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

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Funding by NASA Ocean Salinity Science Team

Ocean Sciences 2018, Feb 12, 2018

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^{o}E-76^{o}W, 30^{o}N-30^{o}S), 1^{o}x1/3^{o} 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 (GTSPP *NODC 2006*)

Coupled Model Atmosphere

- Use anomaly coupling technique (similar to e.g. *Kroeger and Kucharski, 2011 Clim.Dyn.*)
- SPEEDY – for Simplified Parameterizations, primitivE-Equation Dynamics - Version 4.1 (*Molteni 2003 Clim.Dyn., Kucharski et al., 2006 BAMS*)
  - ~3.8^{o} 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

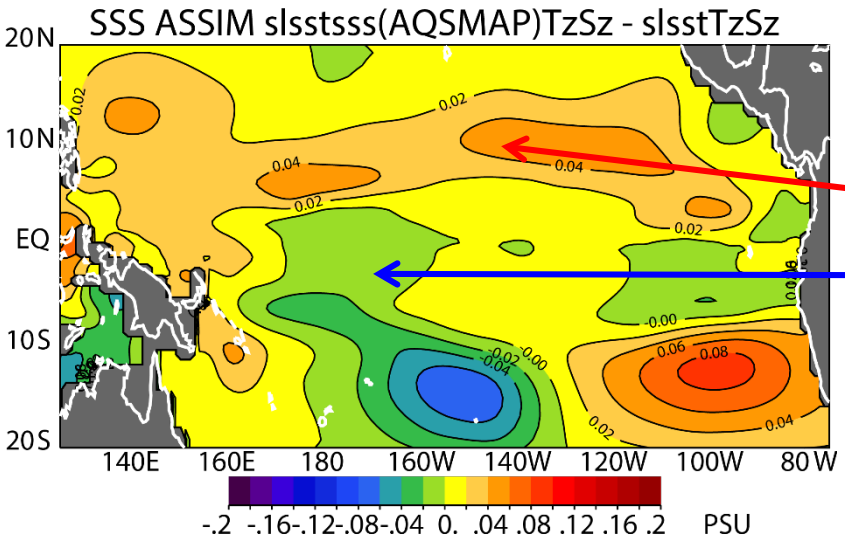
Experiment Design

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



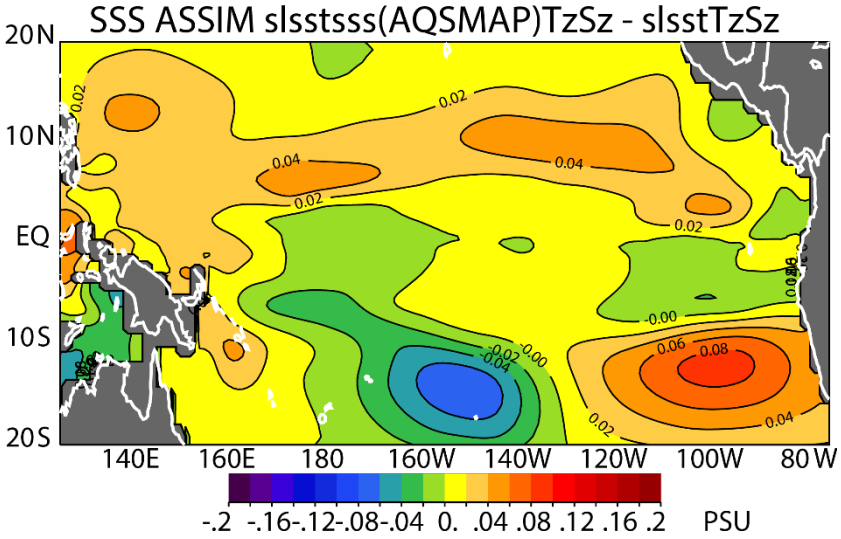
SSS

Salting near the ITCZ

Freshening at the eastern edge of the WP

Impact of Sea Surface Salinity

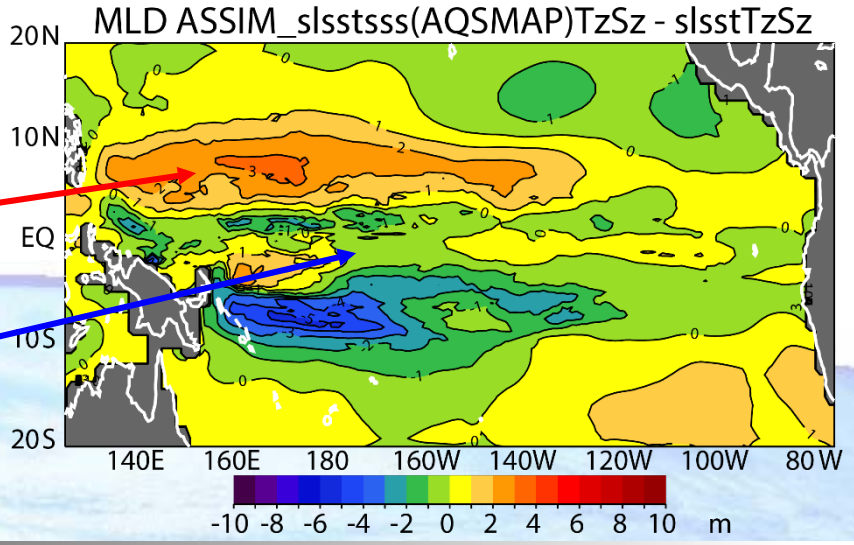
SSS ASSIM – Control



MLD

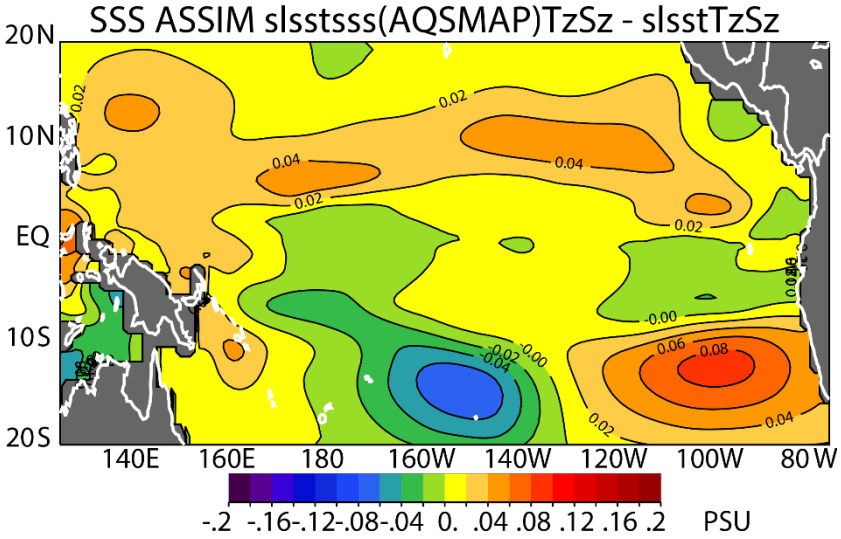
Deepening of MLD near the ITCZ

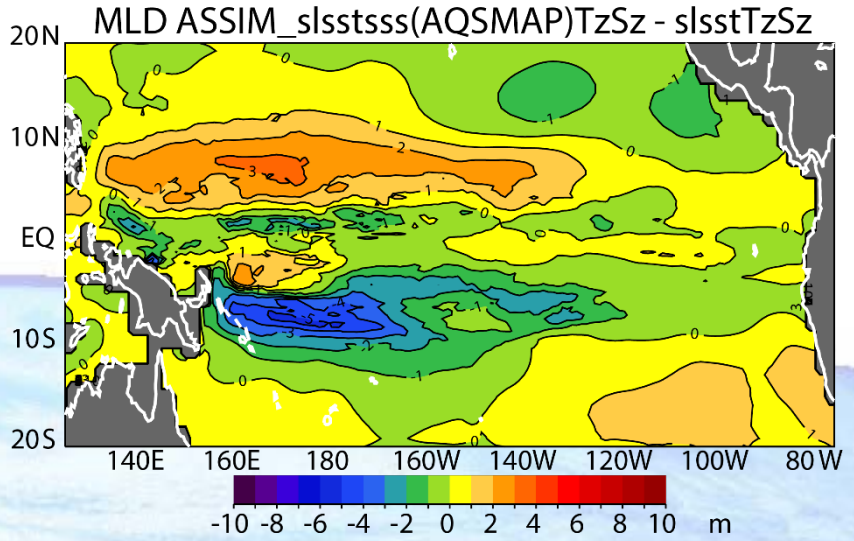
Shoaling of MLD within 15S-5N



Impact of Sea Surface Salinity

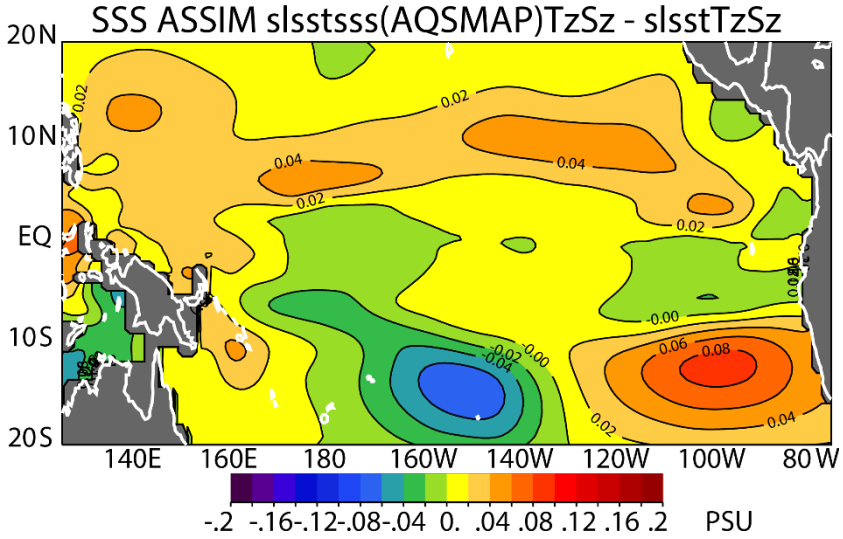
SSS ASSIM – Control

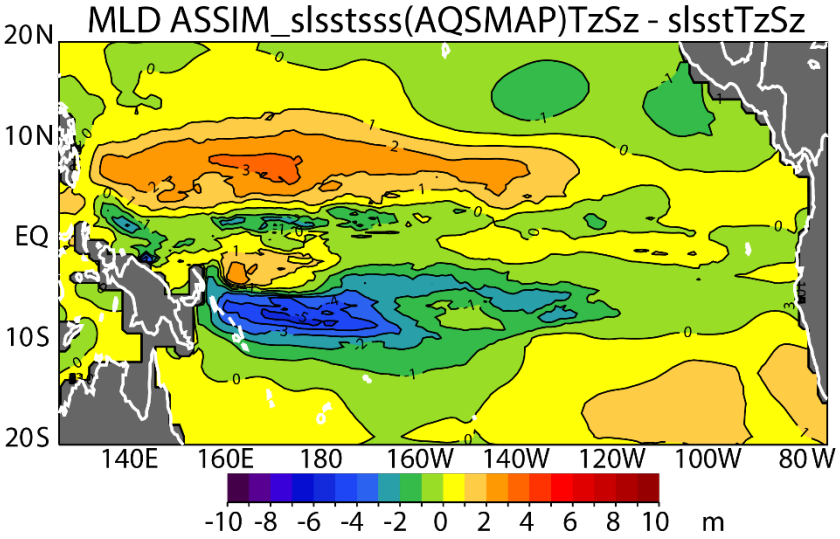


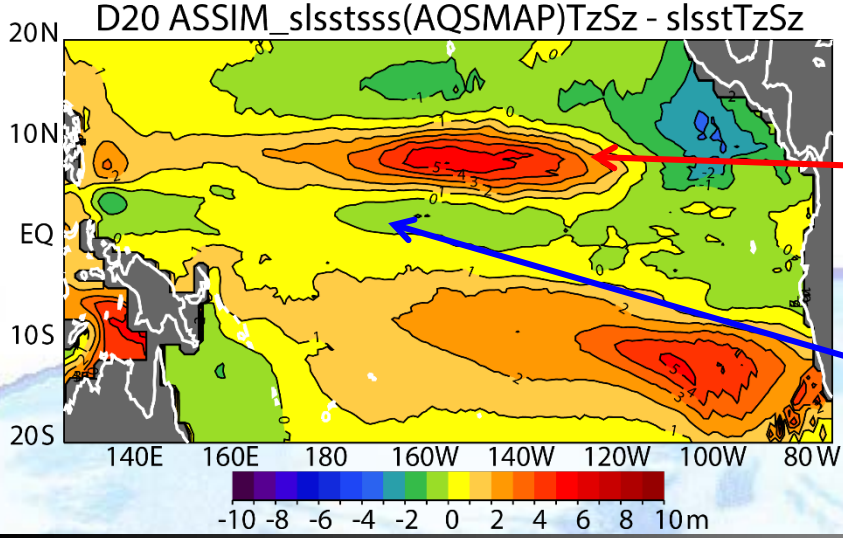


Impact of Sea Surface Salinity

SSS ASSIM – Control





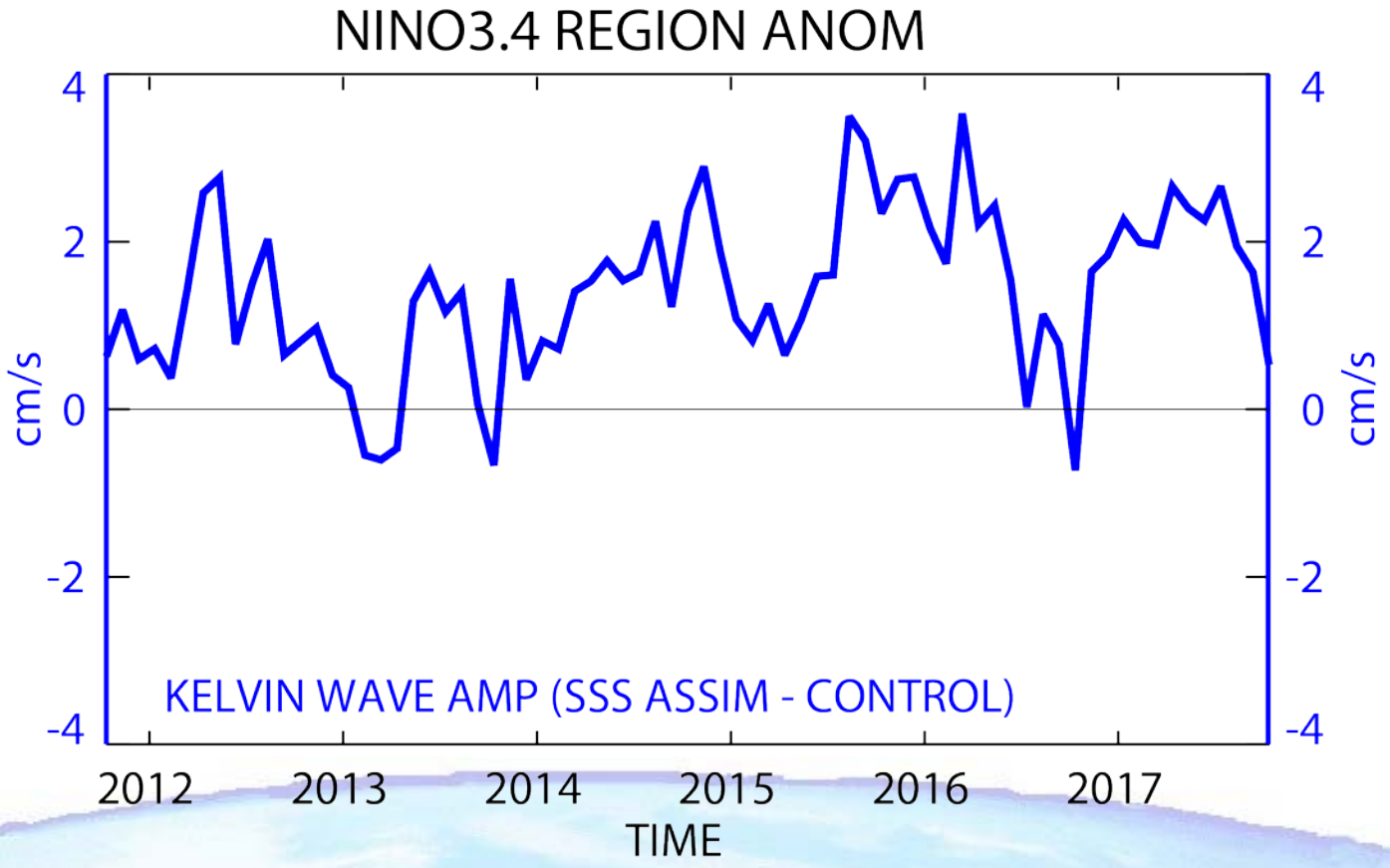


D_{20} (for thermocline depth)

Deepening the D_{20} just off the equator

Shoaling near the equator

Kelvin Amplitude



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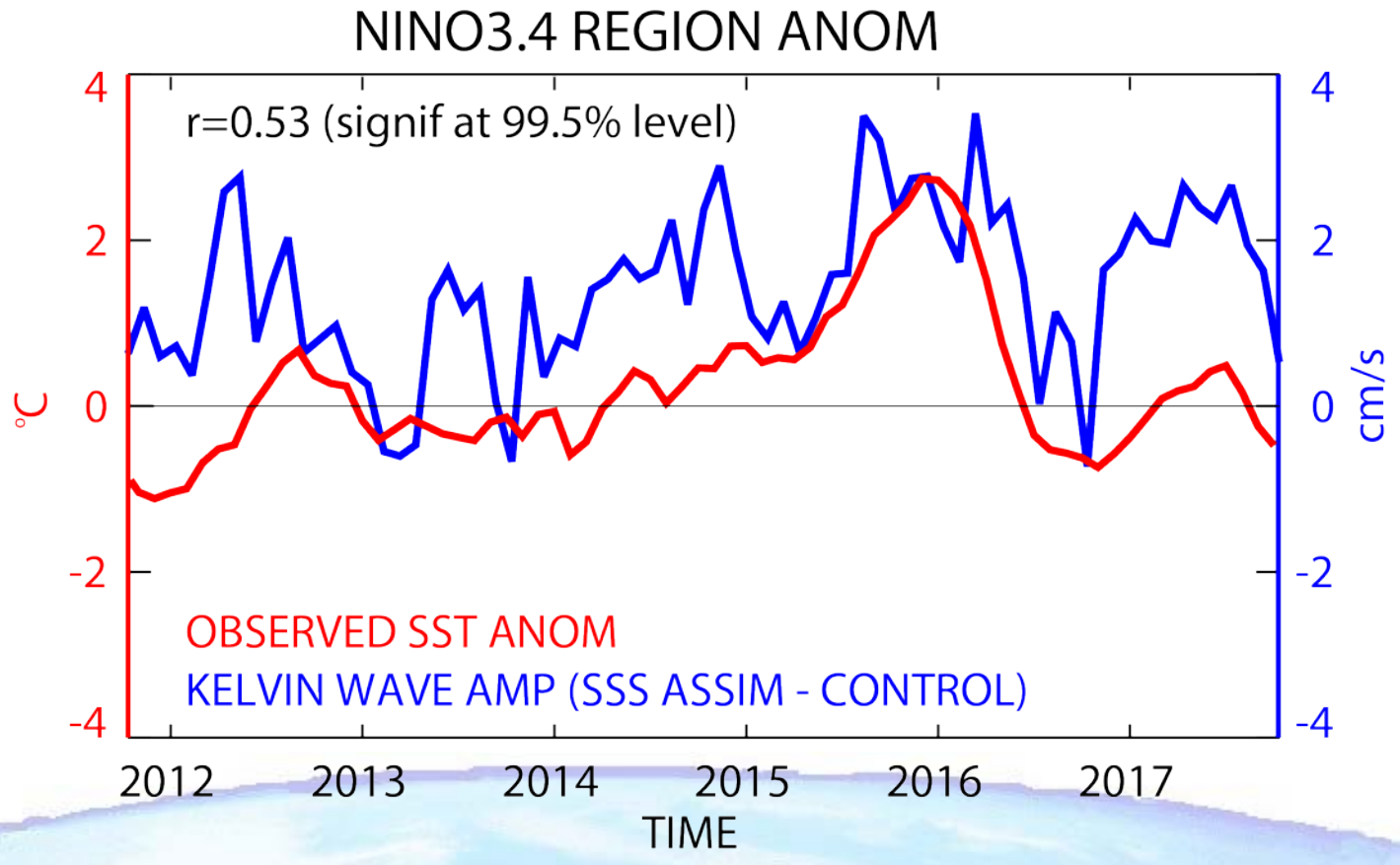
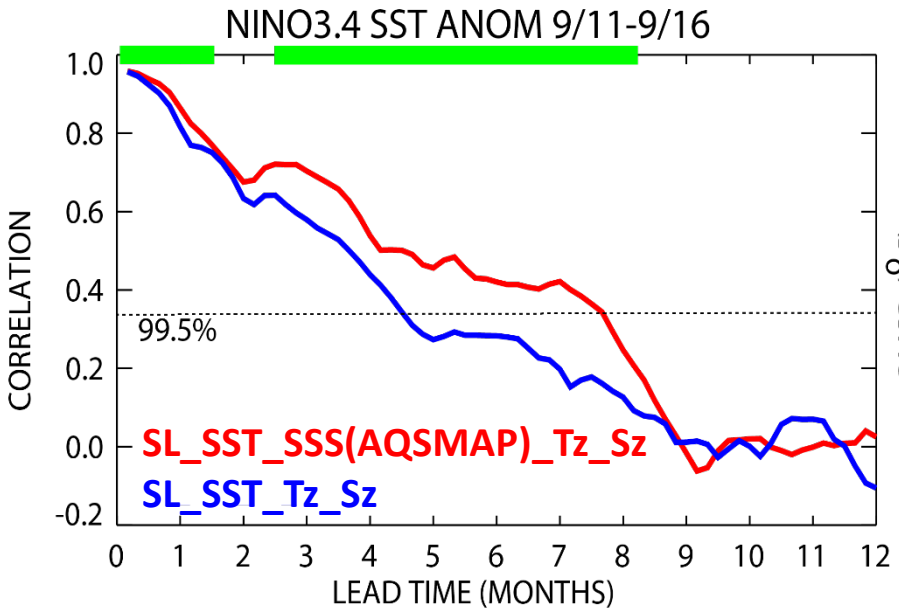
Kelvin Amplitude versus SSTA



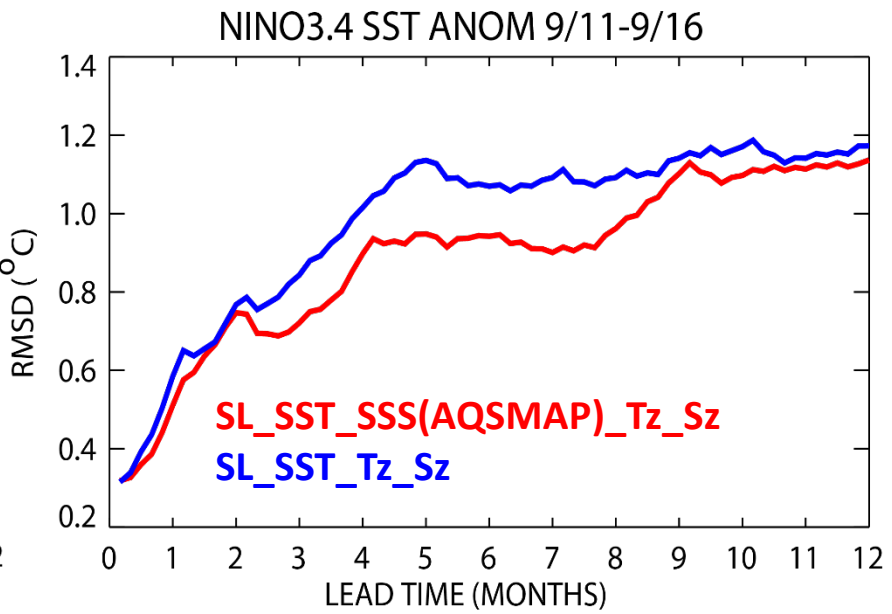
Significant correlation between obs NINO3.4 SSTA and Kelvin amplitude (SSS assimilation – control) in NINO3.4 region shows that SSS assimilation enhances Kelvin wave

Coupled Model Validation

Correlation



RMS

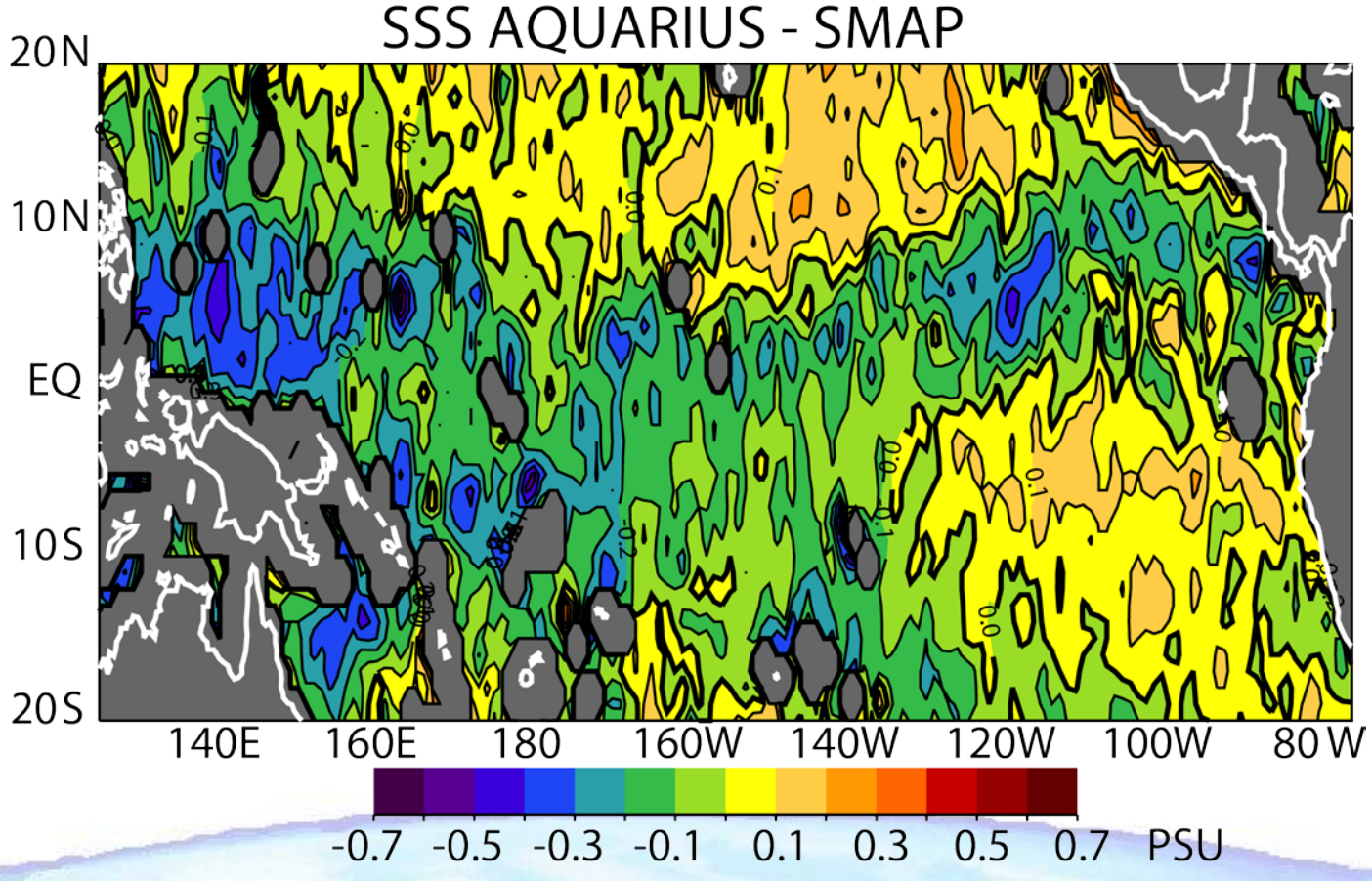


SSS ASSIM = ASSIM_SL_SST_SSS(AQ+SMAP)_Tz_Sz

Control = ASSIM_SL_SST_Tz_Sz

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

Bias Between Aquarius and SMAP



Aquarius V5
SMAP V2

April 6 – May 26, 2015

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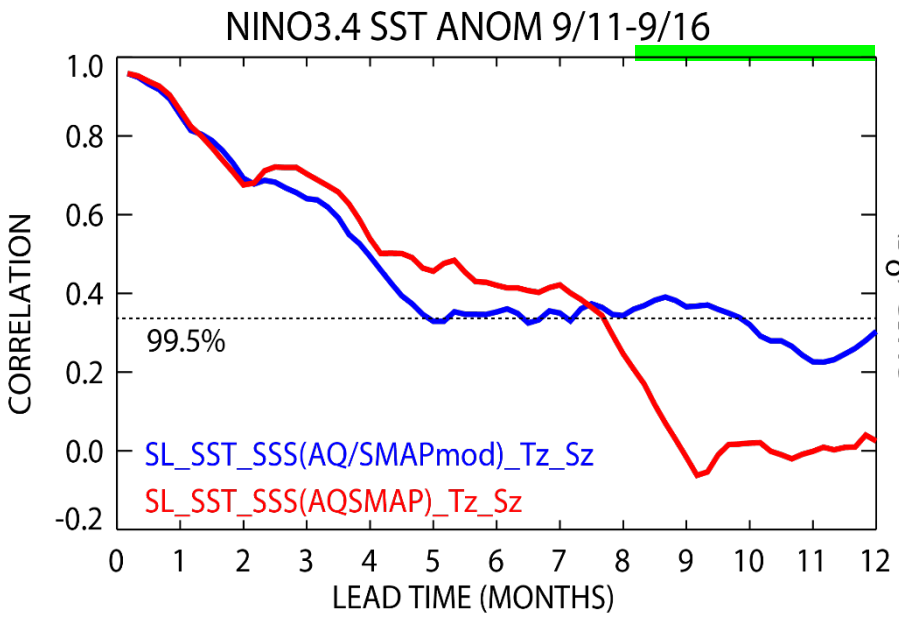
Impact of Sea Surface Salinity

Experiment Design

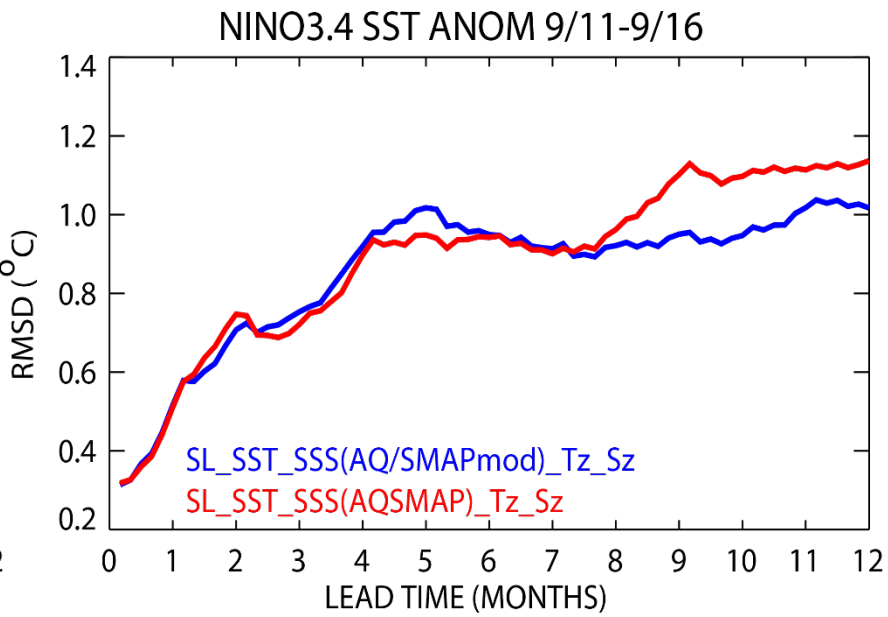
Experiment Name	Period	Assimilation Variables
ASSIM_SL_SST SSS(AQ/SMAP_mod)_T_z_S_z "AQ/SMAP MODIFIED"	Sep 2011 – Sep 2017	Level 3 SSS data from Aquarius /SMAP with (AQ–SMAP) added and SL, SST, T_z, and S_z

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