An eddy resolving tidal-driven model of the South China Sea assimilating along-track SLA data using the EnOI

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Tides and forecasting system

Data assimilation in model including tides is problematic in particular for altimetry, and profiles

Assimilation of altimetry in a tidal model:

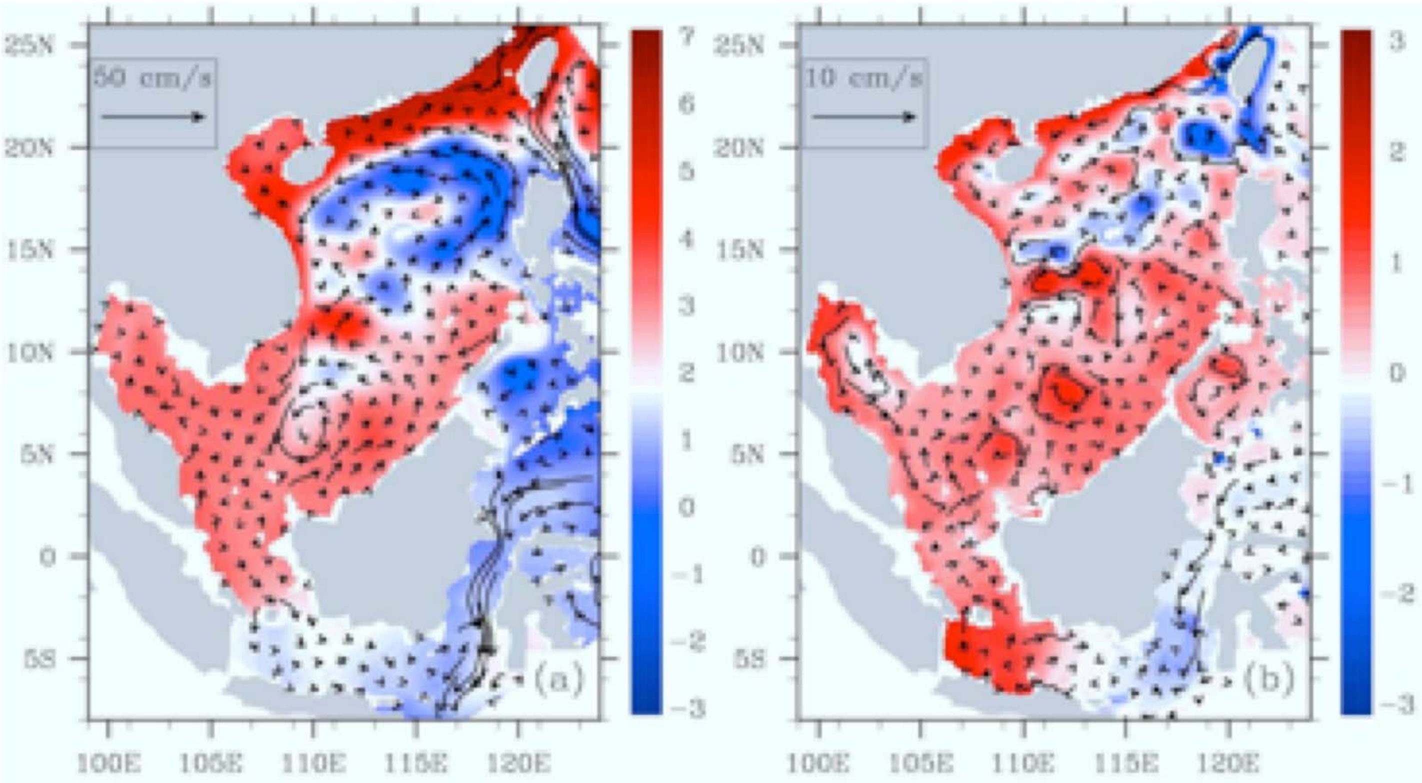
- Altimeter combines tidal signal and mesoscale features
- They have different time-scale
- Need different corrections ([Bathymetry; BC] vs. [SLA; T; S])

Barth et al 2009 show that it was possible to improve tidal boundary condition assimilating the "M2-contribution" from observations (HF radar)

Here, we want to correct mesoscale features leaving tidal signal unchanged.
We focused on the SCS because it combines mesoscale feature and tidal signal

Tides in the SCS

It is not sufficient to add tidal barotropic signal to the model without tides because tides interact with the circulation

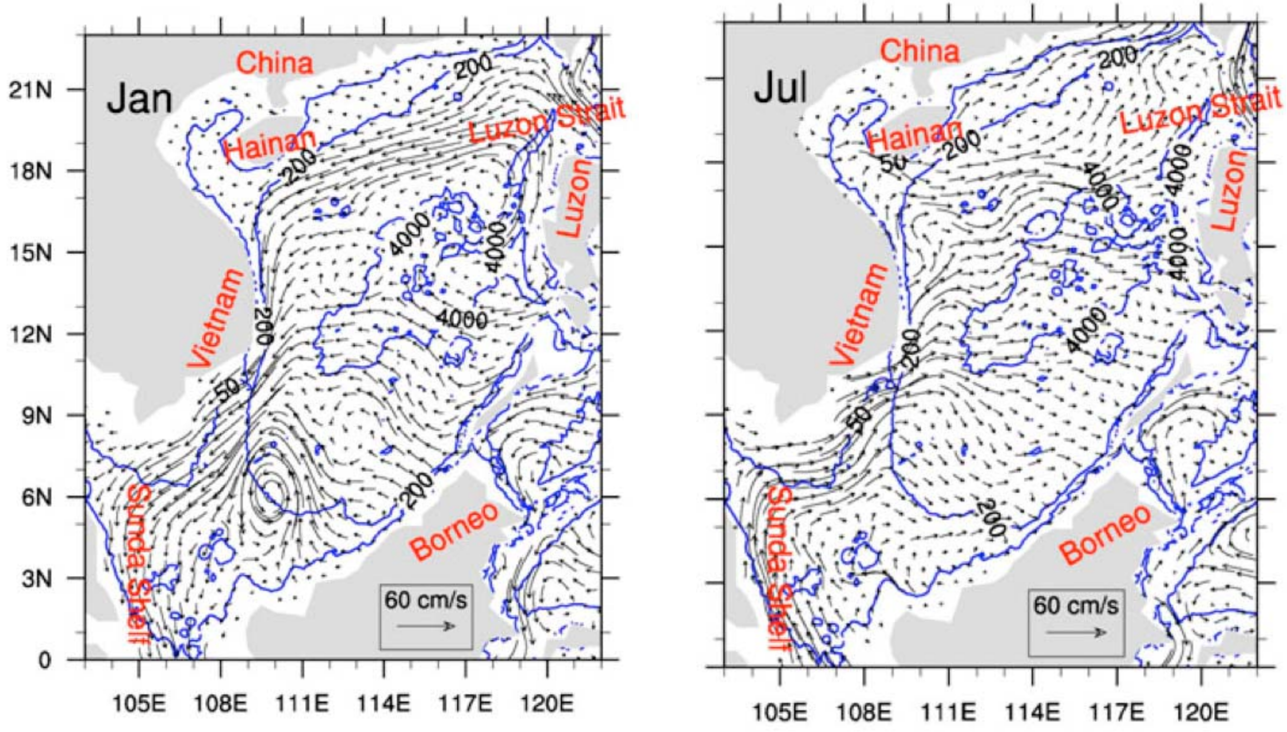


Mean SSH without tides

Anomaly from a model run with tides

Additional challenges

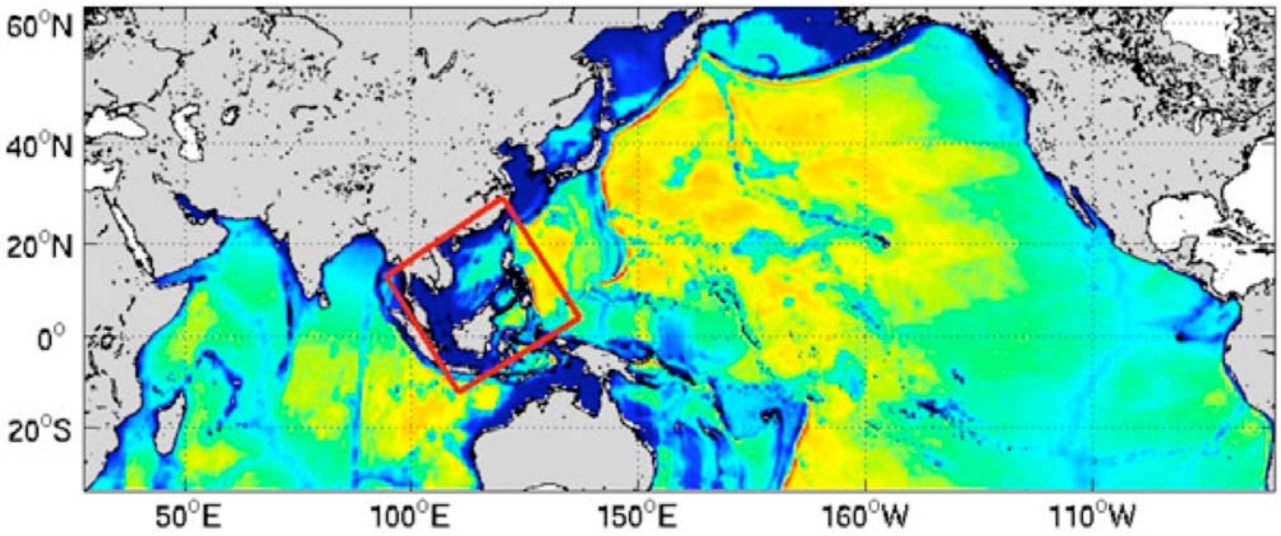
1. Strong seasonal variability due to the Monsoon
   - •Circulation reverse
   - •At transition, high mesoscale activity
   - •Not easy to handle with simple OI-based data assimilation method



Developed a forecasting system for the SCS tested over a 2-year period
Chose 94-95 as independent data set are available (AXBT, drifter …)

Model

•Nested Configuration of **HYCOM 2.2**
•Horizontal Resolution: Outer model (43-20 km); inner model ~12 km (Rd~40km depth >200m)
•22 hybrid layers
•Tides forced barotropicaly at inner-model boundary (FES2004; 8 constituent)
•Forcing fields from ERA-40
•Rivers discharge from a hydrological model (TRIP) + ERA-I run-off
•Spin-up from WOA05 for 26 years



Data assimilation method: Ensemble Optimal Interpolation

EnOI:

•OI-based data assimilation method (Cheap computationally)

•Assume that historical variability is representative of forecasting error

•Allows for 3D and multivariate updates

•**Tested successfully in the GOM, and Australian region** (Oke *08* ; Counillon *09a,b; Srinivasan et al. 10*)

•Method not suited for strong seasonal signal

→ Oke et al. 2005 proposed filtering of seasonal signal

In SCS mesoscale positions vary seasonally

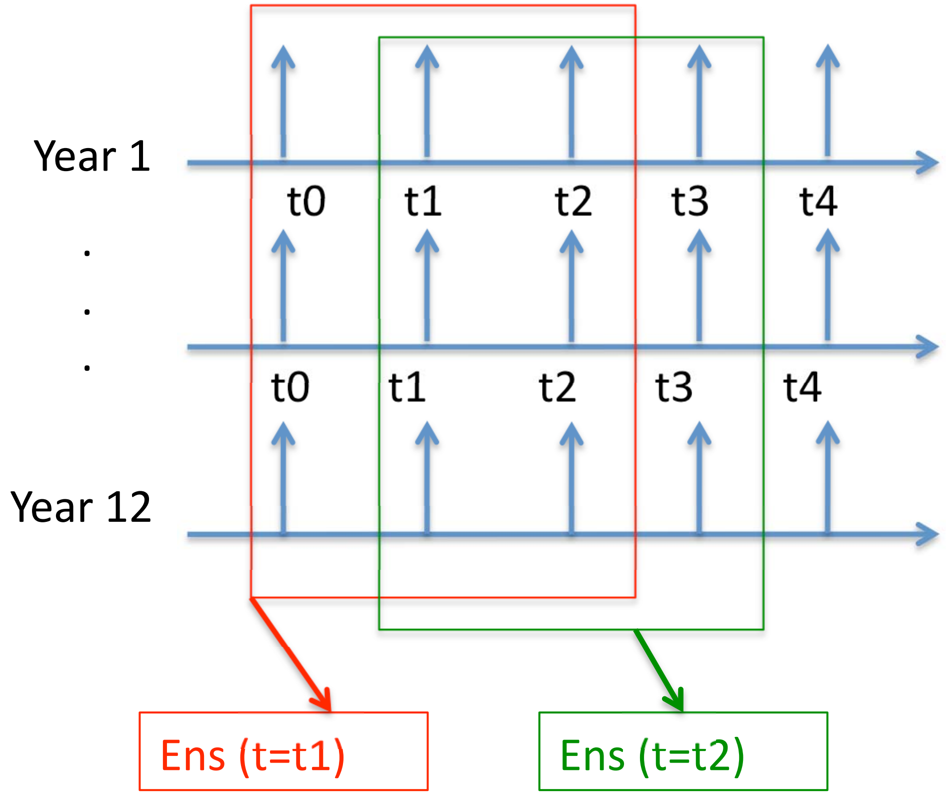
→ Need a different solution

•Method does not handle asynchronous assimilation

Ensemble Optimal Interpolation

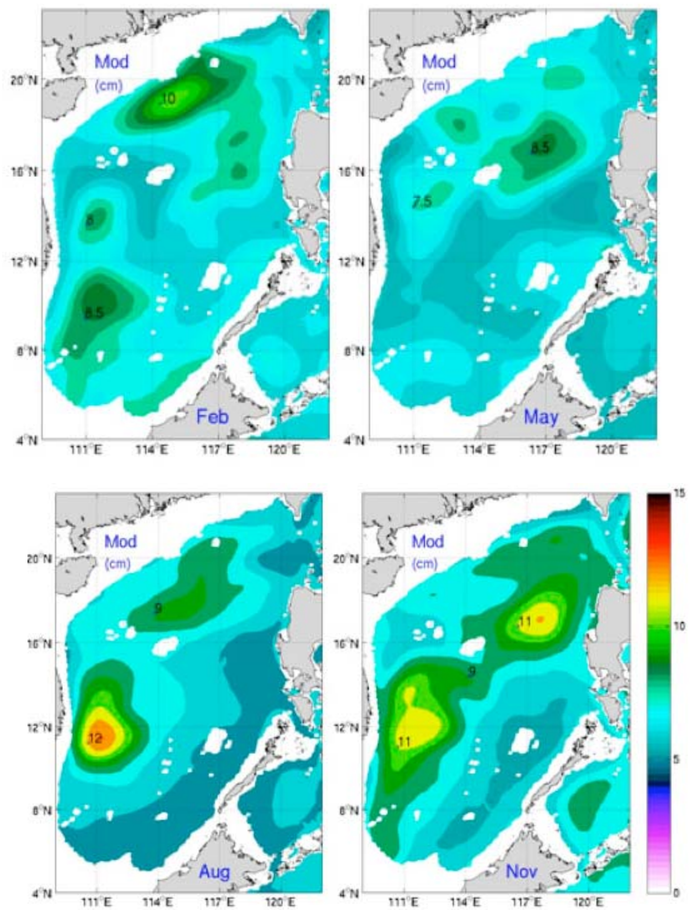
Running seasonal ensemble

Sort a long historical model run by year



C_{t0} compose from 120 members (100 day window)

Ensemble SSH variability

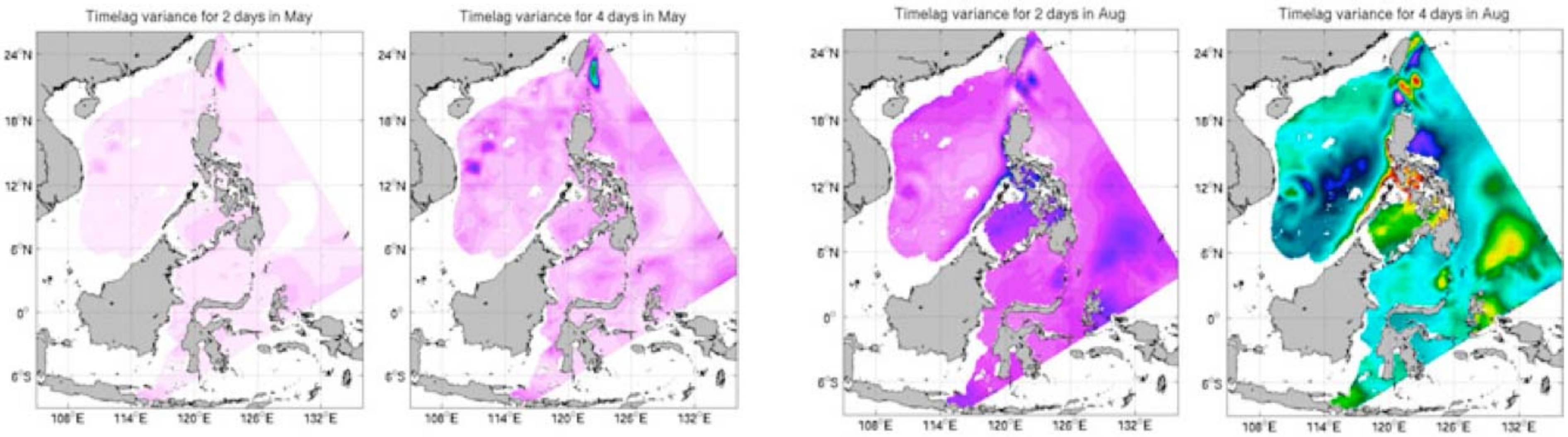


Asynchronous assimilation

•Model and obs are compared at similar time (FGAT)
•Unlike with the EnKF, we cannot compute time correlation from the dynamical ensemble
→ As a proxy, we increase observation error variance with time

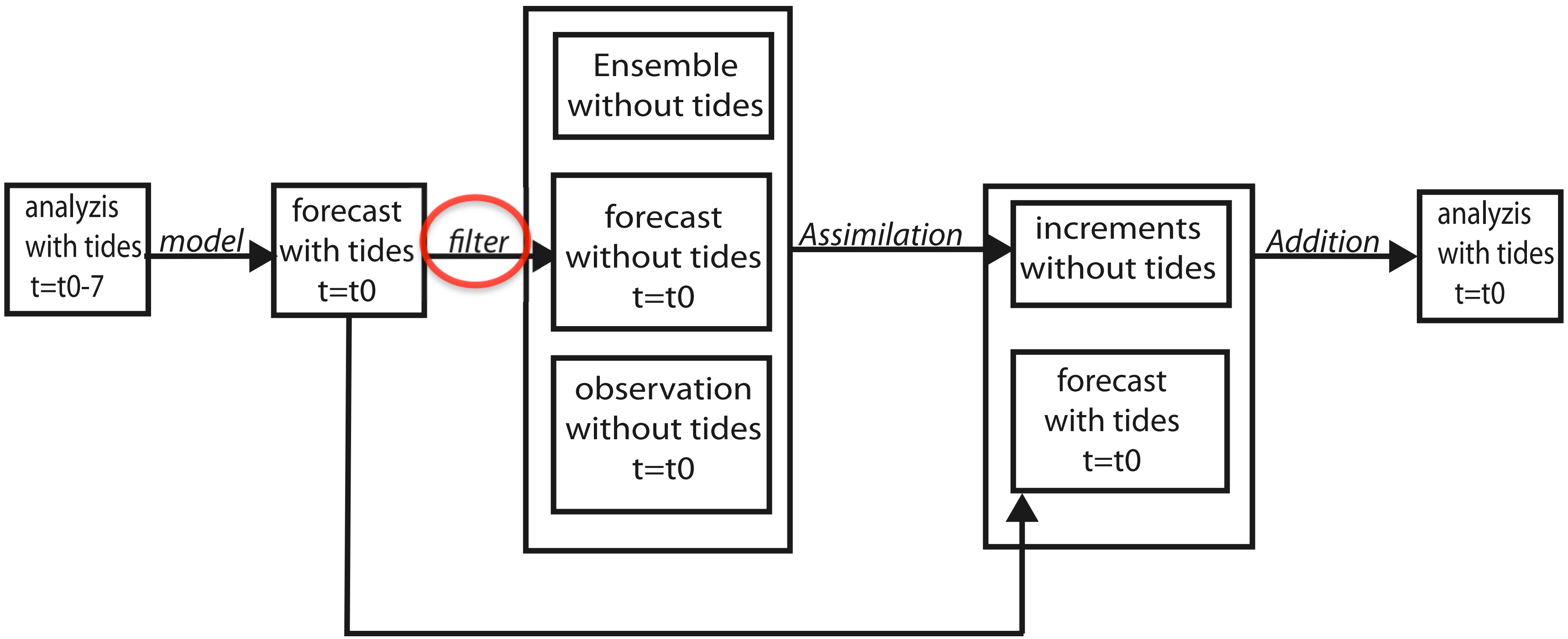
$$\psi^a_{t0} = \psi^f_{t0} + \sum_{t=t_0:t_0-6} C_{t0}H^T (HC_{t0}H^T + R_t)^{-1} (Y_t - H\psi_t)$$

$\varepsilon_{obs}^2 = \varepsilon_{inst}^2 + \varepsilon_{rep}^2 + \varepsilon_{age}^2$
ε_{inst} :instrumental error (e.g ~4cm)
ε_{rep} :representativity error accounting for different resolution between obs and model
$\varepsilon_{age}(t,t0)$:age error of the obs estimate from model monthly variability, at of 0-6 days



Assimilation is a model including tides

Focus on correcting the mesoscale signal



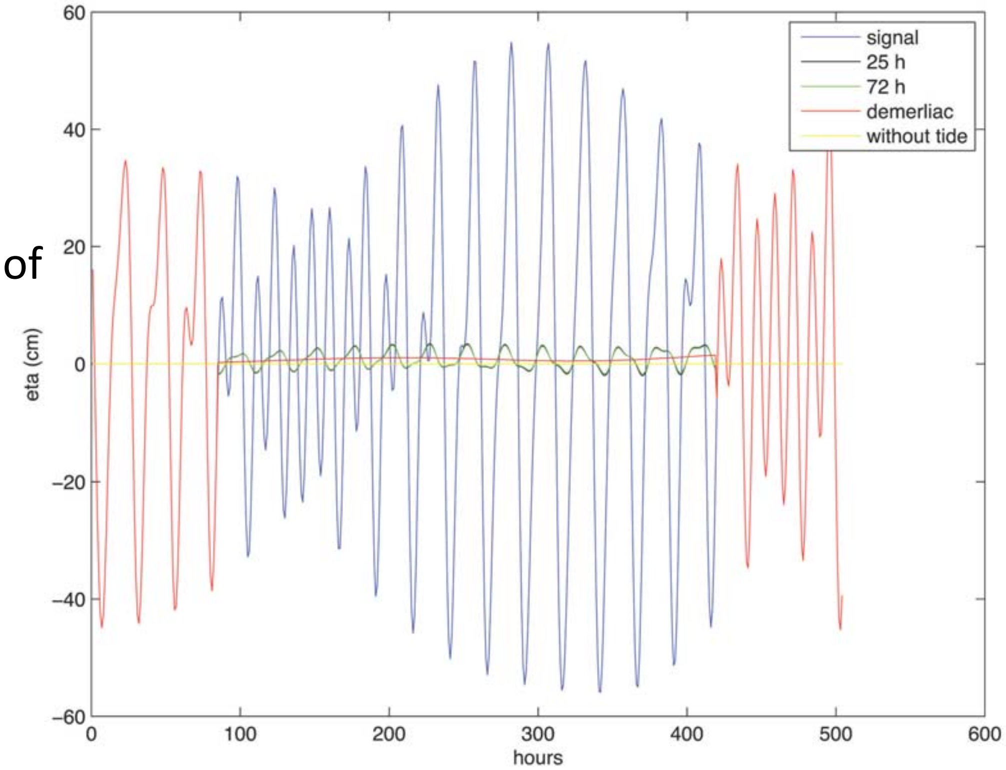
Assimilation is a tidal model

Filter tested at the place where observation are retained (>200 deep & 50 km from coast) and largest amplitude in FES2004

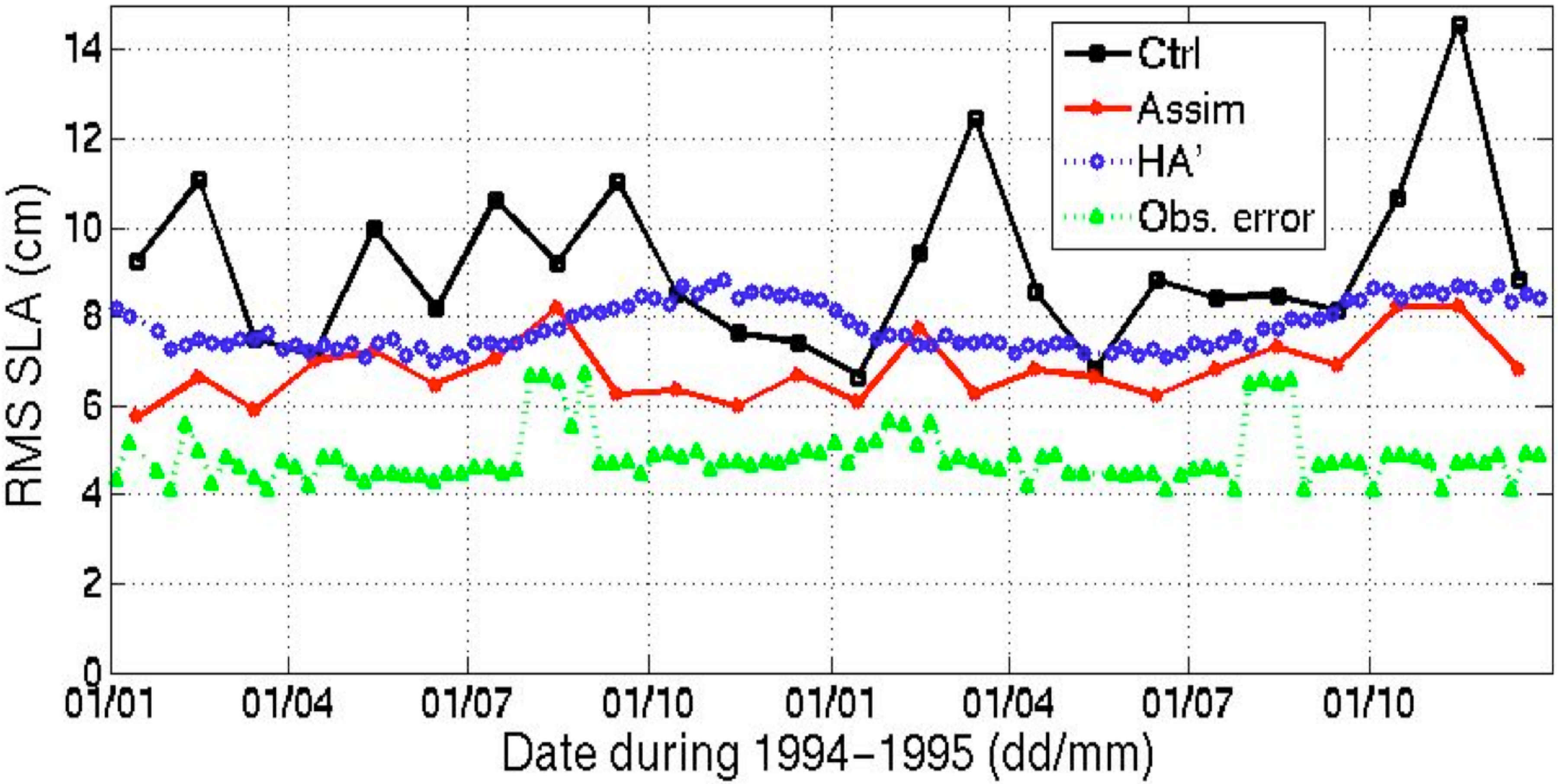
	No filter	1-day	2-days	3-days	Demerliac
RMSE (cm)	28.18	1.65	1.60	1.57	0. 8

Demerliac performs best but requires storage of hourly-model fields

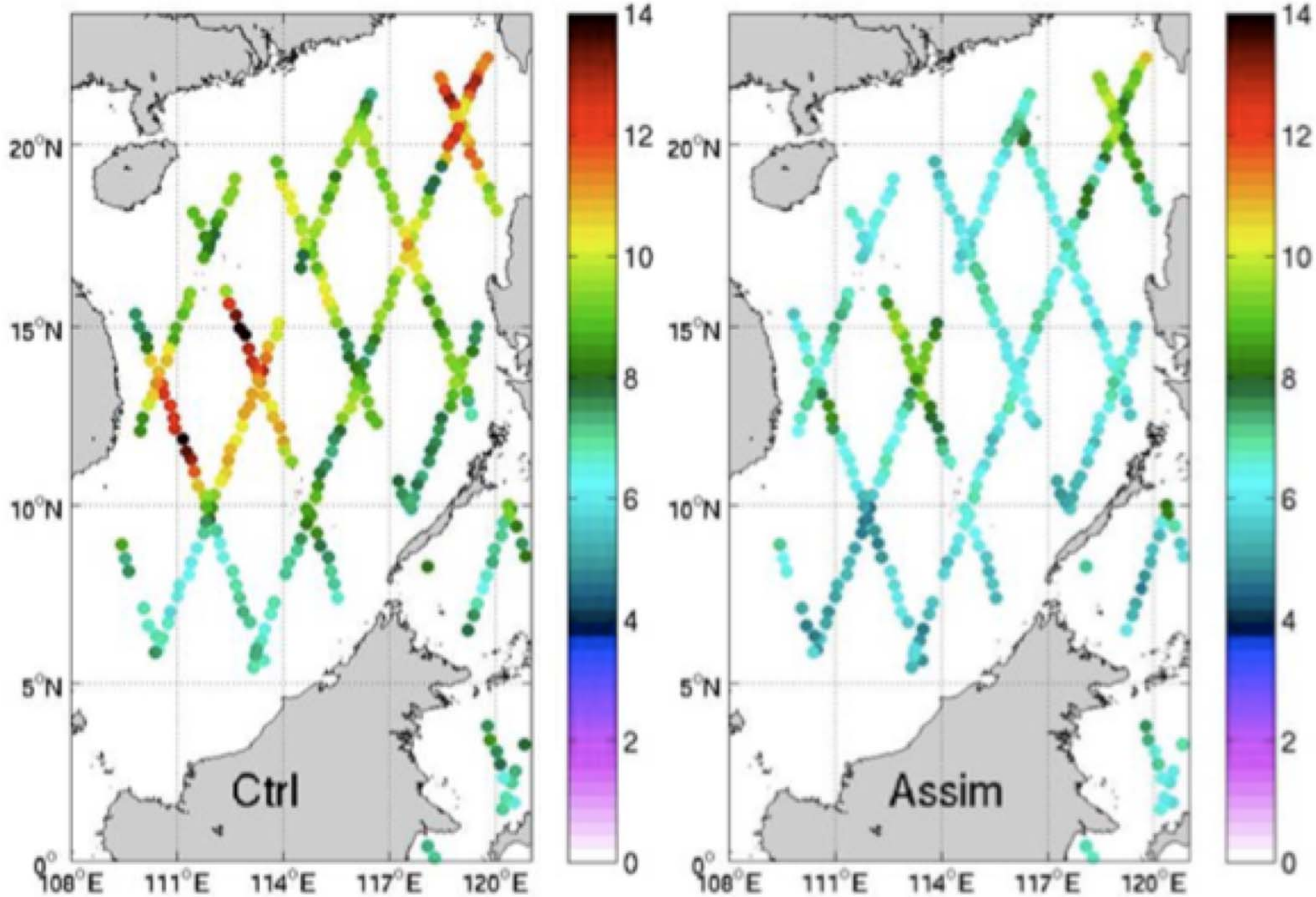
→ **use the 3-day average filter for simplicity**



Forecast RMSE of SSH (monthly average)



RMS of SSH spatial distribution



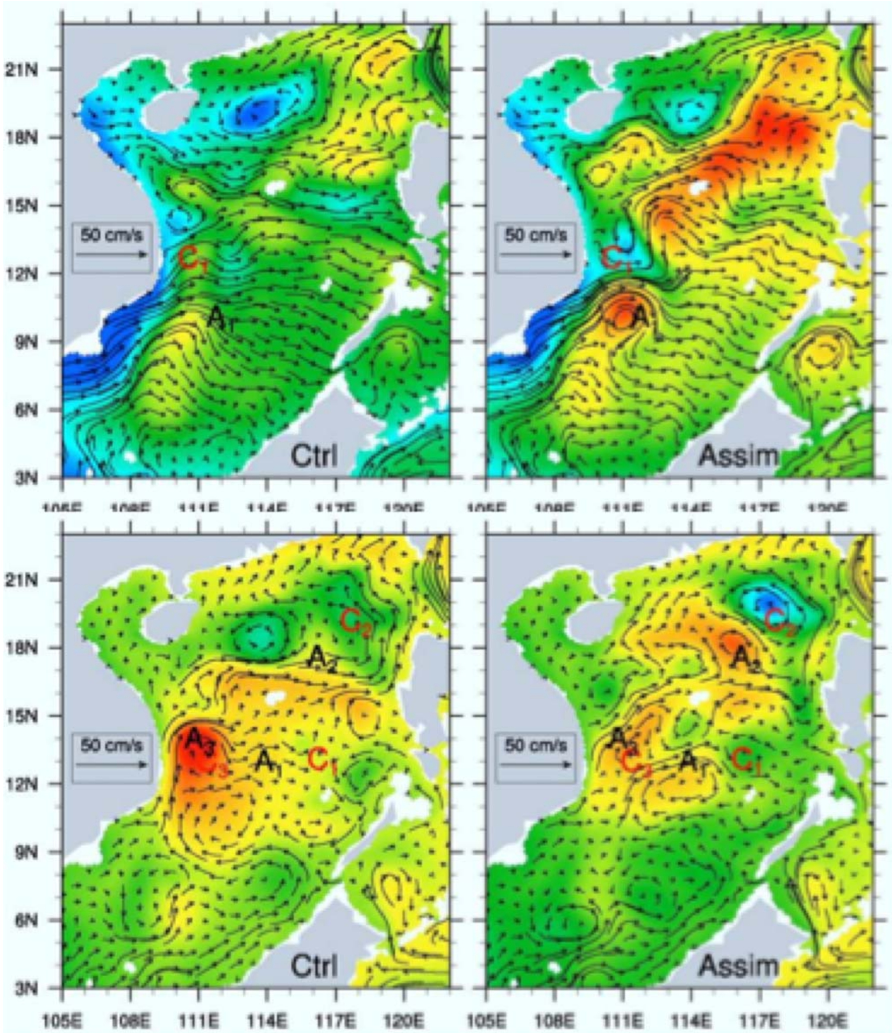
average over 2 years

Comparison to literature

1994-95 additional measurements (AXBT), surface drifters Wang (2003), Wu (1998), Chu (1998)

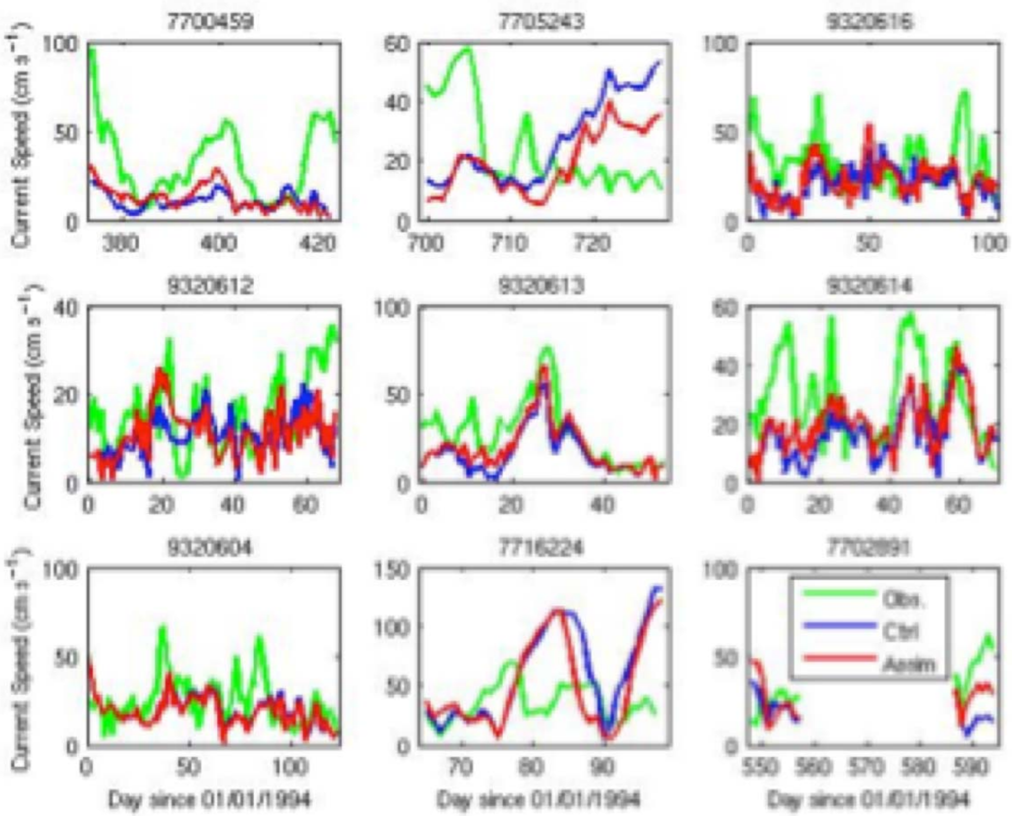
July 94

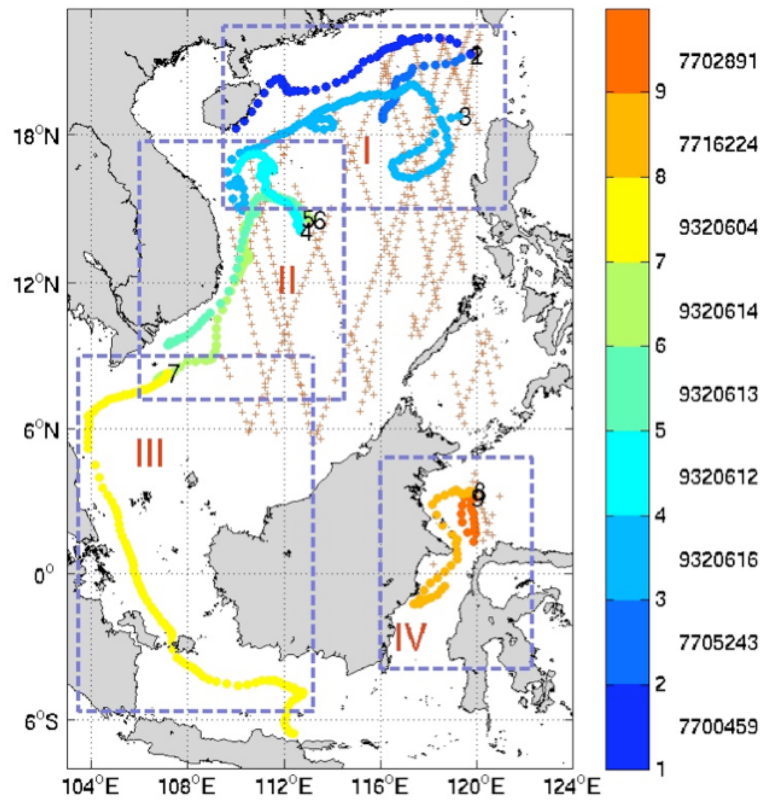
May 95



Drifter validation

Validate model results with available drifter data available from NOAA during the period 1994-1995
Improve the current speed by 8.3%





Conclusion

A nested and tidal version of HYCOM implemented for the SCS successfully

We adapted the classical EnOI to:

- Assimilate altimeter for correcting mesoscale in a model that includes tides
  - Can easily be applied to other data assimilation method
- Prescribe forecast error covariance when strong seasonal variability
- Assimilate asynchronous observation with EnOI

Over a two years period (1994-1995), the current system:

- Reduces the SSH RMS from 9.3 to 6.8 cm (uniformly)
- Better position of mesoscale features from litterature
- Better agreements with current measurement (8.3 %) and trajectory from drifters

Can expect better accuracy using nowadays observational network (more altimeter, OSTIA SST, ARGO)

Further perspectives

•A more complete data assimilation system should be tested including assimilation of SST, T, S profiles,

•The current solution proposed updates that are estimated from a simulation without tides although tides influence the circulation
→Can one use covariance from an historical ensemble taken from a filtered simulation run with tides?

It should be possible to use both:

- the low-pass filtered part of the data for correcting tidal boundary and bathymetry
- the high-pass filtered part of the data for correcting the mesoscale