I. Introduction

Due to near-surface salinity stratification [e.g., Alory et al. 2012; Boutin et al. 2013; Drucker & Riser 2014], it is problematic to compare satellite-measured surface salinity within the first few centimeters (skin-layer) of the ocean with Argo-measured top-level salinity at about 5 m, or with ocean models that do not resolve the skin layer. Although an instrument can be designed to measure the surface salinity, a global scale measurement is currently not available. A regional model can be configured to have a vertical grid in centimeters, but it would be computationally prohibited on a global scale due to time step constraints.

II. Extended Surface-Salinity Layer (ESSL)

Here, we propose an extended surface-salinity layer (ESSL) within a global ocean circulation model to diagnose skin SSS without increasing the computational cost, while allowing comparable solutions with both satellite and Argo salinity at the respective depths.

Regional Averages:

![Fig. 1 Schematics of the extended surface salinity layer (ESSL). The surface point represents the extended surface salinity (ESS). In the equations, \( \Delta S \) is the difference between the top (S1) and the middle (S2) of the layer, \( h \) is the thickness of the top layer of the model, \( C_{F1} \) and \( C_{F2} \) are the correlation function between S1 and E-P, and c0, c1, and c2 are constants.]

![Fig. 2 Regional improvement in: (a) Eastern Indian Ocean from 50°E to 90°E and 10°S to 10°N, (b) Eastern Pacific Ocean from 160°W to 100°W and Equator to 20°N, (c) Eastern Atlantic Ocean from 0°W to 20°W and 10°S to 10°N, and (d) Tropical oceans from 20°S to 20°N.]

![Fig. 3 Annual amplitude (left panels) and phase (right panels) maps from (a-b) Aquarius v3.0 SSS, (c-d) NB-ROMS ESS, (e-f) Argo SSS, and (g-h) HYCOM SSS. Color bars are 34.8 psu, 15 m, 10 m, and 34 psu, respectively. Notice the well-mixed layer salinity, seasonal variability, and surface precipitation.]

![Fig. 4 Vertical profile differences (amplitude of seasonal variability) averaged in (a) South Arabian Sea, (b) North Tropical Pacific, (c) Tropical Atlantic, (d) South Tropical Indian, (e) South Tropical Pacific, and (f) Eastern Tropical Pacific. Notice the well-mixed profile in the South Arabian Sea is due to seasonally reversing ocean currents and monsoon wind, as discussed in Moon and Song [2014].]

III. Validations

Four datasets (two Aquarius SSS products, Argo salinity data, and the data-assimilated HYCOM outputs) have been used in the validation.

Seasonal Variability:

![Fig. 5 After correcting an offset of 0.07 PSU, the two Aquarius products and model ESS agree very well in both (a) global and (c) tropical averages. In addition, the agreement between Argo and models in the sub-surface salinity (at 10 m) are also improved significantly in both (b) global and (d) tropical averages.]

Vertical Profiles:

![Fig. 6 Vertical profile differences (amplitude of seasonal variability) averaged in (a) South Arabian Sea, (b) North Tropical Pacific, (c) Tropical Atlantic, (d) South Tropical Indian, (e) South Tropical Pacific, and (f) Eastern Tropical Pacific. Notice the well-mixed profile in the South Arabian Sea is due to seasonally reversing ocean currents and monsoon wind, as discussed in Moon and Song [2014].]