Impact of Aquarius and SMAP Sea Surface Salinity Observations on Seasonal Predictions of the 2015 El Nino
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ABSTRACT
We assess the impact of satellite sea surface salinity (SSS) observations on dynamical ENSO forecasts for the big 2015 El Nino event. From March to June 2015, the availability of two overlapping satellite SSS instruments, Aquarius and SMAP, allows a unique opportunity to compare and contrast coupled forecasts generated with the benefit of these two satellite SSS observation types. Four distinct experiments are presented that include 1) freely evolving model SSS (i.e. no satellite SSS), relaxation in 2) climatological SSS (i.e. WOA13 SSS), 3) SSS, and 4) SSS initialization. Coupled hindcasts are generated from these initial conditions for March 2015. These forecasts are then validated against observations and evaluated with respect to the observed El Nino development.

METHODOLOGY
The coupled model that is used in this project is the new S2S_v2.1 that has recently become the seasonal coupled forecast production complex coupled models (red curve) improves validation of monthly averaged anomalies from 20 freely coupled experiments relative to the control that allows SSS to vary freely with no SSS relaxation. From these initialization experiments, 12 month coupled experiments withholding SSS (blue) (e.g. Hackert et al., 2014). SSS but does replay to MERRA2 precipitation.

EXPERIMENT DESIGN
Starting from May 2012 separate spin-up experiments were executed that relax to the seasonal cycle of various SSS gridded products including WOA13 (Garcia et al., 2013), Aquarius V4 (Lilly and Lagerloef, 2008), and SMAP V2 (Meissner and Wentz, 2016) along with the control that allows SSS to vary freely with no SSS relaxation. From these initialization experiments, 12 month coupled experiments are initialized every 5 days spanning March 2015. These results are then compared against observed values (Lilly et al., 2002, 2003) and against observations from March 2015 ICs. WOA and S2S observations and SMAP have somewhat warm SSS patterns - fresh in far western Pacific, ITZC and SPCZ and show a predominance of upwelling (with respect to observations) and enhanced warming in the eastern half of the Pacific. Note that the salty IC and shallower MLD for SMAP results makes this product more susceptible to upwelling and cooler eastern Pacific SST anomalies.

CONCLUSIONS
1) Relaxation using Aquarius V4 or WOA13 slightly improves validation of the reanalysis (including ADT and T00-100m) statistics. 2) At forecast initialization, too salty SSS for SMAP within 10° of the equator leads to deeper MLD west of 165°W. This deeper MLD leads to damping of the downwelling signal (i.e. relative upwelling), in turn leading to relatively too cool ENSO forecasts. 3) Plume plots of NINO3.4 forecasts show that ensembles created using relaxation to Aquarius result in a slight improvement with respect WOA13. Also salty SMAP relaxation leads to a consistently cool bias in the forecasts. 4) We acknowledge the immaturity of the SMAP v2 product. Therefore, we anticipate that SMAP algorithm development will lead to reduced SSS biases and lead to improved initialization of coupled forecasts.

ENSO Plume Forecasts – March 2015
(Left) Average of all ensembles of coupled model forecasts for Mar 2015 IC. WOA and S2S have some warm forecasts, Aquarius straddles observations and SMAP initialization leads to too cool ENSO prediction. For each forecast, the model trend (calculated over 1982-2018) has been removed. (Right) Average of Forecasts (Mar12, Mar17, Mar22, Mar27) SST Forecast for Peak of El Nino

Dec 2015 forecast SSS from Mar 2015 IC – All model results show similar SSS patterns - fresh in far western Pacific, ITZC and SPCC and salty bias within 10° of the equator especially at the eastern edge of the fresh pool. SMAP SSS has biggest values centered at 165°W. Increased SSS should tend to deepen the MLD in the central Pacific.

ENSO Plume Results for March 2015 Forecasts
(Left) Average of Forecasts (Mar12, Mar17, Mar22, Mar27) SST Forecast for Peak of El Nino

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