National Aeronautics and Space Administration

Postdoc Research

Using ECCO State Estimate to understand the decadal variation of upper-ocean salinity in the Southeast Indian Ocean

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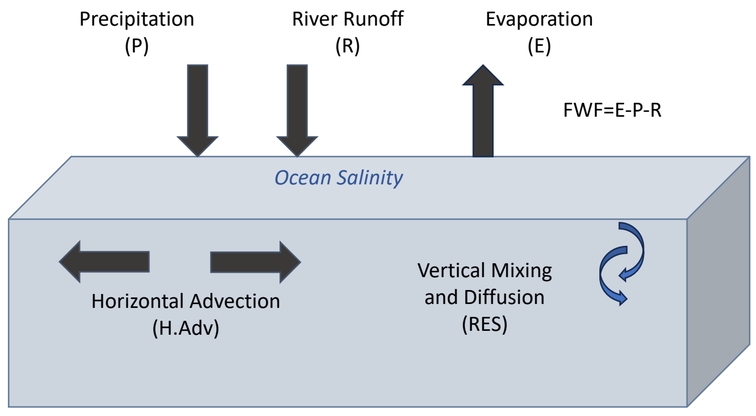
Background and Motivation

- Salinity in the southeast Indian Ocean (SEIO) dominates density stratification with implications for air-sea interaction, ocean dynamics and ecology.
- A pronounced decadal variation in SEIO upper ocean salinity is observed from Argo float measurements.
- No clear consensus on the processes driving decadal salinity variability in the SEIO - previous studies attributing it to either local/remote wind forcing or local freshwater flux.

Data and Methods

- Estimating the Circulation and Climate of the Ocean version 4 release 5 (ECCOv4r5) is a physically consistent monthly global ocean estimate using MITGCM (January 1992 - December 2019).
- Three global ECCO model runs: (1) **CTL** – run with varying surface freshwater flux and wind forcing over the global ocean, (2) **FWF** – run with varying surface freshwater flux and climatological wind forcing (3) **WND** – run with varying wind forcing and climatological freshwater flux.

Upper ocean salinity budget:



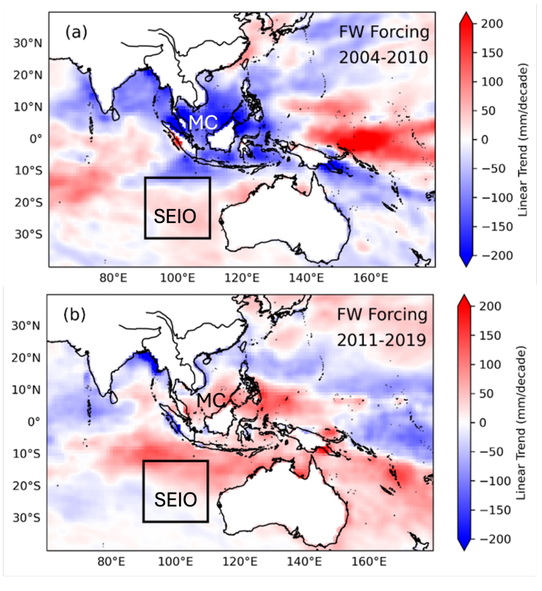
$$dS/dt = FWF + H.Adv + RES$$

H.Adv can be decomposed into four terms, showing how average ocean velocity, salinity and short-term variations in both velocity and salinity work together to move salt around the ocean.

$$H.Adv = \bar{V}\bar{S} + \bar{V}S' + V'\bar{S} + \overline{V'S'}$$

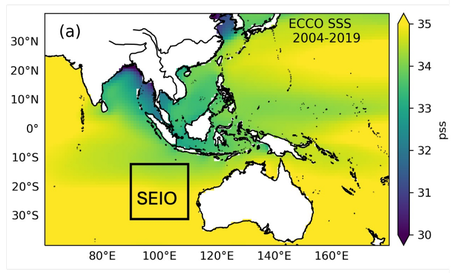
Summary

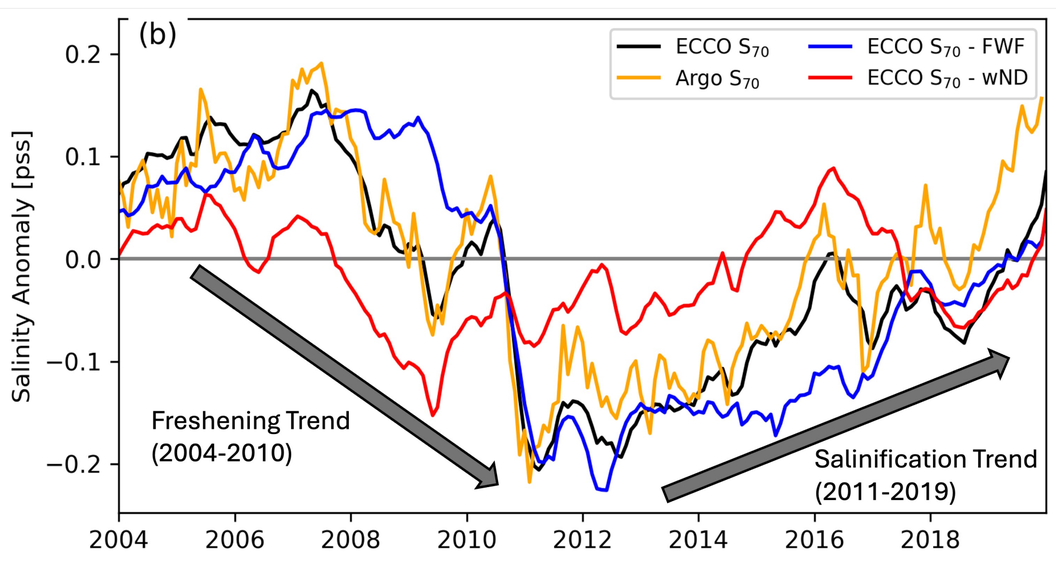
Decadal trends in SEIO salinity are primarily driven by surface freshwater flux over the Maritime Continent (MC).



Advection of anomalous salinity gradients, generated by decadal freshwater variability over MC transmits its influence to the SEIO.

Results: Decadal variability of SEIO upper ocean salinity

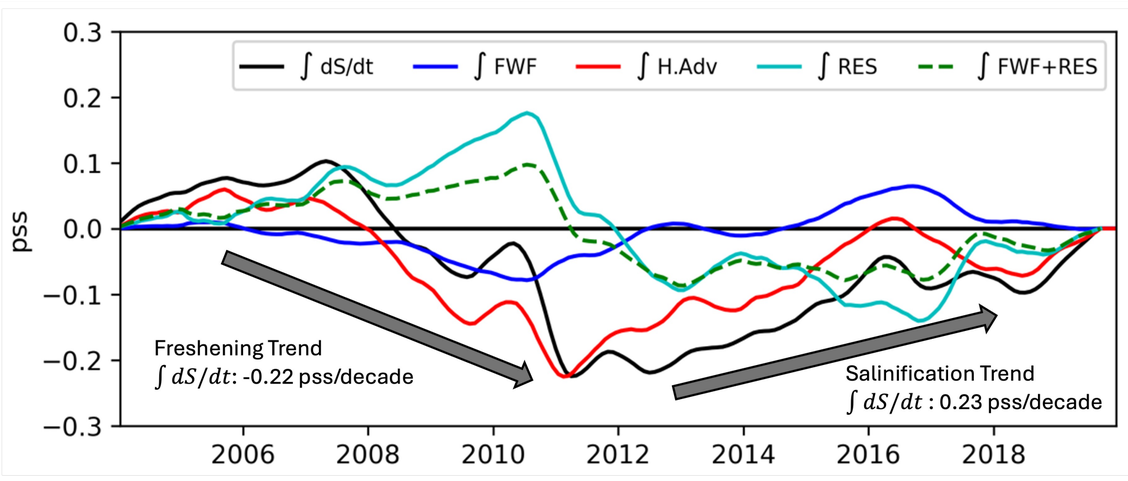




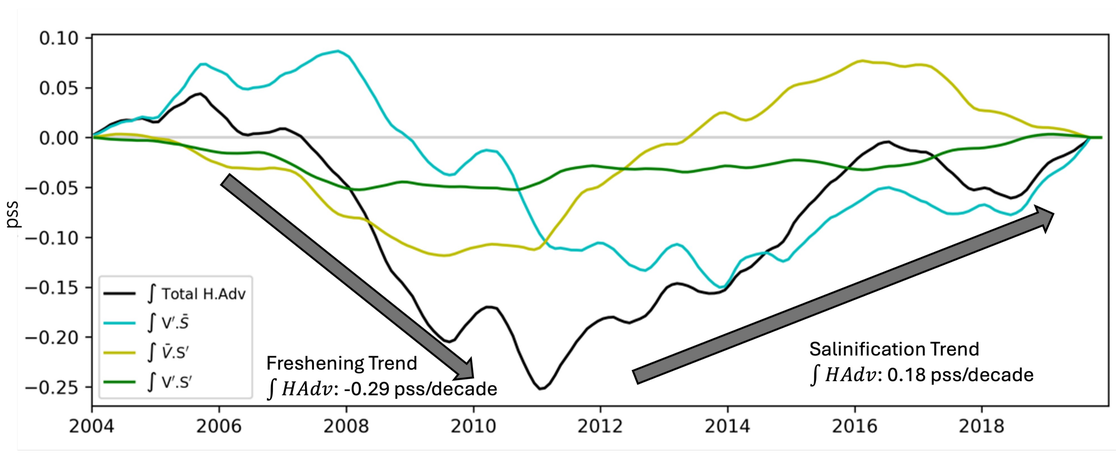
ECCO CTL reproduces the decadal trends in SEIO salinity, consistent with Argo observations.

Freshwater forcing (ECCO FWF) contributes to the decadal variability in SEIO salinity.
Local/remote wind forcing (ECCO WND) alone cannot reproduce the observed trends in SEIO salinity.

Results: Mechanisms driving decadal variability of SEIO salinity



Horizontal advection explains 88% and 64% of the freshening and salinification trends in SEIO upper ocean salinity respectively. Local FWF and RES terms have low contribution.



$\overline{VS}'$ explains 91% and 74% of the freshening and salinification trends in H. Adv respectively. Advection of anomalous salinity gradient by the mean velocity is an important driver of decadal variability of SEIO salinity.

Significance of Results/Benefits to NASA/JPL

Our study demonstrates the value of NASA's ECCO state estimate for investigating the casual mechanisms for decadal variability of SEIO upper-ocean salinity. The findings highlight the need to better understand the linkages between the Maritime Continent water cycle and SEIO salinity, with implications for regional ocean–climate interactions and the importance of sustained Indo-Pacific observations.

Publications and Acknowledgements:
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