GAMBLE WP2

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Objectives of WP2

- **Presentation/discussion of recent research involving the use of combined data from different altimeter missions with relation to applications of SSH measurements.**

- **build on T/P-Jason and ERS/ENVISAT SWT works**

- **The aim is to establish (a) the best way to combine data from different missions, and (b) the optimum combination of orbits and sampling patterns that will allow key ocean features to be studied**

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TASKS FOR WP2

Summarize works that have been carried out to provide recommendations for future missions on :

- **Sampling requirements for SSH (and surface current) measurements**
- **SSH error budget (orbit, noise, corrections, repetitivity, geoid)**
- **Merging methodologies.**

=> Review of past studies and input from Gamble partners

=> HOT SWT (NASA/CNES) report, T/P and Jason SWT reports...

GAMBLE WP2 report based on CLS works on the merging of multiple altimeter missions

Simulation of new altimeter missions/concepts

- **Theoretical analyses of sea level and velocity mapping capabilities of existing multiple altimeter missions (Le Traon and Dibarboure, 1999; Le Traon et al., 2001)**
- **Analyze the WSOA system and analyze constellations of 3/4 satellites (Alti-Ka, Wittex) - HOT SWT report + Le Traon and Dibarboure, 2002, JAOT**
- **Analyze potential contribution of GPS reflected signals (ESA study)**

Merging of existing missions (T/P, ERS, GFO, Jason and ENVISAT) **Effective merging methodologies have been developed and successfully applied for merging TP and ERS (Le Traon et al., 1998, Le Traon and Ogor, 1998; Ducet et al., 2000, Ducet and Le Traon, 2001) and for merging TP, ERS and GFO (Le Traon et al., 2002))**

Used by the SSALTO/DUACS real time multiple altimeter processing system

and studies by Gamble partners on data assimilation (LEGI), feature detection (SOC) and coastal regions (POL, LEGOS)

+ GAMBLE WP2 workshop

Workshop Summary - Theme 1 (SSH) - Requirements

- **Minimum requirement :**
  - **Continue the Jason series for long-term, precise altimeter system**
  - **Fly a post-ENVISAT mission to continue the T/P+ERS (Jason-1+ENVISAT) configuration after 2006 => Alti-Ka is a good candidate and demonstrator for a future constellation system (GANDER).**
- **"more ambitious" requirement**
  - **Fly a three satellite constellation (interleaved Jason tracks or ENVISAT with a 35/3 repeat period) (in addition to the Jason series) that will provide a very significant improvement for SSH operational applications and will "pave the way" for GANDER.**
- **Need a demonstration of WSOA on board Jason-2 before considering swath techniques for future operational systems (post 2010)**

SSH Errors

Radiometer and ionospheric corrections (Ka or dual) are needed. Should be revisited if this becomes a critical issue.

Orbit error should be below 2 cm rms in real time for the Jason series (goal). This can be relaxed for the other missions (if tracking system is an issue).

Orbit should be maintained in a +/-1 km band. Can be relaxed if along ERS or T/P tracks.

TANDEM MISSION ANALYSIS

Several months of the TOPEX/Poseidon – Jason-1 tandem mission were analysed. Results from the tandem mission were compared with those derived from Jason-1 alone and an external verification was performed with ERS-2 data.

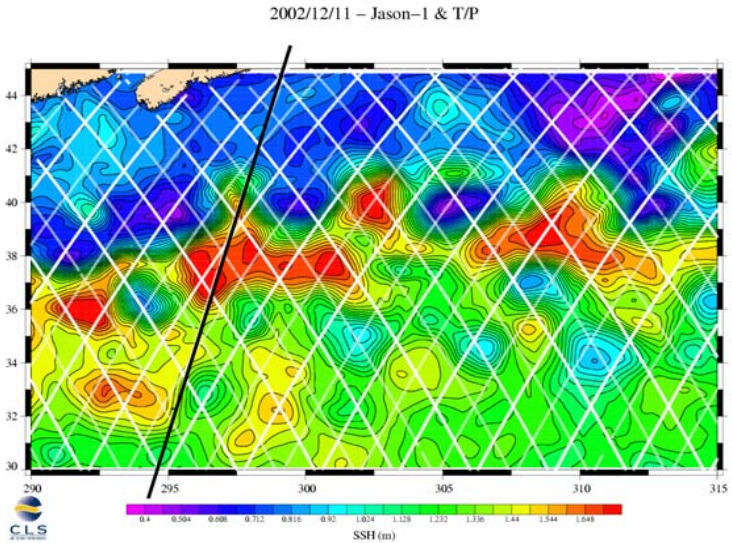
Results demonstrate the potential of an optimised two-satellite constellation for the mesoscale circulation monitoring. They also confirm Le Traon et al. (2001) and Le Traon and Dibarboure (2002) theoretical analyses that were used as an input for GAMBLE Work Package 2.

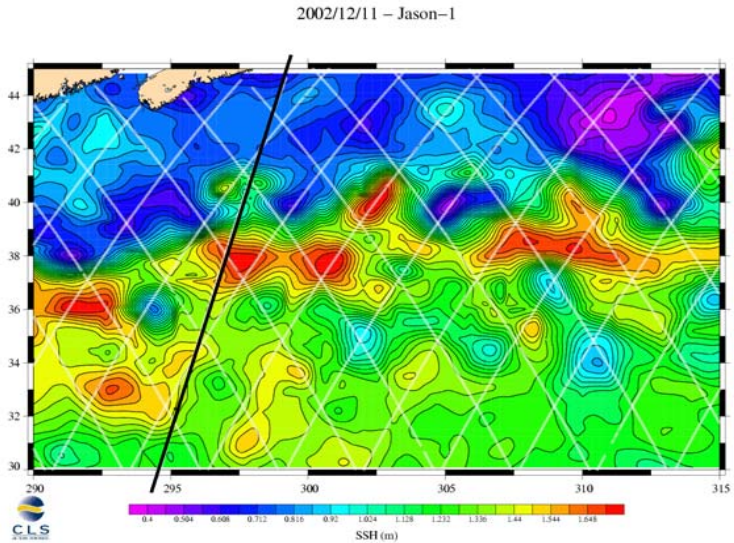
The recommendations for future missions given in Work Package 2 final report can thus now be used with more confidence as an input for Work Package 8.

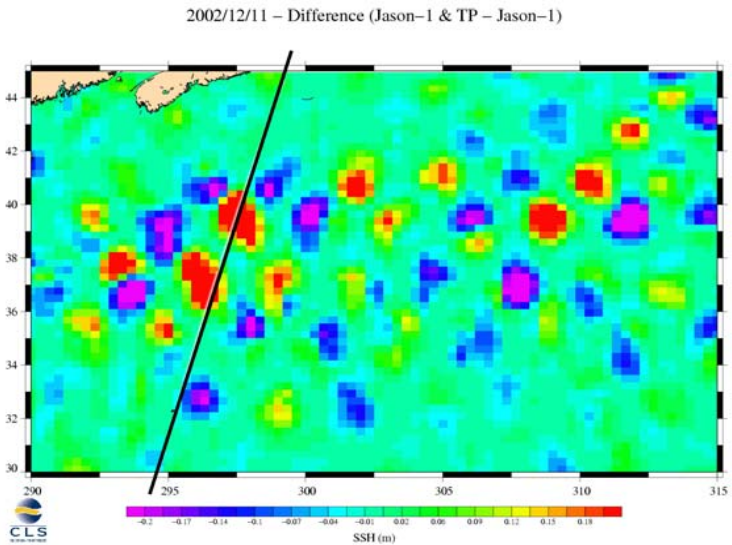
Future studies should now be performed over a longer time series and should also analyse the contribution of the tandem mission together with ERS-2/ENVISAT and GEOSAT Follow On data. Detailed analysis of velocity mapping error (through the comparison with surface drifters, current-meter moorings) and eddy/mean flow interaction estimations should be carried out. External comparison with very high resolution Sea Surface Temperature or Ocean Color images should also be performed to quantify the capability of multiple altimeter configurations to capture small space and time scales of the mesoscale variability.

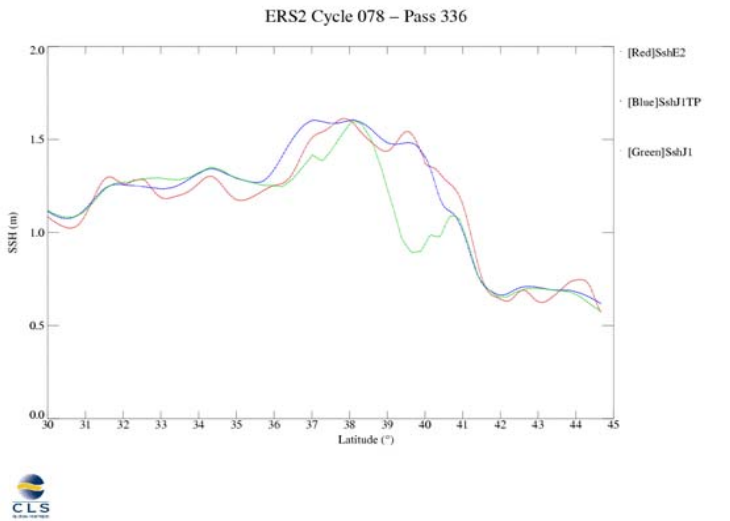
The Jason-1 – TOPEX/POSEIDON tandem mission

A unique opportunity for mesoscale variability studies



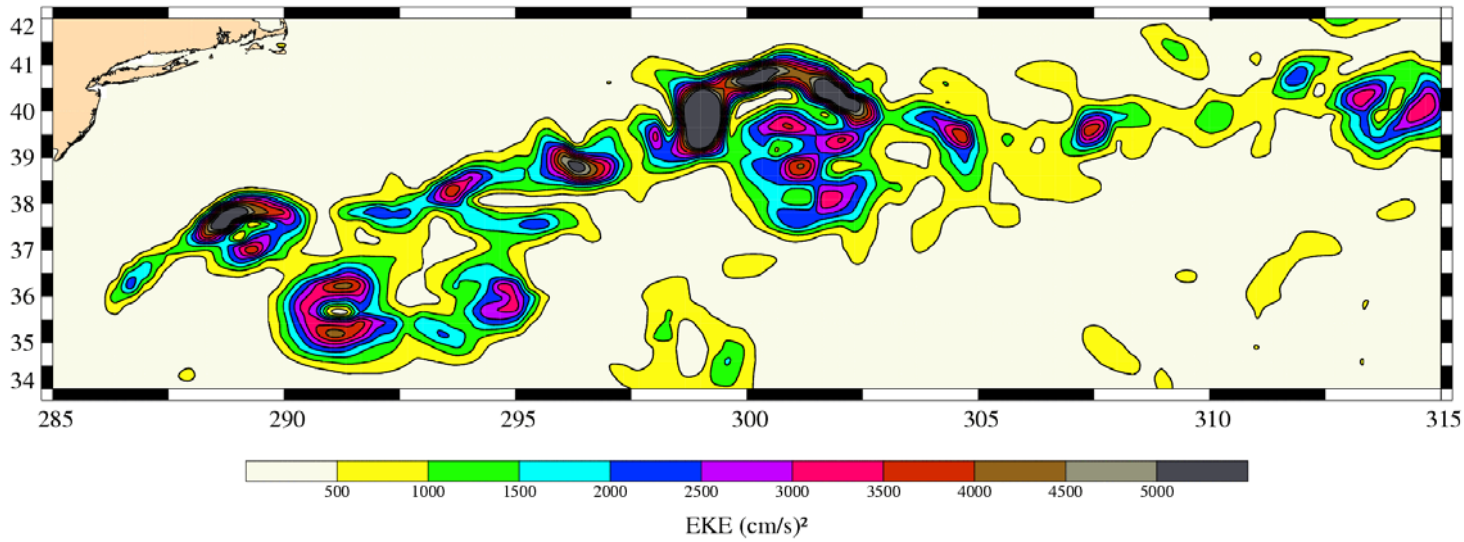




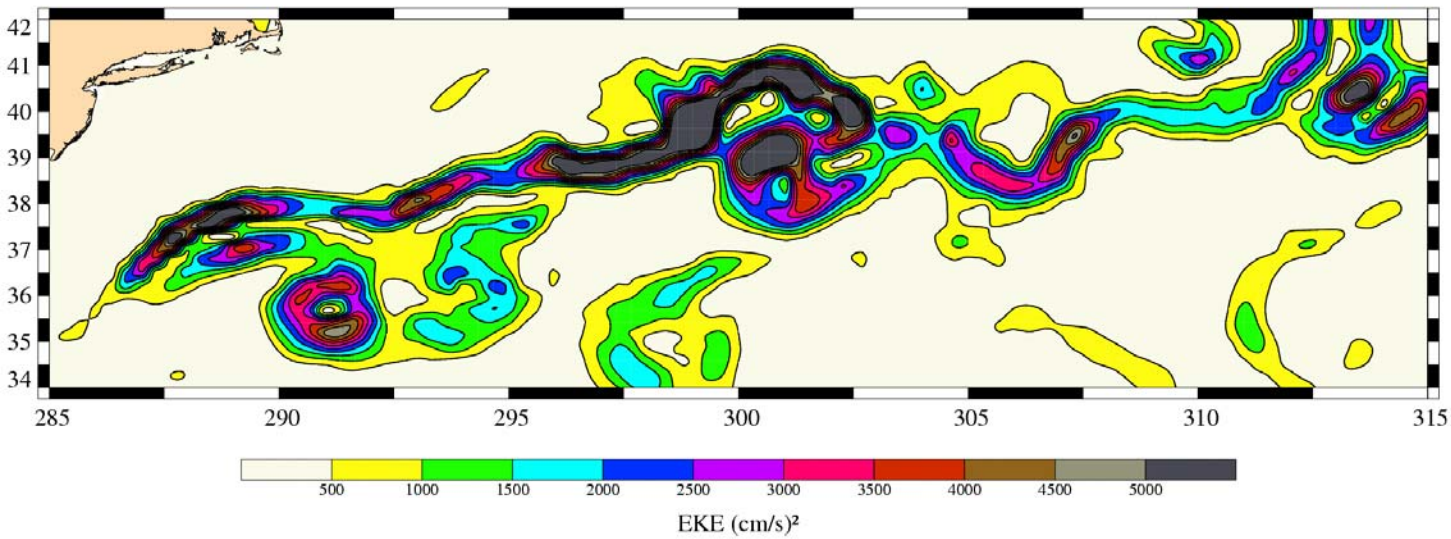


ERS track (in black) used as a reference to compare Jason-1 and Jason-1+T/P

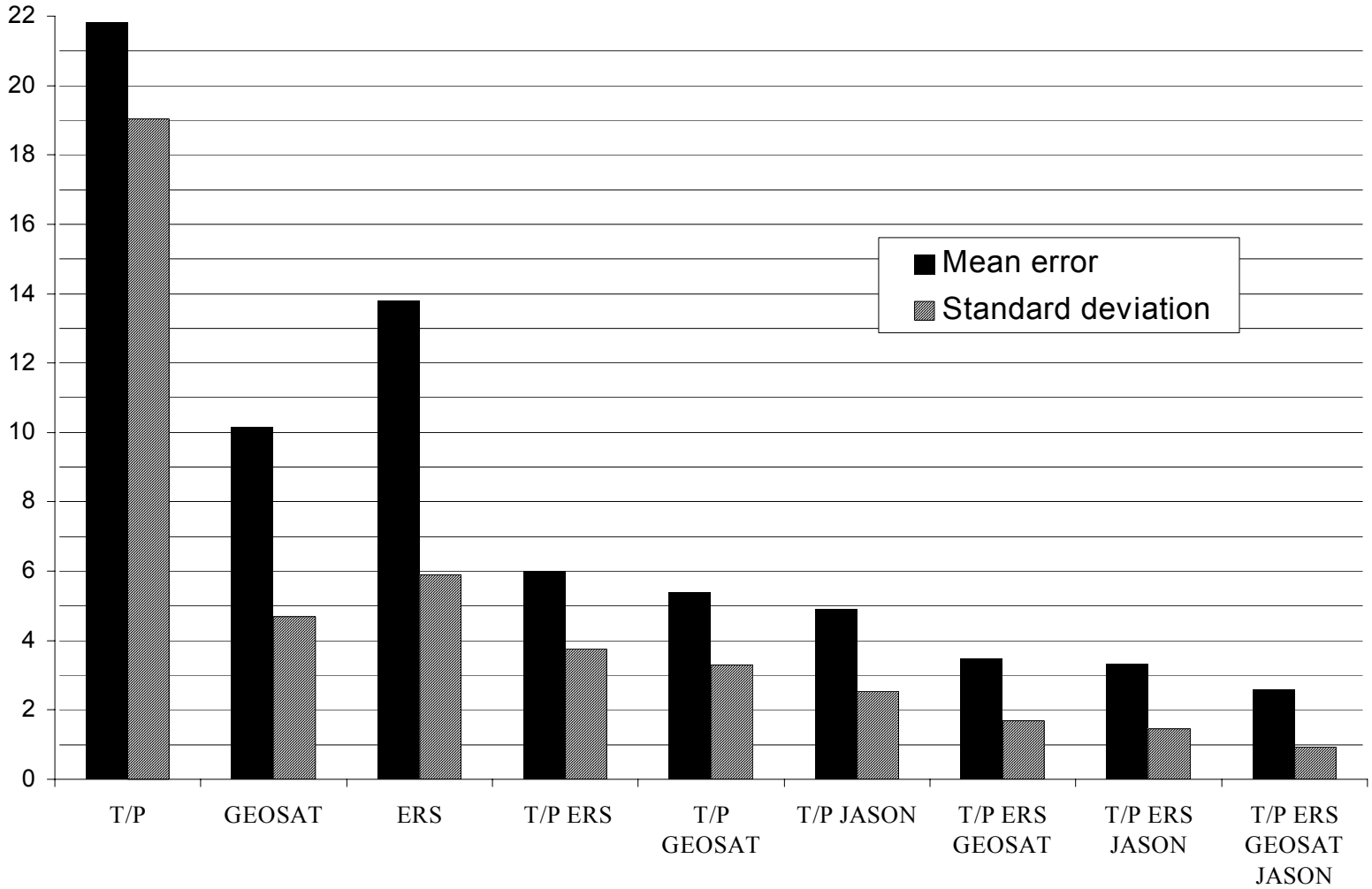
December 2002, Eddy Kinetic Energy in the Gulf Stream area



Jason-1



Tandem mission (Jason-1/TP)



Mean and standard deviation of Sea Level Anomaly (SLA) mapping error for single and multiple altimeter missions (Le Traon and Dibarboure, 1999). Units are in % of signal variance. The calculation assumes a space scale of 150 km and a time scale of 15 days and a noise/signal ratio of 2%.

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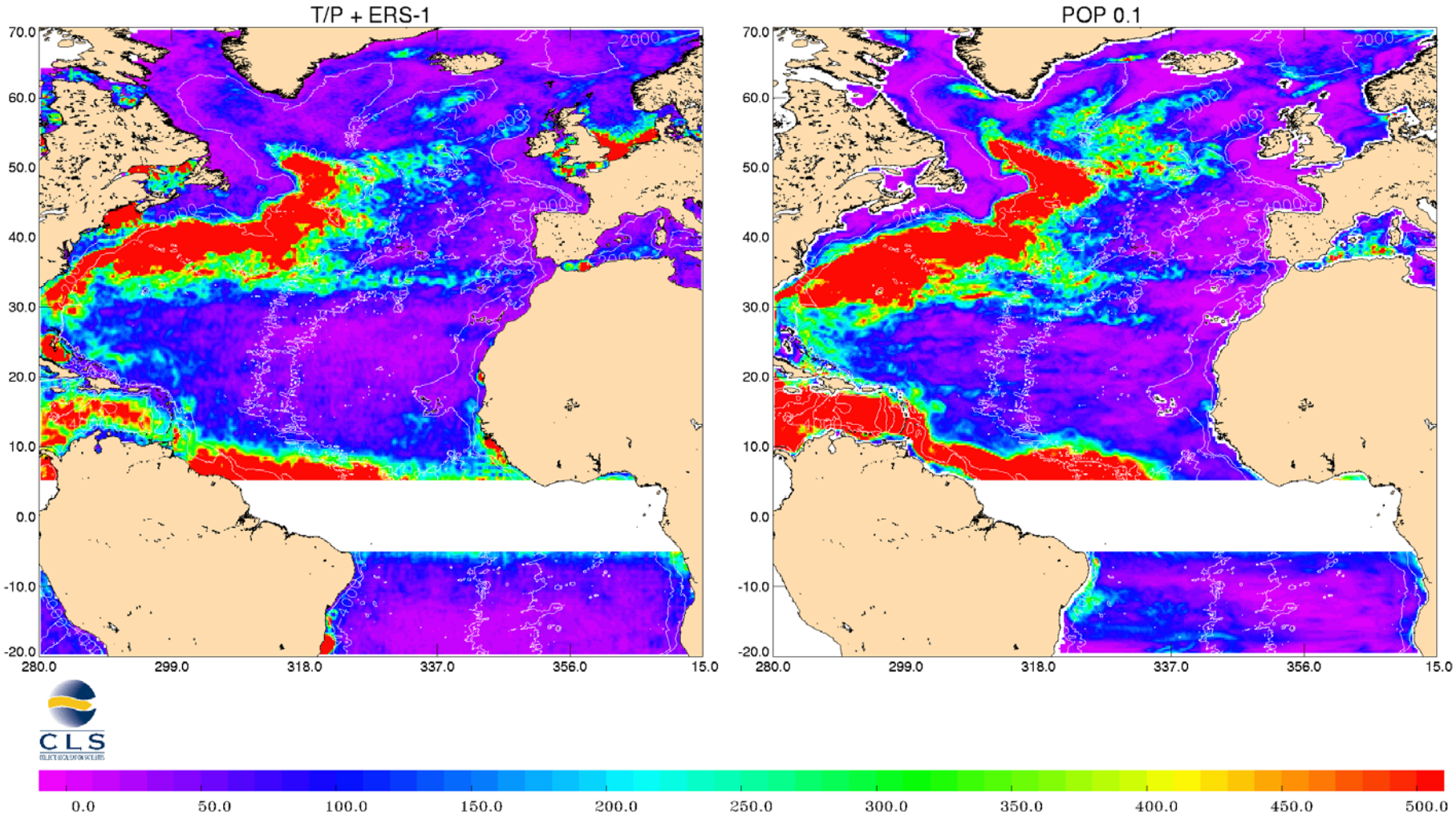


EKE TOPEX/POSEIDON+ERS-1/2 and Los Alamos Model

Use of Los Alamos model to analyze the sampling characteristics of multiple altimeter missions and improve the T/P+ERS processing (Le Traon et al., 2001; Le Traon and Dibarboure, 2002)

SSALTO/DUACS (CLS/CNES) : Real time processing of TOPEX/POSEIDON, ERS-1/2, GFO, Jason-1 and ENVISAT

Serving operational oceanography, GODAE (MERCATOR, FOAM, TOPAZ, MFS), climate forecasting centers (ECMWF) and applications (fisheries, offshore industry)

Real time processing (2-3 days)

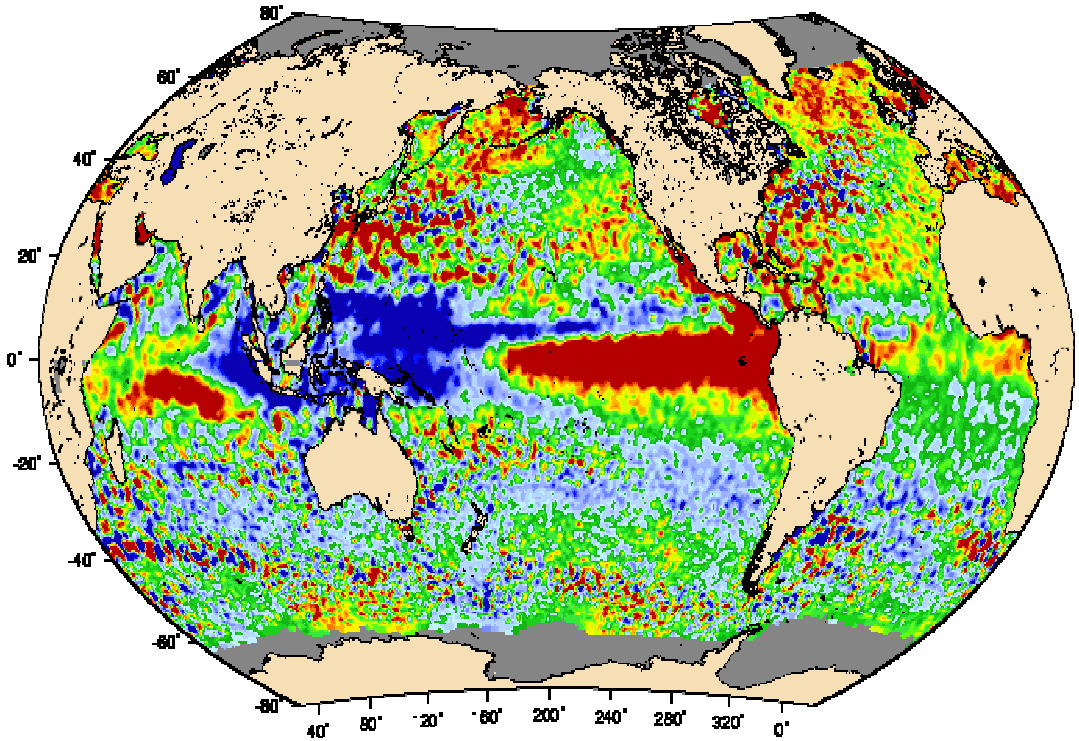
Global crossover minimizations, inverse techniques to remove long wavelength errors => high accuracy SSH (Sea Surface Height) data

Consistent mean profiles to reference multiple altimeter data => consistent SLA (Sea Level Anomaly) data

Products directly useable for scientific and operational applications

(climate and mesoscale)

Sea level and ocean currents



Real time processing of T/P and ERS-2 data during the 1998 El Nino

GAMBLE Workshop for theme 1 - November 7, Delft

10:00 Overview of new altimeter projects

· Jason-2 : Y. Menard 10'
· WSOA : E. Thouvenot 10'
· Cryosat : P. Vincent 10'
· Alti-Ka : P. Vincent 15'
· Gander : D. Cotton 15'

11:15 Results from simulations on the contribution of present/future altimeter missions

· LEGI : J.M. Brankart (20')
· LEGOS : B. Mourre (20')
· SOC : P. Challenor (5')
· Discussion (15')

14:00 Refined requirements for sea level measurements (mainly sampling issues)

· P.Y. Le Traon : Climate/mesoscale and operational oceanography applications 20'
· C. Le Provost : Coastal/tidal applications 20'
· Discusssion : 20'

15:30 Requirements for SSH measurement errors

· General requirements (noise, orbit) : P.Y. Le Traon (10')
· Specific discussion on the choice of orbit (heliosynchroneous or not) : C. Le Provost (10')
· Gander specific issues : dual-frequency, no radiometer, non-repeat orbit (D. Cotton) (20')

16:20 Summary, conclusions and recommendations of day 1

· Gamble recommendations for future altimeter missions

Requirements for sea level measurements

***Main requirements for climate and mesoscale applications** : **at least two altimeter missions with one very precise long-term altimeter system are needed (e.g. Koblinsky et al., 1992)**.*

The long-term altimeter system is supposed to provide the low frequency and large scale climatic signals and to provide a reference for the other altimeter missions. **It requires a series of very precise and inter-calibrated missions** (e.g. T/P, Jason).

The role of the other missions is to provide the higher wavenumbers and frequencies and, in particular, the mesoscale signal, which cannot be well observed with a single altimeter mission. This does not require precise altimeter systems as most of the altimetric errors are at long wavelengths and they do not impact significantly the mesoscale signal.

Le Traon and Dibarboure (1999), Le Traon et al. (2001) and Le Traon and Dibarboure (2002) recently quantified the contribution of single/multiple altimeter missions for the mapping of mesoscale variability. **Results from these studies are used to provide refined requirements for climate and (mainly) mesoscale applications.**

SEA SURFACE HEIGHT ERROR BUDGETS AND RECOMMANDATIONS FOR FUTURE MISSIONS

GAMBLE WP2
Interim Report

CLS (P.Y. Le Traon) , CNES (Y. Ménard, P. Vincent) , DUT (R. Scharroo) , SOC (P. Challenor), ALCATEL (L. Phalipou), SHOM (P. Bahurel), LEGOS (C. Le Provost) , POL (P. Woodworth), LEGI (J. Verron), MPI (D. Muller), and NERSC (J. Johannessen).

November 21, 2002

TABLE OF CONTENT

GAMBLE WP2 report

Interim report prepared for the workshop

Use workshop outputs to finalize the report (almost done)

Specific work on TP - Jason tandem mission to provide new results on constellation optimization ?