Regional Variability in the 30-Year Satellite Altimeter Record

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Motivation

- Sea level predictions benefit from understanding past sea level fluctuations and, to the extent possible, using data to inform the projections.
- To uncover the anthropogenic sea level rise pattern, ideally, natural variability should be quantified and removed from the observations prior to estimating the regional trends.
- In practice, it is difficult to assess whether the natural variability has been completely separated from the forced response, especially if the forced pattern resembles patterns associated with natural variability.
- Elongating the sea level record is critical to identifying the forced response.

Hamlington et al., 2014, 2019, 2022; Nerem et al., 2018; Nerem & Fasullo, 2018; Fasullo & Nerem, 2018; Zhang & Church, 2012

Guiding Questions

- In what parts of the ocean will the satellite-altimeter trends be similar or different as the record lengthens?
- What are the dominant timescales of sea level variability for different regions of the ocean?
- What are the processes – both natural and forced - that are impacting satellite altimeter-measured trends?

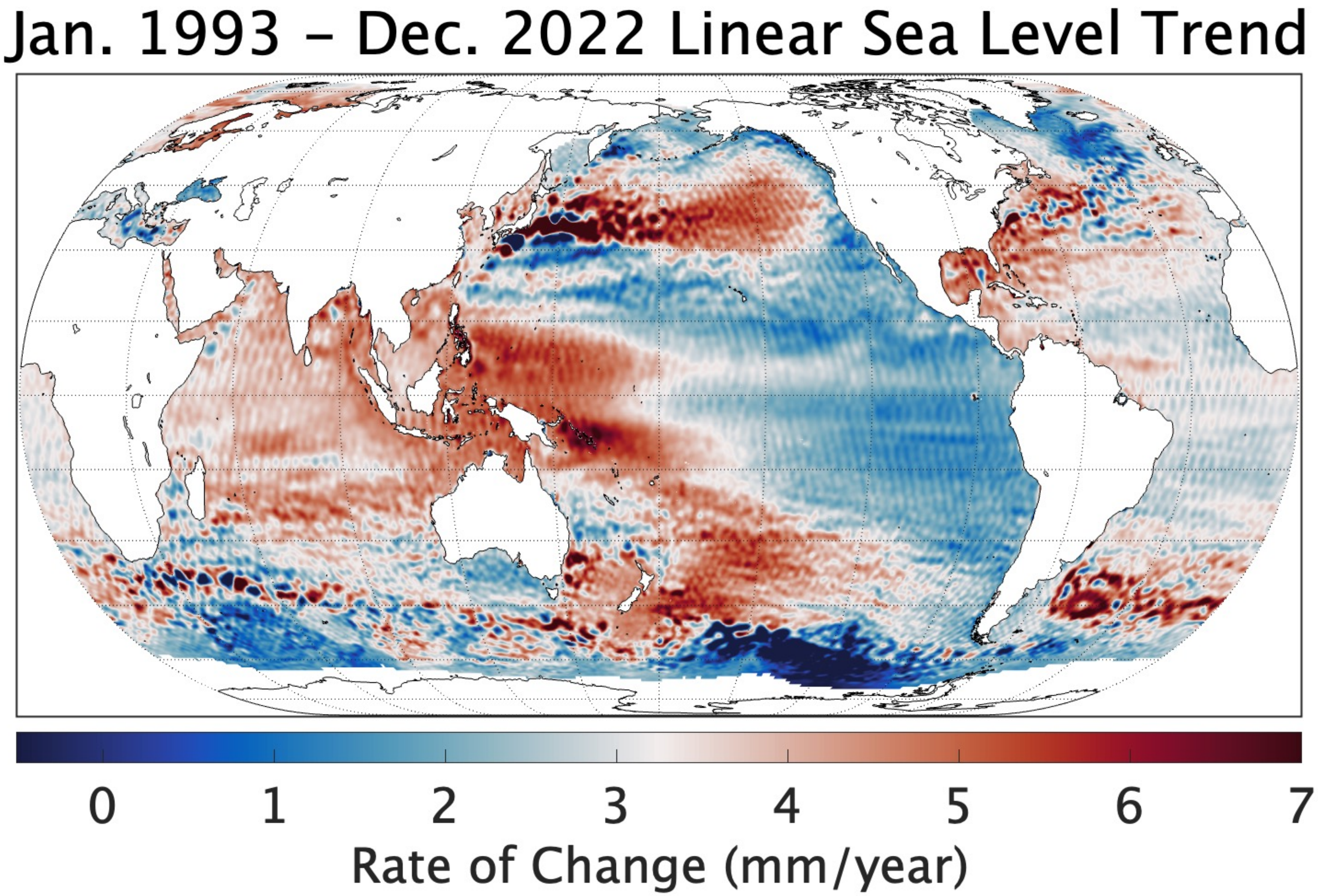
SSHA Data Set

JPL MEaSUREs Gridded Sea Surface Height Anomalies

- JPL MEaSUREs gridded SSHA dataset that is part of the Integrated Multi-Mission Ocean Altimeter Data for Climate Research
- All JPL SSH grids are constructed from along-track data from two simultaneous altimetric satellites.
    - The gridded data use the SSHA of TOPEX/Poseidon, Jason-1, Jason-2, and Jason-3 as the reference data and are supplemented with data from several other satellite altimeters.
- Successfully used in Hamlington et al. 2019a and 2019b to investigate modes of variability of sea level at a global scale as well as examine the natural and forced patterns of sea level rise during the altimeter era.

Fournier et al., 2022

Global Distribution of Sea Level Trends



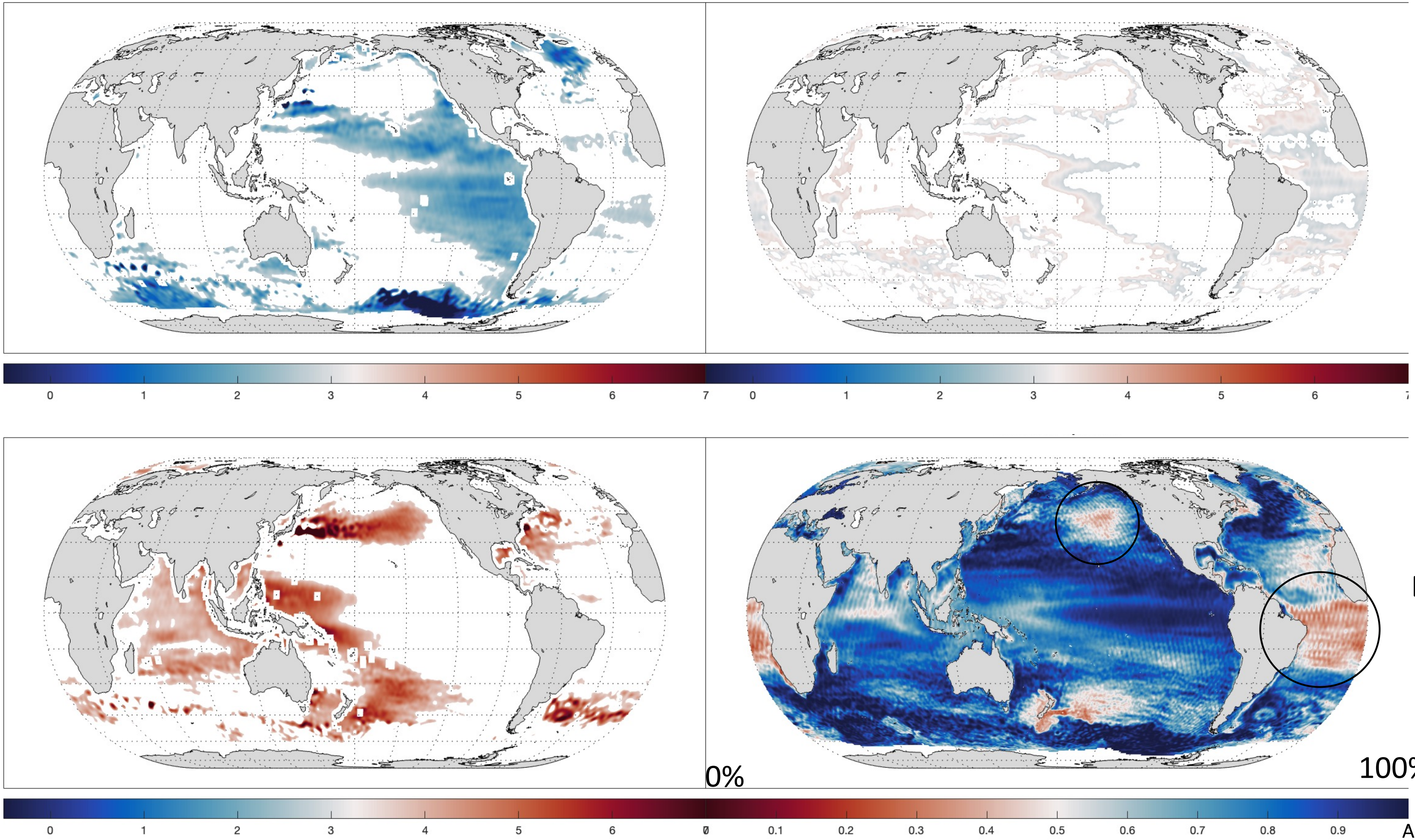
Regional Trend Distribution

Low Regional Sea Level Trends

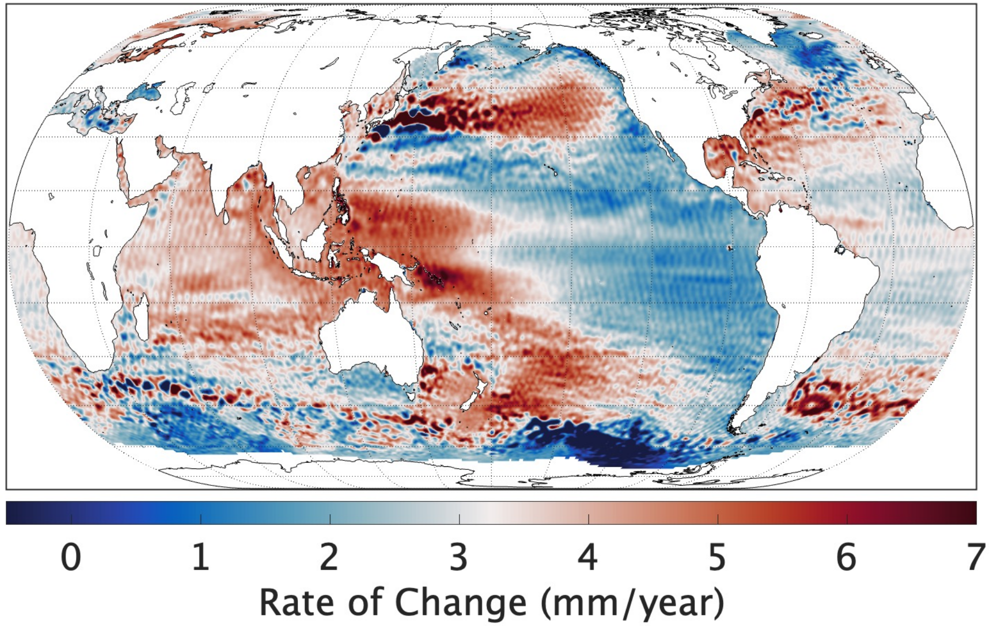
Neutral Regional Sea Level Trends

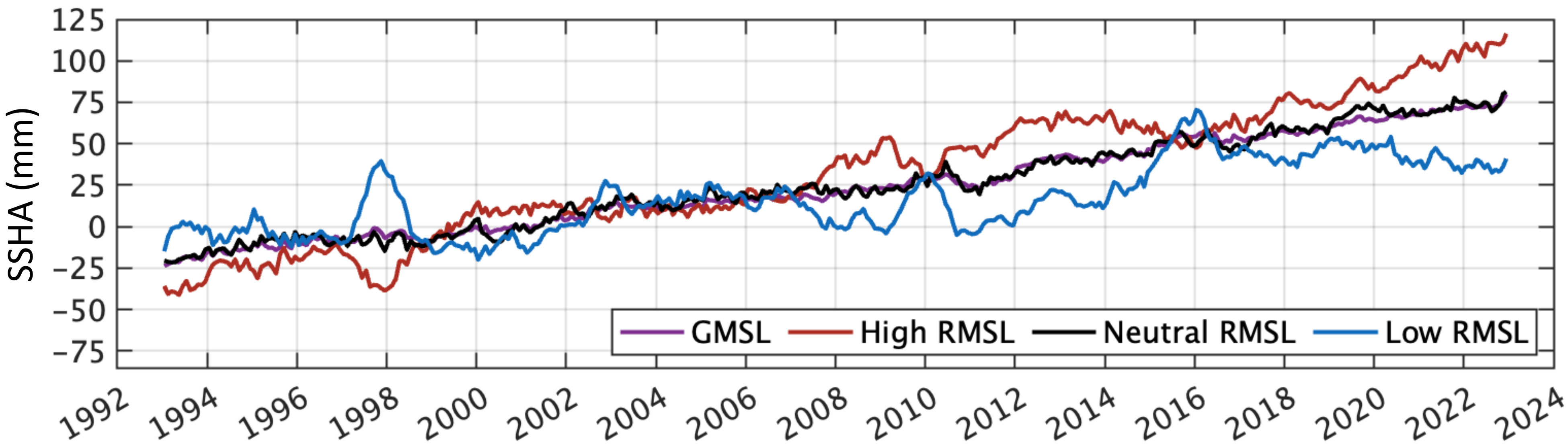
High Regional Sea Level Trends

Variance Explained

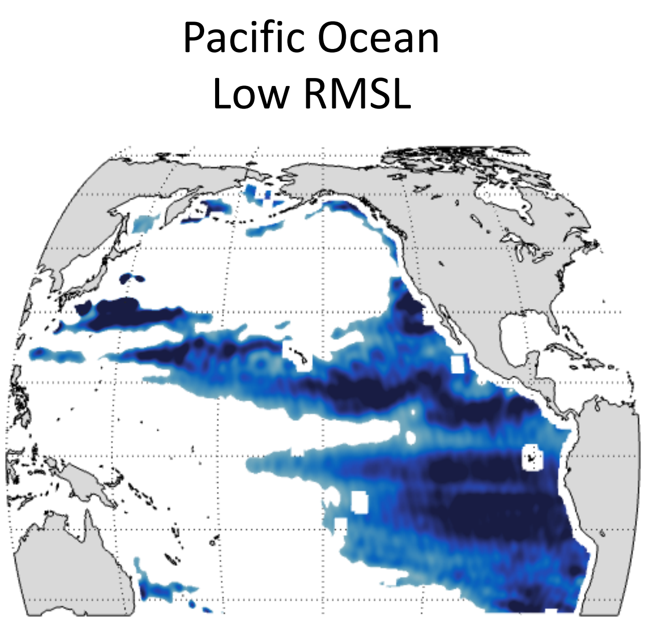


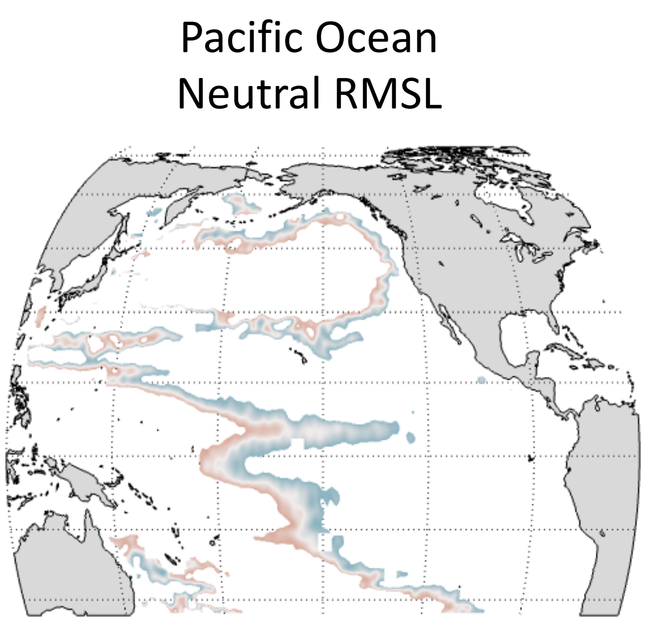
Regionally Averaged Sea Level

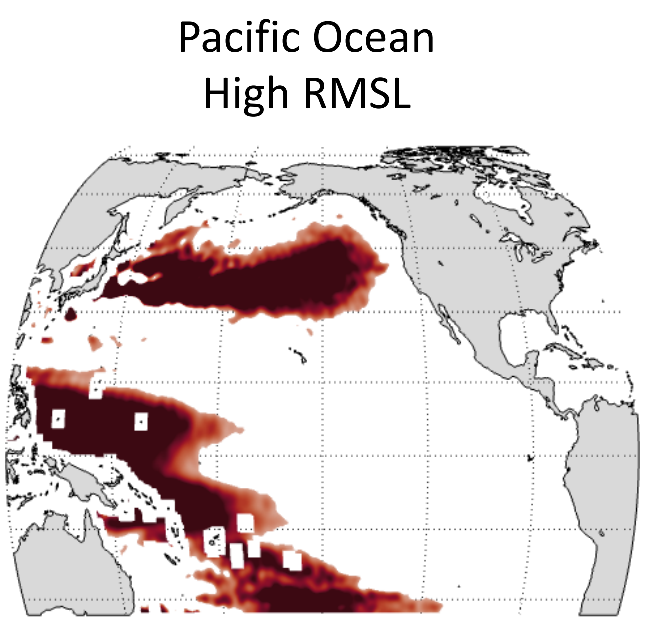


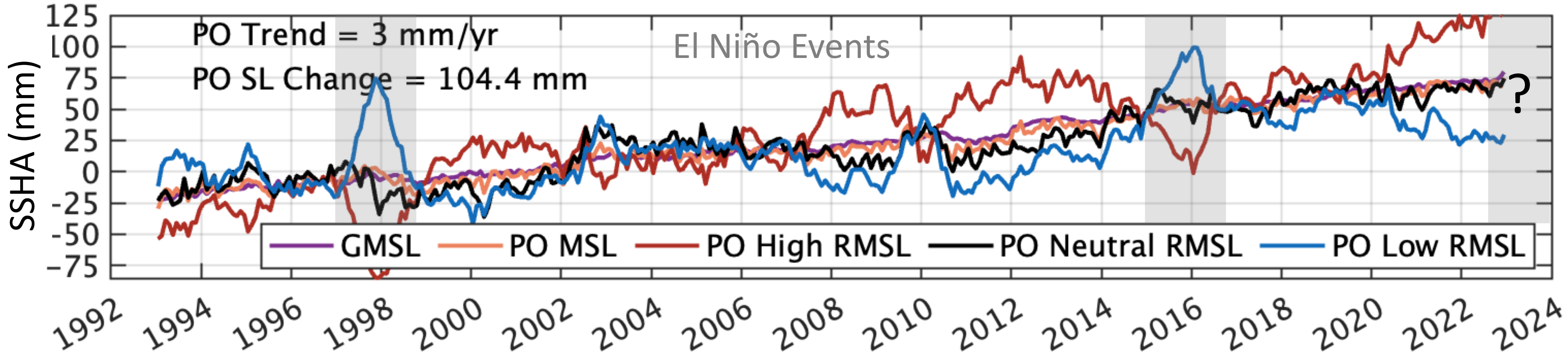


Pacific Basin-wide Partitioning



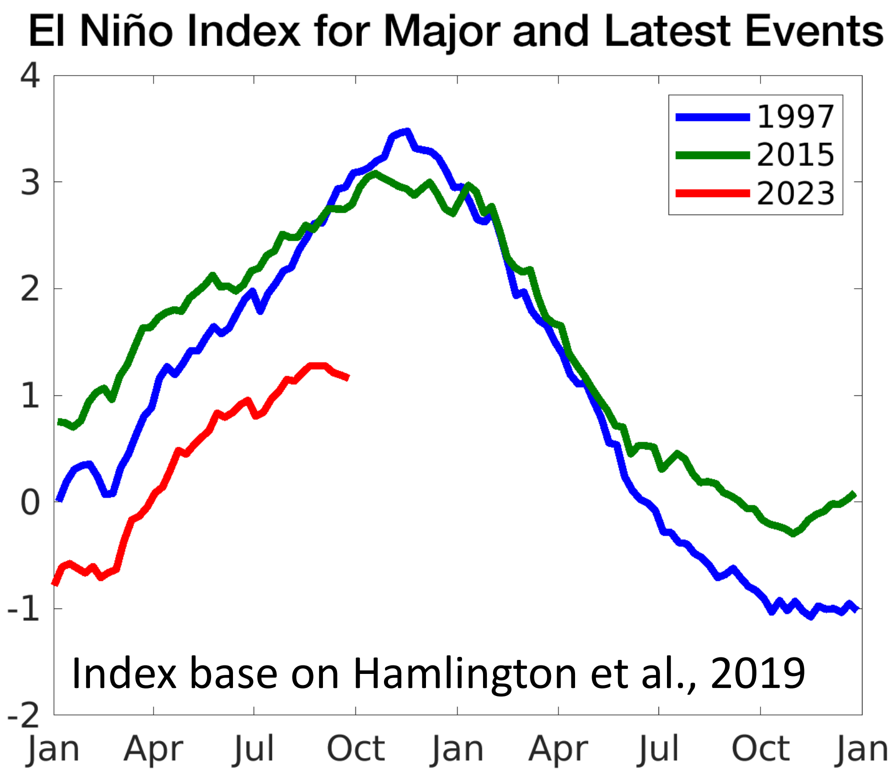




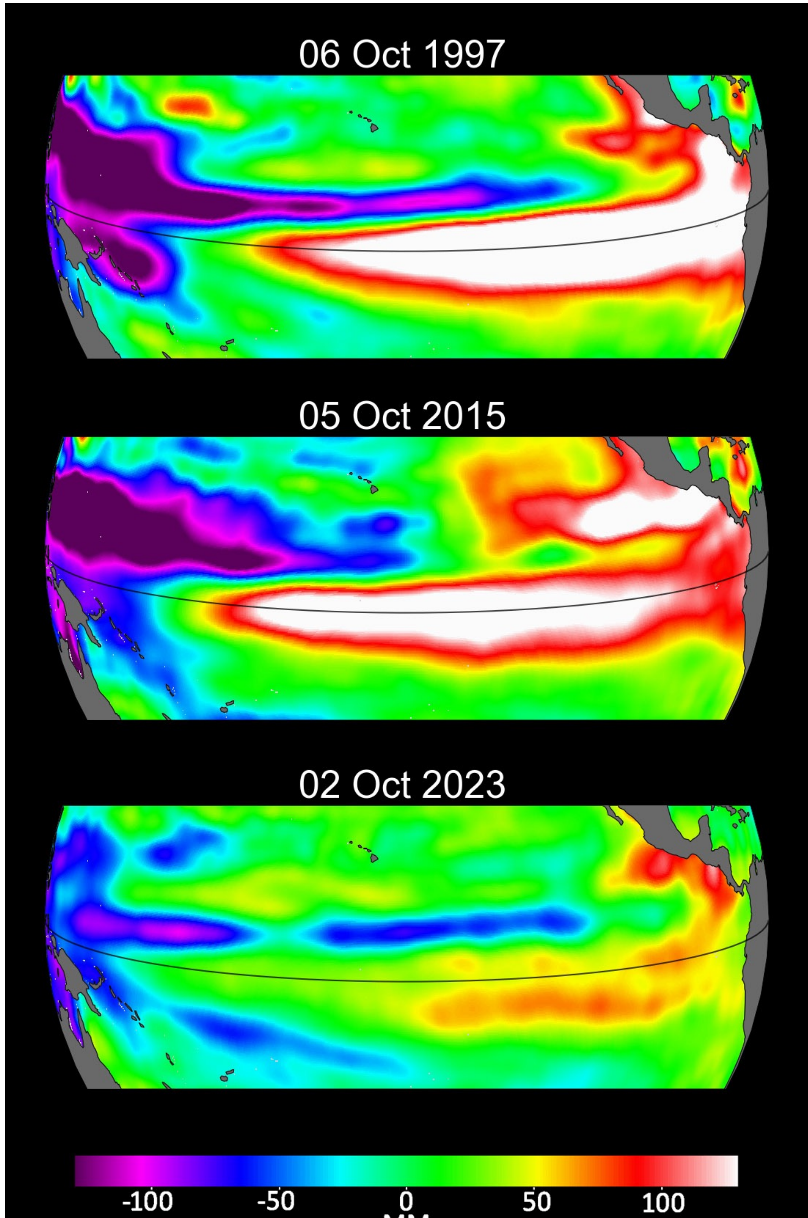


Boening et al., 2012; Fasullo et al., 2013; Hamlington et al., 2016, 2019, 2020; Han et al., 2017; Zhang & Church, 2012

Pacific Basin-wide Partitioning

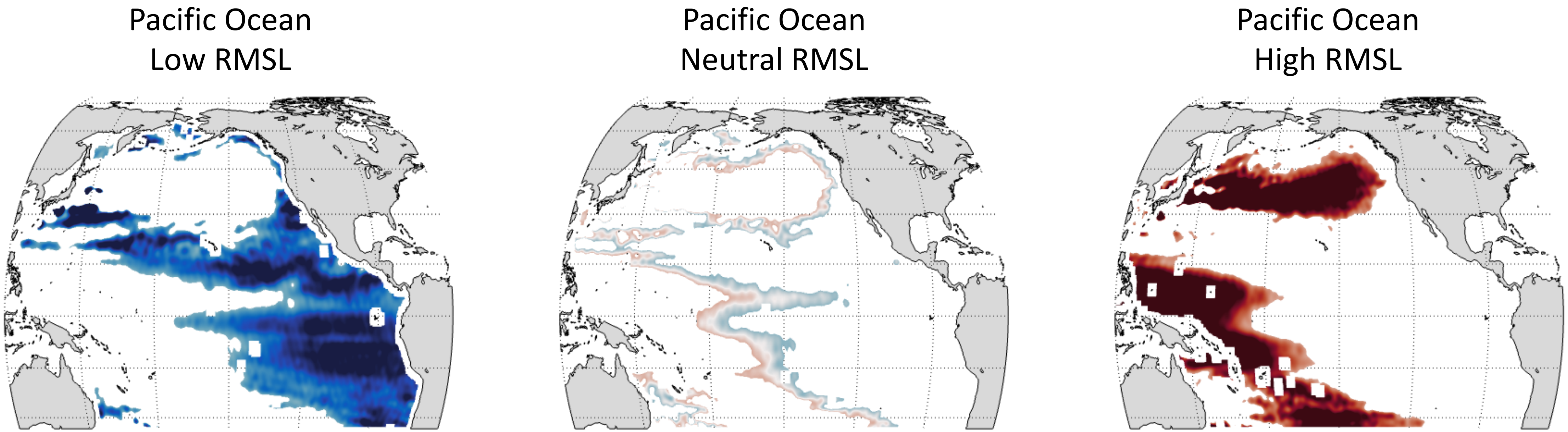


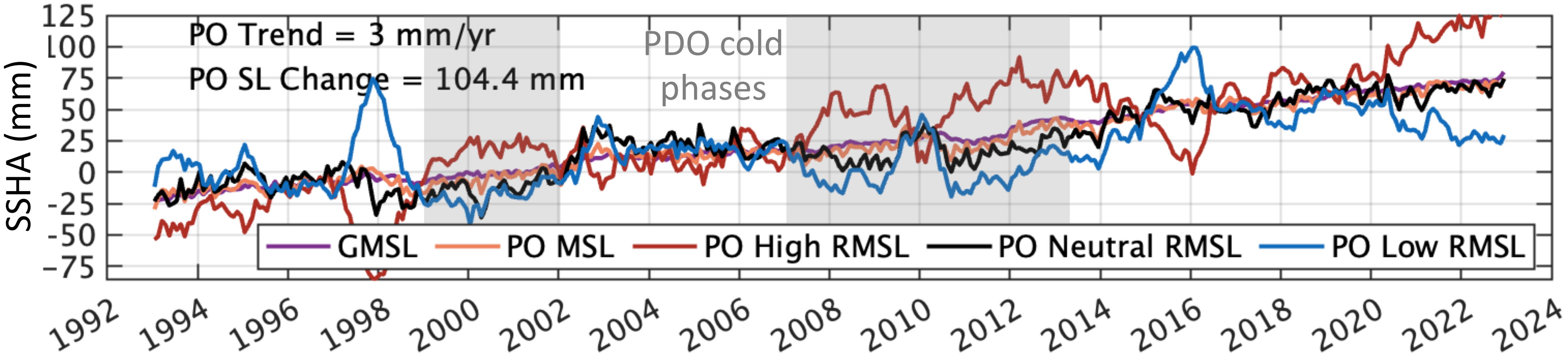
- Equatorial Kelvin wave propagation progressed throughout the summer
- By October, the intensity of this year's El Niño does not quite match that of the largest events in recent decades
- In previous events, sea levels were much higher, and these high sea levels were spread over a much larger area of the central and eastern Pacific.



https://sealevel.jpl.nasa.gov/data/el-nino-la-nina-watch-and-pdo/el-nino-2023/

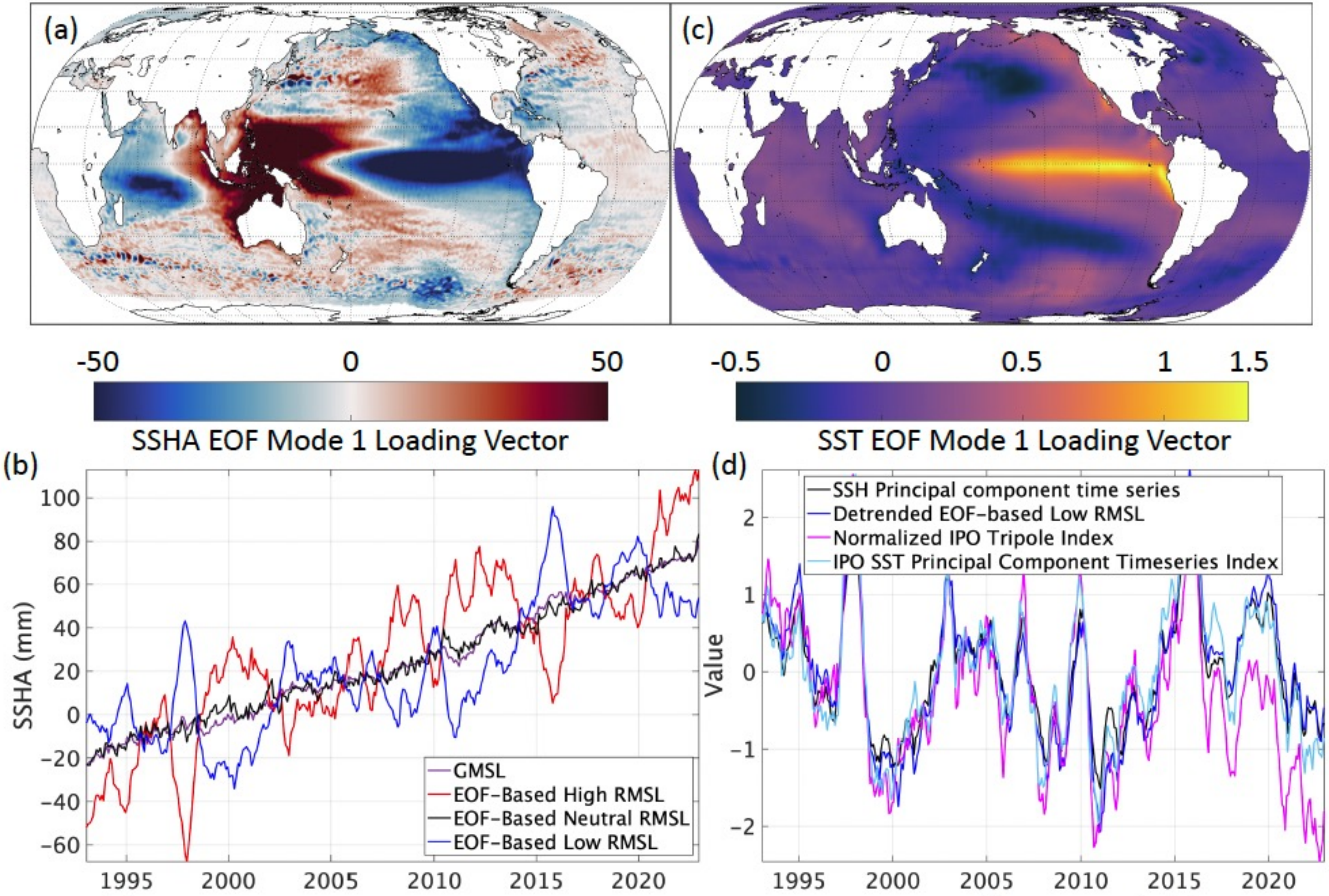
Pacific Basin-wide Partitioning



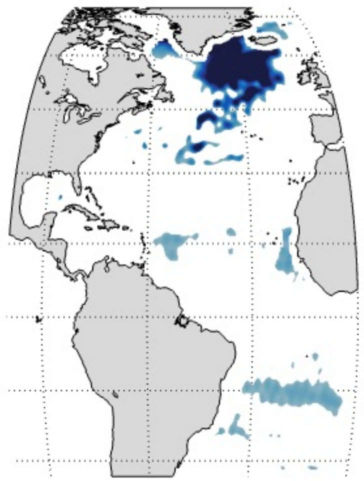


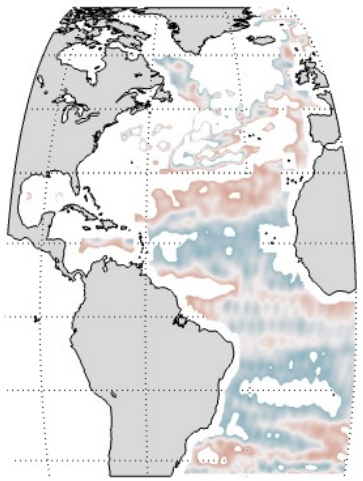
https://sealevel.jpl.nasa.gov/data/el-nino-la-nina-watch-and-pdo/pacific-decadal-oscillation-pdo/

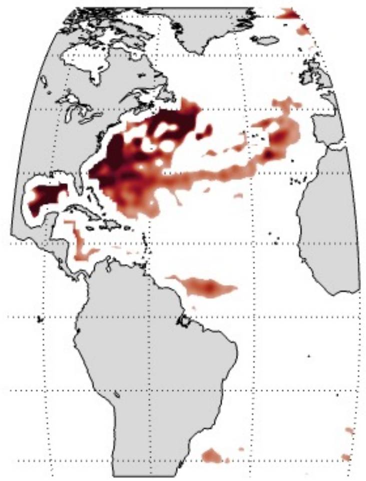
Pacific Basin-wide Partitioning

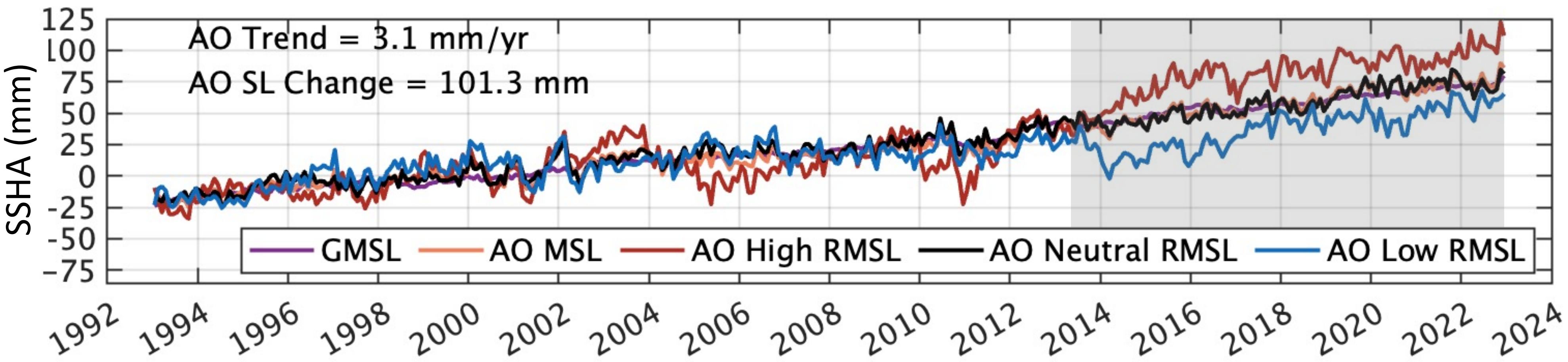


Atlantic Basin-wide Partitioning



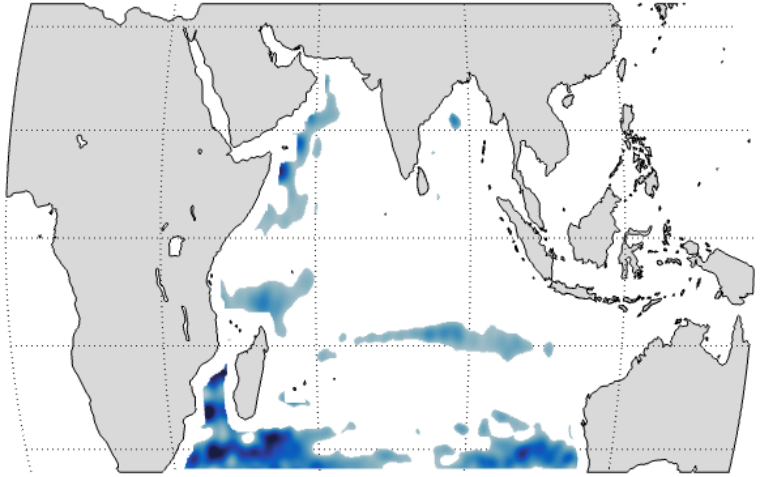




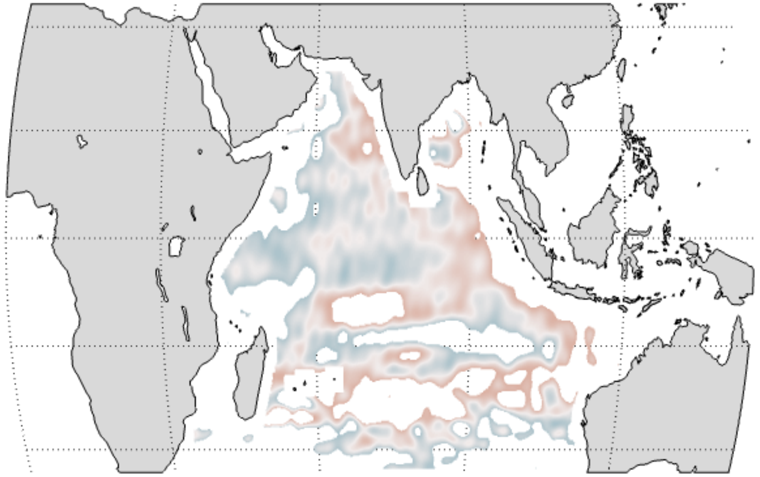


Indian Basin-wide Partitioning

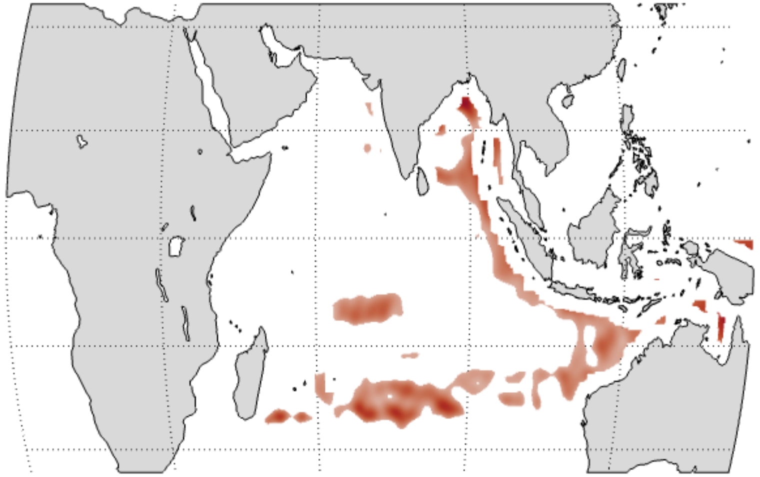
Indian Ocean
Low RMSL

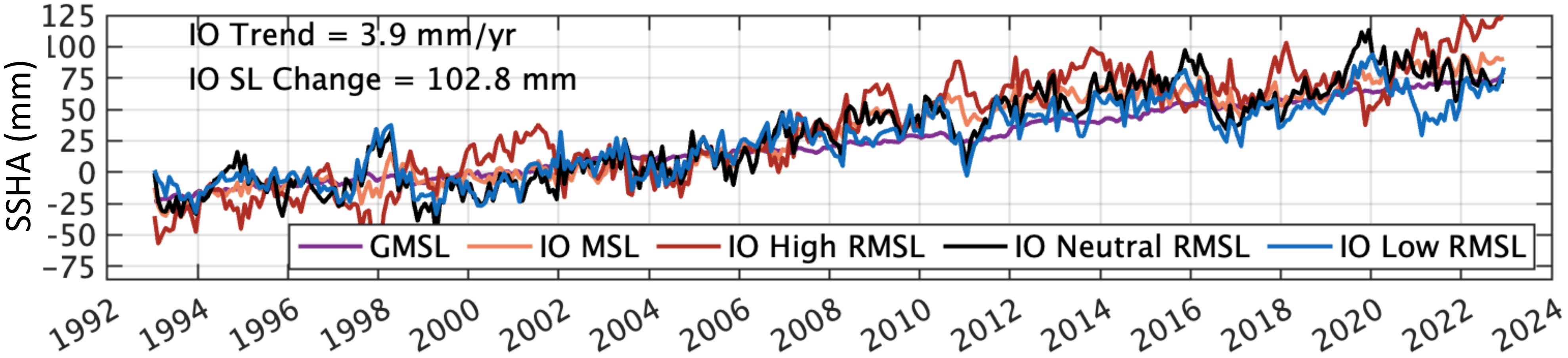


Indian Ocean
Neutral RMSL



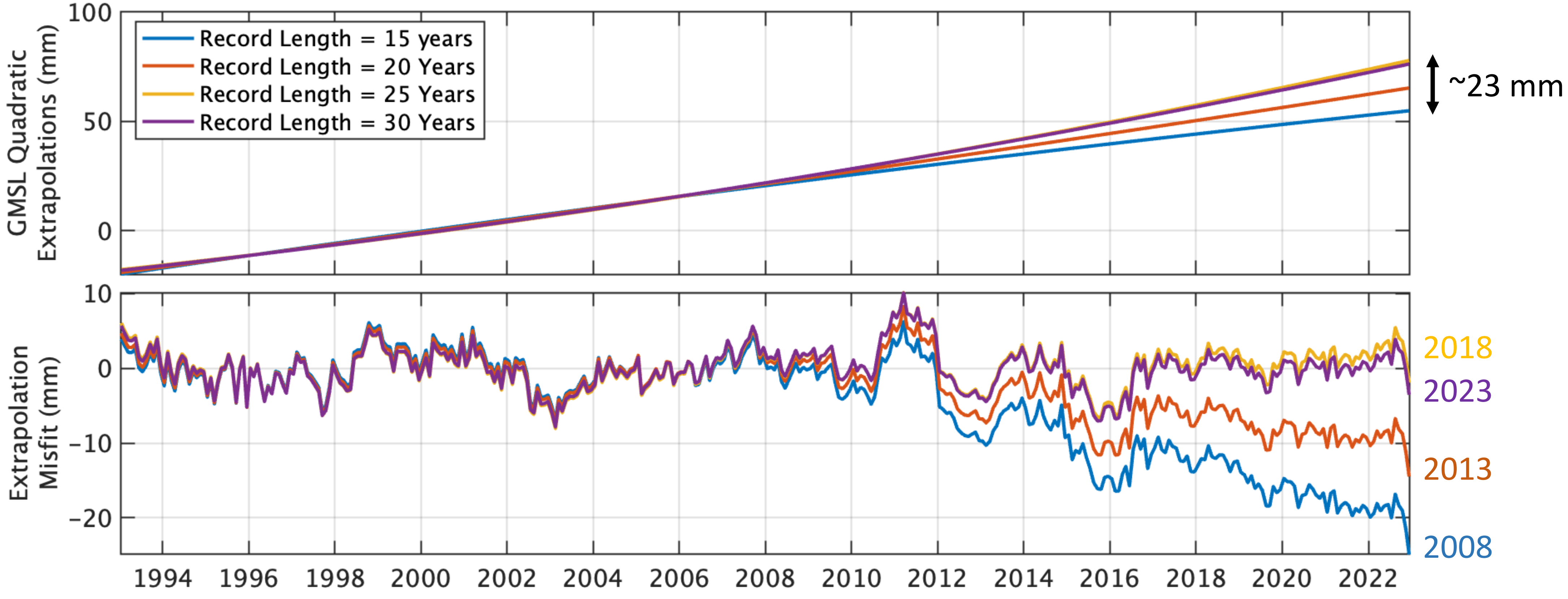
Indian Ocean
High RMSL





Extrapolated GMSL

Observation-based trajectories of sea level are useful for short planning horizons such as for real estate investments and infrastructure development, as well as adaptation pathway pivot points



Hamlington et al., 2022

Conclusions and Future Work

- Globally, regions of low mean sea level oscillate in phase with the Interdecadal Pacific Oscillation, indicating a strong influence of the Pacific Ocean in the globally defined regional averages.
- Sea level trends are comparable to the global mean throughout most of the basin, with the exception of strong trends in the North Atlantic.
- Sea level rise over the Indian Ocean largely tracks the global mean, but also shows a small zonal gradient that appears similar to the Indian Ocean Dipole structure evident first mode loading vector.
- Natural variability will continue to impact the satellite altimetry-based SLR pattern as the record lengthens, emphasizing the critical need for a sustained sea level observing system.
- Further assessment of the regional variability in extrapolation skill is required.
- Further analysis is required to diagnose both the forced and natural processes that are impacting satellite altimeter-measured trends.
- Integrate observation-focused analysis with model representation of sea level patterns (see Sloan's talk coming up!)