Tunnels in the ocean: Following climate signals from the subtropics to the tropics

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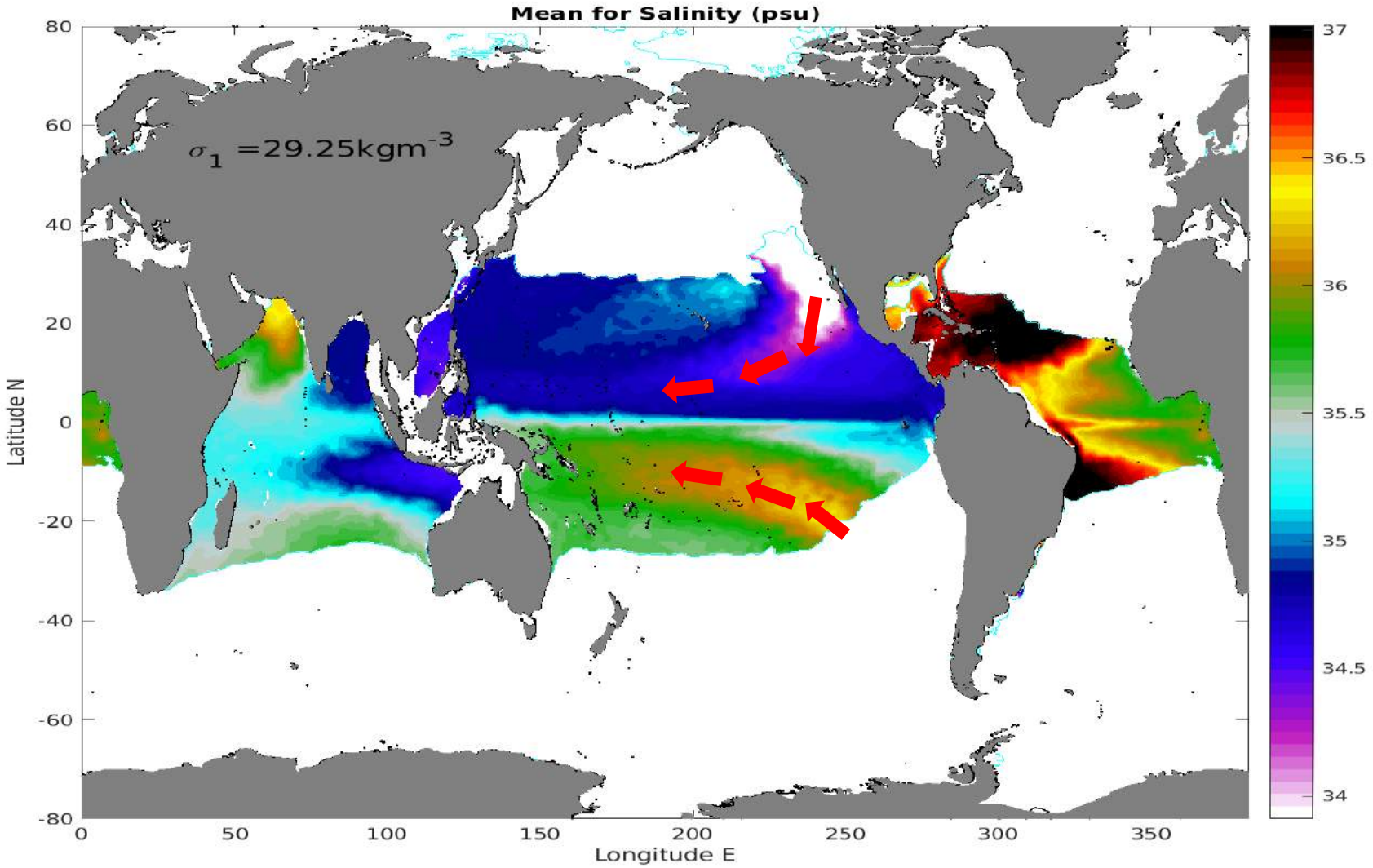
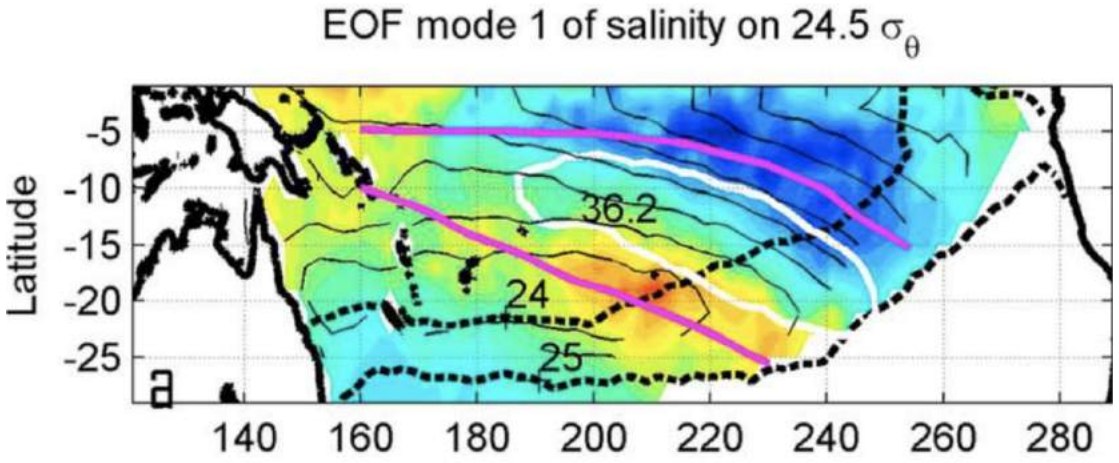
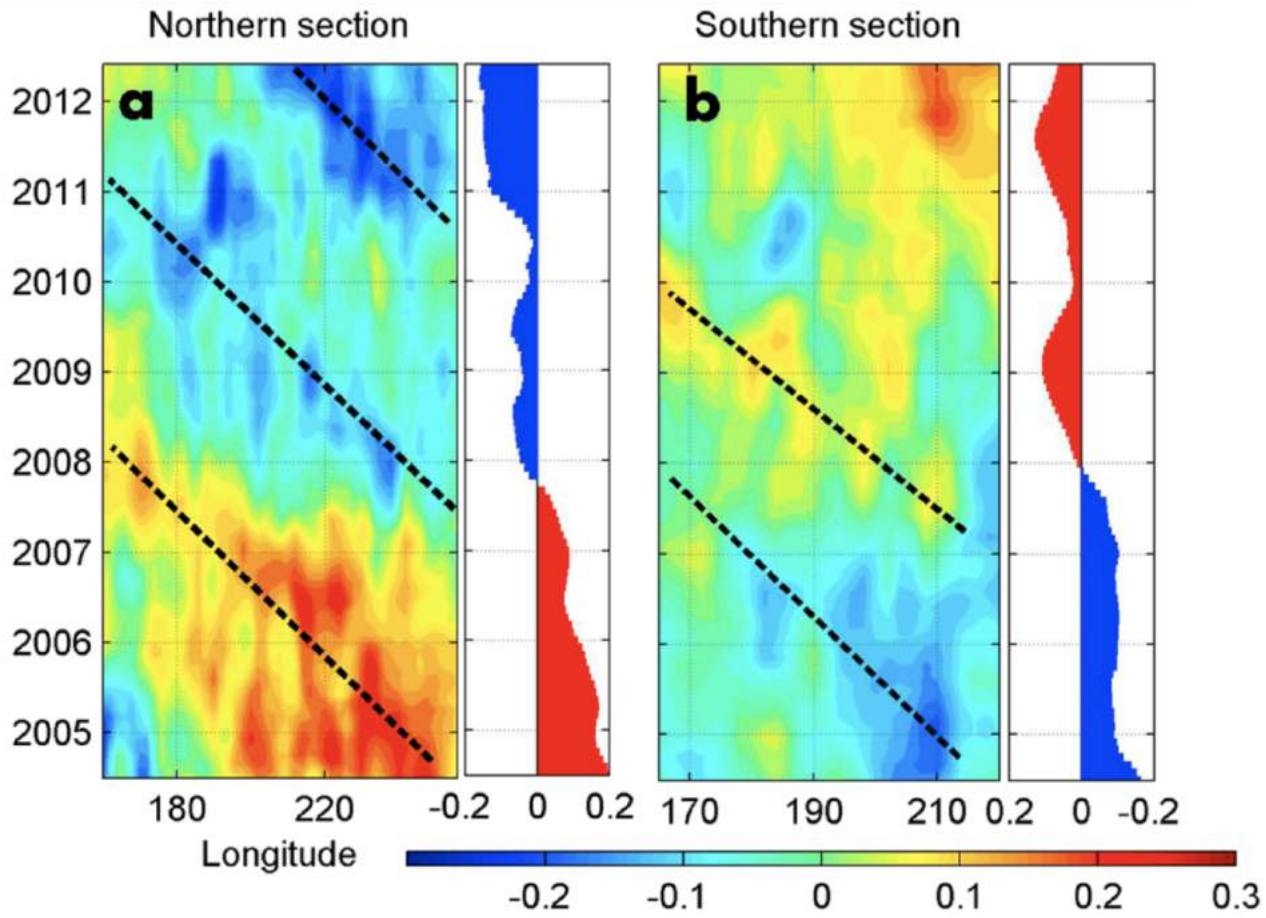
Mean water properties outline a “tunnel” from the subtropics to the tropics



What about the time-varying picture?





Evidence has emerged more recently (e.g. Zhang and Qu, 2014) for persistence along flow pathways of significant interannual anomalies of water mass properties

Salinity anomalies on the order of 0.1 g/kg

Why does this matter?

If interannual water mass anomalies are regularly able to persist from formation until re-emergence into the mixed layer, there could be important implications for interannual- to decadal-scale climate variability and predictability.

Approach: Simultaneously analyze observations (Argo) and state estimate (ECCO v4r4)

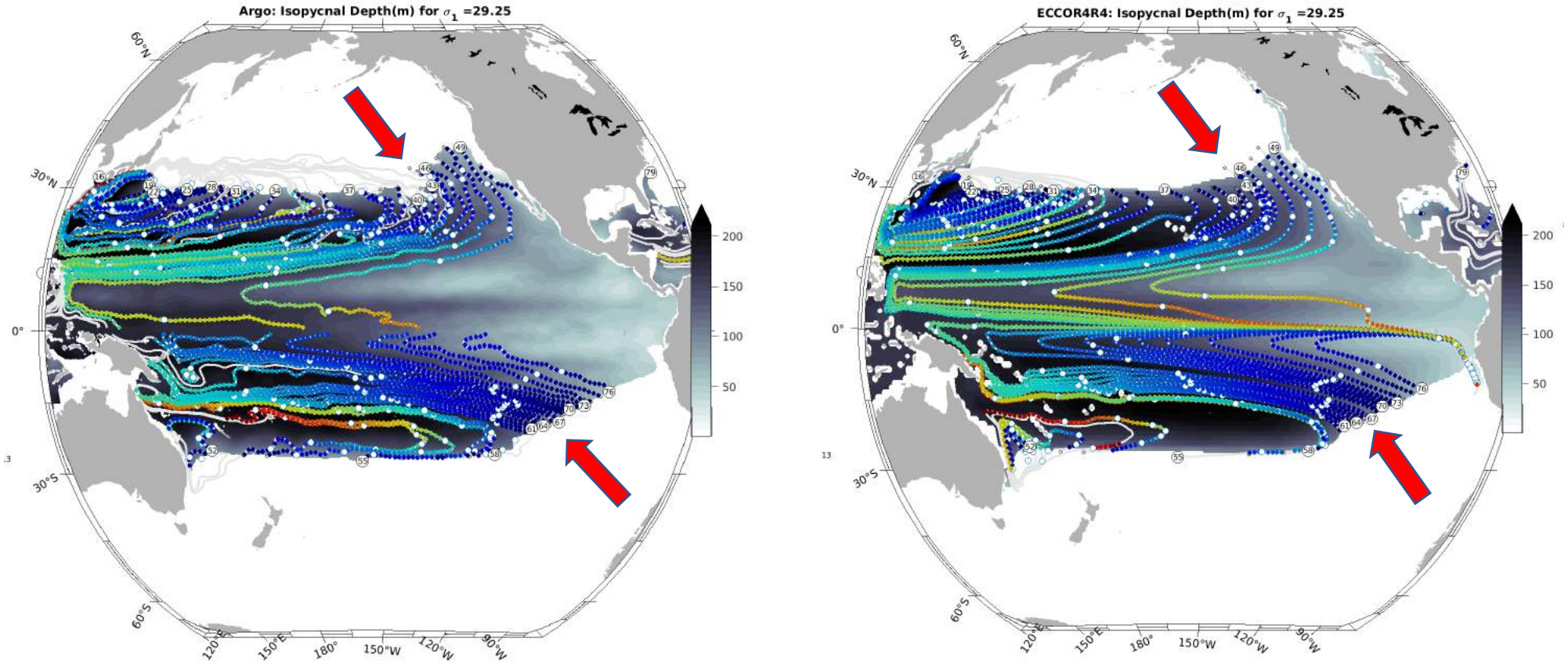
Central questions

- Are long-lived interannual anomalies of physical water properties common along global subtropical-to-tropical pathways?
- How well does the ECCO state estimate represent the behavior of interannual water property anomalies in the subtropics, as compared to the Argo dataset?

Properties we're focusing on:

- Spice: variations in temperature and salinity that compensate each other on a density surface
- Potential vorticity (PV): a conserved dynamical tracer

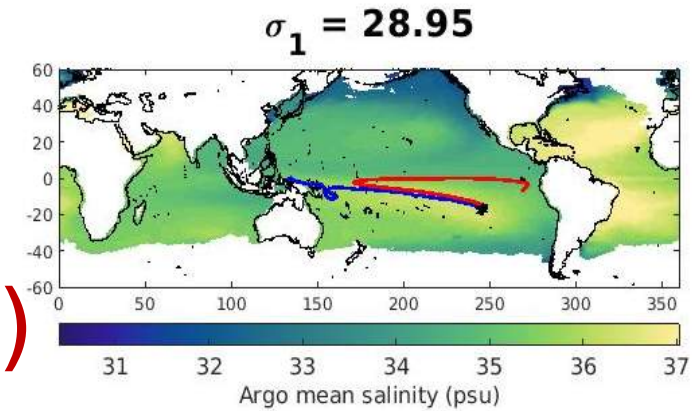
Mean circulation in Argo (left) and ECCO v4r4 (right)



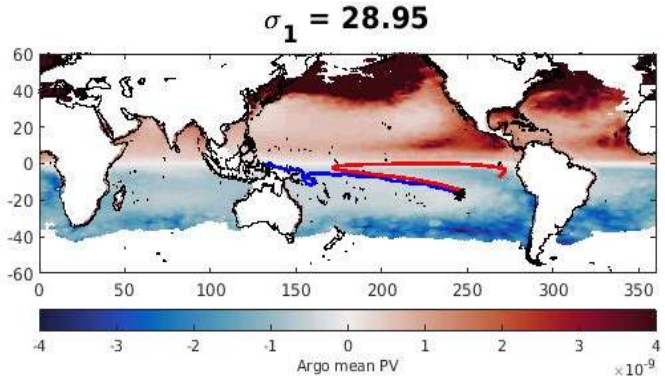
Mean streamlines initiated at outcrops are ventilated by definition

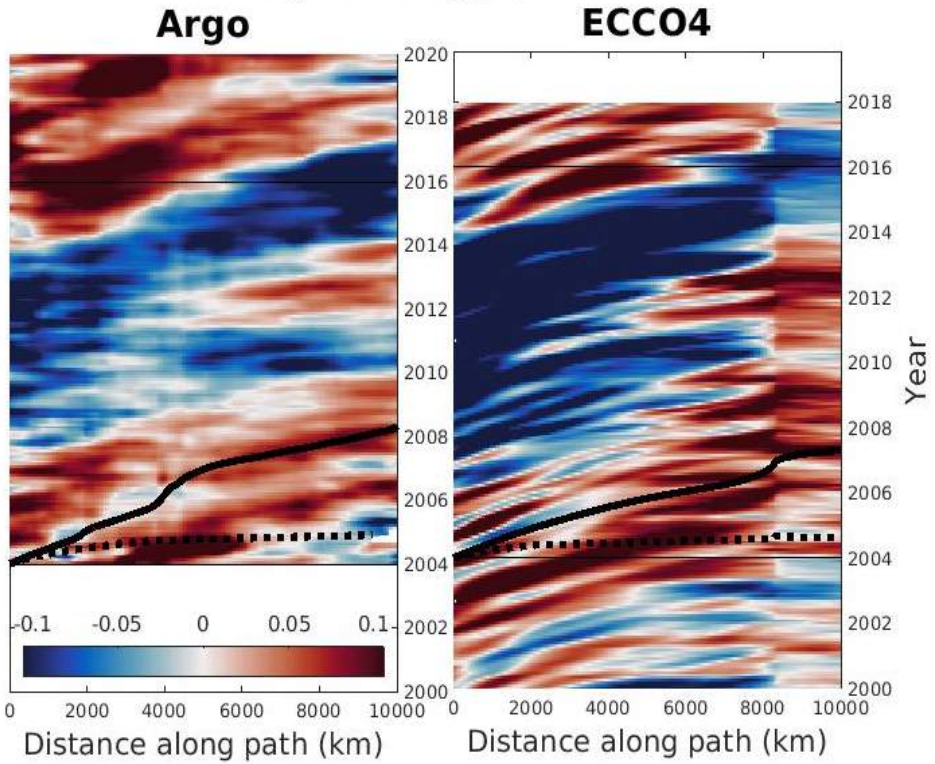
Along-streamline view of water mass anomalies

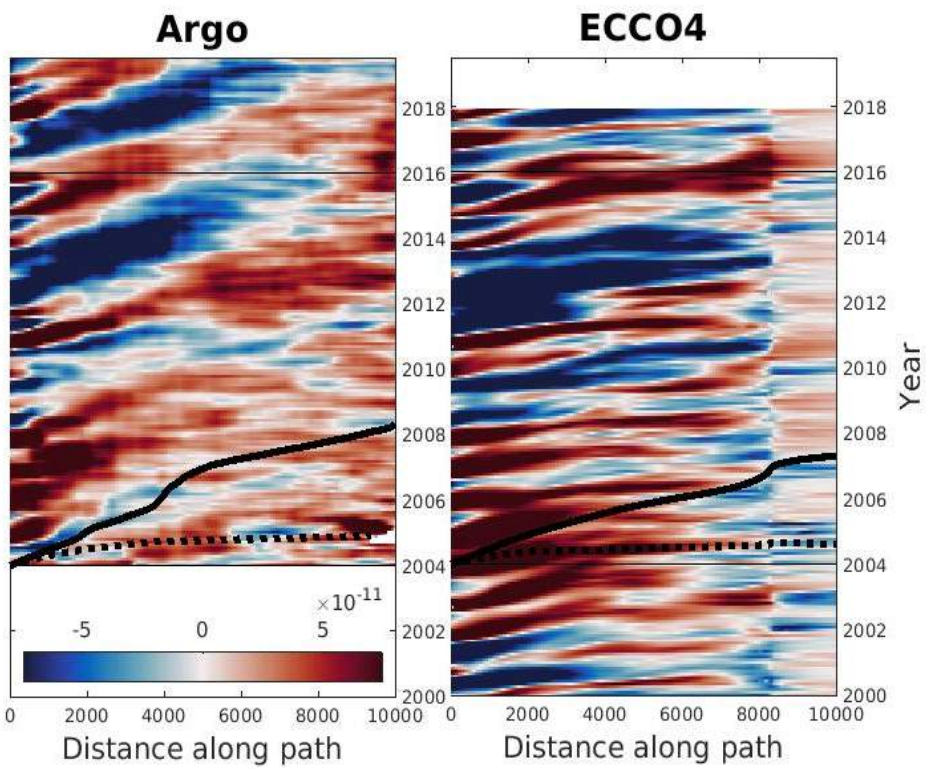
Spice (salinity)



PV

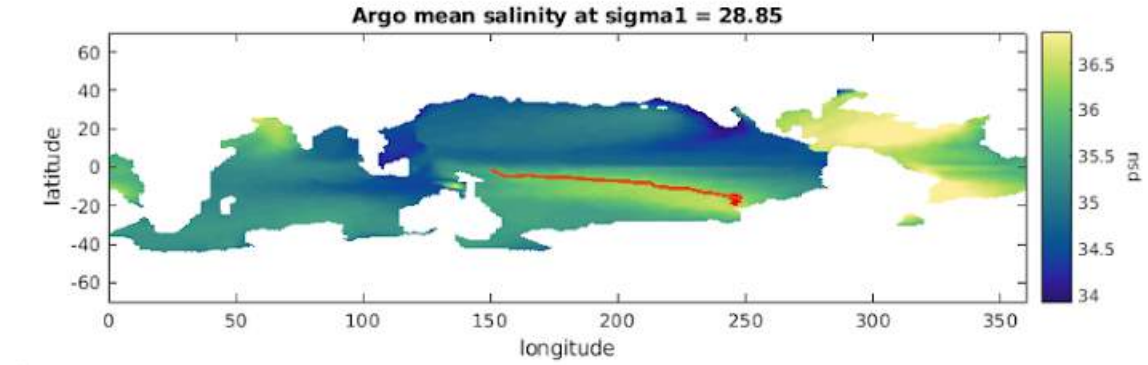


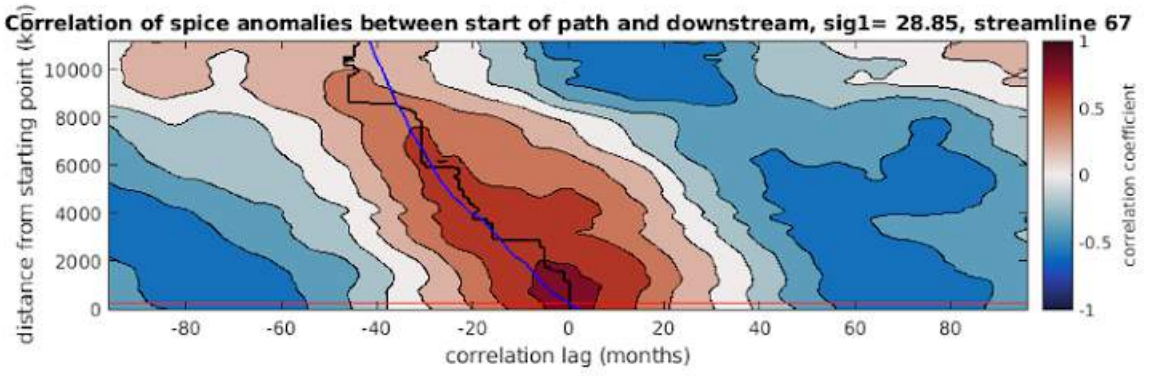


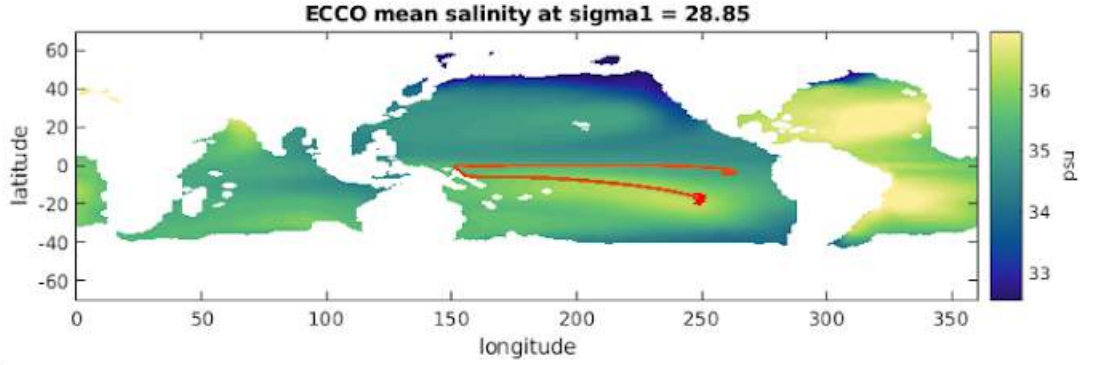


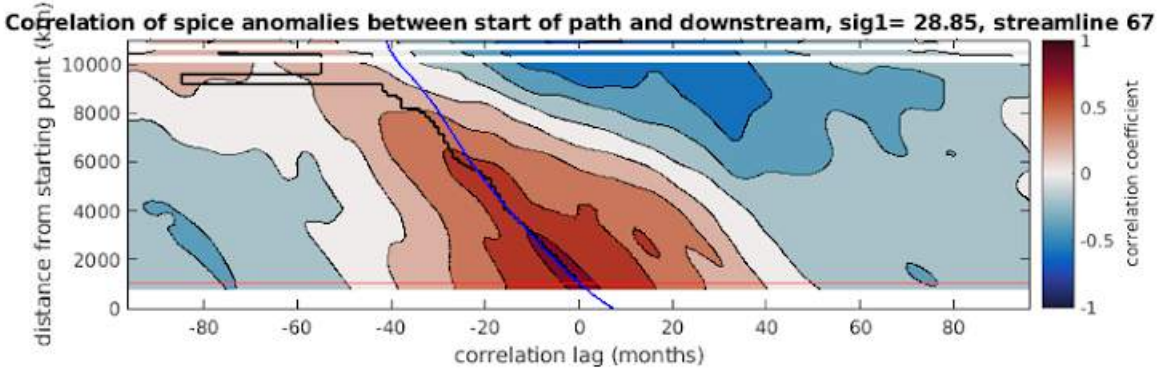
Downstream lagged correlations

Spice, with seasonal cycle removed







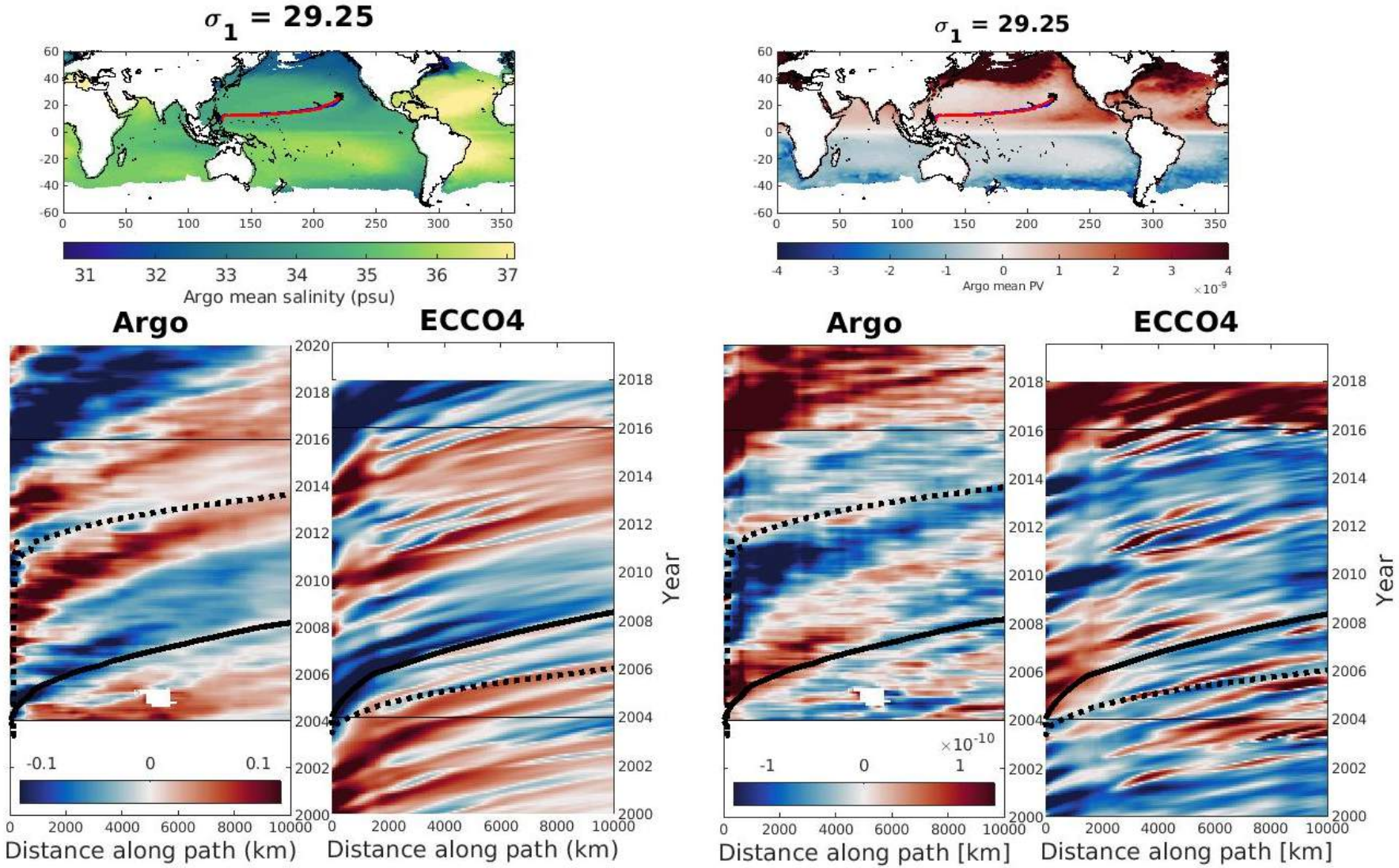


ECCO v4r4 output suggests a missing link through the western boundary and onto the equator, filling in gaps in the Argo observational array.

North Pacific example

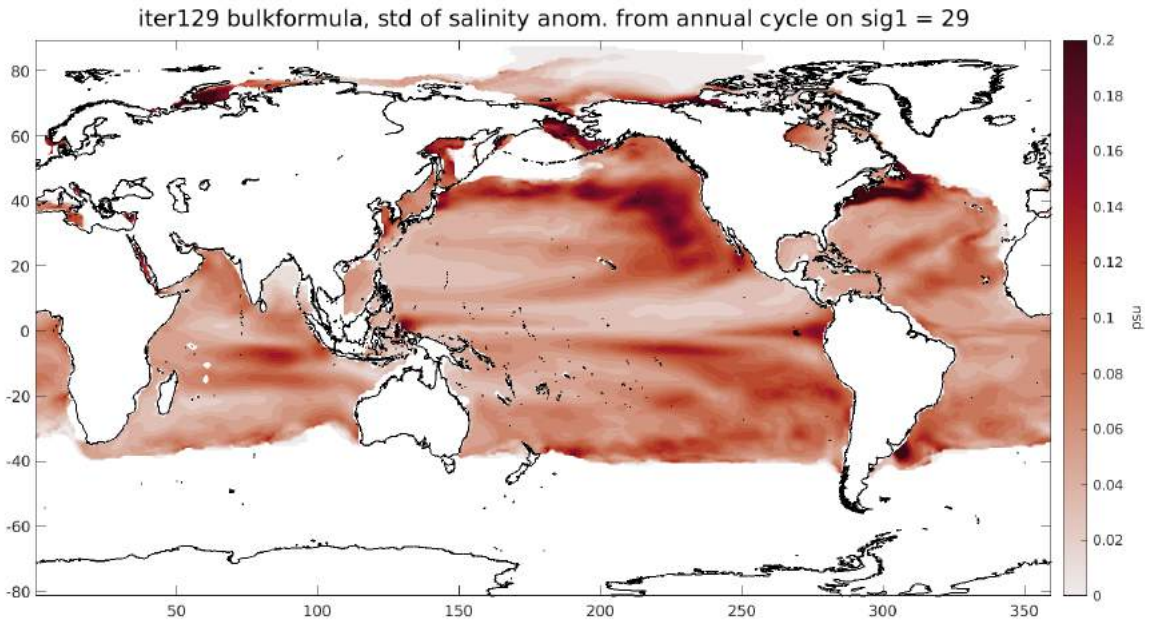
Spice (salinity)

PV

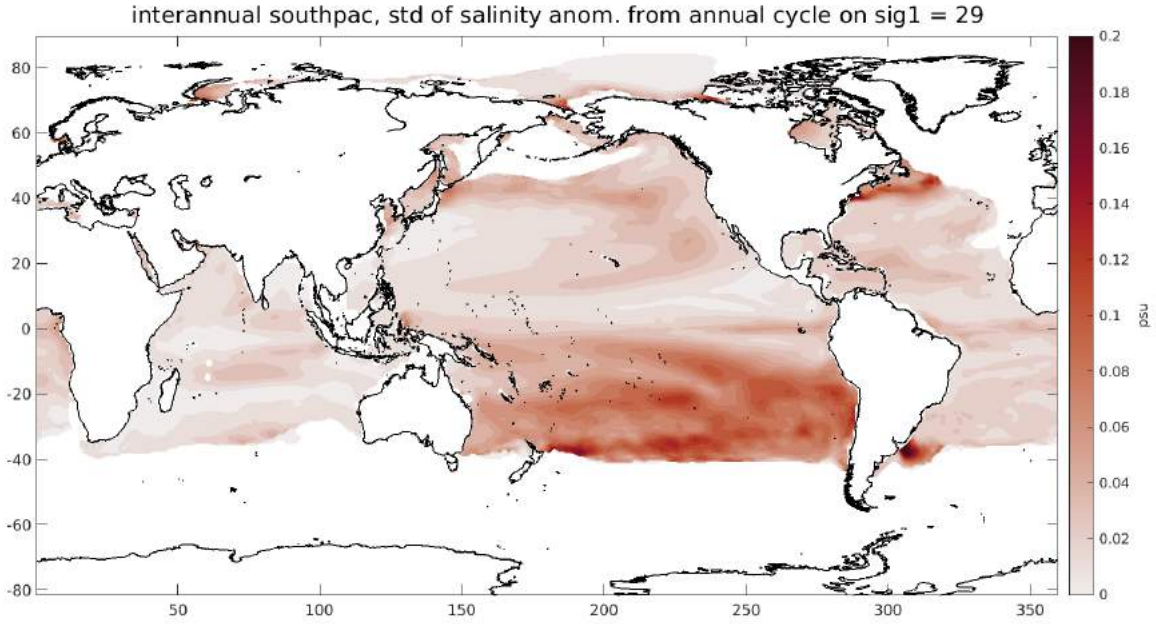


Anomaly propagation of greater than 10,000 km and 5 years is not restricted to the South Pacific.

Interannual variability in forcing is the key driver of salinity and spice variability on an isopycnal, despite the relatively small energy in the atmospheric on these timescales.



ECCO (iteration 129) forcing



ECCO forcing with interannual variability only in S. Pacific

Summary

Argo data show long-lived anomalies in subtropical basins across the world ocean. In the Pacific, these anomalies can last up to 5-6 years and 10,000 km.

ECCO v4r4 is able to represent these phenomena as seen in Argo, suggesting that the state estimate:

1. can be analyzed for the formation mechanisms of these interannual anomalies, and

2. provide a means to identify whether these anomalies re-emerge in the equatorial mixed layer.

Future questions

- What are the mechanisms responsible for the subtropical formation of interannual anomalies of physical water properties?
- Are interannual anomalies that form in the subtropics able to reach re-emergence zones at western boundaries or the equator, and if so, can we detect changes in air-sea fluxes as a result?
- What are the broader climate implications of this “ocean tunnel”?

We will re-run the MITgcm under ECCO configurations with modified forcing conditions to explore possible answers to these questions.

Acknowledgements

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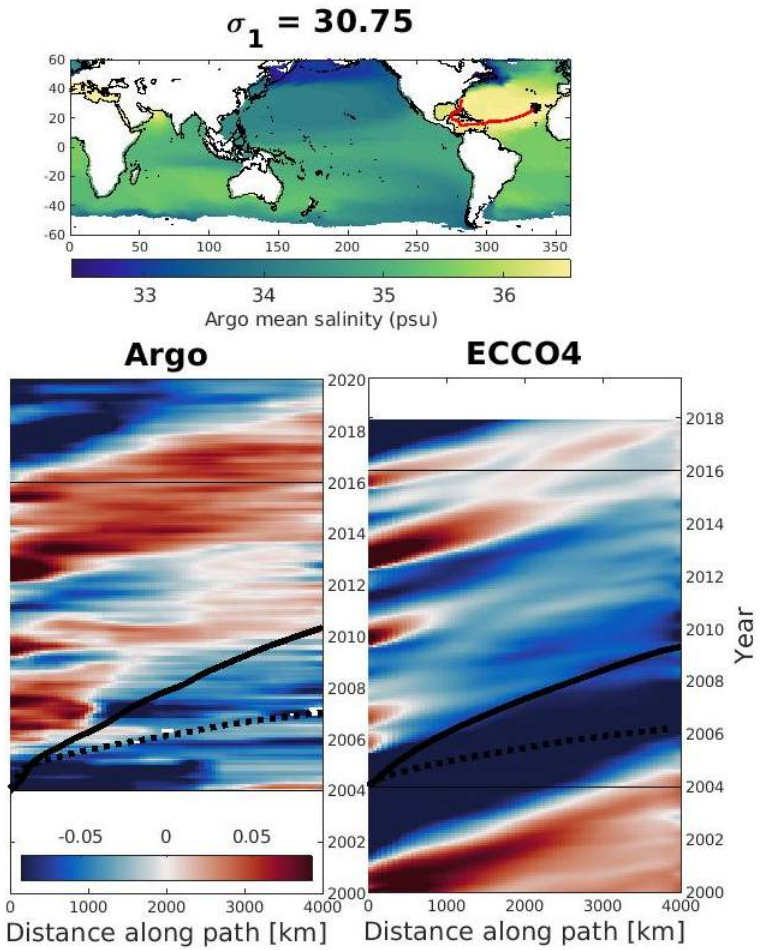
More examples (spice)

North Atlantic:



South Indian: