
REAL-TIME USE OF ALTIMETER DATA IN THE MERCATOR OCÉAN FORECASTING AND REANALYSIS SYSTEMS

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- Mercator Océan in brief
 - Overview
 - The forecasting systems
 - The products
 - The performances relative to altimeter data
 - Results of an Observing System Experiment (OSE)
 - Done a few years ago
 - With a North Atlantic + Med 12° system
 - Impact of the altimeter data
 - Impact of

Who are we ?

- Mercator Océan is a non profit French Organization (recently renewed for 15 years), supported by the 5 major French organizations dealing with oceanography
 - CNRS, IFREMER, IRD, Météo-France and SHOM (Navy).
- It is an **Ocean Core Service Provider** (4D ocean state)
- Member of GODAE OceanView, EuroGOOS partner, ...
- Mercator Océan is leading the **MyOcean** project



- Major EU-funded initiative to develop/operate the GMES Marine Core Service
- 55 M€ (34 from EC, 21 from nations), 61 partners, 29 countries, 3-year (→ 04/2012)
- To be followed by the establishment of sustained European Public Services

Who are our users ?

- At **national** level
 - Our shareholders (institutional)
 - Meteo-France for the seasonal forecast and surface drift (pollution, ...)
 - SHOM (Navy applications, acoustics, ...)
 - Coastal community (PREVIMER, SNOCO, ...)
 - Research institutes
 - Other users (incl. private companies)
- At the **European** level
 - Intergovernmental bodies, European and National agencies, European citizens, research, ...
 - 4 areas of benefit identified: marine safety (short term, near surface), climate + seasonal, living resources, coastal
- At the **International** level
 - the GODAE OceanView community,
 - research users,
 - etc.

Our forecasting systems

- Global eddy permitting (Operated since 2005)
 - **Since April 2008:** 1/4° NEMO/LIM, SEEK assim. of alti, T/S and SST, weekly fcst
 - Target: global ocean climate monitoring, biology, sea ice, reanalysis, ...
 - **Major upgrade planned in December 2010**
- Regional eddy resolving (Operated since 2002)
 - North Atlantic + Mediterranean
 - **Since April 2008:** 1/12° (6.5 km at 45°N), NEMO/LIM, SEEK assim. of alti, T/S and SST, daily fcst
 - Target: mesoscale upper ocean, downscaling to smaller regional and coastal regions, ...
 - **Major upgrade planned in December 2010**
- Global low resolution (Operated since 2004)
 - **Since June 2008:** 2° OPA8, SEEK assim of alti, T/S and SST, weekly fcst
 - Target: oceanic initial conditions for coupled seasonal prediction, reanalysis

- **Global eddy resolving (To be operational at the end of MyOcean)**

- NEMO/LIM+SEEK 1/12°
 - Has been demonstrated in April 2008
 - Pre-op since July 2010
- Target: Global Marine Core Service

- **Northeastern Atlantic high resolution (To be operational at the end of MyOcean)**

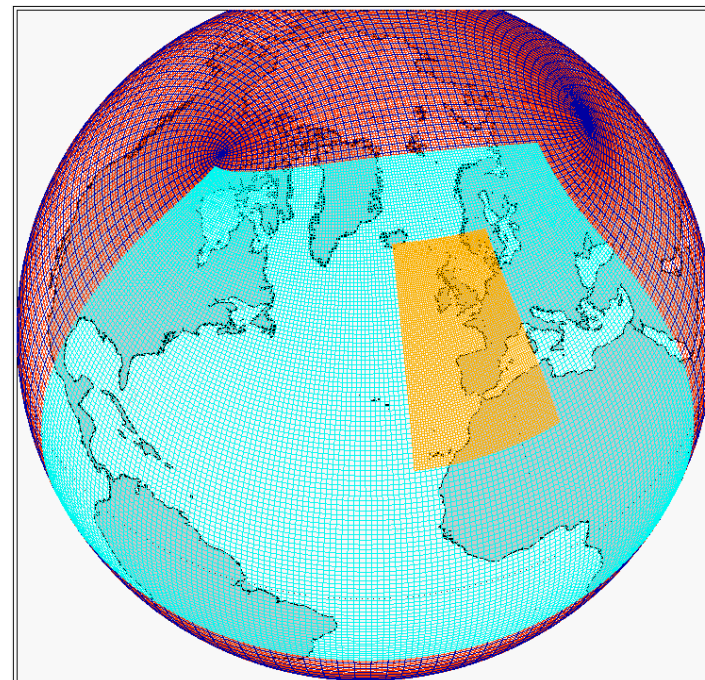
- NEMO 1/36° +SEEK + Tidal free surface
- Target: IBIROOS Marine Core Service → Boundary data to coastal systems



The model configurations

- **1 code** : NEMO (OPA9+LIM)
Ocean and sea ice (LIM-EVP)
physics
- **1 grid** : all the configurations are on the same ORCA (tripolar) grid
- **Forced by ECMWF fields**
BULK formulae
- **One single input dataset** :
initialization and forcing
interpolated inline

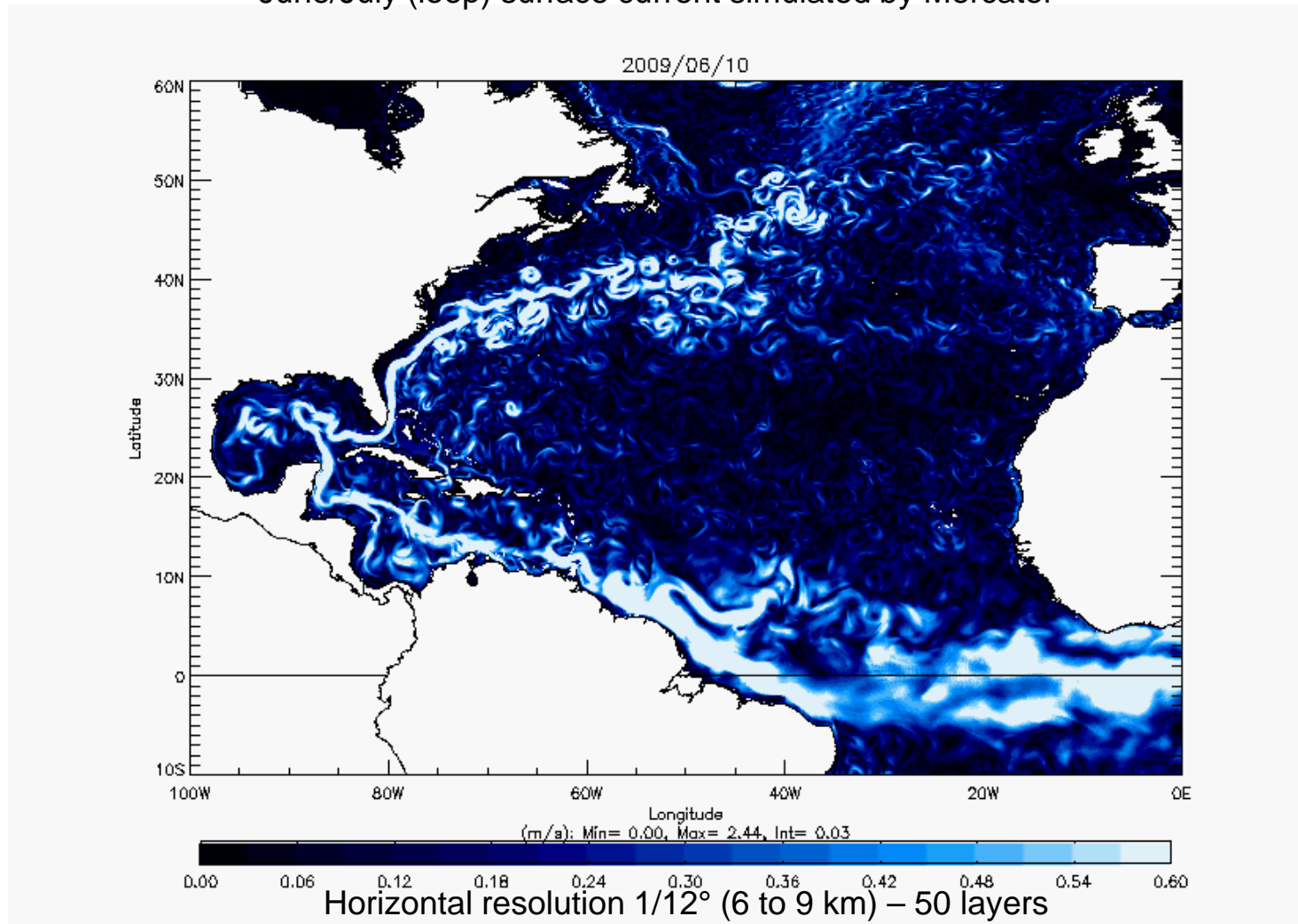
- Some of these configurations are shared with the scientific and operational community
 - ORCA025, ORCA12: Drakkar Project, Barnier et al.
 - UKMO, CMCC, EC, DFO, ...



ORCA025
ORCA12
ATL12
NEATL36

Example of output fields NATL+MED 1/12° surface currents

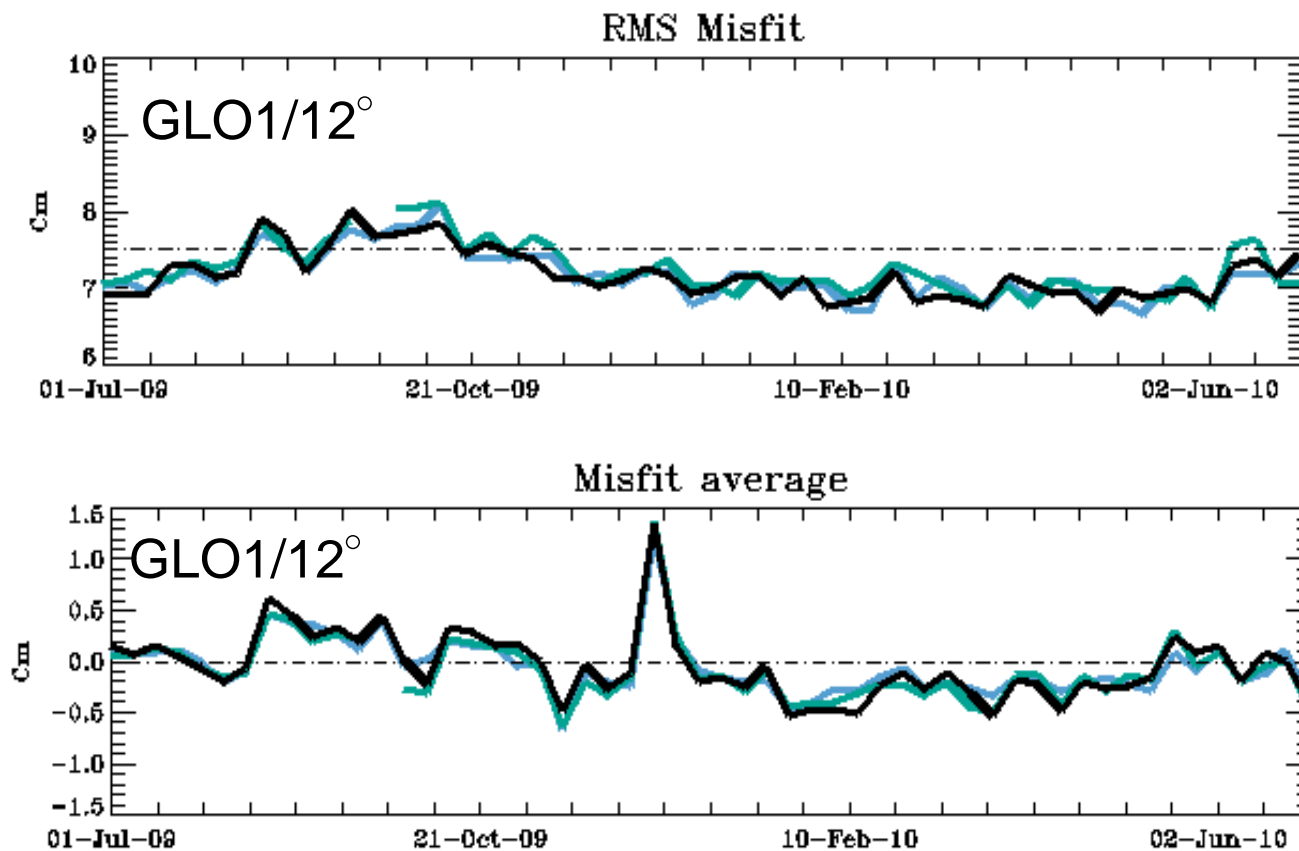
June/July (loop) surface current simulated by Mercator



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The global 1/12° real-time system performances: sea level anomaly

SLA misfit = Obs (not yet assimilated) - forecast



OSE : Impact of multi-mission altimeters on North Atlantic + Mediterranean 5-7 km Mercator forecasting system

- 6-month Observing System Experiment (OSE) in 2004, with our 1/12° regional system (North Atlantic + Mediterranean)
- Start from operational system analysis (3 satellites Jason-1, Envisat, GFO)
- Withdraw 1, 2, 3 satellites, add T/P, and measure impact

Shown here diags from innovation: forecast – obs (not yet assimilated)

$$\frac{\text{RMS}(\text{EXP}_i - \text{obs}) - \text{RMS}(\text{EXP}_i - \text{EXP}_0)}{\text{RMS}(\text{EXP}_0)}$$

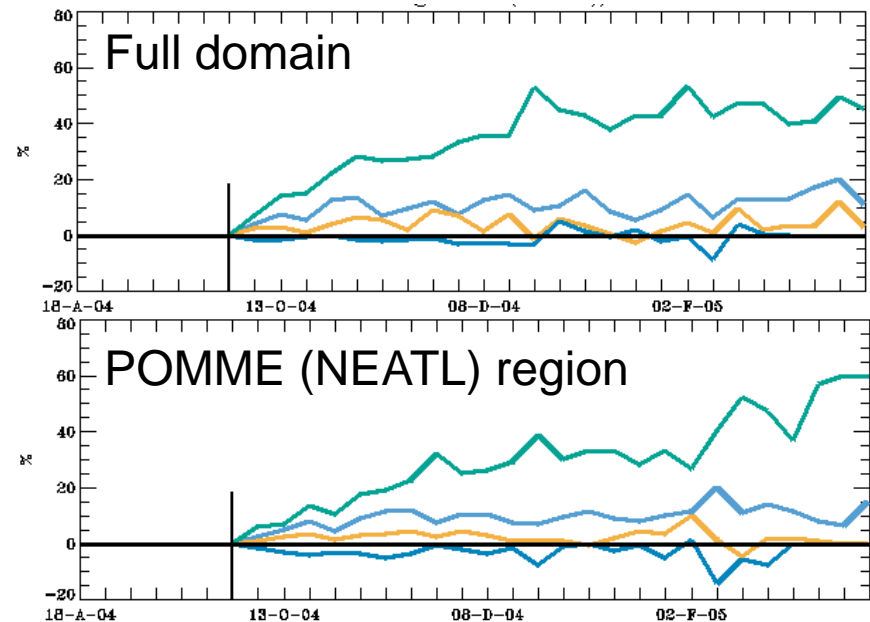
> 0 means degradation in %

0 is the baseline (3 sats)

< 0 means improvement in %

- Jason-1 + Envisat + GFO
- Jason-1 + Envisat
- Jason-1
- No alt
- Jason-1 + Envisat + GFO + T/P

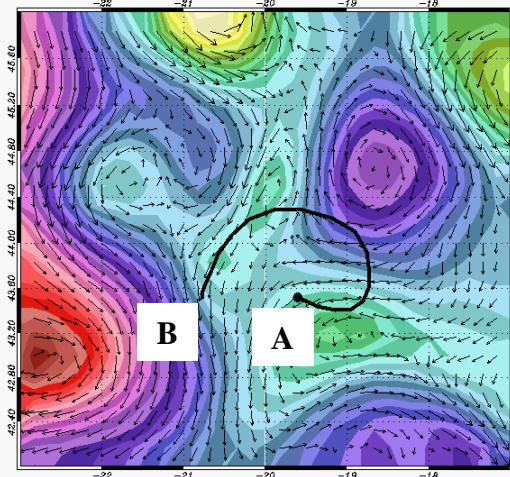
All EXP: In situ T/S + RTG SST



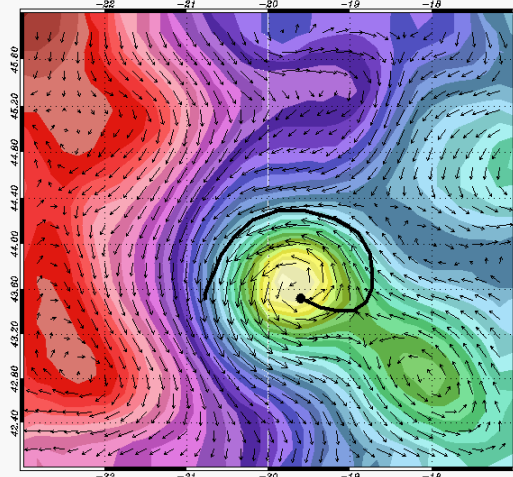
The fate of an individual eddy 44°N- 20°W – Dec 2004

Drifter trajectory
A: 06/12/2004
B: 19/12/2004

mean current & SSH 12/2004 EXP3 No alt

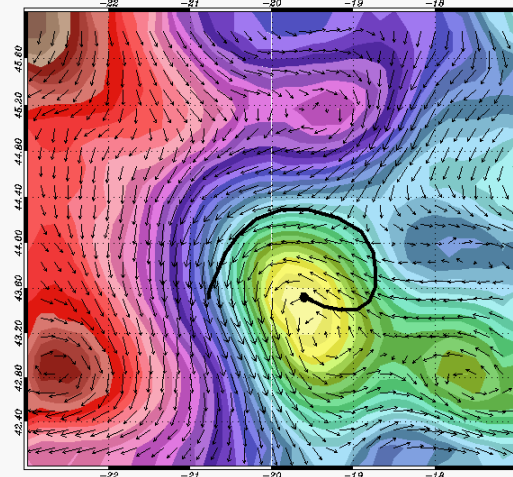


mean current & SSH 12/2004 EXP0 3 sat (oper)

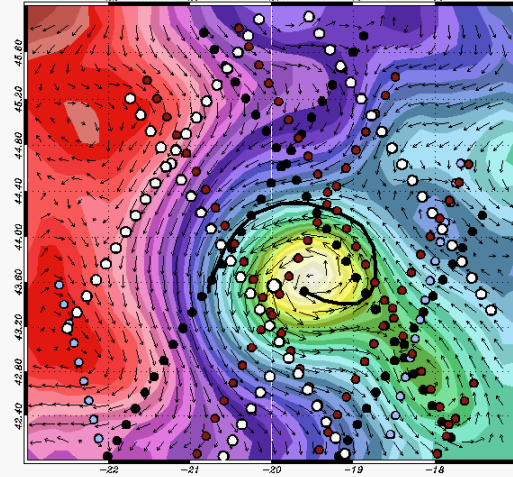


-0.40 -0.20 0. m

mean current & SSH 12/2004 EXP1 Jason-1 only



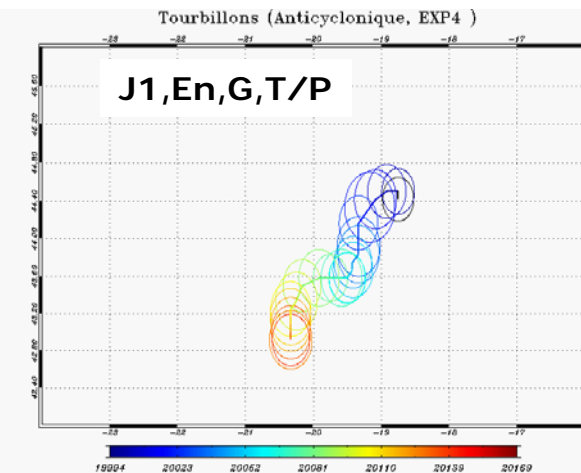
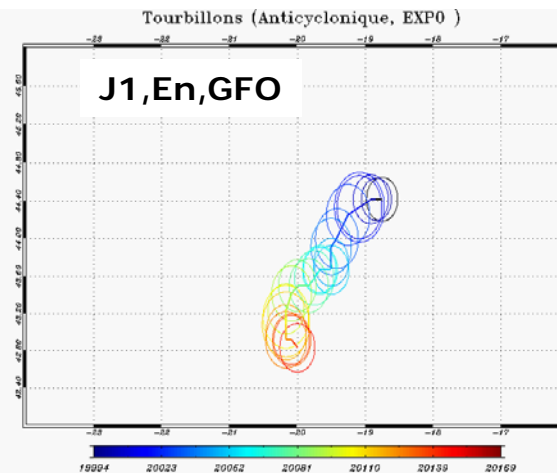
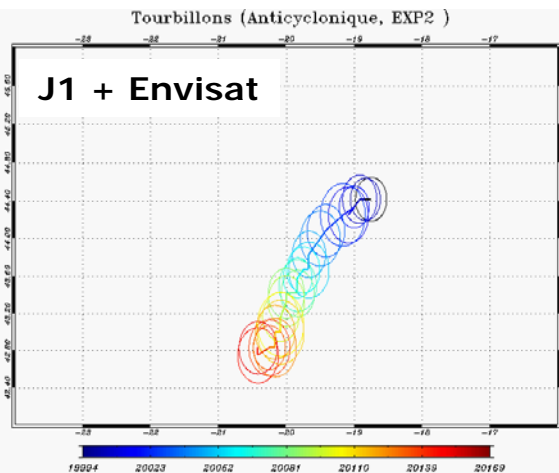
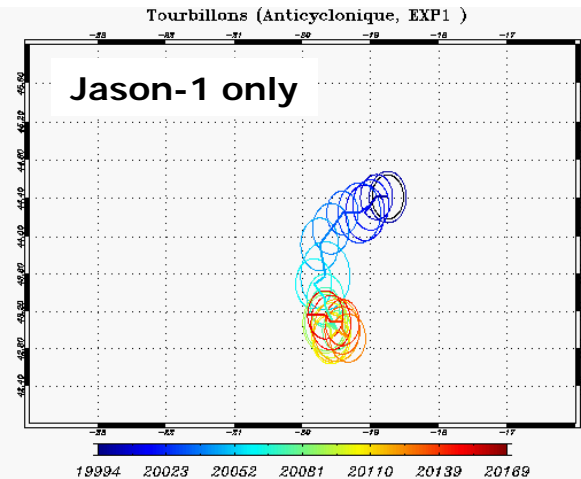
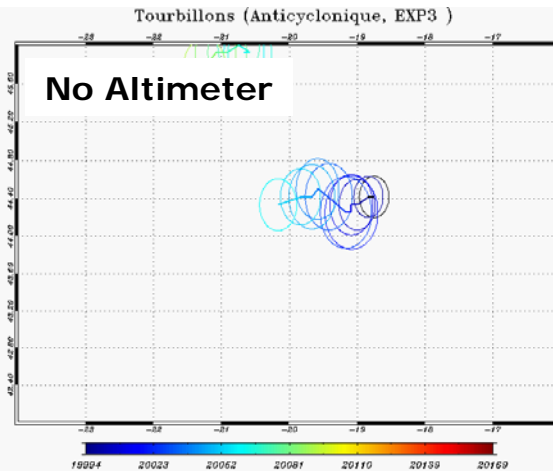
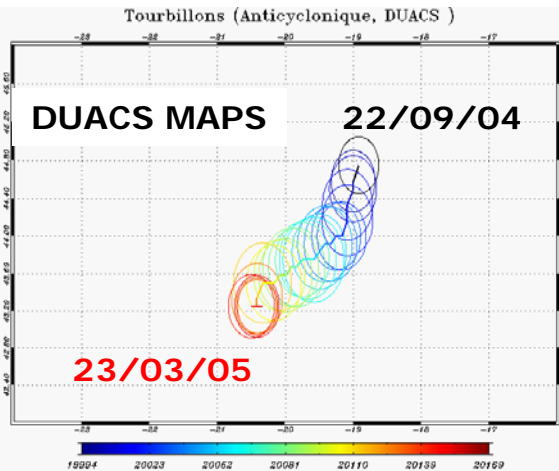
mean current & SSH 12/2004 EXP4 4 sat



-0.40 -0.20 0.00

Black: Jason-1
Light blue Envisat
Red: GFO
White T/P

Automatic eddy tracking

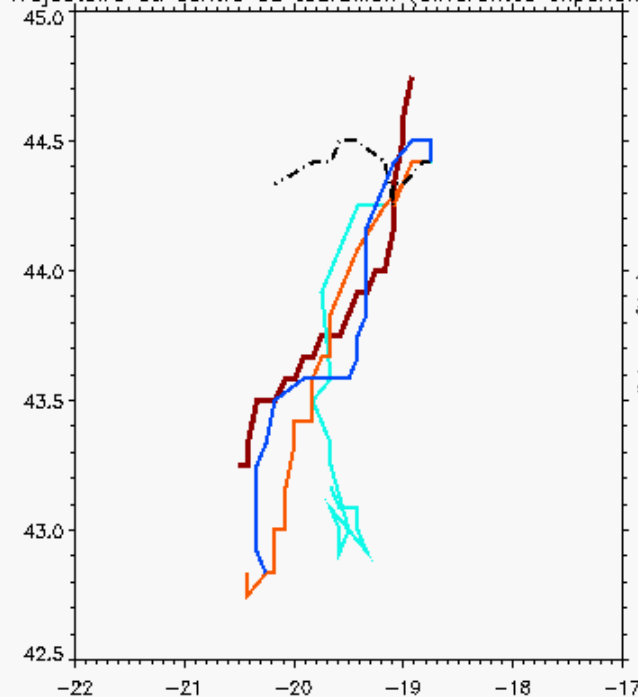


22/09/04 29/12/04 23/03/05

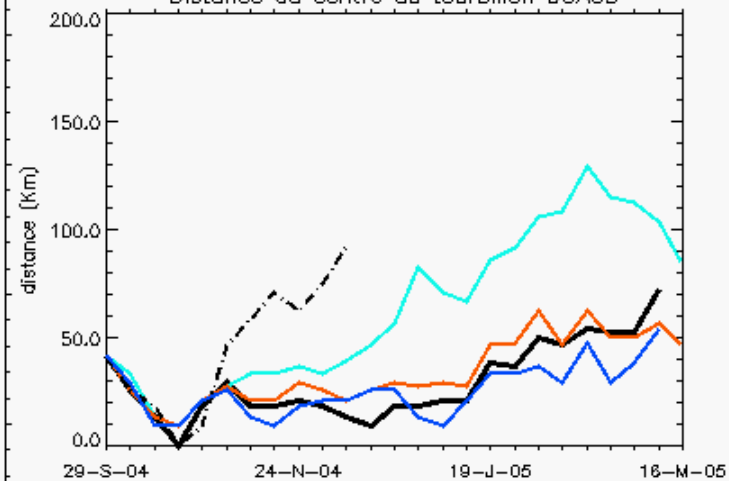
Automatic eddy tracking

Location of the center

Trajectoire du centre du tourbillon (différentes expériences)



Distance du centre du tourbillon DUACS



DUACS
 No alt (dash line)
 Jason-1 only
 J1 + Envisat
 J1 + En+ GFO
 J1 + En + GFO + T/P

Observing systems impact studies: Impact of altimetry on analysis and forecast accuracy

Results of an Observing System Experiment (OSE)

All experiment:

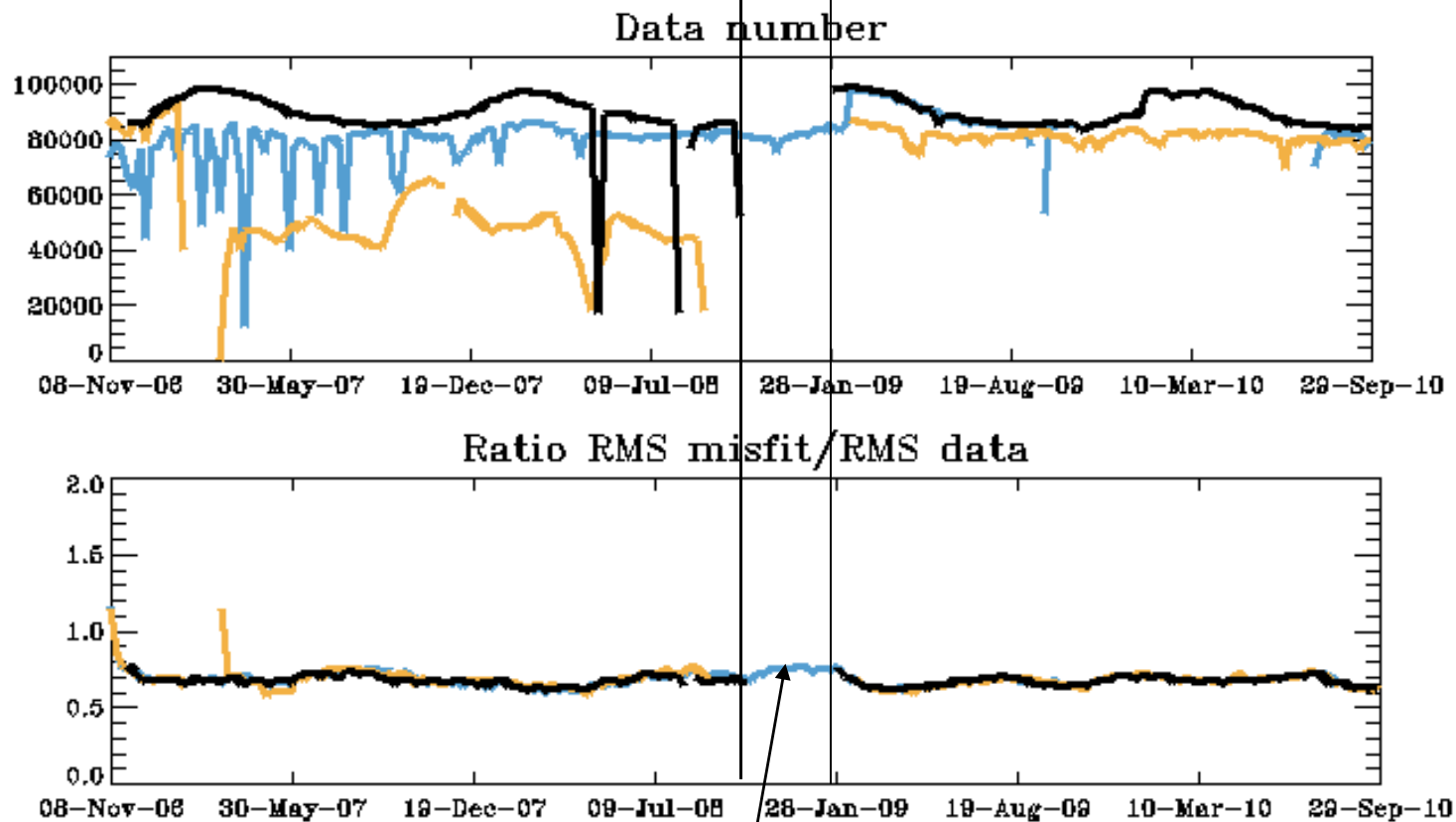
- North Atlantic + Med eddy resolving system (1/15°)
- Multivariate assimilation of SLA+SST+T/S profiles
- 1 year integration (2004)

SLA RMSDIFF	No altimetry	Jason only	Jason + Envisat	Jason +Envisat +GFO	Jason +Envisat +GFO +T/P
7-day Forecast (cm)		10,27	9,67	8,95	8,62
Nowcast (cm)		9,15	8,36	7,50	7,08
Hindcast (cm)	12,94	8,38	7,07	6,18	5,63

Global $\frac{1}{4}^\circ$ ~4 years of hindcast SLA performance

Jason1 - Envisat - GFO

Jason2 - Jason 1 - Envisat



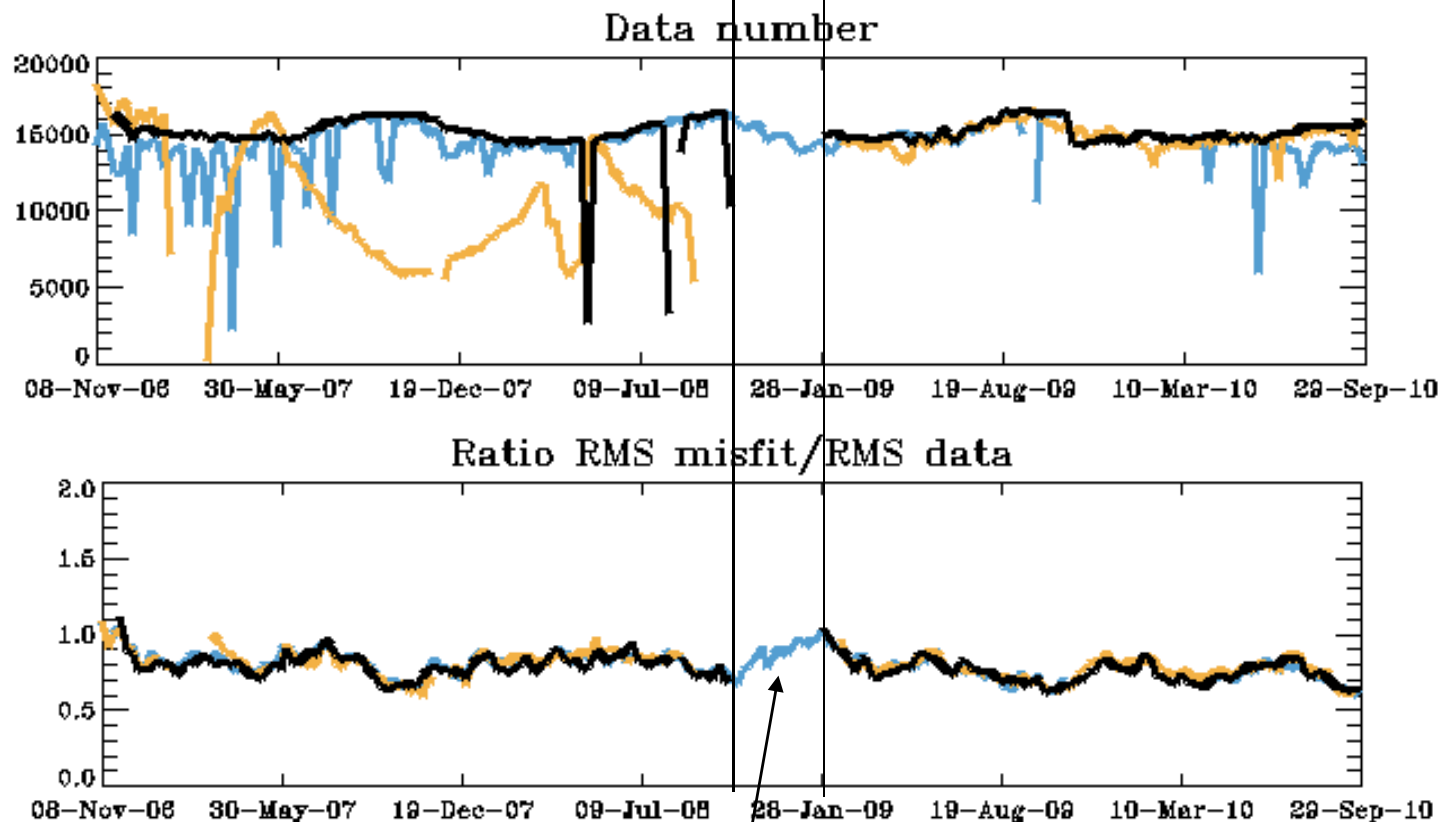
Envisat only (during ~3month)

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Atlantic + Med 1/12° ~4 years of hindcast SLA performance

Jason1 - Envisat - GFO

Jason2 - Jason 1 - Envisat



Envisat only (during ~3month)

Summary and conclusions

- Mercator Océan provides operational ocean services
 - Ocean mesoscale
- These services are done using forecasting systems
 - Multivariate assimilation of altimeter data, SST and *in situ* T/S
 - Global and regional eddy resolving systems
- Mesoscale forecast skill requires assimilation of altimeter data
 - Even if SST and T/S are assimilated, no forecast skill for the mesoscale if no altimeter data are assimilated
- Thanks to the use of the tandem Jason1/2 mission + Envisat data since Beg 2009 (processed by AVISO), we have today stable good performances of the systems
 - O(7-8) cm RMS error for the global SLA
- 1 altimeter satellite is clearly not sufficient – 3 OK
 - Degraded performances when one satellite only is assimilated