SYMPOSIUM OP'24 ADVANCING OCEAN PREDICTION SCIENCE FOR SOCIETAL BENEFITS

Theme #5

Early Comparison of Ocean Analyses Using JEDI/SOCA 3DVar vs. GEOS-S2S-3 ODAS LETKF

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Introduction

At NASA's Global Modeling and Assimilation Office (GMAO), data assimilation (DA) for the next-generation Goddard Earth Observing System Subseasonal-to-Seasonal (GEOS-S2S) coupled-model forecast system will transition to the Joint Effort for DA Integration (JEDI) system, which includes the marine DA component SOCA (Sea ice, Ocean, and Coupled Assimilation). It is envisioned that incorporating SOCA into GMAO Earth System Modeling will allow a more systematic approach to assimilating new data types (e.g., SWOT KaRIn), increasing resolution (e.g., 1/12°), and facilitating weakly (and eventually strongly) coupled DA (air-sea-ice, etc.). To prepare for this transition, testing is underway to compare SOCA results at high ocean resolution against the current GEOS-S2S Version 3 Ocean DA System (ODAS)[1] using similar initial conditions and observations.

Methods

- Standalone ocean analysis, July 1st 2021 (1-day DA window)
- **Background:** World Ocean Atlas initialization (MOM6 ¼° tripolar grid, 75 layers), spun up for 1 month using GMAO's coupled GEOSgcm model with atmospheric replay to GMAO's MERRA-2 reanalysis (remapped to MOM5 lat-lon grid for ODAS analysis)
- **Observations:** SST (OSTIA), SSS (SMOS, SMAPv5), ADT (Sentinel-3A, Jason-3, Saral, CryoSat-2-N), T/S profiles (Argo, TAO, PIRATA, RAMA, XBT, CTD)
- **ODAS:** Non-cycling Local Ensemble Transform Kalman Filter (LETKF), 20 members taken from consecutive days in July from separate coupled-model free run, re-centered on background
- **SOCA:** Incremental 3DVar, background covariance matrix *B* uses GODAS for 3D background errors (T, S, SSH), explicit diffusion[2] for 3D spatial correlations, SSH-T-S balances (but not T-S)[3]

Results

- Broadly similar SST increments for ODAS vs. SOCA, likely due to i) assimilation of dense OSTIA observations and ii) similar-magnitude background errors, with larger ODAS SST increment in NH
- Subsurface T increments show different patterns but comparable magnitudes, with large differences near western equatorial Pacific thermocline consistent with differences in background error
- ODAS SSS increment smaller than SOCA in tropics, larger in Arctic, consistent with spatial variation of background ensemble spread and SOCA rejection of high-latitude SMOS/SMAP data
- Shallower penetration of S increment for SOCA at equator, possibly due to sharp reduction in background error below mixed-layer depth
- Pattern of SSH increment (SOCA only) reflects larger background correlation length scales (not pictured) in tropics vs. midlatitudes, suppressed poleward of 40-50°N/S due to SOCA and GMAO QC

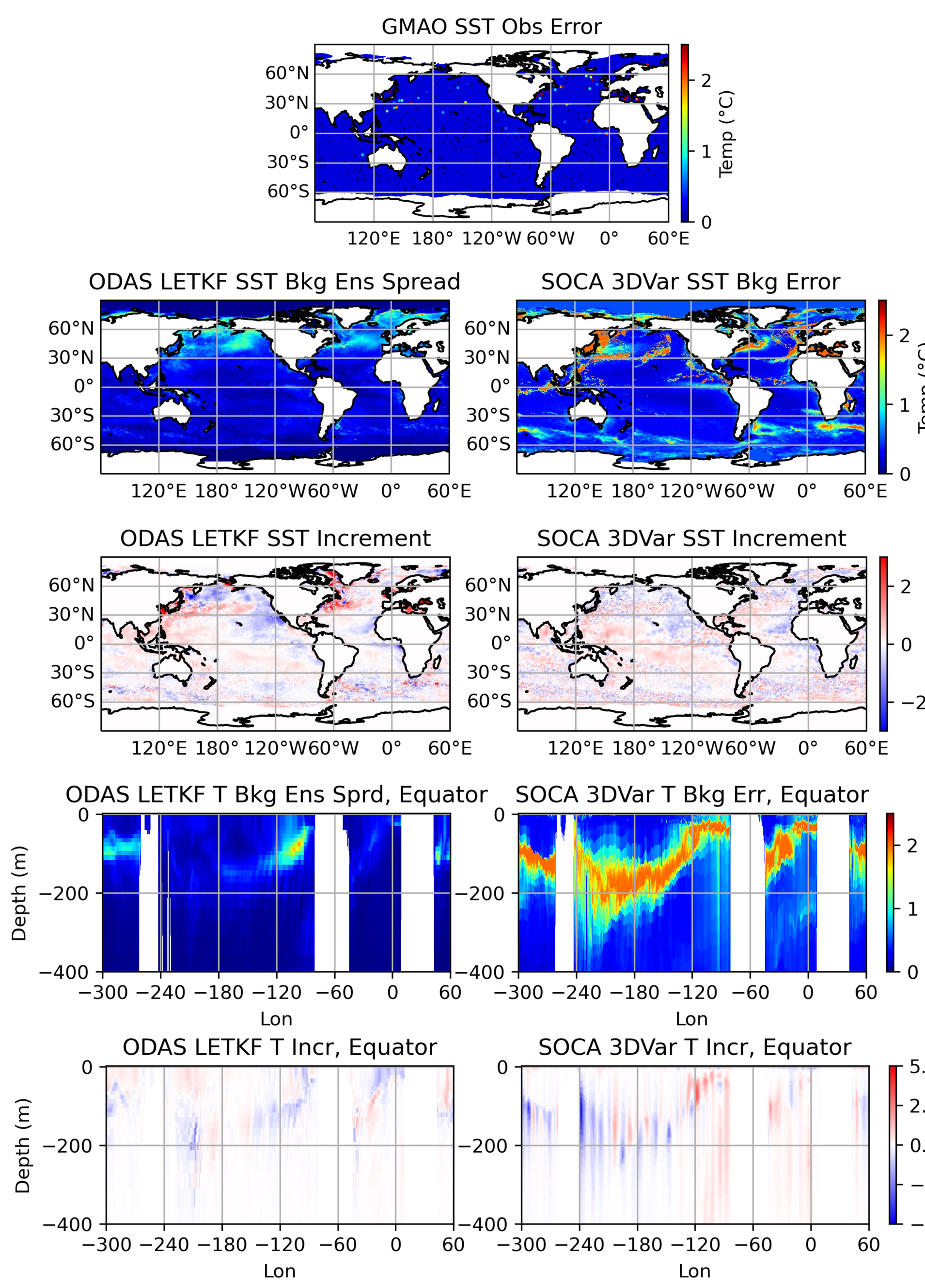

Figure 1: Ocean temperature for ODAS LETKF vs. SOCA 3DVar on Jul 1, 2021. **Top to bottom:** SST observation error, SST background spread/error, SST analysis increment, longitudinal transect through equator (background spread/error and analysis increment).

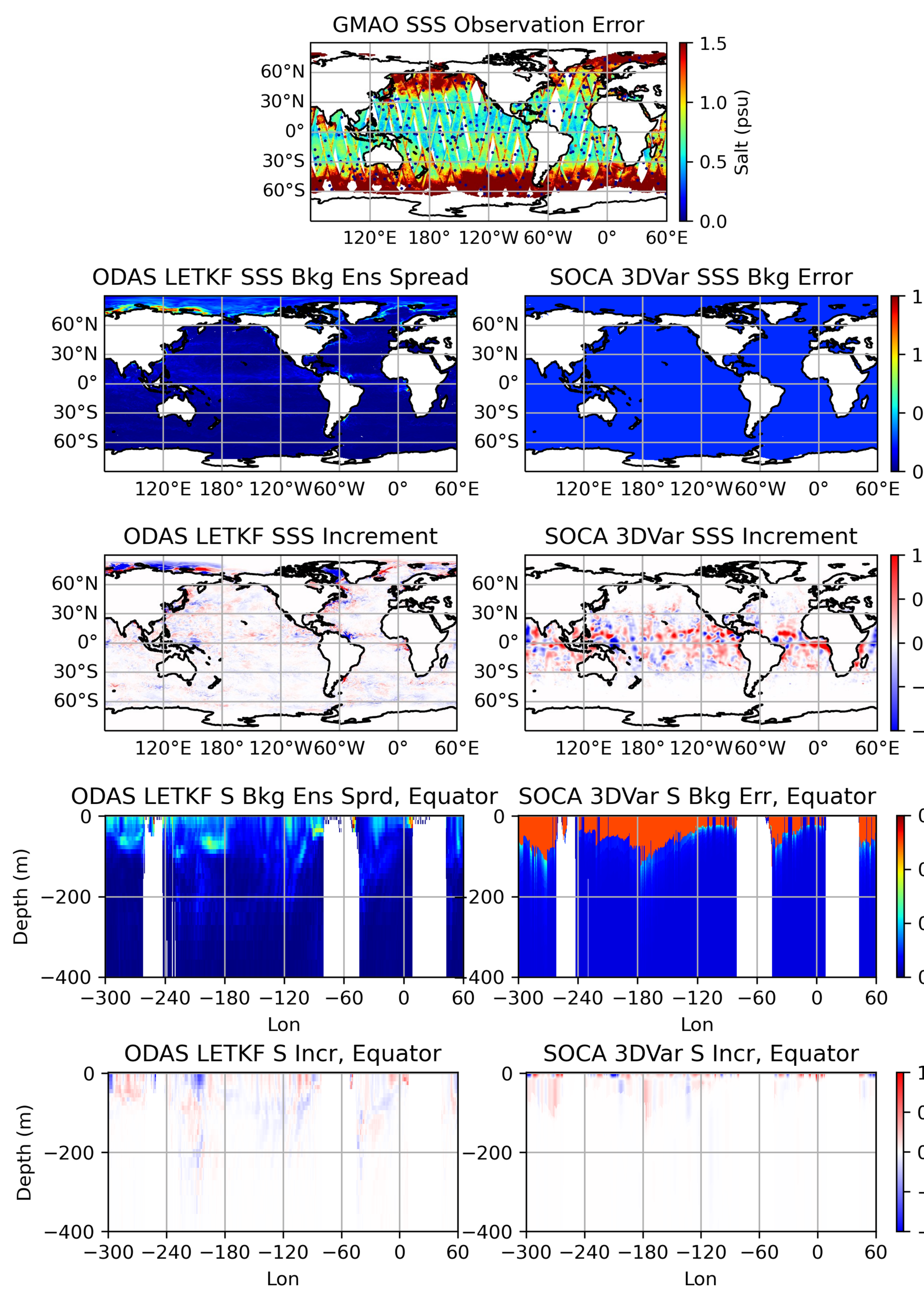

Figure 2: Ocean salinity for ODAS LETKF vs. SOCA 3DVar on Jul 1, 2021. **Top to bottom:** SSS observation error, SSS background spread/error and analysis increment, longitudinal transect through equator (background spread/error and analysis increment).

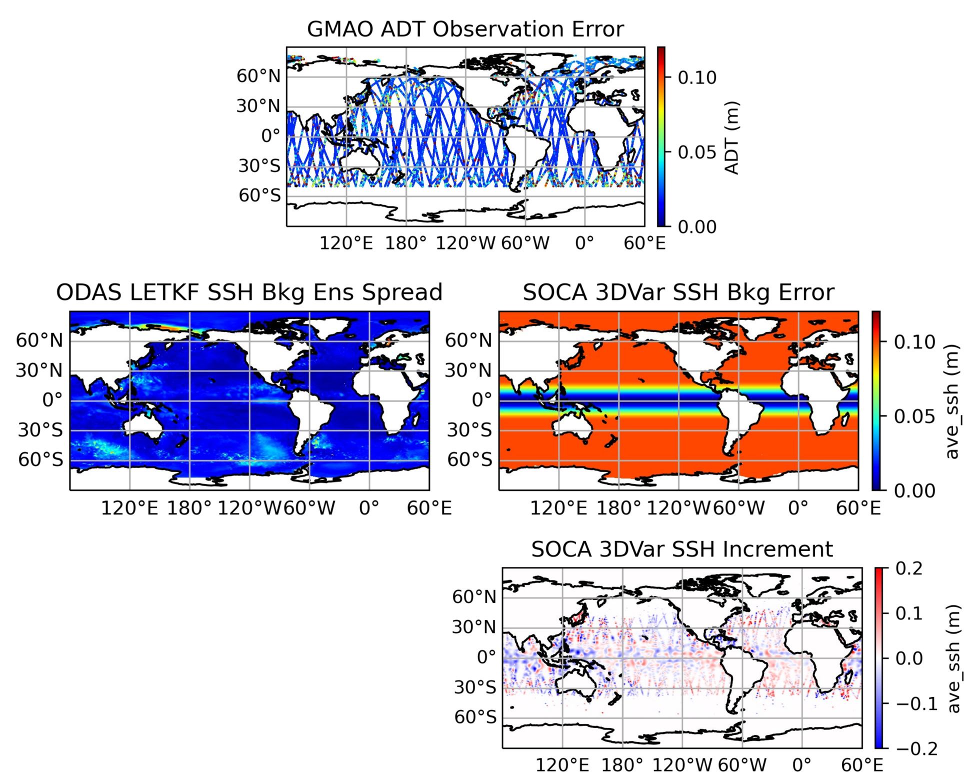

Figure 3: Sea surface height for ODAS LETKF vs. SOCA 3DVar on Jul 1, 2021. **Top to bottom:** ADT observation error, SSH background error, SSH analysis increment.

References

[1]Hackert, E., Akella, S., Ren, L., Nakada, K., Carton, J. A., & Molod, A. (2023). Impact of the TAO/TRITON array on reanalyses and predictions of the 2015 El Niño. *Journal of Geophysical Research: Oceans, 128*, e2023JC020039

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[3]Weaver, A. T., Deltel, C., Machu, É., Ricci, S., & Daget, N. (2005). A multivariate balance operator for variational ocean data assimilation. *Quarterly Journal of the Royal Meteorological Society: A journal of the atmospheric sciences, applied meteorology and physical oceanography, 131*(613), 3605-3625.

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Conclusions

- SOCA 3DVar and ODAS LETKF increments show similar magnitudes overall, but somewhat different spatial patterns where observations are sparse (subsurface T and S) and/or background errors are different (SSS)
- Increment differences not explained by background error may be due to different QC, balances, cross-variable correlations, correlation/localization scales
- Differences in subsurface T/S background error representation may have important implications for accurate forecasting of ENSO
- Future testing experiments will include: i) cycling DA, ii) longer spin up prior to DA, iii) more model-specific SST background errors for 3DVar, iv) SOCA's implementation of LETKF/hybrid DA methods

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