a mechanistic link between coastal sea level rise and offshore subsurface warming

Geophysical Fluid Dynamics Laboratory

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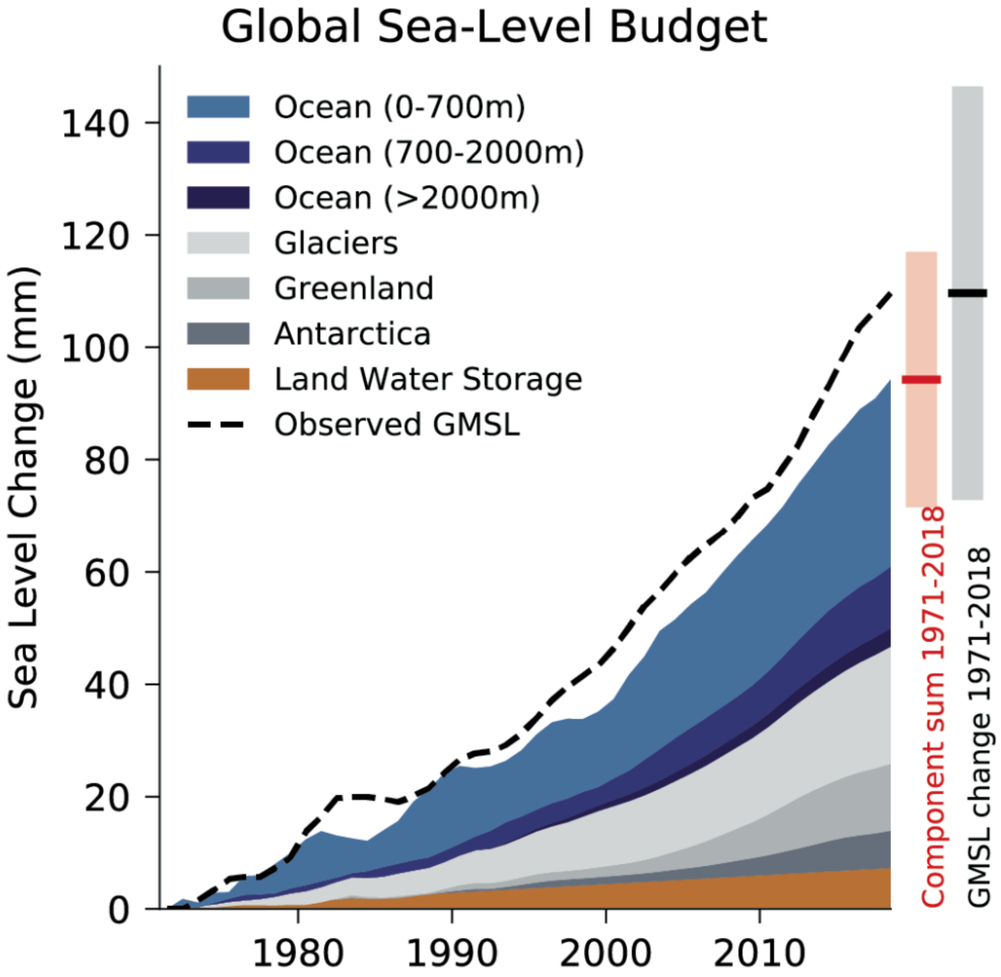
NOAA – GFDL



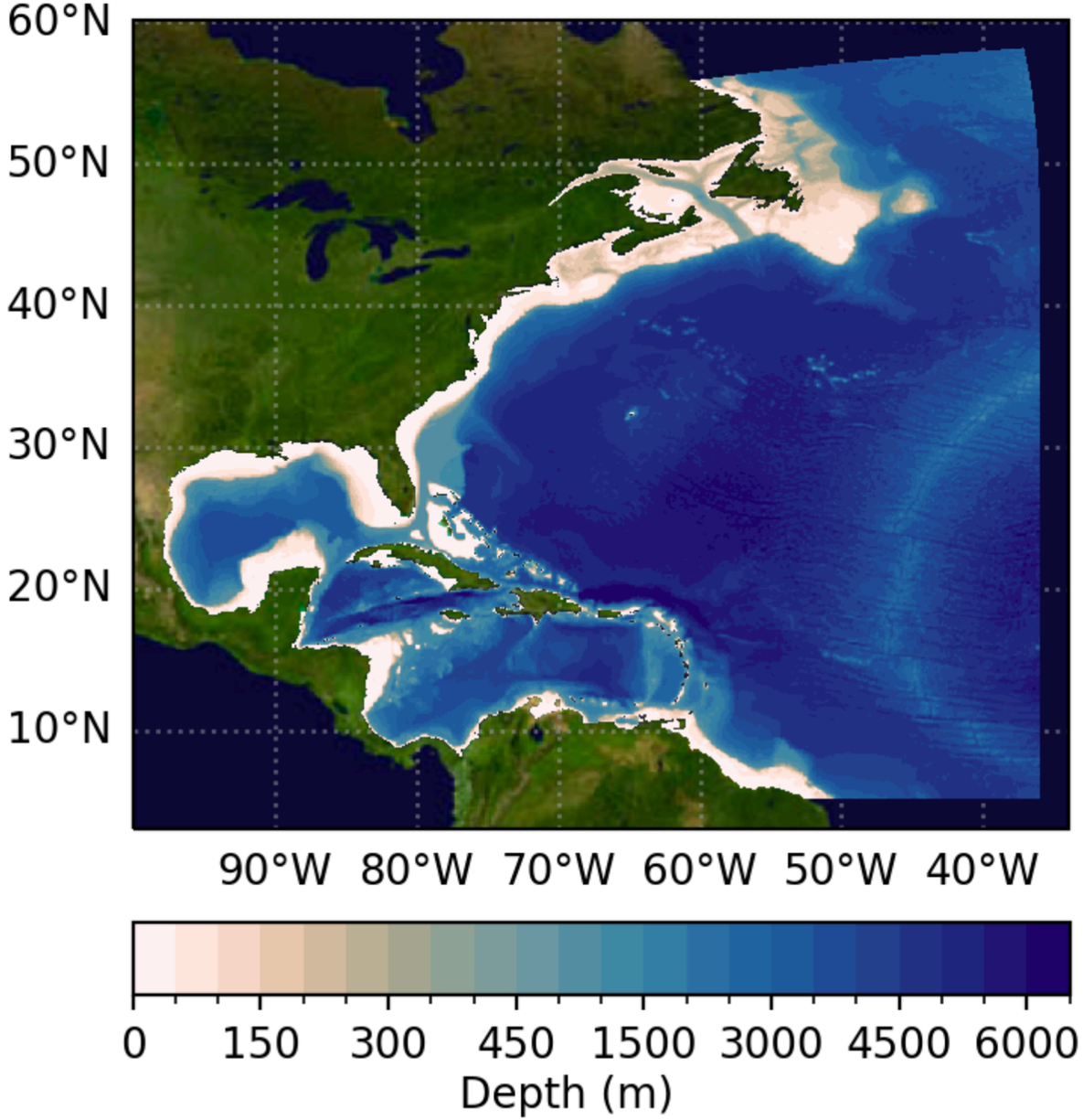
[https://www.ipcc.ch/report/ar6/wg1/downloads/]

11 June 2024
CESM Annual Workshop - sea level

a regional study

NOAA GFDL's NWA12

regional ocean model - MOM6
1/12 degree horizontal resolution
75 vertical levels
1993-2023 (30yr hindcast run)
Surface & ocean boundaries =
- ERA5 atmospheric reanalysis
- GLORYS12 ocean reanalysis



Ross et al. 2023 – Geoscientific Model Development
[https://doi.org/10.5194/gmd-16-6943-2023]

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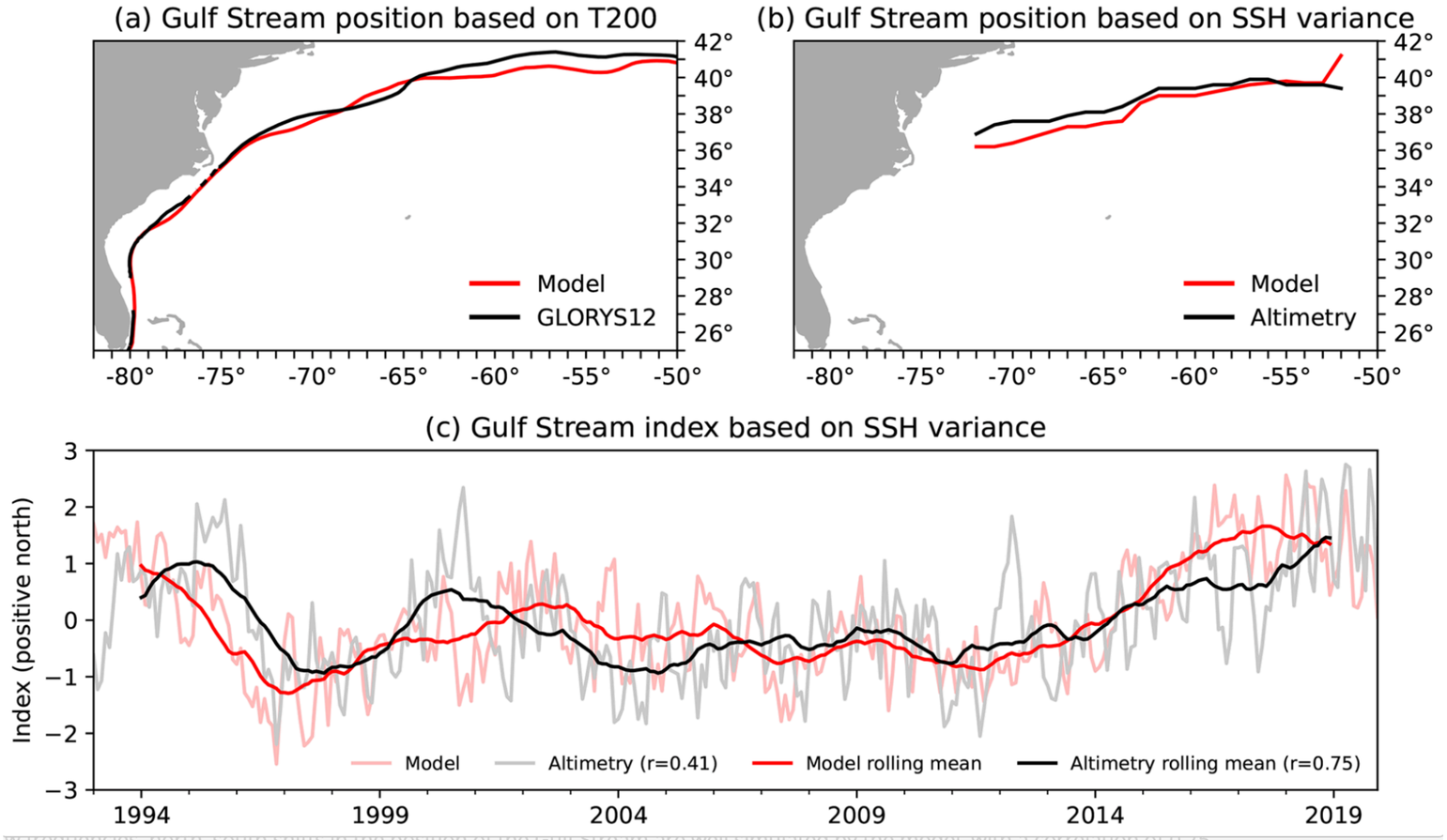

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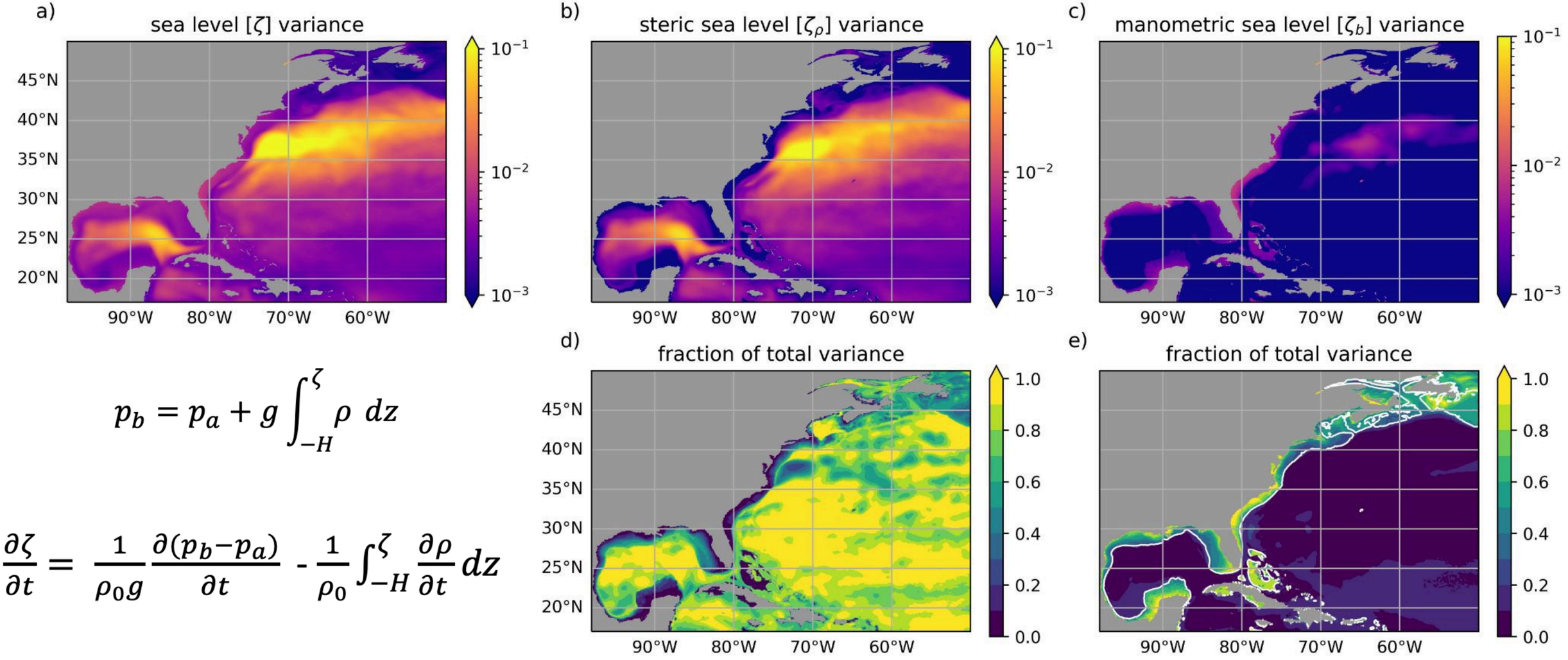
time tendency of sea level decomposed into mass and density contributions

dependence on ocean depth and timescale



$$p_b = p_a + g \int_{-H}^{\zeta} \rho \; dz$$

$$\frac{\partial \zeta}{\partial t} = \frac{1}{\rho_0 g} \frac{\partial (p_b - p_a)}{\partial t} - \frac{1}{\rho_0} \int_{-H}^{\zeta} \frac{\partial \rho}{\partial t} dz$$

low frequency changes ***at the coast***

the spatial patterns of these trends suggest an offshore linkage

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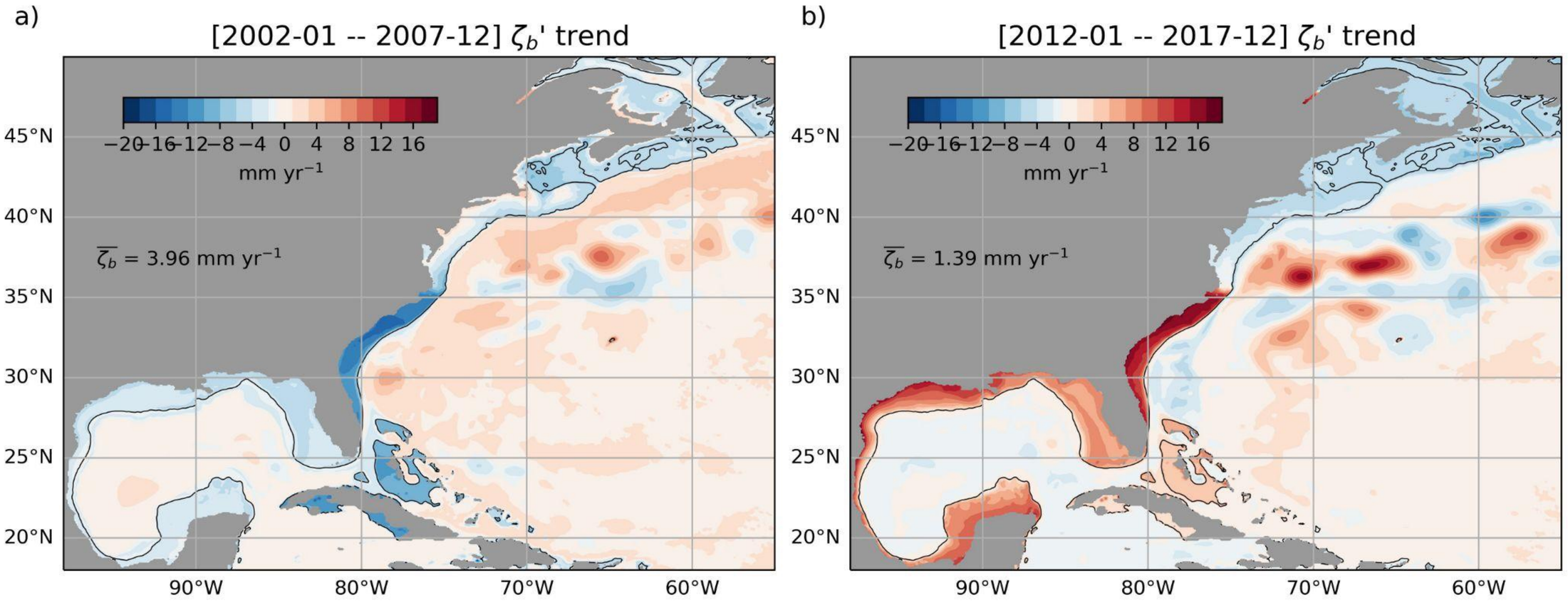
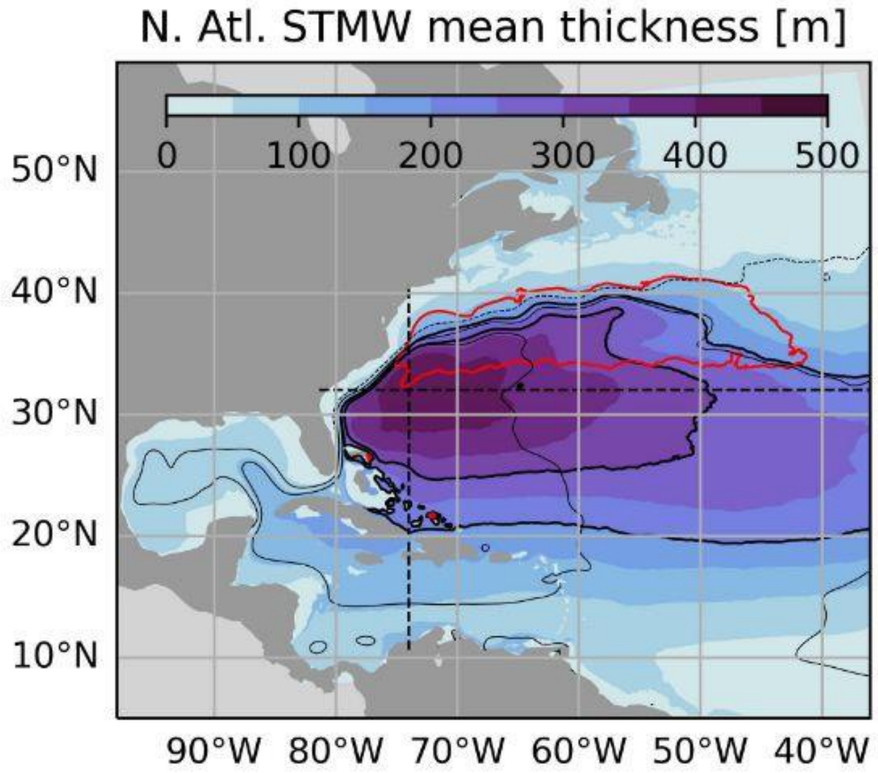
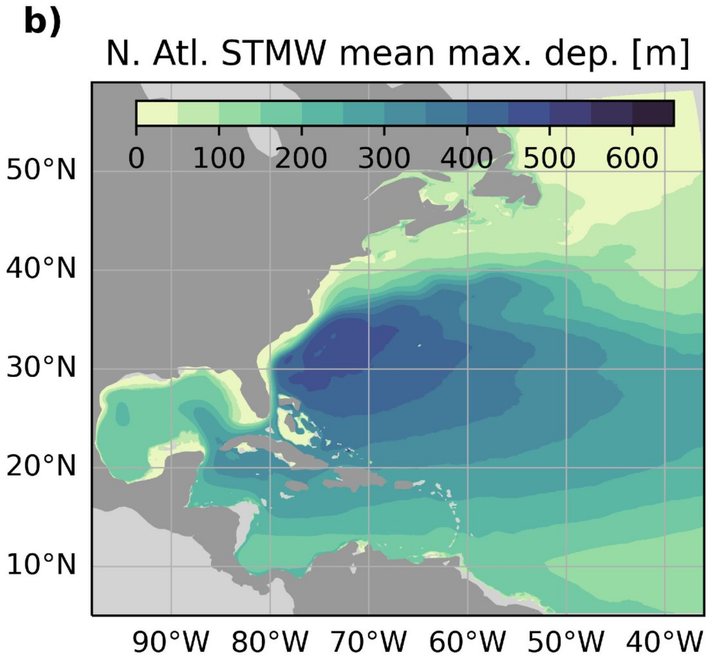
manometric sea level trends over two 6yr periods (with a domain average trend removed)

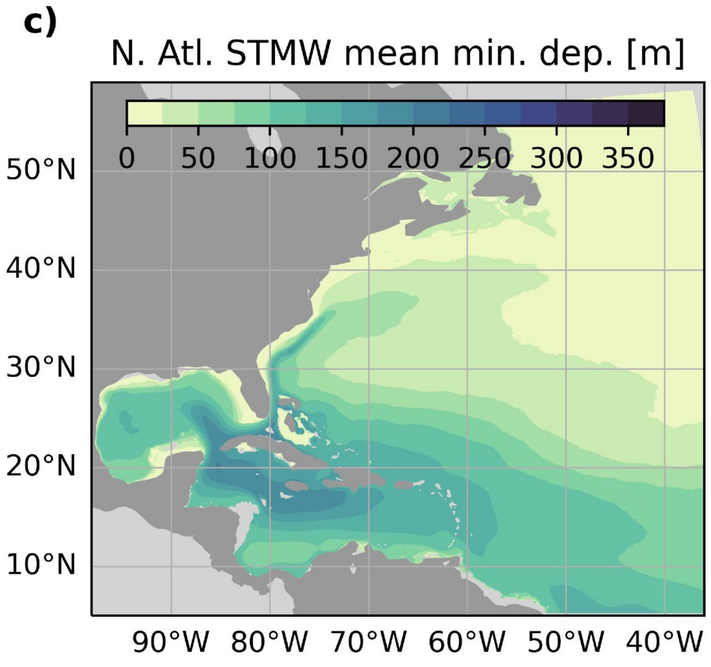


connectivity offshore / a region of interest:

Subtropical North Atlantic
(18 degree water or mode waters)





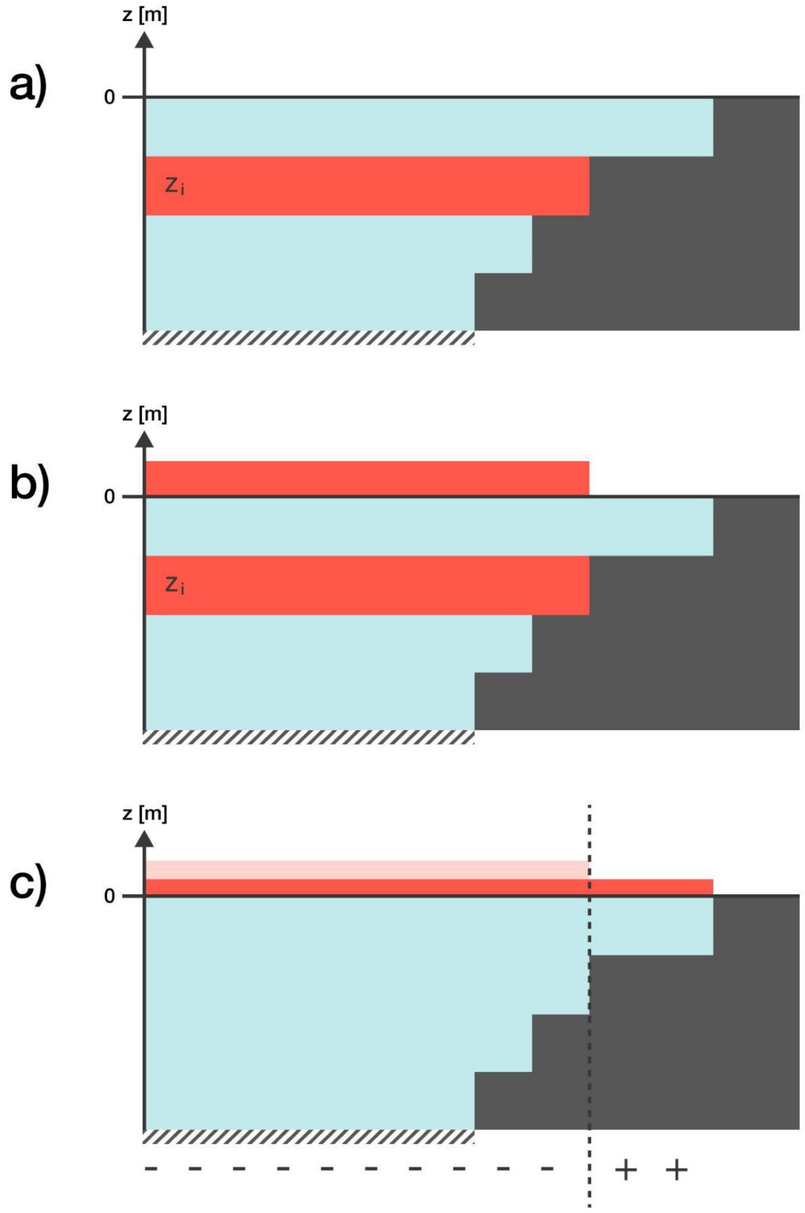


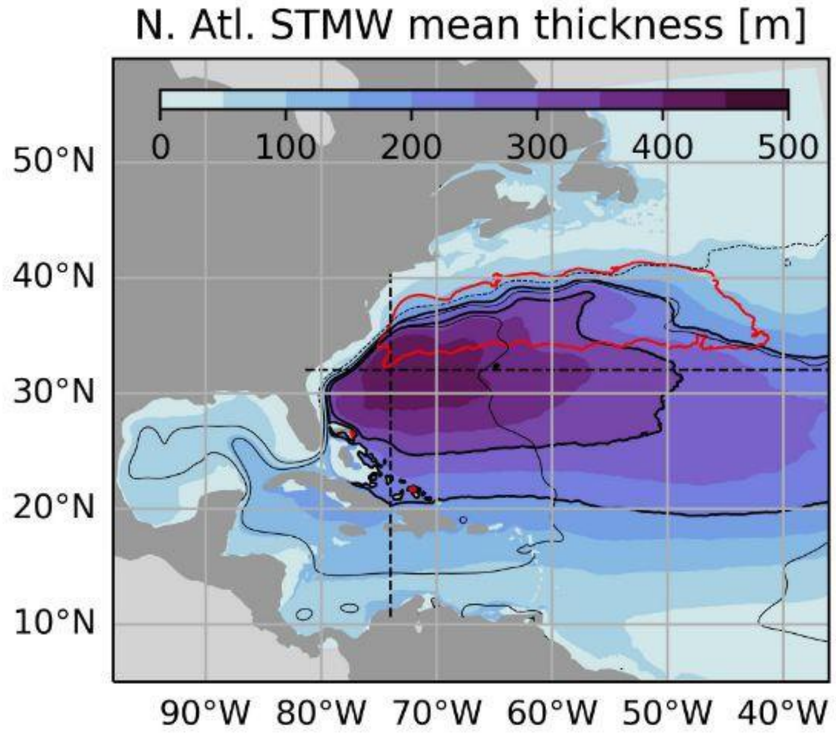
<u>a mechanistic link:</u>

schematic of warming driven mass redistribution

Greatbatch 1994, Landerer et al. 2007, Steinberg et al. 2024 [https://doi.org/10.1029/2023JC019681]

$$\zeta_b^*(z,t) = \frac{1}{\rho_0}\left(\sum_{i=1}^{i}\left(1-\frac{A_i}{A_s}\right)\rho' h \; - \sum_{i=i+1}^{n}\frac{A_i}{A_s}\rho' h\right)$$





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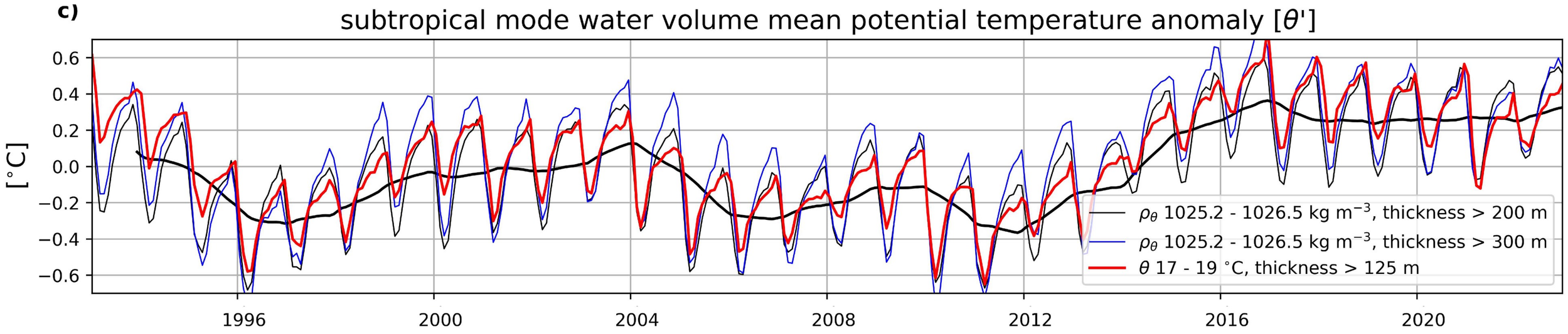
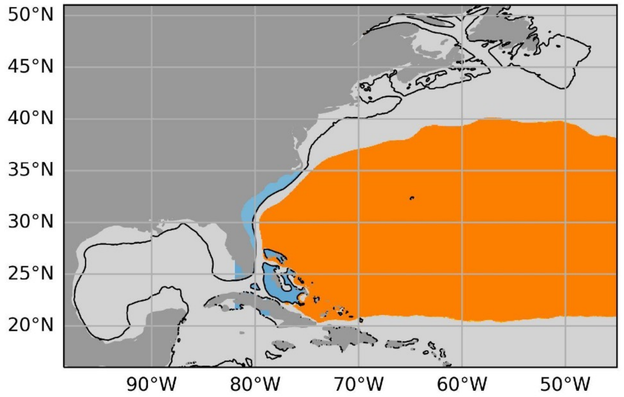
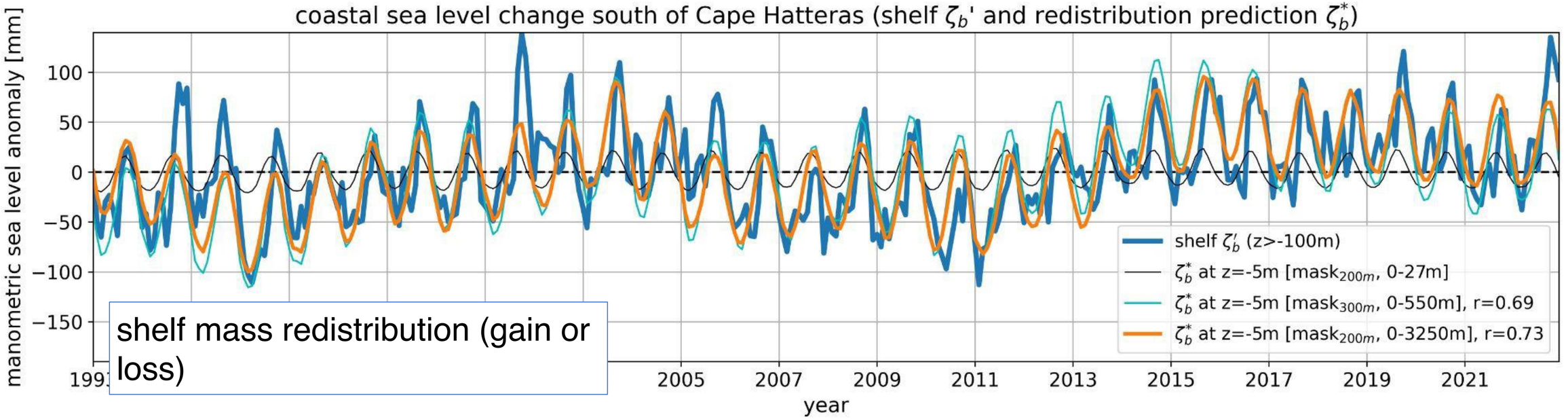


Result: U.S. East Coast Sea Level



open-ocean density change (subsurface warming) corresponds to coastal sea level change south of Cape Hatteras across seasonal to interannual timescales



shelf mass redistribution (gain or loss)

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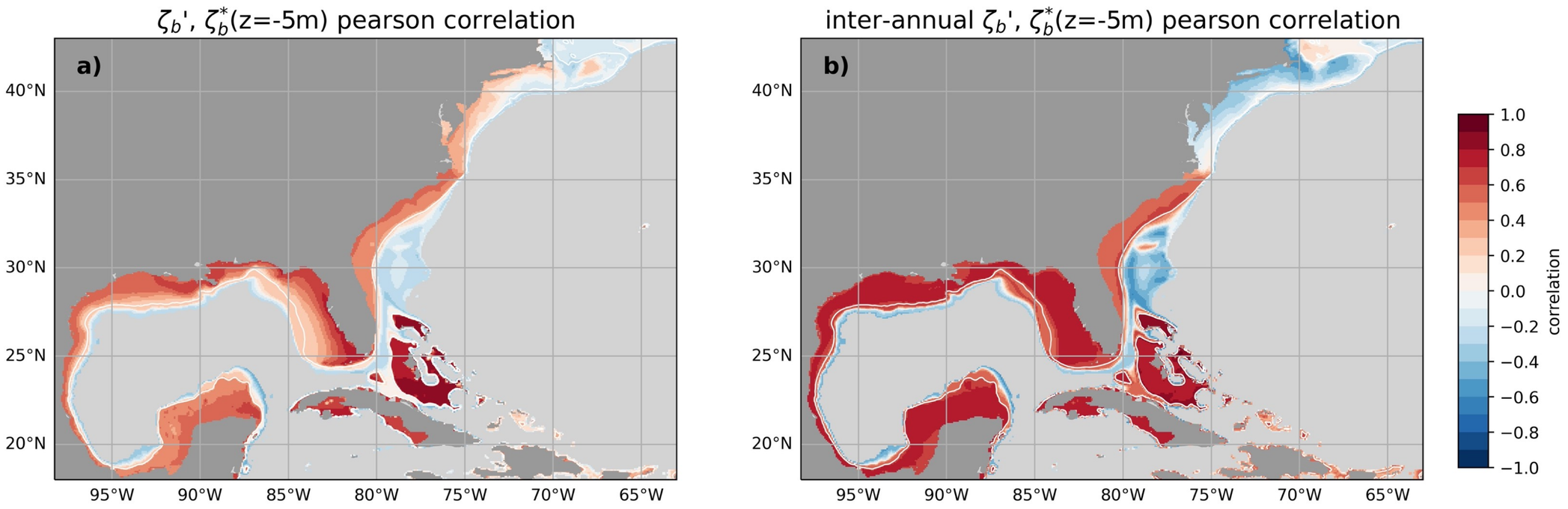

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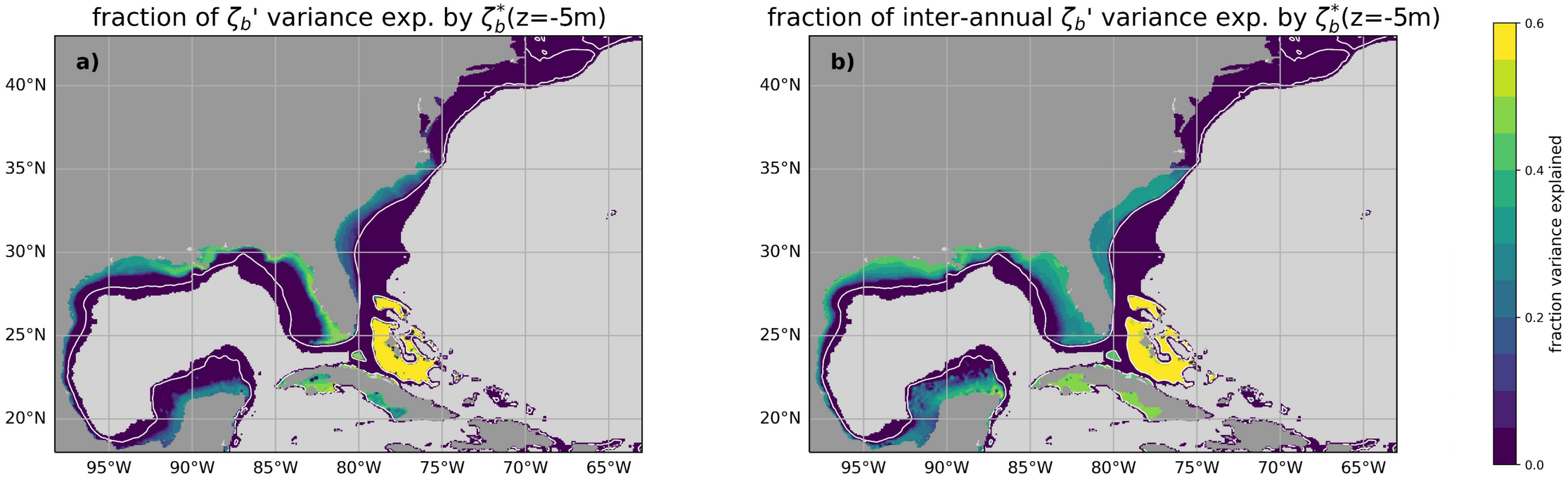

conclusion:
realizing this connection between coastal sea level and offshore density change, we can better understand and anticipate coastal sea level change (where ocean heat uptake as an important contributor)

→ **towards observational monitoring and projections**