Preliminary Results from Assimilating SMOS-mission Satellite Sea-Surface Salinity Fields in an NCEP Operational Ocean Forecast System

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Recently available satellite sea-surface salinity (SSS) fields provide important global data for assimilating into ocean forecast systems. Although an ocean state variable, previous measurements comprised only *in situ* observations, which were and continue to be extremely sparse in time and space; although, *in situ* salinity observations have notably increased through the Argo float program. The European Space Agency's (ESA) Soil Moisture – Ocean Salinity (SMOS) mission, launched in 2009, began providing the first repeated global higher spatial and temporal resolution coverage of SSS. Here, we present results from assimilating SMOS SSS data into National Oceanic and Atmospheric Administration's (NOAA) operational Modular Ocean Model version 4 (MOM4), the modeling platform of NOAA's Global Ocean Data Assimilation System (GODAS) and the ocean component of NOAA's seasonal-interannual Climate Forecast System (CFS). This study employed SMOS Barcelona Expert Centre (SMOS-BEC) 0.25-degree gridded SSS fields for 2010-2012, averaged over a 3-day rolling window and updated every 3 days. The global NCEP ocean model, spanning 81S-90N and employing 0.5-degree zonal resolution with variable meridional resolution of 0.5 degrees or less, provides a fast and robust platform for analyzing ocean dynamics at greater than eddy-resolving spatial scales. Forcing this model with NOAA's daily Climate Forecast System Reanalysis (CFSR) fluxes, we assimilate the SMOS SSS fields using a relaxation technique, running sensitivity experiments with different relaxation time periods to evaluate the importance of high-frequency (daily to mesoscale) and low-frequency (seasonal) SSS variability on the ocean's overall state. Four SSS fields provide the basis for this assessment: a) SSS.0 - SMOS-BEC SSS data; b) SSS.1 – base line unconstrained model values (no SSS assimilation); c) SSS.2 - model values constrained by SMOS SSS (SSS.0); and (d) SSS.3 - model values constrained by NOAA's 2009 World Ocean Atlas monthly climatological SSS.

To establish robustness, we examine the global signal-to-error ratio for SSS.1 data—the unconstrained ocean model SSS values, divided by the error estimates provided for the SMOS SSS data—to identify the oceanic regions and frequency bands for which the SMOS SSS fields can reliably and significantly improve the oceanic state and initialization of coupled forecast models. We then apply the Empirical Orthogonal Function (EOF) technique to analyze the SSS field's modes of variability in the tropical Pacific, a domain where oceanic dynamics are dominated by El Niño interannual variability in the cold tongue region and by high-frequency precipitation events in the western Pacific warm pool region. We expect that assimilating salinity fields at the sea surface will impact surface circulation and, through changes in baroclinic pressure gradients, the three-dimensional circulation patterns in the upper ocean. Thus, we examine changes in upper-ocean heat content, mixed-layer depths, and velocity in the top 300 m of the water column. It is shown here that assimilating surface salinity fields causes significant seasonal and interannual changes in the three-dimensional circulation patterns of mass, momentum, and heat in model results. Finally, preliminary verification studies are conducted using independent variables, such as sea-surface height (SSH) and velocity, to show that SSS improves ocean state representation. The observations used in this study are global merged satellite SSH fields and daily vertical profiles of scalars (temperature, salinity and velocity) from two fixed-location buoys located in the western Pacific warm pool and eastern Pacific cold tongue regions. Our results show that SMOS SSS fields help improve the simulated ocean state, thus providing better initialization of coupled seasonal and tropical cyclone forecast systems.