Insights into the representation of coastal sea level variability in CESM 1.3

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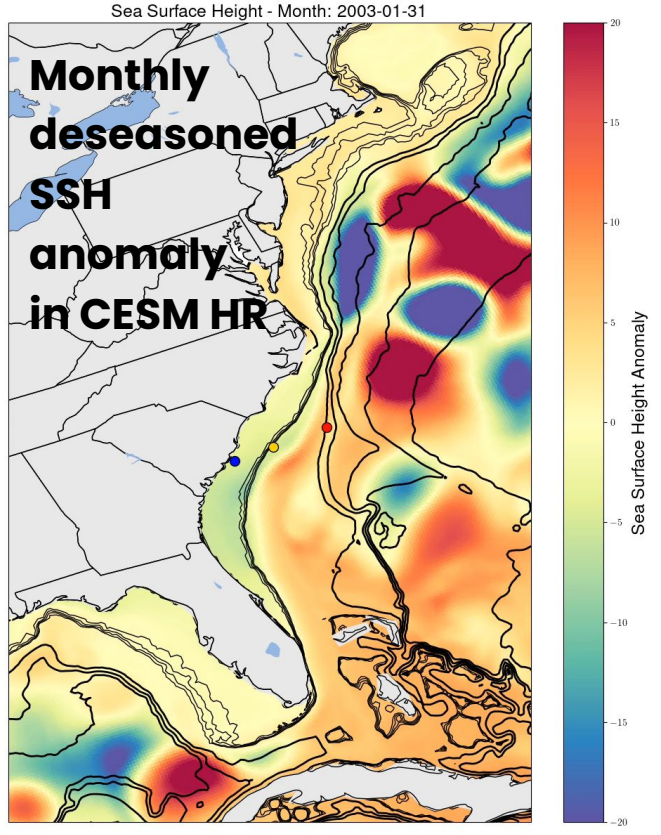
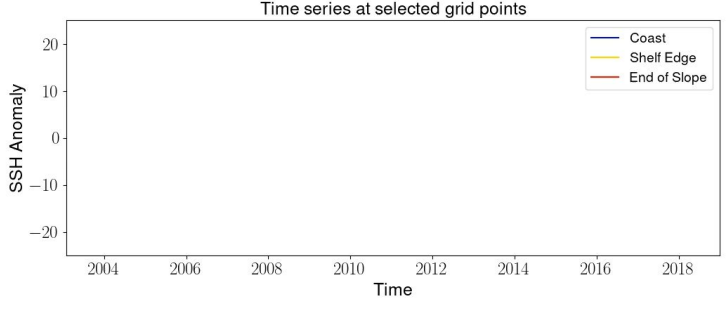
Why high resolution?

* Small-scale oceanic (e.g. eddies; Penduff et al. 2019) and coupled (e.g. air-sea heat fluxes; Kirtman et al. 2012) processes impact the large-scale sea level field

* Coastal sea level is modulated by physical constraints, and modified by local forcing, at small scales (e.g. Woodworth et al. 2019; Hughes et al. 2019)

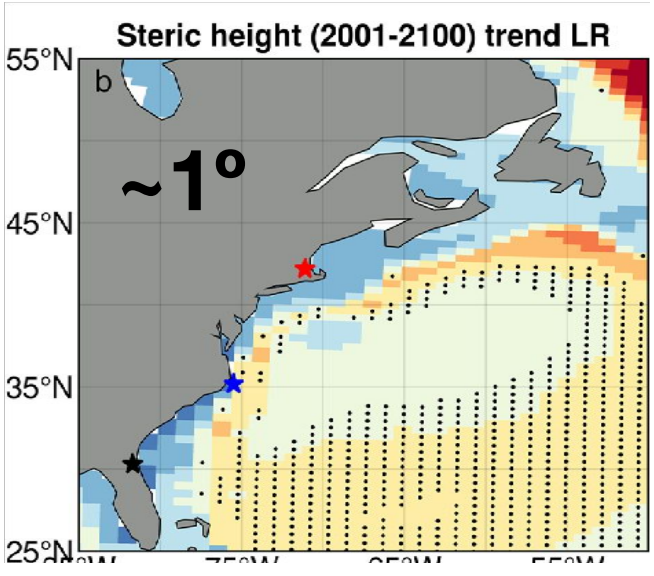


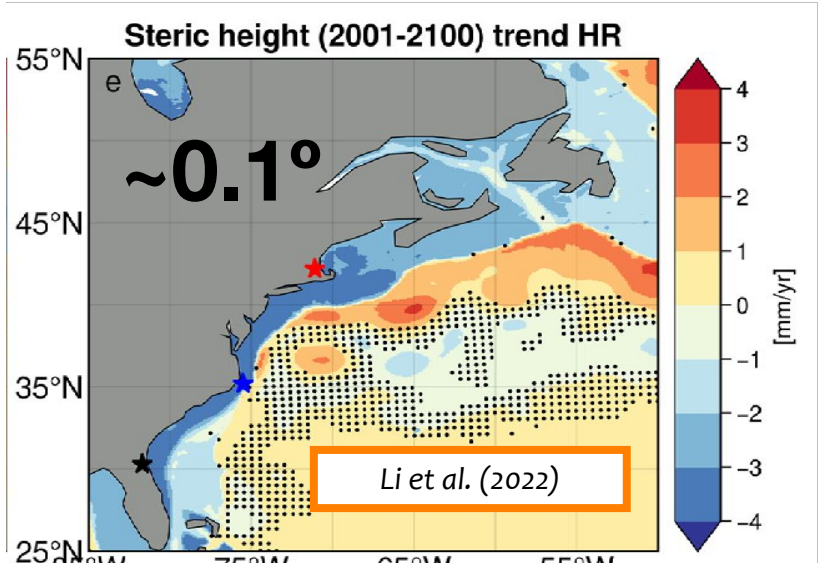


Seizing the opportunity

* Long, high resolution (<~0.1º), simulations resolve **short spatial scale, long timescale, phenomena,** including local gradients in sea level change, and emergent large-scale behavior
  * See, e.g.: Li et al. 2022; Chassignet et al. 2020; van Westen et al. 2020; Hermans et al. 2020; Zhang et al. 2017; Liu et al. 2016; Saba et al. 2016; and many others.

* …but we need to quantify **and understand** resolution-related improvements.





Ocean model simulations and processing

* CESM (1.3)-HR = ~0.1°; CESM-LR = ~1° horizontal resolution
  * See Chang et al. (2020): An Unprecedented Set of High-Resolution Earth System Simulations for Understanding Multiscale Interactions in Climate Variability and Change"
* Forced ocean-sea ice (FOSI) simulations: JRA-55 forcing (Tsujino et al. 2020)
  * Analyze 3 "forcing cycles" (cycles 2-4, following OMIP-2 protocol)

* 1993-2018 period
* **Detrended** monthly timeseries: 13-month low-pass filtered
* Inverse barometer effect and monthly global mean sea level anomaly removed from tide gauge timeseries

Quantifying improvements in the representation of annual-to-multidecadal coastal sea level variability in a 1/10° ocean climate model

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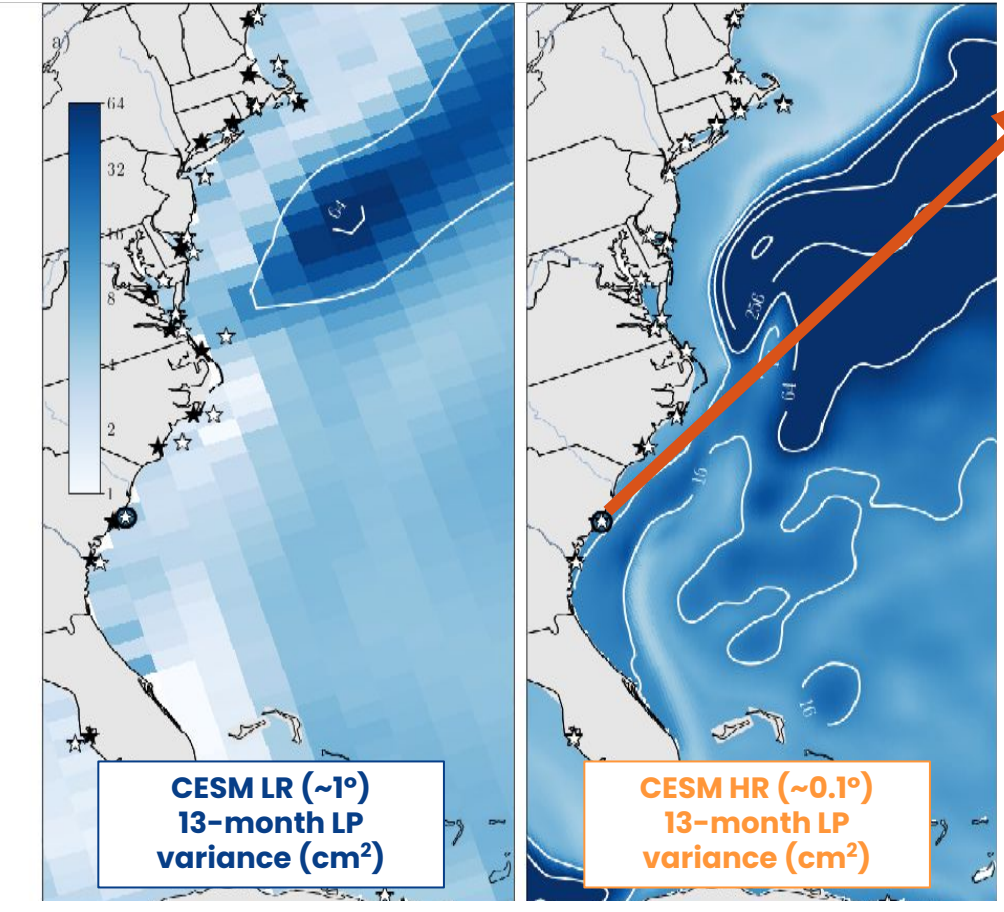
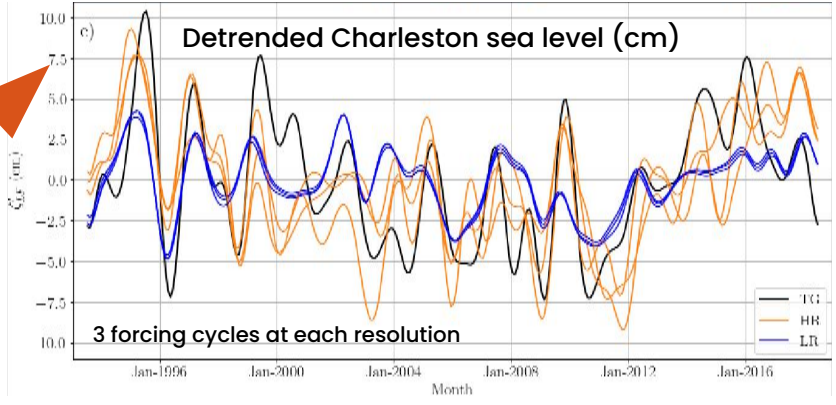
(in review at *Scientific Reports*)

General approach

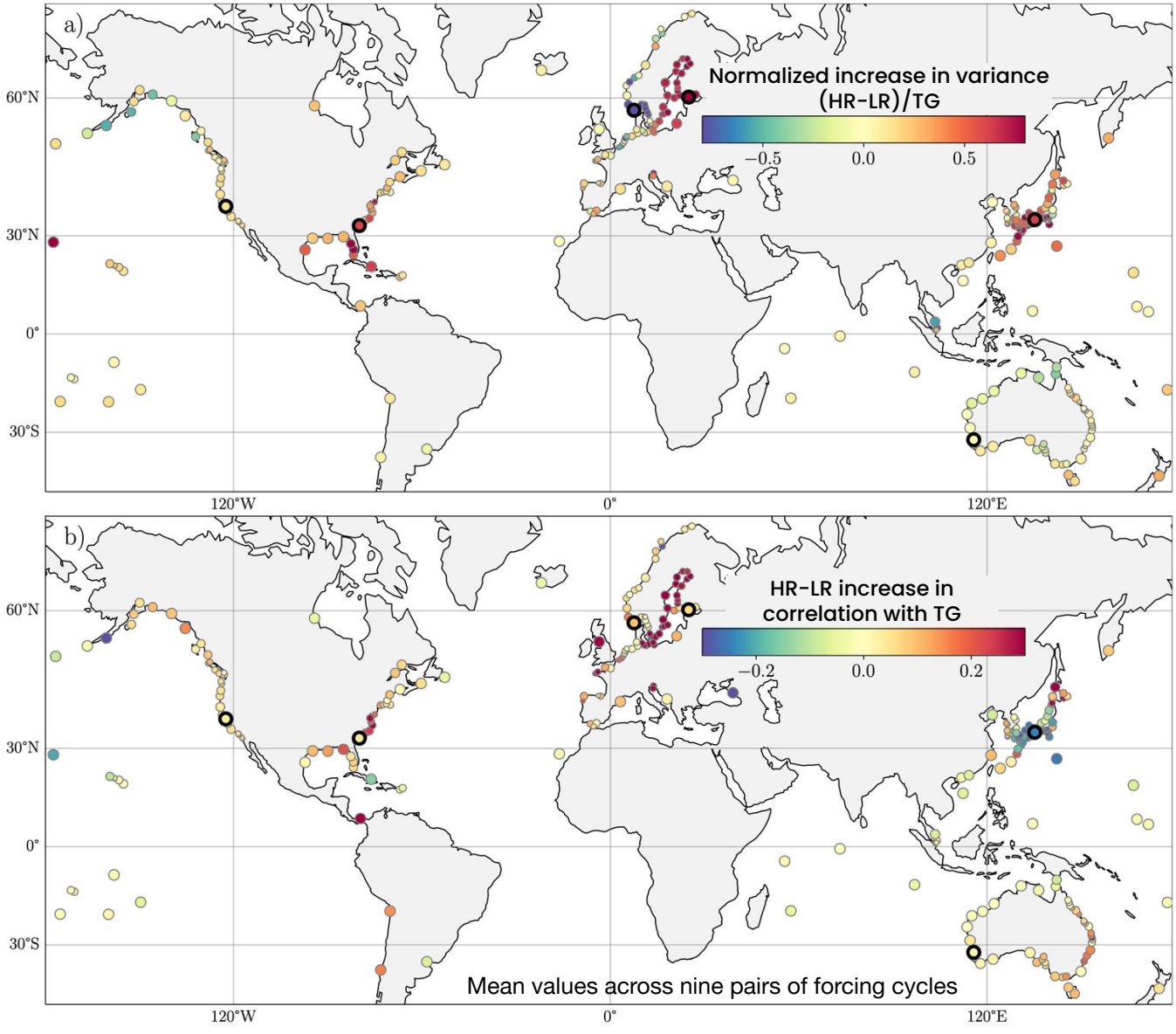




* Pointwise comparison with >300 global tide gauges
* Simple, aggregate metrics:
  * Variance
  * Correlation

Main Results

* Regional-scale “clusters”
* Variance substantially higher (and closer to observed) in marginal seas/western boundary currents
* Correlation with TGs improved in most locations; largest in marginal seas and WBC’s, except for Kuroshio region

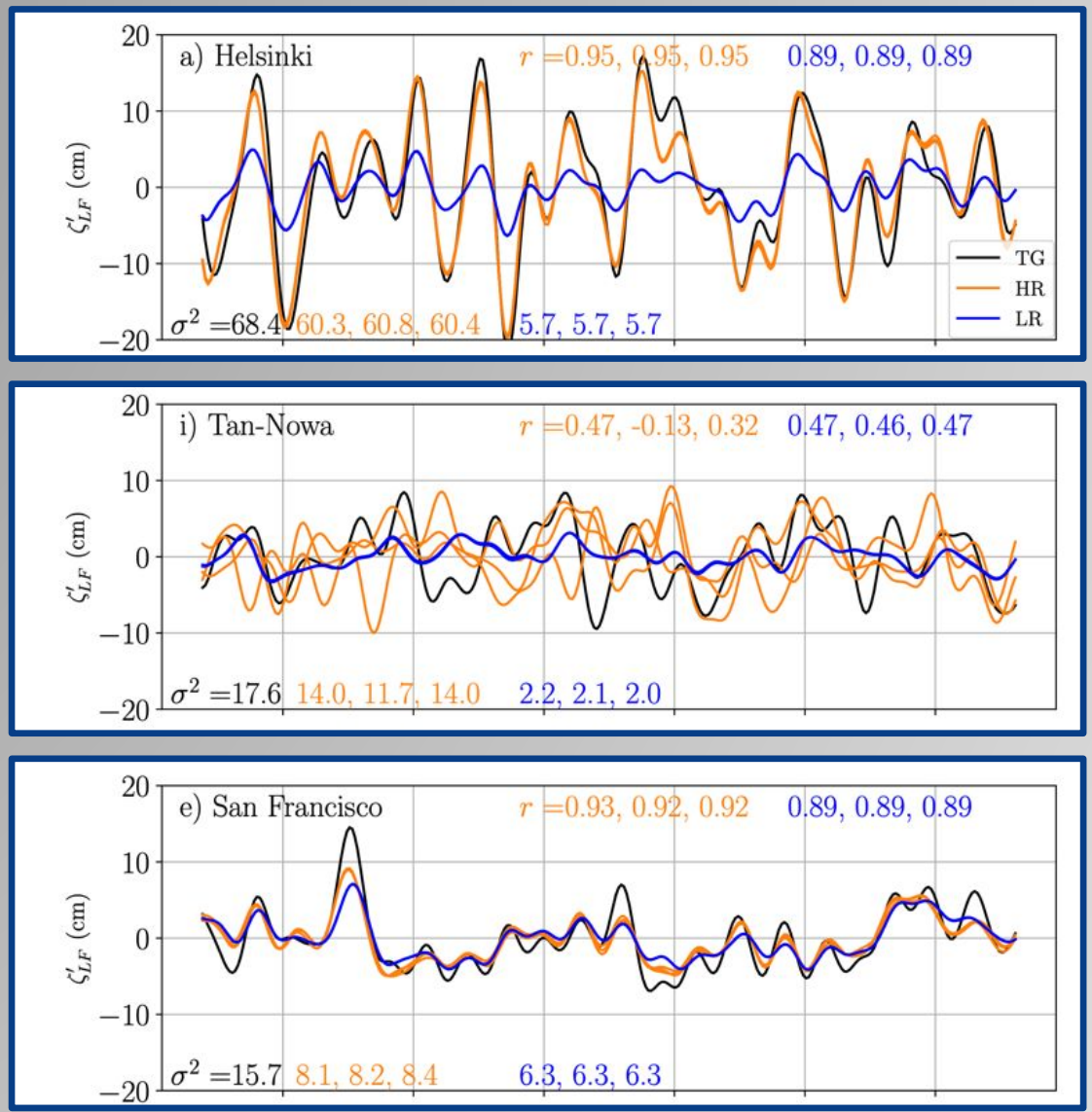


Representative tide gauges

Marginal seas

Attached western boundary currents

Eastern boundary currents



Summary: Global tide gauge/LR/HR comparison

* Model-tide gauge, and HR/LR, differences are largely regional-scale, corresponding to different “dynamic regimes”

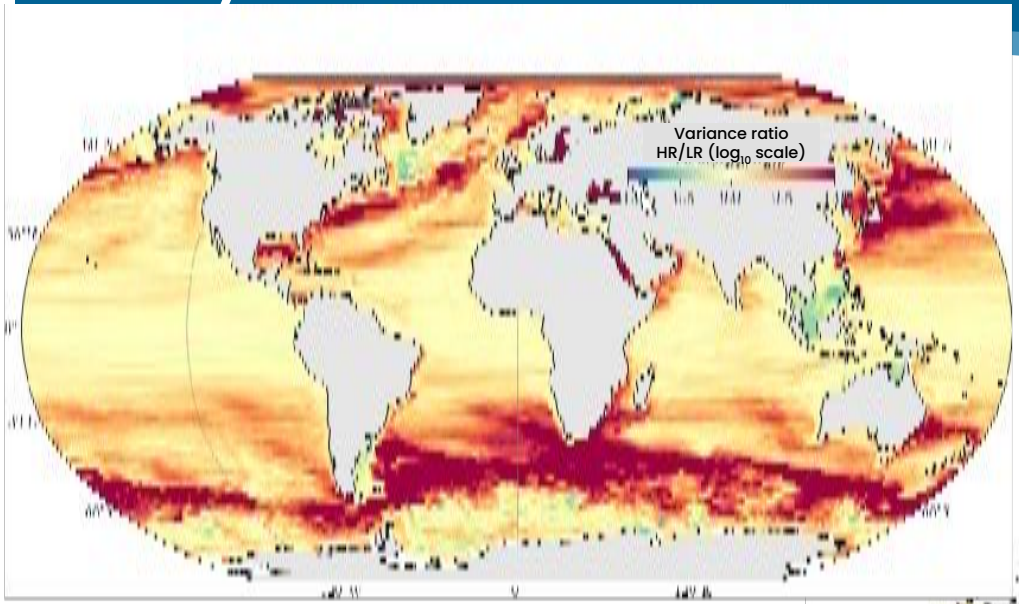
* Increases in ocean model resolution generally improve the representation of coastal sea level variability,

but…

* Increased intrinsic variability poses challenges for model evaluation, and has unclear implications for predictability and forecasting (another talk and project)

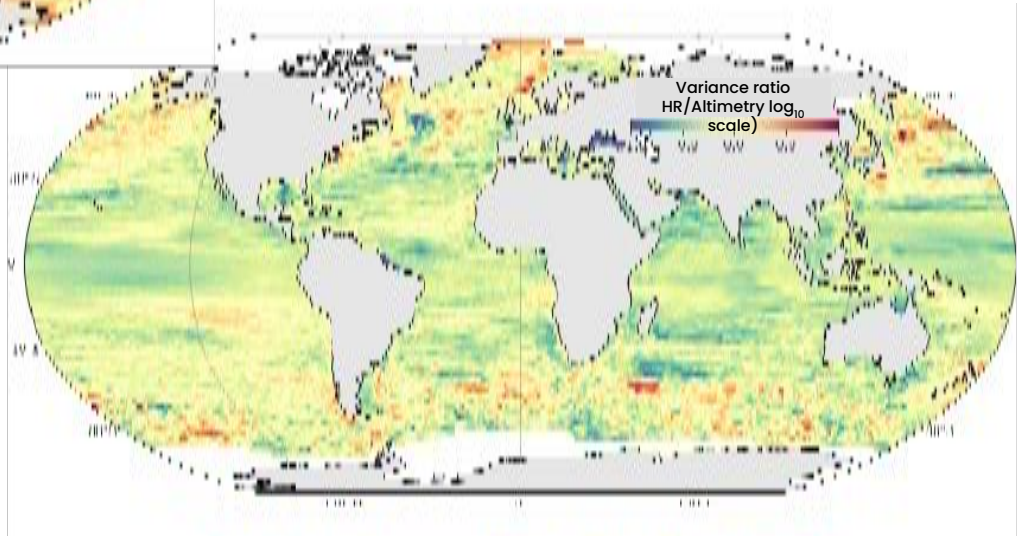
* Many regions do not see substantial improvements

Why does variance remain underestimated?



- Resolution-related increases in sea level variance are more evident in midlatitudes
- Variance remains underpredicted relative to altimetry at low latitudes

- **Ongoing efforts to assess:**
  - **JRA-55 Forcing (probably not the issue)**
  - **Timescale-dependence**
  - **Other OMIP2 ocean models**
  - **Relationship with heat content and thermocline depth variability**



Acknowledgments

OCE-2148507: A global assessment of annual to decadal sea level predictability

* NA23OAR4310458: Understanding the influence of ocean model resolution on seasonal to annual United States coastal sea level forecasts
* NA22OAR4310112: Identifying processes controlling the representation of coastal sea level in climate models

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* Permanent Service for Mean Sea Level (http://www.psmsl.org/data/obtaining/)