Modeling Satellited-Measured Skin-Layer Salinity with an Extended Surface-Salinity Layer

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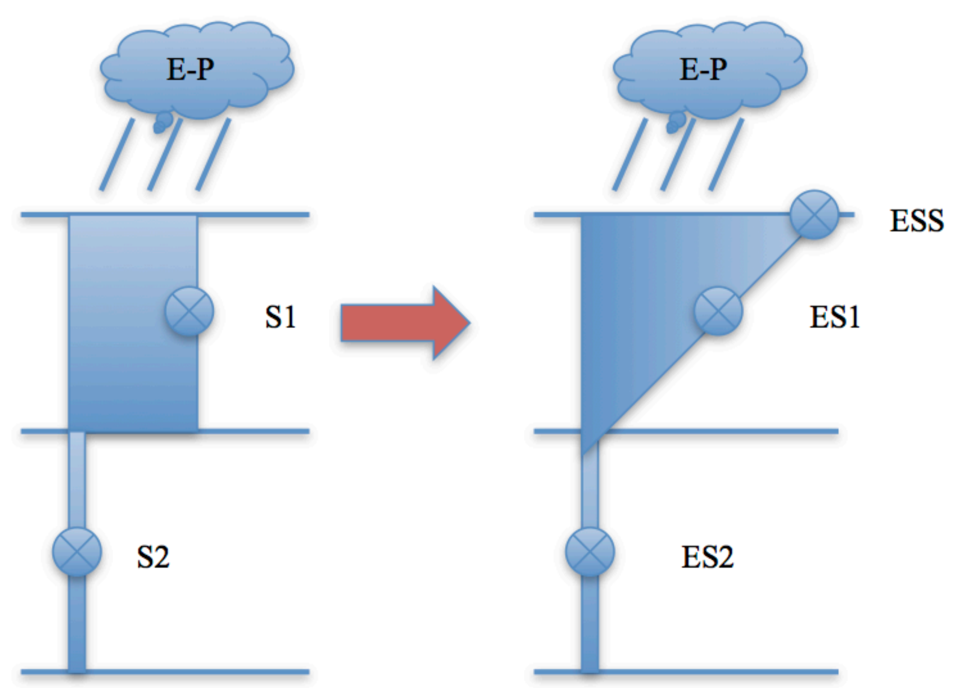
I. Introduction

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.



$$\frac{\partial S_1}{\partial t} = \frac{(E-P)}{h} S_1 + OD$$

$$ESS = S_1 + \Delta S \cdot CF \cdot c_0 \quad (2)$$

$$ES_1 = S_1 - \Delta S \cdot CF \cdot c_1 \quad (3)$$

$$ES_2 = S_2 - \Delta S \cdot CF \cdot c_2 \quad (4)$$

Fig. 1 Schematics of the extended surface salinity layer (ESSL). The surface point represents the extended surface salinity (ESS). In the equations, $\Delta S = S1 - S2$, CF is the correlation function between S1 and E-P, and c0, c1, and c2 are constants.

Regional Averages:

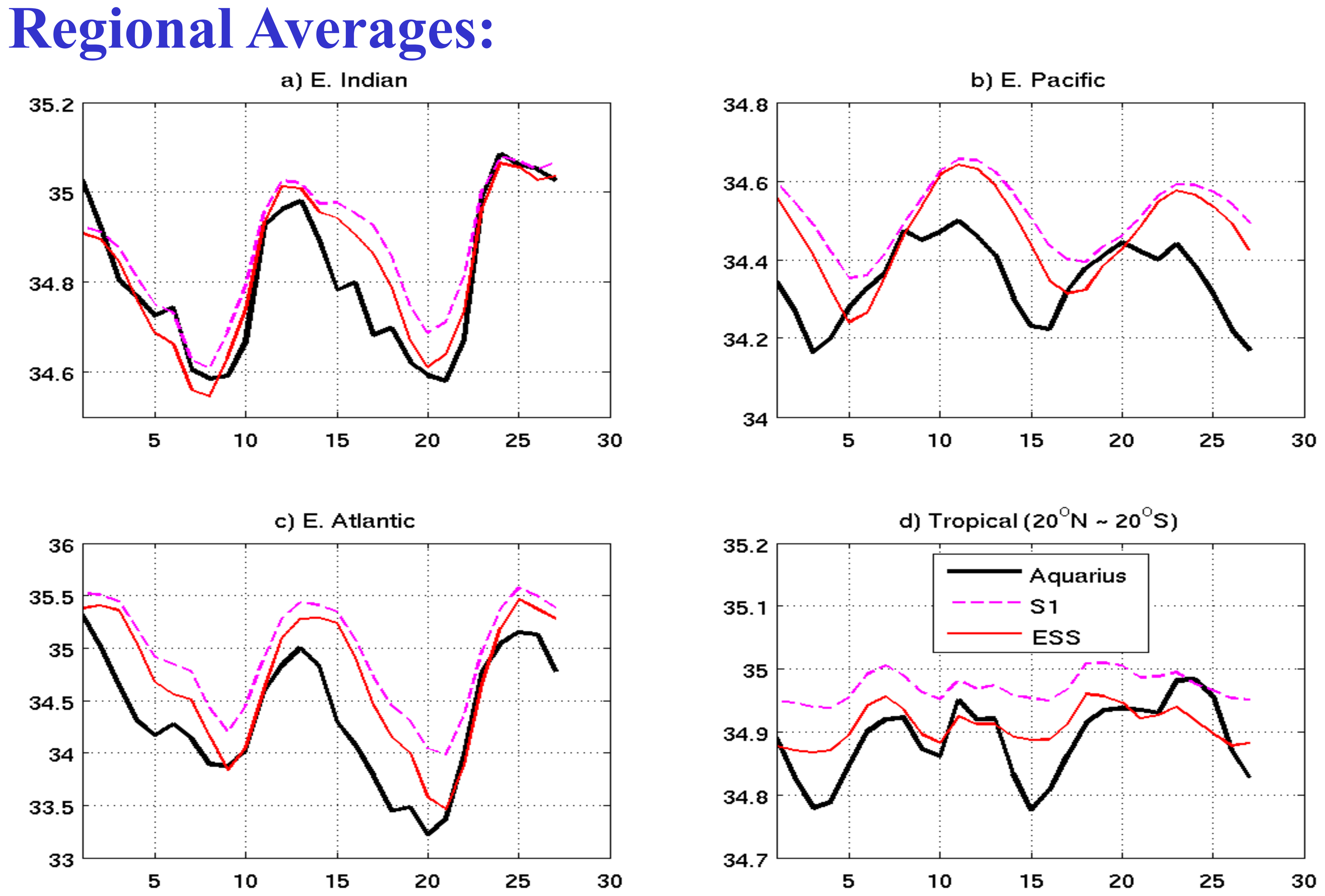


Fig. 2 Regional improvement in: (a) Eastern Indian Ocean from 50°E to 90°E and 10°S to 10°N, (b) Eastern Pacific Ocean from 160°W to 100°W and Equator to 20°N, (c) Eastern Atlantic Ocean from 0°W to 20°W and 10°S to 10°N, and (d) Tropical oceans from 20°S to 20°N.

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:

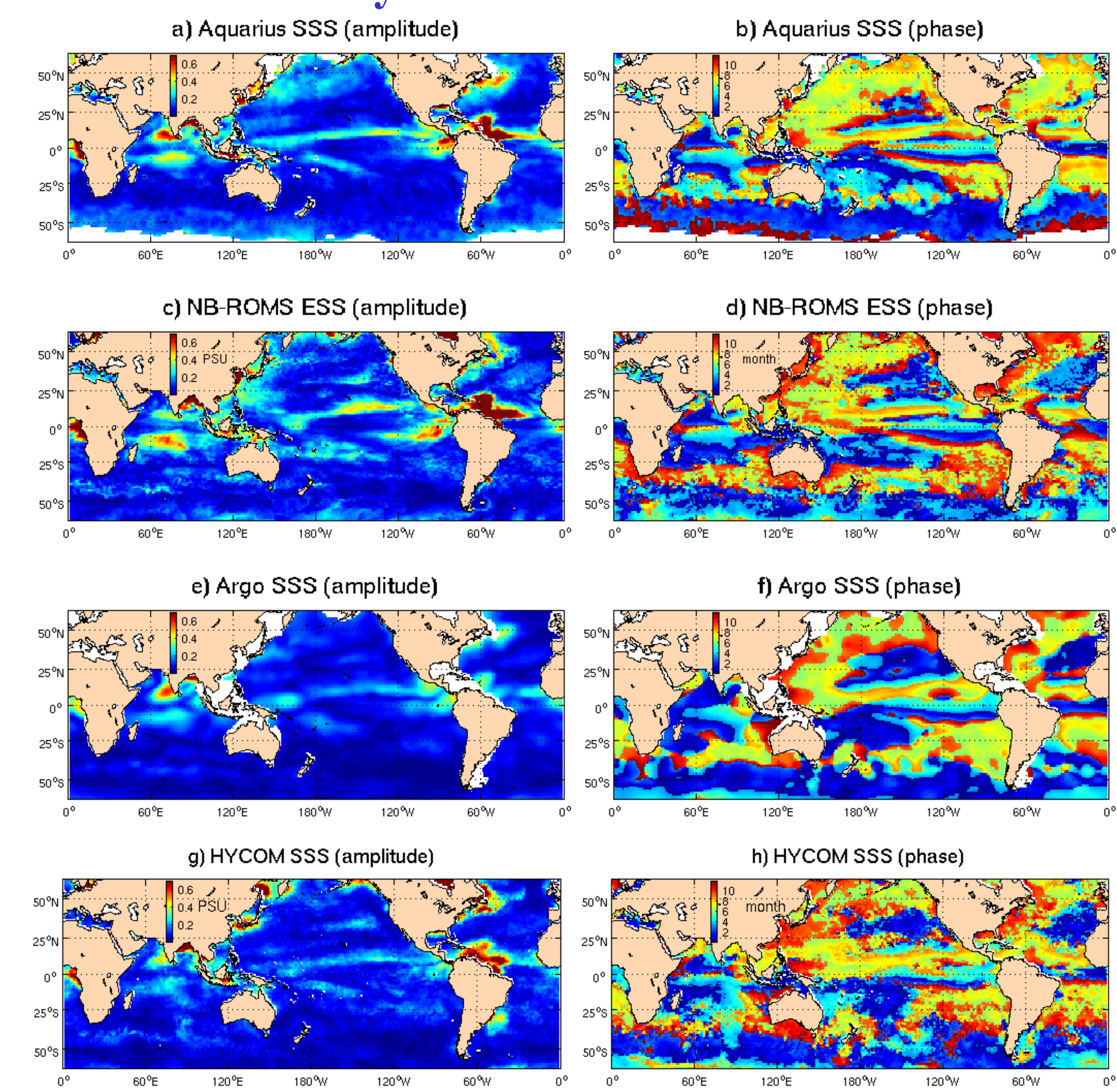


Fig. 3 Annual amplitude (left panels) and phase (right panels) maps from (a-b) Aquarius v3.0 SSS, (c-d) NB-ROMS ESS, (e-f) Argo SSS, and (g-h) HYCOM SSS. Color bars are PSU and monthly scales, respectively. Notice that the ESS matches Aquarius SSS with stronger seasonal variability than Argo and HYCOM SSS without effect on the annual phase that matches the Argo phase well. Color bars are PSU and monthly scales.

Vertical Profiles:

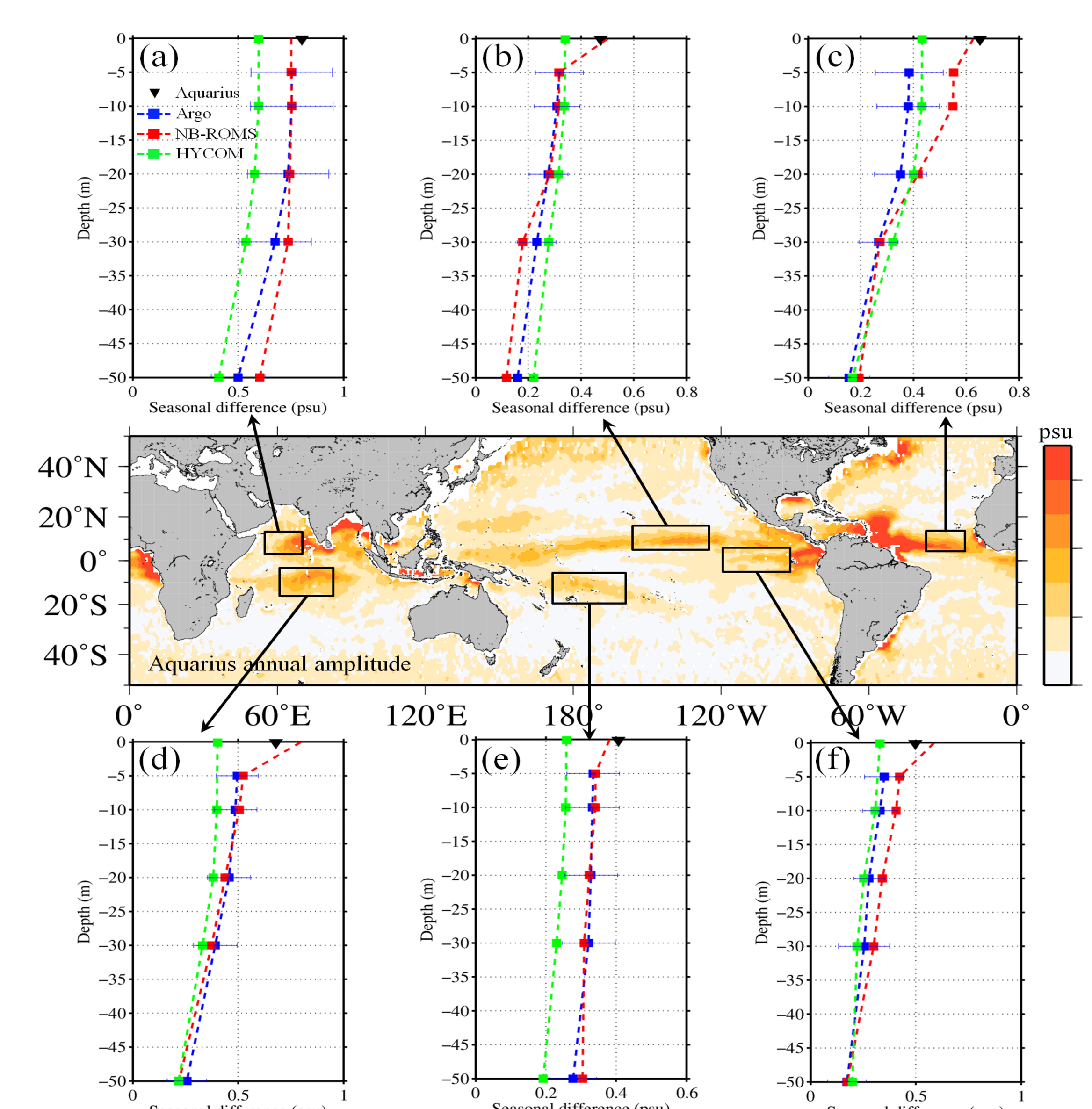


Fig. 4 Vertical profile differences (amplitude of seasonal variability) averaged in (a) South Arabian Sea, (b) North Tropical Pacific, (c) Tropical Atlantic, (d) South Tropical Indian, (e) South Tropical Pacific, and (f) Eastern Tropical Pacific. Notice the well-mixed profile in the South Arabian Sea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

IV. Global Mean SSS and Reference State

Note that Aquarius SSS products are retrieved from surface brightness temperature rather than a direct measurement of the salt content. Therefore, the global mean SSS cannot be obtained by Aquarius alone and a reference state has to be determined elsewhere. Here we demonstrate that the proposed ESSL can be used to determine the reference state of global SSS.

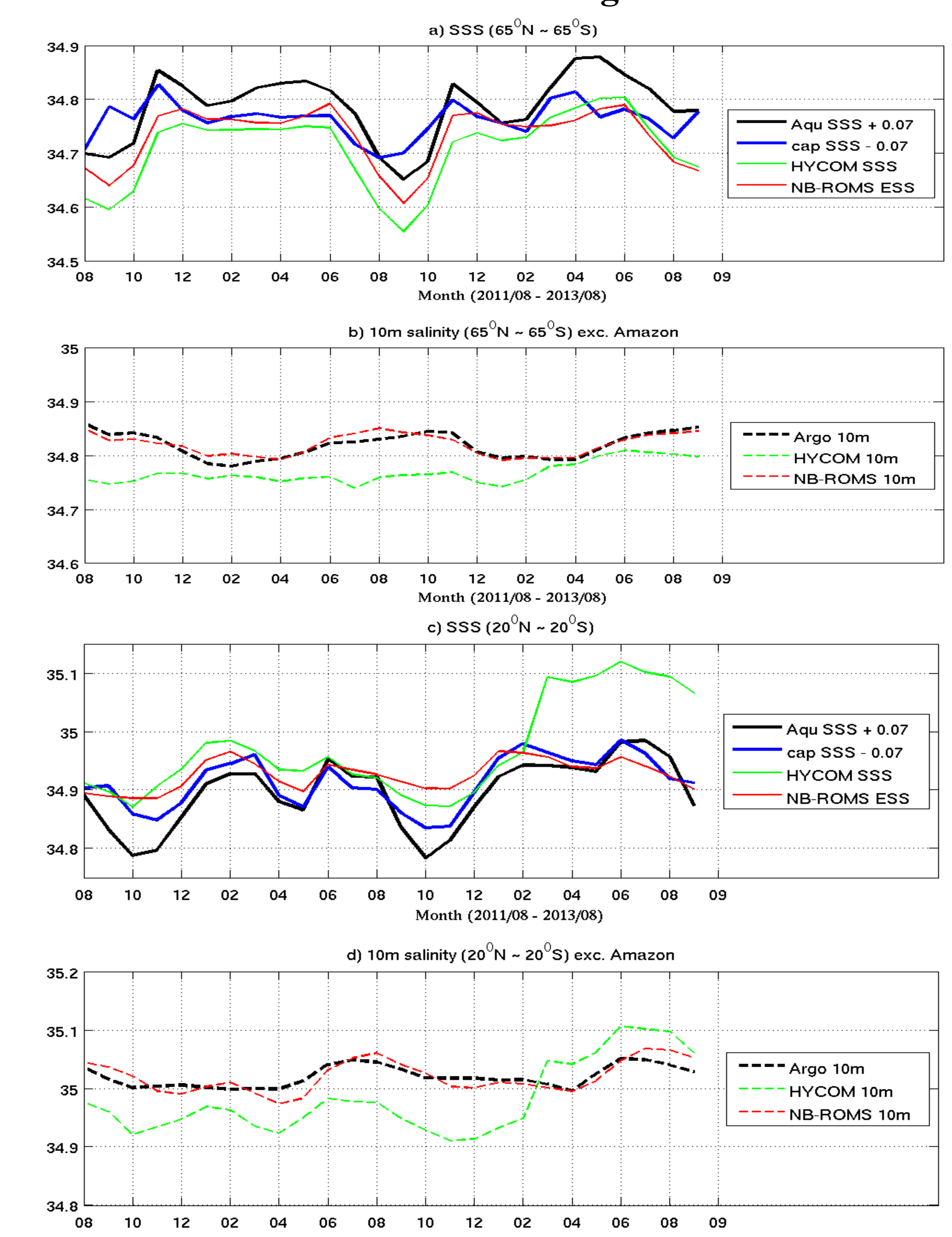


Fig. 5 After correcting an offset of 0.07 PSU, the two Aquarius products and model ESS agree very well in both (a) global and (c) tropical averages.
In addition, the agreement between Argo and models in the sub-surface salinity (at 10 m) are also improved significantly in both (b) global and (d) tropical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

V. Summary

1. Comparisons with the Aquarius SSS and Argo salinity show that the ESSL improves near-surface salinity significantly.
2. Comparisons with data-assimilated HYCOM results reveal that the ESSL provides much stronger seasonal variability of SSS, similar to the Aquarius observations.
3. It also demonstrates that the ESSL solution can be used to constrain the global mean SSS in Aquarius SSS retrieval.

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