Regional State Estimates

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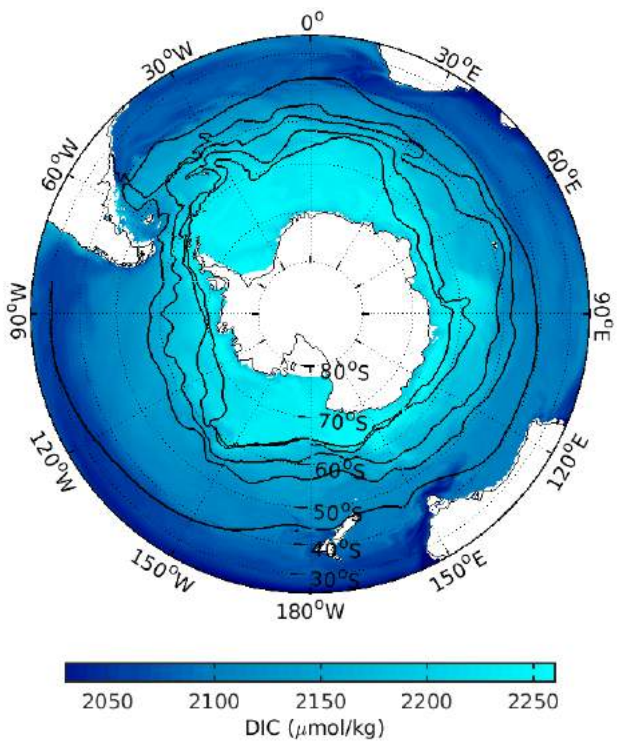
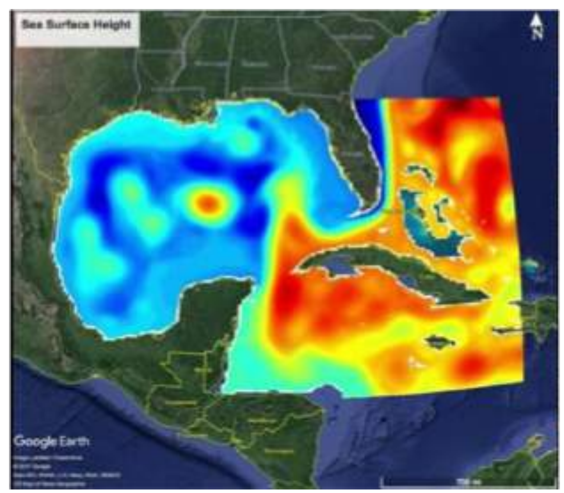
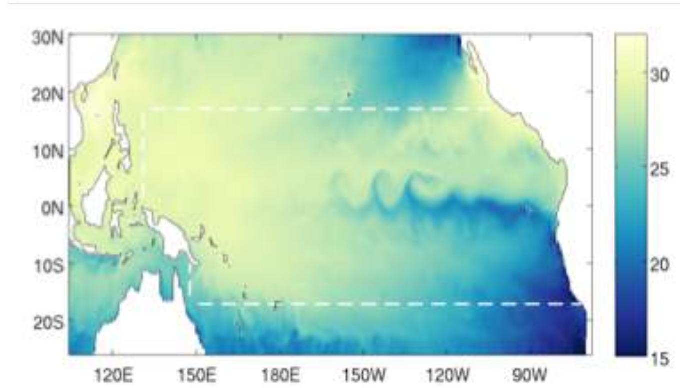
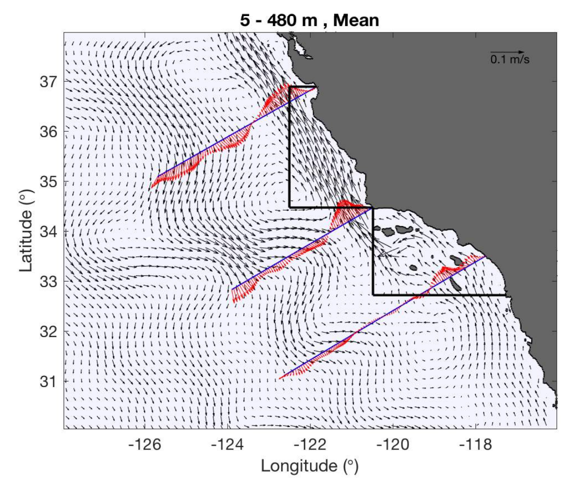
Scripps Institution of Oceanography

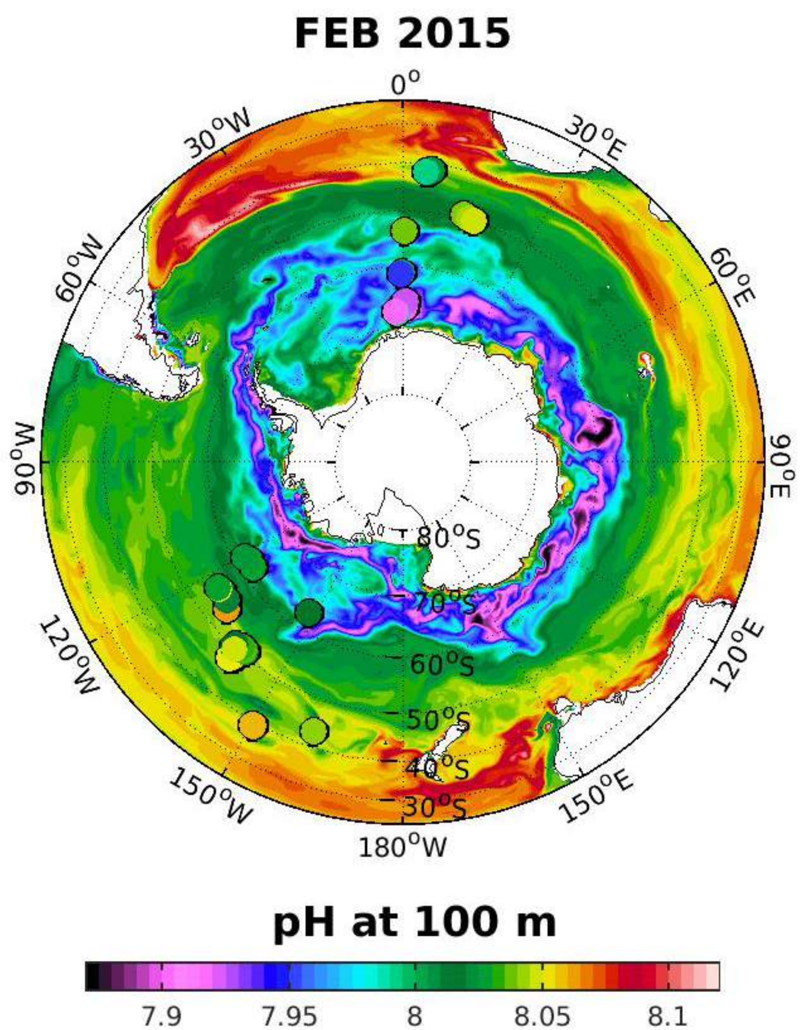






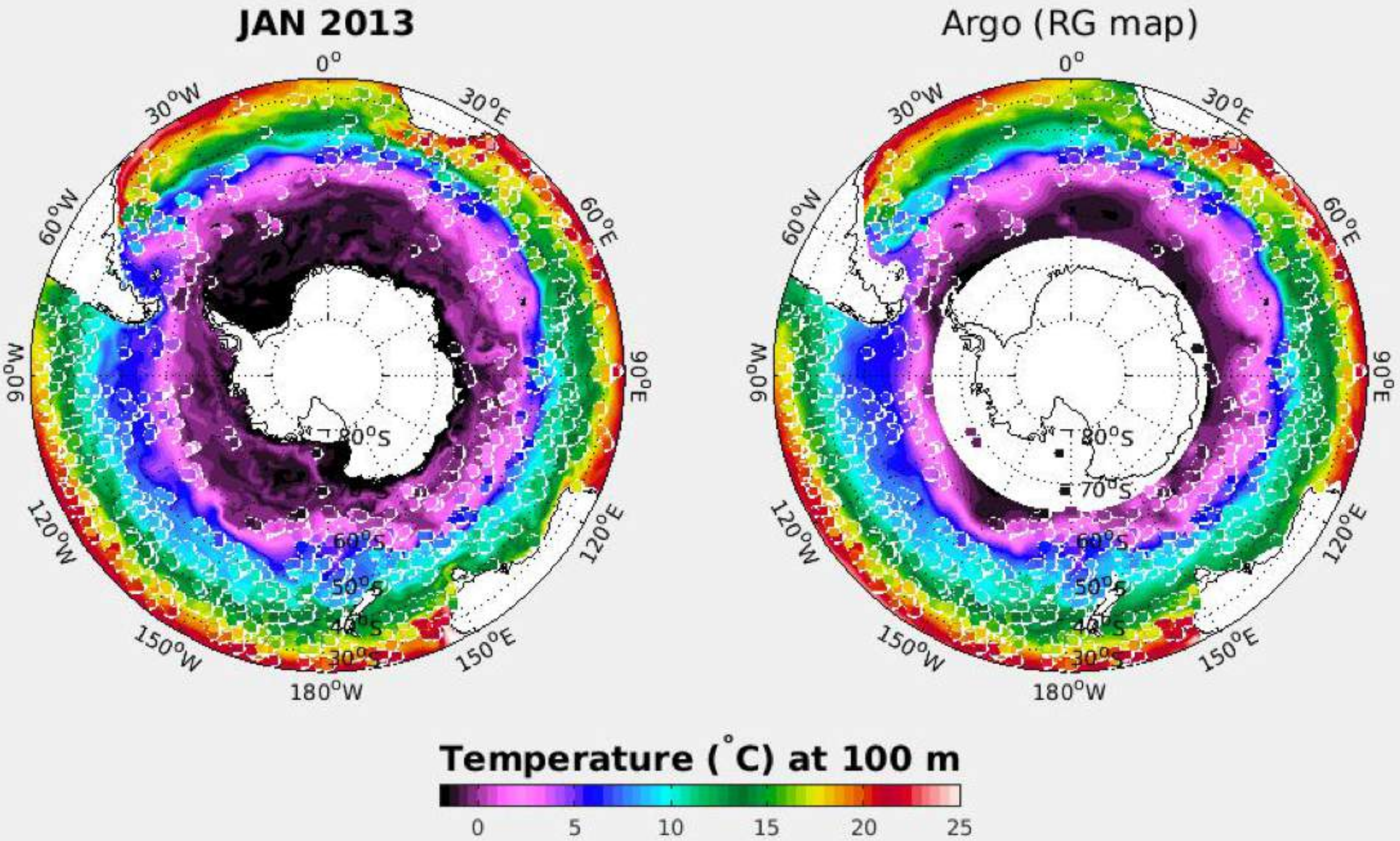


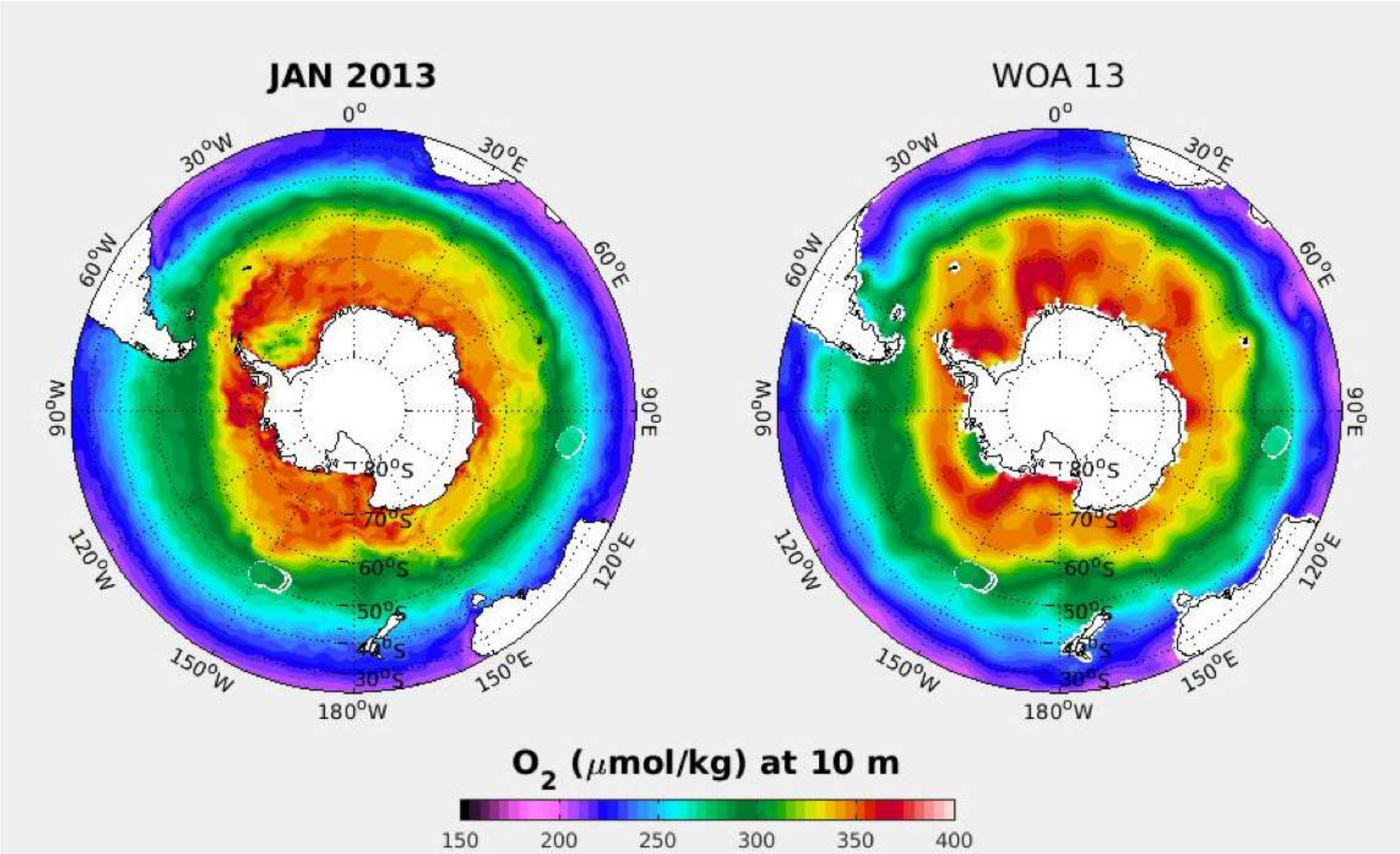
Biogeochemical Southern Ocean State Estimate (B-SOSE)



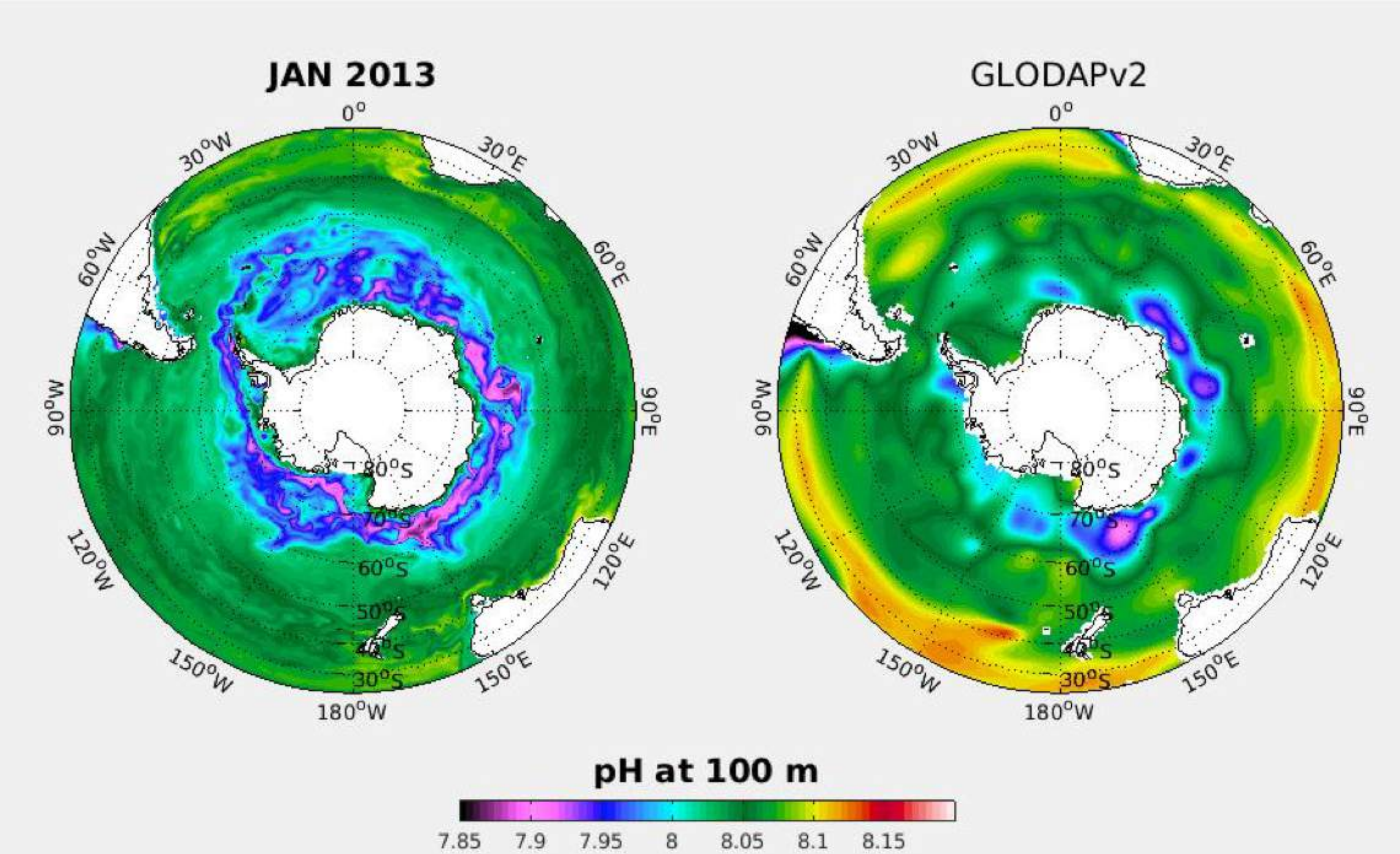
pH in B-SOSE (background colors) and from bgc-Argo floats (colored bubbles).

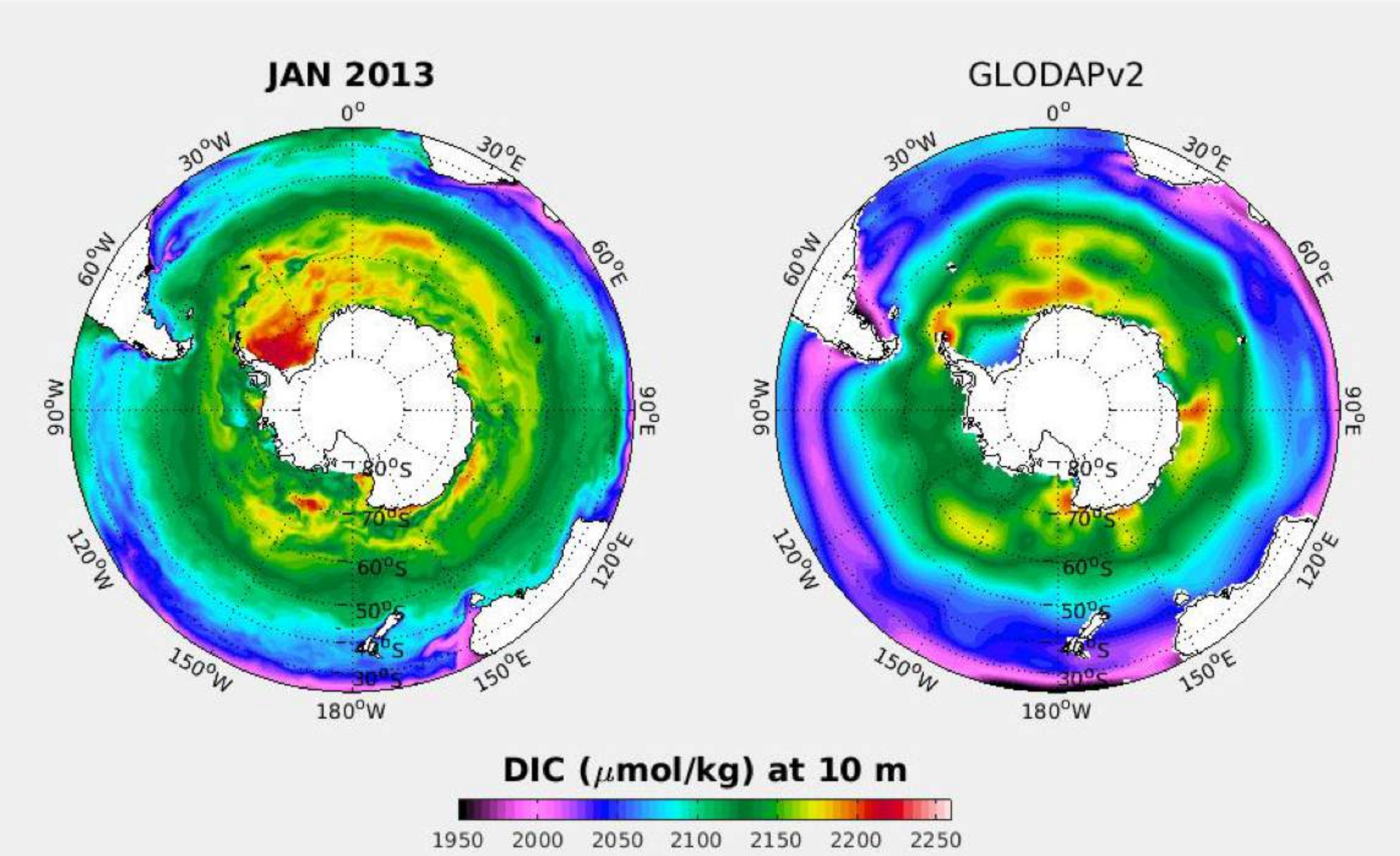
- BLING biogeochemistry
- Open boundary at the equator
- 2008-2012 state estimate published, 1/3°
  http://sose.ucsd.edu/BSOSE_iter105_solution.html
- 2013-2016 state estimate in production, 1/3°
- 1/6° adjoint in development
- 1/12° forward run coming soon
- validation available online
  http://sose.ucsd.edu/bsose_valid.html


JAN 2013
Argo (RG map)
0°
30°W
30°E
60°W
60°E
90°W
90°E
120°W
120°E
150°W
150°E
180°W
80°S
70°S
60°S
50°S
40°S
30°S
Temperature (°C) at 100 m
0
5
10
15
20
25

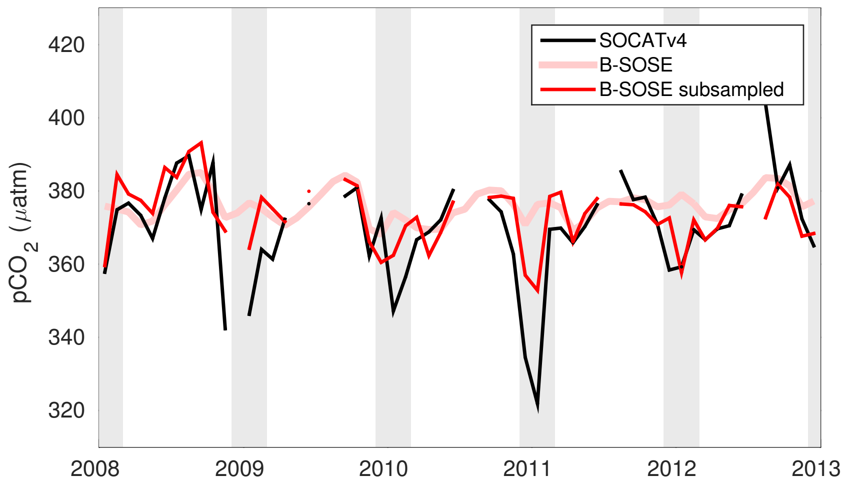


JAN 2013
WOA 13
0°
30°W
30°E
60°W
60°E
90°W
90°E
120°W
120°E
150°W
150°E
180°W
80°S
70°S
60°S
50°S
40°S
30°S
O2 (μmol/kg) at 10 m
150
200
250
300
350
400


JAN 2013
GLODAPv2
0°
30°W
30°E
60°W
60°E
90°W
90°E
120°W
120°E
150°W
150°E
180°W
80°S
70°S
60°S
50°S
40°S
30°S
pH at 100 m
7.85
7.9
7.95
8
8.05
8.1
8.15

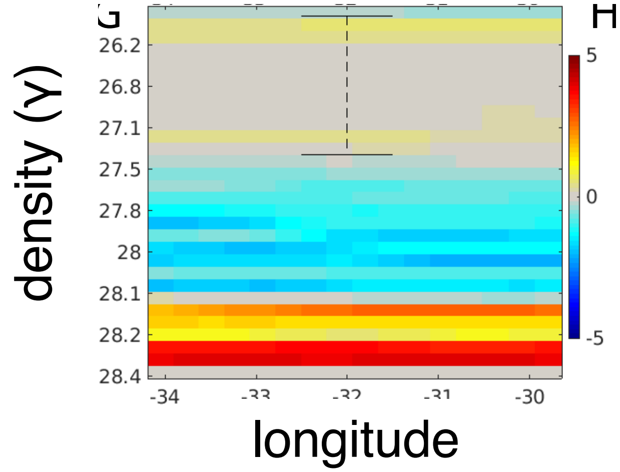

JAN 2013
GLODAPv2
0°
30°W
30°E
60°W
60°E
90°W
90°E
120°W
120°E
150°W
150°E
180°W
80°S
70°S
60°S
50°S
40°S
30°S
DIC (μmol/kg) at 10 m
1950
2000
2050
2100
2150
2200
2250

pCO_2 in Drake Passage

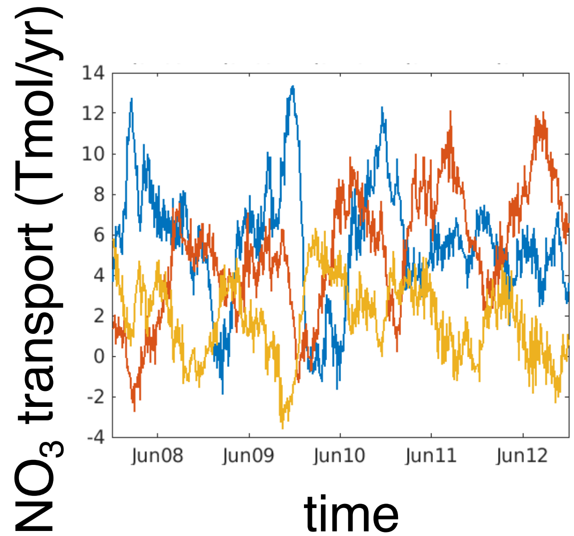


Monthly-averaged pCO_2 in Drake Passage (75°W to 55°W, south of 50°S) from SOCATv4 observations (black) and from B-SOSE (area average in pink; sampled at the location of observations in red). Summer months are shaded gray.

Nitrate transport



Mean transport across 32°S in the Pacific Ocean (Tmol/yr)



Intermediate Water nitrate transport across 32°S

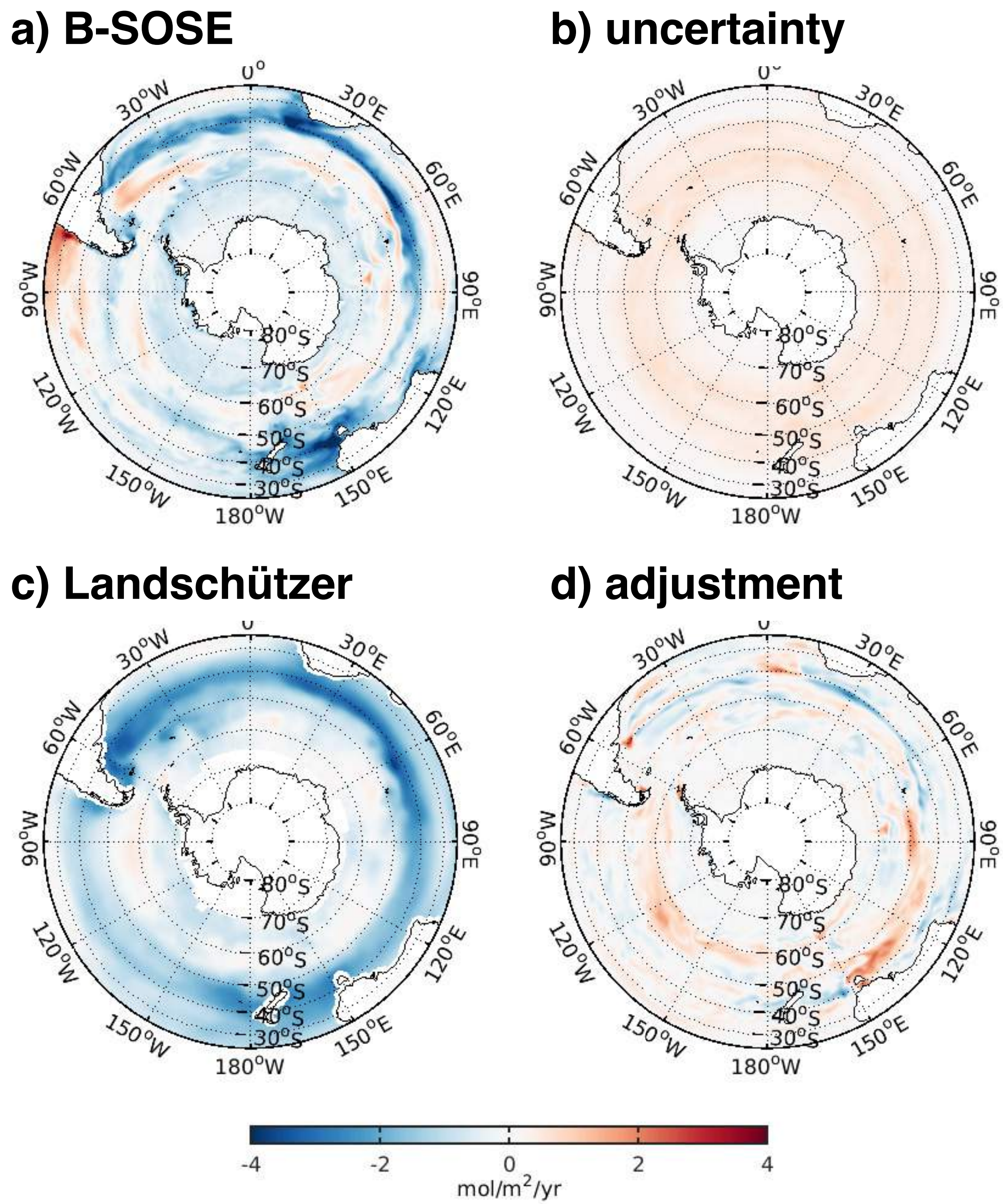
A. Verdy, M. R. Mazloff (2017), **A data assimilating model for estimating Southern Ocean biogeochemistry**, Journal of Geophysical Research Oceans, doi:10.1002/2016JC012650

Air-sea CO_2 flux

Mean air-sea flux of CO_2 for 2008–2011 (a) in B-SOSE and (c) according to Landschützer et al. (2015). Positive fluxes are into the atmosphere.

(b) Uncertainty of the B-SOSE air-sea CO_2 flux estimated from a cost function sensitivity experiment. The maximum value of the estimated uncertainty is 1.0.

(d) Difference in air-sea CO_2 flux between the state estimate and the “prior” forward model run. Over 70% of the domain, the magnitude of the correction resulting from data assimilation exceeds the uncertainty estimate.



Estimating uncertainty…

- assuming that the misfits are a gaussian function of the controls, the likelihood is ~ exp ($-J/2\sigma^2$)

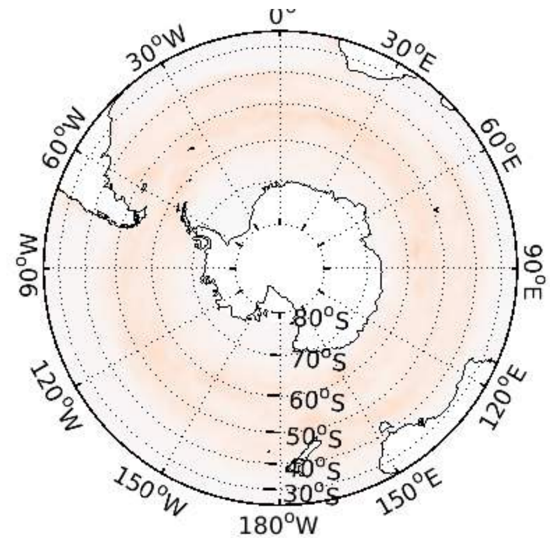
  where J is the cost function
  and σ is the standard deviation of the gaussian

- we generate an ensemble of solutions by varying model parameters

- each solution is weighed by its likelihood

- uncertainty is estimated as the weighted standard deviation of the ensemble

b) uncertainty



Two issues:

1) **Results are highly sensitive to the value of σ. How do we estimate it?**

2) **How do we build our ensemble – What to vary? How large should the perturbations be?**

work in progress:

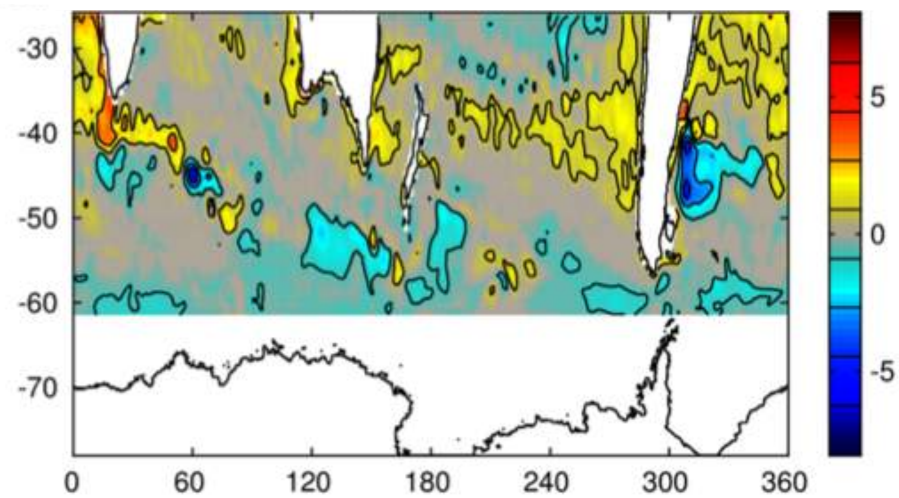
fix circulation issues (Argentine basin, Eastern South Pacific)

multiscale coupling: forward model 1/6 degree (or 1/12!) and adjoint 1/3 degree

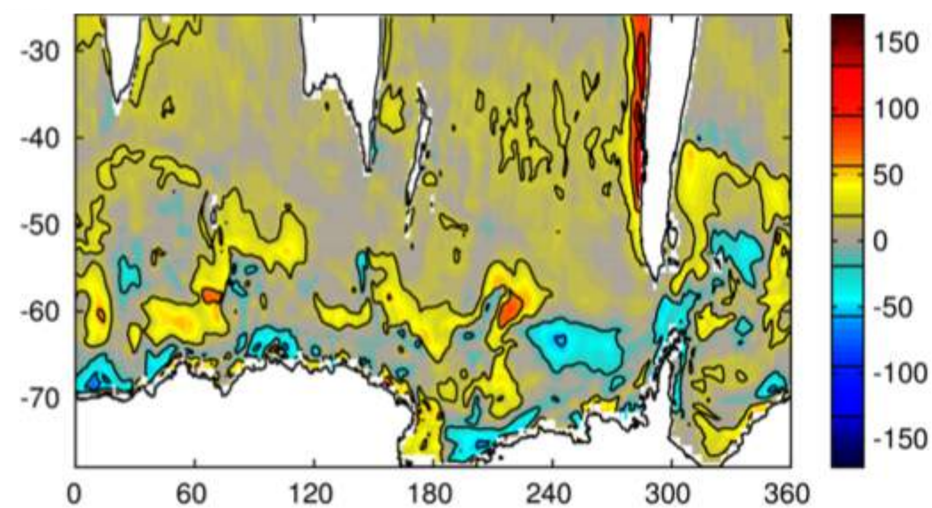
assimilation of ocean color data (chlorophyll and phytoplankton carbon)

refine uncertainty estimation

Temperature mean misfit at 200 m (B-SOSE minus RG Argo mapped product)

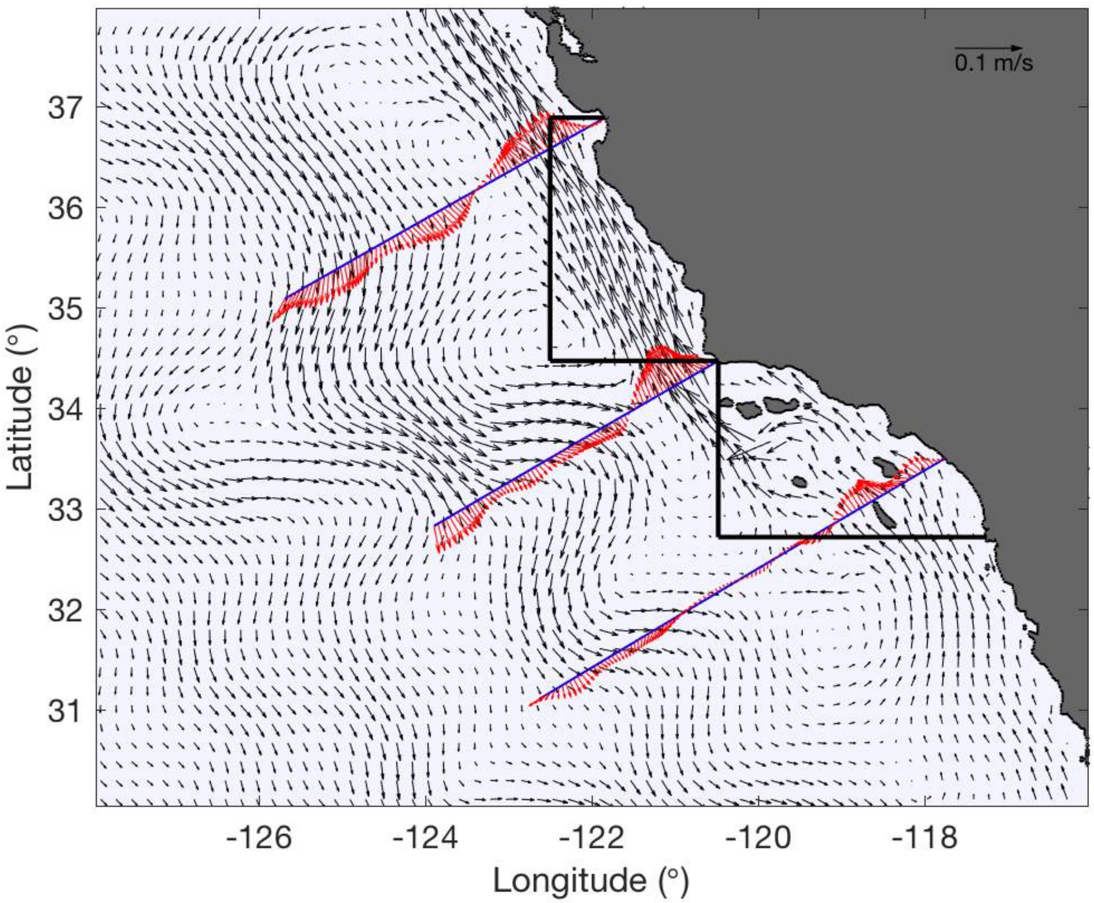


Oxygen mean misfit at 200 m (B-SOSE minus WOA climatology)



California Current System State Estimate

0-500 m mean currents from CASE and glider lines, 2007-2013



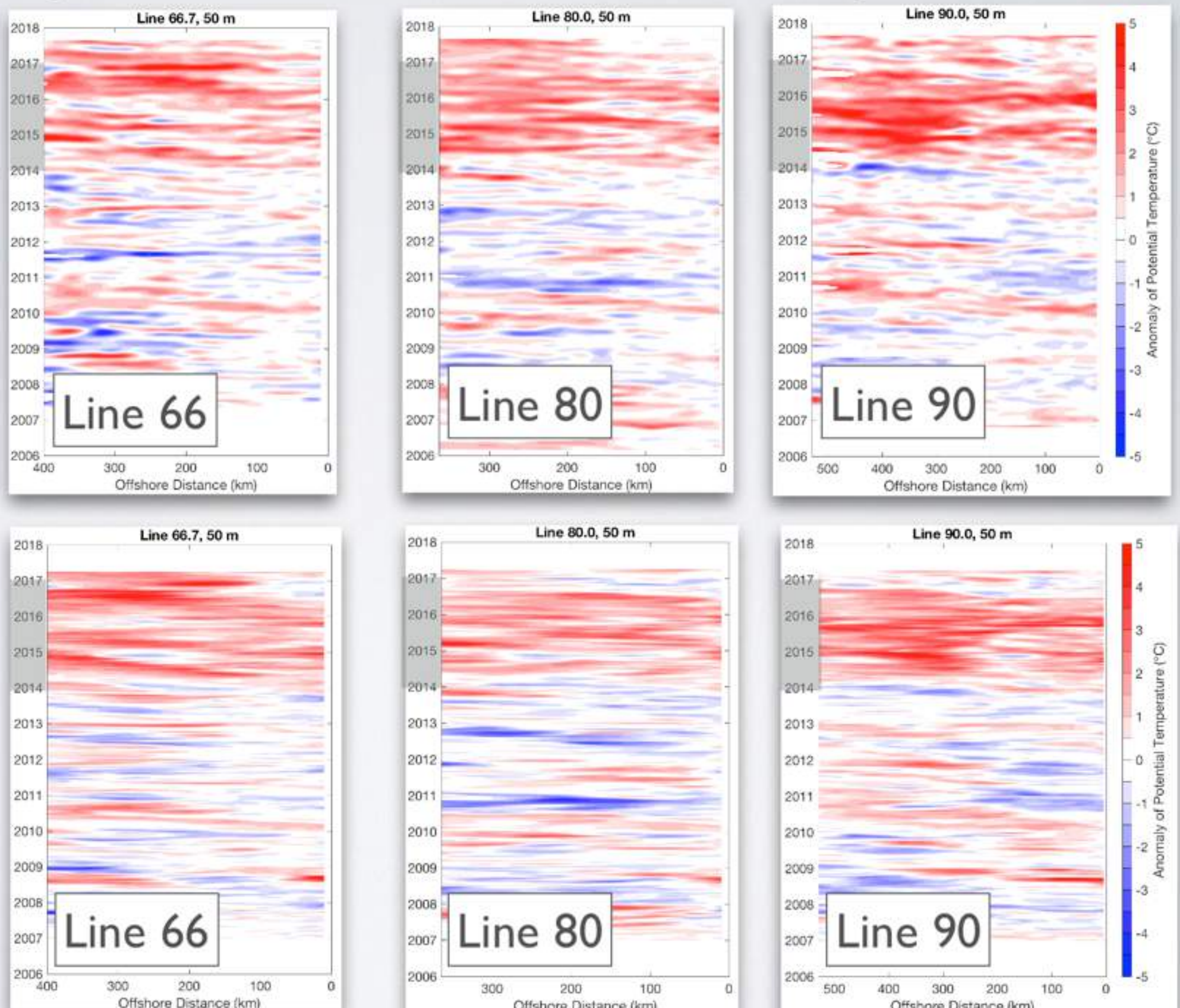
- 1/6° (~7 km) resolution
- 2007—2017
- 3 month assimilation window
- assimilating: SSH, SST, Argo, XBT, gliders
- state estimate velocities consistent with glider observations on lines 66.7, 80, and 90 (10 years of continuous measurement)
- regional heat budgets calculated

2014 - 2016 ANOMALIES

Temperature Anomalies at 50 m depth.

Glider Obs

Interpolated State Estimate



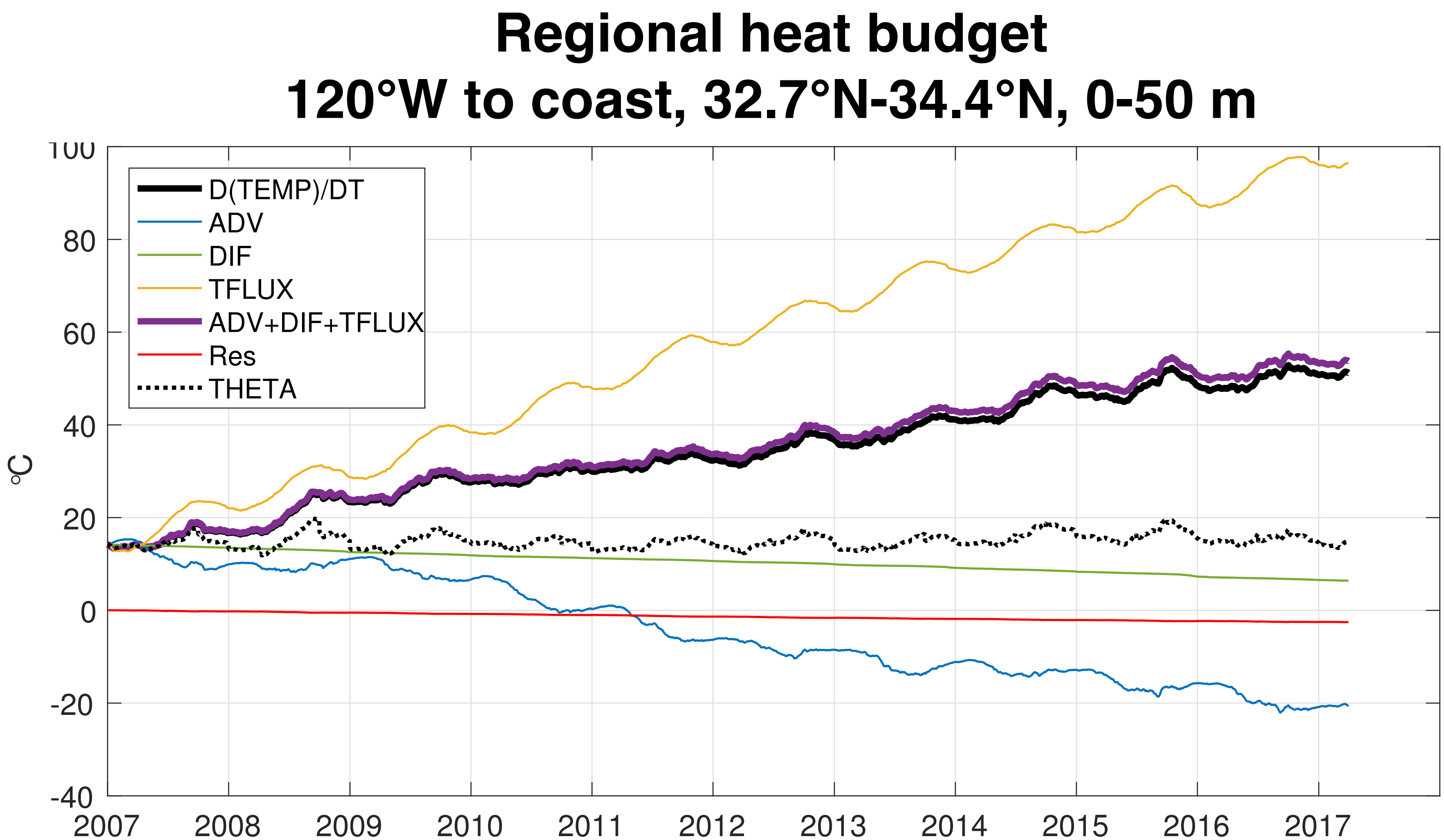


Figure 19: Southern Box, 0 - 50 m, integral of volume-averaged heat budget terms.

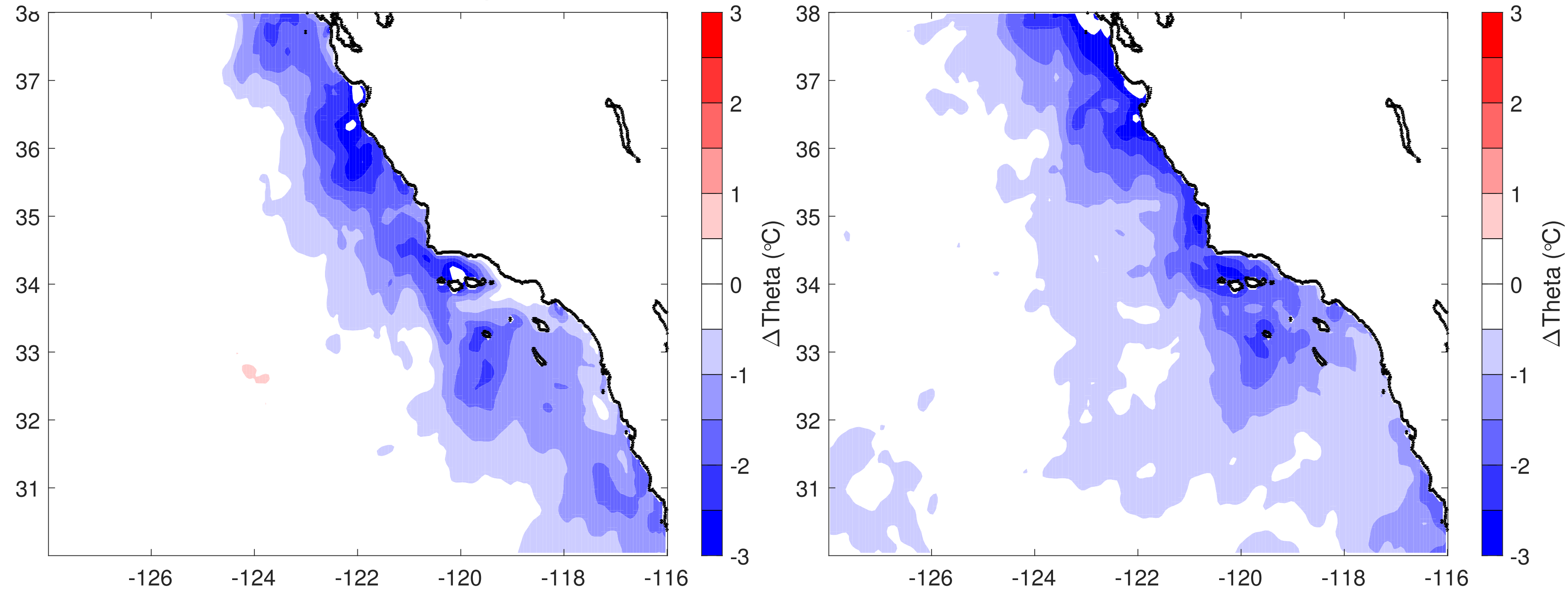
Positive trend in integral of DT/Dt: heat content is increasing

Shortwave heat flux is too strong because weather model does not capture clouds near the coast

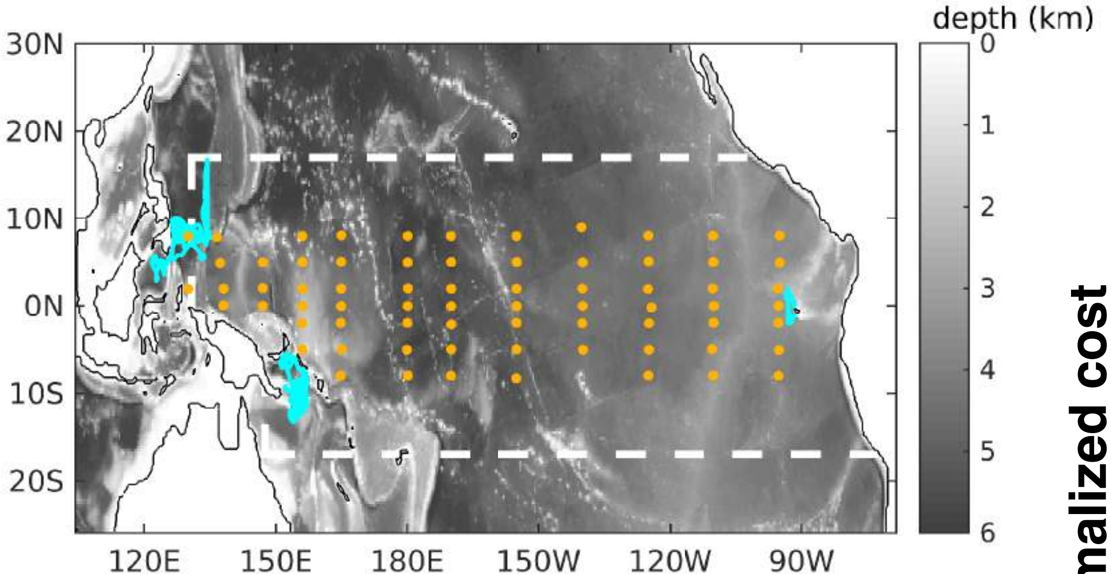
Optimization corrects by reducing T initial conditions (every 3 months)

Mean surface temperature increment

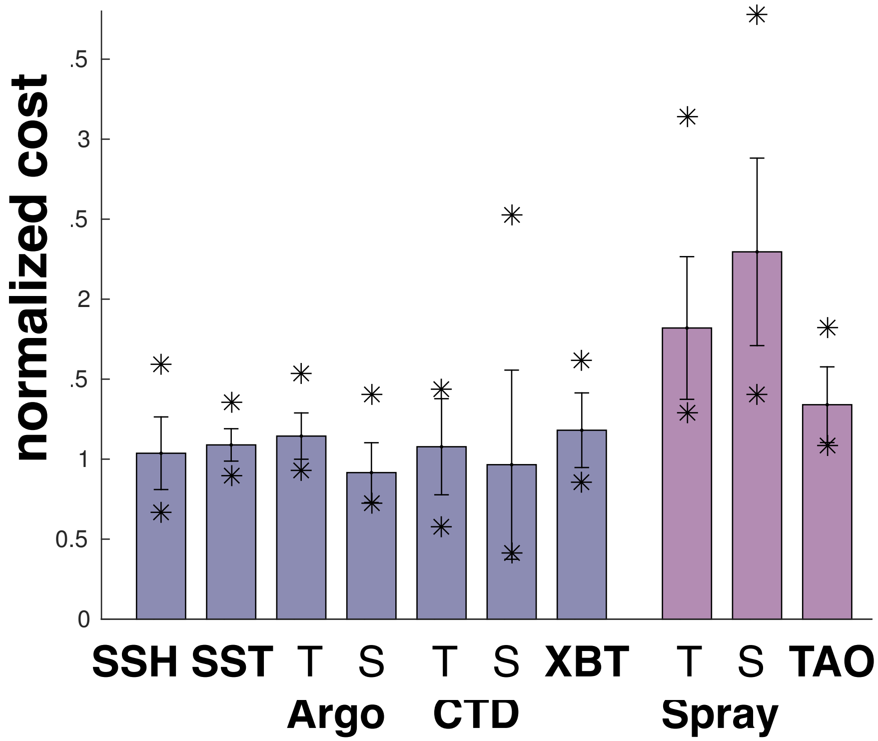
June 30 to July 1 / Sept 30 to Oct 1



Tropical Pacific Ocean State Estimate

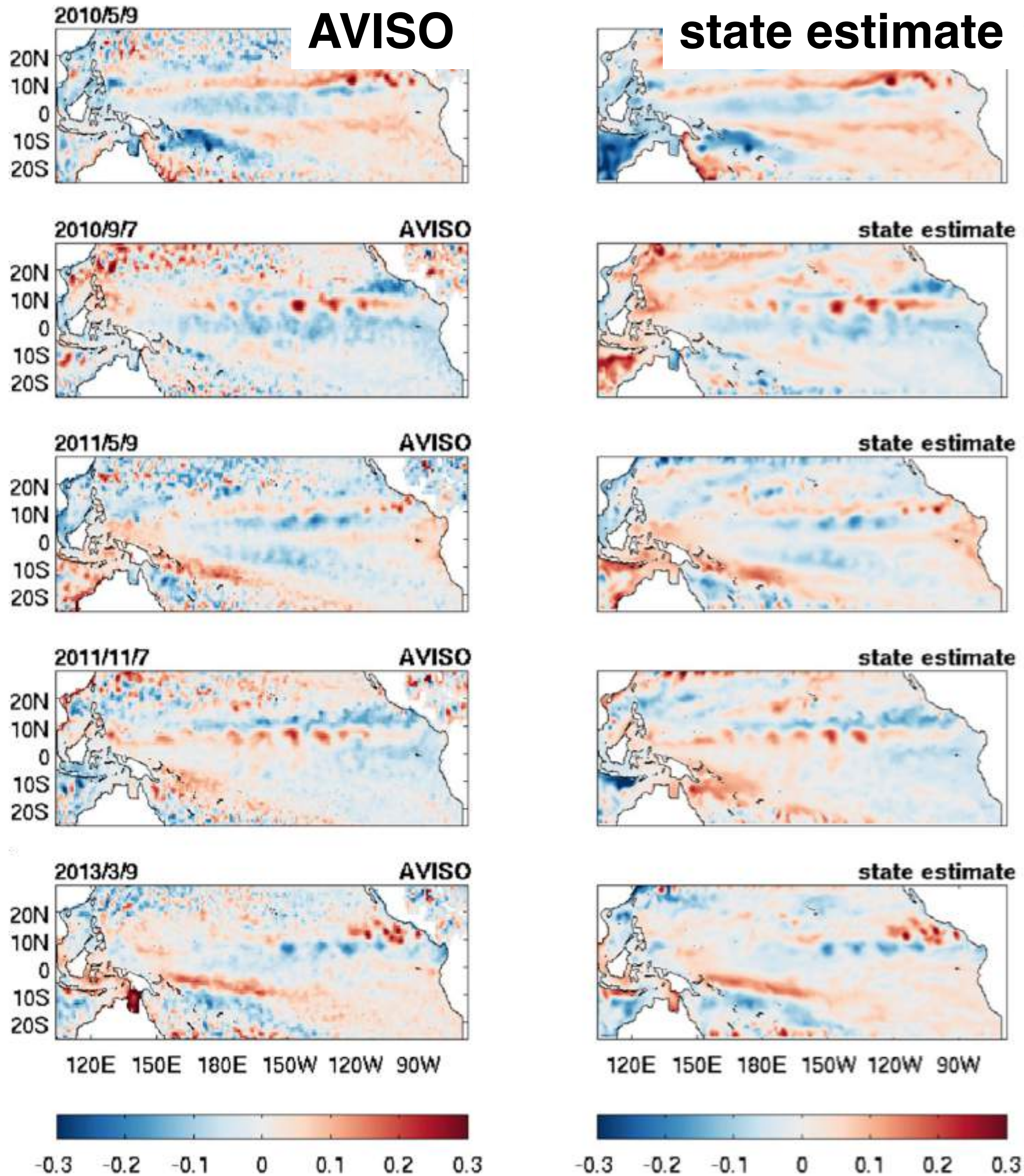


The state estimate has been produced for the period **Jan 2010 to Dec 2014** with a 4-month assimilation window, 1/3° resolution.

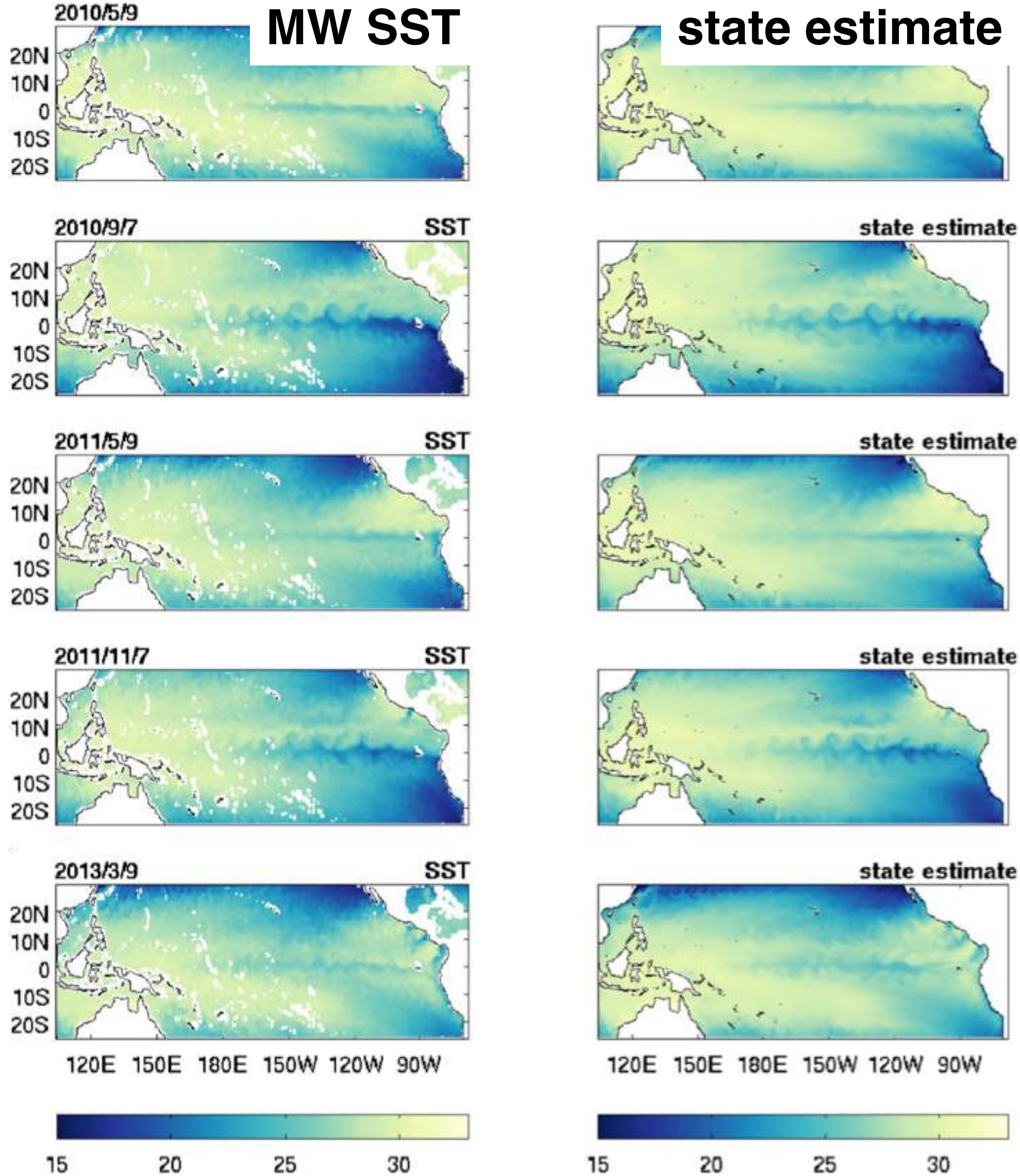


Argo, CTD, XBT, altimetry, and **SST** are used as constraints.
TAO and **Spray glider** data are used for independent validation.

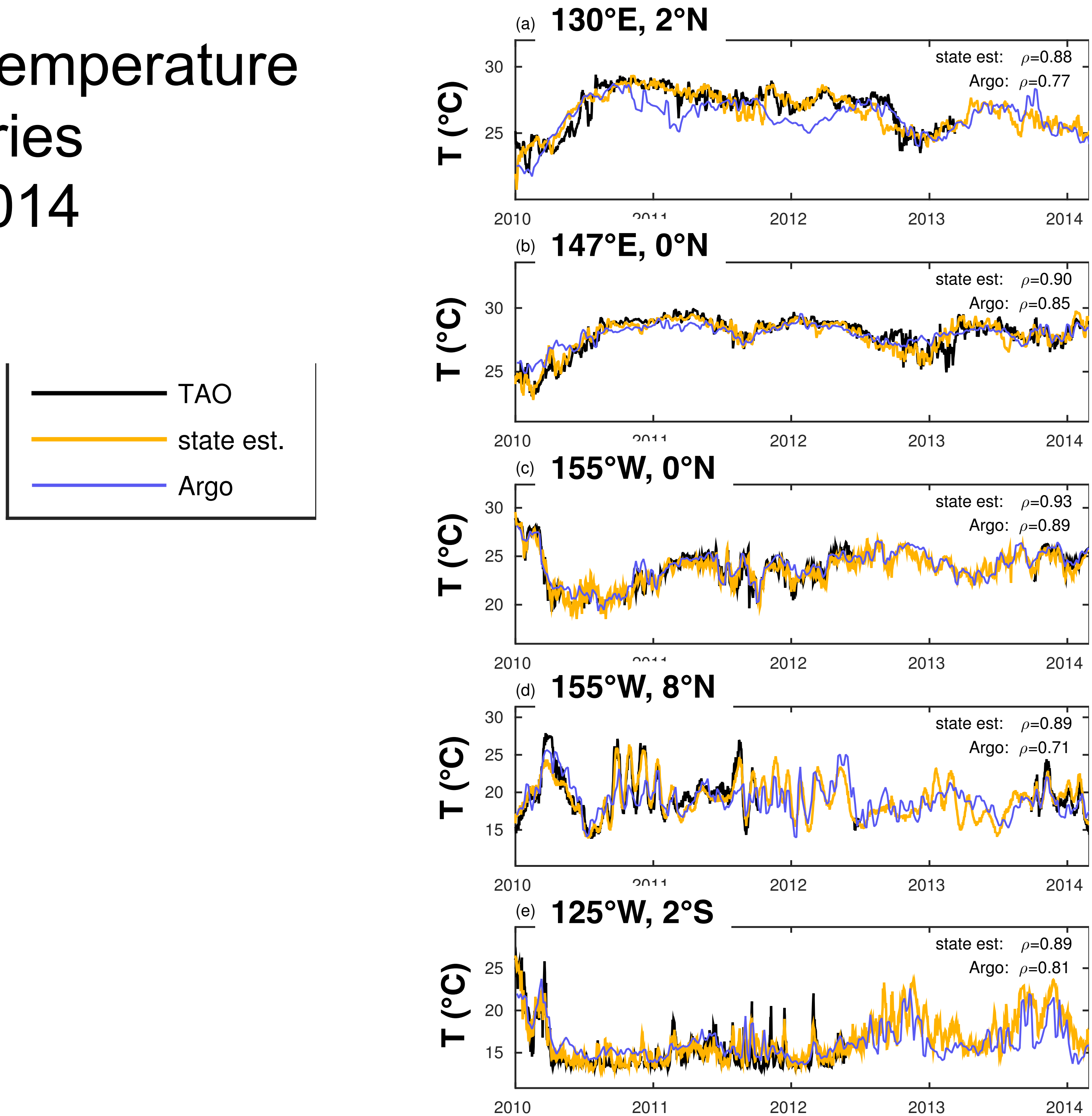
SSH snapshots



SST snapshots

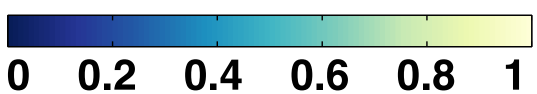


100 m temperature time series 2010-2014

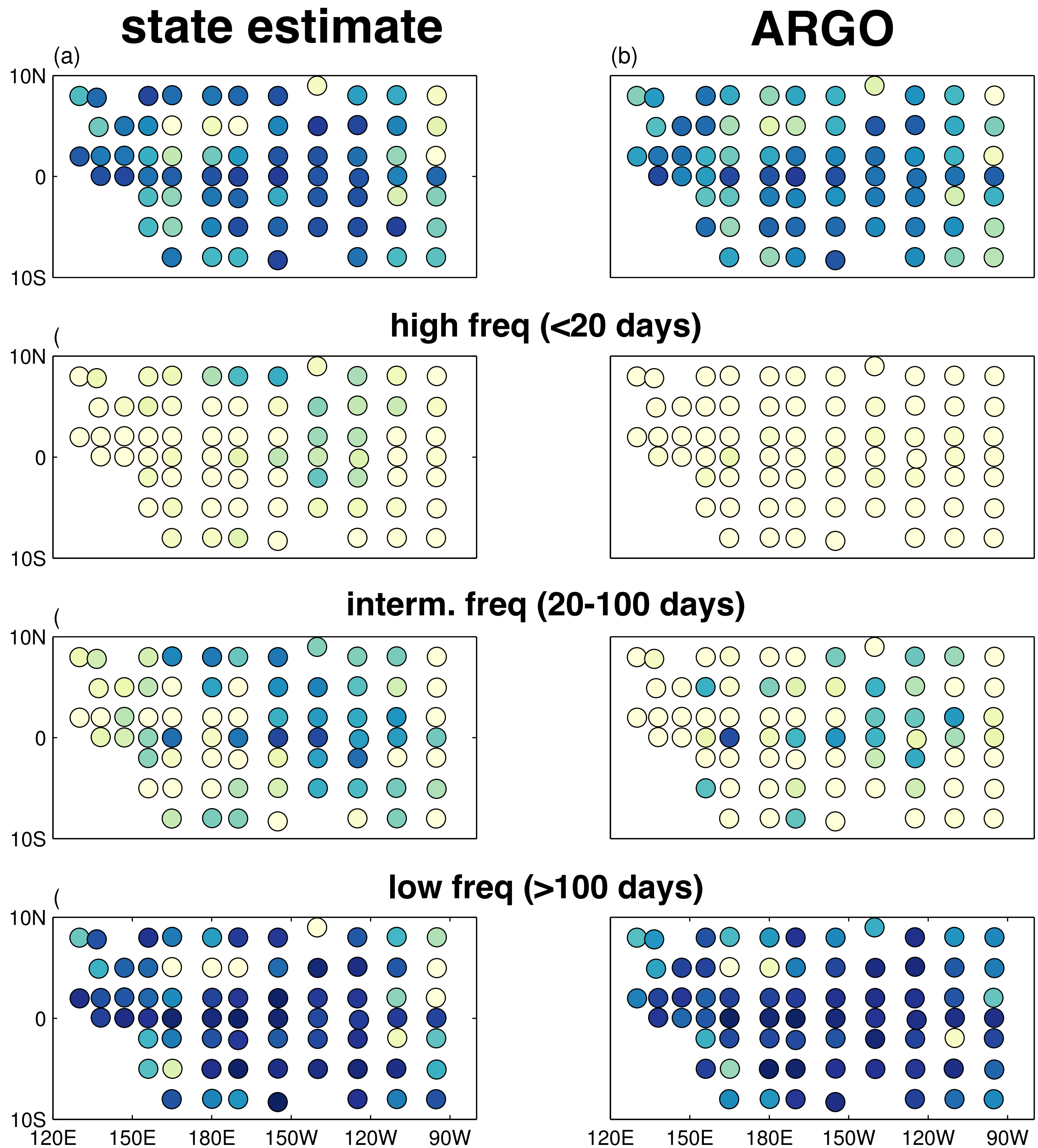


100 m temperature at TAO moorings

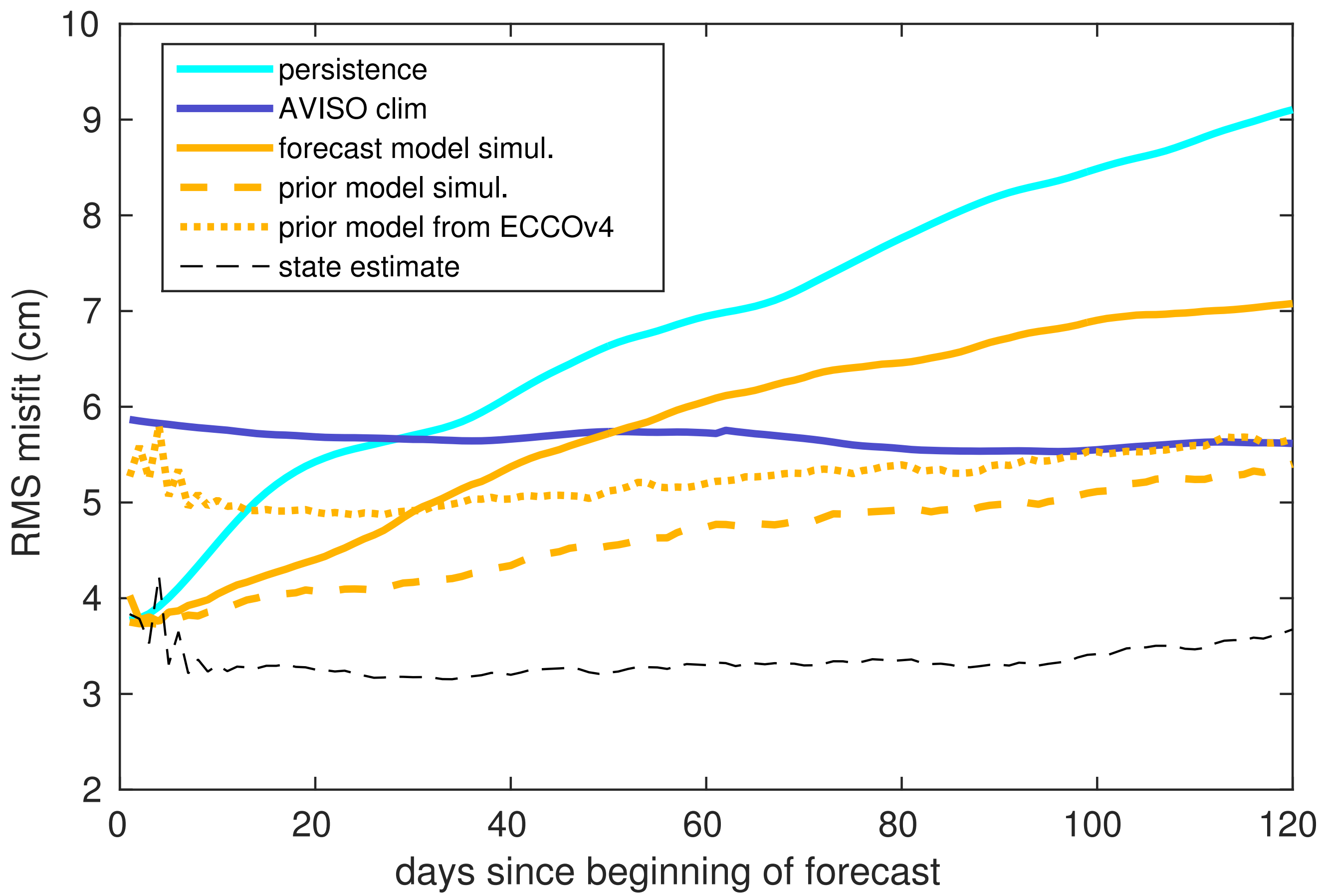
fraction of variance error



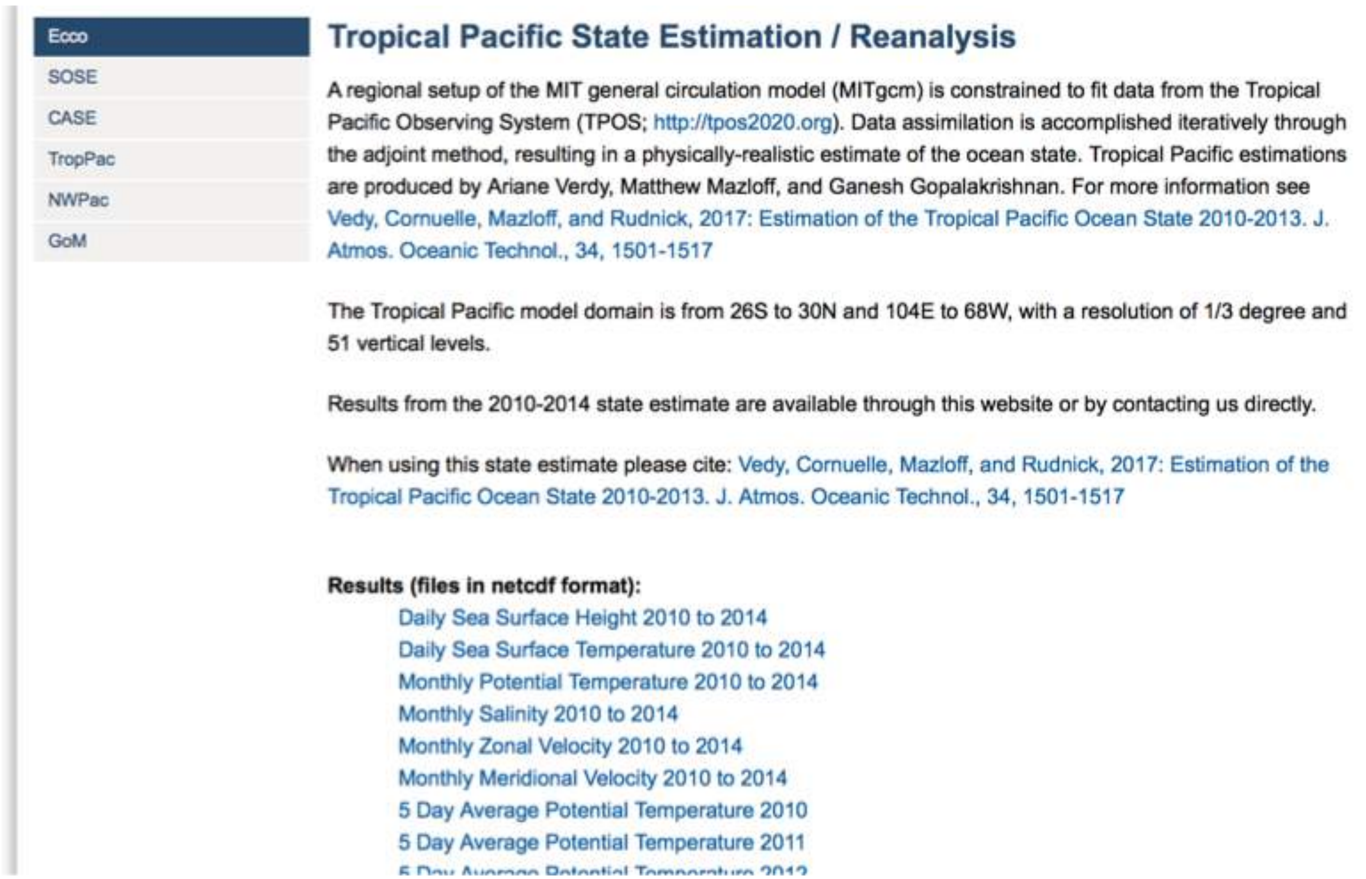
0 (blue) = good
1 (yellow) = bad



Forecasting



Time evolution of the error associated with different forecasts and hindcasts of the Tropical Pacific SSH over a 120-day period. The error is calculated as the Root Mean Square (RMS) misfit with the AVISO mapped product averaged over 4 years of 4-month periods. The forecast model run (solid orange), prior model simulation (dashed orange), and “persistence” forecast (cyan) are initialized with values from the state estimate for the previous assimilation period. The prior model simulation from ECCOv4 (dotted orange) is initialized using the ECCOv4 product. The forecast is run using climatological forcing, while the prior model simulation is obtained using forcing from ERA-Interim during the forecast period. The persistence forecast is obtained by assuming that SSH remains constant in time from the beginning of the forecast period. The AVISO forecast is obtained using climatological AVISO values (blue). The state estimate (dashed gray) is a hindcast, optimized to fit SSH (and other) observations.



Ecco
SOSE
CASE
TropPac
NWPac
GoM

Tropical Pacific State Estimation / Reanalysis

A regional setup of the MIT general circulation model (MITgcm) is constrained to fit data from the Tropical Pacific Observing System (TPOS; http://tpos2020.org). Data assimilation is accomplished iteratively through the adjoint method, resulting in a physically-realistic estimate of the ocean state. Tropical Pacific estimations are produced by Ariane Verdy, Matthew Mazloff, and Ganesh Gopalakrishnan. For more information see Vedy, Cornuelle, Mazloff, and Rudnick, 2017: Estimation of the Tropical Pacific Ocean State 2010-2013. J. Atmos. Oceanic Technol., 34, 1501-1517

The Tropical Pacific model domain is from 26S to 30N and 104E to 68W, with a resolution of 1/3 degree and 51 vertical levels.

Results from the 2010-2014 state estimate are available through this website or by contacting us directly.

When using this state estimate please cite: Vedy, Cornuelle, Mazloff, and Rudnick, 2017: Estimation of the Tropical Pacific Ocean State 2010-2013. J. Atmos. Oceanic Technol., 34, 1501-1517

Results (files in netcdf format):

- Daily Sea Surface Height 2010 to 2014
- Daily Sea Surface Temperature 2010 to 2014
- Monthly Potential Temperature 2010 to 2014
- Monthly Salinity 2010 to 2014
- Monthly Zonal Velocity 2010 to 2014
- Monthly Meridional Velocity 2010 to 2014
- 5 Day Average Potential Temperature 2010
- 5 Day Average Potential Temperature 2011

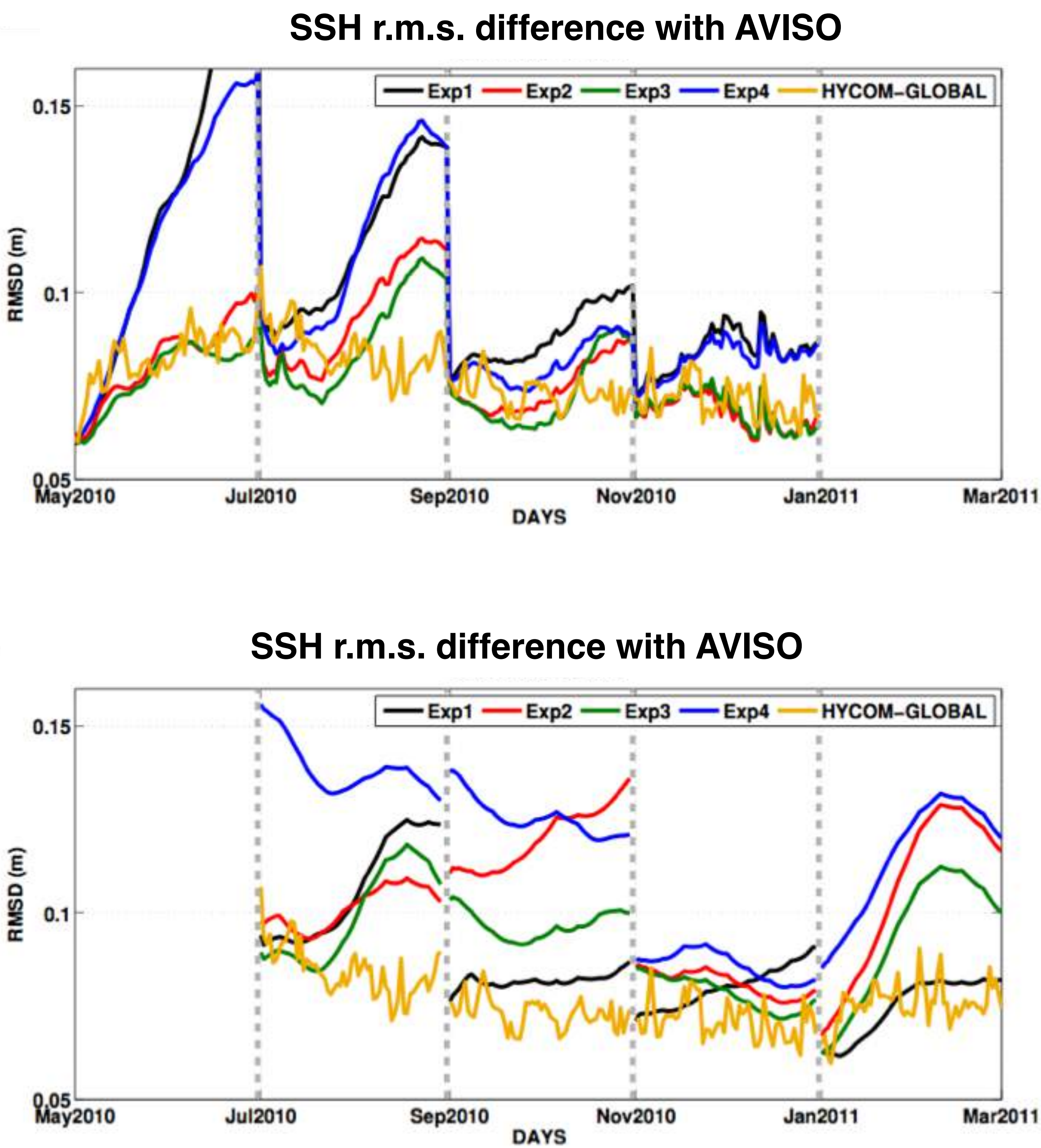
The Tropical Pacific Ocean State Estimate is publicly available (www.ecco.ucsd.edu/tropac.html)

It is being used to diagnose mass and heat budgets in the tropics

We hope to continue production for 2015-present, and contribute to further evaluation of the Tropical Pacific Observing System (TPOS)

Gulf of Mexico State Estimate

Hindcast



Forecast

Ref. no assimilation

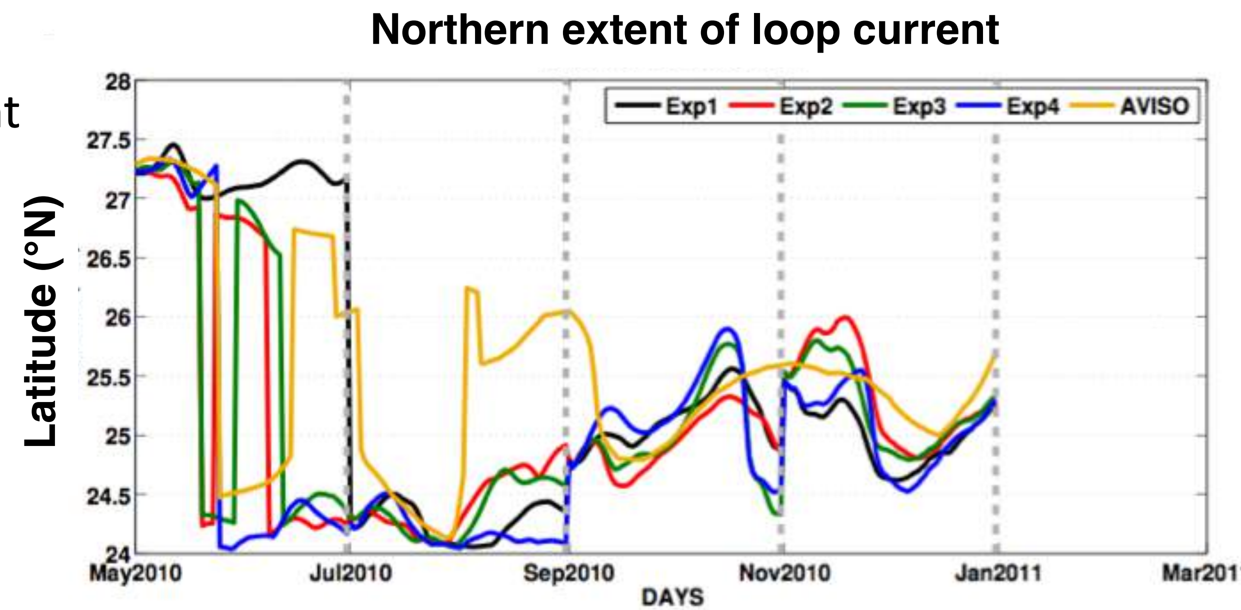
Assimilation Satellite

Assimilation both

Assimilation only mooring

HYCOM

Loop Current Northward extension



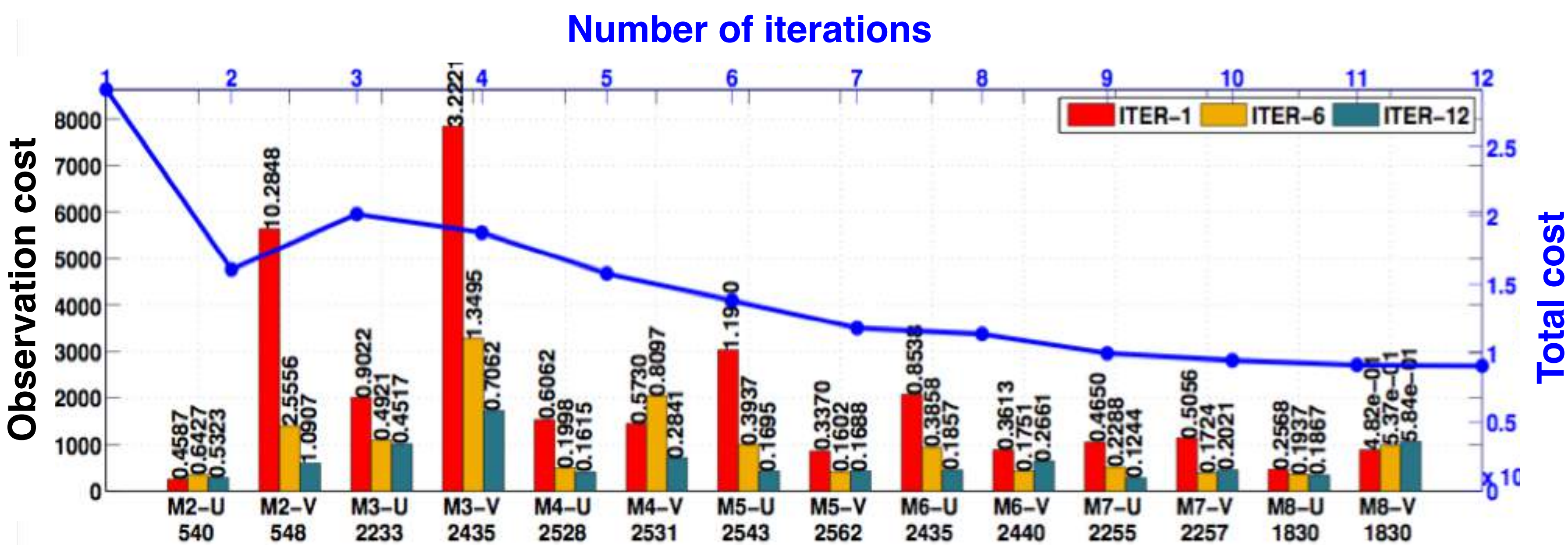
Ref. no assimilation

Assimilation Satellite

Assimilation both

Assimilation only mooring

AVISO



http://www.ecco.ucsd.edu/research.html