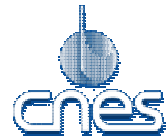


High resolution altimetry and modelling to assess the capability of different observing scenarios to describe coastal dynamics

Baptiste MOURRE



Christian LE PROVOST

Pierre DE MEY



Florent LYARD



Limitations to the use of altimetry in coastal zones

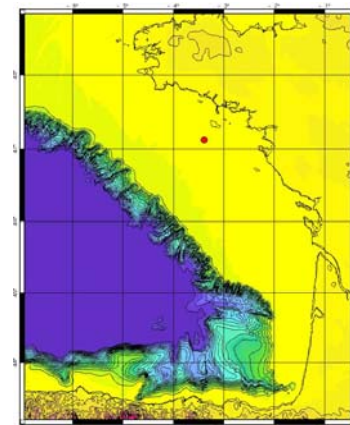
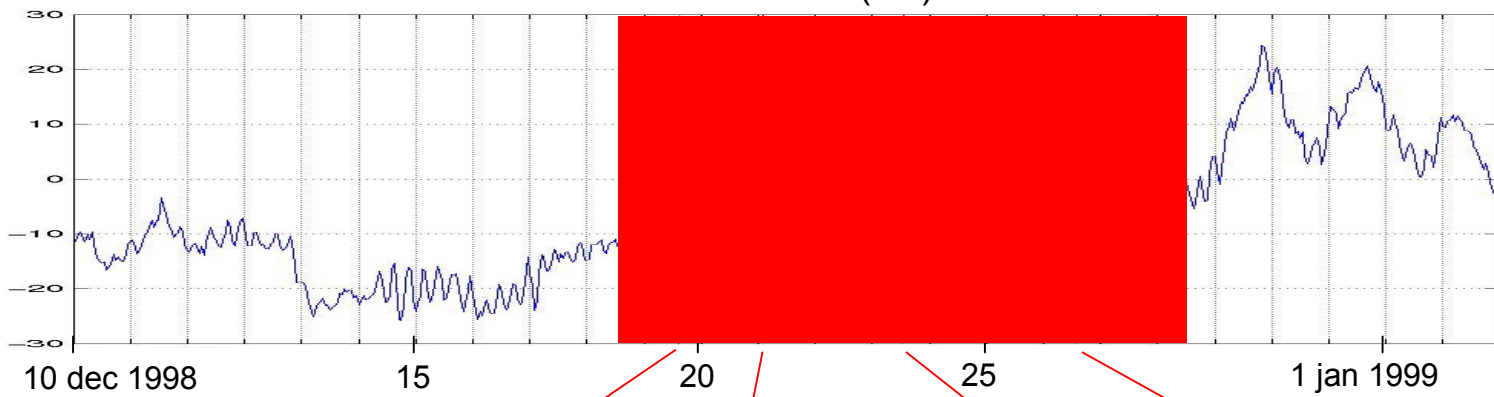
① Instrumental limitations :

- Measurements are contaminated by the presence of land in altimeter and radiometer footprints.
- Lost-tracking of a few kms at transitions between land and ocean.
 - ➔ No reliable data just next to the coast.

Limitations to the use of altimetry in coastal zones

- ① Instrumental limitations :
 - Measurements are contaminated by the presence of land in altimeter and radiometer footprints.
 - Lost-tracking of a few kms at transitions between land and ocean.
 - No reliable data just next to the coast.
- ② Spatio-temporal scales of dynamical processes are much smaller in coastal zones than in the deep ocean, so that the sampling provided by present altimeter satellites is insufficient in these areas.

Detided sea level (cm)

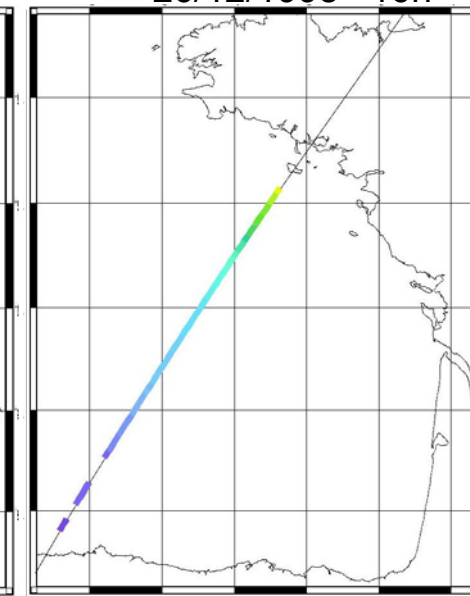
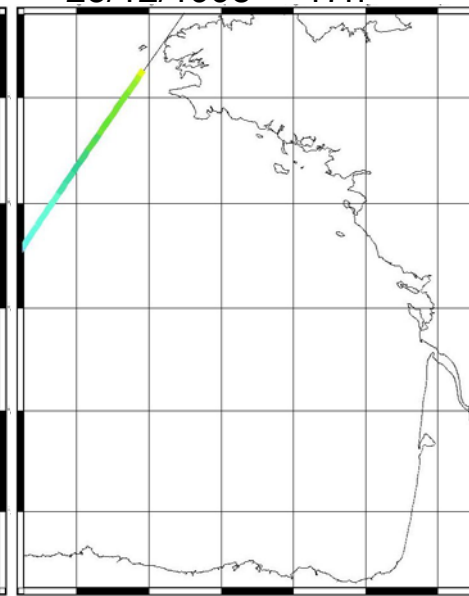
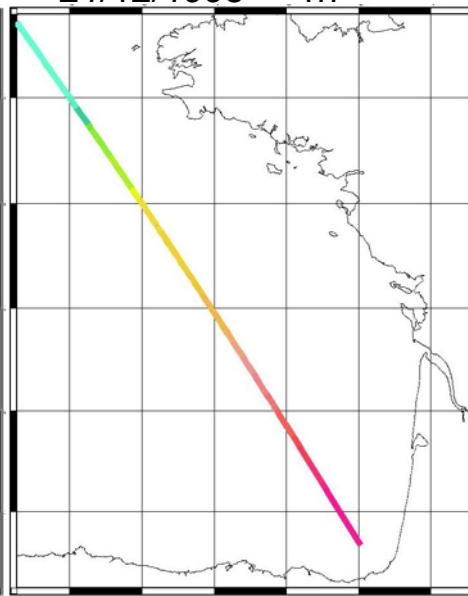
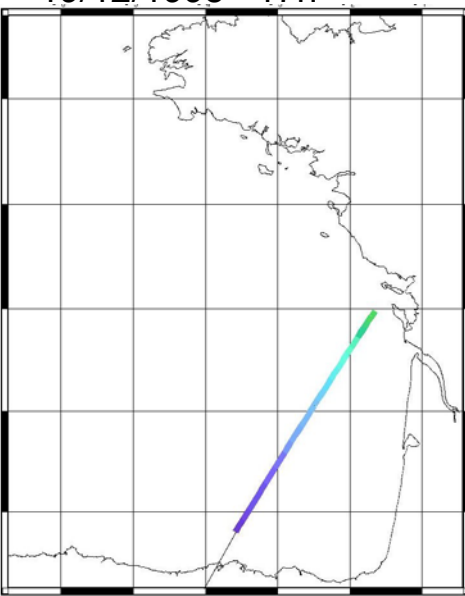


19/12/1998 17h

21/12/1998 1h

23/12/1998 17h

26/12/1998 16h



-15 -5

-25 -11

-14 -7

-14 10

Sea level (cm)

→ What spatio-temporal sampling is then required ?

Approach

➡ Due to these small spatio-temporal scales, contribution of numerical models is necessary.

But models are also limited !

(due to several sources of errors such as meteorological forcing, bathymetry or boundary conditions)

➡ The way to get the best estimate of the state of the ocean in these areas is to use models as dynamical interpolators, both in space and time, of altimeter observations, with the help of data assimilation techniques.

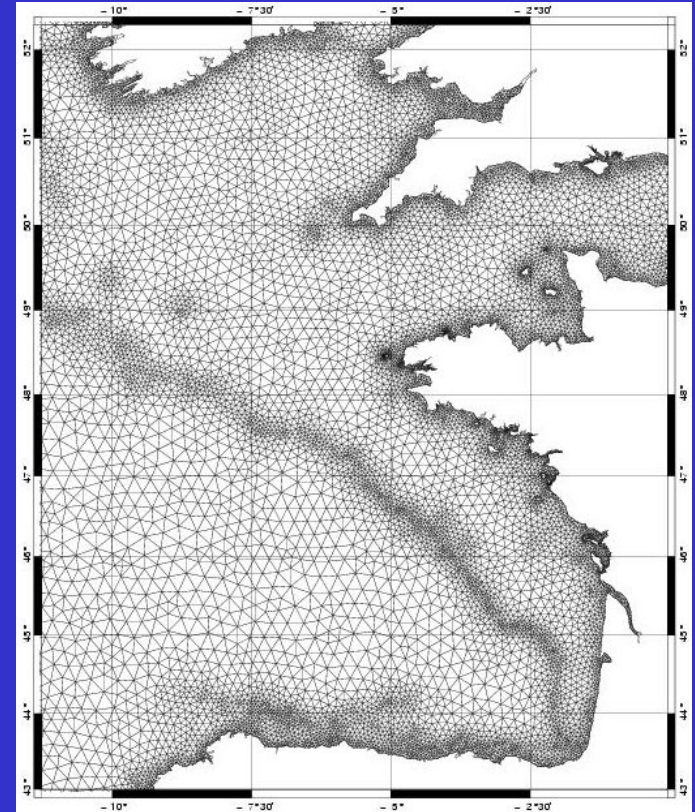
➡ What kind of satellite sampling is required to best correct model errors ?

To what extent can we hope to correct these errors ?

Application

Model MOG2D

- Finite elements
- Barotropic
- Nonlinear
- Implemented on the European shelf
- Meteorological forcing



Focus on errors due to uncertainties on bathymetry

➔ Data assimilation experiments require a specification of error statistics in the model ... tricky point in coastal areas !

Use of Ensemble methods

↳ statistics are computed empirically from an ensemble of “possible states” of the ocean
=> no simplification on the dynamics
(Evensen JGR 1994 ; Echevin et al. JPO 2000)

Examination of the differences between 6 different bathymetric databases

Selection of perturbations making an impact on model dynamics

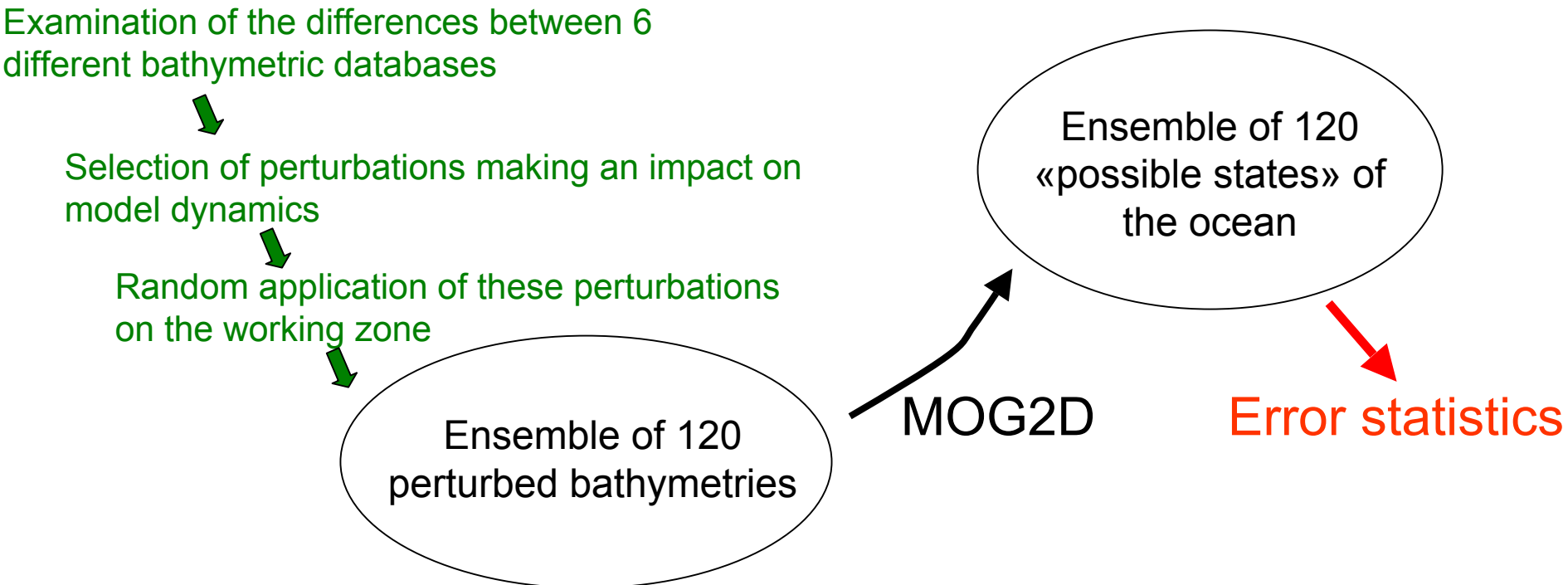
Random application of these perturbations on the working zone

Ensemble of 120 perturbed bathymetries

Ensemble of 120 «possible states» of the ocean

MOG2D

Error statistics

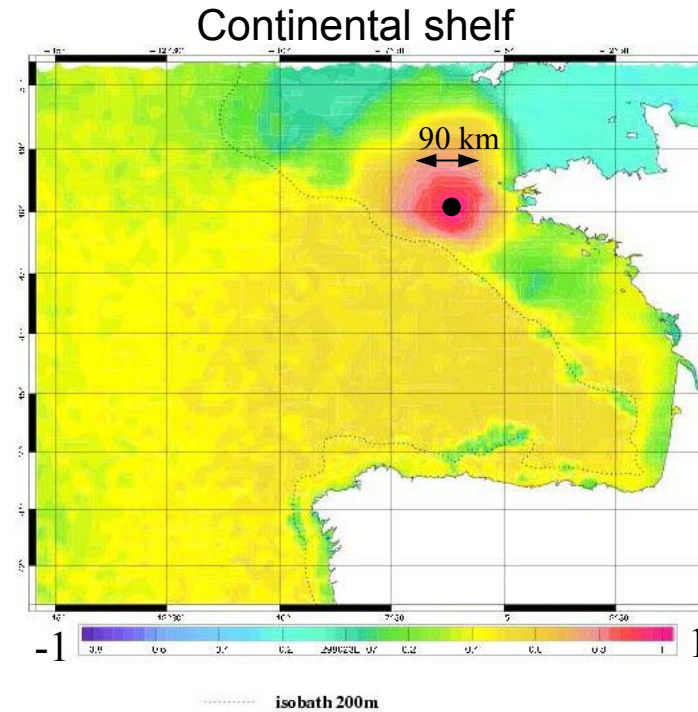
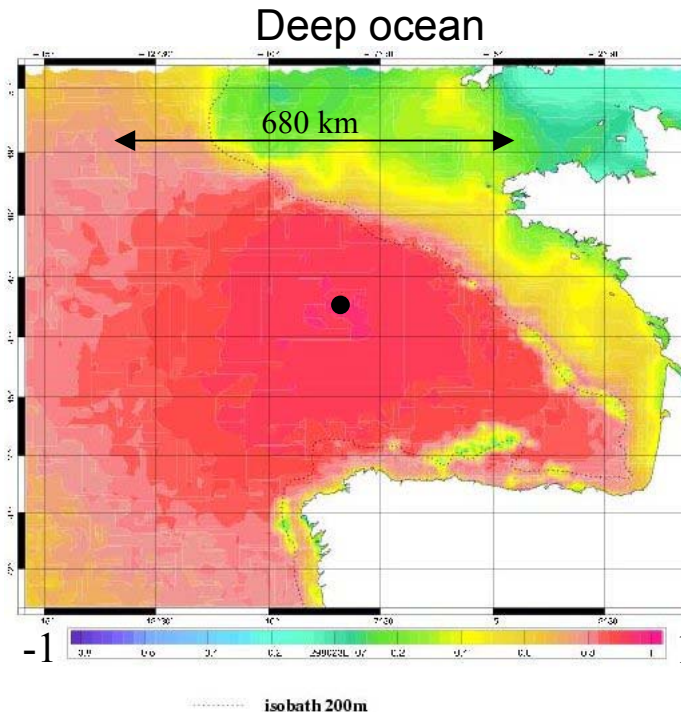


Representers of altimeter observations

(Bennett 1992, Echevin et al. JPO 2000)

- ➔ To each observation is associated one representer (influence function), which contains covariances between the observed variable at the observation point and all other model variables at every other points of the domain.
- ➔ The zone of influence (zone of significant correlations) is the zone in which the observation allows us to correct the model.

- Zone of influence of two different observations :
- Deep ocean
 - Continental shelf



Analysis experiments

OBSERVATIONS

- **Spatial sampling**
- **Observation errors**



Forecast state



Analysis

Analysed state



Forecast error statistics



Analysis error statistics

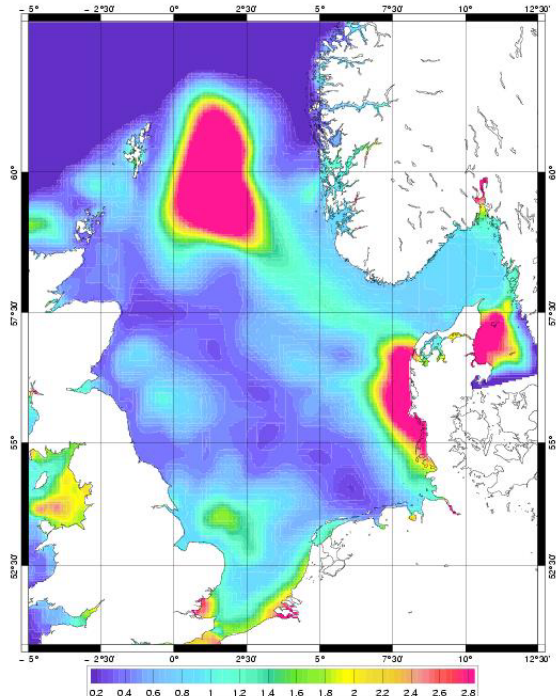
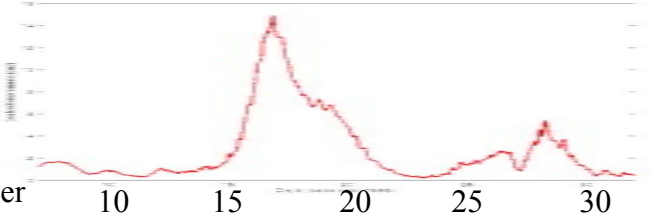


ENSEMBLE

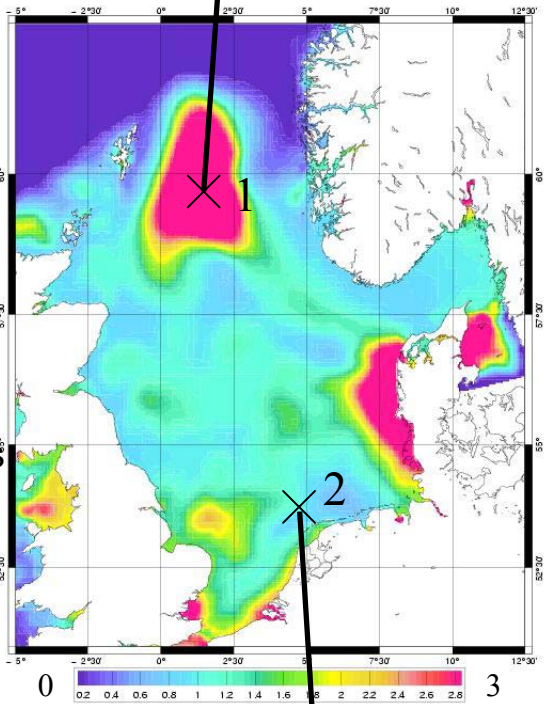


Analysis experiments

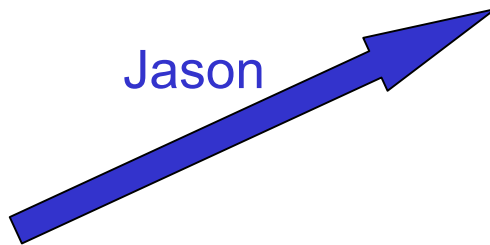
December 1998



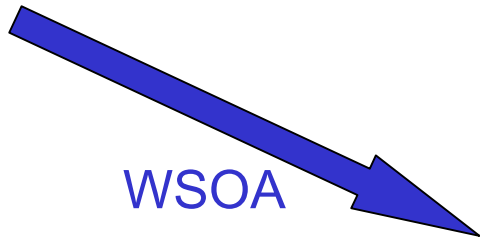
Sea level forecast error variances (cm²)
(18 dec 1998 0h)



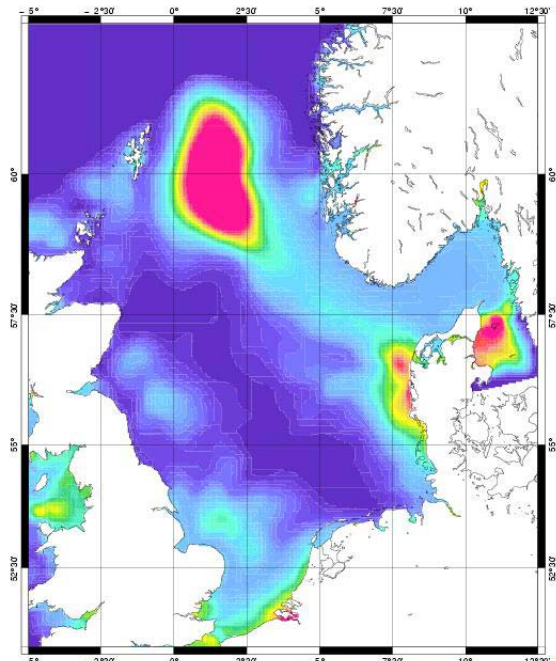
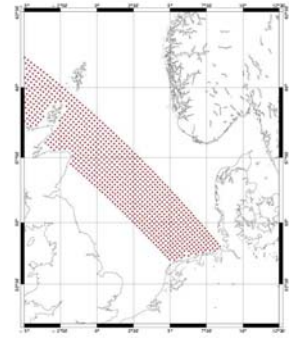
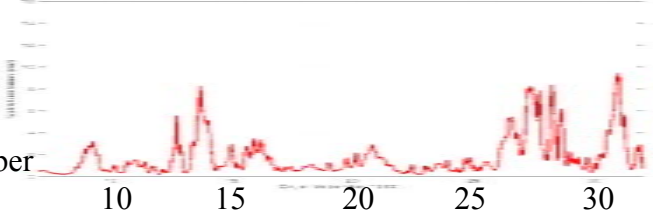
ANALYSIS



WSOA

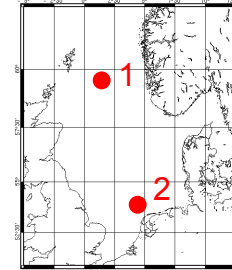


December 1998

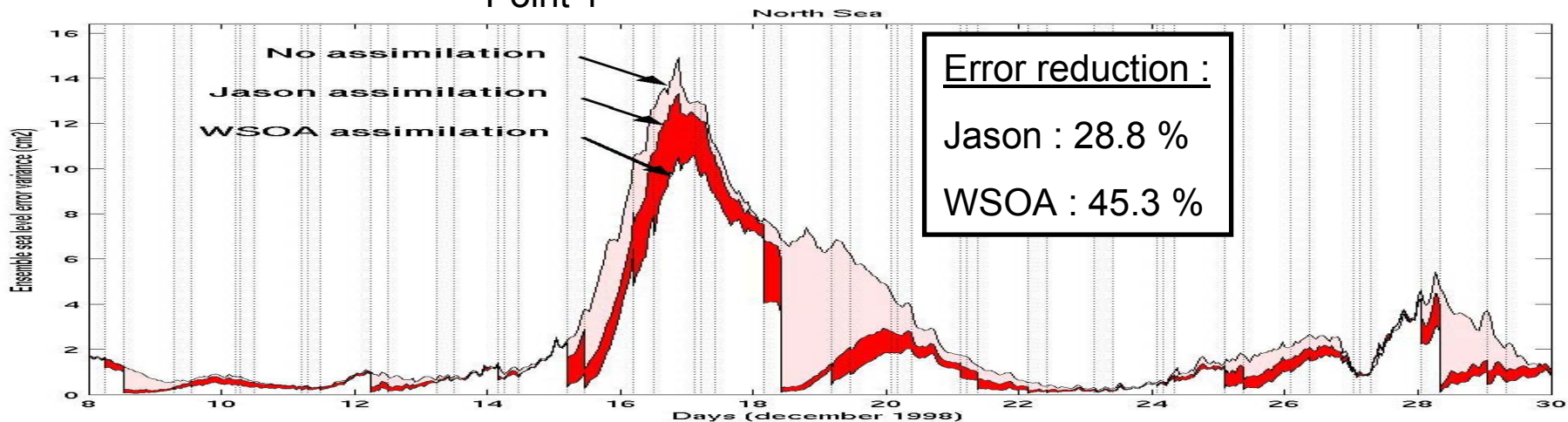


Sequential assimilation of altimeter data

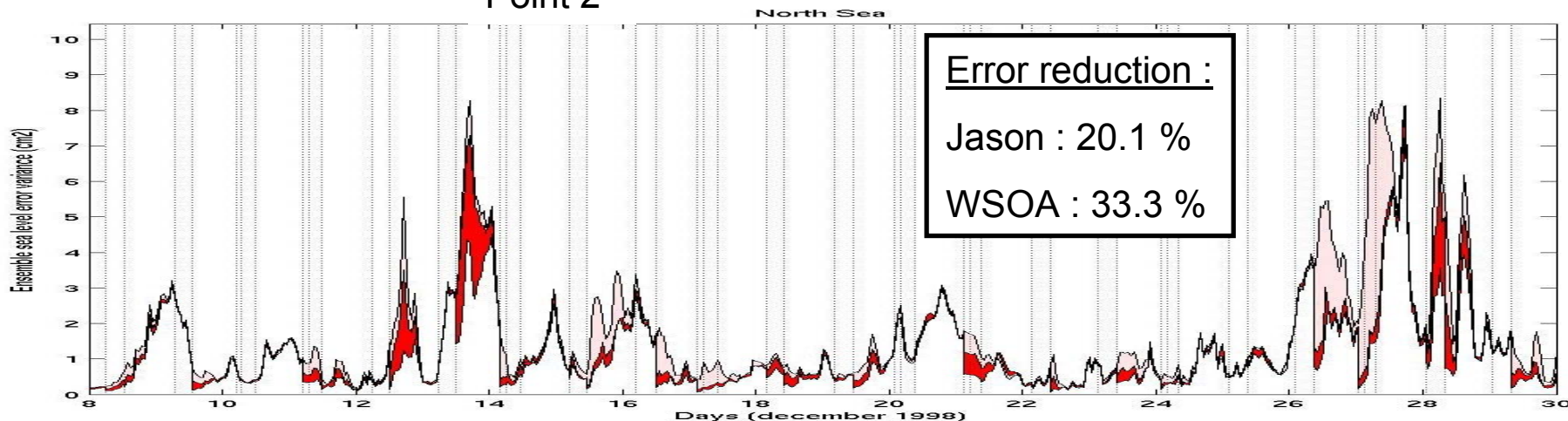
➔ Contribution of the Wide Swath Ocean Altimeter



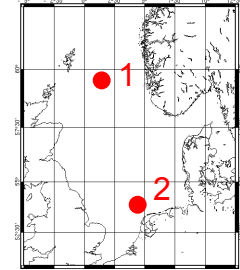
Point 1



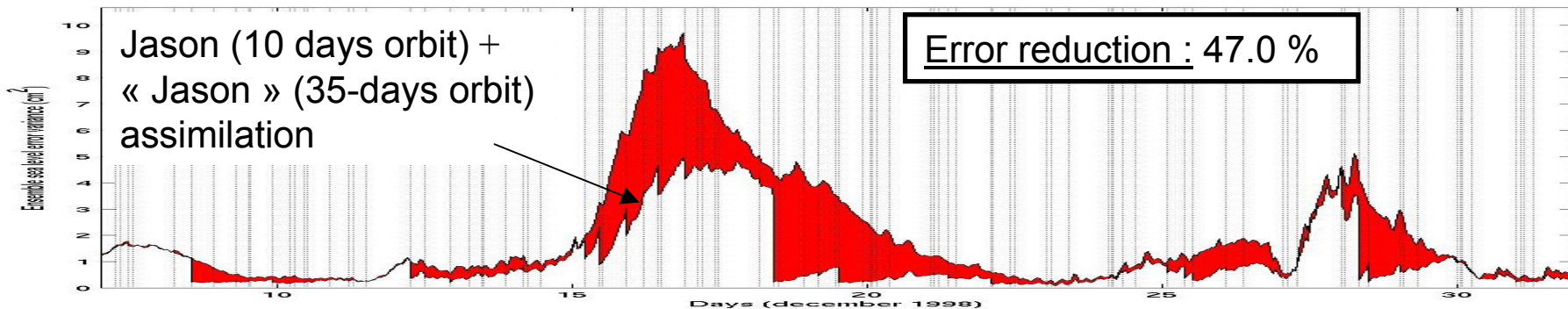
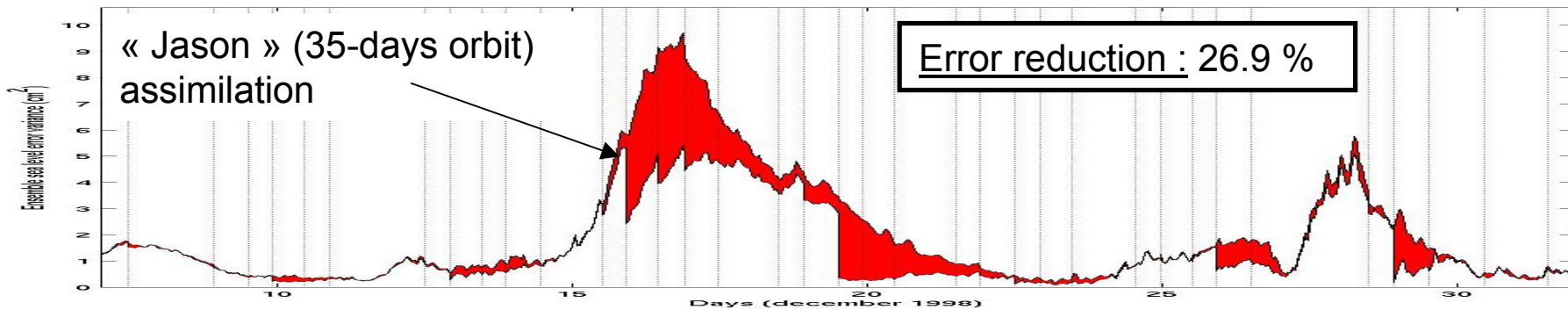
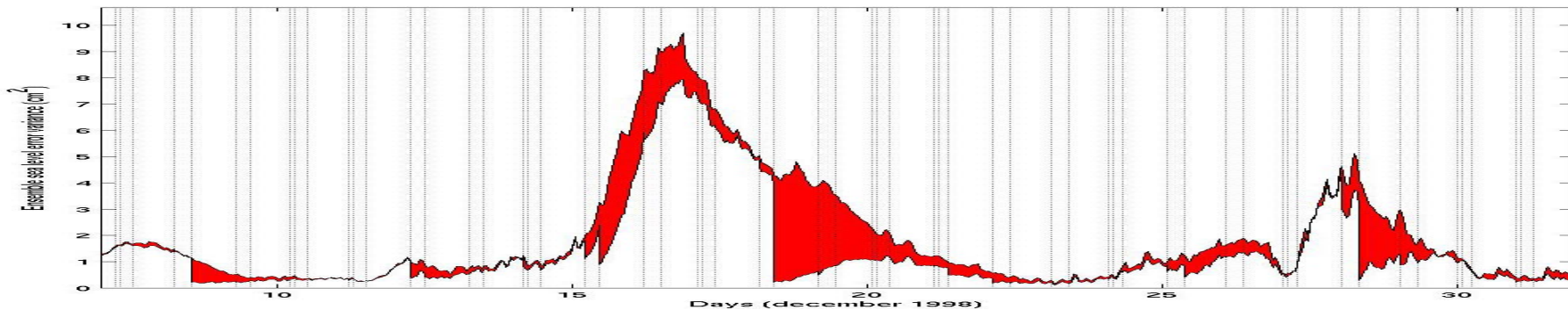
Point 2



Sequential assimilation of altimeter data

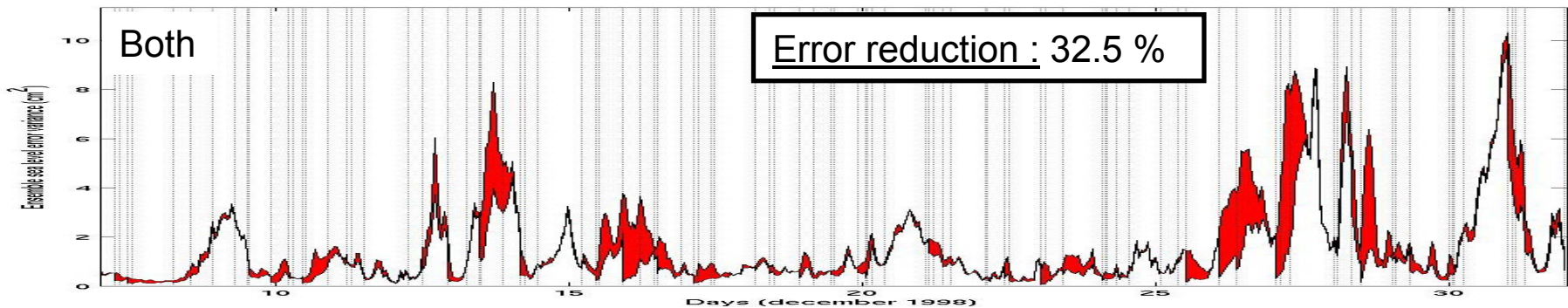
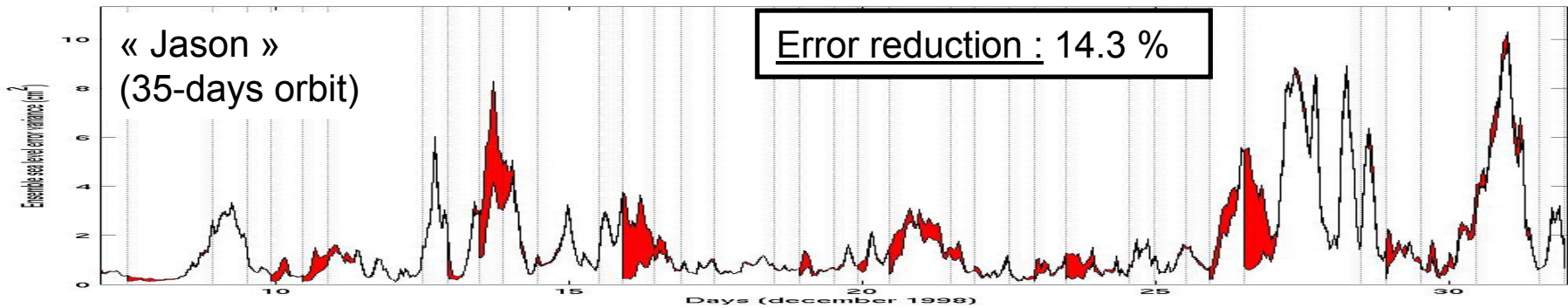
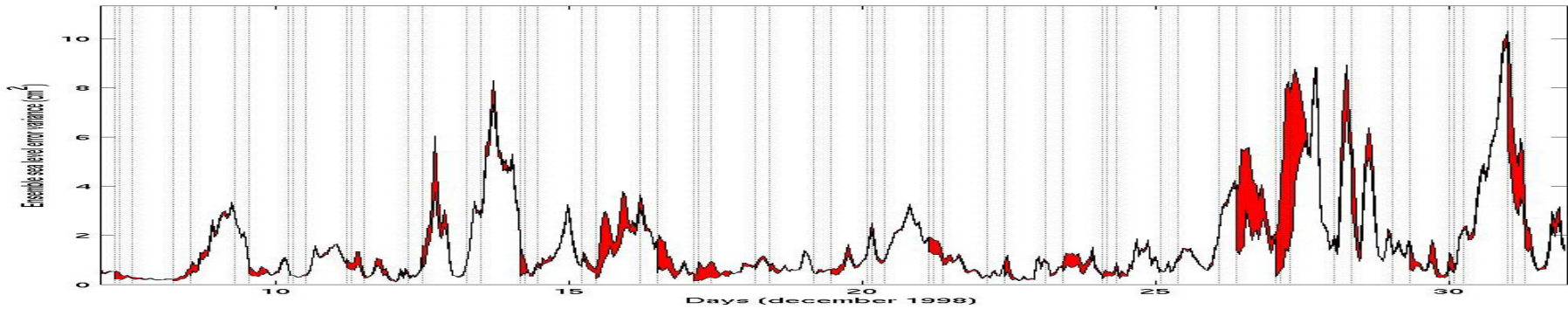
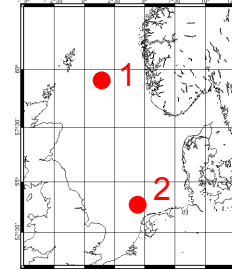


➔ 2 satellites vs 1 satellite (point 1)



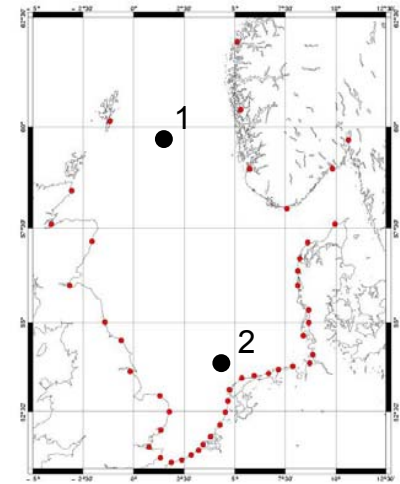
Sequential assimilation of altimeter data

➔ 2 satellites vs 1 satellite (point 2)

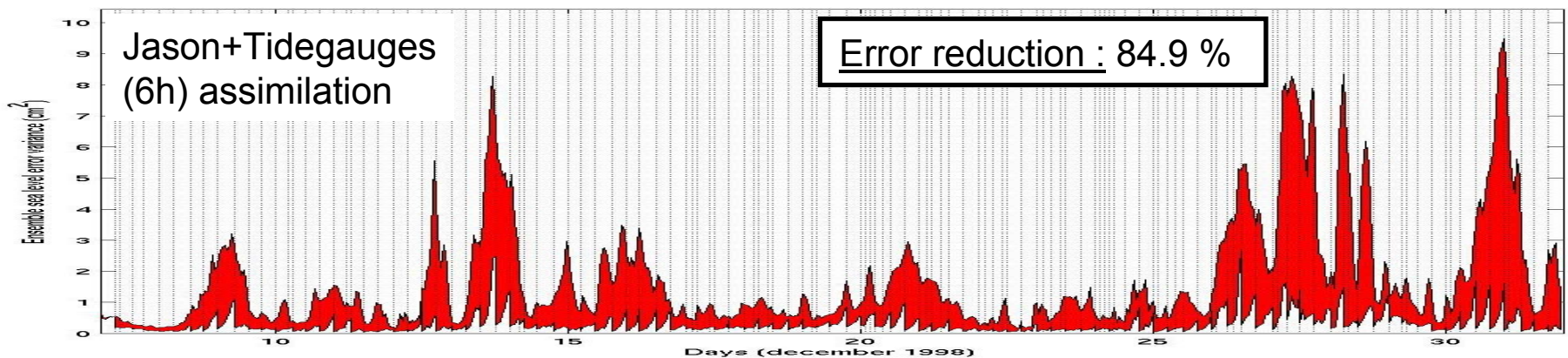
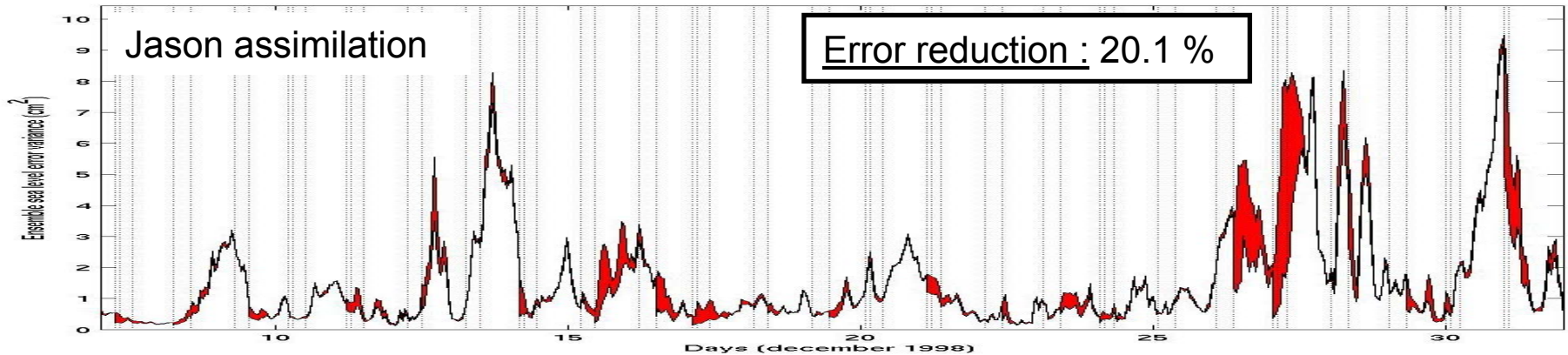


Contribution of tidal gauges ?

Optimistic case : 44 real-time tidal gauges along North Sea coasts



Point 2



Conclusions

➔ The reduced size of the zone of influence of observations over continental shelves implies a need of important spatial coverage.

The assimilation of WSOA data therefore results in a better correction of model errors (32.1% vs 21.0% for Jason alone).

However, the quick evolution of error variances depending on the meteorological forcing limits the performance of the WSOA in terms of model errors reduction and makes high temporal resolution also necessary.

➔ The consideration of 2 satellites in complementary orbits improves the temporal repetitivity at a given point and leads to approximatively the same performance (31.8%) than a single WSOA.

➔ Finally, due to these small temporal scales, the joint contribution of tidal gauges and altimetry shows very great potential. In particular, the regular assimilation of tidal gauges data allows a good control of model errors along the coasts.