Mediterranean use of Medspiration: the CNR regional Optimally Interpolated SST products from MERSEA to MyOcean

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Outline

- Mediterranean SST processing chain & products
- Use of SST in the MFS Mediterranean ocean forecasting system
- UHR SST processing chain & Italian Seas products
- Future Plans

CNR SST-related activities within national and international projects/programmes

NRT products

Mediterranean Forecasting System → EU

Adricosm → Italian Government

Medspiration → ESA

Mersea → EU

PRIMI → ASI → Develop an UHR (up to 1 km) product over the Italian Seas

MyOcean

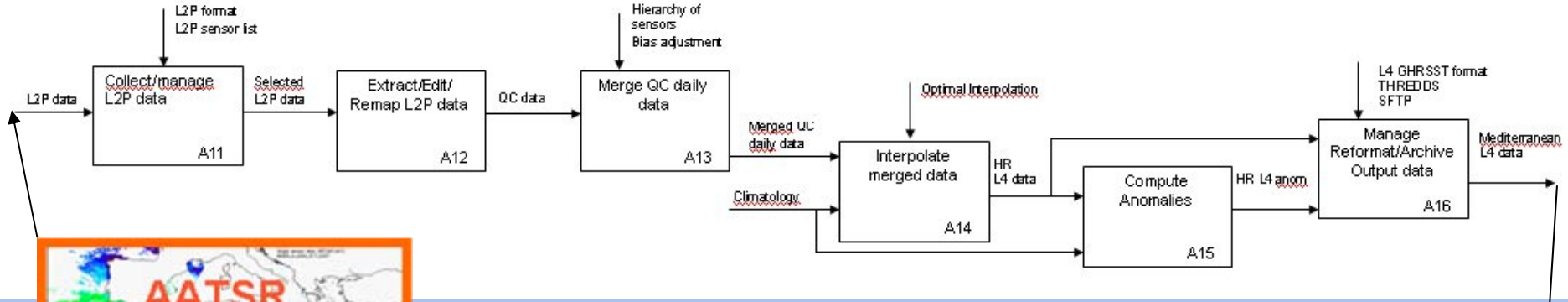
Re-analyses

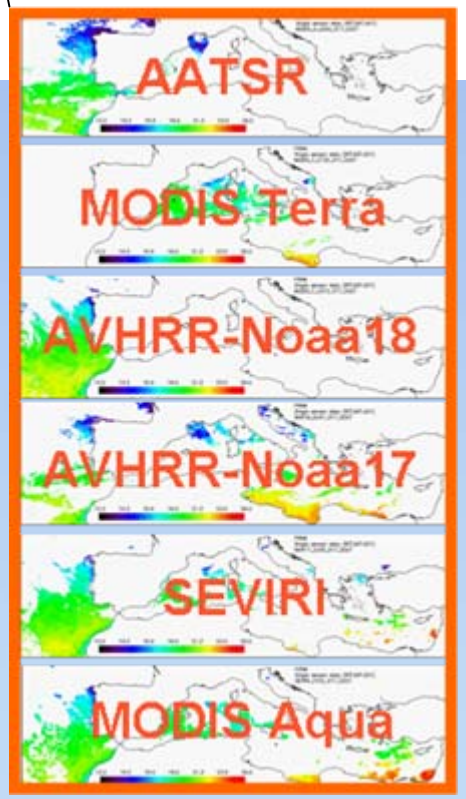
Mediterranean Forecasting System → Med L4 re-analysis (1985-2007)

SESAME → EU →compute a L4 re-analysis over the Black Sea

CNR OI_HR SST operational system:

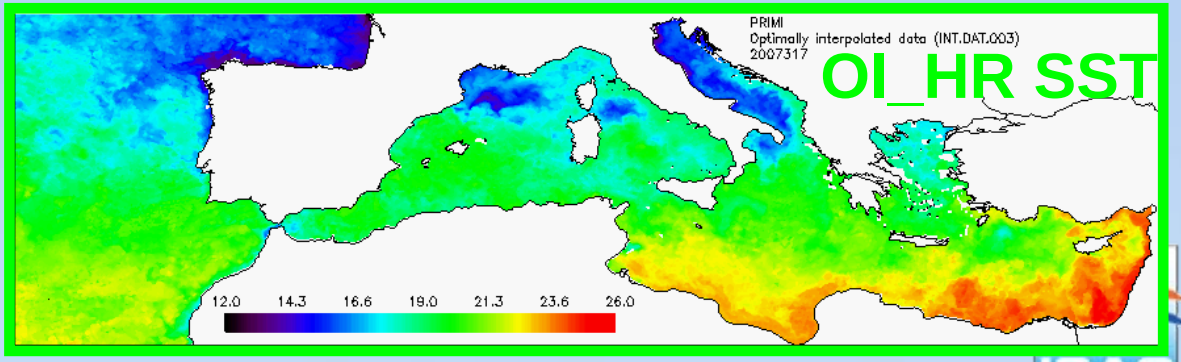
Input data: Medspiration L2P





1/16° grid
all infrared sensors (no microwaves)
only night-time data

operational production since july 2007



CNR OI_HR SST operational system:

L2P data extraction and decloud procedures

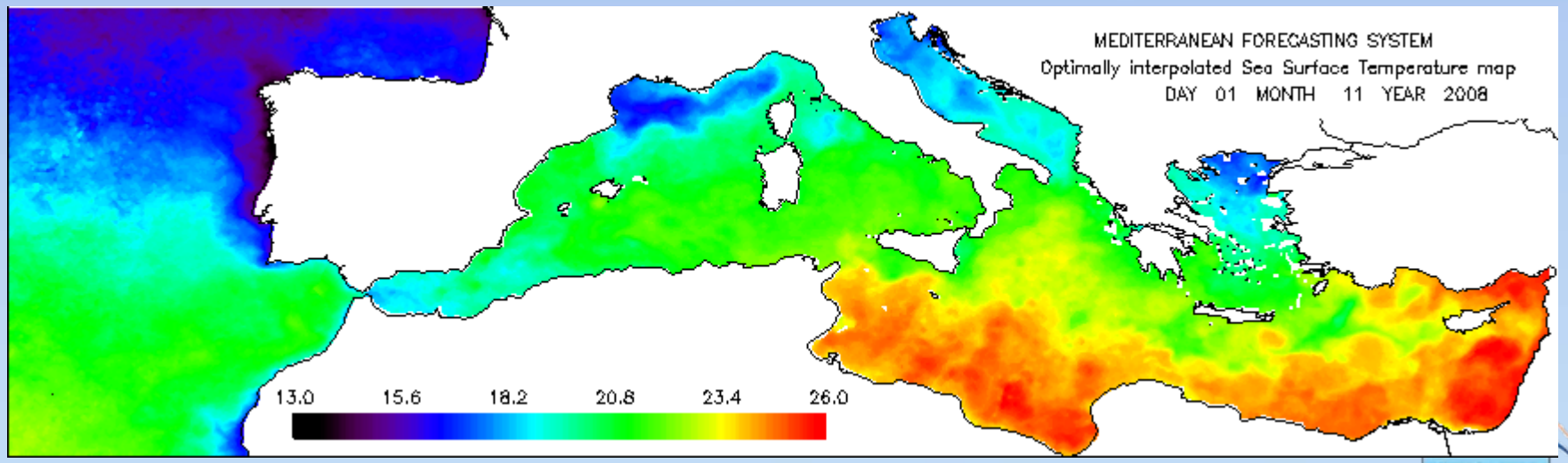
Cloud detection at GOS is performed at various steps:

→**On original images, before the merging is performed:**

Applying selection criteria on L2P rejection flag, proximity confidence (etc.)…

→**Before selecting SST data in the optimal interpolation algorithm**:
-comparison to the nearest analysis available (if interpolation error is lower than a fixed value)

-valid SST area's margin erosion



CNR OI_HR SST operational system:
L2P merging

In theory OI should only weight the data basing on observational error and covariance→ **huge amount of data**

First data sub-sampling

Our scheme builds a single image per day selecting the 'best' measure available for each pixel → **bias between sensors/passes must be corrected**

CNR OI_HR merging strategy:

1. Define a **Reference sensor list** which will not be corrected e.g. AATSR MODIS-Terra AVHRR (NOAA 17)
1. A composite map is built.
2. The merging procedure selects valid pixels using a configurable sensor sequence (**hierarchy based on validation statistics**)
3. Before adding data to the merged map, the bias between each new image and the pixels that have already been merged is estimated and removed

Optimal interpolation in synthesis

- Gives an estimate of an anomaly field with respect to a ***first guess***, assuming statistical characteristics of the variability are known (***background error covariance*** and ***observation error covariance***).
- SST analysis is obtained as a linear combination of the observations, weighted directly with their correlation to the interpolation point and inversely with their cross-correlation

$$\mathbf{x}_a = \mathbf{x}_b + \mathbf{B}(\mathbf{R}+\mathbf{B})^{-1}(\mathbf{y}_o - \mathbf{x}_b)$$

- **The data used to interpolate at a certain time-space location are selected within a limited sub-domain, close to the interpolation point**
- **The scheme drives a 'multi-basin' analysis to avoid information propagation across land, from one sub-basin to the other**

GOS - ISAC - CNR Roma :: Optimally Interpolated SST

http://gos.ifa.rm.cnr.it/index.php?id=407

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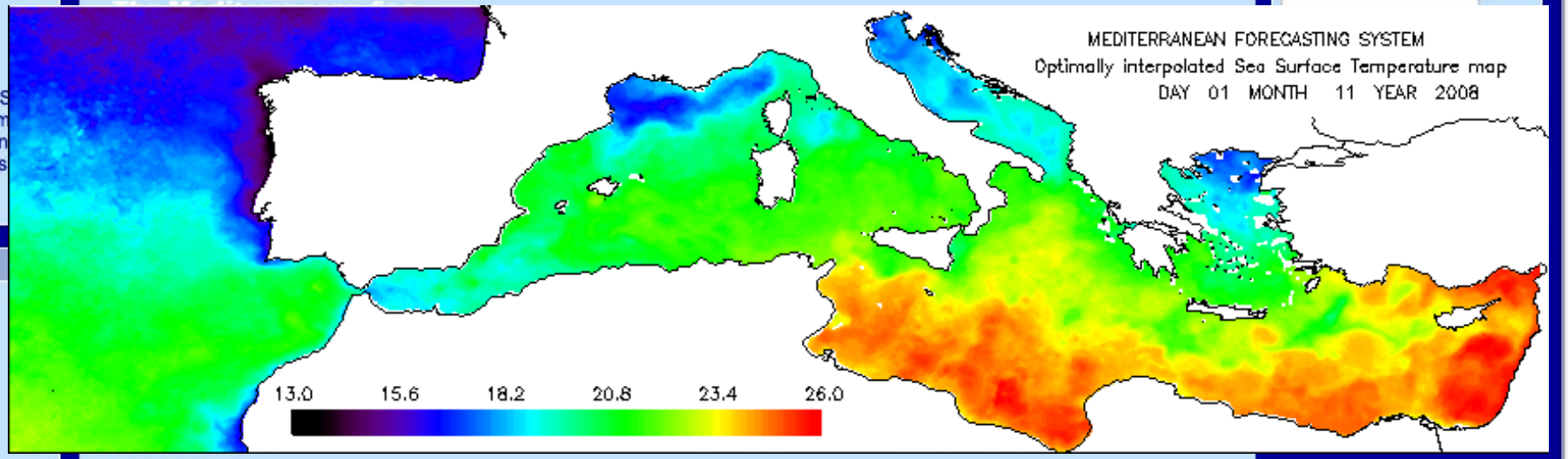
Optimally Interpolated SST
November 18, 2007, 19:10

Optimally Interpolated SST



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User name

Password

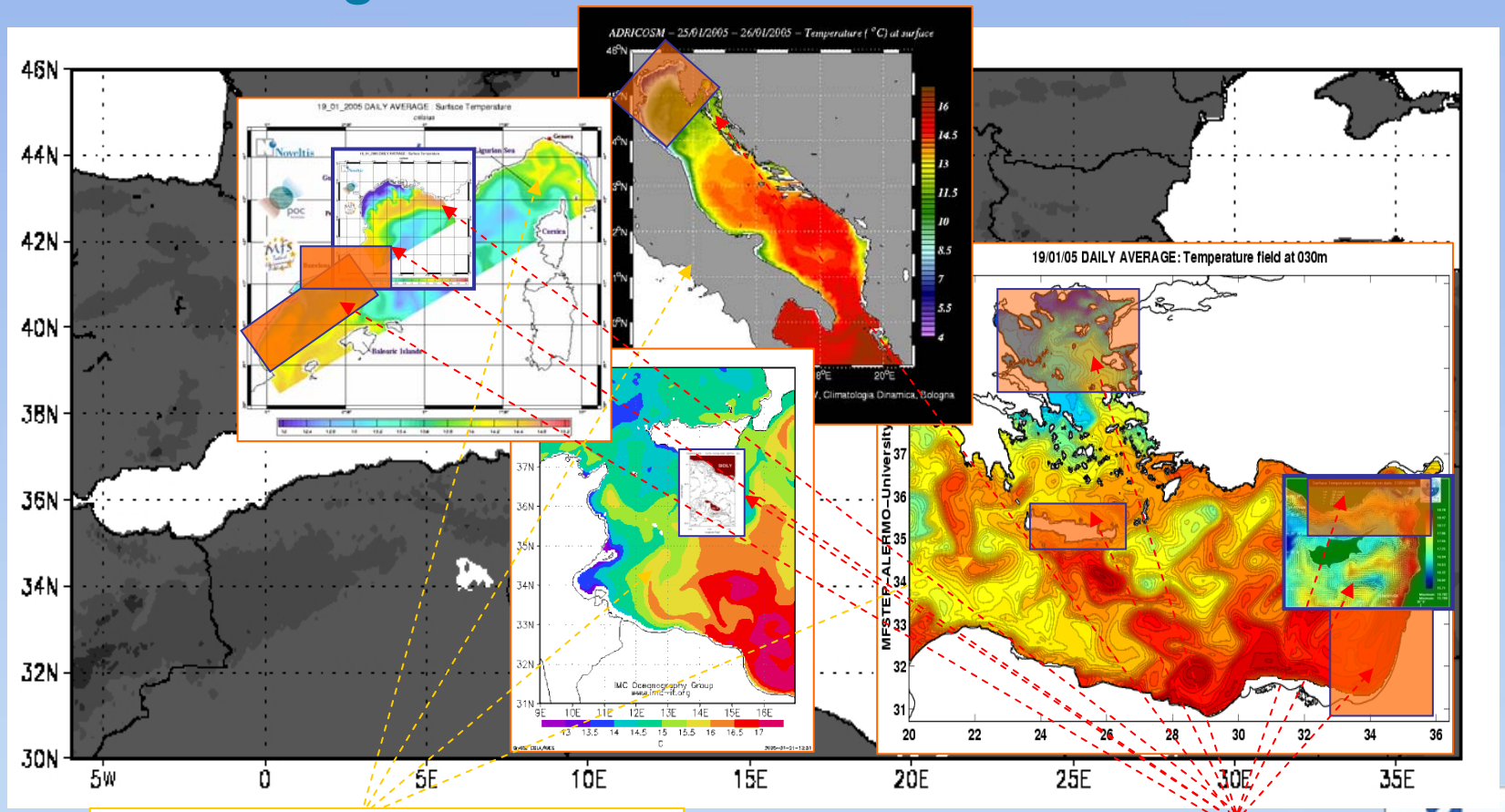
OISST products

- **GOS-L4HRFnd-MED_NRT**: OISST Near-Real-Time product
- **GOS-L4HRFnd-MED_DT**: OISST Delayed-Time product
- **GOS-L4HRFnd-MED_RA**: OISST from AVHRR data (1985-2004 Re-Analysis product)
- **GOS-L4HRFnd-MED_NRT_ANOM**: OISST Near-Real-Time Anomaly relative to the 1985-2004 mean

DIRECT ACCESS TO DATA (THREDDS)

MFS regional sub-regional and shelf systems

MFS supports sub-regional (3 km) and shelf models (1 km) nesting:
weekly forecasts are produced for ALL the sub-regional models and some shelf models

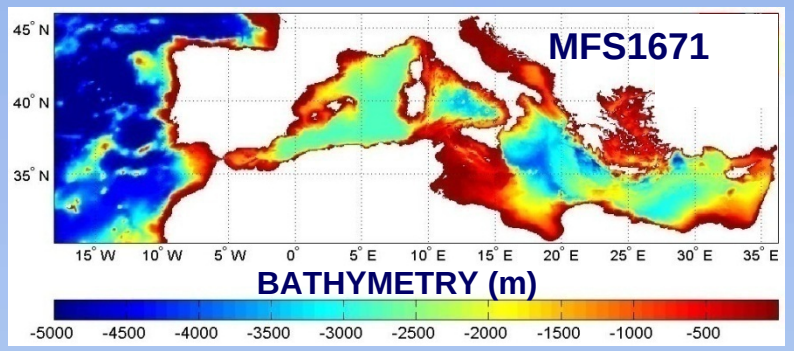


GNOO Gruppo Nazionale di Oceanografia Operativa — INGV

Mediterranean ocean Forecasting System

Italian Ministry for the Environment and Territory

Basin scale forecasting system: gos



NUMERICAL MODEL:

- Horizontal resolution 1/16°x1/16°
- Vertical resolution 72 unevenly spaced levels
- Numerical code: OPA 8.2
- Close boundaries in the Atlantic ocean
- Free surface parameterization
- Asyncrhronously coupled with ECWF analyses or forecasts atmospheric fields

DATA ASSIMILATION SCHEME:

- SOFA: reduced order Optimal Interpolation scheme
- Intermittent (24hr) assimilation of:
  - ✓Satellite SLA
  - ✓Vertical profiles (T & S)
  - ✓Satellite SST

$$\mathbf{X}^a = \mathbf{X}^b + \mathbf{K}(\mathbf{Y}^o - H(\mathbf{X}^b))$$

$$\mathbf{K} = \mathbf{B}\mathbf{H}^T(\mathbf{H}\mathbf{B}\mathbf{H}^T + \mathbf{R})^{-1}$$

$$\mathbf{X} = \left[T \;\; S \;\; \eta \;\; U \;\; V\right]^T$$

$$Q_{corr} = Q - \left.\frac{\partial Q}{\partial T}\right|_{T=T^*} (T - T^*)$$

ISAC

GOS

Forecast production and broadcast:

- Every day a 10 days forecast is produced in Real Time (11hr delay)
- Once a week, 15 past days analyses are produced with the assimilation of all available data (SST contribution)
- Every day a Web Bulletin is published (SST contribution)
- Every month an electronic monthly bulletin is released on the web site describing the results of the MFS system for the previous month together with anomalies and climatic indices (SST contribution)
- Every day the model data (& GOS SST data) are available through a dedicated ftp to users

www.bo.ingv.it/mfs

ISAC

MFS Mediterranean ocean Forecasting System

http://gnoo.bo.ingv.it/mfs/sst.htm

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INGV

Mediterranean ocean Forecasting System

Italian Ministry for the Environment and Territory

italiano

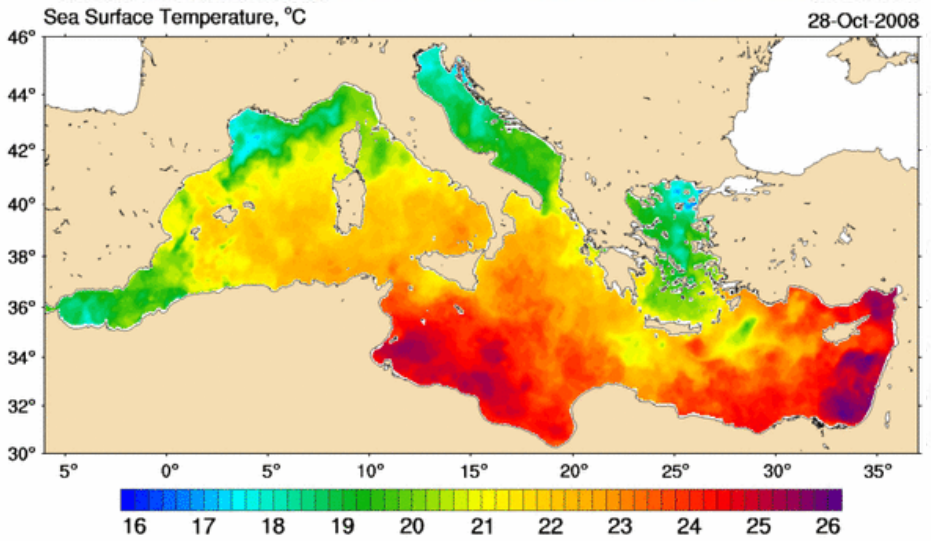
MFS BULLETIN

- Contents
- Assimilated Data
  - XBT
  - SST
  - SLA
  - ARGO
- Forecast
- Analysis
- Evaluation
- Data Access
- Monthly Bulletin
- Monthly Animation
- Analysis Archive
- Analysis History
- Indicators
- Marine Ecosystem Forecast
- Ongoing Projects
  - ADRICOSM
  - BOSS4GMES
  - ECOOP
  - MERSEA IP

GNOO WEB SITE

MOON WEB SITE

Satellite Sea Surface Temperature computed daily



MFS Mediterranean ocean Forecasting System

http://gnoo.bo.ingv.it/mfs/Forecast/bulletin.htm?link=F

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italiano

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GNOO WEB SITE

MOON WEB SITE

Mediterranean ocean Forecasting System Bulletin

back

Daily Mean Forecast Fields from 17_nov_2008 at 12:00 to 27_nov_2008 at 12:00

Select a Day: Animation

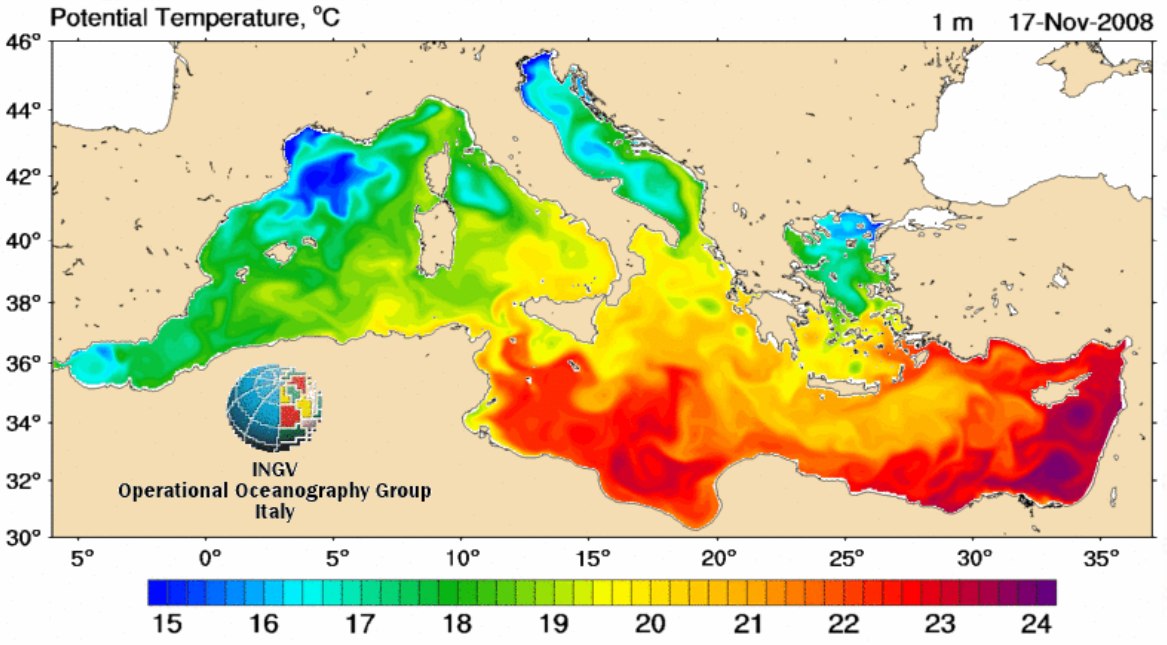
Select a Field: Sea Surface Temperature

Plot

Current Velocity Maps

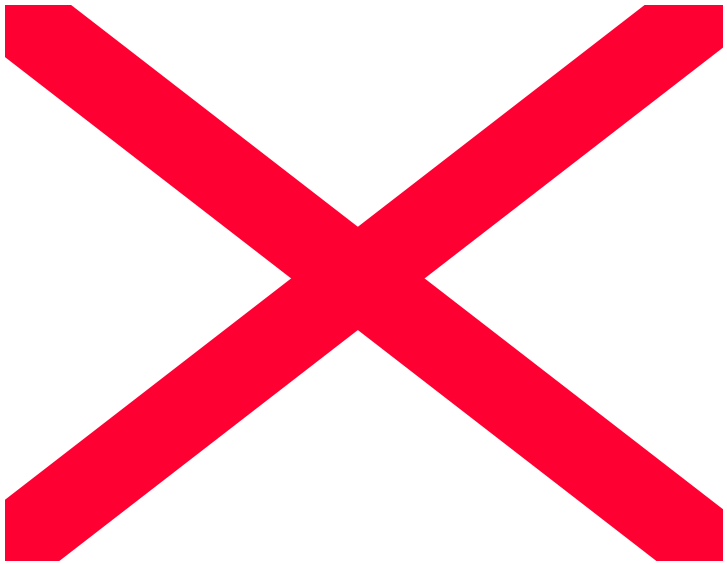
Volume Transports

Transects



Short Term Forecast of the Mediterranean Marine Ecosystem

Istituto Nazionale di Oceanografia e di Geofisica Sperimentale



10 day Forecast starts every Tuesday

Summary of SST Dissemination to Mediterranean Users

- **Primary user of SST is the MFS at INGV**
- **National forecasting Systems and MOON operational system throughout MOON MoU (31 centres)**
- **Environmental Agencies of the Mediterranean region**
- **Italian Meteorological service for use the SST**
- **Research and educational users (> 200)**
  - **Research studies, cruises planning, etc**
- **Few Commercial Users**

UHR Med L4 product: framework

In the framework of National Projects (Adricosm & PRIMI):

- *new multi-sensors UHR SST products will be developed for the Italian Sea (Adriatic, Sicily Channel, Tyrrhenian Sea at 1 Km resolution)*
- *the new SST products will be assimilation in the Adriatic, Sicily Channel forecasting models*
- *The SST assimilation scheme will modified to take into account that the characteristics satellite SST (e. g. restoring coefficient depending on wind intensity & regime, e.g. Artale et al. JGR 2002)*

UHR MED L4: Optimal interpolation strategy

- Different processes at different scales contribute to the variability of the SST
- Consequently, OI does not only interpolate, but also acts as a low-pass filter for the scales smaller than those dominating the background error covariance

RESOLUTION by itself is NOT a 'SCALE SELECTION' tool, COVARIANCE functions shape our 'optimal filters'.

On the other hand…

- Resolution should be linked to covariance scales to avoid 'monster' matrix inversions and huge computational time
  →multi-scale approach to UHR OI
- Generally some sub-sampling strategy can be applied to keep a 'reasonable' amount of data within an 'influential' space/time radius

CNR OI_HR SST operational system:
statistical assumptions

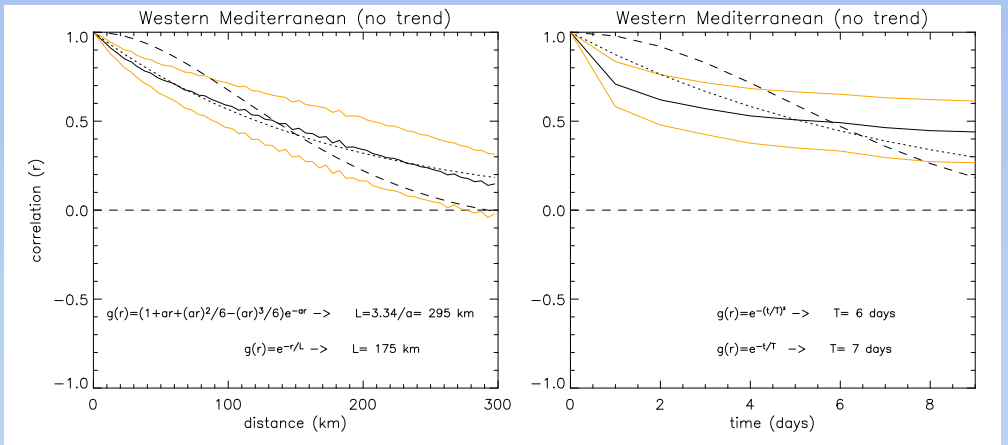
1/16° product:

- the **first guess** is a daily (pentad) climatology built from 20 years of Pathfinder V5 data.

- Correlation function was estimated **directly from observations** in the framework of Medspiration:

$$C(r,\Delta t) = e^{-\frac{\Delta t}{\tau}} e^{-\frac{r}{L}}$$

where
L =180 km
τ =7 days



- Small scale variability strongly filtered!

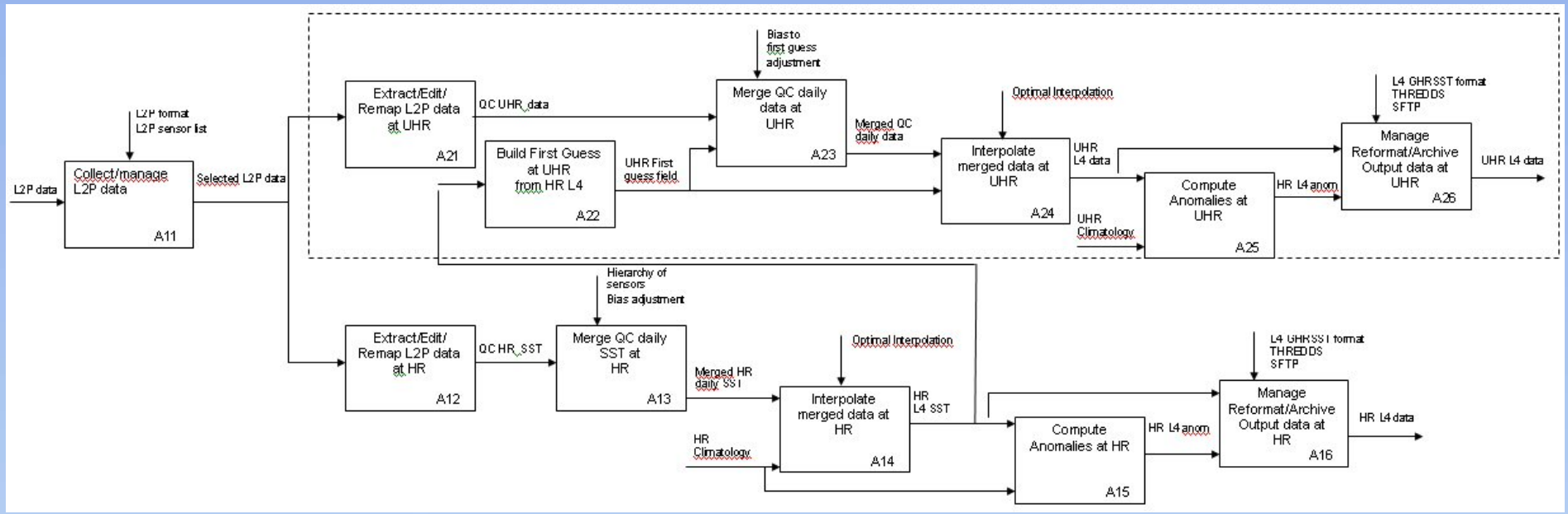
CNR OI_UHR SST scheme:
statistical assumptions

- the **first guess** is the HR SST field→ scale separation
- Covariance function and decorrelation time/space scales are defined **a priori**:

$$C(r,\Delta t) = e^{-\frac{\Delta t}{\tau}} e^{-\frac{r}{L}}$$

- Different configurations will be tested
- Initial configuration L=5 km, τ=2 days

CNR OI_UHR SST scheme:
overview and future implementation architecture



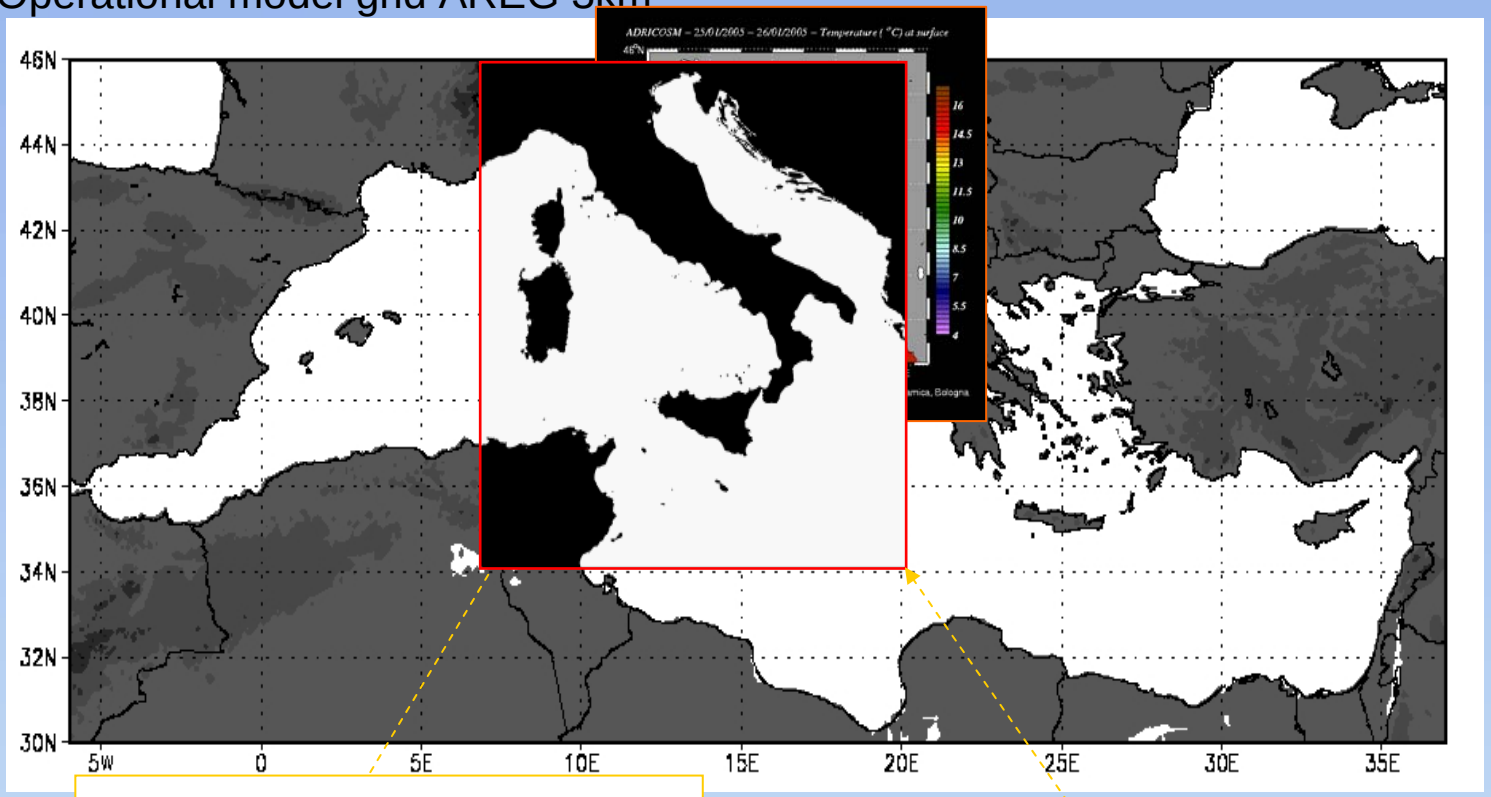
system developed during ASI project PRIMI (National project for oil-spill dispersion monitoring &forecasting)

pre-operational production since september 2008 **only over the ITALIAN SEAS**

needs upgrade & tuning and validation

CNR OI_UHR SST scheme:
selected test areas

Operational model grid AREG 3km

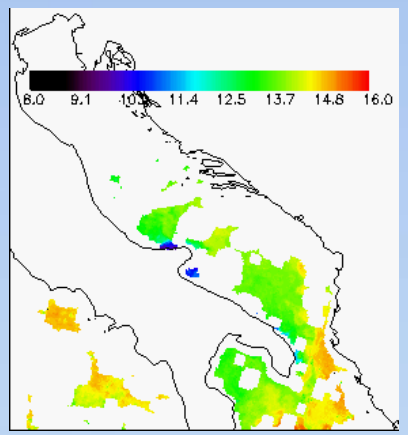


Sub-regional model at 3 km

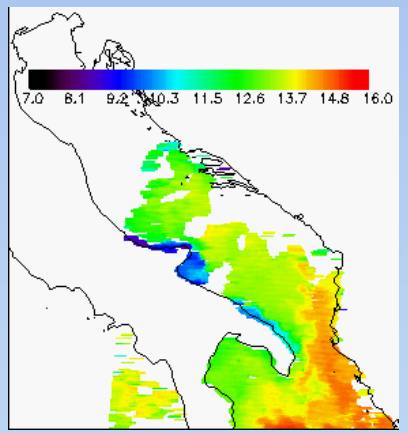
GHRSST UHR grid 1 km

CNR OI_UHR SST scheme:
L2P data extraction

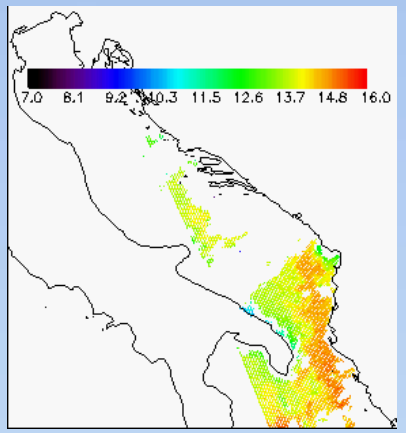
- Same procedure as for LowRes
- Only applied to High resolution sensors



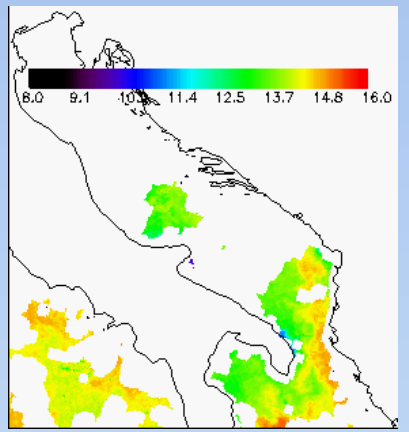
AATSR



MODIS Aqua



MODIS Terra



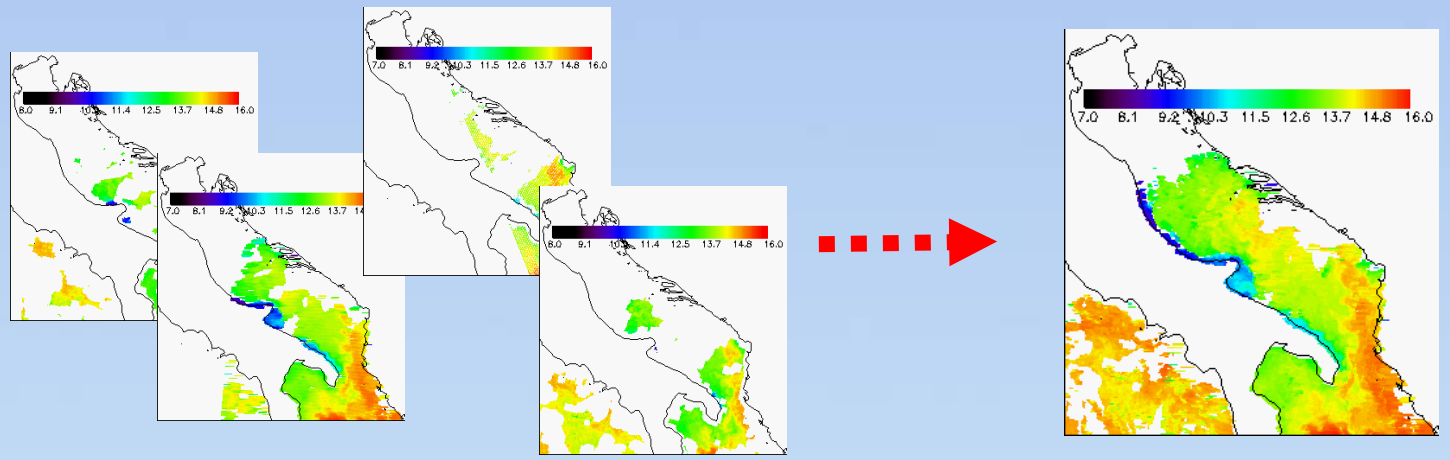
AVHRR 17
AVHRR 18

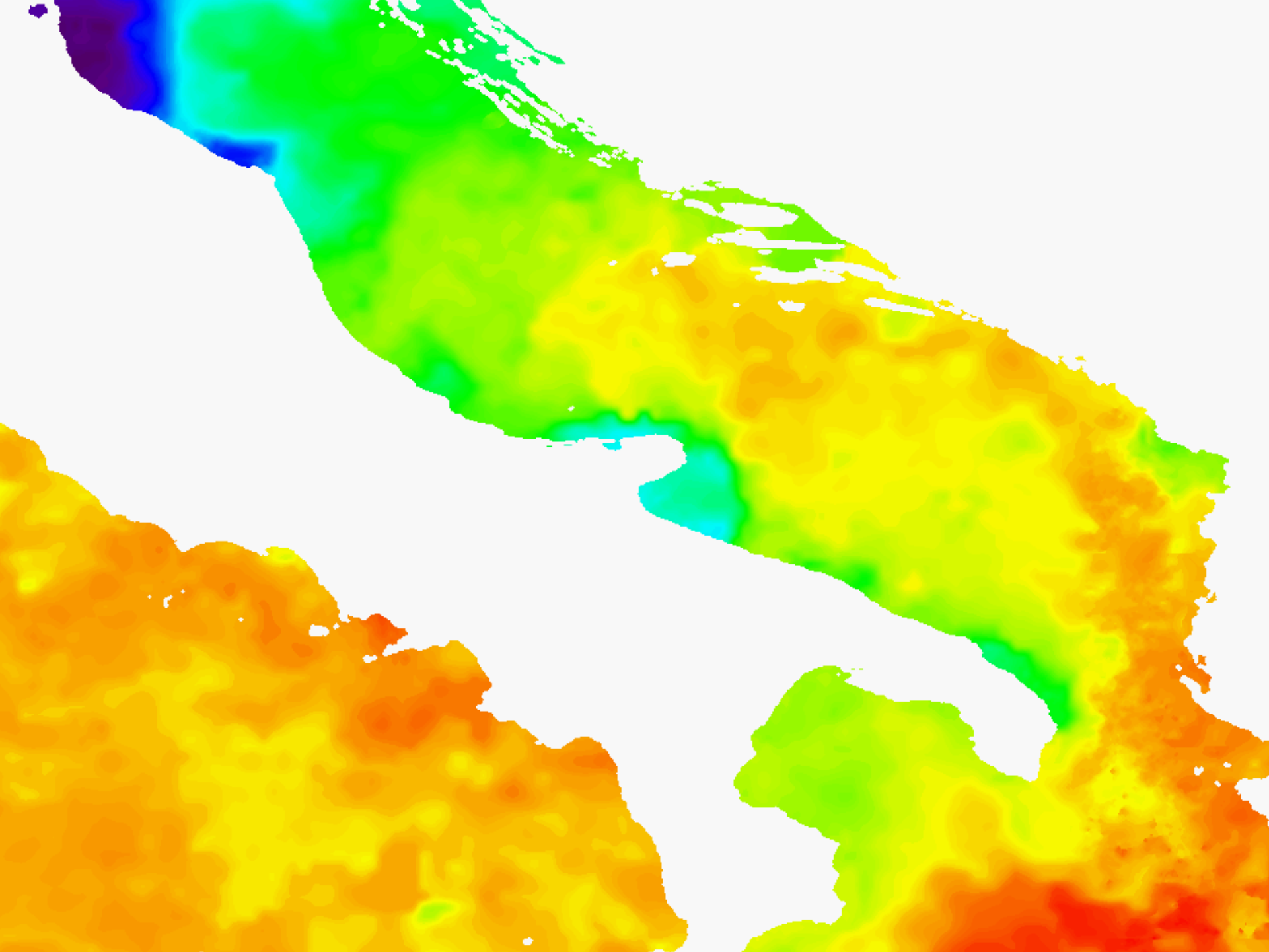
CNR OI_UHR SST scheme:
L2P data merging

- Bias adjustment procedure modified

→OI_HR uses AATSR and/or MODIS-T and/or AVHRR17 as reference

→OI_UHR uses the first guess to remove all biases



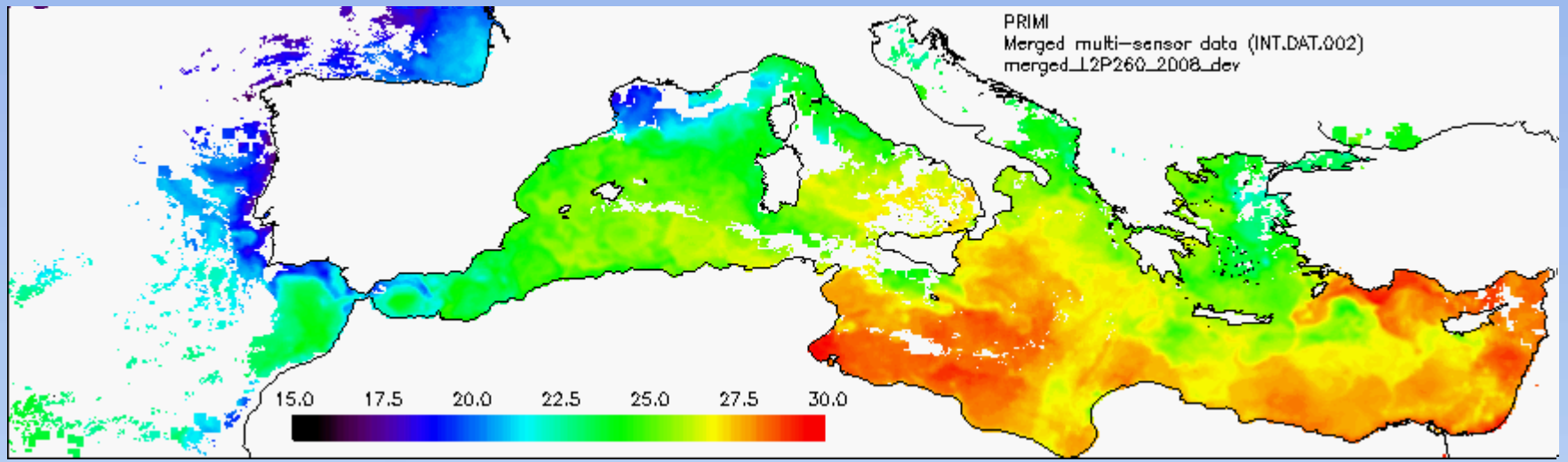


CNR OI_UHR SST scheme:
computing strategy

- Small decorrelation scales allow multiple runs on small sub-basin grids and subsequent ‘collage’…
- several *interpolation grids* and *input data search grids* are defined so that same data are used at the borders of each grid (a sort of buffer area)

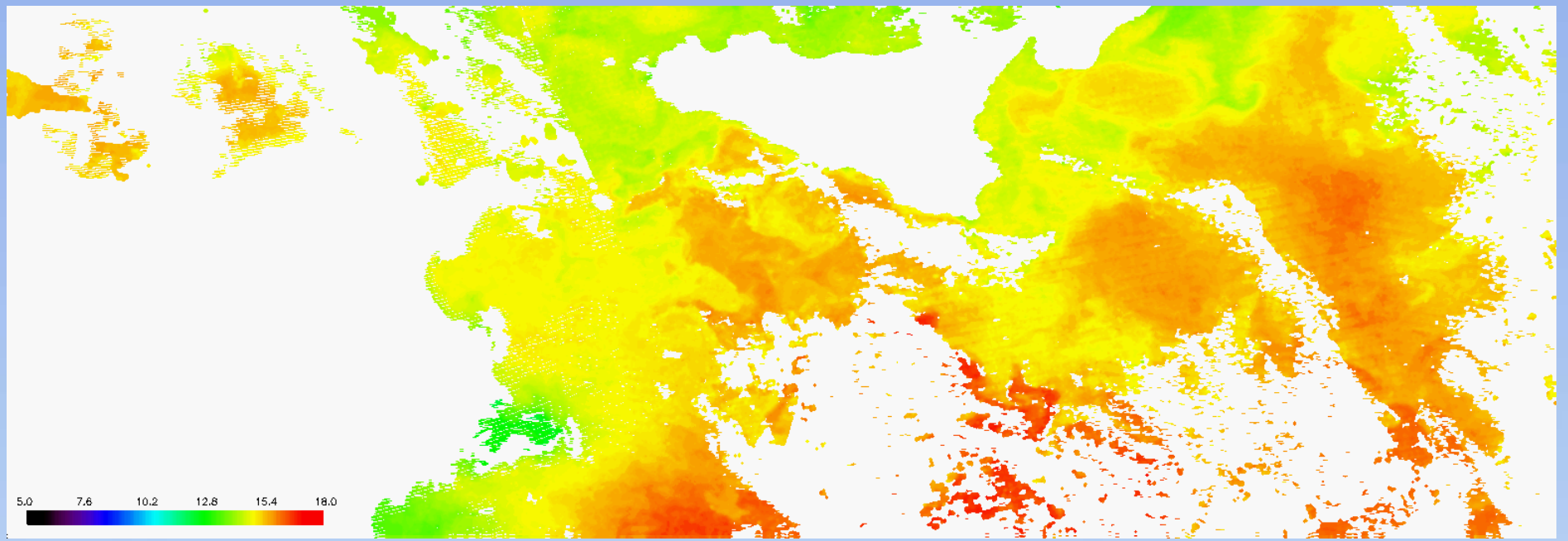
CNR OI_HR SST operational system:

L2P merging: problems identified and new algorithm



Before adding new data to the merged map, a LOCAL bias (100 km) between each new image and the pixels that have already been merged is estimated and removed

CNR OI_UHR SST operational system:
L2P merging: problems identified and new algorithm



- The bias between each image and the first guess field is estimated locally (50 km)
- Data sparseness and quality estimated through SST gradient map (e.g. MODIS striping…). Data that display lower gradients are kept.

CNR operational system:
future work

The Satellite Observing System of the Mediterranean Sea provides NRT, DT, and re-analysis satellite products in agreement with the requirements of the MCS core products

- This system will be the MOON component of the SST-TAC of MCS in the framework of MyOcean
- The CNR processing SST chains will be modified to provide also Black Sea products in accordance with the MyOcean requirements
- New algorithms will be developed and implemented in the operational chain immediately after test and validation