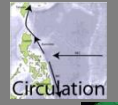
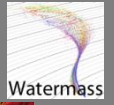
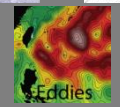
OKMC







State estimation and prediction in the NEC Bifurcation region

Bruce Cornuelle

Ganesh Gopalakrishnan

Dan Rudnick

SIO

From the program

- One such method, that Lien advocated and that may inspire young scientists, is to analyse very high resolution data - obtained from in-situ measurements and high performance computers - using a geophysical fluid dynamics approach.
- Hua, McWilliams, Owens, An objective analysis of the Polymode dynamics program, Parts 1 and 2, JPO 1986

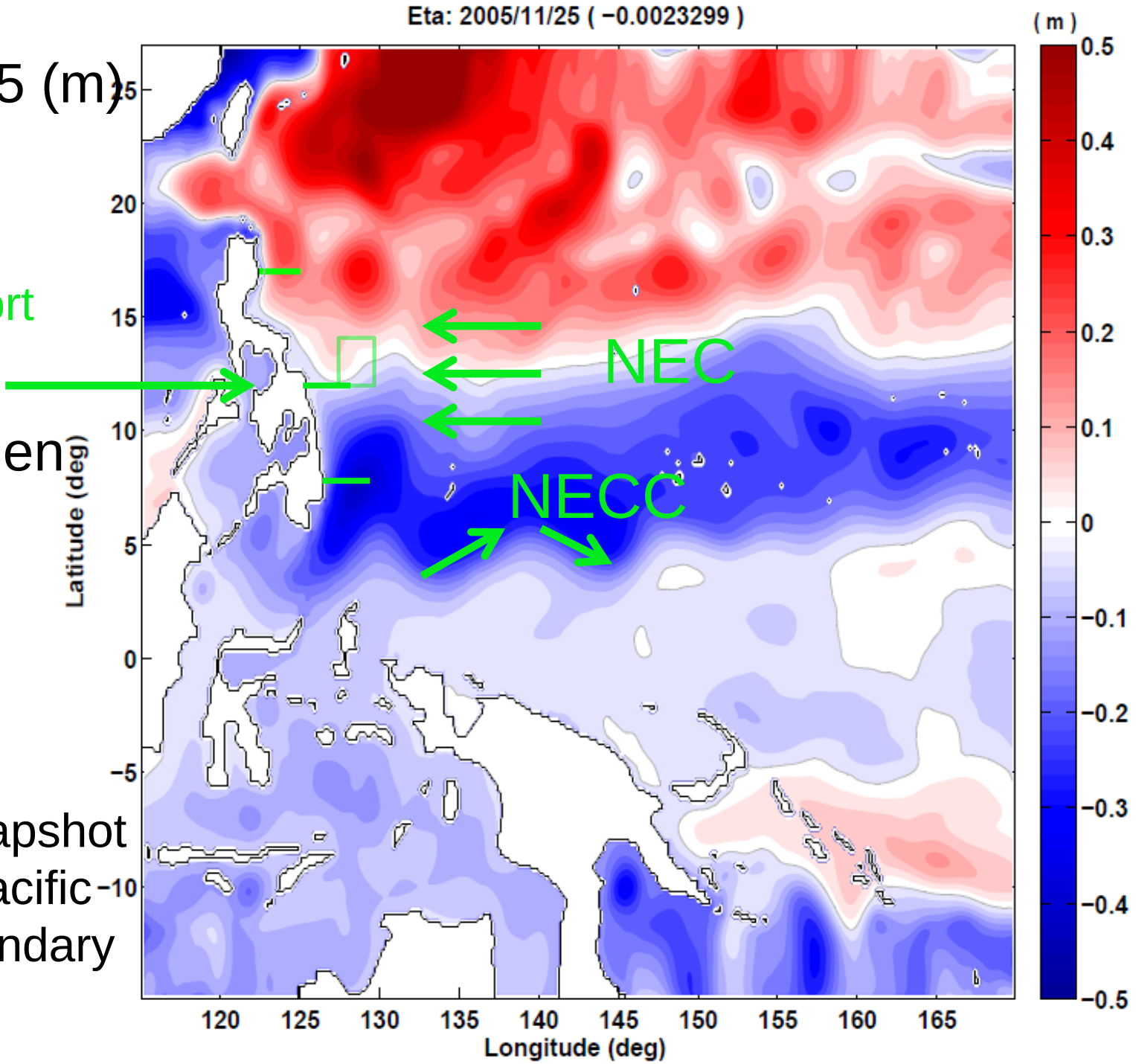
State Estimation: find x so y = F(x)

- “Mapping with benefits” (improved fields)
- The model is the hypothesis, including physics, resolution, parameters (e.g. topo), and forcing
- Don’t reject a model until other options have been explored (e.g. bad controls)
- Can enforce restricted balances if desired (QG)
- Goals: test the model, use dynamics to infer the complete ocean state from limited data

Overview

- Trying to reach the goal of making models represent the real ocean, at least in a scale range
- Working from large scale to small, currently working down to 2.2 km resolution, with the goal of making it to sub-mesoscale. (SWOT)
- But: One person's new physics is another's computational nightmare. Large model state and strong nonlinearity are challenges

SSH
25 Nov 2005 (m)



WBC transport
Influences?

Qiu and Chen
JPO 2010
12-14N
127-130E

Example: snapshot
Of tropical Pacific
Western Boundary

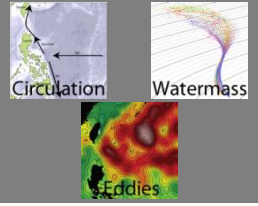
Science motivation

- Influences and predictability of the Western Boundary Current (WBC) near the bifurcation
  - Which influences are most important?
  - What is predictable? Over what time range?
  - Pathways of forcing to the boundary
    - Waves? Eddies? Advection? (momentum and water masses)
- Test of model using the forecasts as cross-validation of the state estimate
- Evaluation of dynamical balances: how nonlinear?

Procedure

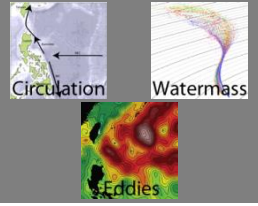
- Regional, month-long state estimates 2010-2013
- Combine most observations with dynamics
- Use as ocean reanalysis for the observations
- Diagnose physical controls and mechanisms
- Assess predictability, use prediction as a cross-validation of the state estimate against independent future observations.

Example Interests



- Bifurcation latitude (Qiu and Chen 2010, …)
- NEC strength, transport
- Sub-surface countercurrent transport
- Kuroshio transport at various latitudes
- Mindanao Current strength
- Water mass properties
- Salinity variance on isopycnals
- Other integrated measures (?)

MITgcm configuration



1/6 degree regional: 115E-170E, 15S-30N

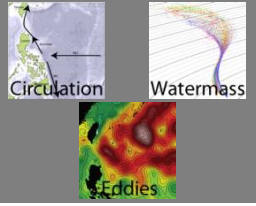
50 levels with 2.5m spacing in the upper ocean

Surface forcing is derived from NCEP/NCAR Reanalysis (1 degree, daily averaged)

Initial and boundary conditions from global HYCOM-NCODA (tend to be very good)

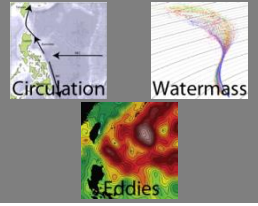
Testing included simulating 2004 -2012 and comparing to AVISO SSH

State Estimation for OKMC



- Fit model to observations using 4D-Var (adjoint): min(y - F(x)) by adjusting x
- Adjust initial conditions, boundary conditions, and forcing (within error bars)
- Estimate is a free forward run of the model that should match the observations (within error bars) (i.e. “Phase validation”)
- Is a dynamically-consistent reanalysis for research use, including sensitivities

Observations



- Along-track altimeter sea surface height
- Temperature and salinity profiles from Argo, Spray gliders
- Geoid constraints from GRACE (“HMEAN”)
- SST from TMI and AMSR-E (microwave)
- To add: Seagliders, moorings, etc.
- 1 month windows, use observations only in a sub-region of the model domain
- Analysis starts Jan 2010

Glider observations of the North Equatorial Current

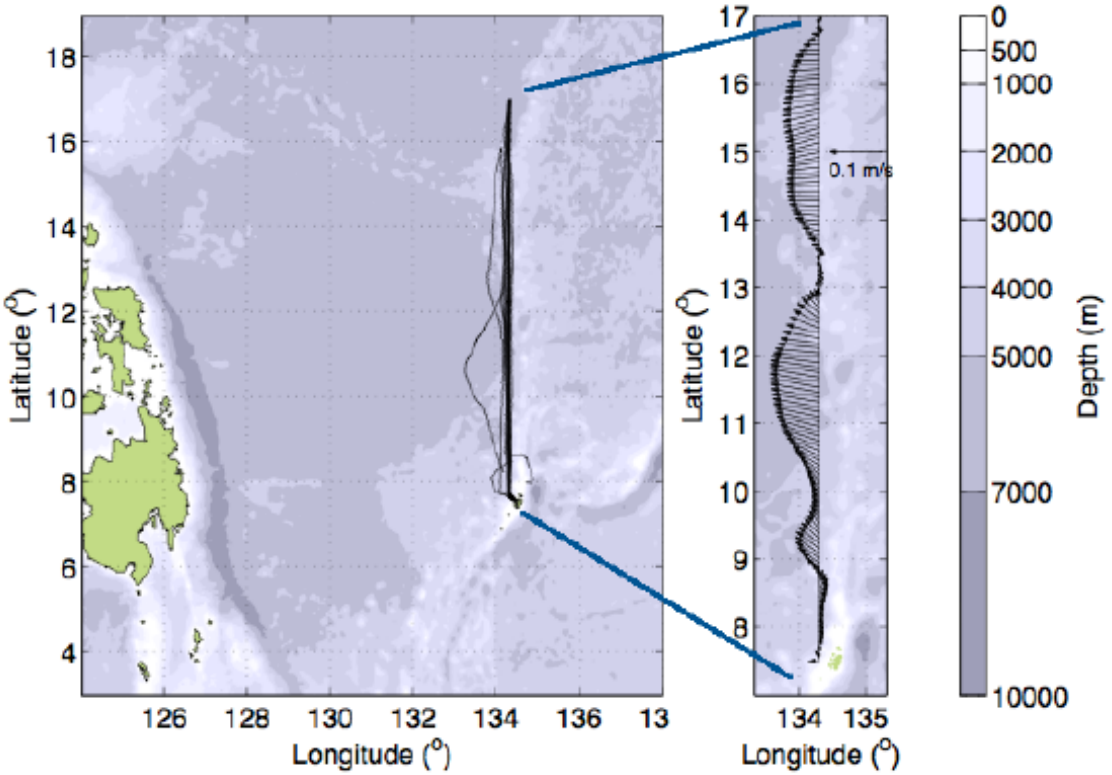
Martha C. Schönau and
Daniel L. Rudnick

Scripps Institution of Oceanography
24 February 2014

Glider Observations

North Equatorial Current (NEC) Section:

134.3 E, 7.5 N to 17 N



Objectives:

- Provide an estimate of NEC mean transport and variability
- Determine water masses and their large scale variability
- Provide an estimate of fine scale variability of water masses

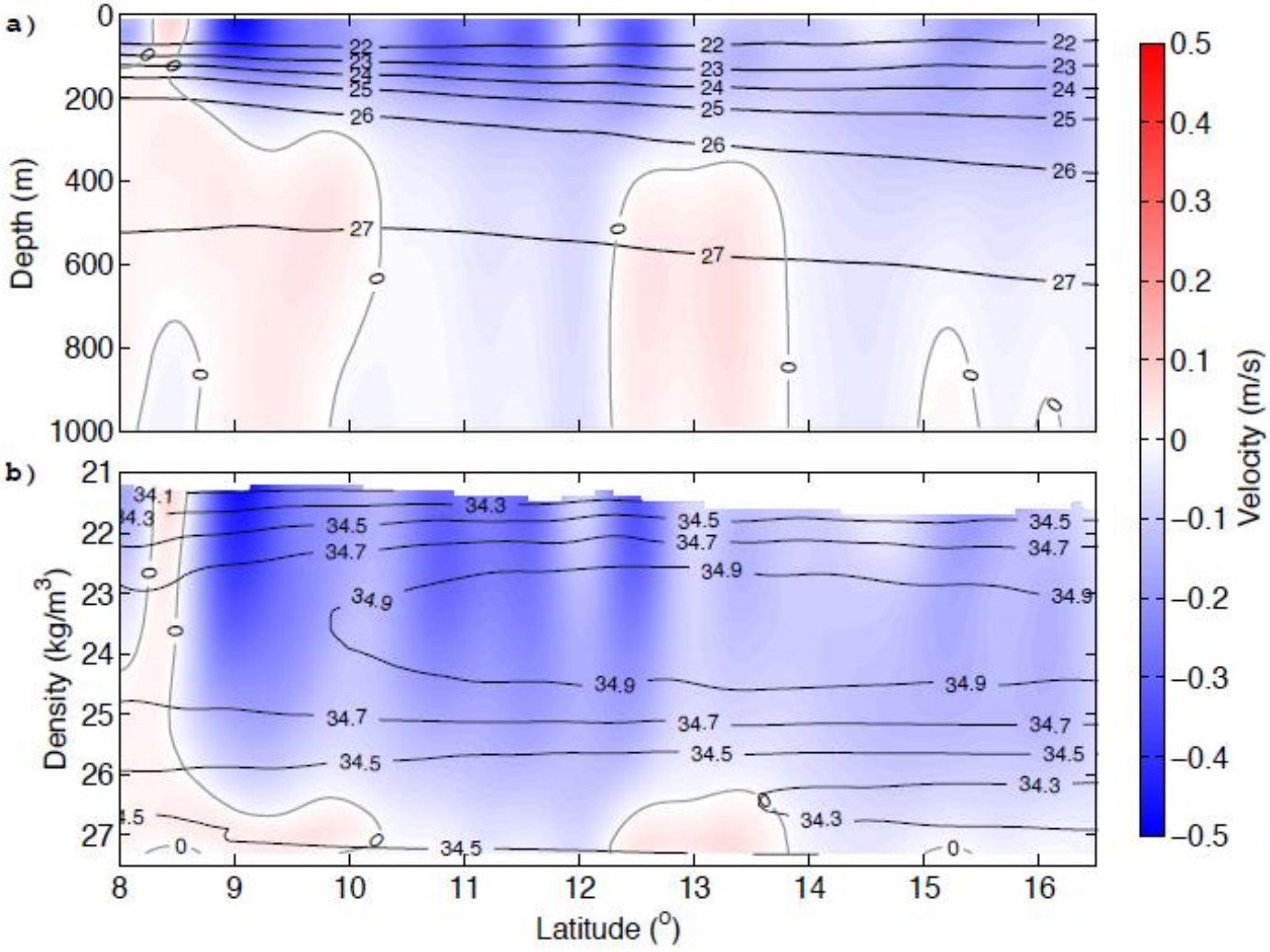
Dates of Observation:

June 2009 - January 2014

Number of NEC sections: 18

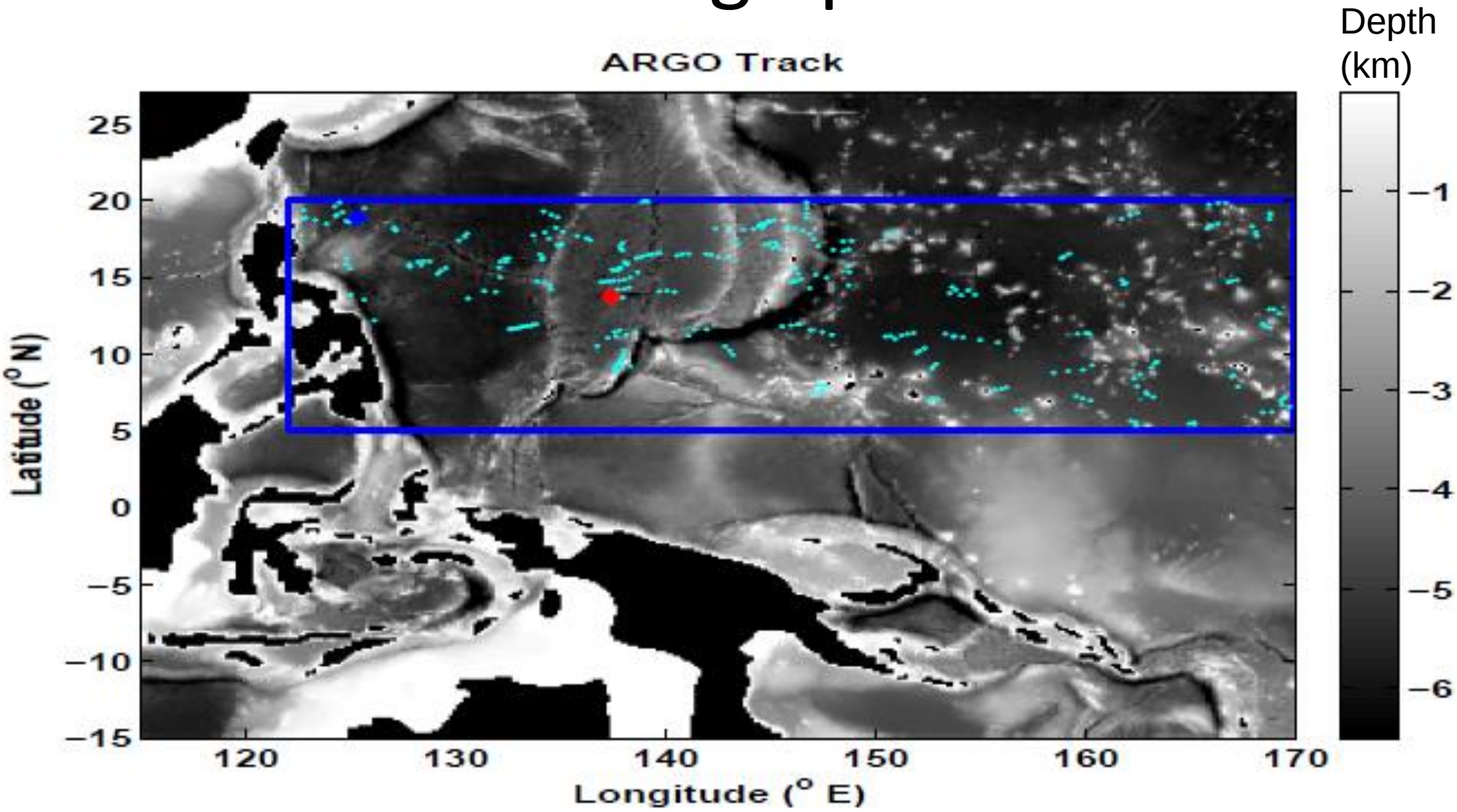
Number of dives: 4281

Geostrophic Velocity: Mean Section



- Mean sections are from objective map of all data.
- Negative indicates westward.
- Maximum mean surface velocity:
  - 0.47 m/s
- Undercurrents present in all sections, mean location 9.6 N and 13.1 N
- Top of undercurrents at 26 σ_Θ

Example: December 2012
Locations of Argo profiles used

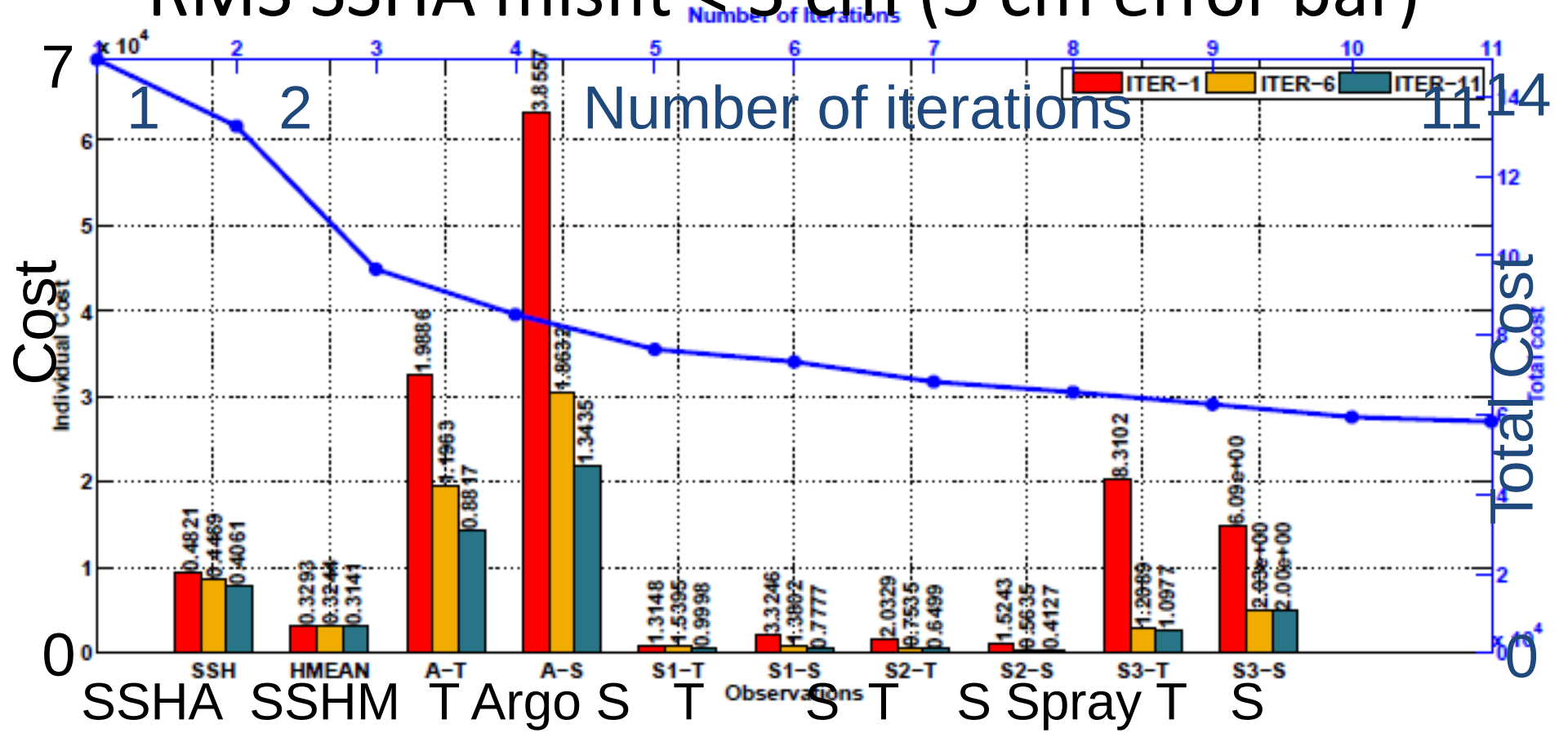


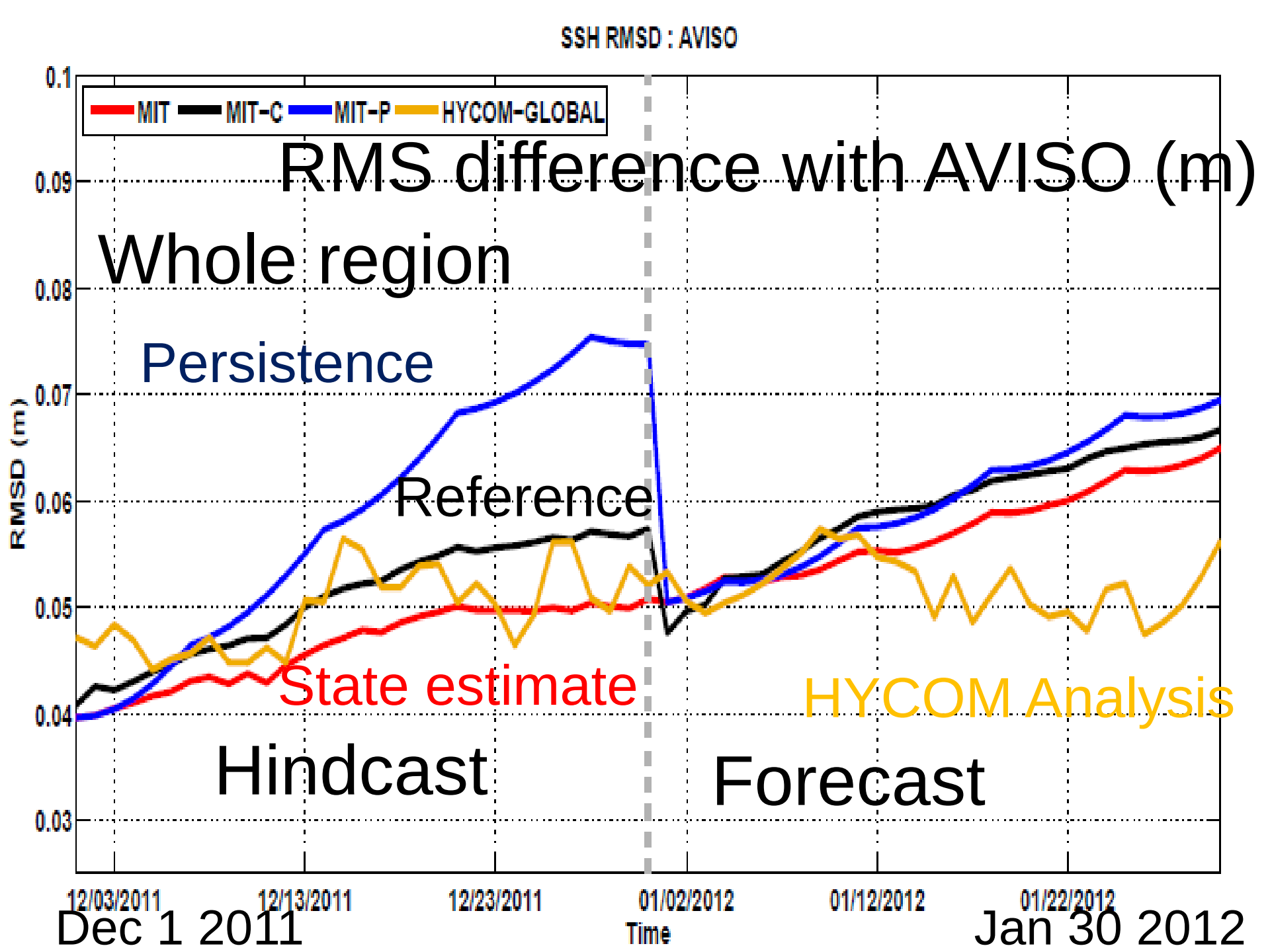
Example: December 2011

Cost function reduced by 60%

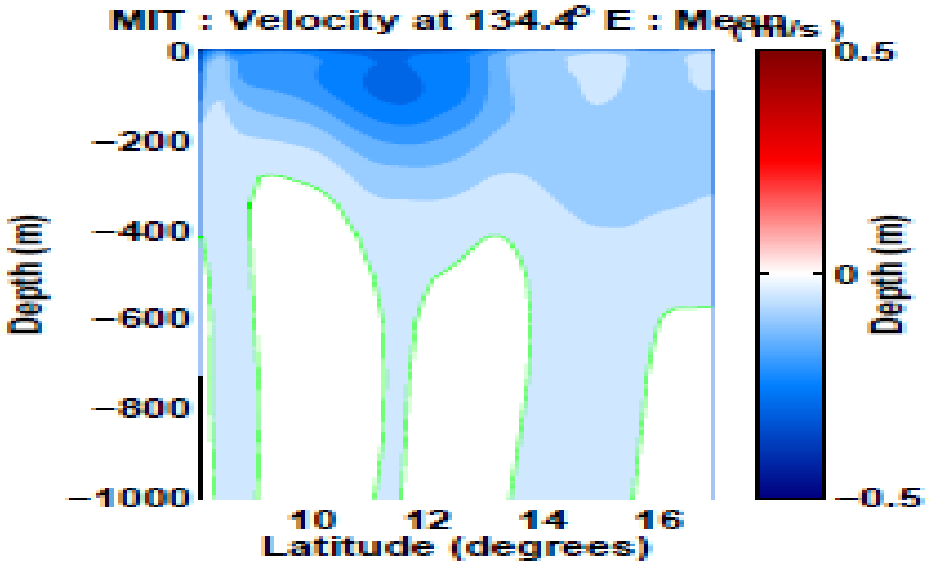
Largest reductions: T and S, Argo and Spray

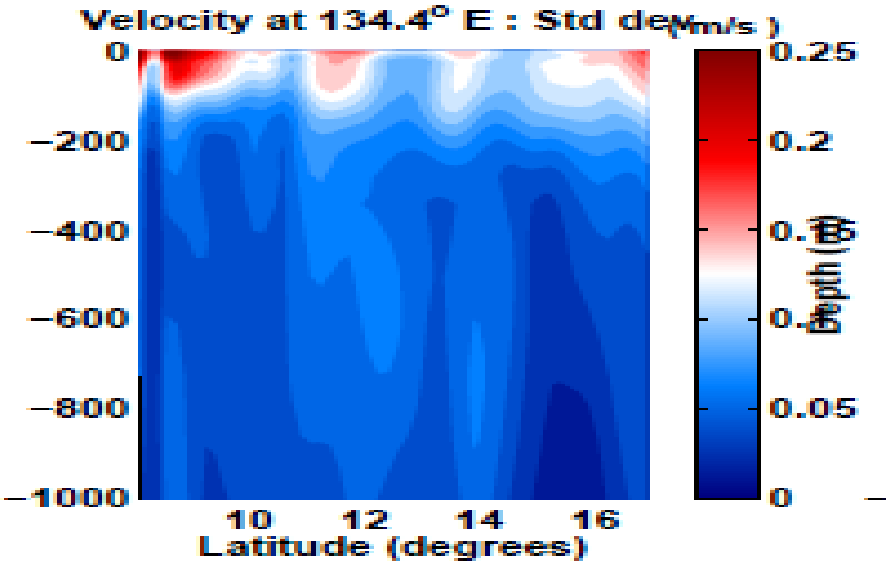
RMS SSHA misfit < 3 cm (5 cm error bar)

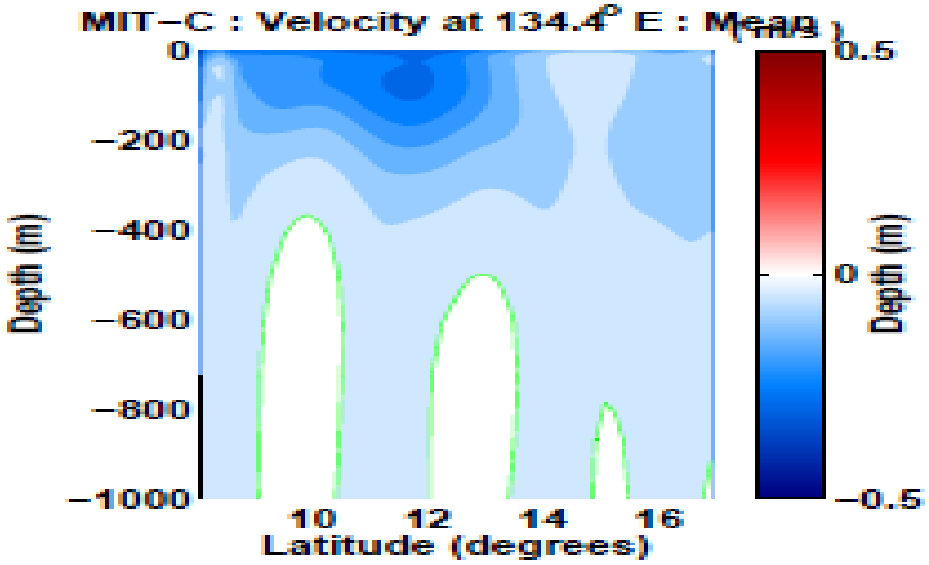


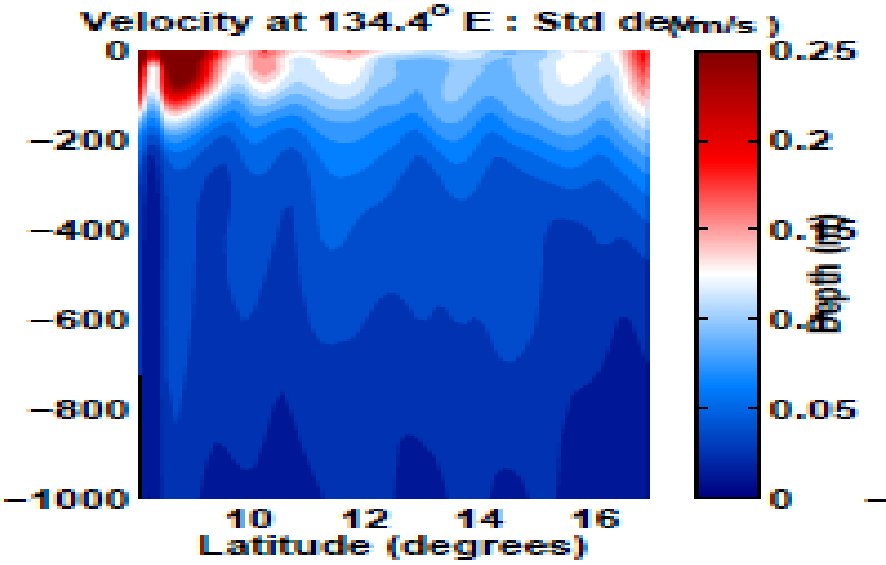

SSH RMSD : AVISO
MIT
MIT-C
MIT-P
HYCOM-GLOBAL
RMS difference with AVISO (m)
Whole region
Persistence
Reference
State estimate
HYCOM Analysis
Hindcast
Forecast
RMSD (m)
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
12/03/2011
12/13/2011
12/23/2011
01/02/2012
01/12/2012
01/22/2012
Time
Dec 1 2011
Jan 30 2012

NEC: State Estimates (top), First guess 2010 mean









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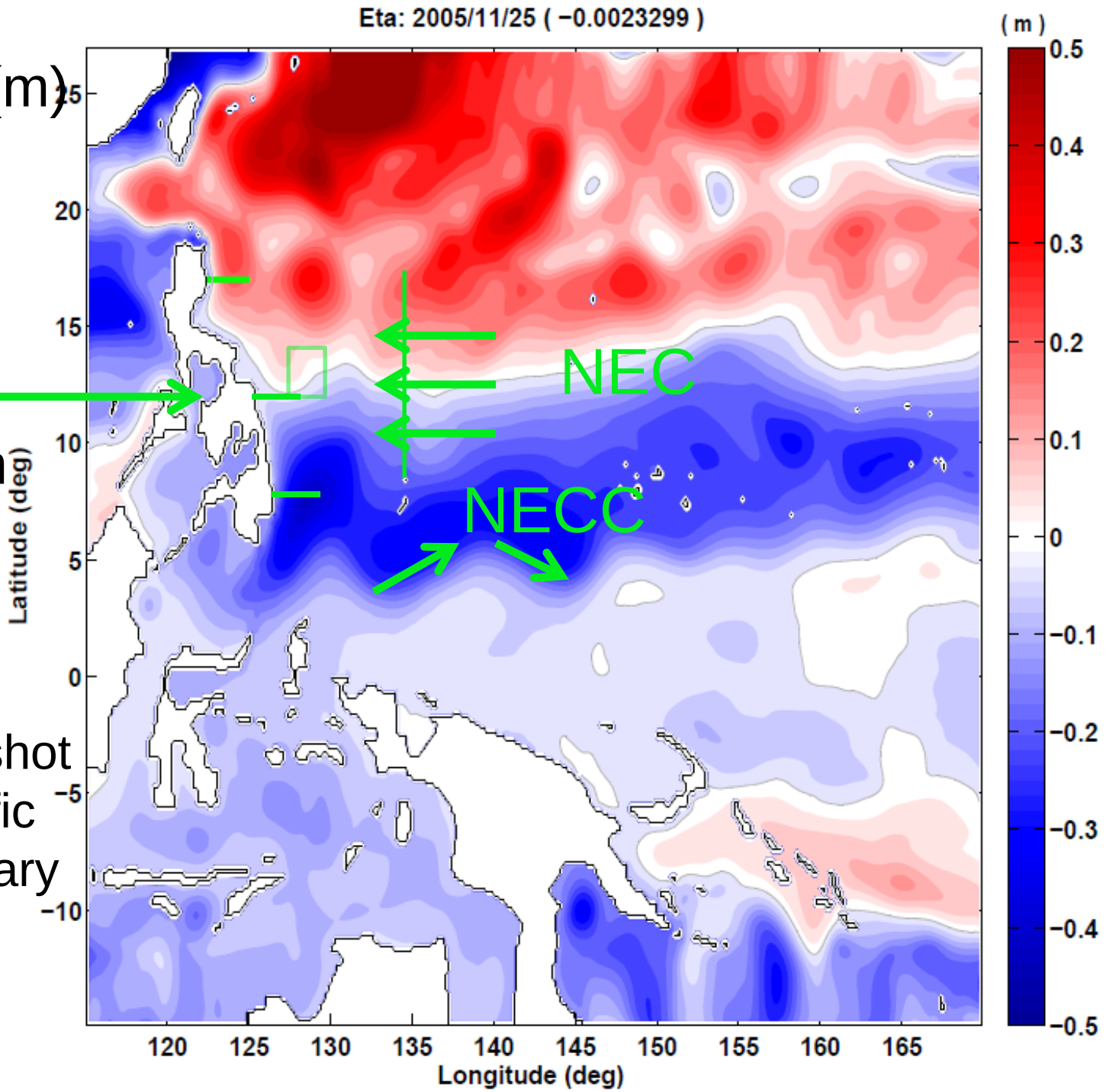

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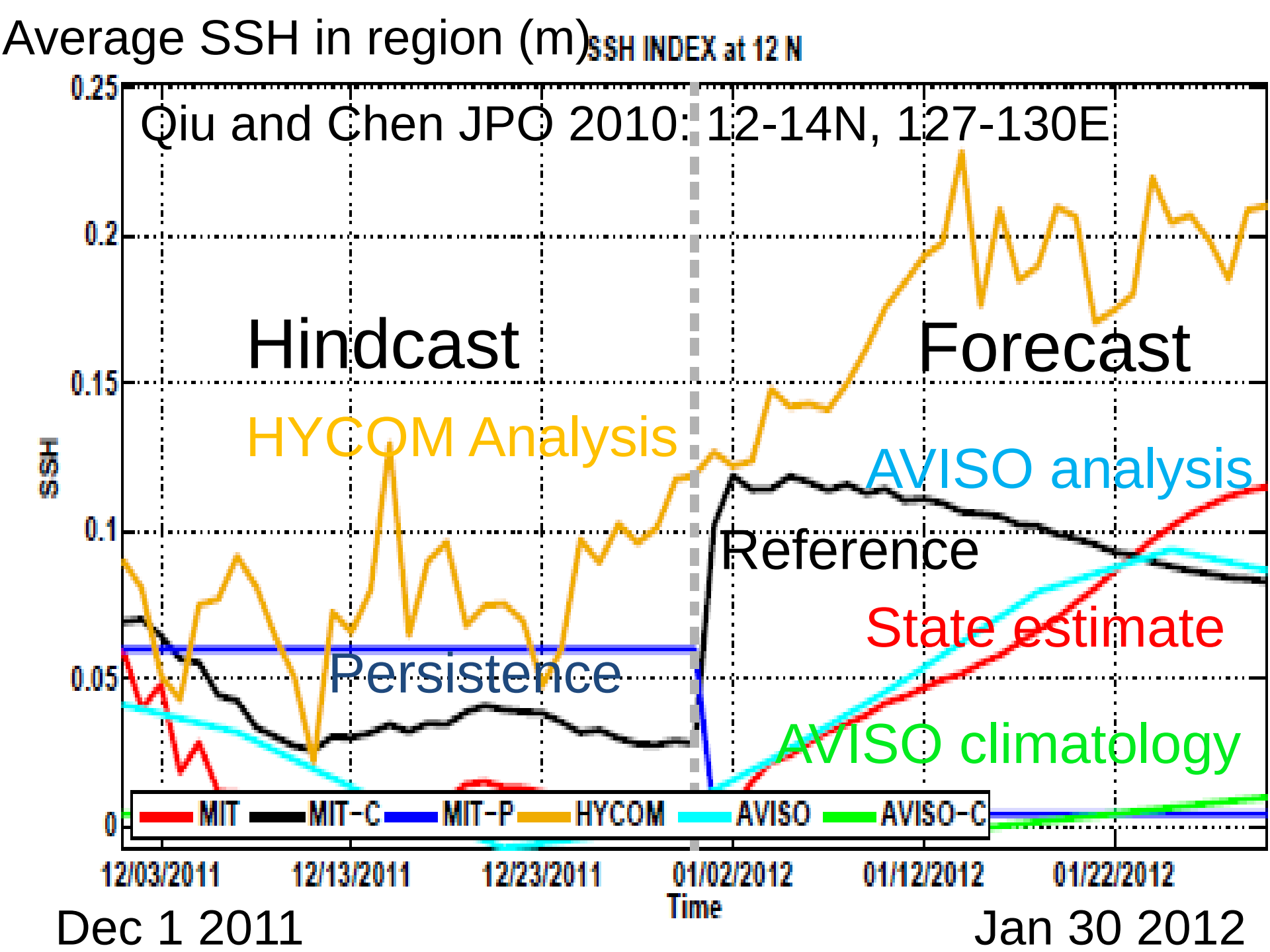
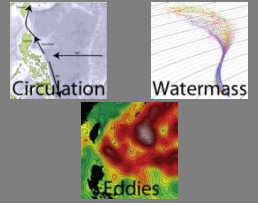
Average SSH in region (m)



Dec 1 2011

Jan 30 2012

Conclusions/Discussion



- State estimation works in the region, but needs to be refined: ongoing work
- State estimation tested by forecast
- North Equatorial Undercurrents are enhanced by state estimate in 2010 mean
- Will use the model to diagnose the controls in the undercurrents, boundaries