Assessment of Sea Surface Salinity Products Using a Coupled ENSO Prediction Model

E. Hackert, R. Kovach, J. Ballabrera-Poy, A.J. Busalacchi, and G. Vernieres

ABSTRACT
We assess the impact of satellite sea surface salinity (SSS) observations on seasonal to interannual variability of tropical Indo-Pacific Ocean dynamics as well as on dynamical ENSO forecasts. Twelve-month forecasts are initialized for each month from September 2011 to September 2017. All experiments assimilate satellite sea level (SL), sea surface temperature (SST), and in situ subsurface salinity and temperature observations. Additionally various satellite, blended, and in situ SSS products are assimilated. Using our intermediate-complexity coupled model as a transfer function, we test if more mature SSS model algorithms actually improve ENSO forecast skill. We find that including satellite SSS significantly improves Niño3.4 sea surface temperature anomaly validation, more mature SSS model algorithms are generally improving ENSO forecasts over time, and more satellite SSS helps to extend useful forecasts.

METHODODOLOGY
Our intermediate-complexity coupled model uses the anomaly coupling technique (e.g. Knoefer and Kucharski, 2011) and is comprised of the reduced-gravity, primitive equation, sigma-coordinate ocean model (Gent and Cove, 1989) that is coupled with the global SPEEZY atmospheric model (Mofton et al., 2003; Kucharski et al., 2008). The Ensemble Reduced Order Kalman Filter (EROKF) assimilates observations to constrain dynamics and thermodynamics for initialization of the coupled system.

Ocean Model – Encompasses the tropical Indo-Pacific (3°F–76°W, 38°F–30°F), resolution of 2°×2° stretched, 20 layers (~1500 m), includes river contribution (Nei and Trenberth, 2002). Forcing by MERRA reanalysis (Gelaro et al., 2017).

Atmospheric Model – SPEEZY for simplified Parameterizations, primitive equation (Gent). Version 4.1 (Mofton 2001, Kucharski et al., 2006) – 3β8° resolution, 8 levels (925-30mb). Winds improved using consecutive momentum transport of Kim et al., 2008. SST is supplied by the model within Indo-Pacific region and by HadISST (Rayner et al., 2003) outside.

EROKF Data Assimilation Technique - Assimilate SL (Multi-satellite product of Aviso, 2013); SST (Raymold et al., 2002) and T, S (GTSPP NODC 2008). Additionally assimilate satellite, blended and in situ gridded (33) SSS products described in the table below.

EXPERIMENT DESIGN

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CONCLUSIONS
1) Including satellite SSS significantly improves Niño3.4 sea surface temperature anomaly validation.
2) For initialization of the coupled forecast, the positive impact of SSS assimilation is brought about by surface freshening near the eastern edge of the western Pacific warm pool and density changes that lead to shallower mixed layer between 10°S-5°N. In addition, salting near the ITZ leads to a deepening of the mixed layer and thermocline near 8°F. These patterns together provide the background state to amplify equatorial Kelvin waves and ENSO signal.
3) Our intermediate complexity coupled model is routinely used as a transfer function to test SSS model and product development.
4) Additional experiments are presented that demonstrate that more mature SSS algorithms lead to better ENSO predictions. In addition, the more satellite SSS data, the better the ENSO forecast.

Evaluating the coupled results using observed Niño3.4 SST, Correlation (r) is significantly higher and RMSE (r) is lower for SSS assimilation, no SSS assimilation. The relative low-cost of our intermediate-complexity coupled model allows us to use this a transfer function to test SSS model algorithm developments. Correlation is measured by the Steiger’s 2 statistics – dashed line.

Validation of the coupled results using observed Niño3.4 SST. Correlation (r) is significantly higher and RMSE (r) is lower for SSS assimilation vs. No SSS assimilation. The relative low-cost of our intermediate-complexity coupled model allows us to use this as a transfer function to test SSS model algorithm developments. Correlation is measured by the Steiger’s 2 statistics – dashed line.

The new SMOSv3 SSS model algorithm is tested against SMOSv2.1 (Bustin et al., 2017). Both have relatively similar validation statistics.

Comparison of gridded SSS fields are presented for Aquarius v5 combined with SMAPv4.1 versus SMAPv4 (Foré et al., 2016). Note that the new SMAPv4.1 is generally a slight (but not significant) improvement upon SMAPv4.

Results show that combination of SMOSv2.1 + Aquarius + SMAPv4 outperforms both SMOSv2.1 and Aquarius + SMAPv4 especially after 6 month forecasts.

The more satellite SSS data, the better for prediction of ENSO.

Note that SMOSv2.1 and the combination of Aquarius + SMAPv4 are statistically indistinguishable from one another.

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