**Submission Title:**

Improving ocean reanalyses and ENSO forecasts by assimilation of rain corrected satellite sea surface salinity using the GMAO S2S Forecast System

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**Abstract**

During the past years, we have seen that the La Nina to El Nino transition has had a significant global socio-economic impact and so has been the key focus for improving coupled ocean-atmosphere forecasts. Assimilation of satellite altimetry and subsurface temperature and salinity from (mostly) Argo help to improve the initialization of the thermocline, while satellite Sea Surface Temperature (SST) aids in constraining surface heat-fluxes, leading to improved subseasonal to seasonal forecasts of the coupled system. However, few studies have focused on improving the fresh-water flux and near-surface density and mixing through assimilation of satellite sea surface salinity (SSS).

For expediency, the few ocean models that do assimilate SSS bias-correct the satellite SSS data to normalize towards the near-surface Argo data. However, in rainy regions, where buoyant water sits as a fresh lens at the surface, this assumption is likely inadequate. In previous work, we have shown that adjusting SSS data to bulk salinity (Sb) using the Rain Impact Model (RIM) of Santos-Garcia et al., 2014 has improved the near-surface density and mixed layer depth, leading to deeper thermocline and improved the NINO3.4 SST forecasts. Now we utilize the Soil Moisture/Ocean Salinity, Rain Corrected (SMOS_RC) SSS product provided by the Centre Aval de Traitement des données SMOS (CATDS CPDC) to represent the Sb more accurately at first model layer (in our case 5 m). Rather than using a diffusivity model as with RIM, SMOS_RC relies on an observed relationship between the spatial heterogeneity of SMOS SSS and instantaneous rain rate (RR) (Supply et al., 2020).

In order to test the impact of SMOS_RC versus SMOS, we compare two reanalyses over the period 2014 to 2021. For both reanalysis experiments, all available along-track absolute dynamic topography and in situ observations are assimilated using the LETKF scheme (Penny et al., 2013). One reanalysis additionally assimilates SMOS SSS data as is (i.e., with the fresh bias), and a separate reanalysis is performed assimilating the SMOS_RC data. We assess the impact for near-surface and subsurface dynamics within ocean reanalyses by validating against observations and explore how SSS assimilation (SMOS versus SMOS_RC) impacts dynamical ENSO forecasts using the NASA GMAO Sub-seasonal to Seasonal coupled forecast system (GEOS S2S-3, Molod et al., 2020, Hackert et al., 2023). We will show that improved SSS estimates and near-surface density and mixing led to more accurate coupled air/sea interaction and better ENSO forecasts.