GHRSST-PP

GODAE High Resolution Sea Surface Temperature Pilot Project

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

David Skaggs building, NOAA, Boulder, USA, May 27th – 31st 2006.

GHRSST-PP Report: GHRSST-23, 2006

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

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1 Introduction

This report documents the main discussions and outcomes of the 7th GHRSST-PP Science Team meeting held at the David Skaggs building, NOAA, Boulder, USA, May 27th – 31st 2006. special thanks to Gary Wick and Sandra Castor and their team for organising all of the local arrangements and helping us all out in times of need. The meeting has been a great success in terms of providing a forum in which the GHRSST-PP Science Team can flourish and develop ideas, strategies and move the GHRSST-PP forward for the benefit of all those that use and produce SST data.

For the GHRSST-PP International Project Office it is a busy but exciting time as it 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. The progress made by the GHRSST-PP project community since the last (6th) International Science Team meeting has been an outstanding achievement. The GHRSST-PP Science Team and 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 Long Term Stewardship and Reanalysis Facility (LTSRF) has been developed to archive all GHRSST-PP data products and the project is making significant progress towards a reanalysis program, set to commence operations in 2006. In short, a version 1.0 of the Regional Global Task Sharing (R/GTS) Framework first developed at the 2nd GHRSST-PP Science Team Meeting, Tokyo back in 2002 has been successfully implemented. 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. This shifts significantly the emphasis within the GHRSST-PP from a technical implementation towards serving a demanding user community with real time operational data feeds and delayed mode Climate Data Records through re-analysis. The remaining technical challenge is to consolidate the GHRSST-PP project activities and facilitate the input of new satellite data such as that from the successful Japanese MTSAT-1R. But most importantly, the key demand placed on the GHRSST-PP is to transition from a pilot project into sustained operations.

Of course there are always issues to resolve and not all components of the R/GTS framework are complete. The GHRSST-PP system requires careful refinement based on user feedback and experience which is what the seventh Science Team meeting is all about**.**

> ***The aim of the seventh Science Team meeting is to review progress made within the GHRSST-PP since the last Science Team meeting and prioritise coordination and application activities for the next inter-sessional period.***

In particular, the need to consider Sea Ice and SST in the marginal ice zone in more detail; better single sensor error statistics (SSES); implementation of improved schemes to account for diurnal variability in a way that provides users with a useful and error-bound product; and the requirements of our user community in the light of product application tests and trials. Issues raised by the user community must all be considered and addressed by the GHRSST-PP Science Team and regional projects if the project is to transition successfully into operations.

As the international Science Team of the GHRSST-PP we have an obligation to serve the RDAC and GDAC projects with a clear roadmap, based on our collective scientific judgment, to guide and nurture a globally integrated and sustainable high resolution SST operational data provision system. In this way I am sure that we can resolve many of the outstanding issues and concerns in that have been raised since the development of the draft GDS v1.0 rev1.5. We must make the most of our time together as e-mail and telephone discussions are no substitute to an intensive discussion in plenary. The meeting format was once again biased toward plenary discussion with keynote talks to identify key issues but in addition, at the request of the Science Team, several breakout sessions were arranged to provide time to consider specific issues. In addition, a GCOS Sea Ice Working Group meeting was held on Sunday afternoon prior to the GHRST-PP meeting that discussed options and issues that could assist both GCOS and GHRSST-PP. The plenary/breakout format worked exceptionally well during the workshop and the GHRSST-PP plans and specifications have moved forward with over 70 Actions for the Science Team to address before the next international meeting**.**

On behalf of the GHRSST-PP Science Team I would like to take this opportunity to thank again Gary Wick and the NOAA 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.

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

2 Executive Summary of the 6th GHRSSST-PP Science Team Meeting.

Summary reports of the key issues raised at the 7th GHRSST-PP science Team meeting are reported in Session Rapporteur summary reports provided in section 3 of this report.

3 Detailed Session Reports

The GHRSST-PP 7th Science Team meeting was split into the following sessions:

1. Reports to the GHRSST-PP Science Team on project components
2. A User Consultation
3. Applications and development of new data streams
4. Sensors and single sensor error statistics
5. Parallel breakout groups
6. Emerging and future issues for the GHRSST-PP
7. The GHRSST-PP Re-analysis project
8. L4 Analyses: What is right and wrong?
9. The GHRSST-PP HR-DDS and MDB systems
10. Reports from session Rapporteurs and plenary discussion

The following sections of the report provide a summary of the main issues raised during each presentation

3.1 Welcome address from Randy Dole

The GHRSST-PP seventh Science Team was opened by Randy Dole (Chief Scientist NOAA ESRL/PSD) who welcomed all the participants to the David Skaggs building of NOAA. Dole noted that the Earth Science Research Laboratory (ESRL has been formed through the consolidation of 5 distinct laboratories and has resulted in a single complex but interesting laboratory. ESRL was formed to pursue a broad and comprehensive understanding of the Earth system. This system comprises many physical, chemical and biological processes that need to be dynamically integrated to better predict their behaviour over scales from local to global and periods of minutes to millennia. The staff within ESRL we are working toward a greater stewardship of the Earth through a number of themes aimed at understanding the Earth system processes and changes which are summarised as

Understanding atmospheric mechanisms that drive the Earth's climate.

- Aerosols: Climate
- Carbon Cycle Science
- Radiative Forcing of Climate by Non-CO2 Atmospheric Gases
- Surface and Planetary Boundary Layer Processes

Assuring the continuing health and restoration of atmospheric resources.

- Aerosols: Air Quality
- Stratospheric Ozone Layer Recovery
- Tropospheric Ozone and Air Quality

Improving predictions through expanded climate and weather products.

- The Weather-Climate Connection
- Climate and Water Systems

Dole noted that satellites formed an essential input into the work of ESRL and that in particular, the tropical regions are of high interest as these were fundamental across all timescales. SST has a particular role in the understanding of atmosphere – ocean heat, momentum and gas flux which are all important for coupled modelling. Integrated earth system analysis and the coupling between component systems is critical to success. This is especially the case for the ocean and is a major issue for coupled systems to implement correctly if the fundamental heat content and air-sea fluxes are to be determined correctly. Dole explained that several high level meetings including NSF & senate briefs are considering these issues and that the GHRSST-PP reanalysis discussions are a very important part of this meeting.

At ESRL there is a drive to bring in situ observations, satellite observations and coupled modelling together and SST is a critical variable for all of these systems. The ESRL is moving towards an integrated model suite similar to that of the Met Office Hadley Centre and the way forward is to look at integrated solutions to problems at different timescales. GHRSST-PP is thus in an excellent position to participate in this work by assisting Scientists with the best SST data for data assimilation by models or other components of their work.

Dole explained that Boulder was a great place to do science and urged the Science Team to take time away and talk to ESRL staff especially those in the tropical modelling processes in the new Climate Diagnostics branch. Finally Dole encouraged the participants to enjoy the meeting and wished everyone successful outcomes.

3.2 Session 1: Reports to the GHRSST-PP Science Team

The purpose of this session was to provide the GHRSST-PP ST with a summary of developments within the GHRSST-PP R/GTS and provide a 'health check' on the overall system. Representatives from each of the component GHRSST-PP projects were asked to present their activities since the 5th GHRSST-PP meeting including planned future developments.

3.2.1 Report from the GHRSST-PO, Craig Donlon

Donlon noted that the GHRSST-PP had made good progress since the last Science Team meeting and presented a summary of activities since 2002 when the Science Team generally had good ideas, some basic plans and a whole lot of enthusiasm – and not much money. Two international workshops had already been held (one in Italy (2001) and a second in Japan 2002) and there was promise of some funding in the EU from the European Space Agency (ESA). A consensus on the product line had been reached (which continues to evolve in a useful manner e.g., L2P core) and the supporting infrastructure requirements for a global operational system had been agreed following proposals from Japan (H. Kawamura) of the so called 'Regional/Global Task Sharing (R/GTS)' framework. Verification and diagnostics system requirements were well articulated, as was the importance of user feedback. The methods and tools for specific satellite SST uncertainty specification was basic but followed on from operational implementation in the US Navy and EUMETSAT OSI-SAF. Donlon noted that 4 years later, this still remains a key area for GHRSST-PP.

Today the efforts of the Science Team and GHRSST-PO have resulted in a version 1 of the GHRSST-PP R/GTS framework that is now in place and functional. (Figure 3.2.1.1)

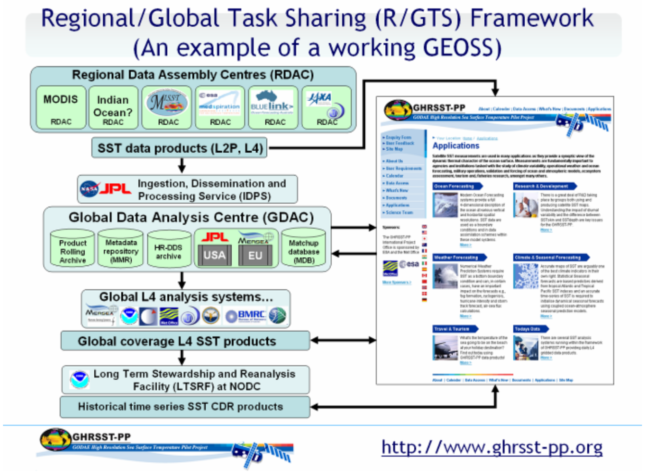


Figure 3.2.1.1 The GHRSST-PP Regional/Global Task Sharing (R/GTS) Framework

In particular, since the last Science Team Meeting the first GHRSST-PP Global Data Assembly Centre (GDAC) system has been consolidated at NASA JPL by the PO.DAAC team providing a functional service – see http://ghrsst.jpl.nasa.gov/). Furthermore, the GHRSST-PP Long Term Stewardship and Re-analysis Facility (LTSRF) has been developed at the NOAA National Oceanographic Data Center (NODC) located at http://ghrsst.nodc.noaa.gov/. These two services are starting to work together to provide the core of the GHRSST-PP R/GTS and provide a demonstration of the success that GHRSST-PP has become. Data access tools, FAQ, dataset descriptions and a prototype Application and user Support (AUS) service are all being developed in this context. In addition, the GHRSST-PP Master Metadata Repository (MMR) system, allowing search and discovery of GHRSST-PP data sets has been implemented as a core component of the GHRSST-PP GDAC allowing users to browse and search for GHRSST-PP data sets held within the R/GTS. It is a considerable achievement for the GDAC, LTSRF and GHRSST-PP Science Team to have developed the GHRSST-PP R/GTS concept from vision to reality and marks a turning point bin the project.

In terms of L2P and L4 data sets generated within the project, Figure 3.1.1.2 shows the status of data streams within the R/GTS in May 2006. Several Regional Data Assembly Centre (RDAC) systems are now operational for L2P and L4 products with others in development or in a pre-operational configuration. All of the major SST satellite systems are in place and are providing L2P or L2Pcore data (the latter complemented to full L2P data at the JPL GDAC) and several global and regional L4 systems are providing data products on a daily basis. User communities are starting to work with the GHRSST-PP data streams and feedback is being actively solicited by the RDAC and GDAC teams.

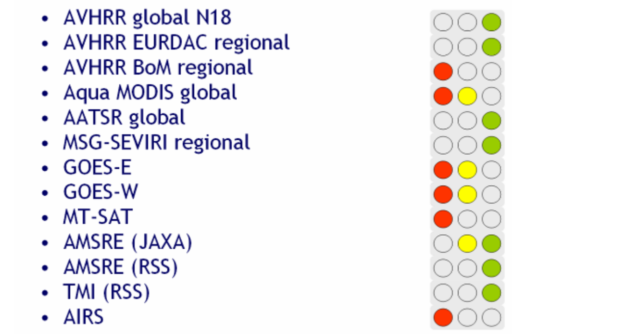


Figure 3.2.1.2(a) GHRSST-PP L2P System Status May 2006

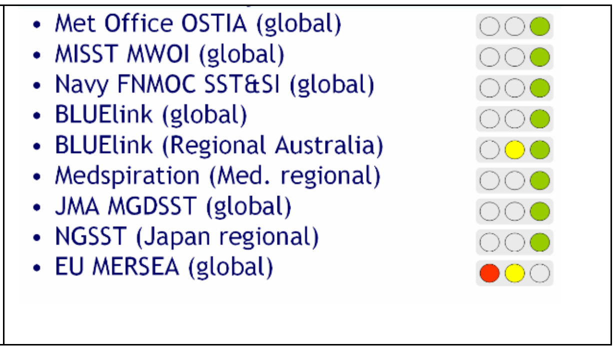


Figure 3.2.1.2(b) GHRSST-PP L4 System Status May 2006

Some issues remain and several users (NWP systems, climate/seasonal monitoring systems and the general scientific community) have requested that the GHRSST-PP data streams should include lake temperatures as a standard part of L2P and L4 products. Currently, some L2/L2P systems provide lake temperatures but others do not. This is due to several complicating issues relating to:

- variable atmosphere and the need for specific lake surface temperature (LST) retrieval algorithms,
- differences between surface emissivity of salt and freshwater,
- validation and connection to lake surface temperature community
- the resolution and definition of GHRSST-PP 'lakes'
- the complication of ephemeral lakes and receding shorelines, etc

Donlon urged the Science Team to consider how best to develop LST within the framework of the GHRSST-PP and proposed that the ST endorse the inclusion of lake temperatures within L2P and L4 systems if possible with specification introduced into the GDS-v1.7 and follow on GDS-2.0 as soon as possible. The Science Team noted that LST should be included in the GHRSST-PP specification but that the responsibility was with the L2 data providers rather than the GHRSST-PP R/GTS systems as they had no control on what L2 data were provided. It was agreed that RDAC and GDAC teams would liaise with data providers to explore these issues and report back at the next GHRSST-PP science Team Meeting.

Donlon then reviewed the GHRSST-PO core work which has been funded by ESA and the Met Office for the last 3 years on a full-time basis (70%/30%). The Project Office had overseen an intensive development of the pilot-project during this time going from ideas to implementation with the main elements of the work being:

- Management of the GHRSST-PP Science Team, meetings and working groups
- Delivery of the GHRSST-PP ST meeting proceedings and an annual report
- Support to Medspiration, MISST, GDAC, and all teams/WG's
- Development and maintenance of the GHRSST-PP WWW space
- Promotion and support of all GHRSST-PP activities through representation at meetings and conferences
- Support to ESA/EUMETSAT/NASA/NOAA/JAXA regarding GHRSST-PP matters
- Development of a sustainable R/GTS system

The GHRSST-PP user requirements document has received no inputs beyond what was provided last year. We need to have a push forward with user applications and Donlon suggested that more application descriptions and 'User stories' were posted on the GHRSST-PP WWW portal. Donlon noted that since the last Science Team Meeting, a new GHRSST-PP web site had been developed with completely revised with new artwork and style (see Figure 3.2.1.3) which provides a more professional promotion and outreach tool. The Project Office has been encouraging feedback and inputs from many sources in order to showcase for GHRSST-PP activities in the best possible way. However, content still required in several areas especially for the pages relating to the GHRSST-PP technical Advisory Groups (TAG) and Working Groups (WG). It is far better for these groups to provide their own inputs to the GHRSST-PP site so that the information is correct and useful to the groups and people trying to find out and get involved with the GHRSST-PP. Donlon suggested that as a minimum, each group should consider providing the groups terms of reference, current membership together with an overview group purpose and role. Together with some images well chosen image, this amount of information easily constitutes sufficient for the top level GHRSST-PP web site. For future versions, Donlon noted that the site should also contain operational status 'traffic light' (see Figure 3.2.1.2) pages and operational log pages. Live metrics for GHRSST-PP activities on the web with links to operational error logs (e.g. Medspiration, MISST, OSI-SAF) provide excellent information form a user perspective. This was how the original OPLOG and ERRLOG functionality should have worked within the GDS and Donlon urged the Science Team to look again at how operational messages and error reports can be efficiently passed between centres to minimise confusion within the R/GTS. If these could also be linked together with RDAC/GDAC performance indices as discussed by Ian Barton in Exeter, then this would be an even better user information service.

The priority issues for the GHRSST-PO during the coming inter-sessional period is to develop opportunities and funding lines that will sustain the GHRSST-PP. The Pilot Project needs to finish and become an operational system but the Science Team need to make sure we are putting L2P, L4, MDB, RAN, MMR, DDS services at core operational institutions (ESA/JAXA/NASA/NOAA/BoM/…). In addition, GHRSST-PP needs to be properly supported by academic R&D which is pulled through to operations.

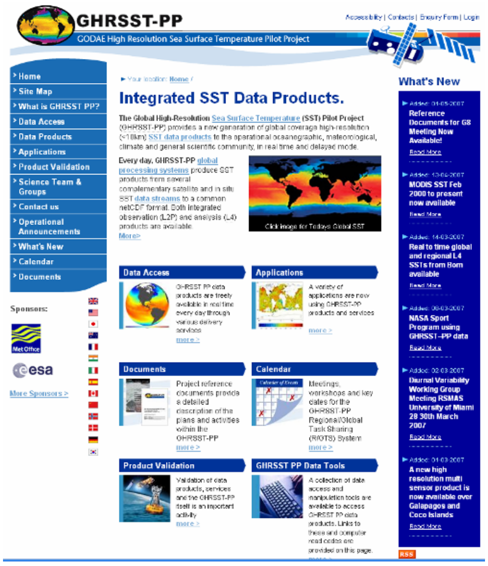


Figure 3.2.1.3 New look and feel GHRSST-PP web site

The GDS-v1.7 (and indeed v2.0) is critical to this aspect of the transition form pilot to operational system. The GDS provides the technical documentation to help people work together. It needs a concerted effort for some sections including:

- New technical sections on SSES from each satellite instrument
- New general section on L4 system descriptions
- New technical section on L4 inter-comparison/poor mans ensemble systems
- New technical section on GDAC <->LTSRF<->User and re-analysis system
- New technical section on L2Pc experimental fields and to document those fields that are becoming standard.
- The structure of the document needs to change to use hyperlinks throughout with several; separate documents for each sub-system. A series of pdf files and a html WWW version probably provide the best way forward
- It should also prepare for new sensors (METOP, IASI, MTSAT, CIMIS, Sentinel, NPOESS…) which are not yet listed or mentioned in the document.

The GDS remains a significant challenge for the GHRSST-PP Science Team as it needs to balance operational stability against common sense evolution and innovation. The best way to view the version 1.7 is an operationally stable version and the GDSv2.0 should develop in parallel as a next generation innovation version for implementation in 2008. This was a key issue for the 7th Science Team meeting.

Donlon reported that an article proposal to the AMS Bulletin of the American Meteorological Society (BAMS) had been accepted and the following deadlines had been issued by BAMS:

- Content submission deadline is May 1st 2006
- 1st draft for ST review by June 2006
- Corrections and submission to BAMS July 1st 2006

The Science Team agreed that an article in BAMS provided an excellent way to advertise the GHRSST-PP and would bring a larger user community and urged the GHRSST-PO to take this action forward by collating Science Team inputs to the paper.

Donlon summarised progress with the GHRST-PP and the Project Office noting that GHRSST-PP is now accepted as 'the' project for SST in many circles including CLIVAR re-analysis, MERSEA, GMES, many operational NWP & Ocean forecasting systems, Universities, for satellite salinity missions (SMOS/Aquarius). As GODAE will end in 2007/8 then the GHRSST-P Pilot Project should 'end' and we must move from GHRSST-PP to self sustaining operations. The challenge is to ensure that the GHRSST-PP becomes part of national infrastructures for sustainability. The Science Team also need to articulate a need for continuity of satellite sensors and in particular MW SST and AATSR class of instruments which are essential tools for the new generation of SST data sets. Donlon urged the Science Team to use the meeting wisely to develop a set of actions that will lead to sustainability of the GHRST-PP framework and the continued R&D necessary to make the most of our satellite investments in all countries. Donlon ended by noting that the version 1.0 R/GTS status is a great achievement for which the Science Team should be proud. The current estimate of 'operationality' is

- ***Phase-I:*** An International project tasked to develop and implement a distributed system to deliver integrated high resolution SST and Sea Ice (SI) data products. (90% complete)
- ***Phase-II:*** Develop a sustained R/GTS system ***and operational user community*** for SST&SI and Manage the ongoing evaluation and evolution of the system (50% complete)
- ***Phase-III:*** Deliver SST & SI Climate Data Records (CDR) in support of GEOSS, GEO, DMAC/IOOS, JCOMM, WCRP, GOOS and GCOS climate objectives (40% complete)

3.2.2 Review of outstanding action items since the 6th GHRSST-PP Science Team Meeting

The actions from the GHRSST-PP 5th Science Team Meeting were reviewed. In general good progress had been made with specific action items and the Science Team had completed over 80% of the tasks it set out at the Exeter meeting. The few outstanding actions considered important were carried through into the Action list developed for this (7th) Science Team meeting which are provided in Appendix-IV

3.2.3 USA: Multi Instrument SST (MISST) project, Chelle L Gentemann, Gary Wick, Jim Cummings, Eric Bayler

Gentemann reminded the Science Team that the MISST project is built around five key areas which are:

1. Data Provision
2. SSES
3. Diurnal Warming / Skin Layer
4. Analyses
5. Impact Studies

NAVOCEAN (Doug May and team) have made excellent progress toward provision of an L2Pcore SST data stream from NOAA-18 including SST, bias, STD, AOD in NRT. Bias/STD SSESW will be updated daily using buoy collocations. Data will be made available form the GDAC who will complement the NAVOCEANO data to full format L2P data at Global 8.8 km in orbital swath and regional 2.2 km data set. Data will be available from http://www.ghrsst.jpl.nasa.gov. In addition, work on AVHRR NOAA 17 will commence soon.

NRT TMI and AMSR-E SSTs in L2Pcore format are now available form http://www.misst.org as global swath data including SST, bias, STD and a diurnal warming estimate (discussed later in the meeting as a separate presentation). The bias/STD derivation is described in document at www.misst.org. The new AMSR-E v5 data set has now been released which includes the following key changes in processing specification:

- The rainfall algorithm was changed, this will affect SSTs by changing where pixels are masked as rain contaminated.
- Geolocation was improved. Errors have been reduced from 5-10 km to 1-3 km.
- Moon contamination adversely affecting in the AMSR-E cold mirror has been corrected
- The product filename has changed to indicate v05
- Data will be timelier as we have switched data sources and changed to forecast fields for a NRT product

Data files (as single orbits) are being made available following user requests at 3 hourly intervals and gridded data will be available soon. There was some discussion regarding the need for L3 Gridded (are these needed if everyone uses swath L2P?) which was inconclusive. The Science Team recommended that the issue of L3/L3P data products should be considered as part of the GDS1.7/2.0 discussions prior to the next Science Team meeting.

MODIS 1km global SSTs are being developed by a tri-partite collaboration between the Ocean Biology Processing Group at Goddard Space Flight Center, the University of Miami (RSMAS) and the JPL

GDAC team. Great progress has been made and HDF4 MODIS 5 minute granules (not compressed or chunked internally) have been developed that include day/night 11 micron, night 4 micron TOB, SST, bias and STD estimates. The bias/STD is derived from a hypercube approach that will be presented by Bob Evans later in the meeting. These files are produced by GSFC OC group using the RSMAS algorithm with the JPL GDAC reconfiguring the data sets to full L2P format (expected soon).

GOES-L2P development is continuing at NOAA/NESDIS although no documentation or test data are available yet. Assurance was given that L2P GOES data can be expected within the next month.

Gentemann then turned to focus on Single Sensor Error Statistics (SSES) development within the MISST project. A comparative study of proposed IR SSES formulations has been completed and reported in fully in a report available from http://www.misst.org. Addition of ancillary data from AMSR-E and TMI and near-surface temperature enables improved corrections for the dependent data where it is available. The best improvements are provided through use of only the AVHRR satellite zenith angle (SZA), SST and channel 4-5 brightness temperature difference. NAVOCEANO reliability data (included in the test files) enabled negligible improvements since only a relatively small number retrievals fall outside the best quality category. A key conclusion is that the GHRSST-PP GDS specified approach utilizing proximity to cloud did not appear to facilitate the best error characterization and requires further investigation. These results are reported in other presentations at this meeting.

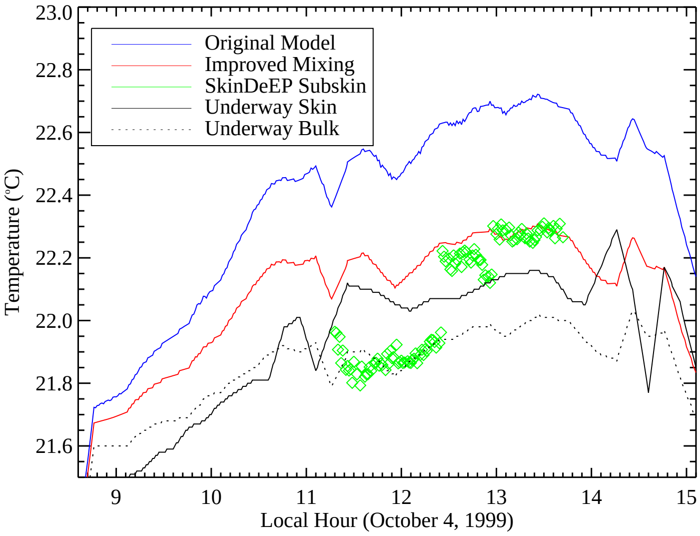


Figure 3.2.3.1 Profiles from SkinDeEP deployments in the waters around Baja California in 1999 and in the Mediterranean Sea in 2003 were used to validate simulated near-surface temperature profiles from a modified version of the Kantha and Clayson (1994) one-dimensional (1D) mixed layer model Comparisons of simulations from full diurnal warming models with detailed temperature profile measurements from the SkinDeEP instrument identified the best combination of model physics for use in evaluation of simplified parameterizations and quantified expected errors in estimates of diurnal warming.

R&D for diurnal warming parameterisation has proceeded well and several studies have been completed using full diurnal variability (DV) models (Figure 3.2.3.1) to understand what the best simplified parameterisations for operational applications are. Sensitivity studies reveal optimal sources of wind speed and insolation data for diurnal warming calculations based on non-continuous satellite data. Instantaneous winds provide the best results for modeled skin temperatures while averaged winds result in reduced error in predicted subsurface temperature. The impact of short term insolation variations was found to be significant only in morning hours. The Science Team noted these excellent results and suggested that parameterisations should also be tested in open ocean conditions.

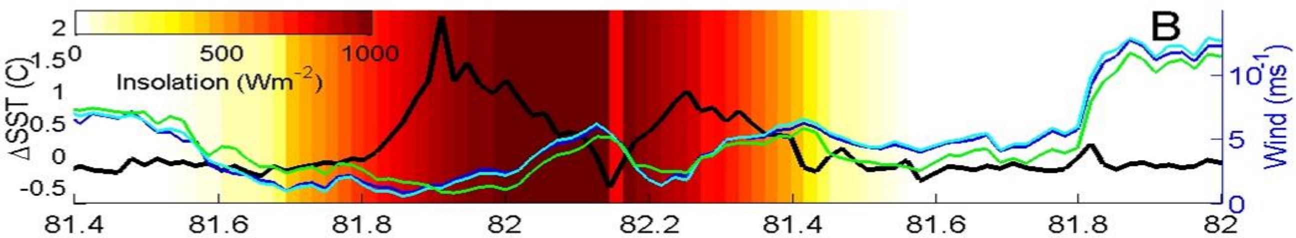
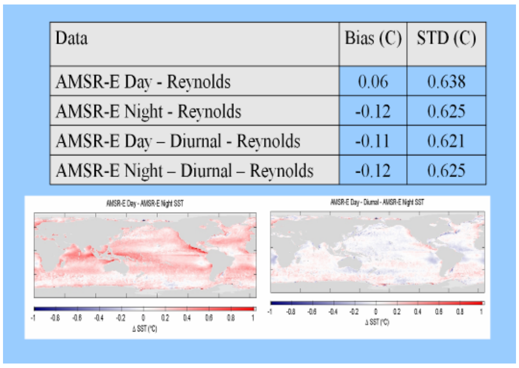


Figure 3.2.3.2 Example data form the M-AERI spectroradiometer aboard the Explorer of the Seas operating in the Caribbean showing the impact of small changes in wind speed on ΔT.

Gentemann use in situ observations (Figure 3.2.3.2) to show how small changes in wind rapidly and strongly affect the magnitude of diurnal warming. Daily peak(s) appear to be directly related to minimum in wind speed and above 6 m/s wind speed, diurnal warming is rapidly erased. The strongest correlation was found at a 30 min lag. Furthermore, fluctuations in insolation need to be large (>100 w/m2) to result in a measurable (0.1 to 0.2 K) impact on the diurnal signal. In these cases the strongest correlation was found at a 50 min lag time.



Data	Bias (C)	STD (C)
AMSR-E Day - Reynolds	0.06	0.638
AMSR-E Night - Reynolds	-0.12	0.625
AMSR-E Day – Diurnal - Reynolds	-0.11	0.621
AMSR-E Night – Diurnal – Reynolds	-0.12	0.625

Figure 3.2.3.3 Impact of applying Diurnal Variability corrections to AMSRE Data when compared to Reynolds OIv2.0 data

Biases between Reynolds and AMSRE before and after applying diurnal model are shown in Figure 3.2.3.3. Clearly the bias in the data is significantly reduced without increase in the STD demonstrating the impact of these approaches and the benefit when analysing combined SSTs for SST foundation (SSTfnd).

Additional work using skin layer models suggest that using simple empirical models to obtain SSTfnd is promising. Skin layer models (Donlon, 2002 & Castro, 2001) generally reproduce the observed behavior of the independent observations. The accuracy observed using new (more complex) air/sea temperature differences and satellite winds relative to the individual observations is only slightly poorer than that obtained with coincident *in situ* wind speeds and should be sufficient for an initial bulk-skin model. Gentemann concluded that at present we are much better at observing DV rather than modelling it and that separate skin and foundation analysis systems may be required depending on the particular application.

The MISST L4 analysis systems include FNMOC High Resolution SST and Sea Ice Analysis for GHRSST developed by Jim Cummings which is available form http://www.usgodae.org on an operational basis. The analysis is updated every 6 hours and uses AVHRR (NOAA-16, 17, 18) GAC satellite SST and in situ SST from ships and buoys (fixed and drifting). The sea ice analysis is produced on the same grid as the SST at the same time, using the same update cycle. Synthetic SSTs at the freezing point of sea water (taking into account salinity) are generated when the ice coverage exceeds 55% and are used in the SST analysis to help maintain SST gradients in the marginal ice zone. In addition an experimental AMSR-E L4 version is being developed and in future the use of MSG, MODIS, AATSR data is planned. The main evaluation of SSES from the MISST data providers is being performed using the Jmin diagnostic (see the discussion document presented at the 5th GHRSST-PP Science Team Meeting by Jim Cummings for a full definition).

Remote Sensing Systems (RSS) has developed a High Resolution MW only SST with a Sea Ice Analysis for GHRSST which is available form http://www.misst.org. Currently only 1 month of data are available but a full 6 month reprocessing I planned. The MWOI L4 product provides daily foundation SST at 25 km MW only OI SSTs (TMI, AMSR-E, TMI+AMSR-E) with sea ice derived from the MW observations themselves. In addition a Experimental 10 km foundation SST using MODIS, AMSR-E and TMI data which will be developed in the coming year. Comparisons between between OSI-SAF and RSS Sea Ice products show that differences exist that need to be resolved (Figure 3.2.3.4)

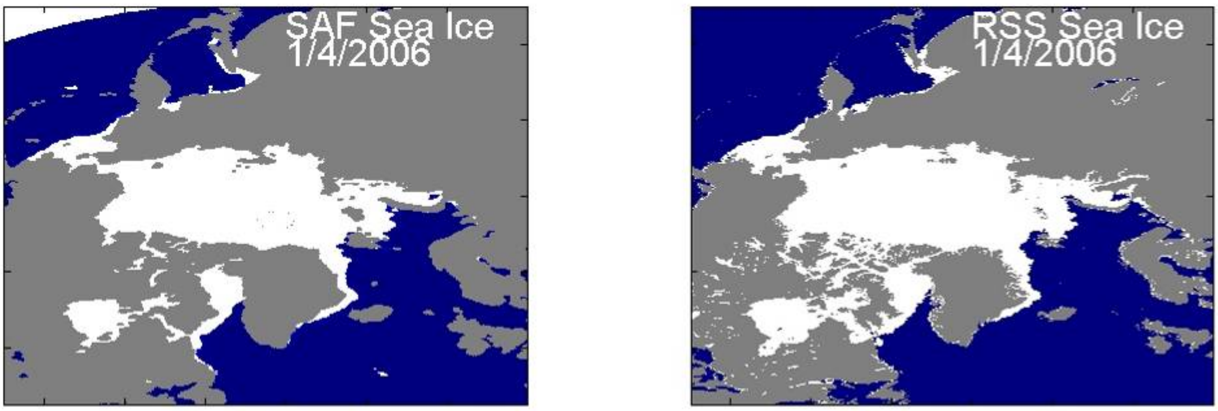


Figure 3.2.3.4 Comparison between EUMETSAT OSI-SAF and RSS Sea Ice mask for the 1/4/2006.

Finally Gentemann noted that a new ***NOAA High Resolution SST Analysis for GHRSST*** was being developed. The analysis will be performed daily at high resolution (1/12°) using NOAA 17 & 18, 3 GOES inputs. So far only images are available that can be viewed at: http://www.orbit.nesdis.noaa.gov/sod/sst/blended_sst. Data will be issued when problems with numerical stability internal to the analysis system are resolved.

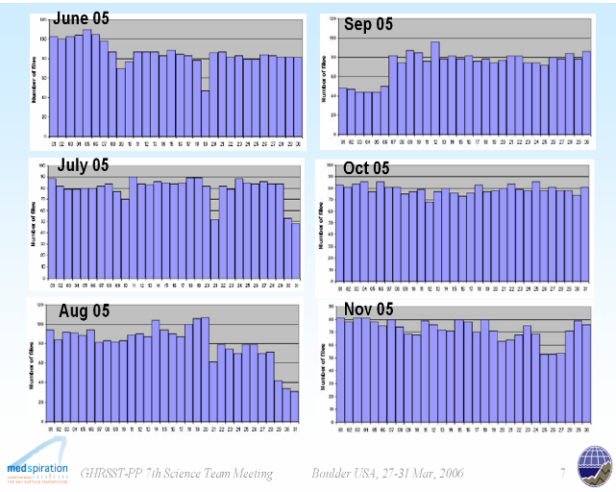
3.2.4 Europe: Medspiration Ian Robinson, Jean-Francois Piollé & Pierre Le Borgne

Robinson presented a brief overview of the Medspiration EURDAC activities between 3/05-3/06 which included the initial service development (following a project start in Jan 2004). A beta test of service was established running 1-28 Feb 2005 and concluding with an Acceptance Review (AR) that was passed in March 2005. Medspiration phase 2 then commenced 1st June 2005 (although L2P data archived from 1st Feb 05) and focussed on the Operational production of L2P products for all SST products over the EURDAC region. In addition, L4 UHR (SSTfnd) products for Mediterranean Sea were developed and served, MDB entries matching all L2P products provided and HR-DDS entries matching all L2P and L4 products generated. A full report provided to the Science Team presents summary production statistics for 6 months June to November 05. Operational reports are produced monthly by Jean-Francois Piollé. From the user perspective, configuration changes are noted under "news" on front page of Medspiration website (http://www.medspiration.org/news/) and a production status message log published on the web site under tools/system status (http://www.medspiration.org/tools/status.html).

Key user developments within the Medspiration project include a user consultation meeting Dec 2005 that reported:

- Medspiration / GHRSST has had a significant impact on the preparation of Global Monitoring for Environment and Security (GMES) 'Sentinel' Satellite mission plans and in particular, the specification of a follow on radiometer to the successful ENVISAT AATSR.
- A high-latitude Nordic L4 product development based on Medspiration / GHRSST
- MERSEA: a European Operational Oceanography project that has provided the main user collaboration for optimal configuration of the Medspiration L4 processor
- IFREMER developments of a global L4 product based on GHRSST / Medspiration
- MARCOAST:ESA will transfer a MarCoast W/P to Medspiration providing a new L4 analysis of the Atlantic coast of France
- GlobCOLOUR: a new ESA project to develop a service for ocean colour data products in a similar way to GHRSST-PP for SST
- Met Office OSTIA system a new global L4 analysis product produced in a test mode since summer 2005 based on data from Medspiration via GDAC. This system is also using the HR-DDS for the analysis development process

Production statistics (Figure 3.2.4.1) were presented that showed the impressive reliability of the Medspiration service and the large volume of data (in terms of both files and total size).



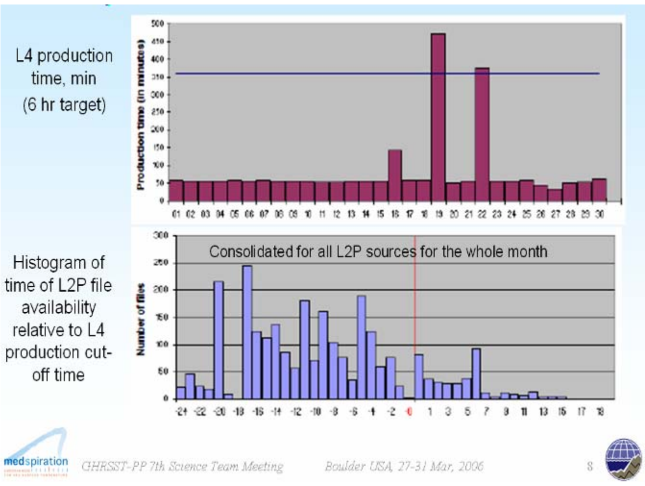


Figure 3.2.4.1 (a) Number of Medspiration L2P files per acquisition day (100% is perfect, values greater than 100% indicate data provided in a delayed mode.

Figure 3.2.4.1 (b) Example L4 (Med Sea) production statistics for June 2005

Following the user consultation, ESA also approved the development of a simple interface to the MDB to assist GHRSST in generating the SSES, retiming of the L4 production to allow more data into the analysis and requested improved publicity of the L4 products e.g., use of Google Earth as shown in Figure 3.2.4.2.

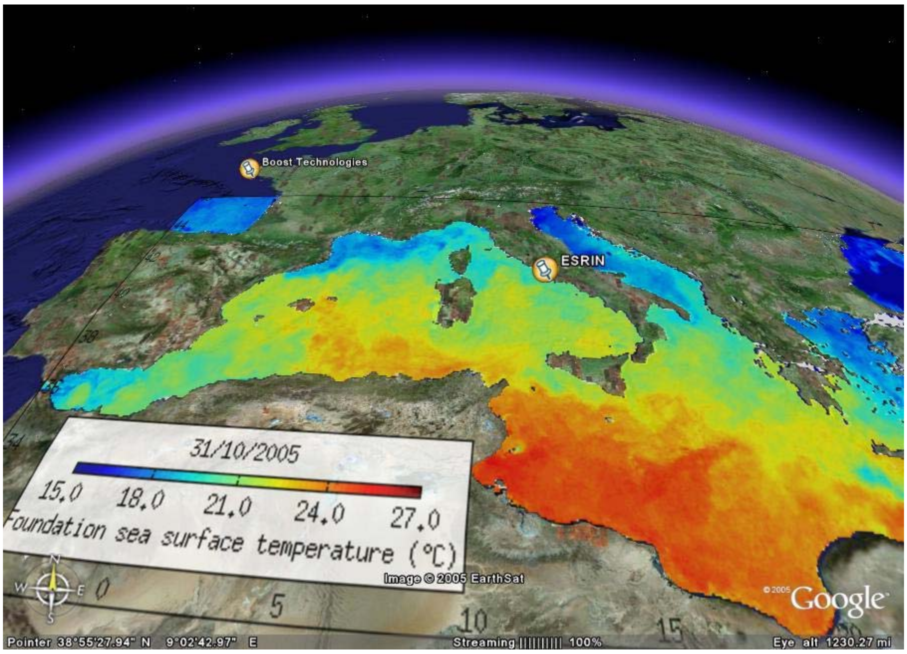


Figure 3.2.4.2 ESA Medspiration L4 outputs over the Mediterranean sea viewed by the Google Earth interface (Boost Technologies)

Robinson noted that the steady development of users to develop new analysis products is an encouraging metric and would not likely have happened without the GHRSST-PP. Ian Barton raised a concern of why GHRSST-PP is now producing so many L4 products -are they that different? And shouldn't GHRSST-PP have just one analysis? Robinson replied that it is not for the GHRSST-PP Science Team to tell users how to do their job rather, a 'horses for courses' approach should be fostered to empower diverse user applications. The GHRSST-PO Director noted that one approach is for GHRSST-PP to provide a poor mans ensemble (PME) approach that would be an extremely useful quality control/verification experiment in its own right including the specification of some uncertainty (based on the agreement between different analysis systems). Dick Reynolds was keen to point out that GHRSST-PP should provide guidance to the users rather than endorse a single L4 analysis which will be different each day depending on what data a system has available. The Science Team agreed to further explore the use of PME techniques using L4 analysis outputs.

Based on the success of the Medspiration service, a new service development phase (June 2006-June 2007) has been negotiated with ESA based on user feedback as part of the Medspiration user consolation process. Questionnaires were prepared together with the GHRSST-PO and sent out to key users. Responses were generally positive about products and it was recognised that key users look globally and use GDAC services for data searches. This is both a blessing and a curse as the Medspiration service needs to know who is using the data through the GDAC in order to (a) remain in contact with the user community and (b) report the growing user take up of Medspiration data (viewed as the major measure of success by ESA). Without direct connection to the user community it is challenging to do either of these things and Robinson requested that the GDAC service take steps to help Medspiration in this respect. It was clear that users like netCDF (especially those who were forced to switch!) and find that much more can be done with L2P files following discussions with the Medspiration team. The main user issues include (in order of priority):

- Users want continuity of L2P service – not science and development (e.g., DV).
- Users need clear warning of significant changes to data characteristics well in advance of changes requiring a planned change control program

- Many users are pleased to have the SSES and are trying to use these data (But are we giving them the best SSES for each sensor?)
- Some users want wider L4 coverage than just the Mediterranean Sea
- Many other detailed specific points were made which are reported in the Medspiration written report to GHRSST-PP available form the GHRSST-PP web site.

The service development focus is to extend the service delivery by 17 months to June 07 by diverting resources from L4 development and optimisation which is now essentially carried out by the Mersea Project and other agencies also developing L4 products. Some minor software and configuration changes will be necessary to extend L2P NAR products to cover the full NAR area and to extend L4-UHR domain to the Mediterranean Forecast system (MFS) further west limit and include the Black Sea. In addition, Medspiration will switch climatology reference to use US Navy FNMOC analysis and extend the AATSR L2P to global coverage with matching global coverage for MDB and HR-DDS entries. Finally, the possibility of converting archived ATSR and ATSR-2 to L2P format is being explored by ESA and UK Agencies including the Department for the Environment and Rural Affairs (DEFRA) who own the AATSR instrument.

Robinson then focussed on the long term vision for the EU RDAC currently operated by Medspiration that will end in mid 2007/early 2008. In principle the EuRDAC function should become the responsibility of the European Commission Marine Core Service (MCS) of GMES which will build on Medspiration (which is just a development and demonstration project). The software for the GHRSST processing for L2P, L4, MDB and HR-DDS is now in place and a number of people and institutions are now experienced. The challenge is to find the best route to sustain the service. For success, the take-up of GHRSST products and its approach is crucial and any new service must consider

- operational users already benefiting from GHRSST data,
- the reality that good SST data needs international collaboration
- that the GDAC offers the credible global SST service that gives confidence to operational forecasters (of ocean and weather)

Both ESA and EUMETSAT seem ready to take up the responsibility for their satellites and production of GHRSST-PP L2P but they need the international credibility and authority of the GHRSST-PP Science Team to help maintain international consensus and shared operatins.

In conclusion, Robinson noted that in Europe we now have a clear demonstration service embodying the vision of the early GHRSST meetings that is teaching us:
- The importance of getting users on board
- The necessity of responding to user needs
- The need to provide useful and credible SSES.
- Inter-comparability is greatly facilitated by GHRSST
- It compares different SST sensors, systems and products
- This is something to welcome – not fear. Users like it.
- GHRSST is not about competition between different SST sensors
- It reinforces the complementarity of different sensors and the value of diverse national contributions
- We need each other. We need what GHRSST is doing

3.2.5 Report from the Australian Regional Data Assembly Centre, Helen Beggs

The Australian Government, through the Australian Bureau of Meteorology, Royal Australian Navy and CSIRO has initiated BLUElink> Ocean forecasting Australia, a $15m 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 hind- and now-cast surface and subsurface fields. The BLUElink> project commenced in 2003 and will run until 2006, although continuation is expected subject to funding.

The main BLUElink> contribution to the GHRSST-PP will be through an Australian RDAC system based at the Australian Bureau of Meteorology delivering LAC AVHRR SST L2P and DDS files for the region 20°N – 65°S, 50°E - 160°W (Rea, 2004) and L4 files from a new 1/12° resolution regional SST analysis based on a modified version of the Bureau's operational SST analysis system (Smith et al., 1999). The current Bureau system provides a 1° weekly global SST analysis and 0.25° daily regional SST analysis based on a univariate statistical (optimal) interpolation system (see http://www.bom.gov.au/bmrc/ocean/results/climocan.htm#SST%20anals). The Bureau's current and archived operational SST analysis maps may be found at http://www.bom.gov.au/marine/sst.shtml.

Ian Barton's team at CSIRO Marine and Atmospheric Research will contribute MDB records of in situ temperature data from the Rottnest Island and Fantasea (Whitsunday Island to Hook Reef) ferries off the coast of Australia.

AVHRR L2P and DDS

In collaboration with Ian Barton's team at CSIRO Marine and Atmospheric Research, the Bureau will contribute L2P and DDS data sets of LAC AVHRR 'bulk' SSTs before the end of 2006. Each DDS will contain LAC 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.

In September 2005 the Bureau successfully ingested AVHRR data into CAPS (Common AVHRR Processing System developed by CSIRO with Bureau 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. Intercomparison with SSTs derived in other ways is about to commence. It is planned to use CAPS to produce the netCDF format SST data required for a Bureau AVHRR L2P data product for GHRSST-PP. In addition to the LAC 1.1 km AVHRR SST(1m) 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 Bureau's LAPS NWP model. The Bureau currently has no real-time source of aerosol optical depth.

GASP and LAPS NWP Winds

The Australian Bureau of Meteorology currently runs two NWP model systems operationally. These are LAPS (Limited Area Prediction System, Puri et al. 1998) at 0.375° resolution, and GASP (Global Assimilation and Prediction System, Seaman et al. 1995) at 0.75° unthinned resolution. The GASP analyses give 6 hourly averaged 10 m winds while the GASP forecast winds are 3 hourly averaged. The LAPS forecasts give hourly instantaneous surface winds. Both GASP and LAPS output netCDF files are available from the Bureau to registered users.
LAPS forecast 10 m winds are used in the current test BLUElink SST analysis system for cool skin correction and removing suspected diurnal warming events. Eric Schulz (Bureau of Meteorology) has compared two years of LAPS and GASP forecast and analysis surface winds with QuikScat satellite winds and found that LAPS wind speeds underestimate by about 5% and GASP winds speeds underestimate by 5 to 10% (see http://www.bom.gov.au/bmrc/ocean/staff/ezs/Flux_verification/index.html). For the next phase of the BLUElink Project, Eric hopes to validate all GASP/LAPS NWP fluxes (sensible, latent, solar radiation) and rainfall using moored buoys, primarily the TAO/TRITON array.

High Resolution Regional SST Analyses

As part of the BLUElink> project, the Australian Bureau of Meteorology, in collaboration with CSIRO Marine Research, is developing a new version of the Bureau's operational SST analysis system to produce a real-time high resolution SST analysis combining SST data from polar-orbiting and geostationary satellites with in situ measurements (see http://www.bom.gov.au/bmrc/ocean/BLUElink/SST_external.html). The system will cover the Australian region (20°N - 70°S, 60°E - 170°W) and will blend all data sources into SST(1m) and SST(foundation) estimates and output daily SST analyses at 1/12° resolution within 6 hours of data reception. In consultation with CSIRO Marine Research, BLUELink> plans to produce and use High Resolution Diagnostic Data Sets (HR-DDS) and in situ observations from ships and buoys as a routine validation source. The BLUElink> High Resolution SST Analysis System aims to be operational by the end of 2006.

The new analysis system is currently in initial test phase. Since 6 March 2006, daily 1/12° resolution SST(1m) and SST(foundation) analyses have been produced routinely in near real-time from blending the Bureau's 1.1 km AVHRR bulk SST data stream (currently from NOAA-15 and NOAA-17, but shortly also from NOAA-18) with NESDIS global 9 km AVHRR bulk SST data (NOAA-15,-17 and –18), 0.17° AATSR skin SST (converted to sub-skin SST using the Donlon et al. (2002) cool-skin correction), 25 km AMSR-E v5 L2P sub-skin SSTs and in situ bulk SSTs from the GTS. The analysis runs daily at 0100 UT and again at 2030 UT in order to include any extra AMSR-E L2P data files for the previous day that have become available since last FTP'd at 0045 UT. The SST analysis performed at 2030 UT is then used as the background field for the following day's analysis at 0100 UT. The 2030 UT blended analysis has excellent data coverage over the study region.

The current method used for blending the SST data streams to produce a foundation SST analysis over the Australian region is given in Figure 3.2.5.1. In order to produce a foundation SST estimate, the L2P AMSR-E sub-skin SSTs are converted to foundation temperatures using the modeled ΔT values in the AMSR-E L2P files. The LAC (averaged over ~ 8 km x 8km) and global 9 km AVHRR 'bulk' SSTs are converted to foundation temperatures by removing data records suspected to be affected by diurnal warming. That is, all SSTs that are measured between sunrise and solar midnight at winds < 6 m/s (using the LAPS hourly forecast, instantaneous surface winds).

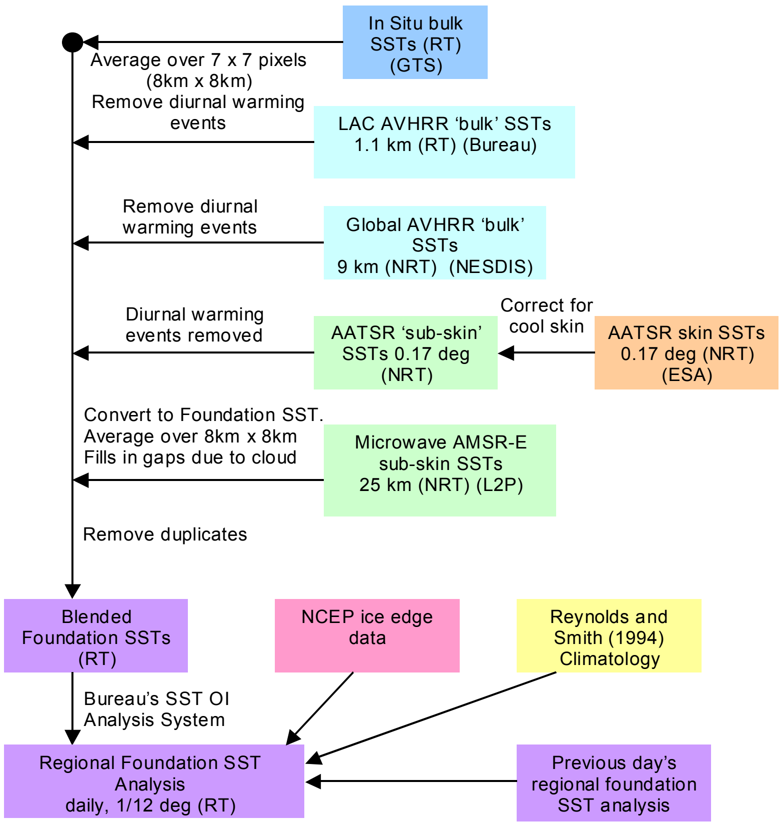


Figure 3.2.5.1 Current blending method for the new BLUElink> Real-Time High Resolution SST Analysis System

The Bureau's OI system (SIANAL) requires all input observations to have zero relative bias. In order to achieve this, the AATSR Meteo 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. AVHRR 'bulk' SST data is not currently debiased prior to analysis however biases are small compared with debiased AATSR and AMSR-E sub-skin SSTs. A comparison of daily (day and night) match-ups of satellite SST data for the period 1-31 Dec 2005 (where data was "collocated" if within one hour and same satellite footprint) yielded the following results:

- 9 km NOAA-18 AVHRR bulk SST minus 25 km debiased L2P AMSR-E sub-skin SST (gridded 0.1°) = 0.04°C ± 0.09°C
- Debiased 10' AATSR sub-skin SST minus 1 km NOAA-17 AVHRR bulk SST (gridded 0.17°) = 0.00°C ± 0.14°C
- 9 km NOAA-17 SST minus 1 km NOAA-17 AVHRR bulk SST (gridded 0.1°) = 0.05°C ± 0.06°C

The aim of the BLUElink> regional high resolution SST analysis system is to resolve SST features at ~10 km over the LAPS model domain, and therefore to be compatible with the GHRSST-PP standard global L4 analyses an analysis grid of 1/12° (~9 km) has been chosen, with a background correlation length scale of 15 km and an observation correlation length scale of 8 km. The background correlation length scale effectively gives the radius of influence of an observation to changes in the background field (the previous day's analysis). Any feature smaller than the observation correlation length scale in extent will be treated by the OI analysis as noise and observations separated by less than the correlation length scale will not have independent errors. The RMS observation 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 RMS error (calculated using matches with in situ SST data over the analysis region) and representativeness RMS errors (both spatial and temporal). The representativeness errors must be estimated over at least the observation correlation length scale. For the current test 1/12° analysis system, spatial representativeness RMS error has been estimated for each satellite data stream, by calculating the mean RMS variation of the Bureau's LAC 1.1 km NOAA-17 AVHRR SST data over 8 km, 0.17° and 25 km pixels during December 2005 and January 2006. The average RMS variation was $0.18 \pm 0.03^\circ$C, $0.29 \pm 0.04^\circ$C and $0.34 \pm 0.04^\circ$C, respectively.

L4 Analysis Files

All SST analysis products used as inputs to the BLUElink> ocean forecast model are required to be in netCDF format and CF compliant. We have chosen to follow the GHRSST-PP GDS v1.7 L4 format as closely as possible for the new BLUElink> regional SST analysis products and legacy Bureau operational SST analyses. The proposed Bureau L4 file formats are described in Appendix V. Eventually, all Bureau operational SST analyses (global and regional) will use L2P SST files as inputs and be output as L4 foundation SST files, but for now it is necessary to continue to produce global and regional SST(1m) analyses (AUST-L4LR1m-GLOB, AUST-L4LR1m-AUS and AUST-L41m-AUS) in addition to the new regional 1/12° resolution foundation SST analyses (AUST-L4fnd-AUS).

For L4 files to be more CF-compliant the BLUElink> Project recommends that GHRSST-PP add standard names and a definition of cell boundaries to the CDL description. The GHRSST-PP could register new standard names (such as "sea_surface_temperature_skin", "sea_surface_temperature_subskin", "sea_surface_temperature_depth" and "sea_surface_temperature_foundation") for the CF convention. A discussion on the L4 format commenced that noted the clear need for the content and specification of L4 and any changes to that format need to be CF-1.0 compliant. For example, in the current netCDF specification, the allocation for the variable time will be out of bounds by 2049. Ideally, GHRSST-PP should change to hours or days for a data file/ analysis output. This would also allow third party software that can use more traditional date-time strings in the netCDF file to function more effectively with GHRSST-PP data files. Furthermore, CF-standard names need to be registered for GHRST-PP e.g., sea _water_temperature at a defined depth, flag_values and flag_meanings to describe flags. It was agreed that the DM-TAG will look at this particular issue.

Future Plans for BLUElink> HR SST Products (2007-2010)

Subject to a continuation of BLUElink> funding from the Royal Australian Navy, a technique will be developed for identifying SST estimates that are affected by diurnal warming events. The technique will allow modification of these satellite data for incorporation into blended 6-hourly SST analyses at selected depths. The technique will also allow for the identification of possible diurnal warming events in cloudy regions.

The Bureau will produce the following new operational, real-time, SST products based on the daily, regional, 1/12° resolution SST analyses produced for BLUElink> Phase 1:

- Six-hourly, regional, blended SST analyses, at 0.05° spatial resolution (L4 format)
- Daily, global, blended SST analyses at around 20 km spatial resolution (L4 format)
- Six-hourly, regional, blended L2 satellite SSTs converted to a common depth (netCDF format)
- Daily, global, blended L2 satellite SSTs converted to a common depth (netCDF format)

Note that the above SST products will be provided at a range of depths as required by the various operational systems at the Bureau from skin (~10 μm) to foundation (below the diurnal warm layer).

To provide 6-hourly SST analyses at common depths it will be necessary to identify satellite SST estimates that are affected by diurnal heating. This heating, in cloud-free areas, will be detected using the 5 km resolution, hourly SST data from geostationary satellites MTSAT-1R and/or FY-2C. Wind and heat flux estimates will assist in the detection and mitigation of these heating events. This will in turn allow for the reliable production of 6-hourly SST fields at common depths. The same techniques will use the NWP winds and heat fluxes, and microwave AMSR-E SSTs, to warn of diurnal heating events in cloudy areas.

In order to produce skin SST analyses in addition to the foundation SST analyses developed for BLUElink-I, the Bureau will develop local SST coefficients for AVHRR, MTSAT-1R and possibly FY-2C, by regressing brightness temperatures from these infrared radiometers against SSTs obtained from Envisat's AATSR radiometer (see http://www.bom.gov.au/bmrc/ocean/BLUElink/SST/GMS22_7-B5_SST_final.doc).

The Bureau will produce real-time, daily, global, SST OI analyses at around 20 km spatial resolution and various depths as required, 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 high-resolution GHRSST-PP L4 global SST analyses will be compared with the Bureau's high-resolution regional and global SST analyses. The proposed method for producing regional skin and foundation SST analyses and a global foundation SST analysis is presented in Figure 3.2.5.2.

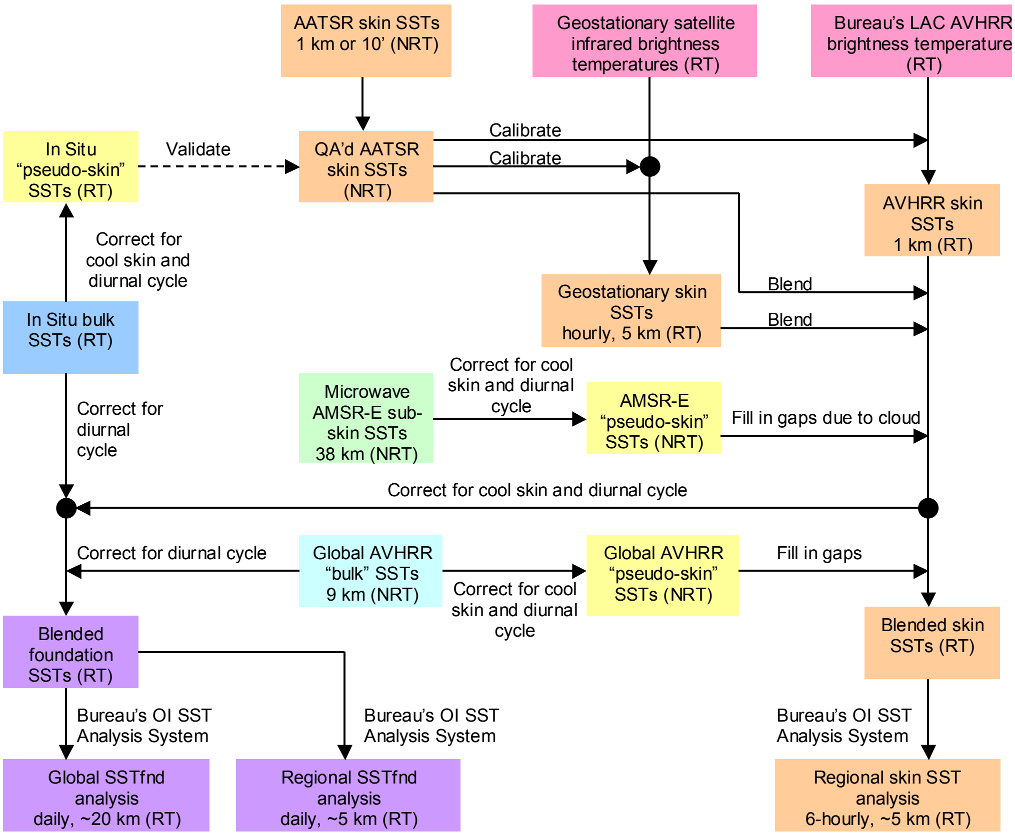


Figure 3.2.5.2. Proposed blending method for the next phase of the BLUElink> Real-Time High Resolution SST Analysis System

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3.2.6 USA Status of the JPL GDAC facility, Ed Armstrong, Andrew Bingham, Jorge Vasquez, Sue Heinz, Alex Cervantes, Qui Chau, Tim McKnight

Armstrong began with an overview of the NASA JPL GDAC tasks which include:

- Ingest project data files including L2P, L4, HRDDS, MMR files from RDACs
- Stage on public FTP site for 40 days
- Deliver to long-term archive (NODC) after 30 days
- Provide a variety data access methods
- Ingest metadata into MMR database
- Provide web-base interface for querying database and data discovery
- Develop system for ancillary L2P population, MODIS L2P
- Support USO and applications development

Since May 2005 the GDAC team has worked steadily to develop a prototype system that builds on existing capability at the PO.DAAC for the GHRSST-PP. Several new datasets have been brought on-line (including NAVO AVHRR 18 GAC and LAC), and ingesting global AATSR since December 2005. OPenDAP systems provide access to L2P/L4 accessible via JPL server: http://dods.jpl.nasa.gov. IDL and C L2P software readers have been developed that are capable of reading entire L2P structures that can be used to test the integrity of L2P format data. The GDAC teams have also assisted RDACs with rectifying L2P/L4/MMR format and file-naming convention anomalies. Armstrong was keen to encourage the use of these software utilities to test the integrity of L2P data sets as many rrrors to the data types are being found – teams seem to be putting any fields into the data streams which cause data sets to be rejected from the GDAC. An ACTION was raised to ask the RDAC groups to check the format and integrity of all L2P data files.

Data access is via ftp at ftp://podaac.jpl.nasa.gov/GHRSST where data are organized by datatype / sensor / RDAC / year / DOY. OPenDAP access is at dods.jpl.nasa.gov and any problems can be reported to ghrsst@podaac.jpl.nasa.gov

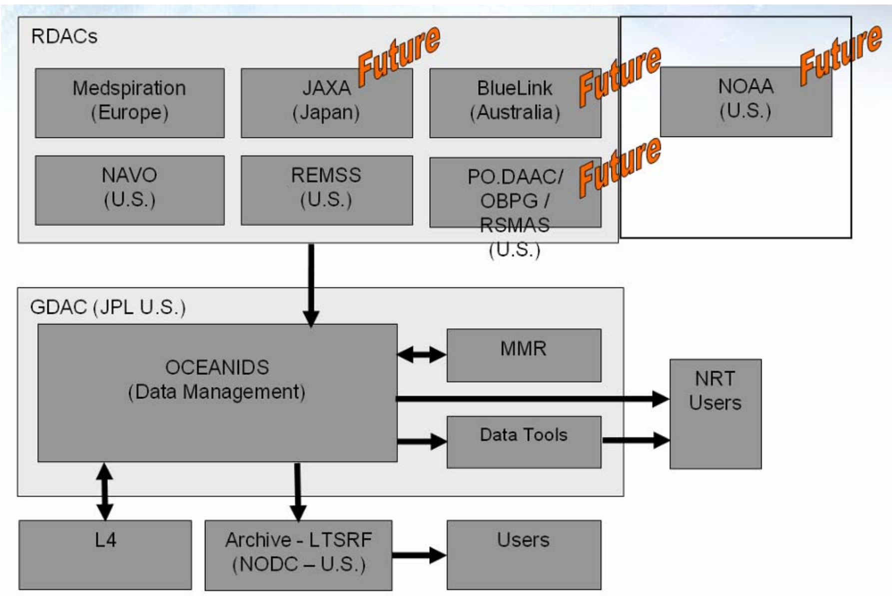


Figure 3.2.6.1 Main elements of the GHRSST-PP JPL GDAC System Architecture

A new interface to the NODC LTSRF is now complete with full FGDC metadata creation at the granule level via the MMR database and the LTSRF retrieving GHRSST data products and metadata 30 days and older. GDAC will soon begin to expire data from FTP site as new GHRSST data streams come online and refer users to the LTSRF for data access.

The GHRST-PP Master Metadata Repository (MMR) system is now fully operational with over 100K records ingested and a completely revised search interface MMR (Master Metadata Repository). NAVO FR and DSD records have been added and a full operational redundant backup and error recovery system has been put in place.

Armstrong noted that GDS v1.7 must include metadata changes that are critical and in addition, the GHRSST-PP needs to look at netCDF 4.0 as this may have lots of advantages including chunking. File compression in Bzip2.0 has really helped the project as it has kept volumes to a minimum -the GDAC disk arrays would now be full if we had used gzip – clearly the choice to use Bzip2.0 was the right decision.

A major investment and successful development to implement ancillary L2P field filling has been successfully completed so that wind, sea ice, aerosol and solar irradiance model data (ECMWF, FNMOC, aerosol etc.) can be appended to L2Pcore data sets using a nearest neighbor approach. Armstrong reminded RDAC not to include empty L2P fields into the file. A small Linux cluster for GDAC operational support has been installed and MODIS L2P ancillary field completion has been initiated in collaboration with the NASA Ocean Biology Processing group and Univ. of Miami RSMAS. The L2 datastream from OPBG is already being acquired at GDAC and tests for L2P provision are now in progress. GDAC Application User Services (AUS) supporting applications development (with S. Heinz) is now actively addressing user inquiries. Data Volumes ingested by the GDA continue to grow (Figure 3.2.6.2).

Month	Granules ingested	Volume (GB)	Unique streams
2005			
5	4055	1.77	17
6	5986	5.55	17
7	5820	5.47	18
8	5355	6.12	11
9	14747	6.86	11
10	6282	6.24	33
11	5759	15.38	21
12	13190	214.16	21
2006			
1	30866	200.27	32
2	13428	194.52	26
3	8539	154.63	26

Figure 3.2.6.2 Data ingest statistics for the GHRSST-PP JPL GDAC System

The GDAC has a considerable future work load to consider including full operationalisation of ancillary L2P fill, L4 delivery from the POET system, L2P via POET implemented with L2 sub-setting, verification of accurate L2 searches via MMR, user subscription services, new data streams and products including Bluelink, JAXA, Met Office OSTIA and MODIS L2P. The latter require operational HDF to netCDF conversion, production and verification of a MODIS SSES hypercube system including appropriate proximity_confidence flag implementation. Several issues remain including REMSS AMSRE & TMI availability, access of products from LTSRF, GDS v1r1.7 completion and the impact of netCDF 4 on GDAC operations. These issues will be considered in the coming 12 months.

3.2.7 Report from the Data Management Technical Advisory Group (DM-TAG) Jorge Vazquez, Edward Armstrong and all other members of the DM-TAG

Vazquez began by reporting the main accomplishments of the GHRSST-PP Data Management

Technical Advisory Group. These included:

- US GHRSST Meeting in Miami November 24, 2006 during which updates were given by all US components of GHRSST including MISST, NAVOCEANO, GDAC, LTSRF (NODC/NOAA)
- Discussion of issues with respect to implementation of netcdf4 (discussion led by Jean-Francois Piolle). The stability of GHRSST-PP data sets is important and while netCDF 4.0 is the future GHRSST-PP must be careful not to present a dynamic format system: users have to get accustomed to data and services over time.
- Review and development of the report on the implementation of L2P and L4 data sets prepared by BlueLink (see Appendix V)
- Review and development of appropriate solutions to add missing Ancillary fields to L2Pcore data by the GDAC at JPL.
- Review and development t of plans for incorporation of MODIS SST into GHRSST including a viable schedule to have MODIS L2P data available for use by Fall of 2006.
- Consideration of how to provide full implementation of ancillary fields for all L2P data
- A discussion on 4km versus 1km MODIS L2P – concluded in 4km data recommended by the Sciwence Team but 1km implementation by NASA. The hope is that L2P sub-setting may solve the problem of data volumes (but not for global users)
- Discussion, as proposed by John Stark, of standardized coordinate systems for L4 merged products(i.e., is the GHRSST-PP indexing convention north->south or south -> north?)
- A re-distribution of High Resolution Diagnostic Data Set locations and within the GDAC system (move to NOC, Southampton, United Kingdom).
- Efficient near real time on demand sub-setting of L2P DATA is underway implemented through the POET tool web interface. Orbit models for different sensors will be applied to sensors to efficiently subset L2P data in near real time. The DM-TAG consider on-demand sub-setting of L2P data (e.g., AATSR and MODIS 1km data) a critical activity to help users

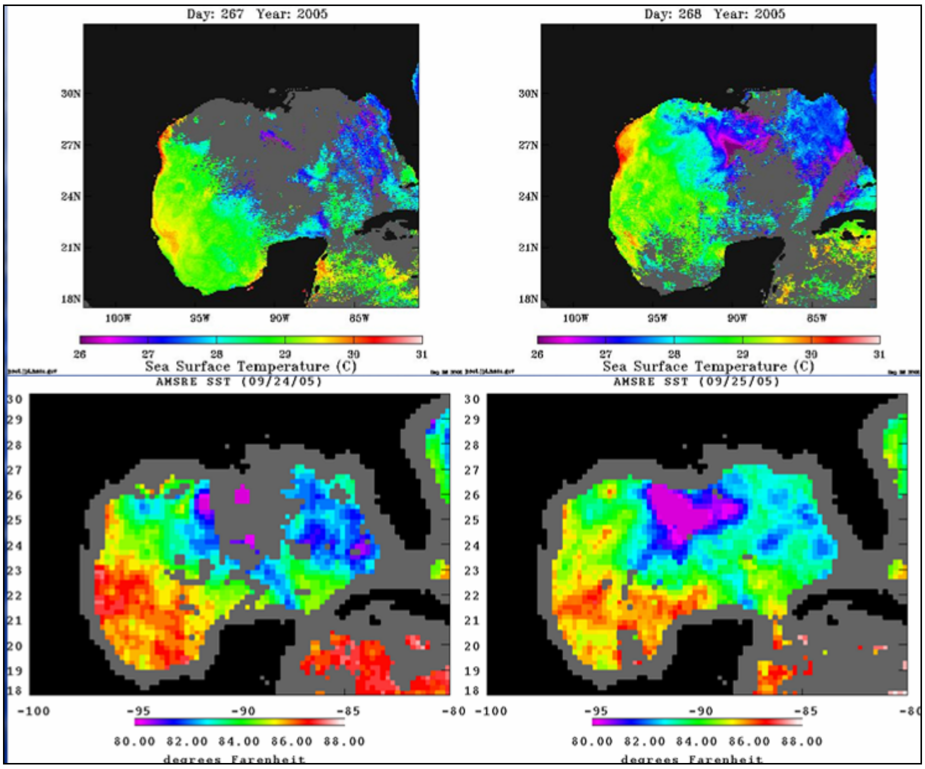


Figure 3.2.7.1 Example GOES and AMSRE SST data following Hurricane Rita with different temperature scales applied (Centigrade and Fahrenheit respectively).

Vazquez concluded that the DM-TAG has been very active and has successfully resolved many data management issues. However, in the wider perspective, the GHRSST-PP must also consider a broad set of data management issues related to the Science Perspective: What are the products that need to be developed and add value to ocean science? What are the formats required and user interfaces? Also, how do operational SST's make a difference - where is the impact on Society and how does the GHRSST-PP capture user feedback into useful data structures and systems? These are not mutually exclusive and the example of hurricane rita was given where users in the USA wanted to access SST data from GOES and AMSR-E formatted as degrees Fahrenheit rather than Kelvin or Centigrade

(Figure 3.2.7.1). The GHRSST-PP DM-TAG and Science Team must consider how to provide the best interface to a non-standard user community.

3.2.8 Report from the GHRSST-PP Reanalysis Technical Advisory Group (RAN-TAG), K Casey

Casey reported that steady progress had been made by the RAN-TAG over the past 12 months and the RAN Implementation Plan v1 has been approved in 06 Sep 2005. However, work had mostly focussed on stewardship of GHRSST-PP data sets and collaboration with the GCOS SST and SI working group. A new web presence established but not populated at http://ghrsst.nodc.noaa.gov (Figure 3.2.8.1)

The present RAN-TAG group was relatively stable (Jo Murray is retiring) and has excellent connections to the re-analysis community which greatly facilitates interactions to establish a good user requirement of what is required from the GHRSST-PP reanalysis project. The RAN-TAG has promoted GHRSST-PP reanalysis at many international meetings including:

- NOAA CoastWatch (Monterey, Oct 2005)
- MARCDAT-II (Exeter, Oct 2005)
- GCOS/SST-SI (Exeter, Oct 2005)
- NOAA - GHRSST (Silver Spring, Nov 2005) Special presentations of the GHRSST-PP to a NOAA wide audience solicited very interesting comments and the GHRSST-PP can help to re-organise part of the NOAA SST effort internally.
- US - GHRSST (Miami, Nov 2005)
- NOAA NPOESS Data Exploitation Team (Suitland, Jan 2006) The NOAA NPOESS exploitation team is trying to get GHRSST-PP L2P from NPP and NPOES
- 2006 AGU/TOS/ASLO Ocean Sciences (Honolulu, Feb 2006) where a special session on Climate Data Records was convened including 2 oral and 1 poster session.
- MISST (Boulder, Mar 2006)

In addition Casey noted that the CLIVAR project has requested an article on GHRSST-PP for the CLIVAR Variations publication and further progress and recognition has been achieved as the GHRSST-PP RAN-TAG has been asked to provide a chapter to the NOAA Office of Climate Observations Annual Report on the oceans.

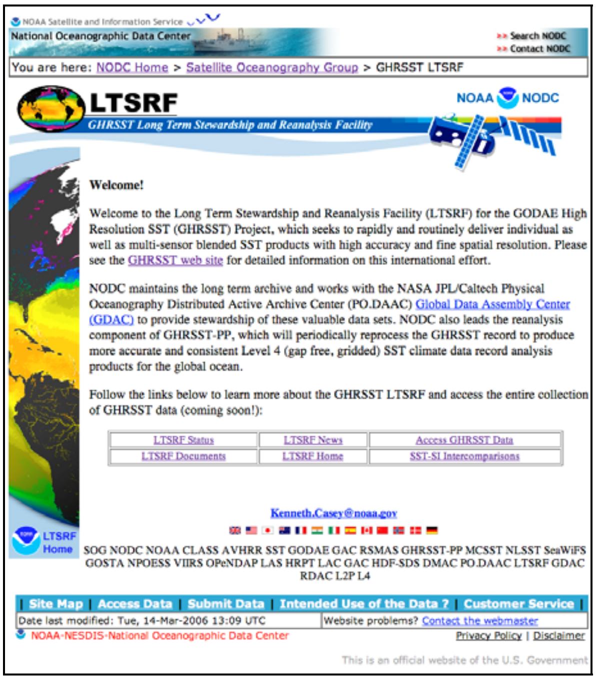


Figure 3.2.8.1 The new GHRSST-PP LTSRF web presence developed at NODC

The GHRSST-PP Long-Term Stewardship And Reanalysis Facility (LTSRF) providing Archive/stewardship capability has been established at NODC. Data are automatically acquired daily from GDAC with a 30-day delay to archive. Automated accessioning (internal mechanism for stewardship at NODC) is now ready for deployment with Open Archive Information System (OAIS) Reference Model compatibility. The initial focus has been on L2P and L4 (and some HR-DDS but not yet resolved) where all data received to date are now online (ftp, http, OPeNDAP). Current Holdings include:

- Data 2004 day 354 (EUR AMSRE) to Today-30 days
- 3088 accessions (RDAC/Sensor/Level/Date) as of 20 March
- Approximately 1.2 TB of data (uncompressed)
- But only the EUR and REMSS RDACs to date – hopefully more RDAC data soon. Holdings go back to day 354 in 2004 .

A Compression/Decompression analyses has been performned within the RAN-TAG to investigate the best possible solution to archiving and compression using Bzip2.0 and gzip. Overall bzip2 compression ratio is 20:1 (AATSR has astonishing 42:1!) whereas the overall gzip compression ratio is 9:1. However these figures must be considered together with the compression times as bzip2 takes 2.4 times longer to decompress than gzip. Full details of the inter-comparison are reported at at http://ghrsst.nodc.noaa.gov/documents.

A GHRSST RAN/GCOS SST-SI Inter-comparison web site has also been created and datasets are being collected as weekly 1º and monthly 5º grids from a variety of sources. This marks the beginning of a GCOS SST/SI inter-comparison experiment with the aim of 200 year inter-comparisons (beyond the scope of GHRSST-PP) that will help understand how to develop appropriate satellite SST CDRs that are homogeneous with the long term climate data record. The plan is to build up from coarse to high resolution data sets.

Casey then reviewed the main requirements for the GHRST-PP Reanalysis effort (a RANual Review). The main requirements are:

- Create delayed mode L4fnd products with higher accuracy and consistency - CDRs
- Link to longer term climate records
- Enable a sustained reprocessing capability
- Spatial: Follow real-time L4 grid ~ 9 km (higher only if feasible)
- Temporal: Once per day
- Types: L4 SSTfnd (plus 4 diurnal offsets)
- Error Stats: Bias and Standard Deviation at each output grid point
- Data Format: netCDF with CF metadata
- Establish reanalysis in late 2006-2007 (Ensemble approach, RAN “branded”?)
- Long-term - sustained effort
- Distributed architecture
- Backward looking (perhaps to TRMM) only if demonstrated first on GHRSST period (2005-)

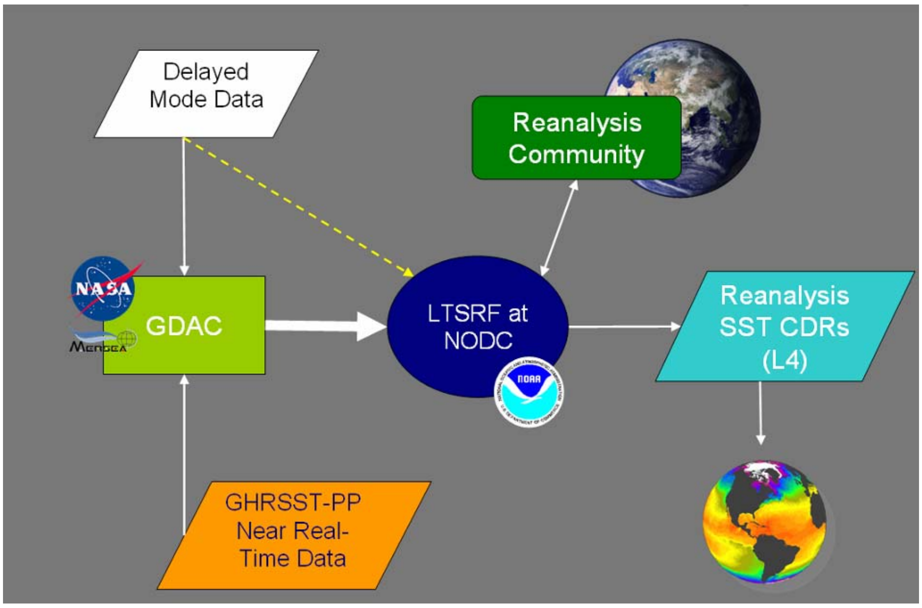


Figure 3.2.8.2: Basic configuration of the GHRSST-PP Long Term Stewardship and Reanalysis Facility (RAN Project).

Casey explained that the basic RAN system is now in place (Figure 3.2.8.2) for the stewardship (including operational delivery of data from the GDAC) and the emphasis will shortly shift to preparing a suitable framework for reanalysis processing activities. These will almost certainly be distributed in practice due to security issues at NODC for teams wishing to access computing facilities remotely. However, this was not foreseen as a major problem for the RAN-TAG.

One particular issue raised was the need to understand the likely data volumes and rates for the coming 12 month (and longer period) in order for NODC to prepare properly. Ideally, the LTSRF should be looking at rates 3 years from now and associated computing power to retrieve and if

possible, analyse these data. In addition, how will other long term archives (e.g., the (A)ATSR reference data set) be made available for the RAN activities? Casey was keen to have teams prepare letters of support for the RAN efforts at national level in order to help justify the systems being put in place at the NODC (user requirements).
Finally Casey noted that there was a dedicated session to consider these issues and more later on in the meeting and encouraged the Science team to discuss reanalysis and stewardship issues before this in order to have a useful discussion.

3.2.9 Report from the Data Processing Specification Technical Advisory Group (GDS-TAG): Gary Wick

Wick began by reviewing where the Science Team left off the extensive discussion of the GDS before and during the Exeter meeting. The main result to the relief of all was a consensus that the concept of L2P core fields was adopted providing a mechanism for RDAC's other than Medpiration to develop a more streamlined approach to the GHRSST-PP. Now that the JPL GDAC has stepped up to provide a means to generate full L2P data streams the discussions have stabilized and a relatively quiet intersession period has passed. As a consequence of the GDAC L2Pcore combination, only relatively minor other changes have been proposed to the GDS for version 1.7. However, the decision to delay the preparation and adoption of a version 2 (with more substantial changes) until additional user input has been received appears to be a sensible way forward.

The GDS-TAG and the GHRSST-PO have been working on formalization of GDS V1.7 which is a substantial effort due to the large and unwieldy size of the GDS document itself. Specialised editors are required to lead the issues and volunteers were requested to contact Gary Wick or the GHRSST-PO. The GDS could be further subdivided into obvious sections with associated responsibilities to aid its application and management. We need to do this for the sake of the users.Pdf files or html files provide two options here as both allow hyperlinks. It was agreed that the GHRST-PO would explore these options. It was agreed that an FAQ should be developed using a nice clean set of data to demonstrate how the GDS is used from a practical position.

Hard copies of the draft GDS v1.7 have been circulated for comment and issues will be discussed at this meeting. However, it was agreed that additional user input should be obtained from RDAC teams especially regarding Single Sensor Error Statistics. How do we do this for the proximity confidence field which is a big priority for the GHRSST-PP? More work is required to explore existing methods and experiences and to try and ensure compatibility of definitions. Regarding Level 4 analyses outstanding issues regarding the format and inclusion of diurnal warming and other components need to be resolved (use of experimental fields was agreed in Exeter but how will these transition to core fields?). Finally, there is a need to reassess the need and timing for a GDS version 2.0. On the latter issue, it was agreed that the GDS-v2.0 should be developed alongside the GDS-v1.7 but that its release would occur only when substantial changes have been proposed, agreed and tested where possible in full collaboration with the GHRSSST-PP user community. User requirements should drive the innovation of the GDS v2.0.

Wick concluded that there was ample time at the meeting to consider the GDS and that the Science Team was in a good position to consider how to innovate the GDS to a version 2.0 in a more relaxed manner which would help ensure that the content was tuned to user requirements,.

3.2.10 Report from the Diurnal Variability Technical Advisory Group (DV-WG): Chris Merchant

Chris Merchant (DV-WG Chair) provided a summary report on the activities of the DV-WG since the last GHRSST-PP ST meeting which included testing of new models work with in situ observations to verify and validate model outputs including SkinDeep temperature profiler data and M-AERI spectroradiometer measurements together with other at-sea variables. Finally new satellite observations from the MSG SEVIRI have been made available by CMS for diurnal variability work have been used to investigate DV parameterisations.

Merchant highlighted work comparing various model schemes to study DV using the same forcing functions (Figure 3.2.10.1) noting that several new papers have been published on DV models in the last 12 months.

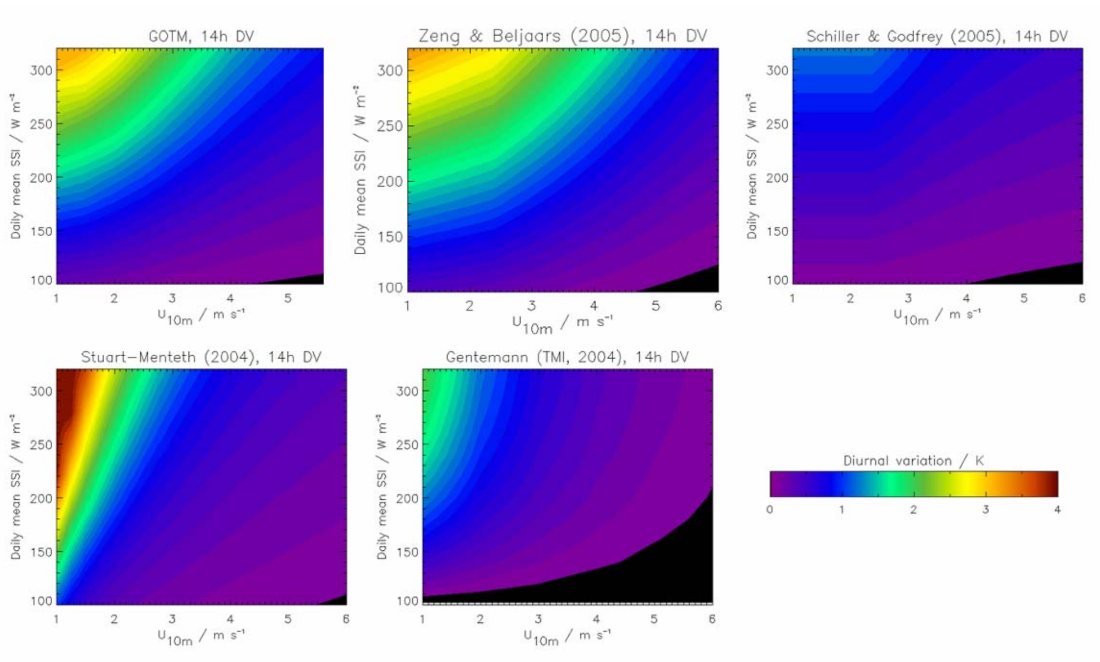


Figure 3.2.10.1 Comparison of DV using several different schemes forced by identical fields.

Schiller & Godfrey (2005) develop a diagnostic parameterisation for an ocean model with ~10 m top layer which represents the DW layer stratification onset time, layer depth and temperature that does not seem to capture the magnitude of DV seen in other outputs (not much variability above ~1K). The Zeng and Bejjaars (2005) prognostic parameterisation takes a different approach that uses an assumed profile from SSTfnd which seems to be tuned well. These results are compared to the Alice Stuart Mentheth (ACSM statistical), Gentemann (TMI satellite derived) and GOTM 1D turbulence model outputs in Figure 3.2.10.1. GOTM and Zeng& Bejjaars have similar max amplitudes which are roughly correct (3-4K). The lower panes show the ACSM and Gentemann schemes show very different behaviour shapes that are different from physically based models and there is clearly more work to do here. The models are not coupled to the atmosphere anyway but if the coupling is turned on there is little difference. Work using a simplified turbulence model Katsatos and Soloviev (2004) looking at vanishing horizontal gradients at low wind speeds was underway and would be pursued further. Merchant highlighted the need for better wind forcing in order to take this work further and consider how best to implement operational schemes for DV.

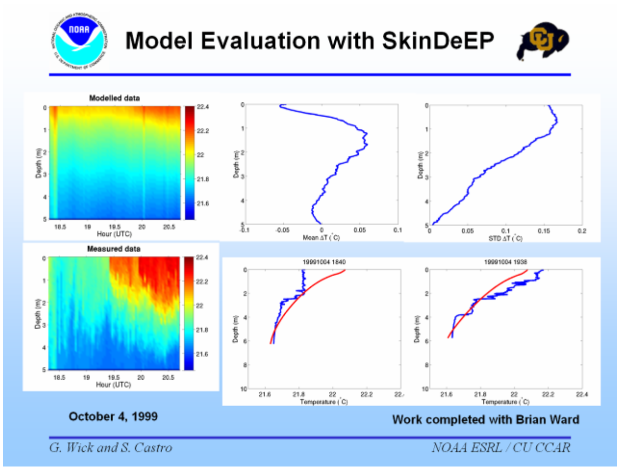


Figure 3.2.10.2 (a) Comparison of model DV warming to SkinDeep temperature profiles. The large DV event at ~19:50 suggests that the profiler has not followed the same water as the onset of the DV is too rapid.

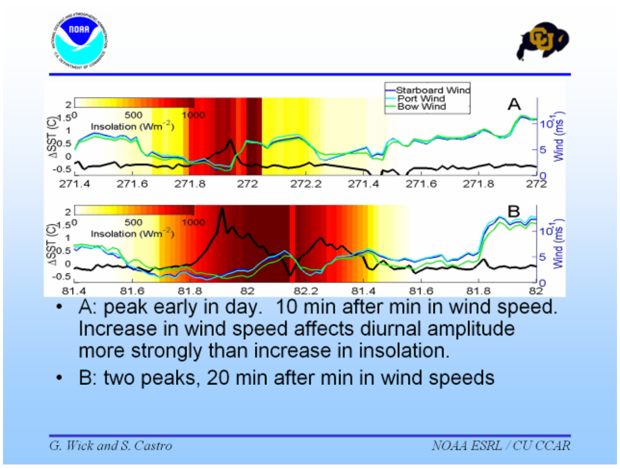


Figure 3.2.10.2 (a) DV Observations from M-AERI spectroradiometer data together with surface wind speed and solar radiation in the Caribbean

The key lessons leaned from in situ validation of DV models within the USA MISST project were

- Diurnal warming is a 3-d phenomenon

- The importance of wind-burst activity and destruction of DV layers was a large challenge
- Asymmetry of warm-layer creation & destruction is important
- Instantaneous wind will provide a better predictor than daily average winds although the choice between one instantaneous wind vs NWP outputs is still not clear

Short time scale winds are exceptionally important as shown by the wind activity in middle of day in Figure 3.2.10.2(b) where the morning peak is warmer than afternoon. These data highlight that timescale for DV onset is 10-20 minutes after low winds but this is not the same timescale for different DV drivers (e.g., solar radiation)..

Merchant then noted that plans had been in place for over a year to exploit hourly SEVIRI data for DV work. CM Meteo France has now prepared an integrated hourly data set that contains SSI and DLI and SST that can be used with outputs from Met Office FOAM and other models. Merchant showed a movie of observed DV observations from a predawn condition highlighting the potential of these data for DV work (Figure 3.2.10.3). Results are generally good but more work is required to determine how far NWP winds can resolve the dynamic DV structures that GHRSST-PP is concerned with.

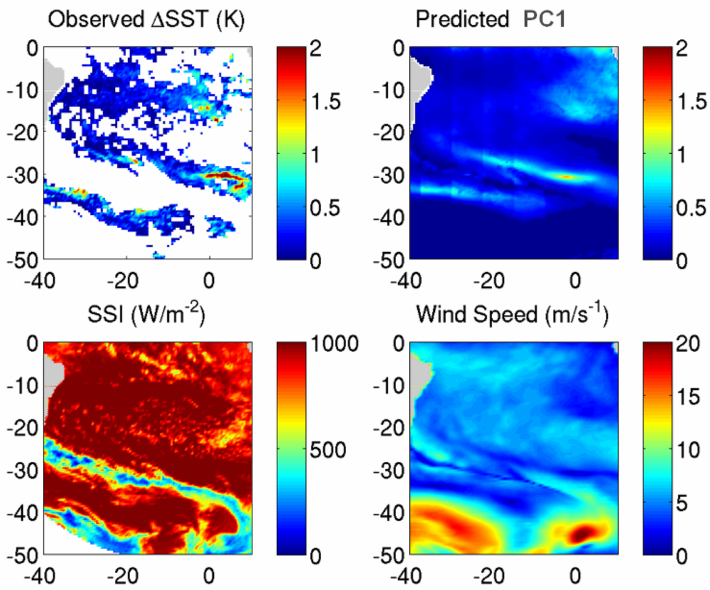


Figure 3.2.10.3 Extract from a movie loop showing measured DV (using SEVIRI data), predicted DV (PC1), measured SSI (SEVIRI) and NWP wind speeds.

Merchant concluded that the DV-TAG had made good progress but was now moving into a new level of activity that will use satellite and in situ data and consider the different spatial and temporal scales when comparing model and observed outputs. It will work towards sourcing different winds from NWP systems and consider the different impact between averaged and instantaneous winds and review the treatment of non solar heat fluxes within DV studies. A larger set of diagnostic model runs are required to for inter-comparison and testing of models which must include both empirical and dynamic model frameworks. Merchant proposed to develop a systematic study to look at what can be achieved using the data that we have operationally available not just DV but also fronts etc.

3.2.11 Report from the GHRSST-PP Sea Ice Working Group (SI-WG): Peter Minnett

Minnett noted that the GHRSST-PP Sea Ice Working Group (SI-WG) was set up at the 6th Science Team Meeting in Exeter with two main objectives:

- To determine best ice-mask for high latitude SST fields
- To improve accuracy of high latitude SST fields

The group has been moderately active and Minnett noted that there is a clear need for more involvement and membership from user community. A conclusion of the SI-WG is that the GHRSST-PP sea ice requirements should focus on developing an accurate **sea ice mask** rather than on sea ice properties. Ideally, a resolution at 1-10km is required with updates every ~6 hours. GHRSST-PP could make use of sea ice properties (e.g., concentration, type) to help define an accurate sea ice mask but these are not necessarily the GHRST-PP primary requirements. Furthermore there are delays incurred when operational groups have to wait for better sea ice properties products which are not all available in a timely manner. In addition, there is great benefit to working with enhanced cloud screening systems as the problems of detection are similar. Minnett noted that for MODIS data, where the cloud mask was good the corresponding MODIS enhanced cloud products were the same in all weather conditions and the same is true for MODIS SI masks.

In addition, the ice edge is a complex regime that is highly variable in space and time so that the concept of an ice edge is time bound. Sea ice includes ice pack, land fast ice and tide-water glaciers that extend beyond the conventional land-mask. It is highly variable in space and time and does not necessarily have a well defined edge. This is comparable to cloud edge and its detection using IR sensors. Minnett showed an OLS image of katabatic winds blowing over open water in the Ross Sea, Antarctica. Streamers of frazil ice forming at the surface are oriented in the direction of air flow are clearly seen (Figure 3.2.11.1). Movies of AMSRE 1 day composite data were shown that highlight how hard it is to to say exactly where the ice edge actually is.

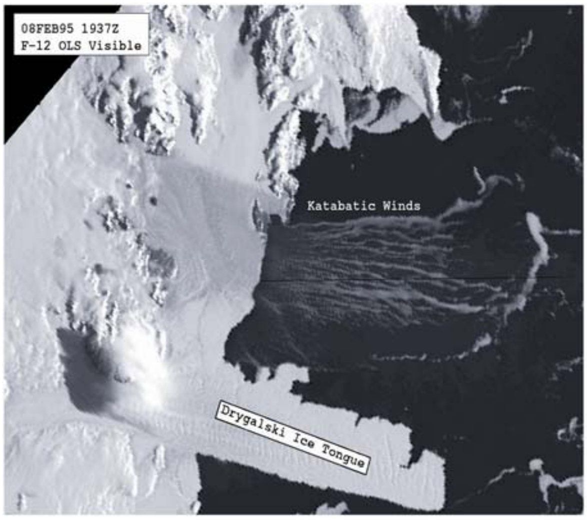


Figure 3.2.11.1. (a) OLS image of katabatic winds blowing over open water in the Ross Sea, Antarctica. (Courtesy of Arctic Antarctic Research Center - arcane.ucsd.edu)

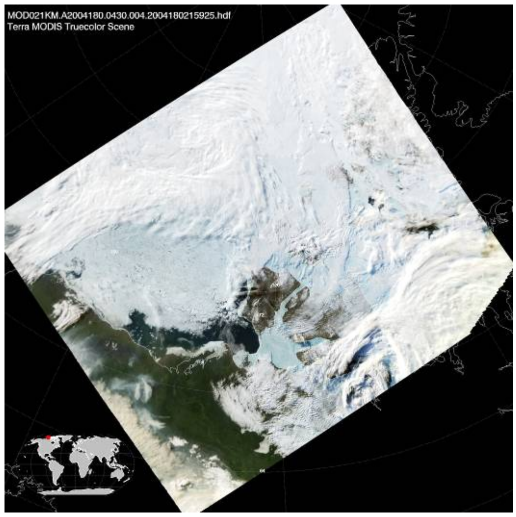


Figure 3.2.11.1. (b) Terra MODIS true colorJune 29, 2004. 21:59 UTC showing the complex nature of the ice edge and problems separating clouds from ice.

Minnett then briefly noted the various sources of data that can provide an ice mask which included

- High resolution (<1km) SAR and visible imagery
- High resolution (~1km) infrared imagery
- Medium resolution (~12km) high frequency microwave imagery
- Low resolution (~50-100km) low frequency microwaves

Each of these data sets has advantages and challenges in terms of its usefulness and availability. Minnett used MOIDIS images of ice land, fast ice, ice pack and clouds to highlight the complex nature of the ice edge (Figure 3.2.11.1(b)). GHRSST-PP is concerned with SST and in general is not concerned about ice ***and*** cloud differences but on a correct ice and cloud mask. GHRSST-PP needs clear information on where open water actually is so that a combined cloud/ice mask is the best approach to take. This demand a high resolution cloud/ice mask which has many complex issues. For example, microwave data resolution of ~25km does not meet the GHRSST-PP high resolution (10km) requirements. SAR is the other end of the spatial resolution (meters) but has problems in open water due to wind effects that result in a similar radar cross section for open water and ice pack. GHRSST-PP can use SAR to get rough ice and smooth water or visa versa but not both together. Also SAR is difficult to obtain operationally at present highlighting another set of challenges.

Minnett noted that polar regions are at a climatological extreme and there is a need to think clearly about the SST retrieval process in extremely dry atmospheres, where large air-se temp differences are normal for open water and the temperature dependence of seawater emissivity. Minnett noted that these situations can asily introduce bias errors into the SST-retrieval in Polar Regions. Using a set of cruise data, large errors in SST retrievals were found at high latitudes where the air temperature is controlled by ice surface temperatures and in open water (typically leads of only a few km wide) there is a huge temperature difference. There is a clear need to consider these effects in SST retrievals from satellite at high latitude.

Minnett concluded that GHRSST-PP should use tools to derive a combined ice mask based on clouds and should not wait for other ice products based on thresholding and histogram techniques. In winter better thresholds may need to be derived due to the loss of visible channels. A similar approach could be adopted for MW data based on the use of SST data streams to produce an ice mask at the same time. Minnett noted that the GHRSST-PP is focussed on 6 hourly real time requirements whereas the GHRSST-PP reanalysis (RAN) project has different considerations operating in a delayed mode so that it can make use of additional information such as integrated SAR data sets.
Finally Minnett noted that there should be a concerted action to review SST retrievals form infrared satellite instruments in high latitude regions as these are often in error due to climatological extreme atmospheres and air-sea fluxes.

3.2.12 Report of the GHRSST-PP XML working group, Ed Armstrong

Armstong noted that this inter-sessional period has been relatively quiet ain terms of XML formatting (principally the Master Metadata Descriptions and associated DTD documents developed by the GHRSST-PP Science Team). Armstrong reported that there had been many small data format problems at the GDAC some of which remain an issue. However these are to be expected as the GHRSST-PP R/GTS system is developed and commissioned and thse will soon be rectified by RDAC providers. The major accomplishments of the group include

- Implementation of FDGC metadata conversions required by the US Federal Government and the LTSRF
- Filename convention issues for HR-DDS properly resolved
- Documentation of L2P data integrity. In particular netCDF Scale_factors and add_offsets are not stored consistently which introduces problems of rounding errors. This doesn't affect the geophysical properties of the data but we need to be aware of these issues and correct them as different software readers may not function properly when using incorrect data types within netCDF files.

Armstrong noted that some RDAC providers are filling L2Pc data files with empty arrays and requested that this in not done. The Science Team also recommend that the GDAC could check the integrity of the ancillary data fields provided by RDAC at some point in the future to assure continuity but this should not be done at present as it may compromise the current GDAC operations.

Armstrong noted that some issues had arisen with the format of MMR_DSD records when non ASCII characters had been used. Furthermore, many of the DSD were basic and needed revising (or at least checking) by the respective RDAC. One particular issue related to the GHRSST-PP definition for longitudinal coordinates in different output products (should they be +/- 180° or 0-350°?) An action was raised to further discuss this issue although the general conclusion following discussion was to standardise on the ±180° specification.

L4 netCDF compliance issues had been raised in the DM-TAG report and in addition, filename delimiters for gridded data sets needed to be resolved (L2P_GRIDDED, L3, L3P??). Actions were raised to consult with the netCDF CF-1.0 group to establish new CF names for GHRSST-PP data sets once the DM Tag had provided the appropriate variable names to register.

3.2.13 Status and application of the HR-DDS: Dave Poulter

Poulter began with a summary of the current GHRSST-PP High Resolution Diagnostic Data Set (HR-DDS) scope and functionality. The HR-DDS works with files that are gridded subsets of L2P and L4 products. They contain appropriate ancillary fields (and may also contain additional fields as appropriate) in a common format and gridding for all data types. One file is produced per input file per site (if site is observed). The HR-DDS provides a web based interface that is ideal for quickly assessing sensor performance. Currently, L2P are produced by the Medspiration RDAC where there is a DDS granule and Figure 3.2.13.1 shows the current location of HR-DDS sites following revision by the GHRSST-PP Science Team at the Exeter meeting. Locations were selected to cover areas of interesting (or representative) oceanographic conditions; area of high variability; locations of repeated *in situ* observations. Also areas of model simulation and variable ice coverage are included.

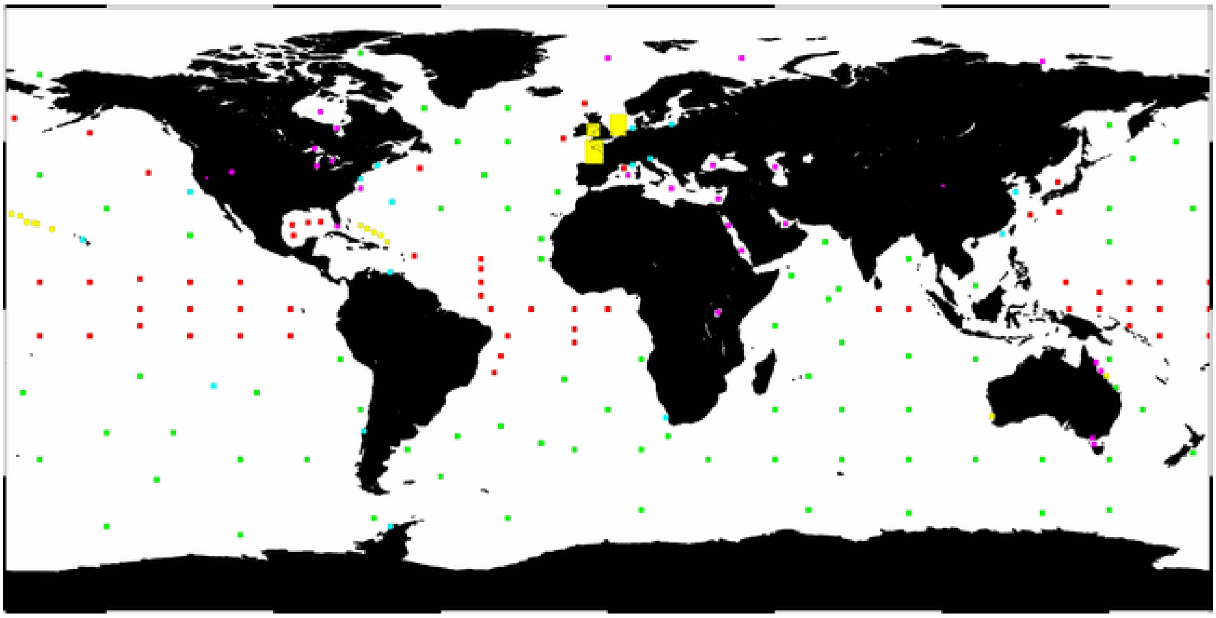
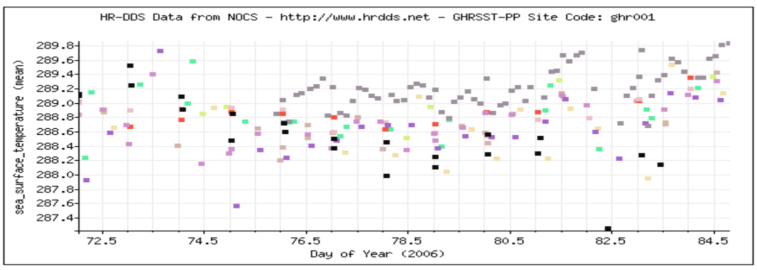


Figure 3.2.13.1 Location of HR-DDS sites including changes since Exeter (GHRSST-PP VI meeting).

The HR-DDS system has reprocessed all data from April 1st 2005, all MMR FR records to GDS 1.6 and has placed documentation on the web site. The current system is fully operational with all data available via Opendap @ nocs with ~300,000 DDS files all with an associated quicklook image for easy applications.

FOAM ocean forecast model data from the Met Office have been added to the system from 1st October 2005 including both global and 1/9 degree North Atlantic model output data. The system has ingested NAR 18 regional AVHRR from Medspiration some L4 products and global AATSR. A new interface has been developed containing several new features that allow data to be analysed on the fly using the web interface at http://www.hrdds.net. As the website is linked to an SQL database basic statistical data from each HR-DDS file (e.g., distribution of mean SST mode etc…) can be easily and rapidly returned to a user query. Tools allow searches by time by date sensor input, and a simple diurnal warming filter (filters data for DV events based on SSI and wind speeds) can be applied to remove DV potentially contaminated data from analyses (Figure 3.2.13.2)



Input Stream	Mean	Stdev	Maximum	Minimum	Samples	Do Not Plot
AMSRE-EUR	288.84	0.34	289.58	288.24	19	
ATS_NR__2P-EUR	289.00	0.29	289.37	288.51	6	
AVHRR16_G-EUR	288.64	0.44	289.54	287.95	15	
AVHRR17_G-EUR	288.72	0.29	289.43	288.21	19	
AVHRR17_L-EUR	288.79	0.21	289.14	288.52	5	
L4UHFnd_GLOB_OSTIA-UKMO	288.85	0.18	289.36	288.63	12	
L4UHRSSTFND-EUR	288.84	0.19	289.20	288.54	13	
NAR17_SST-EUR	288.72	0.32	289.41	288.15	23	

Figure 3.2.13.2 Example line plot output showing HR-DDS mean temperatures over time for several different sensors.

The new HR-DDS system includes a comprehensive plotting functionality allowing many combinations of data to be compared over a user defined time period. Automation of the system allows users to request a download of the data that has been used to produce a plot in a single tar file that gives all the data in the plots full res HRDDS data files. Future capabilities include the development of histogram of differences and spatial difference maps.

3.2.14 Report from the GCOS SST Sea Ice Working Group, Søren Andersen

Andersen began his report noting that the connection between the GCOS SST and Sea Ice Working Group and GHRSST-PP is useful although the dominant component of the work is with SST. The initial group was founded in 1999 with roughly 25 members although the Chair resigned in 2005. The group reformed in Exeter October 2005 with a wide initial representation in SST and the decision to form a specific subgroup on sea ice was taken at this meeting.The GCOS Sea Ice group met on Sunday Afternoon in Boulder prior to the GHRSST-PP Science Team meeting in an attempt to co-locate activities for both GHRSST-PP and GCOS. This first meeting with Andersen as the Chair, was well attended. Andersen noted that GCOS group is not a new group and is mainly connected to the GHRSST-PP SI-WG and RAN projects. The SI core group includes the following representatives:

- EUMETSAT OSISAF:Søren Andersen
- NSIDC: Florence Fetterer & W. Meier
- ASPeCt: Ackley & Worby
- NASA Goddard: Per Gloersen
- NIC/IICWG: Pablo Clemente-Colon
- ETSI/GDSIDB: Vasily Smolyanitsky

With a structure indicated in Figure 3.2.14.1

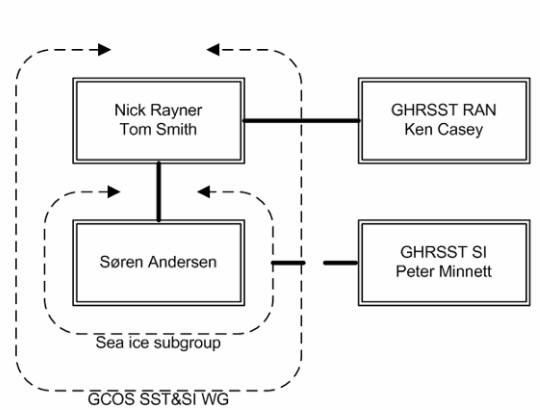


Figure 3.2.14.1 Structure of the GCOS SST and Sea Ice (SI) working group

The main motivation for the Sea Ice working group is to investigate and advise on inconsistencies between different passive microwave sea ice timeseries and ice charts have been identified by climate community constructing longterm SST&SI analyses. The main mission of the SI WG is to provide analysis and recommendations on long term consistent sea ice fields (CDR) for use in SST & SI analyses. Inter-comparison and reconciliation between ice analyses from passive microwave data and ice charts is aq large component of this work.

The main outcomes of the GCOS SI meeting were that the group will:

- Assemble inventories of passive microwave and ice chart data sets
- Develop plans for 1) inter-comparisons and; 2) validation
- Develop standards for error estimates and encourage their inclusion in data sets
- Define methodologies for conversion/handling of GIS format ice charts
- Engage the ice charting community (IICWG) to encourage investigations of chart uncertainties and temporal/spatial variations in detail and quality
- Encourage the support for ASPeCt analyses and data bases of sea ice thickness and other sea ice properties from ship records and ice charts. Extend to Arctic.
- Encourage systematic reporting (GTS) of sea ice conditions from ship expeditions in polar regions, inspired by ASPeCt (JCOMM).
- Monitor definition of accuracy/adequacy requirements in ICOS

The GHRST-PP Science Team welcomed the opportunity to work closely with the GCOS SST and SI group and in particular requested that the GHRSST-PP RAN project work closely together.

3.2.15 GMES & SENTINAL and ERS MEDSPIRATION overview, Wolfgang Lengert

Lengert provided an overview of the European Global Monitoring for Environment and Security (GMES) initiative of the European Commission and ESA. GMES is an initiative designed to provide European independent data sources for environmental monitoring and security and to make the European contribution to the Global Earth Observing System of Systems (GEOSS). GMES was initiated by EC Communication COM(2001)264 on 15 April 2001 which states that

> *"GMES is a joint initiative of ESA and the EC to respond to the need to establish, by 2008, a European Capacity for Global Monitoring of Environment and Security to support the public policy maker's need for global access to reliable, accurate, and up-to-date information on issues of environment and security"*

In terms of the space component of GMES the following are planned missions:

- Sentinel 1 – SAR imaging: All weather, day/night applications, interferometry
- Sentinel 2 – Superspectral imaging
- Sentinel 3 – Ocean monitoring: Wide-swath ocean color and surface temperature sensors, altimeter
- Sentinel 4 – Geostationary atmospheric: Atmospheric composition monitoring, trans-boundary pollution
- Sentinel 5 – Low-orbit atmospheric: Atmospheric composition monitoring

Lengert noted that only /sentinel 1-3 missions are likely before 2013 and the Sentinel 4&5 missions are still in discussion. Included in the GMES initiatives are the appropriate ground segment & access to national mission data sets.

For GHRSST-PP, the Sentinel 3 mission (Oceanography) is the important mission that will carry an Altimeter and high resolution vis/IR system which together will cover nearly all GMES issues. The key mission specifications for Sentinel 3 (useful to GHRSST-PP) are as follows:

- Sea surface topography (SSH) and, significant wave height (SWH) over the global ocean to an accuracy and precision equivalent to or better that of Envisat RA-2.
- Surface temperature (SST) determined globally to an equivalent accuracy and precision as that presently achieved by A/ATSR (i.e. <0.3 K), at a spatial resolution of 1 km. Coastal zone waters and global land require an increased resolution of < 300 m. Dynamic range good enough for the detection of fires without saturation
- Visible and Infrared radiances ("Surface Colour") for land and for oceanic and coastal waters, determined to an equivalent level of accuracy and precision as MERIS data
- Complete Earth coverage in 1 to 3 days, and co-registration of Color and Temperature measurements
- NRT data delivery (< 3 hours) for fundamental products

The Sentinel-3 mission is dedicated to satisfy data continuity requirements for robust provision of operational oceanography services including the Medspiration and GHRSST-PP. ESA will work together with other GMES components to ensure that MEDSPIRATION data and services are continued until the successful launch of Sentinel-3.

Lengert concluded that there are also opportunities within the ERS-1 and ERS-2 ATSR missions in the scope of the GHRSST-PP reanalysis project. An initial proposal to re-format these data into L2P was under consideration that would include better SSES's for the ATSR series tuned to work with the strengths and weaknesses of the satellite sensor. It was hoped that this work would kick off in mid 2007 and be reported at the next GHRSST-PP Science Team meeting.

3.3 Session 2: User Consultation

3.3.1 The GHRSST-PP Applications and User Services (AUS), Sue Heinz

Heinz presented the developments within the GHRSST-PP Applications and User Services (AUS). The main vision for the GHRSST-PP AUS is to:

- Ensure a high level of customer satisfaction through user advocacy,
- Gain new users of diverse applications,
- Provide examples and metrics of demonstrated success to stakeholders.

The AUS is in fact a distributed team involving all of the RDAC and GDAC members of the GHRSST-PP working together to support the GHRSST-PP user community. Examples of activities coordinated by the AUS include:

- The development of an AUS Customer relationship management plan including Goals, Target Audiences, Strategies & Activities, Evaluation Measures, Schedule
- Preparation and launch of the GHRSST-PP GDAC web site http://gdac.jpl.nnasa.gov
- Creation of a US GDAC user requirements document (similar to the EU Medspiration URD) including outline process for GDAC data ingest, storage, distribution and search (Oceanids, MMR, MDB) and a road map for AUS key activities and strategies
- Provision of data and interaction with the US coastguard.
- Attended several meetings to represent GHRSST-PP MISST, Earth Science Info Partners (ESIP) science and commercial
- Preparation of the AGU Ocean Sciences Special Session on Climate Data Records led by GHRSST-PP Science Team members (Casey, Vazquez and Donlon) and represented the GHRSST-PP at these sessions and at the NOAA and NASA booth.
- Preparation of communities for disaster resilience PRiMO (Pacific Risk Management Ohana)
- Documenting end users and customers is a data base which is password protected (see Figure 3.3.1.1) including Customer Contact Log, CRM tool to manage User information, activity log and follow-up tasks. 17 Potential Users are now fully documented and an internal Collaboration Site has been set up.

Figure 3.3.1.1 Example screen form the AUS user and customer database system.

There are many user opportunities for the GHRSST-PP that has not yet been tapped, particularly in the USA. These include

- Pacific IOOS / NOAA IDEA Center
- Pacific Disaster Center
- Alaska IOOS
- GOMOOS
- Great Lakes Ocean Observing System (GLOS)
- PMEL Ferry Box In-situ data - MDB
- NASA Aquarius

- JPL Ocean Modeling
- Gulf of Mexico Oil Industry
- Storm Center

The challenge is between now and end of 2006 to bring these groups on board. Heinz concluded with a set of high-importance actions for the AUS to work on noting that this was all subject to available funding. These included

- Development of appropriate user performance and GHRSST-PP system wide metrics, a full AUS Strategic Plan and Implementation schedule
- Document all Users, follow up, provide mechanisms for User feedback and mechanism to communicate to ST
- Improve communication - consistent, regular content on all sites, publications, presentations, etc. One entry point website and email for publications.
- User Workshop for Ocean.US Regional Area Users

Heinz concluded that the GHRSST-PP web spaces need to be improved as these are the main sources of information that the user community sees. There should be a common look and feel to all spaces so that the user knows that they are working within the GHRST-PP. Want to improve the web spaces and recommend a single point entry to GHRSST-PP. Furthermore a GHRSST-PP Data policy/Strategy document should be developed to clarify the limitations of GHRSST-PP data in the commercial environment. As the GHRSST-PP moves to an operational and sustained system, this will be an essential reference document. An action was raised for the DM-TAG to coordinate a small DT-TAG group to look at data policy and generate procedures to deal with data policy issues.

3.3.2 MISST Impact Study Requirements, Chelle Gentemann/Gary Wick:

Gary Wick and Chelle Gentemann provided a short overview of the MISST impact studies and requirements which are currently being developed within the project and expect to be reported at the next GHRSST-PP meeting. The main impact study planned is to assess how well MIST products help improve applications in including hurricane prediction, Ocean forecasting systems, Numerical weather prediction, SSTskin to SSTdepth modelling, diurnal variability modelling, ocean convection and others.

Most of the effort is based on L4 analyses applications and Jim Cummings (a MISST power user at the Naval Research Laboratory) requests accurate error estimates. Evaluation and impact assessment of error estimates is thus a primary requirement for MISST. Diurnal variability is also a key requirement and the success of MISST hinges scientifically on delivering accurate and useful DV corrections that can be interpreted and applied by MISST users.

SSTfnd is the baseline for users but in addition, adjustments need to be provided so that users can move between SSTfnd, SSTskin, SSTsubskin and various SSTdepth analyses. Furthermore, users want to have 6 hourly updates of L4 analyses as update files to the basic daily analysis. The MISST group are also looking at the potential for hourly update cycles. This requires further refinement of corrections and parameterisations at different depths and the use of numerical models to reproduce the various SST's is important.

MISST is also preparing studies using ocean colour (typically not yet assimilated by ocean models) as a validation data for model output dynamics (e.g. surface currents and general circulation. As MISST has limited funding, there is an effort to collaborate and build on the efforts Charlie Barron and Eric Chassignet in this area.

3.3.3 US Navy Applications requiring SST, Doug May

Doug May presented an overview of real time applications for operational oceanography using Operational Satellite SST at NAVOCEANO. The dynamical ocean analysis and forecast systems at NAVOCEANO are large 24/7 operations that provide routine outputs of ocean state in NRT to various user applications in military operations. In situ and satellite data sets are assimilated by the forecast systems which are pre-processed by the data division including ship, buoy, altimeter, optics, satellite data, subsurface XBT, ARGO, gliders, etc.

The number of SST observations per day from space is enormous (~5 million obs compared to a total of ~200K observations from all other sources including satellite altimeters). The various in situ data from many sources have dedicated format readers, extractions, databases and supply chains to the operational models. Altimeter data from JASON-1, GFO, ENVISAT provides SSH including synthetic profiles and wave heights. MCSST products derived from the AVHRR LAC/GAC/GOES-E/GOES-W, RSS AMSRE are all provided and maintained in a 7 day rolling archive. 10km resolution global MCSST analysis is produced each day with regional extractions as shown in Figure 3.3.3.1 which are used to determine if survival gear should be used for operations for ship efficiency and other applications.

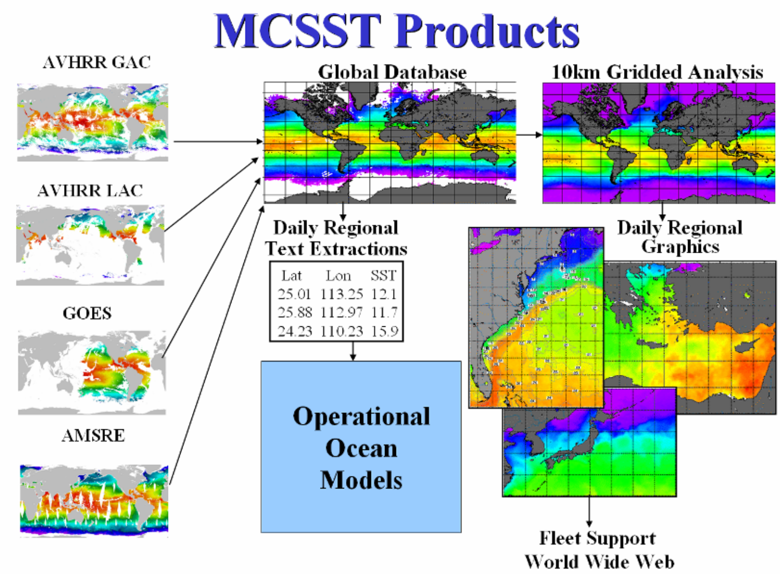


Figure 3.3.3.1 MCSST products produced at NAVOCEANO as part of routine operations

Individual data sets from NOAA 18 –GAC and LAC are generated every orbit and passed on to NESDIS, fleet Numerical and into operational models. L2P data is prepared and is sent to JPL for public access. Also ASCII format data files are prepared and served via the FNMOC GODAE server. NAVOCEANO also maintain an MDB system for normal applications taking collocations at ±25km and 12 hours. The N17 processing chain is similar to N18 and the NAVOCEANO team are currently adding an automated QC procedure. Eventually an automatic feed to JPL for L2P will be set up. GOES imager data are also processed similar to N18/17 but no feeds are sent to JPL for GHRSST-PP as this is foreseen as a NESDIS responsibility. Satellite data are also accessed for AMSRE from Remote Sensing Systems (also available from JAXA), MSG SEVIRI data from Medspiration, Windsat SST's are also used (these are sporadic but available) and Medspiration AATSR.

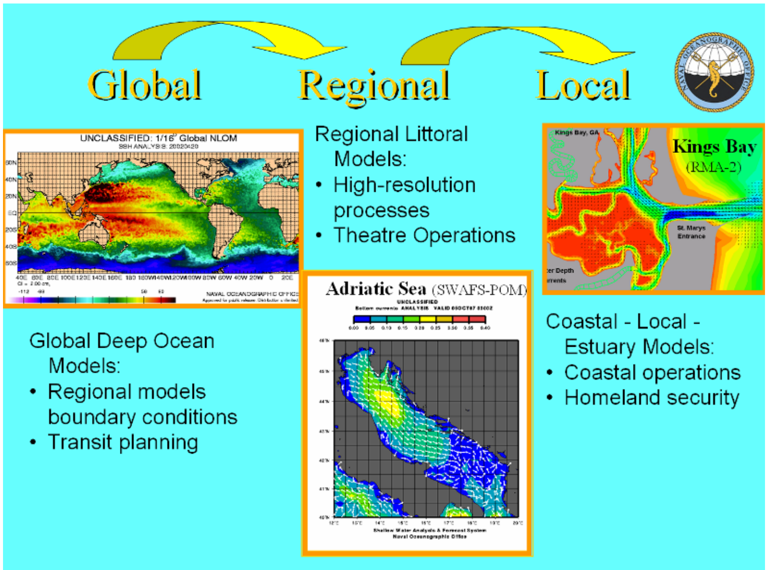


Figure 3.3.3.2 The NAVOCEANO nested modelling approach providing increasing resolution outputs while minimising the cost of analysis systems.

Ocean analyses and model systems are used as a nested global regional and local system coupling distinct model systems together. Global systems are used to provide background information and boundary conditions for higher resolution systems and transit planning. Regional and then local high resolution systems in place including the NLOM (1/16° -> 1/32°, 1/16 --> 1/32 degree resolution, 4 --> 2 nm resolution, 6 vertical layers providing SSH for Global Circulation Models in 200m or deeper water, position of fronts and eddies, SST and Salinity). The global navy coastal ocean model (G-NCOM) is a POM-based model providing 3D Forecasts of Currents, T-S, Elevation running at a resolution of 1/8 deg (~14km / 7.5nm) with 42 vertical layers. Forecasts are issued out to 72hr @ 3hr increments. G-NCOM provides lateral boundary conditions for higher resolution nests (SWAFS / regional NCOM). The shallow water analysis & forecast system (SWAFS), also a POM-based model provides 3D forecasts of currents, T-S, elevation. In this system the model resolution varies by region (1/50 to 1/4 deg - 0.5 to 24km - 1 to 15 nm) and uses 27 to 42 vertical layers. Forecasts are issues to 48hr @ 1hr increments. The system assimilates data from satellites (SST, SSH) & *insitu* (XBTs, CTDs, floats, buoys).

May concluded with a user requirements statement requesting that SST data from GHRSST-PP include:

- Location, time, SST, error estimate
- Have the coverage of observations updated within 12-24 hours
- Production of data sets within 6 hours of sat acquisition
- Include aerosol content, channel BTs and the satellite zenith angle
- Include only ancillary information demonstrated to significantly impact SST accuracy

May noted that the ancillary data included with L2P data sets is valuable to NAVOCEANO but more work is required to refine the content of L2P on a sensor by sensor basis (one size does not necessarily fit all). A particular request of NAVOCVEANO is to include satellite brightness temperatures in order to recalculate the BT's when AOD is high.

3.3.4 Operational use of GHRSST-PP data sets at the Met Office: OSTIA - a new 1/20° SST analysis and FOAM, John Stark

Stark provided a summary overview of applications at the Met Office using GHRSST-PP data. The presentation was not describing the systems at the Met Office but focussed on the use of GHRSST-PP data and systems (HR-DDS) within the Met Office National Centre for Ocean Forecasting (NCOF). Two main applications use GHRSST-PP data:

1. A New operational SST and sea ice analysis (OSTIA) system
2. the Forecasting Ocean assimilation Model (FOAM) system

Each application uses GHRSST-PP data in slightly different ways: OSTIA is a persistence based global daily SST analysis at 1/20° using optimal interpolation that uses all available GHRSST-PP satellite (microwave & IR) and in situ data. OSTIA is expected to daily transition into operations later in year. OSTIA analysis results available from http://www.ghrsst-pp.org. FOAM is a nested system of ocean models and Stark will be working on top set of FOAM models assimilating GHRSST-PP data products within the DA system. FOAM is driven by 6 hourly surface fluxes from the Met Office NWP system and currently the operational version uses poor quality 2.5° AVHRR MCSST products.

Large volumes of GHRSST-PP L2P data are ingested by the Met Office each day including AMSR-E (Aqua), TMI (TRMM), AATSR (EnviSAT), AVHRR (NOAA 17 & 18), MSG SEVIRI (MSG1) together with in-situ data from the GTS. About 30,000 in situ observations per day are available through the GTS and while the N Atlantic is adequately covered, the central Pacific area is less dense. Stark noted that there are pros and cons to each different data source. For example, noise on AMSRE but daily near all weather coverage compared to high accuracy and radiometric fidelity dual view AATSR data which has only a very narrow swath.

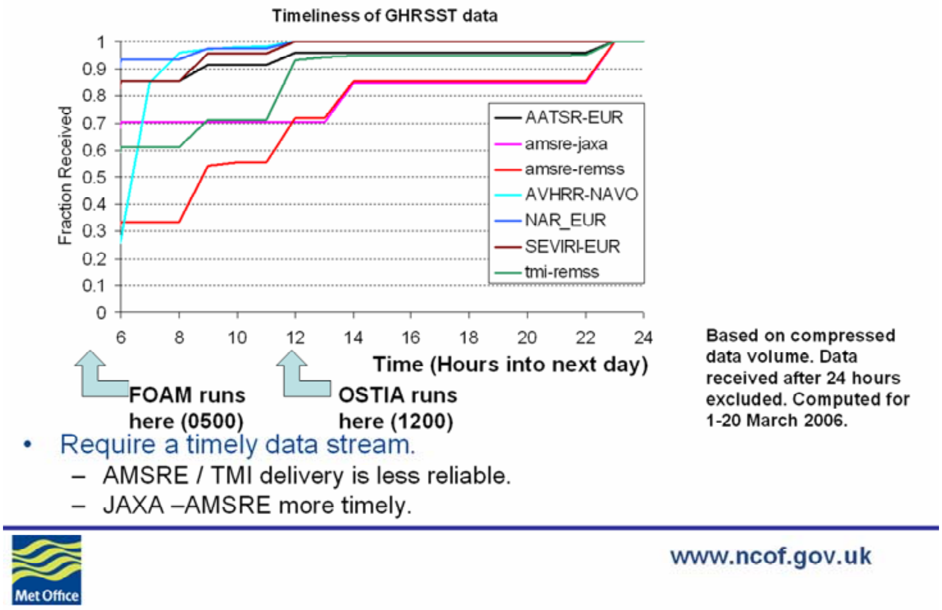


Figure 3.3.4.1 Timeliness of GHRSST-PP data streams at the Met Office expressed as a fraction of data received.

The Met Office has been pulling GHRSST-PP data for over a year in order to monitor the operational stability of the data provision. Figure 3.3.4.1 shows the fraction of data received per sensor. Delays are most pronounced for AMSRE from RSS due to calibration issues. JAXA is now producing L2Pc which is used as a backup data supply to REMSS (who typically have several days missing data, no data or missing data in fields). AVHRR products are the most reliable and well supported by NAVOCEANO/GDAC.

The Met Office within the framework of the EU MERSEA Ocean Forecasting project is preparing the FOAM system to assimilate new satellite SST data sources for which a reasonable record length is required. A 12-month run of FOAM 1/9° North Atlantic is planned for which the observation processing for OSTIA has been adapted for compatibility with FOAM. In addition, the Met Office is performing an going inter-comparison between different data sets, looking at comparisons with climatologies for seasonal forecasting and using the HR-DDS to study variability of the input data sets used by the OSTIA system.

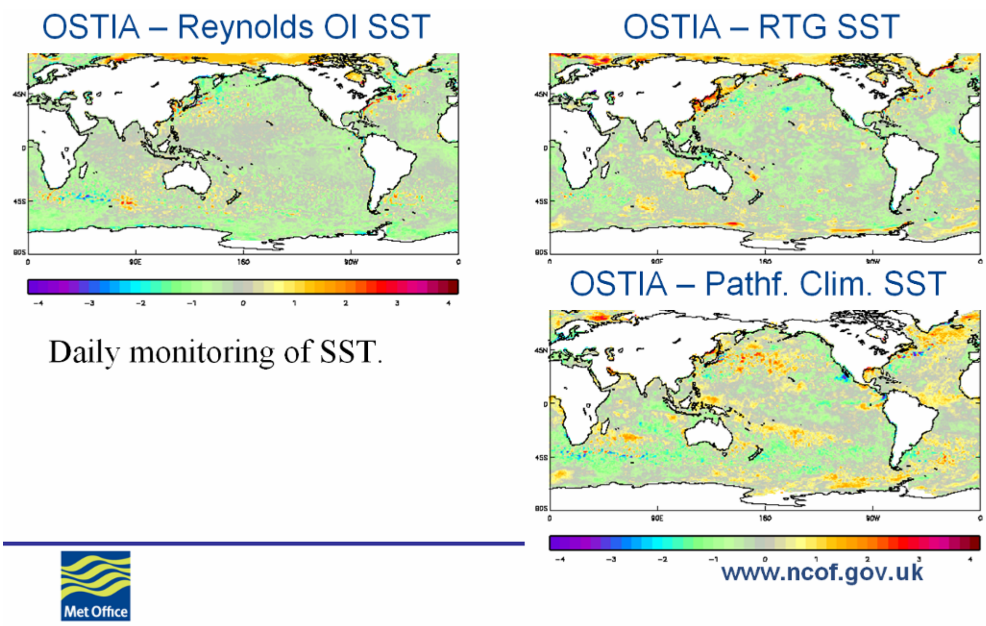


Figure 3.3.4.2 Anomaly fields from OSTIA SST based on re-gridded Reynolds OIv2.0, RTG SST, and Pathfinder Climatology

The ensemble of SST analyses and anomalies was developed in response to user request for SST products for seasonal forecasting. Products use a standardised colour scale and output format re-gridded to ½ degree data (area avg.). Both global & North Atlantic projections are available. Data sets include OSTIA, FOAM, RTG-SST, Reynolds OIv2 and HadISST (see Figure 3.3.4.2) Stark noted that significant work was still required to ingest GHRSST data into in-house data store which included conversion to BUFR from NetCDF (a major setback but in-house data base currently supports only BUFR & GRIB) although this work may encourage provisional plans to use CF-NetCDF as a standard in-house format for gridded data.

Further validation of the OSTIA outputs will be performed and a short contract to validate OSTIA using the HR-DDS diagnostic tools developed at NOCS while in house validation will be used to tune error correlation scales & variances. The Met Office are also collaborating with Chris Merchant to use high resolution 1D modelling to initially quantify an optimal parameter set for flagging DV and investigate possibility of using mixed layer models within the analysis. This work is expected to be complete within a few months.

Stark concluded with the following user requests:

- The GHRSST-PP L4 file format needs to be finalised as soon as possible and should ensure rigorous CF-1.0 compliance.
- When new data streams come online, it would be far better if L2P files for older data are also produced where possible. E.g. AVHRR-18 / Global AATSR before Feb / Dec as OSTIA need a long time series to generate accurate error statistics and to evaluate performance
- The planed MODIS 1km data volume will be a major issue for the Met Office and please consider a reduced resolution (4-9km) product.

3.3.5 Applications of SST within the European MERSEA system, P. LeBorgne

LEBorgne noted that the main aim of the MERSEA system, which is a precursor to the EU GMES framework, is to develop a European system for **operational monitoring** and **forecasting** on **global** and **regional** scales of the ocean physics, biogeochemistry and ecosystems. This includes

- The acquisition and provision of **data** (earth observation from satellites, in situ from ocean observing networks, and surface forcing fields from numerical weather prediction agencies)
- Combination/merging : interpolation, numerical ocean circulation models (i.e. *assimilation*) to produce best estimates of the actual **state of the ocean, hindcasts** and **forecasts (with the aim to** converge on a single high-resolution global ocean forecasting system shared by European partners together with a co-ordinated network of regional systems for European waters **)**.

Specific **applications** include a special focus on seasonal weather forecasting, ecosystem modelling in regional and shelf seas, marine safety, improved wave forecasts, offshore operations, ship routing, and oil spill drift

The majority of the MERSEA project has been dedicated to the design, development, implementation, integration, evaluation and validation rather than the operation of the system itself which builds on expertise and projects developed in national and European programmes. For example, MERSEA is a client of the Medspiration service. MERSEA is based on thematic assembly centers (TACs) that provide data, services or expertise focused on specific kind of data or areas of interest (e.g., SST, Mediterranean sea). The emphasis is toward developing cross cutting functions, integration, consistency, quality of services. Information management is designed in a way that adapts product and delivery to user needs including search and discovery, view, download, order via web based interfaces. From the GMES perspective remote sensing TACS's provide operational interfaces with European and non-European satellite ground segments have been established including those to Level 3/4 (and L2/L2P if required) processing activities including:

- Real-time and delayed mode (reprocessing)
- Quality control, Validation and Error characterization
- High level multi-satellite processing (bias correction/merging)
- Long-term monitoring activities
- R&D (service evolution)

The system must be interoperable, based on a harmonized data distribution system and one of the main successes for SST within MERSEA is the agreement between GHRSST and MERSEA format specifications. In addition to data centres MERSEA also provides interfaces to EU ocean modelling/assimilation centres. Data products are prepared as the "best" set of products for data assimilation and user feedback on data products and on the observing systems is generated to evolve the system properly from a user perspective.

MERSEA is working towards a roadmap cumulating in 2008 with operational services as part of GMES. This includes the configuration of operational ocean remote sensing thematic assembly centers for GMES (R/S TACs as part of GMES Marine Core Service) and TACs based on existing European processing facilities. These include:

- CNES/CLS SSALTO/DUACS for altimetry,
- Eumetsat SAF for sea ice,
- GHRSST, SAF and Medspiration for SST,
- Ocean colour to be built as part of MERSEA and Globcolour.

MERSEA is helping to improve these systems and to develop the links with modelling/assimilation systems. Focus is on R&D activities. In particular, ESA projects (e.g. Medspiration) contribute to the consolidation of the R/S TACs.

The MERSEA Sea Surface Temperature TAC **will** provide operational applications with homogeneous and directly usable high quality SST data from all missions including along-track and gridded products based on **near real time products d**istributed by Ifremer for use by all MERSEA Operational Systems. In the long-term (i.e., buy 2008) the MERSEA SST-TAC will evolve and consolidate the Medspiration Regional Data Center and develop a Global Data Center for SST as a European Service for GMES. The current configuration is shown in Figure 3.3.5.1.

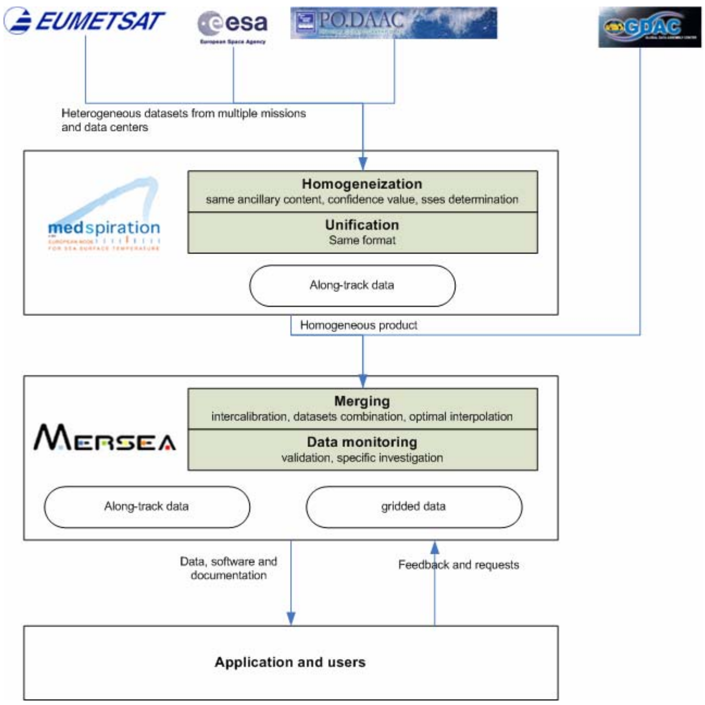


Figure 3.3.5.1. The MERSEA SST Thematic Assembly Centre (SST-TAC) framework showing clearly the relationship between Medspiration, GHRSST-PP and MERSEA

As part of the MERSEA system, remote sensing portal has been set up (http://www.mersea.eu.org) and configured to document all products (lists of products, formats, user guides, tutorials), run a web site to keep updated information and post new information (cf. activities, actualities, R&D reports), provide a well defined set of interface procedures (with partners and other WPs, services and level of services), provide access to gridded data products for all R/S data sets (SST, sea ice, colour) in a Netcdf structure format using the same ocean convention such as COARDS/CF and distribute them in an OPeNDAP catalogue, federate Opendap servers with a LAS server and implement an overall control capability.

In addition, the MERSEA project has developed a GHRSST-PP match-up database (MDB) as a tool for sensor error estimation and bias correction. This is based on the Coriolis worldwide database, populated with Medspiration match-ups. Implementation almost completed and ther first results are now available (seelater presentation). The MDB will be online in May (http://www.medspiration.org). MERSEA has also invested in the GHRSST-PP HR-DDS system which is populated with Medspiration DDS data. This is already online at http://www.hrdds.net.

A common approach and strategy to develop global and regional level 4 products has been developed within MERSEA. This has separated the tasks (input data selection, OI, validation) within a common methodology but with shared responsibilities for global and regional analyses. The current system methodological aspects iinclude

- Preprocessing of data from L2P to collated (L3P files)
- Input data selection
- SSES determination
- Sensor bias correction (based on collated, MDB and DDS)
- Application of an OI scheme using collated data (L3P) to L4 based on Medspiration software (Bretherton) with boith low resolution and high resolution merging (two step analysis).
- Validation of L4, definition of quality indicators.

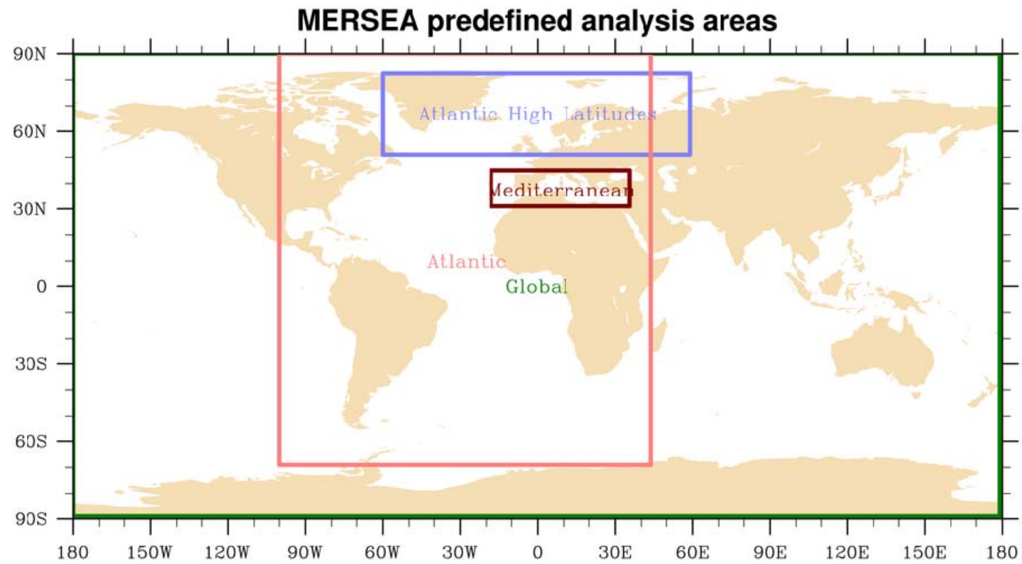


Figure 3.3.5.2. MERSEA pre-defined L4 analysis window areas including Mediterranean sea (2km), high latititudes (2Km), Atlantic (5 km), Global (5-10 km)

LeBorgne concluded with plans for a MERSEA V2 system which includes a pre-operational regional and global MERSEA analyses running in **October 2006. Fuyrther work to i**mprove the validation component and to run this set of pre-operational analysis in 2007. In the longer term, MERSEA will transition into the GMES Marine Core Service and provide a European GDAC (2008) that will consolidate SST TAC to develop functions required for GMES Marine Core Service as a sustainable and operational service. The GMES SST-TAC baseline will be

- Based on Medspiration/MERSEA for data processing model, processing/archiving platform
- Mirror GHRSST-PP GDAC functions => secured access (technically, politically and financially) to data
- Add a reanalysis capacity
- Improved validation and monitoring of products

3.3.6 Application of Medspiration data products, Ian Robinson

Robinson provided a review of the ESA Medspiration applications user community feedback obtained during the first year of Medspiration project. There are several distinct categories of users within Medspiration with different user requirements.

Operational Oceanography

- Near-real time assimilation of L2P data directly into ocean models
- L2P data input to SST analyses
- L4 analyses used in NWP
- L4 analyses used in ocean forecast models

Scales of operational applications

- Global or basin scale ocean forecast models
- Regional models
- Local models

The "operational" basin scale ocean models include MERCATOR – France, FOAM – UK, MFS – Mediterranean forecasting system, TOPAZ – Norway and **MERSEA system.** Regional – local models include POLCOMS – UK Shelf Seas, BOOS – Baltic operational ocean system and NORWECOMS.

Operational user preferences are quite diverse as some want L2P, others L4 and some need the ancillary fields – some don't. It is clear that users need to be informed about the issues that have been debated (and largely resolved) within GHRSST E.g. Foundation temperature and Diurnal variability or about the differences between the SST products provided by GHRSST-PP. To assist in this process, ESA insisted on a number of highly beneficial user consultation meetings to learn from case studies, follow the lead of others and gather new science and team members.

Robinson discussed the concept of intermediate users which is emerging from the EU GMES Marine Core Service development. These are far more diverse than "top-level" operational users and include coastal / local ocean monitoring and management responsibilities, Navigation and maritime safety agencies, Fisheries and primary production, Pollution and water quality, Science users, Military users commercial users (offering value-added forecasters), offshore and coastal engineering, the general public users (e.g. beach temperatures).

Following on from intermediate (value adding) users downstream or 'end users' are the direct users of the SST data. Typically these users prefer analysed products where ease of access is important. This type of user needs clear information about what the data represent and the limits to the data. Many (will) use the outputs from operational models which may not be the SST products at all but information about water quality etc depends on SST observations. This is a complex area that the GHRST-PP AUS must address and Robinson was pleased to see the presentation of Sue Heinz that identified user focussed activities in the USA. Robinson suggested that Heinz and Medspiration could work very effectively together.

Robinson concluded that the GHRSST-PP and Medspiration user base will continue to grow but as operational ocean models develop, so will the user expectations and wider access to SST data will be demanded.

3.3.7 OPenDAP applications using GHRSST-PP data sets, Peter Cornillon

Cornillion began with a short history of the OPeNDAP system which evolved from the Distributed Oceanographic Data System (DODS). DODS was conceived at a workshop held at URI in 1993 and the basic system was designed and implemented in 1993-1995. DAP2 (the current Data Access Protocol or DAP) was first released in 1996. DODS consisted of two fundamental parts:

- A discipline independent core infrastructure for accessing data.
- A discipline specific oceanographic portion – population, location, etc.

To isolate the discipline independent part of the system from the discipline specific part, two entities were formed in 2000:

- The Open Source Project for a Network Data Access Protocol (OPeNDAP), a 501 c(3).
- The National Virtual Ocean Data System (NVODS) a distributed oceanography data system managed from the University of Rhode Island originally funded by NOPP.

The fundamental objective of OPeNDAP is to facilitate internet access to scientific data. This is done by providing a protocol (DAP) to access to data over the internet, hiding from the user the format in which the data are stored, and providing a subsetting capability for the data at the server. OPeNDAP is based on a client-server architecture and the OPeNDAP software is open source which results in it more likely to be adopted by many users and provides benefits from community software contributions. The OPeNDAP Data Access Protocol (DAP) defines the model used to describe the data, the request syntax and semantics and response syntax and semantics. Basically, OPeNDAP is a server<>client architecture and there are more than 1000 data sets served via OPeNDAP that include data form Meteorological, Oceanographic, Land Cover and many other disciplines. A partial list of serving institutions/projects is available at the OPeNDAP web site http://www.opendap.org and Cornillion encouraged the GHRSST-PP community to register their data. Cornillion noted that in the future a new Server 4 system would be developed that will have enhanced capabilities including Integral THREDDS catalog support and be http *and* GridFTP capable.

Cornillion noted that a dedicated Matlab GUI has been developed for the 1/12° North Atlantic Ocean HYCOM Prediction System providing daily time series of the best model outputs estimates. In addition to a GUI, the associated programs may be called as a function in Matlab.

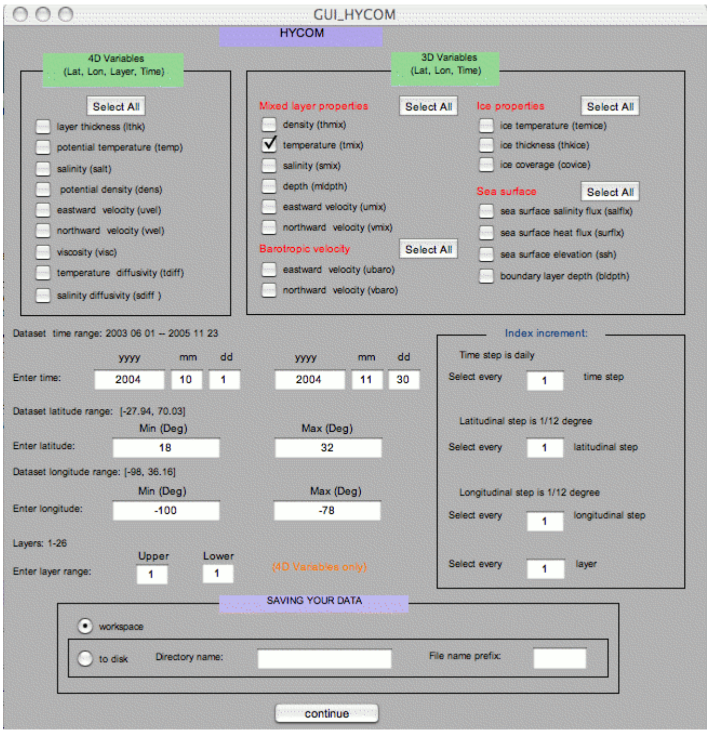


Figure 3.3.7.1 Matlab GUI developed to access HYCOM data via OPeNDAP.

Noting that SST fronts may present a very sensitive measure of the performance of a model, using the interface, Cornillon was able to download all SST fields for the Gulf of Mexico winter months 10/03-12/03, 10/04-12/04, 10/05-11/05, take the gradient of the fields (a Matlab function), threshold the gradient magnitudes - 0 if $|\nabla T|<Tc$; 1 if $|\nabla T|>Tc$, sum the thresholded fields and compare with AVHRR SST fronts for winters 1985-1995.

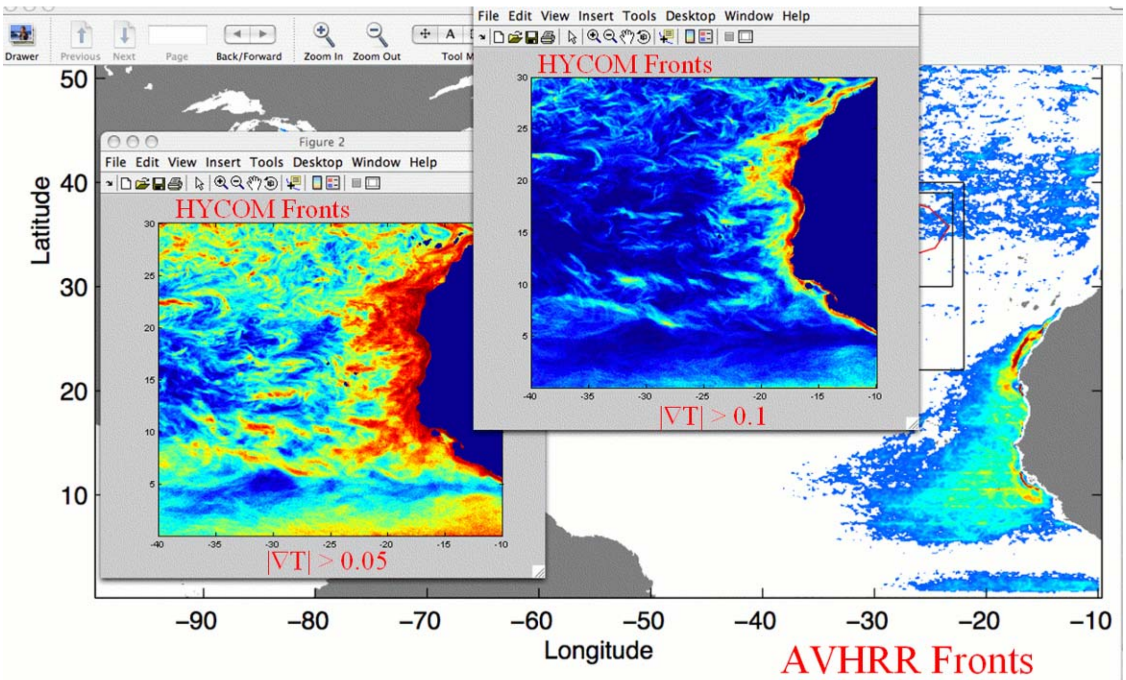


Figure 3.3.7.2. Gradient analysis of frontal systems in the N Atlantic 10/03-12/03, 10/04-12/04, 10/05-11/05 from HYCOM model outputs and AVHRR Pathfinder.

Cornillon concluded that many users want easy access to data in gridded (L3P?) formats and warned the GHRSST-PP Science Team that L2P and other swath data is generally beyond many users other than the operational agencies. Cornillon urged the GHRSST-PP to develop appropriate L3/L3P products and to register data sets with OPeNDAP. In addition, work to improve machine to machine inventory query (e.g., MMR links to OPeNDAP) should be explored. Finally, Cornillon noted that MATLAB GUIette's can be developed fopr some GHRSST-PP data streams.

3.3.8 Diurnal Warming and SST Requirements from SEAFLUX, Carol Anne Clayson

Clayson began noting that the SEAFLUX project was established by GEWEX Radiation Panel. There is a need for high-resolution accurate surface fluxes of heat, water vapour, and momentum over the global ocean at 1° spatial resolution, with 3 - 6 hour time resolution and an accuracy of 5 W m-2. This is a demanding target with many issues and a challenges but is basically limited to the resolution of surface winds. The main questions for SEFLUX are

- What is feasible in terms of time-space resolution, length of time series for global ocean surface turbulent flux dataset?
- Can we produce dataset better than NWP or climatology?
- What are the best methods for producing this dataset?
- How do these fluxes perform?

With these questions in mind, SEFLUX has established a set of activities:

- Create library of in situ datasets
- Create library of satellite datasets collocated with the in situ datasets
- Evaluate and improve turbulent flux models
- Produce high resolution SST
- Evaluate and improve methods for Ta and qa from satellites
- Evaluate and produce global high-resolution satellite-derived surface turbulent fluxes
- Evaluate global flux products in context of applications

SEAFLUX surface fluxes require SKIN sea surface temperature as the use of SSTdepth can introduce errors of up to 10% in fluxes, even more for latent heat fluxes when the SST is high. In particular, the use of deeper observations of temperature can mean larger biases as these are diurnally variable. SEAFLUX needs fluxes that capture the diurnal cycle as the impact can be great. For example, a change in 1°C in SST results in a change of nearly 30 W m-2 in the net surface heat flux in the tropics but diurnal warming can often exceed 3°C in the tropics. There are significant differences between fluxes calculated from SST with a diurnal and without diurnal components (Figure 3.3.8.1).

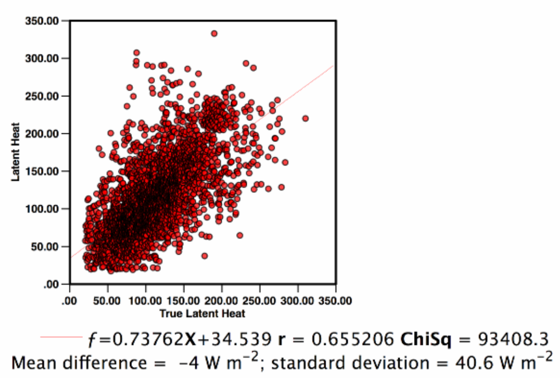


Figure 3.3.8.1(a) Latent heat flux estimates calculated using diurnally corrected and diurnally contaminated SST.

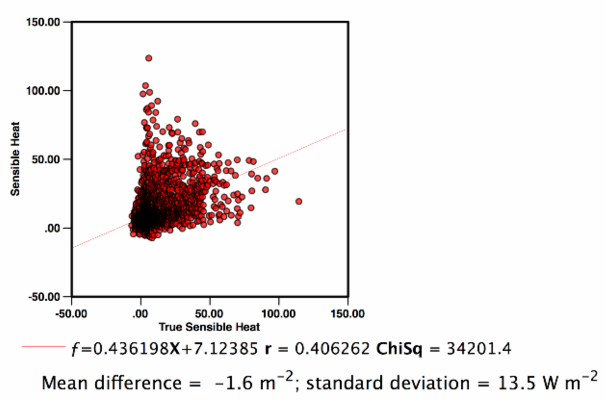


Figure 3.3.8.1(b) Sensible heat flux estimates calculated using diurnally corrected and diurnally contaminated SST..

Current work includes application of the Clayson and Curry (1996) derived method of resolving diurnal cycles in the tropics using satellite data. This method was applied to create a SST dataset for the years 1996-2000 and as part of this process, a derived equation is used that computes the amplitude of the diurnal warming in skin SST, regarded as dSST (Webster et al., 1996). Comparisons of computed dSST show no clear regional patterns for bias or correlation, an average bias (Buoy – Satellite) for dSST comparisons of -0.002°C with a standard deviation of 0.26°C and a correlation between the two dSST datasets of 0.74. The average bias for winds was less than that found for SWR. The random error analysis was run on the data and with the average peak SWR and average wind speeds observed in this dataset, a standard deviation close to the 0.26 observed was found.

To further study the variability an EOF analysis on spatial data was performed. The Average dSST values were calculated for the whole period and for each month and for each tropical ocean basin, an EOF analysis of the dSST data was performed on the years available (1996-2000). Note: The dSST values ranged from 30N to 30S and were at a 0.25° x 0.25° resolution. An example output is shown in Figure 3.3.8.3 for various ocean basins. In the Pacific and Atlantic shortwave radiation is dominant but in the Indian Ocean convection due to the summer monsoons (May-Aug.) and increased wind speeds from low level cross-equatorial jet is eveident in dSST mode 1 EOF's

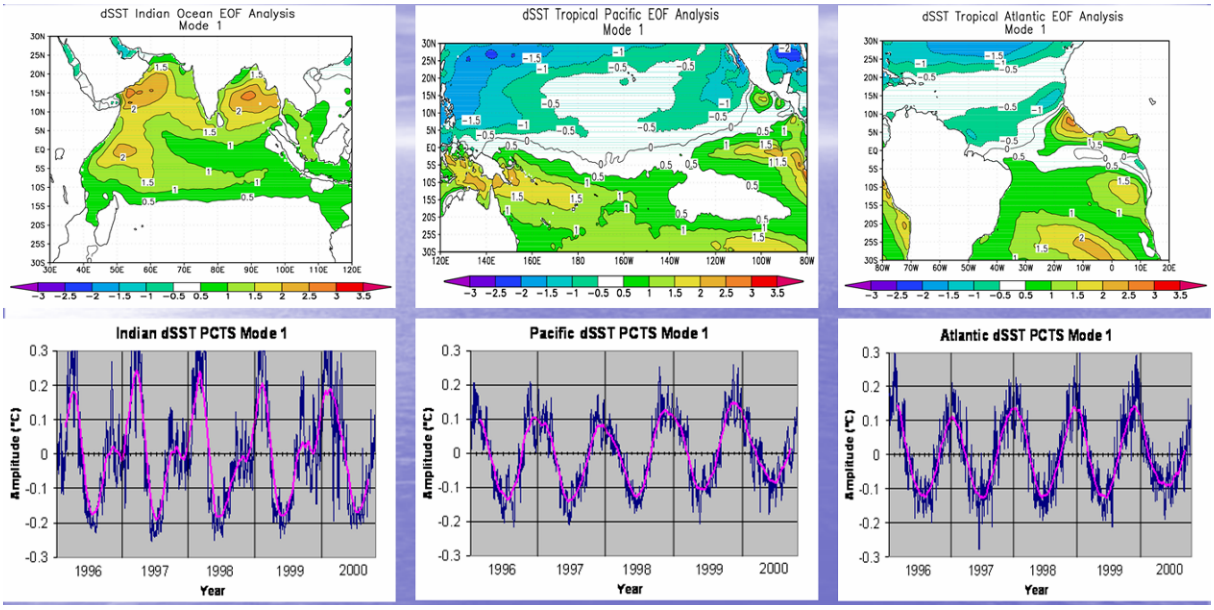


Figure 3.3.8.2 EOF Analysis of dSST showing Seasonal Variability in the Indian Ocean, Tropical Pacific and Tropical Atlantic Ocean.

Clayson concluded that with a user requirement for SEAFLUX and requested the best possible skin surface temperature at the time of the satellite pass (or SST with full diurnal cycle), along with error characteristics. SEAFLUX will use these data to develop improvements to diurnal parameterization (comparisons with other skin measurements, evaluation of turbidity, precipitation effects. uring the discussion several actions were raised including GEWEX and GHRSST-PP to agree on the definitions of SST, a formal user requirement from GEWEX will be sent to the GHRSST-PP

3.3.9 Status and Potential Impact of ICOADS, Scott Woodruff

Woodruff gave an overview of the NCAR-NOAA International Comprehensive Ocean-Atmosphere Data Sets (ICOADS) project status. This is a cooperative project between NCAR and NOAA including contributions from ESRL and NCDC and the wider international community. The project is mainly concerned with observations made by ships for several centuries that are mainly VOS although some Research Vessels are also considered by the project. WMO Pub. 47 is a key reference as this specifies instrumental and platform metadata. Some systems, e.g. Ocean Data Acquisition Systems (ODAS) buoys have very limited metadata.

The latest release of ICOADS covers the 1980 – 2005 data set (GHRSST-PP era) and include millions of observations per year (Figure 3.3.9.1(a)). However, when these observations are broken out by platform type, there is a distinct decline in ship observations and an increase in buoy observations (Figure 3.3.9.1(a) and (b)). Such a change in the configuration of the in situ observing system needs to be considered when developing SSES data sets for SST satellites as there is an additional varying uncertainty associated with the mix of ship and buoy errors.

Woodruff noted that coverage on a monthly basis by ocean basin is relatively good except for the high latitudes and obviously outside of the major shipping lanes. Woodruff noted that delayed mode processing tends to result in more observations within the ICOADS database as processing decreases the number of drifting buoy reports and increases reports for ships, moored, and C-MAN buoys.

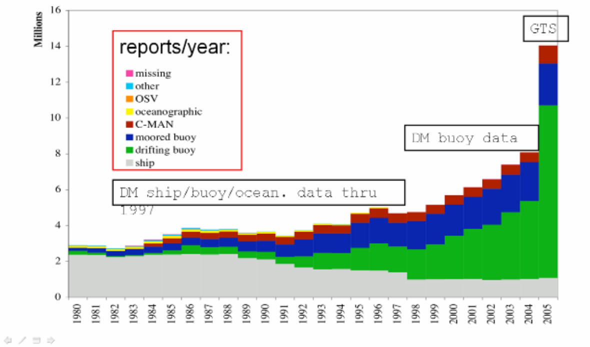


Figure 3.3.9.1(a) Number of reports per year entering the ICOADS release 2.3 between 1784 and 2005

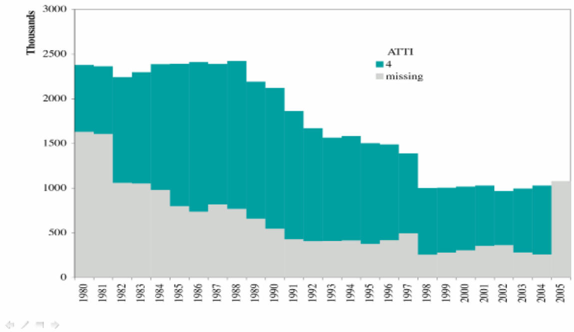


Figure 3.3.9.1(b) The changing nature of the in situ observing system. From *VOS Instrumental & Platform Metadata: WMO Pub. 47* (Liz Kent & Dave Berry, UK NOCS)

Woodruff concluded that ICOADS V2.3 could be released in a few months and would be an excellent resource for GHRSST-PP RAN SSES development. Furthermore, there is a synergy between satellite and in situ data especially as the satellite data can be used to help QC buoy observations but in return also to help define SSES for the satellite data.

Donlon and others noted that it was extremely important to try and keep the ICOADS data set as upto date as possible and recommended that a NRT processor be used to assist the QC team. GHRSST-PP could work with the ICOADS team immediately within the GHRSST-PP RAN effort and urged the RAN Chairman to follow up these opportunities.

3.3.10 Plenary Discussions on the session

During the remaining time of the session, it was agreed that there is a clear need for L3 gridded products within GHRSST-PP that will complement the L2P and L4 data sets and an action was taken to establish a small group to look at L3 gridding of L2P fields including Helen Beggs, P. LeBorgne, J. Vasquez, J. F Piolle and P. Cornillon). At IFREMER there is a system being set up to re-grid and data to develop new products. Will also be used in the OSI-SAF and this could form the basis for L3/L3P discussions. In addition, an action was established for the OSI-SAF/IFREMER/RSMAS/p. Cornillon to discuss the development of an open source L2P regrinding tool and report to next ST meeting

3.4 Session 3. Application/development of new data streams

3.4.1 Use of NSIDC sea ice data sets within the GHRSST-PP, Florence Fetterer

Fetterer began with a short introduction to the National Snow and Ice Data Center (NSIDC) which is located within the University of Colorado's Cooperative Institute for Research in Environmental Sciences (CIRES) acting as a World Data Center for Glaciology since 1976. The NSIDC DAAC provides an operational data facility including data management activities emphasis onsatellite data including passive microwave, e.g.: AMSR-E (AQUA), AMSR (ADEOS II) and VIS/IR at Moderate Resolution e.g.: MODIS (TERRA, AQUA) Snow and Ice Products. NSIDC is supported by NOAA for data management activities with an emphasis on in situ data, data rescue, and data sets from operational communities and is affiliated with NOAA NGDC with links to NPOESS.

There are about 40 sea ice products in all with 18 updated regularly and 7 of these are produced in house which can be accessed at http://nsidc.org/data/sea ice/. NSIDC assumes that for GHRSST-PP sea ice is a contaminant and the applications require high resolution 5-10km data sets, that are available in a timely manner (6-12 hours after acquisition). Fixing the ice edge position accurately is more important than accurate interior pack concentrations and the concentration in the marginal ice zone (MIZ) is important. Uncertainty estimates are required (these become esp. important if swath data are used) and there is a need for both accuracy, and continuity with existing record (though reprocessing at NODC allows for two data streams) as part of the GHRSST-PP RAN effort.

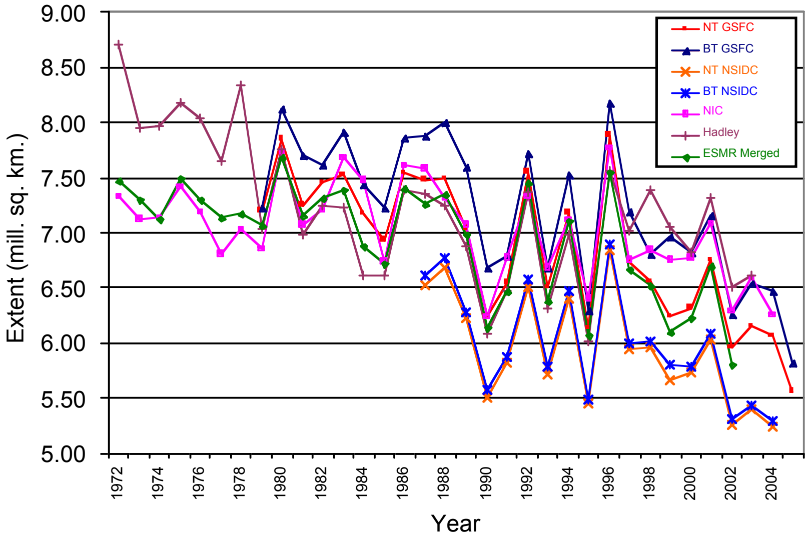


Figure 3.4.1.1 Sea ice extent since 1972 estimated from passive microwave satellite observations using different algorithms

Passive microwave satellite observations provide the workhorse data set for sea ice observations from space (see Figure 3.4.1.1) however there are both positive and negative aspects to this data set:

- *The Positives*
  - Long record *(ESMR, 1972-77; SSMR,SSM/I,SSM/IS; 1978-present; AMSR, 2002-2008;….and going into the future, SSMIS,CMIS, ESA Sensors?…)*
  - Not (much) affected by atmosphere
  - Easy to process, near complete spatial and temporal coverage
  - Almost 30 years of algorithm research

- *The Negatives*
  - Poor resolution, compared with visible, IR, and SAR
  - Underestimates ice concentration – seasonally dependant bias
  - Most products smear out the real ice edge, or fail to detect it if there is a wide MIZ

(~75 km resolution of the 19 GHz channel)

Passive microwave ice concentrations are biased low relative to observations made using other data sources by about 10% to 20%, with the bias being greater in summer (Partington et al., 2003). Comparisons with NIC charts reveal that SSM/I passive microwave data may not detect ice concentrations as high as 60%. The ice edge was in about the same position in Sept 2002 and Sept 2003, but 2003 had a wider band of lower concentration ice within the edge for much of the Arctic. SSM/I data put the ice edge more often along the 60% contour line in 2003 (Figure 3.4.1.2). The Cal-Val algorithm is probably best for concentrations at the ice edge although it does poorly in other areas. This highlights the fact that what is optimal for GHRSST-PP is not optimal for a sea ice CDR

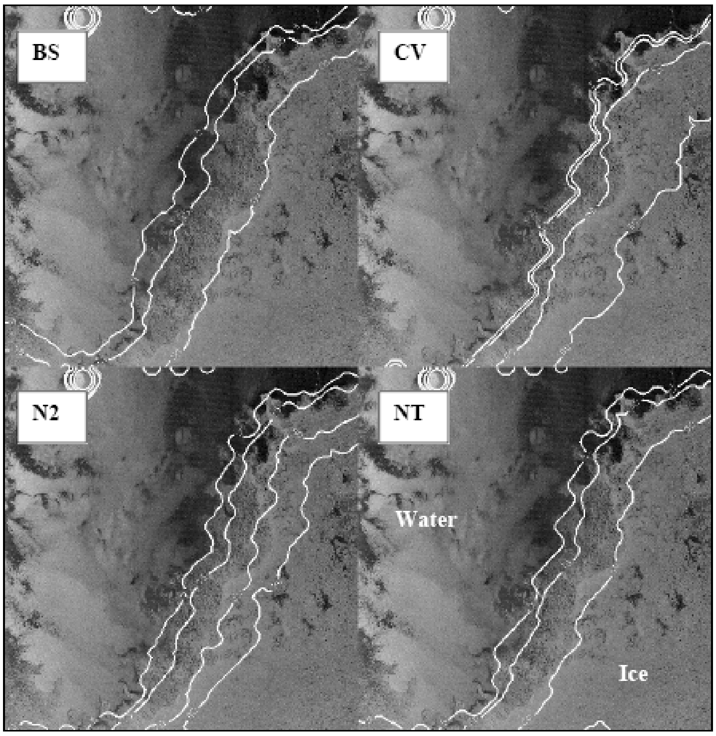


Figure 3.4.1.2 Bootstrap, Cal-Val, NASA Team 2, and NASA Team algorithm ice edge contours compared with SAR imagery.

The main standard product from NSIDC is DMSP SSM/I Daily and Monthly Polar Gridded Sea Ice Concentrations. NSIDC produces these using orbital brightness temperature (TBs) data from Remote Sensing Systems (RSS) and the sea ice data set is updated using these TBs every 3 to 6 months. The products use a 25 km grid, polar stereo projection true at 70 deg N and have been ongoing since 1987. Two algorithm product are provided (Bootstrap, and NASA Team) but land contamination effects not eliminated and a weather filter removes most false ice over water. Goddard also produce Bootstrap Sea Ice Concentrations from Nimbus-7 SMMR and DMSP SSM/I (Bootstrap alg) and Sea Ice Concentrations from Nimbus-7 SMMR and DMSP SSM/I Passive Microwave Data (Modified NASA Team alg).

NSIDC produce in real time DMSP SSM/I Daily Polar Gridded Sea Ice Concentrations (“NRTSI”) using the NASA Team algorithm and orbital TBs from Marshall Space Flight Center (Versus TBs from RSS). Typically these are available within 1-2 days following SSM/I image acquisition (Versus 3-6 months for NSIDC “standard” product) These products have been developed to meet the needs of the MODIS and CERES Science Teams for a NRT product but are not really appropriate for long term trend analysis as they need retrospective QC to account for land contamination effects and residual weather effects (which should be removed). In addition, a sea ice index product is available in NRT as a tool for visualizing and monitoring sea ice based on monthly average data. This is both timely (within a month) and consistent based on the NASA Team algorithm. It is similar to the NRTSI, but processed to match GSFC as closely as possible (for land contamination and weather effects) - “NRTSI-G” and uses DMSP SSM/I Daily Polar Gridded Brightness Temperatures as input. These TBs are produced at NSIDC from RSS orbital (swath) TA data when they become available (generally 3 to 6 months after acquisition). The gap between RSS data and the present is filled with MSFC data.

Feterer then considered the AMSRE data asset which has a higher resolution and gives better ice edge detection as illustrated by this comparison of MODIS (visible band) and AMSR (passive microwave) imagery with SSM/I shown in Figure 3.4.1.3.

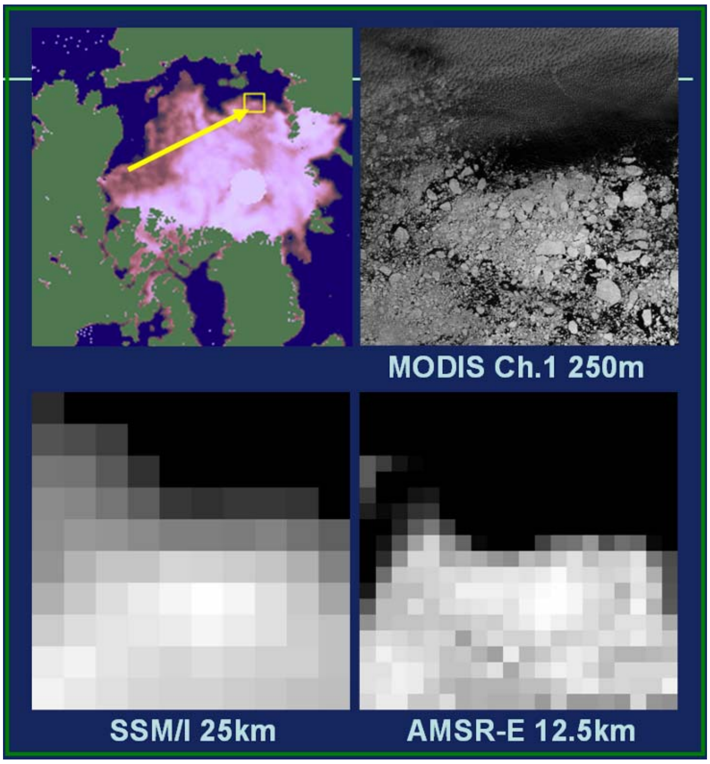


Figure 3.4.1.3 Comparison of MODIS (visible band) and AMSR (passive microwave) imagery in the Arctic Ocean with SSM/I.

AMSR, an instrument similar to the CMIS on NPOESS which will continue the data record, detects ice at higher resolution and thus more accurately than does SSMI, particularly in summer and at the ice edge, as shown in these difference images. A new set of AMSR-E/Aqua daily products with L3 12.5 km Tb, Sea Ice Conc., & Snow Depth Polar Grids is being developed. 2002 - near present (Design life of AMSRE is to 2008). The TBs and ice concentrations include daily ascending averages, daily descending averages, and daily averages; snow depth over sea ice data is a five-day running average. Products using the Bootstrap Basic Algorithm (BBA, Comiso 1995) for the Antarctic and the Enhanced NASA Team (NT2) algorithm (Markus and Cavalieri 2000) for the Arctic will be developed. NT2 uses 89 GHz to select an atmosphere model for better weather filtering and thin ice detection) and studies using AVHRR and operational charts have shown that NT2 on average outperforms other algorithms at the ice edge in the Arctic (McKenna and Meier, 2002; Meier, 2005). An incoming data stream received via JAXA (Japanese Space Agency) and RSS which is processed with QA by the Science Investigator-led Processing System (SIPS) at the Global Hydrology and Climate Center, MSFC, prior to delivery to NSIDC (Conway, 2002). NSIDC receives a provisional product from GHCC about 20-48 hours after satellite acquisition which is distributed via ftp.

The future is towards merging of SSM/I, SSMI/S, AMSR-E, CMIS. As of now there is no single clear-cut superior sea ice data product. There are, however, consistent products that provide the requisite baseline for extension with CMIS. Research is needed to develop Intelligent data fusion and error flagging. While there are some error studies for various products, there is not yet a data product with complete quality flags.

Fetterer noted that NSIDC's Sea Ice data sets could be used within the GHRSST-PP. NSIDC provides sea ice climatology data sets that could be used in the GHRSST-PP RAN. However, most existing NSIDC products (probably) do not meet GHRSST needs (not timely or accurate enough) as in general one must wait longer for higher quality TBs. But once TBs are available, NSIDC can implement any algorithm for SSM/I or AMSR operationally. This might require a processing system outside the existing DAAC system for AMSR. SSM/I offers consistency with past records, near real time (<24 hr) delivery after time of acquisition, relatively low cost to make an operational feed to GHRSST, algorithms that offer improvements in resolution and accuracy (by incorporating scatterometry or 85 Ghz data) would be relatively inexpensive to implement operationally at NSIDC. In addition, AMSR offers better resolution and accuracy, but without a new processing system, latency is about 48 hours, and we are not as certain that AMSR will continue to operate over the next 5 years.

Possible approaches to these issues include

- Enhanced SSM/I with scatterometry – (Long technique), Potentially better resolution, and better accuracy for ice edge since scatterometry may be less influenced by weather effects at edge. However, spatial resolution is gained at the expense of temporal resolution.
- Enhanced SSM/I with 85 GHz – (Markus technique, NT2) – This improves accuracy, does some sub pixel analysis to improve resolution, NT2 products is on 12.5 km grid
- Special ice/no ice algorithm using (Markus technique) for better ice edge
- Use AMSR, if latency is not a problem
- Enhanced AMSR algorithms using 89 GHz, for even better accuracy (G. Heygster, Univ. Bremen), but weather effects are more of an issue
- An accumulating, time-stamped swath ice concentration product – potentially update with new data every 3-6 hours, though some of the data will be 24-36 hours old
- Should evaluate new NIC ice edge and MIZ (8/10 concentration) products

Fetterer concluded that NSIDC needs to understand the GHRSST-PP requirements better in order to work effectively with the project. In particular, what accuracy edge does GHRSST-PP want? (5%, 15%, etc.), can GHRSST-PP use swath data in order to better match the time of acquisition to SST analysis time? (How swath data are gridded makes a big difference at the ice edge.).What is the right balance between consistency, accuracy, timeliness, resolution? What delivery protocol? RSS feed, OAI, etc. There were many requirements to consider.

During the discussion, an action was raised (Gentemann) to ensure that the requirements of GHRSST-PP from operational and RAN are discussed in the light of Fetterers request for better requirements for sea ice in GHRSST-PP

3.4.2 Development of METOP global L2P SST, Pierre LeBorgne

LeBorgne explained that the schedule for the production of METOP global SST data was as follows

- Satellite Launch: June 2006
- End of processing development: June 2006
- End of processing prototyping: February 2007
- Start of operations: August 2007
- Fully operational: beginning 2008

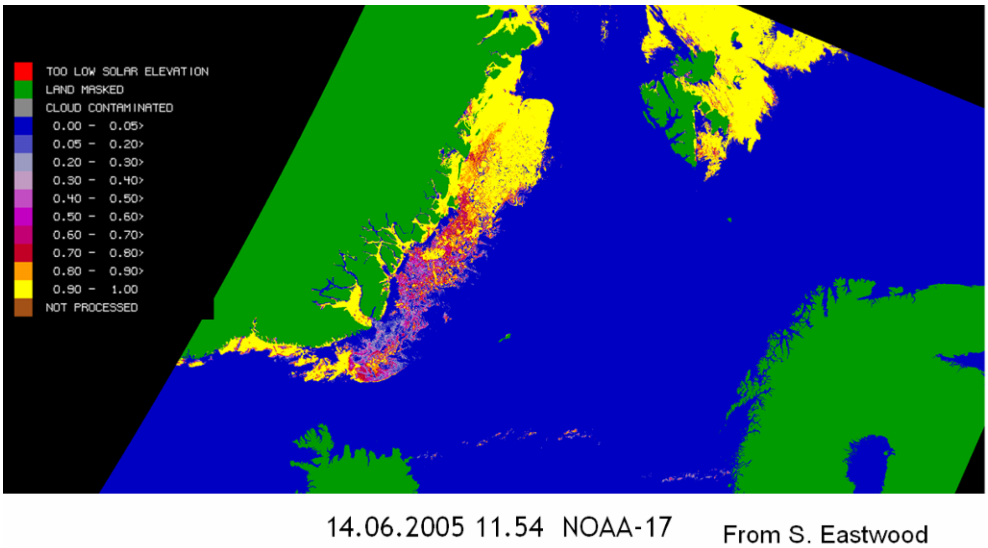


Figure 3.4.2.1 Sea ice fine scale identification (met.no+DMI) using an example daytime ice probability map from N17 AVHRR.

Developments currently in progress include cloud flagging (principle to flag the data rather than mask), SST algorithm development, product serving, AOD correction and ice, minimum temperature values. The scheme used for SEVIRI cloud masking will be developed further for METOP including the building of 6 hourly Aerosol fields from NAAPS and the new SDI correction system developed by

Merchant. Sea ice classification will use a probabilistic approach using ration of Ch2/Ch1 – water, ice, cloud classes with the possibility of 3a/Ch1 ratio to generate an ice coverage probability map. Figure 3.4.2.1 shows an example Ice Probability map developed using N17 AVHRR. Cloud flagging will use a global 1km minimum SST climatology (A too low SST is suspect, especially when close to cloud) as part of the cloud clearing system and a Maximum spatial variability test (too high spatial variability is suspect, especially when close to cloud). In addition a SST front location climatology will be used. Ideally the system needs a an upwelling chart (which does not exist) but we can use the variabiulity of Pathfinder data set.

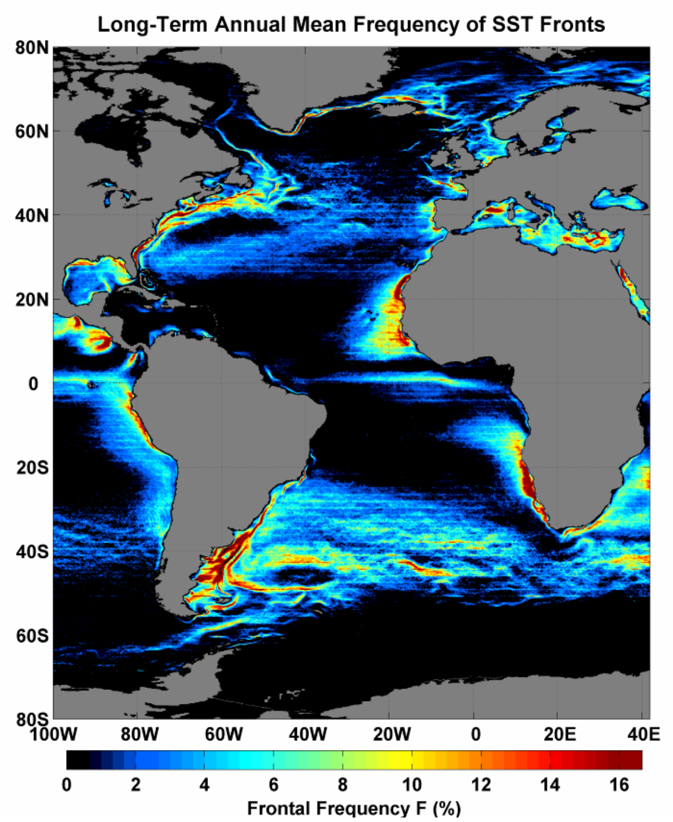


Figure 3.4.2.2 Long-term (1985-1996) mean annual frequency of SST fronts in the Atlantic Ocean (Belkin et

SST algorithms will be based on Radiative Transfer modelling (RTTOV) and will use NWP outputs to simulate BT's and derive the algorithm. Local errors can then be determined through validation. Thus work has been an ongoing experiment over year 2005. Tasks are shared with CMS producing daily (nighttime) SEVIRI errors (0.1 degree resolution), met.no producing daily NWP derived SEVIRI errors (model resolution) and the Univ. Edinburgh analyze the impact on the SEVIRI MDB. For uncertainty estimation a Proximity confidence level will be determined for each pixel based on a similar scheme used for SEVIRI (distance to cloud, distance from climatology). This may not be the best system to use and LeBorgne was keen to hear from the Science Team regarding alternative methods. One improvement is the use of an MDB stratified by regional seas.

Le/borne concluded that both gridded and swath based p[products will be available in netCDF, GRIB and L2P (what is the required content?) from the MERTOP system. Help and advice regarding the most effective method for uncertainty estimation is required especially in terms of setting appropriate thresholds for proximity confidence values.

3.4.3 Development of MODIS global L2P SST, Brian Franz

Franz began by explaining that MODIS L2P data are being developed through a tri-partite agreement and separation of tasks between the Goddard Ocean Biology Processing Group (OBPG), the University of Miami and JPL PO.DAAC. the historical and practical reasons for this arrangement are complex but so far good progress has been made. Standard Global Production (transitioning from MODAPS/DAAC) Level-0 through Level-3 for Terra & Aqua, Day and Night, 11-12um and 4um SST products is done at the OBPC including an online archive and distribution (L1A, L2, L3) of products. The GHRSST L2Pcore Production is a parallel production effort, at no additional cost taking Level-0 through to L2Pcore is operational and includes Terra & Aqua, Day and Night, 11-12um and 4um SST products which are distributed to PO.DAAC for L2P conversion. User Support via SeaDAS (distributed processing software, display and analysis) and the OCForum (online user support forum) is monitored by project staff. Figure 3.4.3.1 provides a summary overview of the MODIS L2P processing system.

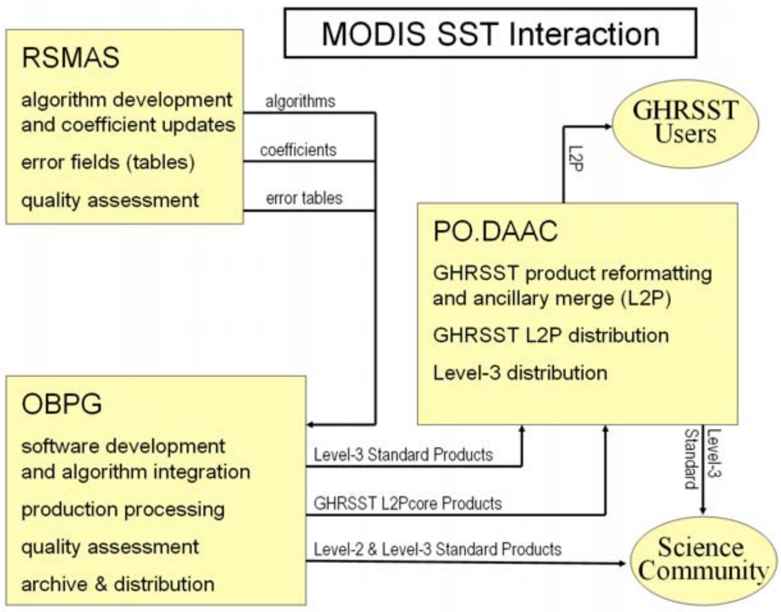


Figure 3.4.3.1 Processing chain to develop MODIS L2P data files

L2Pcore files have been available to PO.DAAC via rolling ftp archive since October 2005 although the actual file content is still evolving - recent updates incorporate SSES derived from the hypercube approach of Miami. SSES are based on static tables developed by RSMAS which is a function of:

- SST
- day or night
- season
- view zenith
- BT difference
- latitude
- quality level

SSES numerical values are assigned to quality levels (similar in concept to proximity_confidence values) so that all data have an associated bias and standard deviation error estimate. The SSES lookup tables are derived form a comprehensive MODIS MDB system maintained at Miami. An example 4µm SST and corresponding quality level is shown in Figure 3.4.2.2.

The current MODIS L2P file content includes:

Data Set	Description
year, day, msec	scan time
longitude	pixel longitude
latitude	pixel latitude
sst	11-12um SST
bias_sst	11-12um SST SSES bias
stdv_sst	11-12um SST SSES std. dev.
qual_sst	11-12um quality levels
sst4	4um SST
bias_sst4	4um SST SSES bias
stdv_sst4	4um SST SSES std. dev.
qual_sst4	4um SST quality levels
sstref	Reynolds SST (co-located)
l2_flags	e.g., land, day/night per pixel

Approximately ~65MB of data are generated per 5-min MODIS granule in uncompressed format which gives ~20GB (288 granules) per day per MODIS sensor.

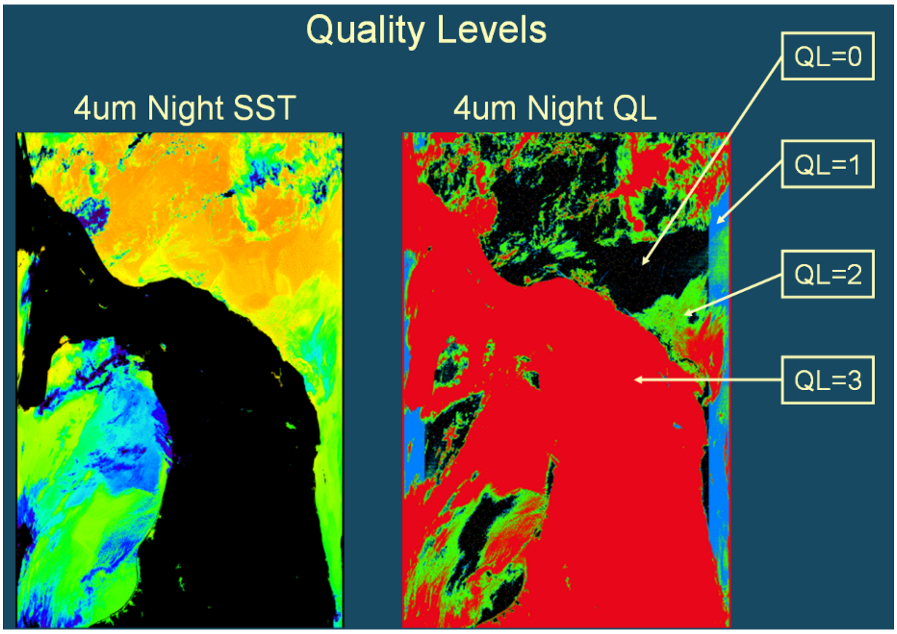


Figure 3.4.3.2 Example of MODIS 4µm SST product and corresponding MODIS L2P quality levels for the 4µm SST product

The large volume of data generated by MODIS L2P was discussed in detail. Franz provided "Potential" Options for L2Pcore File Size Reduction which included:

1) Deal with it ! The "H" in GHJRSST-PP stands for high-resolution.
2) Sub-sample L2Pcore lon/lat along-scan by 8 (28% reduction)
3) 4um 'extra' SST data
    a) eliminate from L2Pcore (19% reduction)
    b) produce separate L2Pcore for 4um (night) and 11-12um
    c) eliminate from daytime L2Pcore (mixed day/night?)
4) Quality Levels
    a) zero-out lower quality pixels to improve compression
    b) reformat from swath to time-ordered vectors and only include best quality pixels.
5) Reduction of Resolution
    a) sub-sample to every 4th pixel & line (4km at nadir, 84% reduction)
    b) average to 4km at nadir (raises many problems/concerns)

However Franz noted that there were also "Potential" Options for L2Pcore Expansion which included

1. Sensor zenith angle
2. brightness temps
3. chlorophyll concentration
4. daytime, cloud & glint-free
5. aerosol optical thickness
6. daytime, cloud & glint-free

The distribution of MODIS processing is through the PO.DAAC and via Goddard. Files distributed to JPL PO.DAAC via rolling ftp archive have been operational since 14 October 2005 with recent updates to incorporate SSES fields. Data access can be found at

- Aqua (ftp://oceans.gsfc.nasa.gov/MODISA/GHRSST/)
- Terra (ftp://oceans.gsfc.nasa.gov/MODIST/GHRSST/)

Quicklook Products are available from the best available ancillary, predicted attitude/ephmerides ~5 hours from time of observation. Refined products including preferred ancillary, definitive attitude/ephmerides are then available 2-8 days later.

The Science Team noted that the OBOPG provide non-standard L2P data although this should not be a major issue as JPL convert these data to correct format L2P. An action was raised on Bob Evans to undertake a mapping of Quality levels for MODIS into GDS-1.7 proximity_confidence levels. In terms of data reduction, the Science Team recommend that MODIS data are sub-sampled to 4km due to swath edges. It was agreed that this product could form a L2P_GRIDDED (L3/L3P?) 4km product, equal angle projection but that 1km L2P should be the 'normal' data set for GHRSST-PP.

3.4.4 Development of GOES L2P SST, E. Maturi and Andy Harris

Harris began with a review of the GOES L2P production chain. The GOES L2P product contains L2P (not just L2P-core) and initially funded an OSDPD contractor who failed to complete the development task. Post-AGU Ocean Sciences, it was decided to employ UMD-CICS post-doc (Jon Mittaz) to develop code following the methodology developed by Andy Harris. The system was implemented by Jon and competent OSDPD systems analyst (Bob Potash) and initial products will be made available on anonymous FTP for validation by GHRSST members. Following successful validation, the code and product will be documented and approved for operation production. It is estimated that the date for completion will be towards the end-May 2006.

L2P data are derived from GOES SST area files (satellite projection) and are therefore ½ hourly. It was chosen to work this way because this is the scale on which the validation is done at so the error information we supply is then consistent. Data are developed for GOES-E & W, N & S sectors, and results in ~0.5 TB per file which equates to ~24 GB day-1. ancillary fields use NCEP wind speed and 3-hr average solar irradiance values that are spatially interpolated to each GOES SST pixel (wind speed is also time-interpolated). AVHRR aerosol optical depth from NESDIS 100-km daily analysis is n-n sampled to each SST pixel, along with age of observation. Proximity confidence is derived from Bayesian probability of clear sky. Sea Ice fraction is spatially interpolated from NCEP analysis and a Sunglint flag is calculated as part of Bayesian cloud detection. The processor also uses NCEP data and pCRTM calculations to estimate SSES for each SST value (currently use NCEP profile and SST – 2 m air temp). Figure 3.4.4.1 presents an example GOERS-12 2P data set.

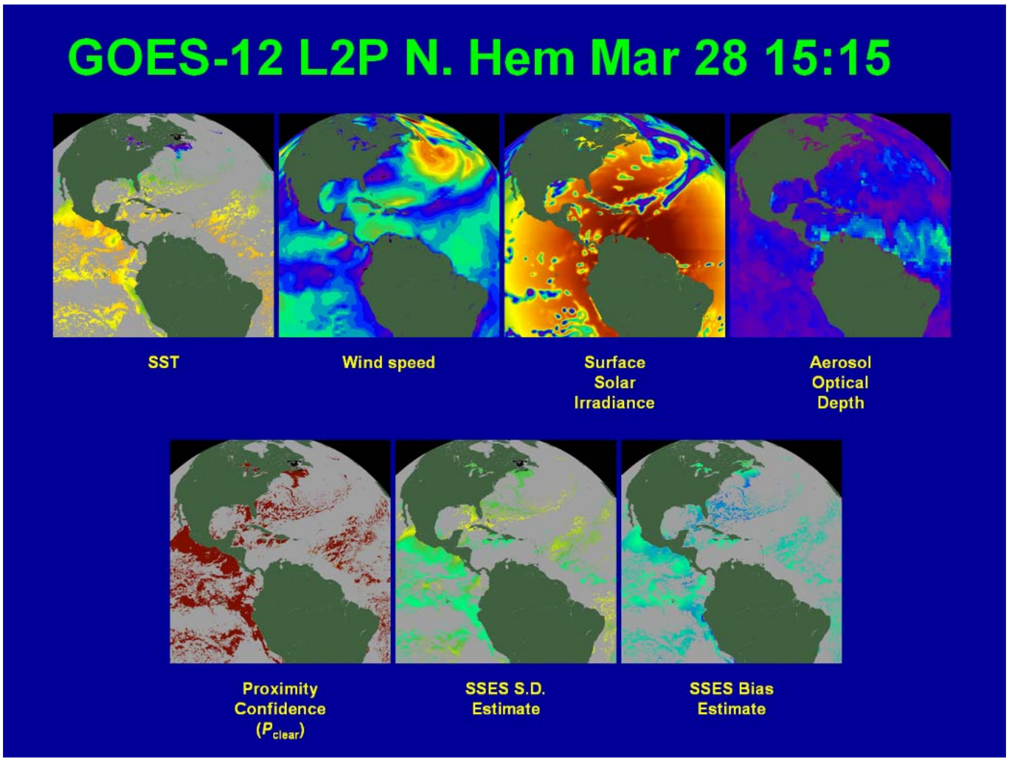


Figure 3.4.4.1 Example of GOES-12 L2P data for March 28th 2006 @ 15:15UTC.

Harris noted that SSES derivation had been an important part of the GOES L2P work. The team is using SSES to provide additional information that cannot be calculated from L2P ancillary data. As a first attempt, it is assumed that the retrieval bias depends on clear-sky transmittance (calculated from NCEP → pCRTM)and the air-sea temperature difference (currently NCEP only). Furthermore it is assumed that sensitivity to ASTD increases with decreasing transmittance. Based on these assumptions, the bias error is derived using

bias = offset + gradient×ASTD for different $\tau 11$

The post-corrected σ is estimated as a function of transmittance only and is different for sensor/day/night. However, more work is required for GOES-12 daytime. The team will also explore expected retrieval bias based directly on BT calculations, but retrieval coefficients currently derived from different RTM.

During the presentation an action was placed on Eileen Maturi to send a mail with ftp site of test products for L2P to go on ghrsst –pp web site. Helen Beggs noted that when MTSAT is available the BoM Intend to produce a skin SST from these data. NOAA/NESDIS will also produce the same products (SSTskin) so these could use NESDIS code. Helen Eileen & Andy Harris took and action to discuss the transfer of code from NESDIS to BoM for MTSAT processing if appropriate.

3.4.5 Use of Windsat data within the GHRSST-PP, T. Mavor

Mavor noted that WindSat is a Risk Reduction Mission for NPOESS CMIS which was launched in January 2003 to see if wind vectors can be derived from polarmetric MW data – SST is not the primary mission requirement. CLW, TPW Rain are also produced by the mission which stayed in "Safe-Hold" from mid-Feb 2005 to mid-Jun 2005 providing Satellite Data Records (Tbs) in near realtime from NRL. Windsat is a fully polarimetric microwave radiometer with channels at 10.7, 18.7, and 37.0 GHz although the 6.8 and 23.8 GHz have vertical and horizontal only. The instrument has a forward and an aft view although the aft view has not been not used properly yet. There are significant calibration issues with windsat which is the most frustrating part of this complex mission so far. Collocated EDRs: for Wind Vector, SST, CLW, TPW, Rain have been developed by NRL (V1.9.0) and delivered to FNMOC since Jan 06. An archive (Registration required) is available at http://podaac.jpl.nasa.gov/windsat. An example global product for 1 day is shown in Figure 3.4.5.1.

Global coverage WindSat SST Statistics (v191) based on 8 months of co-located WindSat, QuikScat, SSMI and NCEP model (GDAS) fields amounting to ~4 million points. The mean bias error is 0.05°C with a StDev of ±0.76°C. SST errors are highly related to wind speed direction effects and it is very important to account for this.

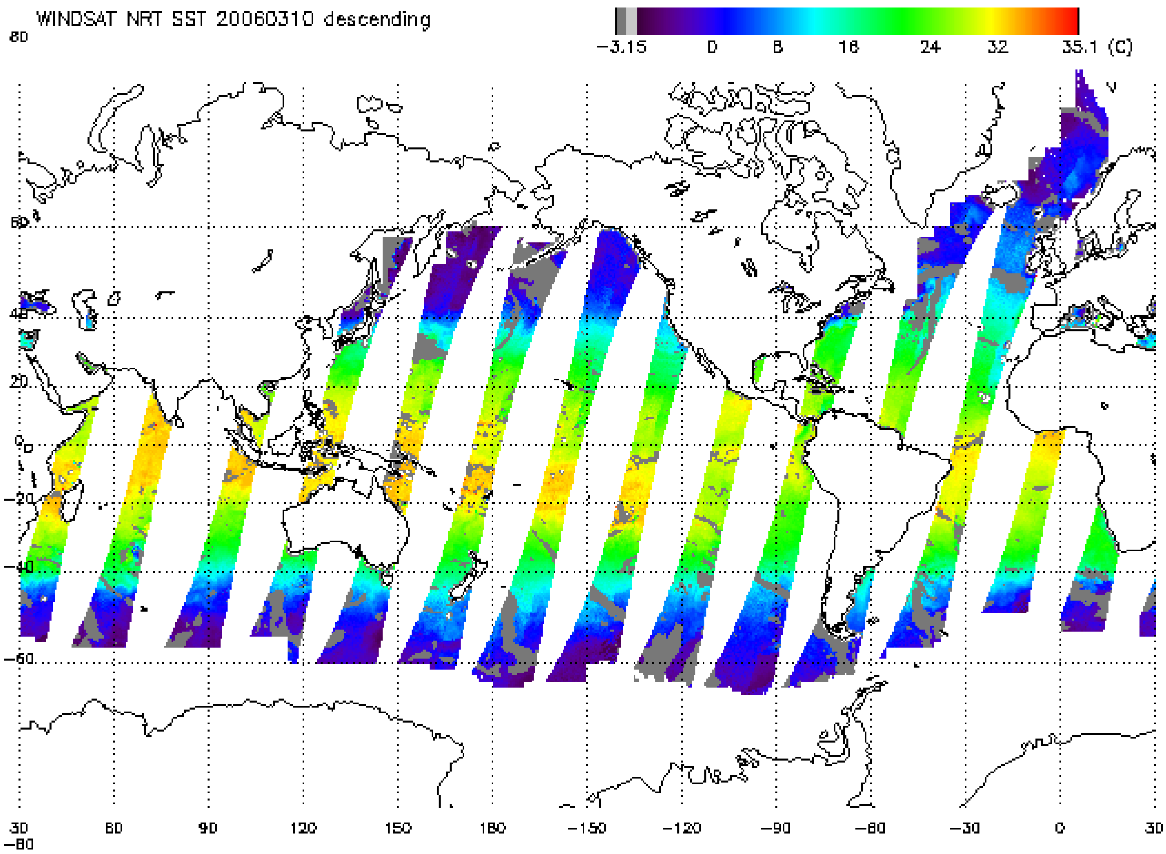


Figure 3.4.5.1. Windsat SST for 2006 03 10 decseding orbits.

Mavor discussed several implications to Sea Surface Temperature from 6.8GHz WindSat data. WindSat provides both 6.8GHz and 10.7GHz, but not for the entire width of the swath. There is a slight decrease in SST on the right-side of swath because of hardware constraints, WindSat does NOT retrieve 6.8GHz in this region. Furthermore, the sensitivity of 10.7 GHz to SST decreases dramatically for SST < 12 C° (same for TMI) as shown in Figure 3.4.5.2.

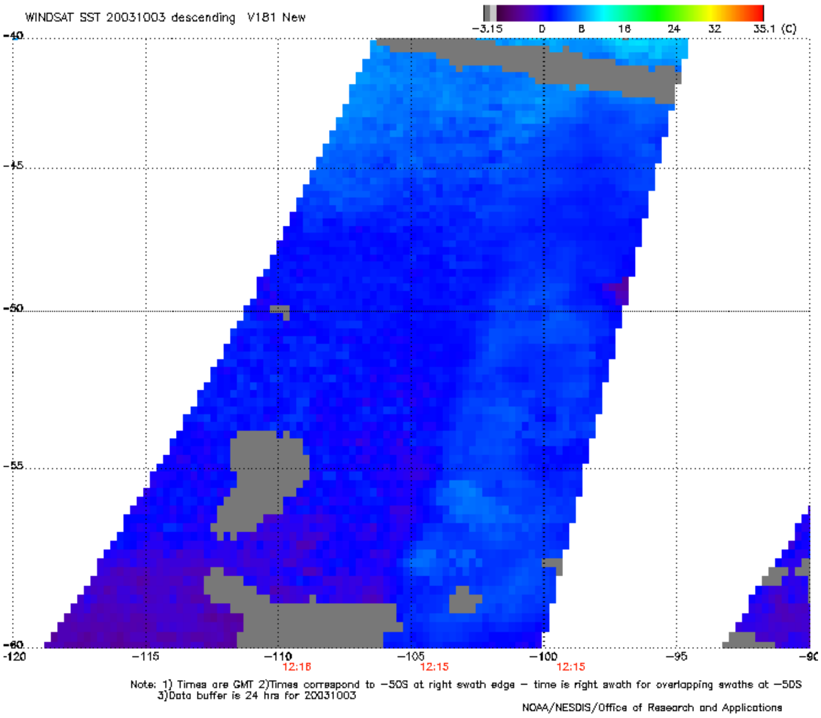


Figure 3.4.5.1. Windsat SST for 2003 10 03 showing the reduced sensitivity of the SST along the right hand edge of the swath.

Mavor noted that a product Data Structure Variable: sstErr is documented in “Estimated retrieval error covariances” and has been implemented by NOAA where the SST error is based upon validation. A Quality Control flag EDR_QC_Flag1 has 1 bit associated with SST Quality and NOAA has implemented a second 32-bit QC Flag strictly for SST which identifies when the Tb is out of range, other EDR are out of range and RFI especially in coastal regions. Further improvements in the landmask routines and better validation are planned for the future to improve Windsat products.

The GHRSST-Pp science Team were keen to gain access to Windsat SST’s and noted that winds from the sensor should be included in the data set. It would be particularly interesting to compare Windsat SST’s to AMSRE SSTs. Mavor noted that there are issues related to the general release of the data set but he was hopeful that this could be arranged in time. Perhaps the best use of WindSat SST’s will be as part of the GHRSST-PP RAN effort.

3.4.6 SST from VIRS and CMIS status of calibration and algorithms:, Denise Hagan

Hagan Gave a review of the NPOESS Mission and evolution through to 2030. The main aims of the mission, which is a Tri-Government Agency Program (DoD, NOAA and NASA) with Industry Partners, NGST Prime Ratheon Ground Data Systems are to:

- Provide a national, operational, polar-orbiting remote-sensing capability
- Achieve National Performance Review (NPR) savings by converging DoD and NOAA satellite programs
- Incorporate new technologies from NASA
- Encourage International Cooperation

The NPOESS evolution through >2030 (a series of 6 Satellites) builds on the legacy operational POES DMSP+EOS as shown in Figure 3.4.6.1. The outputs from the system will be Environmental Data Records (EDR) which is a different concept from traditional science based products. EDR’s should be geophysically calibrated data sets that have been fully validated and are ready for applications. Over 55 product sets of calibrated radiances and environmental data records are being prepared.

Two Developmental Sensors for NPOESS provide key SST Environmental Data Records:

- Visible/Infrared Imaging/Radiometer Suite (VIIRS) planned for the NPP (NPOESS Preparatory Program September 2009) and all NPOESS missions.

- Conical Scanning Microwave Imager/Sounder (CMIS) planned for all NPOESS missions beginning April 2012. CMIS will be the first operational MW SST system.

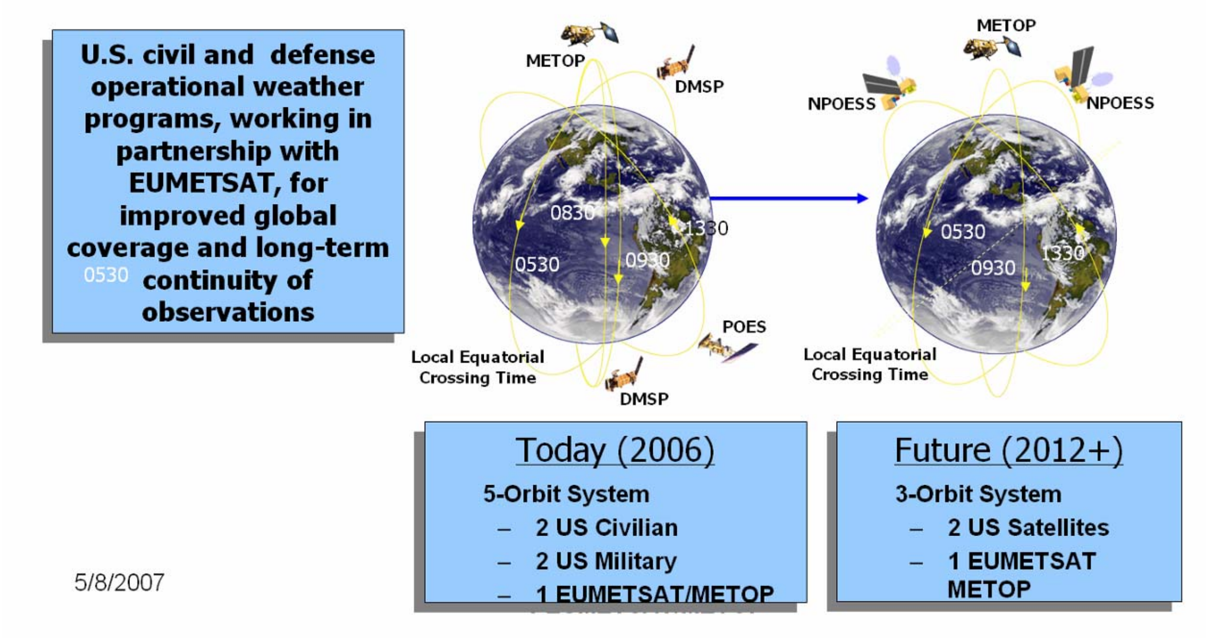


Figure 3.4.6.1 Summary overview of the NPOESS system

The VIIRS design incorporates SeaWIFS Optics and MODIS Calibration provides the Key NPOESS Visible Imagery and SST Key NPOESS Environmental Data products as well as 21 other products. The key features of VIIRS include:

- VIIRS offers 4x-8x improvement over AVHRR spatial resolution 400m nadir swath
- VIIRS 60% better overall Signal-to-Noise Ratio (SNR) than AVHRR
- Day-Night Band Imagery for improved cloud detection
- More bands than AVHRR for cloud detection
- Significant improvement in on-board calibration similar to MODIS

Skin SST and bulk SST will both be produced operationally based on regression coefficients trained from shipboard radiometric (M-AERI) and in situ buoy measurements. The bulk algorithm \approach is below spec for tropics (ECR drafted to relax specs/To be reviewed by VOAT) and the derivation of full set of coefficients for skin SST unrealistic. Solar zenith angle correction terms use of shortwave channels daytime and in general all of the algorithms include a large number of predictors. Non-linear terms in regression equations remain an issue as do aerosol corrections. The strengths of this approach in tests with simulated data show dual split window algorithm to be better than non-linear split window algorithm. Tests with MODIS proxy data show dual split window algorithm to be as good as non-linear split window algorithm

CMIS performs high resolution microwave imaging and sounding using channel sets optimized for prioritized CMIS EDRs. Original 6V and 6H channels sub-banded to permit Soil Moisture EDR in presence of RFI and 6 and 10 GHz channel bandwidths increased to meet SST despite noise increase incurred during RFI Mitigation redesign. CMIS applied lessons learned from operating sensors covering key aspects of sensor design including on-orbit calibration difficulties on AMSR, Windsat, and SSMIS have influenced CMIS calibration design and on-orbit issues with TMI and SSMIS have influenced reflector construction (coatings). The CMIS SST algorithm is based on regression relations (derived from simulated training sets) using 18 channels from 6 to 36 GHz. There are several issues with this approach including SST EDR performance re-capture by increasing channel bandwidths (reduces RFI mitigation); 10 GHz channel no longer protected band; horizontal cell size; Residual warm load (0.3 K rms), channel non-linearity noise, gain. The strengths of the approach are that all weather supplement to VIIRS (Key Clear SST EDR); 6 GHz channel improves accuracy cold water (<15 C); 23 GHz reduces sensitivity water vapor; benefits from WindSat on-orbit calibration studies.

Hagan then considered **some potential VIIRS-CMIS Benefits to GHRSST based on** data fusion of CMIS-VIIRS that will improve spatial resolution in clear regions, coverage near continental regions (reduced RFI interference), latency for global SST all weather retrievals (1 km clear, 40 km partly cloudy) - 15 minutes goal - global distribution of Safety-Net sites. Also, CMIS surface wind measurements (WS,WD, surface stress) can be used for improved skin-bulk temperature difference estimation.

3.5 Session 4. Sensors and Single Sensor Error Statistic formulations

3.5.1 Evaluation of SSES formulations, G. Wick & S. Castro

Wick began by noting that the terminology is not consistent for SSES across the GHRSST-PP. Is it single sensor or sensor specific error statistics? This need to be consistent and the GDS is not correct if we adopt Single Sensor Error Statistics. Wick then reviewed the various data sources available for SSES formulation which include

- Infrared Satellite Data: AVHRR from Operational NLSST - Naval Oceanographic Office
- Microwave Satellite Data: AMSR-E from TRMM Microwave Imager (TMI) using Remote Sensing Systems – Wentz and Gentemann algorithms
- Buoys QC'd GTS buoys via NCEP/CDC

The basic approach is to derive bias and rms error estimates from collocations of satellite data with buoy data. The dependence of uncertainties on sensor and environmental parameters must be determined and uncertainty estimates expressed through multi-dimensional look-up table. Various parameter combinations have also been evaluated through reduction in sensor-buoy and sensor-sensor differences. Wick noted that as part of this work there was a need to look at the definitions of proximity_confidence values used by different groups within the GHRSST-PP. Many sources of uncertainty were considered in the analysis including:

- Wind speed
- Water vapor
- Sea surface temperature
- Air-sea temperature difference
- Climatological SST anomaly
- Satellite zenith angle
- AVHRR channel 4 – channel 5
- Aerosol optical depth
- Number of clear retrievals within 20 km

Figure 3.5.1.1 shows various relationships for the NLSST product explored as part of the SSES derivation work. A main result from these investigations is the fact that the proximity_to_cloud threshold test, at least in the case of the NLSST, does not work well showing little sensitivity to the number of cloud free retrievals in a 20km radius. Pierre LeBorgne noted that this was a contradictary results compared to AATSR and SEVIRI and AVHRR 1km at CMS noting that if the GDS rules are strict for cloud clearing then the proximity_confidence distances need to be sensor specific

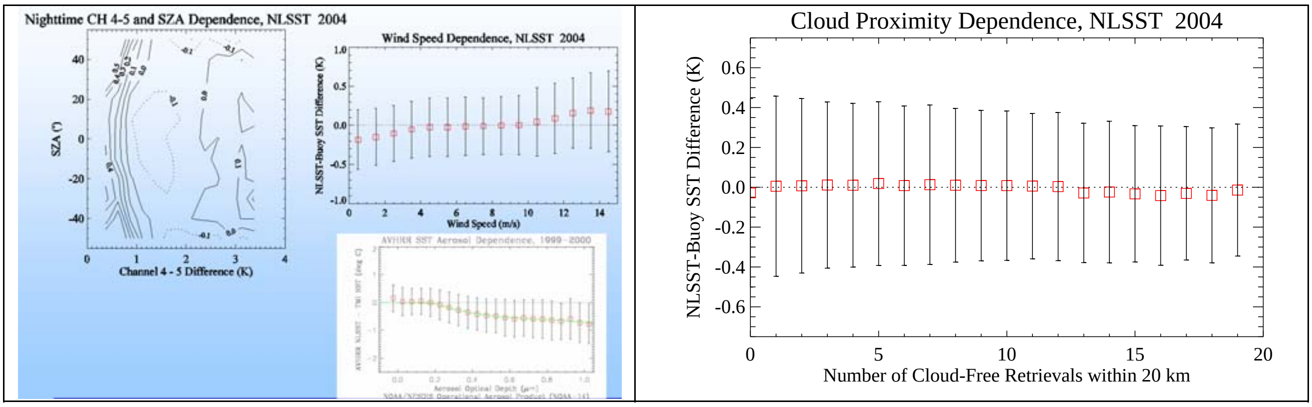


Figure 3.5.1.1 Various relationships NLSST product to SZA and the Ch4-5 differences, wind speed and AOD. Right hand panel shows the dependence of NLSST on cloud proximity.

The derived bias adjustments were then applied to satellite observations and the change in standard deviation of the satellite – buoy differences was recomputed. This was done for both dependent (reanalysis) and independent (operational) periods although the SSES bias was only evaluated. Different combinations of corrections were applied with a corresponding 4-20% impact based on the ancillary data. For the independent period the corrections seem to be make things worse suggesting that adding corrections in a reanalysis mode will be OK (dependent) but not in the independent operational mode. The greatest impact was through the satellite zenith angle and Channel 4-5 differences (Figure 3.5.1.2)

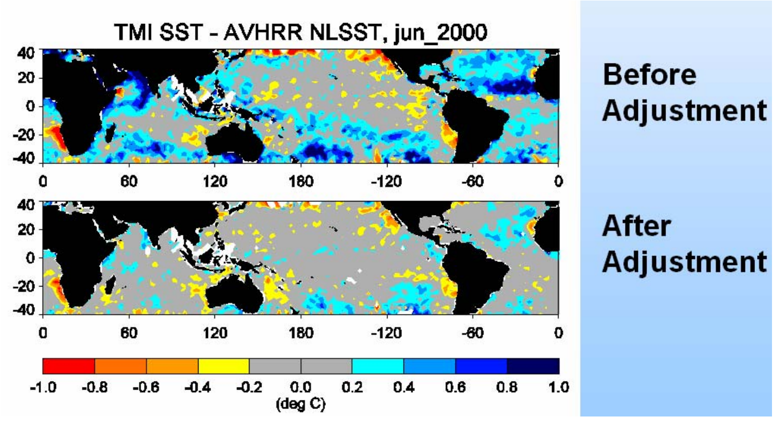


Figure 3.5.1.2. Impact of SSES corrections on NLSST outputs for June 2000.

Wick concluded that different SSES formulations are desirable for different [satellite] products and that different SSES formulation are desirable for operations and reanalysis applications. The Science Team noted that there was a clear need to continue this work and to have sensor specific schemes for each individual satellite sensor that can be mapped into the proximity/quality confidence scale agreed at Exeter

3.5.2 Status of the MSG/SEVIRI derived SST, Pierre LeBorgne

LeBorgne explained that MSG/SEVIRI is the first geostationary imager with a real SST capacity over the Eastern Atlantic. Operational SST production started in July 2004 with an accompanying and extensive validation effort. After one year of production, Saharan dust has been identified as a major problem. Data are available via http://www.osi-saf.org together with documentation.
Three types of MSG SEVIRI product are available:

1. A new 1 hourly MSG data product (not yet L2P) is available for GHRSST-PP together with SSI and DLI estimates at 0.05° spatial resolution data can be accessed using ftp://ftp.ifremer.fr/ifremer/cersat/products/gridded/experimental-cms/netcdf/msg
2. 3 hourly composite SST at 0.1° resolution in GHRSST-PP L2P format accessible using ftp://ftp.ifremer.fr/ifremer/cersat/SAFOSI/Products/ATLSST/
3. Nighttime composites of SEVIRI and other data sets within the OSI-SAF and Medspiration system which clearly highlight the benefit of enhancerd tempral sampling (clouds move so that more data are available when using hourly image data.

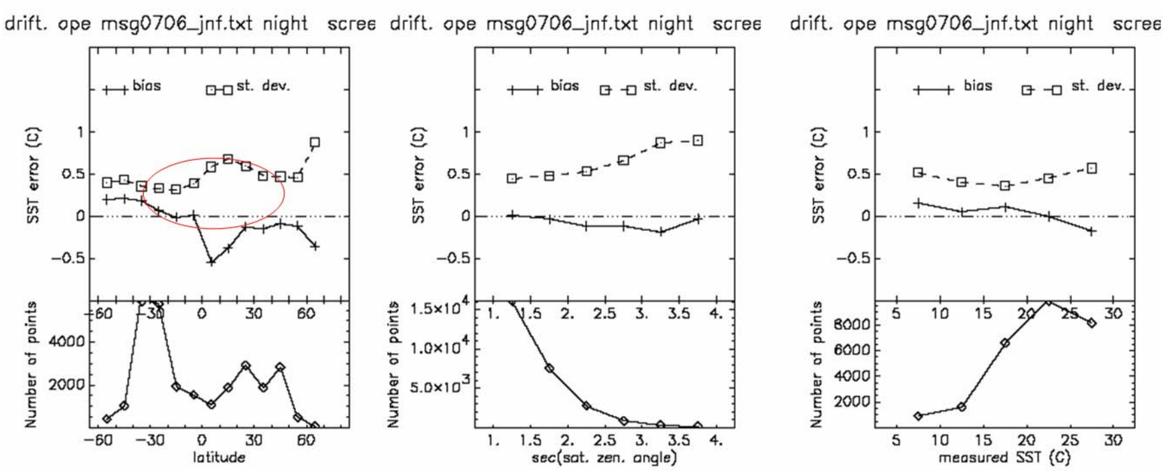


Figure 3.5.2.1 Results from the CMS SEVIRI MDB for (a) latitude dependency (b) SZA and (c) SST

SEVIRI validation is based on an operational CMS MDB system together with intercomparison with

AATSR and more recently with the GHRSST MDB developed at IFREMER. In situ measurements collected on the GTS within a 2 day delay and drifters only are considered for operational validation. For the nighttime only situation the mean SST difference for a 5x5 box where cloud cover <10% over the first year (07-2004 till 07-2005) includes 27756 cases bias=-0.01K, SD=0.49K. For 2005 we have 43003 cases bias =-0.05K, SD=0.44K. This is excellent and well within the SEVIRI SST specifications especially when compared to GOES-08 (bias= 0.4 K) and is reported in *Brisson et al, JAOT 2002*.

Work using the CMS MDB (which includes Bias and SD as a fuction of latitude, SZA) suggests that there is a major problem 0-20N otherwise there are just small trends. (Figure 3.5.2.1). SZA suggests nothing new and the SD increases across the swath but the bias error remains good. Variation in temperature itself when compared to buoys shows an increase in bias which is probably due to aerosol contamination from the Sahara. To further investigate this effect SEVIR data were compared to AATSR data using operational L2P feeds (demonstrating the ease of utility of the L2P product). Difference maps between the two sensors highlight the impact of atmospheric aerosols on the SEVIRI SST retrievals (AATSR is essentially free of aerosol contamination due to the dual view technique) as shown in Figure 3.5.2.2.

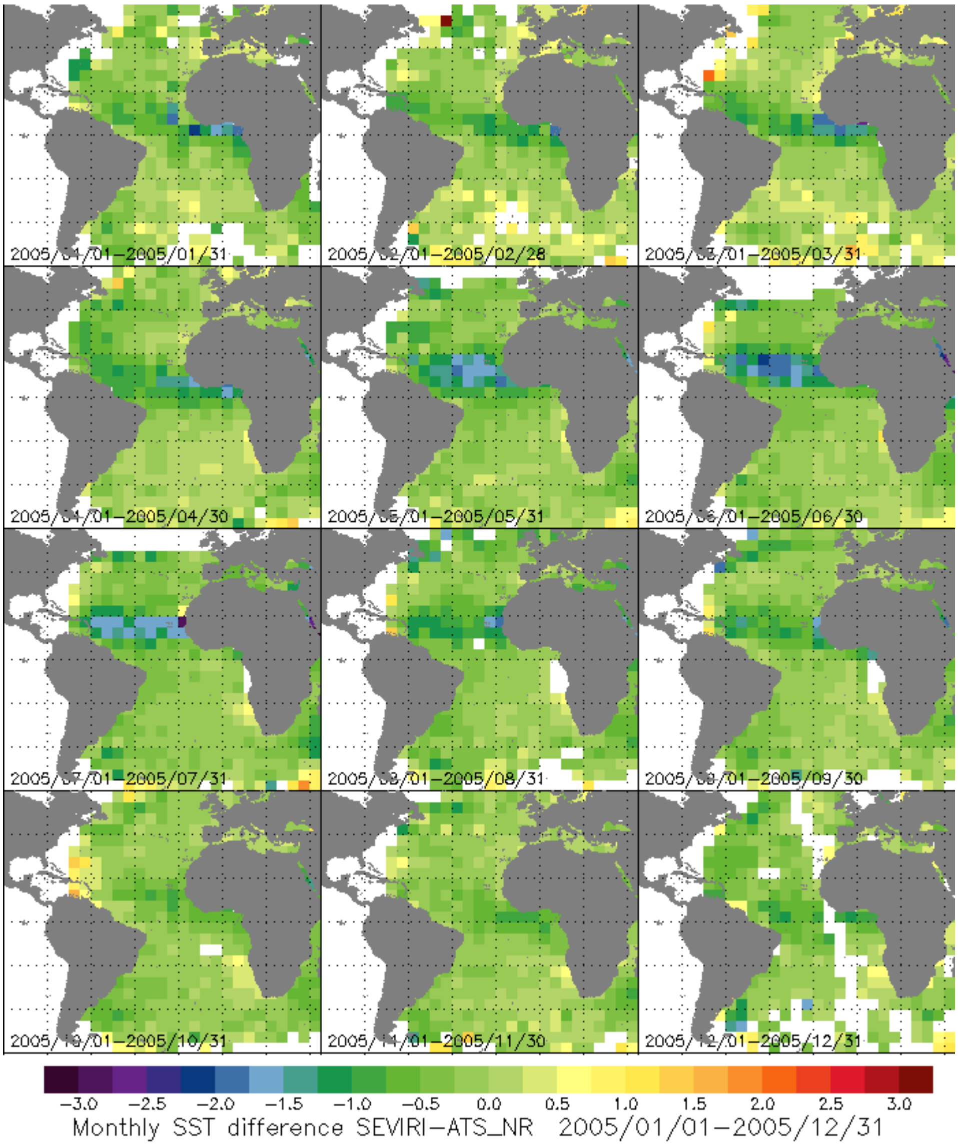


Figure 3.5.2.2 L2P Inter comparison SEVIRI-ATSR over 12 months in 2005. *Average SST on boxes of 5 x 5 degrees*

In order to investigate the error characteristics of SEVIRI SST further, the GHRSST-PP MDB system was used and in this case, data were split into distinct regimes of interest that correspond to known physical situations (aerosol influence, western boundary current, coastal sea etc). These are shown in Figure 3.5.2.3.

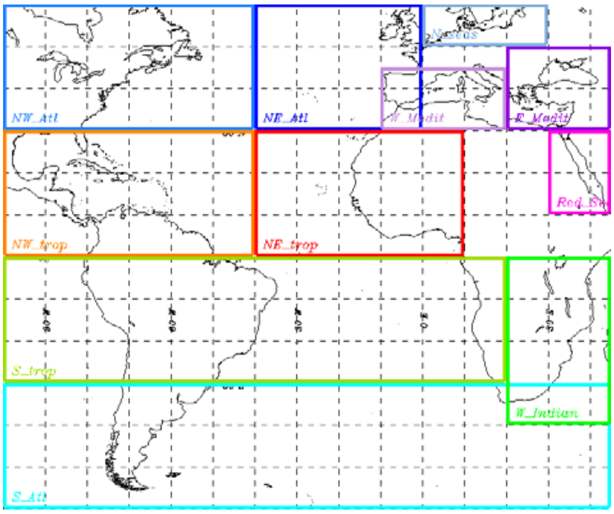


Figure 3.5.2.3 Validation regions used to stratify the GHRSST-PP MDB outputs for SEVIRI validation work.

Moist areas result in acceptable validation results but there are problems in Red sea, Mediterranean and in the Tropical Atlantic related to aerosols. This is a good result as it means that the GHRSST-PP MDB is giving the same result as the CMS MDB. LeBorgne noted that the SEVIRI SSES is a function of proximity confidence and as a function of month and while the proximity_confidence scale is meaningful values of 3&4 still have some issues.

The team has defined a Saharan dust index (SDI) which compared to NAAPS data and with the MDB results to test the algorithms. The SDI is derived from simulated SEVIRI BTs using the RTTOV and an IR scattering model. The mean relationship and 1-σ range of change in BT versus AOD assuming a layer of aerosol evenly distributed between 2 and 3 km altitude (Haywood optical properties). See *Merchant C., O. Embury, P.Le Borgne, B. Bellec, submitted RSE 2006.* There is a very good correlation between errors and SDI. When the SDI is applied in the Mediterranean sea in August a comparison to climatology shows a cool SST wrt.climatology. The team are satisfied that the SDI algorithm works and taking things further have used this as a correction for contaminated SEVIRI SST's within a new algorithm. The team are now developing an operational correction for SEVIRI

LeBorgne concluded that SEVIRI SST allows a good coverage of the Eastern Atlantic with good SST's which will be extended to include the Western Indian Ocean ->60E soon. The SST accuracy is controlled by all available means including the CMS MDB, AATSR and GHRSST MDB. The original SST retreival is satisfactory but vulnerable to aerosols at certain times of the year. A Saharan dust detection method and correction is being implemented that is expected to be operational by mid April 2006. Finally the team are now completing the upgrade of the OSI SAF geostationary suites which is expected by early 2008 to deliver hourly L2P data.

3.5.3 Satellite SST Comparisons, Doug May

May explained that NAVO needs to understand the coverage, timeliness and accuracy olf the SST feeds that are used within the operational systems. At present there are 10 data streams arriving at NAVO which are used in the NAVO Satellite processing system where data are collocated with in situ observations and passed to an MDB. N18/17 GAC and LAC, GOES E/W, Windsat, MSG SEVIRI , AATSR and AMSERE are all processed in the same way (Figure 3.5.3.1).

The team worked with the GHRSST-PP Proximity Confidence Value (IPCV) scale which is defined as

- IPCV 0 – Unprocessed
- IPCV 1 – Cloudy
- IPCV 2 – Bad (probably cloud contaminated)
- IPCV 3 – Suspect (maybe cloud contaminated)
- IPCV 4 – Acceptable (cloud distant, agree with SST)
- IPCV 5 – Excellent (far from cloud, agree with SST)
- IPCV 6 – Cool skin (far from cloud, cooler than SST)

But focussed only on IPCV 3 (suspect), 4 (acceptable) and 5 (excellent) rejecting all other data. NAVO has only 3 categories of quality indicator (analogous to the IPCV scale) which map as follows:

- Category 1 – Clear (far from cloud test thresholds, agree with SST) and is equivalent to IPCV 5 (Excellent)
- Category 2 – Probably Clear (closer to cloud test thresholds, agree less with SST) and is equivalent to IPCV 4 (Acceptable)
- Category 3 – Questionable (disagree with SST, close to cloud test thresholds) and is equivalent to IPCV 3 (Suspect)

In the case of Microwave data, excellent was chosen when all confidence flags are clear, acceptable when some confidence flags are not zero and suspect when the MW confidence rejection flag was set.

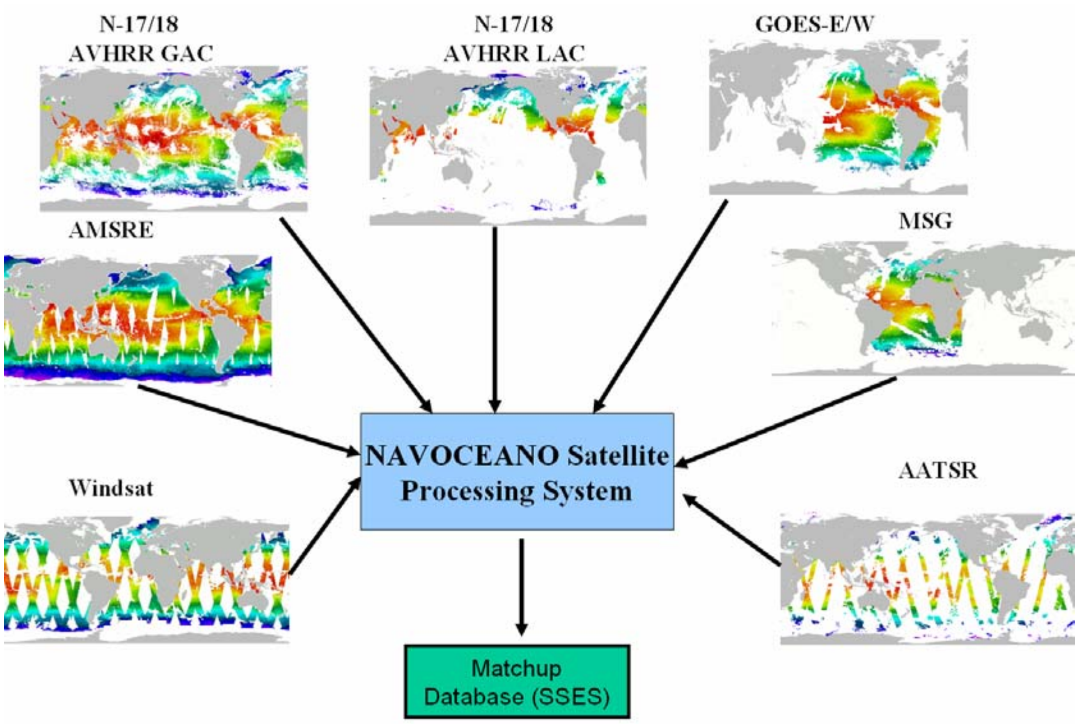


Figure 3.5.3.1 Data sets analysed by NAVOCEANO during this inter-comparison study ujsing the NAVO MDB

For the inter-comparison exercise the following quantities were computed for Feb 2006:

- Average daily spatial coverage (where the average number of daily retrievals generated for each IPCV category per satellite is computed)
- Timeliness calculated average timeliness of data availability per satellite
- Accuracy derived as the Bias, stdev, RMS, and percent of retrievals in category relative to global drifting buoys (4/25km)

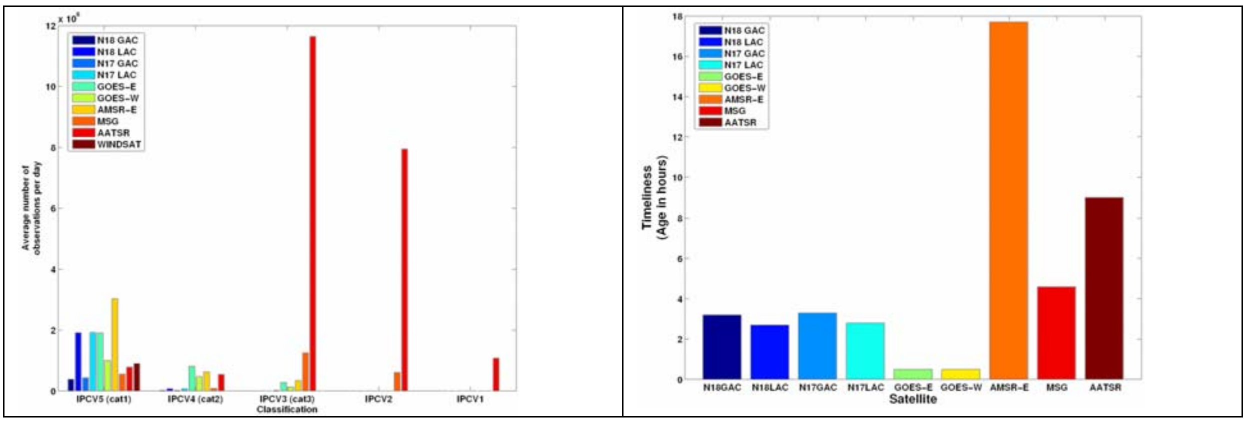


Figure 3.5.3.2 Average daily spatial coverage and Timeliness for GHRSST-PP data streams arriving at NAVOCEANO for February 2006.

The basic results for coverage and timeliness are shown in Figure 3.5.3.2 which shows that the AATSR has the most number of suspect data and that AMSRE has the poorest timeliness (+18 hour delays) followed by AATSR (up to 9 hours) and then MSG at 5 hours. Other data sets have delays of

1 -3 hours.

In terms of accuracy the following statistics were derived:

Satellite	IPCV	Bias	St.Dev	%inCat
N-18	Exc	0.03	.42	96%
N-17	Exc	-0.01	.41	97%
GOES-E	Exc	-0.13	.42	62%
GOES-W	Exc	-0.04	.47	61%
MSG	Exc	0.01	.48	29%
AMSR-E	Exc	-0.05	.56	71%
AATSR	Exc	-0.12	.42	6%
Windsat	Exc	-0.38	.80	100%
N-18	Acc	0.36	.69	3.9%
N-17	Acc	0.30	.74	2.9%
GOES-E	Acc	0.09	.62	30%
GOES-W	Acc	0.16	.67	28%
MSG	Acc	-0.18	.78	5%
AMSR-E	Acc	-0.32	.87	16%
AATSR	Acc	0.05	.66	6%
N-18	Susp	0.99	1.58	0.1%
N-17	Susp	0.25	1.71	0.1%
GOES-E	Susp	0.73	.82	8%
GOES-W	Susp	0.43	1.09	11%
MSG	Susp	-0.11	.63	66%
AMSR-E	Susp	-0.10	.77	13%
AATSR	Susp	0.13	.57	88%

While WindSat has the largest percentage of available data (100%) significant uncertainties are apparent in the data. LeBorgne noted that there is a need to reconsider the IPCV categories for AATSR as the 6% AATSR Exc category is due mainly to the distances chosen for proximity to cloud. Furthermore, while the amount of AATSR data in the acceptable data category is OK, for the suspect data case most (88%) are present. Further investigation by NAVO clearly showed that using their own MDB, these data were of a good quality suggesting that the AATSR IPCF scheme is incorrect.

May concluded that apart from the AATSR accuracy and the AMSERE, MSG and AATSR timeliness, the first conclusions are that the GHRSST-PP r/GTS is doing OK. Based on these results, an action: was raised for the Medspiration PM, AATSR PI and AATSR validation scientist to investigate and rectify the problem with AATSR SSES as soon as possible. Further discussion concluded that further work is required on SSES and to review the terminology for the GHRSST-PP SSES scale. This should be a priority action for the GDS-TAG and all of the RDAC data providers as the credibiulity of GHRSST-PP relies on having good uncertainty estimates.

3.5.4 Error hypercube/impact of reference field, Bob Evans

Evans explained that considerable time and effort has been invested at Miami to ensure that MODIS SST data sets are accurate and homogenous. The SST 4µm residuals (compared against buoys) show that most data is very stable with biases at the level of geophysical skin bulk differences. Significant improvements have been made moving from the v4.1 to the v5.0 schemes as shown in Figure 3.5.4.1. Furthermore there is little difference in the v5.0 collection between Terra and Aqua MODIS.

Evans showed difference plots between AMSRE and MODIS data and identified aerosol contamination in the 11µm SSTs' which is not present in the 4.0µm data highlighting the fact that 4µm SST are really useful and should be used at night. Other comparisons showed that there are many cases where the cloud clearing is good but there are many where there is clear cloud contamination. Evens noted that GHRSST-PP must be careful to define the way in which the confidence values are specified and to consider each satellite instrument separately.

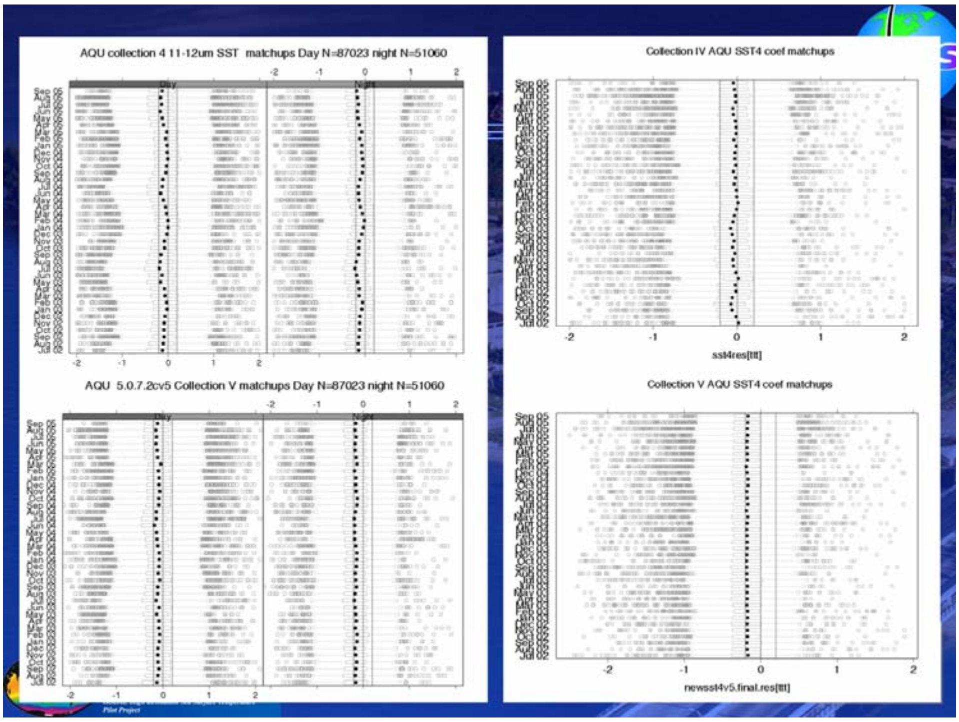


Figure 3.5.4.1. MODIS Aqua Collection 4 & 5 SST & SST4 residuals computed against in situ SST.

Evans then discussed the use of the NAVO K10 SST product which is being used to assess the MODIS data (replacing the use of Reynolds OIv2.0). K10 is basically a gridded product which upgrades each grid point with new data only when the confidence flags are better than the old data. There is no analysis (e.g., an OI) just a gridded product of the best available observations. This means that in a worst case some grid points may be several weeks old (does not really happen in practice apart from in the high latitudes). The K10 provides an excellent representation of mesoscale variability, frontal regions and coastal features and western boundary currents compared to the standard. While K10- is better than 25km gridded AMSRE products in terms of resolution, these tend to be limited by available satellite coverage and the relaxation of space-time scales required to fill missing retrievals. Figure 3.5.4.2 shows an example of K10, MODIS and Reynolds OIv2.0 data.

Evans then discussed the approach to MODIS Single Sensor Error Statistics using a Bias and Standard Deviation Hypercube. The hypercube dimensions (partitioning of Match-up database) is set up as

- Time- quarter of year (4)
- Day/Night split
- Latitude band (5): “60S to 40S" "40S to 20S" "20S to 20N" "20N to 40N" "40N to 60N"
- Sat Zenith angle intervals (4): "0 to 30 deg" "30+ to 40 deg" "40+ to 50 deg" "50+ deg"
- Surface temperature intervals (8): 5 degree intervals
- Channel difference intervals: SST(3), SST4(4)
  - ch31-32 (SST): 0.7<, 0.7->2.0, >2.0
  - ch22-23 (SST4) 0.5 degree intervals: -0.5<, -0.5->0, >0 ->0.5, >0.5
- Quality level (2): cube created only for ql=0 and 1 (Note for ql2 and 3 the bias and standard deviation are each fixed to a single value)

There is no interpolation between adjacent cells within the hypercube itself. The ‘hypercube’ approach provides coverage for all available satellite retrievals but only provides a representative estimate of retrieval bias and standard deviation when conditions present for a given retrieval are well matched by the ‘hypercube’ coverage and atmospheres present in the MDB. Evans showed examples in the central gyre regions where SST gradients are small, both the ‘hypercube’ SSES bias and DT reference SST field anomalies are comparable demonstrating a negative anomaly of order -0.17C expected for a nominal skin, bulk temperature difference.

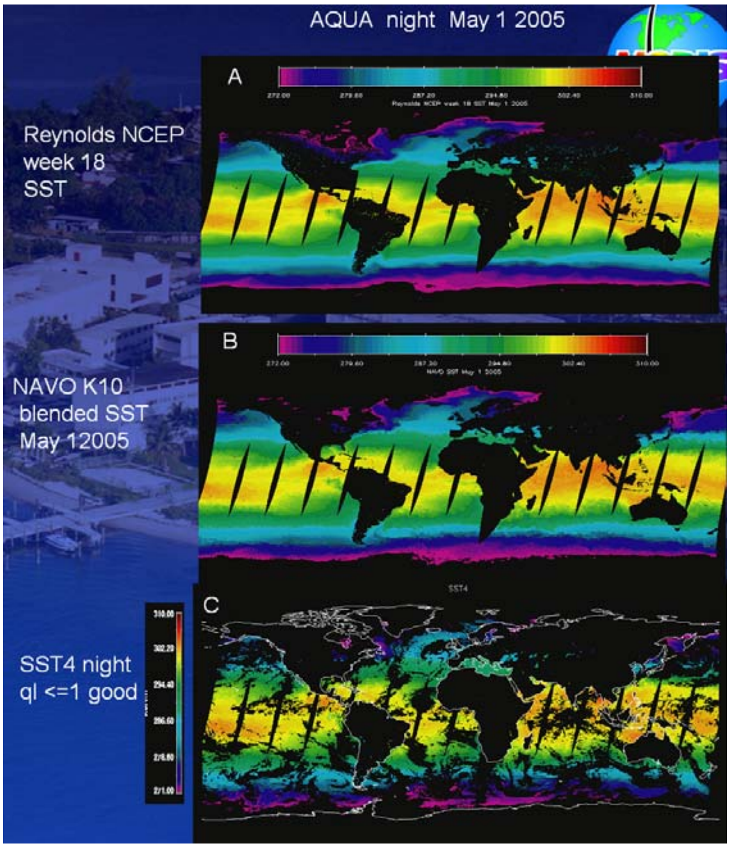


Figure 3.5.4.2 Example of K10, MODIS and Reynolds OIv2,0 data on May 1st 2005.

Evans concluded that new monthly coefficients for MODIS Terra and Aqua have removed seasonal bias trends and Terra mirror side trends. The data sets have improved quality filtering that has removed most cold clouds and significant dust aerosol concentrations. The team have introduced a SSES hypercube that provides insight into bias and standard deviation trends as a function of time, latitude, temperature, satellite zenith angle, brightness temperature difference as a proxy for water vapour and retrieval quality level. The hypercube developed and tested for Terra and Aqua. Evans noted that the GHRSST-PP has been very useful as it has provoked this kind of work which can be continued using a combination of AATSR and TERRA. This will bring an ability to start looking at differences. Pierre LeBorgne appreciated the hypercube approach that allows to account for proper errors across the board but the main concern is how can we educate users to use the SSES? Evans noted that both quality (confidence) levels include many issues that have been used to generate the best SST. The hypercube can be used to make sure that when we have a similar geophysical situation we have a better retrieval and better quality. Given the level of application we can use the hypercube for the best estimates.

3.5.5 Regional SSES for AATSR?, Gary Corlett

Gary Corlett began by summarising the products provided by the ENVISAT AATSR mission which required to measure global SST values to within 0.3 K (1 σ) in single point coincidences **and** over 0.5º (30´) x 0.5 º (30´) averages and various approaches to validating these products. These are:

- ATS_NR__2P **"Gridded" 1km by 1km global product validated against**
    - *in situ* radiometer measurements which only directly measure skin SST providing the only independent method to test the absolute accuracy of AATSR SST retrievals
    - *or* Against *in situ* buoy measurements
- ATS_AR__2P **Spatially averaged products at various resolutions (30´; 10´; 50 km; 17 km)** validated against
    - *in situ* buoy measurements
    - or other satellite sensor measurements

How do we provide GHRSST-PP AATSR SSES? AATSR has 2 sets of coefficients that came into operation in 7th December 2005. Buoy match ups are used extensively but they don't have knowledge of the validation in some areas as there is no coverage. Figure 3.5.5.1 shows the results of buoy matchups for AATSR since late 2002 and highlights the stability of the AATSR calibration.

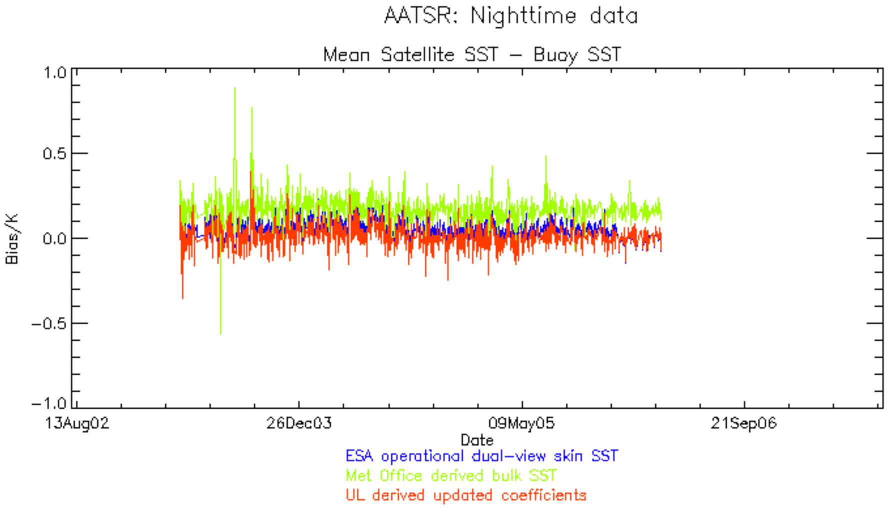


Figure 3.5.5.1 Average weekly AATSR-buoy SST for AATSR showing 2 different SST algorithms and a derived SSTdepth estimate (Data from Anne O'Carroll & Thomas Blackmore (Met Office))

These data show that AATSR is a stable sensor but study of regional statistics shows that there are regional biases evident in the validation data set. The pattern of are similar to the retrieval errors shown in the paper of Chris Merchant paper. A major question is what does GHRSST-PP want for AATSR SSES? SSTskin or SSTdepth SSES? GHRSST-PP has specified that SSES are required for every SST pixel and in this case the bias can be computed either as a retrieval bias (Merchant et al., 2006), or as a bias to a *reference* data set e.g., the GHRSST match-up database. If we choose to use the latter some uncertainty needs to be specified for the in situ data themselves. Furthermore, it is not clear if the biases should be algorithm dependent (although they should be). Corlett then reviewed the Standard deviation uncertainty estimate of the SSES noting there was some debate over what exactly is a single pixel standard deviation? Is it a spatial or temporal variance and can these errors be separated with confidence?

Clearly the path chosen at this point is for SSES to be derived from an in situ MDB. This may change in the future to include retrieval biases but if the MDB is updated, then the MDB will still be required to check that the retrieval bias is correct. In the case of AATSR SSTskin retrievals this requires that the MDB includes all in situ radiometer data. There are significant problems though as we do not have match-ups for all data and are likely to have pixels with no match-ups at all. This can be addressed to some extent by choosing an appropriate spatial and temporal resolution to derive SSES. But even this has problems as transient "extremes" will not be adequately addressed. Furthermore complications of SSTskin and SSTdepth deviations must be addressed (stratify by wind speed?). Recent work has suggested that to derive SSES properly, the nadir only SST is required in addition to the dual view SST (nadir SST is always present when the re is a dual view retrieval) to facilitate confidence flagging and to provide the best available AATSR SST when the forward view is cloudy. It was clear that the SSES for AATSR requires careful thought by the AATSR community and the GHRSST-PP science Team urged progress to define proper SSES for AATSR as soon as possible. An action was raised on the Medspiration team and GHRSST-PO to update configuration file for Medspiration AATSR SSES as soon as possible.

3.6 Session 6: Emerging and future issues for the GHRSST-PP

3.6.1 Ted Haberman: netCDF 4.0 and the GHRSST-PP and the common data model

Haberman began with a review of a data model which is a way of working with about scientific data and in particular about storing and accessing the data. Data models provide an abstraction of the main elements of a data set and are equivalent to an abstract object model in Object Oriented Programming (OOP). An Abstract Data Model describes data objects and what methods you can use on them. An Applications Programming Interface (API) is the interface to the Data Model for a specific programming language. A file format is a way to persist the objects in the Data Model and a data access protocol plays the role of a file format. The Abstract Data Model removes the details of any particular API and the persistence format.

In terms of HDF5 and netCDF these are two separate communities that don't talk much together. A common data model was introduced to connect the netCDF and HDF community together. The oceans and atmospheres prefer the netCDF approach whereas the satellite community favoured the HDF approach. The main idea is to have the HDF5 storage format and the netCDF access protocols working together although the Common data model (CDM) looks at other formats too (especially NOAA) including GRIB, DMSP and the Nexrad (radial radar data format). In principle, the CDM will allow seamless access to all of these data. Haberman noted that both OPeNDAP and THREDDS also part of the general CDM discussion. Figure 3.6.1 summarises these issues in schematic form.

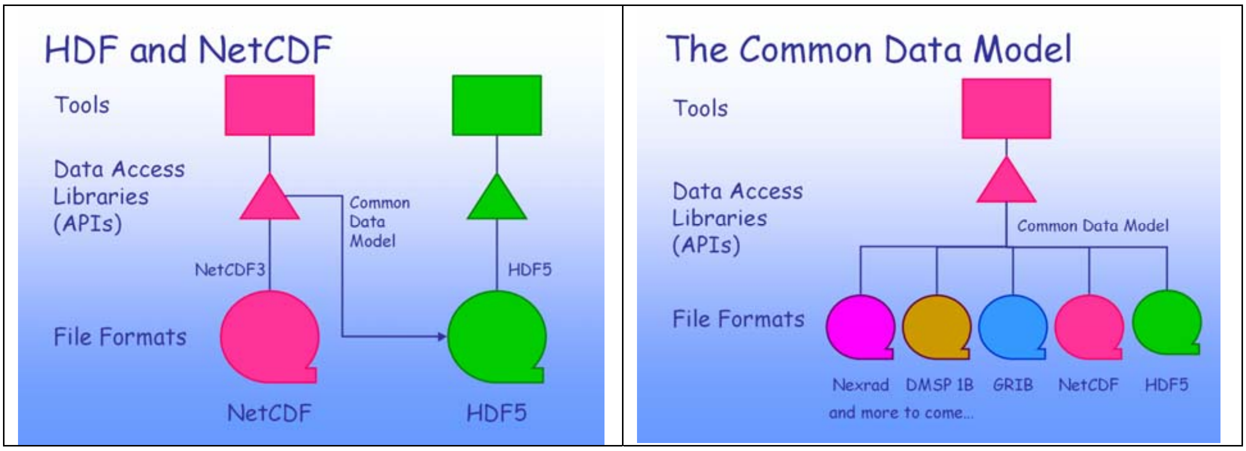


Figure 3.6.1 (a) Relationships between HDF and netCDF highlighting the connectivity of the Common Data Model (b) simplified layered approach of the common data model

In traditional science approaches have simple coordinates systems and the netCDF 4.0 model should include open GIS type functionality (projections) using a coordinates system (level 2). THREDDS data servers sit on top of the CDM serves HTTP and OPeNDAP which is the ultimate objective of the CDM. The GHRSST-PP was keen to ensure that their need for netCDF and especially the option to compress data internally to netCDF (as is the option in HDF) was considered by the netCDF community. This was the subject of the next talk.

3.6.2 NetCDF 4 a GHRSST-PP perspective – JF Piollé and J Carron

Piolle noted that NetCDF provides a much simpler interface for array-oriented data than HDF5 but the latter have very powerful storage features (including different size data sets and compression). Unfortunately, NetCDF-4 does not give access to all HDF-5 features e.g., spatial transformation and the plan is to use HDF5.0 as the storage layer

		Can be read with the following API…		
		NetCDF-3	HDF-5	NetCDF-4
File format	NetCDF-4	X (except new features)	X	X

	HDF-5		X	Some of them
	NetCDF-3	X		X

Figure 3.6.2.1 Compatibility issues between netCDF 3.0, netCDF 4.0 and HDF5.0

Compatibility between netCDF 3.0 and netCDF 4.0 is not great and there are consequences for users if GHRSST moves to NetCDF-4 which include:

- Current user programs can not read netCDF-4 files, except if they don't use the new features (but then why move to NetCDF-4?)
- Users need (at best) to relink their programs with the NetCDF-4 API (when using standard C, Fortran, C++ libraries)
- What about users using on-the-shelf software (IDL, Matlab, Ferret, NCL,...)? we need to wait new available software version and a present there is no current release date available.
- Must use HDF-5 commands (learn a new sets of commands, update scripts,...)

However, there are many issues for the GHRSST-PP to consider by moving to netCDF 4.0. The list below identifies positive issues (+) and negative impacts (-) for each:

- Support to files larger than 2 Gb
    - (+) Issue for netCDF 3.5.1 or earlier
    - (-) Already possible with netCDF 3.6
    - (-) Issue for which GHRSST-PP dataset? AATSR=600 to 800 Mb, MODIS? (not if granules)
- Additional atomic types (unsigned int8, unsigned int16, unsigned int32,string…)
    - (+) avoid ambiguity and reading problems for byte data, which was solved by a 'comment' variable attribute in current L2P data although this is not at all ideal. This is a significant advantage to GHRSST-PP
    - (-) need to wait netCDF-4 support for matlab (release date?)
- Parallel I/O reading/writing
    - (+) Interesting for instance for optimal analysis and modelling systems running on parallel computing environment (MPI) ?
    - (-) depends on the volume of data
    - (-) reading time of GHRSST data not high constraint compared to processing time ?
- Automatic data packing
    - (+) Storage type, offset and scale factor adapted to content
    - (-) Needs more flexible GHRSST-PP data model description (review user reading routines)
- Chunking for unlimited dimensions allowing faster access when sub setting internally compressed variables : may be useful mostly for high resolution gridded datasets

Compression within the netCDF 4.0 will be a big advantage to the GHRSST-PP but at present netCDF plans to use zlib and szip as natively supported with no support for bzip2. The Science Team debated the need for Bzip2 support and raised an action on JF Piolle to request that Bzip2 compression is included in netCDF 4.0 specs for GHRSST-PP.

Poille concluded that NetCDF-4 has promising features from the GHRSST perspective including Parallel I/O, internal compression (arguable depending on which use) and new data types (signed). However, is there any critical need for GHRSST-PP to move forward to netCDF-4? Questions remain about its maturity. There are also issues for GHRSST users in terms of understanding the workload/easiness of switching from netCDF-3 to netCDF-4? Especially if working with both historical and recent data. Are users used to netCDF-4 or HDF5 file structure (grouping, data model,…) and do they have the tools for this? There are also issues for RDAC/GDAC providers. What information can be provided in NetCDF-4 and not in NetCDF-3? Should we stick to GHRSST simple data model? Do we need extra features of netCDF-4? Does it really improve storage? Does it speed up access to data? Processing time? What workload in terms of assistance to users? Complains management? Will users adopt it? Does it imply to convert historical archive? Internal storage format vs distribution format may not have the same requirements.

In summary Piolle recommended that the GHRSST-PP delay implementation of netCDF 4.0 until further tests have to be completed and the new systems are mature and proven. Furthemore it was agreed that GHRST-PP work with the netCDF 4.0 community especially as the native language will be JAVA. GHRSST-PP needs to think about how this can be translated back to C and Fortran version of the library may never be possible although JAVA efficiency issues like this are almost over: JAVA is now 30 times faster than C++. RSS expressed problems in windows when working with the netCDF libraries.

3.6.3 In situ validation of SST data, W. Wimmer

Wimmer began with an overview of the key elements for a successful in situ satellite validation programmes. In the first instance, we need to know error characteristics of the derived satellite SSTs which requires wide ranging measurements. We need to know the time-dependent degradation of the spacecraft sensor and thus we need measurements over whole mission period. Wimmer noted that a poor validation undermines mission objectives e.g., for ENVISAT AATSR accuracies of 0.3 K for a ½° lat x ½° lon area having 20% cloud free conditions need to be demonstrated and confirmed especially as these data are destined for use as climate records that require an accuracy of ~0.1K per decade.

A new validation program has been developed operating from a ship of opportunity in the English Channel and the Bay of Biscay specifically to validate the AATSR using in situ radiometers. Two autonomous infrared SST Radiometer (ISAR) systems are used in a one-on-ship, one-off-ship (in maintenance) to maximise the likelihood of AATSR ship matchups at a reasonable cost. The systems have been running for several years and have now demonstrated operational capability. Although the ISAR calibrates itself internally against two black bodies and delivers its own temperatures, automatically corrected for small degradations of the optical path there is a need to verify the end to end measurement using an independent laboratory black body cavity. For every deployment of the ISAR system, calibrations are obtained in the laboratory before and after deployment over a 20 K range of temperatures (Figure 3.6.3.1). If necessary any detected bias is applied to correct the internally calibrated data (so far none has been required). Significant changes of calibration indicator metrics (reported in NRT) during a deployment trigger an investigation of what caused the change and when it occurred. In this way, the ISAR team aims for traceability of all our measurements.

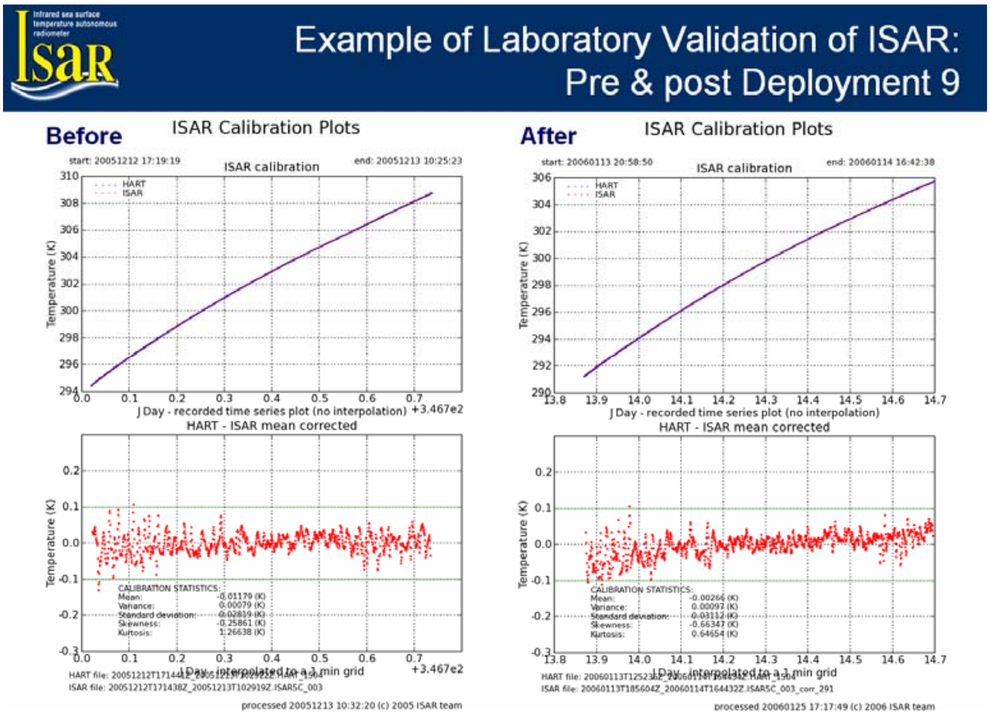


Figure 3.6.3.1 Pre and post deployment calibrations using a CASOTS-II reference black body reference target for an ISAR radiometer.

The accuracy of the CASOTS-II reference blackbody has been investigated during a 4 day experiment at the University of Miami, USA, using a NIST secondary transfer reference blackbody source (RSMAS NIST reference blackbody). In addition, ISAR was calibrated against the RSMAS reference blackbody radiance source at several set temperatures. The CASOTS-II reference blackbody has been verified using secondary transfer standards (M-AERI and RSMAS NIST reference blackbody) and the RSMAS and CASOTS-II reference blackbody systems have been measured using an accurate Thermal Infrared Camera. Data is currently being processed but initial results confirm the accuracy of the CASTOS BB system as a useful reference blackbody cavity for ISAR verification.

Wimmer then discussed the methods being developed at NOCS to validate AATSR using in situ radiometers deployed on ships noting that the concept of validation is easy: validation is just comparing the satellite product temperature with the ***true*** temperature. However, the practice of validation is difficult because very rarely are we able to compare like with like as

- Satellite observations represent the ***instantaneous average*** (sub)skin temperature over the sensor field of view and
- In situ measurement represents ***point samples***, at a specific ***depth***, typically at a ***time and location different from the satellite measurement***

We risk undermining product quality by using inadequate in situ validation data and too simplistic a comparison method.

Wimmer proposed an approach to understanding the uncertainties associated with in situ validation programs. The error, Es, of a satellite measurement of SST is simply

$$ES = VS - V \qquad (1)$$

where VS is the satellite-estimated value and V is the true value of the ocean variable represented by the satellite view, i.e. the average over the satellite pixel area at the instant of the overpass. However in practice V is not known precisely and instead, the in situ measured value, Vw, is used. But, the error associated with an in situ sample is given by EW where:

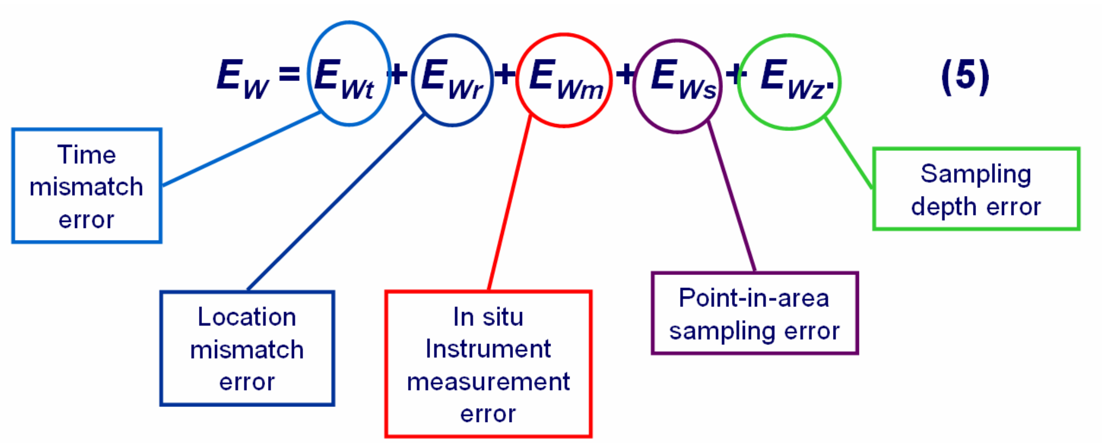
$$EW = VW - V \qquad (2)$$

The matchup deviation (what we typically quote) is based on an analysis of a MDB which then yields a match-up difference, ∆MDB. That is, for a given sample pair (or average of many MDB records)

$$\Delta\, MDB = VS - VW \qquad (3)$$

But, ∆ MDB ≠ Es and ES and EW errors (associated with using the in situ measurement as a proxy for the true temperature, V) must be included in the validation analysis. In order to estimate ***ES*** it is necessary to estimate ***E****w* and if possible to minimise it. It can be broken down into several different types of error:

$$E_W = E_{Wt} + E_{Wr} + E_{Wm} + E_{Ws} + E_{Wz}. \qquad (5)$$



The *EWt* = time displacement error for the mismatch in time, *tdif* between the *in situ* sample and the satellite overpass and is estimated as ***EWt = tdif . ∂V/∂t*** *The EWr* = spatial displacement error represents the error when the *in situ* sample is displaced from the matched image pixel by a distance ∆*r*. It can be estimated as ***EWr = ∆r . ∂V/∂r.***

Base on these criteria, the ISAR team have defined a number of validation grades (quality of validation) to help understand the errors identified in (5). These are defined as

- Grade-1: Coincidence of ISAR and AATSR sample within **± *2000 s time*** window and ***1 km search radius*** in space.
- Grade-2A: Temporal match within **± *2000 s*** and spatial match within **± *20 km***

- Grade-2B: Temporal match within **± *2 hrs*** and spatial match within **± *1 km***
- Grade-3: Temporal match within **± *2 hrs*** and spatial match within **± *20 km***.

These criteria have been used to derive validation results for the ENVISAT AATSR D3 and D2 SST retrievals for the Bay of Biscay and E. Chanel as shown in Figure 3.6.3.2.

Matchup Grade	Bias, deg C	Standard deviation	Number of matches	SST range, deg C
1	0.19	0.33	76	11.3 - 17.9
2a	0.16	0.39	99	10.1 - 21.3
2b	0.10	0.34	274	7.8 - 20.9
3	-0.03	0.62	429	7.8 - 20.9

AATSR Dual-3 Channel retrieval

Matchup Grade	Bias, deg C	Std deviation	Number of matches	SST range, deg C
1	-0.00	0.36	67	10.1 - 19.1
2a	0.03	0.37	82	9.5 - 19.5
2b	0.11	0.60	288	9.3 - 24.9
3	0.16	0.72	388	9.3 - 24.9

AATSR Dual-2 Channel retrieval

Figure 3.6.3.2 Validation results for ISAR radiometer matchups to ENVISAT AATSR data, March 2004-December 2005.

Wimmer concluded that ISAR has been used to provide validation data for AATSR – over 500 match-ups for dual view, grade 2b (preferred and most representative data) with near zero bias and low sd. A new methodology for validation is being developed for the ISART program and the GHRSST-PP are encouraged to consider this when developing MDB systems and validation programs.

3.7 Session 7. Reanalysis Project

3.7.1 GHRSST-PP RAN & GCOS SST&SI working group, Ken Casey

Casey began by noting that the GHRSS-PP LTSRF is now active and has sponsorship for the coming years. This is important as the LTSRF is seen as part of the GCOS SST and SI Working group inter-comparison project. 3 RDAC data streams coming into the archive all in real time via the GDAC archive swept off 30 days after initial ingestion.

The GCOS SST&SI WG inter-comparison goals are:

- To provide unified access to SST and sea ice data for inter-comparison purposes
- To establish some standards for conducting inter-comparisons both long term climate and short term regional
- To support both the needs of longer-term climate inter-comparisons and relatively shorter-term satellite-era inter-comparisons

The inter-comparison work has been initially implemented as a web based access tool to multiple data sets on consistent grids with consistent data format. The main goal is to provide weekly, 1 degree gridded data sets and monthly, 5-degree data sets. Ultimately, the work will also include connections to the daily, high resolution primarily satellite-based analysis products (example, daily, global 5 km analyses). Data in hand include AVHRR Pathfinder Version 5, Operational AVHRR, HadSST2 and OISSTv2 on weekly, one-degree grid, with day and night separates for all but OISSTv2. All in common format (Matlab for now, but could be netCDF, HDF4-SDS, etc.). the main task is to now look at other data sets to bring into the inter-comparison including:

- Kaplan SST
- ERSST (easy to do)
- HadISST2
- AATSR
- MODIS
- Australian Analyses
- Sea Ice Datasets (that require more definition)

Casey then presented a series of example analysis's starting with the pathfinder and operational AVHRR using a common colourbar and presentation (Figure 3.7.1.1). These plots are about understanding the content of the data sets in question and identifying issues of concern that require further investigation rather than establishing what is right and wrong with a given data set. Several discussions were initiated based on these data. Dick Reynolds requested Hovmoller plots and zonal maps that are updated on a regular (weekly? Monthly?) basis. An action was raised for everyone interested in the GCOS ST&SI inter-comparison work to provide information to Ken on the RAN requirements and try to move these data into the same gridded data format to ease the initial RAN effort and assist the GCOS work. Casey would define the base day for the time format. An action for Casey to provide a specification document for data providers outlining the technical requirements for the data sets was raised. Peter Cornillon noted that a LAS style tool would be excellent for this type of work although there is a need to evaluate the security issues and indeed there may be an equivalent LAS doing this work elsewhere.

Casey then presented a number of linear trend calculations using different data sets as the base data to highlight the type of work that would be undertaken within the GCOS and RAN efforts. A new web site for inter-comparison and RAN issues has been set up at http://ghrsst,nodc.noaa.gov which has been branded in a similar manner to the GHRSST-PP.org site. This site will act as the 'hum' for GHRSST-PP RAN and GCOS inter-comparison work and suggestions and contributions for the web site were welcome.

Casey concluded with the following actions that will be undertaken in the coming year:

- Get all datasets online in variety of formats
- Establish standards for inter-comparison (Grids, Colour scales, Basic comparisons)
- Link to higher resolution SST inter-comparisons
- Develop appropriate connections to sea ice climate groups.

- Develop appropriate Live Access Server, TDS, etc.

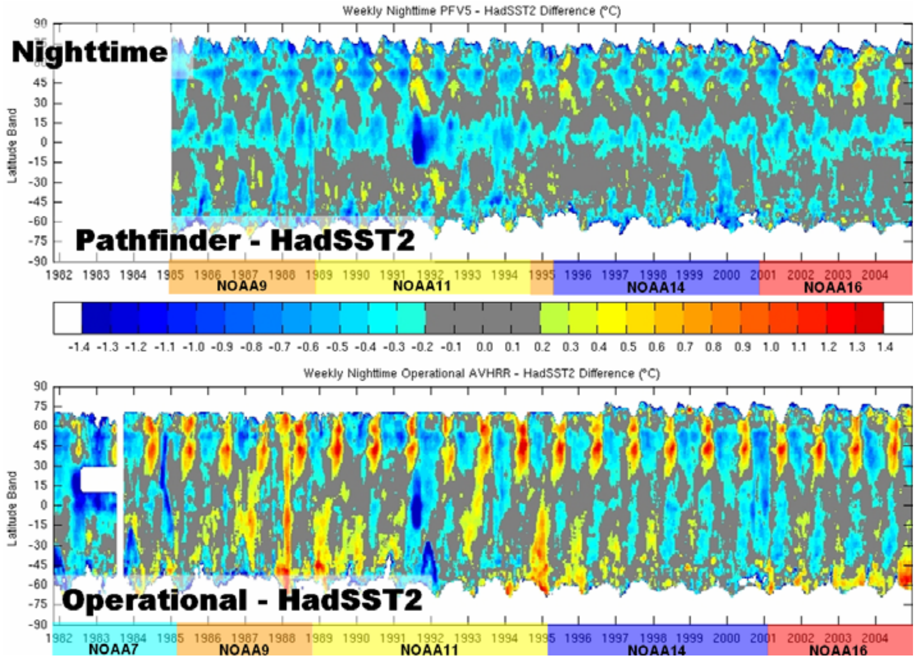


Figure 3.7.1.1 Weekly night-time Pathfinder v5.0 minus HadSST and (lower) operational AVHRR – HadSST.

Progress within the GHRSST-PP RAN and GCOS WG is being made and the data sets are coming in but on a best effort basis. The challenge is to get data on-line in a variety of formats and to work on some standards. At this stage Colour scales are important and there are slight differences between Met Office and the current colour scales used at the LTSRF. There was some discussion regarding colour scales ands it was agreed that grey denotes ±0.2, black indicates no data and white is out of range. Casey noted the scales used by Reynolds and the Met Office were good and action (Casey Reynolds, Stark) was raised to pass the colour scale developed at the Met Office to Casey for review. Once agreed colour table definition (colour indices and inflection points) to be published on the GHRSST-PP& LTSRF web space. Robinson noted that there was a lack of quality information attached to the data sets. Casey noted that some data have quality information (HadSST2 and Reynolds have error estimates) but others do not and this needs to be addressed in a uniform way. Robinson – need to have quantitative error estimates. Casey – need to have errors on a best effort basis.

3.7.2 ERS/ENVISAT Medspiration (A)ATSR Project: Version 2 in GHRSST Format, Gary Corlett

Coreltt noted that a 15 year record of (A)ATSR infrared data from 1991 (when ATSR-1 was launched) up to the present data is available. This provides a traceable global SST record from 1991 to today with sensors (ATSR-1, ATSR-2 and AATSR) cross-calibrated. A 10 year record of visible data is available from the launch of ATSR-2 in 1995 until today which is calibrated using on-board VISCAL systems. Reprocessing is now underway to put ATSR-1 and ATSR-2 data into a common AATSR "Envisat-style" format. The following (A)ATSR versions with particular characteristics are being developed:

- **Version 1 - Currently available**
    - AATSR excellent
    - ATSR-2: partially re-processed to same standard
    - ATSR-1: processed to an earlier standard
    - AATSR is in different format from ATSR-1 & -2
- **Version 2 - Available in 2007 as uniform archive**
    - 15+ years of re-processed data
    - Data will be available in ENVISAT and GHRSST L2P formats
- **Version 3 – ATSR Reprocessing for Climate (ARC Project)**
    - Next presentation

The justification for the new archive is that the Climate Record of 15+ years now achievable, there is a strong scientific need for a uniform data-set, the raw data media (tapes) are deteriorating, major changes in processing technology have occurred between ERS and ENVISAT, computers and hardware have improved performance and lower cost for storage, and there has been a major evolution in retrieval quality since ERS-1. Two copies of the (A)ATSR data set will be developed

- For the UK at the NERC Earth Observation Data Centre (NEODC), located at RAL and linked to British Atmospheric Data Centre neodc@rl.ac.uk
- For everyone else, located at ESA via category 1 registration (GHRSST-PP is covered) eohelp@esa.int

Data will be stored on an 80 Terabyte archive with 1 file structure: - mission/YYYY/MM/DD/product. Data delivery by FTP or HTTP (browser) and a searchable metadata catalogue (MERCI) providing a map interface, preview images, child products & metadata.

Coreltt then presented further work using the (A)ATSR data set and the Pathfinder data set to look at residual climate trends in SST. This work was originally performed by Sea Lawrence and others at the University of Leicester, UK. The methodology to account for the impact of El Nino events had been revised. In the new scheme, the seasonal cycle and the influence of El Niño are removed from the data set following the formulation of Weatherhead et al. (1998) to simultaneously fit the seasonal cycle, influence of El Niño and trend. The AVHRR Pathfinder V5 data is averaged onto a 2.5° resolution grid and only data flagged as having the highest quality in the Pathfinder auxiliary data file (flag value of 7) are used. This provides the only continuous data at a spatial point through the entire time series are included in the analysis and is an extremely important data set that should be properly managed and improved all the time. Observed trends in the new analyses are computed for a shorter time-span of data 1985 to 2001 is 0.13±0.05 °C per decade. Using the new (different) method we obtain 0.13 °C per decade, suggesting the two methods are equivalent. The older version of the Pathfinder data set gives 0.09±0.04 °C per decade for day time data. Coreltt concluded that as the AATSR data set grows and new work to improve the uncertainty of AATSR data due to systemic errors (the ARC project) concludes these estimates will gain more confidence.

3.7.3 (A)ATSR Re-analysis for Climate (ARC) Version 3 Reprocessing, Chris Merchant

Merchant explained that the climate requirements for SST records at the Hadley Centre require the following issues to be considered:

1. The record should be independent for ≥15 year period
2. Biases must be <0.1 K, regionally
3. The target stability should be 0.05 K decade-1, regionally
4. All discontinuities must be understood removed
5. The consistency between sensors <<0.1 K
6. "Bulk" SSTs are required (SSTdepth at what depth??)
7. Comprehensive error characterization must include retrieval errors (random and systematic) and other errors (sampling, screening)

This is an extremely challenging list and demands a significant investment of time and effort if the answers are to be found. The is the task of the AATSR Reprocessing for Climate (ARC) project.

The elements of the problems to be considered (practically) are that across the (A)ATSR data sets there are different periods of channel availability, cloud detection is a challenge, SST retrieval (bias and stability) requires a reference data sets of 'truth' and complications due to the SSTskin temperature deviation. The approach taken is to work with two different data streams one stream will use a basic set of channels that are available throughout all missions and the second stream will use the best combination available at a given location and time. Differences between the 2 analysis will then tell us something about the quality of analysis. Cloud screening scheme will use a Bayesian probabilistic method which is in the testing phase at the moment. An example over Korea (Figure 3.7.3.1) shows the basic cloud screening and false flagging failure of spatial coherence test and how the Bayesian approach is a lot better (although fronts are flagged out in this example).

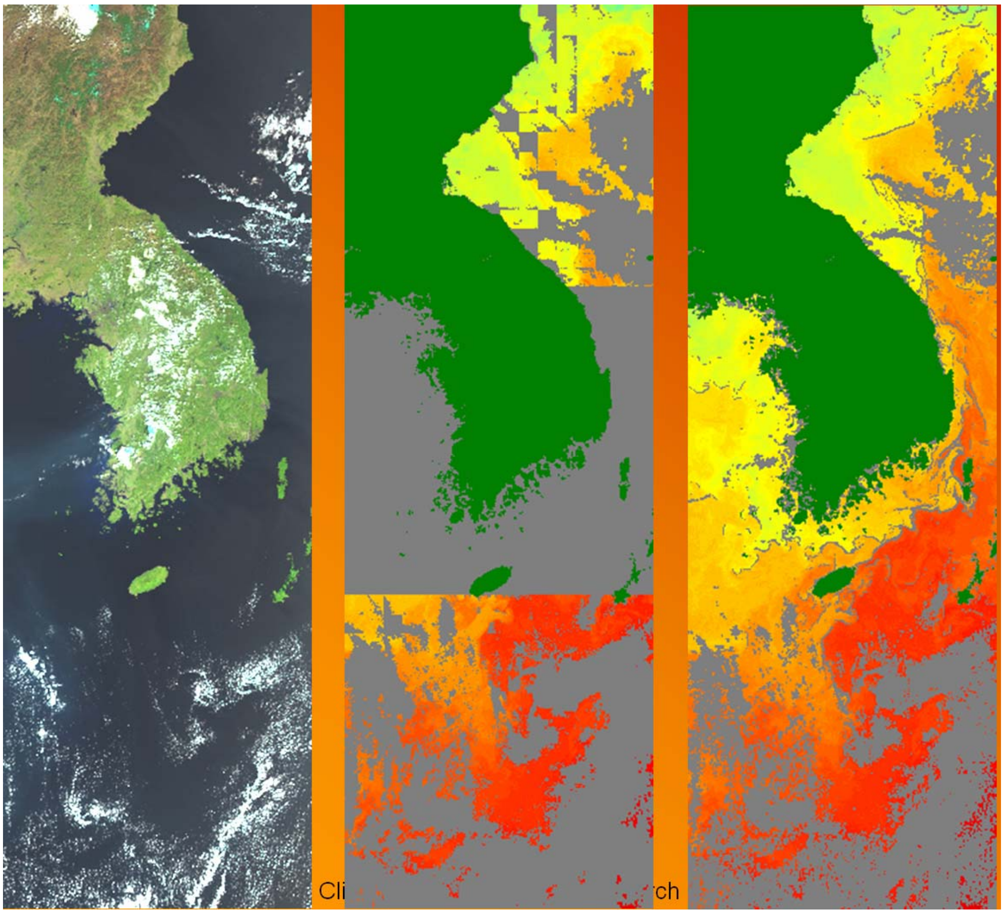


Figure 3.7.3.1 Example cloud flagging example over Korea using (left) visible channel data, (centre) operational code and (right) Bayesian techniques.

ARC will also work on the retrieval system for AATSR SST's using Radiative transfer modelling ton try and reduce the systemic biases inherent in the retrieval algorithm which result in a 'seagull wing' bias with increased bias errors in the tropics and Southern Ocean. There are still some residual errors in the scheme seen in differences between global monthly gridded D2-D3 SST retrievals over 6 months. Merchant concluded that this is an exciting time for the AATSR and GHRSST-PP community as the (A)ATSR data set is now being refined in a similar way to Pathfinder in order to establish a reference data set for SST observations that will form an essential input into the GHRSST-PP RAN project.

3.7.4 DLJ: AATSR data

Llewellyn-Jones reiterated many of the points made by Corlett and Merchant made ion the previous presentations. As PI for the (A)ATSR missions, Llewellyn Jones notes several important messages that had been learned so far from the 7th GHTSST-PP ST meeting.

- There were very distressing results shown by Doug May noting that only about 6% of AATSR data is being flagged as high quality data. The thresholds within the proximity_confidence values are clearly in error and should be changed as soon as possible by the Medspiration team. An action was raised and the Medspiration Project Manager is to supervise the update of proximity_confidence values to ensure that AATSR data are flagged as excellent appropriately. Doug May agreed to monitor the impact of these changes.
- Reanalysis of SST data sets is an important component of working with a data set and GHRSST-PP needs to see improvements in the data sets resulting from re-analysis including feedback to users so that they know what the improvements have been made.
- One of the great strengths of the AATSR is that it is independent of the buoys which is not true of the other satellite data sets within the GHRSST-PP. the GHRSST-PP need to be wary of inter-dependence of data sets when in situ and satellite data are used together. The AATSR record can help to understand these differences for the benefit of everyone and within the GHRSST-PP RAN effort this should be a key effort.

In terms of what users can expect form the GHRSST-PP reanalysis project, Llewellyn-Jones concluded that the most obvious is inclusion of missing data. The RAN can also take advantage of any re-processed data from providers but this requires information from providers (why should data be used for re-analysis?). In addition there may be a need for a transparent Policy on bias corrections to help monitor and keep track of various versions including the 'official' SSES version for all sensors that may be maintained by the data provider as opposed to GHRSST-PP.

3.7.5 GOES reprocessing plans, A. Harris

Andy Harris gave a brief presentation to explain the current plans for GOES reprocessing. The GOES team is currently working on a consistent data set back to 1994 using the Bayesian cloud mask. This is a very large data set and there are many issues of homogeneity to consider: this is the main challenge of the work. Of particular interest are plans to study the diurnal variability and tropospheric Instability waves. The data sets are regional at present but soon we will have a near complete geostationary array over Indian Ocean. The team expect to start processing in late 2006 and develop from there depending on the issues arising as the data are processed. A status report will be provided at the next GHRSST-PP meeting

3.7.6 GHRSST RAN Discussion conclusions

During the session discussion, the Pathfinder SST's were identified as a critical data set that the GHRSST-PP RAN must be sure has good stewardship and ideally, these should be prepared in L2Pc format with appropriate uncertainty estimates. Filtering on the collocations of the Pathfinder MDB will require additional wind speed although the latest version of the pathfinder data set includes winds. The RAN will take these actions forward as funds and time are available. Casey noted that this was an exciting time for RAN project as there are large activities in the EU with AATSR and in the USA (GOES, MODIS, Pathfinder). While the RAN can't do the L2P/L2 reprocessing itself it seems that international groups are getting the message that this work needs to be done.

Several questions were raised to help guide breakout session discussions which included

- What does the RAN want from the DV WG?
- What does the RAN want in terms of the validation?
- What should be included in a basic plan in place to guide groups now working towards the RAN.

It was agreed that the RAN-TAG needs to start work on a strategic plan to help guide groups working on this. It should include a wish list of data and a specification of the ideal work to be completed. An action was raised for the RAN-TAG Chair (Casey) to coordinate the RAN-TAG documentation to help guide the groups working on RAN TAG.

3.8 Session 8. L4 Analyses: What is right and what is wrong?

3.8.1 Validation of Medspiration L4 analyses, Jean Tournadre

Tournadre explained that two analysis systems were being used within the Framework of ESA projects the Medspiration Mediterranean Sea and the MARCOAST (NW European Shelf) analysis. Validation of L4 outputs is not really about in situ comparisons (all in situ data should ideally have been used in the analysis procedure…) but more about the consistency and quality of the analyses themselves. The task is to understand the analysis system and its ability to extract and preserve information while at the same time smooth and fill gaps. Input observations are all different scales and we say we want a 2km product but what does such a product actually mean? What are the limits to the analysis system and the validity of the results? What can we expect from a ill-conditioned problem where patches of high resolution data (1km) are available and holes with length scale of the order of 100's km require filling? What is the spectral behaviour of resulting fields? What is the trade-off between preserving the HR and filling the gap?

The L4's really depend on what we want to use the outputs for and the OI needs to be turned to the application itself. For biologists, spectral behavior is certainly irrelevant but resolution is (in the English Channel, and Adriatic Sea for example). For modelers, the spectral distribution of energy is crucial! For feature analysis it is important to preserve the frontal features; i.e. to preserve the gradients present in the data. These are all contradictory needs and the L4 processors have to both fill the gaps and preserve small scale structures and a trade off between these two conflicting requirements is required tuned to different applications. A series of tests using the OA processing and the resulting fields was performed as follows

- Resolution test : comparison 2 and 4 km L4
- Test of OA : fix the SST in L2P files and run the system to analyze the system performances
- Analysis of OA parameters (correlation length in time and space, Number of point used, …)

For the resolution test no statistical differences between 2 and 4 km were found but a comparison of spectral behavior for 2 and 4 km for fixed SST fields was significantly different (Figure 3.8.1.1). At scales smaller than 10km we introduce too much energy and at 4km we have more problems at low scales including the dominant impact of the prevalent sensor ~ 25km AMSRE and 10km SEVIRI. Tournadre concluded that it will be difficult to avoid spectral peaks at sensor resolution wavelengths.

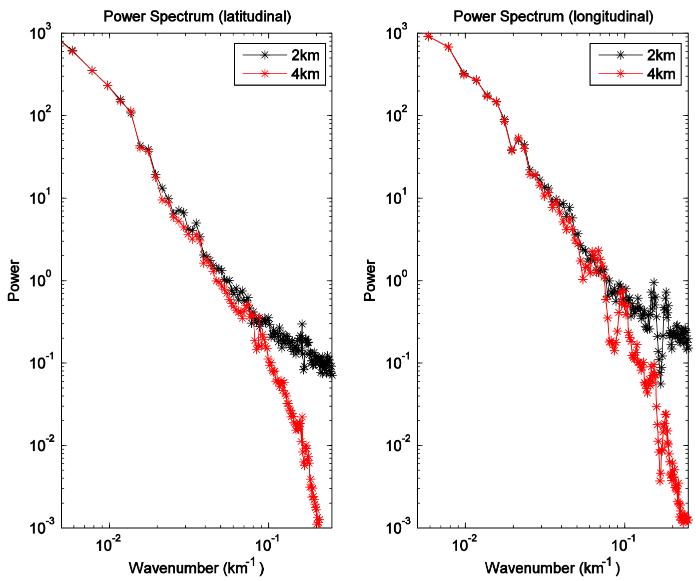


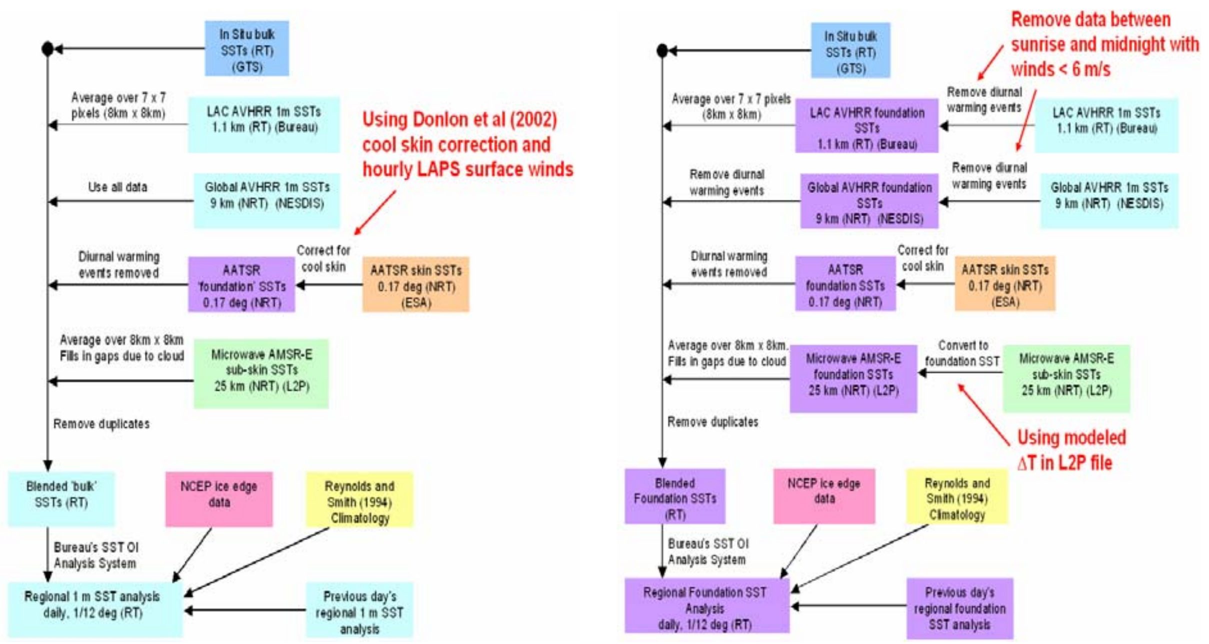
Figure 3.8.1.Comparison of spectral behavior for a 2km and 4km OI in the MARCOAST (E. Channel and Bay of Biscay) region.

The OI was used to test the inversion of fixed SSTs and in this case, the OI performs well and there is very little influence of the OA parameters when enough data is present (the analysis is perfect when we have no gaps!). The main differences are due to gap filling even over a 4 day period we still get some areas with no data others and in others we have a mixture of the data. With the current systems, below 60 observations in 4 days there are difficulties. Both MARCOAST and Medspiration L4 systems have problems of instability as the OI is sensitive to small scale gradients. Some of this has been solved by using night time data but it is far from perfect. A Medspiration report is available on these issue.

Tournadre noted that the basic Medspiration L4 verification tool has been set up on the Medspiration site http://www.medspiration.org/tools/validation/ and has allowed us to look at instabilities and their sources as all input data are provided together with maps of gradients and time varying gradients. It is a tool that allows L2P to be quickly QC's (in an objective manner) based on increments to the L4 system. Tounadre noted that there is a need within GHRSST-PP to define common tools to analyse and test the L4 analyses including the Medspiration L4 viewer, the HRDS and the MDB systems. Can wee define common metrics and can we define and implement a L4 quality index at high resolution that users could look to for help in ik interpreting the L4 quality (a simple version could be 'was there an input data point here or is this an analysis only grid point).

3.8.2 A New High Resolution SST analysis over the Australian Region, Helen Beggs

Beggs reminded the GHRSST-PP Science Team that Australia was currently about a year behind everyone else in terms of L4 analysis systems but progress should accelerate from now on within the framework of the BLUElink project which must set up HR Regional SST Analysis System. The L4 system is based on Bureau's operational, optimal interpolation SST analysis system (Smith et al., 1999) covering the region: 60°E - 170°W , 20°N - 70°S and is now operating in a pre-operational test mode. The system produces daily SST1m analyses (at 0020 UT and 1730 UT), daily SSTfnd analyses (at 1730 UT) and aims to resolve SST features at ~10 km. The analysis grid spacing was chosen as 1/12° (~9 km) and two observation correlation length scales of 8 km and 15km (background) are used with an time scale of 0.5 days. NCEP ice edge data are used and the Reynolds OIv2.0 is used as the background field.The main elements of the processing chain for the analysis system are shown in Figure 3.8.2.1.



(a) (b)

Figure 3.8.2.1 Main elements of the BLUElink project hiigh Resolution SST analysis over the Australian Region (a) BLUElink Regional SST1m Analysis – daily (0020 UT, 1730 UT), 1/12° and (b) BLUElink Regional SSTfnd Analysis – daily (1730 UT), 1/12°

Cool skin corrections are made to the AATSR data using the Donlon et al (2002) method for wind speeds > 6m/s and daytime data uin wind speeds < 6m/s are not used in the analysis. The OI system (SIANAL) requires an estimate of standard deviation (σtot) for each input observation. The Standard deviation gives the relative weight to give each observation in the OI analysis relative to each other and the background field so that the total variance ≅ instrument var + representativeness var

$$\sigma_{tot}^2 \cong \sigma_{instrument}^2 + \sigma_{space}^2 + \sigma_{time}^2$$

Figure 3.8.2.2 presents the instrumental and spatial representativeness error estimates currently used by the analysis system. Temporal representativeness errors are assigned differently for the SST1m and SSTfnd systems

- SST(1m): σ*time* = 0 but probably should use DV model or TAO/TRITON array SSTs to estimate
- SSTfnd by definition σ*time* = 0, in practice this should be negligible

Instrument Errors

Sensor	$\sigma_{instrument}$ (°C)	Source
Moored/Drifting Buoys	0.4	Emery et al (2001) Reynolds et al. (2002)
NOAA-15 AVHRR	1.0 Too high?	Bureau (matches with GTS in situ SSTs, ±3 h, 10 km, day+night)
NOAA-17 AVHRR	0.86 Too high?	Bureau (matches with GTS in situ SSTs, ±3 h, 10 km, day+night)
NOAA-18 AVHRR	0.27 ? $(0.49^2 - 0.41^2)^{1/2}$	Helen Beggs (matches with AMSR-E sub-skin SSTs, ±1 h, 10 km, day+night)
AATSR (10' Meteo Product)	2 channel = 0.32 3 channel = 0.23	Anne O'Carroll (matches with GTS in situ SSTs, ±1 hour, 17 km, night only)
AMSR-E	0.41	Chelle Gentemann (matches with TAO/TRITON buoy SSTs, ±0.5 hour, 25 km, night only

Figure 3.8.2.2 (a) instrument errors used in the BLUELink> 1/12°SST L4 system.

Spatial Representativeness Errors

- Spatial representativeness errors must be estimated over at least observation correlation length scale (8 km) and during same calendar day

Sensor	σ_{space} (°C)	Source
In situ	0.18	Helen Beggs (Gridding 1 km NOAA-17 AVHRR SSTs, ±1 h, 8 km, day+night)
AVHRR	0.18	Helen Beggs (Gridding 1 km NOAA-17 AVHRR SSTs, ±1 h, 8 km, day+night)
AATSR (10' Meteo Product)	0.29	Helen Beggs (Gridding 1 km NOAA-17 AVHRR SSTs, ±1 h, 0.17°, day+night)
AMSR-E	0.34	Helen Beggs (Gridding 1 km NOAA-17 AVHRR SSTs, ±1 h, 25 km, day+night)

Figure 3.8.2.2 (b) spatial representativeness errors used in the BLUELink> 1/12° SST L4 system.

Operational 0.25° Regional Analysis System – Errors used in analysis

Data Stream	Observation Estimated Standard Deviation (°C)
Ship	1.0
Buoys	0.6
XBTs and Argo Floats	0.6
1 km AVHRR	0.75
9 km AVHRR	0.75
Background Field	1.0

Figure 3.8.2.2 (c) instrument errors used in the BLUELink> 0.25°SST L4 system.

Test 1/12° Regional Analysis System – Errors used in analysis

Data Stream	Observation Estimated Standard Deviation (°C)	
Ship	1.2	
Buoys	0.44	
XBTs	0.44	Too low?
Argo floats	0.44	Too high?
NOAA-15 AVHRR	1.0	Too high?
NOAA-17 AVHRR	0.89	Too high?
NOAA-18 AVHRR	0.32	Too low?
10' AATSR	0.37	
AMSR-E	0.53	Too low?
Background Field	1.0	

Figure 3.8.2.2 (d) errors used in the BLUELink> 1/12° test SST L4 system.

The analysis system takes input data from AVHRR LAC (1km) and GAC (9km), AATSR 10-arc minute data (~18km), AMSRE 25km data. Global AVHRR is sub sampled at about 1/3 volume. The LAC 1 km NOAA-18 and AVHRR SST1m data stream is used to determine SSES. The difference between the SST1m and SSTfnd analysis outputs are shown in Figure 3.8.2.3. Differences are interesting as they are probably related to the input satellite data sets and suggest that further corrections for Diurnal variability might be useful. Other comparisons to high resolution data-only (similar to the NAVOCEANO K10 analysis) CSIRO AVHRR SST composites show that there are some differences. Differences between BoM and the new test analysis is that the bias and the SD are slightly less.

Beggs concluded with plans for future work with the new analysis which include:

- Blend hourly, 5 km, geostationary SST to skin or SST1m data from MTSAT-1R and/or FY-2C (if of value)
- Determine if it is better to blend 1 km AATSR skin SSTs rather than 0.17° AATSR Meteo skin SSTs
- Replace NESDIS global 9 km AVHRR SST1m with NAVOCEANO global 9 km AVHRR

L2P SST1m data

- Replace NCEP ice edge data set with 1/10° OSI-SAF sea-ice concentration
- Determine how best to grid and blend AMSR-E SSTs
- Improve estimates of observation RMS errors input into OI analysis system
- Apply different method for filtering diurnal warming events or apply DV model if reqiured

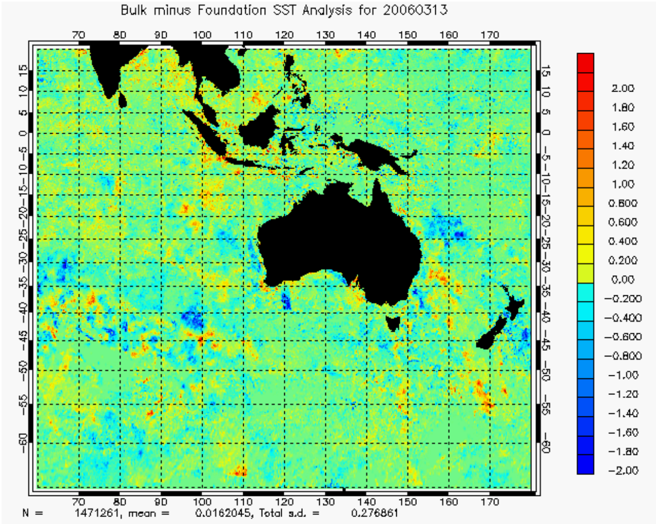


Figure 3.8.2.3The difference between BoM BLUELink> SST1m and SSTfnd analysis outputs (K)

3.8.3 The Met Office Operational SST & Ice Analysis (OSTIA), John Stark

Stark noted that this presentation builds on the general user talk given on Tuesday with a focuss towards the science of the analysis. The OSTIA analysis is a daily 1/20° (~5km) global analysis using optimal interpolation. Data inputs include satellite (microwave & IR) and in situ data and in situ data. The analysis is now running daily on a pre-operational test phase at the Met Office. Te OI is persistence based with no explicit model. The analysis uses 10km and 100km spatial correlation scales and is this effectively 2 analyses requiring that. OSTIA uses sea ice analysis performed by OSI-SAF (met.no / DMI) interpolated to the analysis grid. All analysis results are available from www.ghrsst-pp.org. The aim for the OSTIA team is to become a fully operational system in Mid-2006.

Stark noted that much of the work involved in the OSTIA system is in the QC systems providing observation pre-processing, system background checks and DV checks. All observations with non-zero reject flag are rejected, 'daytime' obs with 'low' windspeed (<6 m/s) are rejected where 'daytime' is defined as 1000 – 1800 local time. The system performs a background check against climatology (which could be a previous analysis) and uses background error and observation error to estimate probability of gross error (PGE). If the PGE is large the observation is rejected. The system then assigns error estimate (variance) using SSES supplied in product. The Bias (if present) is subtracted from observation value for in situ observations, moored and drifting buoy & ship data are ingested via GTS. The system then assigns error estimates to data based on type and station code and background errors added from static 2D fields.

Each observation type has a different footprint which requires that observation operators are used to properly represent the full range of observation footprints. Assimilation of ¼° gridded data at cell centres (e.g. Medspiration TMI) led to artefacts in the analysis (discovered using the HR-DDS) which led to observation operator development. The bias correction routine used by OSTIA is based on matchups between satellite data set and reference observations including in situ and AATSR data (we can choose which data set to correct against). By using AATSR data the bias correction is significantly improved as more matchups are found in areas that have no in situ observations (e.g., Southern Ocean). Matchup criteria use 25km over 24hours are persisted over a 5 day e-folding time with additional uncertainties due to the fairly open matchup criteria. The system first looks for matchups between satellite and the reference data set then performs a bias correction based on the machup's using an OI to provide smooth bias correction fields. At the moment we use one error correlation scale at 750 km to represent errors associated with large weather systems and aerosols. Figure 3.8.3.1 shows example bias correction fields derived using the OSTIA system for several different sensor inputs.

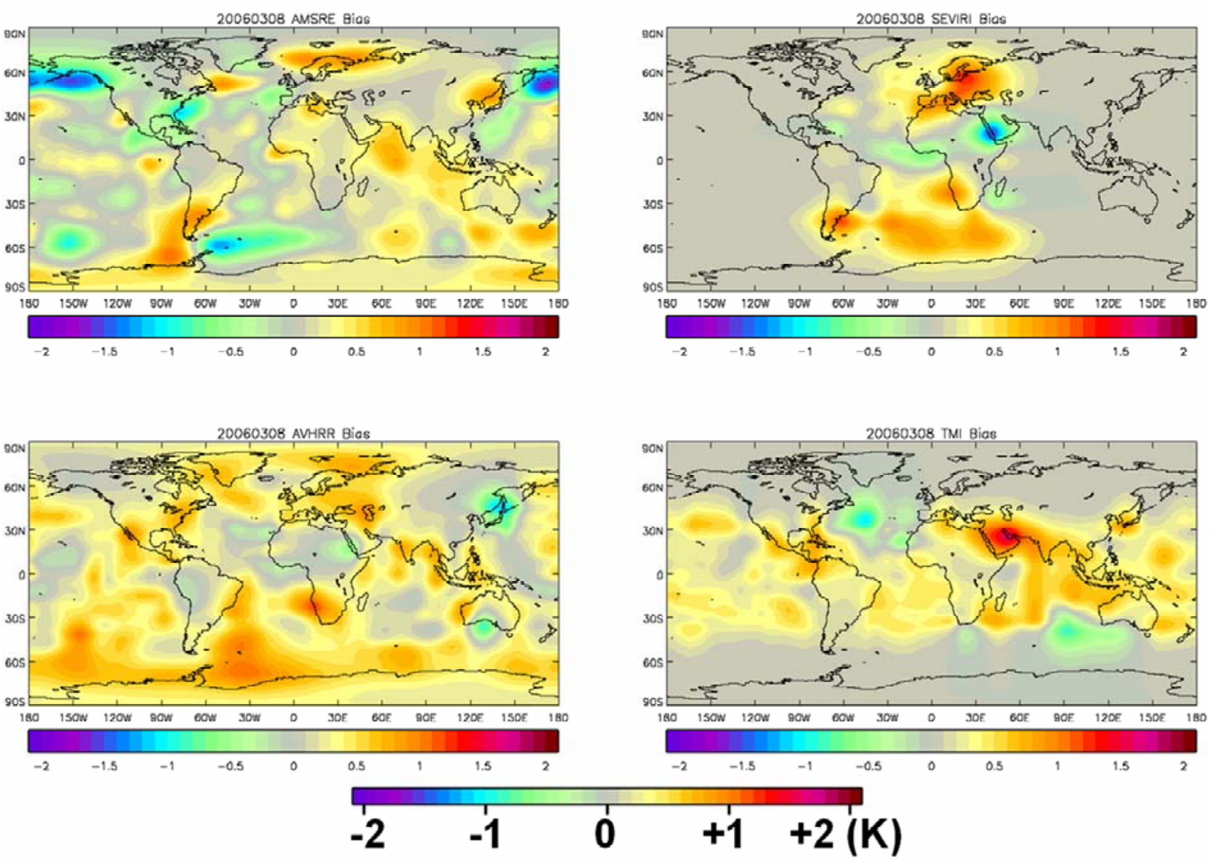


Figure 3.8.3.1 Example bias correction fields derived using the OSTIA system for several different sensor inputs.

Stark showed a series of animations of bias correction which have different characteristics depending on the satellite data set concerned, the location and the time of year. AMSRE appears to be biased on a swath to swath basis whereas AVHRR has large biases at high latitudes. Validation and verification of the output data are performed routinely in a similar manner to that presented by Pierre LeBorgne by splitting the global ocean into distinct regimes with similar known characteristics. A global rms of ~0.6K is found but with large variations in the Arctic Ocean and the Mediterranean Sea (where there are only a few observations).

Stark concluded that a dynamic error estimate is now required for the L4 system as our scheme does not allow us to do this in actuality. There is also a need to develop an analysis quality index to help users apply the analysis data with confidence.

3.8.4 SST analysis, Dick Reynolds

Reynolds explained that the OIv2.0 had been held back by lack of AVHRR observations in the cloudy areas but now that enhanced coverage is available from AMSRE with incredible coverage it was time to revitalise the OI system. In January 2003 the data coverage for AVHRR for > ±40°N and S has roughly only 5 days of data with the number of days increasing toward the tropics. Data drop outs are mainly due to cloud cover. For the AMSR in latitudes > 40°N and S we have more than 20 days of data and a drop off of coverage due to precipitation in the ITCZ and SPCZ. Reynolds noted that with so few data how does the OI work at all in dynamic western boundary currents? Using animations of gradients calculated from AMSRE data in an OI we can see that in the Gulf Stream area the gradients have a stationary part due to topography so that even limited AVHRR data are useful. In the Aghulas regions the gradients have a stationary part with some slow eastward prorogation so that again, limited AVHRR data are useful. However in the Tropical eastern Pacific, gradients propagate westward as unstable waves so that limited data coverage is not as useful here (Figure 3.8.4.1). Monthly averaging smooth's out most of gradient signal so at this temporal scale it is not a big problem but as the time space scales of the OI increase this becomes a major issue and without data there is no real chance of providing a useful solution using the OI.

Reynolds then summarised the differences between the weekly OIv2.0 system and the new daily 1/4°

OI system as follows:

- *Weekly (OI.v2):* Gridded 1° resolution using **Infrared AVHRR** satellite plus in situ (ship and buoy) data. A 7-Day large-scale satellite bias correction is applied to each satellite
- *Daily OI:* Gridded 0.25° resolution using **Infrared AVHRR and Microwave AMSR-E** Satellite plus in situ (ship and buoy) data. A 7-Day large-scale satellite bias correction for each satellite but separate analyses are performed using AVHRR and AMSR-E

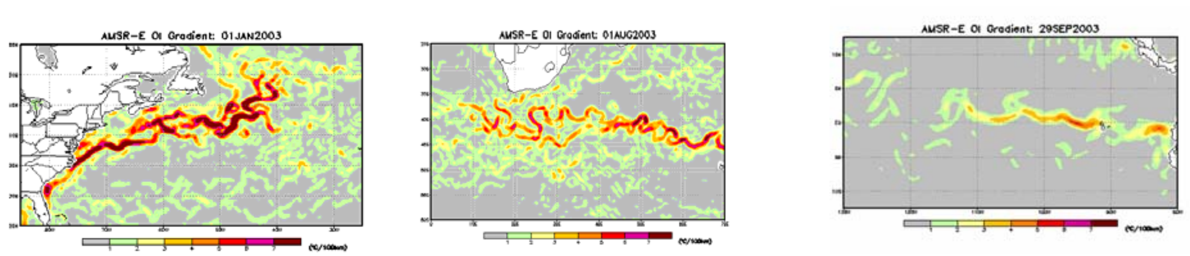


Figure 3.8.4.1 Gradients computed from AMSRE OI system showing the nature of gradients in different locations.

In terms of the AVHRR data there are two choices the Pathfinder and the operational AVHRR stream. The main advantage of the Pathfinder data is a lower bias variability but as a delayed mode stream. The Advantages of the operational stream are that it is provided in real-time data but with lots of 'issues' requiring better QC procedures. When using the AMSRE a large SDT error is required as the data are much more noisy. Within the new analyses the correlation scales have been changed to higher resolution down to 50 km or so dynamic areas such as the Gulf Stream. In order to asses the new OI scheme it was decide to examine daily OI (1/4°grid) outputs (using constant e-folding spatial scale (100 km) and a constant noise to signal ratio (1), as 2 versions using initially the operational AVHRR and then the AMSR-E) compared to the OI.v2 (weekly, 1°) and the RTG_SST (daily, 1/2° grid).

Considering the Jan 2003 mean SST Gradient in the Gulf Stream area (where we have sparse AVHRR data coverage and AMSR data missing near coast but otherwise almost complete in terms of data) the OI.v2 gradients very weak, but the daily OI and RTG gradients are similar. The AMSR OI has strongest gradients due to better data coverage than AVHRR. For the STD AMSR-E has stronger standard deviations than Pathfinder especially in mid-latitude winter as clouds reduce Pathfinder sampling. These differences plus gradient differences suggest that separate Pathfinder OI and Pathfinder + AMSR OI is needed. In terms of the zonal OI correlation scales, daily spatial scales are strongly reduced from weekly scales especially in high gradient areas (scales <100 km in Gulf Stream). Daily scales of between 100 & 200 km are appropriate in most regions.

The OI has been run using Pathfinder and In Situ data using the 1/4° Daily OI with and without bias correction. The bias correction is constructed using separate average of 7 days of in situ and satellite anomalies on a 2° grid. The OI is computed for the collocated differences (bias) and the bias removed from the original satellite data. In this way the system is using in situ and corrected satellite data. The results are then compared with the weekly OIv2.0 outputs. There are different bias problems in the Pathfinder and the Operational AVHRR data sets which required separate investigation.

Reynolds noted that bias correction is the biggest challenge in the OI system and that new techniques based on the use of Empirical orthogonal teleconnections really help to improve the bias correction. The approach is not prefect but much better than using the OI in the trasditional sense.130 modes are derived from Extended Reconstruction SST (ERSST) and modes are fitted to 7-day in situ and satellite anomalies. Modes are only used if supported by both types anomalies and then you can reconstruct anomalies from modes. The bias is then the difference between the two reconstructions.

Reynolds summarised the method used to deal with SST in the marginal ice zone which relies on the basic technique developed by Nick Rayner which effectively converts sea ice to SST's going from 0.6 - 1 depending on sea ice concentration using a linear approach. Other issues raised included the relative bias between ships and buoys (Ships are warming up) and the need to develop appropriate corrections that may need to include the changing shape of the observing system (now more buoys than ships). Reynolds concluded that the plan is to continue to test and refine the AMSRE and AVHRR system which can then be extended to include other data sets including AATSR, TRMM MODIS etc. Finally, Reynolds agreed to put out his analysis to the GHRSST-PP GDAC in GHRSST-

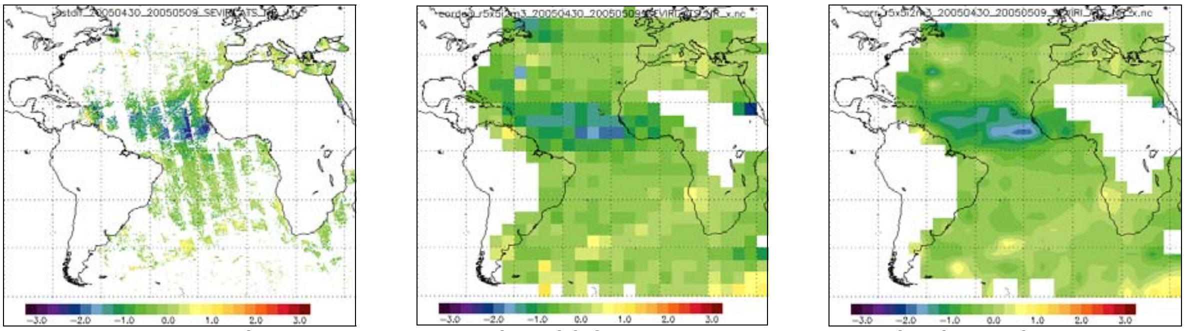
PP L4 format.

3.8.5 Collated files for SST analysis, P. Le Borgne, A. Marsouin, F. Orain

LeBorgne explained that within the MERSEA project a global L4 SST analysis was being developed base on the use of L2P data which are passed to a pre-processing system that Collates the data (gridded, one file per night) before passing the collated files to an optimum interpolation system that produces the L4 product. CMS is responsible for defining pre-processing rules and the main issue foir this presentation is bias correction.

The planned scheme at CMS is to first build mono-sensor collated files (1 per night of all the 'best' data per grid point). SSES bias corrections are then applied to the data. The L4 analysais will be centered at 00:00h daily, and have a native spatial resolution from 0.02 to 0.25 degree covering the 60S – 90N – 100W - 45E region (to be extended to global). Sensor biases are then corrected for each of the collated data sets which are then combined to produce a super collated file containing the best available data according to an a priori selection procedure.

LeBorgne described a bias correction experiment conducted over 10 days in May 2005 using SEVIRI, AVHRR17-G and ATSR with the CMS nighttime composites as draft collated files. In this experiment AATSR data were used as a reference with nthe aim to correct for atmospheric scale errors. Varous combinations of spatial and temporal scales were considered to optimise the impact of the AATSR to provide a useful intput to the bias correction procedure as shown in Figure 3.8.5.1.



SEVIRI - ATSR over 10 days, at 0.1 deg. 30 Apr 05 to 09 May 05 | **Averaged at 5 (?) degrees. 30 Apr 05 to 09 May 05** | **Interpolated at 0.1 degree 30 Apr 05 to 09 May 05**

Figure 3.8.5.1 Example difference AATSR-SEVIRI fields derived for different spatial and temperal scales.

LEBorne noted that due to the narrow swath of the AATSR some care needs to be exercised in terms of the spatio-temperal coincidence of AATSR and other sensors as there is little overlap. Each sensor type requires different scales for the derivation of appropriate bias correction fields (SEVIRI, AVHRR, AMSRE, TMI etc). Experiments show that 5 day temporal averaging gives the best quantitative result for most sensor bias correction. The L4 system is based on the CLS L4 Processor developed as part of the ESA Medspiration processor and uses nighttime SST of a given date providing 0.1° resolution outputs. This system was used to test the impact of using the AATSR as a bias correction for the other satellite sensors. Figure 3.8.5.1 shows the results when using the AATSR bias correction and using normal bias correction clearly indicating the benefits of the AATSR as a reference sensor for L4 analyses.

LeBorgne concluded that

- Correction of SST fields by AATSR data is certainly possible and is useful and the AATSR makes a significant impact on the bias correction
- Filtering spatial structures below 5° seems OK
- Time variability over 10 days matters: solution: increasing the weight of the most recent information through compositing or analysis of the difference fields
- Correction efficiency must be recorded for each corrected field (daily basis)
- Corrections are being tested each month in 2005 to adjust the time/space scales

There is still more work to select the most appropriate timescale for the corrections and how best to use these in the OI

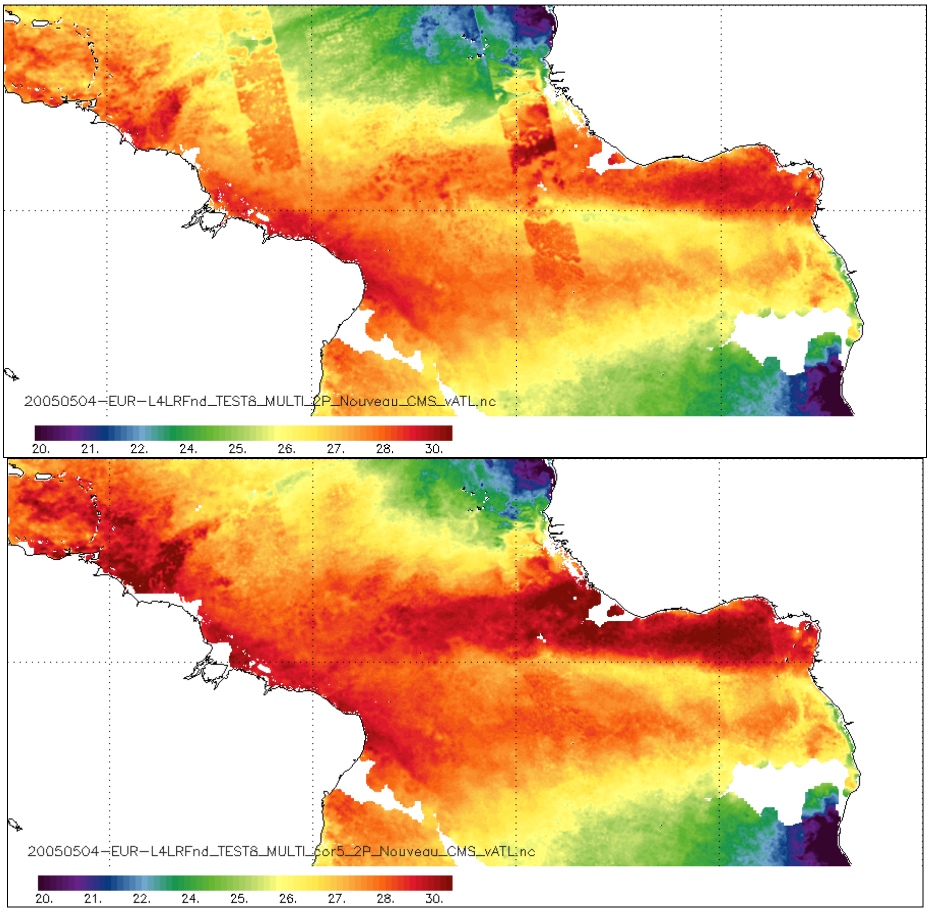


Figure 3.8.5.2 L4 analysis in the Tropical Atlantic Ocean (5-day analysis 2005-05-04) derived using the MERSEA L4 prototype system (top) WITHOUT AATSR bias correction and (bottom) WITH AATSR bias correction.

3.8.6 RSS High Resolution MW only SST, MW+IR SST and Sea Ice Analysis for GHRSST C. Gentemann

The Remote Sensing Systems (RSS) is a L4 analysis system that is continually updated and reprocessed as new data become available. Three microwave L4 analyses are available from www.remss.com. One analysis contains only TMI SSTs, another contains only AMSR-E SSTs, and the final analysis blends the two SSTs. The TMI OI SST are available between 40° N and S form January 1998 to the present, AMSR-E OI SSTs are available globally from June 2002 to the present, and the combined global OI TMI+AMSR-E SSTs are available from June 2002 to the present. Data are available in binary files with a 0.25 x 0.25 degree grid (1440 x 720) of single byte values representing SST for a given day. Interim products ("rt") are updated several times per day until the data become final ("v02"). Data are blended using OI, which requires estimates of retrieval error. MW SST retrieval errors are mainly a function of wind speed and SST. These errors are added in a root-sum-squared sense to the daily standard deviation (STD) derived from buoy collocations to obtain a total retrieval error. The daily STD and bias are calculated using collocations with NRT GTS in situ observations. A collocation is made only if there is a satellite observation within 25 km and 6 hours. Collocations within 200 km of land are excluded as these are typically in regions with highly variable (both temporally and spatially) currents. Collocations between 12 Noon and 4 PM (local time) with wind speeds less than 6 ms-1 are also excluded. The remaining collocations provide daily mean bias and standard deviations for both TMI and AMSR-E SSTs and are available in NRT from www.remss.com. A correction to the TMI measurements for an error resulting from the antenna coating is applied before TMI data are included in the OI analysis. Before blending the data from TMI and AMSR-E, diurnal warming is estimated using the Gentemann (2003) model (see 3.1.3 above). Using this diurnal model, all MW SSTs are 'normalized' to a daily minimum SST, defined to occur at approximately 8 AM, local time. Validation of the MW OI SSTs has mainly been through comparisons to Reynolds SSTs. Tables 1 and 2 show validation statistics: one for collocations within the range of TMI data (±40°); another for global collocations (±90°).

Table 3. Data from Latitudes: 40S – 40N Dates: 2002-Jun through 2004-Feb

MW OI SST	Bias (°C)	STD (°C)	# Collocations
TMI	0.12	0.59	198,622,601
AMSR-E	-0.03	0.53	202,317,843
TMI+AMSR-E	0.01	0.56	196,485,267

Table 4. Data from Latitudes: 90S – 90N Dates: 2002-Jun through 2004-Feb

MW OI SST	Bias (°C)	STD (°C)	# Collocations
TMI			
AMSR-E	-0.02	0.64	313,865,230
TMI+AMSR-E	0.01	0.65	319,671,057

The larger biases when latitudes greater than 40° are included is likely due to the presence of more dynamic SST features at higher latitudes. Such as the western boundary currents and the Antarctic circumpolar current. A separate L4 analysis that blends MW and IR SSTs is under development and test data along with read routines are available at ftp.misst.org (user = testdata, password=1000violin.

This L4 blends TMI, AMSER and MODIS at 10 km resolution. The MW SSTs are processed similarly to the MW only OI analysis described above. Aqua MODIS data has no time of observation or error information. An instrument simulator developed at RSS along with nadir track information from RSMAS is used to estimate time of observation for retrievals. The MW and IR SSTs have different regional biases which would result in errors in the OI analysis. A running ten day, 100 km, smoothed mean difference (MODIS minus AMSR-E) is calculated and subtracted from MODIS SSTs to remove regional differences. The regional differences are due to error in both the MW and IR SST algorithms, removing this regional difference from MODIS simply sets the regional error in MODIS to that of AMSR-E. Finally, all data have an estimate of diurnal warming removed to form the foundation SST.

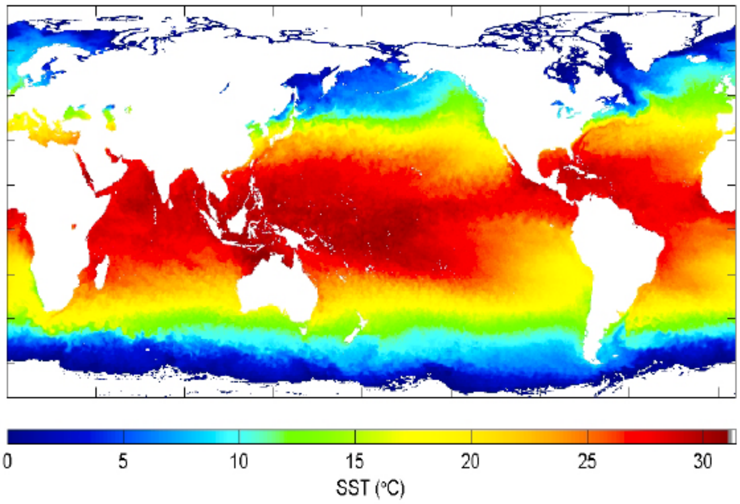


Figure 7. 10 km AMSR-E, TMI, MODIS OI SSTs on November 16, 2002.

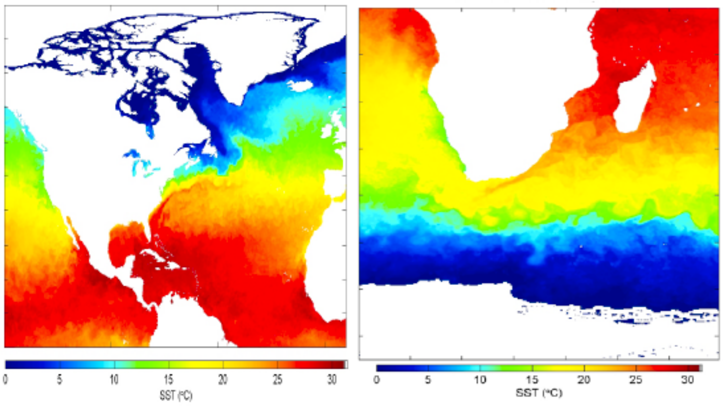


Figure 8. 10 KM AMSR-E, TMI, MODIS OI SSTs on November 16, 2002. The North Atlantic is shown on the left and Agulhas Current on the right.. The lack of an ice map is seen near ice and near land retrievals of SST that are realistically sea ice.

Several methodologies for calculation of diurnal warming in MODIS were explored. Simultaneous wind speeds for most MODIS SST retrievals are available from AMSR-E. Unfortunately, the AMSR-E swath is narrower than MODIS and AMSR-E is unable to retrieve with speed near land. For MODIS SST retrievals where AMSR-E wind speed is unavailable it was found that using NCEP wind speeds resulted in significant differences in wind speeds near swath edges and near land. It was found to that using nearby AMSR-E retrievals (weighting any retrievals within 2.5°) to be a better methodology. If MODIS SSTs had no AMSR-E wind retrieval within 2.5° then NCEP winds were used. Although this data appears to be a significant improvement in resolution from the 25 km MW OI SSTs, noticeable errors due to undetected clouds occasionally are seen. It is expected with the new MODIS SST's many of these issues will be resolved. The product currently does not contain an ice mask. Development of this product is focusing on removing the cloud contamination, the addition of a high-resolution ice mask, and adjustment of the TMI sensor errors. Several examples of these fields are shown in Figure 7 and Figure 8.

Finally, development of a high-resolution (10 km) daily ice map specifically focused on ice-edge and near land retrievals is on-going at RSS (Figure 9). The ice algorithm is being developed from carefully inter-calibrated RSS SSM/I brightness temperatures. This should allow the algorithm to be easily extended from the development period (2005) to the entire SSM/I time series. Use of the 85 GHz channels near land has provided some promising results for near-land ice retrievals.

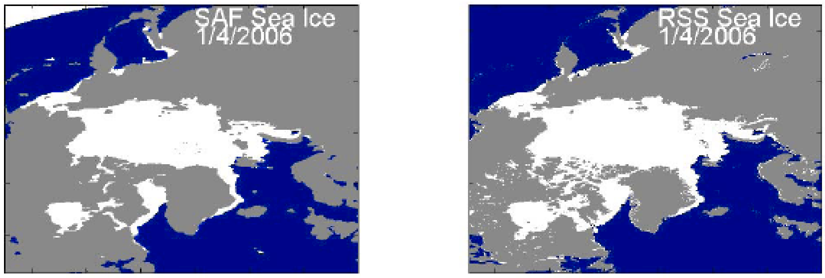


Figure 9. Sea Ice, 10 km analysis for OSI SAF and preliminary RSS sea ice on January 4, 2006. The RSS product uses combinations of the 89 GHz channel to retrieve sea ice near land. In the SAF Sea Ice, near land retrieval are not made, in the image these missing areas are colored the same as land. The additional near-land retrievals in the RSS algorithm show that it may be possible to retrieve ice near land using the higher resolution channels. Validation of this product is on-going.

3.8.7 Impact of biases and diurnal warming on analyses, Wick/Jackson

Jackson noted that blended SST analysis provides opportunity to use strengths of microwave (TMI and AMSR-E) and infrared (AVHRR) MCSST products. The purpose of this work was to investigate the effects that bias corrections developed by Wick/Castro to microwave (TMI and AMSR-E) and infrared (MCSST) SST products have on blended SST analysis. In addition, the work examined the effects of diurnal warming and DV corrections have on optimally interpolated SST analysis. The methodology used in this work focussed on the application of a modified version of Reynolds and Smith (1994) optimal interpolation method that creates daily 0.25° gridded SST product. Buoy data are not used as input but only d for validation. The Wick/Castro 3D bias correction tables (IR: sza, c45, sst, MW: wv, ws, sst) were applied to input data fields before optimal interpolation and the Fairall ocean flux model used to predict diurnal warming from solar and wind speed inputs. Figure 3.8.7.1 shows a typical input data set and the resulting SST analysis output.

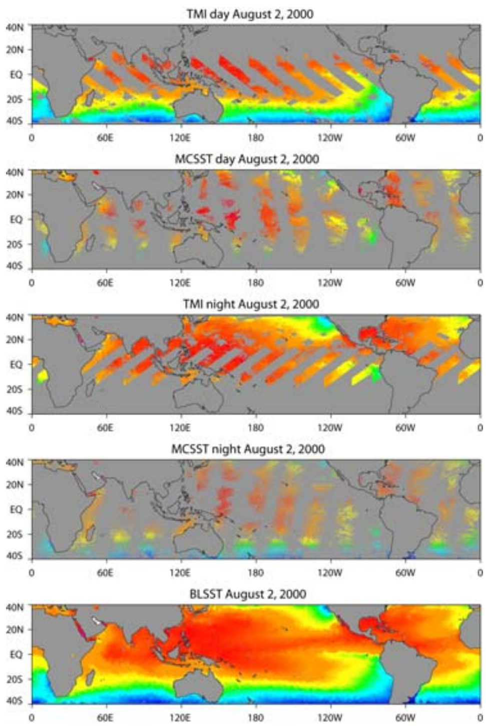


Figure 3.8.7.1 Typical input SST data sets and the resulting SST analysis output used in this study for August 2 2000.

A simple case study was run where TMI/MCSST and AMSR/MCSST combinations were analysed for August 2000. The SST analyses were validated with night-time buoy data. Five cases were considered:

1. No bias corrections applied
2. 3D correction tables applied
3. 3D + climatological correction applied
4. 3D + climatological + only winds > 3 m/s.
5. 3D + climatological + diurnal correction

The results of the experiment are shown in Figure 3.8.7.2.

Jackson concluded that bias corrections improved bias and standard deviation errors in analyzed SST field for both TMI and AMSR cases (especially in the daytime). Diurnal correction reduced the overall bias but may be overestimating warming. Clearly there is a need to evaluate longer time series to better assess improvements in analyzed SST field and to assess the stability of 3D bias corrections for independent time period.

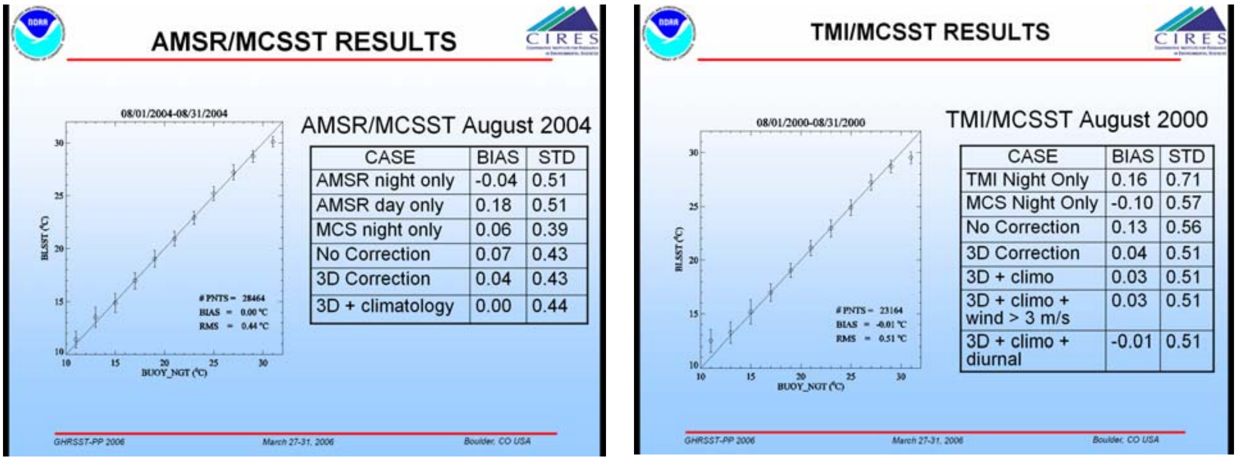


Figure 3.8.7.2 Results obtained for bias correction case study based on buoy collocations to the L4 analysis SST.

3.9 Session 9: The GHRSST-PP DDS and MDB systems

3.9.1 Topic Summary, Dave Poulter

Poulter reviewed the concept of the HR-DDS which is to provide a tool for the QC of L2P, L4 and other data in via web based interaction. Data can be obtained in a common format interpolated to 0.01° using a nearest neighbour approach to allow simple inter-comparisons. The HR-DDSS system provides a way to control the spatial and temporal characteristics of the GHRSST-PP data sets. In contrast, the MDB system includes in situ data from Coriolis matched to satellite data within 25km and 6hrs with data products available as either ASCII or netCDF fields.

Thus the application of the HR-DDS and the MDB is different. Poulter used an HR-DDS site in the Western Mediterranean to show how observations obtained within an hour of each other show large differences in the temperatures and changes in cloud masks. L4 products from the OSTIA system reveal significant problems in the Caspian Sea where OSTIA had a large increment from the AATSR (which was the only data set available at the time). The benefit of the HR-DDS is that data are on-line and can be used in real time to monitor the performance of various analysis outputs. The uses of the MDB are mainly for the derivation and confirmation of SSES and for validation of L2 input data and need top be explored much further. Poulter posed several questions to the session:

- Medspiration has put a lot of effort into the HR-DDS system and there is an opportunity to include more data and features. What are the development priorities (Pathfinder, JAXA AMSERE, different L4 data etc)?
- Do we need more HR-DDS sites? There is a trade off between database speed and the volume of data. For any new sites we need the coordinates fro DDS sites which is not a complicated issue. e.g. cruise area (for example).
- MERSEA requested that the HR-DDS should include in situ data by linking to the MDB. Which in situ data should be used in the HR-DDS?
- More interface options colour scales, 3d plots could be developed – is this the priority issue?
- For the MDB system what do we want? Are interactive graphics required? Are there sources of data that should be included in the database beyond what the Coriolis database contains?
- What is the relationship between the MDB and other MDB's? The Science Team agreed in Exeter that the GHRSST-PP MDB would be at IFREMER EUGDAC and that there should be some ingestion of FNMOC into CORIOLIS or at least an inter-comparison of the data. Can this be developed today?

3.9.2 The GHRSST-PP Matchup Database (MDB), JF Piollé

The GHRSST-PP Match-up DataBase (MDB) stores coincindent in situ and satellite measurement with respect to some time difference and spatial distance criteria. The development and delivery of MDB records was originally part of GDS requirements intended to provide a resource for unified SSES (specific sensor error sattistics) determination. SSES should be derived as Bias and standard deviation between satellite measurement and an independant in situ source. These estimates would complement estimation by providers (or provide SSES if they were not provided). In addition, the MDB provides added value for use in sensor merging as SSES's are derived using the same source of in situ data and using the same estimation methodology.

The MDB was developed at IFREMER as both the European RDAC (and upcoming GDAC) archive and Coriolis database are hosted at IFREMER. The Coriolis system is used as a single source of in situ data and is a worldwide database that ingests real-time (GTS) to delayed mode (ship data) from many providers. The Coriolis system in involved in all major programs (main or mirror archive) including ARGO, GOSUD, WOCE, CLIVAR etc. In addition to the database itself, IFREMER has expertise for quality assessment, properties of data allowing a close interaction between satellite data center and in situ data center. As a single source Coriolis makes collection of in situ data easy (same format, same delivery mode), provides a data set that is homogeneous in terms of quality control, content (quality flags) and takes benefit of delayed mode QCs. Finally it is used within the Medspiration and MERSEA frameworks. Figure 3.9.2.1 shows a schematic overview of the GHRSST-PP MDB system implemented at IFREMER.

Currently, the only data sources used within the MDB are MDB records produced by the Medspiration project L2P(AATSR, AVHRR GAC 16/17, NAR16/17/18, SEVIRI, AMSRE and TMI) and L4 products over the MEditerranenan Sea. Howeverm the system will be extended to global coverage of AATSR (April) and available US-GDAC datasets (May-June).

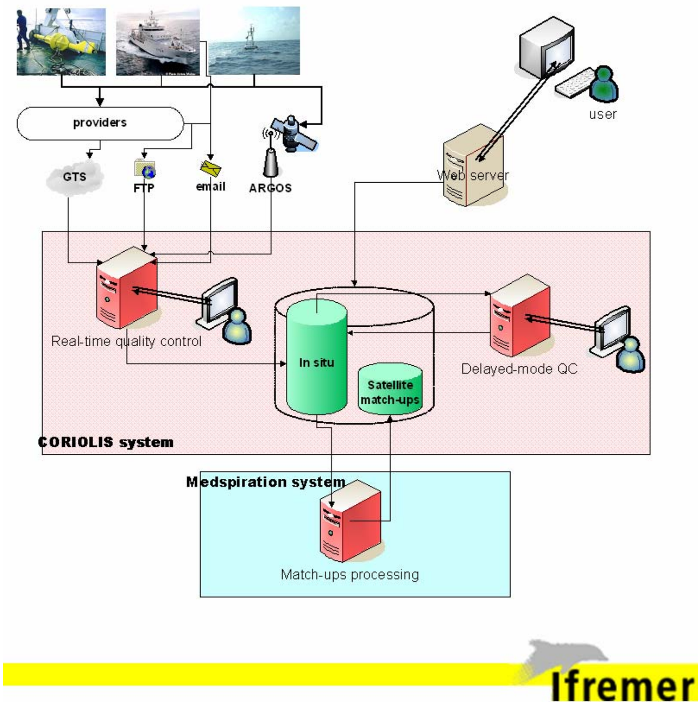


Figure 3.9.2.1 Schematic overview of the GHRSST-PP MDB system implemented at IFREMER.

The in situ data sources considered by the system are specified by the CORIOLIS system (see: www.coriolis.eu.org). Daily delivery of data is available at ftp://ftp.ifremer.fr/ifremer/medspiration/data/insitu/coriolis/atlantic. Data within the MDB include:

- Drifting buoys
  - Meteorological buoys, floats parking at surface
  - More than 70% of surface data
  - Project/network : DBCP (Drifting buoy cooperation panel),ARGO
  - Real-time (24h), GTS & FTP
  - Quality control: real-time (global range, climatology test) & planned control with objective analysis alert system
- Ship data (TSG)
  - Research institutes ships, voluntary observation ships
  - GOSUD project (temperature and salinity)
  - Real-time (48h), FTP
  - Quality control : real-time (gradient, range, climatology,…) & visual control & delayed mode QC
- Profile data (Moored buoys)
  - TAO,TRITON,PIRATA, OceanSites (2006), NODC/NDBC, European buoy,…
  - Providers : research institutes, PMEL,..
  - Real-time (24h), FTP & GMES
  - Depth usually ranges from 1m
  - Quality control : real-time (gradient, range, climatology,…) & visual control & control with objective analysis alert system
- Profile data (Floats)
  - ARGO
  - Real-time (from transmission)
  - Quality control : real-time (gradient, range,…) & visual control & control with objective analysis alert system (daily)
- Ship data (XBT/CTD)
  - Research institues, CORIOLIS, CLIVAR, GTSPP…
  - Real-time (24h) to delayed mode
  - Quality control : real-time (gradient, range,…) & visual control & control with objective analysis alert system (daily)

The Matchup process is performed by first **selecting the relevant in situ data** according to the following criteria

- keep only the in situ stations matching the GHRSST-PP datasets coverage limits (if not global)
- keep only the in situ stations more recent than 30 days. Taking into account larger time period would involve scanning to many data files and would require online storage of large amount of data as well as too much processing time
- keep only the in situ stations having a valid temperature value above 10 meters

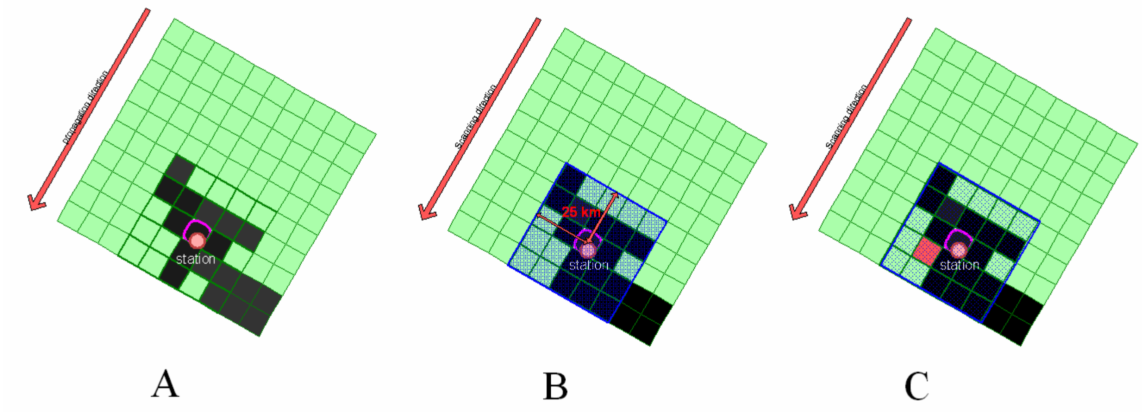


Figure 3.9.2.2 Schematic figures showing the GHRSST-PP MDB Satellite extraction criteria (see text for explaination).

The next step is to identify the **closest** pixel (in spatial **distance**) to the in situ station. This pixel may be valid or not, it is the pixel covering the area in which the in situ station is located (Figure 3.9.2.2(a)).
Next the **surrounding** pixels in a 50km x 50km box (**validation box**) are extracting centred on the pixel identified above (and therefore on the in situ data). Each pixel within this box can be considered approximately at a distance up to 25 km from the in situ station (Figure 3.9.2.2(b)).
Finally, selecting within this box the **closest** pixel in **time** from the in situ station. Time criteria has therefore precedence on space criteria. However, if another pixel is closer in space and not older than 5 minutes, it is selected instead : this allow to process correctly the swath data for which all pixels within the box have more or less the same time (a few seconds) so that the space criteria should then have precedence on time (Figure 3.9.2.2(b)). An in situ station is colocated only **once** with a ghrsst dataset.

The system includes a new web interface that can be used to extract data using a fully configurable query. The basic Portal was set-up in May 2006 and the URL will be circulated among GHRSST-PP community soon (http://www.medspiration.org/tools/mdb. Two basic products are produced

1. pre-extracted files
   - contain all match-ups per GHRSST dataset and in situ category
   - netCDF format
   - additional information can be added aftwerwards :
   - so far : climatology value, zenital solar angle, …
   - fast access, link on web site
   - users have then to apply their own filters
2. interface for customized requests
   - specific user criteria for advanced requests

Piolle noted that a variety of analyses can be performed with the data once retrieved and presented several examples of SEVIRI verification (Figure 3.9.2.3). As the format is relatively simple, IDL and MATLAB scripts are easily developed to manipulate the data. Piolle noted that in the future, short tem plans include

- more validation/documentation work…
- development of a user manual including sections ondata content, in situ measurement issues, quality controls and a complete format description
- Complete the web interface for data extraction
- Complete the ingestion of historical data (January-June 2005)
- Compute match-ups for global AATSR
- Provide graphical plots of database content as static (pre-computed) with sampling, monthly

statistics and also dynamic plots (similar to HR-DDS system)
- Interaction with HR-DDS system will also be investigated

Evolution of the system is planned to extend the coverage to Global scale (Coriolis is already global) which for satellite data is linked to the set-up of European GDAC. An RDAC can also use the Coriolis daily delivery to produce their own MDB records and deliver them back to Coriolis this will keep the same in situ source If You don't find your favourite in situ data source in the MDB contact Coriolis; they are probably interested in! A SSES estimation system (related to GHRSST-PP recommandations) will be investigated to provide a selection of in situ and satellite match-ups based on rules on filtering of input data (quality level, neighbouring, range, deviation to climatology,…) and tools to compute statistics on averaged boxes instead of single match-ups. The SSES estimation model could vary according to satellite system e.g., categories by proximity confidence, by basins, by seasons, definition of a SSES hypercube.

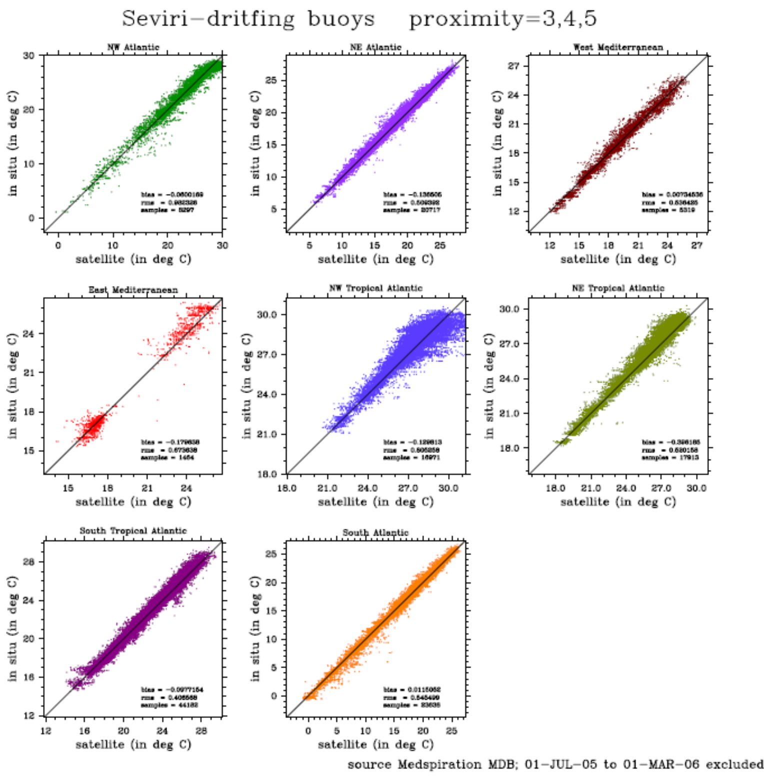


Figure 3.9.2.3 Example application of GHRSST-PP MDB data records to provide validation of SEVIRI data for different regions of the satellite disk.

3.9.3 DDS and MDB Developments in Australia, Ian Barton

DDS files for all AVHRR passes in the Australian region are now produced operationally at CMAR, Hobart (from August 2005). Initially our DDS sites were all located over the Rottnest Island and Whitsunday ferry transects and 16 TAO/TRITON moorings to the north of Australia. The northwest-most site is at 8N, 165E. Further sites may be added in the future. These may include some AIMS sites on the Great Barrier Reef where regular SST measurements are made. DDS files from AATSR data are to be provided by the Medspiration Project (Europe's GHRSST RDAC). These files are expected in Hobart soon. AMSR-E DDS files can also be produced in the Australian region from data on the WWW. When operational the DDS production will move to BoM.

A preliminary study in the Australian region using MTSAT-1R data from the BoM has been completed. This analysis is based on the collection of satellite and in situ data to investigate methods for data blending and accounting for diurnal variability. The study area (Figure 3.9.3.1) and period was set up initially in August 2005 as the ITCZ will be in the northern hemisphere and clearer skies are expected in the Australian tropical region. Ground-based data come from the array of TAO-TRITON moored buoys. The in situ data have been kindly supplied by the Australian Bureau of Meteorology (BoM). Nominally, hourly wind and SST values are available at each buoy. In reality there are considerable data gaps.

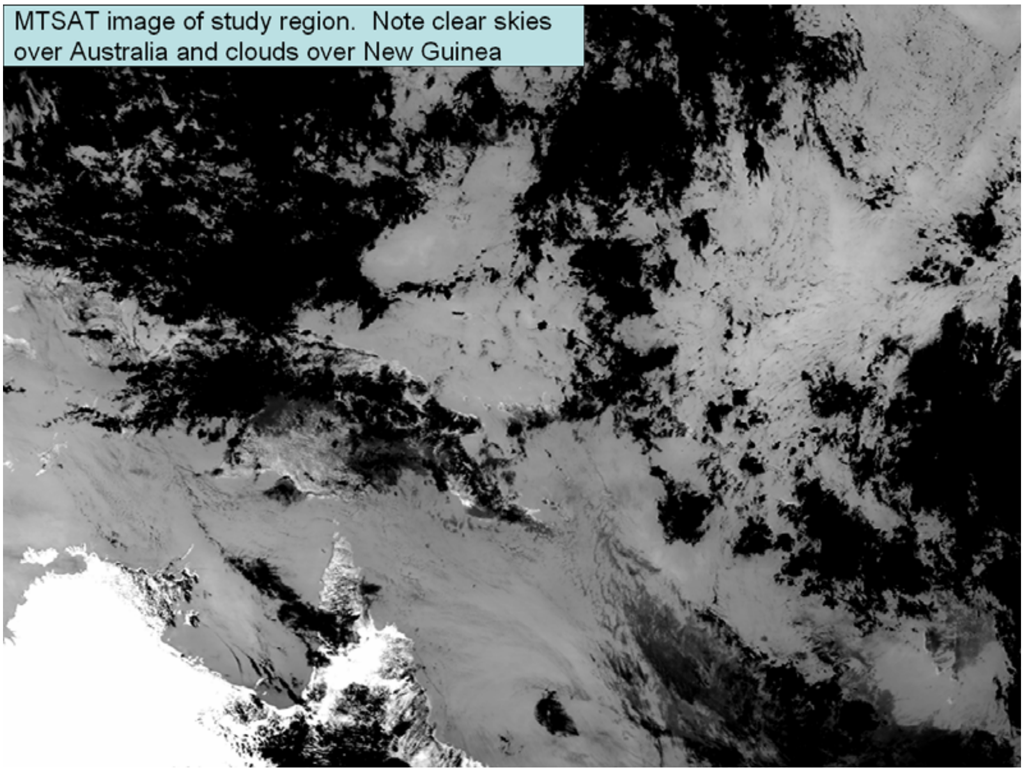


Figure 3.9.3.1 Study area for the Australian MTSAT1R investigations.

AVHRR data from Australian stations in Darwin and Townsville. Data from 9-31 August are available in GHRSST Diagnostic Data Set (DDS) files. AMSR-E data kindly supplied by Remote Sensing Systems. Data have been down-loaded for all of August. Data are then converted to DDS files for each site. AATSR NR files down-loaded from the ESA Web File Selector. All August daytime files in the study area. Data are also converted to DDS files. MTSAT full disk files for August supplied by the ABoM. 10-bit 11 and 12 micron IR data with a 5 km spatial resolution. 40x40 pixel areas (200x200km2) are extracted for each site. Figure 3.9.3.2 shows the DDS sites extracted from AATSR and MTSAT-1R.

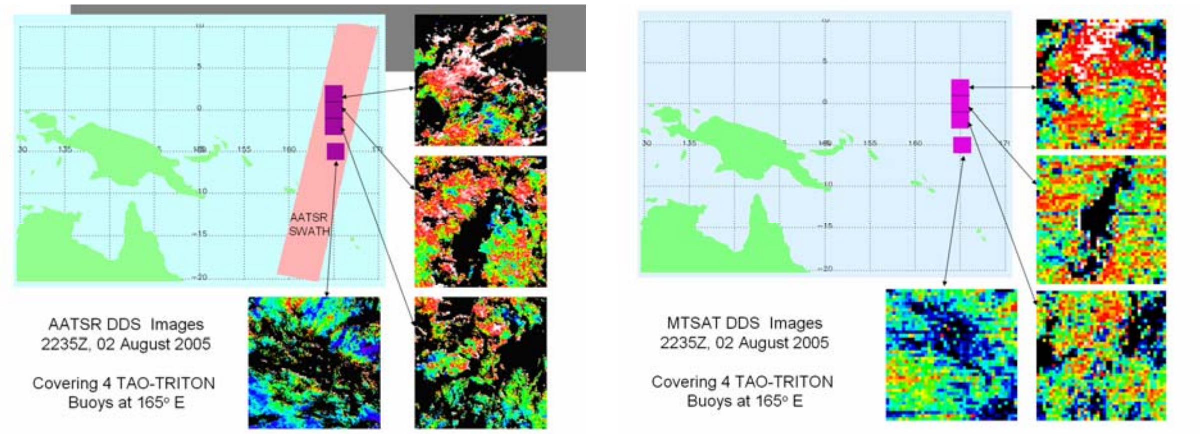


Figure 3.9.3.2 GHRSST-PP DDS sites extracted fro (left) AATSR and (right) MTSAT-1R

During August most areas of the TAO/TRITON array were cloud contaminated. A location in the Gulf of Carpentaria was chosen for study (Figure 3.9.3.3). A more cloud-free data set may be obtained during the northern hemisphere winter. MTSAT data were not yet able to provide an SST estimate but 11 micron brightness temperatures have been chosen to show diurnal variability. MTSAT SSTs are required to investigate the diurnal variability of SST in this region. The main conclusions from the DDS work were summarised. Data sets for studies of diurnal variability and SST data blending need to be collected at times of low cloud cover. For the TAO/TRITON array this may be during November – March. Geostationary satellite SST estimates are essential for DV studies. Satellite estimates suggest diurnal heating of more than 2 K in the study region with significant diurnal warming is evident at depths of 1 m. This study will be repeated in April 2006 using FY-2C data.

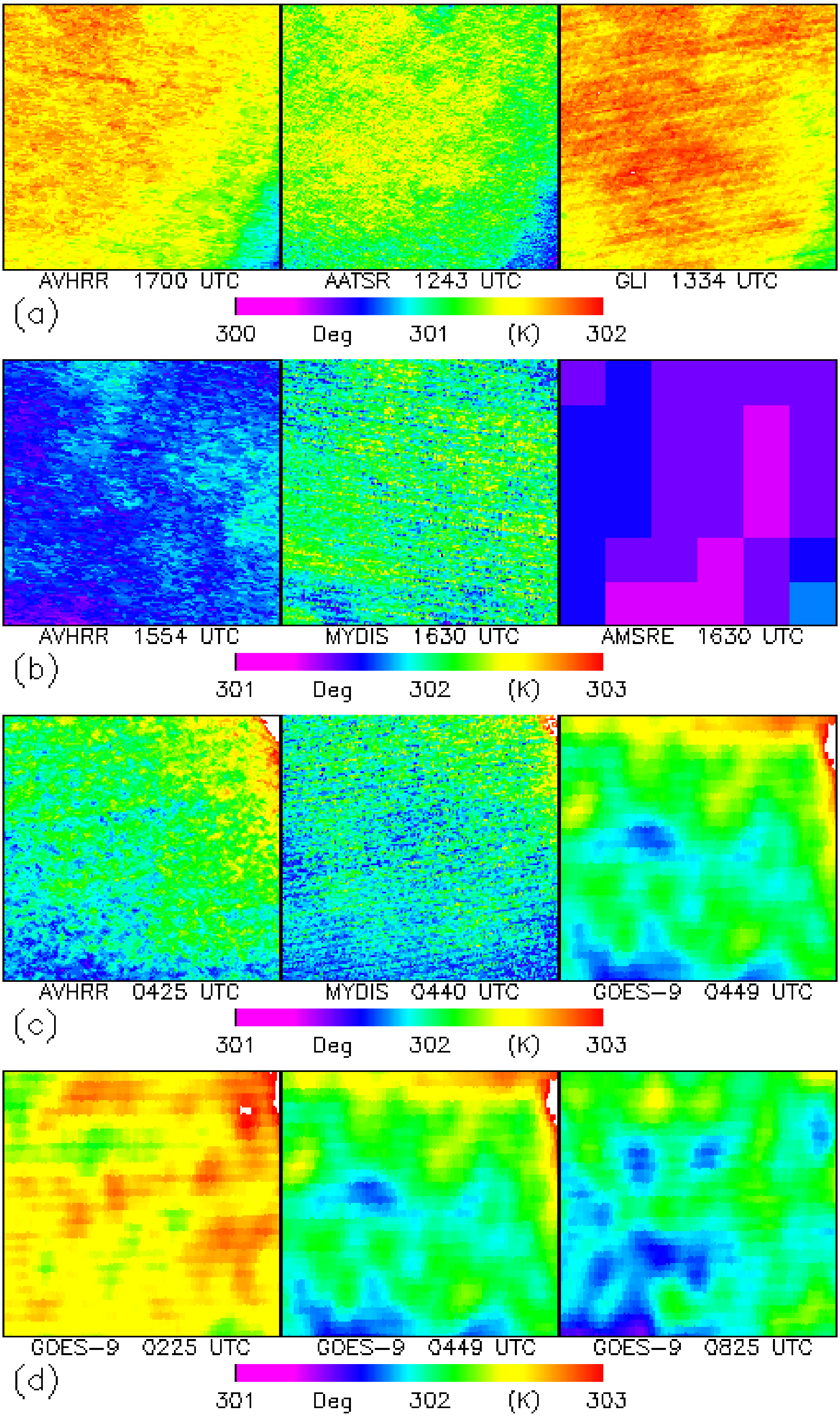


Figure 3.9.3.3 DDS data sets over the Gulf of Carpentaria form a variety of different satellite data sets

Barton summarised plans to develop an MDB of in situ data in Australia provided from 3 ship platforms

1. Rottnest ferry in Perth (Alan Pearce, CMAR)

2. Fantasea ferry in the Whitsundays (AIMS)
3. DAR011 radiometer deployment on the Southern Surveyor and other research vessels

These measurements and analyses will be used to generate SSES values for data blending in the GHRSST project. Initial data analysis form the Perth Ferry contain one year of data February 2003 to January 2004 and include 1434 ferry transects mainly from Hillarys Marina to Rottnest Island. Bulk SST from the intake PRT with no radiometer data. The transects split into five longitude zones between Hillarys and Rottnest, and the PRT data were averaged in each of these zones for each transect. Usually 4 or 5 one-minute readings in each zone. First and last zones are discarded to give three data points for each transect. More data will be used to develop the DDS and the analysis and validation of satellite data in the next few months.

3.10 Session 10. Rapporteur reports and general discussion

During this session, Rapporteurs presented their summary overview of key issues presented and discussed in each of the Science Team Meeting sessions. These reports consolidate the general status of the GHRSST-PP activities in each of the session areas.

3.10.1 Session 1 reports to the GHRSST-PP Science Team, Ken Casey

Casey noted that 13 talks were presented in session 1 which represented an impressive amount of world class work within the GHRSST-PP. The project has so much going on today within the international projects that collectively delivers the GHRSST-PP R/GTS system. The USA MISST is focussed on scientific issues but now starting to move into applications and user impact studies. The AATSR and AVHRR data sets are flowing in L2P format with daily NRT coverage. The HR-DDS is fully function al and providing an excellent tool for quality control and L4 verification validation studies. In Australia L2P and L4 data set are beginning to flow into the GHRSST-PP system and at the GDAC a tremendous amount of development has taken place and a fully functioning system is in place and is working with many data providers including the co-production of MODIS L2P. The MMR system is working and can be used to look up GHRSST-PP data that can then be accessed via OPeNDAP at the GDAC which is an excellent development that really helps users get to grips with the GHRSST-PP data sets. Finally, the LTSRF archive is fully working and lots of new data are being ingested in preparation for the GHRSST-PP RAN activities.

In terms of moving forward with GHRSST-PP development, the GDS-v1.7 is now underway which is viewed as a stepping stone to a more complete review and revision of the GDS under release 2.0 planned for 2008. AS input, the DV-TAG is providing excellent science advice on DV models, profiles and applications using satellite data (including GOES and SEVIRI). The SI-WG while recently formed, is now laying out clear objectives and a ToR to improve the way GHRSST-PP manages SST in the marginal ice zone adopting approaches similar to cloud masking. The XML-WG has managed to develop tools and strategies to move from GHRSST-PP GCMD to FGDC records as required by US Federal law which is a particularly tortuous piece of work. In the future, these records will transition to ISO 19115 geospatial metadata records although more work is required to data mine the exact configuration between these metadata standards that will assure interoperability. In terms of L2P and L4 descriptions and content GHRSST-PP is now at the point where the Science Team are just refining these definitions which is a good sign of maturity. In conclusion, the session was fantastic and provides a great way to kick off the Science Team meeting as it sets the stage for a really productive meeting. The GHRSST-PP is developing well and 2006/7 should be an extremely dynamic and interesting year for SST developments

3.10.2 Session 2 User Consultation I and User Consultation II, Sue Heinz

During the session on AUS development a cross cutting line up of presentations ranging from global to regional kin terms of user issues were presented. The Rapporteur had looked at all the presentations and had talking to users and data mined themes within the presentations. The table below identifies several themes for AUS infrastructure and user feedback/ implementation that should be followed up by the Science Team in the coming inter-sessional period.

AUS Infrastructure issues	User Feedback/ Implementation issues
◆ Collaboration tool for Management, **ST**, Data Providers and AUS ◆ A Metrics Dashboard would be useful ◆ Improved web content is essential ◆ User Tracking Tool (CRM) is required and ◆ MERSEA – GMES provides an EU component of services & levels of service ◆ The JPL GDAC and EU GDAC should work effectively together	◆ Improving product quality ◆ Improving models ◆ Adding variables/attributes ◆ User Consultation Workshops ◆ Better error reporting in operational manner ◆ Better communication when changes to data products are made ◆ Better operational messaging system is required

Access to Data was discussed and the issue of user registration was raised several times. This is Agency dependent but clearly knowing who and what data products are used for is necessary for accurate metrics although this could also be measured by other output metrics. One strength of user registration is that operational messages can be sent to the user community in real time when issues (e.g. data outages) arise that will help minimize the impact of problems. However, it was not possible to agree on a common approach as other Science Team members were concerned that registration would put some users off using the GHRST-PP data streams. It was concluded that an optional registration should be promoted that encourages users to register so that they can stay in operational contact with the GDAC and RDAC services.

In terms oif the user portfolio, this is now expanding well and references to the following user communities was made during the session: Military, Science, Research, General Public, Commercial, Power Users (NWP, operational ocean forecasting), Intermediate and End Users, Downstream users and other operational systems (e.g., oil and gas producers). Specific applications included Military and Marine Operational Survival Temperature maps and Ship efficiency, global, Regional and Local ocean forecast outputs for routine operations, NWP and studies within the WCRP SEAFLUX program.

The following actions were raised during the sessions:

Jorge Vazquez	Data Access: registration or not. Coordinate a working group meeting or discuss in DM TAG
Sue Heinz Ian Robinson	Review and recommend a User Tracking Tool (CRM) for the GHRSST project. Requirements document first?
Peter C & GDAC	Discuss OPenDAP Application and implementation for GHRSST data
Peter C & Ed Armstrong	Discuss THREDDS and GHRSST MMR
Carol Anne and Craig	Draft a Requirements request from SEAFLUX to GHRSST-PP
Carol Anne and Craig	Discuss Term definitions
Helen Beggs	Will lead a group to define the needs and methods for L3. Jorge, Pierre and… will participate. Deliverable will be a position paper
Jean Francois Bob Evans	Collaborate on gridding s/w. Report update on next science team meeting.

Several Suggestions for Cross-Project Activities were made during the session including the following:

1. Post and maintain a list of active and “coming soon” datasets. Link this to proper documentation.
2. Build FAQ’s to help users make the most of the GHRSST-PP which will need input from RDAC’s
3. Target a User Conference or Workshop to attend in force (e.g. the AGU or the EGS conferences (notre the Joint EGU/AGU conference in 2007)
4. Develop a Science Team page on the GHRSST-PP website
5. Work towards a shard CRM tool (AI for Sue and Ian). Pat Liggett noted that the new content management tool at PO.DAAC could be tested for other RDACs the GDAC also have metrics that can be circulated to all to help common metrics development
6. GHRSST data sets and services should try and interact with the new emerging Google earth and related geo-browsers
7. One entry point for Users should be promoted and all groups should point to the GHRSST-PP web portal site at http://www.ghrstt-pp.org.
8. Website content management needs to be improved and all of the GHRSST-PP web sites need to be polished with consistent high quality content.
9. An internal Collaboration Site should be set up to hold a Document Library, provide information on Project Scheduling/Monitoring, a proper Calendar function, Announcements, Forums and Working Group virtual offices, Tasks/AI’s and a Knowledge Base.
10. A Metrics Dashboard should be developed that provides information on processes, input and

output metrics for each RDAC and GDAC. This should be displayed at Project level website to demonstrates progress to team members and stakeholders. It also provides good project visibility and will help process improvement and improved project planning. Figure 3.10.2.1 provides an example mock up for such a dashboard.

11. A user bug database should be accessible to users to report problems this can be done within work at University of Rhode Island.

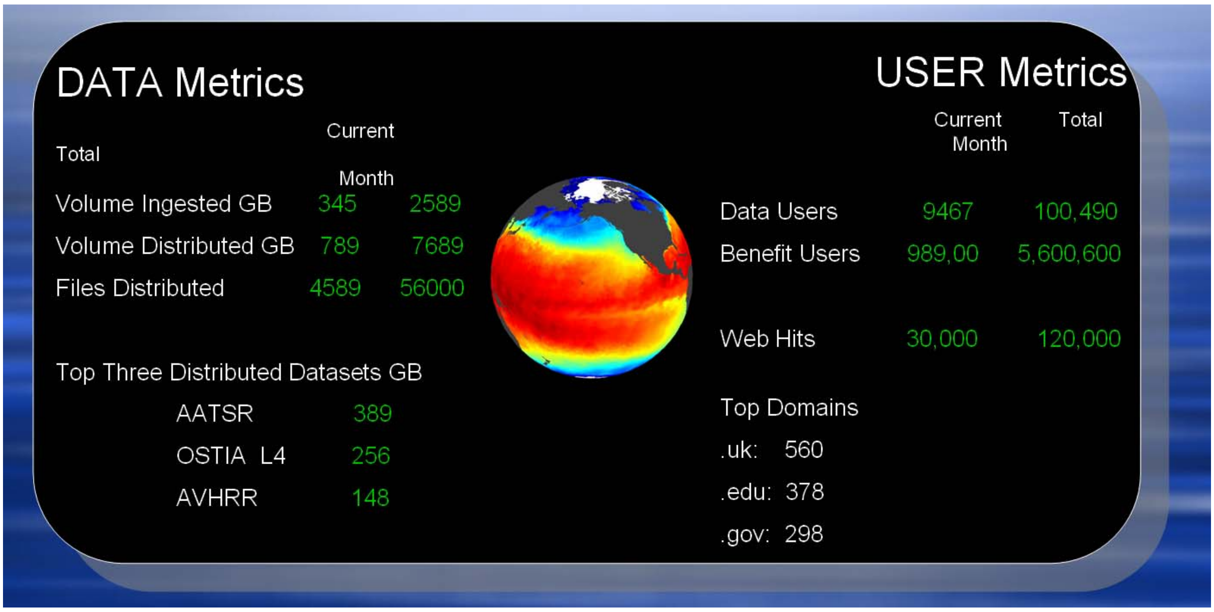


Figure 3.10.2.1 Mock up of a GHRSST-PP Metrics Dashboard that should be developed for the GHRSST-PP web site

3.10.3 Session 3 Application/development of new data streams, Gary Corlett

This session was a technical session that considered many developments with satellite sensors for SST and sea ice in the GHRSST-PP R/GTS system. The use of NSIDC sea ice data sets within GHRSST-PP was explored in some detail. The NSIDC produces 40 sea ice products see http://nsidc.org/data/seaice_index/ and the NSIDC team made assumptions of GHRSST-PP requirements for sea ice products as High resolution; 5-10km; 6-12hrs; ice edge position, not concentration. A key conclusion noted that that what is optimal for GHRSST-PP is not necessarily optimal for ice CDR which are mainly based on passive microwave for sea ice detection. While there is a long record and significant heritage these sensors tend to underestimate ice concentration, have a seasonal bias and may not detect ice concentrations as high as 60%. A significant improvement was found when using AMSR-E data at higher spatial resolution(12.5 km better than 25 km). It was concluded that these data do not currently meet GHRSST-PP needs as they are not timely/accurate enough although several potential improvements can be made and operational products could be implemented for SSM/I or AMSR-E. However NSIDC noted that they need to further understand GHRSST requirements further in terms of the following

- What edge do we want (5%,15%, 50% ,…)
- Would climatology be useful?
- Can you use swath data, in order to better match the time of acquisition to SST analysis time
- What is the right balance between consistency, accuracy, timeliness and resolution?
- What delivery protocol?

An action on C. Gentemann to data mine the requirements for sea ice and forward these to NSIDC for further discussion.

The development of METOP global L2P data was discussed in detail following the presentation of Piere LEBorgne. METOP will launch in June 2006, with SST retrievals from the AVHRR instrument.
METOP products are produced by the EUMETSAT Ocean & Sea Ice SAF who expect to have GHRSST format products by February 2007 with a first distribution of SST products in early 2008. The processing chain will perform cloud mask post processing through flagging. Other issues regarding aerosols; ice; min temp; max temp variability are included in the processing chain currently being built.

Of particular concern was the need to decide what to implement for proximity confidence level? The current plan is to use GHRSST-PP ands the basis noting that current confidence flags are okay – but not brilliant. Excellent and bad flags seem to work very well but intermediates do not. There was also some discussion on which products should go into L2P? (Gridded, swath or both). No clear consensus (other than the existing L2P and L4 formats) was reached on these issues although there was general agreement that the proximity confidence mapping needs to be reviewed and harmonised.

Great progress has been made in the development of MODIS Global SST products for the GHRSST-PP. The current focus is on ensuring that a well formed L2P core data set is made available to JPL GDAC who have agreed to add ancillary data to provide 1km L2P data sets. Both Terra & Aqua, Day and Night, 11-12 micron and 4 micron products are currently included in the L2Pcore product and the Level 0 through Level 2P Core processing chain is now operational. The SeaDAS processing software could be used for sub-setting and re-gridding for any Level 2P data stream and providing an easy to use interface for the user community at the GDAC/GHRSST-PP level. However questions remained about the capacity of SeaDAS to read NetCDF CF-1.0 data. It was clear that the OCForum for user support to MODIS SST data products could be really useful and the GDAC are encouraged to follow up this possibility. The MODIS SSES are derived from an interesting hypercube of data that generates a look up table of SSES for a given situation. This seems to be a promising approach and ought to be investigated by other teams looking to improve SSES for their own sensors. An action was raised on Bob Evans and Brian Franz To show how MODIS Quality Levels map to GHRSST confidence flags. Finally, the MODIS data products in L2P format are extremely large (65 MB per 5 minute MODIS granules uncompressed resulting in~20GB per day per sensor!). The Science team urged the MOIDIS team to consider options for file size reduction to provide a 4km data product.

Several key issues were discussed in the plenary discussion including a discussion on differences between the NOAA/NESDIS and Navy GOES processors which generated significantly different data volumes. This could be an issue for the GDAC and the LTSRF in the short term and there is a need to properly scope the final data volumes. The Australian RDAC team noted that it would be better for NOAA to send MT-SAT to GDAC rather than the Bureau as saves man power and costs. The overall conclusion from the session was that a lot of progress had been made much better than last year but the critical element was to get MODIS as well as GOES and MT-SAT data out to the community within the R/GTS system. Finally it was noted that the CMIS/VIIRS combination could be extremely useful for understanding data merging (why hasn't more been done using TRMM TMI and the TRMM IR imager?)

3.10.4 Session 4: Breakout group reports

3.10.4.1 BG-1: Uncertainties, SSES, Bias

The main issues discussed during this breakout group were the Definition of Proximity Confidence/Quality values including the naming of flags (confidence/quality) and the naming of states (English/numerical). In addition, the naming of files with changing content/version (RSS real time) was discussed and a discussion of aerosol index for various sensors took place. What SSES provide and how they can be used was discussed noting the conclusion that there is a trade off between the number of matchup data and the proximity of satellite to in situ data. There is a clear need to share Matchup databases between organizations. A discussion regarding RSS AMSR-E files that currently have changing content but use the same filename concluded in an action for this issue to be referred to the DM-TAG to resolve by incrementing a number within the product filename.

Doug May has found optimum matchup period for AVHRR and in sit buoys to be 4 hours and optimum spatial scale to be 25 km which is specified in the GDS as a recommendation although each data provider is allowed to use the matchup period and spatial scale they think best. Several people were concerned about errors changing over temporal and spatial scales. Craig Donlon suggested using the Donlon et al (2002) method to filter out diurnal variation using winds. There followed discussion on whether the globe should be split into regions for matchups as spatial scales to use for matchups depend on the ocean region.

The main conclusions from the session were:

- Proximity Confidence Value should be called Quality and have values of 0-5 (where value 5 is referring to the best quality data)
- The L2P format should retain a “Confidence Flag” (and “Rejection Flag”) to elaborate on reasons for “suspect” data

- Buoys remain truth for SSES but it is noted that values are not directly coupled to Quality values. Values are product specific (not just sensor specific) and require further thought and work on a case by case basis at present.
- Action to DM Tag to see if should be a increment number in filename
- It was agreed that good practice suggest that groups use a wind speed data set to filter diurnal variations before computation of SSES to minimize the impact of diurnal variability.
- Matchup data bases from various organizations should be shared within GHRSST and there were actions to multiple groups to explore how sharing could occur practically.
- Dick Reynolds recommended that SSES standard deviations are not used directly in the OI analyses but as a scaling factor for the input standard deviation.
- An action was raised on Doug May to investigate if Gary Corlett is allowed to used the NAVOOCEANO matchup data base for AATSR. Craig and John Stark will do likewise with the OSTIA data base.
- Action: Helen Beggs to see if the Bureau can supply its LAC AVHRR to in situ matchup data base.
- GDS v1.7 should define SSES in the GDS as product specific since SSES can change between products from the same sensor.

3.10.4.2 BG-2: Data management TAG

This breakout group discussed netCDF 4 adoption, reviewed L4/L2P file structures, reviewed the basic GDSv1.7 (RDAC, sensor and product tables) considered a gridded product specification and held a general data-management brainstorming session.

The main conclusions from the session were:

- GHRSST-PP should 'wait and watch' before a decision on netCDF 4 is taken as there are many issues with the proposed changes that are not yest clear even in the netCDF/HDF community. It seems unlikely that much wioll happen in the coming 12 months duie to funding issues.
- Regarding the content and format of L2P / L4 files, the breakout agreed to
  - Adopt new CF "standard_names" for L4 including:
    - sea_surface_temperature_at_skin
    - sea_surface_temperature_at_foundation
    - sea_surface_temperature_at_depth etc.
  - Add a bit flags variable
  - Agreed on a general longitude specification that will be -180 to +180. Users will be free to choose their own L4 grid starting locations
    - Changed L4 variable names: for example, normalized_analysis_error --> estimated_analysis_error
  - Changed L2P names: "delta_time" to reflect the offset in time of an ancillary field to the values in the time array; CF field for "reference"
  - Specification for time will remain the same in both L4 and L2P.
- **Reviewed GDSr1.7 RDAC, sensor and product tables**
  - modified the table to include correct RDAC prefix codes
  - modified L2P data_set_name codes (e.g., SEVIRI --> SEVIRI_SST)
  - modified L4 data_set_name codes
  - modified L4 region name codes
  - modified summary table of data streams
- **Gridded product specification**
  - currently some L2P products fit the CEOS definition of L3 (resampled satellite data)
  - Do we want "L2P_GRIDDED" or "L3P"? No consensus was reached which would be reconsidered at the next GHRSST-PP Science Team meeting if required
- **General brainstorming** of new ways to deliver and discover data using MMR, OpenDAP, THREDDS etc.
- **Documentation**
  - Better product documentation and metadata needed. E.g. how to use quality flags.
  - GDAC has some guide document. Need to be updated by RDAC data providers.
  - GDAC remains the focal point for distributing these documents. GDAC will put together a simple table of products and documents.

A plenary discussion on potential changes to L2P and L4 formats revealed that several users did not want changes as they already had a considerable investment in the L2P format. The Science Team agreed that that this was an important issue but that the GHRSST-PP needs to revise and improve the data products it provides to users and as the project is still at a relatively early stage, it was inevitable that changes would occur. The Tem noted that the use of Experimental fields in the L2P and L4 products provided one mechanism to allow flexibility within the format and agreed to keep the L2P format as it is for the time being. The GDS-TAG should work with the L2P production teams to generate a next generation format (GDSv2.0)

3.10.4.3 BG-3: Diurnal Variability WG

The DV-WG had an involved breakout session during which new observations from the SkinDeep profiler and M-AERI spectro-radiometer were presented. In addition preliminary applications of SEVIRI hourly SSI, SST and DLR observations were presented and discussed. It was reported that a collocated TRMM VIRS-TMI data set would be made available for use by the DV-WG soon.

Many new models are now available for inter-comparison studies. These include (in order of decreasing complexity going from top to bottom)

- GOTM-Diurnal
- Kantha-Clayson
- Fairall
- Kraus-Turner
- Schiller & Godfrey
- Zeng & Beljaars
- Stuart-Menteth
- Webster & Clayson
- Kettle (SEVIRI-based)
- Gentemann-VIRS (soon)

In the coming year, it was agreed that now the DV WG has many observations and models the group can begin to apply these to study the DV problem in detail. Sudies will be carried out focussed on data-model evaluations and the evaluation of methods of use for particular DV models. A Twiki for data and model sharing, co-ordination will be developed by the DV-WG Chair and a DVWG 1-week “workout meeting” is being planned for summer 2006, leading to recommendations to ST at the 8th Science Team meeting.

3.10.4.4 BG-4: Sea Ice WG

The aims of the SI-WG are to:

- To determine the best ice mask for high latitude fields.
- Improve high latitude SST

Membership of the group was agreed as: Peter Minnett (U. Miami), Chelle Gentemann (RSS & U.Miami), Søren Andersen (DMI) and John Stark (UK Met Office). It was agreed that Steinar Eastwood (met.no) should also be asked to join as he has experience working with high latitude SST for the OSI-SAF. An action for Peter Minnett to ask Steinar Eastwood to join the SI-WG (s.eastwood@met.no) was raised. In order to improve communication a web page will be set up for the SI-WG. ACTION Andersen to set up a Sea Ice WG web page.

Determining lake ice cover was identified as an issue with no obvious solution. The solution was thought to lie with vis./IR. instruments, although Gentemann had found the MODIS ice mask to be unreliable. Validation data is also sparse. The Canadian organisation, CCORE, may also have lake ice data as part of the PolarView GMES project. An action for all to report to the working group any lake ice data sets was raised. Gentemann has developed a new ice mask for passive microwave which is has encouraging results so far. She will collaborate with the OSI-SAF to validate this mask further. ACTION Gentemann / Andersen to collaborate to perform further validation of the new microwave ice mask algorithm. An action for Gentemann to add the Great Lakes to her RSS ice mask was also raised

The group noted that ice charts are often used as validation data sets, although their quality is variable and poorly recorded. The US National Ice Centre (NIC) has recently begun producing a vector-format ice mask called SPAROS. An action for Fetterer to send the web address to Stark and action for Andersen to investigate whether the Greenland ice service charts could be released onto the SI-WG web page. Other validation data may be available through the GCOS Sea Ice group. An action for Andersen to approach ASPeCt to obtain their sea ice validation data was raised.

Some discussion of what SST to use in L4 near/under sea ice took place. Reynolds has re-evaluated the pseudo-observations of SST used where ice is present. Stark presented a scheme developed by Nick Rayner to set the sea ice using a quadratic function of sea ice concentration. Reynolds has since found the quadratic fits to be poor, and is now considering using a linear fit for ice concentrations greater than 60%.

The following issues were noted by the SI-WG:

- Atmospheric correction algorithms require improvements for high-latitude, and near ice edge factors are also important:
  - Dry atmospheres
  - Large air-sea temperature differences
  - Temperature dependence of infrared emissivity.
- The high variability of sea ice in space and time.
- Microwave sensors have all year, all weather capability but resolution is poor compared to IR, coastal is challenging.
- SAR provides high resolution but poor coverage.

The SI-WG made the following recommendations:

- For NRT : Should use data from the same sensor where possible.
  - Ice mask for IR can come from within the product in the same manner as clouds.
  - Ice mask can be retrieved from within the MW radiance data also.
- Different requirements for reanalysis.
  - Will have potential problems getting SST data from before 2002 due to cloud cover (AVHRR).
  - Recommend the use OSI-SAF or NSIDC for reanalysis.
- Sea Ice WG will have a web page.
  - Coordinated validation efforts between RSS & OSI-SAF.

The following issues were thought to warrant further investigation.

- Physics of high-latitude SSTs well understood in terms of the problems, solutions are wanting.
  - Requires better characterization of polar conditions.
- The ‘best’ ice mask for reanalysis needs further investigation.
  - Gentemann will continue refinement of AMSR-E ice mask algorithms.

3.10.5 Session 5: Sensors and Single Sensor Error Statistic formulations, G Wick

Presentations were made in plenary during Session 4 on Sensors and Single Sensor Error Statistic Formulations. Gary Wick presented an Evaluation of SSES Formulations that explored a variety of SSES schemes with quantitative evaluation of forms. The results acknowledged that comparisons of this type are valuable and needed. A formal write-up of the statistics and best results for each category considered has been requested and a response to write-up the results are in preparation.

Pierre LeBorgne presented the Status of MSG/SEVIRI SST which highlighted the good sampling that will be possible from SEVIRI using new hourly data sets. The accuracy of products is checked in multiple ways including a year of validation with MDB, inter-comparison with AATSR, and HR-DDS systems. The results are satisfactory but expose a vulnerability to aerosols and bias/std values show expected variations with confidence level (quality). An aerosol correction scheme (Saharan Dust Indicator (SDI) is being implemented into the operational SST retrieval that will alleviate the aerosol problems. It is expected that significant progress will be made using SEVIRI hourly fields for DV studies in the coming year based on the new combined SST, SST and DLR data set now being produced at Meteo France/CMS.

Doug May presented an excellent evaluation of Satellite SST Comparisons that considered the coverage, timeliness, and accuracy of several satellite SST data streams relative to buoys and stratified by IPCV value for Feb 06. The comparison was done for 10 different satellite datasets. In general the statistics are good for the “excellent” IPCV category but are chaotic for other IPCV values. Significant discussion followed that considered the diverse numbers/results for different categories. In particular the AATSR results could easily be modified, but with as a “best effort” had not been studied properly before. In this case most of the AATSR data were being set to suspect when in fact the data were of good or even excellent quality. An urgent action for the Medspiration and AATSR team to sort out the definition of AATSR SSES was raised. May agreed to rerun the inter-comparison exercise for the next Science Team Meeting to investigate improvements to the various SSES and IPCV schemes within the GHRSST-PP. Further discussion focused on the definition/equivalence of quality values and IPCV values and an action to explore common scales/names for IPCV values was raised on the GDS-TAG. It was proposed to change “Proximity Confidence” to “Confidence.” but following further discussion this was amended to become “Quality”

Gary Corlett reviewed biases and SSES for the AATSR and drew attention to the different notation for gridded -> swath; spatially averaged -> gridded products that are produced by the AATSR. Using validation to buoys and M-AERI the AATSR is clearly an excellent sensor but validation is limited when using in situ radiometers and buoys must be used to provide SSES. However, there are still large regions with limited buoys especially in the southern hemisphere. Several issues were raised including SSES Bias estimates – should these be based on retrieval bias or bias to a reference data or both? What does a single pixel STD actually represent (variability in time? Or variability of the statistical reference data set? Corlett also recommended that the product content for AATSR L2P data is urgently reviewed as the 11um BTs and/or the 11um nadir only SST data should be included in the product in order to provide the best SST and be able to compute view difference vales which have an important bearing ton the value of AATSR SSES.

Bob Evans reviewed the formulation of the MODIS validation results and error hypercube approach to SSES derivation. New coefficients for the v5.0 MODIS collection successfully remove previous seasonal biases and improved quality screening allows a new quality scale to be mapped into a flag. However there are multiple choices for a validation reference field including buoys, satellites, analyses (OI, K10) which all have strengths and weaknesses. The best approach is to try and use all sources of data in a Hypercube MDB approach (defining quality levels with numeric values). Spatial variations track reasonably well with analysis differences and this approach was a key component of the discussion on linkages between quality and SSES. Further work to map quality and IPCV confidence scales will take place before the next GHRRST-PP Science Team meeting to resolve these issues.

3.10.6 Session 6: L4 Analyses: What is right and what is wrong?, J Tournadre

The session had 7 technical presentations on various SST L4 analysis systems and considered aspects of the L4 systems themselves, data pre-processing, error partition, validation of L4 outputs at high resolution and the impact of diurnal variability on L4 systems. L4 format discussions concluded with a review and a stable L4 GHRSST-PP format specification which will be part of the GDS-v1.7. In addition agreement was reached for a longitude definition although some issues relating to grid definition of -180 to +180° remain.

The validation web tools developed by the Medspiration project provided a simple way to consider the quality of L4 analysis systems. There is a clear need to start educating the user community on the limits to the L4 outputs in terms of their statistical and spectral properties as different user communities have different requirements. The L4 Medspiration system has determined that in general there is little added value to L4 2km vs 4km outputs from a statistical perspective but significant impacts to the spectral properties.

Considerable progress has been made at the Met Office where an new system called OSTIA is now providing daily 1/20° SSTfnd outputs at a horizontal resolution of 6.4km Data are accessible via the GHRST-PP web site. Further validation work is on-going at the Met Office who also produce global daily SST anomalies from various climatologies. The system should be operational by the end of the year which is a significant development for the GHRSST-PP as most of the inputs are L2P data fiels from the GHRSST-PP R/GTS system.

A new set of SSTfnd and SST1m L4 products is being developed using a new analsyiss system at the BoM, Australia. The system makes use of AVHRR LAC data from Australian receiving stations together with GHTSST-PP L2P data sets. A great deal of effort has been placed on understanding how to partition error estimates for the various input data sets. Products will be provided at 1/12° and 0.25 ° spatial resolution on a daily basis. These systems should be operational by the next GHRSST-PS Science Team Meeting.

Dick Reynolds has developed a new ¼ ° OI system that uses AVHRR and AMSRE data sets that are assumed to be independent of each other. The system is now running in a test mode and is expected to provide a new data set in GHRSST-PP L4 format by the end of the year. A great deal of effort is invested in the bias correction strategy which now uses EOF's to derive bias estimates for the input data sets. Future versions of the OI will consider other data sets including AATSR, SEVIRI, GOEAS and TMI sensors.

The European MERSEA system has developed a prototype L4 processor in the Atlantic Ocean that will be expanded to global daily coverage. Much of the effort has been spent developing appropriate pre-processing chains to bias correct input satellite data streams. Experiments show that the AATSR sensor can be used as a viable reference sensor that is capable of accounting for biases due to atmospheric aerosol loads and this will form a key component of the analysis bias correction strategy.

Work at NOAA has shown that there is a significant impact of L4 systems if Diurnal variability in input data sets is not properly accounted for either in the pre-processing of input data streams or as part of the analysis itself (although this still needs to be developed.

There is a clear need to develop an ensemble L4 analysis inter-comparison that could be done in part using the HR-DDS. Further discussions would be required to develop these ideas further and it was hoped that progress would be made by the next GHRSST-PP Science Team meeting. Further work with the Jmin statistic first proposed by Jim Cummings should be undertaken as part of this work if possible.

There is also a need to establish a field that indicates the quality of the L4 output products on a grid point level (e.g. a quality indicator). In the simplest approach, such an indicator could simply show if the grid point was derived from data or from the analysis system itself.

There is a need to explore the benefit of common tools for the verification and validation of L4 outputs such as those used by the Met Office, the Medspiration project, and the HR-DDS.

3.10.7 Session 7: The GHRSST-PP DDS and MDB systems, JF Piollé

Poulter opened with a review of the architecture of the HR-DDS and MDB systems developed for GHRSST-PP by Medspiration, highlighting the specific and common uses of both systems. The HR-DDS system is especially useful to both users and GHRSST-PP for rapid evaluation of SST retrievals under different conditions, whereas the MDB is an optimal system for quantitative analysis of GHRSST-PP data. Both the HR-DDS and MDB have been demonstrated to the extremely valuable tools for SSES determination, diurnal warming studies, sensor comparison and correction.

Medspiration has developed and MDB for the use of GHRSST-PP based on the CORIOLIS (http://www.coriolis.eu.org) in situ database at IFREMER. This system ingests all data from the GTS along with some other sources. Medspiration currently produces matchups with CORIOLIS (up to 6 hours and 25 km), with all Medspiration data products, although this will be applied to all GHRSST-PP at the GDAC in the coming months. An interactive search and retrieval tool will be available http://www.medspiration.org in May 2006. The issue of inter-compatibility of different RDAC MDBs was raised, and it was suggested that RDACs should try to make entries available to GHRSST in a common format. Furthermore, the issue of resources for development of the MDB and HR-DDS system was raised, and it was stated that development of the MDB systems would be related to the proven use of the system.

Several RDACs will not construct an HR-DDS system, therefore Medspiration will, on a best effort basis, attempt to produce HR-DDS file for these datasets. Specific attention will be given to JAXA AMSRE and NAVO GAC data as these sensors do not have global coverage in Medspiration. There was significant interest from the science team, especially from members of the DV-WG, in providing in situ data with the HR-DDS system. This could be done through linking the MDB and HR-DDS search mechanisms or inclusion of in situ data directly into the HR-DDS, the former will be investigated by Medspiration. Medspiration will also investigate the possibility of making available an ASCII CSV file containing the data within an interactive web plot.

The session concluded that there is a clear need to make sure that the MDB and the HR-DDS systems are used but the development teams need to have feedback from the Science Team on their prototype systems. Sue Heinz noted that a customer in Alaska wants to put data into the MDB but how do we do this? Actions were raised to discuss how a user will ingest data into the MDB.

3.10.8 Session 8: Reanalysis project

- Intercomparisons are excellent
- Action on Ken to get RAN specs correct
- AATSR v2.0 will be significantly improved.
- Action: Reynolds to provide a letter of support to ESA for application of v2.0 data stream
- Action: Casey to provide a ltter of requirmrnt to ESA for AATR v2.0 data set for use in RAN project

3.10.9 Session 9: Emerging and future issues for the GHRSST-PP, Ed Armstrong

The session dedicated to emerging issues for the GHRSST-PP included a further discussion on the adoption of NetCDF4 which uses HDF5 storage engine, essentially a layer on HDF5 (Ted Haberman and JF Piolle). A Common Data Model as been adopted with the following general advantages:

- Internal compression
- Data “chunking”
- Parallel file I/O
- Backwards compatible to netCDF3
- Additional types
- Automatic data packing

NetCDF 4.0 doesn’t support bzip2, only gzip and szip and the release date and support through third parties is unclear. Furthermore the C and Fortran API is also unclear (JAVA is the base language). Discussions with the UNIDATA team (Russ Rew, Unidata lead developer for netCDF4) confirmed the benefits of netCDF4 and confirmed there would be no bzip2 support. However a C and Fortran interface will be supported (and Java). NetCDF 4.0 is currently only in alpha release, beta by summer 2006. The netCDF4 final release is dependent on release and implementation of HDF5v1.8 which is not expected sooner than October 2006. We are at least a year away from a stable netCDF4 release. The session examined workload and conversion issues and the advantages look so promising and the Science Team agreed the GHRSST should look more carefully at adopting netCDF 4.0 once it has stabilized.

The session made the following recommendations:

- GHRSST should start to experiment with beta release of netCDF 4.0. Some this can be done at the LTSRF and GDAC level and other aspects at the RDAC level
- Also various people for exploring bzip2 and third party support
- No decision on adoption of netCDF 4.0 will be made until next ST meeting
- That the DM-TAG and GDS-TAG should carefully follow the development of netCDF4

The session also discussed validation of L2/L2P data streams and was presented with an AATSR validation methodology using ISAR by F. Wimmer. This motivated discussion on how to use the matchups and L4 validation and suggested that a there ought to be a validation TAG (perhaps under SSES). Such a group would need to consider the different needs for regional vs climate scale validation techniques, use of the GHRSST-PP MDB and the HR-DDS. The need for such a group was thought to be premature and was deferred until the next GHRSST-PP Science Team Meeting.

Several action items were raised as follows:

- Peter Cornillon to lobby for inclusion of Bzip2 in netCDF 4.0
- Cornillon and Armstrong to lobby for inclusion of HDF5.0 interfaces in IDL/Matla

3.11 Concluding session

During the concluding session the GHRSST-PP reviewed and agreed the list of actions generated by the meeting which are presented in Appendix III of this report.

The GHRSST-PO Director presented a short summary of workshop noting that excellent progress had been made since the last ST meeting and that the project was now moving from technical issues (formats) to implementation (refinement and collaboration). There is a clear need to be careful and preserve the identity of GHRSST-PP and protect the growing user community from dramatic changes. The challenge is to make sure that we go through the dangerous section of the project as it transitions form pilot to operational distributed system – this is where projects like GHRSST-PP often fail as it explodes as more people take ownership. Donlon noted that the preparation of a BAMS paper will help create an identity and provide a common vision. Donlon congratulated the Science team on developing, implementing and operating the GHRSST-PP which was a significant achievement for all involved and looked forward to an exciting an productive inter-sessional period between now and the next Science Team meeting.

The GHRSS-PP Director Thanked the Science Team for all their excellent work and especially to Gary & Sandra & Karen for local organisation of the meeting, to NOAA for hosting the meeting and to all sponsors for supporting the GHRSST-PP. Finally Donlon whished everyone a safe trip home and looked forward to the next Science Team meeting.

3.12 Any other business

Nominations for additions to the GHRSST-PP science Team were presented.

- Olivier Arino was proposed by DLJ and accepted
- Peter Cornillon was proposed by Ken Casey and accepted

A short review of current membership established that some members had not attended a Science Team meeting for several years (A Bingham, H. Kawamura, C. Mutlow, N. Smith) . The GHRSST-PO director agreed to contact these people to confirm their status.

3.13 Data and location of next meeting

The 7th GHRSST-PP Science Team meeting will be held in Mauritius in March 2007 (with a backup of Australia). There was some concern regarding the cost of a trip to Mauritius and also the problems of a mosquito borne disease. It was agreed that the timing should be in May 207.

The 7th GHRSST-PP Science Team meeting closed at14:00 Local time.

Appendix-I: GHRSST-PP 7th Science Team Meeting Agenda

The following agenda was followed.

Monday, 27th March 2006

Time	Agenda item	Session leaders	Ref
08:30	Registration & Coffee		
08:50	Welcome and logistics & review of Agenda	G Wick	
09:00	Welcome address from Randy Dole (Chief Scientist NOAA ESRL/PSD)	G Wick	
09:15	Report from the GHRSST-PP International project Office: Overview of the GHRSST-PP project status, priorities and aims of the Workshop.	C Donlon	WD-3
09:35	Review of outstanding action items since the 6th GHRSST-PP Science Team Meeting	C Donlon	WD-8
Session 1. Reports to the GHRSST-PP Science Team			
09:55	**USA:** Chelle Gentemann	Chair: G Wick Rapporteur: Ken Casey	WD-5
10:15	Coffee		
10:35	**Europe**: Ian Robinson	Chair: G Wick Rapporteur: Ken Casey	WD-4
10:55	**Australia:** Helen Beggs		WD-6
11:15	**JPL GDAC report:** Ed Armstrong		
11:35	**Report from the Data Management Technical Advisory Group (DM-TAG):** Jorge Vasquez		WD-7
11:55	**Report from the Reanalysis Technical Advisory Group (RAN-TAG):** Ken Casey		
12:15	**Report from the Data Processing Specification Technical Advisory Group (GDS-TAG)**: Gary Wick		
12:35	**Report from the Diurnal Variability Technical Advisory Group (DV-WG):** Chris Merchant		
12:45	Lunch		
14:00	**Report from the GHRSST-PP Sea Ice Working Group (SI-WG):** Peter Minnett	Chair: G Wick Rapporteur: Ken Casey	
14:20	**Report from the XML working group:** Ed Armstrong		
14:40	**Status and application of the HR-DDS:** Dave Poulter		
15:00	Tea		
15:20	**Report from the GCOS SST Sea Ice Working Group,** Søren Andersen	Chair: G Wick Rapporteur: Ken Casey	
15:40	**Wolfgang Lengert, report from ESA**		
16:00	**Plenary discussion:** • **Identification of priority issues for the 7th workshop** • **Agreement of Breakout group membership**	Chair: C Donlon Rapporteur: C Gentemann	
17:00	Close		
17:00 – 18:00	1 hour meeting of the GHRSST-PO Advisory Council to review progress location TBC		
20:00	Workshop Social event - Informal, opportunity to meet everyone and to exchange ideas and plan, Southern Sun (Table Mesa Road and Broadway, see http://www.mountainsunpub.com/index.html).		

Tuesday, 28th March 2006

Time	Agenda item	Session leaders	Ref
Session 2. User Consultation			
08:30	**The GHRSST-PP Applications and User Services (AUS),** Sue Heinz	**Chair: J Vasquez Rapporteur: Sue Heinz**	
08:50	**MISST Impact Study Requirements**, Chelle Gentemann/Gary Wick**:**		
09:05	**US Navy Applications requiring SST**, Doug May		
09:25	**Operational use of GHRSST-PP data sets at the Met Office: OSTIA - a new 1/20° SST analysis and FOAM**, John Stark		
09:45	**Applications of SST within the European MERSEA system,** P. LeBorgne		
10:05	**Application of Medspiration data products,** Ian Robinson		
10:25	**Coffee**		
10:45	**OpenDAP applications using GHRSST-PP data sets**, Peter Cornillon	**Chair: J Vasquez Rapporteur: Sue Heinz**	
11:05	**Diurnal Warming and SST Requirements from SEAFLUX,** Carol Anne Clayson		
11:25	**Status and Potential Impact of ICOADS,** Scott Woodruff		
11:45	**Plenary discussion**		
12:45	**Lunch**		
Session 3. Application/development of new data streams			
14:00	**Use of NSIDC sea ice data sets within the GHRSST-PP,** Florence Fetterer	**Chair: D Llewellyn-Jones Rapporteur: Gary Corlett**	
14:20	**Development of METOP global L2P SST,** Pierre LeBorgne		
14:40	**Development of MODIS global L2P SST,** Brian Franz		
15:00	**Development of GOES L2P SST,** E. Maturi		
15:20	**Tea**		
15:40	**Use of Windsat data within the GHRSST-PP,** T. Mavor	**Chair: D Llewellyn-Jones Rapporteur: Gary Corlett**	
16:00	**Denise Hagan**		
16:20	**Plenary Discussion**		
17:00	**Close**		
18:00	**Conference Dinner – Boulder Dushanbe Tea House (13th and Pearl, see http://www.boulderteahouse.com)**		

Wednesday, 29th March 2006

Time	Agenda item		Session leaders	Ref
Session 4. Sensors and Single Sensor Error Statistic formulations				
08:30	**Evaluation of SSES formulations,** G. Wick & S. Castro		**Chair: C Donlon** **Rapporteur:G Wick**	
08:45	**Status of the MSG/SEVIRI derived SST,** Pierre LeBorgne			
09:00	**Satellite SST Comparisons,** Doug May			
09:15	**Error hypercube/impact of reference field**, Bob Evans			
09:30	**Regional issues,** Gary Corlett			
09:45	**Plenary Discussion** • **Updates on sensors** • **Possible SSES formulations** • **Degree of specification** • **What constitutes truth?**			
10:40	**Coffee**			
Session 5. Breakout Groups				
	Parallel session			
11:00	**BG-1: SST Uncertainties: SSES, Atmospheric Aerosols and SST biases** Chair G Wick Rapporteur: H. Beggs **Location: TBC**	**BG-2: Data Management Technical Advisory Group** Chair Jorge Vasquez Rapporteur: Ed Armstrong **Location: TBC**	**Breakout Groups-1**	
13:00	**Lunch**			
	Parallel session			
14:00	**BG-1: SST Uncertainties: SSES, Atmospheric Aerosols and SST biases** Chair G Wick Rapporteur: H. Beggs **Location: TBC**	**BG-3: Diurnal Variability Working group** Chair Chris Merchant Rapporteur: Pierre LeBorgne **Location: TBC**	**Breakout Groups-2**	
15:30	**Tea**			
15:50	**BG-2: Sea Ice Technical Advisory Group** Chair: Peter Minnett Rapporteur: John Stark **Location: TBC**	**BG-3: Diurnal Variability Working group** Chair Chris Merchant Rapporteur: Pierre LeBorgne **Location: TBC**	**Breakout Groups-3**	
18:00	**Close**			

Thursday, 30th March 2006

Time	Agenda item	Session leaders	Ref
Session 6: Emerging and future issues for the GHRSST-PP			
08:30	**netCDF4 – JF Piollé and J Carron**	**Chair: Craig Donlon Rapporteur: Ed Armstrong**	
08:50	**In situ validation of SST data, W. Wimmer**		
09:10	**Plenary discussion**		
09:40	Coffee		
Session 7. Reanalysis Project			
10:00	**ERS/ENVISAT Medspiration (A)ATSR Project: Version 2 in GHRSST Format,** Gary Corlett	**Chair: Ken Casey Rapporteur: Ian Barton**	
10:25	**(A)ATSR Re-analysis for Climate (ARC) Version 3 Reprocessing,** Chris Merchant		
10:40	**The GHRSST LTSRF and GCOS SST/SI Intercomparison Site,** Ken Casey		
11:00	**GHRSST RAN Discussion**		
11:30	Lunch		
Session 8. L4 Analyses: What is right and what is wrong?			
12:30	**Topic Summary**	**Chair: H Beggs Rapporteur: J Tournadre**	
12:35	**Validation of Medspiration L4 analyses,** Jean Tournadre		
12:55	**A New High Resolution SST analysis over the Australian Region,** Helen Beggs		
13:15	**The Met Office Operational SST & Ice Analysis (OSTIA),** John Stark		
13:35	**SST analysis**, Dick Reynolds		
13:55	**Global MERSEA/IFREMER Analysis system,** J-F Piollé		
14:15	**MISST Analyses,** C. Gentemann		
14:35	**Impact of biases and diurnal warming on analyses,** Wick/Jackson		
14:45	**Plenary Discussion:** • **Accuracy assessments and validation** • **Optimum choice of errors?** • **How best to reduce biases before entering analyses?** • **Relationship to radiance assimilation**		
15:10	Tea		
Session 9: The GHRSST-PP DDS and MDB systems			
15:30	**Topic Summary**, Dave Poulter	**Chair: Dave Poulter Rapporteur: JF Piolle**	
15:40	**The GHRSST-PP Matchup Database (MDB),** JF Piollé		
16:00	**Experiences in Australia,** Ian Barton		
16:20	**Topics for Discussion:** • **Access and population of MDB and DDS** • **Interaction between GDS and MDB** • **Applications and tools required** • **Development priorities**		
17:00	**Close**		
19:30	**Margaritas at the Rio Grande (Walnut and 10th St. see http://travel.yahoo.com/p-travelguide-2816048-rio_grande_mexican_restaurant_boulder-i or http://riograndemexican.com/)**		

Friday, 31st March 2006

Time	Agenda item	Session leaders	Ref
Session 10. Rapporteur reports and general discussion (10 minutes per report)			
08:30	**Session 1 reports to the GHRSST-PP Science Team,** Ken Casey	Chair: Craig Donlon Rapporteur: Ian Robinson	
08:45	**Session 2 User Consultation I and User Consultation II,** Sue Heinz		
09:00	**Session 3 Application/development of new data streams, Gary Corlett**		
09:15	**Session 4: Report on Breakout group conclusions,** I Robinson		
09:30	**Session 5: Sensors and Single Sensor Error Statistic formulations,** G Wick		
09:45	**Session 6: L4 Analyses: What is right and what is wrong?,** J Tournadre		
10:00	**Session 7: The GHRSST-PP DDS and MDB systems,** JF Piollé		
10:15	**Session 8: Reanalysis project,** Ian Barton		
10:30	**Session 9: Emerging and future issues for the GHRSST-PP,** Ed Armstrong		
10:45	Coffee		
11:00	**Plenary discussion** • **Review of Action list** • **Identification of priorities for the GHRSST-PP**	**Chair: C Donlon Rapporteur:Ian Robinson**	
13:00	Lunch		
14:00	**Wrap up session and close** 1. **Summary of workshop** 2. **Assignment of Writing tasks: Preparation of proceedings** 3. **Science Team Membership** 4. **Next meeting** 5. **AOB**	**Chair: C. Donlon**	
15:00	Close		
15:30	Visit to the spectacular 'Science on a Sphere', see http://sos.noaa.gov/		

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Appendix-III: Report of the GHRSST-PO Advisory Council

Report by the GHRSST Advisory Council

April, 2006

The GHRSST-PP Advisory Council (AC) convened on Thursday 30th March, during the penultimate day of the GHRSST-PP 7th Science Team Meeting held in Boulder, Co., USA. Those present were Ken Casey (acting chairman), Gary Wick, Jorge Vazquez, Ian Robinson and Craig Donlon (Director of the International Project Office, ex-officio). Apologies for absence were accepted from Ian Barton and Jean-Francois Piolle who were unable to be present. Following the Boulder meeting this document has been prepared, and agreed, by all members of the Advisory Council.

Recommendations by the AC to the GHRSST Project Office

The general consensus of the Advisory Council was that the Boulder meeting had been one of the most successful so far. The AC members agreed unanimously that the high quality of the presentations made at the Science Team meeting and the constructive collaborative spirit of the ensuing discussions demonstrate that the project is presently operating very well. The Advisory Council was particularly pleased to note that the issues and disagreements previously evident between the project leadership and regional special interests have been resolved. The successful implementation of several new L2P products from different RDACs has given a new confidence to the Science Team as a whole. Moreover, the steady increase in usage of the L2P products, especially for the pre-operational development of new high and ultra-high resolution L4 products (both global and regional coverage), is evidence of the growing maturity of GHRSST.

While the Director of the Project Office cautioned that there was no room for complacency, the Advisory Council encouraged the Director to start preparing for the eventual transition from Pilot Project to establishing GHRSST as the international oversight panel for the production of SST from satellites. The AC encourages Space Agencies, GEOSS and CEOS to look to the GHRSST Project office to fulfil this role.

Meanwhile the AC recognises that the development of the full vision of GHRSST is by no means complete. As the US, European and Australian RDACs become established it recommends that the project office should focus effort on nurturing the growth of those additional RDACs needed in other parts of the world (e.g., the Indian Ocean). It would also welcome a more active involvement within GHRSST by the Japanese RDAC, which provided the original model for the regional task-sharing that is the foundation of GHRSST's success.

Finally the AC wishes to express its gratitude to ESA and the UK Met Office for supporting the GHRSST-PP International Project office and encourages them to maintain this support as GHRSST matures from a Pilot Project to become a key element in the operational delivery of high-quality integrated satellite-derived SST products to the world community.

GHRSST-PP ACCOMPLISHMENTS

The Advisory Council reflected on both the development and achievements of the GHRSST Pilot Project during the ten months since the Advisory Council was first established in May 2005 at the 6th Science Team Meeting. It wishes to highlight the following progress.

Global Data Assembly Center (GDAC) Status

The GDAC has now become fully operational at NASA's Jet Propulsion Laboratory. A metadata repository (MMR) is fully functional with search capabilities through a web interface. Level 2 pre-processed data (L2P) are now available from 3 regional data assembly centres (RDACs) with several more coming on line in the near future. These provide L2P data from several different sensors including:

- AATSR global
- AVHRR
- SEVIRI SST

- AMSR-E
- TMI

This is a major achievement for the GHRSST-PP and reflects the commitment to the GHRSST-PP made by NASA and NOAA.

RDAC status

Medspiration is producing L2P products over the European region from NOAA-17 and -18 data (produced by the Eumetsat OSI-SAF at Meteo-France), SEVIRI, TMI, AMSR-E and. AATSR data (over the European region only until Dec 2005, since when it has been produced globally at 1-km resolution). Currently one Medspiration L4 optimally interpolated SST high resolution 2-km Mediterranean product is being distributed through the GDAC.

NAVOCEANO is now producing 4-km global coverage L2P SST data for NOAA-18 as well as 1-km local area coverage from the AVHRR on NOAA-18. NAVOCEANO is also providing access to global high resolution blended SST data products (K12).

Remote Sensing Systems is producing global AMSR-E and TMI L2P data in near real time and global coverage L4 microwave blended SST products.

Other RDACs poised to come on line in the near future include a Miami/NASA MODIS L2P global 1-km product, the Australian Bluelink RDAC, and GOES-10 and -12 L2P data from NOAA.

Progress has been exceptionally good in developing a linked system of RDAC's providing common format L2P data products that are passed to the GHRSST-PP GDAC in real time as well as serving regional and local users. This is the foundation of the GHRSST-PP R/GTS implementation model and the level of investment made by national agencies (both now and in the long term) marks a significant step towards the sustainability of the GHRSST-PP legacy.

LTSRF Status

The Long Term Stewardship and Reanalysis Facility at NOAA/NODC is now retrieving data on a daily basis from the GDAC. These include all GHRSST L2P and L4 data that are more than 30 days old. The automated procedures for building NODC archive accessions are in place, and automatic placement of these accessions into the formal archive is expected within weeks, pending only final enhancements to the FGDC metadata creation process that is taking place in conjunction with the GDAC. A new web presence for the LTSRF has also been established at http://ghrsst.nodc.noaa.gov. To date, approximately 3 Terabytes of GHRSST data have been acquired by the LTSRF at NODC.

The LTSRF has also made progress in the area of establishing a reanalysis and L4 SST intercomparison framework in conjunction with the GCOS SST/SI Working Group. Several data sets have already been collected and put into a common data format, with more to follow in the coming year. Plans are also being laid to establish a reanalysis capability at the LTSRF, including the acquisition of a computing cluster and key personnel.

The LTSRF will provide the basic system for generating re-analysed GHRSST-PP long-time series data sets for use in climate and seasonal forecasting activities as well as for operational monitoring programs requiring accurate climatological data sets. It is foreseen that repeated re-processing runs will be required as new data sets are made available and old data sets are themselves re-processed and updated. The implementation of the LTSRF is a major achievement for the GHRSST-PP and the AC wishes to acknowledge the investment committed to this activity by NASA and NOAA.

High Resolution Diagnostic Data Sets (HRDDS)

HRDDS have been implemented through the European Medspiration Project. Data sets have been calculated for all predefined sites. A web interface has been implemented that allows for visualization and downloading of the HRDDS data sets. This is now used as a tool within the MERSEA Project to prepare a European operational ocean forecasting system for implementation in 2008.

Second Meeting of the US GHRSST Team

A meeting was held November 24, 2005 at the University of Miami for the US participants in GHRSST. In addition to representatives from all the US GHRSST projects, program managers from NASA (Eric

Lindstrom) and NOAA (Stan Wilson) attended the meeting. Updates were given from the different USA RDACs and the GDAC. Sue Heinz, from Geologics, was welcomed to coordinate the Application and User Services component of U.S. GHRSST. The main result from the meeting was that GHRSST should focus on both the societal benefits of the project as well as products that will have a scientific value.

Seventh Meeting of GHRSST Science Team in Boulder, Colorado, USA

The 7th meeting of the GHRSST science team in Boulder was a success as all components of the project are making huge strides towards the overall aim and objectives of the GHRSST-PP. Major points of the meeting included reports from several sub committees of the GHRSST science team including the sea ice group, the diurnal warming group, data management technical advisory group and the XML working group. Breakout sessions from plenary occurred for each group with reports incorporated into the final meeting document. These reports will all be available through the GHRSST web site. As always a comprehensive action item list was generated from the Boulder meeting. The action item list has always proven to be a comprehensive way of focusing the science team on issues that need to be accomplished before the next GHRSST meeting in February of 2007. Such issues are far ranging from a discussion on the generation of L3 gridded products, to a review of NETCDF4, along with a review of L4 file attributes. Action item lists, generated by the GHRSST chair Craig Donlon, are extremely comprehensive and useful as a means of driving the project forward.

Application and User Services

Sue Heinz was asked to head up the Application and User Services Office for the GHRSST project. She will coordinate all user services and applications.

Progress expected in the coming year

Several L4 global products will be incorporated into GDAC for distribution, such as the Operational SST and Sea Ice Analysis (OSTIA) and the Reynolds OI pathfinder and microwave blended products. Bluelink is also expected to produce L4 regional products in the Australian region. Several new L2P products will be coming on line, including those from MODIS, GOES, and the Australian Bluelink Project. In the coming year the GDAC will focus on incorporating MODIS L2P data into the project. This presents a great challenge to the GDAC because of the volume of data, the requirement for implementing subsetting of L2P, and the need to add ancillary fields.

Further information

Further information on the GHRSST-PP project and its components are available from a variety of sources. These include the website at www.ghrsst-pp.org, the Project Office, the Science Team Meeting reports, and individual Science Team members.

12th April, 2006.
(Final revised version 10th May 2006)

Appendix-IV: Action list resulting from the 6th 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 31st March 2006. Greyed text indicates a closed action.

No	Action	Owner	Date Due	Status
1	A new chair for the GDS-TAG to be elected.	**GHRSST-PP & ST**	Immediate	Closed
2	A FAQ and summary document will be generated by the GDS-TAG describing the GDS v1.7 in a simple manner. The FAQ will be published on the GHRSST-PP web site as soon as possible.	**GDS-TAG**	September 1st 2006	Open
3	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 at the 8th Science Team meeting.	**Donlon**	To report at the next ST meeting	Open
4	GHRSST-PP RDAC team leaders to look at the GODAE inter-comparison project in preparation for GHRSST- VIII 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**	June 1st 2006	Open
5	A GHRSST-PP RAN user requirements document will be developed and circulated to the Science Team for review.	**Casey/ Donlon/ Heinz**	End of 2006	Open
6	Estimates of L4 operational processing costs (volumes, CPU time, etc) should be provided to Ken Casey to help scope GHRSST-PP activities at NODC. Casey to draft and circulate an appropriate response template.	**Casey**	End of April	Open
7	A version 1.7 of the GDS including all revisions noted by Science Team members and working groups will be developed by the GHRSST-PO and GDS-TAG. Inputs to be sent to the GHRSST-PO by 1st July 2006	**Donlon**	End of May – L4 and L2P sections to be done ASAP for MODIS	Open
8	The GHRSST-PO will Set up mailing lists for GHRSST-PP ST, TAGS and WG's. In addition will circulate the e-mail addresses of Current Science Team members to the Science Team and meeting attendees.	**Donlon**	July 2006	Open
9	The DM_TAG/RAN_TAG will coordinate the development of GDS-v1.7 Table A2.1 and Table3.2.1 for correct codes and descriptions inputs to be provided by RDACS.	**Vasquez/ Casey**	Mid May 2006	Open
10	Modifications for the GDS-v1.7 agreed by the DV_WG and Science Team will be provided to the GHRSST-PO for inclusion into the GDS-v1.7.	**Merchant**	Mid May 2006	Open
11	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
12	RDAC representatives to review NODC ATBD Institutions template and return to Ken Casey. Casey to circulate the latest version of the ATBD document as soon as possible to RDAC leaders for review.	**Casey**	Ongoing when available	Open
13	GHRSST-PO to develop appropriate framework for L4 ensemble SST products and inter-comparison of L4 Products within European MERSEA/GMES framework	**Donlon**	Report at next ST meeting	Open

14	EURGDAC to develop a new acronym and send to the DM-TAG and GHRSST-PO.	**Piolle**	Mid May 2006	Open
15	Update the Action list from GHRSST-PP VI to GHRSST-PP VII.	**Donlon**	Immediate	Closed
16	Put Medspiration documents onto the GHRSST-PP web site (including a paper given at the MAVT/MERIS workshop, report on the last Medspiration User Consultation meeting and the User Consultation questionnaire developed for user feedback).	**Donlon/ Robinson**	Immediate	Open
17	Each RDAC group to check the consistency and correctness of L2P data files with the GDAC.	**Armstrong**	Immediate	Open
18	The GHRSST-PO to contact JAXA to establish if the GDAC can host and serve JAXA L2Pc data at JPL	**Donlon/ Vazquez**	Immediate	Open
19	All ST members to review and critically asses the GDAC interfaces to data. GDAc TO PROVIDE TEMPLATE	**Vazquez**	Immediate	Open
20	GHRSST-PP ST to raise the need to 'chunk' data in the new netCDF 4 system with John Caron.	**Cornillion**	Immediate	Closed
21	Establish a plan for rationalisation of the GDS documentation. Assign where possible to TAG/WG	**Donlon/ Wick/ Heinz**	Immediate	Open
22	Review and establish GHRSST-PP netCDF L4 file format including DM-TAG recommendations.	**Donlon**	Immediate	Open
23	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.	**Donlon**	Mid May 2006	Open
24	The DM-TAG will establish and coordinate a small working group to review the data policy issues impacting GHRSST-PP and generate procedures to deal with data policy issues. The first step in this process is to establish what the GHRSST-PP data policy actually is.	**Vazquez/ Donlon**	Report at next ST meeting	Open
25	Establish the most efficient manner to use the US Navy K10 analysis product within GHRSST-PP for inter-comparison experiments.	**Donlon/ May/ Armstrong**	On-going	Open
26	Ingest OOSTIAL L4 products at the GDAC. Provide a revised Master Metadata Repository (MMR) data set description (DSD) record for the Met Office OSTIA L4 product to GDAC. For each OSTIA data set a MMR_FR will be generated and sent to GDAC MMR system.	**Stark**	May 1st 2006	Open
27	Investigate the use of an electronic catalogue tool to coordinate and manage user feedbacks	**Heinz/ Robinson**	June 30th	Open
28	Establish how GHTSST-PP data sets can be made visible to the THREDDS community in a coordinated manner by linking to the GHRSST-PP MMR system	**Cornillon/ Armstrong**	Report at next ST meeting	Open
29	GHRSST-PP Project office to provide the GEWEX Seaflux project Director with an electronic version of GHRSST-PP SST definitions.	**Donlon**	June 1st 2006	Open
30	The GEWEX Seaflux project Director will provide a formal Seaflux SST user requirement to the GHRSST-PP.	**Clayson**	June 1st 2006	Open
31	The DM-TAG will establish a small WG to consider the development of gridded L3 fields within the GHRSST-PP. Agreed membership: Beggs[chair], LeBorgne, Evans, Vazquez, Poulter, Piolle, Cornillon. DM-TAG/GHRSST-PO to provide a ToR for the group. The group will report back to the ST with a short position paper. The Chair will issue a feedback template to the group to initiate discussions.	**Vazquez/ Beggs**	Report at next ST meeting	Open

32	The OSI-SAF/IFREMER/RSMAS/URI will discuss the development of an open source L2P re-gridding tool.	**Cornillion/ Piollé**	Report to next ST meeting	Open
33	The requirements for sea ice data within GHRSST-PP from operational data and RAN CDR to be reviewed with NSIDC.	**Minnett**	Report at next ST meeting	Open
34	A mapping of MODIS Quality levels into GDS-1.7 confidence levels will be established.	**Evans**	30/03/2006	Closed
35	The ftp address of GOES L2P test products will be provided to the GHRSST-PO and published on the GHRSST-PP web site.	**Maturi**	Immediate	Open
36	Content for the GDS-1.7 describing GOES L2P will be provided to the GHRSST-PO for inclusion into the GDS.	**Harris**	Mid may 2006	Open
37	NOAA/NESDIS to discuss the installation of L2P generation code for geostationary data (MTSAT) at BoM.	**Beggs/ Maturi**	Report at next ST meeting	Open
38	Develop and implement new HR-DDS functionality (e.g., difference plots, histograms, etc) as discussed at the VII GHRSST-PP ST meeting	**Poulter**	Report at next ST meeting	Open
39	The GDS-v1.7 specification of proximity_confidence will be updated to reflect discussions at GHRSST-PP VII ST meeting. Emphasis to be switched toward a quality measure.	**Donlon**	May 2006	Open
40	Medspiration PM, AATSR PI and AATSR validation scientist to review and rectify the specification of SSES for AATSR so that appropriate data are included in the appropriate proximity_confidence scale [excellent, acceptable, suspect].	**Corlett/ Robinson/ Llewellyn-Jones**	Immediate	Open
41	Doug May will monitor the impact of changes to the AATSR quality flags.	**May**	Liase/Report to Medspiratrion team & next ST meeting	Open
42	RDAC teams will update L2P processing system documentation to properly describe proximity_confidence for their sensors.	**Vazquez/ RDAC teams**	Report at next ST meeting	Open
43	A SSES working group will be established within the DM-TAG to review the harmonisation of SSES and their reporting through the L2P proposed quality and proximity_confidence scale. Proposed group: LeBorgne [chair], Robinson, May, Gentemann, Harris, Evans, Beggs. GHRSST-PO to develop a Terms of reference.	**Donlon**	Report at next ST meeting	Open
44	Update the configuration file for Medspiration AATSR SSES distance to cloud thresholds [1.5km and 3.5km].	**Robinson/ Donlon**	Immediate	Open
45	L2P producers to provide the GHRSST-PO with a short description of the SSES scheme used for inclusion into the GDS-v1.7	**Donlon and RDAC L2P providers**	Mid May 2006	Open
46	L2P providers to generate a GHRSST-PP SSES configuration file for the GHRSST-PP web site with documentation.	**Donlon**	Report at next ST meeting	Open
47	GHRSST-PP MDB team (IFREMER) to explore how other MDB records can be efficiently included within the GHRSST-PP MDB	**Piollé**	Report at next ST meeting	Open

48	An incremental file naming convention (suggest either _fv.01_ or use of the free text component t of the filename) is required for all GHRSST-PP data files to cater for re-release of data files following reprocessing. This will be reviewed and options passed to the GHRSST-PP ST inter-sessionally for review and inclusion n GDS-v1.7	**Vazquez/ DM-TAG**	Report at next ST meeting	Open
49	Evans, Merchant and LeBorgne to work on the AMSRE and MODIS comparisons using the Saharan Dust Indicator (SDI). Report findings at the next ST meeting.	**Evans/ LeBorgne/ Merchant**	Report at next ST meeting	Open
50	Advertise GHRSST-PP OPeNDAP servers within the OPeNDAP community.	**Cornillion/ Casey/ Armstrong**	Report at next ST meeting	Open
51	Register the GHRSST-PP web site with search engines to ensure that GHRSST-PP is one of the first search results returned. Action to urge people to link to the GHRSST-PP web page	**Heinz**	End 2006	Open
52	Request bzip2 compression is included in HDF 5 specification for GHRSST-PP.	**Cornillon**	Report at next ST meeting	Open
53	The RAN-TAG will develop documentation to help guide the groups working on RAN TAG. As part of this, a formal technical requirements specification for data sets participating within inter-comparison work is required.	**Casey**	July 2006	Open
54	John Stark will send a definition of anomaly colour scale developed at the Met Office to Casey and Reynolds for review. Once agreed the colour table definition (colour indices and inflection points) will be published on the GDAC, GHRSST-PP & LTSRF web spaces.	**Stark/ Casey/ Vazquez/ Donlon/ Reynolds**	Mid April 2006	Open
55	Chris merchant to review the (A)RC report for the GHRSST-PP VII proceedings and pass to the GHRSST-PO.	**Merchant**	End May 2006	Open
56	An external review of the GHRSST-PP web site will be conducted to highlight areas needing improvement.	**Liggett**	July 2006	Open
57	The use of a WWW based metrics dashboard for the GHRSST-PP project will be explored.	**Heinz/ Robinson**	June 2006	Open
58	ST members to provide inputs to the GHRSST-PO BAMS paper by June 1st 2006.	**All**	June 1st	Open
59	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. Proposed Membership: Vazquez [Chair], Bingham, LeBorgne, May, Poulter.	**Vazquez**	Report at next ST meeting.	Open
60	GDS-TAG to provide content for the GHRSST-PP web space. Suggest as a minimum, ToR + membership + overview (1 paragraph) + some images	**Donlon**	July 1st 2006	Open
61	RAN-TAG to provide content for the GHRSST-PP web space. Suggest as a minimum ToR + membership + overview (1 paragraph) + some images	**Casey**	July 1st 2006	Open
62	SI-WG to provide content for the GHRSST-PP web space. Suggest as a minimum ToR + membership + overview (1 paragraph) + some images	**Minnett**	July 1st 2006	Open
63	DV-WG to provide content for the GHRSST-PP web space. Suggest as a minimum ToR + membership + overview (1 paragraph) + some images	**Merchant**	July 1st 2006	Open

64	Dick Reynolds to provide new analysis in GHRSST-PP L4 (GDSv1.7) format (with errors).	**Reynolds**	End September 2006	Open
65	The DM-TAG to review the data access policy for GHRSST-PP data sets and consider if user registration should be mandatory? Answer: This is data set specific and is therefore at the discretion of data providers and their data policy	**Vazquez**	30/03/2006	Closed
66	Sue Heinz to investigate hosting a special session at the AMS – EUMETSAT OSI-SAF conference at the end of 2007	**Heinz**	End of summer 2006	Open
67	Craig to improve the ST pages on the GHRSST-PP web site including feedback form, connected to the GDAC, LTSRF and RDAC's.	**Donlon/ Ken/ Sue/ Cornillon**	End of Summer 2006	Open
68	Pat Liggett to send Sue Heinz PO.DAAC metrics definitions for circulation within the GHRSST-PP Science Team to help develop GHRSST-PP metrics.	**Liggett**	End April 2006	Open
69	A 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**	Report at next ST meeting	Open
70	RDAC's to provide summary documentation for their products to Vazquez for inclusion on the GDAC and GHRSST-PP web site DM-TAG chair to send a request and template for RDAC's to fill in.	**Vazquez**	End of May 2006	Open
71	GHRSST-PO to develop a timeline for GHRSST-PP to upgrade the L2Pc and L2P format and advertise these timeline for proposed changes on the GHRSST-PP web site.	**Donlon**	September 2006	Open
72	Sue Heinz to talk to Piollé to discuss how a user will ingest data into the MDB	**Heinz/ Piollé**	May 1st 2006	Open
73	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**	Immediate	Open
74	Ken Casey (GHRSST-PP RAN)to provide a letter to ESA stating the requirement for AATR v2.0 data set for use in RAN project.	**Casey**	Immediate	Open
75	PO.DAAC (NASA) to provide a letter to ESA stating the requirement for AATR v2.0 data set for use in RAN project and GHRSST-PP,	**Vazquez**	Immediate	Open
76	Cornillon and Armstrong to lobby for inclusion of netCDF 4.0 interfaces in IDL/Matlab	**Cornillon/ Armstrong**	Report at next ST meeting	Open
77	Send copy of all GHRSST-PP document in paper and electronic which will be submitted to the International library.	**Donlon/ Casey**	September 2006	Open
78	GHRSST-PO on behalf of ST to send letter of thanks to Wick and Castro Line Managers and to Karen Martin.	**Donlon**	Immediate	Open
79	A plan to link the GHRSST-PP MMR and HRDDS systems will be developed to provide an integrated system.	**Piolle/ Poulter**	Report at next ST meeting	Open
80	DV-WG breakout session (BG-3) report to GHRSST-PO for inclusion into GHRSST-PP proceedings	**Merchant**	Immediate	Open
81	DM-TAG breakout session (BG-2) report to GHRSST-PO for inclusion into GHRSST-PP proceedings	**Armstrong**	Immediate	Open
82	SSES breakout session (BG-1) report to GHRSST-PO for inclusion into GHRSST-PP proceedings	**Beggs**	Immediate	Open
83	Sea Ice breakout session (BG-4) report to GHRSST-PO for inclusion into GHRSST-PP proceedings	**Stark**	Immediate	Open

84	Donlon to update the membership of the GHRSST-PP Science Team based on revisions agreed at the VIIth ST meeting.	**Donlon**	Immediate	Open
85	GHRSST-PO to contact ST members to review membership.	**Donlon**	Immediate	Open
86	GHRSST-PP Science Team Chair to contact Olivier Arino and Peter Cornillon to invite them on to the GHRSST-PP Science Team	**Donlon**	1/04/2006	Closed

Craig Donlon 1st April 2006, Boulder Colorado.

Appendix V: Format Specification for BLUElink SST Analysis L4 files

Helen Beggs and Tim Pugh, 16 March 2006

(Based on the GHRSST-PP GDS v1.5 document (section A.1.3) at http://ghrsst-pp.metoffice.com/pages/documents/DocumentFiles/GDS-v1.0-rev1.5.pdf)

This document is located at: http://www.bom.gov.au/bmrc/ocean/BLUElink/SST/BLUElink_L4_file_format_v1.doc

Note: Text highlighted in blue relates to BLUElink specific issues and text highlighted in yellow relates to proposed changes to the GHRSST-PP L4 format specification.

Bureau's Current SST Analysis Binary (UARCH) Files

Global SST Analysis Files:

Global files (1° resolution) are weekly, named sstanal.glob.sMMsDD.eMMeDD.n2.mom where sMM sDD are start month, day of week (Monday) and eMM eDD are end of week (Sunday).
Stored currently on SAM in /samnmc/sstanal/anal/YYYY.
Array dimensions: dimlon = 360, dimlat = 180

Regional SST Analysis Files (Coarse resolution):

Regional files (0.25° resolution) are daily, named sstanal.reg.MMDD.n1.mom where MM DD are month and day.
Stored currently on SAM in /samnmc/sstanal/anal/YYYY.
Array dimensions: dimlon = 481, dimlat = 321

Test Regional SST Analysis Files (Fine Resolution):

Regional files (1/12° resolution) containing SST(1 m) estimates are daily, named SSTanal.DDMMMYYYY.Fine where DD, MMM and YYYY are day, month, year. Regional files (1/12° resolution) containing foundation SST estimates are daily, named foundSSTanal.DDMMMYYYY.Fine where DD, MMM and YYYY are day, month, year. Both types of fine resolution analysis binary files are stored currently on gale in /bm/gdata/hmb/nmoc/sstanal/regional.
Array dimensions: dimlon = 1561, dimlat = 1081

Proposed Bureau L4 SST Analysis File Names

The GDS filename convention used for GHRSST-PP L4 data products has been designed to provide useful information in an easily readable format. All L4 data product filenames are derived according to the following convention:

> **<Date Valid>-<Processing Centre Code>-L4<Product type>-<Area>-<Processing Model ID>.<base format>**

which is defined in Table A1.3.1.

Table A1.3.1. L4 analysed data product filename components.

Name	Definition	Description
<Processing Centre Code>	Refer to Appendix A2 Table A2.1	Processing centre code
<Area>	Table A1.3.2	The area covered by the L4 product
<Date Valid>	YYYYMMDD	Refers to the date for which this particular data set
<product type>	LRfnd=low resolution, UHfnd=ultra-high resolution	Resolution of analysed foundation SST (fnd) data
<processing model ID>	v*nn* (where *nn* is the GDS version number, e.g., 01	Version number of the GDS system used to process the data file

<base format>	Nc	Generic file format (nc=netCDF)

For example:

20040621-EUR-L4UHfnd-MED-v01.nc

For the Bureau's SST analysis files the filenames will be as follows:
Global 1° SST(1m) analyses: 20060224-AUST-L4LR1m-GLOB-v01.nc
Regional 0.25° SST(1m) analyses: 20060224-AUST-L4LR1m-AUS-v01.nc
Regional 1/12° SST(1m) analyses: 20060224-AUST-L41m-AUS-v01.nc
Regional 1/12° SSTfnd analyses: 20060224-AUST-L4fnd-AUS-v01.nc

Proposed Bureau L4 File Global Attributes

For BLUElink, we need to somehow add background correlation length scale, observation correlation length scale and observation correlation time scale values to the L4 global attributes. Should these values be added to the history or comment fields? We also need to add the observation estimated standard deviation (OBSESD) values to the comment or history fields. These OBSESD values are currently global attributes of each analysis but different for each input data stream. The current Bureau binary analysis (UARCH) files contain all observation data values, with corresponding latitude, longitude, time and rms error value.

Global SST(1m) Analysis (legacy product):
:Conventions = "CF-1.0";
:title = "Analysed global low resolution 1 m sea surface temperature";
:DSD_entry_id = "AUST-L4LR1m-GLOB";
:references = "http://www.bom.gov.au/bmrc/ocean/BLUElink/SST/The_Bureau_of_Meteorology_SST_analysis_system.doc"; (We need to move this paper to a more permanent URL)
:institution = "Australian Bureau of Meteorology";
:contact = "G.Warren@bom.gov.au";
:GDS_version_id = "v1.0-rev1.7";
:netcdf_version_id = "3.5"; (version of linked library comes from nc_inq_libvers())
:creation_date = "2006-03-01";
:product_version = "1.0"; (Check version)
:history = " ";
:source = "Univariate statistical interpolation package, SIANAL v13"
:grid_resolution = "1.0 degree";
:start_date = "2005-01-01";
:start_time = "00:00:00";
:stop_date = "2005-01-07";
:stop_time = "23:59:59";
:southernmost_latitude = "-90.00f";
:northernmost_latitude = "90.00f";
:western_longitude = "-180.00f";
:eastern_longitude = 180.00f";
:file_quality_index = "0";
:comment = "This is a legacy research product (run operationally at the Bureau) which does not comply with all GDS v1.0-rev1.7 L4 guidelines";

Regional 0.25° SST(1m) Analysis (legacy product):
:Conventions = "CF-1.0";
:title = "Analysed low resolution 1 m sea surface temperature over Australian Region";
:DSD_entry_id = "AUST-L4LR1m-AUS";
:references = http://www.bom.gov.au/bmrc/ocean/BLUElink/SST/The_Bureau_of_Meteorology_SST_analysis_system.doc; (We need to move this paper to a more permanent URL)
:institution = "Australian Bureau of Meteorology";
:contact = "G.Warren@bom.gov.au";
:GDS_version_id = "v1.0-rev1.7";
:netcdf_version_id = "3.5";

:creation_date = “2006-03-01”;
:product_version = “1.0”; (Check version)
:history = “ ”;
:source = “Univariate statistical interpolation package, SIANAL v13”
:grid_resolution = “0.25 degree”;
:start_date = “2005-01-01”;
:start_time = “00:00:00”;
:stop_date = “2005-01-07”;
:stop_time = “23:59:59”;
:southernmost_latitude = “-70.00f”;
:northernmost_latitude = “20.00f”;
:western_longitude = “60.00f”;
:eastern_longitude = -170.00f”;
:file_quality_index = “0”;
:comment = “This is a legacy research product (run operationally at the Bureau) which does not comply with all GDS v1.0-rev1.7 L4 guidelines”;

Regional 1/12° SST(1m) Analysis (new BLUElink product):
:Conventions = “CF-1.0”;
:title = “Analysed high resolution 1 m sea surface temperature over Australian Region”;
:DSD_entry_id = “AUST-L41m-AUS”;
:references = http://www.bom.gov.au/bmrc/ocean/BLUElink/SST_external.html; (Before end of 2006 Helen Beggs will write a BMRC Research Report explaining how the new analysis was performed)
:institution = “Australian Bureau of Meteorology”;
:contact = “H.Beggs@bom.gov.au”;
:GDS_version_id = “v1.0-rev1.7”;
:netcdf_version_id = “3.5”;
:creation_date = “2006-03-01”;
:product_version = “1.0”;
:history = “ ”;
:source = “Univariate statistical interpolation package, SIANAL v13”
:grid_resolution = “1/12 degree”;
:start_date = “2005-01-01”;
:start_time = “00:00:00”;
:stop_date = “2005-01-07”;
:stop_time = “23:59:59”;
:southernmost_latitude = “-70.00f”;
:northernmost_latitude = “20.00f”;
:western_longitude = “60.00f”;
:eastern_longitude = -170.00f”;
:file_quality_index = “0”;
:comment = “This is a Bureau experimental research product produced for the BLUElink> Ocean Forecasting Australia Project and does not comply with all GDS v1.0-rev1.7 L4 guidelines”;

Regional 1/12° SST(foundation) Analysis (new BLUElink product):
:Conventions = “CF-1.0”;
:title = “Analysed high resolution foundation sea surface temperature over Australian Region”;
:DSD_entry_id = “AUST-L4fnd-AUS”;
:references = http://www.bom.gov.au/bmrc/ocean/BLUElink/SST_external.html; (Before end of 2006 Helen Beggs will write a BMRC Research Report explaining how the new analysis was performed)
:institution = “Australian Bureau of Meteorology”;
:contact = “H.Beggs@bom.gov.au”;
:GDS_version_id = “v1.0-rev1.7”;
:netcdf_version_id = “3.5”;
:creation_date = “2006-03-01”;
:product_version = “1.0”;
:history = “ ”;
:source = “Univariate statistical interpolation package, SIANAL v13”
:grid_resolution = “1/12 degree”;
:start_date = “2005-01-01”;
:start_time = “00:00:00”;

:stop_date = “2005-01-07”;
:stop_time = “23:59:59”;
:southernmost_latitude = “-70.00f”;
:northernmost_latitude = “20.00f”;
:western_longitude = “60.00f”;
:eastern_longitude = -170.00f”;
:file_quality_index = “0”;
:comment = “This is a Bureau experimental research product produced for the BLUElink> Ocean Forecasting Australia Project”;

Proposed Bureau L4 File Formats

For L4 files to be more CF-compliant the BLUElink> Project recommends that GHRSST-PP add standard names where appropriate and add the cell boundary data to the CDL description.

The GHRSST-PP should register the following proposed CF standard names:

standard_name = “sea_water_temperature_at_skin”
standard_name = “sea_water_temperature_at_subskin”
standard_name = “sea_water_temperature_at_foundation”

along with a description of each name. “sea_water_temperature” is preferred over “sea_surface_temperature” as the word “surface” is misleading.

Another issue is whether only salt water is measured and analysed, or whether water can contain various degrees of salt, such as the North American Great Lakes or the Dead Sea. Is the word “sea_water_temperature” representative of the data or should it simply be “water_temperature”.

The following name should not be considered a standard name unless there is a specific definition measurement and use for sea water at 1 metre.

“sea_water_temperature_at_1m”

See the following sources for requesting additions to CF standard name tables: http://www.cgd.ucar.edu/mailman/listinfo/cf-metadata and Jonathan Gregory <j.m.gregory@reading.ac.uk>

BLUElink would also like to see an attribute added to coordinate variables to define which axis is represented, such as for the time coordinate variable

axis = “T”

or “Y” for latitude, “X” for longitude. This does seem redundant for humans, but could be useful for software.

If the analysed fields represent the average composite value for a cell, the cell’s spatial and temporal boundaries should be defined in the coordinate variable. The attribute for any coordinate variable is:

bounds = “lon_bnds”

where the attribute value “lon_bnds” defines a variable name with the bounds data. This data provides an explicit definition of cell bounds and is most useful for regridding, interpolation, and visualization software.

BLUElink would like to see the CF convention attributes for flags added to variables when appropriate:

flag_values = 1b,2b,4b,8b
flag_meanings = “sea land lakes ice”

The current BLUElink L4 time specification has inherent limitations if the data producer or user is not careful. The current specification of four byte integers representing time with a reference time of seconds since 1981-01-01 has a limitation of representing time until 2049. Seems like the Year 2000 issue again. Two solutions are to change to double precision floating point data types, or to remain using four byte integers and change the reference time every year. A common pitfall for the user is to assume the reference time will no change, and to write their software with this assumption. Time representation should be handled by udunits functions or other high level functions for consistent handling of time values and time conversions. BLUElink would prefer to see time data represented as double precision floats in units of hours or days. For the best human readable format, the units should be in hours since start date of analysis.

For the time coordinate and units, a calendar should be specified. BLUElink would suggest "Gregorian" for observational time representation. Our models will be using "Julian" which is compatible with "Gregorian" time units for time conversions and computations.

sst_foundation variable

The variable 'sst_foundation' will be included with the format requirements shown in Table 1. Note this is equivalent to the ocean temperature at around 10 m depth which is unaffected by diurnal warming or cool-skin effects. The foundation SST is output from the new BLUElink test 1/12° regional SST analysis system and is the AN variable in the foundSSTanal.ddmmmyyyy.Fine analysis files.

Table 1 CDL description of sst_foundation variable

Storage type	Name	Description	Unit
short	sst_foundation	SSTfnd from analysis	K
CDL description			
short sst_foundation(time, lat, lon) ; sst_foundation:long_name = "sea temperature at foundation depth" ; sst_foundation:standard_name = "sea_water_temperature_at_foundation"; sst_foundation:units = "kelvin" ; sst_foundation:_FillValue = -32768s ; sst_foundation:add_offset = 273.15 ; sst_foundation:scale_factor = 0.01 ; sst_foundation:valid_min = -200s ; sst_foundation:valid_max = 4000s ;			

sst_1m variable

The variable 'sst_1m' will be included with the format requirements shown in Table 2. Note this is the current bulk SST output from the Bureau's legacy global and regional SST analysis systems (AN in the UARCH files). The sst_1m variable will replace the sst_foundation variable in the SST(1m) L4 analysis files.

Table 2 CDL description of sst_1m variable

Storage type	Name	Description	Unit
short	sst_1m	SST1m from analysis	K
CDL description			
short sst_1m(time, lat, lon) ; sst_1m:long_name = "sea temperature at 1 metre depth" ; sst_1m:units = "kelvin" ; sst_1m:_FillValue = -32768s ; sst_1m:add_offset = 273.15 ; sst_1m:scale_factor = 0.01 ; sst_1m:valid_min = -200s ; sst_1m:valid_max = 4000s ;			
Comments			

normalised_analysis_error variable

The variable 'normalised_analysis_error' will be included with the format requirements shown in Table 3. Note that for the Bureau's analyses we are assuming that this variable is equivalent to the "analysis field error" (ANERR in the Bureau's UARCH files).

Table 3 CDL description of normalised_analysis_error variable

Storage type	Name	Description	Unit

short	normalised_analysis_error	Error estimate output from analysis system	K
CDL description			

short normalised_analysis_error(time, lat, lon) ;
normalised_analysis_error:long_name = "normalised analysis error estimate" ;
normalised_analysis_error:units = "kelvin" ;
normalised_analysis_error:_FillValue = -32768s;
normalised_analysis_error:add_offset = 0. ;
normalised_analysis_error:scale_factor = 0.01 ;
normalised_analysis_error:valid_min = 0s;
normalised_analysis_error:valid_max = 32767s;			

Comments			
Refer to WP-ID3.2.3 for definition (No such section in GDS v1.5 or v1.6)			

bias variable

The variable 'bias' will be included with the format requirements shown in Table 4. At present I have no idea how we obtain this "bias" variable.

Table 4 CDL description of bias variable

Storage type	Name	Description	Unit
short	bias	Analysis error bias	K
CDL description			
short bias(time, lat, lon) ; bias:long_name = "analysis error bias" ; bias:units = "kelvin" ; bias:_FillValue = -32768s ; bias:add_offset = 0. ; bias:scale_factor = 0.01 ; bias:valid_min = -32767s ; bias:valid_max = 32767s ;			
Comments			
Refer to rule 6.2.3 for definition (No such rule in GDS v1.5 or v1.6)			

sst_bgf variable

The variable 'sst_bgf' will be included with the format requirements shown in Table 5. Note this is the background field used in the analysis and is a combination of the previous analysis and climatology. The background field is the BGF variable in the Bureau's UARCH binary files.

Table 5 CDL description of sst_bgf variable

Storage type	Name	Description	Unit
short	sst_bgf	SST background field for analysis	K
CDL description			
short sst_bgf(time, lat, lon) ; sst_bgf:long_name = "sea water temperature analysis background field" ; sst_bgf:units = "kelvin" ; sst_bgf:FillValue = -32768s ; sst_bgf:add_offset = 273.15 ; sst_bgf:scale_factor = 0.01 ; sst_bgf:valid_min = -200s ; sst_bgf:valid_max = 4000s ;			
Comments			

bgf_error variable

The variable 'bgf_error' will be included with the format requirements shown in Table 6. Note this is the background field error used in the analysis. The background field error is the BGFERR variable in the Bureau's UARCH binary files.

Table 6 CDL description of bgf_error variable

Storage type	Name	Description	Unit
short	bgf_error	Error estimate for SST background field	K
CDL description			

short bgf_error(time, lat, lon) ;
bgf_error:long_name = "background field error estimate" ;
bgf_error:units = "kelvin" ;
bgf_error:FillValue = -32768s;
bgf_error:add_offset = 0. ;
bgf_error:scale_factor = 0.01 ;
bgf_error:valid_min = 0s;
bgf_error:valid_max = 32767s;			

Comments			

sst_clim variable

The variable 'sst_clim' will be included with the format requirements shown in Table 7. Note this is the bulk SST climatology (Reynolds and Smith, 1994) input into the Bureau's global and regional SST analysis systems (CLIM in the UARCH files).

Table 7. CDL description of sst_1m variable

Storage type	Name	Description	Unit
short	sst_clim	SST climatology used in analysis	K
CDL description			
short sst_clim(time, lat, lon) ; sst_clim:long_name = "sea temperature climatology at 1 metre depth" ; sst_clim:units = "kelvin" ; sst_clim:_FillValue = -32768s ; sst_clim:add_offset = 273.15 ; sst_clim:scale_factor = 0.01 ; sst_clim:valid_min = -200s ; sst_clim:valid_max = 4000s ;			
Comments			

sea_ice_fraction variable

The variable 'sea_ice_fraction' will be included with the format requirements shown in Table 8.

Table 8. CDL description of sea_ice_fraction variable

Storage type	Name	Description	Unit
byte	sea_ice_fraction	Fractional sea ice concentration	
CDL description			
byte sea_ice_fraction(time, lat, lon) ; sea_ice_fraction:long_name = "sea ice fraction" ; sea_ice_fraction:standard_name = "sea_ice_area_fraction"; sea_ice_fraction:units = " " ; ← fraction, not percent sea_ice_fraction:_FillValue = -128 ; sea_ice_fraction:add_offset = 0. ; sea_ice_fraction:scale_factor = 0.01 ; sea_ice_fraction:valid_min = 0 ; sea_ice_fraction:valid_max = 100 ;			
Comments			

Refer to WP-ID2.1.1.3 for definition This variable shall not be used for the Mediterranean UHR/L4 product or any other area for which this parameter is not relevant. The 'source' variable attribute was removed : the variable 'sources_of sea_ice_fraction' was added instead to reflect the GDS table A1.3.2 specifications.

sources_of sea_ice_fraction variable

The variable 'sources_of sea_ice_fraction' will be included if relevant with the format requirements shown in Table 9. What are the source codes?

Table 9. CDL description of sources_of sea_ice_fraction variable

Storage type	Name	Description	Unit
byte	sources_of sea_ice_fraction	Source(s) of fractional sea ice concentration (should be the same as for L2P)	none
CDL description			
byte sources_of_sea_ice_fraction (time, lat, lon) ; sources_of_sea_ice_fraction:long_name = "sources of sea ice fraction " ; sources_of_sea_ice_fraction:_FillValue = -128b ; sources_of_sea_ice_fraction:comment = "detail here source codes" ;			
Comments			
Refer to WP-ID2.1.1.3 for definition This variable shall not be used for the Mediterranean UHR/L4 product or any other area for which this parameter is not relevant.			

the source code is selected from Table 2.1.3.

mask variable

The variable 'mask' will be included with the format requirements shown in Table 10.

Table 10. CDL description of mask variable

Storage type	Name	Description	Unit
byte	mask	Composite of field masks for sea, land, lake, ice	none
CDL description			
byte mask(time, lat, lon) ; mask:long_name = "land/water/ice field composite mask" ; mask:_FillValue = -128b ; mask:flag_values = 1b, 2b, 4b, 8b; mask:flag_meanings = "sea land lake ice"			
Comments			
Refer to WP-ID2.1.1.11 for definition b0: 1=sea b1: 1=land b2: 1=lakes b3: 1=ice			

Example of BLUElink L4 SSTfnd CDL Header

```
netcdf example {
dimensions:
        lon = 1561 ;
        lat = 1081 ;
        time = 1 ;
        nv = 2;

variables:
```

```
double time(time) ;
        time:long_name = "reference time of sst field" ;
        time:standard_name = “time”;
        time:axis = “T”;
        time:calendar = “Gregorian”
        time:units = "hours since 2005-01-01 0:0:0" ;   ← substitute analysis start date
        time;bounds = “time_bnds”;
float lat(lat) ;
        lat:long_name = "latitude" ;
        lat:standard_name = “latitude”;
        lat:axis = “Y”;
        lat:units = "degrees_north" ;
        lat;bounds = “lat_bnds”;
float lon(lon) ;
        lon:long_name = "longitude" ;
        lon:standard_name = “longitude”;
        lon:axis = “X”;
        lon:units = "degrees_east" ;
        lon:bounds = “lon_bnds”;
double time_bnds(time,nv) ;
float lat_bnds(lat,nv) ;
float lon_bnds(lon,nv) ;
short sst_foundation(time, lat, lon) ;
        sst_foundation:long_name = "sea water temperature at foundation depth" ;
        sst_foundation:standard_name = “sea_water_temperature_at_foundation”;
        sst_foundation:units = "kelvin" ;
        sst_foundation:_FillValue = -32768s ;
        sst_foundation:add_offset = 273.15 ;
        sst_foundation:scale_factor = 0.01 ;
        sst_foundation:valid_min = -200s ;
        sst_foundation:valid_max = 4000s ;
short normalised_analysis_error(time, lat, lon) ;
        normalised_analysis_error:long_name = "normalised analysis error estimate" ;
        normalised_analysis_error:units = "kelvin" ;
        normalised_analysis_error:_FillValue = -32768s ;
        normalised_analysis_error:add_offset = 0. ;
        normalised_analysis_error:scale_factor = 0.01 ;
        normalised_analysis_error:valid_min = 0s;
        normalised_analysis_error:valid_max = 32767s ;
short bias(time, lat, lon) ;
        bias:long_name = "analysis error bias" ;
        bias:units = "kelvin" ;
        bias:_FillValue = -32768s ;
        bias:add_offset = 0. ;
        bias:scale_factor = 0.01 ;
        bias:valid_min = -32767s ;
        bias:valid_max = 32767s ;
byte sea_ice_fraction(time, lat, lon) ;
        sea_ice_fraction:long_name = "sea ice fraction" ;
        sea_ice_fraction:standard_name = “sea_ice_area_fraction”;
        sea_ice_fraction:units = " " ;
        sea_ice_fraction:_FillValue = -128 ;
        sea_ice_fraction:add_offset = 0. ;
        sea_ice_fraction:scale_factor = 0.01 ;
        sea_ice_fraction:valid_min = 0 ;
         sea_ice_fraction:valid_max = 100 ;
byte sources_of_sea_ice_fraction (time, lat, lon) ;
        sources_of_sea_ice_fraction:long_name = "sources of sea ice fraction " ;
        sources_of_sea_ice_fraction:_FillValue = -128 ;
        sources_of_sea_ice_fraction:comment = "details here source codes" ;
byte mask(time, lat, lon) ;
        mask:long_name = " land/water/ice field composite mask " ;
        mask:_FillValue = -128 ;
        mask:flag_values = 1b, 2b, 4b, 8b;
        mask:flag_meanings = “sea land lakes ice”
short sst_bgf(time, lat, lon) ;
        sst_bgf:long_name = "sea water temperature analysis background field" ;
        sst_bgf:units = "kelvin" ;
        sst_bgf:FillValue = -32768s ;
        sst_bgf:add_offset = 273.15 ;
        sst_bgf:scale_factor = 0.01 ;
        sst_bgf:valid_min = -200s ;
        sst_bgf:valid_max = 4000s ;
short bgf_error(time, lat, lon) ;
        bgf_error:long_name = "background field error estimate" ;
        bgf_error:units = "kelvin" ;
        bgf_error:FillValue = -32768s;
        bgf_error:add_offset = 0. ;
```

```
                    bgf_error:scale_factor = 0.01 ;
                    bgf_error:valid_min = 0s;
                    bgf_error:valid_max = 32767s;
            short sst_clim(time, lat, lon) ;
                    sst_clim:long_name = "sea temperature climatology at 1 metre depth" ;
                    sst_clim:units = "kelvin" ;
                    sst_clim:_FillValue = -32768s ;
                    sst_clim:add_offset = 273.15 ;
                    sst_clim:scale_factor = 0.01 ;
                    sst_clim:valid_min = -200s ;
                    sst_clim:valid_max = 4000s ;

// global attributes:
                    :Conventions = "CF-1.0";
:title = "Analysed high resolution foundation sea surface temperature over Australian region";
                    :DSD_entry_id = "AUST-L4fnd-AUS";
                    :references = http://www.bom.gov.au/bmrc/ocean/BLUElink/SST_external.html;
                    :institution = "Australian Bureau of Meteorology";
                    :contact = "H.Beggs@bom.gov.au";
                    :GDS_version_id = "v1.0-rev1.7";
                    :netcdf_version_id = "3.5";
                    :creation_date = "2006-03-01";
                    :product_version = "1.0";
                    :history = " ";
                    :source = "Univariate statistical interpolation package, SIANAL v13"
                    :grid_resolution = "1/12 degree";
                    :start_date = "2005-01-01";
                    :start_time = "00:00:00";
                    :stop_date = "2005-01-07";
                    :stop_time = "23:59:59";
                    :southernmost_latitude = "-70.00f";
                    :northernmost_latitude = "20.00f";
                    :western_longitude = "60.00f";
                    :eastern_longitude = -170.00f";
                    :file_quality_index = "0";
                    :comment = "This is a Bureau experimental research product produced for the BLUElink> Ocean
                    Forecasting Australia Project";

}
```

How to find out more about GODAE and the GHRSST-PP:

A complete description of the GODAE project 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.csiro.au/bluelink
NGSST	http://www.ocean.caos.tohoku.jp
GHRSST-PP USGDAC	http://www.jpl.nasa.gov
GHRSST-PP EUGDAC	http://www.mersea.eu.org
GODAE	http://www.godae.au

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