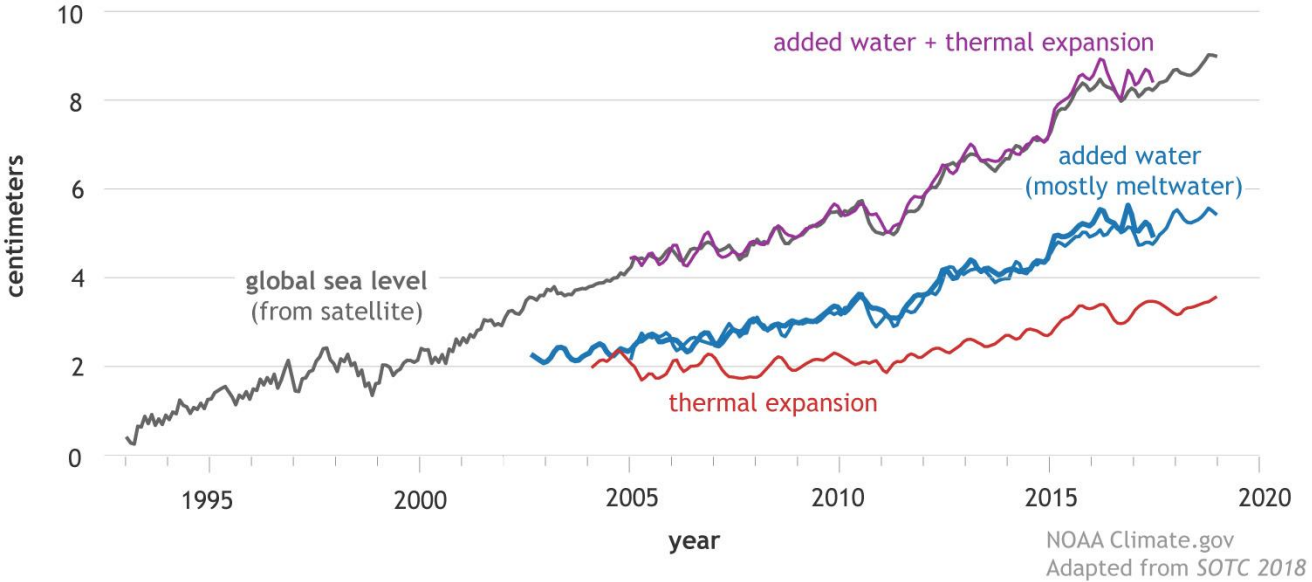
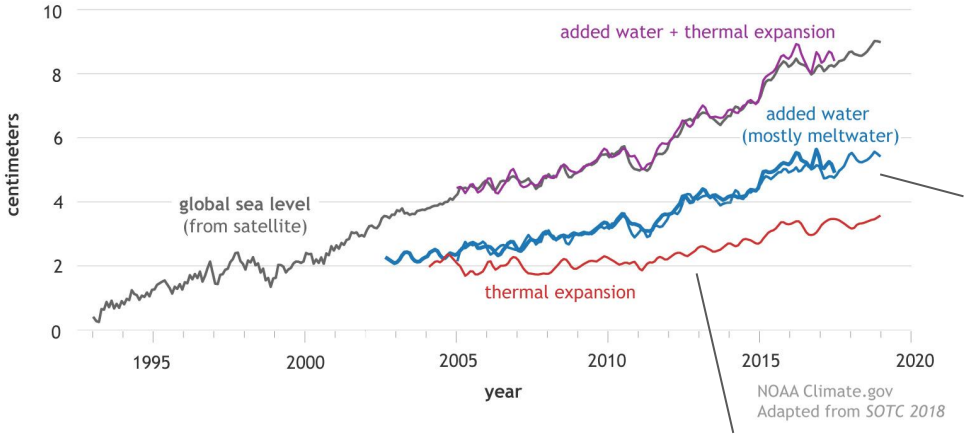


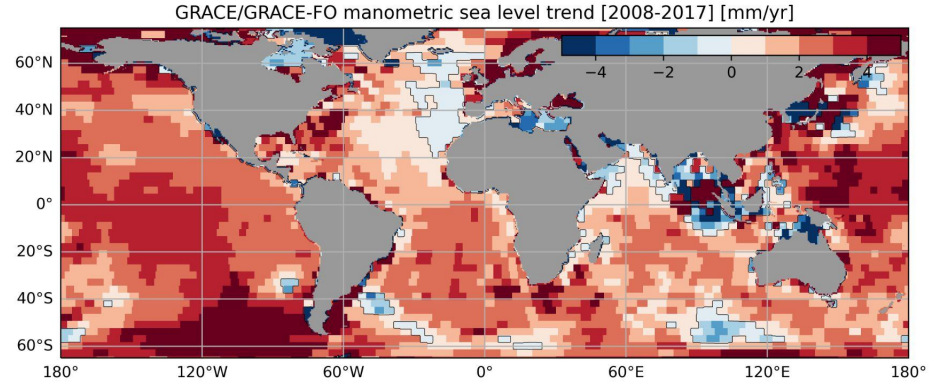
a link between U.S. east coast sea level rise and offshore subsurface ocean warming

Jacob Steinberg, Stephen Griffies, John Krasting, Christopher Piecuch, Andrew Ross
NOAA Geophysical Fluid Dynamics Laboratory - Princeton, NJ

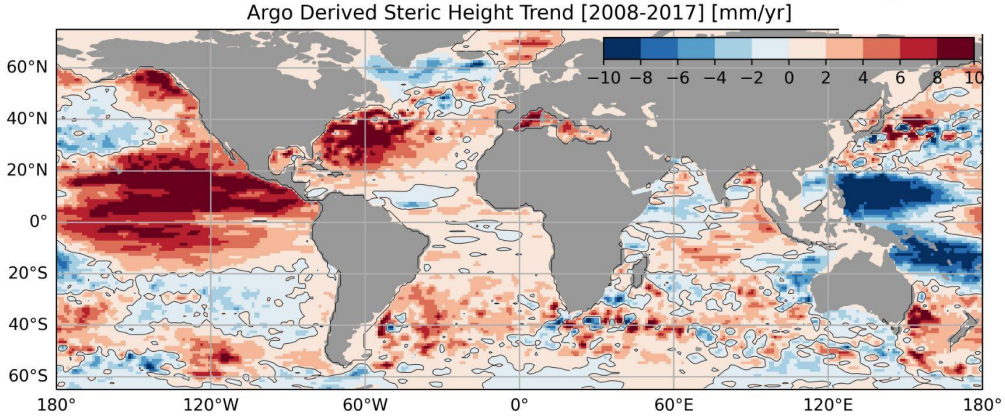
US CLIVAR - Optimizing Ocean Observing Networks for Detecting the Coastal Climate Signal Workshop
Boulder, CO - 2024-09-24

there are spatio-temporal patterns in mass and density driven trends





satellite gravimetry mission GRACE and GRACE-FO measurements of changes in the gravitational field

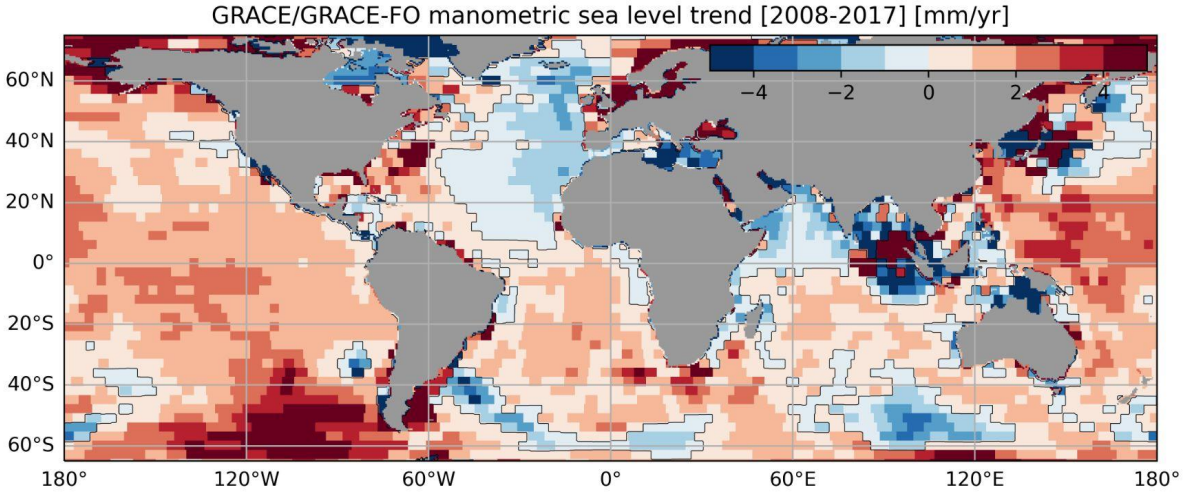


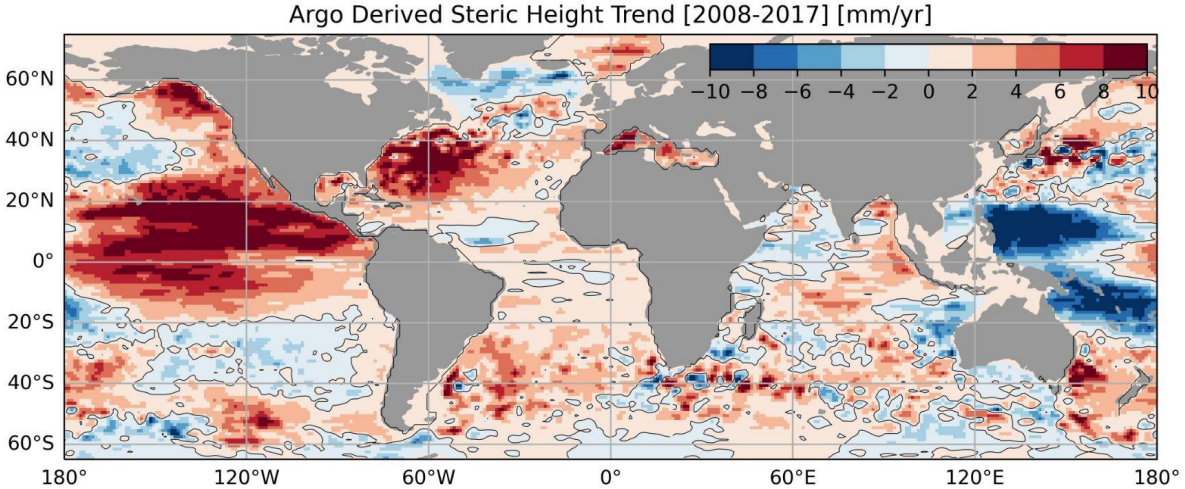
profiling float measurements of temperature and salinity over the upper 2000 m

components of the sea level change budget (mass + density)

mass trend
(w/ global mean removed)

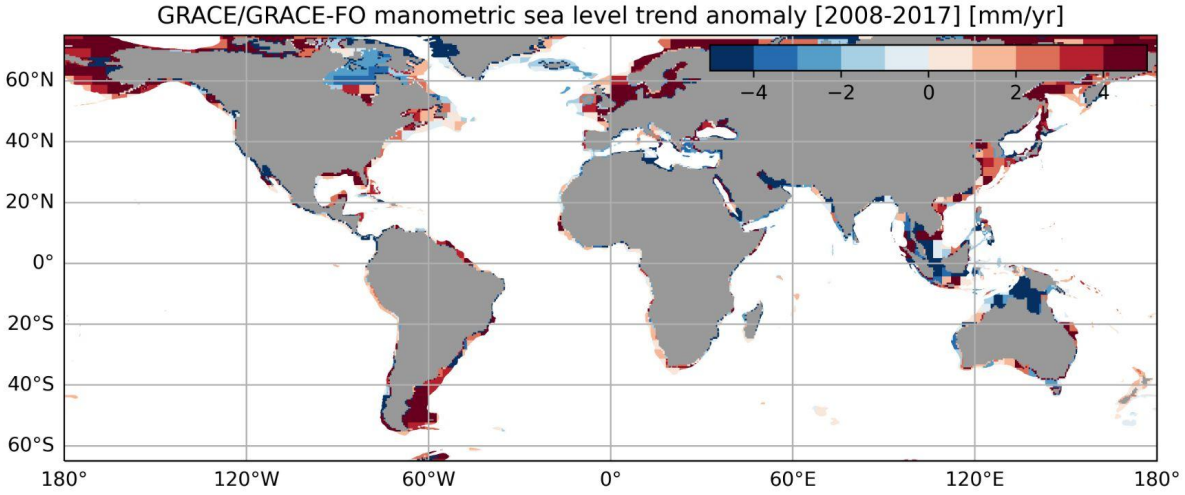
steric trend
(w/ global mean removed)



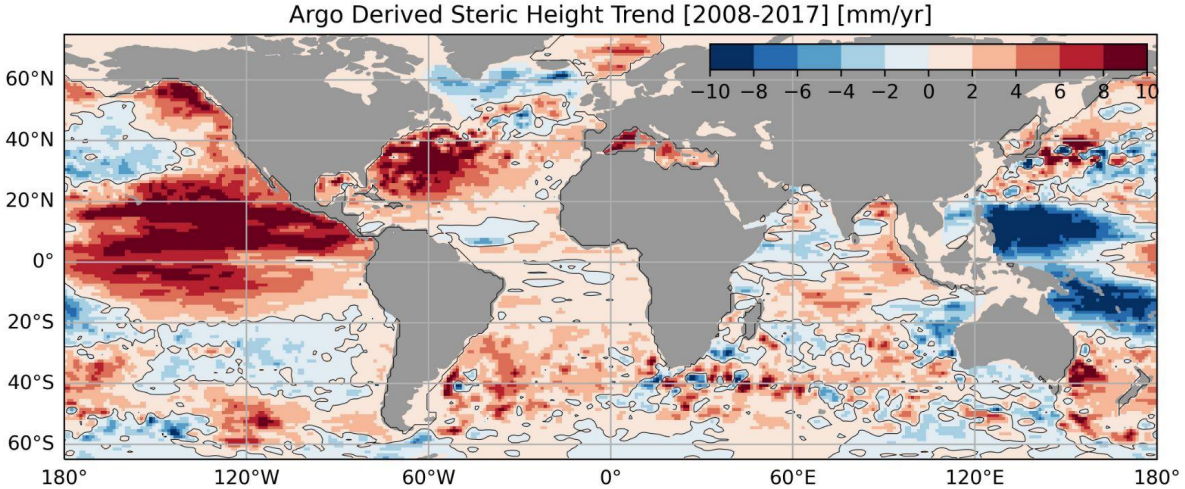


can we relate near coast mass-driven sea level change with offshore density-driven sea level change?

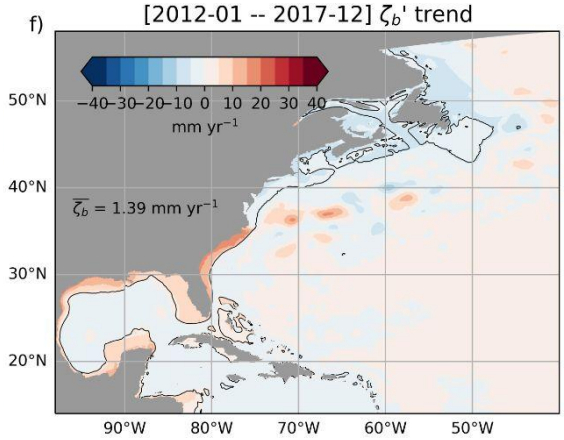
mass trend
(w/ global mean removed)

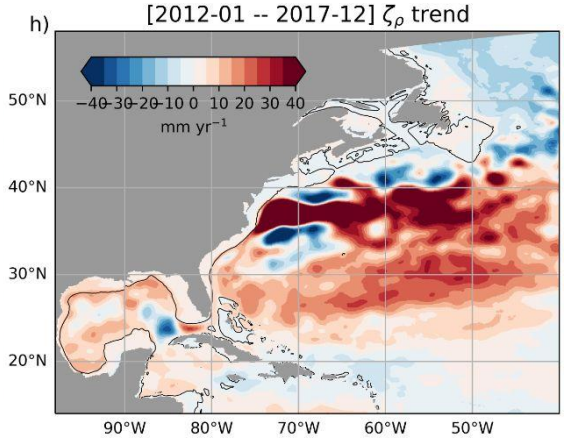


steric trend
(w/ global mean removed)



zooming in [w/ GFDLs NWA12 high resolution [1/12, 1/25 degree] regional ocean model] …
can we relate near coast mass-driven sea level change with offshore density-driven sea level change?

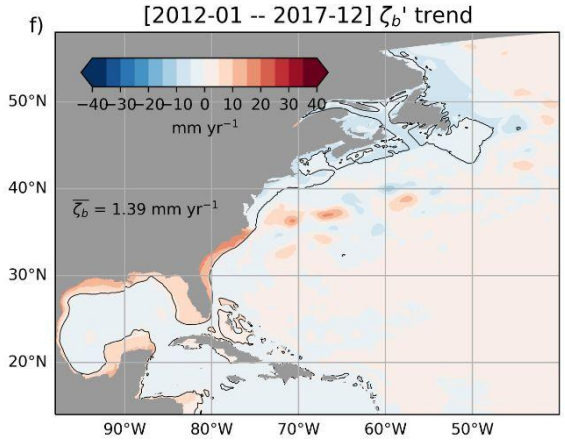


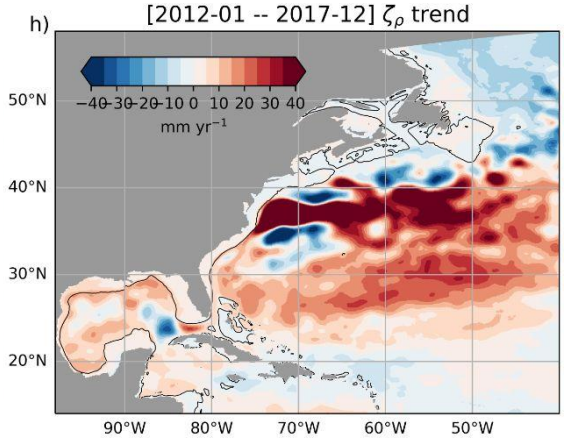


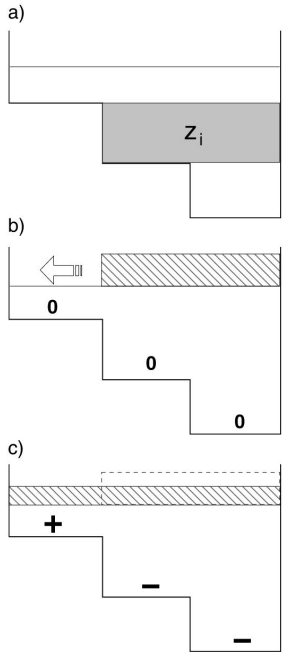
context: simulating sea level at NOAA GFDL [gfdl.noaa.gov]

- MOM6 regional and global ocean model [1/12 → 1 degree resolutions]
- ocean only, coupled atmosphere-ocean, earth system models
- preindustrial control, historical, scenario, retrospective, and forecast modes
- towards simulating additional physics relevant for sea level questions:
  - ocean + sea ice + ice shelf + ice sheet
  - non-boussinesq
  - tides
  - wetting/drying
  - self attraction and loading
  - inverted barometer effects

zooming in [w/ GFDLs NWA12 high resolution [1/12, 1/25 degree] regional ocean model] …
can we relate near coast mass-driven sea level change with offshore density-driven sea level change?



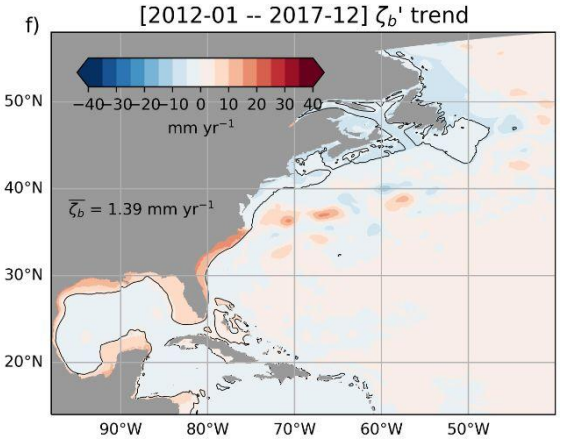


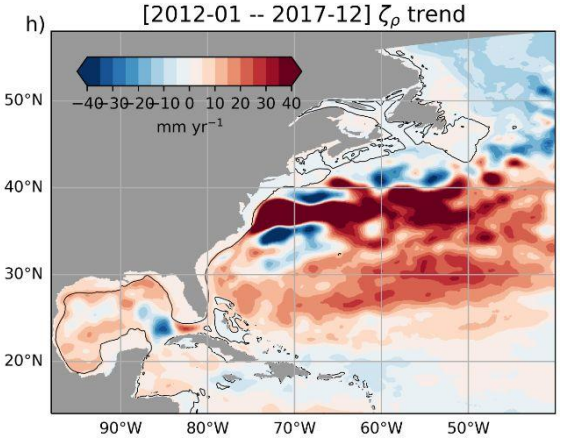


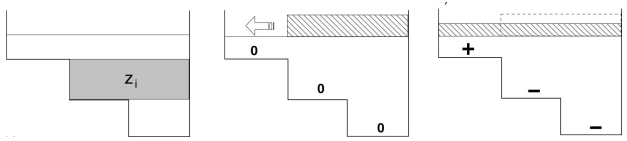
$$\zeta_{bi}^{*} = \frac{1}{\rho_0}\sum_{i=1}^{i}\left(1-\frac{A_i}{A_s}\right)(\rho_i-\rho_0)h_i - \frac{1}{\rho_0}\sum_{i+1}^{N}\frac{A_i}{A_s}(\rho_i-\rho_0)h_i$$

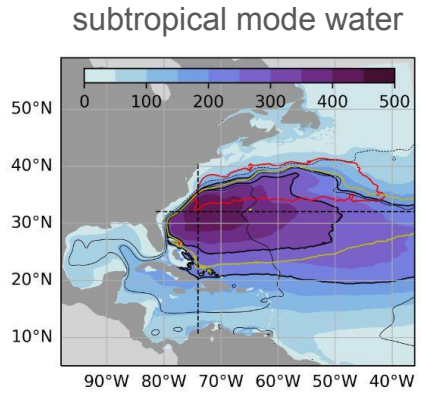
Landerer et al. 2007, Steinberg et al. 2024

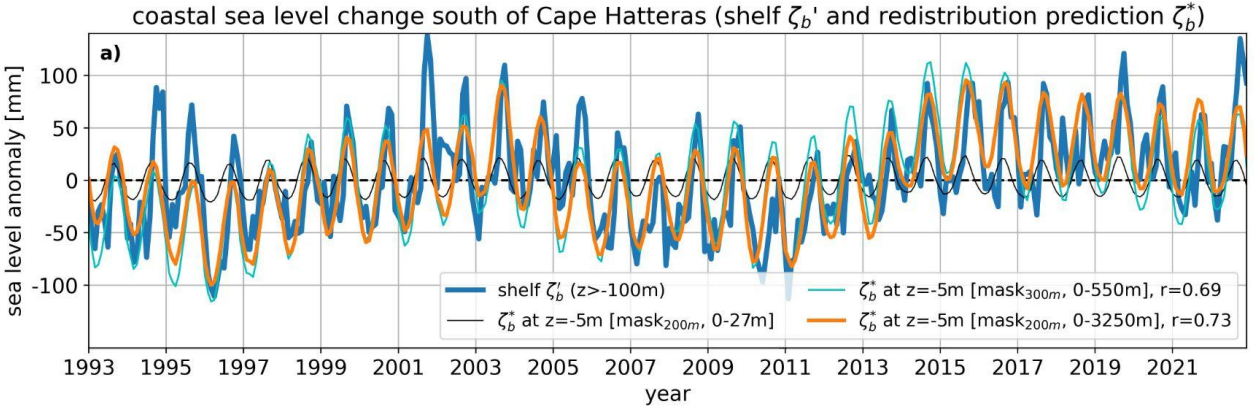
zooming in [w/ GFDLs NWA12 high resolution [1/12, 1/25 degree] regional ocean model] ...
can we relate near coast mass-driven sea level change with offshore density-driven sea level change?







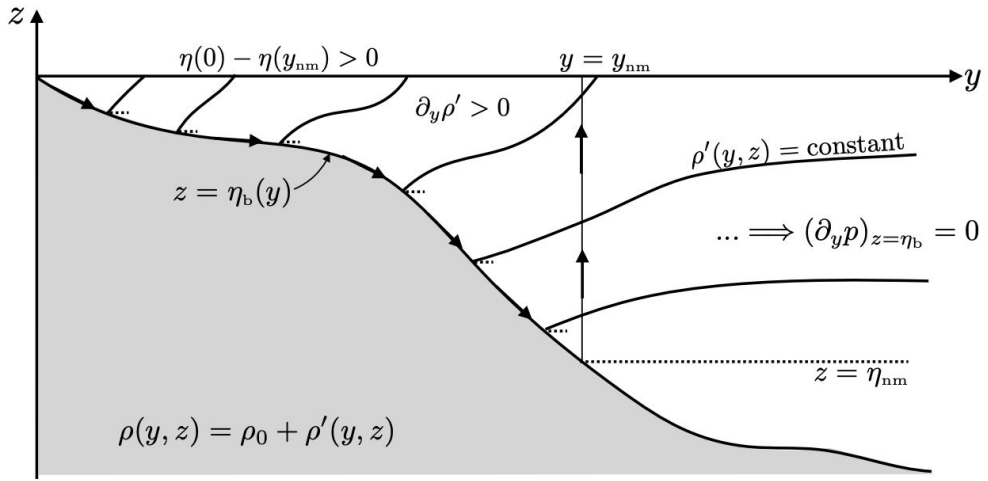




coastal / open ocean links → bottom density

Helland-Hansen 1934, Csanady 1979, Bingham and Hughes 2012

a mechanistic framework linking the coast to the open ocean in the presence of more realistic stratification



courtesy of S. Griffies

$$\eta(0) = -\int_{H_0}^{\text{coast}} \rho_b g \, dz.$$

bottom density integral limits and isopycnals connections offshore

coastal / open ocean links → bottom density

Helland-Hansen 1934, Csanady 1979, Bingham and Hughes 2012

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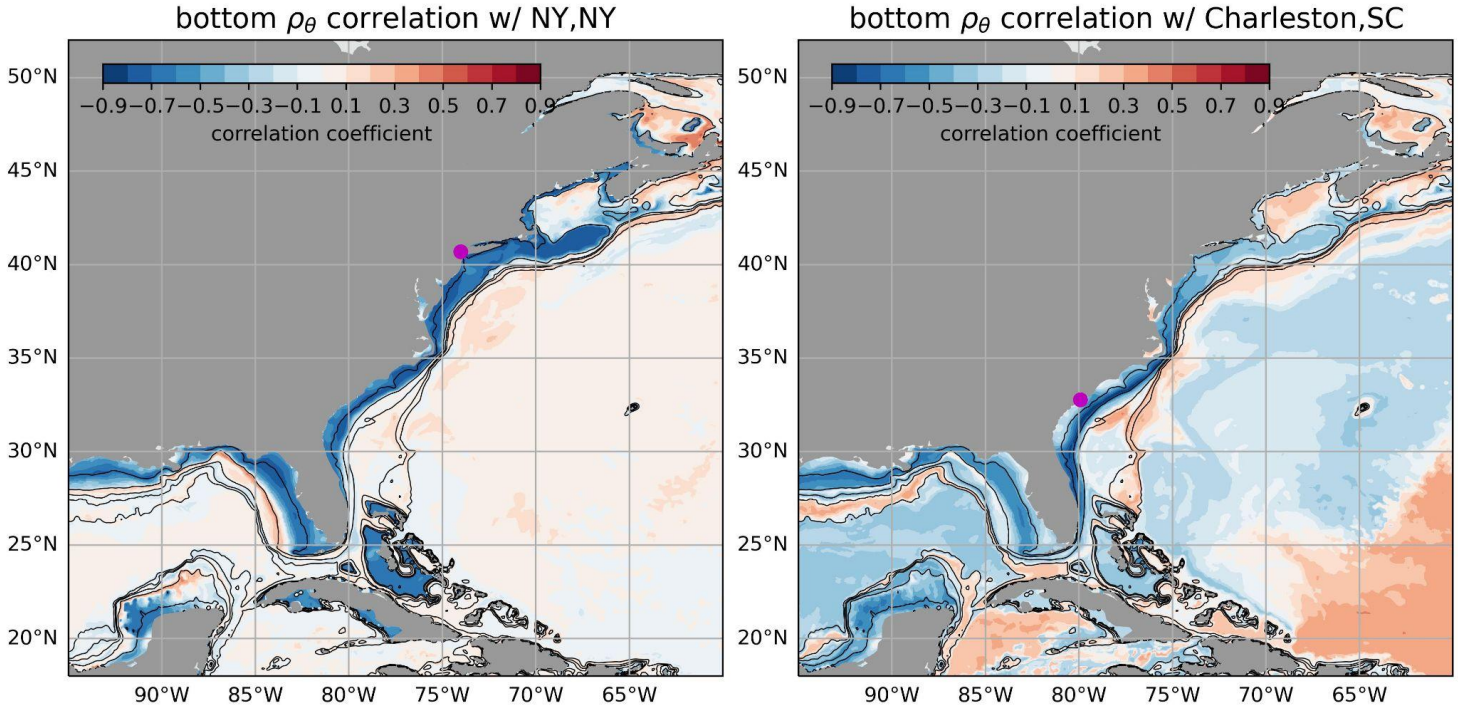

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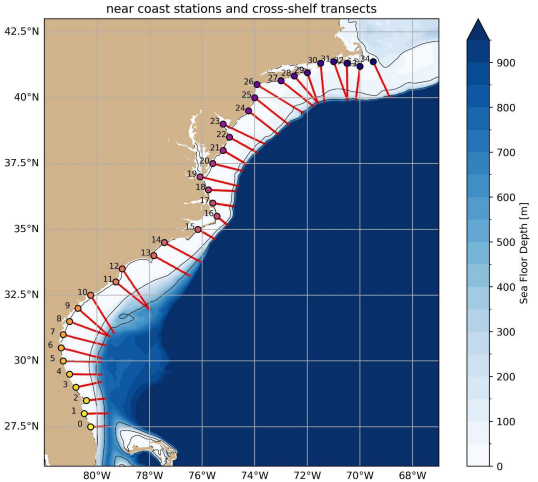

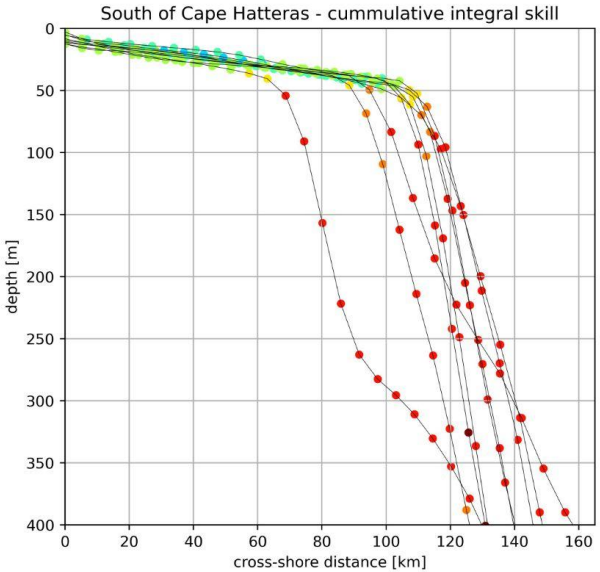

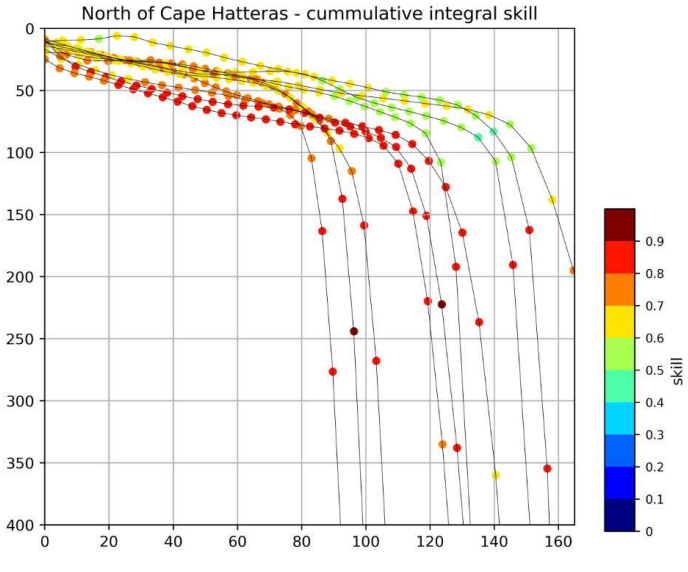

conclusions

near coast sea level change largely reflects local mass change

patterns of bottom pressure and bottom density change suggest along-coast vs. offshore drivers/connectivity

at GFDL we're developing a framework to understand how offshore water mass transformation and ocean heat content change affect coastal sea level

results motivate near-coast T/S/rho/surface-pressure/wind monitoring to be used in anticipating seasonal to interannual sea level change on top of which higher frequency flooding events cause damage