Mesoscale Mapping Capabilities of Multisatellite Altimeter Missions

First Results with Real Data in the Mediterranean Sea

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1. Introduction

- Satellite altimetry is considered as one of the most important input datasets for operational applications.
- At least two altimeter missions are needed to resolve the main space and timescales of the ocean [*Koblinsky et al*, 1992].
- However, theoretical studies [*e.g. Le Traon et al,* 2001] have revealed that three altimeters should improve the mesoscale variability mapping.

Objectives of this work

1. To merge up to 4 altimeter missions [Jason-1, T/P, ERS-2, GFO]
2. To evaluate the impact in the monitoring of mesoscale variability

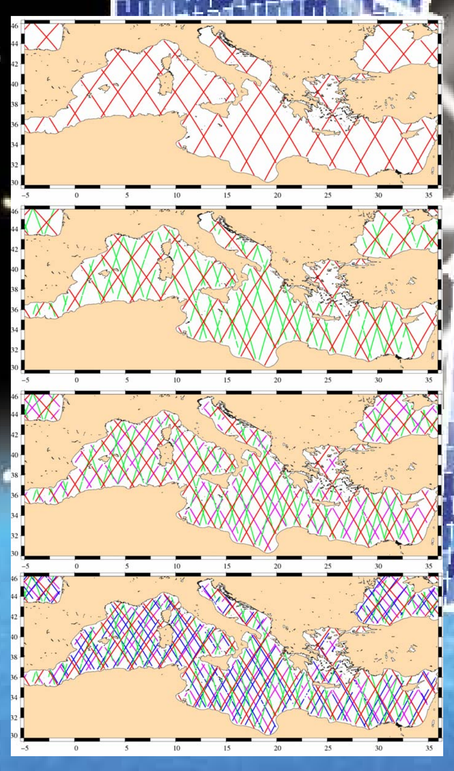
2. Data Sets

- **Jason** (10-day repeat period)
- **TP** (interlaced) (10-day repeat period)
- **ERS** (35-day repeat period)
- **GFO** (Geosat Follow On) (17-day repeat period)

- **Period**: 2 Oct 2002-18 June 2003 (8.5 months of data)

- **Data processing:**
  - Usual geophysical corrections (Le Traon and Ogor, 1998).
  - SLA computed by removing a
    - 7-years mean (1993, 1999) Jason and ERS,
    - New temporal mean for GFO
    - New temporal mean for TP interlaced
- **Objective analysis:**
  - Objective analysis = multi-satellites combination (Le Traon et al., 1998).
  - Long wavelength error corrected.
  - Space and time correlation functions with 100 Km and 10 days correlation radius
  - Weekly maps, 1/8° spatial resolution

3. The different altimeter configurations



1 satellite
Jason-1

2 satellites
Jason-1 + ERS-2

3 satellites
Jason-1 + ERS-2 + T/P

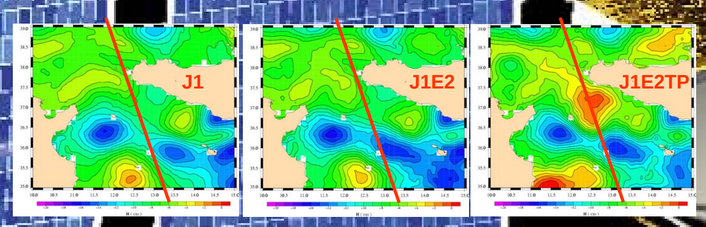
4 satellites
Jason-1 + ERS-2 + T/P + GFO

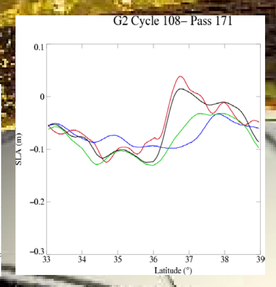
The study area with the different satellite configurations considered in this study superimposed. Jason-1 is in red, ERS-2 is in green, T/P is in purple and GFO is in blue.

4. Validation with independent altimetric data

In order to quantify the improvement of merging several satellites, we carry out an external comparison with the sea level observed along GFO tracks.

Estimation of SLA from combined maps (J1, J1E2, J1E2TP) along GFO tracks

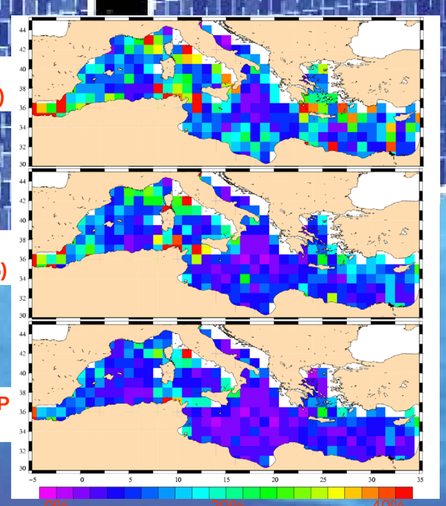




Rms error for the estimation of **sea level** along GFO tracks from:

- **J1** (15.2 %)
- **J1E2** (11.0%)
- **J1E2TP** (7.3%)

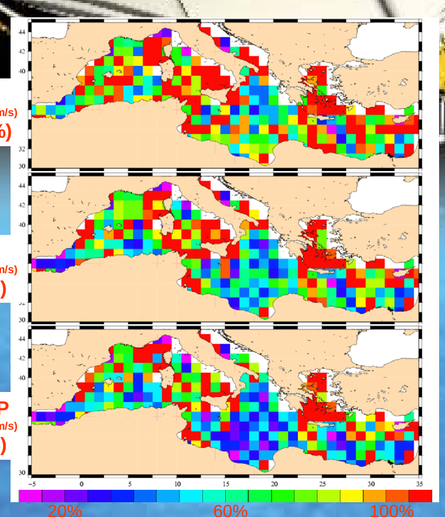
The along track data have been averaged in square boxes of 1°x1°. Units are % of signal variance.



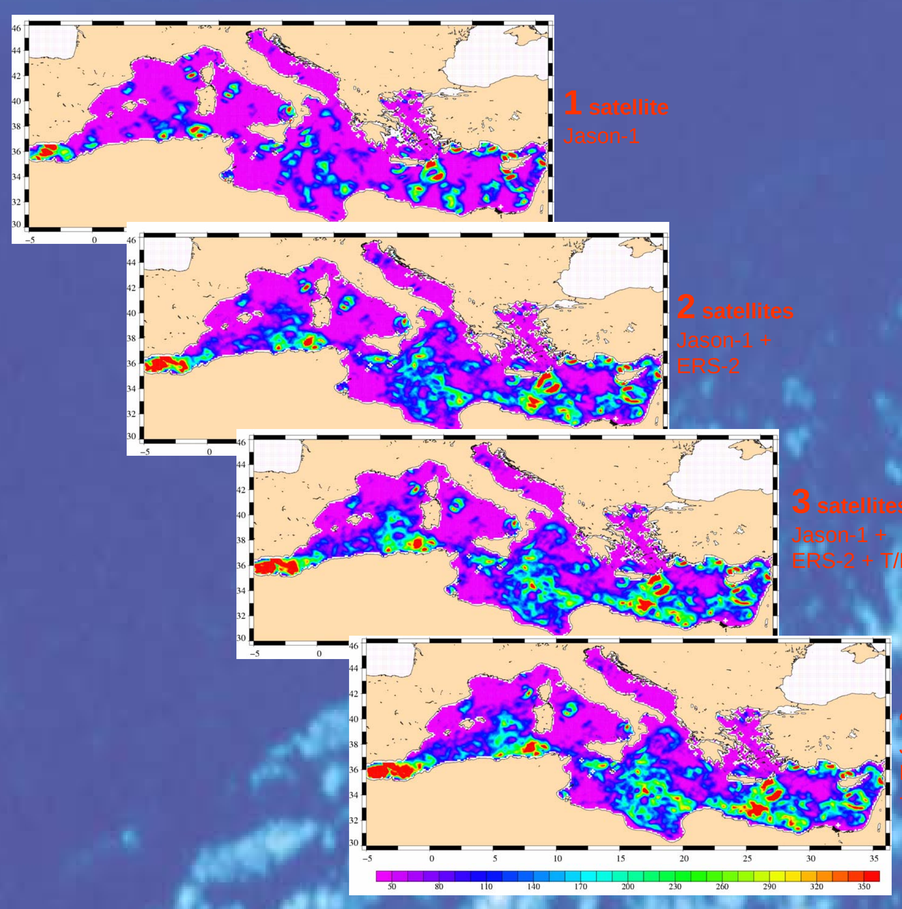
Rms error for the estimation of **velocity** across GFO tracks from:

- **J1** (rms > 15 cm/s) (51.1 %)
- **J1E2** (rms > 15 cm/s) (34.1%)
- **J1E2TP** (rms > 15 cm/s) (22.9%)

The along track data have been averaged in square boxes of 1°x1°. Units are % of signal variance.



5. Eddy Kinetic Energy



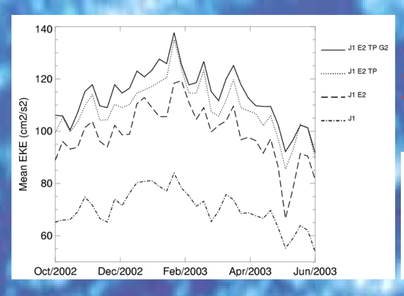
1 satellite
Jason-1

2 satellites
Jason-1 + ERS-2

3 satellites
Jason-1 + ERS-2 + T/P

4 satellites
Jason-1 + ERS-2 + T/P + GFO

(above) Mean Eddy Kinetic Energy (EKE) averaged over the period of study for the different satellite configurations. Units are cm²/s². The combination of four altimeters reveals important differences from the reference 2-satellite configuration. In particular, the variability of western Alboran gyre and the continuity of the Atlantic Ionian Stream, crossing the Ionian Basin are better reproduced with 4 altimeters, and there is a significant increase of energy in the Levantine Basin, in the Mersa-Matruh area.



(on the left) Temporal evolution of mean EKE averaged over the whole Mediterranean.

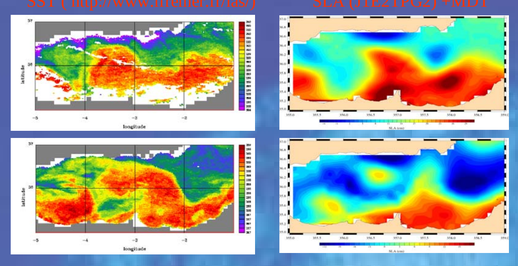
J1E2TPG2	113 cm2/s2
J1E2TP	109 cm2/s2
J1E2	99 cm2/s2
J1	70 cm2/s2

(+15% J1E2)

Credits: CNES/D. Ducros

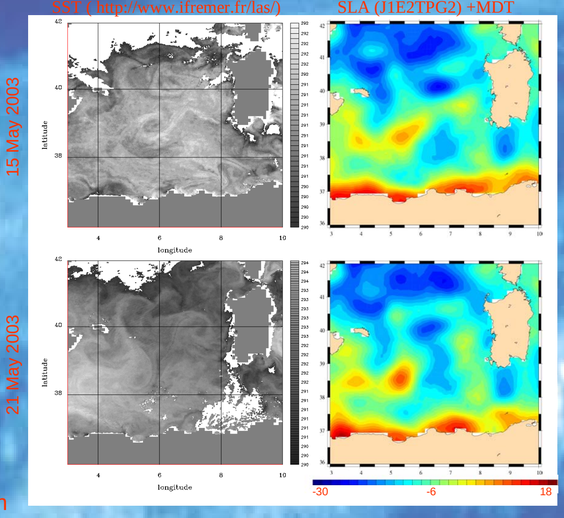
6. Comparison with other kind of data

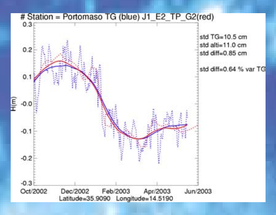
SST (http://www.ifremer.fr/las/) | SLA (J1E2TPC2) +MDT

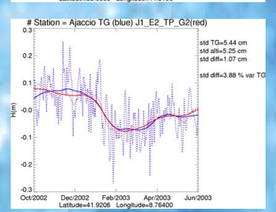


Comparison of altimetry and SST in the Alboran Sea (on the top) and Algerian Basin (on the right). The combination of four altimeters enables to reproduce the position, size and intensity of the mesoscale signals. In particular, a deformation of the eastern Alboran gyre and the separation of two twins eddies in the Algerian Basin within the period of only one week, are well captured.

SST (http://www.ifremer.fr/las/) | SLA (J1E2TPC2) +MDT







(on the left) Comparison of tide gauge (in dotted blue) and altimetry (in dotted red). The continuous lines are the filtered (30-day running average) data. The SLA time series correspond to the interpolation of the 4- satellites merged maps onto the position of the tide gauges.

Rms diff between SLA and TG

STATION	J1E2	J1E2TPG2
Ajaccio	5.27%	3.88%
Casablanca	6.44%	2.21%
Monaco	10.5%	9.32%
Nice	10.9%	9.70%
Portomaso	1.70 %	0.64%
Toulon	7.07%	4.38%

Units % of TG variance

(on the left) Comparison of altimetry and the trajectory of a lagrangian buoy in the central Ionian Sea. In the figures, the trajectory followed by the drifter (red line) between 11 June 2003 and 25 June 2003, and Absolute Dynamic Topography of 18 June 2003 for the Jason-1 +ERS-2 (on the top) and Jason-1+ ERS-2 + T/P +GFO (on the bottom) configurations.

7. Conclusions

❖For the first time we have successfully merged 4 altimeter missions, that provide:
- a mean EKE 15% higher that J1E2
- a better description of the mesoscale variability

❖The external verification with G2 data shows that with a combination of 3 satellites:
- sea level and velocity can be mapped with an accuracy of about a factor two less than the results derived from 1 satellite.

❖The comparison between altimetry and other kind of data (SST, tide gauges, ...) is improved when 4 altimeters are included.

This study demonstrates that 3/4 altimeters are needed for the correct monitoring of the mesoscale in the Mediterranean Sea

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