National Aeronautics and Space Administration

GHRSST-PP

GODAE High Resolution Sea Surface Temperature Pilot Project

http://www.ghrsst-pp.org

GDAC

http://ghrsst.jpl.nasa.gov

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NOVEL GHRSST-PP SATELLITE PRODUCTS: AN EXAMPLE OF MODIS L2P SST

GHRSST Products & Data Management

MISSION

The Global Ocean Data Assimilation Experiment (GODAE) high-resolution sea surface temperature pilot project (GHRSST-PP) provides a new generation of global high-resolution SST data products to the operational oceanographic, meteorological, climate and general scientific community, in near realtime, delayed mode and reanalysis mode.

Every day, GHRSST processing systems produce SST products from several complementary satellite and in situ SST data streams to a common netCDF format. Both integrated observation (L2P) and analysis (L4) products are available.

SST L2P Production from Regional Data Assembly Centers (RDACs)

RDAC	Sensor	Resolution (km)	Region
Medspiration (Europe)	AATSR	1	Global
Medspiration	SEVIRI	6	Atlantic regional
Medspiration	AVHRR-17,-18	2-9 (HRPT and GAC)	Atlantic regional
Medspiration	TMI	25	Atlantic regional
REMSS (US)	AMSRE	25	Global
REMSS	TMI	25	Global
JAXA (Japan)	AMSRE	25	Global
JAXA	MTSAT	6	Pacific regional
NAVO (US)	AVHRR-17, -18	2-9 (LAC and GAC)	Global
JPL/OPBG/RSMAS (US)	MODIS-A, -T	1	Global
BlueLink (Australia)	AVHRR-17, -18	1	Indian/Pacific regional
NOAA OSDPD (US)	GOES-11, -12	6	Pacific/Atlantic regional

Regional/Global task sharing for data production, distribution and archiving

RDACs: Medspiration (Europe); JAXA (Japan); Bluelink (Australia); NOAA OSDPD (U.S.); NAVO (U.S.); REMSS (U.S.); JPL/OBPG/RSMAS (U.S.); NOAA NCDC (U.S.)

L2P, L4

GDAC (JPL): OCEANIDS (Data Management); L2P Ancillary Field Filling; Master Ancillary Files; Metadata Repository (MMR); Data Interface (FTP, POET, OPenDAP, L2 subset)

NRT Users

Archive - LTSRF (NODC – U.S.)

Delayed Users

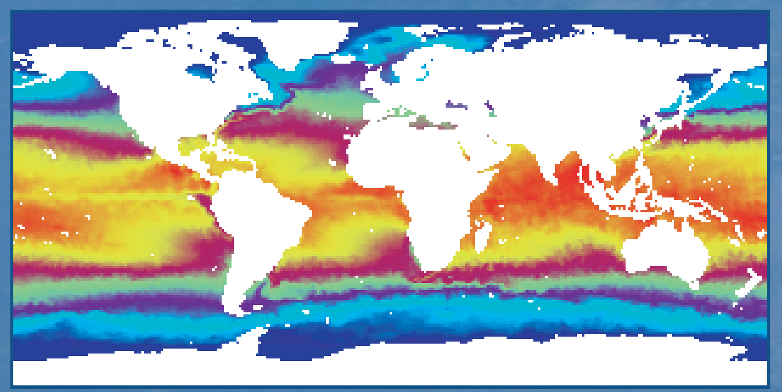
Data management, distribution and production at the JPL Global Data Assembly Center (GDAC)

http://ghrsst.jpl.nasa.gov

In the GHRSST task sharing framework, L2P and L4 products produced by centers of expertise (RDACs) are distributed through the Global Data Assembly Center (GDAC). The GDAC is the core data management node and "clearinghouse" for near realtime data ingestion and distribution, metadata management, and data search and discovery. The GDAC supports applications development for decision support, marine resource management and scientific users (e.g., IOOS) through regional merged products and user services. The GDAC distributes products from a 1-3 month "rolling store" and exchanges 30 day old data and metadata with the LTSRF (GHRSST archive).

Data products: Level 4

L4 merged SST netCDF (foundation temperature)

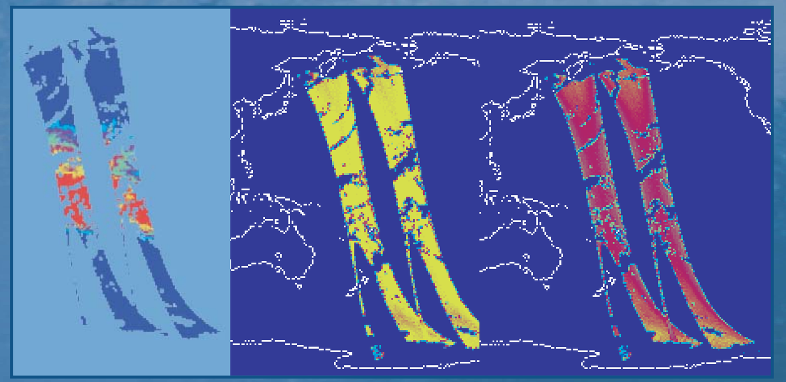


Example:
Global daily 5 km
OSTIA SST analysis
(UK Met Office)

Data products: Level 2 Preprocessed (L2P)

SST L2P netCDF with error statistics, time tags, geolocation, confidence flags, ancillary meterological and sea ice information, and SST reference field (DT analysis)

Example:
ascending orbits from AMSRE on Aqua (JAXA)



SST Bias Std Dev

Future Activities

- Regional merged (<2 km) L4 products
- Ensemble comparisons of L4 products
- Climate data records
- L2 subsetting
- Subscription data deliveries

Reanalysis and Archiving: LTSRF

http://ghrsst.nodc.noaa.gov

The **Longterm Stewardship and Reanalysis Facility (LTSRF)** at the **NOAA NODC** will maintain the historical archive of **GHRSST** products and serves as the reanalysis component for climate data records.

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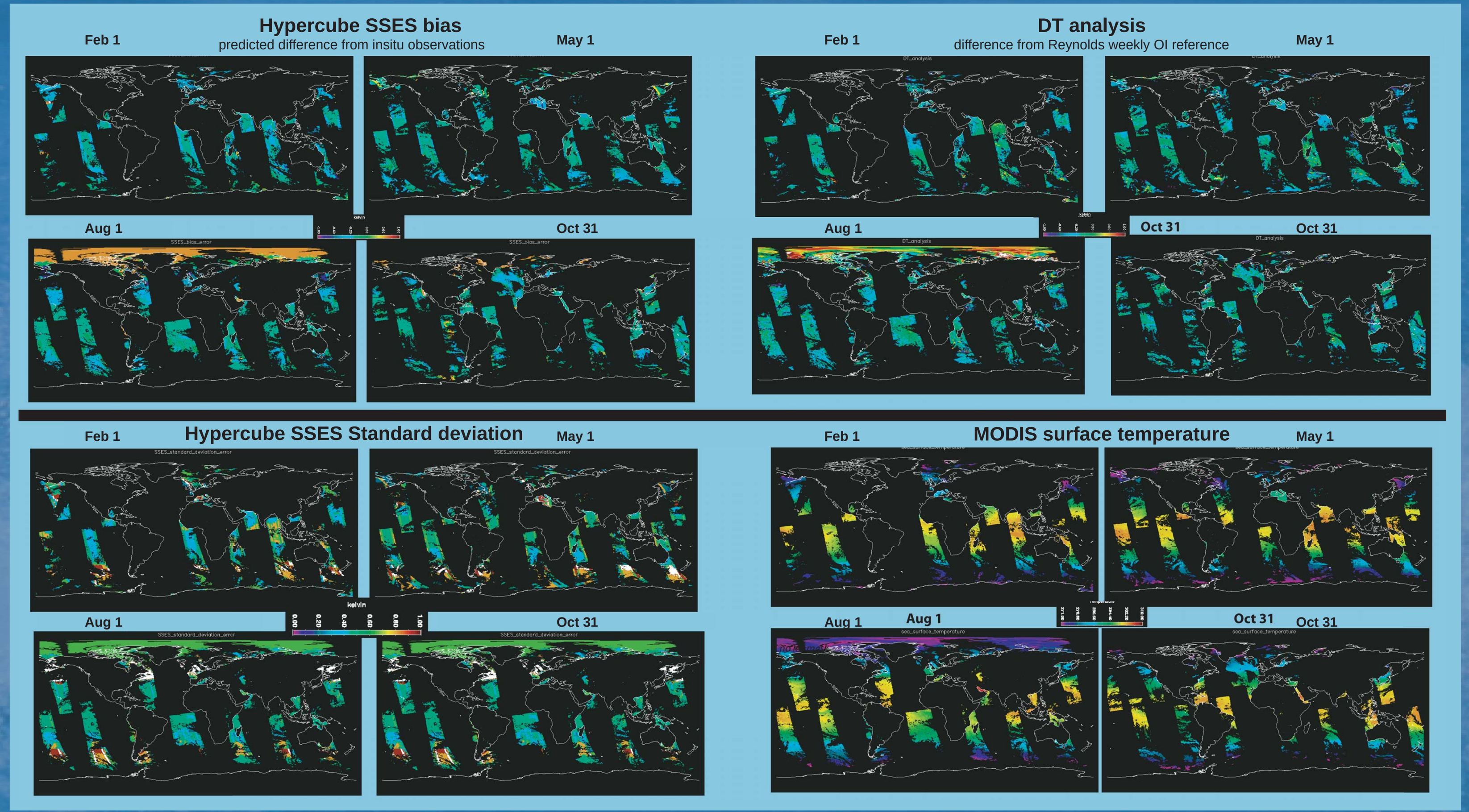
MODIS L2P Uncertainty Characterization



MODIS SST Matchup Database (MMDB) and development of the uncertainty Hypercube

A match-up data base has been constructed for the Aqua and Terra MODIS sensors that includes contemporaneous, co-located satellite brightness temperature, in-situ buoy and radiometer SST, environmental 'observations' from analyzed model or satellite observed fields, satellite viewing geometry, time and location. The entire mission for each satellite, 2000-2005 for Terra and 2002-2005 Aqua Collection V has been matched using drifting buoy and the Marine Atmosphere Emitted Radiance Interferometer (MAERI) observations for reference in-situ data. The complete database for each sensor contains over 1 million matchups. A series of quality tests has been applied during processing of the MODIS data to identify cloud and dust aerosol contaminated retrievals and assign pixels to one of four different quality levels with quality 0 being the best quality possible. Selection of dust contaminated retrievals relies on the relative immunity of the MODIS 3.95 and 4.05 mm bands to both water vapor and dust aerosols as compared to the increased sensitivity to both in the MODIS 11 and 12 mm bands.

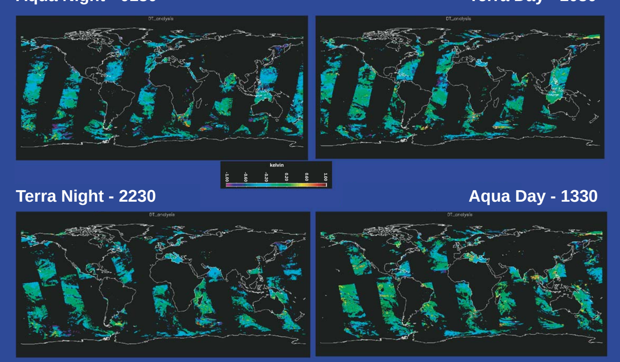
After eliminating records with quality levels greater than 1, each match-up database is partitioned into a multi-dimensional array with the following 7 dimensions: time by season (4), latitude bands (5 steps in 20 degree increments from 60S to 60N), surface temperature (8 increments in 5 degree steps), satellite zenith angle (4 increments), brightness temperature difference as a proxy for water vapor (4 intervals for 4 um and 3 intervals for 11-12 um SST), retrieved satellite SST quality level (2 intervals) and day/night selection (2 intervals). (see Table 1). The bias (satellite-in situ) and standard deviation are then computed for each element. This hypercube look up table is then used during processing to predict the uncertainty **bias** and **standard deviation** of the retrieval. These are the Sensor Specific Error Statistics (SSES).

Table 1 SSES uncertainty statistics Hypercube partitions
Hypercube 7 dimensions (partitioning of Match-up database):

- Day/night
- Time-quarter of year (4)
- Latitude band (5):
  "60S to 40S" "40S to 20S"
  "20S to 20N" "20N to 40N"
  "40N to 60N"
- Sat Zenith angle intervals (4):
  "0 to 30 deg" "30+ to 40 deg"
  "40+ to 50 deg" "50+ deg"
- Surface temperature intervals (8):
  5 degree intervals
- Channel difference intervals:
  SST(3), SST4(4)
  sst:ch31-32 (SST):
  0.7<, 0.7- >2.0, >2.0

Panel A- Evidence of diurnal thermocline

Diurnal Warning of the Western Pacific
11-12 um MODIS DT analysis Aqua and Terra, day and night.
Every other orbit shown to eliminate orbit overlap. May 1, 2005



What are we learning?

When the bias and standard deviation and DT analysis (deviation temperature, i.e., difference from reference field) are mapped into global fields (shown in the panels to the top), the effects of observing geometry, atmospheric water vapor, time of year and location become readily apparent. Insights gained through analyzing these fields should lead to improvements in the SST retrieval and quality assessment schemes. Initial comparison of the MODIS SST to these reference fields is based on seasonal processing of selected Aqua and Terra day and night SST fields. In the global images only every other orbit is shown to eliminate orbit overlap and facilitate examination of uncertainty fields at the swath edge.

Central Gyre regions
In the central gyre regions where SST gradients are small, both the 'hypercube' SSES bias and DT reference SST field anomalies are comparable demonstrating a negative anomaly of order -0.17C expected for a nominal skin, bulk temperature difference.

Evidence of the diurnal thermocline
In regions such as the western Pacific Warm pool, daytime temperatures exhibit a warm bias of order 1degC indicative of diurnal warming. This can be clearly be seen when examing both the SSES bias and the DT analysis for May 1, 2005 day time retrievals from Terra MODIS with a morning overpass, and AQUA with an afternoon overpass to the night time fields for each sensor. Day and Night Aqua and Terra May 1, 2005 images shown in **Panel A**

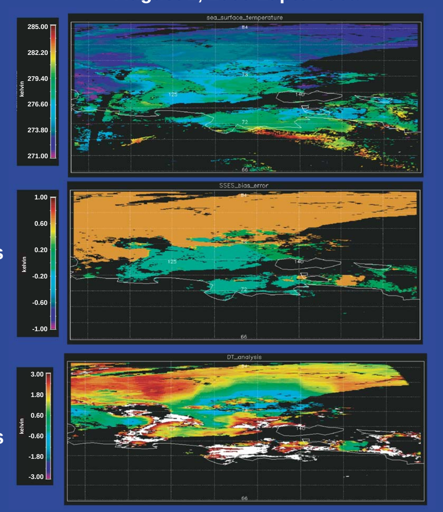
High Laititude Northern Hemisphere
Both the hypercube bias and DT reference field difference suggest that high latitude, summer infrared based SST retrievals tend to be biased warm. Seen in the August 1 global images to the top and **Panel B** 1 km Artic images. However this geographic region is poorly represented by the distribution of in-situ observations and more conclusive results await the availability of high accuracy in-situ radiometric SST. Several cruises are planned for this year for the polar regions that hopefully will provide the needed observations.

High gradient regions
In contrast to the excellent agreement of the SSES bias and the DT analysis obtained in the central gyre regions, high gradient regimes such as the eastern and western boundary currents show well behaved 'hypercube' bias but large reference field differences due to the mismatch between the scales in the in-situ gradients and the scale of the reference field. Using the Reynolds' OI as a reference primarily shows mesocscale spatial variability as SST retrieval uncertainty (**Panel C)**.

Exploring Alternative reference fields
Using a higher resolution product such as the 25km AMSR-E microwave maps provides a substantial improvement but is limited by spatial coverage. Other reference products such as the 10 km NAVOCEANO K10 daily product are being investigated (Panel D); however these tend to be limited by available satellite coverage and the relaxation of space-tme scales required to fill missing retrievals. The 'hypercube' approach provides coverage for all available satellite retrievals but only provides a representative estimate of retrieval bias and standard deviation when conditions present for a given retrieval are well matched by the 'hypercube' coverage and atmospheres present in the MDB.

Panel B-High Northern Hemisphere Summer warm bias

August 1, 2005 Laptev Sea



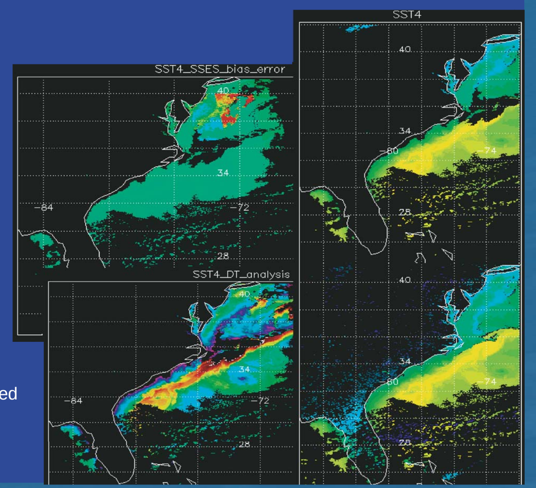
Panel C. High Gradients and Western Bounday Currents

Challenge of using NCEP Reynolds OI SST as the reference in DT analysis
SST4 night Terra Oct. 31, 2005

- **Top Left**
  Hypercube SSES bias
- **Bottom Left**
  DT analysis bias
- **Top Right**
  Areal coverage using OI-Sat <3K
- **Bottom Right**
  Areal coverage using all pixels

High gradient, mesoscale variability not represented by OI

Contemporaneous higher resolution analysis better than 25km desired eg.NAVO K10 product, 10km)



Panel D. Exploring alternative SST reference fields

Comparison of NAVO K10 as reference versus Reynolds NCEP

SST4 filtered best quality (ql=0)
A. standard reference
Reference weekly 1 degree
B. NAVO K10 10km SST as Reference

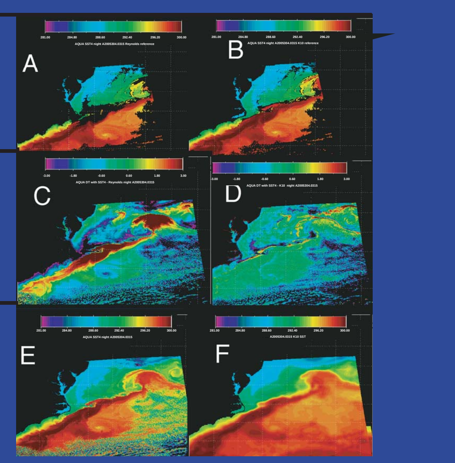
Use of the NAVO K10 product improves quality level assignment in higher gradient regions

AQUA DT analysis all pixels
C. MODIS SST4-Reynolds
D. MODIS SST4-NAVO K10

The position of the gulf stream and other dynamic features are better represented in the higher resolution NAVO K10 product

SST fields
E. all pixels MODIS AQUA SST4
F. NAVO K10 SST reference field
used in the analysis

Gradients in the MODIS products are better collocated in both time and space with those present in the NAVO K10 SST fields



The NAVO K10 is an operational product available at www.navo.navy.mil. It is a blended 10km global product that is updated 4 times a day. The analysis uses observations from several different satellites. These include NOAA AVHRR 18, 17, and 16 GAC SST, GOES 10SST, NOAA 17 and 18 LAC SST and Microwave SST (AMSR-E) from Remote Sensing Systems. An SST observation is included in the raw K10 data file if it is newer than the current observation in the K10 file. The K10 time file is updated accordingly. The date of an observation is adjusted with a reliability estimate: An SST value at location (i.j) in the interpolated K10 data vile is a weighted average of all points within a window centered at (i,j) in the raw K10 data file. To preserve oceanographic features the weights were chosen to decay exponentially with the distance from the window center to the neighbor points and the difference in time from the last observation (procedure developed by Jean-Francois Cayula).