# Multi-sensor Improved Sea-Surface Temperature (MISST) for IOOS

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## LONG-TERM GOALS

Sea Surface Temperature (SST) is vital to coastal and marine spatial planning, global weather prediction, climate change studies, search and rescue, and ecosystem based management. SST is derived from measurements taken by numerous satellites carrying infrared and microwave radiometers, and measured from moored buoys, drifting buoys, and ships. This project focuses on completing research to improve the quality of the satellite SSTs from existing and new sensors, produce multi-sensor blended gap-free SSTs from US and international datasets, and successfully broaden the use of these products within specifically targeting coastal applications and the Integrated Ocean Observing System (IOOS).

## OBJECTIVES

The objectives of this project are to (1) improve and continue generation of satellite SST data and SST analyses in the IOOS DMAC and CF compliant Group for High Resolution Sea Surface Temperature (GHRSST) Data Specification GDS format; (2) distribute and archive these data; and (3) use this improved SST data in applications, many specifically targeted for the Integrated Ocean Observing System (IOOS).

## APPROACH AND WORK PLAN

In the full proposal, each task has been assigned to one or more partners. This partnership consists of 28 scientists from industry, academia, and government with wide ranging experience spanning the initial calibration of satellite sensors, development of SST algorithms, assessment of SST uncertainties, production of NRT satellite data, research into data fusion methodologies and the production of blended data sets, research into diurnal warming and the cool skin effect which both affect satellite SST measurements, and applications that utilize SSTs.

**FY1 work plan:** Error! Reference source not found. Evaluate GDAC needs for historical production of MODIS Aqua and Terra L2P data (Vazquez). Process and distribute N-18, N-19 and METOP-A

GAC, and N-19 LAC (May and McKenzie) and TMI and AMSR-E (Gentemann) in GDS 2.0. Update data ingest to GDS 2.0 (May and McKenzie). Evaluate NRT AMSR-E SST (Sienkiewicz). Error! Reference source not found.: Process and distribute L2P AVHRR HRPT SSTs for the western N. Atlantic, 2000-present (Cornillon). 1st generation revised AVHRR calibration methodology (Mittaz & Harris). Error! Reference source not found.: Review current lake temperature algorithms (Crosman). Error! Reference source not found. Update POSH to run on NWP outputs. Validate POSH, CG04, and other diurnal models against satellite data (Gentemann). Assess uncertainty in existing DW models (Castro). Error! Reference source not found. Assess impact of additional parameters on accuracy of skin effect estimates (Castro). Error! Reference source not found. Validate AMSR-E SSTs using WindSAT retrievals, update SSES (Gentmann). 1st generation version of SSES for geostationary SST using chi-square metrics (Harris & Mittaz). Deployments of M-AERI Mk2 and other radiometers for NPP VIIRS post-launch validation; initial assessment of NPP VIIRS SSTs (Minnett, Evans). Error! Reference source not found. Process and distribute MWIR SST (Gentemann), daily OI ¼°

**WORK COMPLETED**

Funding for only part of the proposal was received August 2011. This funding was used for subcontracts to several partners. Work from these funded partners is discussed below.

**Task 1.1.2.** *New L4 data to GDS 2.0 (Chao).* We are collecting data and testing the diurnal warming model, e.g., POSH, with a goal to provide a diurnal warming correction to the G1SST.

**Task 1.2**: *Process and distribute L2P AVHRR HRPT SSTs for the western N. Atlantic, 2000-present (Cornillon).* We have acquired all of AVHRR HRPT data for the western North Atlantic (Wallops Island receiving station) from 2000 through 2010. With other funding, we are in the final stages of testing the Pathfinder retrieval software for the HRPT data. We hope to run the North Atlantic data through this software in the next several weeks. A test run using all of the NOAA-15 data has been made through the Pathfinder software. These are the data that we are using to validate the software.

Error! Reference source not found. *Assess uncertainty in existing DW models (Castro).* We have obtained forcing data and observations from the Tropical Warm Pool experiment (TWP+) and derived foundation SST values and diurnal warming estimates. Using these have begun an evaluation of existing physical models and simplified parameterizations over the domain.

Error! Reference source not found. *Assess impact of additional parameters on accuracy of skin effect estimates (Castro).* We have learned of a potential new renewal time scale for air-sea interaction processes associated with convection that scales with the mixed layer depth. We have begun to implement this formulation and assess whether it can add skill to estimates of the skin effect where deviations from normal behavior are observed.

**Task 1.6** *Include MISST data in GCOS SST Inter-comparison; identify statistics to track in Rich Inventory (Casey).* There has been no progress yet on GCOS Intercomparison, since no new MISST2 data (though we could begin working on one of the older MISST products if we need to). Rich Inventory statistics have been identified for each granule of data (defined appropriately for each data set): Min, Max, Mean, Median, Standard Deviation, Sum, and Sum of Squares of SST, for each SST quality_level.

**Task 1.6.1.1** *Process and distribute 1km SST (Chao).* G1SST is continuously being distributed to the community through the OurOcean portal, http://ourocean.jpl.nasa.gov/SST

**Task 2.2** *Upgrade LTSRF for GDS 2.0 data. Archive MISST data. Provide MISST data following IOOS-standard protocols including OPeNDAP and TDS services (Casey).* LTSRF upgrade work underway to allow us to handle GDS2 data, now that a real GDS2 data set exists in the form of the Pathfinder Version 5.2 dataset that we published in the fall. OPeNDAP/TDS services are ready to go once the data arrive, and have been updated to the latest server version.

**Task 2.3** *Make MISST L3 and L4 products available to the IOOS community via NOAA/SWFSC/ERD data services (Foley and Mendelssohn).* Several MISST L3 and L4 products have been placed for fully interoperable access on the ERDDAP server at NOAA/SWFSC/ERD (http://coastwatch.pfel.noaa.gov/erddap). Additionally, we have formed several partnerships with fisheries and protected species researchers to ensure that they are aware of these data sets, and can readily access and use them.

**Task 3.1** *Extend coral bleaching indices based on MISST and additional remote sensing data to reefs of the Florida reef tract and Caribbean. (Hendee, Gramer).* Using cutoff MISST sea temperature values for coral bleaching based on statistical analysis of data from other sites (American Samoa, Florida Keys), ecological forecasts have been implemented by Gramer and Hendee at NOAA's Atlantic Oceanographic Meteorological Labs, for sites in the Gulf of Mexico, Caribbean Sea, and other Pacific Islands (Saipan, Guam).

**Task 3.3** *Determine gradients and fronts in 1985-2000 AVHRR HRPT SST fields for the western N. Pacific (1985-2000) and eastern N. Pacific (1990-2000) (Cornillon).* In previous work we have developed a workflow for to determine the gradients and fronts (using the Cayula-Cornillon edge detection algorithm) from SST fields. The first step in the workflow 'conditions' the SST fields, that is, it rewrites the data into a directory and file structure that is recognized by all the gradient and edge detection software; i.e., once 'conditioned' the data are processed in exactly the same way regardless of the original source of the data. The 'conditioning' also generates CF-compliant metadata that is consistent and that is used in subsequent steps in the processing. We have modified the 'conditioning' program to read the L2 Pathfinder data. In the next several weeks we will test the gradient/edge detection workflow on a subset of the NOAA-15 mentioned above.

## RESULTS

None. Yet…

## IMPACT AND APPLICATIONS

### National Security

SST is routinely used both directly in Naval fleet operations and as an input to weather forecast models used to support Naval operations. The improved SST products and better understanding of the associated errors resulting from this project will provide a more accurate description of environmental conditions enabling better planning of operations. A key aspect of this project is directly evaluating the impact of the improved SSTs on Naval applications. SSTs are also a key parameter for identifying the location and strengths of thermal fronts and eddies, information crucial to assessing the acoustic

environment for submarine and antisubmarine operations, as well as for Homeland Security considerations of coastal currents and eddies for public health and safety in the advent of deliberate dumping and dispersion of hazardous material.

**Economic Development**

SST data is a significant consideration for planning and conducting commercial fishing operations, as well as fisheries management and monitoring efforts. Likewise, SST data is relevant to marine protected species monitoring and de-conflicting protection efforts from commercial fishing.

**Quality of Life (Delete this section if there are none)**

The potential for producing more accurate SST products has important application to areas including environmental monitoring and weather forecasting. More accurate knowledge of the SST can lead to improved understanding of coral health, better forecasting of routine and severe weather events, improved recreational fishing, and increased ability to monitor climate change. Improved understanding in these areas will lead to a more informed public and better decision-making.

**Science Education and Communication (Delete this section if there are none)**

The NASA Earth Observatory (EO) provides an online magazine includes feature articles, daily news and images, breaking news Earth Sciences events (www.earthobservatory.nasa.gov). MISST SSTs provide visuals for a variety of media updates, alerts (the most common of which are hurricane-related), and a number of museum projects. These data are quite useful for periodic requests from NASA/GSFC Public Affairs Office, staff scientists wanting to talk about events with reporters, etc. The MISST SSTs has also been appearing in flagship NASA productions, (eg: Hurricane Watch (www.nasa.gov/mission_pages/hurricanes/main/index.html), of which one of the most intriguing visualizations uses MISST SSTs, GOES clouds, and recorded storm tracks to show the 2005 hurricane season: (http://learners.gsfc.nasa.gov/mediaviewer/27storms/ ).

**TRANSITIONS**

**National Security:** Through direct project partnership with US Navy efforts, the improved SST products and methodologies will be directly integrated into Naval SST products and numerical weather forecasting procedures both in use and under evaluation. To accomplish the goal of determining the impact of the SST improvements in Naval applications, transitioning results to the Naval partners is a central focus of this project.

**Economic Development:** Satellite IR SST data are already in use by the National Marine Fisheries Service. Improved coverage in persistently cloudy regions will facilitate protected species and fisheries management efforts. The merged IR-MW SST product will be provided when available via the NOAA CoastWatch program. MISST SST fields will be used for targeted applications including IOOS regional partners, coral reef research and monitoring, fisheries planning, commercial fisheries.

**RELATED PROJECTS**

The need for a uniform approach to SST measurements and estimation of measurement errors resulted in the formation of the international Group for High Resolution SST (GHRSST), with partners in Japan, Europe, Australia, and the United States. This groups acts to coordinate international

collaboration, research, and SST data sharing. A full description of GHRSST can be found at http://www.ghrsst.org.

NASA's Physical Oceanography Data Active Archive Center (PO.DAAC) is the GHRSST global data assembly center (http://ghrsst.jpl.nasa.gov). After 30 days, all of the data are sent to the GHRSST Long Term Stewardship and Reanalysis Facility (LTSRF) at NOAA's National Oceanographic Data Center (NODC, http://ghrsst.nodc.noaa.gov) for long term preservation and to support climate-oriented applications. This global, collaborative system supports the research necessary to estimate and reduce uncertainty in SST retrievals and improve the multi-sensor blending methodology, which in turn results in enhanced societal benefits.

MISST SST fields will be used for targeted applications including IOOS regional partners, coral reef research and monitoring, fisheries planning, commercial fisheries, Navy fleet operations, naval and civilian NWP, operational oceanography including coastal applications, and climate monitoring and forecasting. More information on IOOS is available at www.ioos.gov.