The GMAO Ocean Retrospective Analysis

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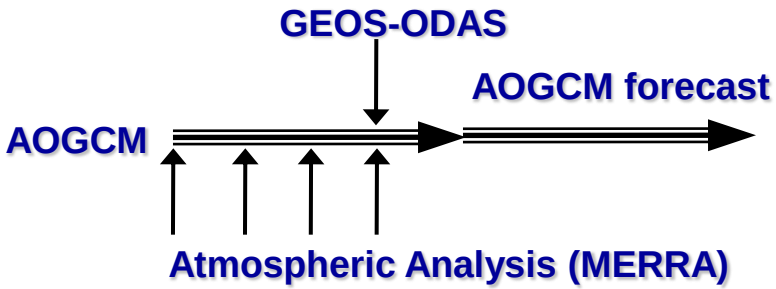
The GMAO's GEOS-ODAS

Ocean and sea-ice reanalysis

- GEOS-5 AOGCM
  - GEOS-5 AGCM, 1°×1.25°×72L
  - MOM4, ½° with ¼° equatorial refinement, 40L
  - CICE
- Currently constrained by MERRA (GMAO's atmospheric reanalysis)



Ocean Analysis algorithms

- **EnOI or EnKF**
- **Flow-adaptive localization of covariances following neutral density surfaces**
- **Observation-adaptive representation error – for SSH**

GEOS-IODAS: The sea-ice assimilation

1: *Calculate ice concentration increment*

Form ice concentration (*aice)* analysis - does not feedback directly to the model state

2: *Use aice analysis to update model temperature (T) and salinity (S) fields in the mixed layer*

Given the new analyzed ice concentration (aice) and the background T and S, the new grid-cell temperature (T') and salt (S') are given by:

$$T' = (1\text{-aice})*T + aice*T_f$$
$$S' = (1\text{-aice})*S + aice*S_f$$

Where $T_f = T+DT$, $S_f = S+DS$.

We solve for DT and DS such that the following two conditions are satisfied.

condition 1 [thermodynamic state equation]: $(T+DT)=a*(S+DS)$ [a = -0.054]

condition 2: $(DS/\sigma_s)^2+(DT/\sigma_t)^2 = (DS/\sigma_s)^2 + ((a*(S + DS)-T)/\sigma_t)^2$ is minimized

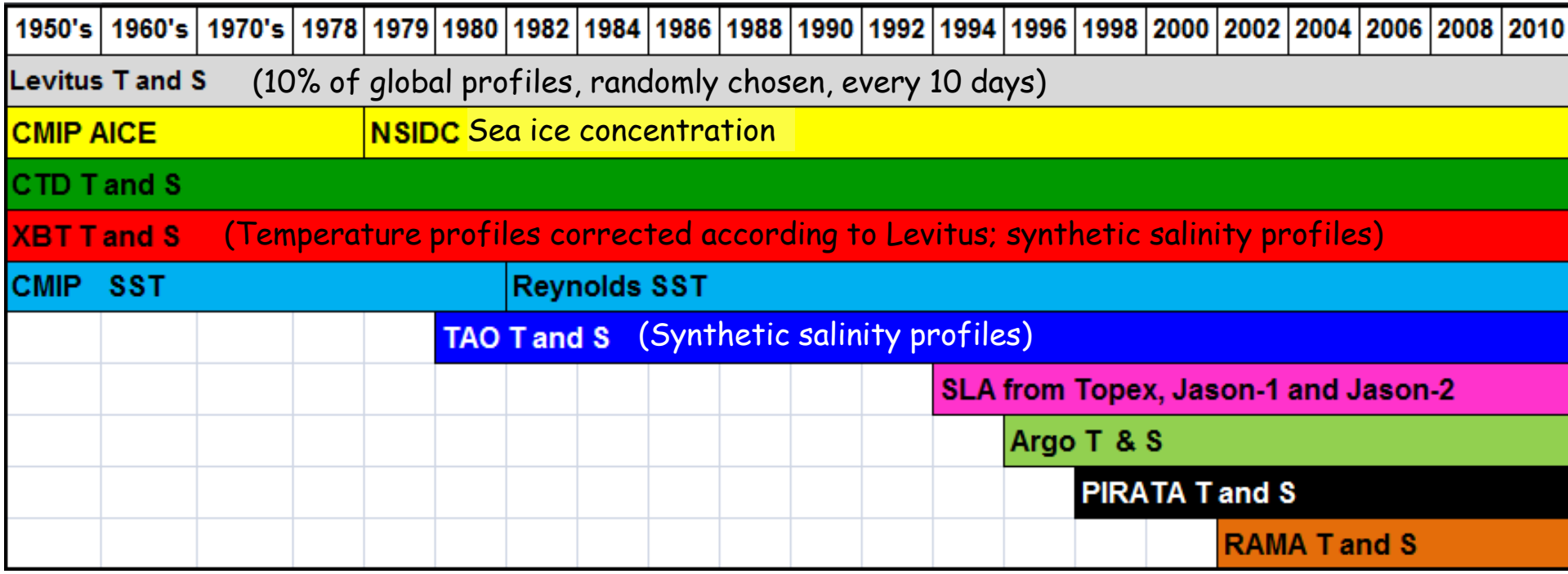
3: *Incremental update modifies ice distributions*

The temperature (T' – T) and salt (S' – S) increments are applied using IAU.

The aice analysis increment is not applied directly. Rather, we let the model gradually adjust the ice concentration and thickness in response to the T and S increments. This method helps maintain a balanced ice state.

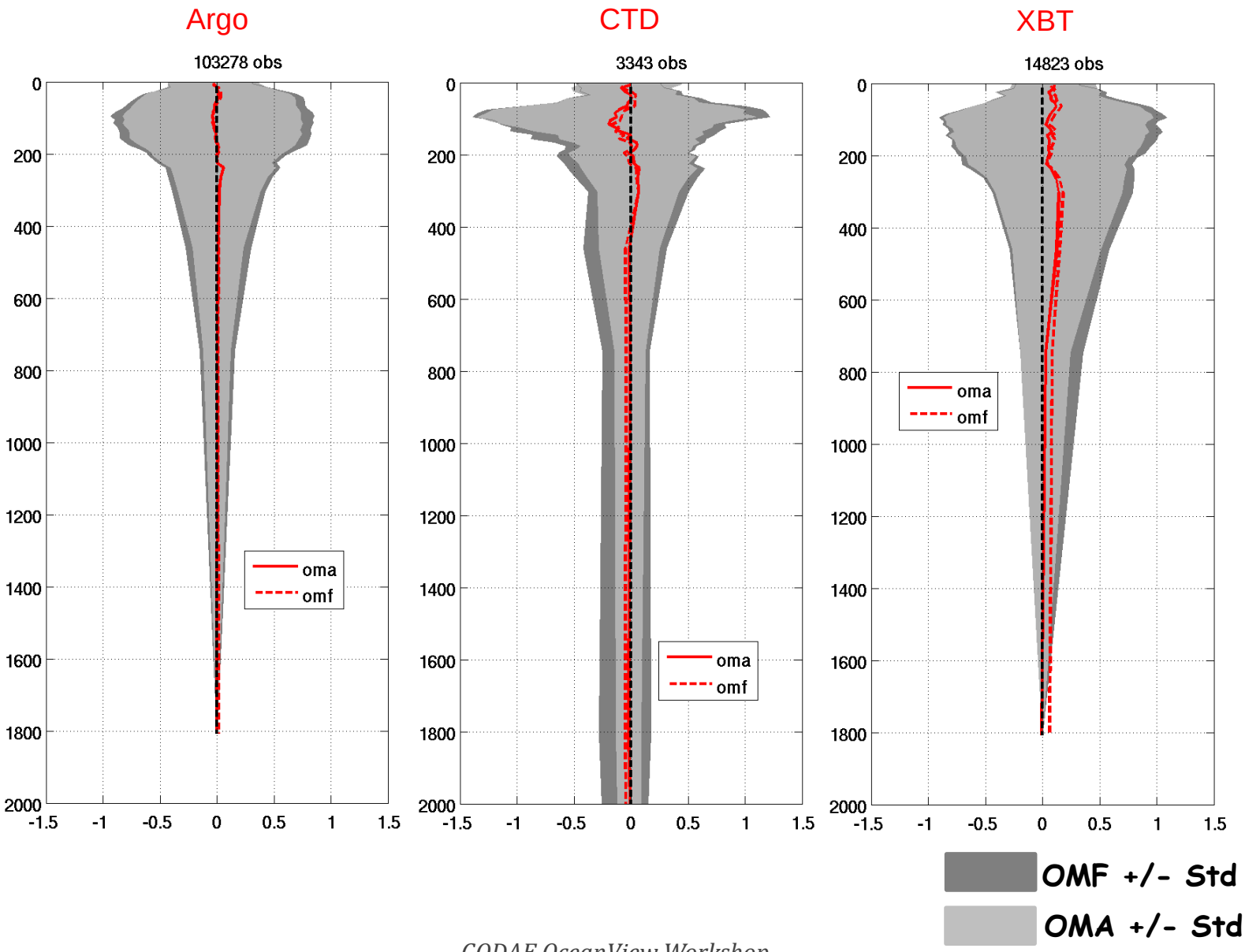
GMAO's Ocean and sea-ice reanalysis

- 1960-present
- *Coupled A-O-L initialization* of decadal predictions for IPCC/AR5 and seasonal forecasts
- Contributed to multi-model climate analysis (NCEP/Xue)



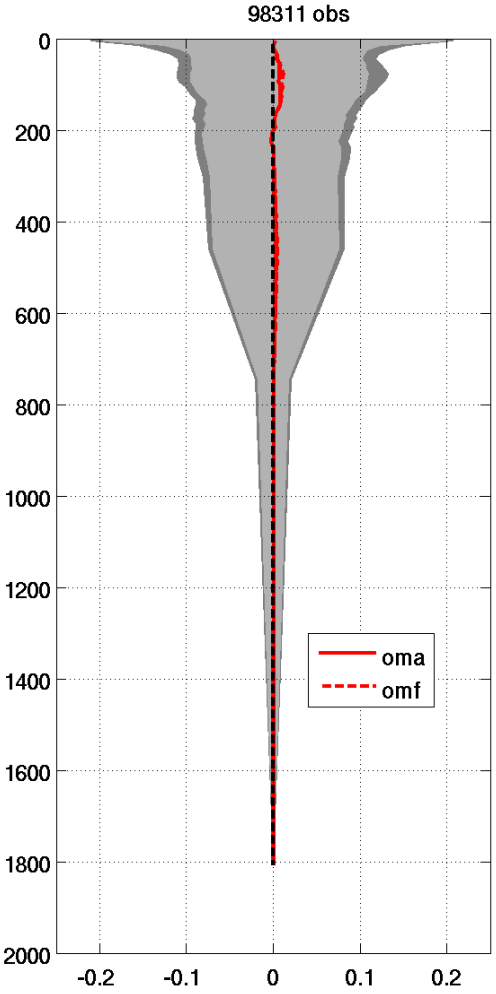
We have used the UKMO QC procedures (slightly modified version) and the EN3 data archive with much gratitude to Simon Good!

Mean and stdev of innovations and analysis departures – temperature
Jan 2008 30S-30N

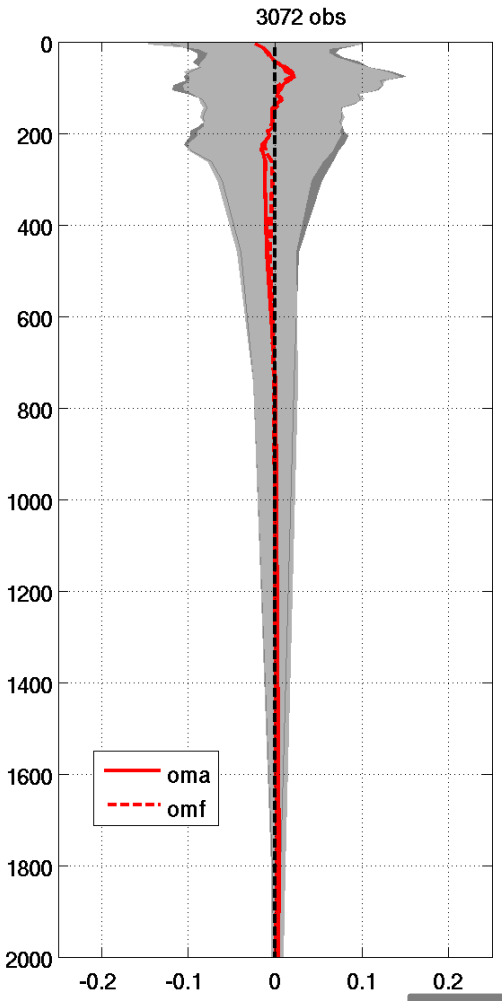


Mean and stdev of innovations and analysis departures –salinity Jan 2008 30S-30N

Argo



CTD



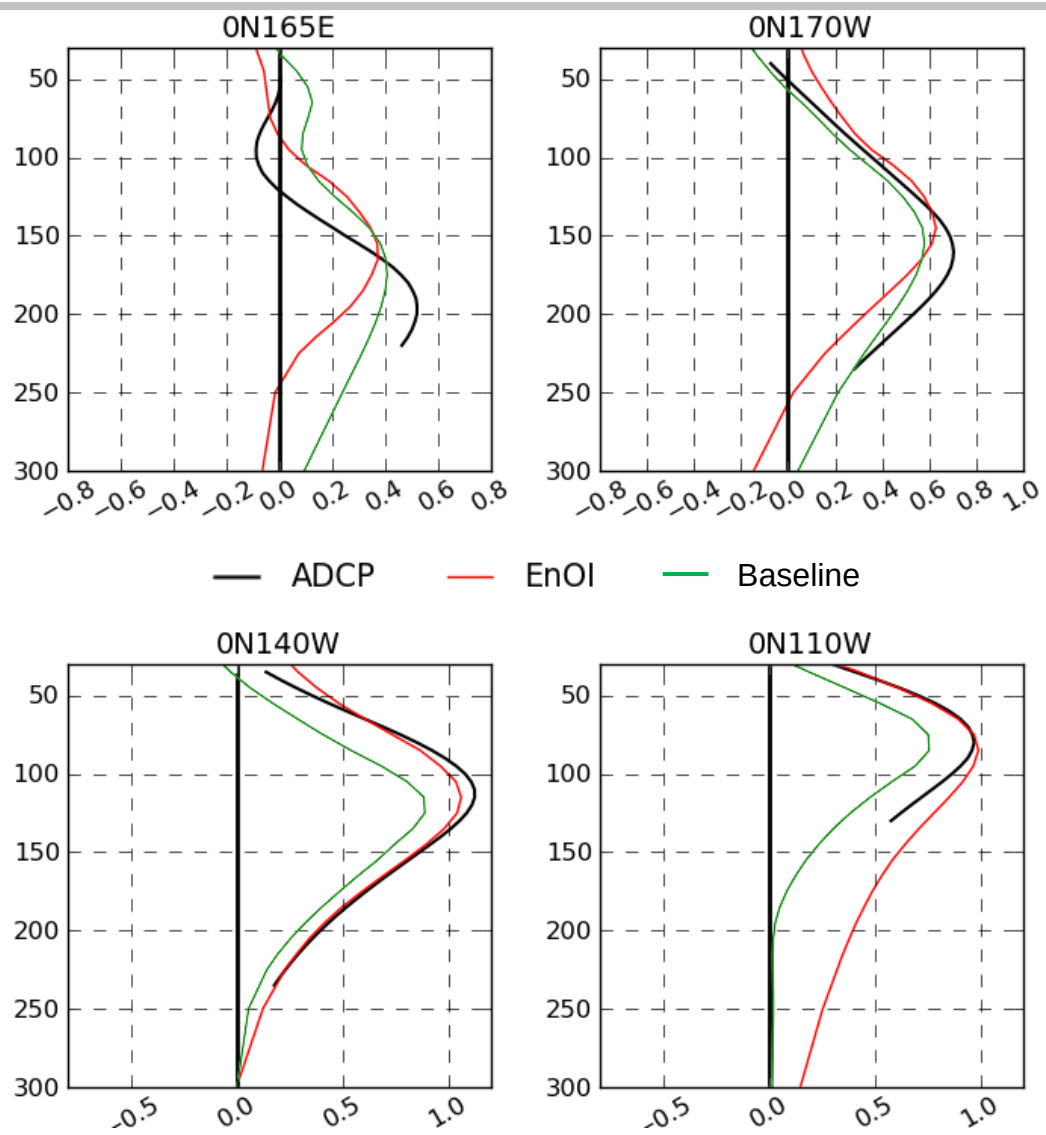
OMF +/- Std OMF

OMA +/- Std OMA

Annual mean equatorial Pacific current

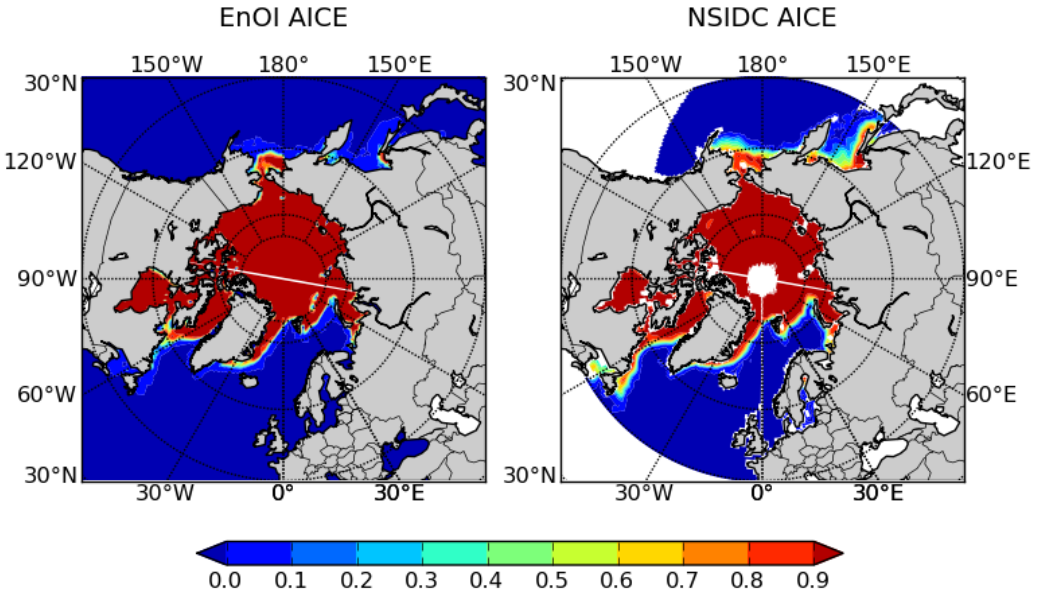
Baseline (no assim): 1980-1990

EnOI & ADCP: 2000-2006

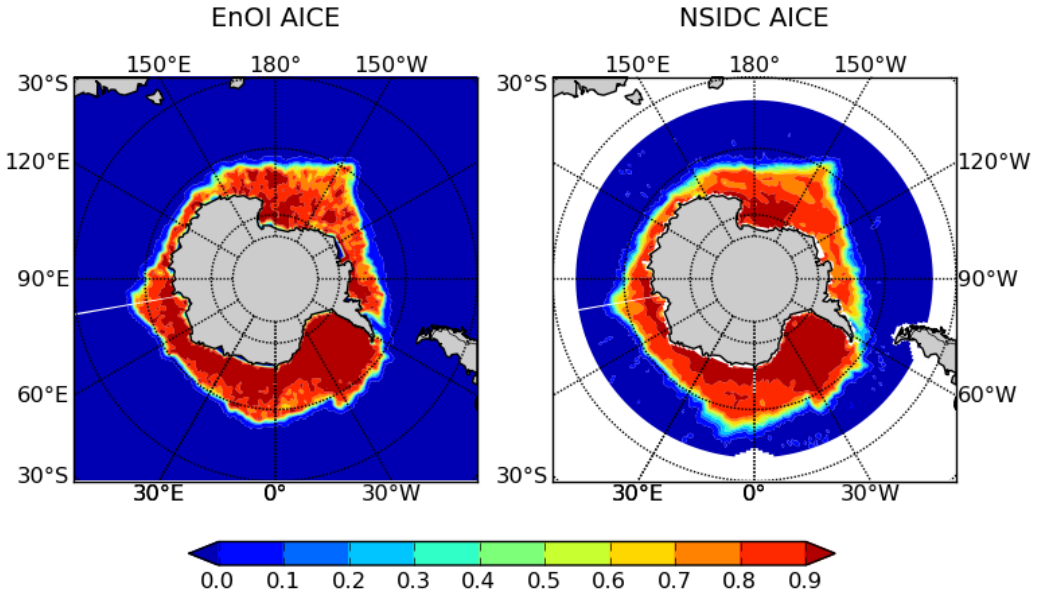


Monthly mean sea-ice concentration

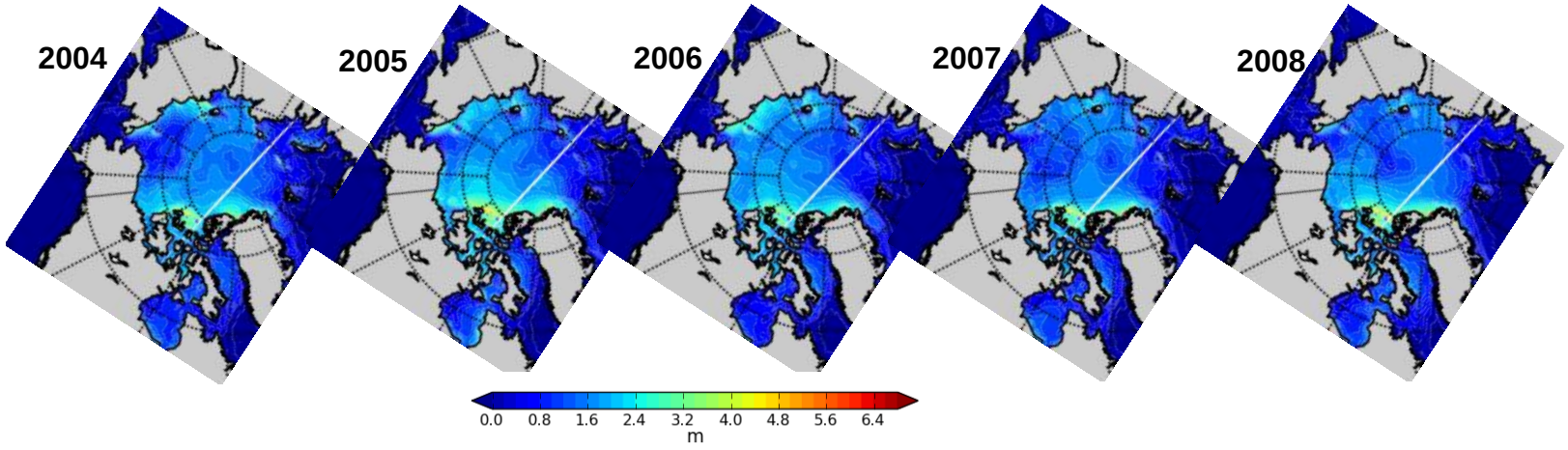
N. Hemisphere
March 2009

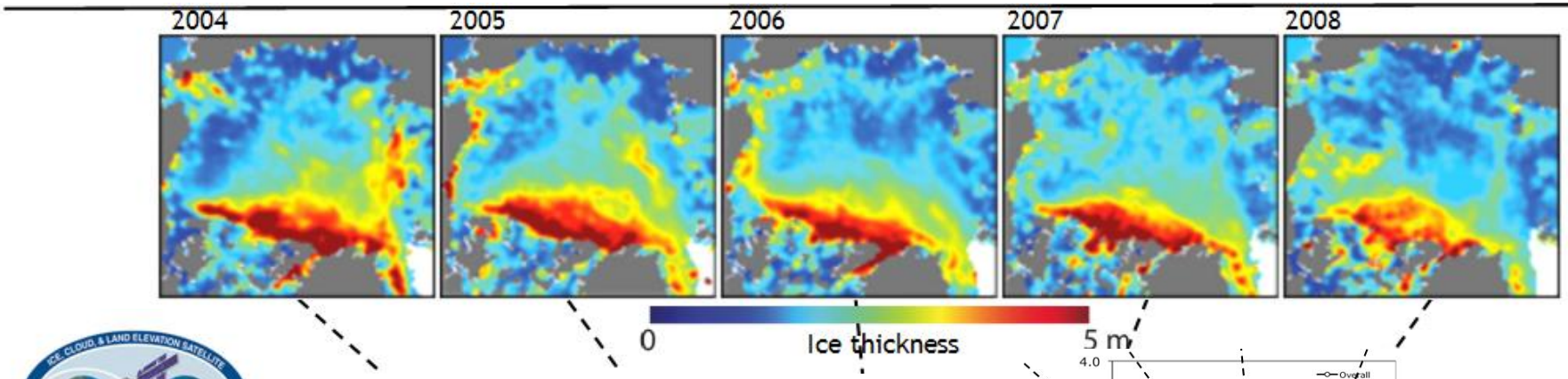


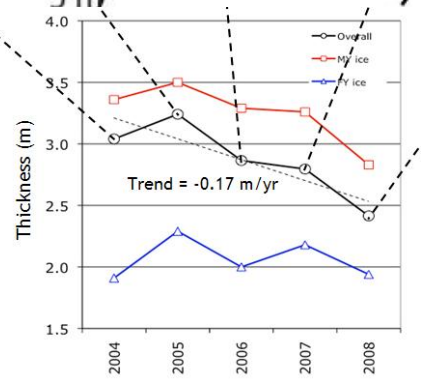
S. Hemisphere
August 2009



Sea-ice assimilation – March mean ice thickness

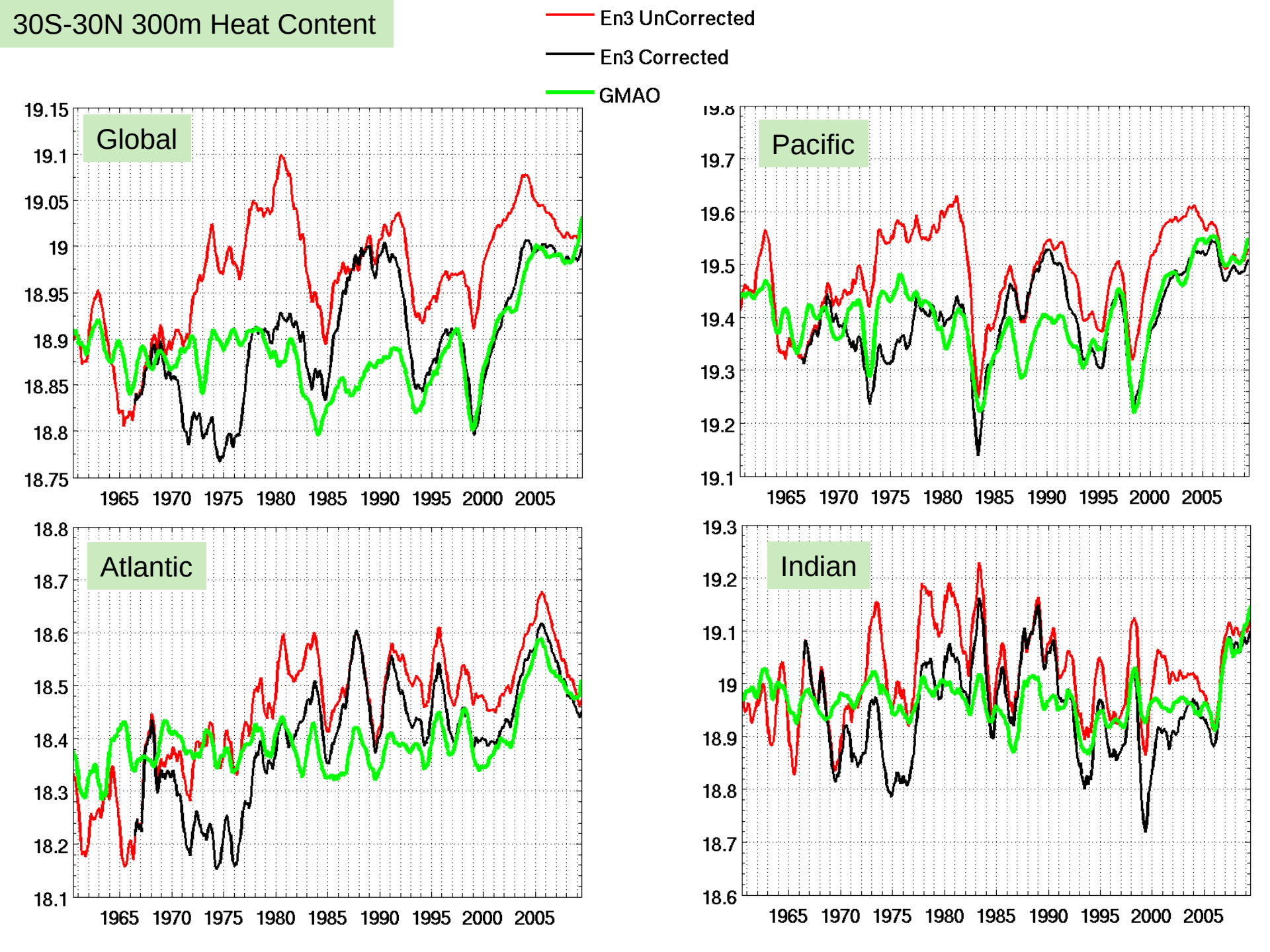






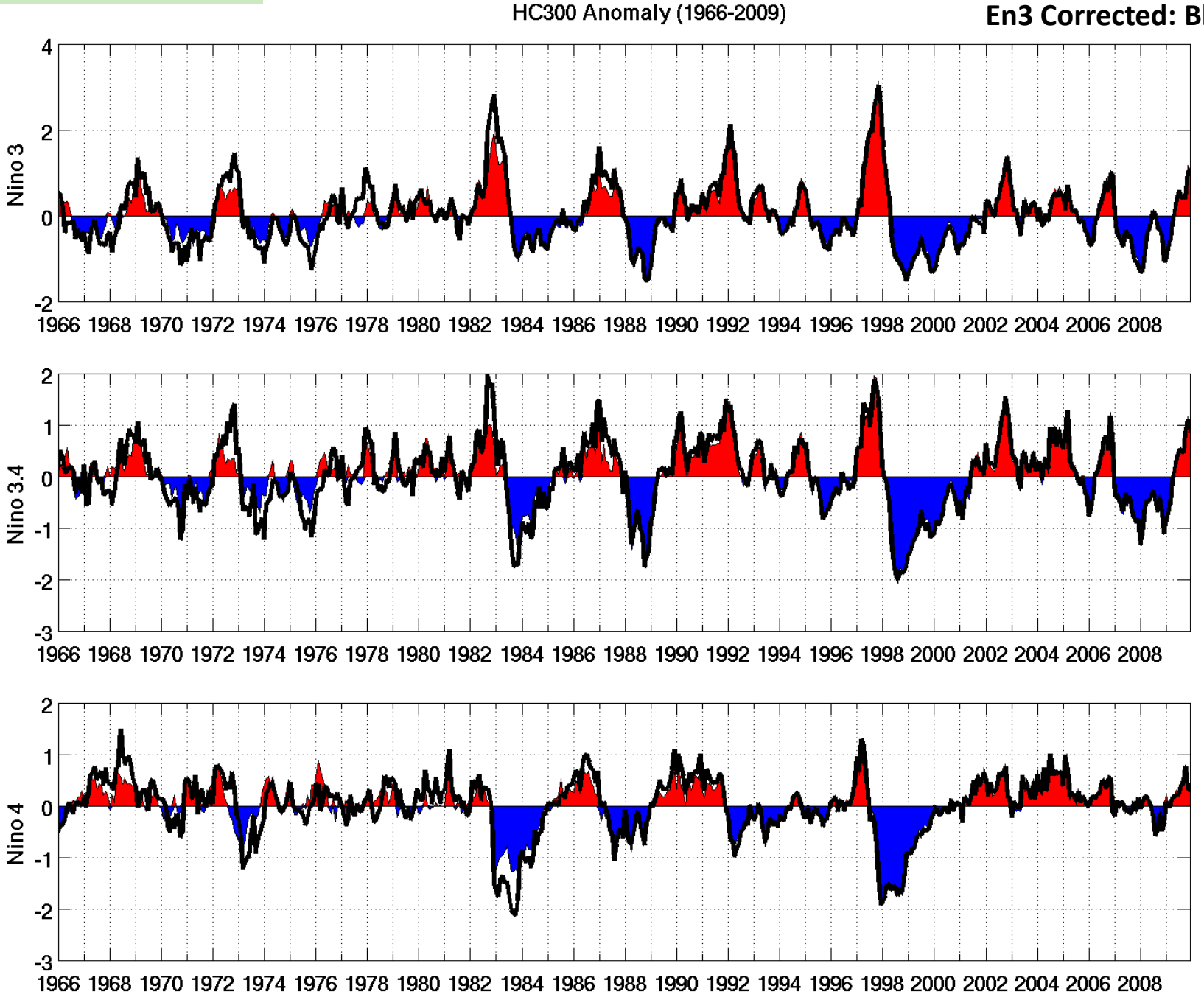
http://www.nasa.gov/topics/earth/features/icesat-20090707r.html
Ron Kwok/JPL

30S-30N 300m Heat Content



Heat Content Anomaly

EnOI: Shaded Areas
En3 Corrected: Black Line



Summary

Ocean and sea-ice reanalysis

- GEOS-5 AOGCM
- Constrained by MERRA
- 1960-present

Issues

- Still working to improve altimetry assimilation – able to correct salinity more effectively than temperature in western eq. Pacific – plan: turn on the online bias correction

Future plans

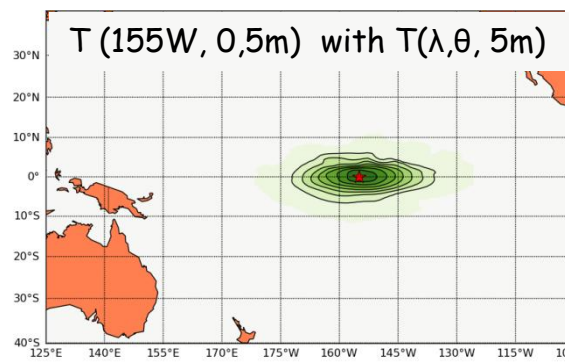
- Radiance-based SST assimilation implemented in the Atmospheric DAS – linking this with the ODAS

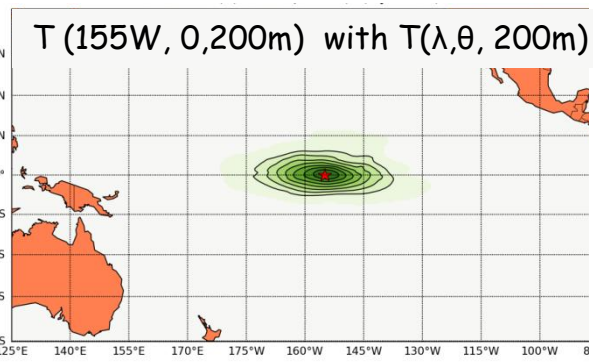
Many thanks to Simon Good of UKMO for the En3 analyses!

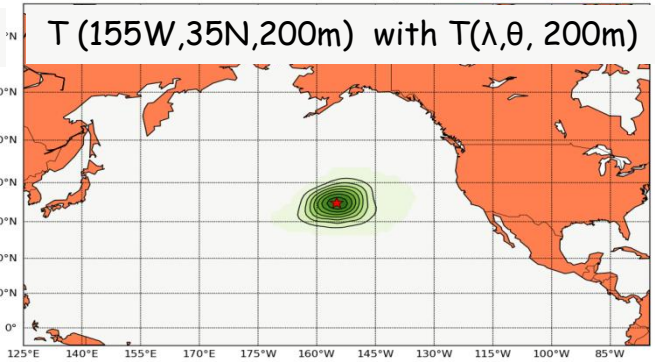
Some Additional Slides

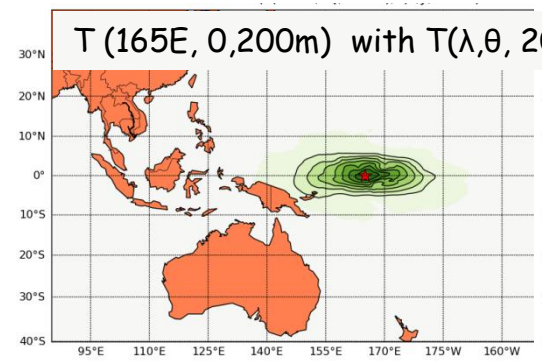
GEOS-IODAS: The covariances for EnOI

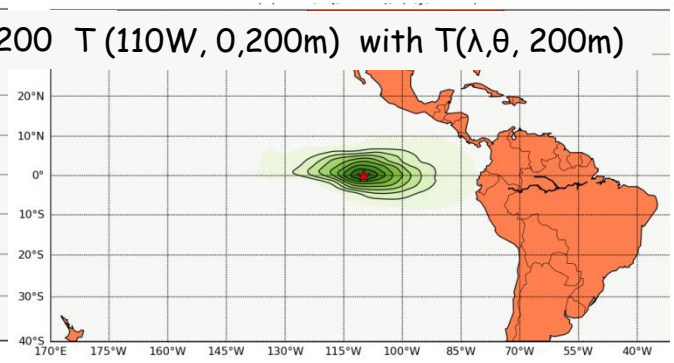
- Ocean: Ensemble differences from GEOS-5 AOCGM integrations
  - 20-members; differences every 5 days for 2 years
  - Retain 20 leading eofs

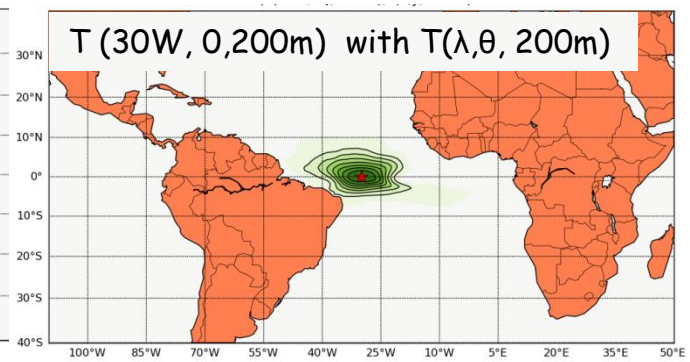




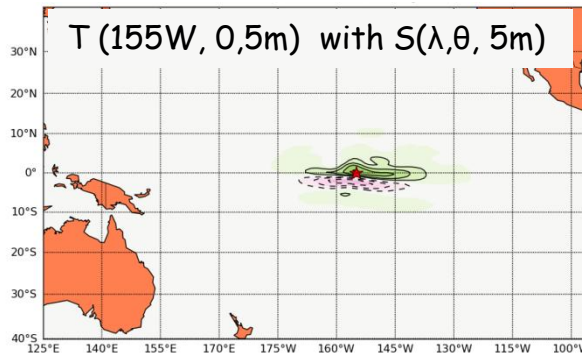


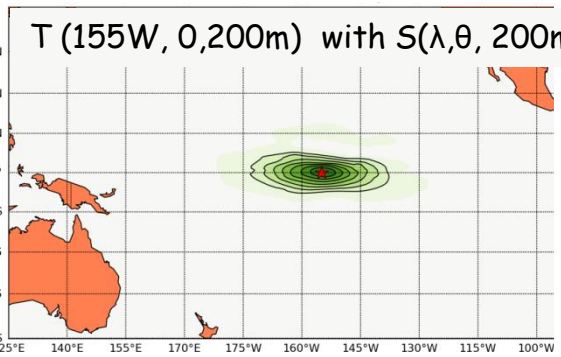


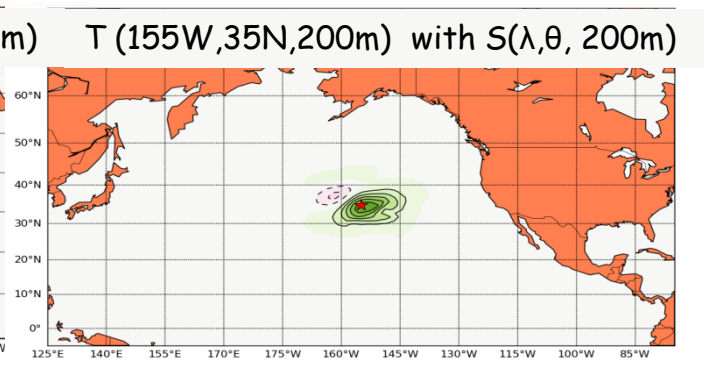


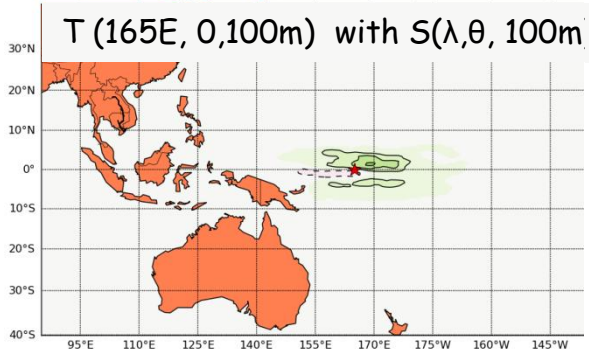


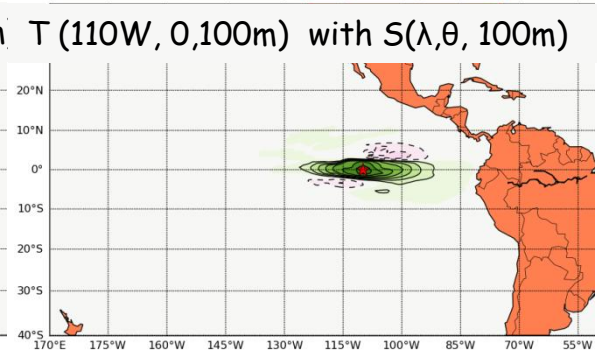
GEOS-IODAS: The covariances for EnOI

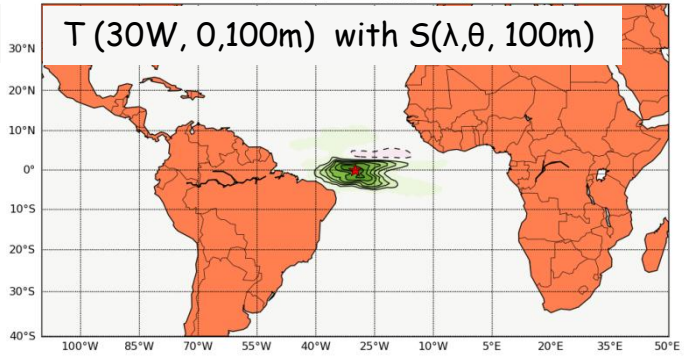


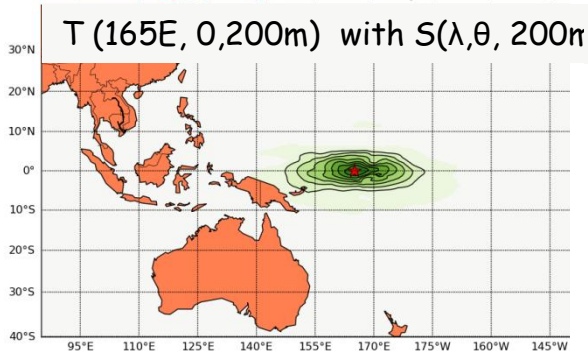


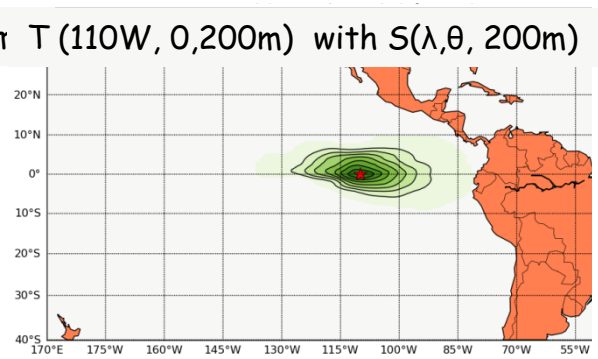


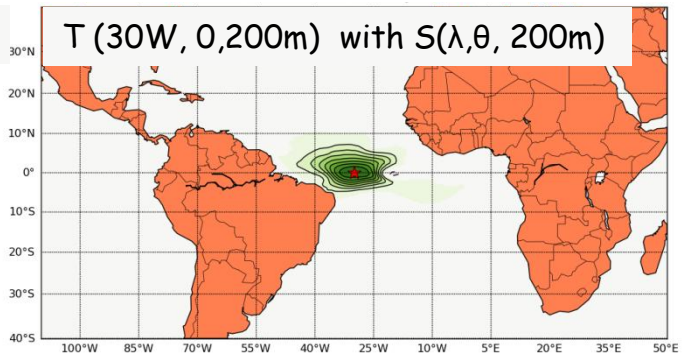


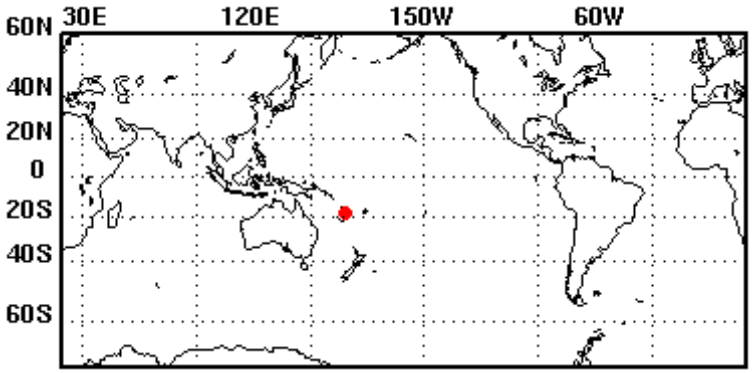












RMSD 2000-2004

TG-GMAO(sla) = 0.059
TG-GMAO(nosla) = 0.066
AV-GMAO(sla) = 0.042
AV-GMAO(nosla) = 0.055
TG-AV = 0.049

Tide Gauge (TG)
AVISO (AV)
GMAO sla
GMAO nosla

Near Vanuatu

LON = 168.3, LAT = -17.8

SLA (m)

0.20
0.15
0.10
0.05
0.00
−0.05
−0.10

Jan 2002
May 2002
Sep 2002
Jan 2003
May 2003
Sep 2003
Jan 2004
May 2004
Sep 2004

Comparison with Tide Gauge and Aviso SLA data