NASA's Ocean Observations for Climate Analyses and Prediction

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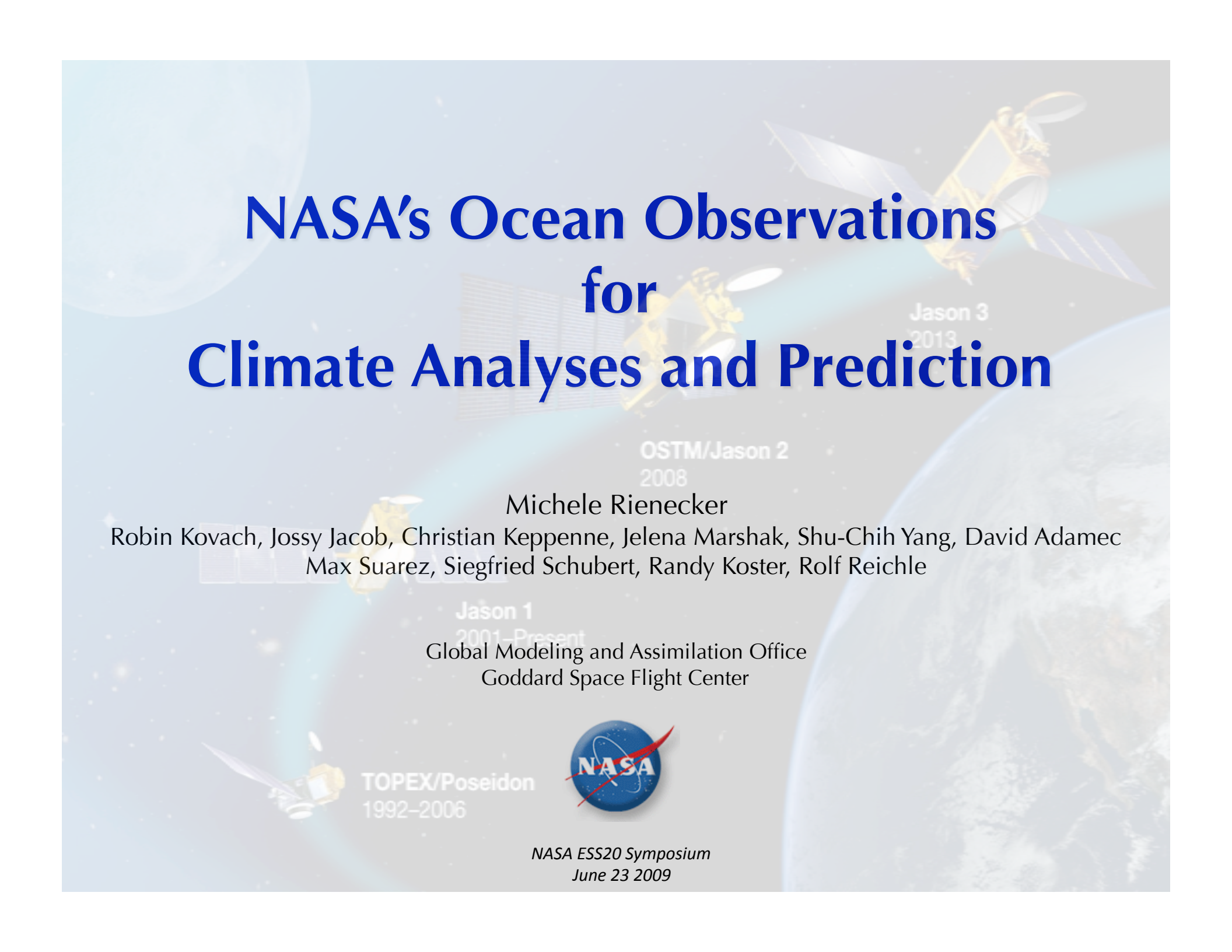
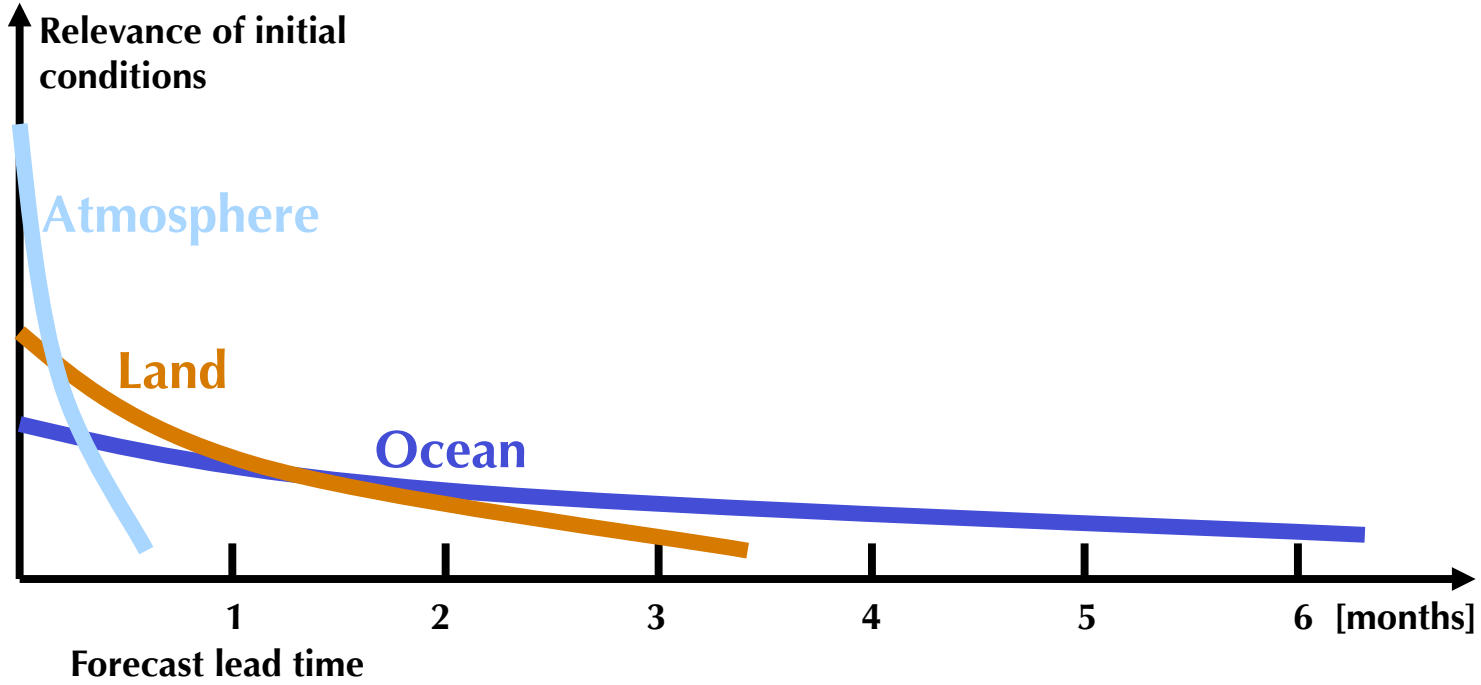


NASA ESS20 Symposium
June 23 2009

Initial conditions and forecast lead time



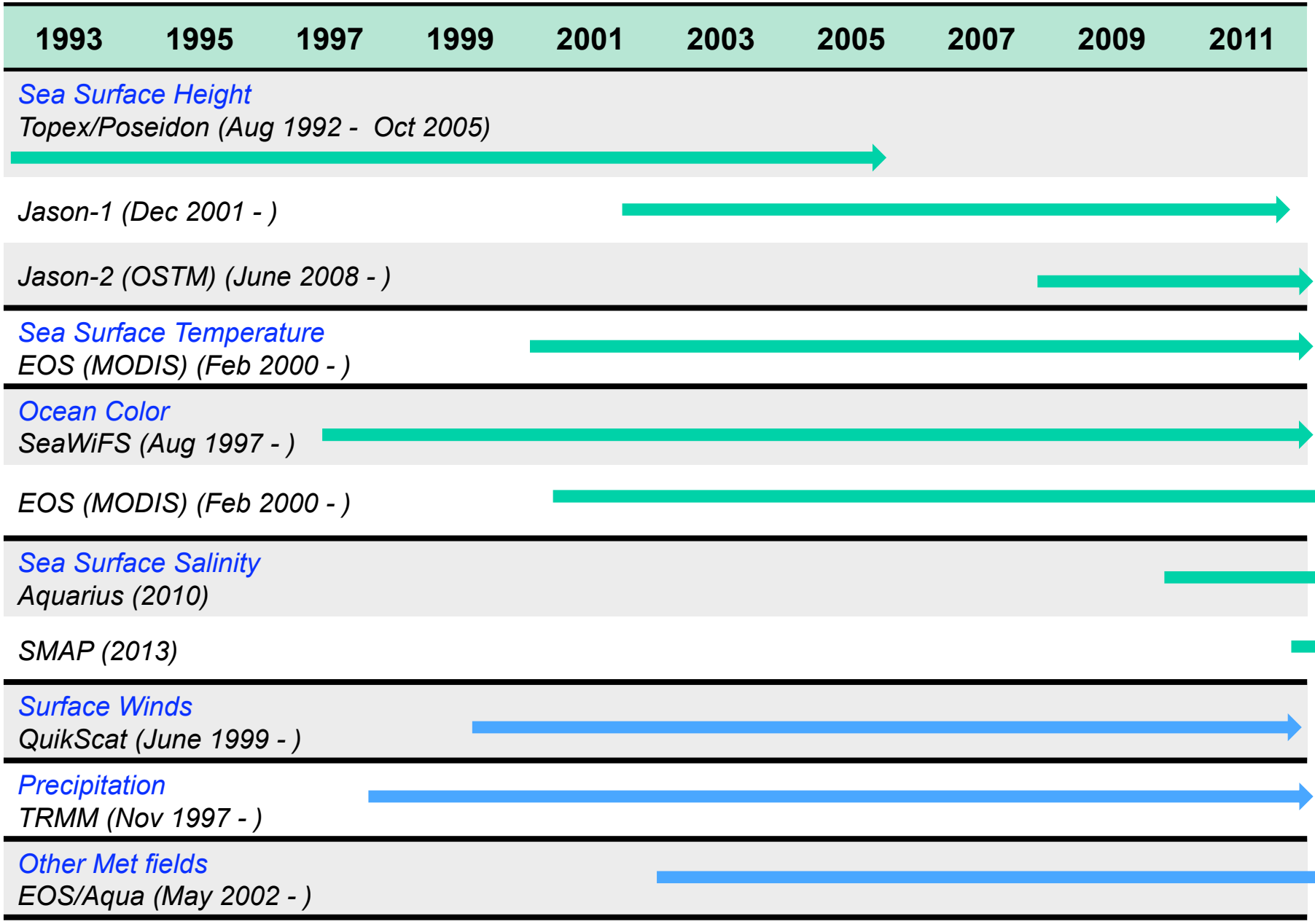
Short-term weather prediction with numerical models are limited by chaos in the atmosphere.

For seasonal climate prediction, we must rely on slower moving components of the Earth's system, such as ocean heat content and soil moisture.

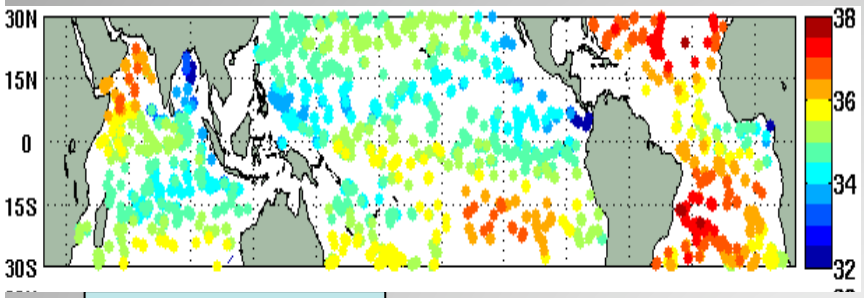
Land initialization important at 2 week – 2 month (sub-seasonal) time scales.

Ocean initialization important from weather to multi-decadal climate time scales.

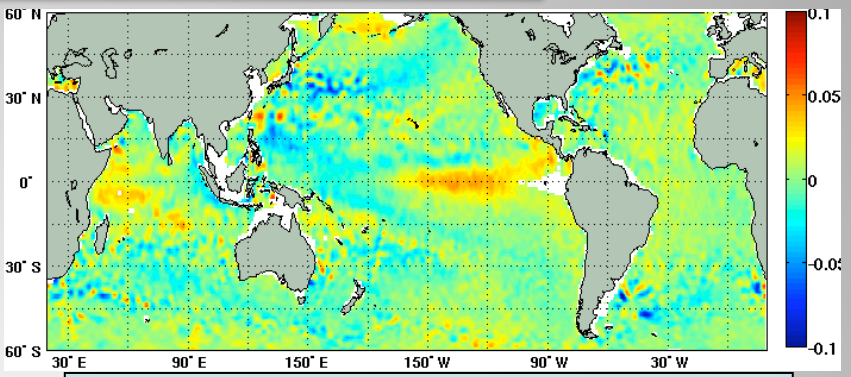
NASA Missions for Short-term Climate Forecasts – with focus on the ocean



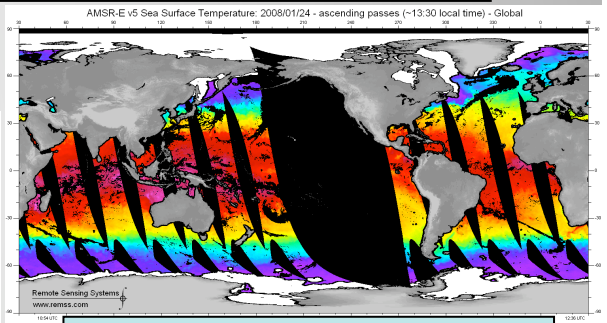
Ocean data assimilation in the GMAO



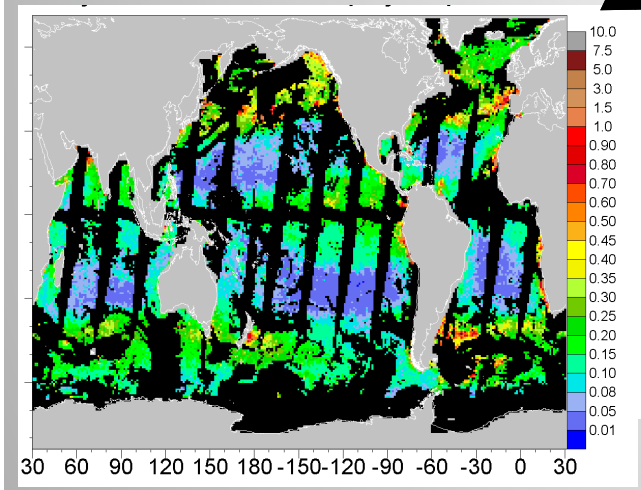
Temperature and salinity profiles from Argo floats



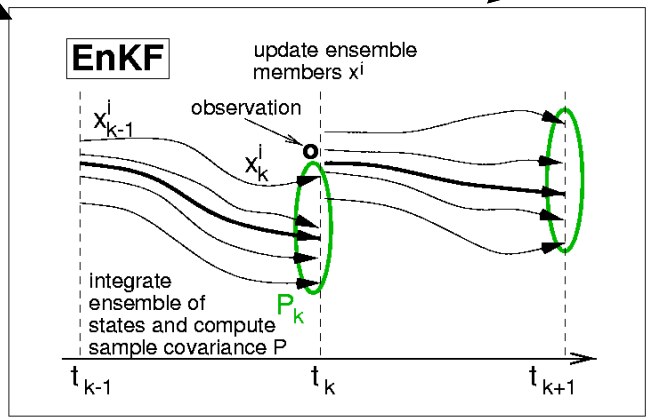
Sea Level anomalies (TOPEX/JASON)

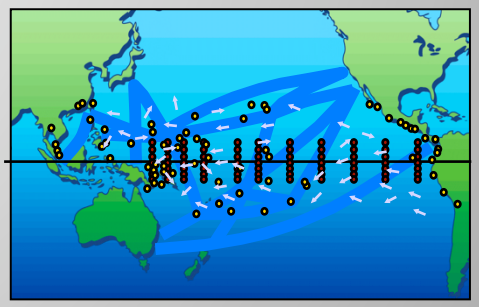


SST (AMSR-E; MODIS)



Surface chlorophyll (CZCS, SeaWiFS, MODIS)



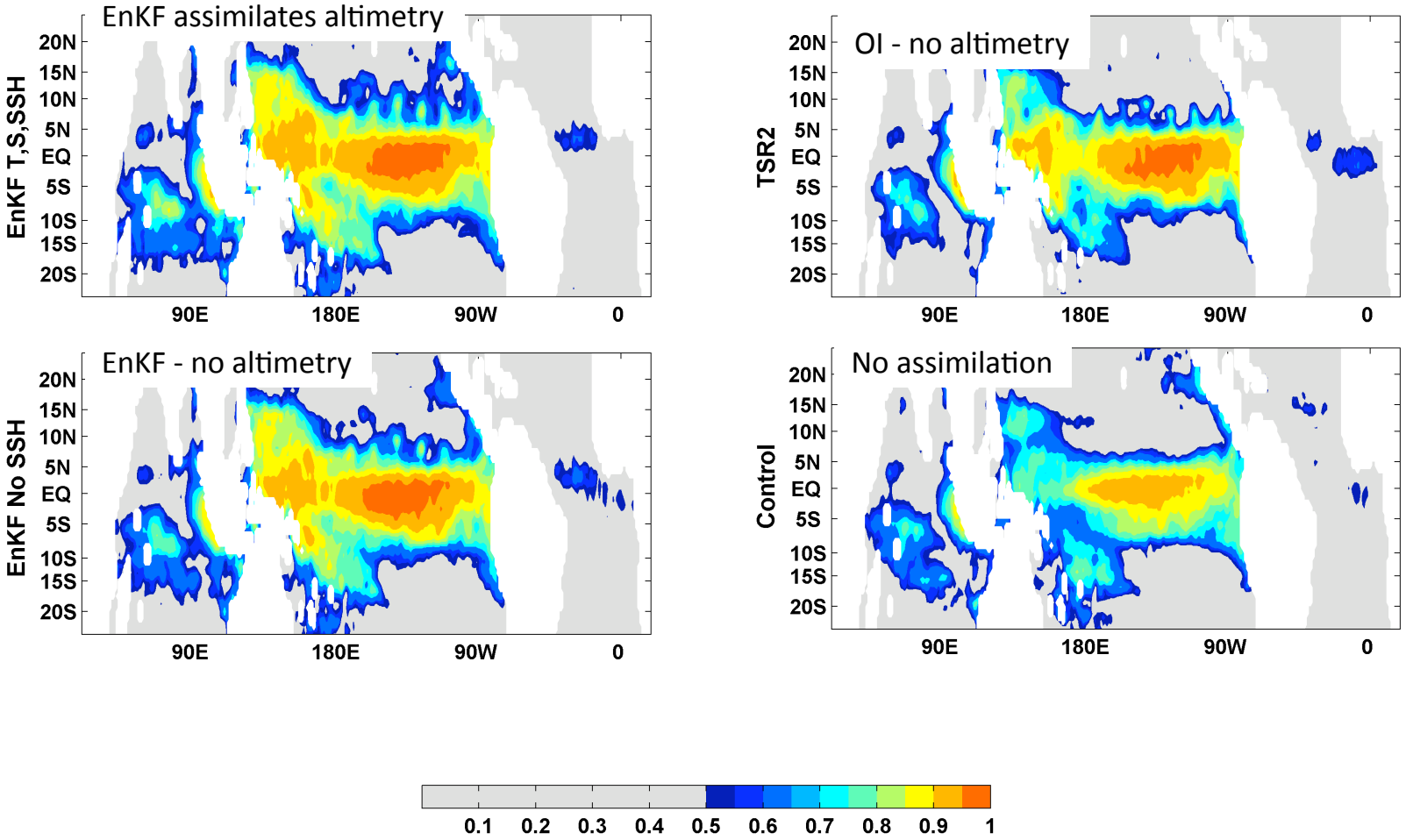


In situ temperature profiles (TAO/PIRATA, XBTs)

Coupled augmented ensemble Kalman filter

Ocean state estimates for climate analysis and for short-term climate forecasts

Verifying SSH analyses against Satellite Altimetry
Anomaly Correlation, 1994-2006

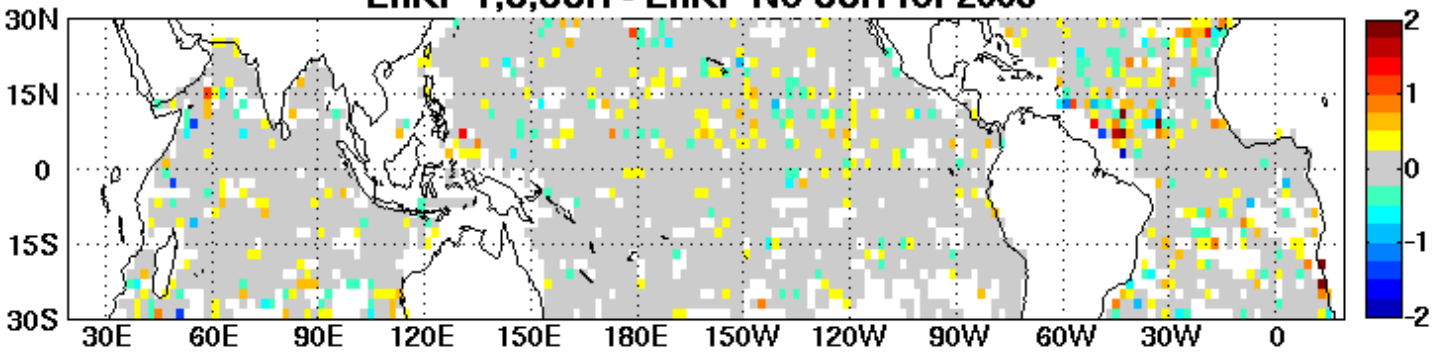


Impact of altimeter assimilation

Verifying subsurface analyses against *in-situ* data
RMS(innovations): 0-300 m for 2006
Salinity from Argo drifters

All Temperature: RMS OMF Difference (0 to 300 meters)

EnKF T,S,SSH - EnKF No SSH for 2006

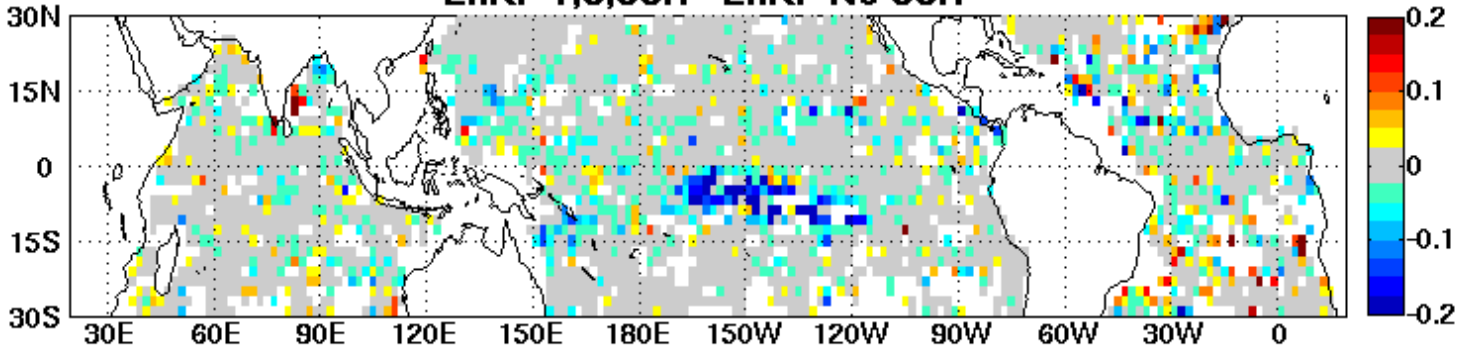


EnKF - No SSH is better

EnKF - T, S, SSH is better

Argo Salinity: RMS OMF Difference (0 to 300 meters): 2006

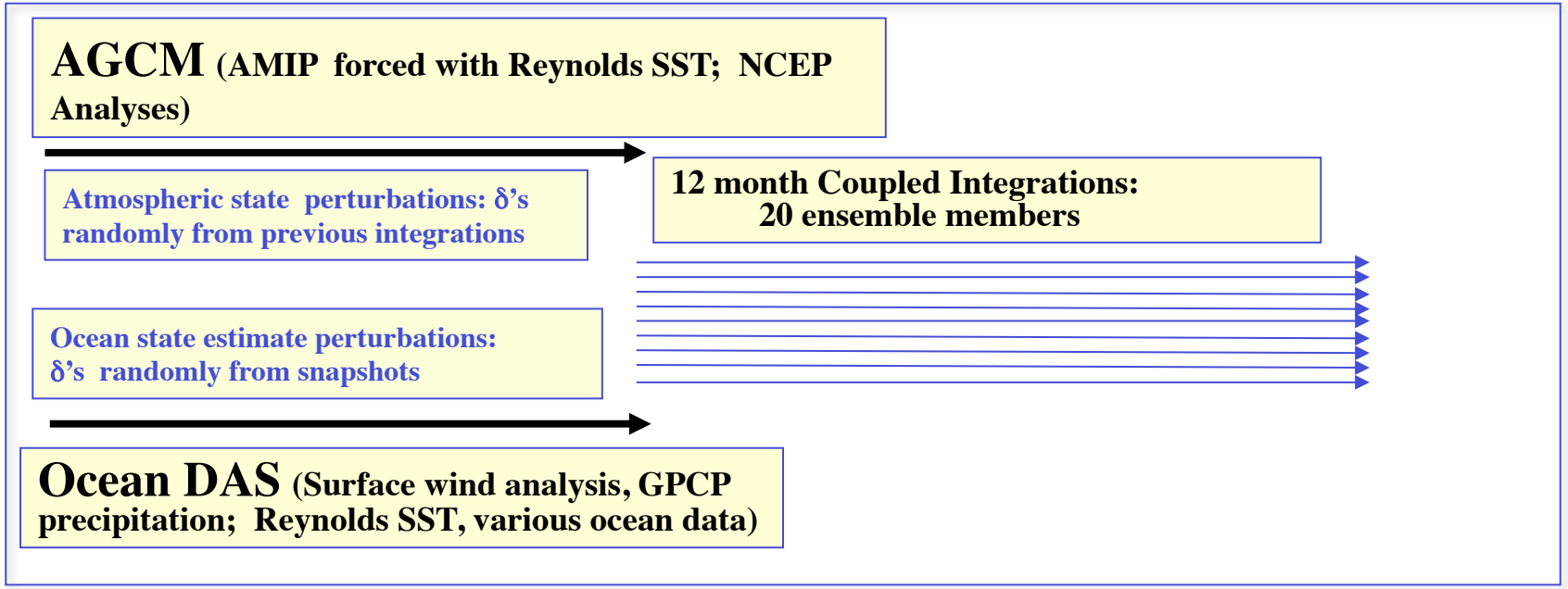
EnKF T,S,SSH - EnKF No SSH



EnKF - No SSH is better

EnKF - T, S, SSH is better

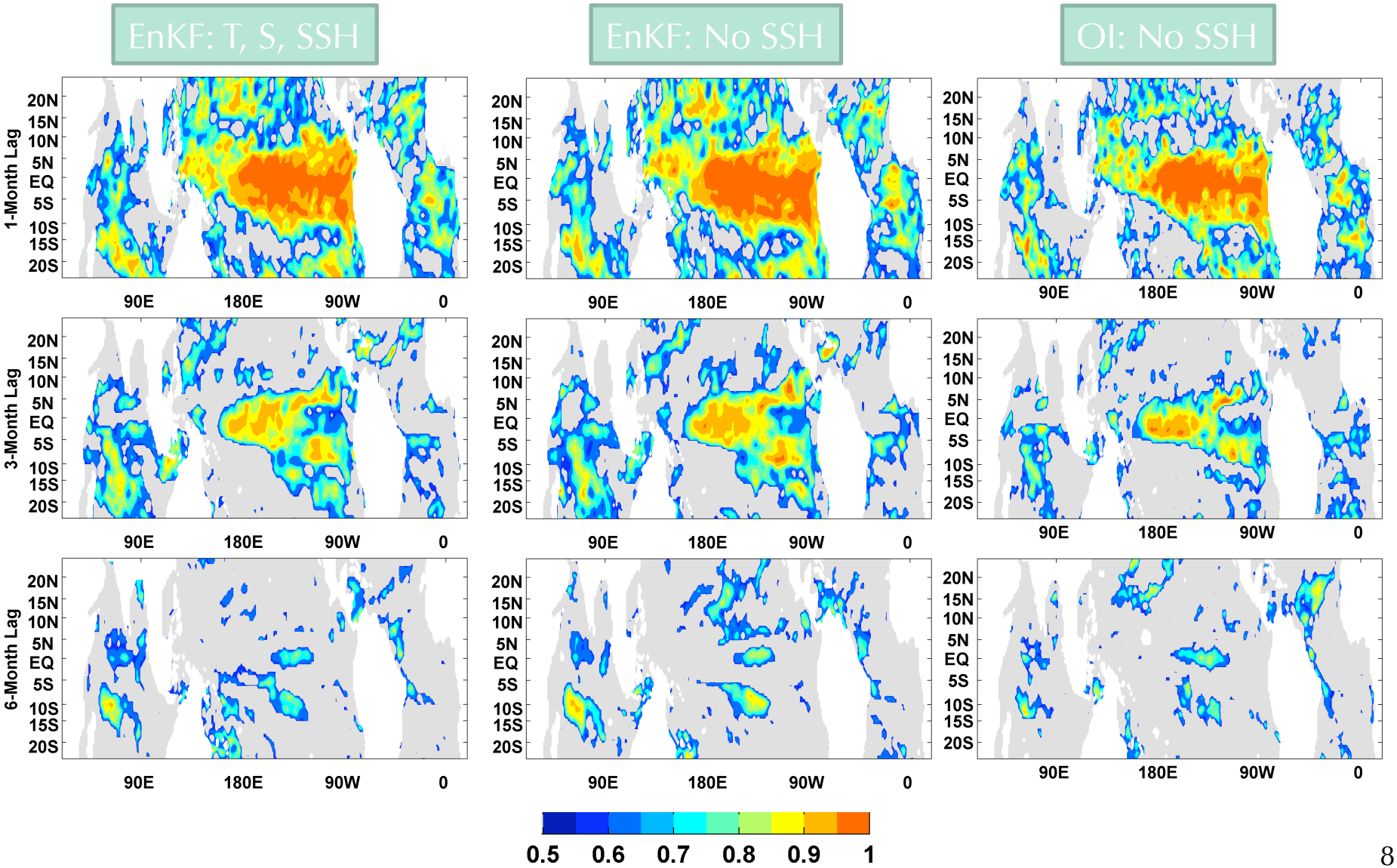
GMAO CGCMv1 (Tier1) Forecast Ensembles



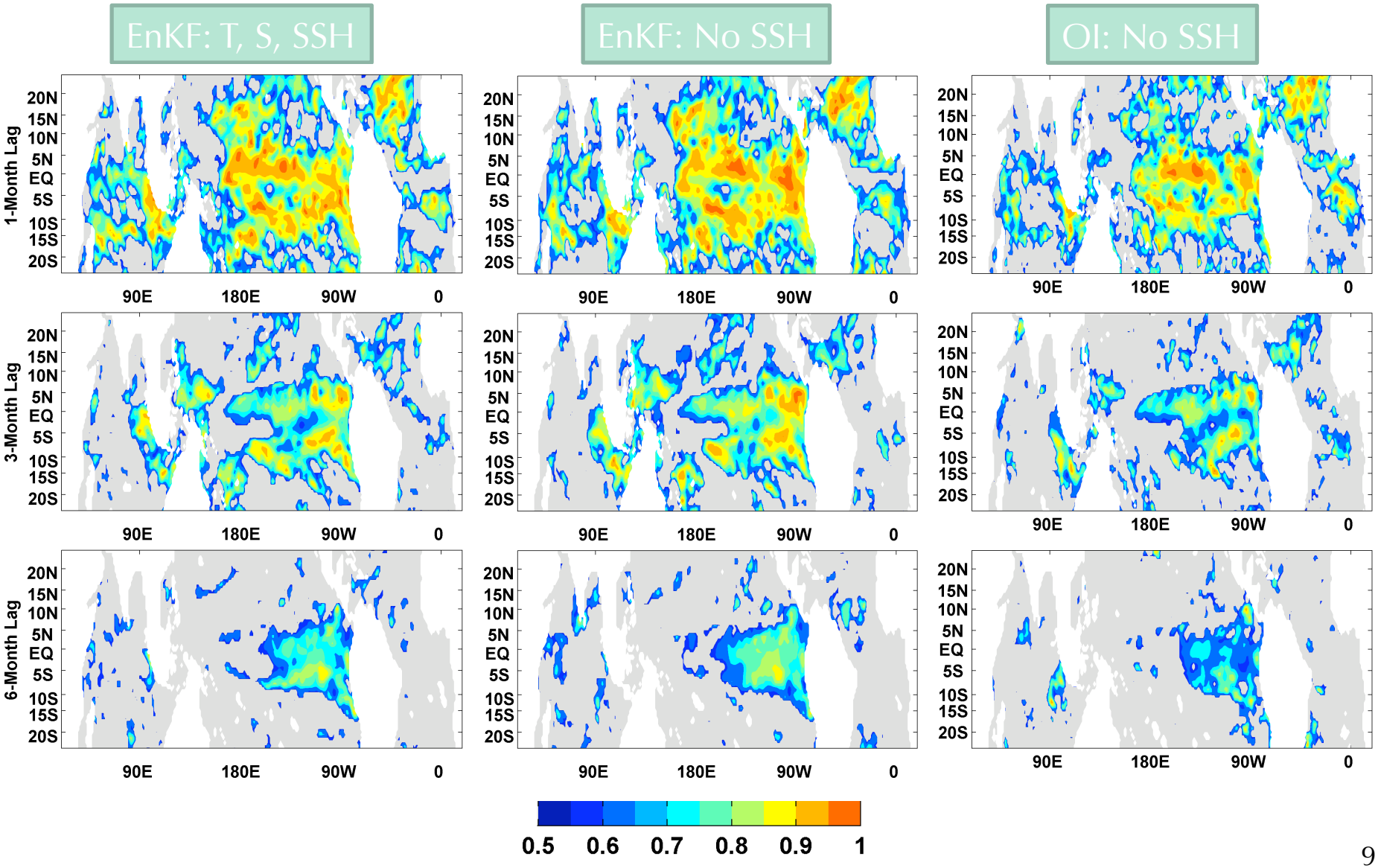
AGCM: NSIPP1 AGCM, 2 x 2.5 x L34
LSM: Mosaic (SVAT)
OGCM: Poseidon v4, 1/3 x 5/8 x L27, with embedded mixed layer physics
CGCM: Full coupling, once per day

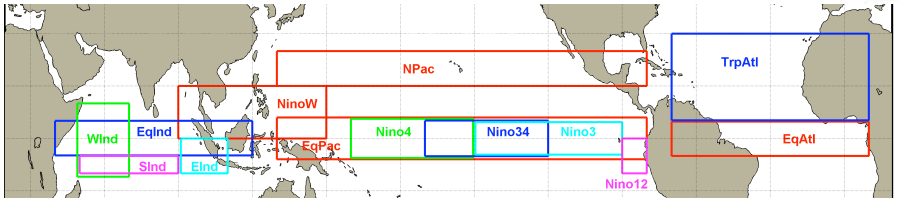
ODAS: Ensemble Kalman Filter with *in situ* T & S, *satellite* SSH; Optimal Interpolation of *in situ* T & S
"LDAS": Offline forced land states (recalibrated)

SST Anomaly Correlations (1994-2006): January Starts Verified Against Reynolds SST



SST Anomaly Correlations (1994-2006): July Starts Verified Against Reynolds SST



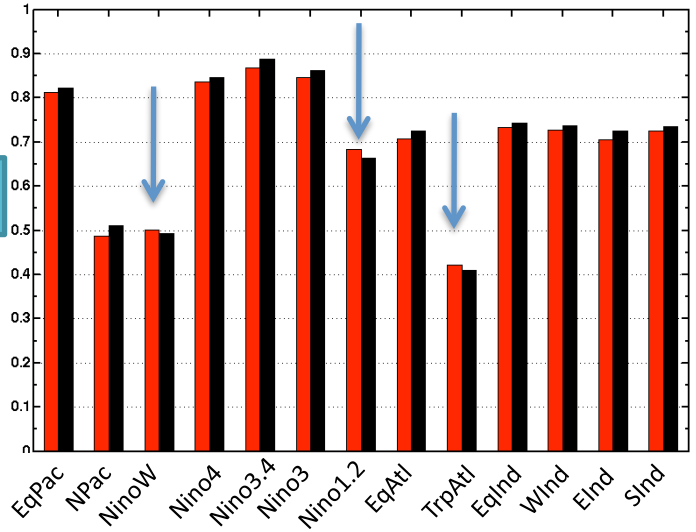


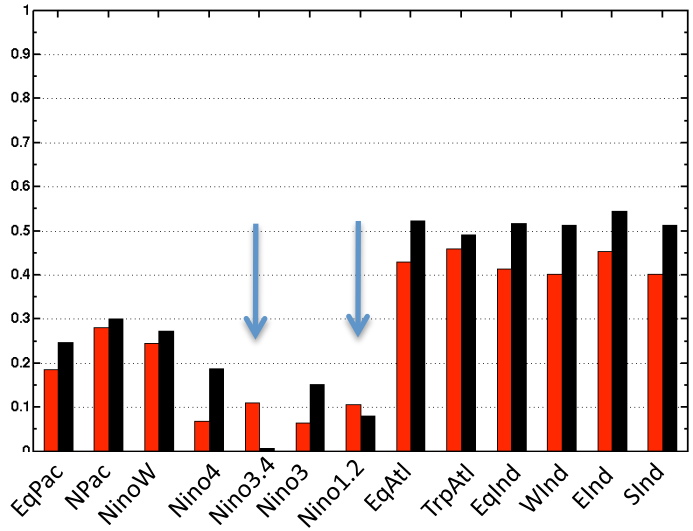
SST Anomaly Correlations (1994-2006) Verified Against Reynolds SST

Jan Starts

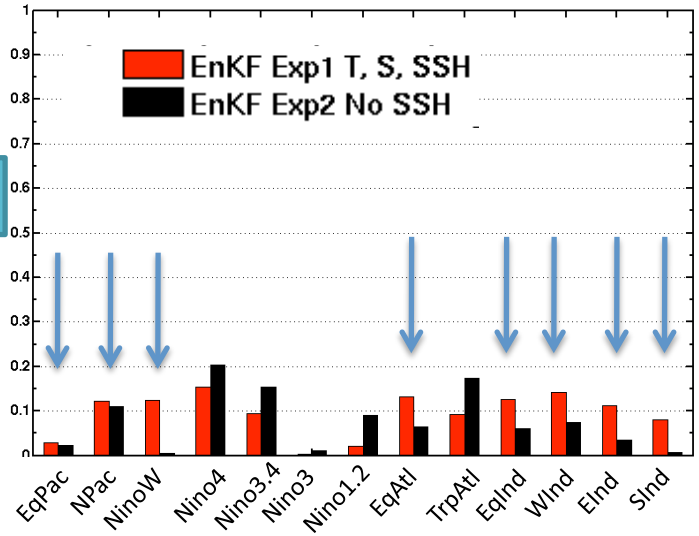
July Starts

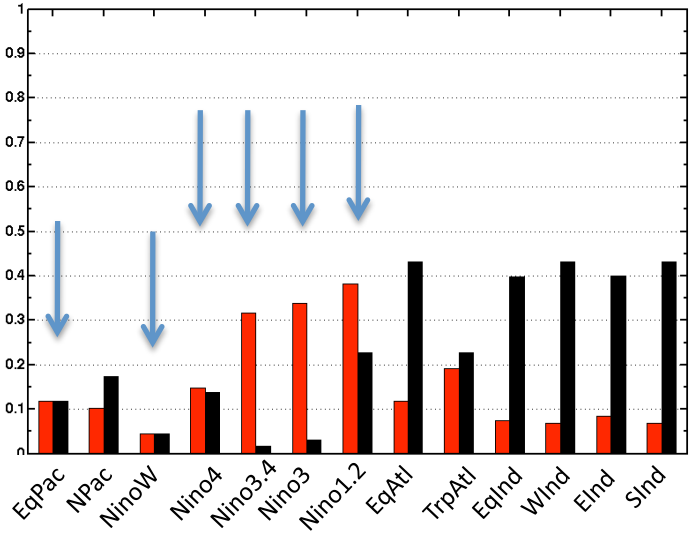
1st season





2nd season





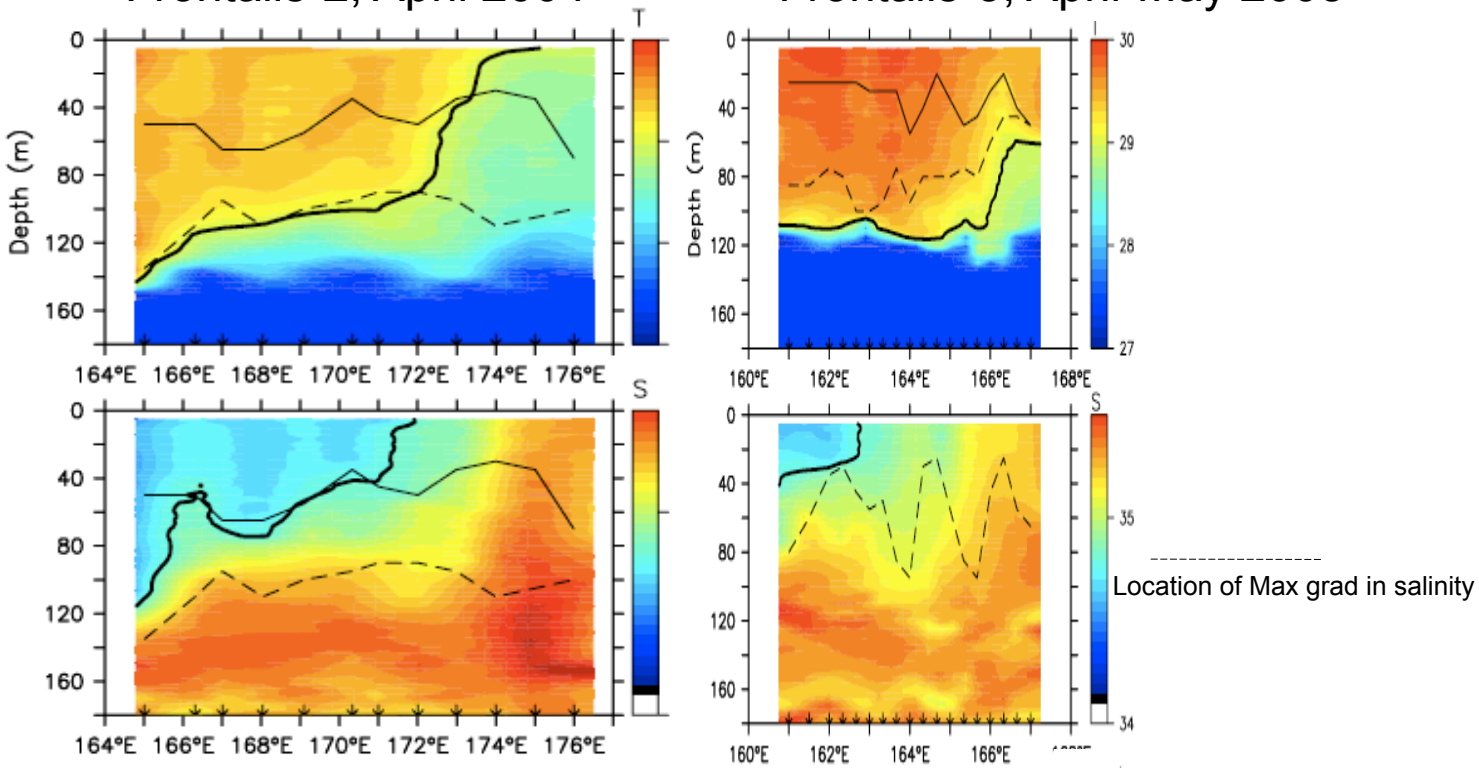
Looking forward to Aquarius
Along the equator, salinity matters…..

Frontalis-2, April 2004

Frontalis-3, April-May 2005

Temperature

Salinity



Location of Max grad in salinity

Mixed layer depth

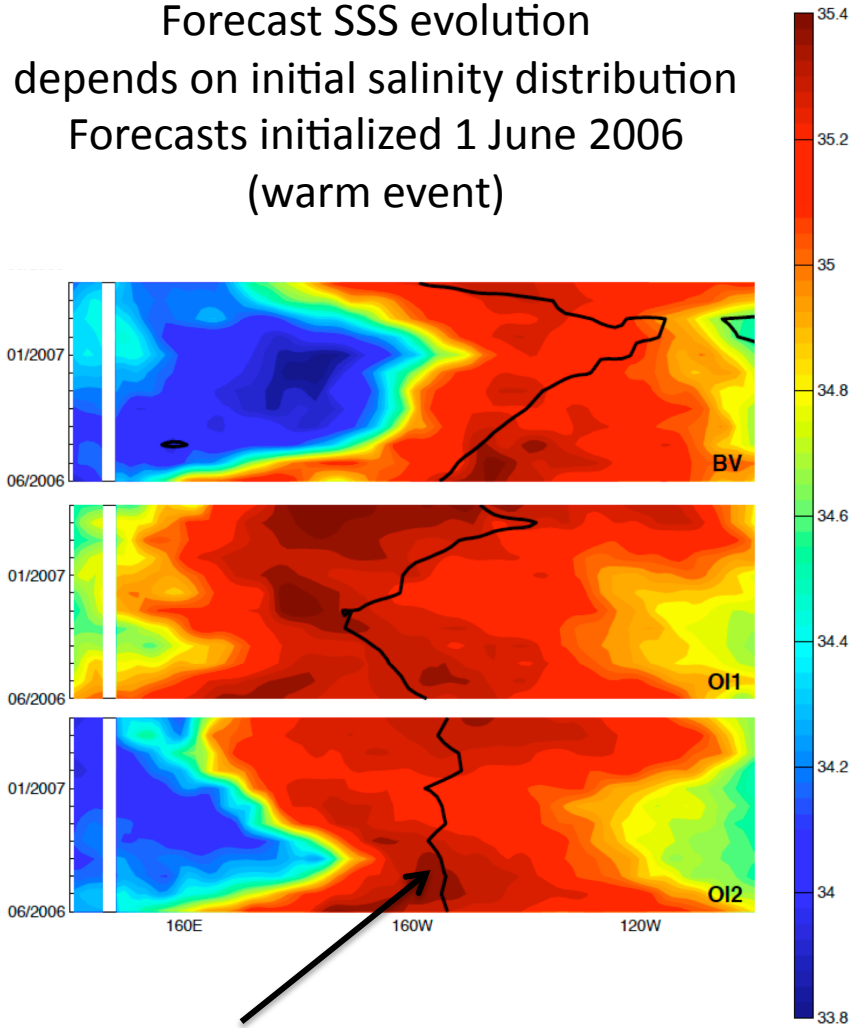
Isothermal layer depth

29C isotherm *or* 38.4 isohaline

From Maes, JGR, 2009

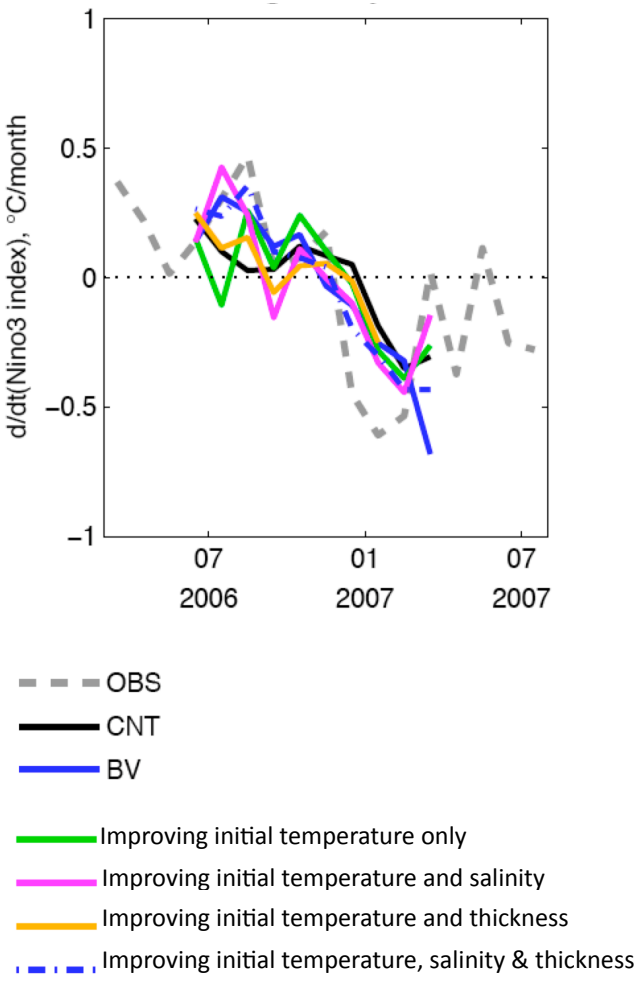
Looking forward to Aquarius
Salinity matters…..

Forecast SSS evolution
depends on initial salinity distribution
Forecasts initialized 1 June 2006
(warm event)



28C isotherm

Niño-3 SST anomaly tendency
Forecasts initialized 1 June 2006
(warm event)



SUMMARY

• Assimilation of ocean satellite data requires sophisticated covariance modeling to project surface information to the thermocline where much of the ocean's memory resides.
• Satellite altimetry improves representation of the mass field – but using it effectively requires good covariance modeling – state-dependent covariances from EnKF and the Breeding Method appear to be effective.

• Salinity matters – an important component in the mass field *and* it mediates the ocean-atmosphere exchanges in the western-central equatorial Pacific.

• **Challenges** remain in the initialization of coupled models – reducing initialization shocks requires attention to the *coupled* system (integrated analyses).

• **Changing observing systems** are a challenge to ocean climate analyses, even more than for the atmosphere.