atlantic system at all 3 resolutions were run for the period end of Jan 2005 to beginning of May 2005. One integration assimilated the coarse resolution data previously used – this is called the control run. One integration assimilated the GHRSST data as is used for OSTIA instead – called the GHRSST run. All other data types were assimilated into both integrations, including the in situ temperature and salinity profiles and altimeter data. The results show t GHRSST data has clearly had a significant impact in all configurations with much more information in regions of high variability, such as the Gulf Stream in the 1/9 degree model. There is a reduction in temperature error in the top 600m but some problems with salinity remain which need to be investigated further.

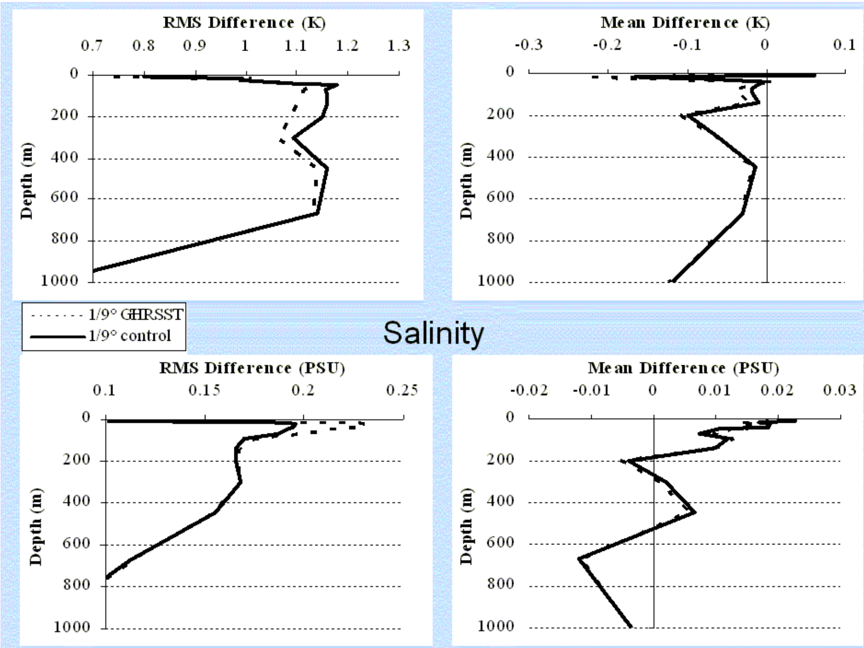


Figure 9.5.3. Impact of assimilating GHRSST-PP SST data on the vertical structure within the FOAM Ocean model against a control run that does not assimilate GHRSST-PP data (solid line)

Martin noted that further work includes

- Trials into the use of OSTIA in the NWP system at the Met Office are underway.
- Case studies into the impact of OSTIA on hurricane prediction in the Met Office NWP system show improvement.
- Plans for reanalysis using Pathfinder (AVHRR and (A)ATSR) back to 1985 – will be available in 2008.
- Plan to implement use of GHRSST data in the operational FOAM system by 2008

9.6 BLUElink> Regional high-resolution SST analysis: verification and inter-comparison, *H. Beggs, BRMC, Australia.*

Beggs described a new regional high resolution SST L4 analysis system implemented at the BRMC which is based on the existing low-resolution global Bureau of Meteorology (BoM) operational, optimal interpolation SST analysis system. The new system has a daily resolution at 1/12° over the region 60°E - 170°W , 20°N - 70°S as shown in Figure 9.6.1. The data sources used by the analysis include:

- AVHRR SST1m (Local 1km, Global 9km x 4 km)
- AATSR Meteo SSTskin (17km)
- AMSR-E SSTsubskin L2P (25 km)
- In situ bulk SST from GTS
- NCEP ice edge data

Test daily foundation SST analyses are available by ~0230 UT (fv01) and ~2030 UT (fv02) as GHRSST-PP GDS v1.7 netCDF L4 files from OPeNDAP server accessible via: **http://godae.bom.gov.au** More information on the analysis system can be found at **http://www.bom.gov.au/bmrc/ocean/BLUElink/SST/Bureau_HR_Regional_SST_Analysis_vg1.0.pdf**

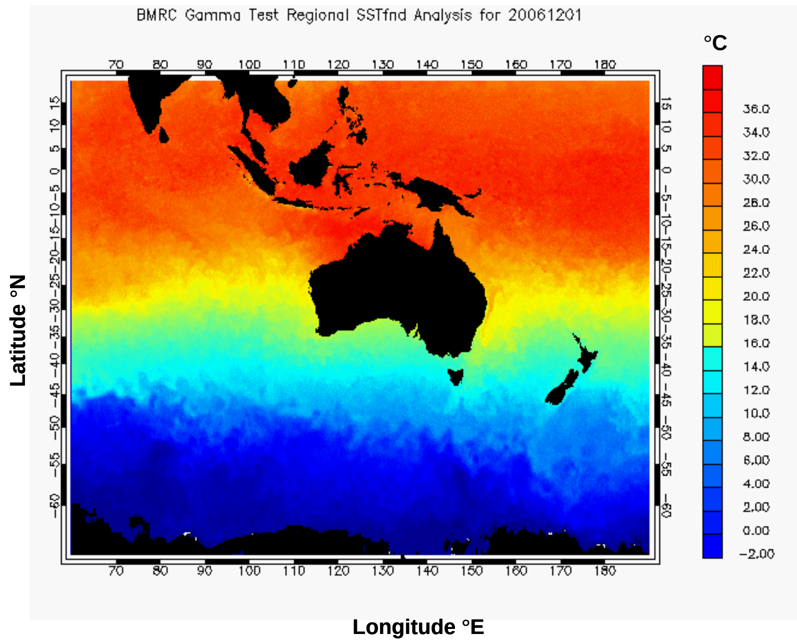


Figure 9.6.1 Domain of the BLUElink< regional high resolution SST analysis.

Beggs then focused on How does BLUElink> test 1/12° regional SSTfnd analysis (Gamma SSTfnd) compare with other SST analyses/composite products over the same region (20°N to 70°S, 60°E to 170°W)? In order to answer this question, comparisons between SST L4 analysis products was performed. Table 9.6.1 describes the characteristics of the L4 products used in the inter-comparison.

Table 9.6.1 L4 SST analysis products used to verify the performance of the BLUElink> Gamma SSTfnd regional high resolution SST analysis.

L4/L3 Product	GAC AVHRR (~1m)	HRPT AVHRR (~1m)	AMSR-E (subskin)	AATSR (skin)	TMI (subskin)	In Situ (bulk)
BoM 1/12° regional SSTfnd	X	X	X	X		X
BoM 1/4° regional SST1m	X	X				X
OSTIA 1/20° global SSTfnd	X		X	X	X	X
Reynolds 1/4° AMSR+AVHRR SSTblend	X		X			X
CSIRO 1/25° 3 Day AVHRR Composite SST1m		X				

The OSTIA and Reynolds analyses were chosen as useful comparison data sets largely because they are operational and easy to access. The comparisons also used CSIRO composite maps of AVHRR which, while not independent data, are extremely useful to delineate features that the analysis should be able to replicate. This approach received wide endorsement form the Science Team,. CSIRI composite products are derived from AVHRR LAC data received at stations in Hobart, Perth, Darwin and Townsville. Beggs first presented a series of difference plots for a single day as shown in Figure 9.6.2 which clearly show significant regional biases of the order ±1K.

A time series of average statistics (bias and rms.) was then constructed and plotted for 25th September to 4th December 2006 as shown in Figure 9.6.3. Significant differences exist between the data sets (particularly the BoM global system). The mean results for the entire time series are over ther region: 60°E - 180°E , 20°N - 70°S and 1 Oct – 30 Nov 2006 perkiod are:

Test – BoM Operational Regional SST1m: 0.07 ± 0.41°C
Test – CMAR Composite AVHRR SST1m: -0.15 ± 0.73°C
Test – OSTIA SSTfnd: 0.09 ± 0.45°C
Test – Reynolds SSTblend: -0.02 ± 0.61°C

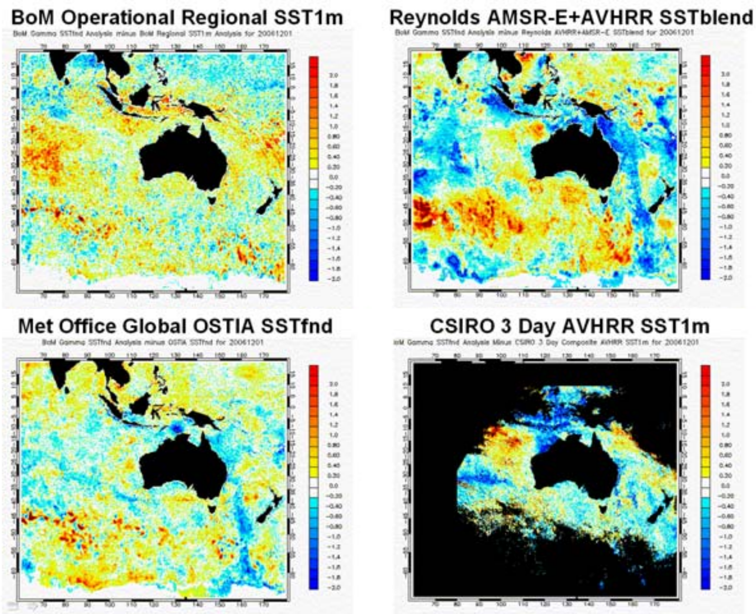
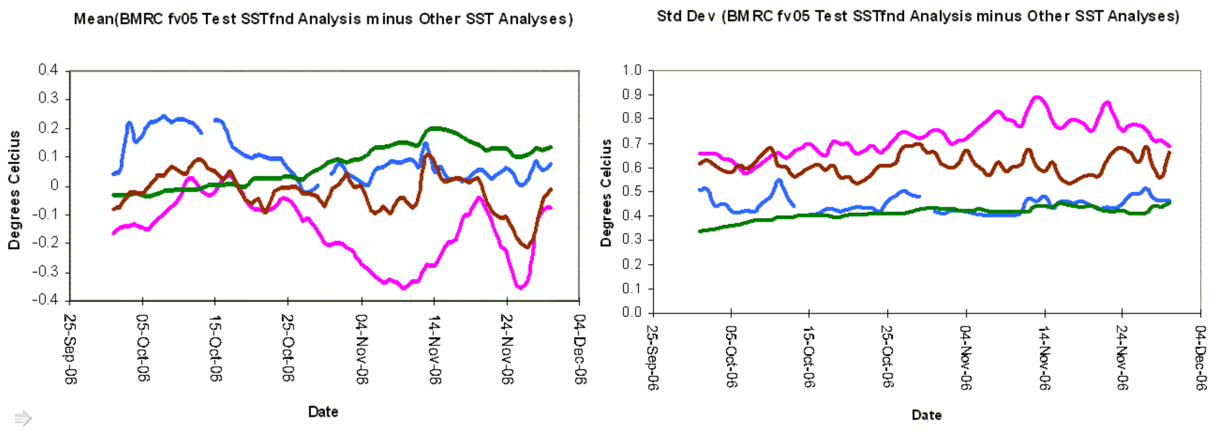


Figure 9.6.2. Difference plots between the BLUElink> Gamma SSTfnd and (a) BoM operational L4, (b) Reynolds AVHRR + AMSERE, (c) Met Office OSTIA and (c) CSIRO 3-day AVHRR SST composite for 1st December 2006.



(A) bias **(b) rms**

Figure 9.6.3 Time series of bias and rms deviation for differences between Gamsa SSTfnd and other L4 analyses 25th September 4th December 2006 over the Gamsa SSTfnd region.Test – BoM Operational Regional SST1m (green) Test – CMAR Composite AVHRR SST1m (pink), Test – OSTIA SSTfnd (blue), Test – Reynolds SSTblend (brown)

Beggs then considered the GODAE metrics as a series of methods to analyse the differences between the L4 products noting the following definitions:

- **Performance Analysis** diagnostics based on statistical measures including
  - Innovation Vector (Obs - BGF and rms(Obs – BGF))
  - Withheld Observations (Analysis (no buoy data) – Buoy SST)
- **Quality Analysis** based on direct comparisons with observations
- **Consistency Analysis** based on understanding of the ocean processes and reality where time series animations are particularly useful

In both the performance and consistency analyses the Gamsa SSTfnd was able to beat the BoM operational systems showing a definite improvement. Beggs showed a series of plots that considers the consistency of each analysis as shown in Figure 9.6.2. In this case the benefit of the CSIRO 3-day composite is evident acting as a reference 'observational' truth data set. A particular issue related to the high resolution grid cell spacing of the OSTIA analysis yet its lack of detail at the same scale suggesting that significant improvements to OSTIA could be made. Furthermore, the Science team suggested that the OSTIA team should inform the user community that while the OSTIA grid resolution was 1/20° the analysis itself was more like 30km.

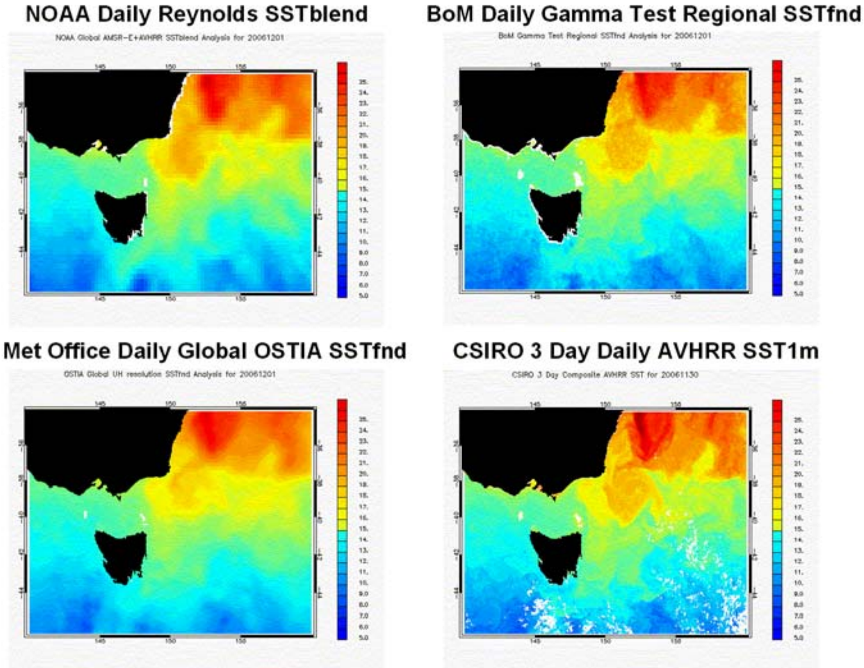


Figure 9.6.4. Consistency analysis plots of SST analyses over the Tasman Sea.

Beggs concluded that over the study period (1 Oct – 30 Nov 2006) BoM Gamma Test SSTfnd Analyses

- Have less bias and RMS error than BoM Operational or Beta Test Regional SST analyses (based on Obs – Analysis, Obs – BGF and Analysis – Buoy Obs)
- Agree more closely with OSTIA SSTfnd analyses than Reynolds AMSR-E+AVHRR SSTblend or CSIRO's 3 Day AVHRR SST1m Composite
- More closely resolve meso-scale ocean features than 1/20° resolution OSTIA SSTfnd analyses
- Exhibit better temporal consistency between daily analyses but less spatial homogeneity than OSTIA

Parallel tests with LAPS0.125 and LAPS0.05 (Sydney) ingesting Gamma SSTfnd and BoM operational regional SST1m are currently underway to determine impact on skill.

- **ACTION: (Beggs) can the L3 composite product for Australia be made regularly available to GHRSST-PP in L3P format?**
- **ACTION: (Beggs) To inter-compare results use of the 3-way statistics method for the analysis systems could be made.**

9.7 Validation tools and methods for the global SST analysis of MERSEA, *E. Autret, IFREMER, France.*

Autret began by explaining that in the framework of the European project MERSEA, IFREMER has set up a new L4 SST analysis system producing the global high resolution SST fields required by various ocean models and downstream services. SST fields are being produced daily on a 0.1 degree grid based on OI of SST satellite measurements from both IR and MW sensors (GHRSST L2P products (except MODIS for the current version)). Table 9.6.1 shows the data sets used in the analysis.

The background field is taken from a daily climatology derived from the Pathfinder V5 constructed as a 5 day climatology filled and averaged on a 1°x1° grid and linearly interpolated in time. This smooth climatology avoids artefacts in the analysis by limiting a noisy background. The structure function is modelled by the sum of Gaussian functions (different scales) with relative weights. Isotropic correlation scales (in time Lls=1 day, Lms=2 days) and in X and Y are ~Rossby radius bounded by 20 km and by the large scale set to 80 km). The variance is partitioned as measurement errors on 4 scales including unresolved scales

Table 9.7.1 Data sets used in the ODYSSEA L4 analysis system

Original resol.	Satellite/sensor	product	Provider
1 km	AATSR	EUR-ATS_NR_2P	MEDSPIRATION/IFREMER ftp://ftp.ifremer.fr/ifremer/medspiration/data
2 km	AVHRR	EUR-L2P-NAR17_SST EUR-L2P-NAR18_SST	MEDSPIRATION/IFREMER ftp://ftp.ifremer.fr/ifremer/medspiration/data
2 km	AVHRR	NAVO-L2P-AVHRR17_L NAVO-L2P-AVHRR18_L	GDAC/NASA ftp://podaac.jpl.nasa.gov/pub/GHRSST/data
3 km	GOES/VISSR	OSDPD-L2P-GOES11 OSDPD-L2P-GOES12	NOAA/NESDIS ftp://gp16.ssd.nesdis.noaa.gov/pub/goessst/L2P
9 km	MSG-1/SEVIRI	EUR-L2P-SEVIRI_SST	MEDSPIRATION/IFREMER ftp://ftp.ifremer.fr/ifremer/medspiration/data
10 km	AVHRR	NAVO-L2P-AVHRR17_G NAVO-L2P-AVHRR18_G	GDAC/NASA ftp://podaac.jpl.nasa.gov/pub/GHRSST/data
25 km	AMSRE	USA-RSS-AMSRE-MW-L2-SST	MISST/RSS ftp://ftp.misst.org/amsre/swath/nc
25 km	TMI	REMSS-L2P-TMI	MISST/RSS ftp://ftp.misst.org/amsre/swath/nc

Pre-processing steps include a remapping of GHRSST L2P products onto a common 0.1 deg. Grid as composite products called collated “L3P” products (per /day /sensor on 0.1 deg. grid) using data within a time interval of ±3 days around the analysis date. The L3P products are then merged and inter-calibrated to produce a single multi-sensors ‘super-collated’ composite product (per /day, 0.1 deg grid, data witin ±3days). This process is shown in Figure 9.6.1 and the resulting super-collated products shown in Figure 9.6.2. Only night-time measurements are used and all quality indicators in L2P files are applied including the SSES estimates which are subtracted from the observations.

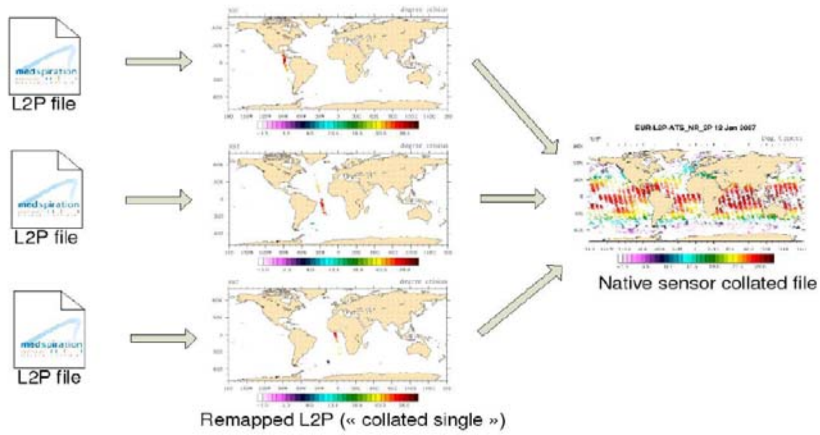


Figure 9.6.1 Observations pre-processing to collate and super collate SST data sets before analysis.

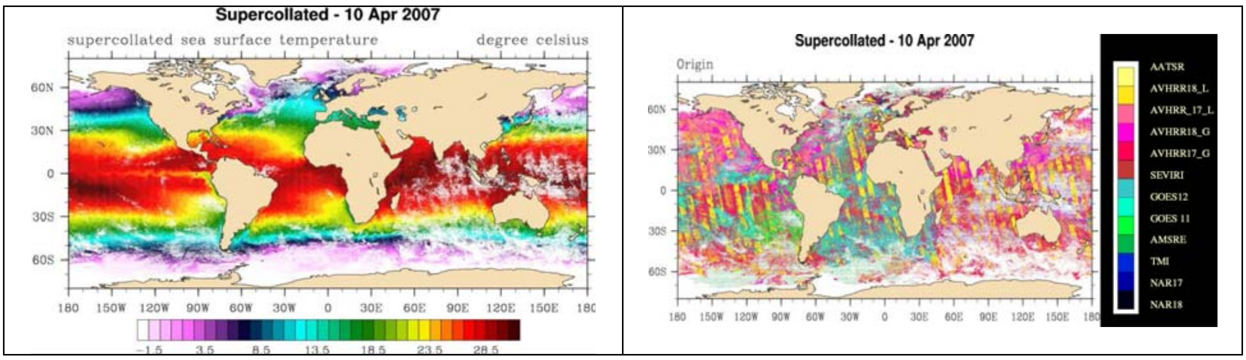


Figure 9.6.2 (a) Super-collated input L3 data set and (b) corresponding source of SST information for the super-collated array.

Autret then explained how the basic L4 processing system had been validated using a combination of NAR NOAA 18 1km test data sets as input demonstrating that the system is working well. HJowever, a more testing case is required using complete data. The ODYSSE team chose to use model data fields to validate the system configuration to understand if the system can properly resolve scales. Complete field MERCATOR ocean model data (Mercator (psy2v2 1/12°) over the North Atlantic at 0.1° resolution were use for the test which showed extremely good performance when compared to SST gradients and for spatial structures which were only smoothed slightly by the configuration. Spectral analysis indicates that there is some energy lost within the system at scales of ~60-120km.

In situ SST measurements from the CORIOLIS databank (drifting and moored buoy) for night-time cases are averaged in time and space (10km, 6hours) with outliers removed using a variety of different tests. Systematic monitoring of the products has been set up using a variety of tools including monthly statistics of the input observations to study the impact of biases and monitoring of observations – analysis at measurement point. In this case, the mean is uncorrelated and no trend in time or regional inconsistencies are found. Tools to consider the gradient fields (as part of the L4 inter-comparison effort (shown in Figure 9.6.3) are quite spectacular whdn compared to the OSTIA and RTG L4 products in the Gulf Stream region.

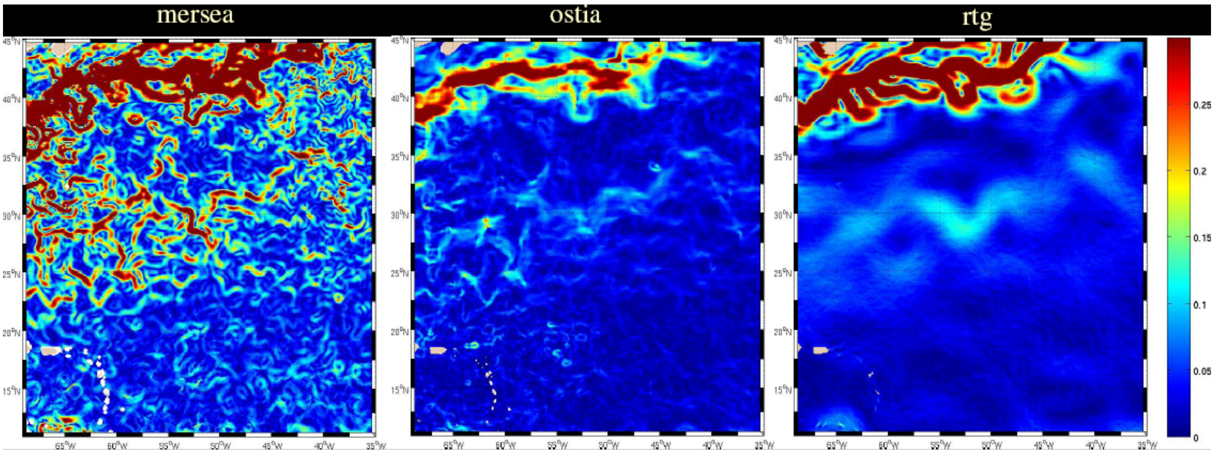


Figure 9.6.3 Inter-comparison of gradients in the Gulf stream region using MERSEA ODYSSEA, OSTIA and NOAA RTG SST analyses.

Autret concluded that the new MERSEA ODYSSEA operational system producing the global SST analysis of MERSEA has been successfully set up and evaluated (products available by June 2007). Diagnostic tools are provided to users to study the quality of the L4 products in real time available at the MERSEA web site (http://www.mersea.eu.org/Satellite/sst_validation.html) that are updated on a daily basis. Future work includes improvements to the observation pre-processing system and cleared definitions of methods for evaluation of the L4 product.

- **ACTION (LeBorgne) L3P collated and super-collated definitions need to be derived and agreed as L3P data sets**

9.8 Assessment and inter-comparison of five GHRSST products in the shelf and coastal seas around China, J. Xie.

Xie began by explaining that the Chinese team are looking for a major data source to feed our data assimilation system for preoperational ocean forecast. This motivated the investigation of five GHRSST Level 4 products in the coastal and shelf seas around China over the region 116-135ºE, 20~42ºN and 2005.10 - 2006.9 period. Table 9.8.1 describes the L4 analysis products used in this study and Figure 9.8.1 shows the annual mean SST for each product computed overt the study domain which look quite similar. However, a more detailed analysis of weekly data shows that significant differences exist between these products. Xie posed the following questions:

I. What are the differences and errors of the five GHRSST products in the coastal and shelf sea around China?
II. How can we improve the GHRSST products as a major input for data assimilation in this region?
III. Can we use the multi-product ensemble mean method to improve the presently GHRSST products?

Table 9.8.1 Characteristics of the GHRSST-PP L4 SST products used in this study.

	Coverage	Resolution	Satellite/sensor
MWOISST	Global	25 km, daily	TRMM/TMI, AQUA/AMSR-E
NGSST	116-166ºE, 13-63ºN	2 km, daily	NOAA/AVHRR, AQUA/MODIS, AQUA/AMSR-E
MGDSST	Global	25 km, daily	NOAA/AVHRR, AQUA/AMSR-E
OSTIA	Global	5 km, daily	ENVISAT/AATSR, NOAA/AVHRR, MSG/SEVIRI, AQUA/AMSR-E, TRMM/TMI
FSTIA	Global	10 km, 6 hourly	NOAA/AVHRR
EMSST	116-135ºE, 20-42ºN	10 km, daily	[synthesis]

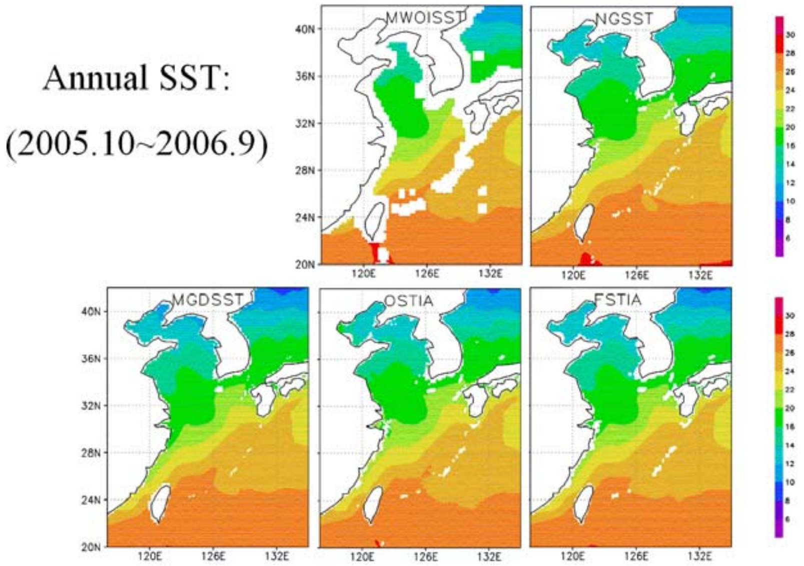


Figure 9.8.1 Comparison of the annual mean SST (2005.10~2006.9) for 5 GHRSST-PP L4 analysis products in the shelf seas around China.

A multi-product ensemble mean was constructed for all data sets and used to compute anomalies for each input data set as shown in Figure 9.8.2. Significant differences in all cases are seen in the coastal regions with biases exceeding ±1K in some areas. Two of the 5 analyses show negative anomalies whereas the other 3 show positive anomalies.

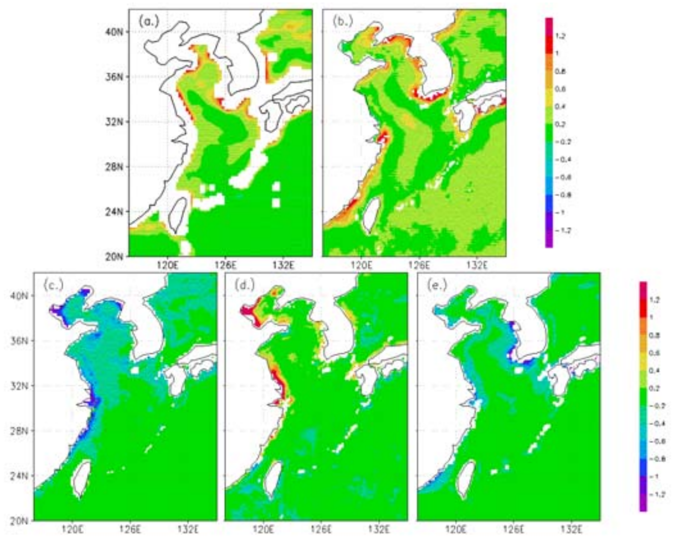


Figure 9.8.2 Anomaly difference plots for each of the SST analysis products shown in Figure 9.,8.1 based on a multi-product mean SST computed from all data.

To investigate differences drifting buoy and ship reports are collected by Near-Goos (http://near-goos1.jodc.go.jp) from the GTS. Data were pre-processed using the following steps:

1) Exclude reports with invalid ship call sign.
2) Exclude redundant reports.
3) Check the consistency of the data using the consistency tracking method described in *Kent and Challenor(2006).*

The pre-processing steps yielded for night-time SST data only: ~ 3167 SHIP reports and ~ 7284 BUOY reports for analysis. An initial quality control analysis was performed by comparing the monthly SST for a ship or buoy with climatology. If it lies outside a 3 standard deviation limit the observations in this month will be rejected. Any record outside a 4.5 standard deviation referring to monthly climatology from GDEM-V3.0 was further excluded and consistency checking by the EMSST linear regression with 99% confidence level was used to reject data. Following these procedures 2715 ship records and 6835 BUOY records were retained for further analysis.

Observations were then stratified by depth and compared to the L4 GHRSST-PP analyses. In the case of the multi-product ensemble, good agreement (<0.6K) is found at all depths over the entire domain although significant differences (>2K) exist in the immediate coastal region. Figure 9.8.3 shows the mean bias and rms for each analysis for all buoy matchups and the numerical values are provided in Table 9.8.2.

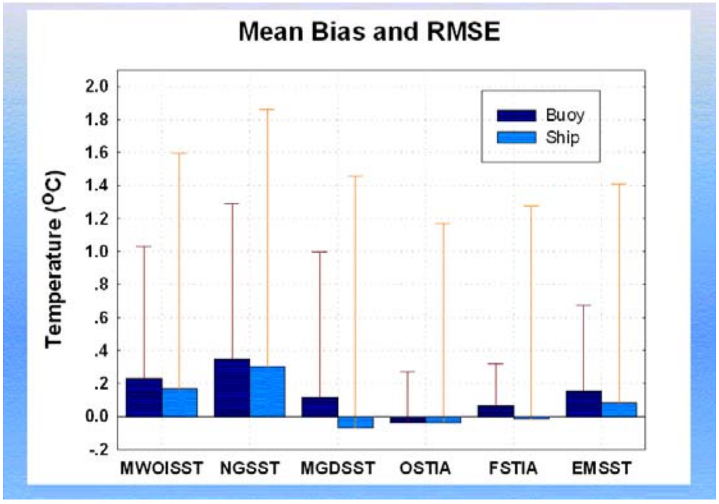


Figure 9.8.3 Mean bias and RMSE for L4 analyses in the shelf seas around China computed from in situ observations. The histogram denotes the bias, and the error bar denotes the corresponding RMSE.

Table 9.8.2 Mean bias and RMSE for L4 analyses in the shelf seas around China computed from in situ observations.

	MWOISST	NGSST	MGDSST	OSTIA	FSTIA	EMSST
Bias	0.23	0.35	0.12	-0.04	0.06	0.15
RMSE	0.80	0.94	0.88	0.31	0.26	0.52

Based on an exponential function, buoy data can be used to adjust the bias in each analysis and using this technique, Xie showed that each analysis can be successfully adjusted to agree with the in situ data. Referring to buoy SST, the bias can be decreased by an order of magnitude, but the RMS is decreased by **1%** (OSTIA) and **4%** (FSTIA) of RMSE. Comparison of bias and RMSE of OSTIA and FSTIA by exponent correction relative to costal station observations shows that on average, the RMSE can be decreased about 5% and 3%, respectively to OSTIA and FSTIA.

Xie concluded that all of the L4 products are agreed with very well when water depth is larger than 80m. However, near the coast around China, large differences exist. For example, as the depth is less than 40m, the annual mean spread of them is nearly to 0.9ºC.

- Comparing to in situ observations, most of them are excellent for reasonable bias and RMSE. Especially the RMSE of OSTIA and FSTIA (reference to buoy SST observations) are about 0.3ºC. However near the coast, i.e. the depth is less than 40m, the warm bias (>0.2ºC) and the considerable RMSE (>0.6ºC) are prevalent in the five products.
- A bias correction scheme that uses an exponent function of depth is applied to two products (OSTIA and FSTIA). The correction can reduce bias effectively however, the RMSE doesn't reduced so effectively.

- The current GHRSST L4 products, especially some of them, can be safely used as a major input of data assimilation system in the shelf sea around China. However, near the coastline where depth is less than 40m, they are not ready to be assimilated. It is necessary to make further correction or improvement.

- **ACTION (Donlon, Xie) Add this study to the GEO DA-06-03 GHRSST-PP task.**

9.9 GEO ActionDA-06-03 for GHRSST-PP ensemble based techniques: C Donlon

Donlon began by noting how important the opening presentation of Jim Cummings which called for a variety of tools and a framework for verification and metrics for validating the L4 SST analyses of their GHRSST-PP. The group needs to have some way to easily compare L4 analyses and check for consistency. Inter-comparisons revolutionised the way GODAE modelling teams worked together and as individual teams. Through careful inter-comparison studies L4 teams learn a lot and at the same time will provide a useful service to the seasonal and climate community (especially when coupled to the GHRSST re-analysis work. Furthermore, Donlon noted that the groups will be able to follow up with good science and papers.

Against this background, the Group on Earth Observations (GEO) have agreed to GHRSST leading an action on ‘ensemble approaches’ using L4 SST analyses. The Group on Earth Observations is coordinating international efforts to build a Global Earth Observation System of Systems (GEOSS). This emerging public infrastructure is interconnecting a diverse and growing array of instruments and systems for monitoring and forecasting changes in the global environment. This “system of systems” supports policymakers, resource managers, science researchers and many other experts and decision-makers. A Framework Document was adopted in the Earth Observation Summit II and set out nine socio-economic benefit topics to be derived through Global Earth Observation System of Systems (GEOSS). The 9 topics are as follows;

- Reduction and Prevention of Disasters
- Human Health
- Energy Management
- Climate Change
- Water Management
- Weather Forecasting
- Ecosystem
- Agriculture
- Biodiversity

From the perspective of GEO and GEOSS, the GHRSST-PP *is* GEOSS in action and the GHRSST-PP provides a formal demonstration for GEO. Action DA-06-03 (as described in the 2007-2009 Work plan) has the following objectives:

- Demonstrate the application of the next generation SST observations provided by GHRSST-PP. Activities include:
  - ***Ensemble techniques to account for uncertainty estimates in output products*** (both analyses and observational products);
  - Use ***data assimilation techniques to assimilate GHRSST-PP products*** and improve output from ocean and atmospheric forecast systems;
  - ***Apply ensemble techniques to improve climate monitoring*** using global and regional SST data sets;
  - ***Organize and hold a series of focused working sessions/seminars*** to initiate an in-depth, continuous scientific and technical dialogue between the ocean/weather/climate modelling community and other scientific communities – potential users and/or developers of ensemble techniques.
- ***Promote the development of these activities*** through advocacy for international collaboration at organization-, government-, and/or agency- level to help connect most relevant entities and communities for project implementation.
- Work effectively together as a community

Donlon then quickly reviewed the L4 global and regional SST analyses within the GHRSST-PP (many having been presented in this session and recalled that the idea of a GHRSST-PP multi-product ensemble had been raised at the previous Science Team meeting. Based on this and on the GEO action several activities have taken place to develop such a GHRSST-PP Multi-product Ensemble (GMPE) approach. The development and use of a GMPE provides an optimal way forward as it preserves regional autonomy maximises benefits to user community by providing a measuring stick on which to monitor and study differences. However, to function effectively it requires a framework to deliver the ensemble product. The cornerstone of this is the GHRSST-PP L4 format descriptor which allows easy manipulation of several analysis products as the code writing and data management is relatively straight forward. Furthermore, the GMPE stimulates better products and scientific/production interactions and develops a useful community. All of these aspects are called for in the GEO action.

At the Met Office a prototype Multi-product Ensemble system has been developed as part of the OSTIA verificatyion work which has in part been developed in response to user request for SST anomaly products in near real time (daily) in support of the Met Office seasonal forecasting activities. The system currently uses data from the NOAA RTG, OIv2, RSS and OSTIA each day. Data are pulled from source and re-gridded to a common ½° global grid using area averaging. Standardised data sets and a standard 'Reynolds/Stark' colour scale has been agreed and approved by the GHRSST-PP Science Team. Figures 9.9.1 and 9.9.2 show sample output from the prototype system.

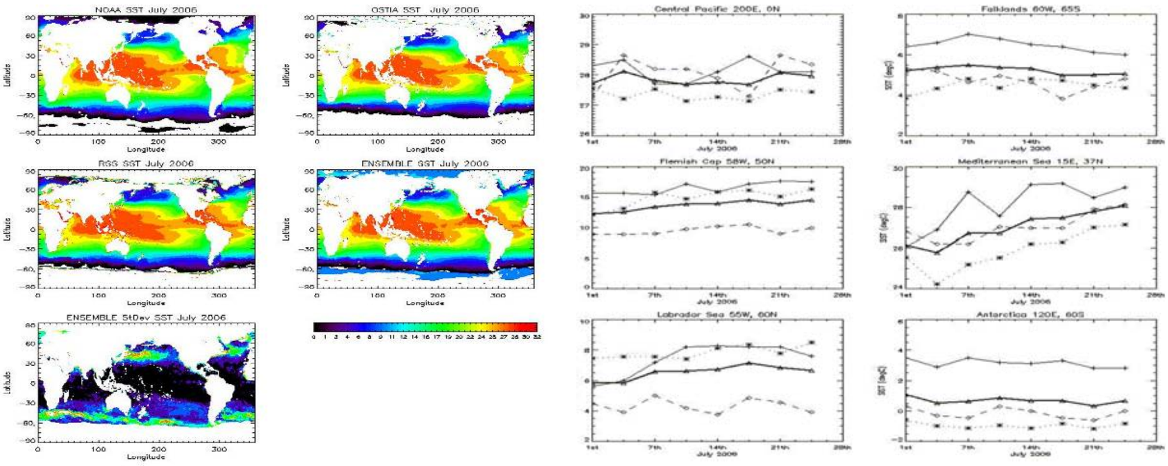


Figure 9.9.1 Sample output of the Met Office multi-product ensemble prototype. Left panel shows the SST data sets and the ensemble mean and the right panel the global mean SST as a function of time for different regions.

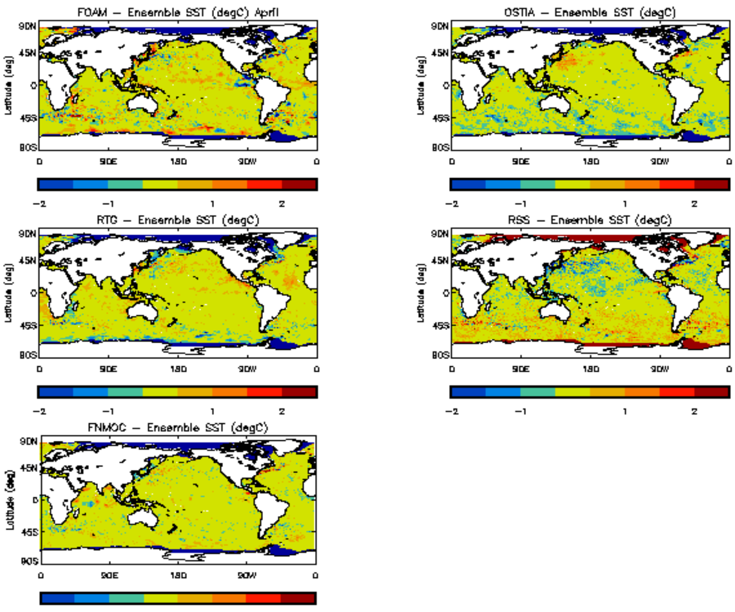


Figure 9.9.2 Global SST anomalies computed from the prototype multi-product ensemble for the period April – September 2006. Included in the example are the FOAM 1° x 1° ocean model outputs , OSTIA, NOAA RTG, RSS MWOI, and FNMOC SST analysis for GHRSST-PP.

Interestingly all analyses seem to have relatively good performance with major anomaly differences in areas of high variability (western boundary currents, sea ice edge, tropics etc). Tests using high-resolution anomaly plots computed on a weekly basis have been made as shown in Figure 9.9.3, These plots are extremely useful for flowing regional trends annual and inter-annual trends in SST. The North Atlantic SST map clearly shows large warm anomalies in the 'Ratcliffe' area off the coast of Nova Scotia and around the UK in 2007 which unsurprisingly had a particularly warm summer (although wet). The second panel in Figure 9.9.3 shows global anomalies for the same week.

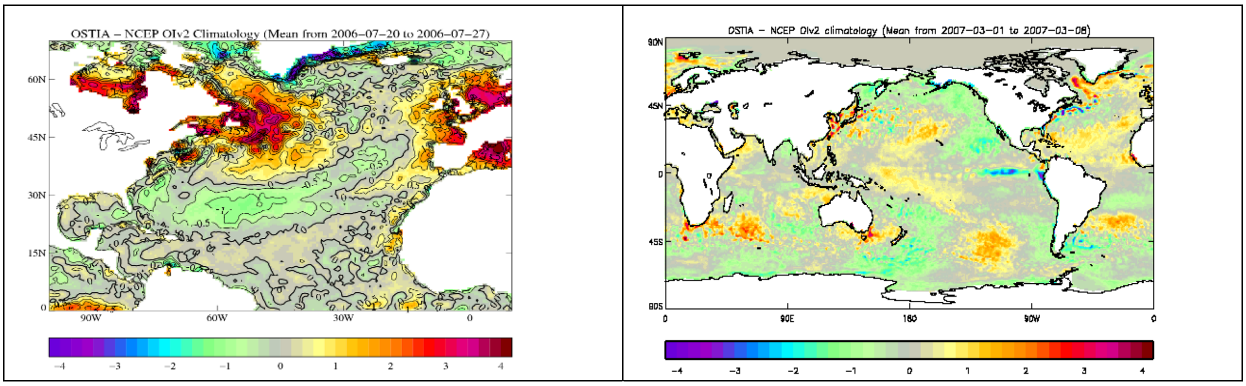


Figure 9.9.3 High resolution SST anomaly based on the NCEP OIv2.0 climatology in the Atlantic Ocean and over the globe for a 1 week period in July 2007.

As a second part of the ensemble activities at the Met Office, comparisons between background climatologies have been performed using Pathfinder AVHRR climatology, HAdISSTv1.0 and Reynolds OIv2.0 and comparisons between ocean model outputs (at various depths) and OSTIA. The latter have proved extremely useful for seasonal forecasting in the North Atlantic.

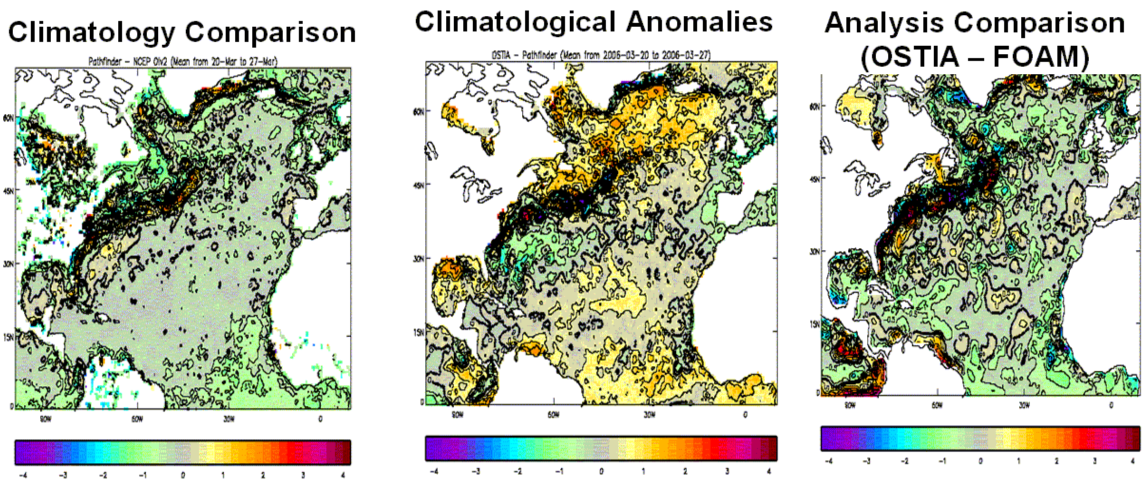


Figure 9.9.3 Left Comparison between Pathfinder v5.0 climatology and NCEP OIv2.0 climatology for 12 week in March 2007, Centre: difference between OSTIA and Pathfinder climatology for the same week and left, difference between OSTI and FOAM 1/9° model SST.

Donlon explained that based on these simple first steps which have been received very well within the Met Office, the OSTIA team intend to develop and extend the ensemble system further initially focussing on global SST's. Regional inter-comparisons are more challenging as there is a clear need to:

- Agree key dynamic area boundaries (e.g. Gulf of Mexico, Western boundary Currents, central ocean gyres, ice edge (Greenland) etc)
- Agree time periods for study (or should the system run in NRT using operational outputs?)
- Agree verification areas (area and the observing system inputs: buoys and ships? Just buoys? Other satellite data not used ion L4 analyses?)

In addition Donlon noted that the GHRSST-PP High Resolution Diagnostic Data Set (HRDDS) provides some basic ensemble type outputs which also contribute to the GEO Action DA-06-03 and could be linked to the Met Office activities.

Donlon concluded with a list of issues related to a GMPE project within GHRSST-PP for the ST to consider:

- Working together through L4 inter-comparisons experiments and activities helps improve our analyses as shown in the presentations of Begs and Xie.
- A GMPE project needs to be more formal and in particular inject discipline into the inter-comparison framework following the ideas and metrics raised in Cummings presentation
- The Met Office has planned an multi-product ensemble 'service' as part of the QC/verification and uncertainty estimation for OSTIA and as part of its role in the European Commission MyOcean project currently being defined.
- However, some key L4 outputs are not in GHRSST-PP format and are therefore not easily used in the system.
- The GMPE should include at a minimum:
    - Mainly L4 metrics: QC outputs, formal analysis metrics, choose areas of interest (W Boundary currents, include L3 composite 'truth' fields (K10, L3P LeBorgne, imagery and the HRDDS system;
    - Should agree formal Validation areas (we could start with those proposed by Pierre LeBorgene)
    - Should produce a variety of time series outputs at any locations (use Google Earth?)
    - Should include animations;
    - Should include inter-comparison of gradient maps from different L4 outputs;
    - Should include spectral analysis of different SST analyses;
    - Should include Hovmöller plots (GODAE Metrics lines XBT, CLIVAR repeat sections)
    - Should produce and plot on a web page 2D fields and their anomalies for global and regional areas;
    - Should consider sea ice regions and especially SST in the marginal ice zone;
- Do we want to include Altimeter data and Ocean Colour using the same toolkit?
- The DDS is complementary to this activity but could also be used to develop some of this functionality (better as data are more complete?)
- Does it need to be an open site or closed site? (anonymous or labelled) issue or non-issue.
- Do we need to include in situ data?
- Aim for a 2nd GHRSST-PP paper in 2008/9?

Donlon concluded by noting that GRSST-PP ***is*** the community to run a SST L4 Multi0-product ensemble study. It could help to join up with Radiance Assimilation groups and we will learn a lot about our products and the RAN will greatly benefit. The GHRSST-PP would then have a way to provide some uncertainty estimate for the L4 analyses beyond the model. GHRSST already has a high profile activity within GEO (report later this year to the GEO Plenary) but it needs your L4 support and I need you to sign up through your GEO National Representatives.

Donlon recommended that the Science Team develop a L4-Metrics/Ensemble-TAGto manage the activity noting that both the scientific community and operational centres MUST be involved. The Met Office is happy to coordinate the operational centres and basic framework under the GEO action which we lead.

- **ACTION: (Donlon) Initiate the GHRSST-PP Multi-Product Ensemble Technical Advisory Group (GMPE-TAG).**

Following some discussion it was agreed to initiate a GMPE-TAG and aim for outputs following the suggestions of Jim Cummings in the spring 2008 time period. In particular the group should try and focus on developing metrics for SSES statistics and their impact on L4 systems as well as automated anomaly plots etc. Ian Barton agreed to Chair the group with contributions from NRL, UKMO, BoM, OSPD, MERSEA, Medspiration, China, MISST, LTSRF and PO.DAAC.

The main elements of a Terms of Reference (to be developed by the GMPE-TAG Chair and the GHRSST-PO International Project Office) should include the following:

1. Set up a regular basic MPE between NRT Global L4 systems on highest spatial grid
2. Set up a regular basic MPE between NRT regional analyses including downscaling of Global systems to highest spatial grid of the regional analyses
3. Develop a web presence (GHRSST-PP.org, HRDDS, others) to work with basic outputs
4. Develop an intensive metrics experiment for 2-6 months for full computation of intensive fields

10 Session 8. Reanalyses and Climate Data Records

10.1 Rannual Review: Ken Casey

Ken Casey, Chair of the GHRSST-PP Reanalysis technical Advisory Group (RAN-TAG), began with a review of the reanalysis project goals including related GCOS (global climate observing system) SST/SI working group activities. The goals of the RAN effort within GHRSST-PP are to produce delayed mode products with higher accuracy and consistency than the NRT operational data sets. There is also the need to link the GHRSST-PP satellite-era SST records to longer term climate records. To do this there is a clear need to ensure a sustained reprocessing capability in which SST records are continually reviewed and reprocessed using the best available tools, methods and algorithms.

Casey reminded the Science Team of the RAN targets have been agreed as:

- Spatial resolution: Follow real-time L4 grid ~ 9 km (higher only if feasible)
- Temporal resolution: Once per day
- Type of product: L4 SSTfnd (plus 4 diurnal offsets)
- Error Statistics required: Bias and Standard Deviation at each output grid point
- Data Format: netCDF with CF compliant metadata

Following discussions Casey noted that these targets have now been revised to a spatial resolution goal of 4-5 km globally with 1-2 km regional products. This will be a challenging target but one that is worth aiming for. It will require new Diurnal Variability work and supporting data sets that may not be immediately available.

10.2 The Analysis of Long Time-Series of SST from the AVHRR and ATSR Sensors: David Llewellyn-Jones

Llewellyn-Jones began with a summary of the current AATSR data record which now spans 16 years from 1991 and includes three satellite instruments. 2007 has been a particularly good year for (A)ATSR activities as:

- A new archive system has been launched
- There has been take-up by operational users as the direct result of GHRSST/Medspiration!!
- Future Continuity of AATSR-standard SST data secured through the ESA GMES/Sentinel Programme in the form of a new instrument called the sea and land surface temperature radiometer (SLSTR) on Sentinel 3
- A new UK AATSR Reprocessing for Climate (ARC) project is now in place for future development of product quality Led by C Merchant (U of Edinburgh)

Llewellyn-Jones then reviewed the work of Lawrence et al (JGR 2004) which showed that ATSR (8 years) and AVHRR (15 years) could be used to infer rates of change in measurements of Global SST Results were mutually consistent despite complete independence of both measurement systems as shown in Figure 10.2.1. The results from AVHRR and ATSR are mutually consistent (within errors) despite independence of measurement systems. Good et al (Journal of Climate, published April 1, 2007) have tested and validated the methodology using the complete 20-year AVHRR record. The key findings from 20 yrs of AVHRR SST are that Lawrence's Methodology is valid, some refinements introduced (good error estimation) and El Niño events do NOT mask trends in Global mean SST over the 20-yr period. Furthermore, spatial distribution is important and should provide means for more rapid estimation from the higher accuracy of AATSR data than previously thought possible (Good et al, J Climate, April 2007).

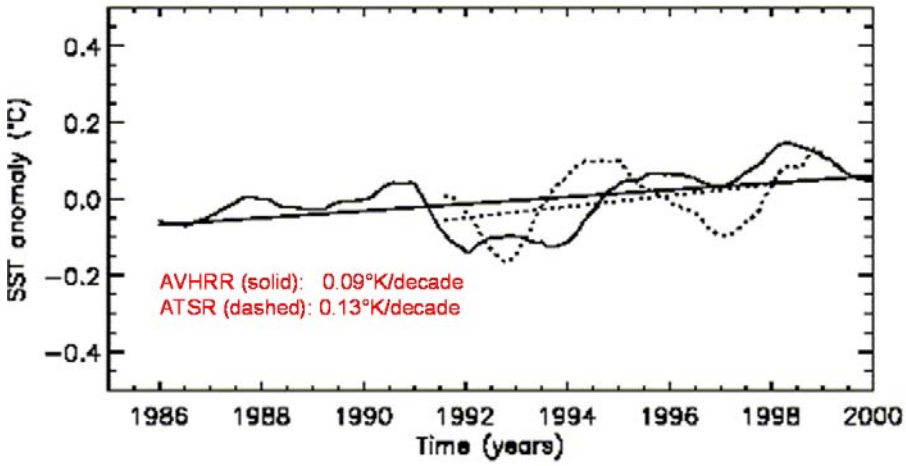


Figure 10.2.1 Trends in global SST from the ATSR and AVHRR.

The new (A)ATSR archive (to be completed in the coming months) marks a major milestone for ATSR users worldwide and is a turning point for the ATSR project. All ATSR-1, ATSR-2 and AATSR data will be available processed to same format and same processing standard and will be available in UK through the National Environmental Research Council (NERC) Earth Observation Data Centre (NEODC) and in rest of World via ESA. The current versioning of the (A)ATSR project outputs are:

- Version 1.0 – what we have until now
- Version 1.1 – what is now being put into the archive today
    - ENVISAT SST's not re-processed
    - Uniform format
    - A major new asset for users
- Version 2.0 – available Spring 2008
    - 16 years of SST Uniformly processed to state-of-art start standard
    - LST complete time-series
- ATSR Version 3.0 to be generated by ARC project
    - Consortium includes U Edinburgh, UK Met Office, NOCS, RAL and U Leicester,
    - Improvements include:
    - Better aerosols corrections
    - Full analysis of overlap periods and appropriate corrections
    - Further improvement in retrieval coefficients
    - Introduction of new cloud-clearing scheme
    - Ready in 2011 approx

Several new operational activities have used AATSR data including MEDSPIRATION, ESA's contribution to GHRSST which has made AATSR 1Km data available to worldwide operational users in near real time. The Met Office OSTIA system now uses AATSR data every day and Meteo France use AATSR data as part of the MSG SEVIRI quality control and as a bias correction for their Atlantic Ocean L4 analysis system. This is great progress and demonstrated the usefulness of AATSAR as a reference SST data source.

- **Action: (Donlon) Write to ESA requesting that the name of SLSTR is changed to ATSR-4 as this is adding confusion to the international community.**
- **ACTION: Users wanting to use the AATSR BT's for radiance assimilation should provide a summary of their application and request access through the GHRSST-PO.**

10.3 SST Data Continuity: The impact of a data gap between AATSR and SLSTR on operational services: Gary Corlett

Coreltt began noting that SST is an Essential Climate Variable (ECV) of the Global Climate Observing System (GCOS). The (A)ATSR SST record has been defined as a Fundamental Climate Data Record (FCDR) within the GCOS Implementation Plan and conforms to the GCOS Climate Monitoring Principles (GCMPs) which include a requirement for an overlap between successive instruments in a series. GCOS defines 20 GCMP for satellite climate data records: ten for all data records and ten further requirements specific to satellite instruments. A full list of these is available in *Implementation* *plan for the Global Observing System for Climate in Support of the UNFCCC, GCOS-92, October 2004 (WMO/TD No. 1219)*. The AATSR time-series adheres to many GCMP and specific examples include:

- On-board calibration
- Overlap period between sensors to ensure homogeneity
- Ground-based monitoring throughout lifetime of satellite

However, although AATSR is expected to operate until 2010, at which time Envisat is expected to run out of fuel but the Sea and Land Surface Temperature Radiometer (SLSTR) on Sentinel 3 will not fly before 2012, so there may be an enforced break in the SST climate record, with no overlap between instruments.

This raises two fundamental SST data continuity questions:

- Can the SST data from Sentinel 3 be tied to the same absolute temperature reference as the SST data record in the (A)ATSR archive?
- How might the data gap between ENVISAT and Sentinel 3 be filled using alternative sources of SST data with the minimum loss of quality?

A project was established to consider these questions which aimed to ensure that the SST data record provided by the (A)ATSR-SLSTR series continues to fulfil the needs of international Earth observation initiatives, including GCOS, GEOSS, GMES, GHRSST, CEOS/IVOS, IPCC and UNFCCC. The main elements of the strategy include:

- Assessment of how satellite and in situ data can best be used to tie the Sentinel 3 SST data to the AATSR SST data by identifying possible sources of SST data that might be available to bridge the gap between the end of the Envisat mission (or failure of AATSR) and the start of the Sentinel 3 mission.
- Devise a strategy for national and international agencies to respond to the challenge of maintaining the (A)ATSR series as a climate standard for SST.
- Recommend a programme of work to be implemented before and during an interval when no ATSR-class sensor is operating, with the aim of securing the integrity of the SST climate record from 1991 to at least 2021.
- Review alternate SST data sources that might fikll the gap between Sentinel-3 SLSTR and the AATSR.
- Identify potential sources of SST data, especially in the 2010 to 2012 timeframe, when the gap is expected to occur in ATSR SST data record
- To make recommendations as to the suitability of these alternatives for bridging the gap between AATSR and Sentinel 3
- Consider both current and planned instrumentation, and their availability, through consulting within the GHRSST-PP community and mission scientists for planned instrumentation. Several different types of data sources alternate to the AATSR are available including:
    - Infrared satellite instruments,
    - Microwave satellite instruments and
    - In situ data.

Possible sources of data as of May 2007 include the two polar-orbiting IR satellite data sets that cover the period from 2010-2012, AVHRR (on MetOp) and VIIRS on NPP. The availability of the MODIS dataset through 2010-2012 cannot be confirmed at this time and it is noted that VIIRS will sample at 05:30 and 13:30 and not at the 10:00-10:30 sampling time of the ATSRs There will also be data from geostationary IR satellites such as SEVIRI, GOES and MTSAT. It is likely that there could be only one MW SST data set available for the period 2010-2012, provided by the CMIS instrument on NPOESS but the CMIS instrument will not sample at the same time as the ATSRs. Finally the availability of the AMSR-E dataset through 2010-2012 cannot be confirmed at this time. In summary there are several options but several problems using satellite data making them far from ideal to ‘fill the potential AATSR gap’.

Several high quality in situ radiometers are available which provide excellent validation data and could be used as a ‘transfer standard’ and bridge the gap. However, there is the obvious need for a long-term commitment to maintain and deploy radiometers aboard ships. The importance of continuing the M-AERI and ISAR in situ data records is noted, as they may provide the key link from AATSR to Sentinel 3, and are required to ensure the ATSR data record continues to adhere to the GCMPs. **Therefore, we recommend that the AATSR and Sentinel 3 funding bodies should provide a way**

to ensure the continuity of these datasets as a high priority.

The project also recommends that the GHRSTT-PP High Resolution Diagnostic Data Set (HR-DDS) system at NOCS is sustained and used to perform a global-wide comparison between AATSR data and other satellite derived SST products to identify:

- The magnitude of the bias and uncertainties
- Their geographical and seasonal variability

In addition the project will examine how much deviation there is between SST recorded by the different satellite SST products, when sampled coincidentally at each of the HR-DDS site including the scale of the mismatch between different sensors and AATSR, and the extent to which this varies with geographical location

A comparison of the validated performance of potential sources of SST data with that of AATSR will be conducted that will employ the high quality in situ skin measurements, presently used to validate the AATSR products, as a means of determining the errors of the other satellite SST products. This will use 1 year of in situ skin temperature measurements obtained from the ISAR instrument operated by NOCS on the P&O car ferry Pride of Bilbao over the English Channel and Bay of Biscay. This study will provide an objective comparison between the performance of the alternative sources of SST data and AATSR performance with reference to the in situ data and provide a first indication of the bias corrections that would have to be applied to the alternative SST data to make it consistent with AATSR-measured SST data in that region. Initial results are shown in Figure 10.3.1.

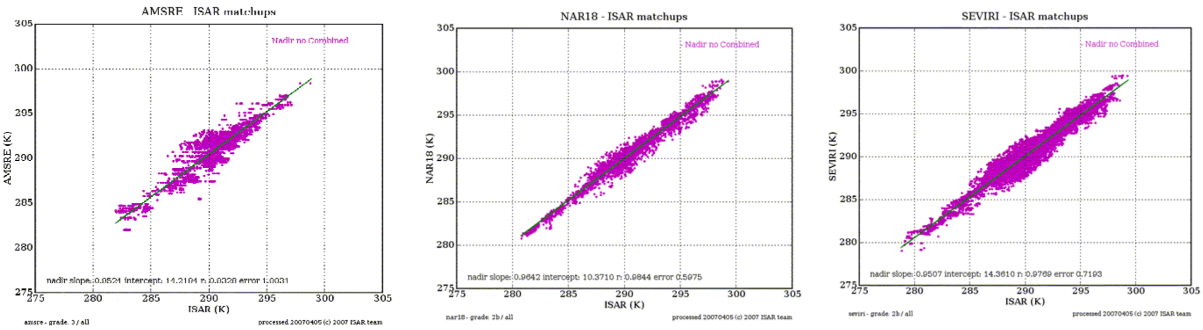


Figure 10.3.1 A comparison of the validated performance of potential sources of SST data with that of AATSR using the ISAR radiometer data in the Bay of Biscay for 2006.

In the ISAR validation area (English Channel and Bay of Biscay) the match-ups for the infrared sensors (SEVIRI and NAR17/18) yield very good agreement in the grade 1 and 2b cases. The microwave sensor (AMSR-E) does not produce similarly good match-ups statistics, although it is not clear whether that is due to the data product or because of sensor limitations close to coastal areas. The main reason for the good validation performance of the infrared sensors is a stable atmosphere in the ISAR validation area in 2006. Therefore the static single view atmospheric correction of theses sensors does almost as well as the dual view dynamic atmospheric correction of AATSR. However the comparison of the validation results of the different sensors will look very different in atmospheric conditions with a high aerosol count.

The project will analyse long-term variability of SST Data Quality using AMSR-E v5, AVHRR Pathfinder v5, MODIS Aqua, MODIS Terra, Reynolds OI v2 to identify

- Regions of the world where alternative SST data sources have a quality comparable to AATSR,
- Where new validation activities will be required to ensure the best chance for an accurate tie between AATSR and Sentinel 3 SST data.

In order to complete this study, 37 regions have been defined to look at variability shown in Figure 10.3.2.

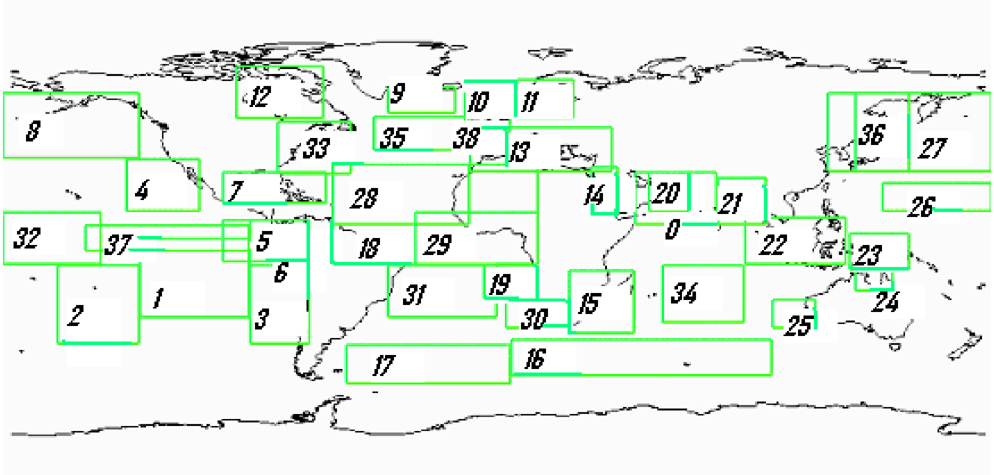


Figure 10.3.2 Regions defined to study long-term variability of SST Data Quality using AMSR-E v5, AVHRR Pathfinder v5, MODIS Aqua, MODIS Terra, Reynolds OI v2

A draft plan for discussion with Defra, NERC, ESA and GHRSTT-PP will be formulated on what needs to be put in place to maintain the quality and continuity of the (A)ATSR data set using alternative sources of SST data where appropriate. The plan will include an outline of the steps that need to be taken and recommendations for a programme of work that will be required and will be circulated to GHRSST-PP science team for comment.

- **ACTION: The RAN-TAG Chair and Gary Corlett to write to ESA, NASA and DEFRA (others) noting the importance of M-AERI and ISAR as a reference standard for CDR**
- **ACTION: (Corlett) Circulate the final plan for maintaining SST data quality to the GHRSST-PP Science Team for comment.**
- **ACTION: (Donlon) Send Jim Cummings the GHRSST-PP anomaly colour scale inflection points**

10.4 Connection with GCOS SST/SI WG and inter-comparison work, Nick Rayner

Casey noted that the GCVOS SST and SI working group had recently resumed activities. The current work-plan includes an initial and follow-on phase. During the initial phase Time series of global and hemispheric anomalies, time-latitude sections of anomalies and fields of standard deviation, linear trend and lag1 correlation will be derived. During the follow on phase maps of RMS differences between fields, time averaged difference maps, time series for selected regions and a small selection of GHRSST diagnostic data set sites and spatial autocorrelations will be computed on Weekly, 1-degree and Monthly, 5-degree basis. Casey noted that based on the presentations made at this workshop, there is a need to examine relationships to Jim's metrics classes and suggestions for GHRSST L4 analysis.

The following data sets are currently included in the GCOS SST/SI inter-comparison work whiuch are hosted at the GHRSST-PP Reanalysis Long Term Stewardship and Reanalysis Facility website (http://ghrsst.nodc.noaa.gov/)

- Kaplan et al
- HadISST1
- NOCS SST analysis
- ERSST
- AVHRR Pathfinder V5
- OISSTv2
- Daily OI SST
- OSTIA
- Plus input data, including ICOADS and HadSST2

The aim of better collaboration between GHRSST-PP RAN and the GCOS SST/SI working group is to ensure that the knowledge within that group is fed into the GHRSST-PP reanalysis activities from the beginning. Through better links we will also address compatibility with the climate record and gain a

GCOS WG "seal of approval" on the GHRSST-PP outputs. Both the GHRSST and GCOS groups benefits from the infrastructure which is an asset to collaboration.

10.5 GHRSST Reanalysis Discussion

Casey led the discussion and began by asking what qualifies as GHRSST reanalysis? Should this include ensemble means and inter-comparison efforts (eg Xie's talk) or should more emphasis be placed on individual sensor reprocessing efforts and inter-sensor calibration? What about metrics and processing of L3P and L4? There was little response on the question of an ensemble approach.

- The discussion agreed that any one who provides non-real time SST analysis in GHRSST format qualifies as a component of the GHRSST reanalysis.
- It was agreed that the GHRSST-PP RAN should aim to start from the beginning of the usable satellite SST data record (~1982) and efforts to source funding to process the AVHRR data from this time should be made.
- The group noted that a central center could provide a way to undertake a final reanalysis although in practice it was unlikely that funding would be available in the short term for such an effort.
- The group agreed that GHRSST should start to develop a L3 product which was considered essential by many in the ST. Documentation should be produced to start everyone thinking about the se products A long discussions on the development of L3 products took place which focussed on trying to specify the methods used to merge data. There is a lot of interest inL3P data products from the user community. The L3P discussion concluded that
    - L3P is the name to use for gridded data products;
    - Only the format and not the mechanism of how to grid data should be specified;
    - An L3P un-collated file contains one orbit of satellite data only.
    - L3P collated products contain more than one orbit of data (composite) from the same sensor;
    - L3P super-collated data products contain data from multiple orbits and multiple sensors
    - It was noted that the HRDDS is a L3P file
    - It was agreed that L2P_GRIDDED should be replaced with L3P nomenclature.
- It was noted that many products must be discussed in terms of the L3P nomenclature (what about L4 analysis products) and it was agreed that both L3 and L3P terminology was required but needs to be properly discussed and agreed.
- The discussion noted that there are two logical product lines: L2P->L3->L3P and alternatively Products defined as Primary, Secondary and Analysed which should bear in mind CEOS Rules and conventions.

- **ACTION: RAN Chair to write a letter to the EUMETSAT office to request a reprocessing of the SEVIRI data set at full spatial resolution and on an hourly basis**
- **ACTION: PO.DAAC request that RSS AMSRE and TMI data is sent to GDAC**
- **ACTION: GHRSST-PO on behalf of the ST should write to NASA and JAXA to ask for VIRS data to be processed to L2P for application within GHRSST-PP RAN**

11 Session 9: GHRSST-PP quality control and validation

11.1 GHRSST-PP metrics, validation and quality control, Ian Barton

Ian Baton introduced the session noting that there is a clear need to define a set of internal verification tests and metrics. Metrics will ensure the validity and usefulness of the GHRSST products and are required for:

- data delivery
- data processing, archiving, and distribution
- data quality (L4 metrics of Cummings)
- data coverage

Barton emphasised the need for the metrics to be defined by quantitative diagnostics, and highlighted one or two specific examples such as, noting the occurrence of data voids around the globe as we are supposed to be providing global data sets, and user support should be monitored to find out how long we are taking to respond to user issues. Also, Ian stressed the need for realistic metrics.

During the GHRSST #6 meeting it was agreed that metrics define common quantities and diagnostics with given mathematical definitions. Given a specific metric, there is a need to absolutely classify a numerical threshold that defines acceptable and unacceptable performance. Thus, metrics must provide numbers that show how GHRSST is performing in well-defined operations. The metrics required by the GHRSST-PP fall into several categories:

1. The timely delivery of data to RDACS, GDACS, and to users.
2. The accuracy of SST fields (Number of in situ data points available for SST validation, rms, and bias).
3. The number of satellite data sets (orbits, overpasses) available to GDAC.
4. The extent to which all geographical areas covered.
5. The production of DDS: areas covered, timely on-line access to DDSs.
6. Access to in situ data via MDB records. Links to DDS.
7. Timely updates of MMR.
8. Delivery to the LTSRF, updates of RAN

Following GHRSST- #6, a document of metrics was produced based on the above list but was considered far too long and complex (see https://www.ghrsst-pp.org/modules/documents/documents/GHRSST-PP-Metrics-v1.0.doc. The document should be summarised and condensed into a few generic headings. In total GHRSST-PP has 21 main metrics each with a sub-set of metrics (over 100 in total). Ian then led the plenary through the discussion document to begin to fill in the metrics. The following issues were raised as the document was updated:

- M1.1: We need to add MODIS to this list (as well as to other metrics related to polar orbiters) but should check with Bryan about data availability
- M3: Data coverage for some polar-orbit sensors should be set to full orbits, and the metrics are the percentage of orbits with missing data per month and the percentage of missing data per month.
- M4: Data coverage for the geostationary sensors is set to full disk, and the metrics are the percentage of full disk acquisitions with missing data per month and the percentage of missing data per month.
- M5: Ian asked if we really need this metric. After much discussion the question could not be answered and the issue is left as unresolved
- M6: As for M5
- M7: The general opinion of the science team was that it is not good for the two GDACS (EU and JPL) to provide ancillary data and it should be left to just the current JPL GDAC.
- M8: As M7
- M9: It was noted that L2P availability will take longer than L4 as the GDAC have to test to see if the ancillary data are present and then compress the data before it can be made available.
- M10-M15: Ian stressed the importance for the RDACs and the GDAC to log the number of

users, so we can see how well GHRSST-PP data is being taken up by the community.

The remaining metrics were not discussed as the plenary session was closed at this stage.

- **ACTION: B and GC to reconfigure the discussion document (30/06/2007)**
- **ACTION: Data providers to provide feedback on updated discussion document (30/09/2007)**

12 Session 10. Preparing the GDS v2.0

12.1 GlobColour: Implementation of a European Ocean Colour RDAC: Samantha Lavender

Lavender presented an overview of the ESA Globcolour project which aims to produce a long (10 year) time-series of merged global ocean colour information from MERIS, MODIS-Aqua and SeaWiFS. The project will develop the capacity to continue the ocean colour service in the future as a near-real time system although SeaWiFS will not be included) and will ensure the continual involvement of end-users (originally IOCCG, IOCCP and UK Met Office) but this is likely to expand prior to a 2007 user meeting planed in Olso, Norway. Globcolour is the ocean colour community analog of the GHRSST-PP and the 2nd user's workshop will be held jointly with Medspiration and GlobIce in Norway (Oslo), week of 19th November 2007.

The project will produce a number of outputs that could be useful to GHRSST-PP particularly for diurnal variability studies where ocean colour plays an important role in the vertical distribution of solar input. The main output is a global (4.63km ISIN grid using flux conservative method) ocean colour data set covering 1997-2006 daily, weekly (8-day) and monthly products:

- Chlorophyll-a concentration
- Coloured dissolved and detrital organic matter (CDM)
- Total suspended matter or Particulate back-scattering coefficient
- Diffuse attenuation coefficient (in-water)
- Fully normalised water leaving radiances (available bands)
- Aerosol optical thickness
- Data quality flags
- Cloud fraction
- Error estimates per pixel for each layer

Further details: http://www.globcolour.info/CDR_Docs/GlobCOLOUR_PUG_v1.1.pdf and examples are presented in Figure 12.1.1.

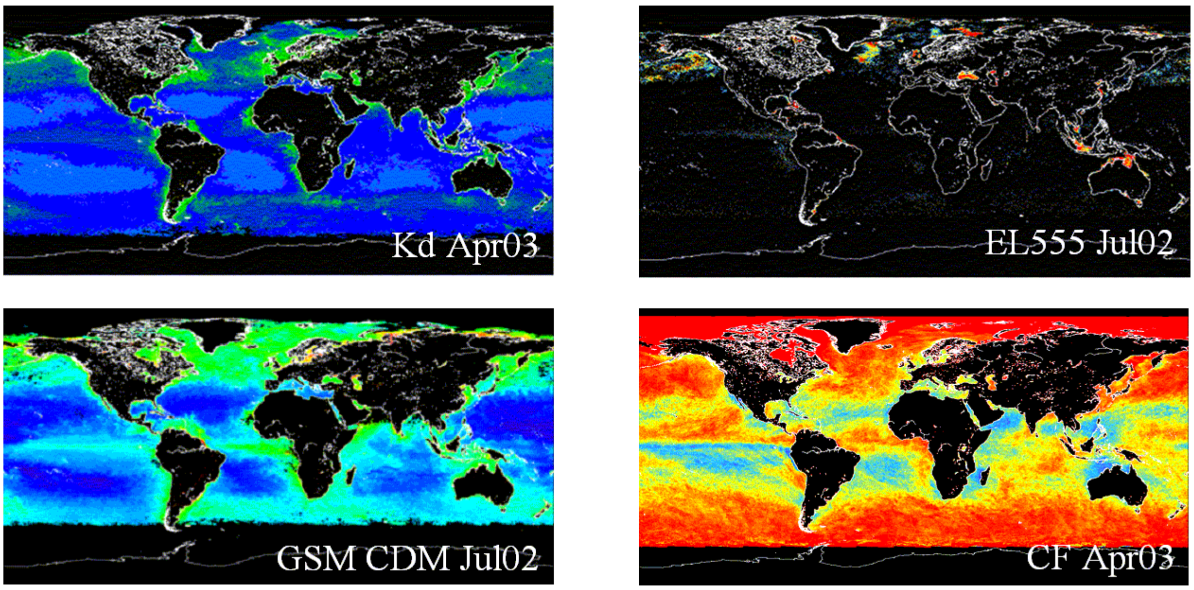


Figure 12.1.1 Example data products currently being produced by the Globcolour project that could be of use to the GHRSST-PP.

Input from ongoing user consultation includes the following:

- New user requirements to be monitored and included as research provides suitable validated methods e.g. PAR, warming depth and PFTs. Also, extension into coastal waters.
- Need to strengthen/broaden the ocean colour community e.g. ocean colour equivalent of GHRSST and pursue links with GHRSST via European RDAC status.

- New dissemination methods (Google-Earth products: available from the data access page of GlobColour web site).
- Rigour, uniformity and honesty in error statistics – need to develop an operational & centralised quality control approach?
- Development of multi-disciplinary integrated (SST + OC + …) data sets for model assimilation, seasonal forecasting etc.
- Need to prepare for a probable gap between ENVISAT and Sentinel-3 data supply, and how to manage the impact of this gap on the users.

At the Medspiration/GlobColour meeting, December 2006, the use of ocean colour and SST by an assimilating ocean model was shown by R. Barciella (Figure 12.1.2).

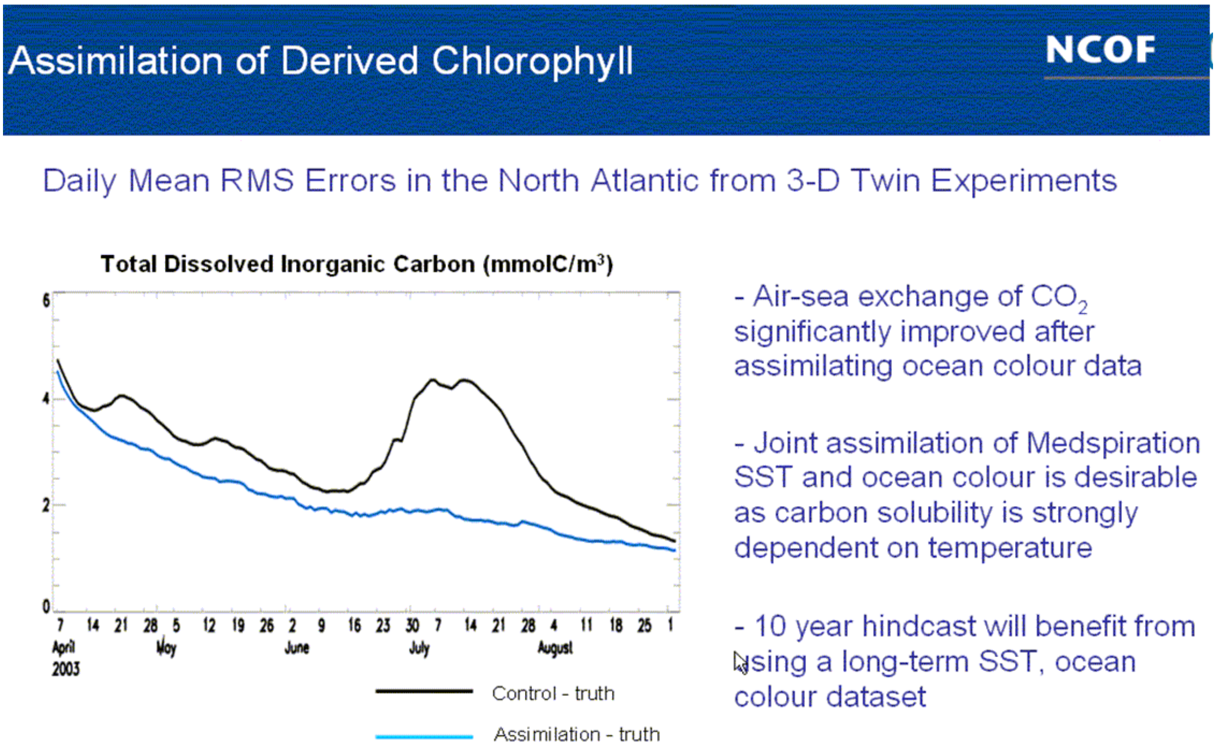


Figure 12.1.2 Impact of assimilating ocean colour and SST data using the Met Office FOAM model.

Lavender concluded with the questions why do we need an ocean colour RDAC? Satellites such as Aqua/Terra and ENVISAT/Sentinel-3 contain both SST and ocean colour instruments, and users often would like both. MODIS SST / Ocean Colour are already available via NASA Ocean color WWW site. Ocean colour products can be used to interpret SST (and vice versa); of relevance to diurnal warming, aerosols (dust) and data reanalysis and the assimilation into 3D physical + biological oceanographic models; needs both SST and ocean colour products with "Quality control and error estimation". The provision of global merged ocean colour long time-series and demonstration NRT global products to the GHRSST community via the GDAC/LTSRF including

- DDS linkage between GlobColour & Medspiration (Dave Poulter), meeting in Jan 07 and further actions to link the two ongoing.
- Subset being provided to the ALADIN Diurnal Working database

Lavender noted that rather than adding ocean colour products to L2P SST files there could be L2P ocean colour files that would not be tied to a particular SST sensor/product and hence affect their size or format, and would be optionally obtained.

The GHRSST-PP Science Team noted that stronger links between Globcolour and GHRSST-PP shousl be developed as interoperability is essential and recommend further discussion (e.g., CF conventions, netCDF etc). The following issues/opportunities were identified:

- o Linkages with the NASA color group are encouraged
- o NESDIS is starting to produce ocean color products also which should be included in any plans
- o Globcolour has the same format, same projections and same metadata standards as GHRSST which would make merging data easily.
- o Interfaces at the HRDDS level should be coordinated and use the same system if at

all possible.
  - A Small working group on interoperability between GHRSST and Globcolour should be established

- **ACTION: (GHRSST-PO) The GHRSST-PP user community should be contacted and the need for ocean colour data within GHRSST-PP products established. (report at next ST meeting)**
- **ACTION: (Poulter, Lavender) Globcolour and GHRSST-PP should work with the HRDDS and link to NASA ocean biology team.**
- **ACTION (Maturi, Poulter) OSPD are generating ocean colour products that use different algorithms should be included in the HRDDS.**
- **ACTION: (GHRSST-PO) A small interoperability working group to be established: Casey, Maturi, Franz, Lavender, Poulter, Karen Patterson (NAVO).**

12.2 Proposals for a new Top Level Governance of the GHRSST-PP, C Donlon

Donlon began by explaining the issue. In 2008 GODAE may end as an experiment and the GODAE GHRSST Pilot Project will formerly end. Should GHRSST-PP then declare success and end its pilot project or should it continue and if so what form and governance should be used to ensure that the the project remains useful (if any at all?)? Donlon then considered that the purpose and role of the GHRSST-PP actually is. It is not an operational agency but rather an International Science Team coordinating SST activities for the benefit of all. It has been a successful activity that has raised considerable National investment and is essentially secure until the end of 2008. However, other groups and bodies are beginning to take an interest in GHRSST-PP as the project transitions into a stable and more sustained system. The question is what form do we want the project to take?

GODAE and others want us to continue to provide guidance on the application of SST data. Furthermore, improvements to SST products through experiments both Scientifically (feedback of SSES) and for operations in the R/GTS system (timeliness metrics) are not yet complete. The GHRSST-PP provides some discipline (somewhere between that of an operational agency and the R&D community) which is a good balance to coordinate both groups which share a common SST data set. The ST concluded that continued coordination of international SST activities by a GHRSST-PP like group is required and this is what we should be aiming to continue rather than building an operational system.

Donlon presented several options for future governance of the GHRSST-PP which include:
- GODAE if it continues
- The World Meteorological Organisation (WMO)
- The UNESCO Intergovernmental Oceanographic Commission (IOC)
- WMO/IOC Joint Commission on Oceanography and Marine Meteorology (JCOMM)
- The Global Climate Observing System (GCOS) Ocean Observation Panel for Climate (OOPC)
- CEOS
- GEO/GEOSS

Donlon noted that in discussions, the future ‘home’ for GHRSST-PP has turned out to be a political issue and one that can impact funding for the GHRSST-PO, impact the control of the ST, impact the role and scope of the ST, and impact the obligations of National States for GHRSST-PP funding. Donlon then presented an overview of transition from a Pilot-Project to a sustained operational service based on dicussions with WMO Marine Meteorology and Oceanography division Secretariat. In this model GHRSST-PP practices and methods become part of the ’normal’ operation within WMO member communities. Coordination of these activities is then required typically in the form of an Expert Team within a Commission. Based on the discussions, the GHRSST-PP should explore the options for the Project and present these at the next ST.

However, at this stage, it was agreed that the GHRSST-PP should explore the options for the Project and present these at the next ST which would be before the end of GODAE. In order to assist this process it was proposed that an internal and an external review of the GHRSST-PP should be undertaken by independent experts. The reports from these reviews should help identify the scope and role of the GHRSST-PP in a post-GODAE world.

- **ACTION GHRST-PO to arrange an internal review of the GHRSST-PP to report at the next Science Team meeting**
- **ACTION GHRSST-PO to arrange an external review of the GHRSST-PP to report top the next Science Team meeting**

12.3 Proposal for new L3/L3P products in the frame of the MERSEA SST project: Pierre LeBorgne

LeBorgne started with a review of the background and objectives to the development of a GHRSST-Pp L3P product line noting that L2P files are nearly always brought together for an area and a time window before they are used in most applications and almost always this is the case for L4 analysis systems. As seen already in several talks and discussions the need for composite data products is high for L4 metrics and for other applications – this is what a L3P data set is. The idea for a GHRSST-PP L3P data product line is to provide a new range of products that synthesise the data together on a common easy to use grid format and in addition, correct data for known problems and apply SSES. This means that the L3P products are fundamentally different form L2P 'raw observations' data products as the L2P data sets have been changed (bias adjusted and re-gridded). LeBorgne was clear that in all cases, it is extremely important that the traceability of the pixel value back to the native L2P file is maintained. There was strong support from the Science Team for L3P data products.

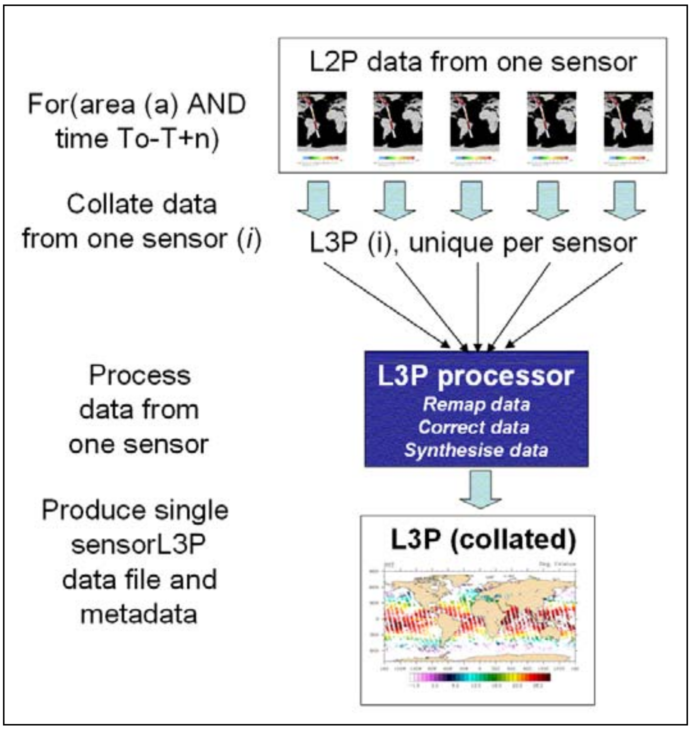


Figure 12.3.1 Overview of the processing steps required to generate a L3P collated data file.

Figure 12.3.1 provides a general schematic overview of the L3P processing steps proposed by LeBorgne. The processing steps are:

1) Define an area of interest: e.g. Atlantic Ocean
2) Define a period of interest (time window): e.g. 12 hours or 3 days
3) For sensor(*i*)
    1) Collect all data over are and time window. Any L2P showing a pixel within the zone and time window.
    2) Remap all data to a common grid. Nearest pixel (general case), or..
        - Averaging pixel showing the best confidence level
        - Filtering according to
        - quality level values (the best)
        - SSES values
        - DT_analysis
        - Diurnal warming
        - Sun zenith angle

- ……..

3) Synthesis of all data (over time and area to a single data set.
   - Lowest diurnal warming
   - Lowest satellite zenith angle
   - Closest to the nominal time
   - …..
4) Correct data using SSES and for other issues if required

endfor

4) Create L3P data file
5) Create metadata record

Table 12.1.1 Suggestion for content of L2P, L3PCol and L3PSupCol data files

L2P	L3PCol	L3PSupCol
(ORIGINAL) sst	(CORRECTED) sst	(CORRECTED) sst
time	time	time
		origin
	original latitude	original latitude
	original longitude	original longitude
SSES_bias	SSES_bias	SSES_bias
SSES_std dev	SSES_std dev	SSES_std dev
DT_analysis		
Rejection flag		
Confidence flag		
Proximity confidence	Proximity confidence	Proximity confidence
	Diurnal warming	Diurnal warming
	Solar zenith angle	Solar zenith angle
	Satellite zenith angle	Satellite zenith angle
	Bias_error	Bias_error
	Bias_error confidence	Bias_error confidence
SSI/ sources/DT from SST		
Wind speed/ sources/DT from SST		
Sea_ice/ sources/DT from SST		
Aod/ sources/DT from SST		
Additional fields		

The L3P output is essentially a L2Pc record for each pixel (ancillary data re not included (should they be? If so which? A summary of content was provided as shown in Table 12.1.1. LeBorgne noted that the following principles must be upheld when producing L3P Collated data files

- When synthesizing information the best quality data should take precedence
- Information allowing traceability from L2P to L3P at the pixel level should be included with the minimum content as [Origin (which sensor), time of original observation, Original lat lon, the quality level, the SSES, Applied correction (if any)]. This needs to be discussed and agreed.

LeBorgne then described the concept of a super-collated L3P data file which is a SST data for time To-To+n, over area(A) and for sensors(i->j). In this case the final data set includes SST observations from all available satellite sensors. Selection of the ‘best’ data to include in the product could be done according to a number of different rules and approaches (e.g. a priori, maximum cross correlation etc). Figure 12.2.2 shows a schematic overview of the processing steps used to create a L3P super-collated data set. Note that in this case L3P collated data sets could be used as input to the processor if available.

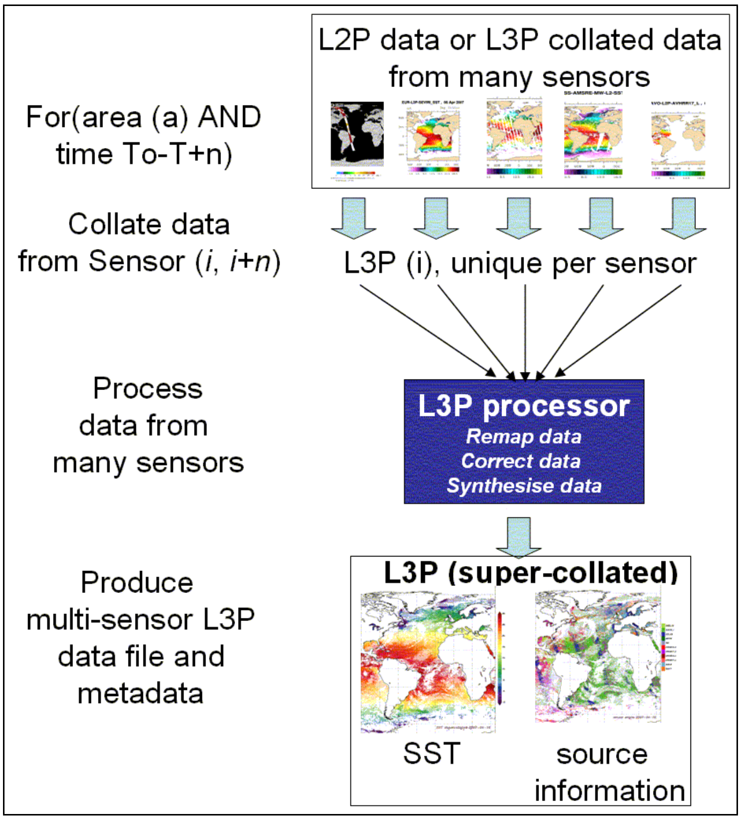


Figure 12.3.2 Overview of the processing steps required to generate a L3P super-collated data file.

An example of using AATSR data as a correction reference data set for SEVIRI data was used to show the benefit of the L3P process in the Atlantic Ocean where Saharan dust outflows severely contaminates the SEVIRI data. The AATSR data was used to derive a 5 day bias correction map which was applied to the SEVIRI data set as part of the L3P production process. The method works very well and is being transitioned into operations.

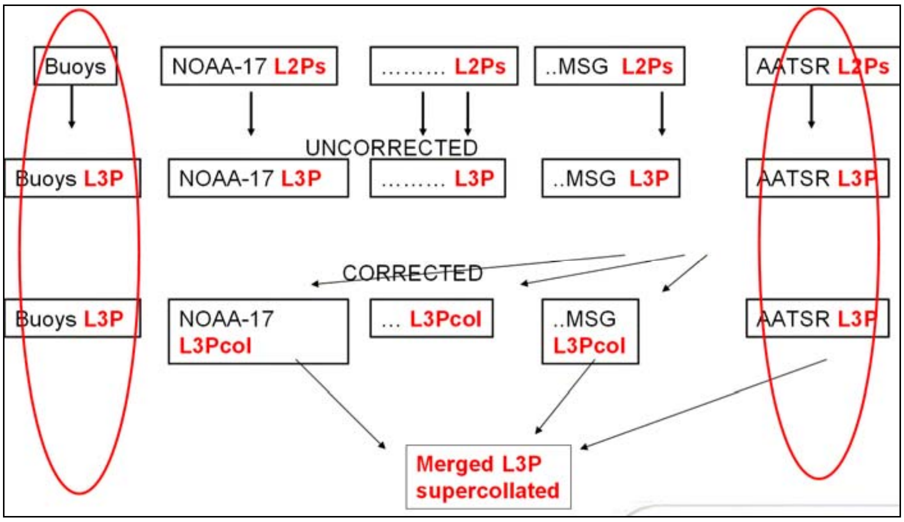


Figure 12.1.2 Schematic overview of validation processes using in situ buoy and AATSR satellite data within the L2P to L3P process.

LeBorgne then explained that there is a validation obligation for L3P data producers as the corrections applied to the L2P input data as well as the re-gridding must be valid for collated and super-collated data (do step functions exist between data types?). Figure 12.1.3 shows an overview of the validation approach used in the test processor. In this figure both buoys and AATSR play a key role. The L3P system first produces collated but uncorrected L3P (L3 data?) files. Then a correction is applied to generate an L3P collated data set. L3P data are then further combined to produce a merged multi-sensor L3P super-collated data set. Validation using buoys and AATSR is performed by producing

L3P buoy data sets that can be easily compared to the L3P satellite data products. LeBorgne showed experiments between January-May 2007 which showed that the L3P validation data are noisy as there are not many data inputs per grid-cell each day due to clouds. However, time-averaged data sets show that the technique is useful. One particularly useful aspect of this approach is that regional bises for each sensor can be studies easily and LeBorgne used Hovmoller plots to look at biases in the SEVIRI data sets.

The current processing chains at IFREMER are now producing global L3P data sets as part of the ODYSSEA MERSEA L4 SST analysis observations pre-processing system. LeBorgne showed a large variety of L3P data sets produced by IFREMER as part of this system noting that in the case of the super-collated data sets a separate map of source information is provided with each output (see Figure 12.1.4).

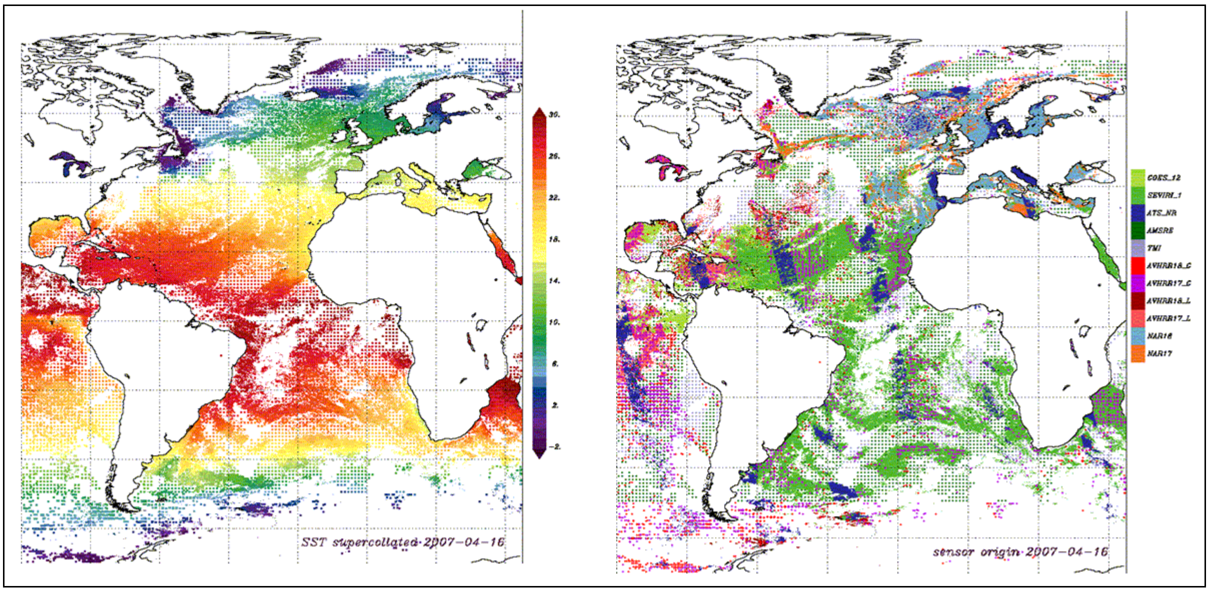


Figure 12.1.4. (left: Super-collated data set over the Atlantic Ocean (right) corresponding map of source data for the Super collated L3P data.

LeBorgne concluded that using AATSR as a reference data source for bias correction of other satellite data sets is acceptable and a method developed to correct SEVIRI data at Meteo France works well. There are limitations and it is difficult to use this in the high latitudes as cloud cover and the limited swath of AATSR limiting the amount of AATSR data available. The L3P methodology for L3P collated and L3P super-collated has been proposed. There remain issues concerning the content and methods that are applicable to produce L3P which must be agreed by the Science Team.

The Science team were keen to develop the L3P methods and deferred discussion in detail until the discussion of GDS-2.0 where the inclusion of L3P would be mandatory.

12.4 Operational Agreements (Service Level Agreements, SLA) within the GHRSST-PP: J Vazquez and the DM-TAG

Vazquez introduced the concept of Operational Service Agreements noting that these should be used within the GHRSST-PP GDAC in order to monitor and improve the GDAC service to the user community. However these need to be established and there are various issues for the Science Team to discuss as to the content and scope of GHRSST Service agreements. Vazquez noted that the service3 agreements should address the following:

- How users access data and supporting information as defined in Interface Control Documents
- The need for providers and RDACs to provide proper and complete documentation written from a user perspective (users basically want how to access and apply the GHRSST-PP data sets i.e. use confidence flags know the limitations and strengths of each data set, know where to find validation and quality assurance information etc.
- The SSES product user manual should be part of the Product user manual
- User Support. How should users receive user support? Centrally from the GDAC or do

RDACS want to receive questions about their data sets? The overwhelming response was that a combination of both support options was required and the GDAC should be able to provide an interface for the RDAC teams to review the user support provided/requested fro their products. This will mean that reporting of user statistics could be improved from the current metric which is a simple count of the total number of users.

- Vazquez noted that in discussions there has been an emerging requirement for the GDAC to provide appropriate acknowledgement pages that allow users to properly acknowledge the data provider without having to read metadata. There should be a pointer to data sets citation and use policies at the RDAC in addition to the GDAC.

There was general agreement on all of these issues from the Science Team.

Vazquez then reviewed the accomplishments of the DM-TAG since the last meeting which included

- A revision GDS-1.7 including small changes to Level 4 and L2P specifications. The discussions revealed that little change was required as the group is really waiting for substantial changes as part of the GDS-v2.0.
- An official letter endorsing the integration of the GDAC into the Physical Oceanography Distributed Active Archive Center (PO.DAAC) has been received. Endorsement came from the PO.DAAC User Working Group (UWG).
- A "Data Access Tutorial" written by Ken Casey has been written and is accessible through both LSTRF and GDAC web sites.
- A new SSES working group has been formed (discussed later)
- A draft Data Policy Document has been written (discussed later)
- netCDF discussions for the specification of GHRSST-PP requirements had taken place with the netCDF community.
- Discussions on Level 3 specifications (led by Ken Casey) and based on Pierre LeBorgne's document had taken place initiated based on paper presented by Pierre LeBorgne which raised several issues for the DM-TAG to consider. The major topics include:
    - The need for new GHRSST-PP file naming conventions (L2P_GRIDDED vs L3P)
    - GDS specification of processing and file content rules for L3P collated and L3P super-collated data sets

  Vazquez noted that L3P issues will be taken forward in the coming inter-sessional period.
- NASA's MEaSURE Proposal Call Making Earth System Data Records for Use in Research Environments (MEaSURE) has a focus on product development. Several proposals submitted in support of GHRSST activities. Decisions should be known by the Fall of this year. Several of these proposals will have an impact on possible future GHRSST products.
- Some progress has been made on Action Item 28 from GHRSST 7 meeting in Boulder "Establish how GHRSST-PP data sets can be made visible to the THREDDS community in a coordinated manner by linking to the GHRSST-PP MMR system." THREDDS catalogs are XML descriptions of data and format issues for GDS_v2.0, beta netcdf4, HDF5, bzip2 still need to be addressed by the DM-TAG.

Discussions with Steve Hankin on CF specifications driven by GHRSST (led by Edward Armstrong) have taken place. The major outcomes are:

- There are no major show stoppers for GHRSST-PP and main issues appear to be no explicit standard for codes in CF and difficulty incorporating swath data within the regular grid constraints of netCDF. One goal of this meeting is to write a report to Steve Hankin on needs of GHRSST with respect to CF standards.
- Ed Armstrong had a discussion with CF developers to add time_offset to COARDS attributes.
- Ed Armstrong petitioned CF community to submit CF/COARDS to the NASA Standards Process Group
- Craig Donlon agreed to help in defining standard names for the GHRSST-PP products with the Climate Forecast (CF) group.

At NASA Headquarters, Program Manager Eric Lindstrom has an increased emphasis on SST and salinity. Gary Lagerloef and Jorge Vazquez have been mentioned as points of contact for salinity and SST respectively. NASA's Research Opportunities in Space and Earth Sciences 2007: Appendix A6 Physical Oceanography Call ROSES 2007 has been issued with specific text referring to the use of GHRSST-PP data. "NASA is playing a central role in providing the next generation of data products for sea surface temperature through the Global Ocean Data Assimilation Experiment (GODAE) High-Resolution Sea Surface Temperature (GHRSST) pilot project (http://www.ghrsst-pp.org). Products. Proposals are sought which characterize and/or reduce uncertainties in these data products, utilize prototype products to constrain ocean general-circulation models or interact directly with the GHRSST project to prepare for exploitation of data.” Work under this call is expected to lead to a large increase in users at the GDAC in the USA.

A new Single Sensor Error Characteristics Working Group has been formed led by Pierre LeBorgne. The SSES-WG membership includes:

- Robert Evans
- Gary Cortlett
- Gary Wick
- Peter Minnett
- Bryan Franz
- Doug May
- Chelle Gentermann
- John Stark
- Jorge Vazquez

A terms of Reference document will be generated by the SSES-WG and the GHRTSST-PO. Initial questions proposed for discussion by the SSES-WG include:

- Are SSES exclusively defined against buoys measurements? if so how to make a partition of the MDB?
- Any alternative to use the confidence levels to partition the MDB?
- How to define the confidence levels?
- Can we agree on a range of errors per confidence level?

The PO.DAAC has implemented new Data Acceptance Procedures which should be compatible with GHRSST data policy. As part of this work, a draft GHRSST data policy document has been written in collaboration with DM-TAG members and led by Ken Casey. For GDAC purposes this means that GHRSST is treated as a ‘mission’ in the same way as a satellite mission. Final authority for data acceptance (from a PO.DAAC/GDAC perspective) now rests with the GHRSST Science Team. However, what are the requirements for GHRSST acceptance? This needs to be defined and Vazquez suggested that the starting reference point should be the draft Data Policy document. The following 8 points have been identified by the GHRSST Team and are open for discussion

1. Agree to provide all data and metadata in a free and open manner to the GDAC, without usage restrictions.
2. Agree to allow all data and metadata to be provided by the LTSRF in a free and open manner in perpetuity, without usage restrictions.
3. Routinely review and report to the chair of the DM-TAG on data and metadata compliance to the current version of the GHRSST Data Specification (GDS) using the *GHRSST Data Compliance Checker* and *GHRSST Metadata Compliance Checker* [these would need to be written and maintained].
4. Annually review and report to the chairs of DM-TAG and RAN-TAG with anticipated data streams and data volume rates for the coming year.
5. DM-TAG and RAN-TAG will provide the results of the above review and report to the GDAC(s) for their planning and support preparation.
6. Bring all existing product streams into compliance within 6 months of issuance of new versions of the GDS.
7. Routinely monitor product quality and completeness and report any anomalies to the GDAC, LTRSF, and GHRSST Project Office.
8. Agree to bring two bottles of nice wine from their local region to each Science Team meeting: one as a gift for the local host, and one for sharing at the Meeting Dinner. In addition, send additional bottles of wine, and at least ¼ Kilo of top quality chocolate to the GDAC(s).

Vazquez concluded noting that there is no expectation that all of these issues will be resolved at this meeting. Hopefully discussions will provide the basis for a decision making process that can be achieved via email or teleconferencing. Finally, Vazquez noted that the soon to be published BAMS article describing GHRSST-PP will lead to a marked increase in the number of users and there is a need to provide a period of stability of data products and be prepared to listen to our users.

- **ACTION: (DM-TAG) To review the DSD and FR metadata to check that it is correct**
- **ACTION: (RDAC representatives) To provide appropriate citation reference at the point of data access**

- **ACTION: (GHJRSST-PO/DM-TAG) Develop a discussion group to consider user interactions and metrics by contacting RDACS and their needs/ideas for applications and user services and functionality.**

12.5 Open Discussion on key aspects of GDS 2.0

GDS has largely been used internally in the past and only a few users have needed to use the document which is very large and difficult to use in its present format. Many internal users only need to refer to a sub-section of the document. The GDS, as a technical manual for those working in GHRSST-PP is clearly required but it was agreed that what is missing is a user document. This should probably be a separate document, or the GDS could be made more accessible to the user community. For example, use boxes for decisions that have been made. It was agreed after some discussion that there is a need a high level simple document.

- **ACTION (Donlon) The GHRSST-PO will lead an effort to update the GDS and an effort to write a user's manual. The GDS rewrite team includes Craig Donlon (lead), Ken Casey, Jim Cummings, Chris Merchant, Matt Prichard, Dave Poulter, Pierre Le Borgne, Chelle Gentemann, Ed Armstrong, Jean-Francois Piolle and Jorge Vazquez.**
- **ACTION (Vazquez): Vazquez to develop a Users Manual. The User's Manual writing team includes Jorge Vazquez (Lead), Craig Donlon, Ken Casey, Sam Lavender, Jacob Hoeyer, Pierre Le Borgne, Dave Poulter and Sue Hines**

The group then considered the use of brightness temperatures within the GHRSST-PP data products noting that they do not belong in L2P data sets (except for quality control purposes. Instead, several people noted that there was a clear need for an 'L1P' product. The Team noted that there were a lot of requirements for brightness temperatures. Harris argued against including brightness temps in L2P. May suggested a subset of brightness temperatures should be allowed as these are used calculate SST. Are brightness temps needed everywhere or just at SST? NAVOCEANO need BT's for diagnostic whereas Cummings only needs cloud cleared radiances. The group agreed that cloud free brightness temperatures could optionally be included in L2P files where a valid SST retrieval is available using the Experimental_Field. This was viewed as a stop-gap measure with a long term solution being the specification and provision of L1P files. It was clear that the producer teams felt that this was the job of the space agencies and L1P goes beyond the terms of reference for GHRSST-PP. The group agreed that it was important to make sure that the brightness temperatures are more accessible. The team agreed that Brightness temperatures used to obtain SST retrievals at retrieval locations are of interest now. Where possible, these could/should be included as ancillary fields in current L2P products. Andy Harris will coordinate an effort to investigate an L1P product, its value, what would need to be done, etc.

- **ACTION: (Harris) Define a set of requirements for an L1P product including archive and provision options for L1P fields (RDAC, GDAC, Space agency?)**

Discussions concluded that the GDS should describe diurnal warming in a more general way and a small section should be introduced into the document.

Following a discussion about land masks that allows for inclusion on lakes (for example the MODIS land mask is static while some lakes are disappearing) it was agreed that the group needs to come to an agreement on a land mask.

- **ACTION: (GHRSST-PO) Establish a leader and small team to look at the definition of a land mask including lakes for application within the GHRSST-PP.**

The discussion then moved to the proposed framework for L3P production. Llewellyn-Jones noted that the L3P products (the one presented earlier in this session) should be viewed as a flagship for what GHRSST is all about, providing the best SST product. There is agreement that an L3P product is needed. The group agreed that what differentiates L3 from L4 is that L4 interpolates to locations where there were no measurements.

- ACTION: (Casey) An outline of L3P production will be discussed with a interested team members and then reviewed by the Science Team to obtain consensus on a suitable way forward.

Donlon noted that there was a need to have the GHRSST-PP reviewed before the end of GODAE in order to obtain recommendations on what the project should develop as a strategy for its future. The team recommended that an internal review is first performed followed by an external review.

- **ACTION: (GHRSST-PO Arrange an internal and external review of the GHRSST-PP (internal review to be conducted first).**

The group agreed a timetable to allow at least 2 reviews and a final publication of the GDS-v2.0 before April 1st 2008.The following sections for the GDS 2 should be included:

- New sections for L3/L3P
- Section on operational message exchange
- GDAC complementarily including Service Level Agreements, Interface Control Documents, Governance etc.
- Revise the L2P, L4, MDB, HR-DDS, MMR, SSES and QC sections.
- Revise data management (naming conventions, filename structures, description of data, contacts, DSD records)

Finally it was noted that GSDS-2.0 should determine whether or not GHRSST will move to netCDF4.

13 Review of Action list from the 8th GHRSST-PP Science Team Meeting and outstanding actions from 7th Science Team Meeting

Actions were reviewed and agreed in plenary by the GHRSST-PP Science Team which are based on the reports made by session Rapporteurs and the GHRSST-PO on the 18th May 2007, BoM, Melbourne Australia. An action list is available in Appendix-III to this report.

14 Wrap up session and close

14.1 Summary of workshop

Donlon provided a summary of the key outcomes from the Science Team meeting. He recalled the opening remarks of Neville Smith which noted that the main tasks set before the GHRSST-PP were to Test of data sources, devise implement and operate diagnostic data sets and data assembly, conduct inter-comparisons and assist data assimilation. He noted that through the work to date the GHRSST-PP community has tremendous respect due to its progress and outcomes. Most importantly, he noted that the key challenge for the future is integrating GHRSST-PP outputs into climate, NWP and Ocean Forecasting products where surface fluxes remain the weakest parts of these systems and GHRSST-PP should consider the application of its products and continue to support the user community with products and assistance and excellent scientific inputs. Donlon said that this workshop has once again shown that the GHRSST-PP Science Team has great strength and remains committed to taking the project on the through the often difficult transition to a sustained framework

Donlon then recalled the priorities for the workshop presented at the start of the meeting and summarised progress made.

- **G8 Priority 1: *Write GDS v2.0***: needs to be specified building on what we have done so far. The discussions at the workshop have been excellent and a clear plan and timetable with commitments from people to write up the GDS-2.09 have been agreed. The challenge remains to complete the task.
- **G8 priority 2: Need to have a concerted effort to define L3P for GDS2.0**. Discussions and presentations have shown a clear path to developing L3P products within the GDS-2.0 and indeed some groups are already using L3P products so the task should be relatively easy as we have something to build on already. The LK3P are important especially as there is a clear user requirement for these products.
- **G8 Priority 3: Improve the Application and User Services of GHRSST-PP.** Throughout the meeting there has been lots of feedback and we clearly have an increasing user community which our national projects need to manage effectively. We expect the BAMS GHRSST-PP paper to be published in late 2007 and at this point we can expect more users. In addition, NASA calls for proposals to use GHRSST-PP, the EU MyOcean project, BLUElink> activities and new activities in China all show that the GHRSST-PP user community is expanding.
- **G8 Priority 4: Document & continue to improve SSES procedures, provide user support and try to bring SSES together in GDS2.0.** Good progress has been made and a SSES-WG has been set up to take the management and development of SSES forward in a coordinated manner. We now need to produce appropriate documentation (including peer reviewed papers) do consolidate the methodology, verify it and validate it before the GDS-2.0 is written.
- **G8 Priority 5: Work towards integrating appropriate Ocean Colour providers and *appropriate products* (DV-WG, L4 PME) into the R/GTS system and GDS v2.0.** Presentations and discussions have shown that there is a useful synergy between the GHRSST-PP and ocean colour community particularly for diurnal variability studies. A small WG has been established and the HR-DDS promoted for SST/Ocean Colour experiments.
- **G8 Priority 6: *Establish formal agreements* and relationships (GDAC< >GDAC< >RDAC< >L2 Providers) within the R/GTS as required**. Good progress has been made to identify the key issues and target them for work during the coming year but this part of the GHRSST-PP is not complete. One particular aspect is to establish good GDAC system interfaces and collaborative operations in the EU and USA.
- **G8 Priority 7: Develop more RAN activity (now that data collection is in place)**. More activities clearly intended within the RAN and the wheels of a juggernaut are starting to roll. OF particular interest is the strong relationship to the GCOS SST and SI working group. Funding opportunities are available to support activities in the EU and in the USA to take the RAN forward.
- **G8 Priority 8: MDB and HRDDS *user led applications.*** There are clear actions established for user led services in these two systems which cot across many of the GHRSST-PP structures (applications, systems and quality assurance). It is expected that systems will be upgraded in the coming months.

G8 Priority 9: *Implement operational messaging* and the GHRSST-PP common interface system and metrics dashboard (RSS syndication?, email? Other?). Options based on RSS datacasting could be used to take these activities forward and a concerted effort will be made by the GHRSST-PO to develop a prototype system using the GHRSST-PO web pages.

- **G8 Priority 10: Decide on a *preferred home for GHRSST-PP* WMO (WGNE?, DBCP? WWRP? WMO/IOC JCOMM? GCOS? CEOS?).** It is clear that GHRSST-PP is not building an operational system but it is coordinating and supporting such a system. Others organisations are better placed to take on the coordination role using the GHRSST-PP and it is for the GHRSST-PO to explore the most useful options for the future GHRSST-PP. by the next Science Team meeting. Internal and external reviews will be conducted and presented at the next ST meeting to provide advice on these aspects.
- **G8 Priority 11: Have faith and enjoy a week of unbridled SST!!** This was easily achieved and the GHRSST-PP Science Team is stronger for it.

Donlon then described the current status of the GHRST-PP Regional/Global Task Sharing framework based on the presentations and discussions at the workshop as follows:

- Australia is powering ahead in GHRSST-PP. L2P LAC, MTSAT, BoM analyses, WMS, In situ data are all flowing well. There is a clear and strong user request to continue and provide inputs (Oke, Brassington, Maynard…) and GHRSST-PP is making an impact.
- GDAC system in JPL is working extremely well and really moving forward now into a new phase. There remain some issues for filling L2P's but this is now nearly there. MMR revisions required for GDS-v2.0 (ISO19115) are now being studied.
- LTSRF is working well and there is now a need to promote the use of the data held within in LTSRF for reanalysis activities.
- USA applications phase is beginning in MISST with key applications in Tropical Cyclone prediction, L2P for GOES, MODIS, AVHRR, AMSRE, TMI are all flowing well. However, the MISST funding is coming to an end and there is an urgent need to publish papers and promote the success of GHRSST-PP/MISST in the USA
- EU applications strengthen with a new project called MyOcean that will take on a wider responsibility for SST in Europe than Medspiration. The system will; provide an operational system in support of ocean forecasting systems and will work closely with all of the teams within the GHRSST-PP – in particular with the JPL GDAC system.
- The Diurnal Variability-WG has made excellent progress and the session during this meeting showed just how much progress the team has made. This now needs to be written up and published on the GHRST-PP web site
- New web pages based on a fully dynamic Wiki style web site system have been developed and implemented at the GHRSST-PO. All Science Team can log in and edit/change/add information to the site and each WG/TAG has its own page. The content needs to be maintained and updated with progress by the teams involved and a proper Calendar, Document library and events registration system is included in the system.
- Many issues remain for the GDS in terms of detail which will be worked on in the coming year

In conclusion, Donlon said that the GHRSST-PP VIII had been a resounding success and thanked the Science Team, speakers and the staff at BoM/BRMC for making the meeting so successful.

14.2 Science Team Membership (New nominations and Resignations before the session please)

David Poulter (UK) was proposed by David Llewellyn-Jones (UK) and Seconded by Ian Barton (Australia). No objections were received and Poulter was duly elected to the Science Team.
Peter Cornillon (USA) was proposed by Kenneth Casey (USA) and Seconded by Jorge Vazquez (USA). No objections were received and Cornillon was duly elected to the Science Team.

14.3 Next meeting location and dates

Following a proposal submitted by Mete France, the next GHRSST-PP Science Team meeting (IX) will be hosted by Meteo France at Perros Guirec, Brittany, France 9-13th June 2008. The Science Team thanked Meteo France for this offer.

14.4 AOB and Thanks

There were no AOB issues raised.

Craig Donlon, on behalf of the GHRSST-PP science Team thanked the Bureau of Meteorology (BoM) Research Centre (BMRC) for hosting this meeting and for funding the icebreaker. He also thanked the BoM Space Based Observations section for co-funding the workshop and to all BRMC staff for preparing so well and supporting the meeting. Special thanks were given to Meryl Wiseman, Margaret Hughes, Val Jemmeson, Sussana Casso, Tim Pugh and Helen Beggs for all their hard work and patience.

Finally, Donlon thanked all other sponsors and to the Science Team members for their continued hard work and support to the project.

Appendix-I: Agenda for the GHRSST-PP 8th Science Team Meeting

Sunday, 13th May 2007

Time	Agenda item	Session leaders
18:30	Informal dinner for those in town at the Bourke Armoury Restaurant, 655 Bourke St, Melbourne, across the road from the Alto Hotel and one city block from the Vibe Savoy Hotel. Please email h.beggs@bom.gov.au by 1 May if you would like to attend.	H Beggs

Monday, 14th May 2007

Time	Agenda item	Session leaders
08:30	**Registration & Coffee: Location Level 6 Bureau of Meteorology Building, 700 Collins Street, Melbourne**	
08:50	**Welcome and logistics**	**H Beggs**
09:00	**Welcome address from Neville Smith (Chief Scientist, Bureau of Meteorology Research Centre, Australia)**	
09:15	**Review of Agenda**	**Chair: C Donlon Rapporteur: Ken Casey**
09:20	**Report from the GHRSST-PP International project Office: Overview of the GHRSST-PP project status, priorities and aims of the Workshop.**	
09:40	**Review action items since the 7th GHRSST-PP Science Team Meeting**	
10:10	**Coffee**	
Session 1. R/GTS Components: Reports to the GHRSST-PP Science Team		
10:30	**USA (MISST) report:** Chelle Gentemann	**Chair: Gary Wick Rapporteur: Ken Casey**
10:50	**Europe (Medspiration) report**: J-F Piollé	
11:10	**Australia (BLUElink>) report:** Helen Beggs	
11:30	**USA Global Data Assembly Centre report:** Ed Armstrong	
11:50	**GOES-SST RDAC:** Eileen Maturi/ Andy Harris	
12:10	**Global Processing of MODIS for Operational SST, Ocean Color, and GHRSST**: Bryan Franz	
12:30	**Lunch**	
13:30	**Reanalysis Technical Advisory Group (RAN-TAG) report:** Ken Casey	**Chair: Gary Wick Rapporteur: Ken Casey**
13:50	**Status and application of the HR-DDS:** Dave Poulter	
14:10	**The GHRSST-PP MDB system: Status and Plans:** J-F Piolle	
14:30	**Data Management Technical Advisory Group (DM-TAG) report:** Jorge Vazquez	
14:50	**Data Processing Specification Technical Advisory Group (GDS-TAG) report**: Jorge Vazquez	
15:10	**Diurnal Variability Technical Advisory Group (DV-WG) report:** Chris Merchant	
15:30	**Tea**	
15:50	**GHRSST-PP Sea Ice Working Group (SI-WG) report:** Peter Minnett	**Chair: G Wick Rapporteur: Ken Casey**
16:10	**Report from the XML working group:** Ed Armstrong	
16:30	**Report on plans for an EU-GDAC: The MyOcean system,** Craig Donlon/Herve Roquet	
16:50	**Plenary discussion:** • Identification of priority issues for the 8th workshop • Role and selection of a New GDS-2.0 Working Group for the duration of the meeting – Terms of Reference to be agreed based on Appendix I • Agreement of Breakout group membership	**Chair: C Donlon Rapporteur: Ken Casey**
17:30	**Close**	

17:30	**Icebreaker (drinks and nibbles) in Summit Café, Level 5 Bureau of Meteorology Building (700 Collins Street, Melbourne). An opportunity to meet everyone and to exchange ideas and plan for the week ahead.**

Tuesday, 15th May 2007

Time	Agenda item	Session leaders
Session 2. Application/development of new data streams/products		
08:30	**On the relative importance of SST, Argo and altimetry for an ocean reanalysis:** Peter Oke	**Chair: Andy Harris Rapporteur: Tim Nightingale**
08:50	**BLUElink> toward merging GHRSST and GODAE for sea surface temperature forecasting:** Gary Brassington, Tim Pugh, Helen Beggs and Peter Oke	
09:10	**The Sensitivity of the Statistical Hurricane Intensity Prediction Scheme (SHIPS) to Sea Surface Temperature:** Joe Cione	
09:30	**ReefTemp – An improved tool to nowcast coral bleaching risk in the Great Barrier Reef Marine Park and the need for detailed climatology analyses:** Jeffrey Maynard and Peter Turner	
09:50	**Plenary Discussion**	
10:10	Coffee	
10:30	**Future plans of ESA for GHRSST-PP:** Olivier Arino	**Chair: Andy Harris Rapporteur: Tim Nightingale**
10:50	**NAIAD : a new advanced system to access satellite data:** Jean-François Piollé	
11:10	**METOP/AVHRR derived SST products:** Pierre LeBorgne	
11:30	**Utilization of Earth Science Datacasting by the GHRSST Project:** Andrew Bingham, Robert Deen, Kevin Hussey, Timothy Stough, Sean McCleese, Alex Cervantes	
11:50	**Calculating sea surface temperature, emissivity and atmospheric state using hyperspectral radiances:** John Le Marshall, W. L. Smith and Jim Jung	
12:10	**Plenary discussion**	
12:30	Lunch	
Session 3a. Sea Ice		
13:30	**Sea ice introduction (see Sea-Ice WG report):** Peter Minnett	**Chair: Peter Minnett Rapporteur: Jacob Hoeyer**
13:50	**A reanalysis of sea ice concentration from the SMMR and SSM/I Passive Microwave Records:** Soren Andersen (J Hoeyer)	
14:10	**Sea Ice discussion: topics for breakouts**	
Session 3b. Diurnal Variability		
14:30	**Diurnal variability introduction (see DV-WG report):** Chris Merchant	**Chair: Chris Merchant Rapporteur: Gary Wick**
14:50	**In situ observations of diurnal warming in the skin layer:** Chelle L. Gentemann and Peter J. Minnett	
15:10	**Diurnal variability discussion: topics for breakouts**	
15:30	Tea	
Session 4. Breakout Groups		
	Parallel session	
15:50	**BG-1: Sea Ice TAG** **Chair:** Peter Minnett **Rapporteur:**Jacob Hoeyer **Location: Level 6 Conference Room 2** **BG-2: Diurnal Variability TAG** **Chair:** Chris Merchant **Rapporteur:** Gary Wick **Location: Level 6 Conference Room 3**	**Breakout Groups-1**
17:30	**Close**	
17:30-18:30	**Meeting for the EU-GDAC (MyOcean Project) team (Location TBD).**	

18:30	**Conference Dinner – Royal Melbourne Hotel 629 Bourke Street, City (http://www.rmh.com.au), across the road from the Alto Hotel and one city block from the Vibe Savoy Hotel. Please email h.beggs@bom.gov.au by 1 May if you would like to attend. Attendees will order off the menu and pay separately.**

Wednesday, 16th May 2007

Time	Agenda item		Session leaders
Session 5. Sensors and Single Sensor Error Statistic formulations			
08:30	**Introduction:** Pierre LeBorgne		**Chair: Pierre LeBorgne Rapporteur: Helen Beggs**
08:50	**Improving the SSES inputs to AATSR L2P Products:** Gary Corlett		
09:10	**3-way statistics for uncertainty estimation:** Anne O'Carroll (Craig Donlon)		
09:30	**Plenary discussion: priority issues for SSES breakout group**		
10:10	Coffee		
Session 6. Breakout Groups			
	Parallel session		
10:30	**BG-3: Developing homogeneous SSES for all GHRSST-PP sensors** **Chair:** Pierre LeBorgne **Rapporteur:** Helen Beggs **Location: Level 6 Conference Room 2**	**BG-4: GHRSST-PP Data Processing Specification Technical Advisory Group (GDS-TAG)** **Chair:** Jorge Vasquez **Rapporteur:** C Donlon **Location: Level 6 Conference Room 3**	**Breakout Groups-2**
12:30	**Excursion to Healesville Wildlife Sanctuary and Riverstone Winery travelling by chartered coach from Bureau of Meteorology Building, 700 Collins St, Melbourne. Please email h.beggs@bom.gov.au by 1 May if you would like to attend. Cost: AUD$94. Pay by credit card or cash during the meeting.**		
22:00	Coach returns to Vibe Hotel		

Thursday, 17th May 2007

Time	Agenda item	Session leaders
Session 7: L4 Analyses		
08:30	**Introduction: L4 Key Issues facing the GHRSST-PP:** Jim Cummings	**Chair: Jim Cummings Rapporteur: Matt Martin**
08:50	**SST L4 analysis at DMI using GHRSST-PP data:** Jacob Hoeyer	
09:10	**Global 9 km OI SSTs – lessons learned from MODIS/AMSR-E/TMI blending:** Chelle Gentemann	
09:30	**Status of POES-GOES SST analysis:** Eileen Maturi	
09:50	**OSTIA analyses at the Met Office:** Matt Martin	
10:10	Coffee	
10:30	**BLUElink Regional High-Resolution SST Analysis: Verification and Inter-comparison:** Helen Beggs	**Chair: Jim Cummings Rapporteur: Matt Martin**
10:50	**Validation tools and methods for the global SST analysis of MERSEA**: Emmanuelle Autret	
11:10	**Assessment and inter-comparison of five GHRSST products in the shelf and coastal seas around China:** Jiping Xie	
11:30	**Assessment of one year of Medspiration L4 SST fields: what can we learn from this experience?:** Jean Tournadre	

11:50	**GEO ActionDA-06-03 for GHRSST-PP ensemble based techniques:** C Donlon	
12:30	Lunch	
13:30	**Plenary discussion (Cont.)**	**Chair: Gary Wick Rapporteur: Bruce McKenzie**
Session 8. Reanalyses and Climate Data Records		
14:00	**Rannual Review:** Ken Casey	**Chair: Ken Casey Rapporteur: G Wick**
14:20	**The Analysis of Long Time-Series of SST from the AVHRR and ATSR Sensors:** David Llewellyn-Jones	
14:40	**SST Data Continuity: The impact of a data gap between AATSR and SLSTR on operational services:** Gary Corlett	
15:00	**Plenary discussion**	
15:20	Tea	
15:40	**GHRSST Reanalysis Discussion**	**Chair: Ken Casey Rapporteur: G Wick**
Session 9: GHRSST-PP quality control and validation		
16:40	**Plenary Discussion on metrics, validation and Quality Control.** **See** https://www.ghrsst-pp.org/modules/documents/documents/GHRSST-PP-Metrics-v1.0.doc **for details on metrics**	**Chair: Ian Barton Rapporteur: G. Corlett**
18:00	Close	
18:00-19:00	**Meeting of the GHRSST-PO Advisory Council to review progress. Location TBC.**	
18:30	**Informal dinner for anyone interested at Brux Bar & Restaurant (Micro-Brewery), 582 Little Collins Street, Melbourne (http://www.brux.com.au/), ½ block from Vibe Savoy Hotel and one city block from the Alto Hotel. Please email h.beggs@bom.gov.au by 1 May if you would like to attend.**	

Friday, 18th May 2007

Time	Agenda item	Session leaders
Session 10. Preparing the GDS v2.0		
08:30	**GlobColour: Implementation of a European Ocean Colour RDAC:** Samantha Lavender	**Chair: Craig Donlon Rapporteur: Peter Cornillon**
08:50	**Proposals for a new Top Level Governance of the GHRSST-PP:** C Donlon	
09:10	**Proposal for new L3/L3P products in the frame of the MERSEA SST project:** Pierre LeBorgne	
09:30	**Operational Agreements (Service Level Agreements, SLA) within the GHRSST-PP:** J Vazquez and the DM-TAG	
09:50	**Main issues to develop GDS v2.0:** Chair of the GDS-v2.0 WG	
10:10	Coffee	
10:50	**Plenary discussion: agree a plan and roadmap for the GDS-v2.0** 1. New sections for L3/L3P, operational message exchange, GDAC complementarily, SLA, ICD, Governance etc. 2. Revise L2P, L4, MDB, HR-DDS, MMR, SSES and QC sections. 3. Revise data management (naming conventions, filename structures, description of data, contacts, DSD records) 4. Assign drafting teams for each section including lead-authors 5. Agree timetable to allow at least 2 reviews and a final publication before April 1st 2008.	**Chair: Craig Donlon Rapporteur: Peter Cornillon**
12:30	Lunch	

13:30	**Review of Action list from the 8th GHRSST-PP Science Team Meeting and outstanding actions form 7th Science Team Meeting**	**Chair: C Donlon**
14:30	**Wrap up session and close** **1. Summary of workshop** **2. Preparation of proceedings: Chair & Rapporteur inputs** **3. Science Team Membership (New nominations and Resignations before the session please)** **4. Next meeting location and dates** **5. AOB**	
15:30	**Thank you and close of meeting**	
15:45	**Catch the No. 112 tram from stop 1 on corner of Spencer Street and Collins Street, City, to St Kilda Beach for Penguin Cruise (see http://www.penguinwaters.com.au/cruises.html). The Penguin Cruise boat starts boarding at 4:30 pm at St Kilda Pier and leaves at 5 pm sharp. Pay by cash on the boat. The cruise will be followed by dinner at Mash Restaurant Bar, 12 Fitzroy Street, St Kilda (http://www.mashrestaurant.com.au, ph: 9537 1777). Please email h.beggs@bom.gov.au by 1 May if you would like to attend. Cost of cruise: AUD$40. Cost of daily tram ticket: AUD$6. Dinner extra. Wear a warm, waterproof jacket.**	

Appendix-II: Participant contact details

Armstrong, Edward
Jet Propulsion Laboratory/California Institute of Technology
300/320 4800 Oak Grove Dr.
Pasadena, California
United States
Phone: 818 393-6710
Fax: 818 393 6720
E-mail: Edward.armstrong@jpl.nasa.gov

Arino, Olivier
ESA/ESRIN
Via Galleleo Gallili
Frascati
Italy
Phone:
Fax: +39 06 94180552/80942
Email: oarino@esa.int

Autret, Emmanuelle
IFREMER/CERSAT
29280 Plouzane,
France
Phone:
Fax:
E-mail:emmanuelle@ifremer.fr

Bainbridge, Scott
Australian Institute of Marine Science
Australia
Phone:
Fax:
E-mail: s.Bainbridge@aims.gov.au

Ball, Graeme
Bureau of Meteorology,
Melbourne,
Australia
Phone:
Fax:
E-mail: g.ball@bom.gov.au

Barton, Ian
CSIRO Marine Research
PO Box 1538,
Hobart, Tasmania 7001
Australia
Phone: +61 3 62325481
Fax:+61 3 62325123
E-mail: ian.barton@csiro.au

Beggs, Helen
Ocean and Marine Forecasting Group,
BRMC, Bureau of Meteorology
PO Box 1289k,
Melbourne, Victoria,
Australia
Tel: +61 (0)3 9669 4394
Fax: +61 (0)3 9669 4660
E-mail: h.beggs@bom.gov.au

Brassington, Gary
Ocean and Marine Forecasting Group,
BMRC, Bureau of Meteorology
PO Box 1289,
Melbourne, Victoria 3001
Australia
Fax: +61 (0)3 9669 4660
E-mail: g.brassington@bom.gov.au

Casey, Kenneth S.
NOAA/NESDIS
National Oceanographic Data Center, E/OC1,
1315 East-West Highway
Silver Spring, MD 20910,
USA
Phone: +01 301-713-3272 x133
Mobile: +1 410-507-5902
Fax: +01 301-713-3300
E-mail: Kenneth.Casey@noaa.gov

Castro, Sandra
University of Colorado,
Boulder,
Colorado
USA
Phone:
Fax:
E-mail: sandrac@colorado.edu

Cione, Joe
NOAA/HRL,
USA
Phone:
Fax:
E-mail: Joe.Cione@noaa.gov

Corlett, Gary
Univ. of Leicester
Space Research Centre
University Road
Leicester, LE17RH
UK
Tel:+44 116 2522465
Fax: +44116 2522464
Mobile: 0044-116-2522464
Email: gkc1@le.ac.uk

Cornillon, Peter
University of Rhode Island
USA
Phone:
Fax
E-mail: pcornillon@gso.uri.edu

Cowen, Lisa
Bureau of Meteorology,
Melbourne,
Australia

Phone:
Fax:
E-mail: l.cowen@bom.gov.au

Cummings, Jim
Naval Research Lab
USA
Phone:
Fax:
E-mail: cummings@nrlmry.navy.mil

Donlon, Craig
Director of the GHRSST-PP Project Office
Met Office Hadley Centre,
Met Office,Fitzroy Road
Exeter,EX1 3PB
United Kingdom
Phone: +44 (0)1392 886622
Fax: +44 (0)1392 885681
E-mail: craig.donlon@metoffice.gov.uk

Evans, Robert
Rosenstiel School of Marine and Atmospheric Science
University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149-1098,
USA
Tel: +1 (305) 361-4799
Fax: +1 (305) 361-4622
E-mail: bob@rsmas.miami.edu

Ferraro, Robert
Jet Propulsion Lab
NASA
USA
Phone:
Fax:
E-mail: Robert.Ferraro@jpl.nasa.gov

Franz, Bryan
NASA Goddard Space Flight Center
Phone:
Fax:
E-mail:bryan.franz@gsfc.nasa.gov

Gentemann, Chelle
Remote Sensing System
438 First St. Suite 200;
Santa Rosa, CA 95401
USA
Phone: +1 707-545-2904x14
Fax: +1 707-545-2906
E-mail: gentemann@remss.com

Grant, Ian
Space Based Observations Section
Bureau of Meteorology
Australia
Phone:
Fax:
E-mail: i.grant@bom.gov.au

Harris, Andy
NOAA/NESDIS ORA,
World Weather Building 5200 Auth Road
Camp Springs, MD 20746
USA
Phone: +1-301-763-8102 x169
Fax: +1-301-763-8108
Email: Andy.Harris@noaa.gov

Heinz, Susan
GeoLogics Corp.
USA
Phone:
Fax:
E-mail: sheinz@geologics.com

Hoeyer, Jacob
Danish Meteorological Institute
Denmark
Phone: +45 2627 8990
Fax:
Email: jlh@dmi.dk

Hirst, Kathleen
Bureau of Meteorology
Melbourne
Australia
Phone:
Fax:
E-mail: k.hirst@bom.gov.au

Lavender, Samantha
University of Plymouth
Plymouth
United Kingdom
Phone:
Fax:
Email:s.lavender@plymouth.ac.uk

Le Borgne, Pierre
Meteo-France/Centre de Meteorologie Spatiale
CMS, B.P. 147,22302
Lannion Cedex,
France
Phone: +33 2 96 05 67 52
Fax: +33 2 96 05 67 37
E-mail:Pierre.LeBorgne@meteo.fr

Liggett, Patricia
Jet Propulsion Laboratory Physical Oceanography Distributed Active Archive Center
300/323 4800 Oak Grove Drive
Pasadena, CA 91109,
USA
Phone: 818-726 5976
Fax: 818-393-2718
E-mail:pat.liggett@jpl.nasa.gov

Llewellyn-Jones, David T
Univ. of Leicester

Space Research Centre
University Road
Leicester, LE17RH
UK
Phone:
Fax:
E-mail:dlj1@le.ac.uk

Martin, Matthew
Met Office, Fitzroy Road
Exeter,EX1 3PB
United Kingdom
Phone: 07985 257702
Fax: +44 (0)1392 885681
Email: matthew.martin@metoffice.gov.uk

Mahoney, Mike
Australian Institute of Marine Science
Australia
Phone:
Fax:
E-mail: m.Mahoney@aims.gov.au

Maturi, Eileen
NOAA/NESDIS/ORA
USA
Phone:
Fax:
E-mail: Eileen.Maturi@noaa.gov

May, Doug
NAVOCEANO Code N32.
1002 Balch Boulevard
Stennis Space Center
MS 39522-5001
USA
Phone: +001(228) 688-4859
Fax: +001(228) 688-5577
E-mail: doug.may@navy.mil

Maynard, Jeff
Climate Change Response Programme
Great Barrier Reef Marine Park Authority
2-68 Flinders St
PO Box 1379
Townsville, Qld 4810
Australia
Ph:61 (07) 4750 0771
Fax: 61 (07) 4772 6093
Email: J.Maynard@gbrmpa.gov.au

McKenzie, Bruce
Naval Oceanographic Office
NAVOCEANO Code N32.
1002 Balch Boulevard
Stennis Space Center
MS 39522-5001
USA
Mobile: 228-363-1965
Fax:
Email: bruce.mckenzie@navy.mil

Merchant, Chris
Institute for Meteorology
The University of Edinburgh
Mayfield Road
Edinburgh EH9 3JZ
United Kingdom
Phone:
Fax: +44 (0)131 662 0478
E-mail:c.merchant@ed.ac.uk

Minnet, Peter
Rosenstiel School of Marine and Atmospheric Science
University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149-1098,
USA
Phone: +1 (305) 361-
Fax: +1 (305) 361-
E-mail: pminnett@rsmas.miami.edu

Le Marshall, John
Bureau of Meteorology,
Melbourne,
Australia
Phone:
Fax:
E-mail: jlm@bom.gov.au

Li, Yan
National Marine Environment Forecasting Center,
China
Phone:
Fax: [+86 1] 62173620
Email: liy@nmefc.gov.cn

Mittaz, Jonathan
NOAA CICS,
University of Maryland
USA
Phone:
Fax:
E-mail: Jon.Mittaz@noaa.gov

Nightingale, Tim
Rutherford Appleton Laboratory
Chilton, Didcot
United Kingdom
Phone: +44/0 1235 445 914
Fax: +44/0 1235 445 848
E-mail: t.j.nightingale@rl.ac.uk

Oke, Peter
CSIRO Marine and Atmospheric Research
Australia
Phone:
Fax:
E-mail: peter.oke@csiro.au

Perry, Kelly
PO.DAAC,

Jet Propulsion Laboratory/California Institute of Technology
300/323 4800 Oak Grove Drive
Pasadena, CA 91109,
USA
Phone:
Fax:
E-mail: Kelly.L.Perry@jpl.nasa.gov

Piollé, Jean-François
IFREMER/CERSAT
Technopôle Brest Iroise
29280 Plouzané
France
Phone: 33 2 98 224691
Fax: 33 2 98 224533
E-mail: jfpiolle@ifremer.fr

Poulter, David
School of Ocean and Earth Science
University of Southampton
Southampton Oceanography Centre
European Way Southampton SO14 3ZH,
United Kingdom
Phone: +44 02380596107
Fax: +44 02380593059
E-mail djsp@soc.soton.ac.uk

Procter, Sian
VEGA Group
United Kingdom
Phone:
Fax:
E-mail: sian.procter@vega.co.uk

Pugh, Tim
Ocean and Marine Forecasting Group
BMRC, Bureau of Meteorology
Australia
Phone:
Fax:
E-mail: t.pugh@bom.gov.au

Rea, Anthony
Space Based Observations Section
Bureau of Meteorology
Australia
Phone:
Fax:
E-mail: a.rea@bom.gov.au

Reed, Greg
Australian Ocean Data Centre Joint Facility
Australia
Phone:
Fax:
E-mail: greg@metoc.gov.au

Rutherford, Martin
Royal Australian Navy
Australia
Phone:
Fax:
E-mail: D_dir@metoc.gov.au

Pritchard, Matt
NEODC
Rutherford Appleton Laboratory
Chilton, Didcot
United Kingdom
Phone: +44 7917262810
Mobile: 07917262810
Fax: +44 1234 445848
Email: m.j.pritchard@rl.ac.uk

Schiller, Andreas
CSIRO Marine and Atmospheric Research
Hobart,
Australia
Mobile: 0400 501 162
Fax: 03 62 325123
Email: andreas.schiller@csiro.au

Tournadre, Jean
IFREMER/CERSAT
Technopôle Brest Iroise
29280 Plouzané
France
Phone:
fax:
E-mail: jean.tournadre@ifremer.fr

Turner, Peter
CSIRO Marine and Atmospheric Research
Hobart,
Australia
Phone:
Fax:
E-mail: Peter.Turner@csiro.au

Vazquez, Jorge
PO.DAAC,
Jet Propulsion Laboratory/California Institute of Technology
300/323 4800 Oak Grove Drive
Pasadena, CA 91109,
USA
Phone: +01 818-354-6980
Mobile: 626 862 3771
Fax: +01 818-393-6720
E-mail: jorge.vazquez@jpl.nasa.gov

Weeks, Scarla
University of Queensland
Australia
E-mail: s.weeks@uq.edu.au

Wick, Gary
NOAA Environmental Technology Laboratory
R/ET6 325 Broadway
Boulder, CO 80305,
USA
Phone: +01 303-497-6322
Fax: +01 303-497-6181

E-mail: Gary.A.Wick@noaa.gov

Wimmer, Werenfrid
NOCS
United Kingdom
Phone:
Fax:
E-mail: w.wimmer@soton.ac.uk

Xie, Jiping
Institute of Atmospheric Physics,
Chinese Academy of Sciences
Beijing,
China
Phone:
Fax: +86 1 8299 5123
Email: xiejp@mail.iap.ac.cn

Xinmei, Huang
Bureau of Meteorology
Melbourne,
Australia
Phone:
Fax:
Email: x.huang@bom.gov.au

Zhong, Aihong
Bureau of Meteorology
Melbourne,
Australia
Phone:
Fax:
Email: a.zhong@bom.gov.au

Appendix-III: Report of the GHRSST-PO Advisory Council

GHRSST Advisory Council Meeting

Melbourne Vibe Hotel, Thursday May 17, 2007 @ 1800 hrs.

Present: Ian Barton, CSIRO, (Chair)
Gary Wick, (NOAA)
Ken Casey, (NOAA, NODC)
Jorge Vazquez, (NASA/JPL)
Jean-François Piollé, (IFREMER)
Pierre Le Borgne (Meteo-France)
representing Ian Robinson (SOC, Medspiration Project)
Craig Donlon, ex-officio (Director of GHRSST-PP Project Office)

Apologies: Ian Robinson

Agenda: It was agreed that the agenda would be done "on the fly".

Discussion: PLB stated that the GHRSST program was a great success especially for the Medspiration Project. There had been an issue with the timeliness of the L2P file deliveries but through GHRSST this problem had been resolved.
The main discussion centred on the future of the GHRSST-PP. Options included keeping the original name (with the danger of a perception that nothing had been advanced), dropping the "-PP" and keeping GHRSST (even though GODAE was to finish in 2008), or finding a new name and umbrella organisation. One of the problems is to gain secure funding for the Project Office as this is an essential component of the project. A call would be made in tomorrow's wind-up session for agencies to provide some small support for the Office.
GW stated that, in the USA, the project shouldn't close now as they were at a critical stage for gaining future funding. This view was reinforced by JV with a critical GDAC funding meeting coming up in June. It is important that the GHRSST project develops and maintains a strong profile to ensure future support.
PLB said that we need to keep the project alive and preserve what we have already achieved. The option of going under a WMO umbrella may mean that operational aspects are maintained but any further research efforts may become "fossilized". It was also thought that aligning with WMO may close other funding doors.
IB mentioned that the ITOVS group had been a great success and may be a model to follow. It was agreed that CD would talk with John LeMarshall about this issue, and the wider aspects of GHRSST-next.
The AC agreed that CD should mention these issues at tomorrow's meeting and ask the Science Team for directions on the future of GHRSST. CD stated that diurnal variability was still a major issue, and that it is important to continue the L2P concept.
It was also agreed that the AC should put out a short report on the 8th ST meeting and include a statement on the status of the program. This would be an update on that provided after the 7th meeting in Colorado.

Next meeting: The next face-to-face meeting would be held at the next GHRSST Science Team meeting. However the Chair stated that an email or phone hook-up could be arranged at any time if a significant urgent issue arose.

Close: The meeting closed at 1915.

Appendix-IV: Action list resulting from the 8th GHRSST-PP Science Team meeting

The following actions were reviewed and agreed in plenary by the GHRSST-PP Science Team which are based on the reports made by session Rapporteur and the GHRSST-PO on the 18th May 2006. Greyed text indicates a closed action.

Last update: 2007-07-24

No	Action	Owner	Date Due	Status
G7-1	A FAQ and summary document will be generated by the GDS-TAG describing the GDS v2.0 in a simple manner. The FAQ will be published on the GHRSST-PP web site as soon as possible.	**GDS-TAG**	ASAP	Open
G7-2	Modifications for the GDS agreed by the DV_WG and Science Team will be provided to the GHRSST-PO for inclusion into the GDS-v2.0.	**Merchant**	ASAP	Open
G7-3	Explore the possibility of make the NOAA/NESDIS Multi-scale OI code for use by the GHRSST-PP.	**Maturi Harris,**	As soon as available	Open
G7-4	The GHRSST-PO will coordinate with other RDAC systems and explore the most appropriate location and time for a GHRSST-PP user symposium. Review proposals prior to the 9th Science Team meeting.	**Heinz, Donlon, Gentemann**	To report at the next ST meeting	Open
G7-5	GHRSST-PP RDAC team leaders to look at the GODAE inter-comparison project in preparation for GHRSST-IX discussion. GHRSST-PO to put a new page describing inter-comparison activities within GHRSST-PP (including links) on the GHRSST-PP web site advise on the location of GODAE documentation.	**Donlon, All**	ASAP	Close
G7-6	A GHRSST-PP RAN user requirements document will be developed and circulated to the Science Team for review.	**Casey**	To report at the next ST meeting	Open
G7-7	Each RDAC group will check the consistency and correctness of L2P data files with the GDAC.	**Armstrong, RDAC leaders**	Immediate	Open
G7-8	The GHRSST-PO to contact JAXA to establish if the GDAC can host and serve JAXA L2Pc data at JPL. Arino to advise and provide input in JAXA role in UNFCC.	**Donlon/ Vazquez Arino**	Immediate	Closed
G7-9	All Science Team members to review and critically asses the GDAC interfaces to data. The GDAC team will provide a questionnaire/template for the review	**Vazquez**	Immediate	Open
G7-10	Register standard names of L4 and L2P files with the CF-1.0 group. The DM-TAG will provide the names to register. Donlon to contact the group in the UK to establish the appropriate procedure. (In progress)	**Donlon/Vazquez**	Immediate	Open
G7-11	Establish how GHRSST-PP data sets can be made visible to the THREDDS community in a coordinated manner by linking THREDDS catalogues to the GHRSST-PP MMR system	**Cornillon/ Armstrong**	Report at next ST meeting	Open
G7-12	The GEWEX Seaflux project Director will provide a formal Seaflux SST user requirement to the GHRSST-PP.	**Clayson/Wick**	Immediate	Open
G7-13	The OSI-SAF/IFREMER/RSMAS/URI will plan the development of an open source L2P re-gridding tool.	**Cornillon/ Piollé**	Report to next ST meeting	Open
G7-14	The requirements for sea ice data within GHRSST-PP from operational data and RAN CDR will be reviewed with NSIDC.	**Minnett/Fetterer**	Report at next ST meeting	Open
G7-15	Doug May will monitor the impact of changes to the AATSR quality flags. The output of 2006/7 monitoring will be posted on www.ghrsst-pp.org using the 7th GHRSST-PP Science Team results presented by May as a baseline.	**May/Donlon**	ASAP	Open
G7-16	L2P providers to generate a GHRSST-PP SSES configuration file for the GHRSST-PP web site with documentation.	**Donlon, L2P providers**	Report at next ST meeting	Open
G7-17	Request bzip2 compression is included in netCDF 4.0/HDF 5 specification for GHRSST-PP GDS-v2.0	**Cornillon/Donlon**	Report at next ST meeting	Open
G7-18	An external review of the GHRSST-PP web site (http://www.ghrsst-pp.org) will be conducted to highlight areas needing improvement. (Liggett done)	**Liggett/Arino**	August 2007?	Open

G7-19	A small group to look at Lake temperatures and provide a position paper for the GHRSST-PP ST will be established. The group should include a recommendation for a common land mask for GHRSST-PP. GHRSST-PO to develop a terms of reference document.	**LeBorgne (lead), Donlon, May, Stark, Poulter**	Report at next ST meeting.	Open
G7-20	RAN-TAG to provide content for the GHRSST-PP web space. Suggest as a minimum ToR + membership + overview (1 paragraph) + some images	**Casey**	ASAP	Open
G7-21	SI-WG to provide content for the GHRSST-PP web space. Suggest as a minimum ToR + membership + overview (1 paragraph) + some images	**Minnett**		Open
G7-22	DV-WG to provide content for the GHRSST-PP web space. Suggest as a minimum ToR + membership + overview (1 paragraph) + some images	**Merchant**		Closed
G7-23	Dick Reynolds to provide new analysis in GHRSST-PP L4 (GDSv1.7) format (with errors).	**Reynolds**	ASAP	Closed
G7-24	The potential for a GHRSST-PP user bug database will be explored. This should be developed so that users report problems in real time (like Microsoft 'do you want to send an error report').	**Cornillon, Donlon**	Report at next ST meeting	Open
G7-25	Dick Reynolds (NOAA) to provide a letter of support to ESA noting the need for a long term consistent (A)ATSR v2.0 data stream.	**Reynolds, Donlon**	Immediate	Open
G7-26	Send copy of all GHRSST-PP documents in paper and electronic format which will be submitted to the International library.	**Donlon/ Casey**	Immediate	Open

No	Action	Owner	Date Due	Status
G8-1	JPL GDAC will data mine and make available delivery latencies and try to decrease these time latencies. Monthly statistics should be published on the www.ghrsst-pp.org and GDAC http://ghrsst.jpl.nasa.gov web sites (linked?).	**Armstrong, Donlon**	End 2007	Open
G8-2	Ask Andrew Bingham for advice, help and support/ideas to look at creating a JAVA/RSS/email based Metrics and Operations Dashboard.	**Donlon, Bingham**	June 2007	Closed
G8-3	DV-WG to test the application of appropriate OC fields to help describe DV and in particular to verify Morel et al (2007) Zhl formulation using the HRDDS and other tools	**Poulter (lead), Lavender, Franz, Merchant (DV-WG)**	Feb 2008	Open
G8-4	Develop a plan and a short project to use the HRDDS to investigate the use of Ocean Colour in GHRSST-PP.	**Lavender, Franz, Donlon, Maturi, Poulter, Pinnock**	ASAP	Open
G8-5	The GHRSST-PO should write to the OBPG to explain the HRDDS Ocean Colour inter-comparison and request OBPG to participate.	**Donlon**	ASAP	Closed
G8-6	Martin Rutherford to test access and application of LTSRF data sets and provide links to WMS for the GHRSST-PP web data access pages GMPE	**Barton, M. Rutherford**	Report at next ST meeting	Open
G8-7	Update the list of L4 analyses on www.ghrsst-pp.org and as part of GHRSST-PP Multi Product Ensemble (GMPE)	**Donlon, Barton**	August 2007	Open
G8-8	Dave Poulter to develop a simple user questionnaire requesting HR-DDS requirements and circulate to all at the meeting.	**D. Poulter**	August 2007	Open
G8-9	Set up a revised MDB system for user verification of GHRSST-PP data products as part of the R/GTS and GMPE. The design of the new MDB should include a means to apply the 3-point [multi-point] statistics methodology proposed by Anne O'Carroll et al. in an automated manner.	**Piolle, Donlon**	End 2007	Open

G8-10	Revise GDS-v2.0 by December 2008 and arrange 2 reviews (internal and external) for a final publication before April 1st 2008. Draft should be in place by Sept/October 2008. A GHRSST-PP User Manual (application of GHRSST-PP products and services) should be developed and published as soon as possible but no later than August 2007 as this is when we expect the BAMS GHRSST-PP paper to be published.	**GDS drafting Team: Donlon (lead), Casey, Cummings, Merchant, Prichard, Poulter, Le Borgne, Gentemann, Armstrong, Piolle and Vazquez.** **User's Manual drafting team: Cornillon (lead), Donlon Casey, Vazquez, Lavender, Hoeyer, Le Borgne, Poulter, Hines**	Dec 2007	Open
G8-11	Agree the SSES group membership and add a web page on www.ghrsst-pp.org. (Web page added)	**LeBorgne, Donlon**	Dec 2007	Open
G8-12	Prepare appropriate user support material in time for BAMS publication and review www.ghrsst-pp.org. pages for sensible content.	**Donlon, Casey, RDACs with with Web pages**	August 1st 2007	Open
G8-13	DV-WG to write up a basic report of their meetings and publish on GHRSST-PP Web site linked to www.ghrsst-pp.org and University of Edinburgh Twiki DV-WG pages.	**Merchant, DV-WG**	August 1st 2007	Open
G8-14	Explore how to provide high resolution winds from NWP systems at UKMO, NRL, and BoM for DV work. Options to be documented in a short document and circulated to Science Team.	**Donlon, Cummings, Beggs**	End of 2007	Open
G8-15	Review the MMR metadata and map into ISO19115. Explore the application of the ISO-19115 International Marine Community Profile to be explored as the basis for GHRSST-PP MMR data (contact: Greg Reid)	**Armstrong, Casey, Piolle**	End of 2007	Open
G8-16	Casey and Peter Oke to develop a plan to bring the BLUElink> reanalysis (BRAN) into the GHRSST-PP RAN effort.	**Casey, Peter Oke, Gary Brassington**	Report at next ST meeting	Open
G8-17	Add an applications page to www.ghrsst-pp.org describing and promoting BRAN and GHRSST-PP	**Beggs, Oke, Brassington**	ASAP	Open
G8-18	Develop a plan of action to use GHRSST-PP data in support of ReefTemp (Climatology, averaging, MDB, HRDDS, L4's etc)	**Maynard, Poulter, Beggs, Weaver, Casey, Donlon, Turner**	End of 2007	Open
G8-19	Develop a set of ReefTemp user requirements for the HRDDS and develop a short paper on their application.	**Maynard, Poulter, Donlon**	September 2007	Open
G8-20	Add an applications page to www.ghrsst-pp.org describing and promoting ReefTemp and GHRSST-PP.	**Donlon, Maynard**	End July 2007	Open
G8-21	Add a web page to GHRSST-PP.org describing new satellite programs relevant to SST	**Arino, Donlon**	August 1st 2007	Open
G8-22	Add a link to the NAIAD system on the data access pages of www.ghrsst-pp.org and on the GDAC pages ghrsst.jpl.nasa.gov	**Piolle, Donlon, Vazquez**	August 1st 2007	Open
G8-23	Provide regular update information on the progress of METOP (availability, issues, plans, information) via mail to GHRSS-PP Science Team.	**LeBorgne**	As Required	Open
G8-24	Provide link to coldest climatology and other climatology data sets via web pages www.ghrsst-pp.org web page.	**LeBorgne/Casey**	August 1st 2007	Open
G8-25	Request Andy Bingham to contact all GHRSST-PP Science Team and request them to consider being a datacaster.	**Donlon, Bingham**	Jun 2007	Open
G8-26	Establish better links with the Joint Center for Satellite Data Assimilation (JCSDA) team within the GMPE. Request access to JCSDA radiance assimilation SST outputs and explore other areas for collaboration within GMPE.	**Donlon, Maturi**	June 2007	Open
G8-27	Explore the availability of WindSat SST data for GHRSST-PP. (Access established at Met Office, discussions with Karen StGermain suggest L2P is feasible)	**Maturi, LeMarshall, Donlon**	July 2007	Open
G8-28	Explore the availability of AIRS SST data for GHRSST-PP.	**Maturi, LeMarshall**	July 2007	Open
G8-29	Work with the SEVIRI revised algorithms together with MODIS to explore other potential improvements to MODIS SST's.	**Evans, LeBorgne, Merchant**	Report at next ST	Open
G8-30	MMR DSD, FR and file metadata for MetOffice OSTIA and AATSR L2P should be updated to carry the appropriate data policy statements.	**Donlon**	ASAP	Closed

G8-31	Develop a 4 page overview of the GHRSST-PP system derived from the BAMS paper and on the current and planned R/GTS framework.	**Donlon, Liggett, Casey, Tim Pugh/Beggs**	End of 2007	Open
G8-32	Produce a series of images to explore various combinations of AATSR SST outputs including N2 + N3+D2+D3 SST retrievals. These will be used to investigate the most useful and viable L2P AATSR data set for the GDS-v2.0 product (using experimental fields) following review by the GHRSST-PP ST and user community using email.	**Corlett, Donlon**	August 2007	Open
G8-33	Develop a GHRSST-PP Multi Product Ensemble (GMPE) description web page on www.ghrsst-pp.org including basic plan and metrics.	**Barton, Corlett, Donlon, Cummings,**	End of Sept 2007	Open
G8-34	Complete the GHRSST-PP metrics description document and publish on www.ghrsst-pp.org web site for review. A draft is expected by the end of June 2007 (Done) for review with a plan to have a definitive version by the end of September 2007.	**Barton, Corlett, Cummings**	End of Sept 2007	Open
G8-35	Develop a Terms of Reference (ToR) and membership for a GMPE Technical Advisory Group (GMPE-TAG).	**Barton, Donlon**	June 2007	Closed
G8-36	GMPE participants should formerly write to their GEO point of contact/country representative. Donlon to Circulate the GEO representatives to Science Team (Done) and include a link to GEO Work-plan on the GMPE pages. (Done)	**Donlon, Barton**	By end of 2007	Open
G8-37	Develop a plan for an operational daily GMPE system and a 2-6m intensive experiment. Explore if the GMPE needs a new data format for exchange of GMPE inputs/outputs (as the DV-WG have agreed for SEVIRI)	**Barton and GMPE-TAG**	By next ST meeting	Open
G8-38	Develop a 24 hr GOES composite L3P product and extracted frontal locations as a product for GMPE.	**Maturi**	Next ST meeting	Open
G8-39	Produce a definition and common vocabulary of the various terms used within the GMPE (building on the WMO paper that will be forwarded)	**Cummings, Barton, Donlon**	ASAP	Open
G8-40	Put up a Galithea-3 story on the GHRSST-PP web site applications pages (give login on web page to Hoeyer)	**Hoeyer, Donlon**	August 2007	Open
G8-41	L4 (& K10) providers to generate GHRSST-PP L4 format outputs + metadata for ingestion into the GMPE via GDAC and LTSRF.	**Cummings, McKenzie, Reynolds, Stark, Gentemann, Tournadre, Hoeyer, Harris**	End of 2007	Open
G8-42	Write up POSH model as a paper and finish edits to PhD.	**Gentemann**	ASAP	Open
G8-43	Agree a common set of L4 basin scale validation areas based on a review of current area definitions. GODAE metrics should be consulted to develop these definitions most appropriately.	**Donlon, LeBorgne, Harris, Cummings, Corlett, Stark**	Next ST	Open
G8-44	L3 definitions and section of GDS-2.0 needs o be written, reviewed and agreed and included in GDSv2.0.	**Casey, LeBorgne**	End of 2007	Open
G8-45	Write to ESA requesting that ESA consider promulgating the name ATSR-4 when referring to the Sentinel-3 SLSTR as this is adding confusion to the international community. (Discussed already with Mark Drinkwater)	**Donlon**	ASAP	Closed
G8-46	Users wanting to use the AATSR BT's for radiance assimilation should provide a summary of their application and request access through the ESA AATSR Category-1 agreement (GHRSST-PP) managed by Craig Donlon. Mail summary of application and formal request to craig.donlon@metoffice.gov.uk	**Donlon, Harris, May, Cummings, others??**	AS appropriate (ASAP is best)	Open
G8-47	RAN Chair to write to ESA, NASA and DEFRA (others) that explains the importance of M-AERI and ISAR in situ radiometers as a reference standard for CDR. In situ radiometers are considered essential to bridge the gap between AATSR and the ATSR-(SLSTR) instrument on Sentinel-3. A copy of the letter should be sent to O. Arino and C Donlon	**Casey, inputs from Minnett, Wimmer/Robinson**	ASAP	Open
G8-48	Develop and circulate a plan for maintaining SST data quality.	**Corlett**	October 2007	Open
G8-49	Send Jim Cumming the GHRSST-PP anomaly colour scale inflection points. Put the colour scale definition up onto the www.ghrsst-pp.org web site.	**Donlon, Stark**	ASAP	Closed
G8-50	RAN Chair to write a letter to the EUMETSAT office to request a consistent reprocessing of the SEVIRI data set.	**Casey**	ASAP	Open

G8-51	PO.DAAC request that all reanalysed RSS AMSRE and TMI data is sent to GDAC to route into GHRSST-PP system.	**Vazquez**	ASAP	Open
G8-52	The GHRSST-PO, on behalf of the ST, should write to NASA and JAXA to ask for VIIRS data to be processed to L2P for application within GHRSST-PP RAN.	**Donlon, Casey.**	ASAP	Open
G8-53	EU GDAC and US GDAC to discuss formal linkages and mode of operation 2008+	**Vazquez, Piolle, Donlon**	Early 2008	Open
G8-54	All to try and publish journal articles with appropriate citations to GHRSST-PP.	**ALL**	ASAP	Open
G8-55	GHRSST-PO to generate a list of GHRSST-PP publications on the www.ghrsst-pp.org web site. All ST members to send references of GHRSST-PP relevant papers to the GHRSST-PO for inclusion in the list.	**Donlon**	ASAP	Open
G8-56	GHRSST-PO to send a letter to E. Lindstrom underlining the importance of the US Participation in GHRSST-PP.	**Donlon**	ASAP	Open
G8-57	A small data/service interoperability working group should be established within GHRSST-PP. ToR to be developed.	**Casey, Maturi, Franz, Lavender, Poulter, Karen Patterson (NAVO), Armstrong, Beggs**	ASAP	Open
G8-58	Conduct an internal review of GHRSST-PP as a preparation for an external review in order to position the GHRSST-PP for the future and develop an appropriate long-term strategy for the project.	**Donlon, Heinz**	ASAP	Open
G8-59	Arrange an external review of the GHRSST-PP following the internal review.	**Donlon, Heinz, Arino**	ASAP	Open
G8-60	Review the DSD, FGDC, FR and sample file metadata to check that it is correct and review with each RDAC. DSD records should be published on the GHRSST-PP web site.	**Armstrong, Vazquez, Casey, Donlon and RDAC/GDAC**	ASAP	Open
G8-61	Provide clear and appropriate citation references at the point of data access on web or ftp sites.	**Armstrong, Vazquez, and RDAC**	ASAP	Open
G8-62	GDAC to feedback to data providers user requests, issues and interactions. A new system to encourage real time feedback is required (metrics/operations dashboard?).	**Armstrong, Donlon, Bingham, Liggett, Vazquez, Arino**	ASAP	Open
G8-63	Develop a discussion group to consider user interactions and metrics by contacting RDACS and their needs/ideas for applications and user services and functionality.	**Heinz**	July 2007	Open
G8-64	Write a letter Michael Freilich and NASA support and to support the GHRSST-PP activities in the USA.	**Donlon**	ASAP	Open
G8-65	Write a letter to NASA regarding CMIS replacement on NPOESS noting the importance of MW derived satellite SST data.	**Donlon**	ASAP	Open
G8-66	A Harris to lead a small group on how GHRSST-PP should develop appropriate products and support to radiance assimilation.	**Harris, Donlon**	Next ST meeting	Open
G8-67	The GHRSST-PP L3P discussion document developed prior to the G8 meeting should be consolidated and published on www.ghrrst-pp.org.	**Casey, Donlon**	ASAP	Open
G8-68	Put all presentations given at the G8 meeting on the www.ghrsst-pp.org and BoM meeting web sites	**Pugh, Donlon**	ASAP	Open
G8-69	Chris Merchant to provide a summary and list of actions agreed at the DV breakout session during G8 meeting	**Merchant**	ASAP	Open
G8-70	The grey list of poor quality/problematic SST in situ observations used by different operational centres should be exchanged and published on the www.ghrsst-pp.org web site (can be password protected).	**Donlon, Cummings, Piolle, Helen, LeBorgne**	ASAP	Open
G8-71	The quality level scales for SSES agreed at the G8 SSES breakout session should be documented on the GHRSST-PP web site.	**LeBorgne**	ASAP	Open
G8-72	An on-line discussion exploring implications for the planned ATSR L2P reprocessing and the final netCDF version (3.0 or 4.0) should be held	**Pritchard, Casey, Piolle, Donlon, Cornillon**	ASAP	Open
G8-73	PO.DAAC to provide DIFs for GHRSST-PP to the GCMD.	**Vazquez**	ASAP	Open
G8-74	Analysis and inter-comparison of L4's over China to be continued and extended to include other L4 analysis outputs if possible.	**Xie, Donlon**	Report at next Science Team meeting	Open

G8-75	Explore the possibility of using Korean data for GHRSST-PP.	**Casey.**	ASAP	Open
G8-76	Develop a better relationship with India for EO data exchange within GHRSST-PP	**Maturi, Arino, Donlon**	ASAP	Open

Last updated: C Donlon, 24th July 2007

How to find out more about the GHRSST-PP:

A complete description of the GHRSST-PP together with all project documentation can be found at the following web spaces:

GHRSST-PP	http://www.ghrsst-pp.org
Medspiration	http://www.medspiration.org
BLUElink>	http://www.bluelink.au
MISST	http://www.misst.org
NGSST	http://www.ocean.caos.tohoku.jp
HRDDS	http://www.hrdds.net
GHRSST-PP GDAC	http://ghrsst.jpl.nasa.gov
GHRSST-PP LTSRF	http://ghrsst.nodc.noaa.gov
ESA	http://www.esa.int
Met Office	http://www.metoffice.gov.uk

GHRSST-PP International Project Office

Met Office Hadley Centre
FitzRoy Road
Exeter, EX1 3PB
United Kingdom

Tel: +44 (0)1392 886622
Fax: +44 (0)1393 885681
E-mail: craig.donlon@metoffice.gov.uk
http://www.ghrsst-pp.org

The GHRSST-PP International Project Office is sponsored by the European Space Agency and the Met Office, United Kingdom.
Layout and design by C Donlon, GHRSST-PO, August 2007.