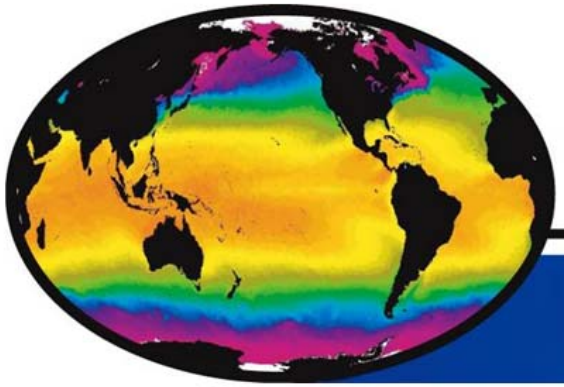


GHRSST

Group for High Resolution Sea Surface Temperature

Medspiration and GHRSST Worldwide

Dr. Craig Donlon
and
The International GHRSST Science-Team

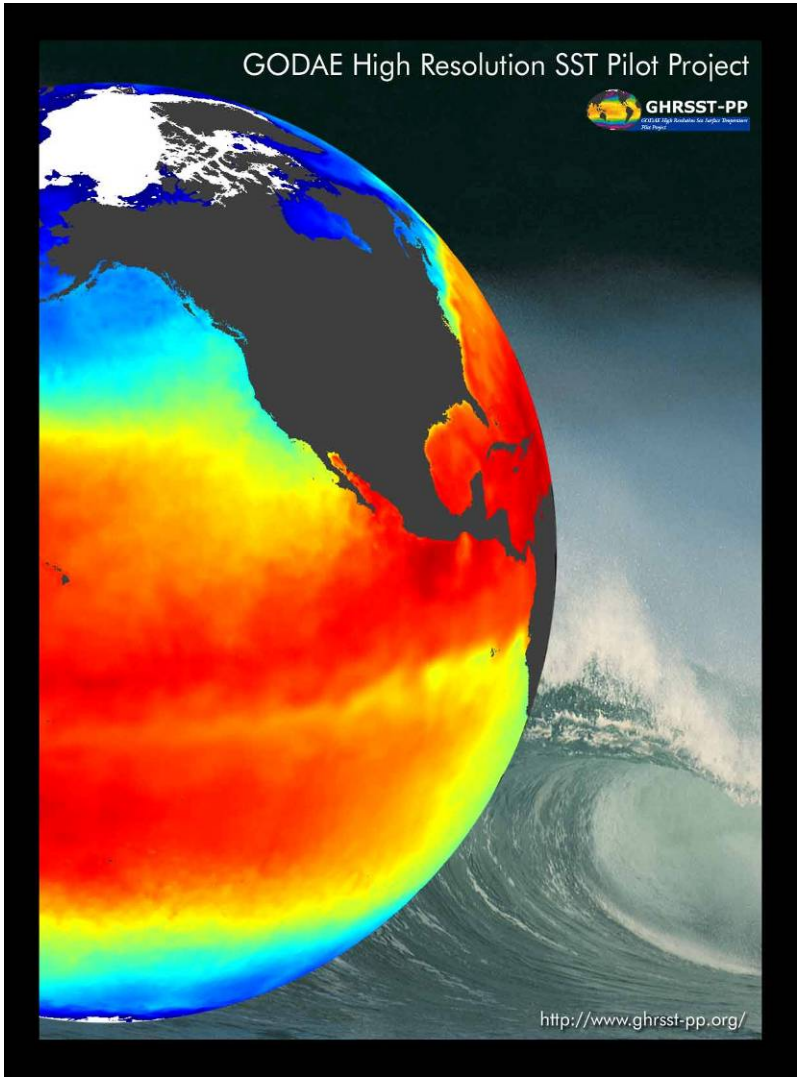
Presented at the Medspiration Final Symposium, ESA/ESRIN, Frascati, Italy, November 19-20th 2008

Met Office CSIRO MARINE RESEARCH NOAA NASA JAXA Japan Aerospace Exploration Agency esa

http://www.ghrsst-pp.org

Outline

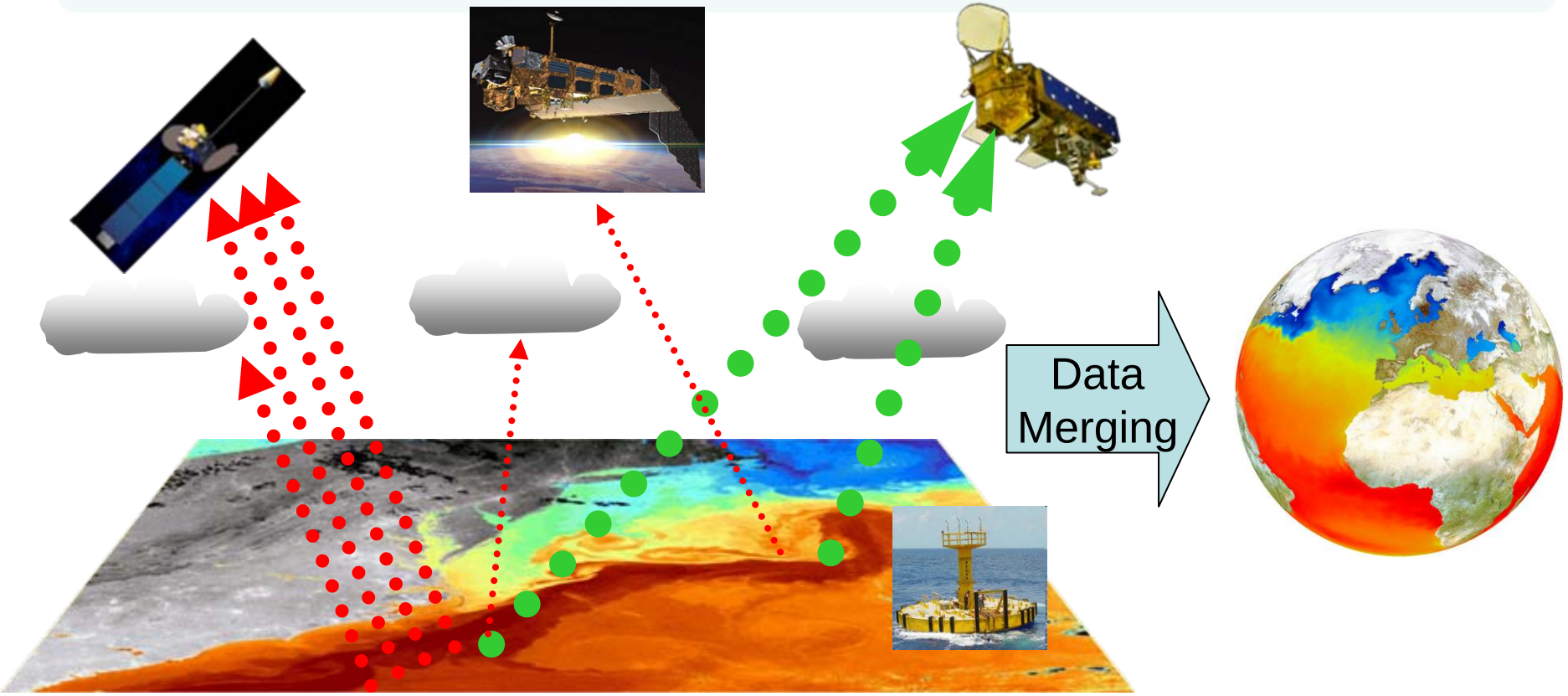
- Requirements
- Implementation
- Results
- Future direction
- Summary



SST requirements for GHRSST-PP

- GODAE defined the minimum data specification required for use in operational ocean models:
  - global coverage
  - a spatial resolution of 10 km
  - an accuracy of 0.5ºC or better
  - updated every six hours
  - be available in near real time.
- GHRSST-PP data products should properly address the difficult issues of:
  - SST at the sea ice edge
  - diurnal variability
  - include uncertainty estimates to facilitate their use by data assimilation systems.

GHRSST-PP Builds on EO complementarities



- Polar Orbiting infrared has *high accuracy & spatial resolution*
- Geostationary infrared has *high temporal resolution*
- Microwave Polar orbiting has *all-weather capability*
- In situ data provide *reality in all weather conditions*

2000: GODAE HiRes SST planning meeting

4 things requested at the GODAE HiRes SST Planning Meeting:

1. SST data assembly/delivery
2. Testing of SST data sources
3. Inter-comparison of SST
4. Data assimilation of SST

GHRSST-PP Science Team (2002)

dup

data user programme

- Develop Earth Observation Application **user** communities
- Support users and European entities to develop and demonstrate applications of **information** products derived from current and future ESA space missions
- Support industry and user groups in establishing useful and cost-effective **services**

User requirements

- European RDAC
- Demonstration of an operational NRT service
- From AVHRR, MSG, AMSR and AATSR
- High Resolution SST products (2-10 km)

1. Collated SST products 6 hours
2. Analysed products 12 hours
3. Skin, subskin and bulk (corrected from diurnal variations)
4. Validated products
5. Contribute to GDAC
6. Contribute to DDS ?

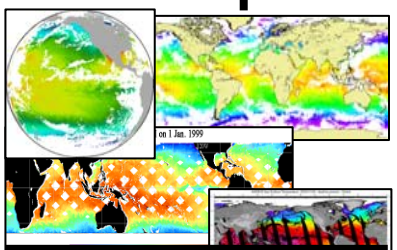
- Description of validation data missing
- Input/Output Data Description and access

Data Processing Model

- GHRSST-PP ISDI-TAG is in charge
- SST skin, SST subskin, SST ctl
- 6 hours - Collated products (all gridded in time and space available information)
- 12 hours- Analysed products (objective analysis and calibration normalisation)
- Atlantic (60S-90N and 100W-45E): 0.1’
- Med, Baltic, Black, North, Greenland: 2 km

The GHRSST-PP Strategy

SST system quality control and uncertainty estimation



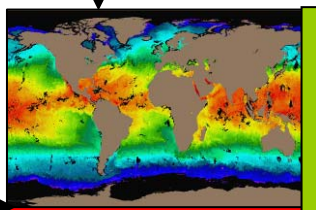
Input SST data of Varied format & with no errors

esa

medspiration
EUROPEAN NODE FOR SEA SURFACE TEMPERATURE

dynamic flags

Data merging and analysis



Analysis Products

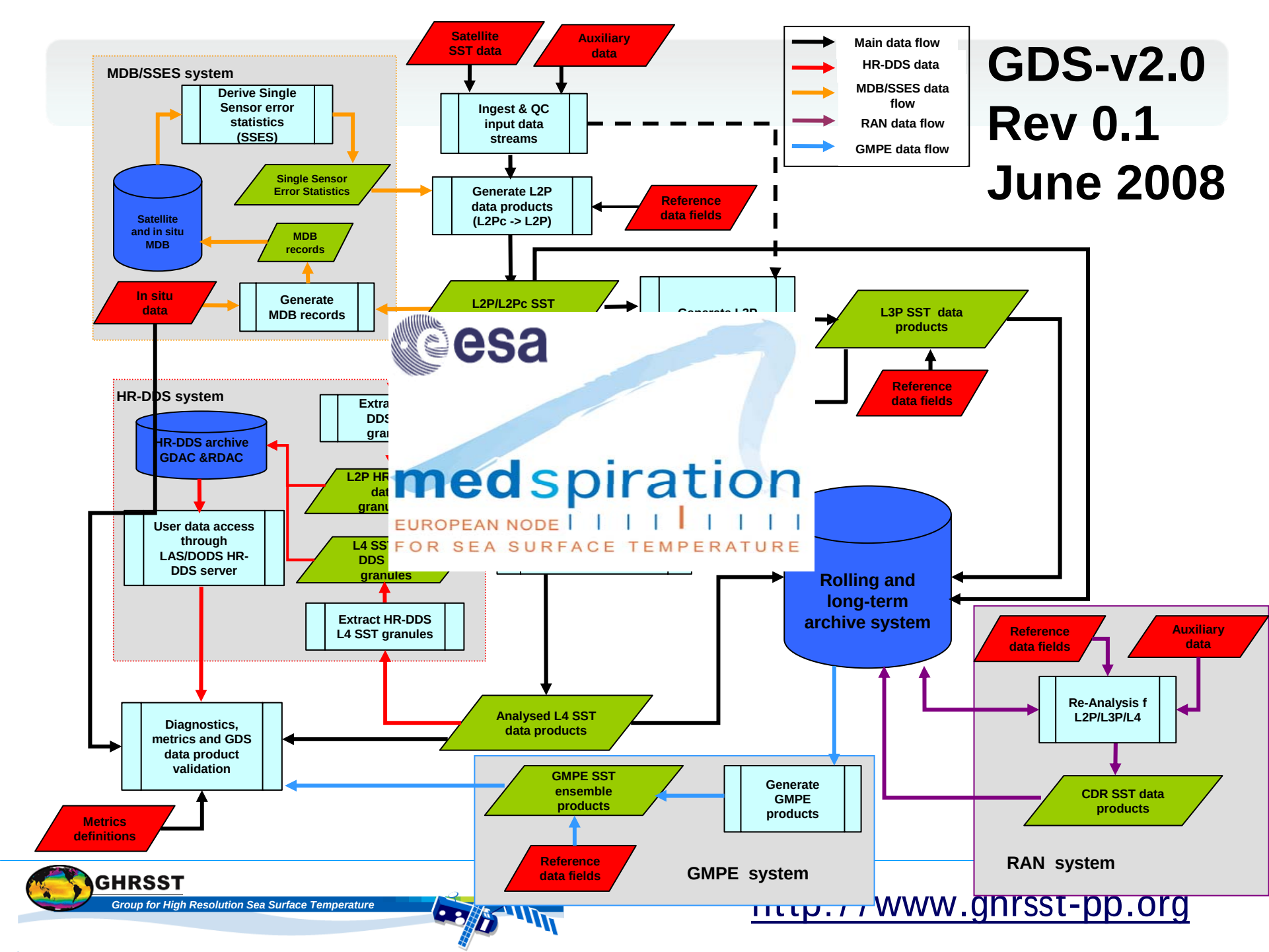
netCDF format

L3/L3P

SST Observations

L1P Radiance data

Applications


GDS-v2.0
Rev 0.1
June 2008
Main data flow
HR-DDS data
MDB/SSES data flow
RAN data flow
GMPE data flow
Satellite SST data
Auxiliary data
Ingest & QC input data streams
MDB/SSES system
Derive Single Sensor error statistics (SSES)
Single Sensor Error Statistics
Satellite and in situ MDB
MDB records
In situ data
Generate MDB records
Generate L2P data products (L2Pc -> L2P)
Reference data fields
L2P/L2Pc SST
L3P SST data products
Reference data fields
HR-DDS system
HR-DDS archive GDAC &RDAC
User data access through LAS/DODS HR-DDS server
Extract HR-DDS L4 SST granules
Rolling and long-term archive system
Diagnostics, metrics and GDS data product validation
Analysed L4 SST data products
Metrics definitions
GMPE SST ensemble products
Generate GMPE products
Reference data fields
GMPE system
Reference data fields
Auxiliary data
Re-Analysis f L2P/L3P/L4
CDR SST data products
RAN system
esa
medspiration
EUROPEAN NODE FOR SEA SURFACE TEMPERATURE
GHRSST
Group for High Resolution Sea Surface Temperature
http://www.ghrsst-pp.org

The Team

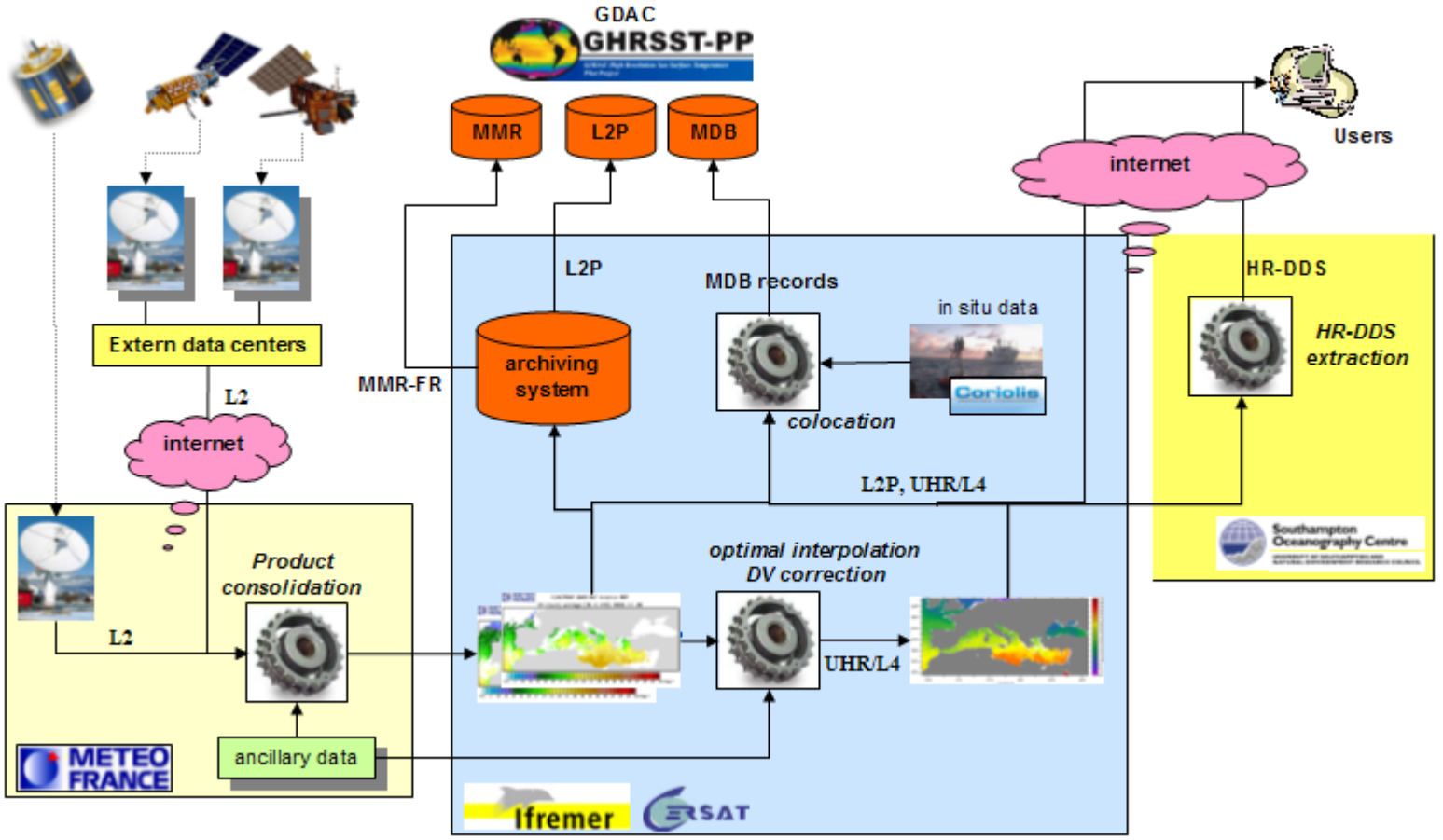
LeBorgne

DPM

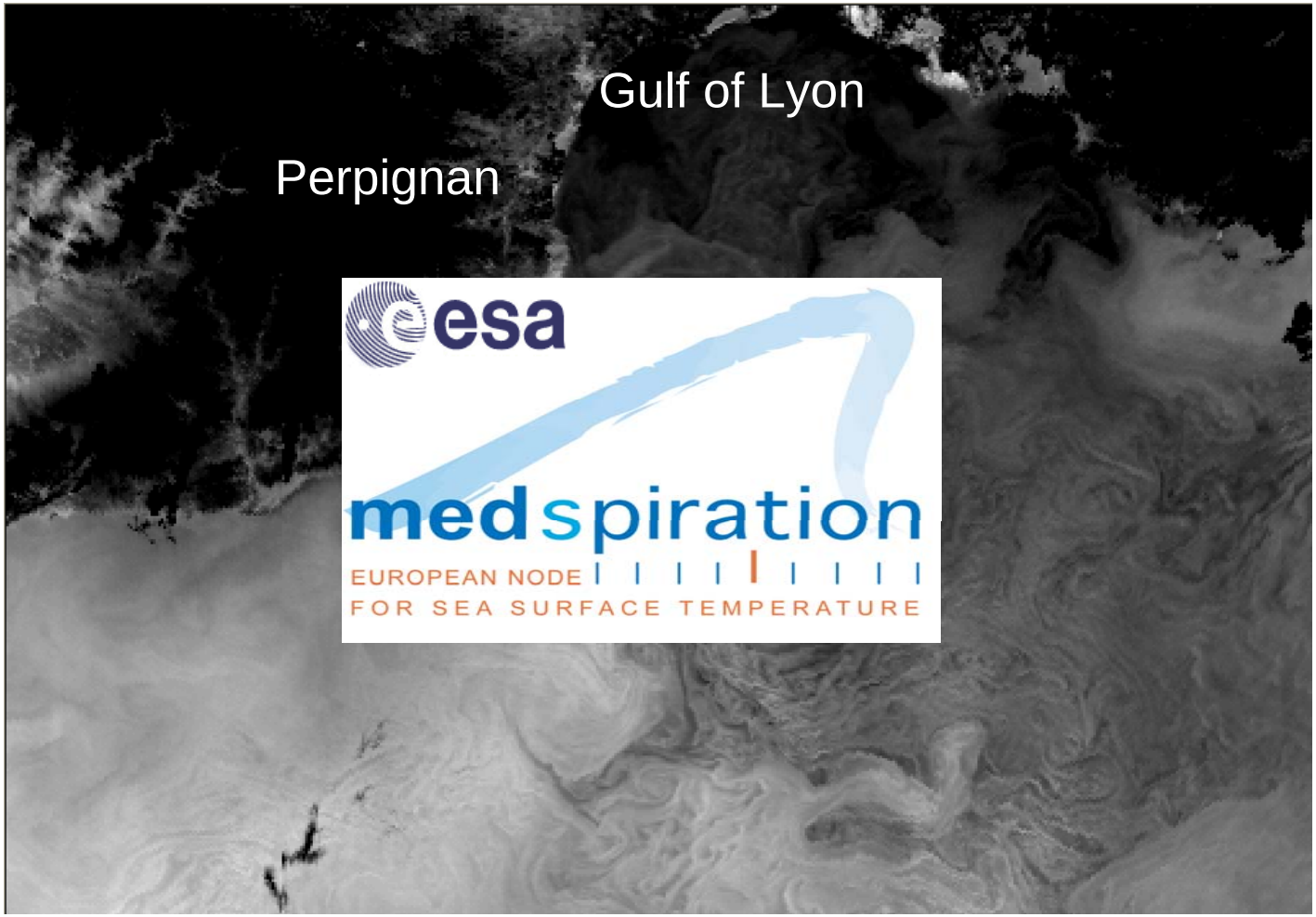
Schedule

- URD v1.4: October 2002
- DPM: v1: December 2002
- URD and DPM v2: January 2003
- ITT: March 2003
- KO: July 2003
- Prototype products: July 2004
- Full validated service: July 2005

Medspiration system



AATSR –where is it they asked?

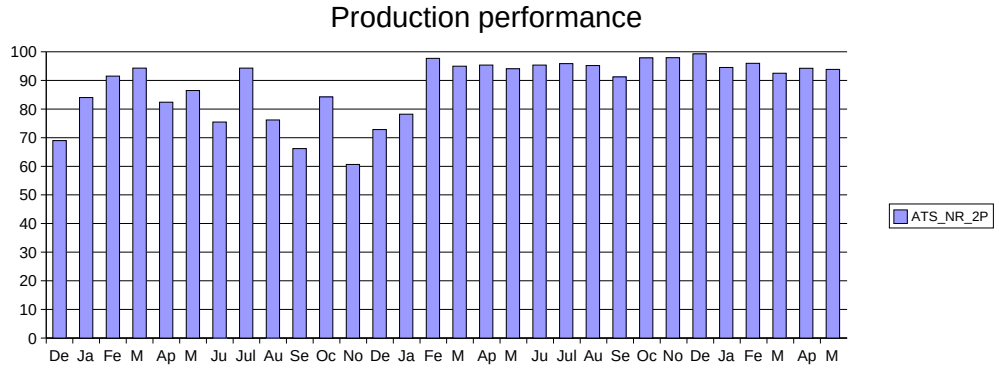


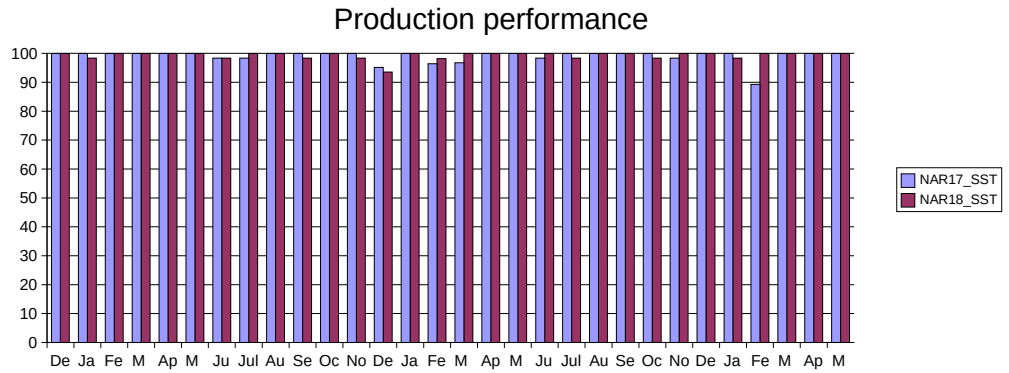
esa

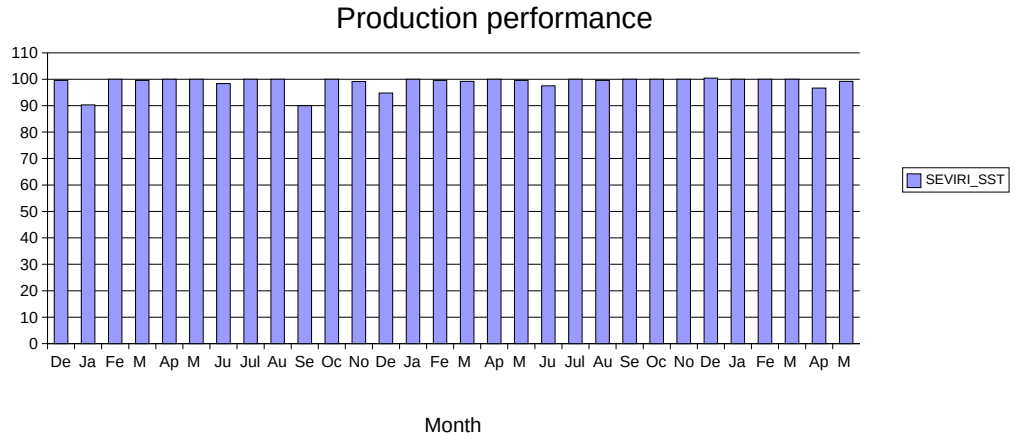
(ENVISAT AATSR)

Can **you** assimilate this information?

Medspiration L2P production







About 60000 files produced since 2005

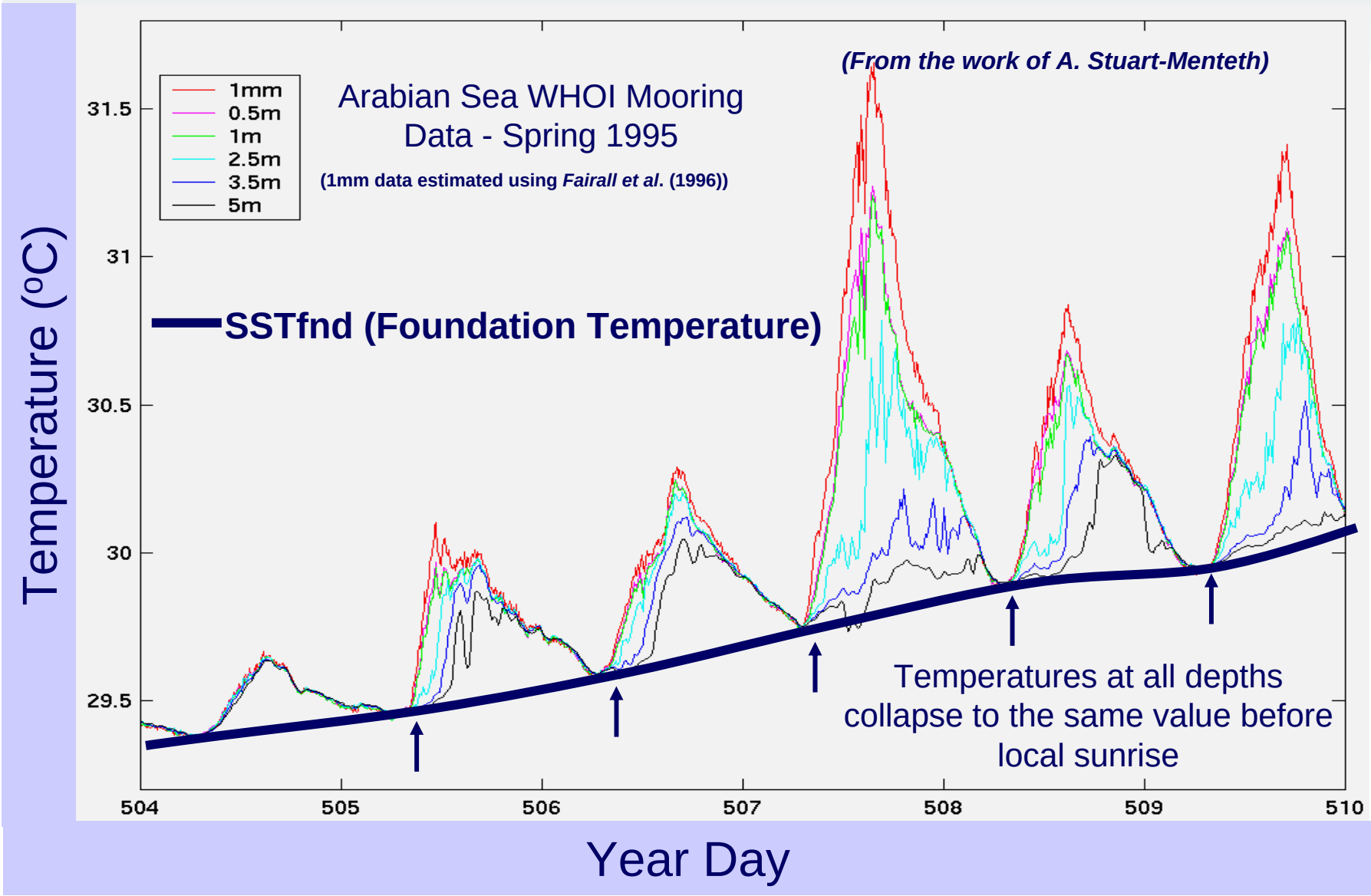
Last 5 months

ATS_NR_2P : 94.2%

NAR17 : 98%

NAR18 : 99.7%

SEVIRI : 99.2%

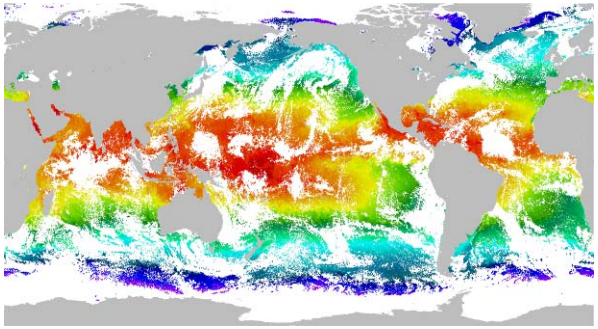

Arabian Sea WHOI Mooring Data - Spring 1995
(1mm data estimated using Fairall et al. (1996))
(From the work of A. Stuart-Menteth)
1mm
0.5m
1m
2.5m
3.5m
5m
SSTfnd (Foundation Temperature)
Temperatures at all depths collapse to the same value before local sunrise
Temperature (°C)
31.5
31
30.5
30
29.5
504
505
506
507
508
509
510
Year Day

Data Assembly and Distribution

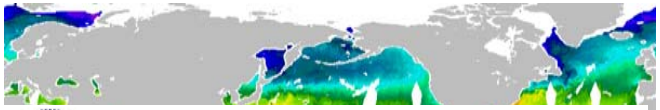
(Free and immediate access)

L2P Common format with uncertainty

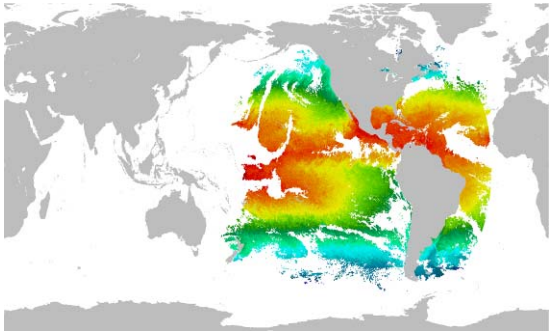
N-17/18
AVHRR GAC (9km)

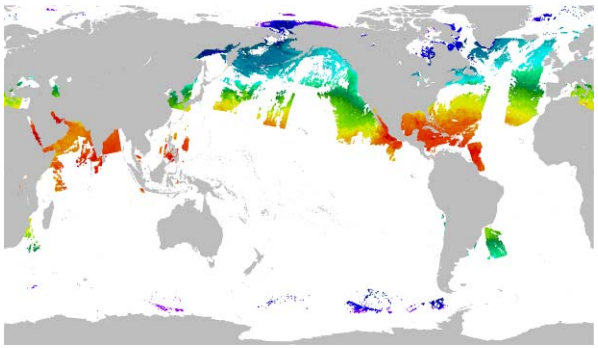


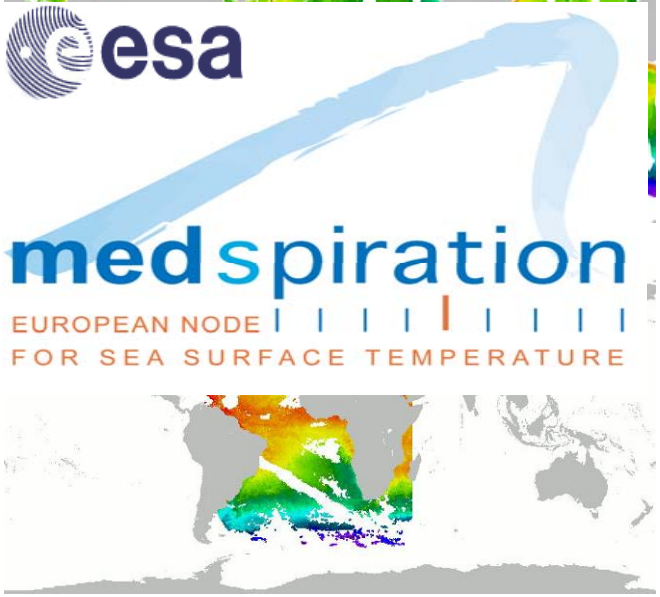
AMSRE (25/12km)

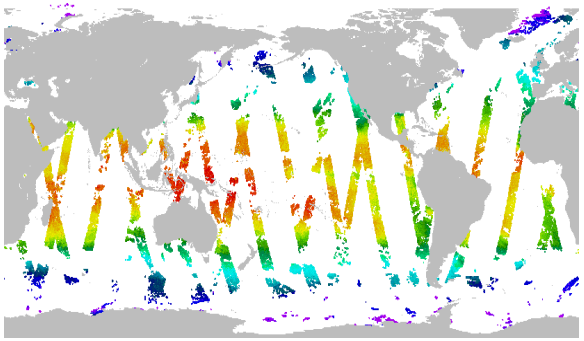


GOES-E/W (5km)







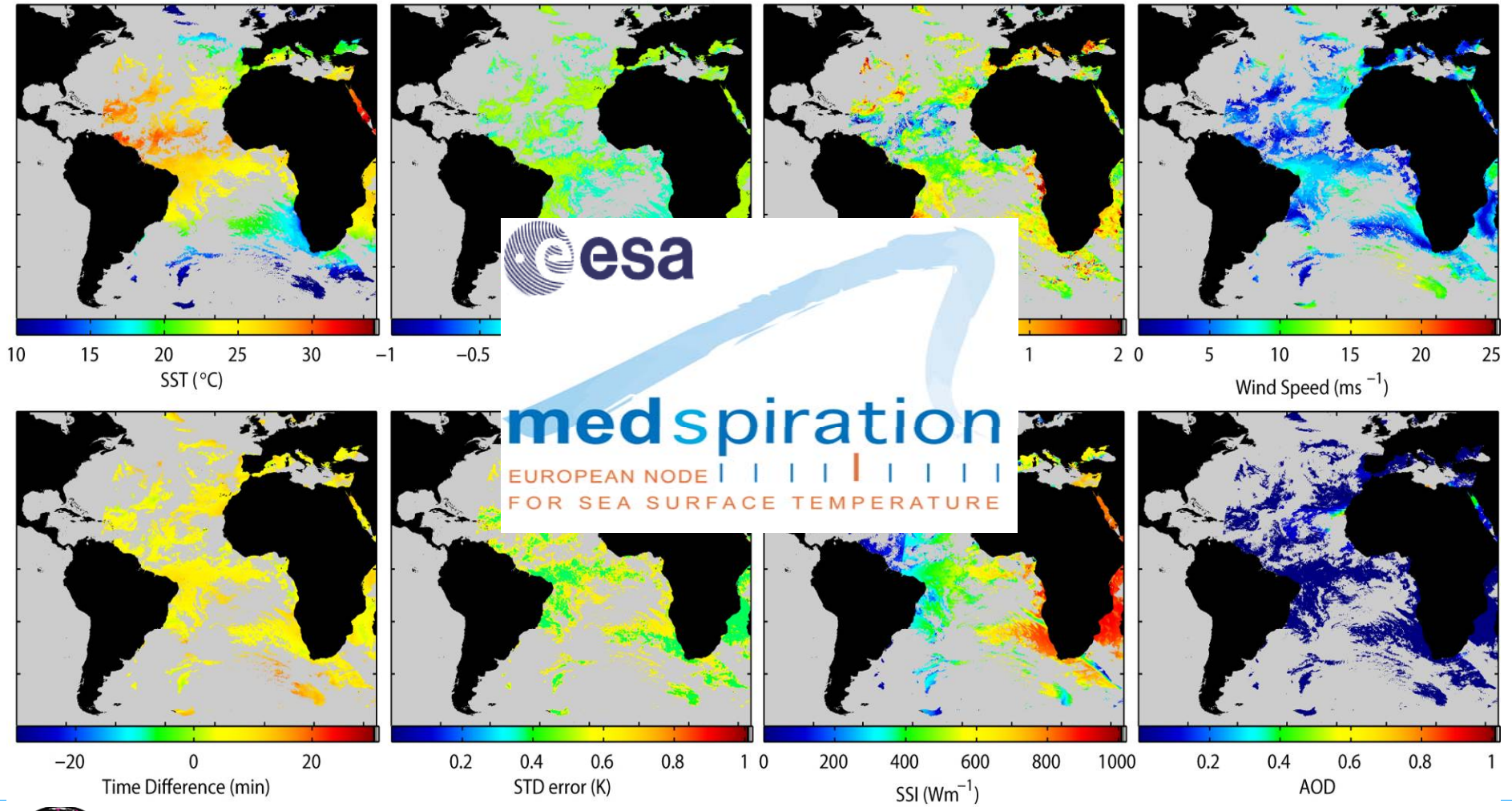


N-17/18
AVHRR LAC (1km)

MSG (5/10km)

AATSR (1km)

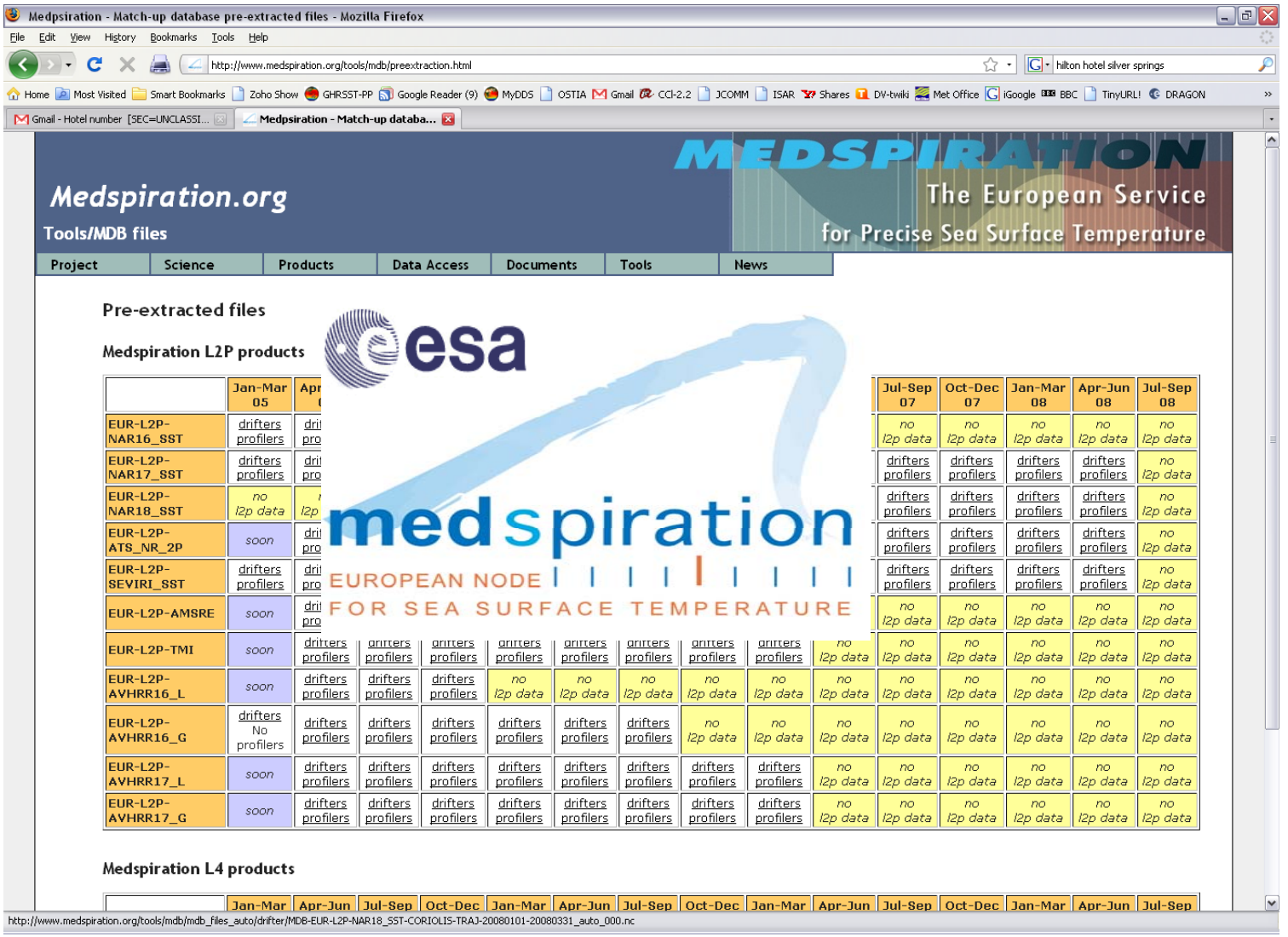
Ancillary information in L2P products: Dynamic flags



esa

medspiration
EUROPEAN NODE FOR SEA SURFACE TEMPERATURE

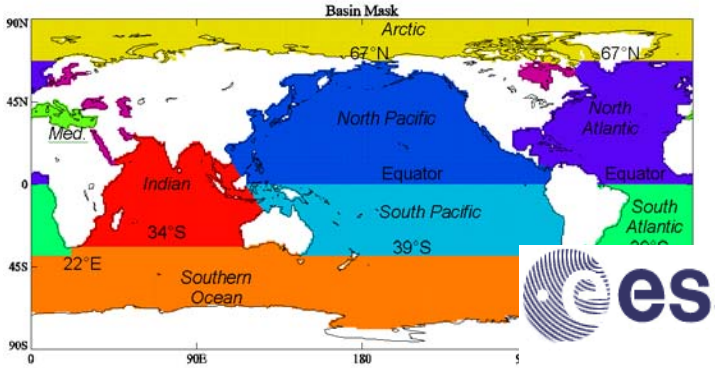
Matchup Database



	Jan-Mar 05	Apr	Jul-Sep 07	Oct-Dec 07	Jan-Mar 08	Apr-Jun 08	Jul-Sep 08
EUR-L2P-NAR16_SST	drifters profilers	dri pro	no l2p data	no l2p data	no l2p data	no l2p data	no l2p data
EUR-L2P-NAR17_SST	drifters profilers	dri pro	drifters profilers	drifters profilers	drifters profilers	drifters profilers	no l2p data
EUR-L2P-NAR18_SST	no l2p data	l2p	drifters profilers	drifters profilers	drifters profilers	drifters profilers	no l2p data
EUR-L2P-ATS_NR_2P	soon	dri pro	drifters profilers	drifters profilers	drifters profilers	drifters profilers	no l2p data
EUR-L2P-SEVIRI_SST	drifters profilers	dri pro	drifters profilers	drifters profilers	drifters profilers	drifters profilers	no l2p data
EUR-L2P-AMSRE	soon	dri pro	no l2p data	no l2p data	no l2p data	no l2p data	no l2p data
EUR-L2P-TMI	soon	drifters profilers	drifters profilers	no l2p data	no l2p data	no l2p data	no l2p data
EUR-L2P-AVHRR16_L	soon	drifters profilers	drifters profilers	drifters profilers	no l2p data	no l2p data	no l2p data
EUR-L2P-AVHRR16_G	drifters No profilers	drifters profilers	drifters profilers	drifters profilers	drifters profilers	drifters profilers	no l2p data
EUR-L2P-AVHRR17_L	soon	drifters profilers	drifters profilers	drifters profilers	drifters profilers	drifters profilers	no l2p data
EUR-L2P-AVHRR17_G	soon	drifters profilers	drifters profilers	drifters profilers	drifters profilers	drifters profilers	no l2p data

	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	Jan-Mar	Apr-Jun	Jul-Sep

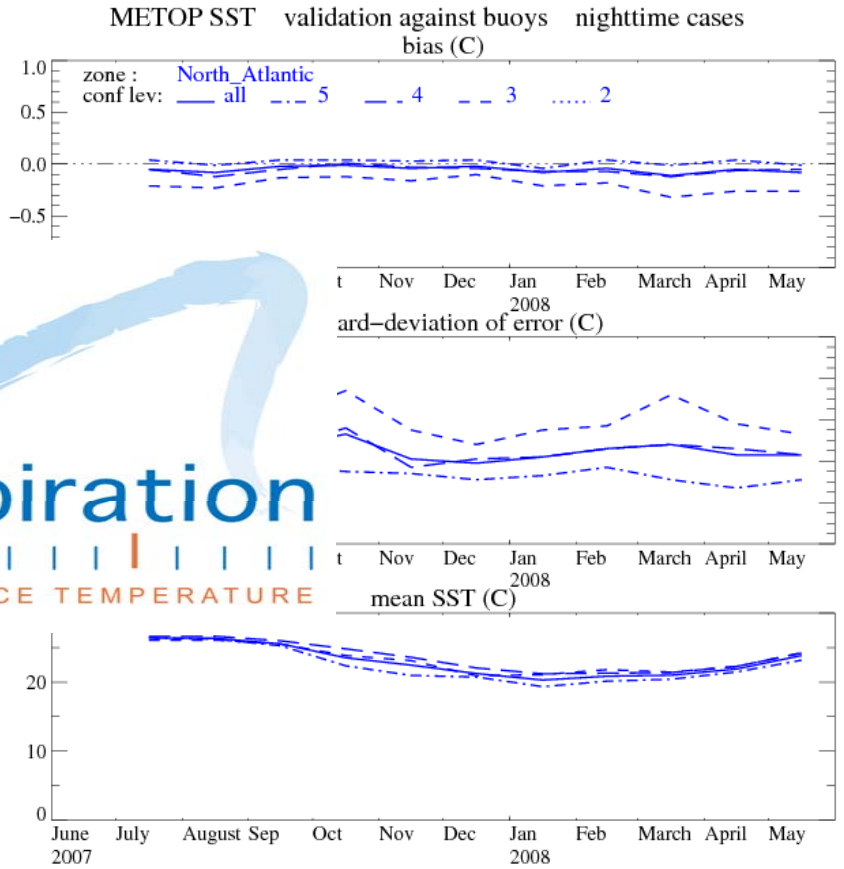
METOP: Uncertainty estimates



Areas used to calculate uncertainty statistics

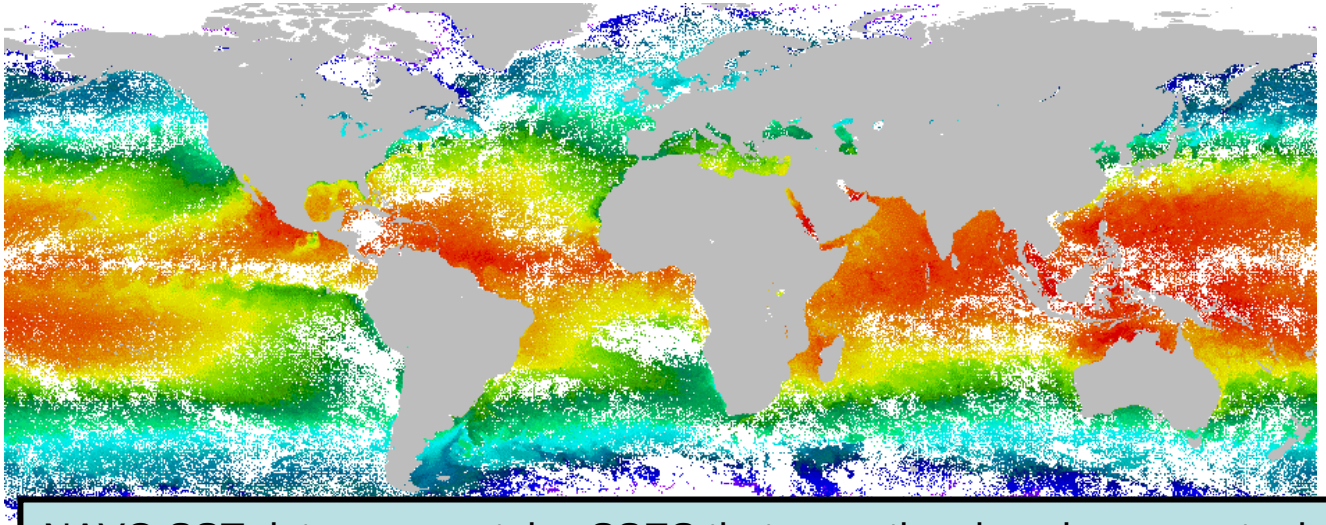
OSI-SAF teams leading the dis
Derivation of single sensor err

Excellent progress and results for METOP!



Example METOP SSES for South Pacific and North Atlantic

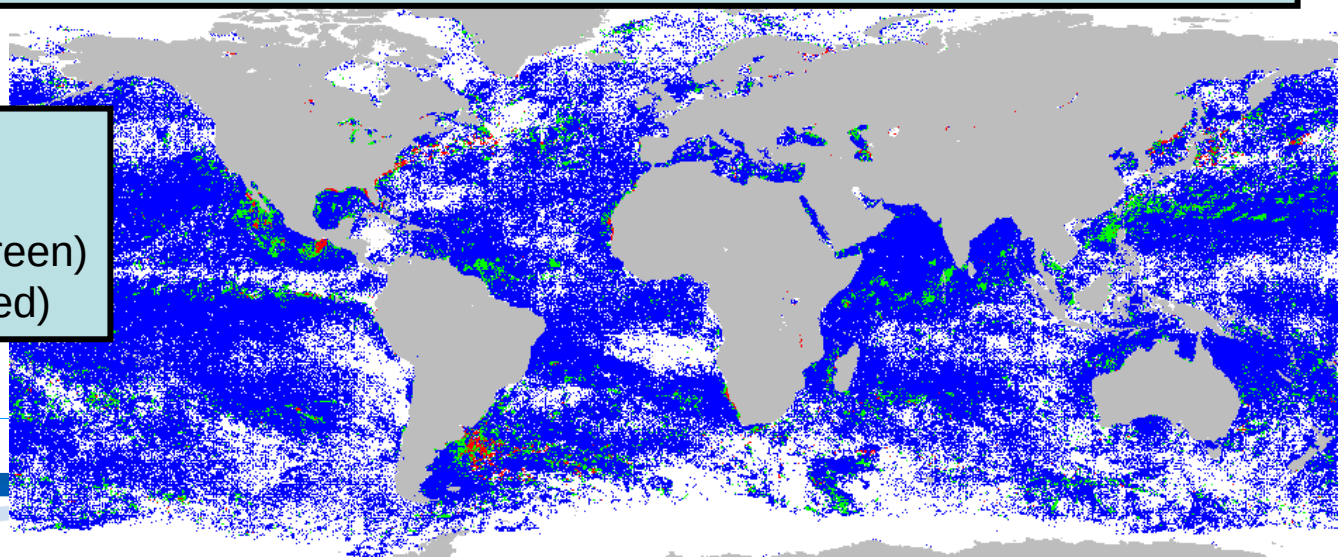
Collaborative Development of the Single Sensor Error Statistics (SSES)



MetOp-A Global SST retrievals

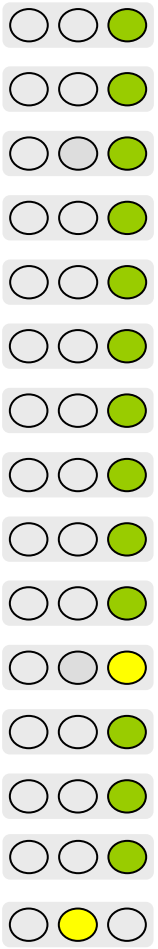
NAVO SST data now contains SSES that operational analyses use to determine assimilation weights

MetOp-A SST SSES
97% are clear (blue)
2.5% are probably clear (green)
0.5% are questionable (red)



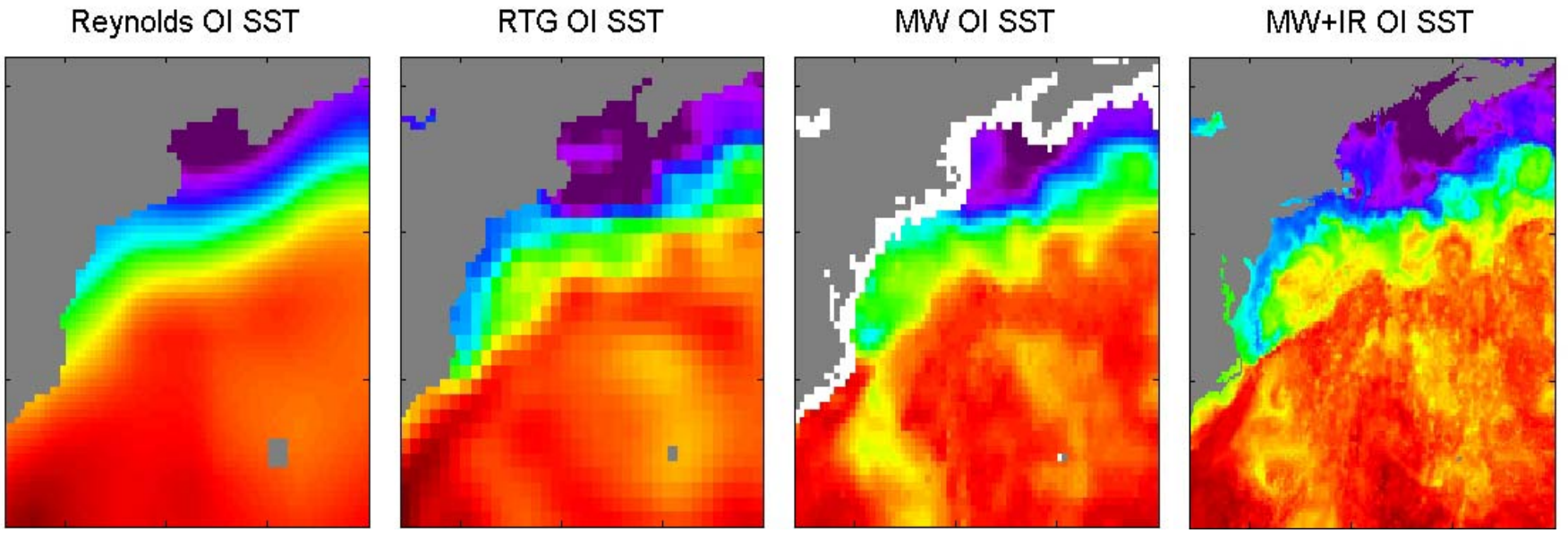
GHRSST L2P system status (Nov 2008)

- AVHRR `LAC (1km)
- AVHRR GAC (4km)
- AMSRE (JAXA)
- AVHRR BoM
- Aqua MODIS global
- Terra MODIS global
- AATSR global
- MSG-SEVIRI
- GOES-E
- GOES-W MT-SAT
- AMSRE (RSS)
- TMI (RSS)
- METOP AVHRR (global)
- WindSat



Plans to use data in GHRSST-PP
A GHRSST data set is in progress
Operational within R/GTS

Gulf Stream Analyzed SSTs



Access to more SST observations should lead to: increased resolution, accuracy, stability

Should lead to better NWP, hurricane prediction, ocean modeling, air-sea interaction studies, research

BOM Global Australian Multi-Sensor SST Analysis System

BLUElink
Ocean Forecasting Australia

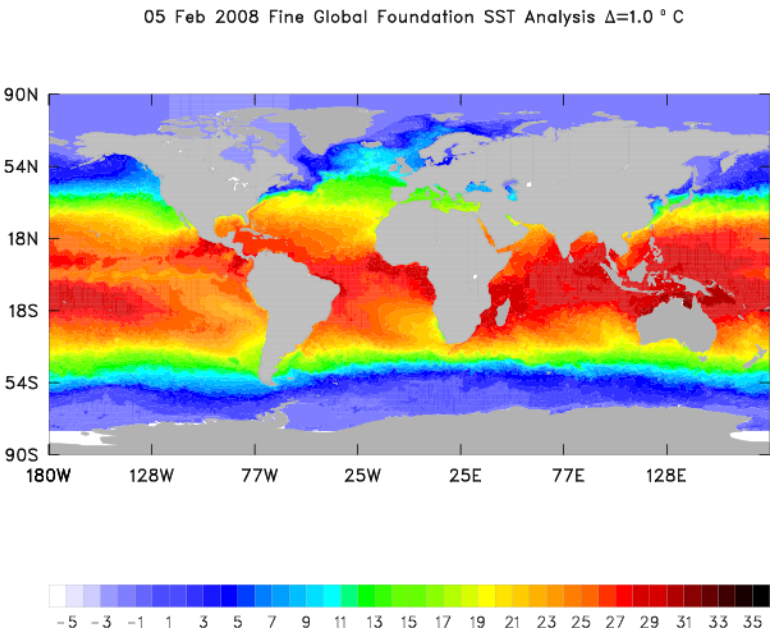
Operational: 2 October 2008

Resolution: Daily, 1/4°

Estimate foundation SST by removing all observations for

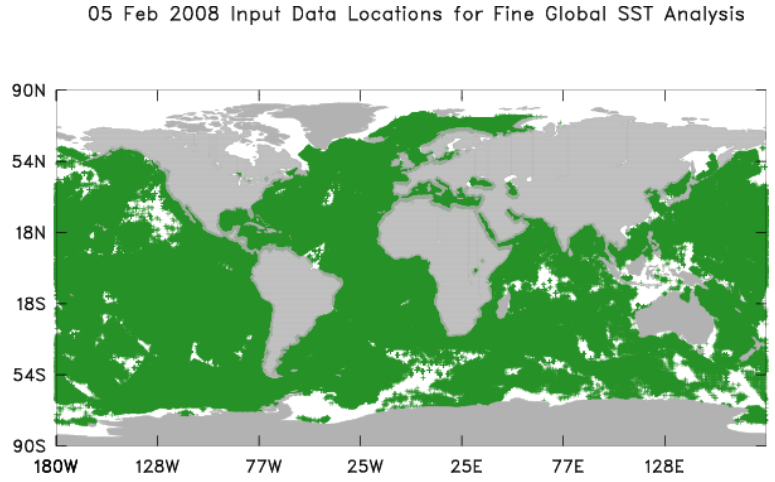
daytime winds < 6 m/s

night-time winds < 2 m/s

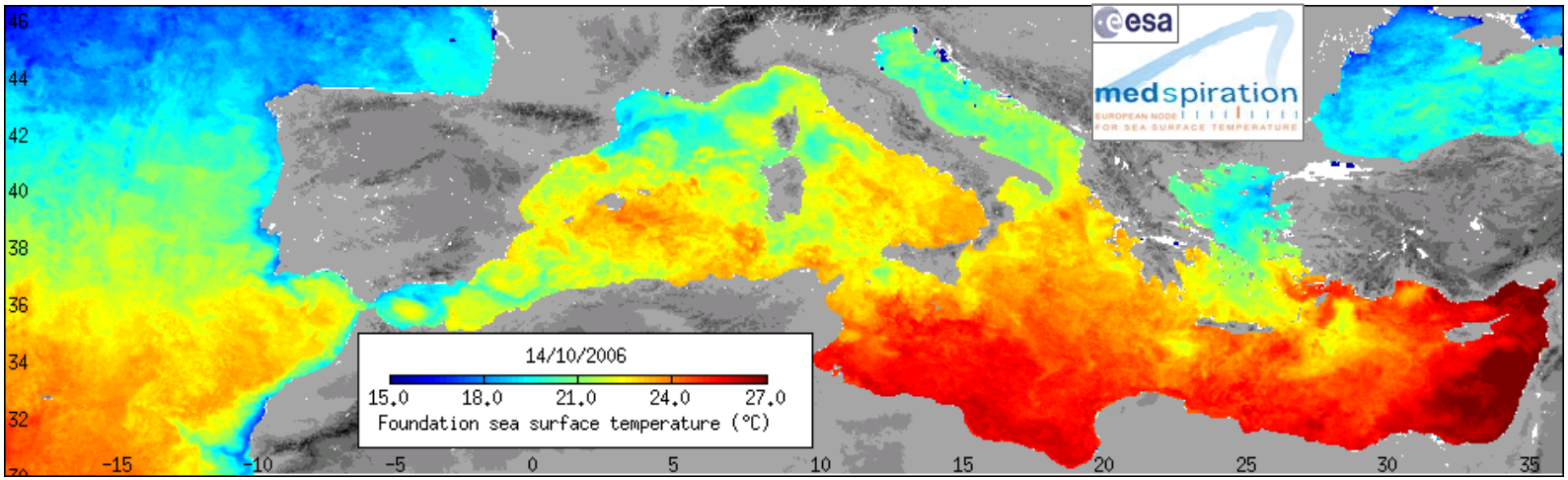


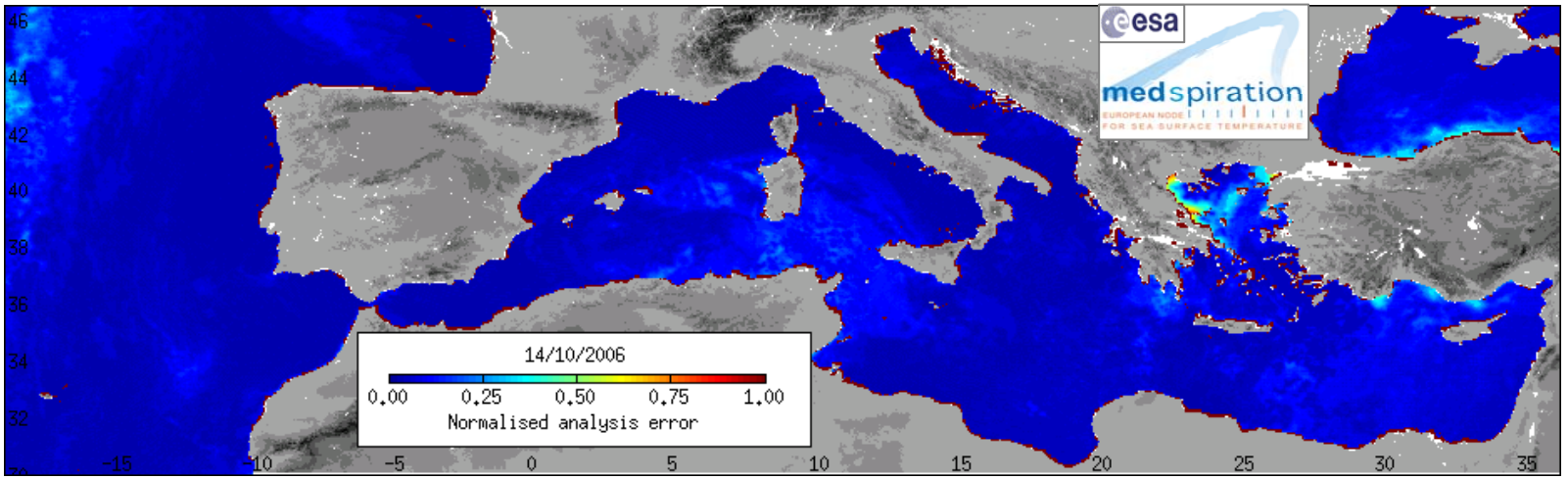
Data Inputs:

- 9 km NAVOCEANO GAC AVHRR (NOAA-17, -18, METOP-A) **L2P**
- 25 km AMSR-E (Aqua) **L2P**
- 1/6° AATSR (EnviSat)
- Buoy and ship obs (GTS)
- 1/12° NCEP ice edge analyses



14/10/2006, ESA Medspiration L4 2km Mediterranean

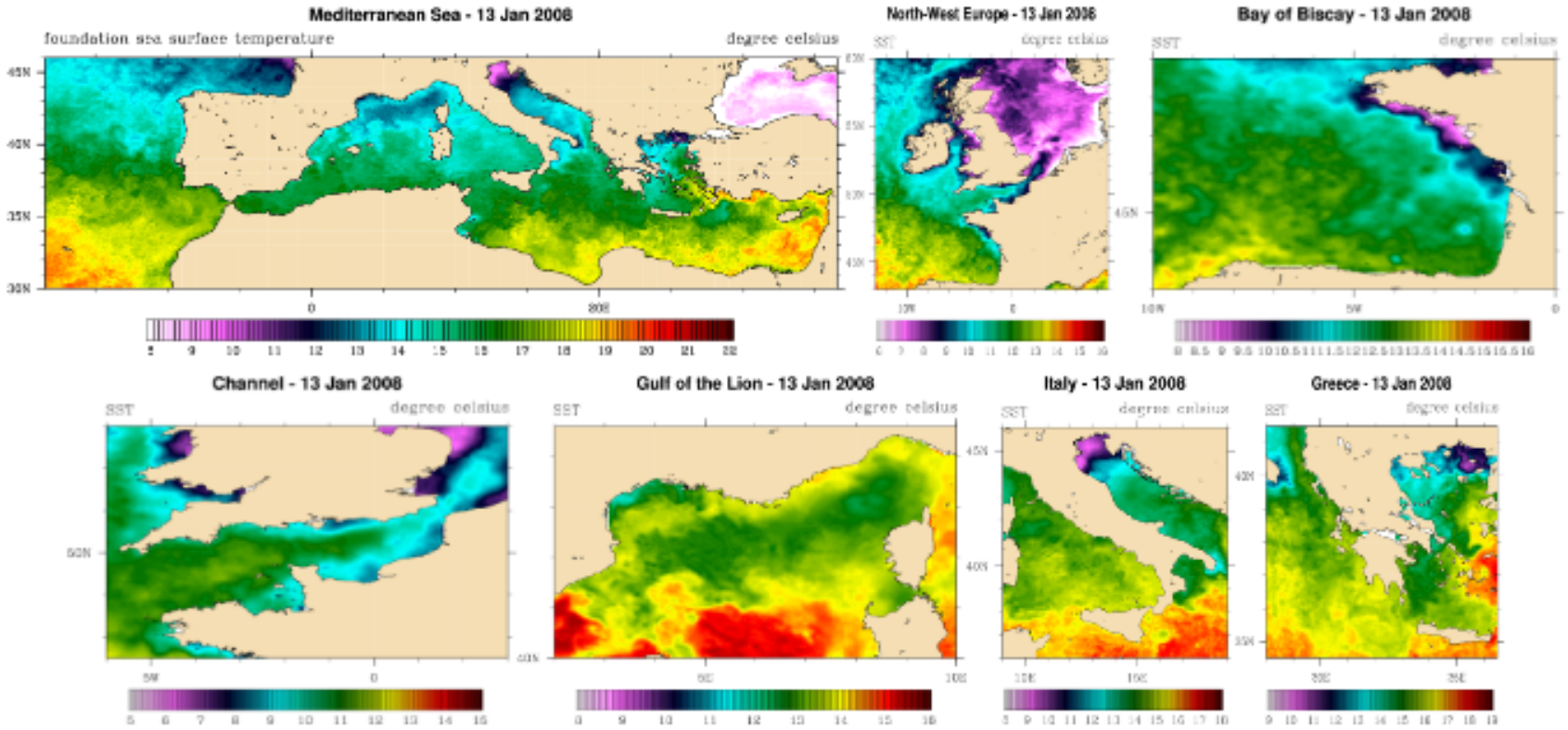




http://www.medspiration.org

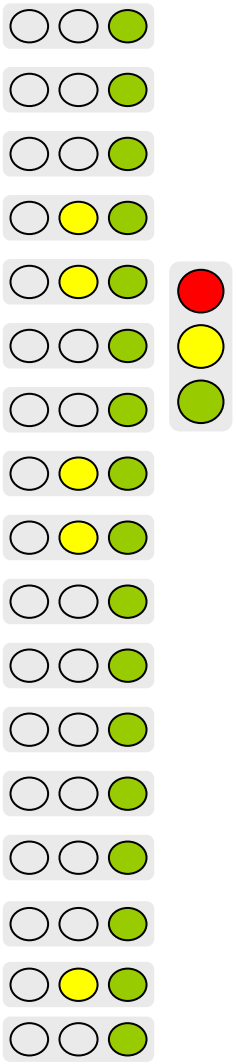
Medspiration L4 Domains

- Processed with the IFREMER ODYSSEA system



GHRSST L4 system status (Nov 2008)

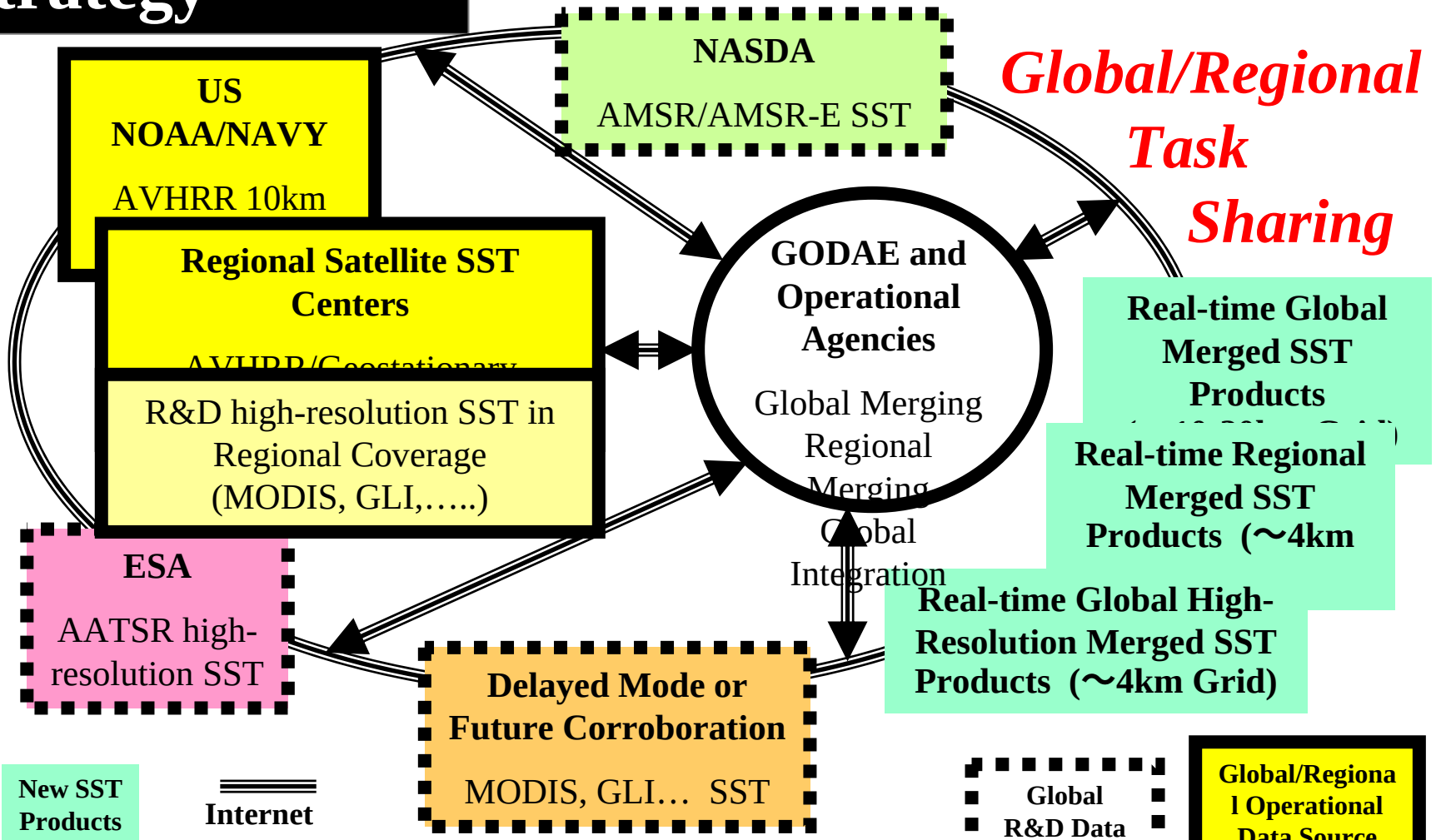
- Reynolds HR OI (GHRSST-PP L4)
- Met Office OSTIA (global)
- MISST MWOI (global)
- Navy FNMOC SST&SI (global)
- BLUElink (GAMSSA global)
- BLUElink (RAMSSA Australia)
- Medspiration (Med+Atl. Shelf)
- JMA MGDSST (global)
- NGSST (Japan regional)
- EU MERSEA (global)
- NAVOCEANO K10 (AVHRR Obs.)
- OSI-SAF HL Sea Ice Concentration
- DMI Regional (NSea/Baltic)
- GOS (CNR) Regional (Med)
- Medspiration Galapagos/Amazon
- Medsp. Great Barrier Reef
- MERSEA ODYSSEA

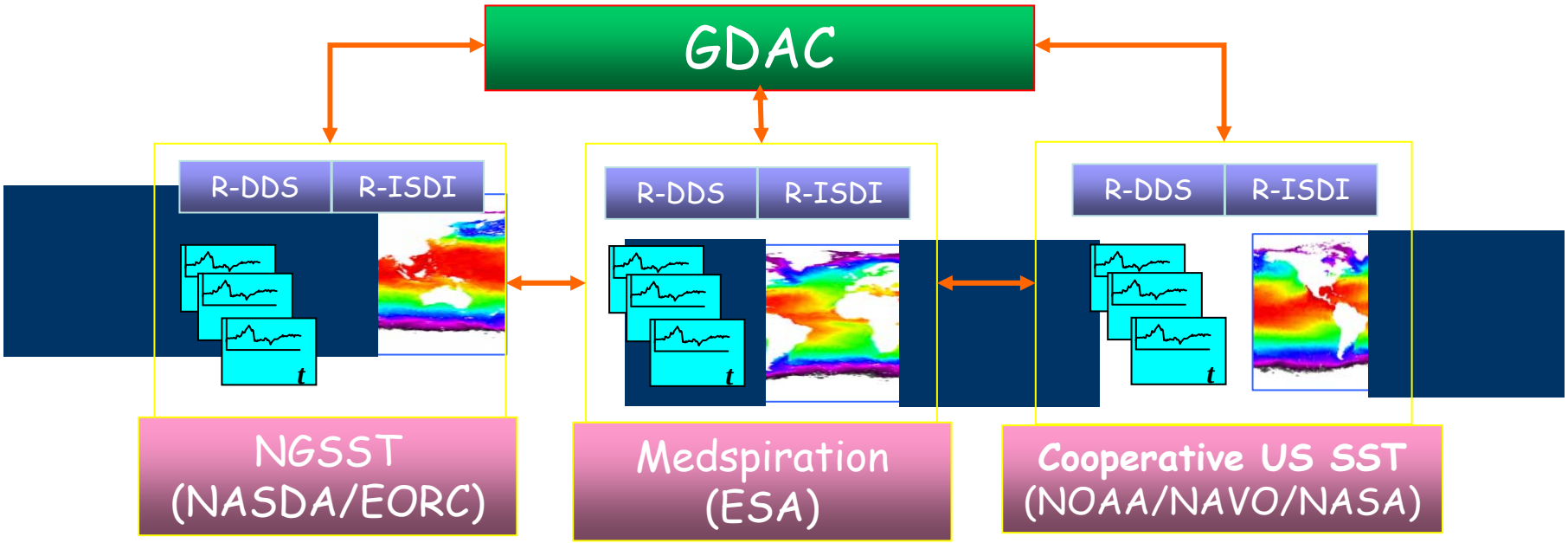


Plans to use data in GHRSST-PP
A GHRSST data set is in progress
Operational within R/GTS

Red shows systems using Medspiration data products

GHRSST-PP Implementation Strategy



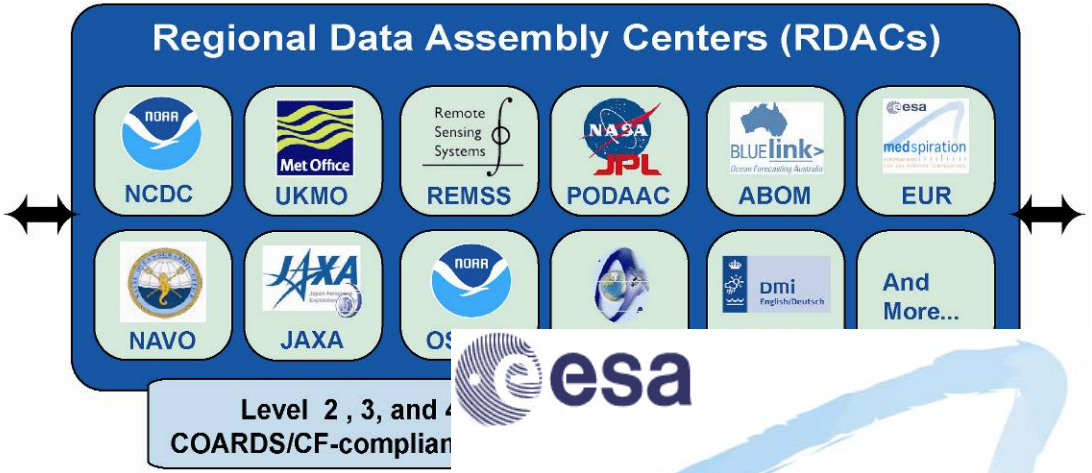


The regional projects will implement the RDAC and feed the GDAC providing:

- o Regional data merging and analysis
- o Regional error statistic generation
- o Regional DDS data extraction
- o Regional product validation
- o Regional user application feedback

GHRSST-PP Regional/Global Task Sharing Framework

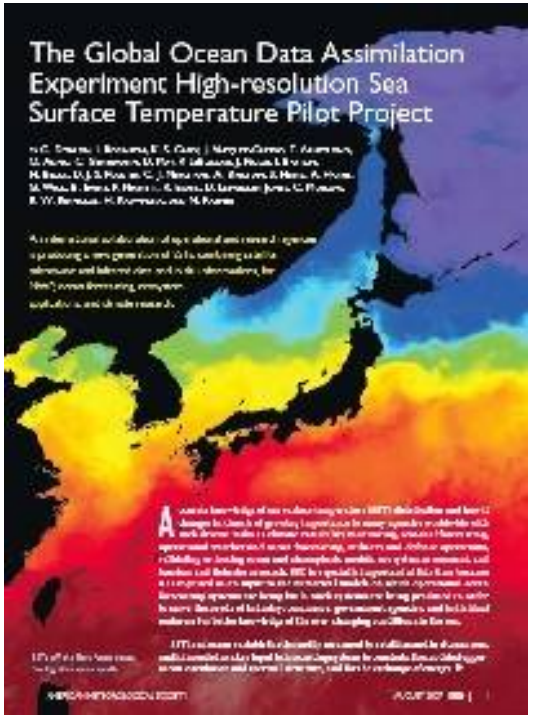
GODAE High Resolution Sea Surface Temperature Pilot Project



esa

medspiration

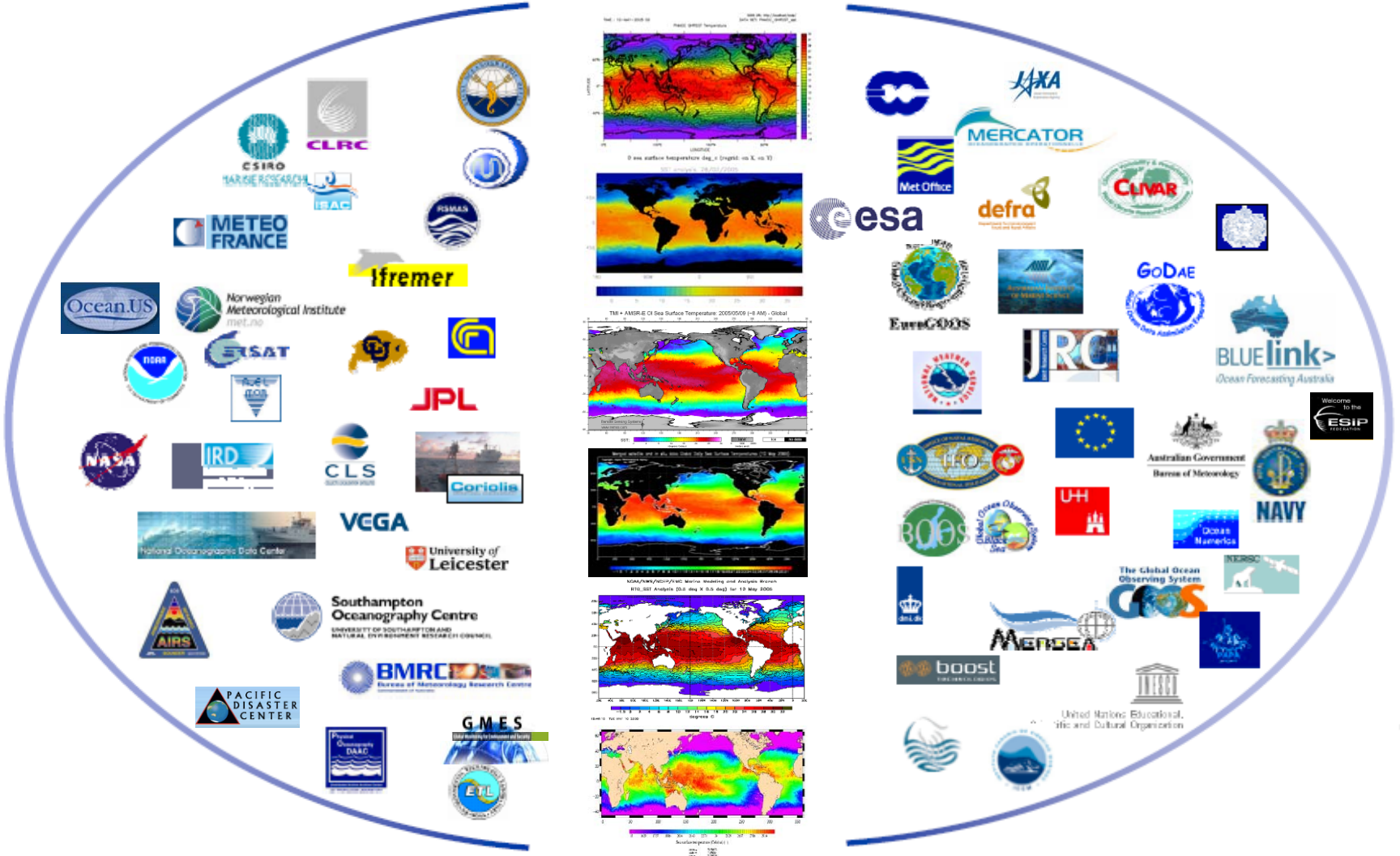
EUROPEAN NODE FOR SEA SURFACE TEMPERATURE



Donlon *et al*, 2007, BAMS, **88**, 1197–1213.

ww.ghrsst-pp.org

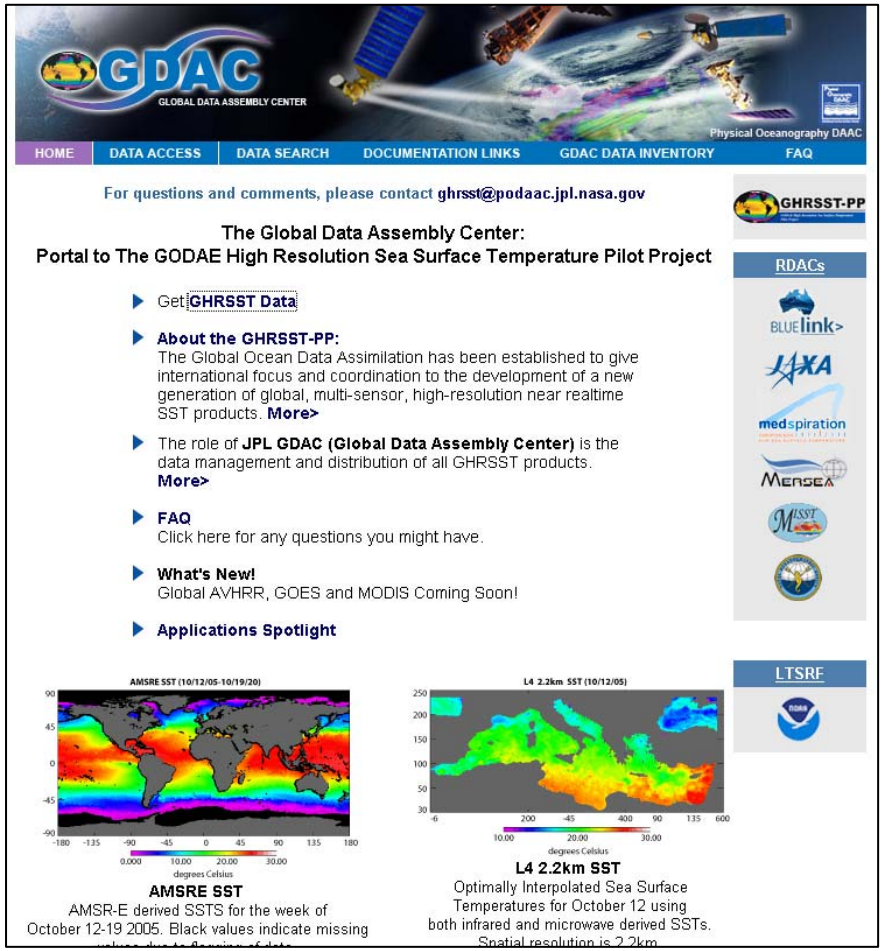
$28 Million invested by the international GHRSST-PP community

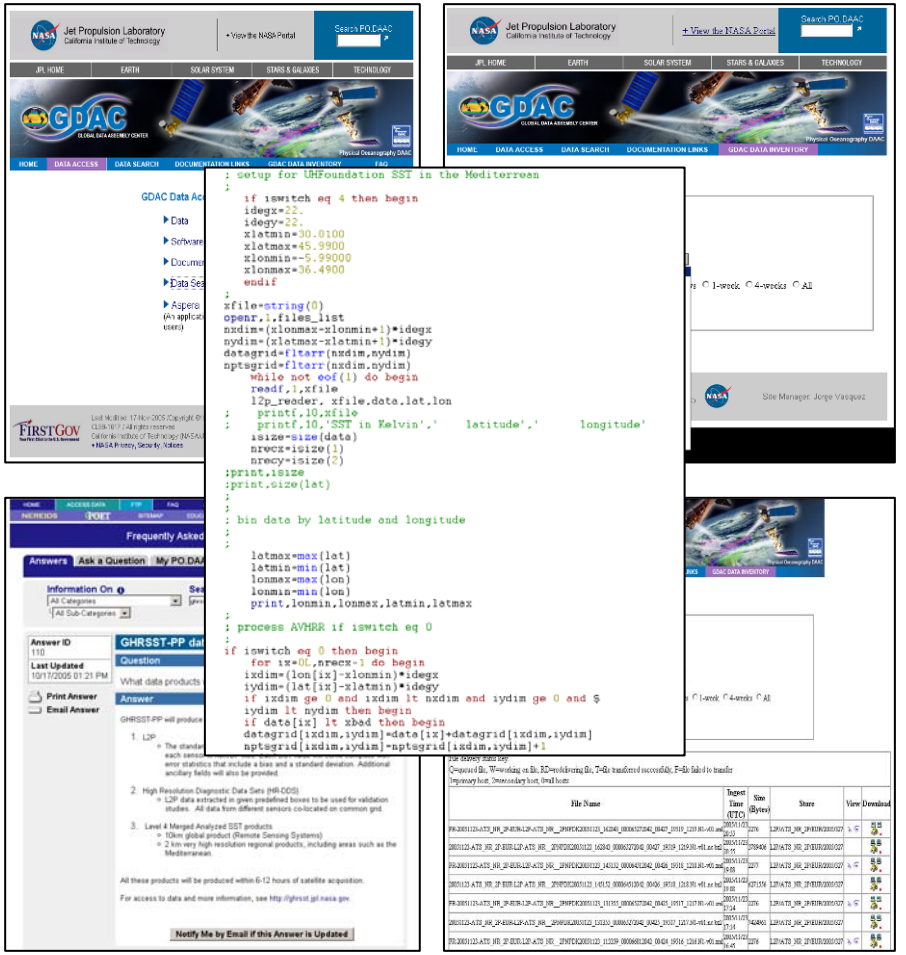


GHRSST
Group for High Resolution Sea Surface Temperature

http://www.ghrsst-pp.org

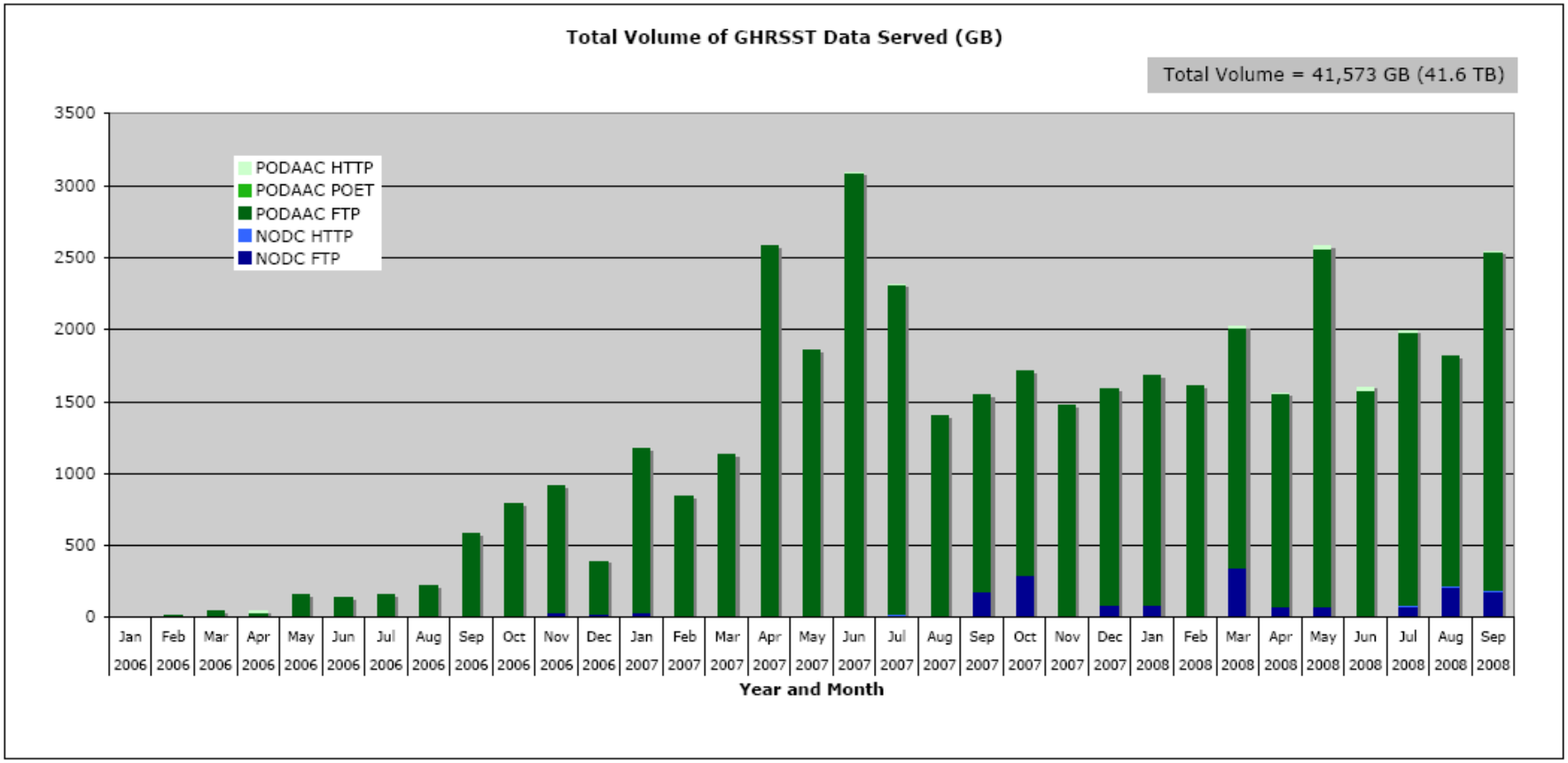
GHRSST-PP Global Data Services





- http://gdac.jpl.nasa.gov

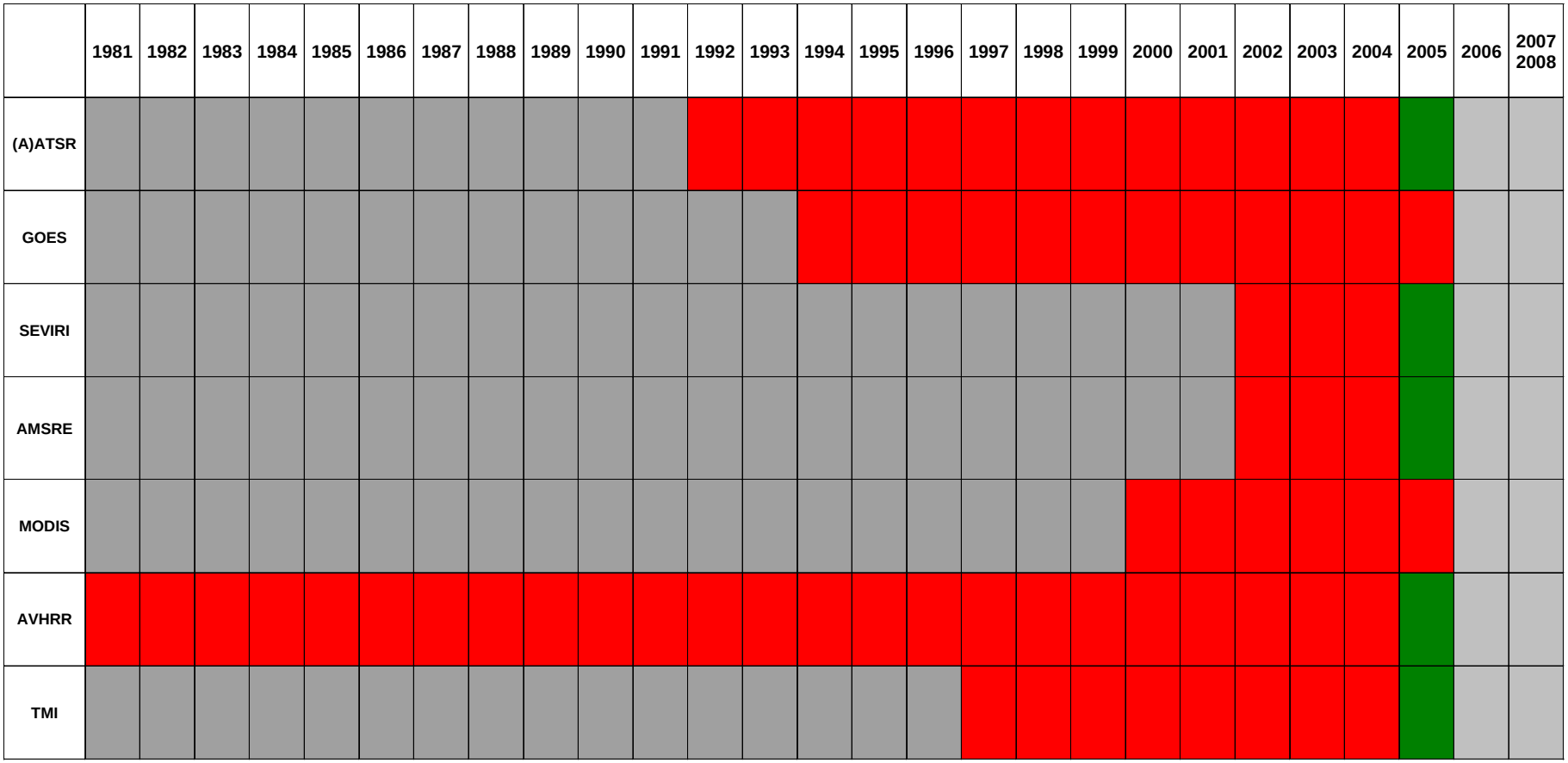
User numbers and data volumes…



Total archive now exceeds 16Tb from 1981 to present

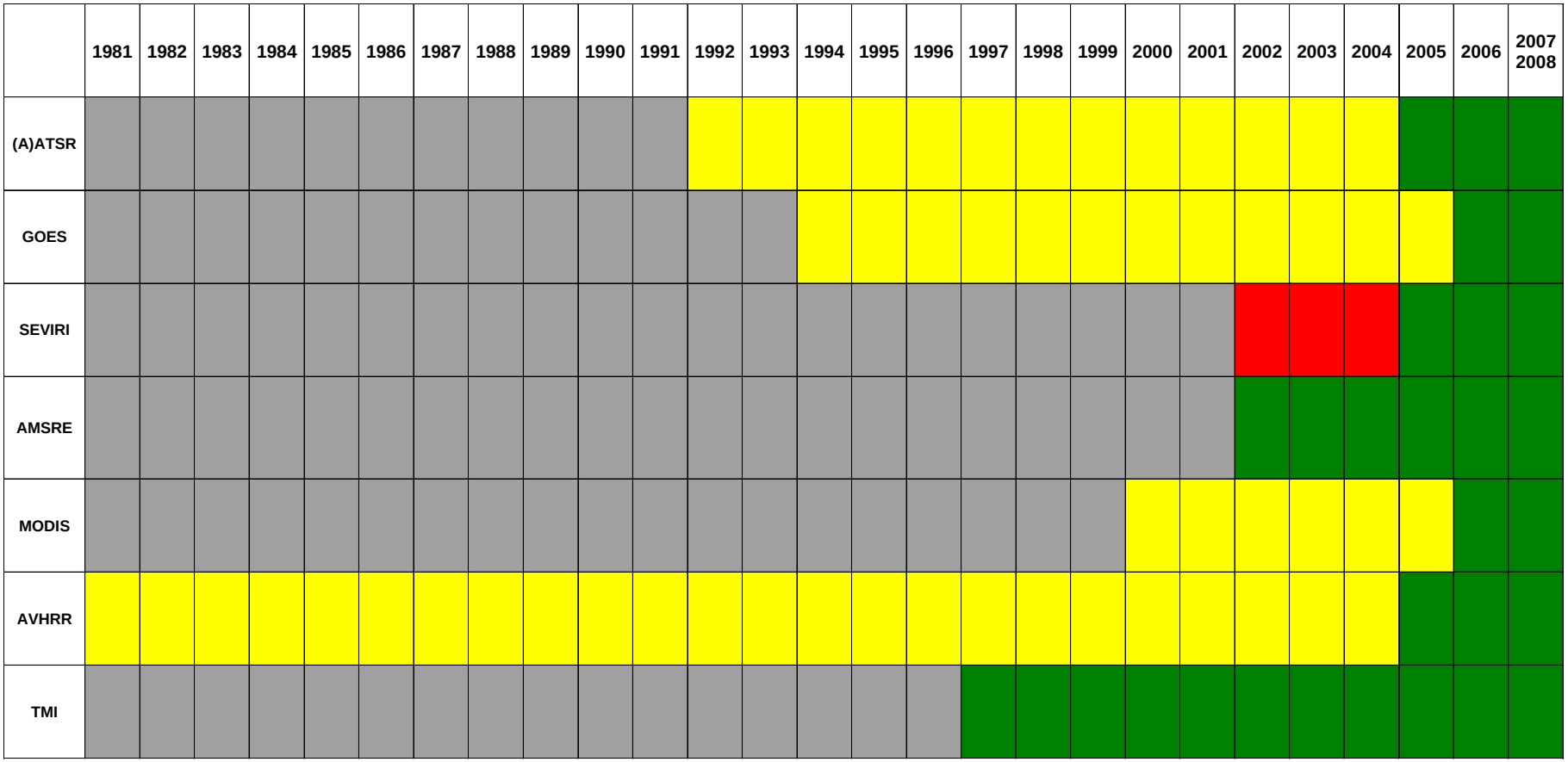
GDAC is at http://ghrsst.jpl.nasa.gov
LTSRF is at http://ghrsst.nodc.noaa.gov

Reanalysis Datasets - Start of GHRSST



Sensor not in operation or capable of SST observations	
No plans yet for GHRSST L2P	
Efforts underway or proposed for GHRSST L2P	
Data available in GHRSST L2P	

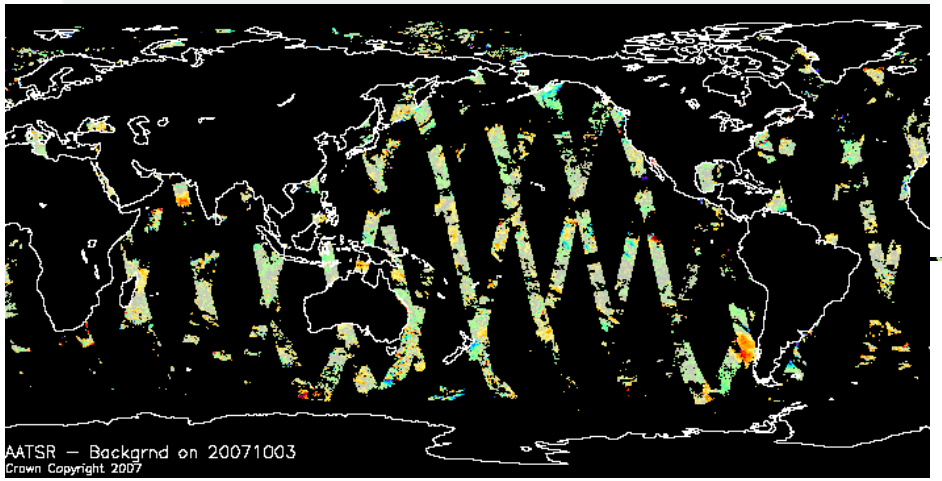
Reanalysis Datasets - November 2008



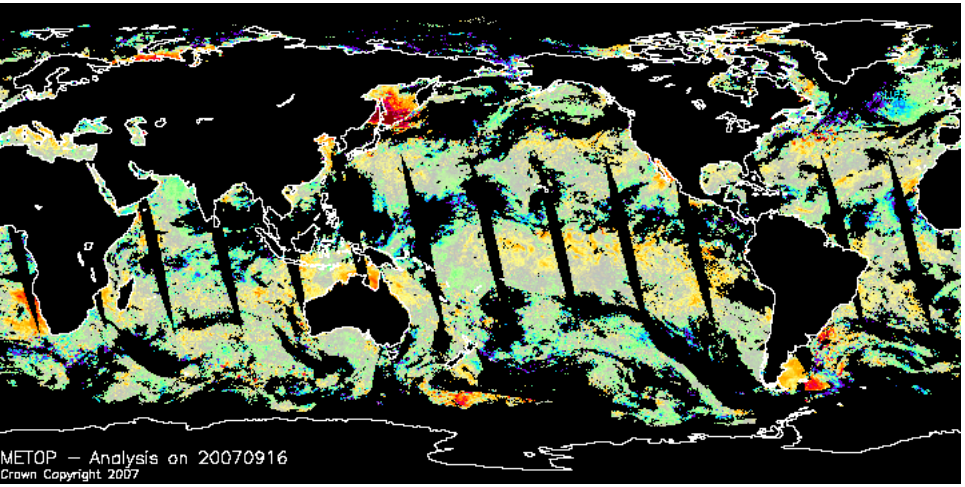
Sensor not in operation or capable of SST observations	
No plans yet for GHRSST L2P	
Efforts underway or proposed for GHRSST L2P	
Data available in GHRSST L2P	

Testing Data Sources and Diagnostic Data Sets (DDS)

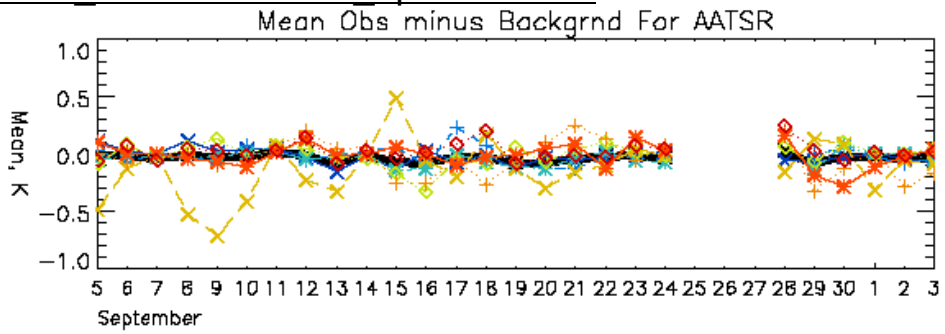
See http://ghrsst-pp.metoffice.com/pages/latest_analysis/sst_monitor/monitor_op/index.html

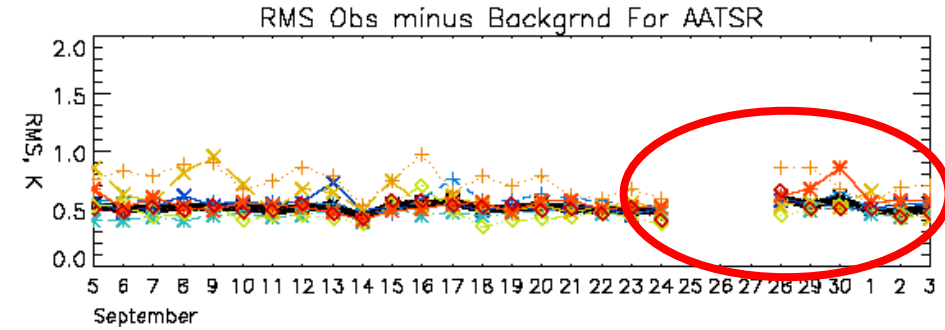


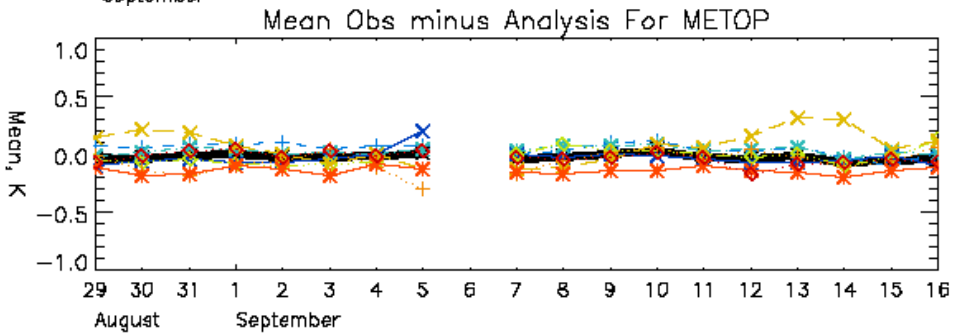
AATSR

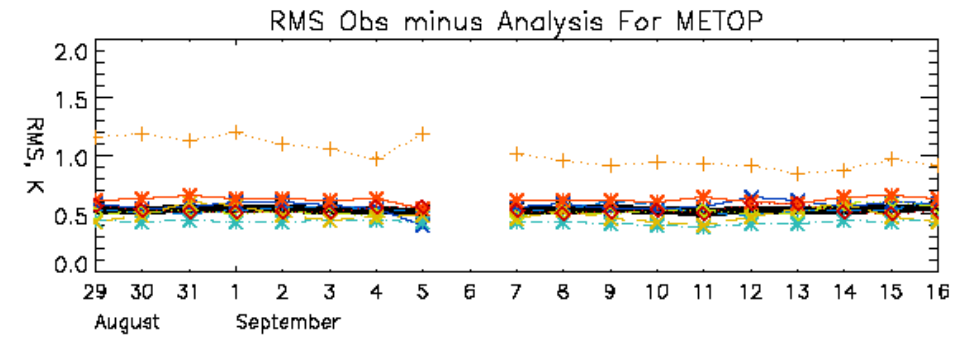


MetOP-A







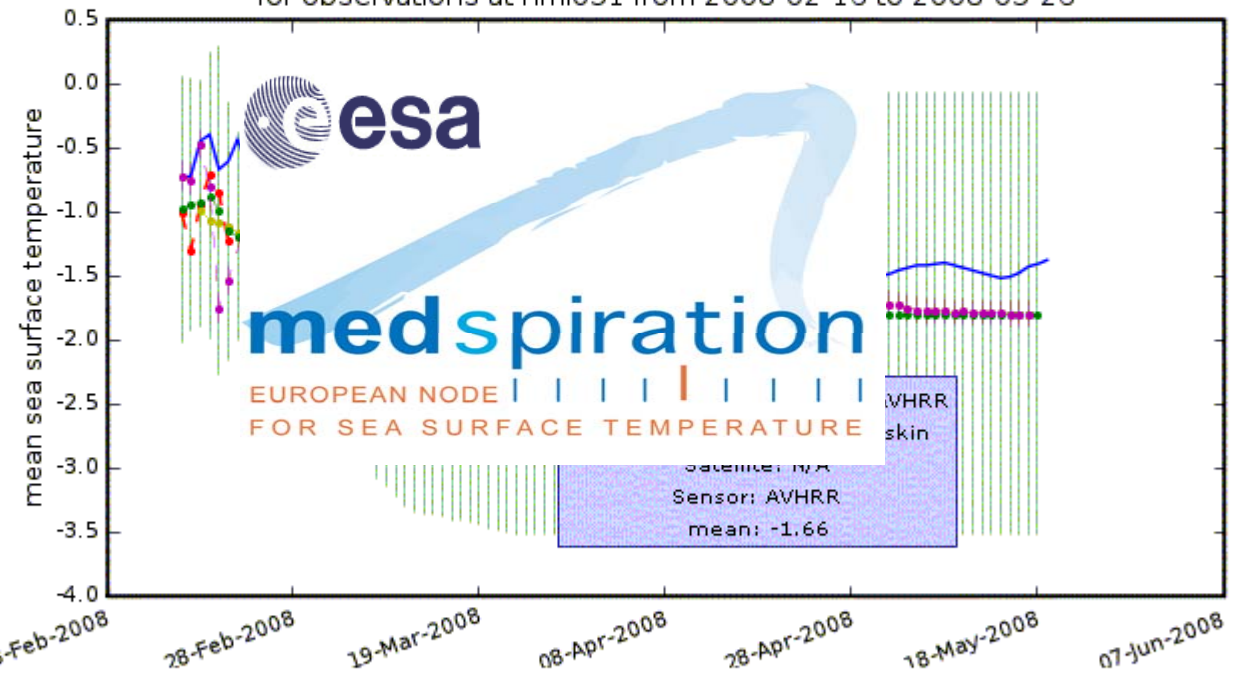


Interactive SST results for site nmi051

Site nmi051 (Metno_Weddell_Sea_South): Centered on (-70° N, -30° E), 3° by 3&deg.

<- 1 Year-> <- 1 Month-> <- 1 Day->

Plot of the mean centre_best values of sea surface temperature
for observations at nmi051 from 2008-02-16 to 2008-05-26

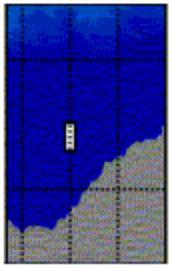


Please click here for a legend of observations, here for a legend of other product types and here for a detailed legend.

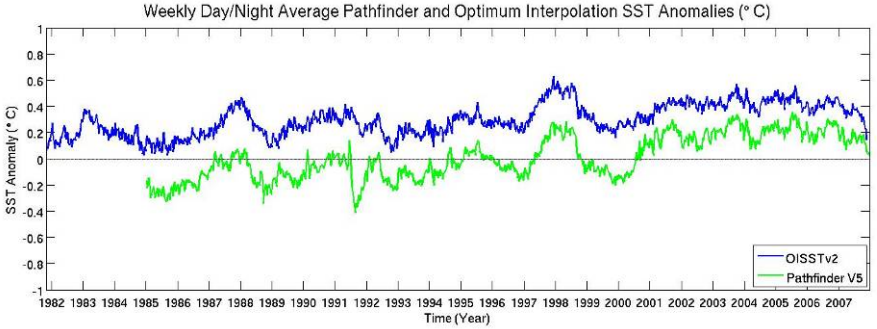
Select y-axis maximum [auto], an y-axis minimum [auto] and a minimum valid data percentage [5]
Note: Please enter no units for the above entries.

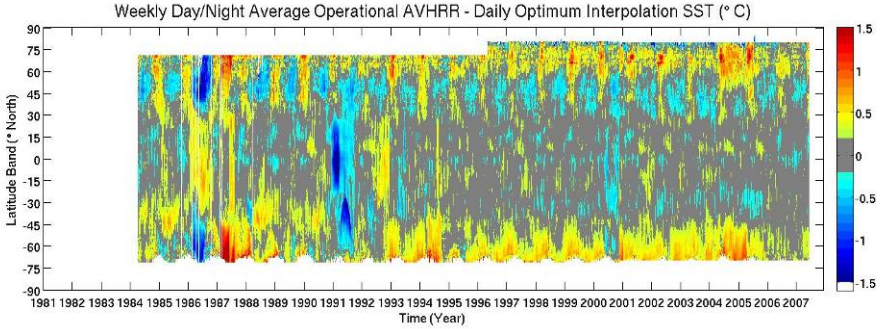
Parameter Type	Statistical Operator	Coverage and Quality
sea surface temperature	mean	centre area and best quality

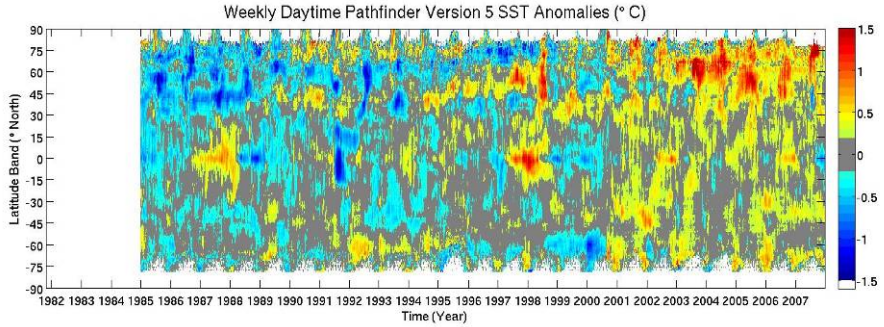
Site map:

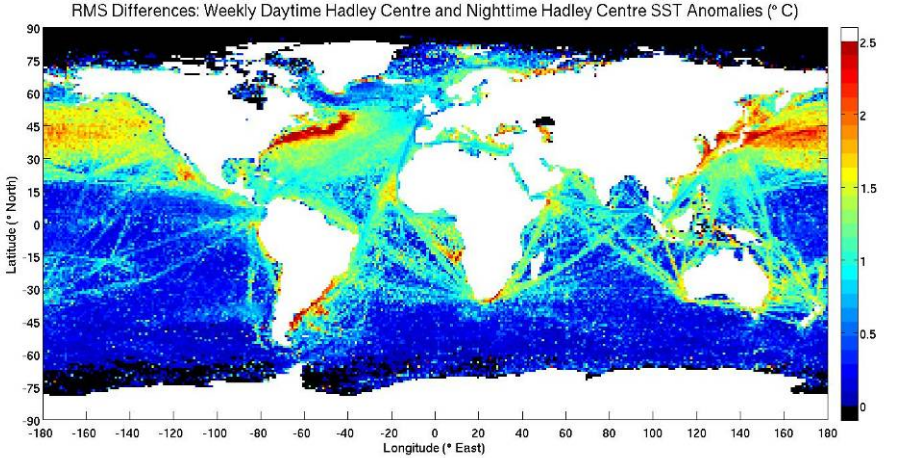


GCOS/GHRSST time series extensive inter-comparisons









http://ghrsst.nodc.noaa.gov/intercomp.html

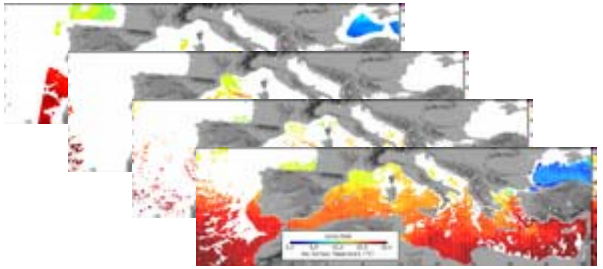
Inter-comparison

Goldilocks & the 3 Bears

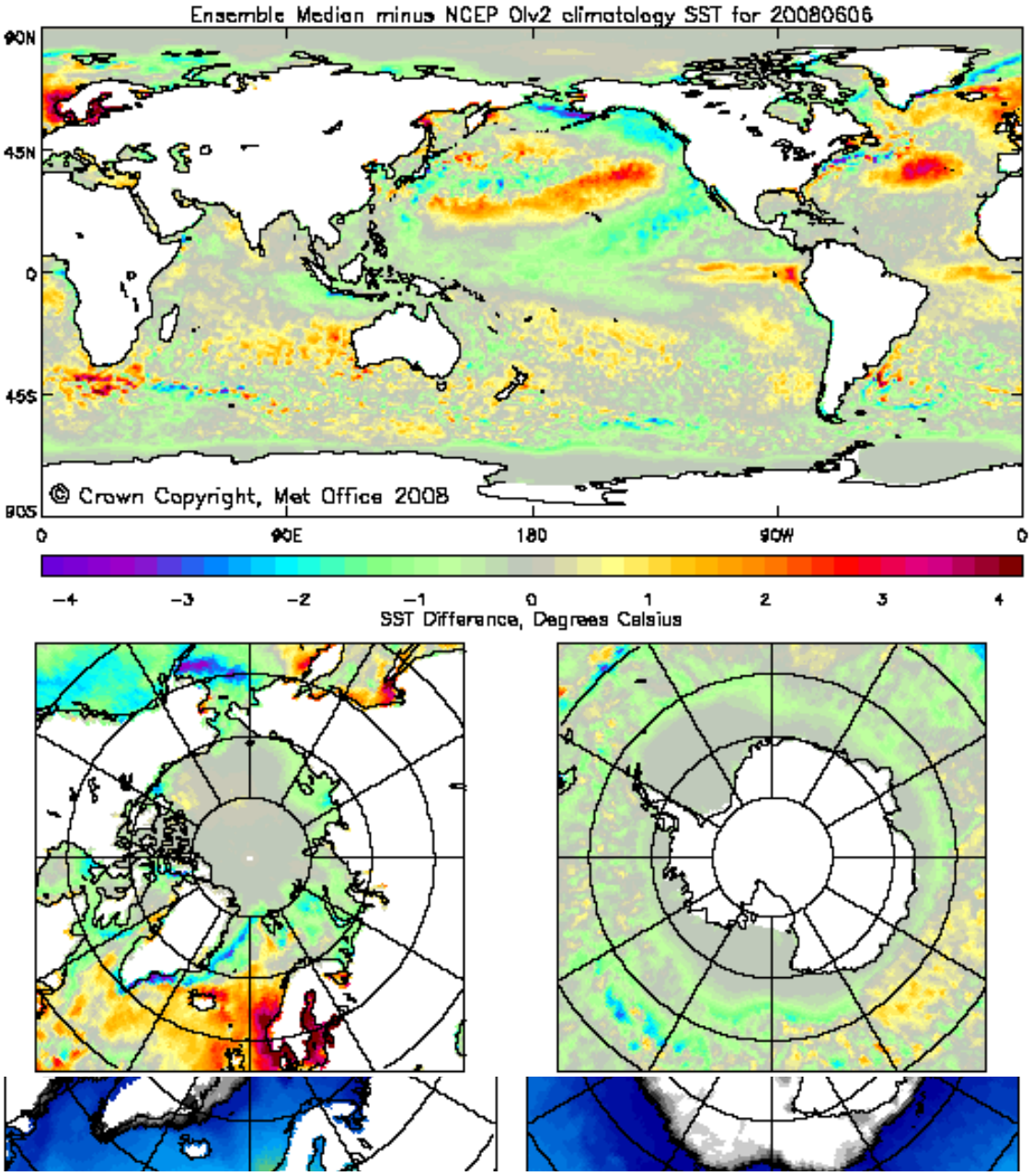
Need to help users find the SST analysis that "is just right"

Medspiration L4 Validation

Observations used in L4



Anomaly Observations used



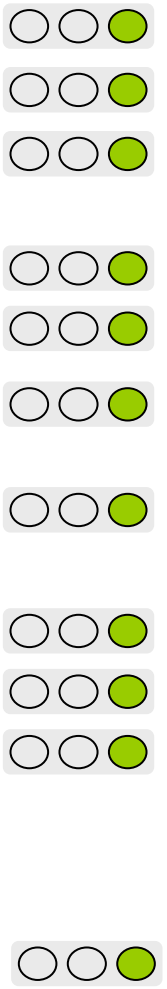
GHRSST-PP Multi-Product Median Ensemble (GMPE) Computed using:

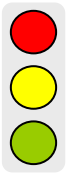
Met Office OSTIA SST
NCEP RTG_SST_HR SST
NAVOCEANO NAVO K10 SST
JMA MGDSST SST analysis
RSS RSS MW Fusion SST analysis
RSS RSS MW+IR Fusion SST
FNMOC GHRSST-PP SST
MERSEA ODYSSEA SST
Canadian Met. Centre (CMC)
NOAA AVHRR OI (Reynolds)

http://ghrsst-pp.metoffice.com/pages/latest_analysis/sst_monitor/daily/ens/index.html

GMPE system status (Nov 2008)

- Met Office OSTIA SST analysis
- NCEP RTG_SST_HR SST analysis
- NAVOCEANO NAVO K10 SST observations
- JMA MGDSST SST analysis
- RSS RSS MW Fusion SST analysis
- RSS RSS MW+IR Fusion SST analysis
- FNMOC GHRSST-PP SST and sea Ice analysis
- MERSEA ODYSSEA SST analysis
- NOAA AVHRR OI (Reynolds).
- Meterological Service of Canada (CMC) 1/3 degree SST analysis courtesy of Bruce Brasnett @ CMC.
- NOAA AVHRR OI (Reynolds).





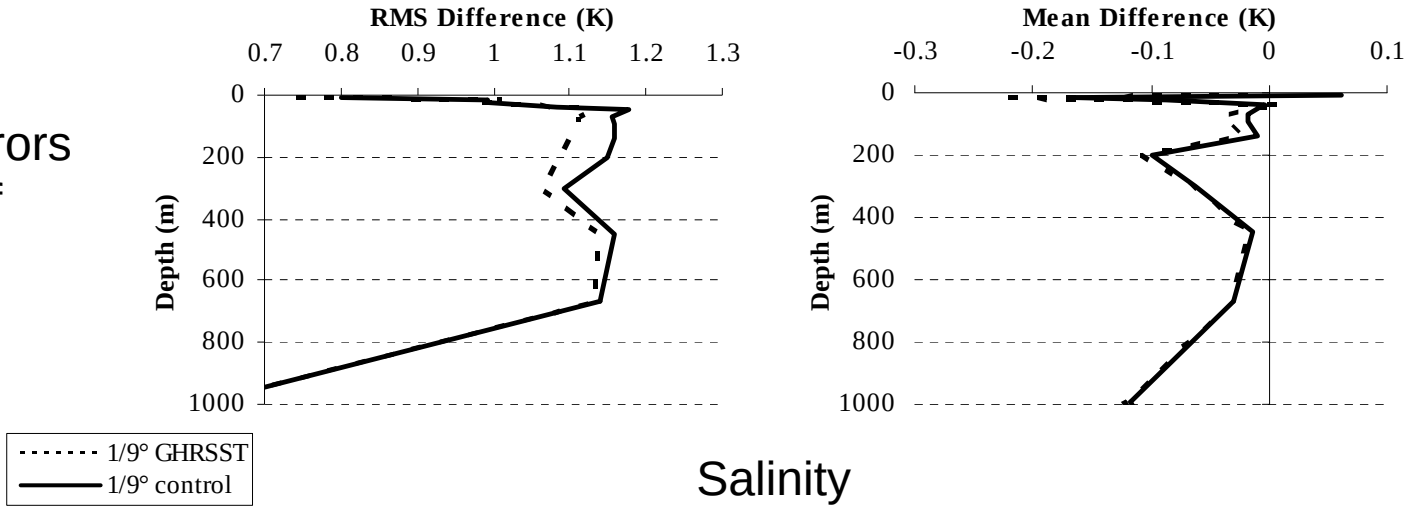
Plans to use data in GHRSST-PP
A GHRSST data set is in progress
Operational within R/GTS

Data Assimilation

Impact of GHRSST in FOAM 1/9° - comparison with profile data

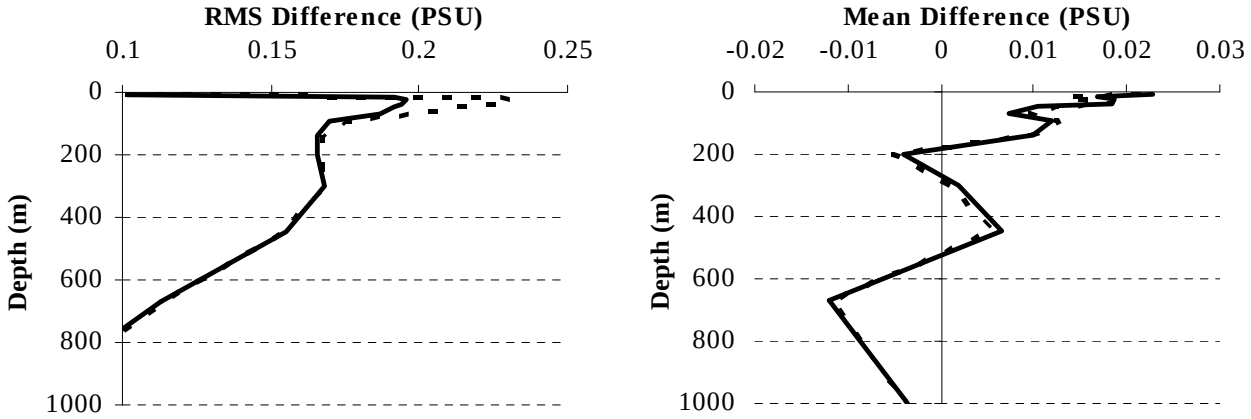
- GHRSST data reduces the RMS errors over the top 600m of ocean, with little change in the bias

Temperature



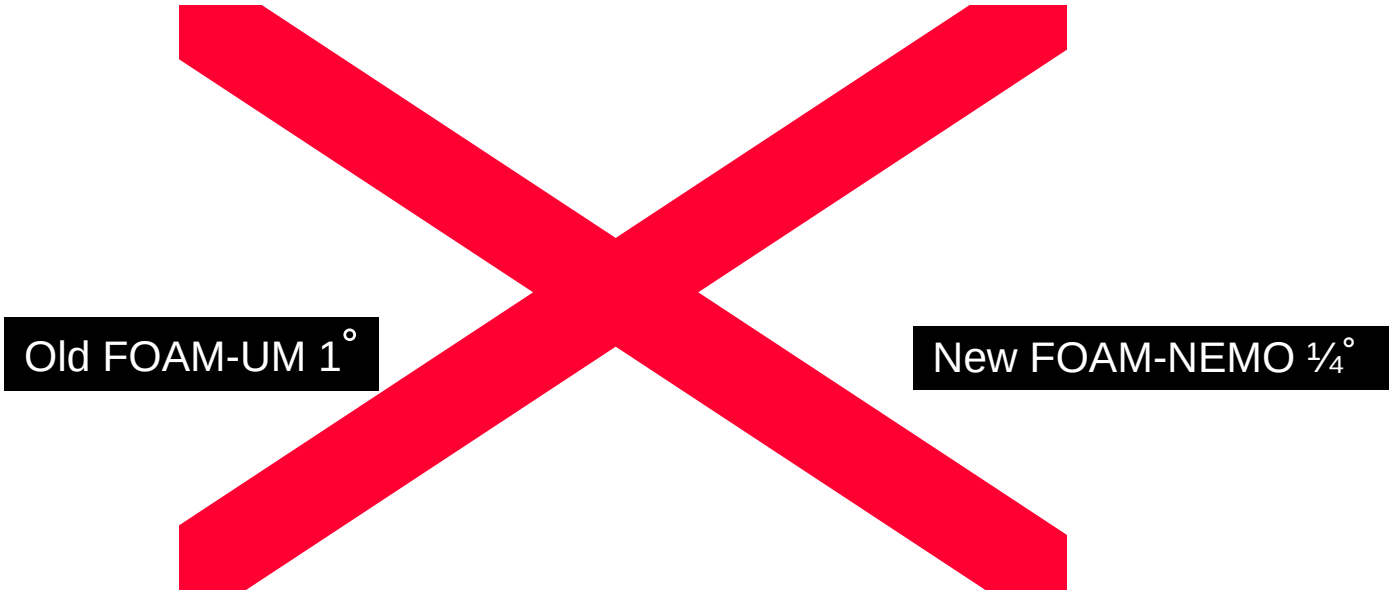
- Near-surface salinity errors increased, particularly in NW Atlantic
- Reason for this is unclear at present – impact on stability?

Salinity

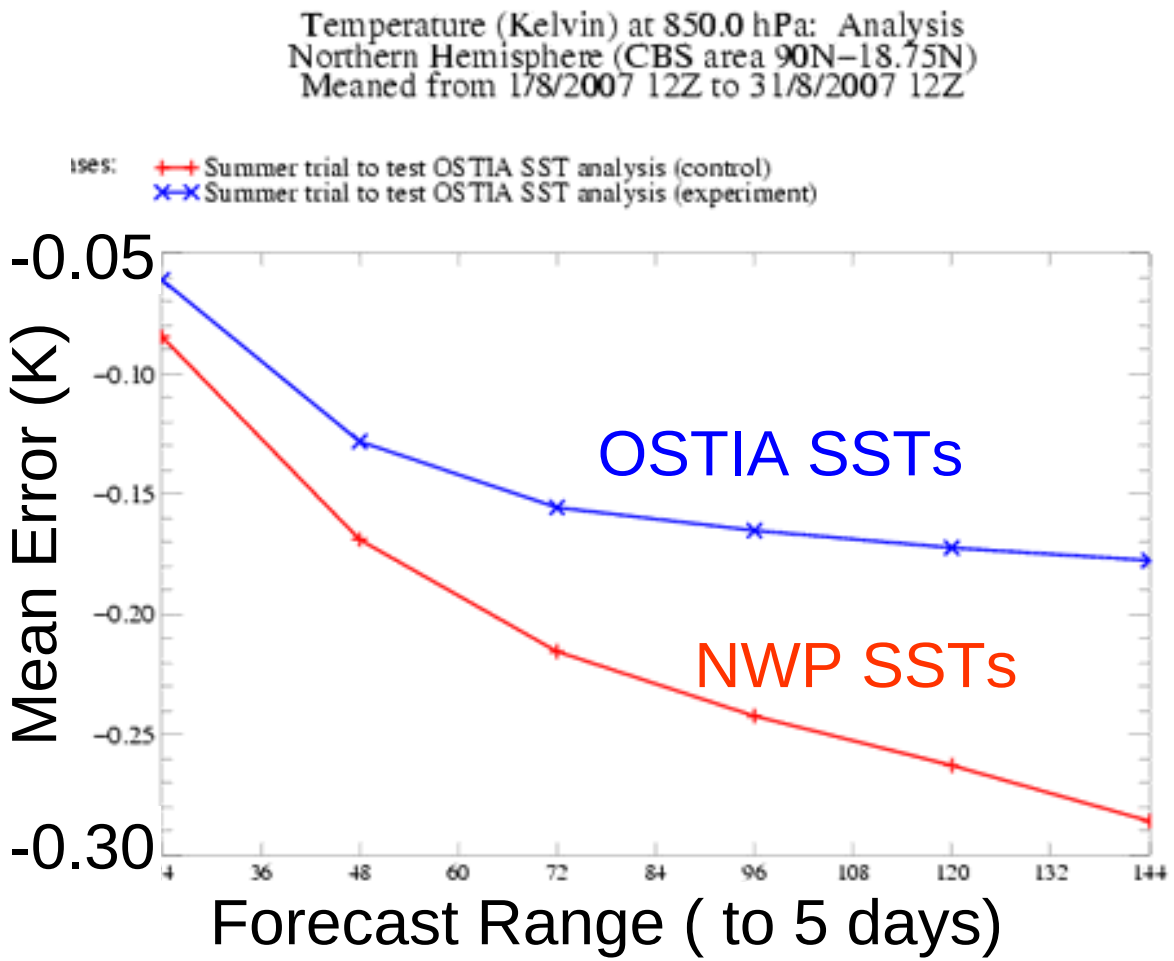


Animations of SST: July – September 2005

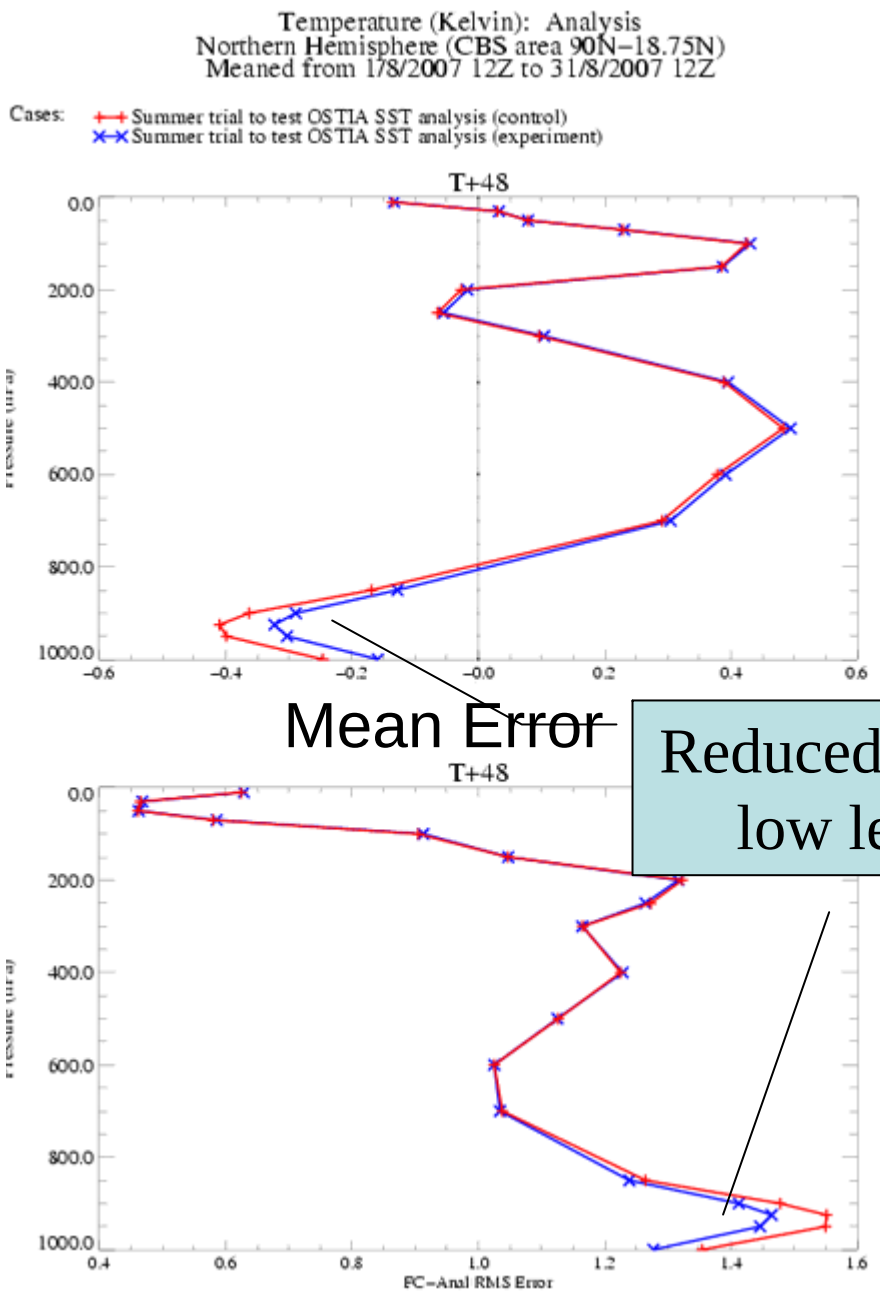
(Matt Martin, Met Office)



Met Office: August 2007 NWP Trial Results



- OSTIA SSTs substantially reduced the negative bias seen with NWP SSTs at 850hPa.



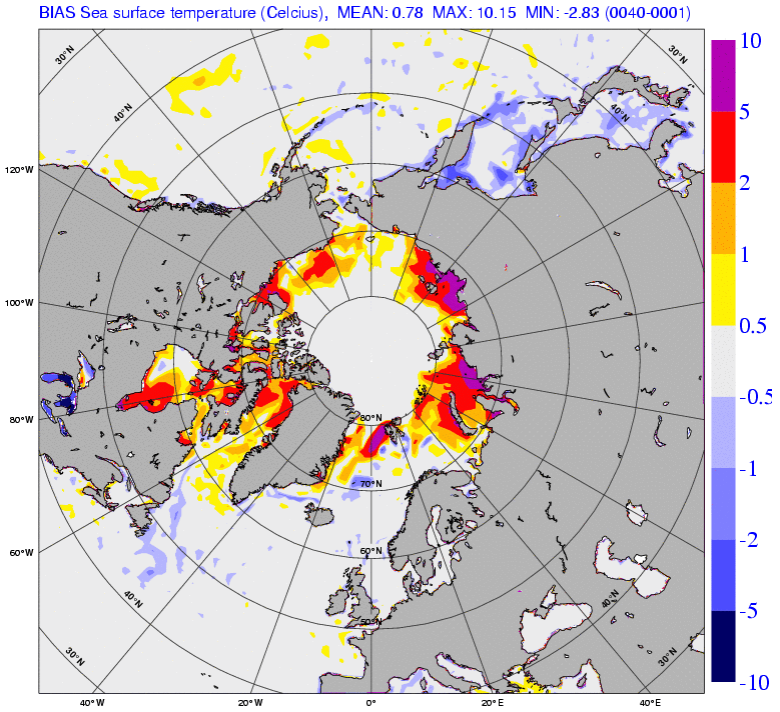
Reduced Bias at low levels

- OSTIA improved the RMS and bias in the NWP forecasts during the trial period.

GHRSST / OSTIA at ECMWF

OPER / NCEP SST
- **RTG SST**
- **0.5 x 0.5 degrees**

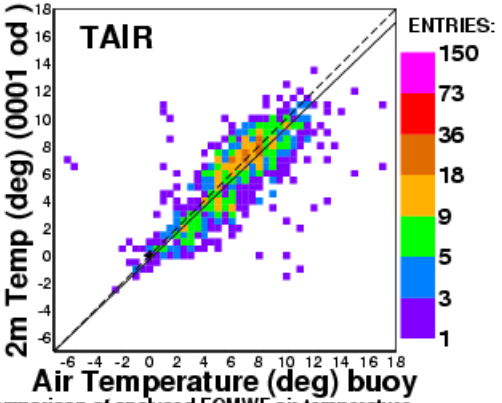
OSTIA / GHRSST – OPER / NCEP



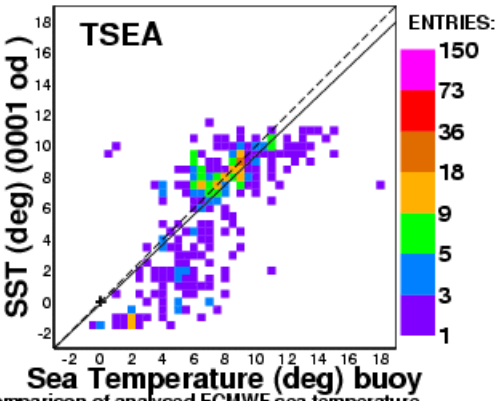
August 2008

Validation against buoy data (North of 70 N, August 2008)

OPER / NCEP

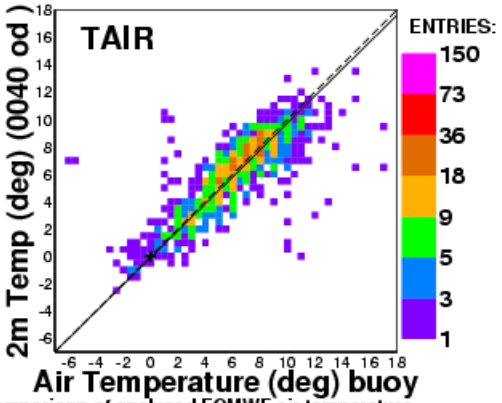


Comparison of analysed ECMWF air temperature with averaged buoy data.

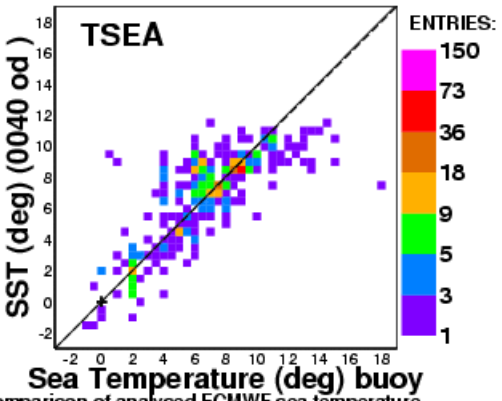


Comparison of analysed ECMWF sea temperature with averaged buoy data.

GHRSST / OSTIA



Comparison of analysed ECMWF air temperature with averaged buoy data.

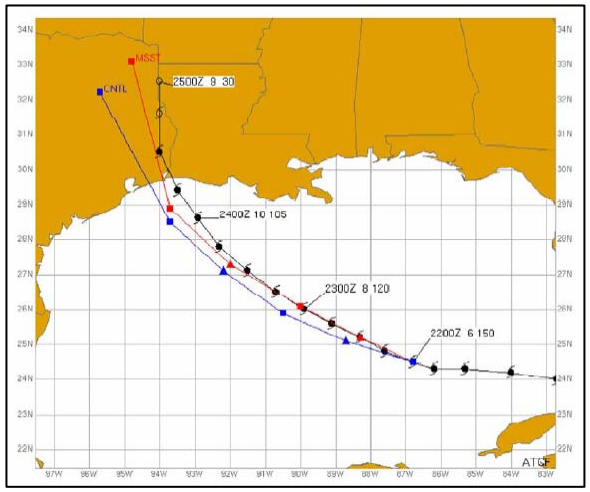


Comparison of analysed ECMWF sea temperature with averaged buoy data.

GHRSST
Group for High Resolution Sea Surface Temperature

http://www.ghrsst-pp.org

Hurricane prediction



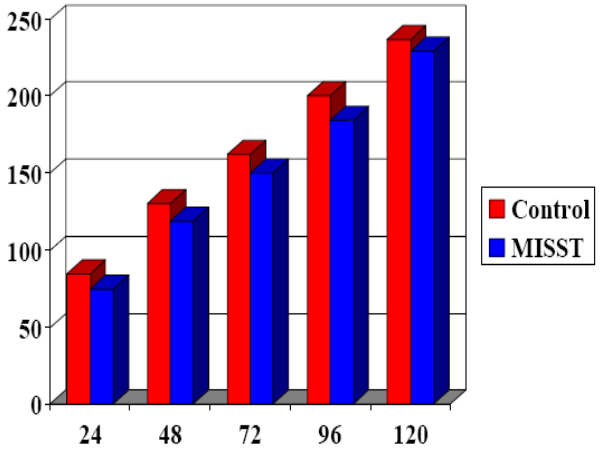
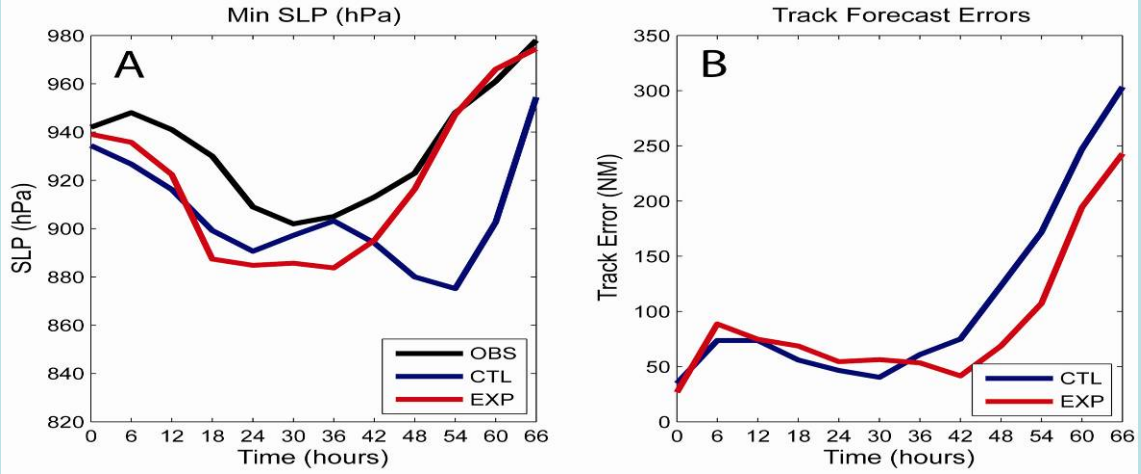


Figure 31. NOGAPS TC track forecast error (n mi) for eastern North Pacific Hurricanes Jova and Kenneth. The number of forecasts was 54, 50, 46, 42, and 38 for the 24-h, 48-h, 72-h, 96-h, and 120-h forecasts, respectively.

US Navy

Time series of Hurricane Katrina every 6 hours (12 UCT 27 August to 0600 UTC 30 August 2005, from the best track data (black), the IR-only SST analysis run (blue) and the IR+MW SST run (red). A) The sea level pressure. (SLP) B) The track forecast errors. **Image from J. Cummings**



GHRSST SSTs give improved TC forecast track errors

Sustainability: GHRSST-PP -> GHRSST

- Move from GHRSST-PP to GHRSST
  - *Phase-I:* An International pilot project tasked to develop and implement a distributed system to deliver integrated high resolution SST and Sea Ice (SI) data products in a sustainable manner (Complete)
  - *Phase-II:* Develop a sustained R/GTS system for SST&SI and Manage the ongoing evaluation and evolution of the system (Matured)
  - *Phase-III:* Deliver SST & SI Climate Data Records (CDR) in support of WCRP, GOOS and GCOS climate objectives (Underway)
  - *Phase-IV:* Transition to self sustained group and activities supporting Science & Operational communities (In progress)

Where to next?

Long term SST user requirements…

- Sustained & meaningful SST **products**
  - Excellent Science
- Sustained and adaptive-user driven **services** for SST
  - Excellent technology for users
  - Reliable data access (ftp, OPeNDAP etc)
- **Better confidence** in SST products and their delivery (new instruments)
- **Ease of access**, easy documentation
- **Proven standards**, nomenclature, symbology
- An **international forum** for practitioner and user communities (Science Team, User Consultation)

Summary

- GHRSST-PP has delivered the requests made by GODAE for a new generation of SST data sets
- Considerable momentum within the project for Science and Operations
- GHRSST-PP is closed but activities will continue as the Group for High Resolution SST (GHRSST)

IXth GHRSST ST Meeting, Perros-Guirrec France, 2008

Medspiration Achievements

- GHRSST **could not have happened** without Medspiration
- Its as simple as that!

- Thanks to ESA, and the Medspiration team!
  - Thanks to Olivier for Faith and
  - Ian Robinson for Dedication and
  - to both for excellent friendship over the last 8 years
- It was fun! Now onwards to the next challenges…

medspiration

EUROPEAN NODE
FOR SEA SURFACE TEMPERATURE