Mesoscale and submesoscale variability in the Luzon Strait: A data-assimilative two-way nested modeling approach

J Zavala-Garay
John Wilkin
IMCS, Rutgers, The State University of New Jersey, USA

jzavala@marine.rutgers.edu
http://marine.rutgers.edu

RUTGERS

OSTST 2015

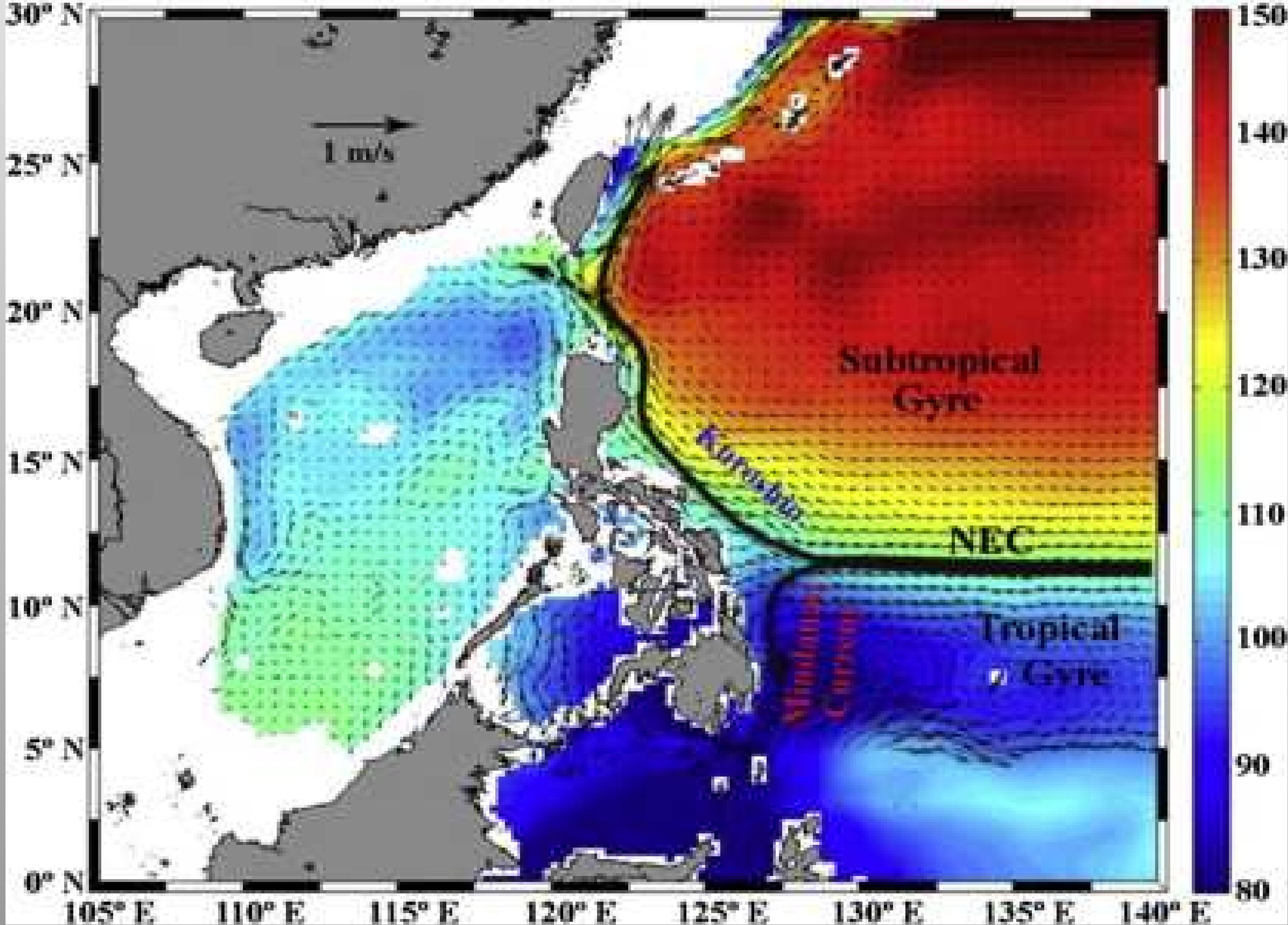


Fig. 1. Mean Absolute Dynamic Topography (ADT) (units: cm) and the corresponding surface geostrophic currents (units: m s−1) derived from the 18-year (1993–2010) satellite altimeter data. Black solid lines represent a schematic of the NMK current system.

Nan et al., 2015

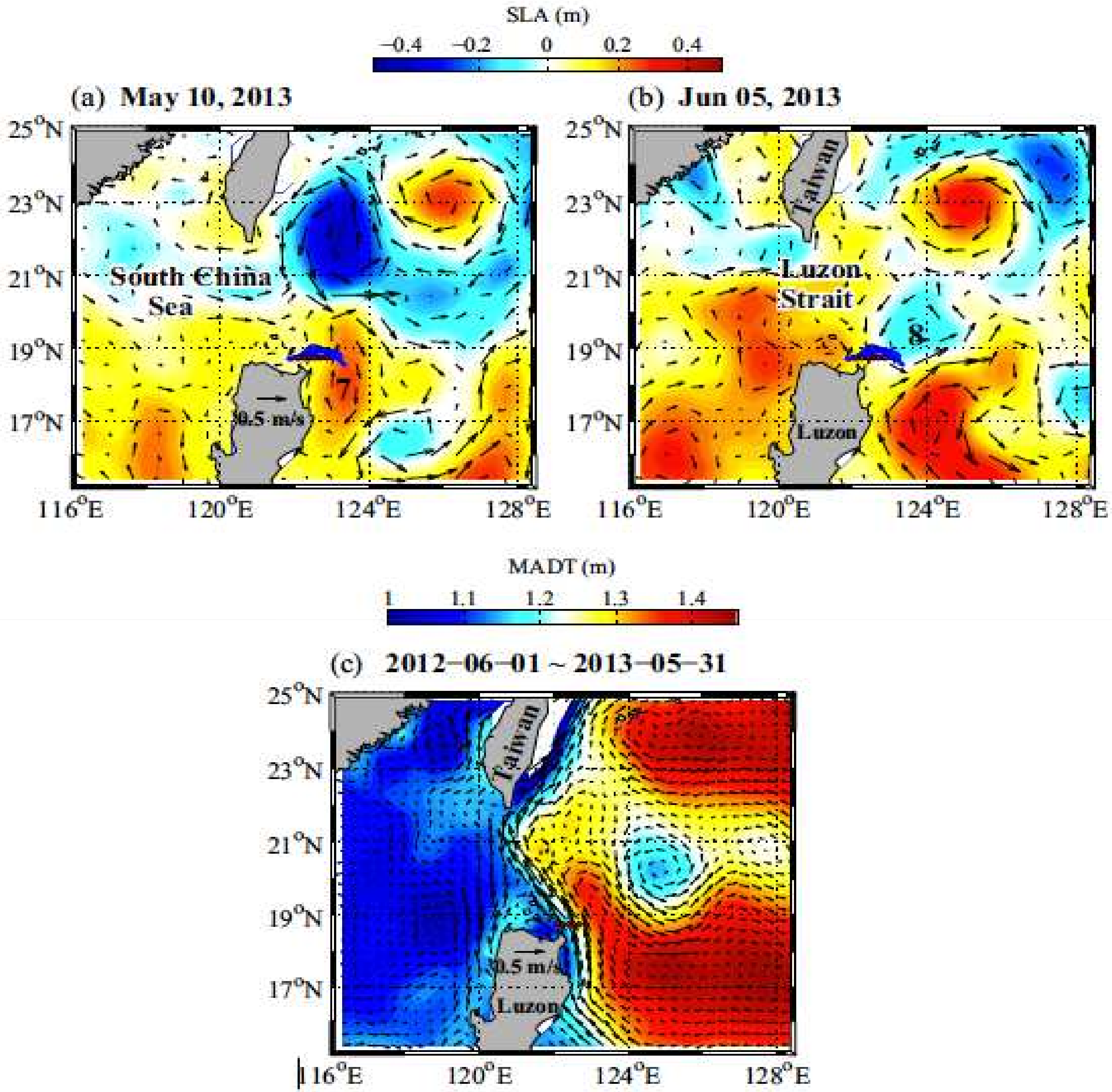


Figure 1. Positions of six moorings at the entrance to Luzon Strait (red dots), Aviso sea level anomaly (SLA) (color shading), and Aviso surface current anomaly (vectors) on (a) 10 May 2013 and (b) 5 June 2013. Velocity reference scale of 0.5 m s^{-1} is labeled in Figure 1a. Two eddies leading to Kuroshio transport anomaly events 7 and 8 are labeled in Figure 1b. Blue curves northeast of Luzon represent Seaglider tracks. Figure 1c shows the map of absolute dynamic topography (MADT) and Aviso surface current.

Kuroshio transport has an annual mean of 15 Sv with a standard deviation of 3 Sv. It is modulated strongly by impinging westward propagating eddies. Anomalies of up to 10 SV.

R.-C. Lien at al., 2014

Topography in the vicinity of the LS and the sketch of the different types of Kuroshio intrusions. Isobath depths are in meters.

(adapted from Caruso et al., 2006)

The combination of the Kuroshio Current, westward propagating eddies from the Pacific ocean, the monsoon, strong tides, and the dramatic topography of the Luzon Straits lead to a rich physical forcing environment that is not fully understood, specially at the meso- and submeso-scales.

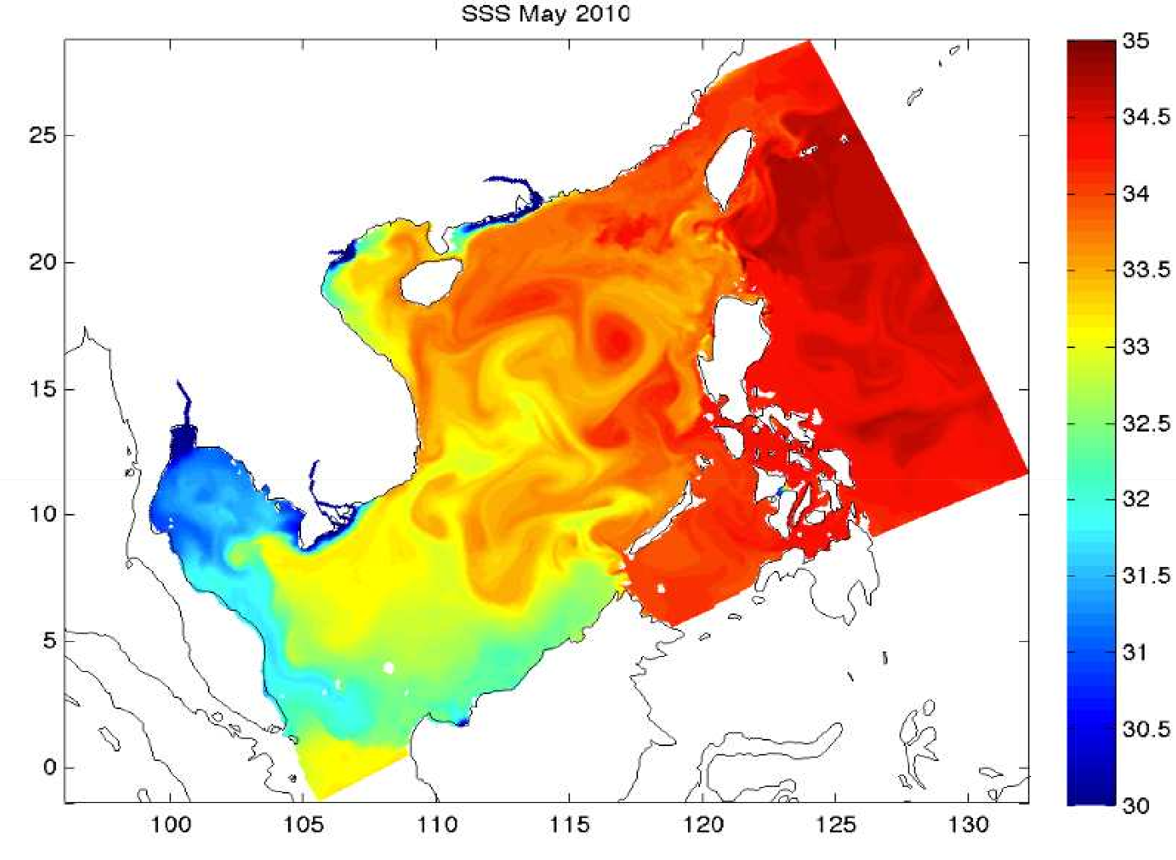
Objective: Explore to what extent the remotely-sensed observations can help to constrain the meso and submesoscale variability in the Luzon Strait region.

- The SSH variability in the Luzon Strait is anisotropic with shorter length and time scales due to the interaction of westward propagating eddies with the Kuroshio current.
- Large eddies are sampled by satellite altimeters and gridded SSTproducts, but the shorter scales not.

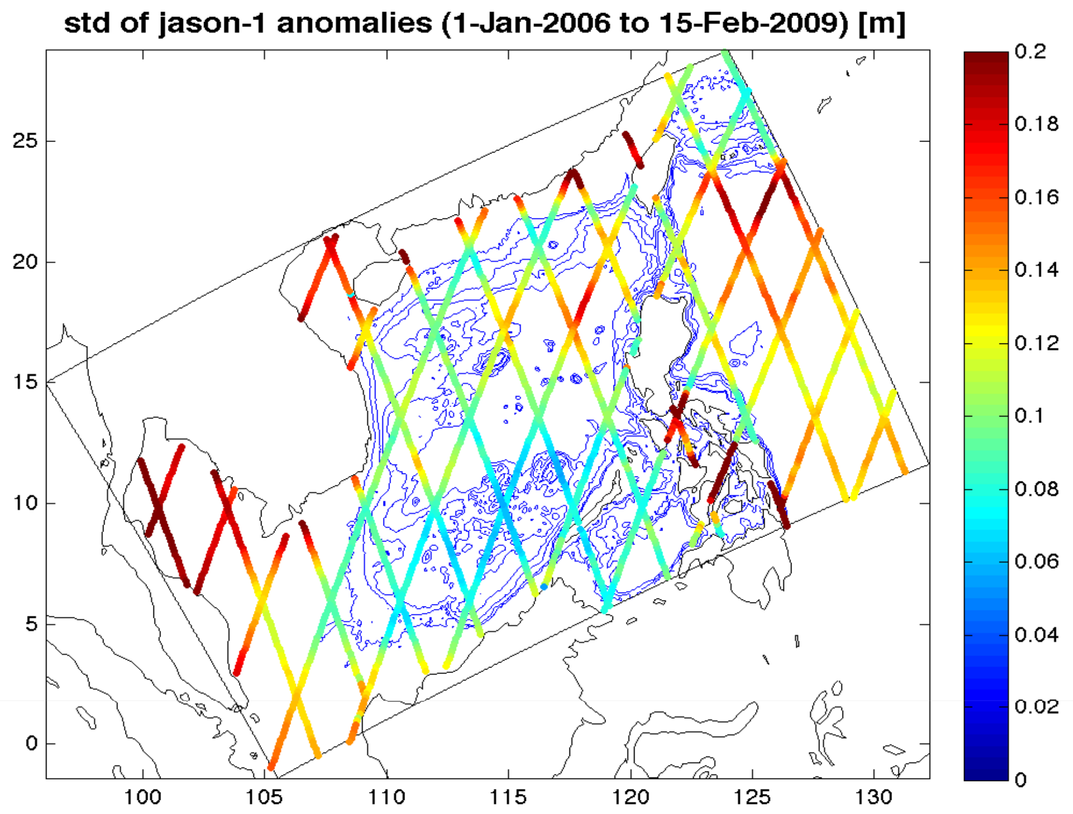
Use along-track altimetry and satellite SST with variational data asimilation:

- 4DVar uses the data at time of satellite pass
- model "grids" the along-track data by simultaneously matching the observations and the model dynamics

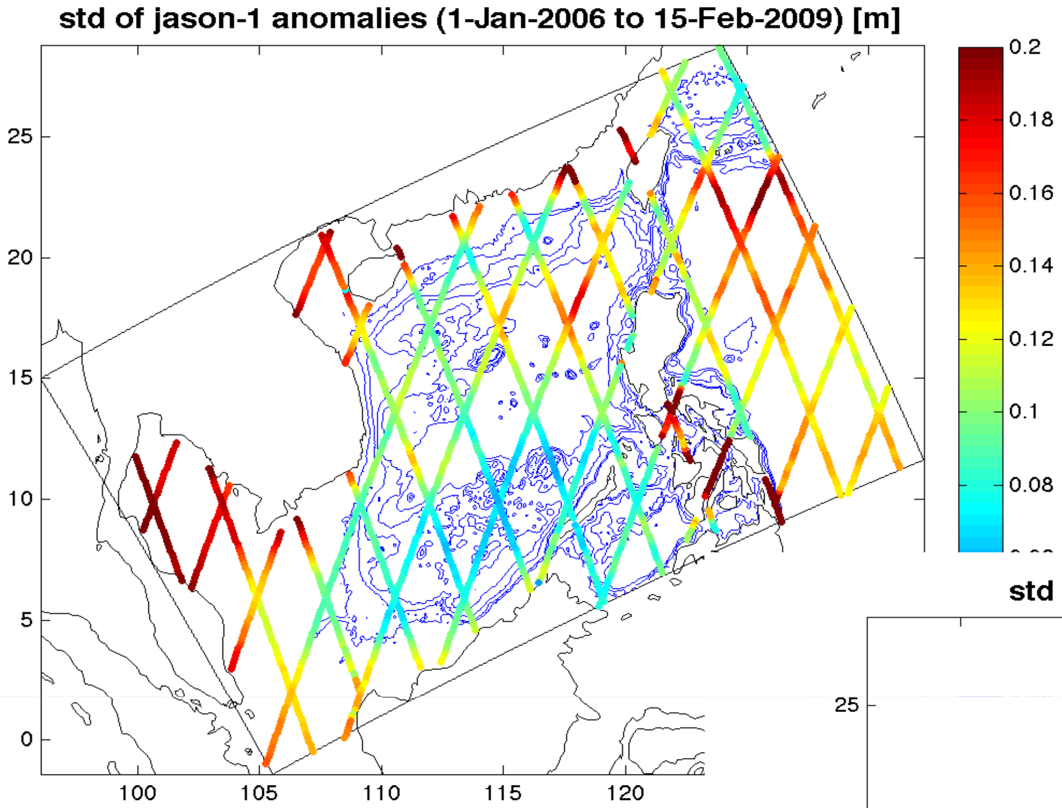
The parent model

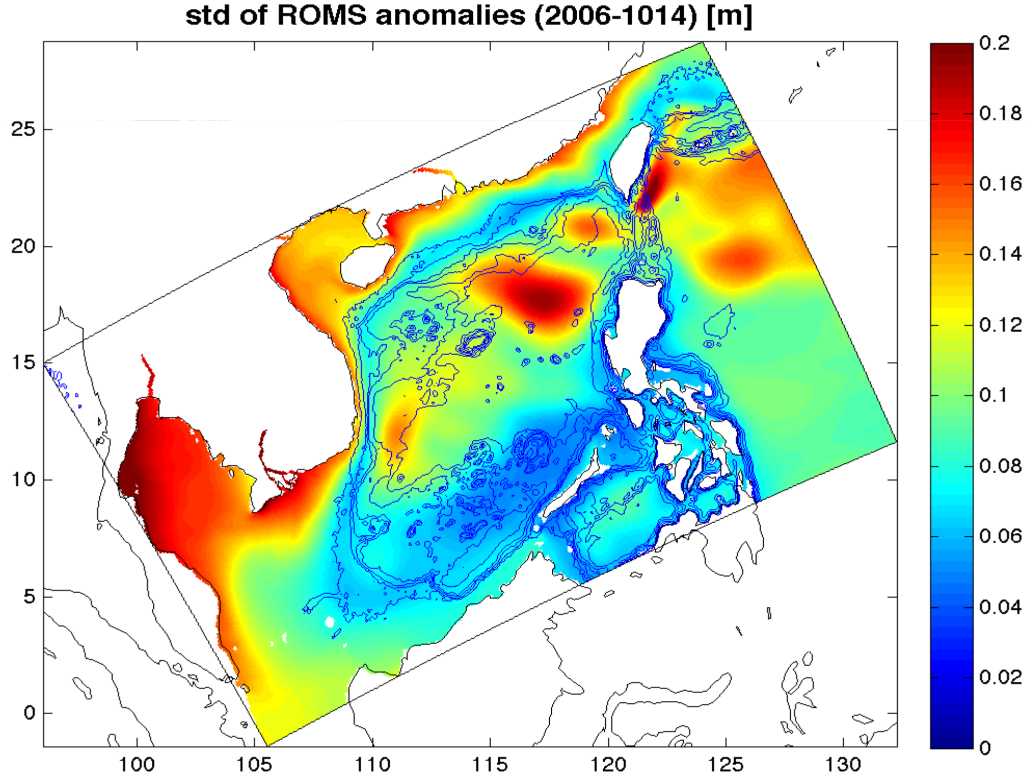


- Regional Ocean Modeling System (ROMS) configured for the South China Sea and Kuroshio vicinity
- 7 km resolution
- 1-day HYCOM boundary forcing
- Sponge and nudging (T and S) buffer zones at the boundaries
- Tides from TPXO (Egbert and Erofeeva,2002)
- Surface heat and fresh water fluxes calculated using ERA-iterim atmospheric analysis (1/8 deg resolution every 3 hours).
- River flow from different sources (climatological after 2012).
- 9 years of simulation (2006-2014)


std of jason-1 anomalies (1-Jan-2006 to 15-Feb-2009) [m]
25
20
15
10
5
0
100
105
110
115
120
125
130
0.2
0.18
0.16
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0

SLA variability





Data assimilation in the parent model

- Incremental, Strong-constrain 4-Dimensional Variational (IS4DVAR) data assimilation
- Satellite observations assimilated: Along-track Jason-2 data and gridded OSTIA SST
- Model for the seasonal background covariance obtained from the anomalies of the 9 years of model simulation. This is a crucial step to develop a robust vertical projection of the altimeter anomalies.

How to assimilate along-track data?

ROMS assimilates total ssh, defined as the sum of MDT, the tides, and the SSH anomaly. We want to fit the anomalies, therefore the MDT is defined as the long term mean of the forward model, and the observations area adjusted to include the model tide.

Our approach:

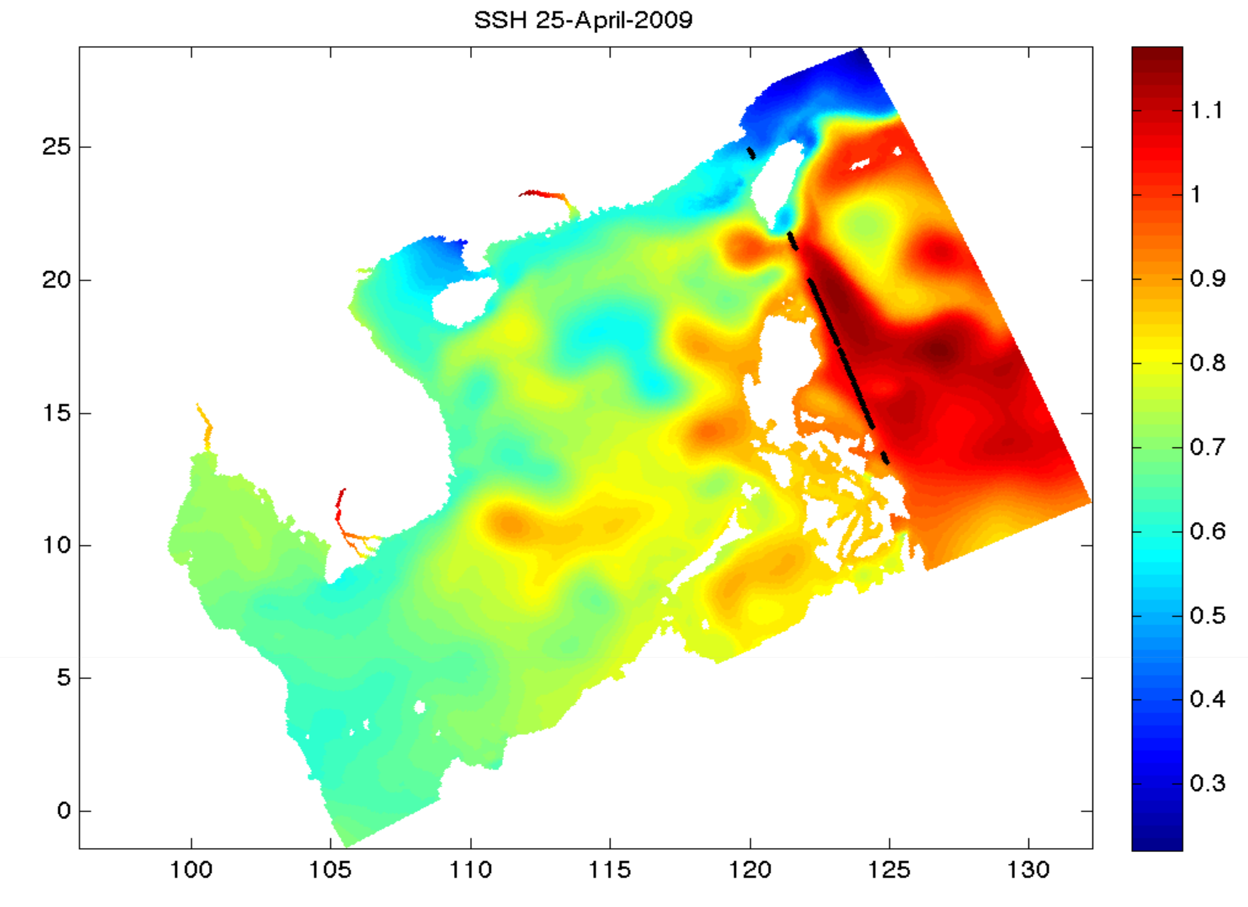
- Run 1-year ROMS (no assimilation) forced by boundary TPX0 global tidal solution (Egbert and Erofeeva, 2002) and compute ROMS tidal harmonics at each grid point.
- de-tide along-track altimetry
- add ROMS tides to de-tided altimeter data
- thus the *observations* are *adjusted* to include model tide
- assimilate – high frequency mismatch of model and altimeter is minimized and cost function is, presumably, dominated by sub-inertial frequency dynamics

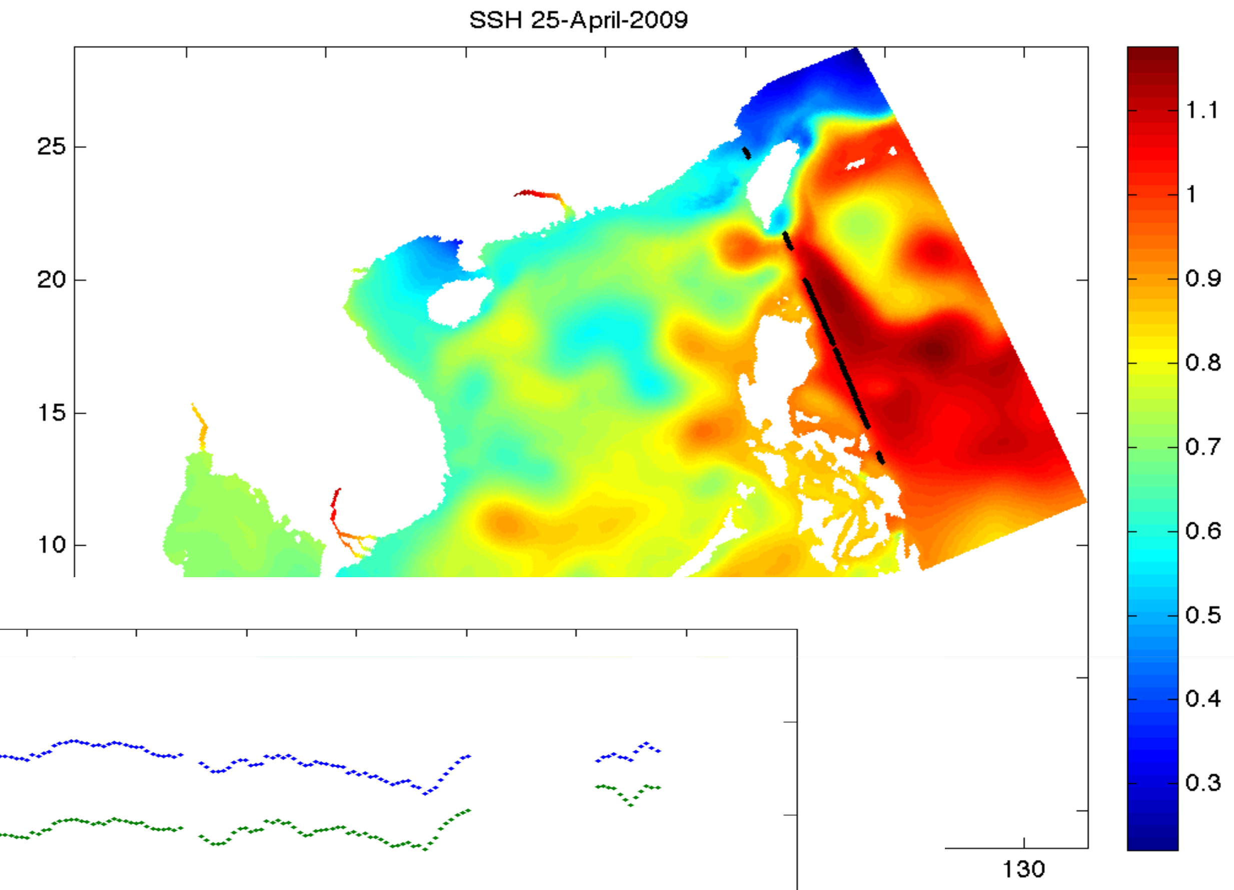
How to assimilate along-track data?

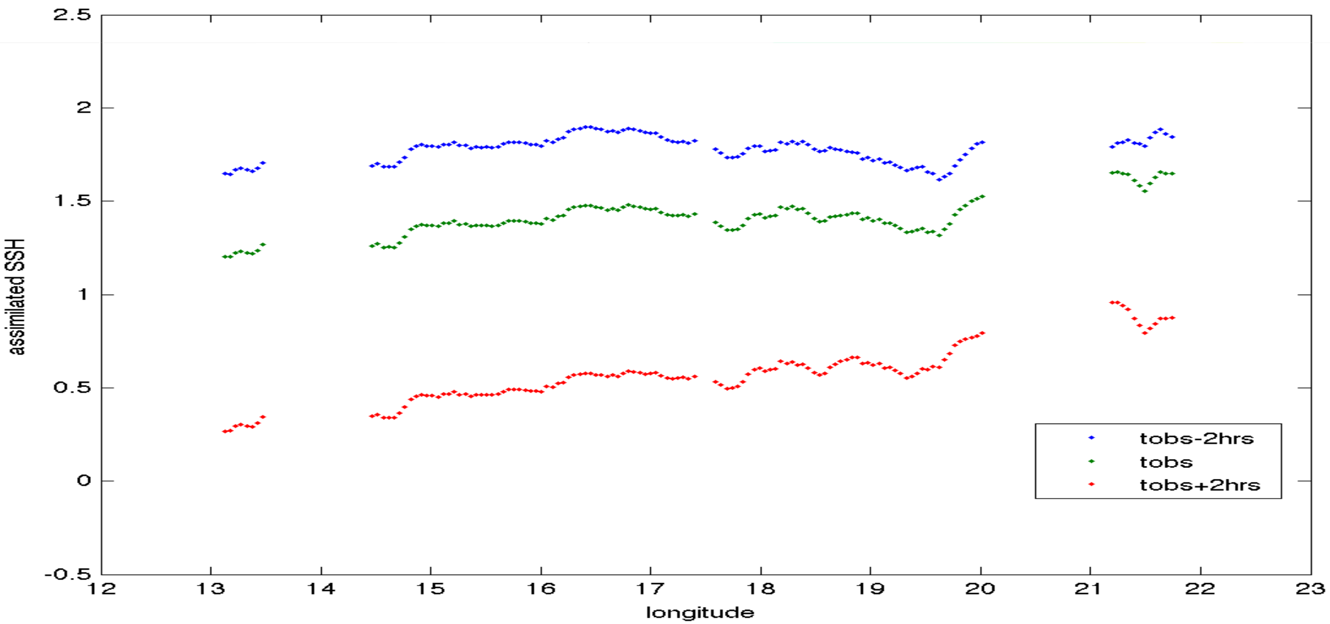
The adjoint model can erroneously accommodate too much of the SLA model-data misfit in the barotropic mode, sending gravity waves that match the alon-track SLA at the observation time.

Our approach:

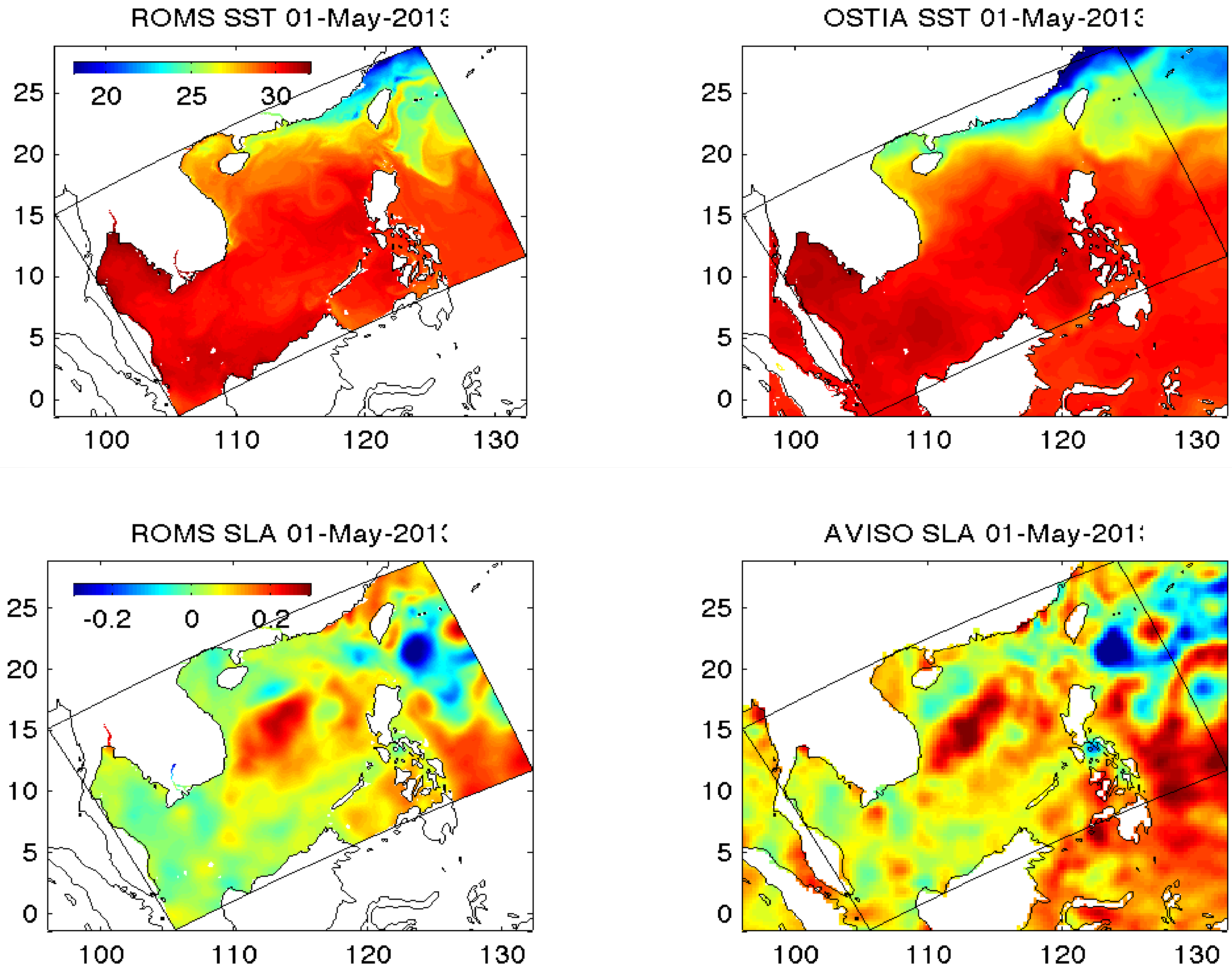
- Repeat (duplicate) the altimeter SLA observations at *t = tobs-2 hour, t=tobs and t = obs+6 hour* but with appropriate time lags in the added tide signal
- These data cannot easily be matched by a gravity wave
- We are effectively acknowledging the temporal correlation of the sub-tidal altimeter SLA data


SSH 25-April-2009
25
20
15
10
5
0
100
105
110
115
120
125
130
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3

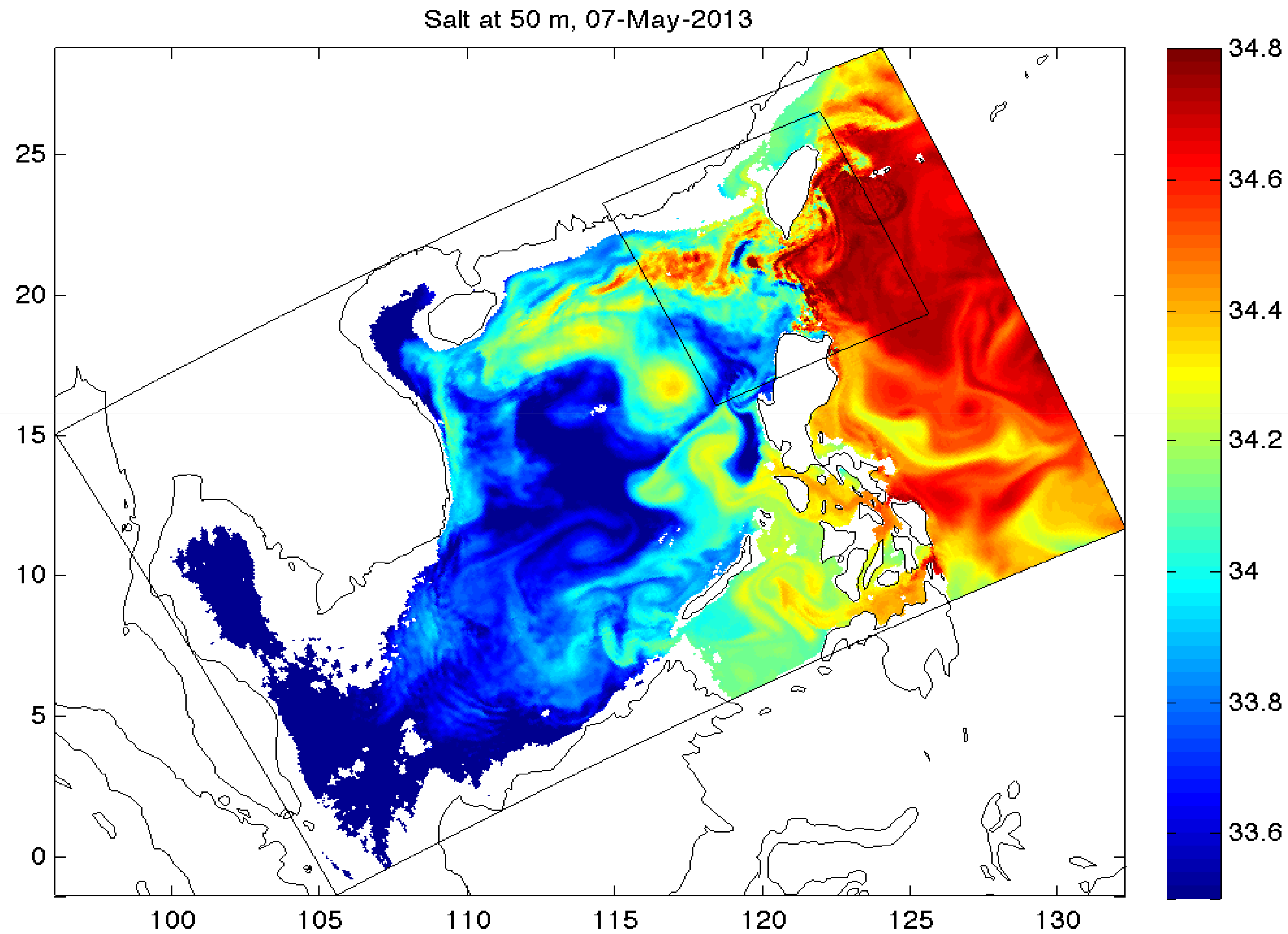

SSH 25-April-2009
25
20
15
10
130
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3


assimilated SSH
longitude
2.5
2
1.5
1
0.5
0
-0.5
12
13
14
15
16
17
18
19
20
21
22
23
tobs-2hrs
tobs
tobs+2hrs

Data assimilation in the parent model. Example

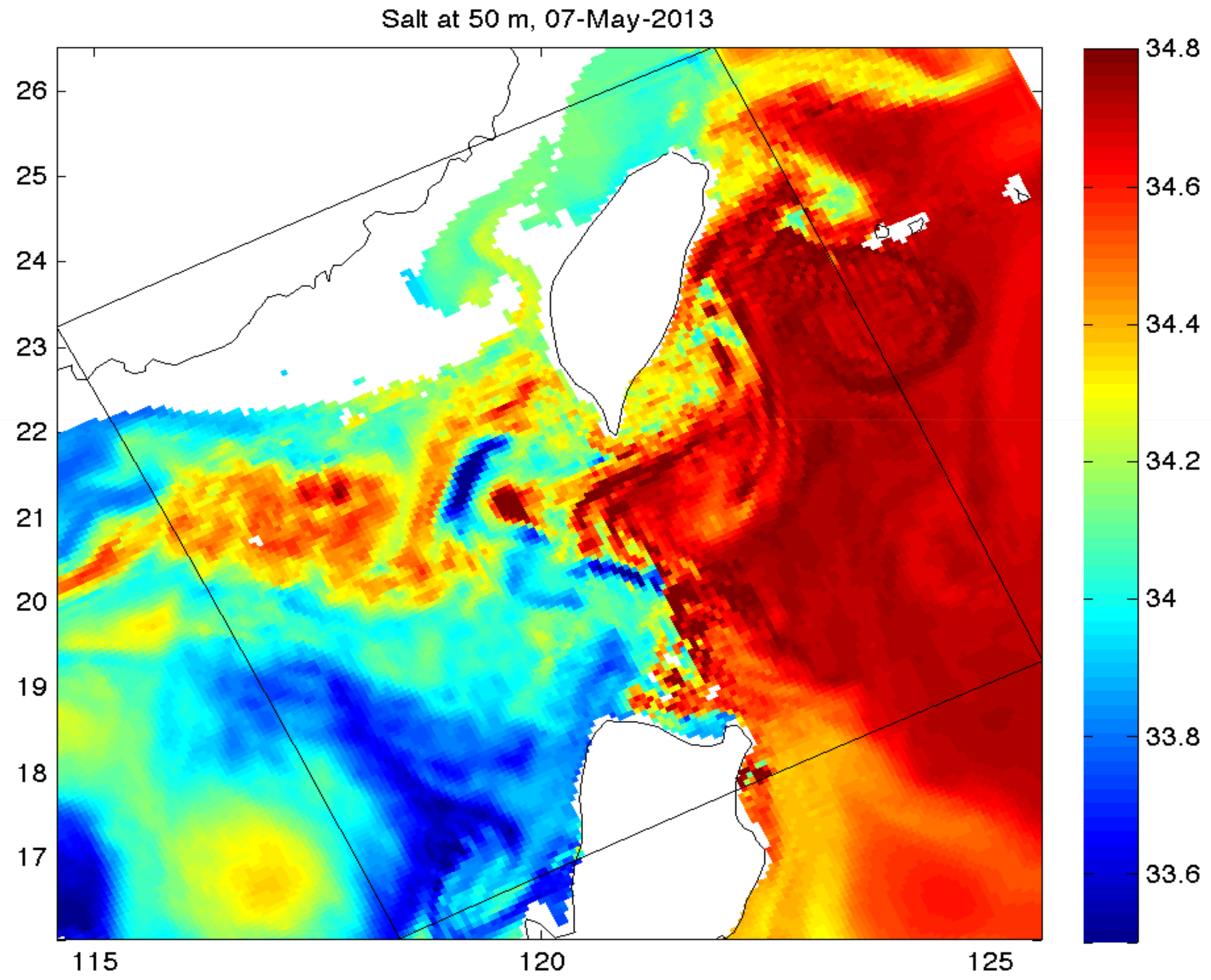


The two-way nested model: Parent model 7 km resolution, child model 2 km resolution

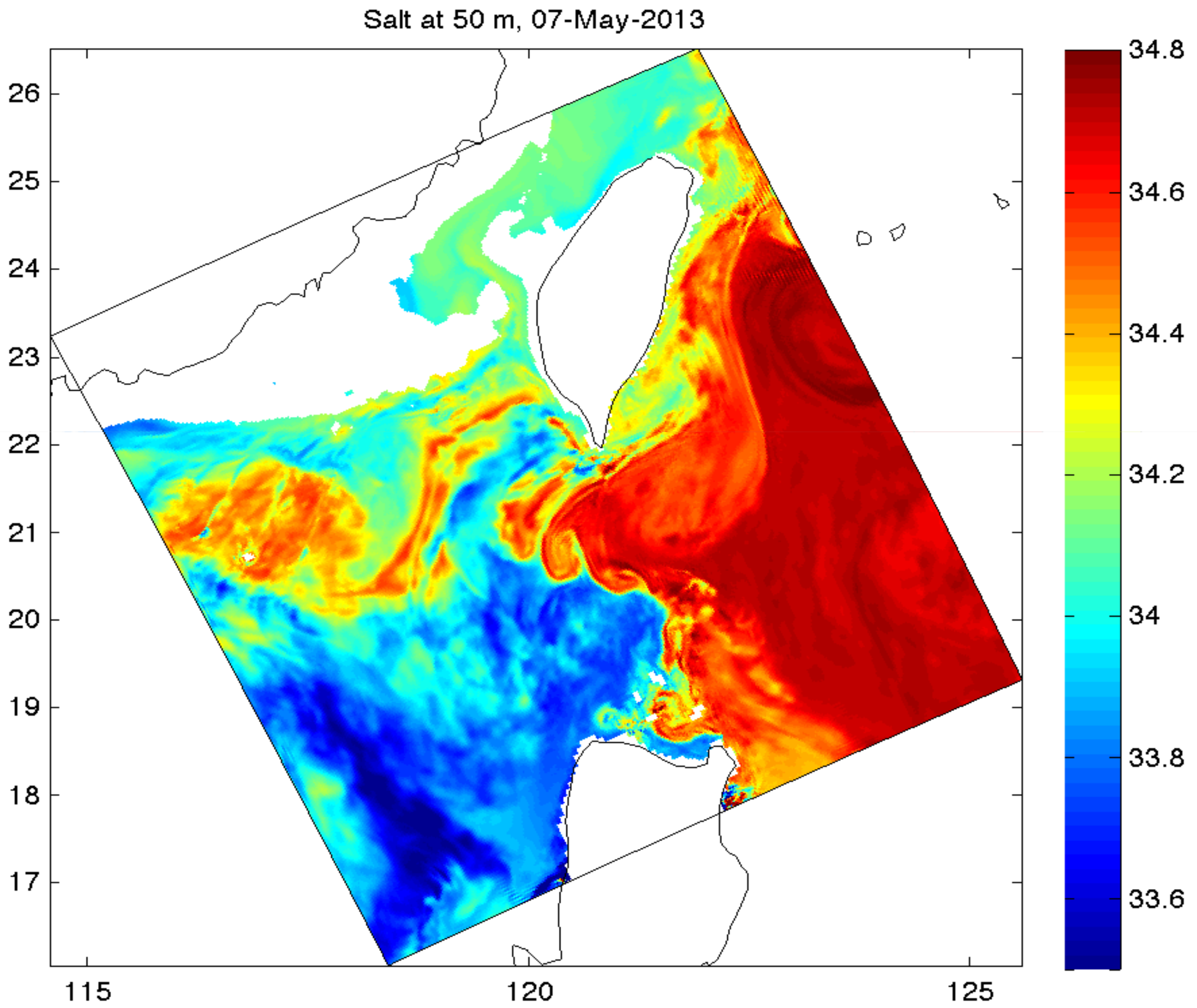


Similar approaches presented in this conference: Pascual, Zhijin Li

The two-way nested model: Parent model 7 km resolution, child model 2 km resolution



The two-way nested model: Parent model 7 km resolution, child model 2 km resolution



Summary and future work

- Work in progress.
- We presented a data-assimilative two-way nested model application based on the Regional Ocean Modeling System (ROMS), designed to study mesoscale and submesoscale variability in the Luzon Strait.
- The parent model of the nested application is constrained by satellite (SSH and SST) using variational data assimilation.
- The information content of the assimilated observations is then propagated to the scales not resolved by the parent model using a two-way nested approach.

- The performance of the system needs to be validated with in-situ observations, with specially emphasis to those resolving sub-mesoscale.

jzavala@rmarine.utgers.edu

THANKS!

jzavala@rmarine.utgers.edu