Importance of Argo in Mediterranean Operational Oceanography Network (MOON)

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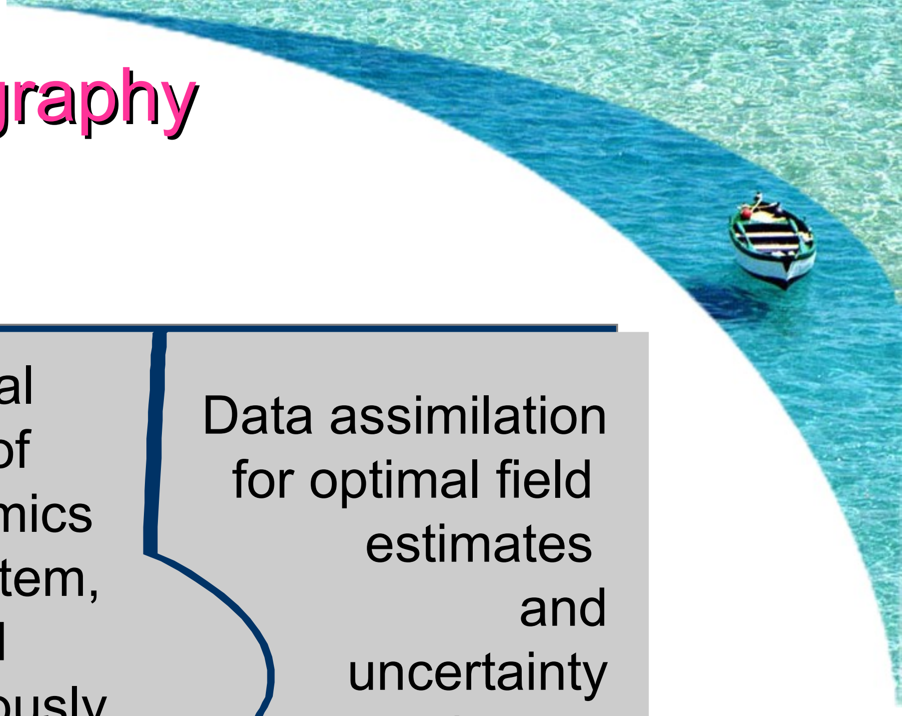
Outline

- The Operational Oceanographic Service in the Mediterranean Sea: products, core services and applications (downstream services)
- Use of Argo floats in MOON

The Operational Oceanography approach



Multidisciplinary Multi-platform Observing system (permanent and relocatable)

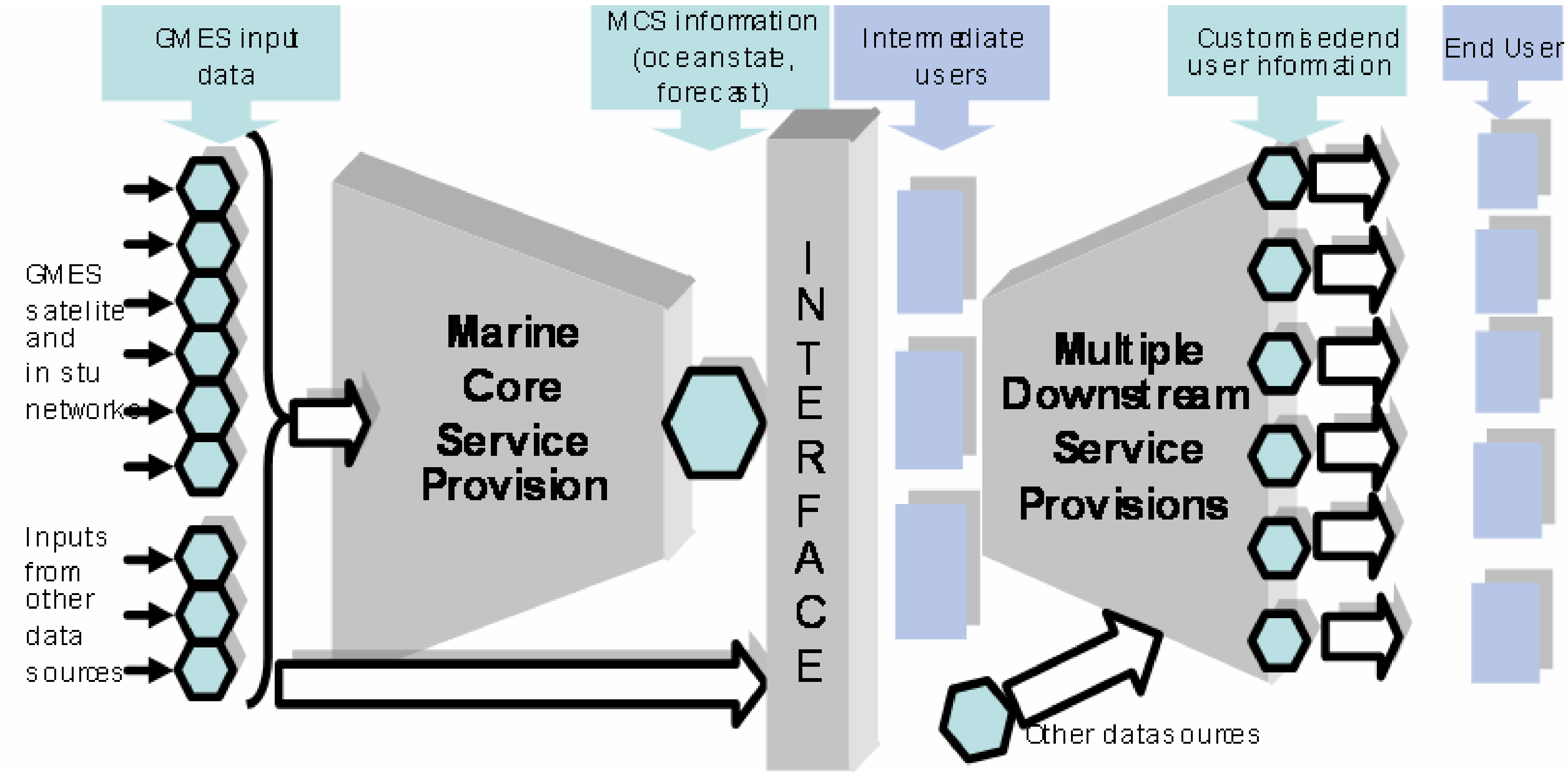
Numerical models of hydrodynamics and ecosystem, coupled a/synchronously to atmospheric forecast

Data assimilation for optimal field estimates and uncertainty estimates

Continuos production of nowcasts/forecasts of relevant environmental state variables

The operational approach:
from large to coastal space scales (NESTING),
weekly to monthly time scales

European OPERATIONAL OCEANOGRAPHY: the Global Monitoring of Environment and Security (GMES) concept



The Marine Core Service will deliver regular and systematic reference information on the state of the oceans and regional seas of known quality and accuracy

The implementation of operational oceanography in the Mediterranean Sea: 1995-today

RT Observing System
satellite SST, SLA,
VOS-XBT, moored
multiparametric buoys,
ARGO and gliders

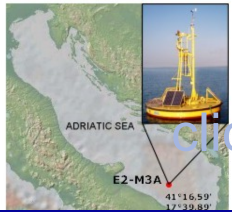
Numerical models of hydrodynamics and biochemistry at basin scale

Numerical models for shelf and coastal areas

End-User applications
-
Downstream services

MOON: Mediterranean Operational Oceanography Network
15 nations involved, 30 institutions

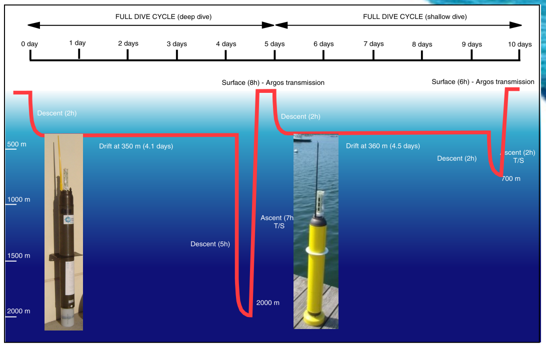
MOON data collection system: Basin Scale RT Observing System



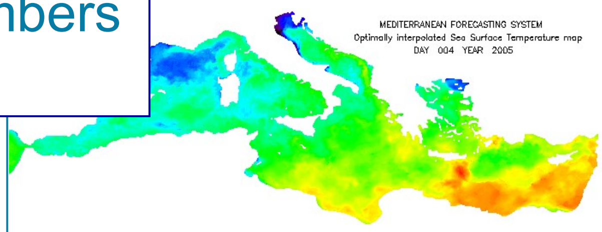
The National coastal networks are started to be interfaced and data shared between MOON Members in real time

Multiparametric buoys in: Ligurian Sea, Adriatic Sea and Cretan Sea (few hours delay)

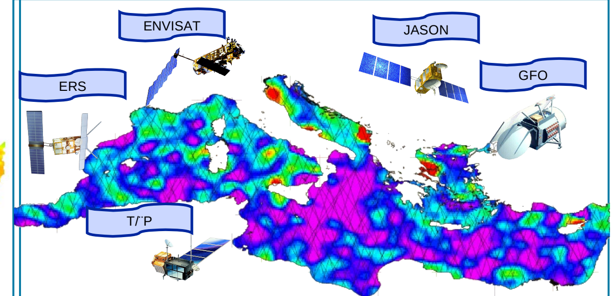
…OS/SOOP high resolution … along track and full profile … mission, few hours delay)



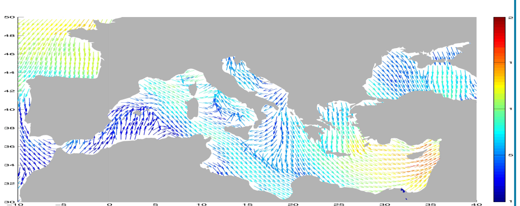
20 ARGO floats deployed from VOS (few hours delay)



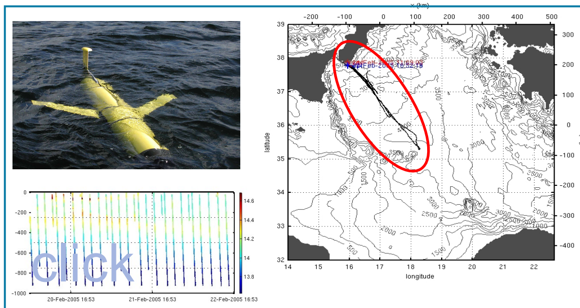
Daily satellite SST interpolated in RT on model grid (one day delay)



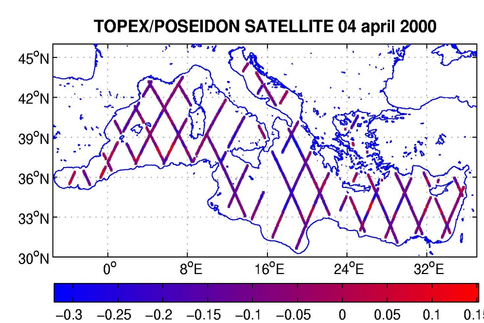
JASON-1, GFO, ENVISAT, T/P Sea Level Anomalies (few days delay)



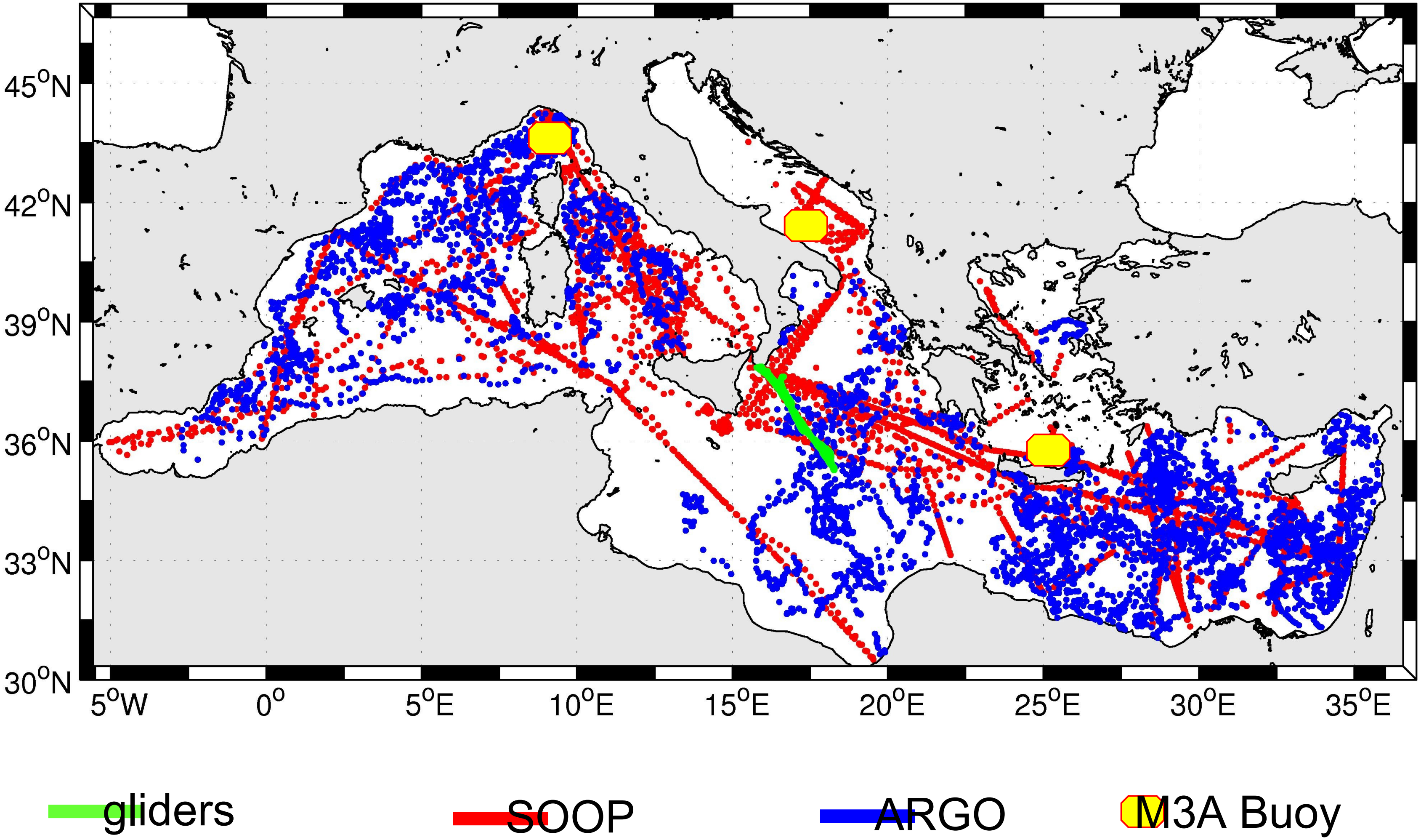
Scatterometer DAILY winds analysis, 1/2x1/2 (one week delay)



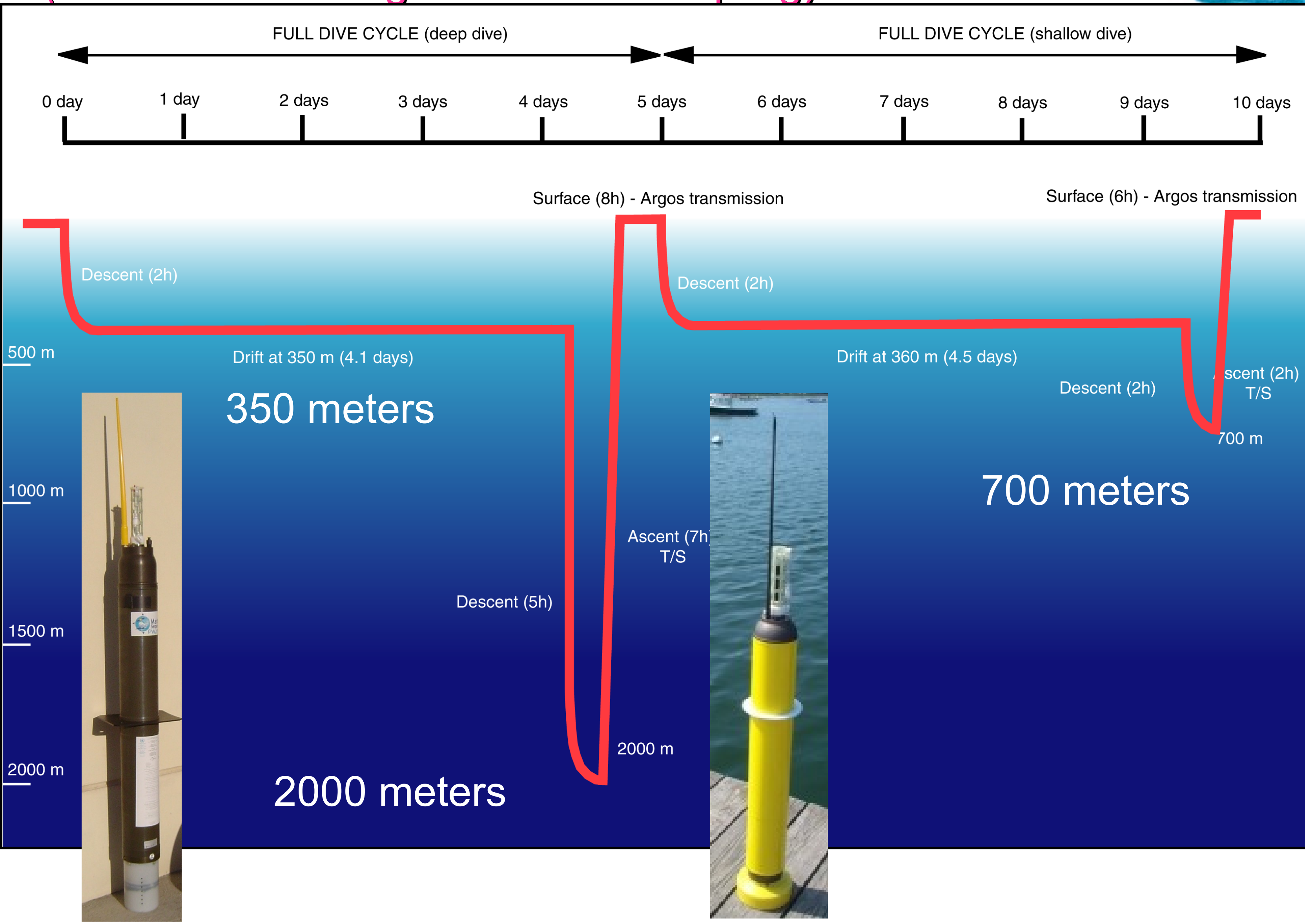
Open ocean monitoring by gliders (few hours delay)



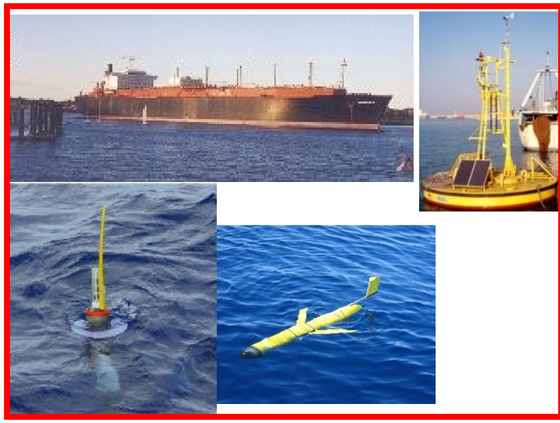
MOON data collection: real time data coverage (2004-2008 period)



MEDARGO Sampling cycle characteristics (different from the global ocean sampling)

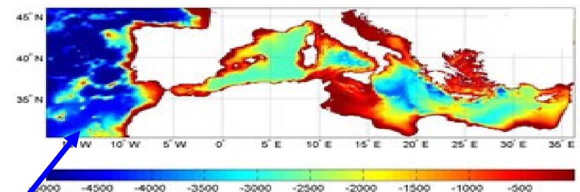


The MOON Real Time data dissemination network



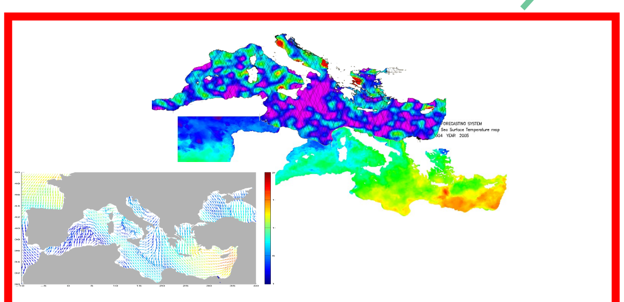
- In situ data

MFS Models



Mediterranean Thematic Observational Centers: satellite, SOOP-VOS, ARGO, fixed buoy

- satellite data



World-wide Data Dissemination Center (IFREMER)

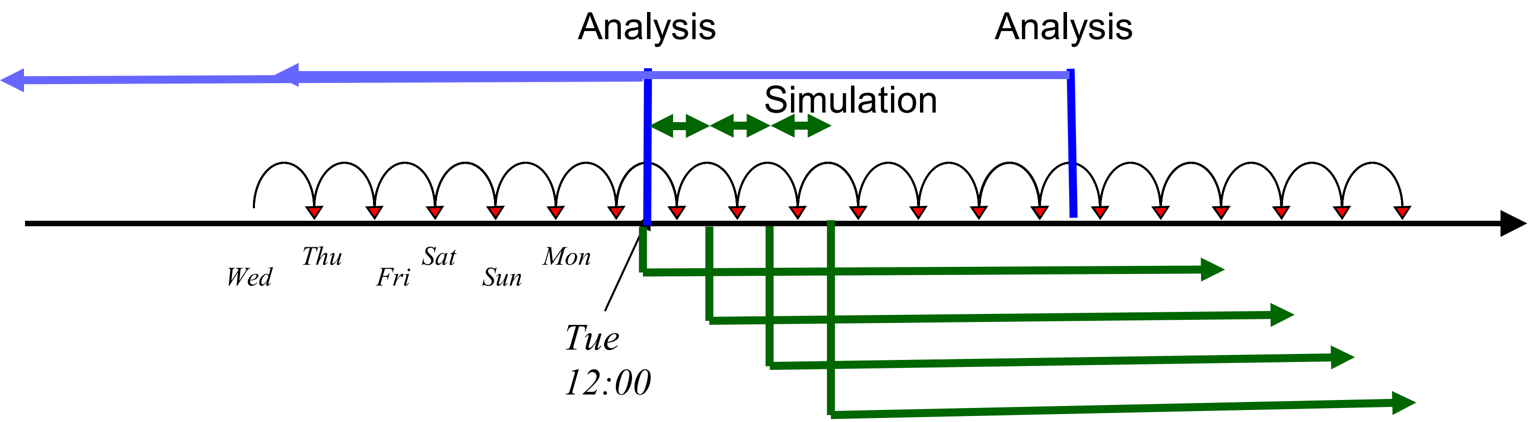
GTS

WMO

Analysis – forecast procedure in MFS

Weekly analyses with daily cycle

- all satellite and in situ observations are assimilated
- ECMWF atmospheric forcing fields



Daily 10 days forecasts

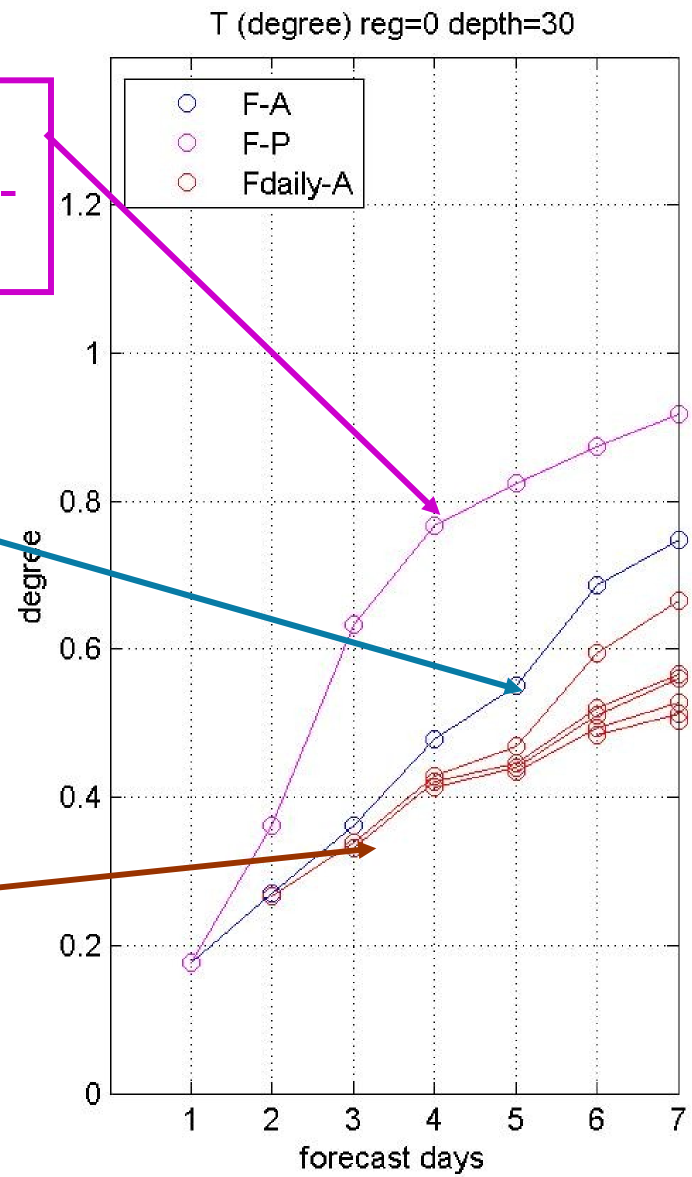
The daily forecast: improvement of the skill

Control:
Persistence-analysis

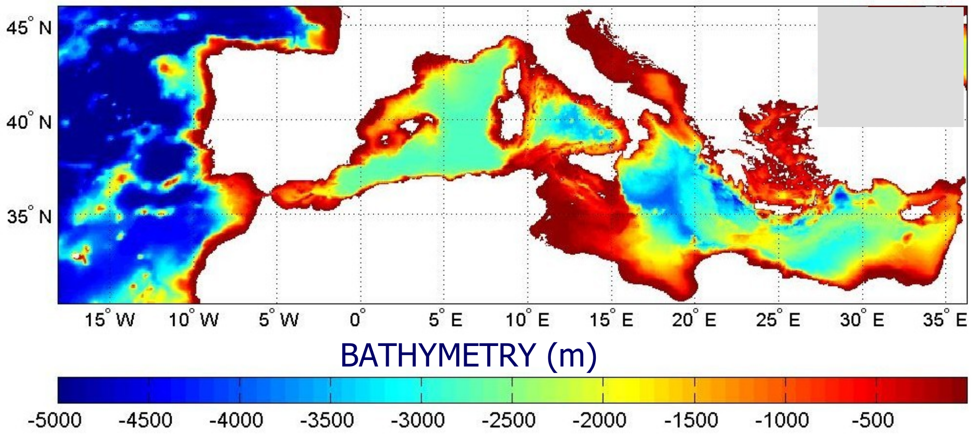
Single one week forecast:
forecast- analysis

Daily forecasts starting from simulation i.c.:

forecast-analysis



MFS OGCM characteristics

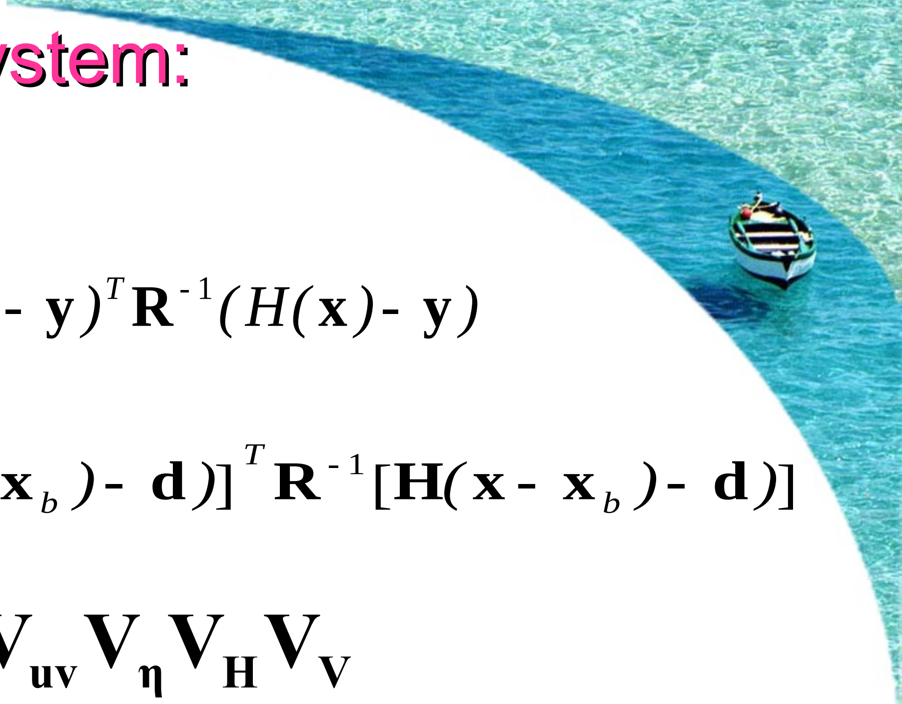


MFS 1671

OPA 8.1, implicit free surface
1/16º * 1/16º horizontal resol.
1 vertical levels (1.5-5000m)
49 islands

- Modifications at the Strait of Gibraltar in order to parameterize the mixing by internal wave breaking
- The Atlantic box is restored to climatological values and it is closed
- Model is forced with interactive fluxes calculated from ECMWF surface fields

The new MFS assimilation system: 3DVAR



$$J = \frac{1}{2}(\mathbf{x} - \mathbf{x}_b)^T \mathbf{B}^{-1}(\mathbf{x} - \mathbf{x}_b) + \frac{1}{2}(H(\mathbf{x}) - \mathbf{y})^T \mathbf{R}^{-1}(H(\mathbf{x}) - \mathbf{y})$$

$$J = \frac{1}{2}(\mathbf{x} - \mathbf{x}_b)^T \mathbf{B}^{-1}(\mathbf{x} - \mathbf{x}_b) + \frac{1}{2}[\mathbf{H}(\mathbf{x} - \mathbf{x}_b) - \mathbf{d})]^T \mathbf{R}^{-1}[\mathbf{H}(\mathbf{x} - \mathbf{x}_b) - \mathbf{d})]$$

$$\mathbf{B} = \mathbf{V}\mathbf{V}^{\mathbf{T}} \qquad \mathbf{V} = \mathbf{V}_{\mathbf{D}}\mathbf{V}_{\mathbf{uv}}\mathbf{V}_{\boldsymbol{\eta}}\mathbf{V}_{\mathbf{H}}\mathbf{V}_{\mathbf{V}}$$

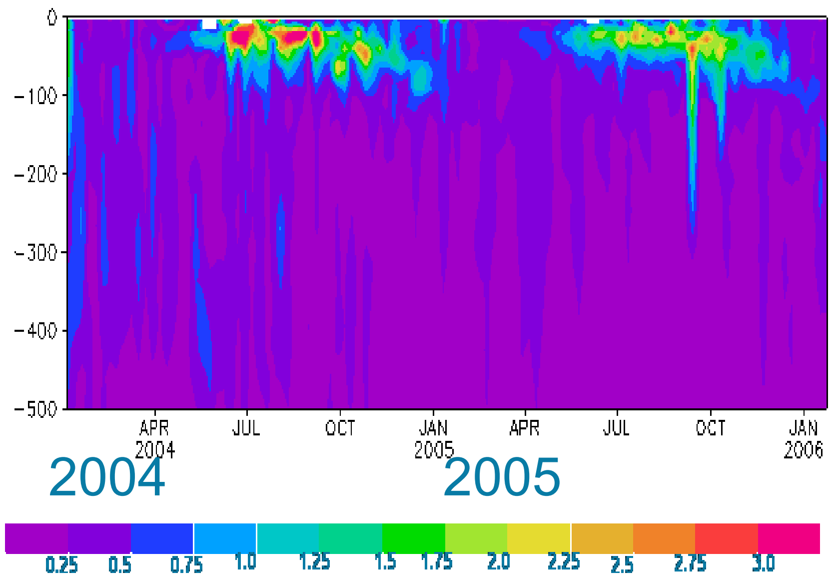
Where now:

$\mathbf{V}_{\mathbf{D}}$	Divergence dumping operator
$\mathbf{V}_{\mathbf{uv}}$	U,V geostrophic velocity error correlations
$\mathbf{V}_{\boldsymbol{\eta}}$	Linear error covariance for ‘eta’ corrections
$\mathbf{V}_{\mathbf{H}}$	Horizontal covariance matrix
$\mathbf{V}_{\mathbf{V}} = \mathbf{S}\Lambda^{1/2}$	Vertical error covariance matrix

Verification of the assimilation system:

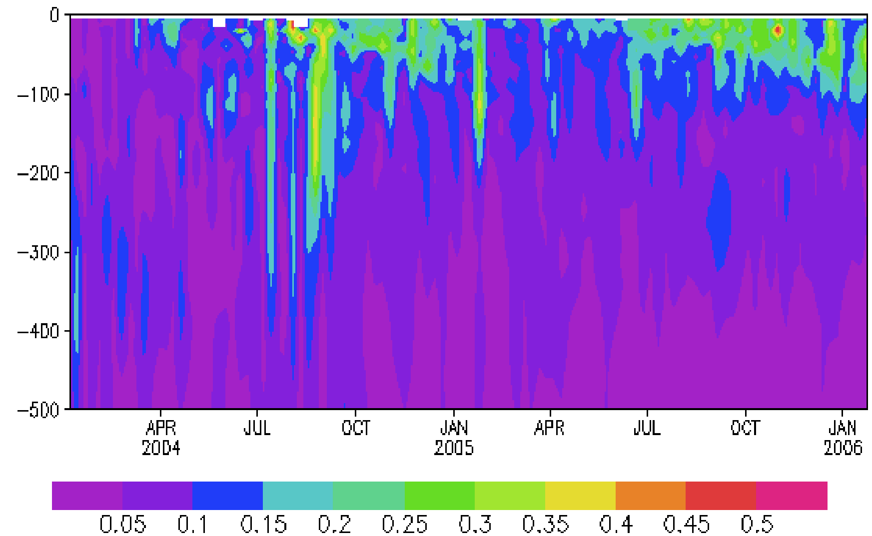
RMS of Argo temperature misfits (Jan 04 – Jan 06)

RMS temperature misfit



2004 2005

RMS salinity misfit



2004 2005

Misfit = observations – (model before assimilation)

Numerical forecasting of ocean biogeochemistry

The present forecasting system considers:

- Multiple platform off-line coupling
- ‘Best’ physics + ’best’ biogeochemistry
- Professional support to routinely delivered Products on the web
- Validation fields (Chl-a) produced with algorithms customized for the Med Sea

Satellite
CHL data
ISAC-CNR

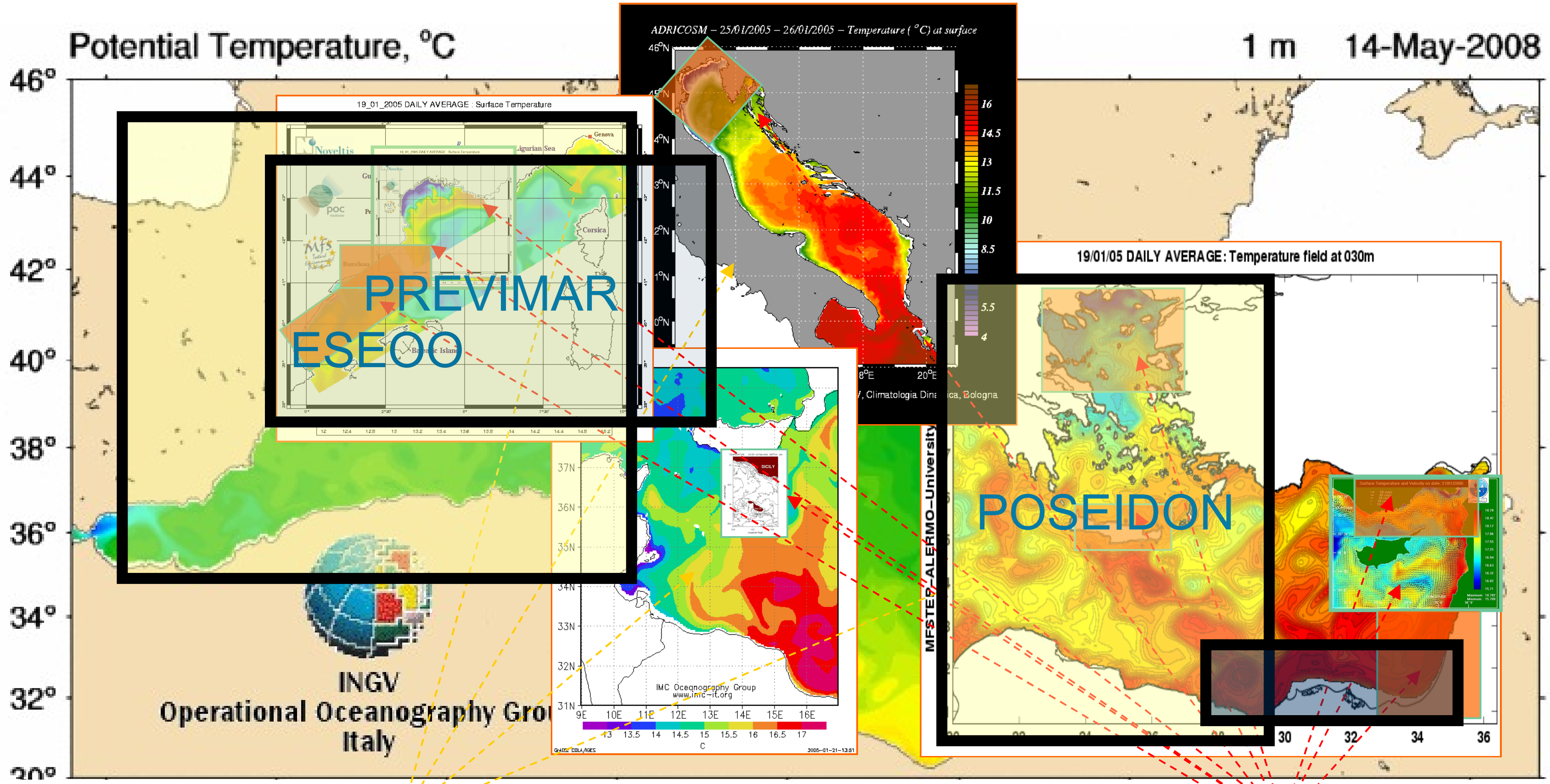
Circulation Model
OPA 1/16°
INGV

Biogeochemical
Flux Model
OPATM-BFM
1/8°
OGS CINECA

Quality Control
Products
OGS

MOON Services: from the basin scale to the shelves

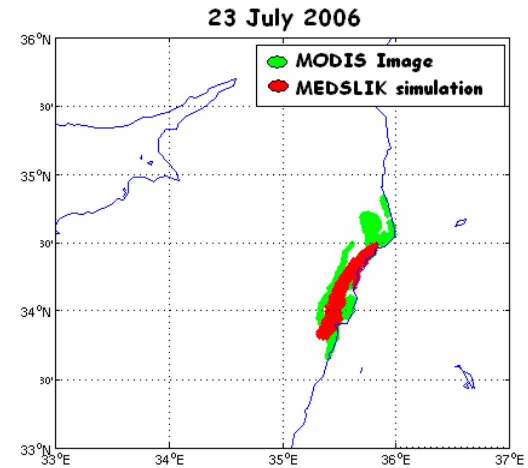
Every day a forecast of the marine state at the resolution needed by different users



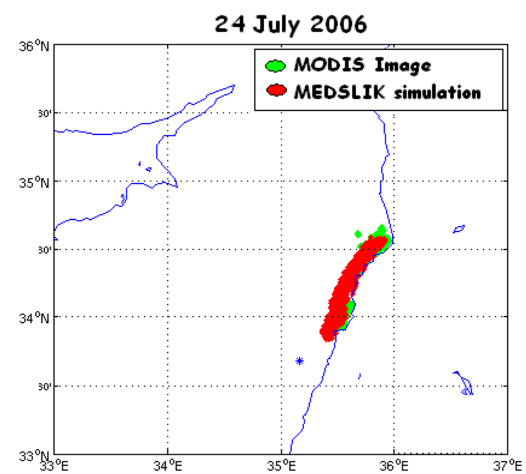
Sub-regional models at 3 km

Shelf models at 1-2 km

MOON downstream service: the Lebanon accident July 2006



Overlay of the MODIS image (23 July 2006 8:35) and the MEDSLIK simulation
(Wind drift=0.03, Wind Angle=0 and Current depth =30m)



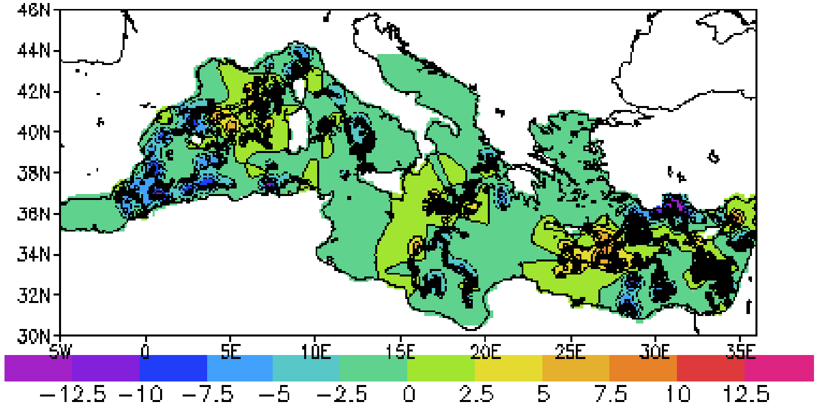
MODIS image
July 23: (08:35) oil (green)
is already in Tripoli.
Mushroom-like feature.

Overlay of the MODIS image (24 July 2006 11:00) and the MEDSLIK simulation
(Wind drift=0.03, Wind Angle=0 and Current depth =30m)

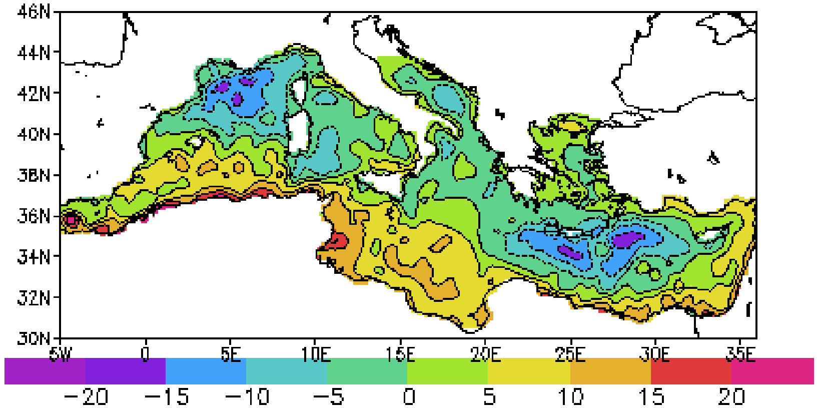
Argo floats:
Data asimilation in the basin scale system (publications)

- Dobricic, S., 2009, A sequential variational algorithm for data assimilation in oceanography and meteorology, Mon. Wea. Rev., 137, 269-287.
- Taillandier, V., S. Dobricic, P. Testor, N. Pinardi, A. Griffa, L. Mortier, G.P. Gasparini, 2009, Integration of ARGO trajectories in the Mediterranean Forecasting System and impact on the regional analysis of the Western Mediterranean circulation, submitted to J. Geohys. Res.
- Dobricic S., and N. Pinardi, 2008, An oceanographic three-dimensional assimilation scheme, Ocean Modelling, 22, 89-105.
- Dobricic, S., Pinardi, N., Adani, M., Tonani, M., Fratianni, C., Bonazzi, A., and V. Fernandez, 2007: Daily oceanographic analyses by Mediterranean Forecasting System at the basin scale, Ocean Sci., 3, 149-157.
- Taillandier, V., A. Griffa, P.-M. Poulain, and K. Béranger, 2006, Assimilation of ARGO float positions in the North Western Mediterranean Sea and impact on ocean circulation simulations. 853 Geophys. Res. Lett., L11604.
- Taillandier, V., and A. Griffa, 2006, Implementation of a position assimilation method for ARGO floats in a Mediterranean Sea OPA model and twin experiment testing. Ocean Sci., 2, 223-236.
- Dobricic, S., 2005, New mean dynamic topography of the Mediterranean calculated from assimilation system diagnostics, Geoph. Res. Lett., 32, L11606.

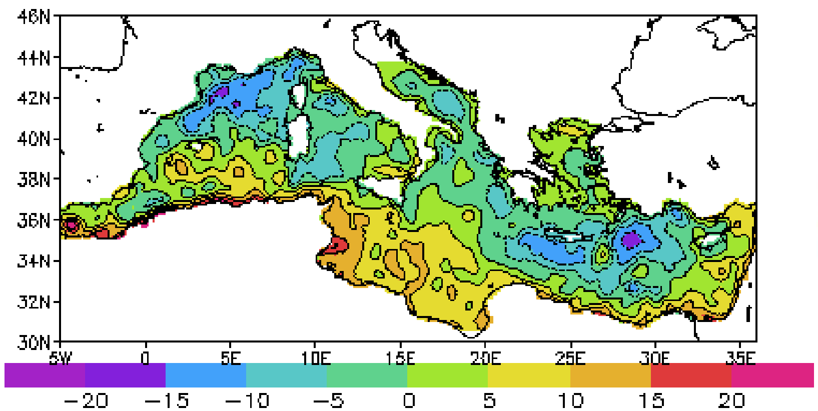
SLA observational bias: Mean Dynamic Topography error



MDT corrections using the estimate of the bias by ARGO floats (Dobricic 2005, GRL)

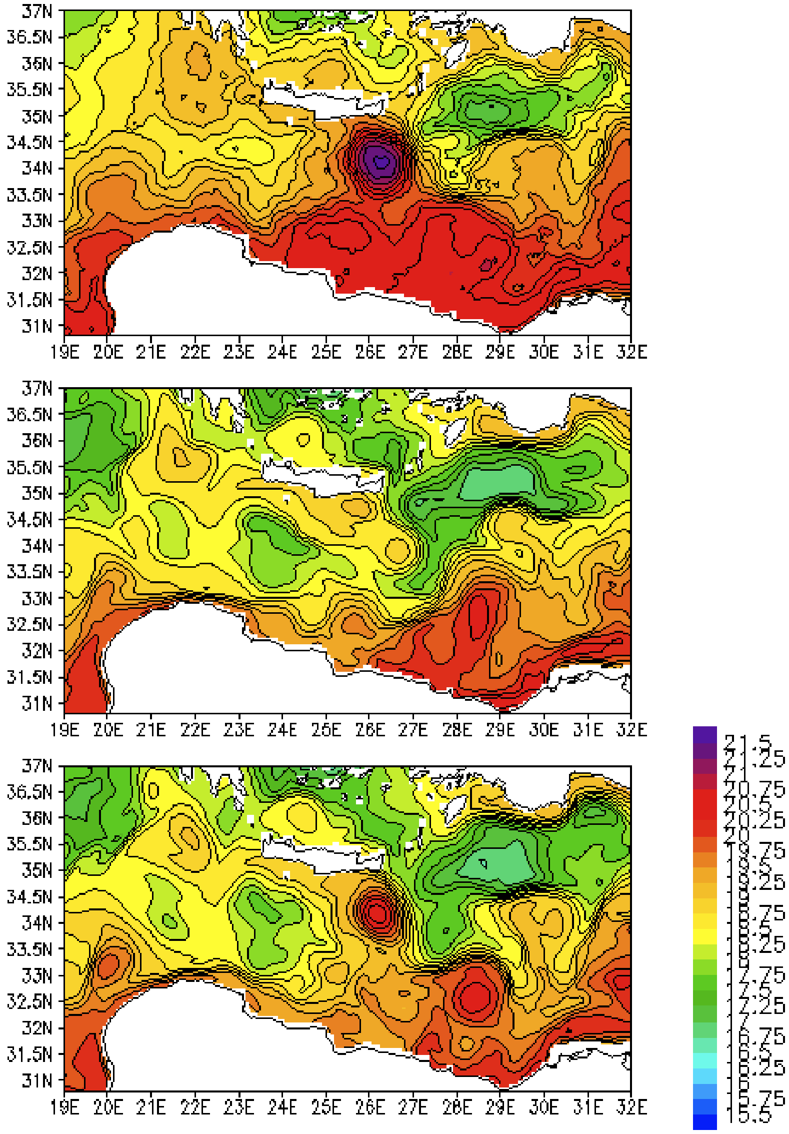


Rio et al. 2007 MDT



MDT estimate after correcting the bias

SLA observational bias: Mean Dynamic Topography error



SST objective analysis – December 2004

Temperature analysis at 30m – December 2004 (old MDT)

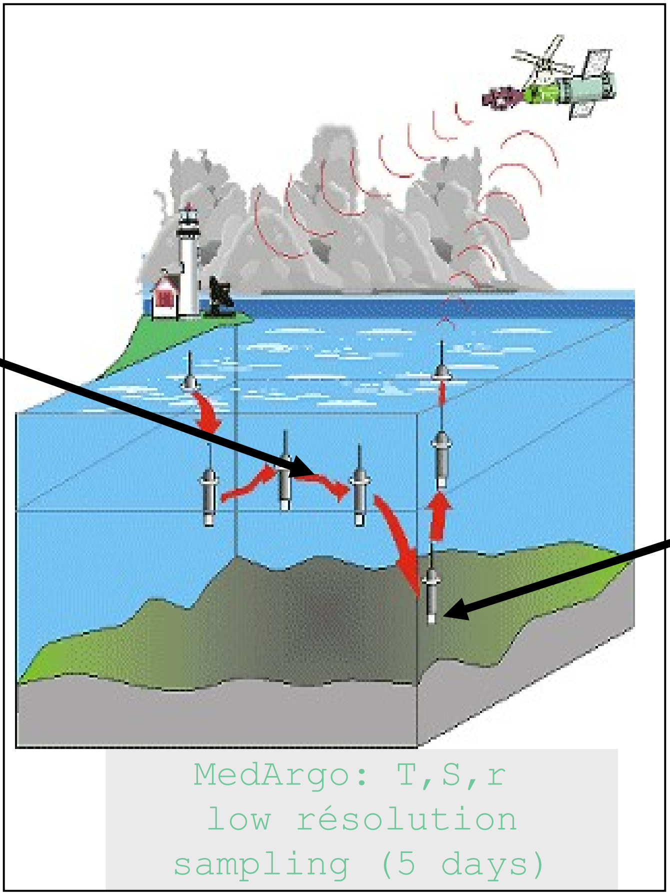
Temperature analysis at 30m – December 2004 (new MDT corrected by ARGO floats)

Argo floats:
Non-linear trajectory model acting as observational operator

$\mathbf{y}$ - Observation of Argo position (r)

H - Non-linear model of the trajectory

350m



700m or 2000m

$$\frac{d\mathbf{r}}{dt} = \mathbf{u}(\mathbf{r})$$

Discussion

- At the basin scalergo floats represent the major observing data set for the state estimate in the Mediterranean Sea below the surface

- It is important to extarct as much as possible all the available observations by Argo floats in order improve the quality of the analysis. The variational approach in data assimilation seems to facilitate this process.

- A strong interaction between the data assimilation and the observing system design has permitted a higher impact of Argo floats on the analyses

- An OSE directly applied to the operational data assimilation system could further increase the impact of Argo floats.