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Improving ocean reanalysis & ENSO forecasts by assimilation of rain-corrected SSS using the GMAO S2S Forecast System

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RATIONALE:

- **Assimilating satellite surface salinity (SSS) improves global modeling systems simulations** and, thus, El Niño forecasting in the Central Pacific (i.e., Niño 3.4) (Hackert et al. 2019, 2020).
- However, **SSS (skin salinity) is assimilated into the first layer of the ocean model** (i.e., 5 m depth) **as bulk salinity, creating an over-freshened surface state, especially in regions with high precipitation**.
- Transforming SSS to bulk salinity has been attempted by implementing a diffusion model (Hackert et al. 2020), rendering improved results for El Niño prediction.
- The Ocean Salinity Center of Expertise for CATDS (CATDS CEC-OS) developed an experimental SSS product from SMOS (Soil Moisture and Ocean salinity) with a correction for rain instantaneous effect (+ other bias corrections). (Supply, 2020; Boutin, 2022)
- We assess the effect of assimilating rain-corrected vs regular SSS in a global ocean reanalysis and the subsequent impact of the simulated initialization state in ENSO forecasting.

1. The system: GMAO GEOS-S2S-3 (Molod et al., 2018)

Component	Ocean	Atmosphere	Land	Sea ice
Core	MOM5	GEOS ~~non-hydrostatic finite volume cubed sphere~~	Catchment Land Surface Model	CICE4
Ref. Resolution	0.25° 50 levels	0.5° 72 levels		0.25°
Assimilation	LETKF	~~Grid point Statistical Interpolation~~ 3DVar		

Replay to MERRA-2

In-situ (S,T)	Argo CTD XBT TAO PIRATA RAMA
Altimetry (ADT)	Jason-2 Jason-3 Saral Sentinel-3a HY-2A CryoSat-2
SST	MERRA-2
SSS	**SMOS (Control vs RC)**

2. SMOS RAIN CORRECTION - CATDS (2022).

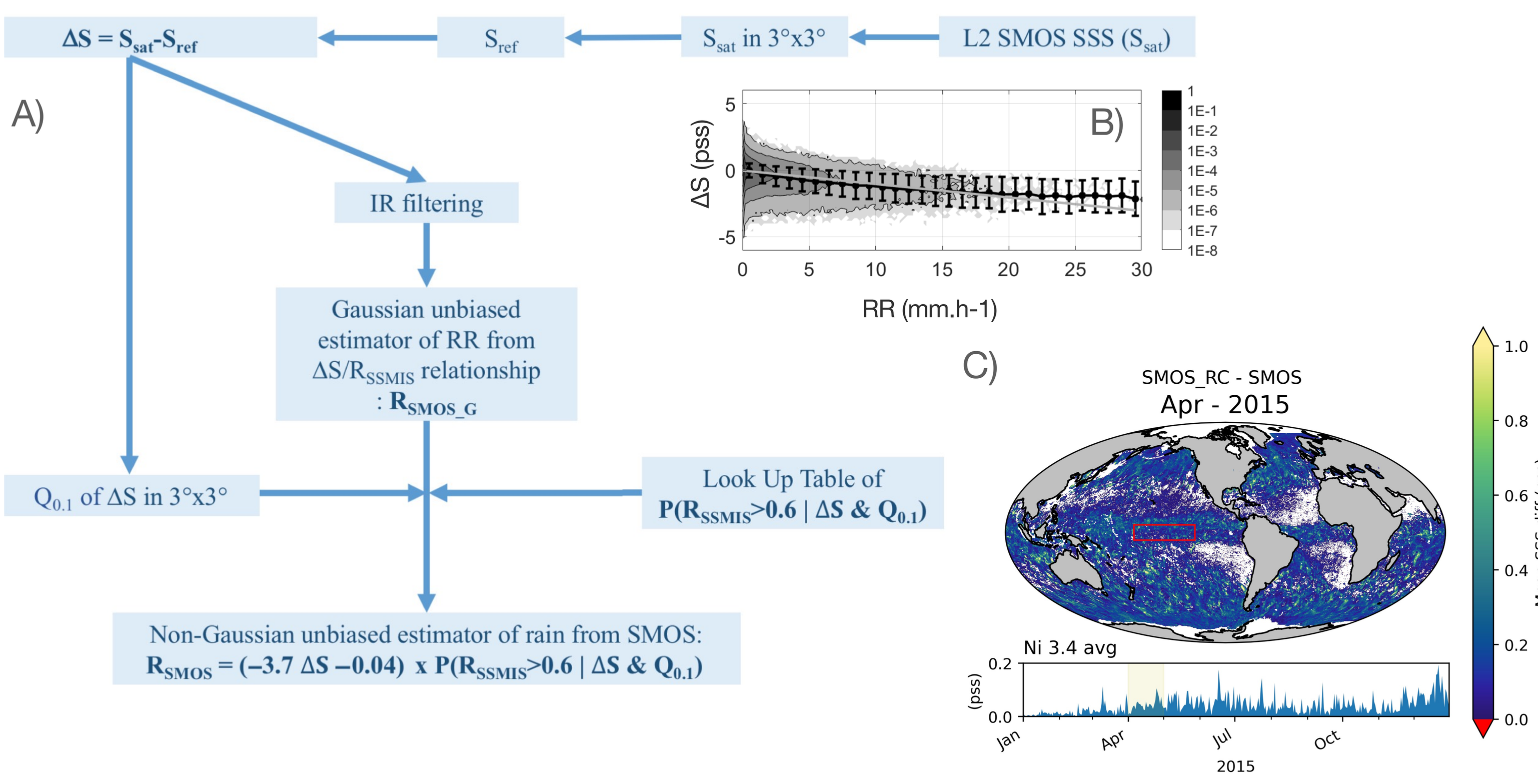


Figure 1: SMOS rain-corrected salinity data. A). Algorithm to generate the salinity correction (ΔS) from collocated rain rates (RR) as described in Supply et al. (2018). B) Relationship between ΔS and RR from IMERG, showing a regression fit (Supply et al., 2020). C) Mean spatial distribution of rain corrected salinity difference for April 2015 (globe) and the El Niño 3.4 daily mean over time (inset).

3. Reanalysis and forecast initialization

Reanalysis experiments were initialized in January 2014 per the specifications in **1**, with a 5-day assimilation cycle. Along-track SSS was assimilated with one experiment using the regular surface salinity (SMOS as control) and one using the rain-corrected salinity (SMOS RC) reconstructed as per details in **2**. Coupled forecasts were initialized from all the 5-day spanning April restarts produced for 2014 and 2015 (El Niño) and ran for 9 months. Results are validated against the EN4 data product (EN.4.2.2, Good et al., 2013).

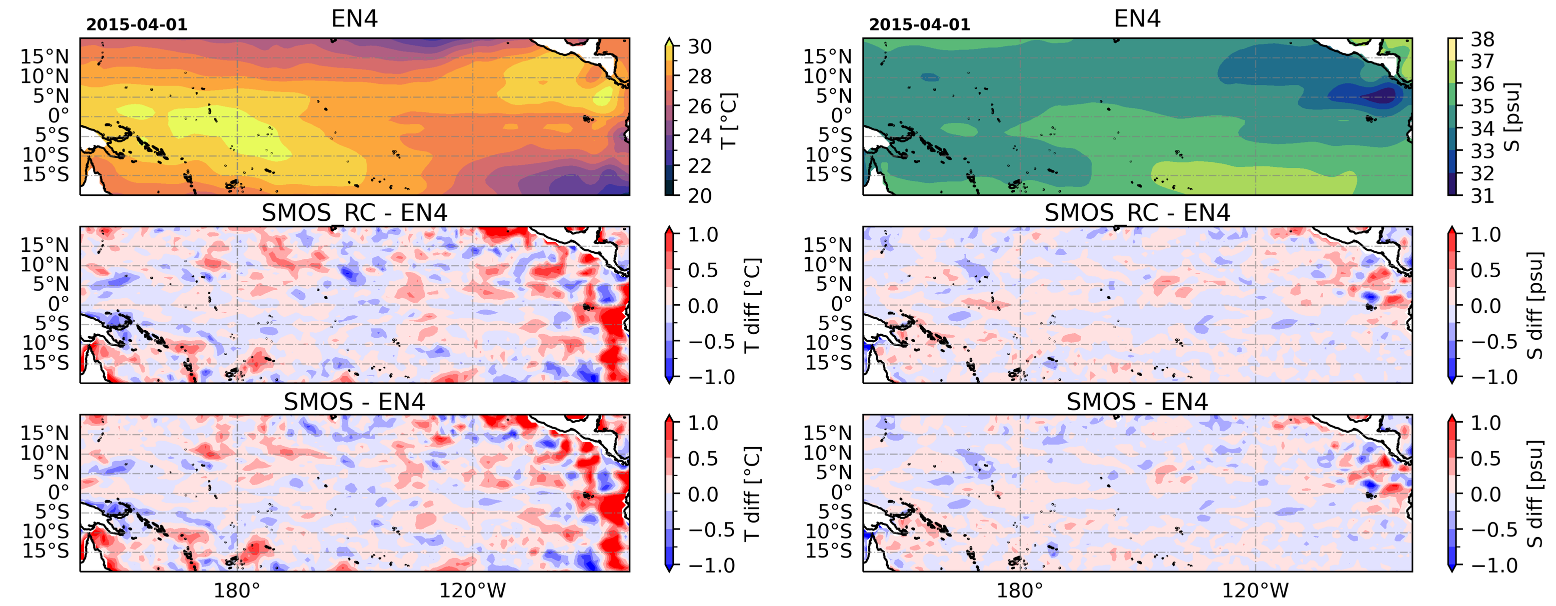


Figure 2: Validation of average monthly (April 2015) reanalysis results against EN4 dataset. Reanalysis output is agreeable for both experiments in the salinity field, and in the open ocean for the temperature field, showing slightly warmer temperatures in the eastern pacific costal region. While differences between both experiments seem slight, they are enough to generate a different dynamical response (Figure 3), and thus a different initialization state for the forecasts (Figures 4 and 5).

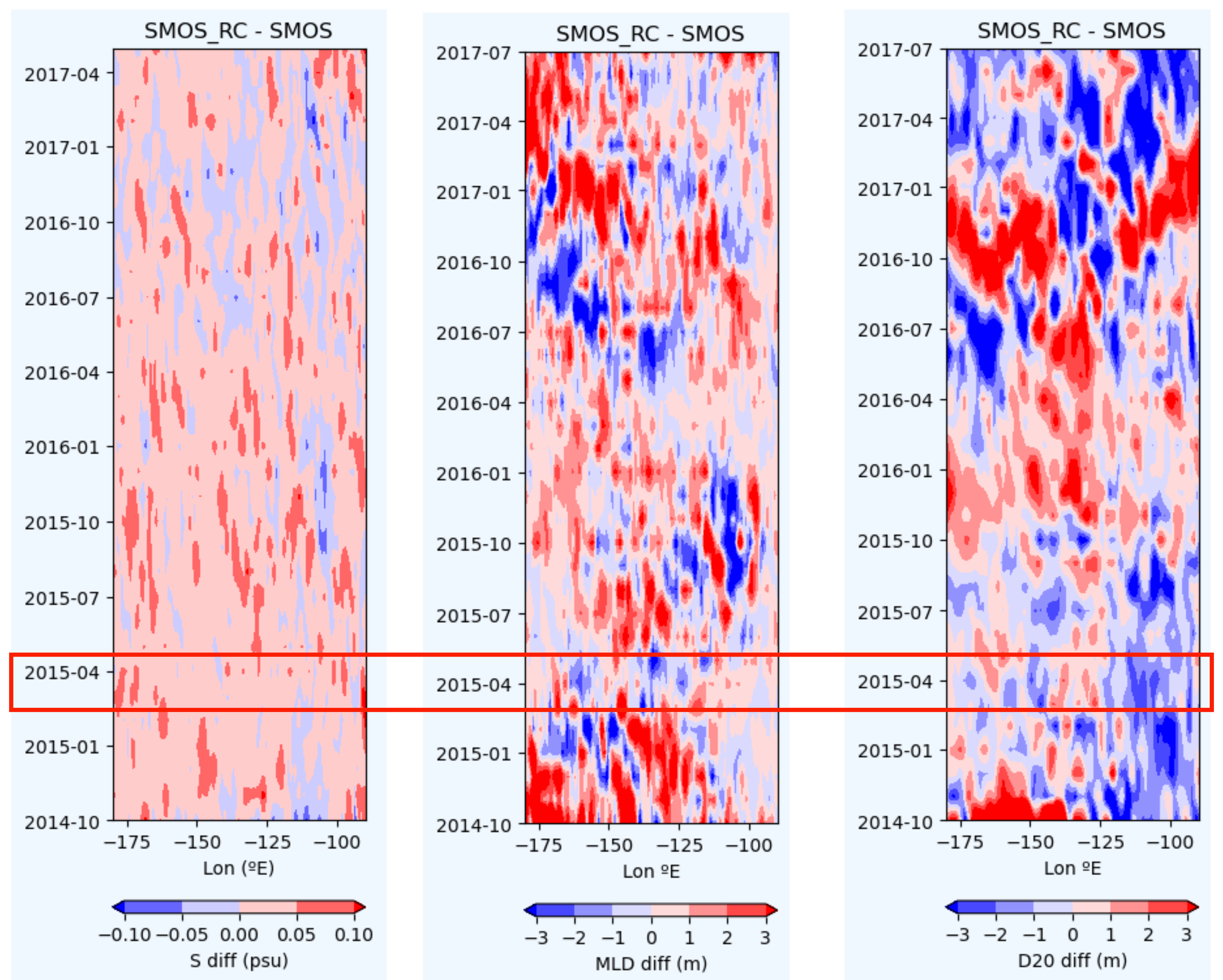


Figure 3: Latitudinal average (5 S to 5 N) in the Equatorial Pacific (180 E – 90 W) of the first layer salinity (S), the mixed layer depth (MLD), and the thermocline depth (i.e., 20 °C isotherm) over time, showing differences of monthly rain corrected minus regular experiments. Differences show that rain-corrected salinity produces a saltier surface layer, progressing into a generally deeper mixed layer depth and a deeper thermocline on the western side of the region. The state leading to the initialization state for the forecasts is highlighted in a box.

Assimilating rain-corrected along-track sea surface salinity to better match bulk salinity in the first model layer (i.e., 5 m) improves the simulated ocean state, generating a deeper thermocline and mixed layer, and thus resulting in a more stable initialization field for forecasting. The spread of S2S surface and subsurface temperature forecast in the equatorial pacific and the El Niño 3.4 region is considerably reduced.

4. Forecast spread

Forecast initialized in 5-day spawns in April 2014 and 2015 generate a more stable ocean state in the coupled model, evidenced by a smaller standard deviation of the surface and subsurface temperature in the Equatorial Pacific.

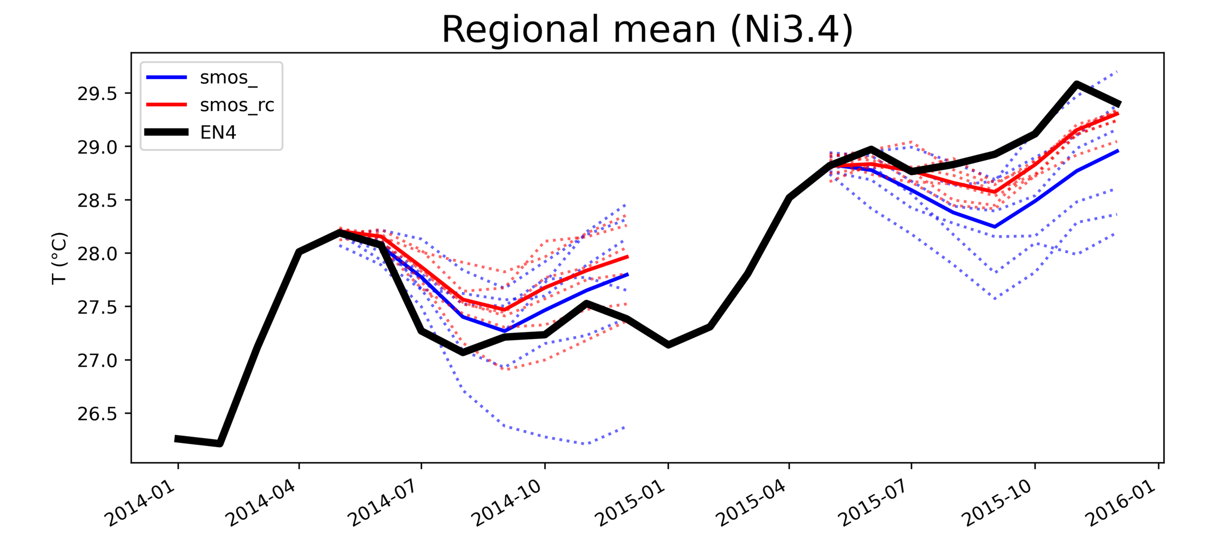
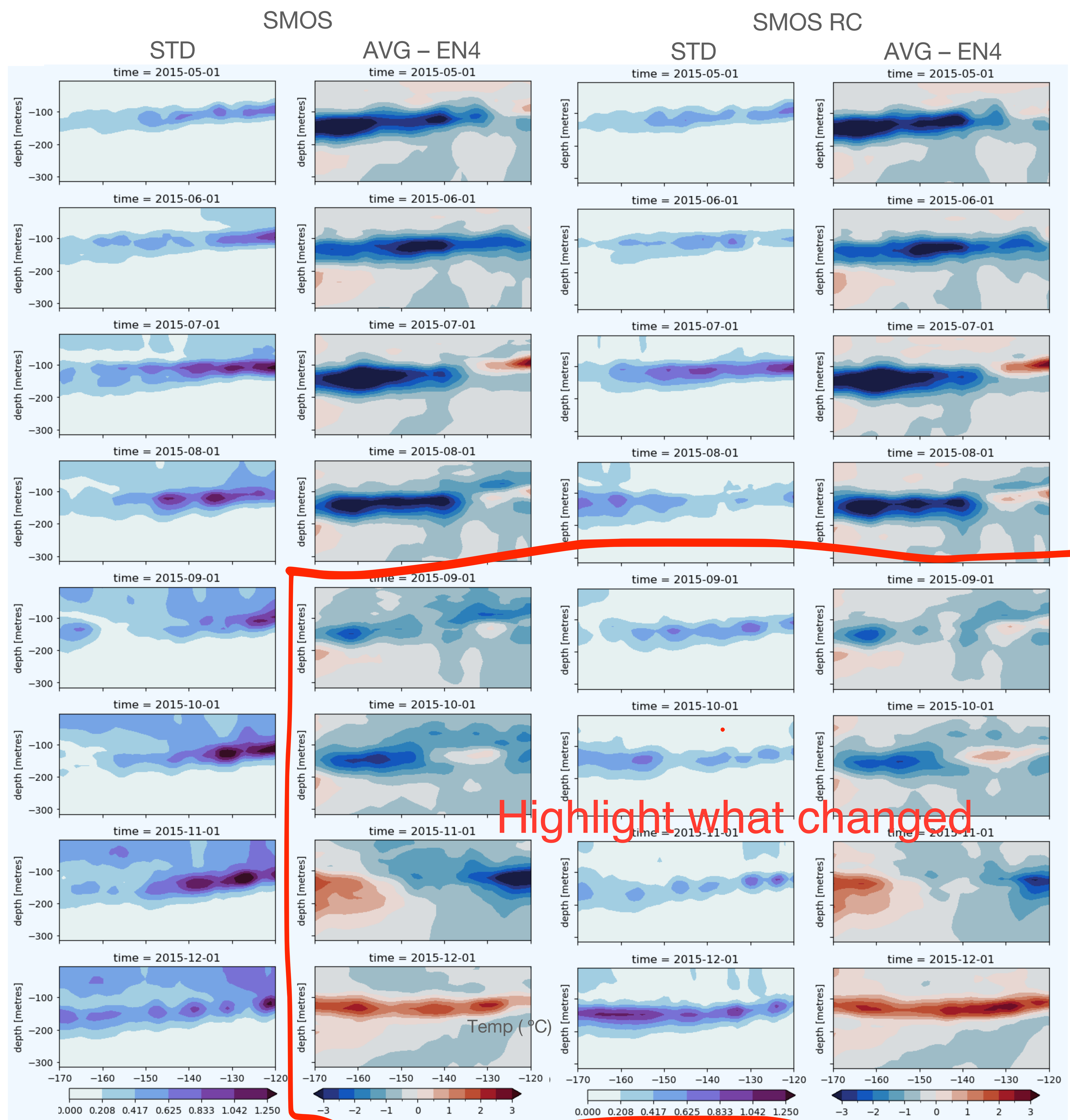


Figure 4: Monthly mean sea surface temperature of the El Niño 3.4 region from the 9-month couple forecasts for 2014 and 2015 showing the individual forecasts members (dotted lines) for SMOS (blue) and SMOS RC (red), and the corresponding member mean (solid lines). EN4 observations are shown for contrast in black.



Highlight what changed

Figure 5: Spread (STD) of the monthly mean **subsurface temperature (°C)** of forecasts initialized in April (6 members) and difference of the mean (AVG) minus observations (EN4 dataset) for SMOS (left) and SMOS RC (right). The region shown is the El Niño 3.4 latitude average (5 S to 5 N). While there isn't a remarkable difference in the mean deviation from EN4, the spread of the ensemble is significantly smaller throughout the 9-month simulation.

References

- Boutin, J., et al., 2018: New SMOS Sea Surface Salinity with reduced systematic errors and improved variability. RSE(214).
- CATDS, 2022: CATDS-PDC L3OS 2Q - Debiased daily valid ocean salinity values product from SMOS satellite.
- Good, S. et al., 2013: EN4: Quality controlled ocean temperature and salinity profiles and monthly objective analyses with uncertainty estimates, JGR: Oceans
- Hackert, E. et al., 2019: Impact of Aquarius and SMAP satellite sea surface salinity observations on coupled El Niño/Southern Oscillation forecasts. JGR: Oceans, 124(7).
- Hackert, E., et al., 2020: Satellite sea surface salinity observations impact on El Niño/Southern Oscillation predictions: Case studies from the NASA GEOS seasonal forecast system. JGR: Oceans, 125(4).
- Molod, A. et al., 2018: NASA GMAO GEOS S2S Prediction System: Metrics, Post-Processing and Products. In Metrics, Post-Processing, and Products for Subseasonal to Seasonal Workshop.
- Supply, A., et al., 2018: Precipitation estimates from SMOS sea-surface salinity. Quarterly Journal of the Royal Meteorological Society, 144, 103-119.
- Supply, A., et al., 2020: Variability of satellite sea surface salinity under rainfall. In: Satellite Precipitation Measurement, Advances in Global Change Research, 69.

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