GHRSST-PP

GODAE High Resolution Sea Surface Temperature Pilot Project

The First Report of the GHRSST-PP In situ and Satellite Data Integration-Technical Advisory Group (ISDI-TAG)

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Executive Summary

The GODAE High Resolution Sea Surface Temperature Pilot Project (GHRSST-PP) has been established to provide international focus and coordination for the development of a new generation of global, multi-sensor, high-resolution (better than 10 km), sea surface temperature (SST) products provided in real time (6 hourly). Its primary aim is to oversee the development, timely delivery, assembly and processing high-quality, global scale, SST products at a fine spatial and temporal resolution, for the diverse needs of GODAE and the wider scientific community.

The GHRSST-PP In situ and Satellite Data Integration Technical Advisory Group (ISDI-TAG) is the formal GHRSST-PP body that is responsible for the scientific and operational methods and algorithms used to generate GHRSST-PP data products. This document describes the working discussions and the final recommendations that emerged from extended discussions of the ISDI-TAG following the initial GHRSST-PP data product specification that emerged at the Second GHRSST-PP Workshop. They constitute a "consensus opinion" of the GHRSST-PP community and form the basis of all operations that will be implemented at GHRSST-PP Global Data Analysis Centres (GDAC) and Regional Data Assembly Centre (RDAC) facilities that exist within the global/regional task sharing model that forms the basis of the GHRSST-PP Implementation Plan.

Further information, including all reference material, can be found at the GHRSST-PP international Project Office web site: http://www.ghrsst-pp.org.

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Table of Contents

1 Introduction

Satellite SST measurements are required for use in operational monitoring and forecasting of the ocean, and for assimilation into coupled ocean-atmosphere models for applications in short-term numerical weather prediction and longer term climate change detection. The Global Ocean Data Assimilation Experiment (GODAE), initiated in 1997, will provide a global system of observations, communications, modelling and assimilation which will deliver regular, comprehensive information on the state of the oceans during 2005-2007. Information will be made widely available for operational applications in regional and local situations calling for timely knowledge and forecasting of the ocean state.

The GODAE international steering committee initiated the GODAE High Resolution SST Pilot Project (GHRSST-PP) in recognition that current SST data sets are not able to fulfil the requirements of GODAE. The purpose of GHRSST-PP is to develop an operational high resolution SST data product that will be able to meet those needs within the time frame of GODAE. GHRSST-PP will maximise the use of SST data by fusing complementary data from a variety of sensor types and platforms, including conventional wide-swath polar orbiting infra-red sensors, microwave radiometers and infra-red scanners on geostationary satellites.

The coordination and implementation preparations for the GHRSST-PP commenced at the first GHRSST-PP workshop held in November 2000. The GHRSST-PP ***preparation phase*** is mainly concerned with engaging and consolidating the GHRSST-PP community and implementation of the basic GHRSST-PP. It will run until July 2003 cumulating in an operational demonstration of "version 1.0" GHRSST-PP products and services.

The preparation phase will be superseded by the GHRSST-PP ***demonstration phase*** that will continue until the end of 2005. During the demonstration phase, GHRSST-PP data products and services will be continually refined and made available, in real time, to the broad GHRSST-PP user community. Throughout the demonstration phase, a parallel and continual process of project development and refinement is foreseen with particular emphasis on the improvement of demonstration data products and delivery to operational users.

During 2004-2005, data products will be provided to a number of specific operational users who will work closely with the GHRSST-PP Science Team to evaluate the products using a variety of specific applications demanding real time high-resolution SST data products. Dedicated model runs, inter-

comparison exercises and assimilation experiments will all take place in real time. This period is called the GHRSST-PP ***intensive application phase***.
The In situ and Satellite Data Integration (ISDI) component of the GHRSST-PP refers to the operational methodology that will be used to deliver GHRSST-PP data products. The ISDI is expected to evolve as new research results become available and is coordinated by an International Technical Advisory Group (ISDI-TAG) answering to the GHRSST-PP Science Team.

Following the second GHRSST-PP Workshop (NASDA-EORC, Tokyo, May 2002), the GHRSST-PP In situ and Satellite Data Integration Technical Advisory Group (ISDI-TAG) was convened and tasked with assessing the scientific and operational feasibility of producing GHRSST-PP data products. During the period May-September 2002, the ISDI-TAG, Chaired by Dr. Gary Wick, has worked to consider the initial GHRSST-PP Data product specification that emerged from the GHRSST-PP Second Workshop.

This document describes the working discussions and the final recommendations that emerged from extended discussions of the ISDI-TAG. They constitute a "consensus opinion" of the GHRSST-PP community and form the basis of all operations that will be implemented at GHRSST-PP Global Data Analysis Centres (GDAC) and Regional Data Assembly Centre (RDAC) facilities that exist within the global/regional task sharing model that forms the basis of the GHRSST-PP Implementation Plan. Annex I describes the membership of the group during this period. This first report presents the discussion and conclusions of the ISDI-TAG that was formerly convened to consider in detail the methodology that will be used to generate the GHRSST-PP data products.

2 GHRSST-PP Initial Data Product Specifications

During the 2nd GHRSST-PP Workshop, held in Tokyo, May 2002, the GHRSST-PP Science Team (ST) agreed on the specification of the project data products. Three types of GHRSST-PP SST demonstration products will be produced: **merged products**, **analysed products** and **reanalysis products**. Following the workshop, a preliminary GHRSST-PP Data Product Specification document (GHRSST-PP Reference document GHRSST/10) was released. Table 1 summarises the initial specification of GHRSST-PP data products and forms the basis of the following reported discussions.

Table 1. Initial GHRSST-PP data product specification following the GHRSST-PP Second Workshop to be considered by the ISDI-TAG.

Characteristic	Merged SST	Analyzed SST	Reanalyzed SST
Grid Size	Better than 10 km	Better than 10 km	Better than 10 km
Temporal resolution	6 hours	12 hours	6 hours
Delivery timescale	Real time	Real time	7-60 days following data reception
Accuracy	< 0.5 K absolute 0.1 K relative	< 0.5 K absolute) 0.1 K relative	< 0.3 K absolute (target), 0.1 K relative
Error statistics	rms. and bias for each input data stream at every grid point	rms. and bias for each output grid point (no input data statistics are retained)	rms. and bias for each output grid point (no input data statistics are retained)
Coverage	Regional (Best effort Global)	Global, (Regional extracted)	Global
SSTskin product	Yes	Yes	Yes
SSTsub-skin product	Yes	Yes	Yes
SST1m product	Yes	Yes	Yes
Cloud mask	For each input data set	Yes	Yes
Confidence data	No	Yes (sea ice information, diurnal warming mask, quality flags)	Yes (sea ice information, diurnal warming mask, quality flags)
Nominal product format	Hdf/GRIB/NetCDF	Hdf/GRIB/NetCDF	Hdf/GRIB/NetCDF

Merged products consist of L2a collated separate satellite data streams that have been calibrated cleared of cloud re-gridded to a common grid format. Each data set will be produced at the highest spatial and temporal resolution possible with a common grid format. No interpolation or combined analysis will be performed on the data. Merged data products retain all of the error statistics derived from error coding schemes based on in situ data sets for each pixel in each input data set (e.g., LeBorgne et al., 2002). These products are volatile, changing as new data arrives in real time but will be consolidated and archived at 6 hourly intervals corresponding to the synoptic Meteorological forecast times. Due to high data volumes and time constraints, only a moderate level of quality control may be possible. These products are expected to directly serve the ocean modelling community.

In contrast, analysed products are derived from the combined analysis of all merged products produced at 12 hourly intervals corresponding to the synoptic Meteorological forecast times (00:00 and 12:00 UTC). Analysed data products have a single output grid together with confidence data including information on the diurnal signal, sea ice and a set of confidence flags. Error statistics consist of a mean bias and rms. estimate for each grid point derived from a combination of errors due to the analysis methodology and error coding schemes based on in situ data sets for each pixel in each input data set. A high level of quality control is expected. Analysed data are permanent data that are deep archived. These products are expected to serve the NWP and ocean modelling community.

Finally, reanalysis products are derived in a delayed mode 7-60 days after data reception to take advantage of additional data sources, particularly in situ observations and satellite data sets unavailable in real-time. The highest level of quality control will be performed on these data that will be produced at 12 hourly intervals. Analysed products are expected to serve the climate and general user community and will replace archived analysed products as they become available.

3 ISDI-TAG Terms of Reference

The following Terms of Reference were agreed for the ISDI-TAG (Annex I):

(i) Based on the conclusions of the 2nd GHRSST-PP Workshop, develop a consensus methodology that can be implemented within RDAC and GDAC ISDI providing global coverage SST_{skin}, $SST_{sub\text{-}skin}$ and SST_{1m} merged and analysed data products according to the specification in Table 1;

(ii) Work with specific applications of GHRSST-PP data products and act on any feedback;

(iii) Form and operate an international panel to undertake the development and implementation of the GDAC and RDAC GHRSST-PP ISDI, including its final transition into an operational system at a GHRSST-PP GDAC. This should address (a) merged and analysed data product format (b) product validation protocols based on GHRSST-PP diagnostic data sets (c) common implementation of the ISDI at the GDAC data product computational facility (DPCF) and within RDAC (e) data archive of GHRSST-PP data products (d) suitable metrics to assess the performance of the GHRSST-PP products and ISDI;

(iv) Review and assess proposals for improvements to the ISDI methodology and decide if and how such improvements should be incorporated into the operational ISDI;

(v) To work together with GHRSST-PP users and report on the progress of User Applications and Services (AUS) activities using GHRSST-PP data products;

(vi) Review and assess user applications for experiments to be executed at the GHRSST-PP GDAC DPCF;

(vii) Provide scientific guidance to, and as appropriate, receive advice from, the GHRSST-PP Science Team on the scientific and technical issues associated with the implementation and operation of the ISDI and on the use of GHRSST-PP products by GODAE and other users;

(viii) Provide advice and guidance on scientific and technical innovations relevant to the GHRSST-PP;

(ix) Provide regular reports on progress to the GHRSST-PP Science Team.

Several technical areas that wore deemed appropriate for consideration by the ISDI-TAG have been deferred (no later than December 2002) until the publication and review of this initial report. These include:

- GHRSST-PP reanalyses data products
- Appropriate consideration of marginal Sea Ice
- Computer systems and operational implementation
- User applications and feedback

4 Discussion and Recommendations of the First ISDI-TAG Working Group

The following sections describe the working discussions and the final recommendations that emerged from extended discussions of the first ISDI-TAG working group during May-September 2002. They constitute a "consensus opinion" of the GHRSST-PP community and form the basis of all operations that will be implemented at GHRSST-PP GDAC and RDAC facilities. In particular, they have been incorporated into a revised version of GHRSST-PP report GHRSST/10: "GHRSST-PP Data Product Specification Document" available from the GHRSST-PP web site http://www.ghrsst-pp.org.

4.1 Product Depths

SST products are to be produced for the skin temperature, SST_{skin}, the sub-skin temperature or the temperature at the base of the skin layer, $SST_{subskin}$, and the temperature at a depth below the influence of any diurnal warming, SST_{CTL}, where CTL refers to a "constant temperature layer." The relative depths and relationship between these quantities is shown schematically in Figure 1.

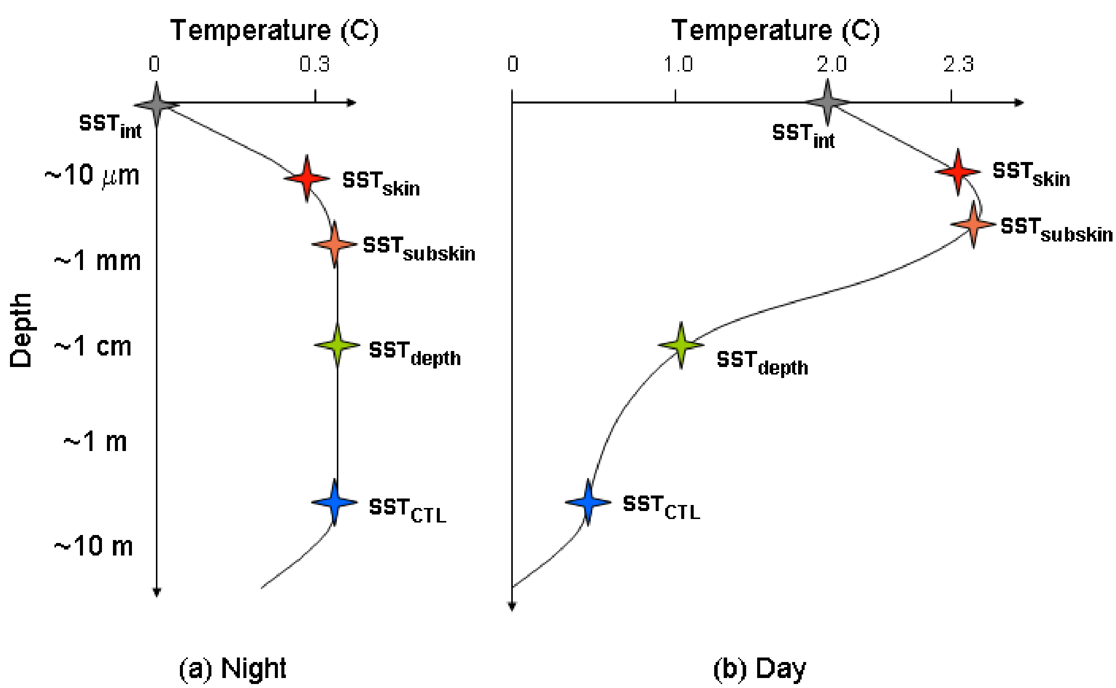

Figure 1. A Schematic diagram showing (a) idealised night-time vertical temperature profile and (b) idealised day-time vertical temperature profile in the upper ocean. SST_{skin}, $SST_{subskin}$, SST_{depth} and SST_{CTL} are all indicated. SST_{int} is a theoretical temperature at the exact air-sea interface and cannot be measured using current technology.

4.1.1 SST_{skin}

SST_{skin} is to be representative of the radiometric skin temperature measured by an infrared radiometer operating in the 10-12 μm spectral region. As such, the effective depth of the measurement is approximately 10 μm. This definition is chosen for consistency with the majority of satellite infrared measurements and radiometers available for in situ validation. The measurement will be subject to both skin layer and diurnal warming effects and will potentially exhibit a significant diurnal cycle.

4.1.2 $SST_{subskin}$

$SST_{subskin}$ represents the temperature at the base of the skin layer. The measurement will be free of skin layer effects but will still be subject to diurnal warming and can exhibit a diurnal cycle. The effective measurement depth will be of O(1 mm) but can vary with conditions. The primary basis for this quantity will be microwave derived measurements, though other measurements will be applied with careful conversions.

4.1.3 SST_{CTL}

SST_{CTL} provides a connection with historical "bulk" [referred to here as depth] SST measurements focused on providing a measurement representative of the oceanic mixed layer temperature. The product gives the temperature at a "constant temperature layer" where there are no significant variations (>0.2K) due to diurnal warming. This may also be considered the temperature at the base of the diurnal layer or $SST_{sub\text{-}warming}$ for consistency with the definition of the sub-skin product. Following this definition, the effective depth of the product can vary significantly depending on the conditions and the strength of the diurnal cycle. It is important to consider this product in relationship to a "bulk" temperature measurement at fixed depth with any diurnal temperature variations removed. Consequently, a nominal depth value for SST_{CTL} should be provided with each measurement. In general, this product will be similar to a night-time minimum SST (see Figure 1) or pre-dawn SST value at depths of 1-2 m, but some differences could exist. The definition adopted here was selected to provide a more precise, well-defined quantity. Such a product will likely provide a better representation of the mixed layer temperature than previous loosely defined "bulk" temperature quantities. The final form and definition of this product, however, should be re-evaluated following user feedback.

4.2 Product Classification

Separate ***merged*** and ***analyzed*** products are to be produced for each of the quantities identified above. ***Reanalysed*** data products are not considered in this document.

4.2.1 Merged Products

GHRSST-PP merged products will be composed of the individual "best" retrievals of each quantity defined in 4.1 for each different sensor type mapped onto a common grid. Contaminated data (e.g., the effects of cloud, rain or aerosol) will be flagged accordingly. No cross-calibration of the different sensor types will be performed and no efforts will be made to fill any gaps in the coverage of the individual sensors. The error characteristics of each individual sensor are preserved.

By defining a common grid and sampling time for the merged products, it becomes necessary to accommodate data with finer temporal resolution and different spatial resolution. The issue of mapping data with a coarser resolution to a finer grid will be addressed in section 4.4. With respect to temporal resolution, various sensors, geosynchronous satellites in particular, can provide multiple measurements within the selected time period. The initial recommendation is that **one value per sensor, per grid point, per time interval is retained**. Error statistics will need to be properly adjusted. Merging procedures will be detailed in section 4.6.

The merged products will represent an intermediate step between the raw satellite data products and the analyzed products to be described below. The merging of data to a common grid will loose some of the information present in the raw data. This information, however, can still be accessed through the original data streams from the original data source (note however that the GHRSST-PP may not be able to formally host all original satellite data). By placing the data on a common grid, various analysis and blending issues can be more readily addressed. Further user input will be considered in later product versions.

4.2.2 Analyzed Products

GHRSST-PP analyzed products will be constructed from the merged data products but incorporating additional analysis to fill in gaps in the sensor coverage and account for possible differences in sensor calibration. Definitions for recommended analysis procedures will be presented in section 5.

4.3 Spatial Resolution

The GHRSST-PP initial product data specifications called for a spatial resolution of better than 10 km for all products. Following this specification, **initial merged and analyzed grids are to be at 10 km spatial resolution**. For some regional areas, within regional projects (e.g., Medspiration, see Robinson et al. 2002), Ultra-High-Resolution (UHR) data products having a spatial resolution of ~2km may be produced.

4.4 Temporal Resolution

Different temporal resolution is to be applied to the merged and analyzed products. Merged products are to be prepared with 6 hour resolution and our initial recommendation is that **analyzed products be produced daily with additional information on diurnal effects**.

4.4.1 Merged Products

Merged products are to be provided every 6 hours at the synoptic times 0000, 0600, 1200, and 1800 UTC as stated in the initial product specifications. These times were selected to facilitate interaction with the numerical weather prediction and ocean modelling communities. The product can be defined either to be representative of the specified time (see Figure 2) or to represent an average of measurements over the preceding 6 hours.

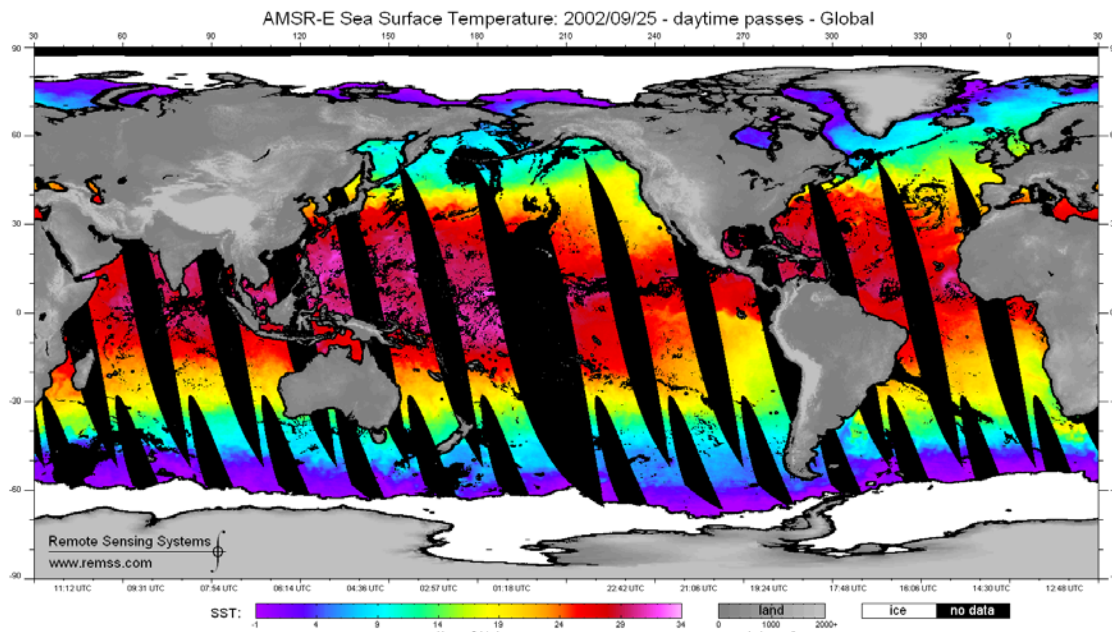

Figure 2. Example daily SST map derived from the AMSR-E sensor showing the local time of data acquisition as the image abscissa. (Courtesy of Remote Sensing Systems)

Having the data representative of a specific analysis time might facilitate operational applications but places a large burden on the accuracy of diurnal time corrections. Given the current experimental nature of many of the diurnal warming models, any adjustment of the effective measurement time might introduce larger than desirable errors into the merged products. Initially it is recommended that the merged products be composed of actual measurements within the 6 hour interval without any attempted time compensation. Adjustments in effective measurement time will first be confined to the analyzed products. ***Timing information should be included with the merged fields*** so that the actual measurement time can be retained. These recommendations will be revisited as necessary based on user input and further validation of models for diurnal warming.

4.4.2 Analyzed Products

Options considered for the temporal resolution of the analyzed products included daily with accompanying information on the diurnal cycle and 12 hourly at 0000 and 1200 UTC. Based on discussions, our initial recommendation is for a **daily product with added diurnal information**. The baseline daily products will be created such that they represent the temperature in the absence of any diurnal warming (SST_{CTL}). This approach provides simple products free of contamination from diurnal effects for users who don't require that information and provides an estimate of the diurnal cycle for those who do.

The SST_{CTL} product is, by definition, free from diurnal effects. Diurnal cycle corrections will be applied to all measurements as required to remove any influence of diurnal warming and construct the baseline products. The form of the diurnal warming products is described in section 4.6 and the nature of the diurnal corrections is discussed in sections 5.2 and 5.3. It is assumed that the $SST_{subskin}$ without any diurnal warming will equal SST_{CTL} and, therefore, only one baseline product representing both will be produced. An independent diurnal cycle product is required for $SST_{subskin}$. SST_{CTL} will not require information on diurnal temperature variations but does require an estimate of the effective measurement depth that varies with time of day. Since SST_{skin} differs in the mean from $SST_{subskin}$ and SST_{CTL}, a separate baseline daily SST_{skin} product is required. A diurnal cycle product is also required for SST_{skin}. To summarize, baseline daily analyzed products will be produced for SST_{CTL} and SST_{skin} and independent diurnal cycle information will be provided for SST_{skin} and $SST_{subskin}$ that can be used to adjust the SST_{CTL} data accordingly at 12 hourly intervals. An additional depth variation product is required in place of the diurnal temperature product for SST_{CTL}. If desired, an additional diurnal cycle product representative of a temperature measurement at a depth of 1-m could be explored. Additional user input is especially desired to support these recommendations.

4.5 Product Data Components

This section indicates how the various different sensor types will be used to construct the selected SST products. Details of the exact procedures to relate measurements at different depths will be described separately in sections 5.1 and 5.2.

4.5.1 SSTskin

Infrared derived skin products from multiple sensors and methods plus microwave derived subskin products converted to skin temperature where appropriate.

4.5.2 SSTsubskin

Microwave derived subskin products plus Infrared derived skin products converted to subskin temperature where appropriate. Parallel studies will continue to explore the usefulness of infrared derived subskin products under appropriate conditions.

4.5.3 SST_{CTL}

SST_{CTL} = $SST_{subskin}$ plus a correction for solar heating effects where required. Initially we will attempt to apply a solar correction (e.g., Gentemann et al., 2002, Kawai et al., 2002) to the subskin measurements (see section 4.6) where needed to increase the data available to compute SST_{CTL}. If the accuracy of the solar correction proves inadequate, we will revert to using measurements only where there is no diurnal correction required. It is also possible to incorporate additional direct subsurface measurements especially in regions where there might be no satellite data. At this time, however, it seems desirable to retain all these data as independent validation of the satellite derived products.

4.6 Diurnal Cycle Products

Diurnal cycle information is required for the analyzed SST_{skin} and $SST_{subskin}$ products. Options exist for the composition of the diurnal product that include the magnitude of warming at specified times or estimates of the total amplitude and phasing. **The option viewed to be most desirable at this point is to provide the estimated peak diurnal warming for that day and the time at which it is expected to occur.** Warming at other specific times could then be calculated from the peak warming and an equation approximating the temporal shape of the diurnal cycle. This enables users to estimate the actual diurnal warming-influenced temperatures at temporal intervals of 6 hours or better if desired. Accompanying the peak warming and time of peak fields should be an estimate of the uncertainty of the diurnal warming. These will be stored in individual files accompanying the analyzed products. **An additional flag or flags can be used to indicate whether the warming was derived from direct observations (and their proximity in time to the peak warming), model based estimates (empirical or numerical), or if there was insufficient data.** These could be part of a bitfield accompanying the product. An equivalent of the diurnal product for SST_{CTL} could contain the effective depth of the measurement and associated uncertainties.

4.7 Confidence Statistics

Each product is to be accompanied by an estimate of uncertainty derived during production of the product. This estimate should consist of an estimated bias and standard deviation. Since all the products are being supplied on a grid, the estimates should be provided for each grid cell. Initial uncertainty estimates should be derived for each retrieval and these estimates should be carefully combined in constructing the statistics for the merged product if more than one retrieval is used to define the grid value.

Additional confidence flags can be included on the pixel level to identify such things as number of retrievals contributing to the grid value, time of observations, sensor types contributing to the analysis, and cloud type detected. The exact components and construction of these fields will be initially explored offline by different contributors and more formal recommendations will be adopted at a later point. The initial requirement is for a minimum of the bias and standard deviation estimate.

The uncertainty estimates will be derived from validation of similar recent measurements against available direct observations. Previous error statistics derived over a specified region and time will be computed as a function of measurement "quality" incorporating such factors as number of measurements, sensor type, environmental conditions, time of day, proximity to some climatology, etc., and these values will be applied to new measurements with similar quality. The quality factors should be closely connected to the confidence fields included with the products. Initial space and time scales to be used for the derivation of the statistics are globally and monthly but smaller regions and different time periods will be explored based on data volume and stability of the statistics.

4.8 Error Statistics

Additional bias and standard deviation error statistics will be computed for the products following the recovery of all available validation data. These values will be computed directly from comparison of the product values with the validation measurements and will provide an independent measure of the product quality. Statistics will be computed at a minimum on a monthly, global basis. Statistics should also be computed at the Diagnostic Data Set locations and will be explored on finer scales down to the grid size as data volume permits.

5 Procedures

The following sections provide advice on the procedures that could be used to construct GHRSST-PP data products.

5.1 Conversion between Skin and Sub-Skin Temperatures

The ISDI-TAG version 2.0 recommendation is to apply a limited conversion based upon measured wind speed (*u*) at higher wind speeds following the basic approach of Donlon et al. (2002):

$$SST_{subskin} = SST_{skin} + 0.17 \quad (1)$$

which is valid for night and day conditions when *u* >6 ms^{-1}

$$SST_{subskin} = SST_{skin} + 0.14 - 0.3\exp\left(-\frac{u}{3.7}\right) \quad (2)$$

valid for night conditions when *u* >2 ms^{-1}.

Coincident wind speed measurements can be used where available, otherwise mean wind fields corresponding to the analysis period can be applied. In parallel, a second approach will be evaluated using a parametric model such as that of Fairall et al. (1996) and measured and modelled wind speed and heat flux fields following the approach in use at the UK Met Office (Horrocks et al, 2002). Analysis of this and other techniques for conversions at lower wind speeds and more detailed corrections at higher wind speeds will be actively pursued as part of the GHRSST-PP and further modifications to the conversions will be considered as new results warrant.

5.2 Conversions between Sub-Skin and Constant Temperature Layer Temperatures

For certain hours of the night, at higher wind speeds, and perhaps at lower wind speeds if the insolation is sufficiently low, no conversion is required between $SST_{subskin}$ and SST_{CTL}. For other periods an adjustment for the effects of diurnal warming is required as shown in section 3.5.3. Two methods have currently been proposed. The first is from Kawai and Kawamura (2000) and the New Generation SST (NGSST) product based on a numerical model run for a wide parameter space. The second is based on an empirical equation derived by Gentemann et al. (2002) from an analysis of existing satellite fields. The numerical model derived estimates of warming as a function of time, wind speed, and insolation have provided good results within the NGSST. For version 2.0 products, the numerical model based approach of the NGSST can be applied to regional analyses where adequate solar radiation data are available. Some refinement of the technique will be required to account for the concept of the constant temperature layer product. For global analyses, however, where solar radiation data might not be fully available or consistent, however, the empirical equation should be applied for consistency within the analysis.

Additional model based solutions from Wick are also undergoing testing and all the approaches should be implemented in parallel for further evaluation. The TAG will promote and conduct these evaluations and revised recommendations for the diurnal warming adjustment will be issued following the studies.

5.3 Application of Diurnal Effects

In addition to relating the sub-skin and constant temperature layer temperatures, diurnal warming effects must also be accounted for in producing the diurnal amplitude products and potentially in using measurements at multiple times through the day in defining the baseline daily analyzed products. It is critical that the methods used to treat diurnal effects here are consistent with those described in section 4.2 for relating the sub-skin and constant temperature-layer temperatures. Initial corrections will be based on the NGSST numerical technique for regional analyses and the empirical formulation of Gentemann et al. for global analyses.

The models should be structured so that measurements at one time can be referenced to another arbitrary time as a function of insolation and wind speed. For production of the diurnal amplitude products, direct measurements at different times during the diurnal cycle should be used with the models to estimate the amplitude and time of peak diurnal warming at the appropriate depth. It should be emphasized that the diurnal amplitude estimates should be calculated directly from individual measurements and not from the constant temperature layer product derived itself from the measurements. Coupled with section 5.2, this represents one of the most significant challenges to the GHRSST-PP and will be a primary focus of the ISDI-TAG activities throughout the GHRSST-PP.

5.4 Treatment of Differing Spatial Scales

For the most basic recommendation, measurements with larger spatial scale than the selected grid size should be applied to all grid elements that fall within their effective spatial extent on the earth's surface. Measurements smaller than the grid size should be contained within the corresponding grid cell. Averaging of these measurements may occur depending on the selected analysis methods. More sophisticated methods need to be explored and will be incorporated as appropriate at a later time.

5.5 Cloud Clearing

The various data streams will be incorporated with the provider's technique. No specific approach is mandated at this time. This will be revisited at a later time especially as new techniques related to use of microwave-derived cloud liquid water and probability of bias ideas are further evaluated.

5.6 Merging Procedures

Mapping all data to a common grid over a discrete period of time introduces concerns with respect to the spatial resolution of the data and the timing of the measurements. Initial recommendations selected in part for consistency with the proposed Medspiration project products were to provide a single value per sensor, per grid point, per time interval, where the measurement time could be anywhere within the 6 hours preceding the time of the measurement. To satisfy this recommendation, several criteria must be set for defining how the single value provided is selected or defined. The selection rules proposed for the Medspiration products were as follows:

- SSTs from a sensor with no required diurnal correction and the highest confidence level are averaged and the measurement time is averaged accordingly.
- If all measurements have a nonzero diurnal correction, the value with the highest confidence level and then the smallest diurnal correction is selected.

These rules can be used as an initial basis for the GHRSST-PP. Further experience and user comments might dictate further changes at a later time.

If a single merged product is to be produced from the multi-sensor data where the values represent the best information drawn from all the sensors, additional procedures must be specified. The initial discussions within GHRSST-PP did not seem to advocate direct provision of such a product but its value could be quite high and it could be more of what the user community desires. Further discussion is required to define how such a single value would be selected. The Medspiration project specifies selection based on confidence level and minimum diurnal correction. These points can be a starting point for discussion within the TAG. Some thought should also be given to the possible existence of bias differences between the sensors.

5.7 Analysis Procedures

Initial analysis procedures to fill in gaps in the coverage of the satellite data sets will be based on optimal interpolation. The NGSST product uses optimal interpolation based on the technique of Carter and Robinson (1987). As noted at the Second GHRSST-PP Workshop, time and regionally dependent decorrelation length scales should be used. Since this technique has already been implemented, it should be used as the first approach. Alternative techniques will be explored in parallel making special use of the DDS. Analyses can be performed initially using the merged products but additional work should compare the utility of using all the individual measurements.

The analysis procedures should also incorporate techniques to account for bias variations between the sensors, if necessary. These techniques are under development and will be evaluated and incorporated if warranted.

5.8 Data product validation

GHRSST-PP data product validation should focus on the use of independent, direct observations (radiometers, buoys, MAERI) to the greatest extent possible. Validation based on relationships between products at different depths that are used in constructing the analyses should be avoided. Validation measurements corresponding to each of the SST products will, therefore, be required. The Pathfinder validation database is available as a possible model to begin construction of a validation data set.

5.9 Formatting/Archival of Products

Final data products are to be archived in a format convenient for users and consistent with archival centers and data exchange protocols. **Recommended formats are HDF and NetCDF along with BUFR.** The Physical Oceanography Distributed Active Archive Center at the NASA Jet Propulsion Laboratory (JPL PODAAC) has been identified as a potential archive center for the final GHRSST-PP products.

6 ISDI-TAG version 2.0 GHRSST-PP data product Specifications

The GHRSST-PP data product specifications (v2.0) including all of the ISDI-TAG recommendations for merged and analysed data products are presented in Table 2.

Table 2. GHRSST-PP data product specifications (v2.0) following review by the ISDI-TAG.

Characteristic	Merged SST	Analyzed SST	Reanalyzed SST
Grid Size	10 km with specific local area products at 2km	10 km with specific local area products at 2km	10 km with Specific local area products at 2km
Temporal resolution	6 hours (00:00, 06:00, 12:00,18:00 UTC)	12 hours (00:00 and 12:00 UTC) produced as a daily product with associated diurnal products.	12 hours (00:00 and 12:00 UTC) produced as a daily product with associated diurnal products.
Delivery timescale	Real time	Real time	7-60 days following data reception and reanalysis
Accuracy	< 0.5 K absolute 0.1 K relative	< 0.5 K absolute) 0.1 K relative	< 0.3 K absolute (target), 0.1 K relative
Error statistics	rms. and bias for each input data stream at every grid point	rms. and bias for each output grid point (no input data statistics are retained)	rms. and bias for each output grid point (no input data statistics are retained)
Coverage	Regional (Best effort Global)	Global, (Regional extracted)	Global
SSTskin product	one value per sensor, per grid point, per time interval retained	Yes	Yes
SSTsub-skin product	one value per sensor, per grid point, per time interval retained	Yes	Yes
SSTctl product	one value per sensor, per grid point, per time interval retained	Yes	Yes
Cloud mask	One value for SSTskin, SSTsubskin and SSTctl	Yes	Yes
Diurnal product content	Peak warming magnitude and time of peak warming (SSTskin, SSTsubskin) with derivation indicator flags	Peak warming magnitude and time of peak warming (SSTskin, SSTsubskin) with derivation indicator flags	Peak warming magnitude and time of peak warming (SSTskin, SSTsubskin) with derivation indicator flags
Confidence Statistics product content	Grid cell bias and standard deviation, data aquisition information, SSTctl depth, pixel level data including number of retrievals contributing to the grid value, time of observations, sensor types contributing to the analysis, and cloud type detected	Grid cell bias and standard deviation, SSTctl depth, quality flags	Grid cell bias and standard deviation, SSTctl depth, quality flags
Nominal product format	Hdf/BUFR/NetCDF	Hdf/BUFR/NetCDF	Hdf/BUFR/NetCDF

7 References

References

Carter, E.F. and A.R. Robinson, Analysis Methods for the Estimation of Oceanic Fields,J. Atmos. & Oceanic Technol.,4, 49-74, 1987.

Donlon, C. J., P. Minnett, C. Gentemann, T. J. Nightingale, I. J. Barton, B. Ward and, J. Murray, Towards Improved Validation of Satellite Sea Surface Skin Temperature Measurements for Climate Research, J. Climate, Vol. 15, No. 4, 353-369, 2002.

Fairall, C. W., E. F. Bradley, J. S. Godfrey, G. A. Wick, J. B. Edson and G. S. Young, Cool-skin and warm-layer effects on sea surface temperature, J. Geophys. Res., 101, 1295-1308, 1996.

Gentemann, C. L., C. J. Donlon, A. Stuart-Meneth and F. J. Wentz, Diurnal signals in satellite sea surface temperature measurements, submitted to Geophysical Research Letters, September, 2002.

Horrocks, L. A., B. Candy, T. J. Nightingale, R. W. Saunders, A. O'Carroll and W. R. Harris, Parameterisations of the ocean thermal skin effect and implications for satellite-based measurements of sea surface temperature, Forecasting research technical report No. 383, pp. 27, available form the UK Met Office, NWP division, London Road, Bracknell, Berkshire, RG12 2SZ, UK, 2002

Kawai, Y. and H. Kawamura, Study on a platform effect in the in situ sea surface temperature observations under weak wind and clear sky conditions using numerical models. J. Atmos. Oceanic Technol., 17, 185-196, 2000.

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