The GHRSSS-PP Development and Implementation Plan (GDIP)

V6.0, Wednesday, 12 January 2005

Prepared by the GHRSSS-PP Project Office
The GHRSST-PP will contribute to the GODAE inter-comparison project (implemented under the European MERSEA-Strand1 project) to inter-compare and assess the merits of each different L4* analysis procedure. As an initial milestone, the 5th GHRSST-PP Workshop, scheduled for July 2004 will focus on the selection of an optimal framework for the GHRSST-PPP analysis procedure based on the experience gained within the GHRSST-PP RDAC projects some of which are only just starting (e.g., EU RDAC and USA RDAC).
1 Executive Summary

This document is the GHRSST-PP Development and Implementation Plan (GDIP) and constitutes the main reference document for the regionally funded projects that will together develop and implement the GHRSST-PP as a global networked community. It is founded on the discussions that took place during two international workshops; the first was held at the National Space Development Agency (NASDA), Tokyo, Japan (Donlon, 2002b). The second workshop was held at the European Space Agency (ESA), Frascati, Italy in December 2002 (Donlon, 2003a). It is not a static document but one that will evolve through time as the GHRSST-PP develops. It will be modified and updated as functionality is realised and/or as requirements change by the GHRSST-PP Science Team.
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2 Introduction
The Global Ocean Data Assimilation Experiment (GODAE) was initiated in 1997 by the Ocean Observing Panel for Climate (OOPC), in concert with the Global Climate Observing System (GCOS) and the Global Ocean Observing System (GOOS), as an experiment in which a comprehensive integrated observing system will be established and operated for several years. From 2003 to 2007 GODAE will provide a global system of observations, communications, modelling and assimilation which will deliver regular, comprehensive information on the state of the oceans. Information generated by GODAE will be made widely available for operational applications in regional and local situations calling for timely knowledge and forecasting of the ocean state.

Sea surface temperature (SST) measured from Earth Observation Satellites in considerable spatial detail and at high frequency, is increasingly required for use in the context of operational monitoring and forecasting of the ocean, for assimilation into coupled ocean-atmosphere model systems and for applications in short-term numerical weather prediction and longer term climate change detection. The international GODAE steering committee focused attention on the centrality of SST measurements to the success of GODAE by initiating the GODAE High Resolution SST Pilot Project (GHRSST-PP). The purpose of the GHRSST-PP is to develop an operational demonstration system that will deliver a new generation of global coverage high-resolution (better than 10 km and ~6 hourly) SST data products. GHRSST-PP data products will be derived by combining complementary Level-2 (L2) satellite and in situ observations in real time to improve spatial coverage, temporal resolution, cross-sensor calibration stability and SST product accuracy. A complete description of the GHRSST-PP can be obtained via the GHRSST-PP web site located at http://www.ghrsst-pp.org.
2.1 Document Scope
The GHRSST-PP Development and Implementation Plan (GDIP) describes in detail, how, where and when the GHRSST-PP will be executed. The GDIP is based on discussions at the Third GHRSST-PP Workshop, held at ESA/ESRIN, Frascati, Italy in December 2002 (Donlon, 2003b) and represents a consensus opinion of the GHRSST-PP community of how the GHRSST-PP will implement and develop a demonstration globally distributed data processing and dissemination service provide a new generation of global coverage SST data products. It is a working document written primarily for the RDAC and GDAC teams as they physically realise, develop and refine the GHRSST-PP demonstration system. As such, it may be considered a “road map” for the GHRSST-PP.

2.2 Applicable documents

3 Project Management
Figure 3.1 provides a summary overview of the hierarchical project management structure for the GHRSST-PP.
In summary, the GHRSST-PP reports directly to the International GODAE Steering Team via the GHRSST-PP Project Office. An International Science Team with several technical advisory groups works together with GHRSST-PP Partner organisations that actually implement and operate the GHRSST-PP system through nationally funded activities.

### 3.1 GHRSST-PP Project Office (GHRSST-PO)

In September 2003, an international GHRSST-PP project office (GHRSST-PO) will become operational at the Met Office, UK taking responsibility for the day-to-day coordination of all aspects of the project. The GHRSST-PO can be contacted using the following information:

The GHRSST-PO will be responsible for the international co-ordination of the logistical, political, scientific, and the administrative aspects of the GDIP, the GHRSST-PP Data processing Specification (GDS) and the Diagnostic Data Set (DDS) under the oversight of the GHRSST-PP Science Team. In practice, the GHRSST-PO will manage the GHRSST-PP in cooperation with international, national and regional institutions, committees, and offices as well as related global programmes. It will act as a central point of contact during the implementation of the GHRSST-PP. It will interact with related international scientific and intergovernmental bodies. It will monitor and oversee the management of GHRSST-PP data sets, and it will ensure good information flow among GHRSST-PP participants.

The following Terms of Reference have been established for the GHRSST-PO:

1. To manage the international coordination and execution of the GHRSST-PP as described in the GHRSST-PP Development and Implementation Plan (GDIP) including all of its sub-components and deliverables. In particular, the GHRSST-PO should foster an open exchange of information, in a timely and appropriate format, in order to successfully coordinate national and international GDIP activities, to identify project planning needs and resource shortfalls, and to assess the progress of the GHRSST-PP in relation to its scientific and operational demonstration goals.
2. To facilitate the transition of the GHRSST-PP demonstration system into an operational service.
3. To coordinate the GHRSST-PP Science Team including the organisation and reporting of an 
an annual GHRSST-PP Science Team meeting and workshop (including workshop preparation, 
edition and publication of workshop proceedings).
4. To establish and enable working groups and panels (e.g., the In situ and Satellite Data 
integration Technical Advisory Group, ISDI-TAG and the GHRSST-PP Data Management Team) 
for specific components of the GHRSST-PP GDIP, the organisation of annual meetings, editing 
and publication of meeting reports and other material generated by GHRSST-PP working groups 
as appropriate.
5. To liaise with the GHRSST-PP applications and user community including the active solicitation 
of feedback, demands and comments that can be presented to the GHRSST-PP Science Team, 
other GHRSST-PP working groups and panels for consideration and action.
6. To coordinate, enable and facilitate, on behalf of the GHRSST-PP Science Team, the open 
exchange of relevant satellite and in situ data streams for use within the GHRSST-PP. In 
particular, the GHRSST-PO should prepare and submit specific data access proposals, 
negotiate with data providers (e.g., in situ observations from the commercial sector), and 
oversee the correct application of any associated data policy requirements and agreements.
7. To actively solicit and negotiate, on behalf of the GHRSST-PP Science Team, with funding 
bodies, sponsors and donors relevant to the successful implementation of the GHRSST-PP 
GDIP.
8. To act as a primary point of contact for the GHRSST-PP and to represent GHRSST-PP at 
scientific conferences and other international fora through scientific presentations and 
exhibitions.
9. To edit, prepare and publish GHRSST-PP documentation including a regular newsletter, 
electronic web based publications, workshop proceedings, technical reports, the GDIP, and other 
appropriate GHRSST-PP documentation.
10. To act as an interface and integrate the GHRSST-PP within other global systems and projects as 
appropriate (e.g., GODAE, COOP, GOOS, CLIVAR, GWEX etc.).
11. To distribute and promote all GHRSST-PP related research, information, and recommendations 
to international, national, and regional sponsors and funding bodies.
12. To build capacity and awareness of the GHRSST-PP and all of its activities, data products and 
services including; the coordination and implementation of scientific and user workshops and 
symposia in order to facilitate the implementation of the GHRSST-PP GDIP.
13. To support Agencies is the coordination of satellite instrument validation activities focussed on 
the development of a user community service for the reporting and exchange of validation results 
and information relating to the operational activities of satellite platforms and data delivery in 
near real time.
14. To report to the International GODAE Steering Team (IGST) on the status and developments of 
the GHRSST-PP.

3.2 GHRSST-PP Science Team (ST)

The planning, management, implementation and monitoring of all aspects of the GHRSST-PP are the 
responsibility of the GHRSST-PP Science Team. As stated in the consensus statement of The Ocean 
Observing System for the 21st Century (Koblinsky and Smith, 2001), the GHRSST-PP Science Team 
has the implementation oversight for the high resolution SST analysis network component of an 
integrated global observation strategy. The GHRSST-PP constitutes the first step towards such an 
integrated system of SST measurements. The Science Team is formed as an international group having 
a broad experience in all aspects of the GHRSST-PP activities and convenes at least once per year to 
review the progress of the project. It plays a particularly important role in the following areas:

1. Reviewing the evolution of GHRSST-PP objectives/goals, maintenance of the GHRSST-PP 
Strategic Plan and, GHRSST-PP Development and Implementation Plan (GDIP), the GHRSST-
PP Processing Model (GPM);
2. Coordination of the international consortium that will undertake the development and 
implementation of the GHRSST-PP, including its final transition into an operational system;
3. Providing advice and guidance on scientific and technical innovations relevant to the GHRSST-
PP;
4. Providing a formal body that can liaise and interact with national agencies in order to implement 
the GHRSST-PP.

The GHRSST-PP Science Team is composed of the following members (June 2003):
<table>
<thead>
<tr>
<th>Name</th>
<th>Affiliation</th>
<th>Roles and Responsibilities</th>
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<tbody>
<tr>
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<td>Name</td>
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<td>Specialization</td>
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<td>Armstrong, Edward</td>
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<td>Vazquez, Jorge</td>
<td>JPL PO.DAAC: Data management and product serving</td>
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<td>Casey, Kenneth S.</td>
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<td>Reynolds, Richard W.</td>
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</tr>
<tr>
<td>Evans, Robert</td>
<td>Expert in satellite SST derivation and processing</td>
<td></td>
</tr>
</tbody>
</table>
### 3.3 GHRSST-PP Technical Advisory Groups

Several format Technical Advisory Groups have been convened within the GHRSST-PP Science Team that have a specific focus.

### 3.4 In situ and Satellite Data Integration Technical Advisory Group (ISDI-TAG)

The ISDI-TAG group is responsible for the development and operation of the GDS. In particular, it will ensure the evolution of the GDS in a well-managed manner by bringing together GHRSST-PP scientists and engineers with user applications. The GDS will evolve as the GHRSST-PP gains more experience and expertise during the implementation of the project and the ISDI-TAG must harness and filter this to ensure that the GDS provides an optimal processing model. Establishing this feedback loop (called the GDS project control loop) ensures that the GDS is built on consensus opinions and evolves from a bottom up user perspective.

The GHRSST-PP envisions two versions of the GDS. An initial version will focus on the specification of a globally networked demonstration system that is able to manipulate satellite and in situ data using currently accepted methods and rules. The emphasis is towards an operational demonstration system rather than scientific research. Creating the initial GHRSST-PP demonstration system that will provide data products in real time to a user community is challenging from a logistical perspective. The version 2 GDS will focus on a refinement of the scientific methodology used to merge and analyse different satellite data streams based on the experience gained while implementing the v1.0 system. The v2.0 system will then be implemented by modifying the existing GHRSST-PP v1.0 demonstration system.

The GHRSST-PP ISDI-TAG is composed of the following members (June 2003):

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<td>resolution products: Pierre.leborgne@</td>
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#### 3.5 Data Management Technical Advisory Group (DM-TAG)

The GHRSST-PP Data Management Technical Advisory Group (DM-TAG) is the formal GHRSST-PP body that is responsible for all aspects of data management within the GHRSST-PP.

The DM-TAG is composed of the following members (June 2003):

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<td>Chair, MetOffice UK: in situ radiometer measurements, satellite</td>
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</table>
3.6 Reanalysis Technical Advisory Group (RAN-TAG)

The GHRSST-PP Reanalysis Technical Advisory Group (RAN-TAG) is the formal GHRSST-PP body that is responsible for the scientific and operational methods and algorithms used to generate delayed-mode GHRSST-PP data products. This document describes the working recommendations that have emerged from discussions of the RAN-TAG following the initial GHRSST-PP reanalysis data product specifications that arose from the first three GHRSST-PP Workshops. They constitute a "consensus opinion" of the GHRSST-PP community and form the basis of reanalysis procedures 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.

The RAN-TAG is composed of the following members (June 2003):

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<td>E-mail:</td>
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</table>
4 GHRSS-PP User Requirements

The GHRSS-PP identifies four types of user that place different demands on the GHRSS-PP demonstration system as follows:

- Regional coverage users
- Global coverage users
- Operational users
- Scientific users

The user requirements for each type of user are described in the following sections and form the basis on which GHRSS-PP data products are defined.

4.1 Regional coverage user requirements

Regional coverage users are defined as those using SST data products in specific regional areas and experiments. Typically, this user group has a requirement for “ultra-high-resolution” SST data sets (1-2 km spatial resolution and < 6 hours temporal resolution) and are often associated with applications in the coastal region or inland seas (e.g., Mediterranean, Sea of Japan, Gulf of Mexico).

Table 4.1 summarises the data sets currently used by several regional SST data user groups together with their specifications/recommendations for improved SST data products.

<table>
<thead>
<tr>
<th>User Name</th>
<th>Currently used SST data</th>
<th>Desired SST data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Name</td>
<td>Time</td>
</tr>
<tr>
<td>MERCATOR</td>
<td>Reynolds</td>
<td>SSTdepth</td>
</tr>
<tr>
<td>Mediterranean ocean Forecast</td>
<td>AVHRR-LAC</td>
<td>SSTdepth</td>
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<tr>
<td>System (MFS)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOPAZ <a href="http://topaz.nersc.no/">http://topaz.nersc.no/</a></td>
<td>Pathfinder</td>
<td>SSTdepth</td>
</tr>
<tr>
<td>Science team to add others</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.2 Global Coverage User Requirements

Global coverage users are defined as those using SST data products extending over the entire global ocean. Typically, this user group has a requirement for moderate resolution SST data sets of better than 10 km spatial resolution and 12-24 hours temporal resolution.

Table 4.2 summarises the data sets currently used by several global SST data user groups together with their specifications/recommendations for improved SST data products.

<table>
<thead>
<tr>
<th>User Name</th>
<th>Currently used SST data</th>
<th>Desired SST data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Name</td>
<td>Time</td>
</tr>
<tr>
<td>JMA/OMP/MRI COMPASS-K</td>
<td>JMA Oil-analysis</td>
<td>SST1m</td>
</tr>
<tr>
<td>JMA/CPD ODAS system</td>
<td>JMA Oil-analysis</td>
<td>SST1m</td>
</tr>
<tr>
<td>University: FORSGC1&amp;2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>JAMSTEC and Kyoto University:</td>
<td>Reynolds</td>
<td>SSTdept</td>
</tr>
<tr>
<td>FORSGC1&amp;2</td>
<td>h</td>
<td></td>
</tr>
<tr>
<td>FNMOCS</td>
<td>NAVOCEANO (MCSST)</td>
<td>SSTdept</td>
</tr>
<tr>
<td>NASA Seasonal-to-Interannual</td>
<td>Reynolds</td>
<td>SSTdept</td>
</tr>
<tr>
<td>Prediction Project (NSIPP)</td>
<td>h</td>
<td></td>
</tr>
<tr>
<td>ECMWF : Impact on MRWF</td>
<td>Reynolds</td>
<td>SSTdept</td>
</tr>
</tbody>
</table>
4.3 Operational User Requirements

Table 4.3 summarises the data sets currently used by several operational global SST data user groups together with their specifications and recommendations for improved SST data products.

<table>
<thead>
<tr>
<th>Operational NWP User</th>
<th>Currently used SST data</th>
<th>Desired SST data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Name</td>
<td>SST</td>
</tr>
<tr>
<td>UK Met Office NWP</td>
<td><a href="http://www.met-office.gov.uk">http://www.met-office.gov.uk</a></td>
<td>In house analysis using in situ and AVHRR</td>
</tr>
<tr>
<td>FOAM <a href="http://www.met-office.gov.uk/sec5/OA/FOAM/FOAM.html">http://www.met-office.gov.uk/sec5/OA/FOAM/FOAM.html</a></td>
<td>MCSST AVHRR</td>
<td>SSTdept</td>
</tr>
<tr>
<td>NRL/NAVOCEANO NLOM <a href="http://www.navo.navy.mil/global_nliom.html">http://www.navo.navy.mil/global_nliom.html</a></td>
<td>NAVOCEANO (MCSSST)</td>
<td>SSTdept</td>
</tr>
<tr>
<td>MERCATOR <a href="http://www.mercator.com.fr">http://www.mercator.com.fr</a></td>
<td>Reynolds</td>
<td>SSTdept</td>
</tr>
<tr>
<td>ECMWF <a href="http://www.ecmwf.int/research/ifsdocs">http://www.ecmwf.int/research/ifsdocs</a></td>
<td>Reynolds</td>
<td>SSTdept</td>
</tr>
<tr>
<td>FNMC <a href="http://www.fnmc.navy.mil/PU">http://www.fnmc.navy.mil/PU</a></td>
<td>MCMST</td>
<td>SSTdept</td>
</tr>
<tr>
<td>NCEP <a href="http://www.ncep.noaa.gov/modelinfo/index.html">http://www.ncep.noaa.gov/modelinfo/index.html</a></td>
<td>Reynolds</td>
<td>SSTdept</td>
</tr>
</tbody>
</table>

4.4 Scientific users

Scientific users are those groups interested in developing new tools and methods for the generation of GHRSST-PP data products. They include those interested in;

- SST validation
- Bias correction methods
- Analysed SST algorithm and method development
- Coding of the GHRSST-PP GDS
- Etc..

Typically, this user group requires access to the highest spatial and temporal resolution SST data products in a format that is easy to work with. The majority of work is focussed on inter-comparison between different data sets for different regions of the ocean that are characterised by different atmospheric and oceanic conditions. In the case of validation experiments, only specific pixel values at specific times and locations are required whereas for other studies, access to a time series of different but complementary satellite data streams is required for certain areas ranging in size from a few degrees latitude x longitude to the entire global ocean at a monthly resolution.

Table 4.4 provides a summary of the World Meteorological Organisation (WMO) project SST data requirements taken from the CEOS/WMO Online Database of Satellite Systems and Requirements. It provides an overall specification of SST data requirements in terms of delivery timeliness, spatial coverage, temporal coverage, accuracy and desired SST parameter.
<table>
<thead>
<tr>
<th>Requirement</th>
<th>SST</th>
<th>Spatial resolution</th>
<th>Observation frequency</th>
<th>Accuracy</th>
<th>Delivery Delay</th>
</tr>
</thead>
<tbody>
<tr>
<td>WMO now casting</td>
<td>SSTfnd</td>
<td>5 - 50 km</td>
<td>1 - 6 h</td>
<td>0.5 - 2 K</td>
<td>1 - 2 h</td>
</tr>
<tr>
<td>WMO synoptic Meteorology</td>
<td>SSTfnd</td>
<td>5 - 50 km</td>
<td>3 - 24 h</td>
<td>0.5 - 2 K</td>
<td>1 - 24 h</td>
</tr>
<tr>
<td>WMO Seasonal and inter-annual analyses</td>
<td>SSTfnd</td>
<td>50 - 250 km</td>
<td>3 - 12 h</td>
<td>0.1 - 0.5 K</td>
<td>3 - 24 h</td>
</tr>
<tr>
<td>WMO Global NWP</td>
<td>SSTfnd</td>
<td>25 - 50 km</td>
<td>1 - 12 h</td>
<td>0.5 - 1 K</td>
<td>1 - 24 h</td>
</tr>
<tr>
<td>WMO Regional NWP</td>
<td>SSTfnd</td>
<td>50 - 250 km</td>
<td>3 - 360 h</td>
<td>0.5 - 2 K</td>
<td>3 - 180 h</td>
</tr>
<tr>
<td>GCOS AOPC</td>
<td>SSTfnd</td>
<td>100 - 500 km</td>
<td>24 - 72 h</td>
<td>0.3 - 1 K</td>
<td>3 - 12 h</td>
</tr>
<tr>
<td>GCOS OOPC</td>
<td>SSTfnd</td>
<td>200 - 500 km</td>
<td>24 - 72 h</td>
<td>0.5 - 2 K</td>
<td>3 - 12 h</td>
</tr>
<tr>
<td>GOOS Marine biology (coastal water)</td>
<td>SSTfnd</td>
<td>1 - 5 km</td>
<td>24 - 48 h</td>
<td>0.1 - 0.5 K</td>
<td>3 - 7 h</td>
</tr>
<tr>
<td>GOOS Marine biology (open ocean)</td>
<td>SSTfnd</td>
<td>24 - 48 h</td>
<td>0.1 - 0.5 K</td>
<td>3 - 7 h</td>
<td></td>
</tr>
<tr>
<td>GOOS Climate - large scale</td>
<td>SSTfnd</td>
<td>10 - 300 km</td>
<td>6 - 720 h</td>
<td>0.1 - 1 K</td>
<td>6 - 720 h</td>
</tr>
<tr>
<td>GOOS Surface</td>
<td>SSTfnd</td>
<td>1 - 10 km</td>
<td>6 - 12 h</td>
<td>0.1 - 2 K</td>
<td>2 - 4 h</td>
</tr>
<tr>
<td>IGBP JGOF/LO-Regional</td>
<td>SSTfnd</td>
<td>1 - 5 km</td>
<td>12 - 24 h</td>
<td>0.5 - 2 K</td>
<td>12 - 24 h</td>
</tr>
<tr>
<td>IGBP Global Ocean Ecosystem Dynamics (GLOBEC)</td>
<td>SSTfnd</td>
<td>50 - 200 km</td>
<td>168 - 720 h</td>
<td>0.5 - 2 K</td>
<td>168 - 720 h</td>
</tr>
<tr>
<td>WCRP Global modelling</td>
<td>SSTfnd</td>
<td>50 - 250 km</td>
<td>1 - 12 h</td>
<td>0.5 - 2 K</td>
<td>720 - 1440 h</td>
</tr>
<tr>
<td>Climate Variability and Predictability (CLIVAR)</td>
<td>SSTfnd</td>
<td>10 - 50 km</td>
<td>3 - 6 h</td>
<td>0.1 - 0.3 K</td>
<td>24 - 72 h</td>
</tr>
<tr>
<td>Arctic Climate System Study (ACSYS)</td>
<td>SSTfnd</td>
<td>25 - 100 km</td>
<td>24 - 48 h</td>
<td>0.5 - 2 K</td>
<td>720 - 1440 h</td>
</tr>
</tbody>
</table>
5 Overview of the GDIP

This section of the GDIP provides a detailed overview of how the GHRSST-PP scientific strategic vision is translated into reality. It includes a description of the GDIP global implementation model and the major project components, their purpose, position and importance within the project. It explains how the components of the GHRSST-PP will interact with each other to provide a seamless, distributed, real-time demonstration system.

Following a two year planning phase the GHRSST-PP Strategy Plan has been endorsed by GODAE and the GHRSST-PP Development and Implementation Plan (GDIP) is about to be issued [RD-1]. This envisages a layered approach to the generation and application of GHRSST-PP SST data products as illustrated in Figure 5.1. Due to the large volumes of data that are considered by the GHRSST-PP and the demanding data product delivery constraints, the GHRSST-PP is designed as a distributed processing system. The strategic implementation concept of regional/global task sharing (RGTS) by regional data product assembly centres (RDAC) interconnected by dedicated, fast data connections has been adopted to underpin the practical implementation of the GHRSST-PP SST data processing system outlined in Figure 1. RDAC ingest, quality control and merge together existing L2 satellite and in situ data sources to generate regional area coverage quality controlled data products in real-time. Every 6 hours, these data products are consolidated at RDAC and sent to a Global Data Analysis Centre (GDAC) where they are integrated together with other RDAC data streams having an identical data format but covering different geographical areas to provide global coverage data products. The GHRSST-PP Development and Implementation Plan [RD-2] provides a complete description of the RGTS system and the GHRSST-PP.

5.1 The GHRSST-PP Regional/Global Task sharing Implementation Framework

Due to the large volumes of data that are considered by the GHRSST-PP and the demanding data product delivery constraints, the GDIP adopts a strategic implementation concept of global task sharing by regional data product assembly centres. Thus, while the overall concept of GHRSST-PP is an international and global activity, the GDIP is founded on the assumption that the tasks within the project will be performed by regionally funded projects. Figure 5.1 provides a simplified schematic overview of the GHRSST-PP GDIP which proposes an implementation model built on a layered approach. The right hand side of Figure 5.1 describes five distinct layers following the theme of “Moving SST data to applications” that are explained in the following sections.

5.1.1 Data provision layer.

The activities in this layer are concerned with the real time ingestion of satellite and in situ SST data streams that will be used to generate GHRSST-PP data products. The GDIP distinguished between Regional coverage data providers (e.g., TRMM-TMI, AVHRR LAC, MODIS direct broadcast, geostationary data, ADEOS-II GLI), Global coverage data providers (e.g., AVHRR GAC, ENVISAT AATSR, AMSR-E etc) and Specialist data servers (e.g., NASDA server, ESA AATSR server, US-GODAE server, REMSS server) and the wider and more diverse network of specialist in situ data centres (e.g., IFREMER CORIOLIS, NDBC). GHRSST-PP will also make use of the Global Telecommunications System (GTS) to ingest SST data sets. In special cases, specific data access and use agreements will be required before SST data can be used within the GHRSST-PP.

5.1.2 Regional data assembly layer.

Regional data assembly centres (RDAC) will ingest, collate, quality control and process regional satellite and in situ data sets using agreed and documented GHRSST-PP methods that are set out in the GHRSST-PP In situ and Satellite Data Integration Processing Model (ISDI-PM, available at http://www.ghrsst-pp.org). RDAC are responsible for the generation of regional area Collated data products that are then merged together, to provide the best regional area coverage Merged data products. Regional coverage Analysed data products may also be produced at RDAC centres according to local user requirements and needs. Regionally funded large-scale projects will actually implement the GHRSST-PP RDAC and collectively, these projects share the data processing required to provide quasi-global coverage GHRSST-PP data products. This is the strategic implementation concept referred to as “global task sharing”. Three RDAC projects are currently in preparation; one in Japan (called the New Generations SST project, NGSST), one in Europe (called the Medspiration project, MEDSP) and one in the USA (called the Production of Enhanced Multi-sensor SST analysis project,
PEMSA). Other RDAC projects are in early discussions (e.g., a tropical RDAC in collaboration with the SEASnet project). GHRSST-PP RDAC projects and data products will serve the specific needs of users in each region and the GHRSST-PP global framework.

5.1.3 Global data analysis layer (GDAC)

Regional GHRSST-PP data products and all ancillary data produced at each RDAC for each Processing Window are passed to a global data analysis centre (GDAC). A GDAC is necessary because some areas (e.g., Indian Ocean) do not currently have a GHRSST-PP RDAC project to provide regional coverage data that can be used to generate complete global coverage data products. RDAC data products are integrated together with data not necessarily considered by the regional data centres to provide global coverage Collated and Merged data products. Analysis procedures are then used to provide global coverage GHRSST-PP L4 analysed data products.

The GHRSST-PP GDAC is foreseen as a distributed system having specific components at a number of different locations. For example, GHRSST-PP validation is coordinated at the University of Miami, the ISDI-TAG and ISDI-PM is coordinated through NOAA, Environmental Technology Laboratory, a Data Product Computation Facility (DPCF) will be installed at the US-GODAE server in Monterrey, a GHRSST-PP Reanalysis project will be coordinated through NOAA/NESDIS, a GHRSST-PP Diagnostic Data Set (DDS) will be coordinated as a distributed system spanning many different sites, and an operational project Metadata repository will be hosted at the JPL PO.DAAC. Collectively, the GDAC activities constitute a GODAE specialist data centre within the GODAE Measurement Network.

5.1.4 Application and User Services layer

The activities of this project layer provide data serving and user interaction services required by specialist and non-specialist data users. Data generated and maintained at both the global and regional centres is interfaced by a suite of distributed services and tools that collectively provide user information and services (UIS). Note that Users may also access GHRSST-PP data products directly at both RDAC and GDAC centres. The specific application of GHRSST-PP data products by operational users encompassing a broad spectrum of activities will be fostered in a set of activities that actively engage the GHRSST-PP with operational user applications. This component of the project, which is distinct from the UIS, is called applications and user services (AUS). Some of the user information services (UIS) and application user services (AUS) functionality may reside in the RDAC projects themselves who are better placed to serve specific regional interests.
6 Overview of the GHRSSST-PP Processing Specificationv1.0 (GDS-v1)

This section of the GDIP provides a general overview of the processing model introducing the data flow within the processor, the processor input and output data definitions (IODD), and the work packages (WP) that will be used to implement the processor. The full GDSv1 specification can be obtained from the GHRSSST-PP web site at http://www.ghrsst-pp.org.

6.1 Summary description of the GDSv1

Figure 6.1.1 shows a functional breakdown diagram of the GDSv1. It identifies the major components of the processing specification as work-packages (WP, shown in light blue) together with their associated input and output data parameters (shown in red and green respectively). The GDS is designed to produce SST data products that satisfy the requirements of operational ocean forecast and prediction systems. The main requirements are:

1. An error estimate for each SST measurement including a bias and RMS.
2. Operational near real time data availability (within 6 hours of data acquisition)

The flow of data and information between each WP is indicated by the direction of connecting arrows. Each GDSv1 WP has been designed to encapsulate a distinct suite of activities, common to all RDAC or GDAC that has a definite input and output definition (IODD). In this way, the exchange and use of all data products within the GDSv1 is greatly simplified by referring to the WP interface IODD provided in section 6.4.

RDAC first ingest, in real time, regional coverage satellite and in situ L2 SST and auxiliary data streams from a variety of different data providers (WP-ID1 in Figure 6.1.1). Each L2 satellite SST data stream is quality controlled to check for gross errors, consistency and timelines. Data that are unacceptable for further use in the GDS are rejected.

Before SST data originating from different sources can be properly assimilated into ocean model systems or analysed together to provide new SST data products that capitalise on their synergy, a bias and rms. error estimate is required for each [pixel] measurement. Assigning error estimates to SST measurements is a fundamental requirement of the GDS. This is performed as a three stage process:
Figure 6.1.1 General overview of the GHRSST-PP GDSv1. Input data sources are shown in red, output parameters are shown in green and GDSv1 processing steps with a further breakdown are shown in light blue. Database storage is shown in dark blue. For each output parameter a corresponding metadata record is generated and delivered to the GHRSST-PP Master Metadata Repository (MMR) system. The MMR system has been omitted to preserve clarity in this figure.

1. A quantitative “confidence value”, having a value from 0 (no data) to 7 (highest confidence in the SST measurement), is derived for each pixel measurement based primarily on an estimate of the surface wind speed, proximity to other cloud contaminated/rain contaminated pixels and, proximity to a SST reference climatology.

2. Error estimates for each L2 SST measurement are based on the statistical analysis of a match-up database (MDB) containing L2 satellite SST data and near contemporaneous quality-controlled in-situ SST observations (WP-ID3 in Figure 6.1.1). Single Sensor Error Statistics (SSES) are produced at regular intervals from an analysis of all MDB data records for a given sensor and correlated with sensor specific confidence values.

3. An appropriate SSES bias and RMS value is assigned to each L2 SST measurement based on the actual confidence value for that specific measurement and its associated SSES.
Data records held within the MDB have been designed to be compatible with other SST MDB (e.g., the Miami pathfinder MDB) in order to take advantage of these data and to further contribute to their development.

Each L2 SST data file is then re-formatted to a common GDSv1 L2 pre-processed data format (referred to as L2P and described in Appendix 1) that is designed to conform to the GODAE data sharing project (WP-ID2 in Figure 6.1.1). L2P data products are the lowest-level, common format data products produced by the GHRSST-PP and provide the “building blocks” for all other higher level data products. Each L2P data product contains L2 SST measurements together with confidence fields and SSES. L2P data products consist of the original L2 SST measurements (that are not re-gridded or modified) together with additional confidence and error estimates. A separate L2P data product is produced for each sensor at each RDAC. Operational users that have requested this type of SST data product may access L2P data products directly in real-time from RDAC and GDAC. In addition, L2P data products provide a direct input to the GHRSST-PP Reanalysis project (Casey et al., 2003) and form the principal data archive for the GHRSST-PP.

GHRSST-PP high resolution diagnostic data set granules (HR-DDS) are extracted from L2P data products and are sent to the GHRSST-PP HR-DDS system for diagnostic analysis and validation of the GHRSST-PP GDS by the GHRSST-PP community. The HR-DDS provides a shared data resource that can be used to test, validate and refine the methods and data products that are produced by the GDS and is fully described in the HR-DDS implementation plan available at http://www.ghrsst-pp.org. Data access to the HR-DDS system will be through a Live Access Server (or variant) system. In addition, the HR-DDS provides a focus for commissioning the GDS and the production of on-going metrics required to assess the performance of the processor. The HR-DDS is therefore closely integrated within the GDS.

GHRSST-PP L2P data products will serve the requirements of many operational ocean modelling groups in real-time. However, many users of GHRSST-PP SST data products (including operational modelling groups) request complete SST fields, free of gaps caused by clouds, rain or lack of data coverage, at regular intervals of between 6 and 24 hours. Some require an estimate of the sub-surface SST field that cannot be directly measured using current satellite techniques whereas others require an estimate of the surface skin temperature that is in direct contact with the overlying atmosphere and subject to considerable diurnal variability. To address these needs, L2P data will be used in an optimal interpolation scheme (e.g., Reynolds and Smith, 1994; Reynolds et al, 2002; Guan and Kawamura, 2003, Murray et al. 2002, Murray et al. 1994, Fieguth et al., 1998;2000, Menemenlis et al. 1997) that is designed to:

(a) Account for differences in spatial and temporal sampling characteristics of each data stream,
(b) Account for gaps in coverage due to the presence of cloud, rain or lack of data,
(c) Account for SST diurnal variability and retrieve an estimate of the subsurface temperature field (referred to as the foundation temperature, SSTfnd ) and SST1m during a pre-analysis bias correction scheme,
(d) Derive a measure of diurnal variability within the data product time-domain to accompany the SSTfnd estimate and,
(e) Retrieve an estimate of the skin temperature of the ocean (SSTskin).

At 24 hour intervals, called Analysed Product Processing Windows (APPW), global coverage L2P data products are used in an analysis procedures that will generate an estimates of the subsurface SST (WP-ID6 in Figure 6.1.1). Clearly, it is extremely important that RDAC data products are provided promptly to GDAC in order that global coverage data products can be made available to the GHRSST-PP community in a timely manner. Two L4 data products are specified by the GDSv1:

1. The SST at depth of 1m (SST1m)
2. The foundation SST (SSTfnd) including an estimate of SSTskin diurnal variability (magnitude and phase).

Each L4 data product is formatted to a common GDSv1 L4 data format that contains the analysis at each grid cell together with quality control and error statistic information. L4 data products will be available in real-time to the GHRSST-PP user community within 6 hours of an APPW. GHRSST-PP high resolution diagnostic data set granules (HR-DDS) are extracted from all L4 data products and are sent to the GHRSST-PP HR-DDS system for diagnostic analysis and MDB data records should be prepared and sent to the GHRSST-PP MDB system for product validation activities.
6.2 Input and output data definitions (IODD) for the GDSv1

The GDSv1 appendix A3 provides a complete description of the input data streams for the GDSv1 and the main outputs of the GDP are listed in Table 6.2.1.
Table 6.2.1 Summary of GDSv1 output

<table>
<thead>
<tr>
<th>Product identifier</th>
<th>Descriptive name</th>
<th>Description</th>
<th>GDSv1 section</th>
<th>Data format definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2P-&lt;filename&gt;</td>
<td>L2 pre-processed data</td>
<td>Native L2 SST and auxiliary data that have been quality controlled and re-formatted to include confidence and error statistic data. &lt;filename&gt; is defined in Table A2.2.</td>
<td>WP-ID2</td>
<td>Appendix A1.2 and A1.4</td>
</tr>
<tr>
<td>L4SST1m</td>
<td>GDAC L4 SST1m analysed data</td>
<td>Global coverage SST1m analysed data products for each APPW based on the New Generation SST method</td>
<td>WP-ID4</td>
<td>Appendix 1.2, A1.3 and A1.7</td>
</tr>
<tr>
<td>L4SSTfnd</td>
<td>GDAC L4 SSTfnd analysed data</td>
<td>Global coverage SSTfnd analysed data products for each APPW</td>
<td>WP-ID4</td>
<td>Appendix 1.2, A1.3 and A1.7</td>
</tr>
<tr>
<td>SSES</td>
<td>Sensor specific error statistics</td>
<td>Mean bias and rms. Error statistical relationships to sensor specific confidence values.</td>
<td>WP-ID3</td>
<td>N/A</td>
</tr>
<tr>
<td>MDB</td>
<td>Match up data base record</td>
<td>Near contemporaneous satellite and in situ data match up record.</td>
<td>WP-ID3</td>
<td>Appendix 4</td>
</tr>
<tr>
<td>L2P HR-DDS granules</td>
<td>L2P HR-DDS data granules</td>
<td>A high resolution diagnostic data set (HR-DDS) granule (2º x 2º latitude x longitude area) extracted from a L2P data product</td>
<td>Appendix A5</td>
<td>Appendix 1.2, A1.3 and A1.7</td>
</tr>
<tr>
<td>L4SST1m-HRDDS</td>
<td>L4SST1m high resolution DDS data granule</td>
<td>A high resolution diagnostic data set (HR-DDS) granule (2º x 2º latitude x longitude area) extracted from a L4SST1M data product</td>
<td>Appendix A5</td>
<td>Appendix 1.2, A1.3 and A1.7</td>
</tr>
<tr>
<td>L4SSTfnd-HRDDS</td>
<td>L4SSTfnd high resolution DDS data granule</td>
<td>A high resolution diagnostic data set (HR-DDS) granule (2º x 2º latitude x longitude area) extracted from a L4SSTfnd data product</td>
<td>Appendix A5</td>
<td>Appendix 1.2, A1.3 and A1.7</td>
</tr>
</tbody>
</table>
6.3 Implementation Schedule

The GHRSST-PP project implementation timeline is split into four main parts; a preparation phase, a demonstration phase and, an intensive application phase as indicated in Figure 6.3.1.

The GHRSST-PP preparation phase (2003-2004) is concerned with engaging and consolidating the GHRSST-PP user, scientific, and operational community as a networked team. This period of the project focuses on the creation of a globally distributed system that can use satellite and in situ data in real-time in an operational manner. A version 1.0 of the methods and algorithms used to generate GHRSST-PP data products will initially configure the GHRSST-PP system during the preparation phase (marked as GDS-v1.0 in Figure 6.3.1). The emphasis during this phase of the project is to implement and test an internationally distributed demonstration system that can be upgraded to provide better quality data products as the project progresses. A Prototype Phase will focus on the commissioning of the GHRSST-PP demonstration system.

Figure 6.3.1. A summary of GDIP schedule identifying major project events and phases. ST= Science team meeting.

The preparation phase will be superseded by the GHRSST-PP demonstration phase in 2004 which will continue until 2006. During the demonstration phase, GHRSST-PP data products and services will be made available, in real time, to a broad GHRSST-PP user community. Throughout the demonstration phase, a parallel and continual process of project development and refinement will take place with particular emphasis on (a) the improvement of the scientific methods used to generate the demonstration data products and (b), the timely delivery of these products to operational users. The GDS-v1.0 will be superseded by a version 2.0 system (indicated as GDS-v2.0 in Figure 6.3.1) following research and development within the GHRSST-PP that will continue throughout the project. This two-stage approach is necessary because the initial ISDI-PM (which will be the New Generation SST v2.0 (NGSStv2) pioneered by the Japanese RDAC project) may not provide an optimal solution for all GHRSST-PP users and services. The GDS-v2.0 provides an opportunity to upgrade the processing model following a period of user feedback.

During 2004-2006, the GHRSST-PP will also operate in an intensive application phase in parallel to the demonstration phase. During this period, GHRSST-PP data products will be provided to a number of operational users (E.g., ECMWF, UK Met Office, MERCATOR, FOAM, etc) who will work closely with the GHRSST-PP Science Team to evaluate the impact of GHRSST-PP data products in their operational applications. Dedicated ocean and atmosphere model assimilation runs and model output inter-
comparison exercises will all take place in real time. Two key workshops are shown in Figure 2 that will be used to consolidate the experiments that will be undertaken with the GHRSST-PP operational application community. The first will be used to specify the exact period, area and input-output definitions that will be used together with establishing metrics and assessment criteria that will be used to assess the performance of GHRSST-PP data products as used in each application. The second workshop will be used as a forum in which the results of the GHRSST-PP experiments will be presented.

The AUS, together with the application of GHRSST-PP data products by the wider scientific community will provide the basis for the transition of the GHRSST-PP from a demonstration system to a truly operational service.
Section 2: Detailed description of GHRSSST-PP components

7 Applications and User Services (AUS)

The applications and user services component is focussed on the specific application of GHRSSST-PP data products in real time, for a number of well defined international real time applications. It will be main focuss of GHRSSST-PP activity during the intensive application phase of the project. A deep relationship will be built in order for maximum user feedback to be harnessed by the ISDI-TAG and GHRSSST-PP Science Team allowing the GHRSSST-PP to mature and evolve in a coordinated fashion led by user requirements and experience. Two major workshops are foreseen within the AUS component. The first workshop will take place in the latter part of 2004 and will result in a specific work-plan for the AUS activities developed in consultation with AUS applications. The second workshop will be held in the latter part of 2005 and will provide a final report on the activities of the GHRSSST-PP.

7.1 GHRSSST-PP Champion Users
8 User Information Services (UIS)

The UIS provides a general interface for interaction between the GHRSST-PP and general users. It consists of a number of sub-components that are designed to provide easy access to data products using a combination of standard and developing technologies (SSH, SFTP, LAS, DOD etc.) in a Data Serving component (UIS-DS), a project web portal and outreach activities (UIS-WWP), a data archive centre (UIS-DAC) and a user services system to handle user enquiries will be implemented.

Several components are necessary for a successful user information services (UIS) within the GHRSST-PP framework. Three key areas, that need to be sustained, can be identified:

- Technical expertise for each data set
- Proper documentation for each data product/data set
- Web based and ftp access that allow for interoperability across a variety of platforms with maximum flexibility of formats. This includes delivery of data between the regional data assembly centers (RDAC) and the GDAC.

Any user information services in support of the GHRSST-PP must include technical expertise in each of the GHRSST-PP data sets, both analysed and merged. This expertise should include knowledge of the errors in the different data sets, as well as data distribution and format issues. To support the data assimilation community, knowledge of the errors within each data is necessary. To best support the data assimilation a thorough understanding of any and all quality information contained within the data set structure must be sustained within the user information services. The Physical Oceanography Distributed Active Archive Center (PODAAC) has developed a model with their User Services Organization (USO) that can be applied to the UIS.

Although, the USO serves as the primary interface between the users and the technical expertise at the PODAAC, it fulfills other important services.

Acts as a filter for technical questions coming into the PODAAC on specific data set details. Each USO personnel are trained on what individuals have the expertise for a particular data set. Thus all email and phone contacts about a specific data set issue are sent to the appropriate PI/scientist who can answer that question. The UIS should contain that type of expertise for the different analysed and merged products.

The USO keeps, as related to data set usage, ftp distribution, subsetting distribution, media distribution, etc. Such metrics include volume of data distributed, volume of data ingested into the archive, number of distinct users, customer satisfaction via a database that logs all customer interactions. These metrics are then reported to the project office. In the case of the UIS such interactions should be accessed via either an internal or external web site. For example, although all user interactions would be logged, specific interactions relating to customer surveys where individual names are involved, would only be accessible via an internal web site and accessible by the project. All user interactions, whether by email, phone or mail are logged into a database and incorporated into statistics used for the reporting of metrics.

USO works directly with data set engineers in setting up individual web sites for data sets. Within the GHRSST framework, the UIS would maintain an appropriate number of web pages for each of the analysed or merged products with access to browse capability contained within each web site.

4) The USO is responsible for coordinating the process of bringing a data set on line. This includes a set of minimum requirements. They are the writing of a guide document, based on a given template, which answers basic questions about the data set. Such a template can be created for the GHRSST products. Additional requirements include read software, creation of a DIF (Directory Interchange Format) that is submitted to the global change master directory, a web page showing example browse images (Level 3), and updating of order pages within the database software. With the submission of the DIF the data set is then searchable within the Global Change Master Directory (GCMD). Such a system can be designed where DIFs are created for the different GHRSST-PP products so that they are searchable both from the GHRSST homepage through the web portal and the metadata repository maintained at the GDAC, and through the GCMD.
For level 3 data sets tools are available that allow for browsing and data extraction. Because the GHRSST-PP intends to produce high-resolution data sets suitable for regional studies this capability is critical for maximizing data set usage. The PODAAC Ocean ESIP Tool (POET) is a web-based interface that allows for easy access to data sets in different formats. It allows for data to be extracted in different regions, along with generating browse images. Currently the interface works with HDF, HDF-EOS and a variety of other formats. POET provides interactive, on-line subsetting and visualization of many data products. Viewing options include: latitude-longitude maps, animations, time series plots, and space-time profiles. Format options include: GIS (GeoTIFF, ArcGrid), image (GIF, PNG, JPG), scientific (HDF, NetCDF), and raw (binary, ASCII). This graphical user interface was developed by Ocean ESIP (Earth Science Information Partner).

For issues of interoperability the Distributed Oceanographic Data System (DODS) allows users to access the data through familiar visualization packages such as IDL and MATLAB.

DODS enables remote data sets to be accessed through familiar data analysis and visualization packages, just as if they resided locally on the user's machine. The interoperability is critical for the relationship between the RDACs, GDACs and the DDS (diagnostic data set) where validation of data products must be done at a near real time rate by several data centers. DODS handles transport, translation and subsetting of data residing in most Earth science data formats. DODS data are accessible to users through: MATLAB, IDL, Ferret, Live Access Server.

Data should also be accessed via FTP with appropriate source code available for read software and makefiles that allow for the creation of executables across a variety of platforms. FTP access, through appropriate high-speed lines via a UNIX based system, still provides a fast, reliable, and easy way of downloading large amounts of data. This particular trait of FTP will be important for users wanting to assimilate the global SST data sets in general circulation models (GCM). An important metric that should be kept within the UIS context are the specific as to how users get the data, i.e. via subsetting, DODS, POET, LAS, or FTP.

A requirement of the GHRSST-PP is the delivery of products in a near real time rate. PO.DAAC's Near-Real-Time Image Distribution Server (NEREIDS) is now online at http://nereids.jpl.nasa.gov. This server provides satellite browse images within a few hours of capture. The images are also kept in a short-term rolling store for observing recent changes. Currently SST AVHRR images are available through the system with implementation planned for the GHRSST-PP products.

The bottom figure shows a proposed model for the UIS and AUS within the context of the RDAC and GDAC. Both the RDAC and GDAC would be interfaced with the UIS, with product generation occurring at both the GDAC and the RDAC. Archiving of final products would occur at the GDAC. Distribution of the products would occur through the AUS specifically through the DODS, POET, and NERIEIDS interfaces, maximizing interoperability.
8.1 User Support Services (USS)

Users of satellite data products are becoming more sophisticated in their requirements and more critical of the data products that are made available for their use. Users now expect that data providers are able to answer complex questions relating to the generation of data sets and on anomalies that are present in specific data sets. The UIS-USS is designed to answer and cater for these user needs and to feedback the information that results form user interaction. The PO.DAAC has a system that it uses to log all user interactions and the GHRSST-PP UIS-USS will be built on a similar system. Where UIS-USS is not able to address a particular issue, the GHRSST-PP Science Team or the ISDI-TAG may be called upon for support.

8.2 Data Product Server (UIS-DP)

GHRSST-PP data products will be served from the UIS-DS component using a number of standard and emerging technologies. These include the Live Access Server (LAS), the Open source Project for a Network Data Access Protocol (OPeNDAP, formerly the Distributed Oceanographic Data Server, DODS), the Internet Data Distribution (IDD) service, the Thematic Real time Environmental Data Distribution Service (THREDDS) and secure file transfer and shell access (SFTP, SSH). These services are expected to play a major role in the implementation of GODAE data services in general (see Hankin et al, 2002).

8.3 GHRSST-PP Web Portal (UIS-WP)

The WWP provides the first point of call for a user interested in discovering the possibilities that the GHRSST-PP offers. It will provide the link to all UIS services and serve the user community with information describing GHRSST-PP data products, systems, and applications. It will provide basic outreach services that educate and inform users of the strengths and weaknesses associated with each GHRSST-PP data product. It will provide generic tools for the visualisation and file independent access to data products using tools such as the Live Access Server and DODS. It will provide an interface to the
GHRSST-PP MDR, report on RDAC and GDAC activities and satellite data stream status. The USI-WWW may be a mirrored service residing at one of several national data centres in order to maximise user access speeds.

8.4 Data Access and Archive (DAAC)
[Vasquez + RDAC and GDAC lead]
The UIS-DAAC is the final long-term data archive for all GHRSST-PP data products. It will be interfaced to the UIS-WWP and be catalogued using the MMR system.
9 Regional and Global Validation (VAL)

Comparison with in situ measurements of SST is the primary mechanism for independently quantifying the accuracy of the satellite SST fields that are used and produced by the GDS. This requires that the input fields and the subsequently merged/analysed fields be compared with high-quality measurements of SSTskin and subsurface SST throughout the period of the GHRSST-PP. The comparisons need not, indeed in most cases cannot, be done in real time, but should be done in as short a time thereafter as practical (in the order of days). This is necessary to ensure that sensor problems are identified promptly and that the consequences of unanticipated geophysical events, such as volcanic eruptions, are quickly identified and their effects on the derived SSTs are quantified without delay. WP-ID3 describes the GHRSST-PP Match Up database (MDB) system that is used to store GHRSST-PP validation data records. This work package is dedicated to outlining the analysis of MDB data records for validation of GHRSST-PP data products.
10 Reanalysis and Data Stewardship Project (RAN)

The RAN is responsible for the delayed mode reanalysis of real time GHRSST-PP merged and analysed products. RAN products should be completed within a short period of time (e.g., 7-60 days) following real time data production in order to maximise the operational usefulness of the data products. RAN will make considerable use of the DDS, MDR, DPCF and UIS facilities in delayed mode.

Section required on applications here – particularly CLIVAR following the Ocean Reanalysis workshop. The CLIVAR ocean reanalysis group endorsed the GHRSST-PP as a basic input to the CLIVAR ocean reanalysis system that is now under discussion. In particular, Dudley Chelton noted that the Real Time Global (RTG) 25km SST data product developed by NESDIS was a good SST data set to provide better resolution SST data and thus, better surface flux estimates. A GHRSST-PP 10km analysis, together with the L2P observation data should provide improvements over the basic RTG data set especially as the GHRSST-PP products will be accompanied by error estimates for each measurement.
11 GHRSST-PP High Resolution Diagnostic Data Set (HR-DDS)

The GHRSST-PP High-resolution Diagnostic Data Set (HR-DDS) system provides a distributed data resource and a framework to analyse and inter-compare L2P and L4 data products in near real time, together with other data products including NWP analyses, operational ocean and atmospheric model outputs and in situ observations. In order to reduce the overhead of data storage and transport, the HR-DDS consists of about 150 globally distributed 2º x 2º latitude x longitude sites. Figure 16.1 shows a map of primary HR-DDS sites (v2.3) for which all L2P and L4* data streams will be extracted and archived as data granules. Each HR-DDS site is strategically positioned in order to address a particular issue; for example, a particularly dynamic or “quiet” oceanographic or atmospheric region, location of additional in situ infrastructure, areas known to be influenced by atmospheric aerosol or persistent cloud cover and areas already having a significant scientific interest. A complete Scientific and technical description of the HR-DDS system can be found in GHRSST/14 available at http://www.ghrsst-pp.org.

Figure 16.1 Location of HR-DDS sites v2.3 (April 2003) Based on output of the 2nd & 3rd GHRSST-PP workshop Science Team feedback. Moorings and permanent in situ installations are indicated by red asterisk (note that some are located on inland lakes). The HR-DDS is fully documented in the HR-DDS Implementation Plan (GHRSST/14).

The HR-DDS system provides a real time data resource the main learning tool for GHRSST-PP project scientists to develop and refine the GDS, to investigate differences between complementary data streams, to investigate regional and time variant bias statistics, to monitor the quality of input and output data streams and as a core component of the GHRSST-PP reanalysis (RAN) project. The HR-DDS constitutes the virtual laboratory of the GHRSST-PP allowing, for example, a full implementation of Integrated Global Observing Strategy (IGOS) measurement principles (see http://www.igospartners.org/).

11.1 Summary of the HR-DDS system configuration and operation

HR-DDS granules are produced by RDAC and GDAC centres in real time as netCDF data files according to the specifications provided in Appendix 1. HR-DDS granules are archived locally together with a corresponding HR-DDS metadata record. HR-DDS metadata records are produced according to the specifications described in the GDS and are identical to other GDS metadata records. HR-DDS archive centres are referred to as HR-DDS nodes and in general, HR-DDS nodes should be part of RDAC and GDAC.

1 In addition, other temporary DDS sets can be established that correspond to cruise tracks or other areas of interest (for example local scale projects in specific areas)

2 Note that Native L2 data streams will also be extracted for certain sensors and HR-DDS locations but these are not discussed in the GDS which focuses on the use of L2P and L4 GDSv1 data products only.
Figure 16.2 provides a schematic diagram of the GHRSST-PP HR-DDS data system which is based on a number of distributed HR-DDS nodes that are interconnected using the Distributed Oceanographic Data System (DODS, see http://www.dods.org).

![Diagram of the GHRSST-PP HR-DDS system](image)

Figure 16.2 Schematic diagram of the GHRSST-PP HR-DDS system. Users may access HR-DDS data through local HR-DDS nodes or the global distributed data archive via a HR-DDS virtual server that coordinates GHRSST-PP HR-DDS data through the HR-DDS MMR.

The DODS architecture uses a client/server model and the http protocol to provide a framework that simplifies all aspects of scientific data networking. It provides tools (such as DODS servers) that make local data accessible to remote locations regardless of local storage format. HR-DDS granules at HR-DDS nodes may be accessed directly using a number of DODS aware client applications (e.g., IDL, MATLAB) from any location. The Open source project to develop and extend a data access protocol (OPeNDAP) has now evolved from the DODS.

In addition to local data access via DODS/OPeNDAP servers at each HR-DDS node, HR-DDS nodal data archives are virtually combined as a single data archive by a HR-DDS virtual server. The HR-DDS virtual server uses GHRSST-PP Master Metadata Repository (MMR) HR-DDS metadata records to catalogue HR-DDS data granules archived at all distributed HR-DDS nodes. Using a HR-DDS interface, users at the HR-DDS virtual server may access all HR-DDS granules (maintained at distributed locations, served by local DODS servers) using DODS aware client applications as if they were a single data archive residing on a local computer.

In addition to DODS access, HR-DDS granules may also be accessed using secure ftp (sftp) transactions or through a Live Access Server (LAS, http://ferret.pmel.noaa.gov/Ferret/LAS/). LAS is a highly configurable Web server designed to provide flexible access to geo-referenced scientific data and can present distributed data sets as a unified virtual data base through the use of DODS networking. Using a web browser interface LAS enables a user to

- visualize data with on-the-fly graphics
- request custom subsets of variables in a choice of file formats
- access background reference material about the data (metadata)
- compare (difference) variables from distributed locations
- LAS enables the data provider to
  - unify access to multiple types of data in a single interface
  - create thematic data servers from distributed data sources
  - offer derived products on the fly
  - remedy metadata inadequacies (poorly self-describing data)
  - offer unique products (e.g. visualization styles specialized for the data)
LAS will be used extensively in the GODAE project and will allow data to be extracted from many operational ocean model systems for inclusion and comparison with HR-DDS SST data. In addition, the LAS system is in active development to provide advanced features such as temporal aggregation of data and advanced display options in collaboration with the GODAE Data Sharing Pilot Project.

Each HR-DDS node is thus responsible for:

(a) Installing and maintaining a data archive of HR-DDS granules and associated MMR DSR and MMR-FS metadata records (see Appendix 6)
(b) Operating a DODS server to serve HR-DDS data
(c) Operating an sftp server for HR-DDS granule access
(d) Operating other optional data interface software (e.g., LAS)
12 Data Product Computation Facility (DPCF)

The DPCF is the hardware and software realisation of the ISDI-PM system and is responsible for the real
time production of GHRSST-PP data products at the GDAC. The functionality of the DPCF is twofold:

1. It provides the computational power to generate GHRSST-PP global data products. The
   DPCF will run a demonstration service ISDI-PM for the global ocean.
2. It provides a computational facility that can be used to test and experiment with new ISDI-PM
   methods and algorithms that will be implemented in the ISDI-PM-v2.0. Approved users can
   work with a development version of the ISDI-PM operational code base to develop, test and
   validate new data fusion approaches, algorithms or improvements to the operational code.
   Access will be overseen by the ISDI-TAG.

The GHRSST-PP DPCF will be a Linux cluster supercomputer of some 16-32 nodes that will be installed
at the US-GODAE server in Monterrey. This type of architecture is appealing because there is
redundancy within the system so that should a particular processor node fail for whatever reason, there
is another processor ready to continue operations. Furthermore, researchers may use data held within
the GDAC (and all other data at US-GODAE) to experiment with new ISDI-PM developments using a
dedicated node that is independent of those nodes used to produce the operational demonstration data
products in real time.
In order to successfully exchange and manipulate data in a real time environment, RDAC and GDAC must know at any instant what data are available, where they are and what level of processing they have completed. This is a particularly demanding task given the global distribution of RDAC and GDAC that are working together. In order to address these issues, a global GHRSST-PP Master Metadata Repository service has been developed. The MMR is required to ensure that all data resources are "visible" to the RDAC and GDAC centres and it is the "core" of the GHRSST-PP data management framework. It provides a searchable catalogue of the distributed GHRSST-PP data holdings providing information on its physical location, contents and any constraints on its use. Without a master catalogue, it would be extremely difficult (if not impossible) to locate a single data resource within the GHRSST-PP without physically connecting to the computers storing the data and searching each one individually.

The MMR is a physical database containing metadata descriptions of all transient and non-transient data holdings within the GHRSST-PP. A minimum set of geo-spatial information describing a particular data granule (in situ observation, satellite image) that has been used in the GDSv1 will be automatically stored within MMR database system in real time. The GHRSST-PP MMR data record format is based on the Global Change Master Directory (GCMD) Directory Interchange Format (DIF) standard. The GCMD has an extensive number of keyword lists that can be used for encoding the physical quantities, the data centres, etc. Use of these keyword lists provides a simple and efficient way for users to make unambiguous searches of the database in order to locate the data they want. GCMD also has a large set of sensibly defined metadata fields based on many years of experience of serving metadata. The GHRSST-PP data files themselves have been chosen to follow the Climate and Forecast netCDF conventions (See GDSv1 Appendix 1) because these conventions provide a practical standard for storing oceanographic data, and have already been adopted for the Data Sharing Pilot project within GODAE. The global attributes of netCDF files are also metadata, since they follow the CF conventions, although they differ slightly from the GHRSST-PP MMR standard. To a certain extent, this is reasonable, since the MMR is intended to help users and processing centres search for data sets and to keep track of processing tasks, while the netCDF attributes are to help users apply the data.

GHRSST-PP metadata consist of two related but distinct types of metadata record:

14. A Data Set Record (MMR-DSR) contains information which is common to all files within a data set, such as the title and contact information and a summary of the data set contents. There is one, and only one, MMR-DSR metadata record for each data set. A DSR exists for each GDSv1 data product type at each RDAC and GDAC. In addition, a DSR exists for every GHRSST-PP High Resolution Diagnostic Data Set (HR-DDS) site as explained in Section 16. The format of MMR-DSR records are given in the GDSv1 Table A6.2.1.

15. Each file in a data set described by a MMR-DSR is represented by a unique File Record (MMR-DR) metadata record. A MMR-FR metadata record contains information that distinguishes that file from all others in the data set. The format of MMR-FR is given in the GDSv1 Table A6.2.2. There are many different MMR-FR metadata records associated with a single MMR-DSR metadata record.
Within the GDSv1 only MMR-FR metadata records need to be created and submitted to the MMR system operationally by RDAC and GDAC as DSR metadata records will already be present within the MMR system. Every time a GDS data file is produced, an associated MMR-FR metadata record must be created (see GDSv1 Appendix A6.3) and registered at the MMR via e-mail (see GDSv1 Section A6.4).
14 RDAC projects

14.1 Japanese RDAC

[Kawamura et al]
This regional project provides RDAC services within the Japanese area via a project called the New Generation SST project. The spatial area covered is that of the GMS geo-stationary footprint.

14.2 European RDAC

[Robinson and Donlon]
This regional project provides the European project and funding to implement services and data delivering the GHRSSST-PP RDAC. The regional area considered is the Atlantic Ocean and European shelf seas (including the Mediterranean and Baltic).

14.3 USA RDAC Project

14.4 Tropical Ocean RDAC Project

14.5 Australian RDAC Project

Primary Contact: Helen Beggs, Australian Bureau of Meteorology (h.beggs@bom.gov.au).

This regional project provides RDAC services within the Australian area via a project called the BLUElink> Ocean Forecasting Australia project. The spatial area covered is that covered by the locally received NPOES AVHRR data, namely, 20°N to 65°S and 50°E to 160°W.

The BLUElink> Ocean Forecasting Australia project was initiated by the Australian Government, through the Australian Bureau of Meteorology, Royal Australian Navy and CSIRO, in order to deliver ocean forecasts for the Australian region. BLUElink> aims to develop ocean model, analysis and assimilation systems, and provide timely information and forecasts for the 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.

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 (Smith et al., 1999) to produce a real-time high resolution SST analysis combining SST data from polar-orbiting (NPOES, Envisat, AQUA) and geostationary satellites (MTSAT-1R, FY-2C) 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 - 65°S, 50°E - 160°W) and will blend all data sources into SSTskin and SST1m estimates and output real-time SST analyses at around 5 km resolution within 6 hours of data reception. Validated AATSR skin SST data will be used to calibrate the regional infra-red AVHRR and geostationary brightness temperatures to obtain skin SST estimates. After subsequent blending with skin SSTs from AATSR and AMSR-E, the blended skin SST product will be converted to sub-skin SST using the Fairall et al. (1996) cool skin correction, corrected for the diurnal cycle using geostationary satellite data, and calibrated to approximately 1 m depth using in situ measurements. Both SSTskin and SST1m products will then be blended with GAC AVHRR SST1m data (to fill in any remaining gaps) and ingested into the Bureau's operational SST analysis system to produce high resolution skin and 1 m depth SST analyses (see Figure 1). 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 BLUElink> project user community comprises Government agencies, the public, selected international capacity building (aid projects), selected industry sectors, the climate community, as well as users within the Royal Australian Navy (RAN), CSIRO Marine Research (CMR) and the Australian Bureau of Meteorology. The output from the BLUElink> High Resolution SST Analysis System will input to the BLUElink> global OGCM ocean data analysis and assimilation system and the Bureau's numerical weather prediction systems.
The BLUElink> High Resolution SST analysis system will require the following data streams in GHRSST-PP L2P format:

- Real-time 1 km Envisat AATSR (NR and TOA L1B) from ESA (probably)
- Real-time GAC AVHRR

The BLUElink> SST product will require close collaboration with the GHRSST project to provide the basis and protocols for blending and analysing the SST data from a range of sources. It would be envisaged that the GHRSST-PP L4 high resolution SST product could be used by BLUElink> for comparisons with the regional L4 product.

The Australian RDAC will contribute to one or more HR-DDS to GHRSST-PP in conjunction with Ian Barton’s team at CSIRO Marine Research. The first HR-DDS is expected to be available by June 2005. The BLUElink> team are currently investigating the resources required to provide L2P and regional L4 data sets to the GHRSST-PP. It is hoped that local AVHRR SSTs can be provided in L2P format by mid-2005 with as much metadata as is feasible within resource and budgetary limitations. Regional L4 SST1m and SSTskin data sets (see Figure 14.1) should be available to GHRSST-PP by the end of 2006. In order to supply data to GODAE an interface will be constructed from the Bureau’s Meteorological Access and Retrieval System (MARS) to external product servers (http://dods.bom.gov.au) and, as required, to other GODAE ocean data servers.

Figure 14.1. The BLUElink> Project’s proposed method to produce real-time SST1m and SSTskin L4 products at around 5 km spatial resolution every 6 hours.
### 14.5 Table 4.1

**User:** BLUElink > Ocean Forecasting Australia  
**Currently used SST data:**

<table>
<thead>
<tr>
<th>Name</th>
<th>SST</th>
<th>Time</th>
<th>Space</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVHRR-LAC</td>
<td>SSTdepth</td>
<td>Real-Time (on local data reception)</td>
<td>1 km</td>
</tr>
<tr>
<td>AVHRR-GAC (NESDIS)</td>
<td>SSTdepth</td>
<td>6 hourly</td>
<td>9 km</td>
</tr>
<tr>
<td>AATSR Meteo Product (ESA)</td>
<td>SSTskin</td>
<td>NRT (single swaths up to 4 hours old)</td>
<td>17 km (10 arc min)</td>
</tr>
<tr>
<td>AMSR-E (Remote Sensing Systems)</td>
<td>SSTsubskin</td>
<td>Daily (2-3 days old)</td>
<td>38 km (0.25°)</td>
</tr>
</tbody>
</table>

**Desired SST data:**

<table>
<thead>
<tr>
<th>Name</th>
<th>SST</th>
<th>Time</th>
<th>Space</th>
</tr>
</thead>
<tbody>
<tr>
<td>MTSAT-1R</td>
<td>SSTskin</td>
<td>Hourly</td>
<td>5 km</td>
</tr>
<tr>
<td>GOES-9</td>
<td>SSTskin</td>
<td>Hourly</td>
<td>5 km (tbd)</td>
</tr>
<tr>
<td>FY-2C</td>
<td>SSTskin</td>
<td>Hourly</td>
<td>5 km (tbd)</td>
</tr>
<tr>
<td>AATSR NR L2 Product</td>
<td>SSTskin</td>
<td>RT</td>
<td>1 km</td>
</tr>
<tr>
<td>AVHRR-GAC (NESDIS)</td>
<td>SSTskin, SST1m</td>
<td>RT</td>
<td>9 km or less</td>
</tr>
</tbody>
</table>

**Intended SST L4 Product:**

<table>
<thead>
<tr>
<th>SST</th>
<th>Time</th>
<th>Space</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSTskin, SST1m</td>
<td>6-hourly</td>
<td>&lt;10 km</td>
</tr>
</tbody>
</table>
15 Acronyms and abbreviations

AATSR  Advanced along-track scanning radiometer
AMSR  Advanced microwave scanning radiometer
AUS  Applications and user services
AVHRR  Advanced very high resolution radiometer
BOOS  Baltic Operational Oceanographic System
CTD  Conductivity, temperature, depth (in situ ocean measurements)
DDS  Diagnostic data set
DPM  data processing model
DIADEM  Operational data assimilation for the North Atlantic and the Nordic Seas
DMI  Danish Meteorological Institute
DUE  Data user element (within EOEP)
DUP  Data user programme (ESA)
ECMWF  European Centre for Medium-range Weather Forecasting
EOEP  Earth Observation Envelope Programme (ESA)
ESL  Expert support laboratory (ESA)
EURDAC  European GHRSST-PP RDAC coverage
FOAM  Forecasting ocean assimilation model
GDAC  Global data analysis centre
GDIP  GHRSST-PP development and implementation plan
GHRSST-PP  Godae high resolution sea surface temperature pilot project.
GI  Global integration
GODAE  Global Ocean Data Assimilation Experiment
GOOS  Global ocean observing system
GOES  Geostationary operational environmental satellite
GTS  Global telemetry system
HYCOM  Hybrid co-ordinate ocean model
IODD  Input-output data definitions
ISDI-PM  In situ and satellite data integration – processing model
L2  Level-2
L2P  Level-2 data with added confidence flags after checking for gross errors, consistency and timelines. This family of data products provides the highest quality data obtained from a single sensor for a given processing window.
L3  Level-3
L3MIR  Level-3 merged infrared SST data. This data product represents the best available infrared SST measurements for a given processing interval
L3MMW  Level-3 merged microwave SST data. This data product represents the best available microwave SST measurements for a given processing interval
L3MIS  Level-3 merged in situ SST data. This data product represents the best available in situ SST measurements for a given processing interval
MCSST  Multi-channel sea surface temperature
MDB  Match up database
MFC  Marine Forecasting Centre of Norwegian Meteorological Institute
MFS  Mediterranean Forecasting System
MICOM  Miami isopycnic co-ordinate ocean model
MSG  Meteosat Second Generation
NCEP  National Center for Environmental Prediction (US)
NGSST  New Generation SST Project (Japan)
NWP  Numerical Weather Prediction
PEMSA  Production of Enhanced Multi-sensor SST Analysis Project (U.S.)
PO.DAAC  Physical Oceanography Data Active Archive Centre (U.S.)
RAN  Re-analysis
RD  Reference document (see section 1.5)
RDAC  Regional data assembly centre
RDANH  Royal Danish Administration of Navigation and Hydrography
RGTS  Regional and global task sharing
SEVIRI  Spinning Enhanced Visible and Infrared Imager
SSMI  Special sensor microwave imager
SST  Sea surface temperature
TOPAZ Toward Operational ocean Prediction system for the north Atlantic European coastal Zones

TMI TRMM microwave imager

UHR Ultra-high resolution

UIS User information services

URD User requirements document

WMO World Meteorological Organisation

XBT Expendable bathythermograph (In situ measurement of ocean temperature profiles)

16 References


Guan, L. and H. Kawamura (2002): Merging satellite infrared and microwave SSTs— Methodology and Evaluation of the new SST, Submitted to J. Oceanogr; (Under review)


Reynolds, R. W., A real-time global sea surface temperature analysis, J. Climate, 1, 75-86, 1988


