



The Impact of Satellite Sea Surface Salinity for Prediction of the Coupled Indo-Pacific System

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Outline

Hypothesis – Impact of Satellite Sea Surface Salinity improves coupled ENSO forecasts

- Models and Data Assimilation
- Results
 1. Impact of salinity for the Indo-Pacific on IC
 2. Impact of salinity on coupled forecast
 3. Impact of AQ/SMAP bias on coupled forecasts
- Summary

Ocean Model and Forcing

- Reduced-gravity, primitive equation, sigma coordinate model [*Gent and Cane, 1989*]
- Hybrid variable depth mixed layer [*Chen et al., 1994*]
- Advective AML coupled to OGCM [*Seager et al., 1995*]
- Realistic coastlines for tropical Indo-Pacific (33°E-76°W, 30°N-30°S), 1°x1/3° stretched, 20 layers, includes river contribution [*Dai and Trenberth, 2002*]
- **Forcing:** MERRA2 reanalysis winds, rainfall, cloud fraction and solar radiation [*Gelaro et al., J.CLIM, 2017*]

Ensemble Reduced Order Kalman Filter

- Assimilate SL, SST, SSS, T_z , S_z
- Basis MEOF of 1985-2004 model experiment and includes SL, H_{sfc} , H_{bot} , T, S, U, V
- Assimilation data
 - SSS (Aquarius V5.0 Level 3 of *Lilly and Lagerloef, 2008*)
 - SSS (SMAP V2 Level 3 of *Meissner and Wentz, 2016*)
 - SL (Multi-satellite product of *Aviso, 2013*)
 - SST (*Reynolds et al., 2002*)
 - T_z , S_z (GTSP *NODC 2006*)

Coupled Model Atmosphere

- Use anomaly coupling technique (similar to e.g. *Kroeger and Kucharski, 2011 Clim.Dyn.*)
- SPEEDY – for Simplified Parameterizations, primitive E-Equation Dynamics - Version 4.1 (*Molteni 2003 Clim.Dyn., Kucharski et al., 2006 BAMS*)
 - $\sim 3.8^\circ$ resolution, 8 levels (925-30mb)
 - Winds improved using convective momentum transport of *Kim et al., 2008 Clim. Dyn.*
 - Within Indo-Pacific tropics SSTA, outside SSTA from HadISST (*Rayner et al., 2003*)

Impact of Sea Surface Salinity

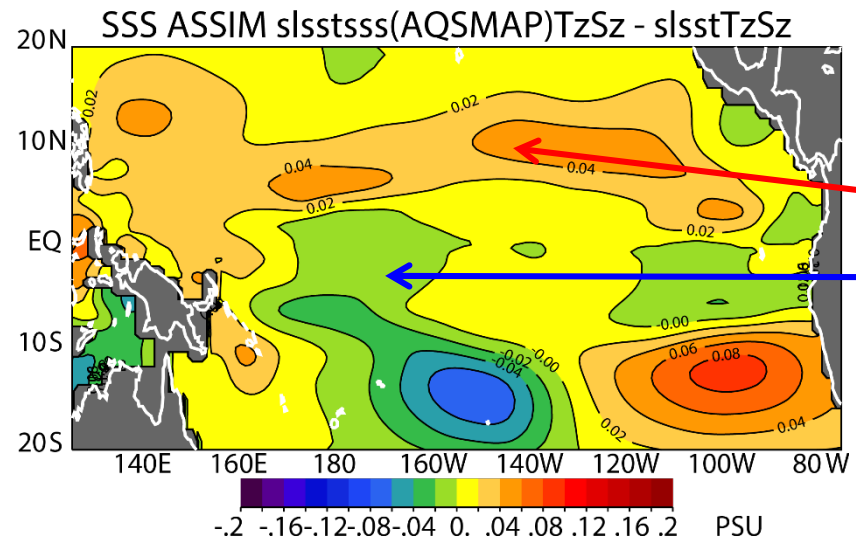
Experiment Design

Experiment Name	Period	Assimilation Variables
ASSIM_SL_SST_T _z -S _z “Control”	Jan 1993 – Sep 2017	SL, SST, T _z and S _z
ASSIM_SL_SST_SSS_T _z -S _z Known as “SSS Assimilation”	Sep 2011 – Sep 2017*	SSS from Aquarius Version 5.0 combined with SMAP Version 2.0 Level 3 data and SL, SST, T _z , and S _z

*NOTE – spin up of SSS Assimilation experiment assimilates an OI of near-surface in situ observations from Jan 1993-Aug 2011

Impact of Sea Surface Salinity

SSS ASSIM – Control



SSS

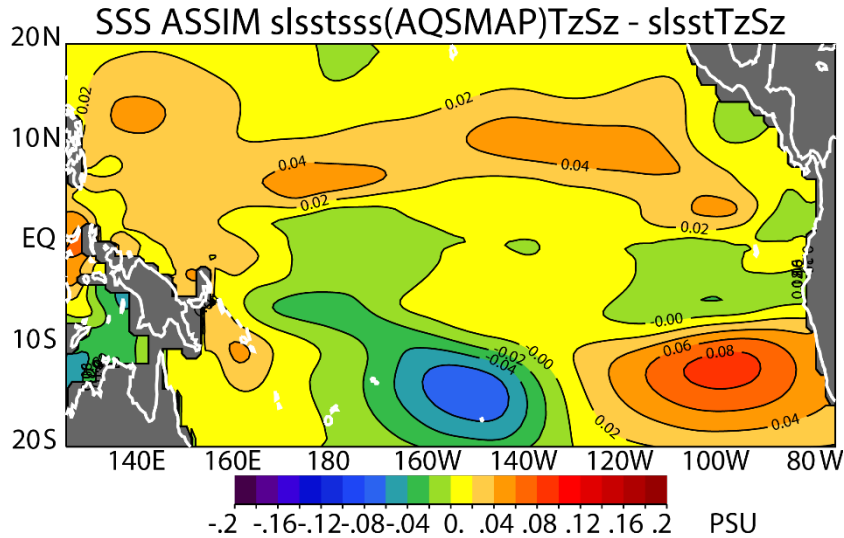
Salting near the ITCZ

Freshening at the eastern edge of the WP



Impact of Sea Surface Salinity

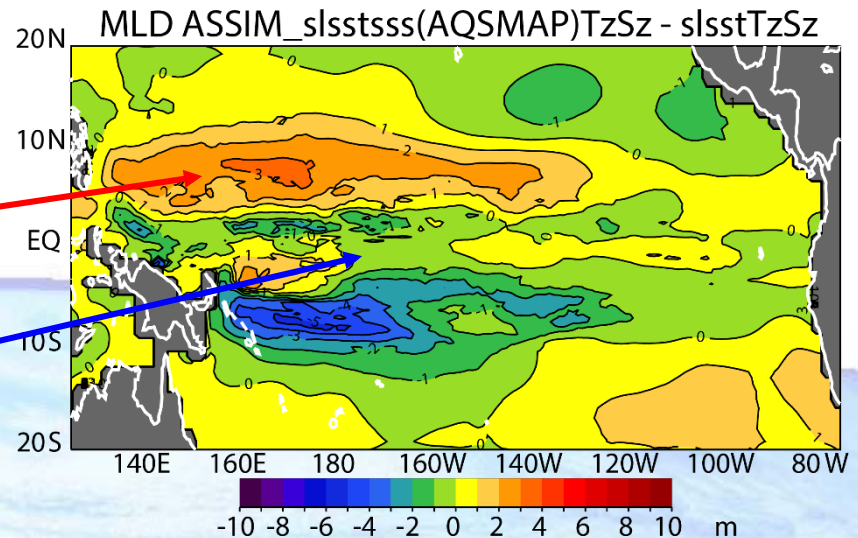
SSS ASSIM – Control



MLD

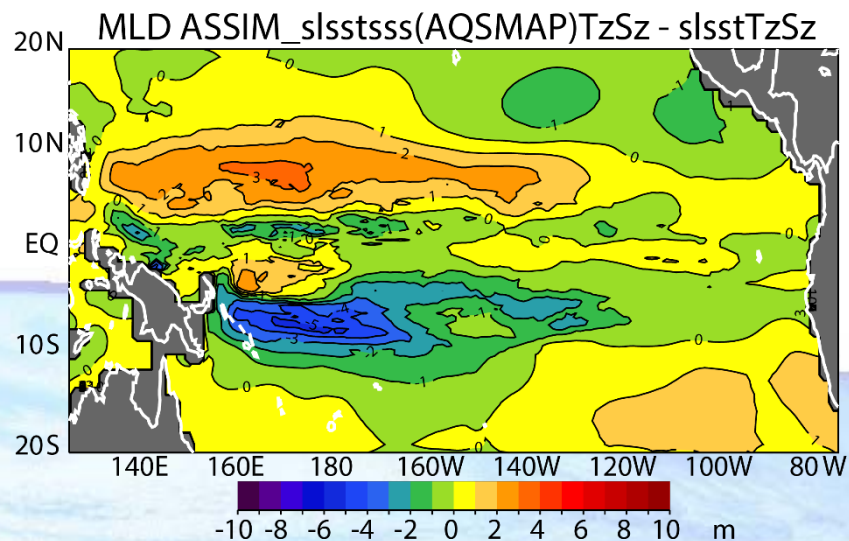
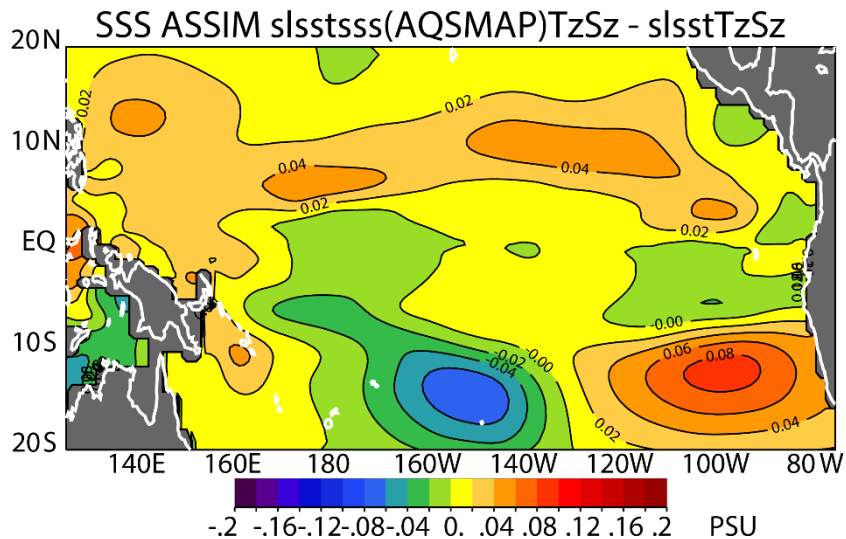
Deepening of MLD near
the ITCZ

Shoaling of MLD within
15S-5N



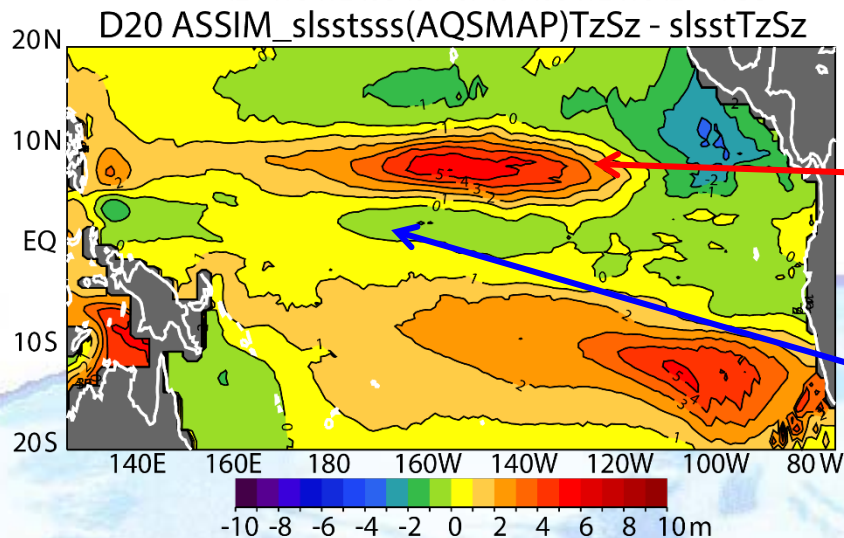
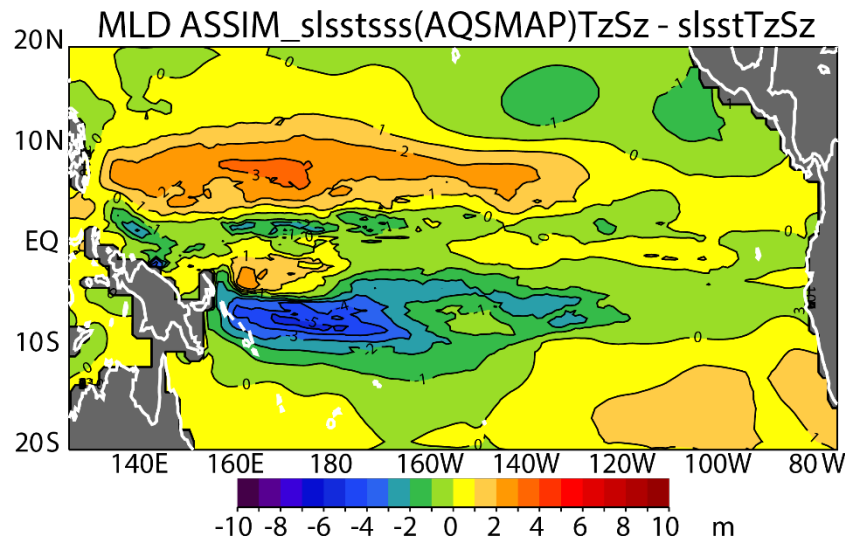
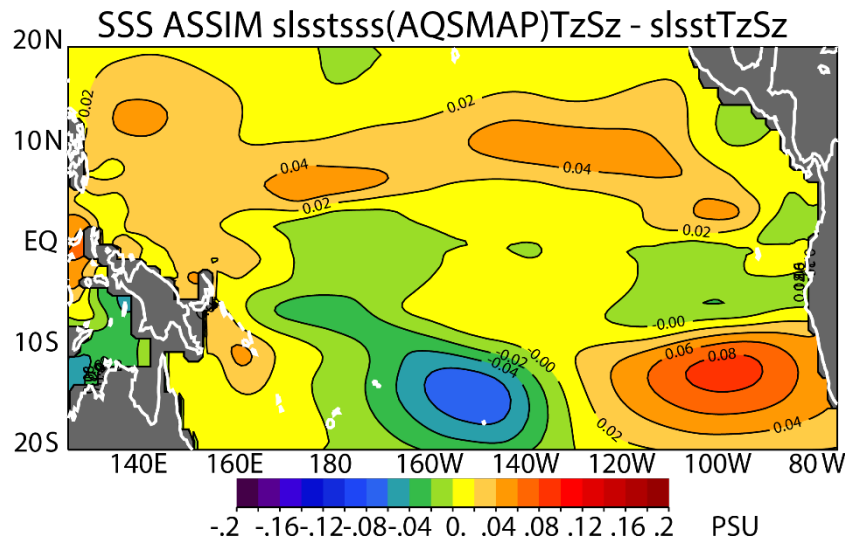
Impact of Sea Surface Salinity

SSS ASSIM – Control



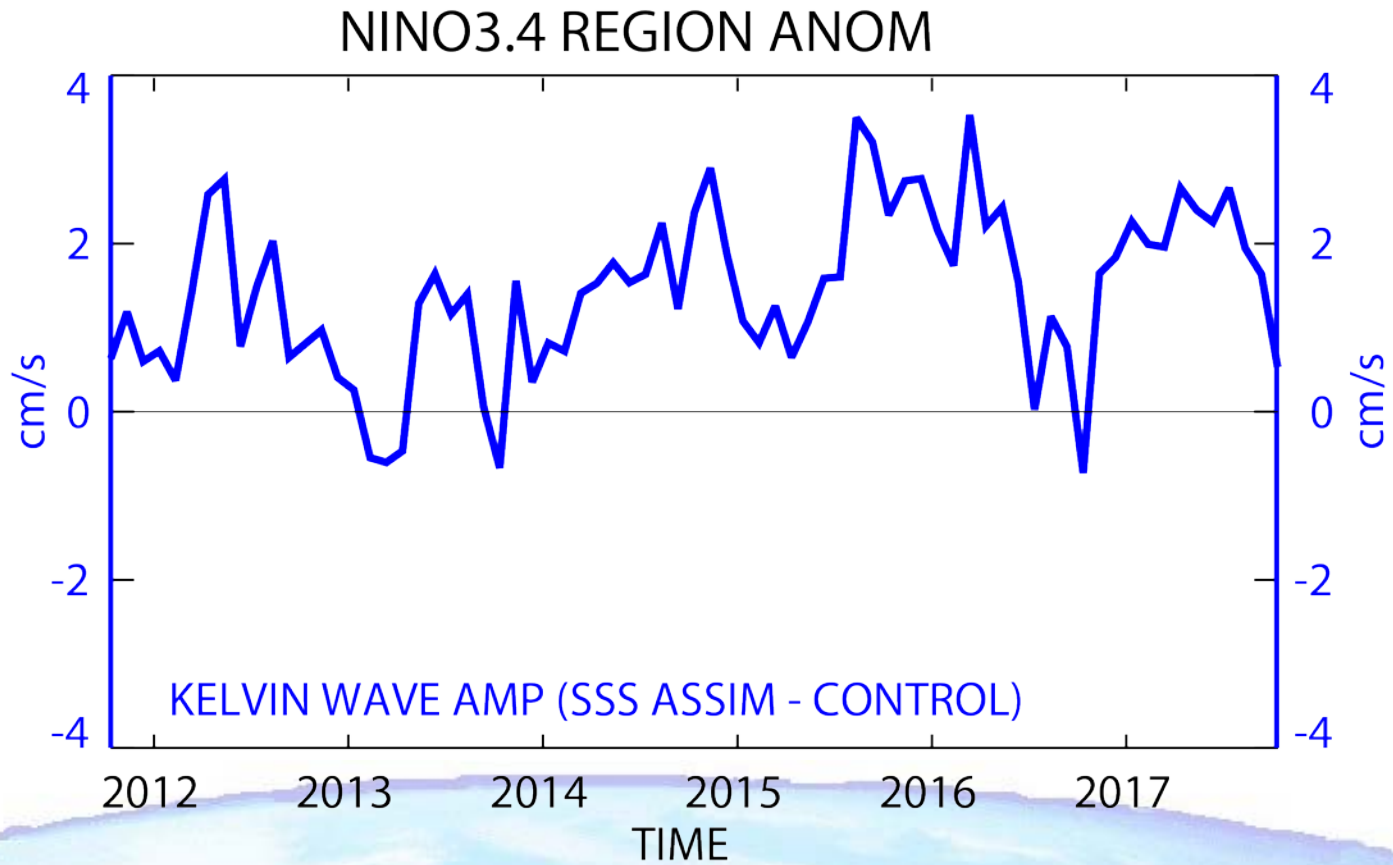
Impact of Sea Surface Salinity

SSS ASSIM – Control

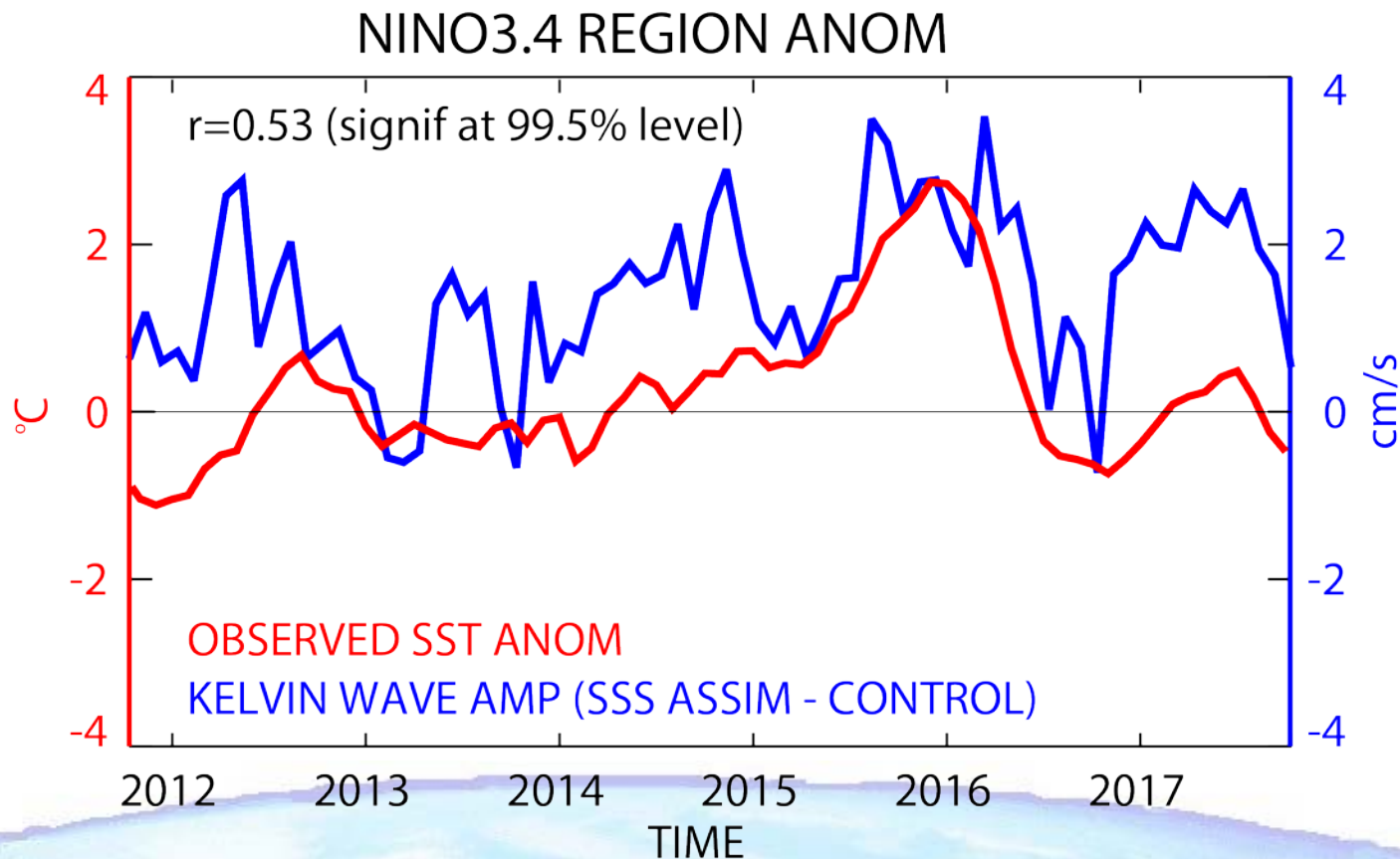


D₂₀ (for thermocline depth)
Deepening the D₂₀ just off the equator
Shoaling near the equator

Kelvin Amplitude



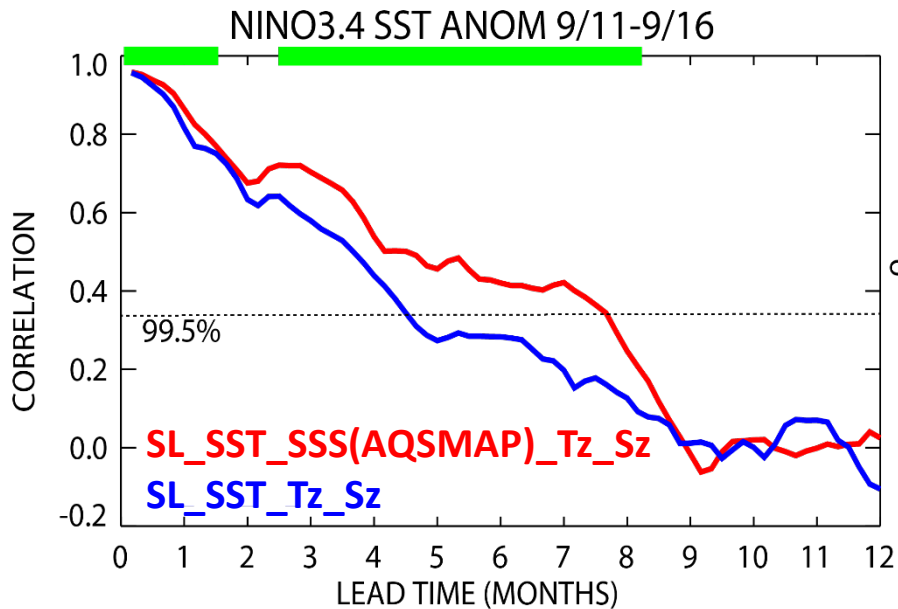
Kelvin Amplitude versus SSTA



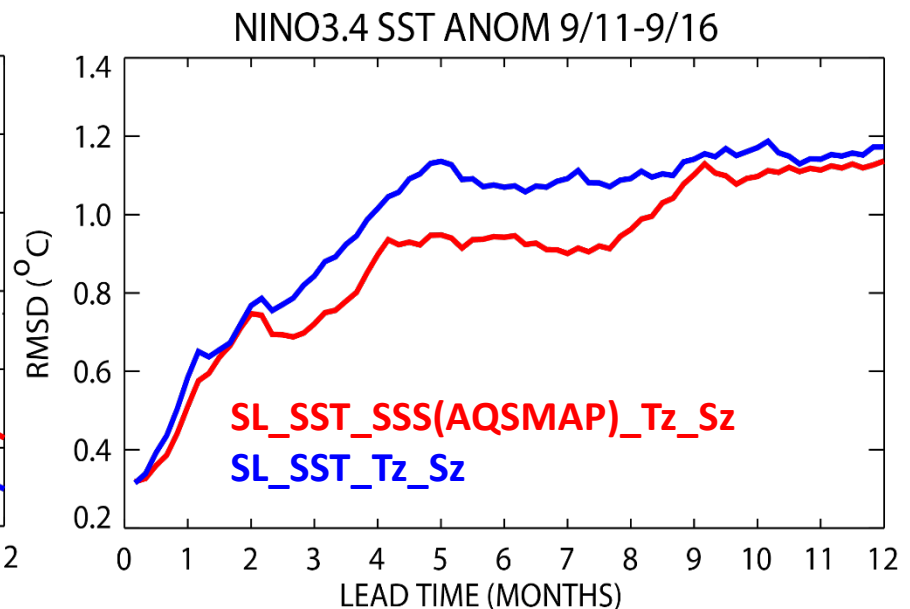
Significant correlation between **obs NINO3.4 SSTA** and **Kelvin amplitude (SSS assimilation – control)** in NINO3.4 region shows that SSS assimilation enhances Kelvin wave

Coupled Model Validation

Correlation



RMS

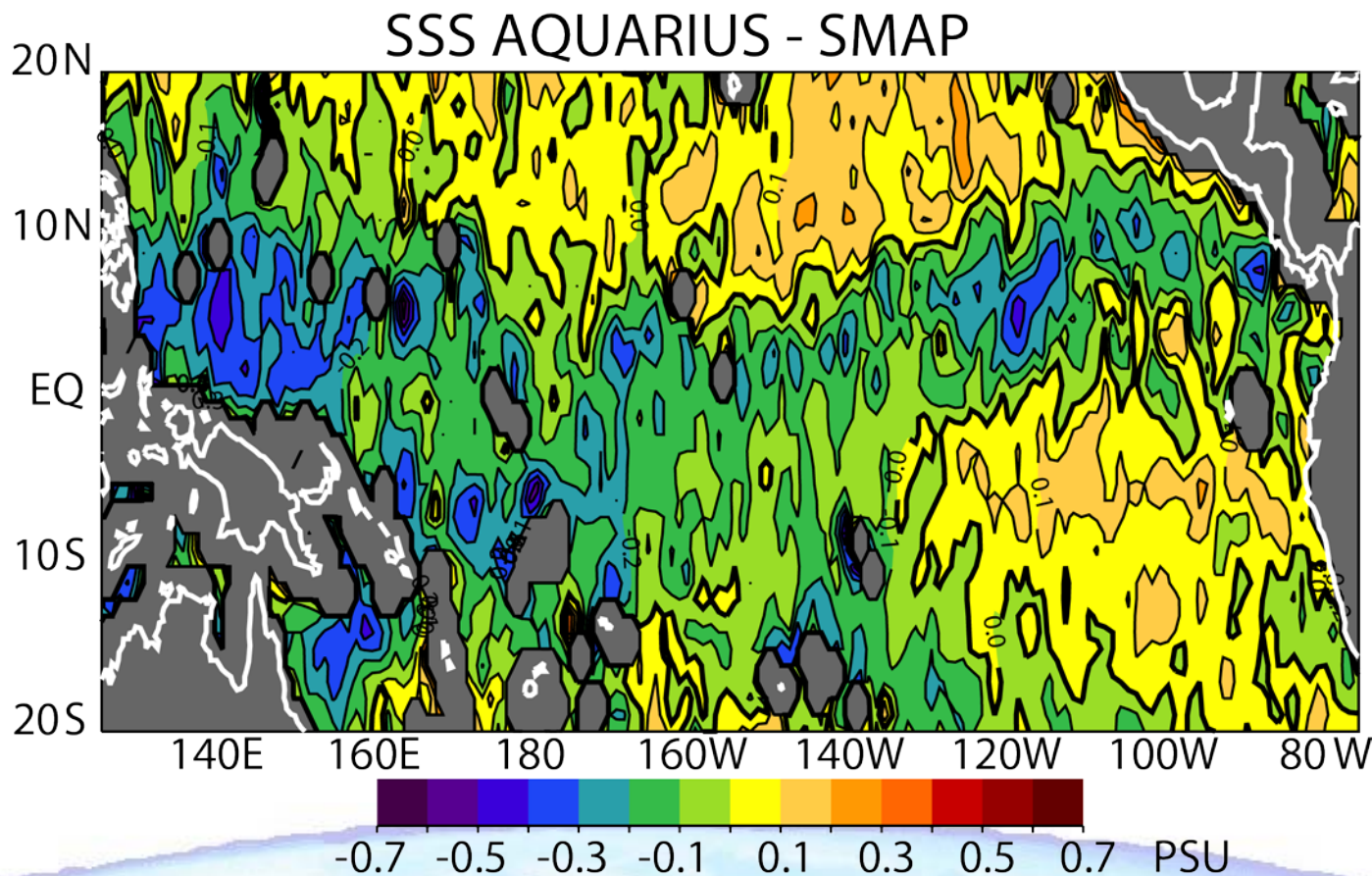


SSS ASSIM = ASSIM_SL_SST_SSS(AQ+SMAP)_Tz_Sz

Control = ASSIM_SL_SST_Tz_Sz

(signif. improved at the 95% level using Steiger Z test)

Bias Between Aquarius and SMAP



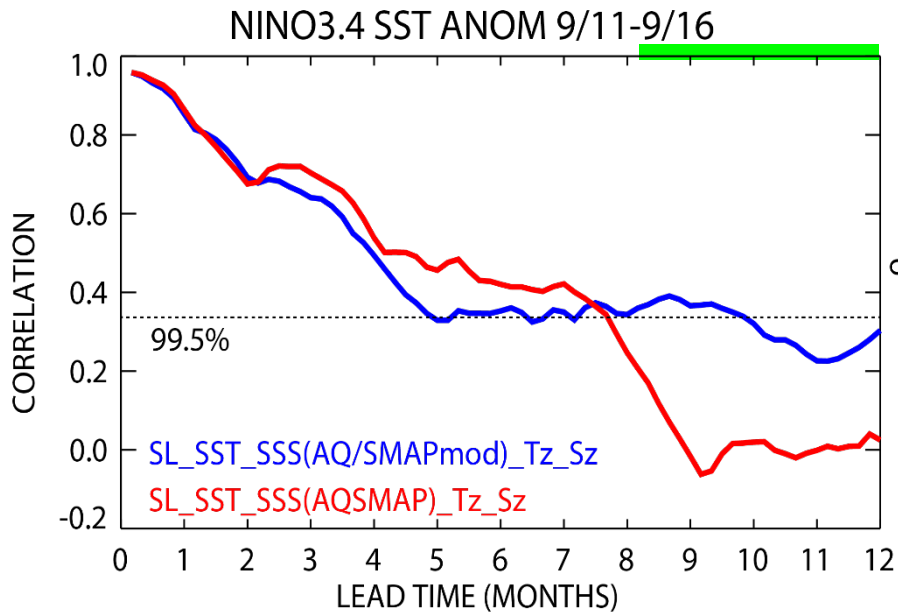
Impact of Sea Surface Salinity

Experiment Design

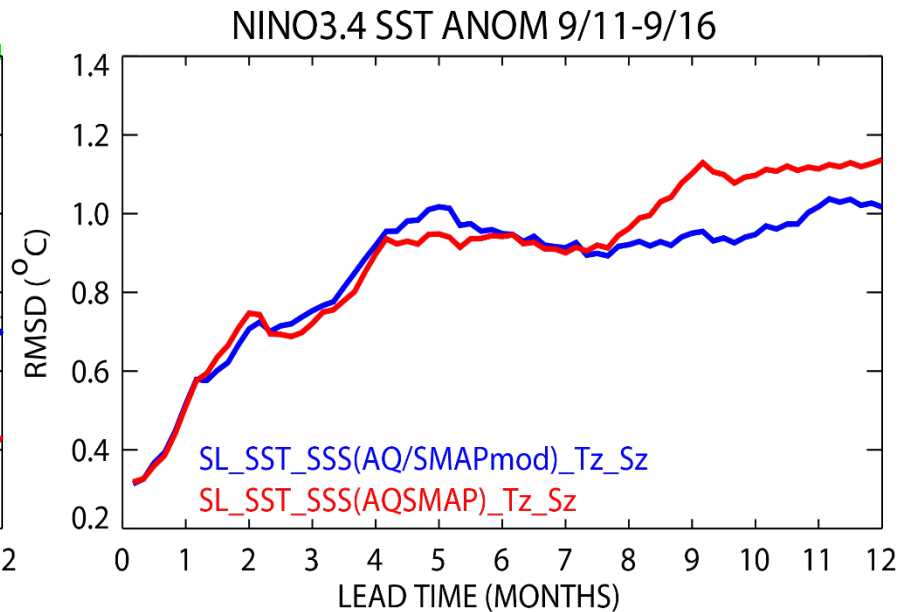
Experiment Name	Period	Assimilation Variables
ASSIM_SL_SST SSS(AQ/SMAP_mod)_T _z -S _z “AQ/SMAP MODIFIED”	Sep 2011 – Sep 2017	Level 3 SSS data from Aquarius /SMAP with (AQ-SMAP) added and SL, SST, T _z , and S _z

Coupled Model Validation

Correlation



RMS



AQ/SMAP_mod = ASSIM_SL_SST_SSS(AQ/SMAPmod)_Tz_Sz

SSS ASSIM = ASSIM_SL_SST_SSS(AQ+SMAP)_Tz_Sz

Summary

- Assimilation of Aquarius/SMAP SSS significantly improves coupled forecasts.
- SSS assimilation leads to density changes in the ML within the equatorial waveguide that act to enhance the Kelvin signal.
- Adding the AQ/SMAP bias to the SMAP data significantly improves long-lead forecasts.

Thanks!

For more information: See poster **AI14A-1557 tonight
from 4:00-6:00 PM**

