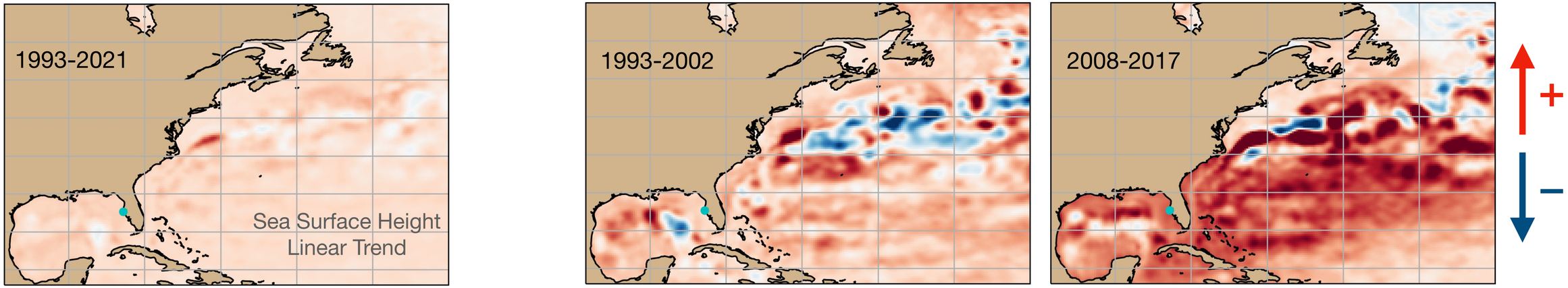
Influence of Deep-Ocean Warming on Coastal Sea Level Trends in the Gulf of Mexico

OSTST Venice 2022-10-31



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Outline:

- Motivation
- Framework
- ECCO state estimate
  - sea level
  - steric height
  - ocean bottom pressure
- Observations:
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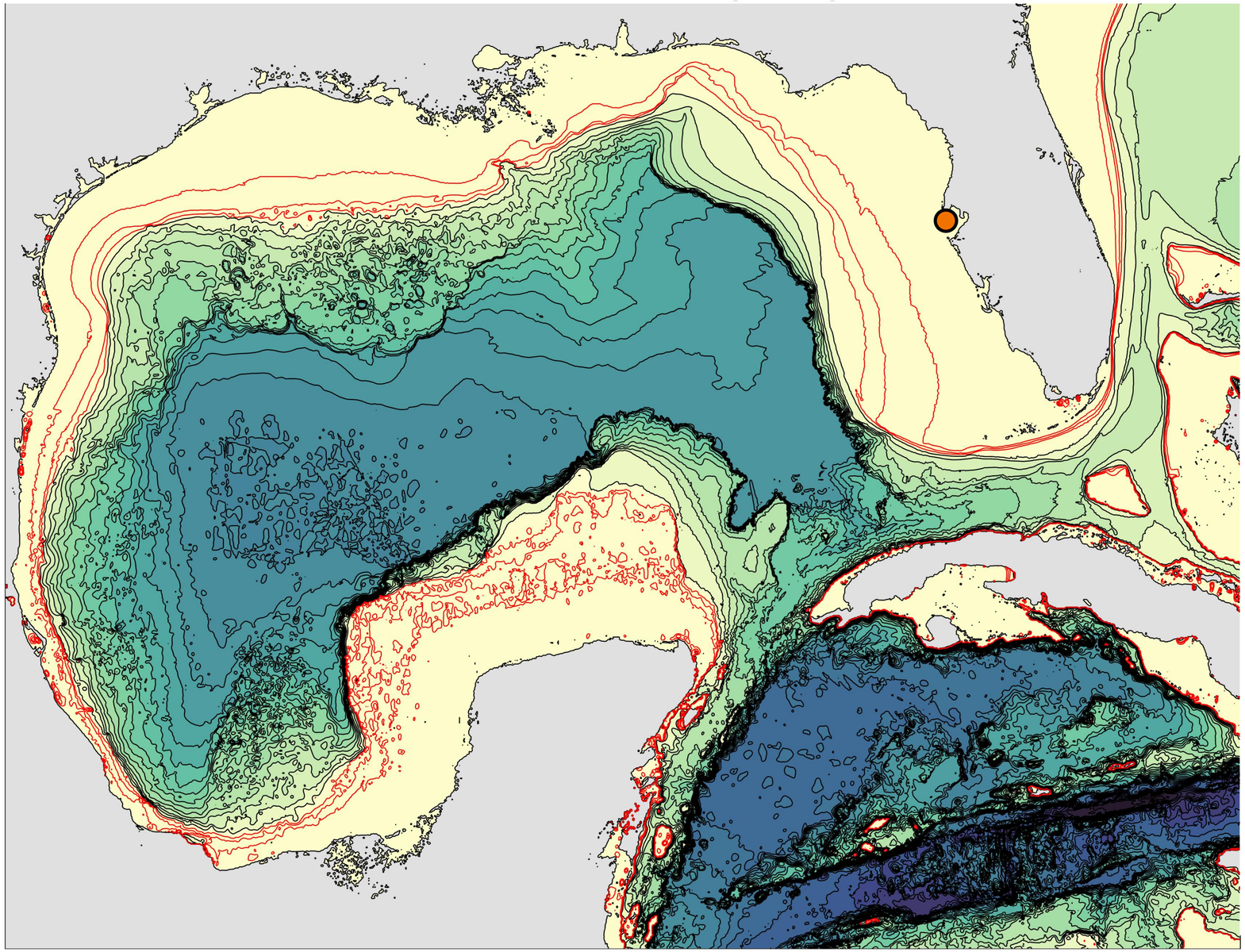
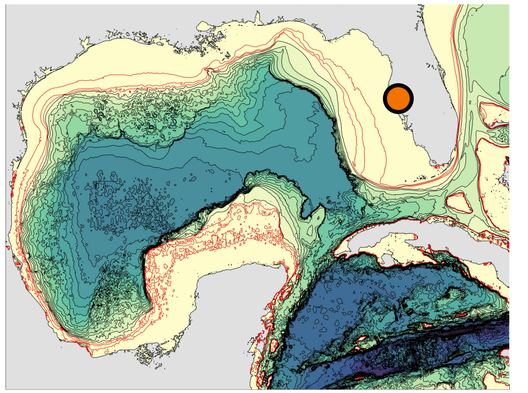
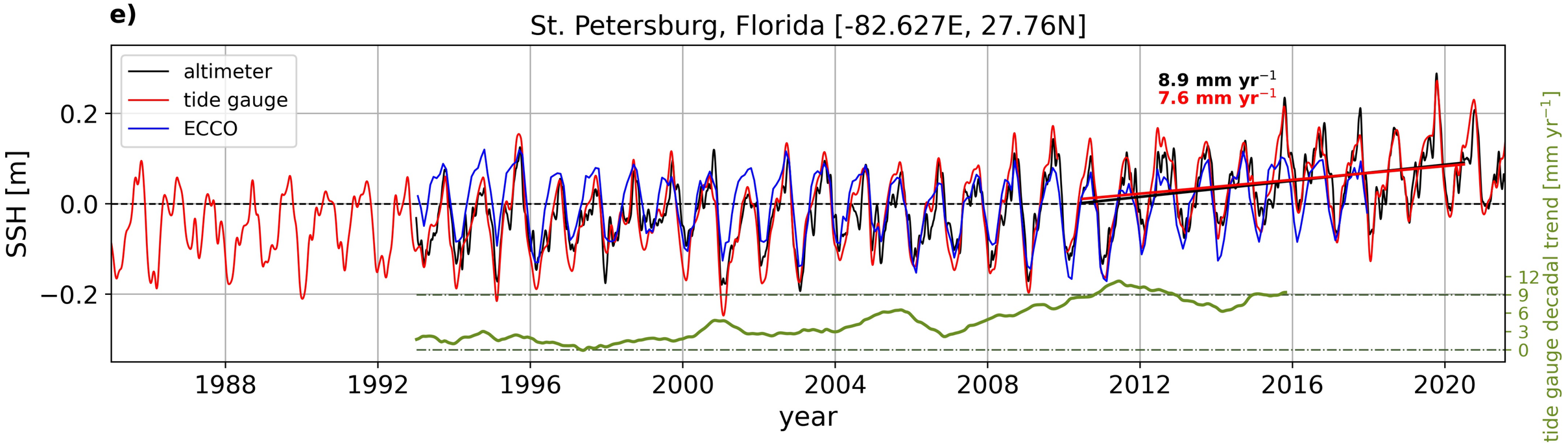
  - Argo
  - tide gauge

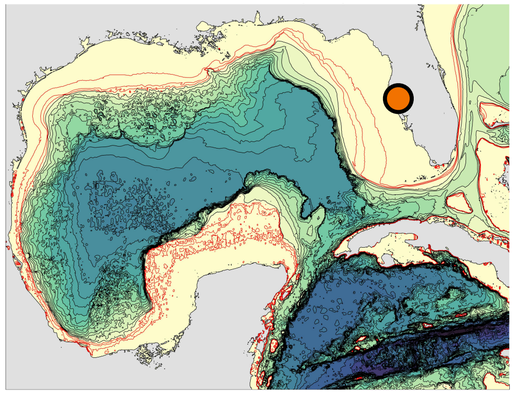


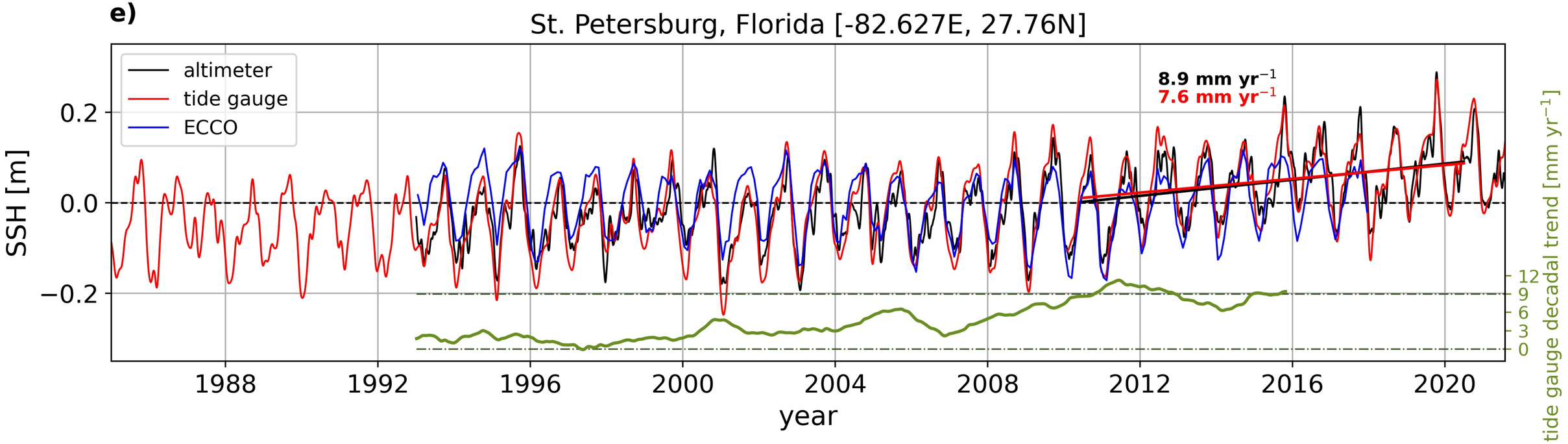
Motivation




e)
St. Petersburg, Florida [-82.627E, 27.76N]
altimeter
tide gauge
ECCO
8.9 mm yr^{-1}
7.6 mm yr^{-1}
SSH [m]
0.2
0.0
−0.2
1988
1992
1996
2000
2004
2008
2012
2016
2020
year
tide gauge decadal trend [mm yr^{-1}]
12
9
6
3
0

Motivation





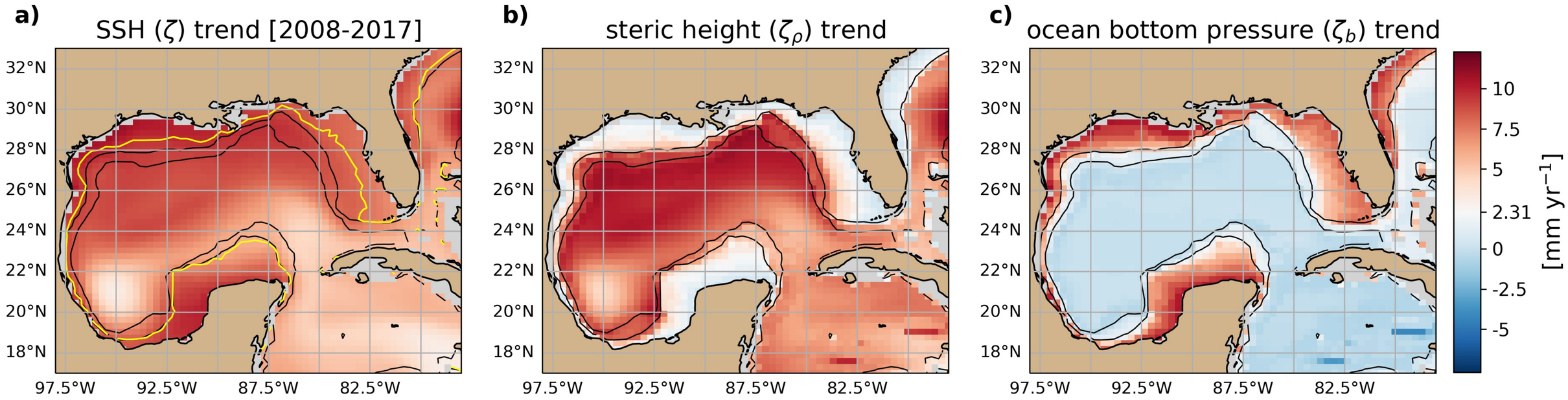
at decadal timescales, sub-surface warming can explain a significant fraction of sea level rise observed at the coast

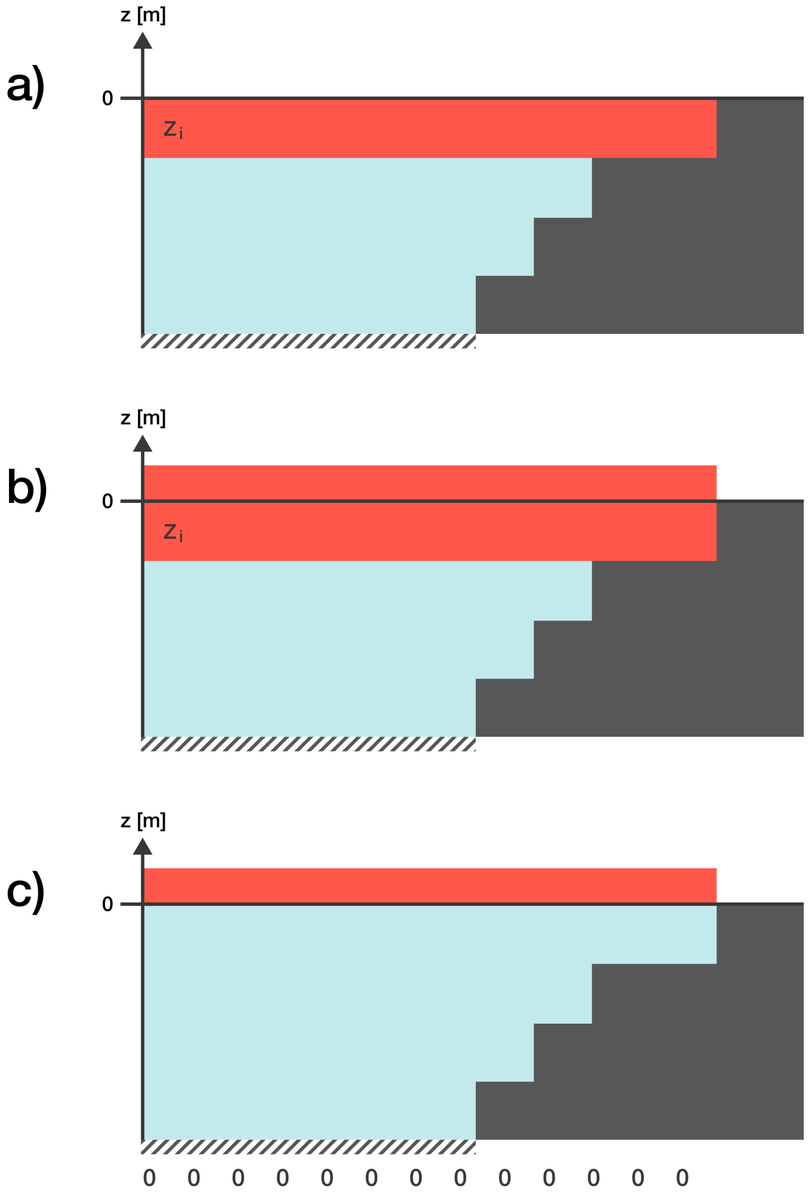
ECCO: 2008 - 2017 decadal trends

changes in sea level =

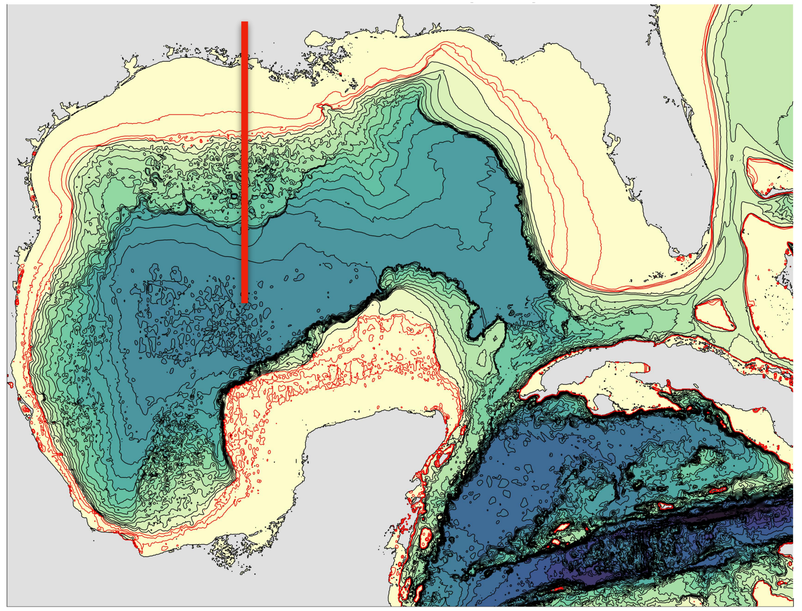
changes in steric height + changes in ocean bottom pressure

(expansion/contraction) (gain/loss of mass)

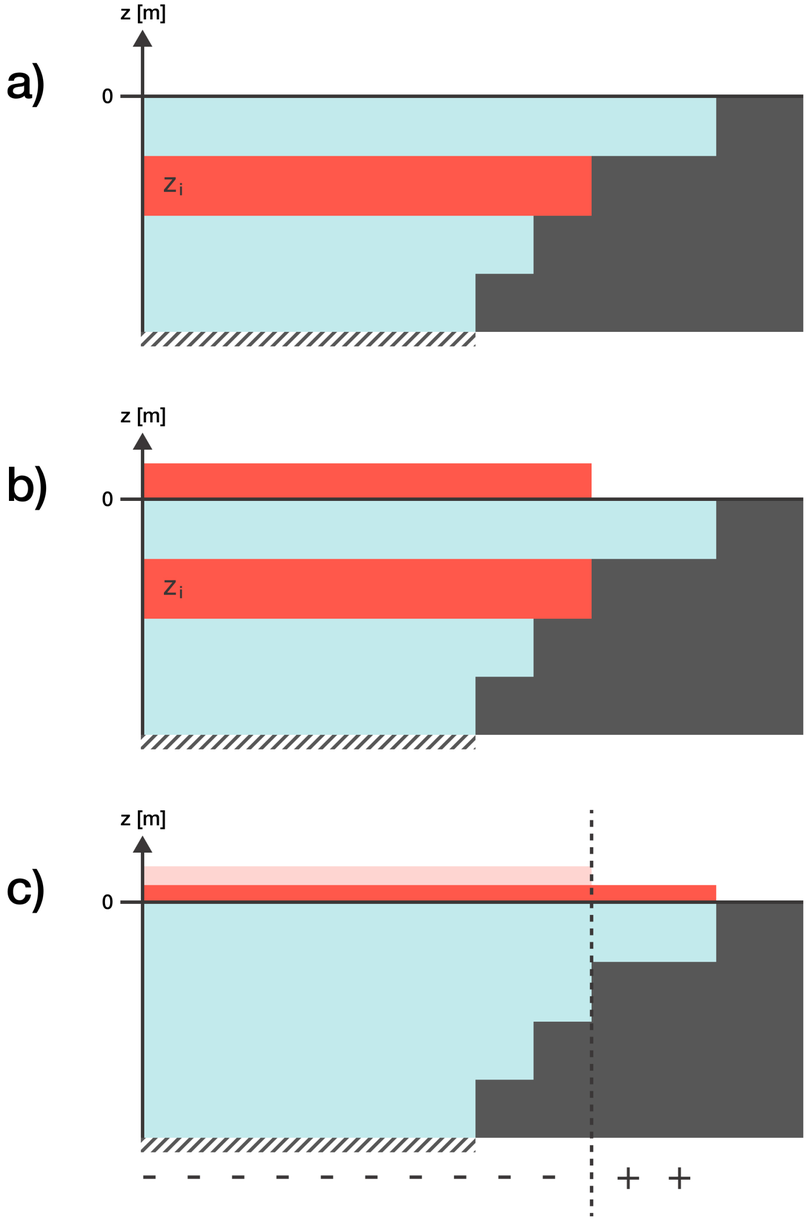




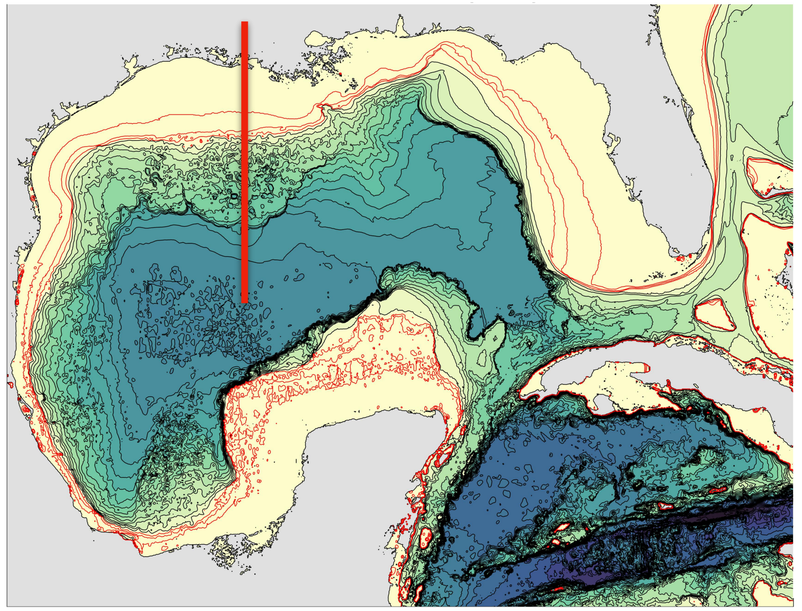
Landerer et al. 2007



no bottom pressure change ✗

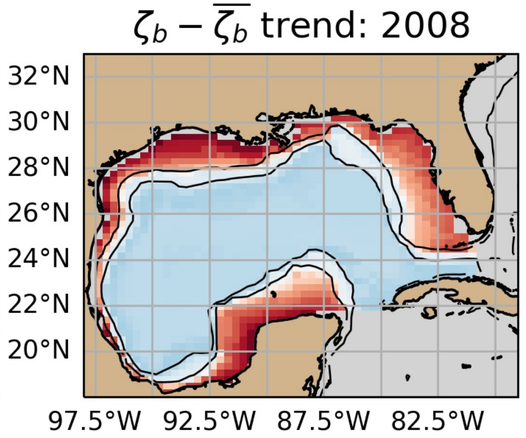


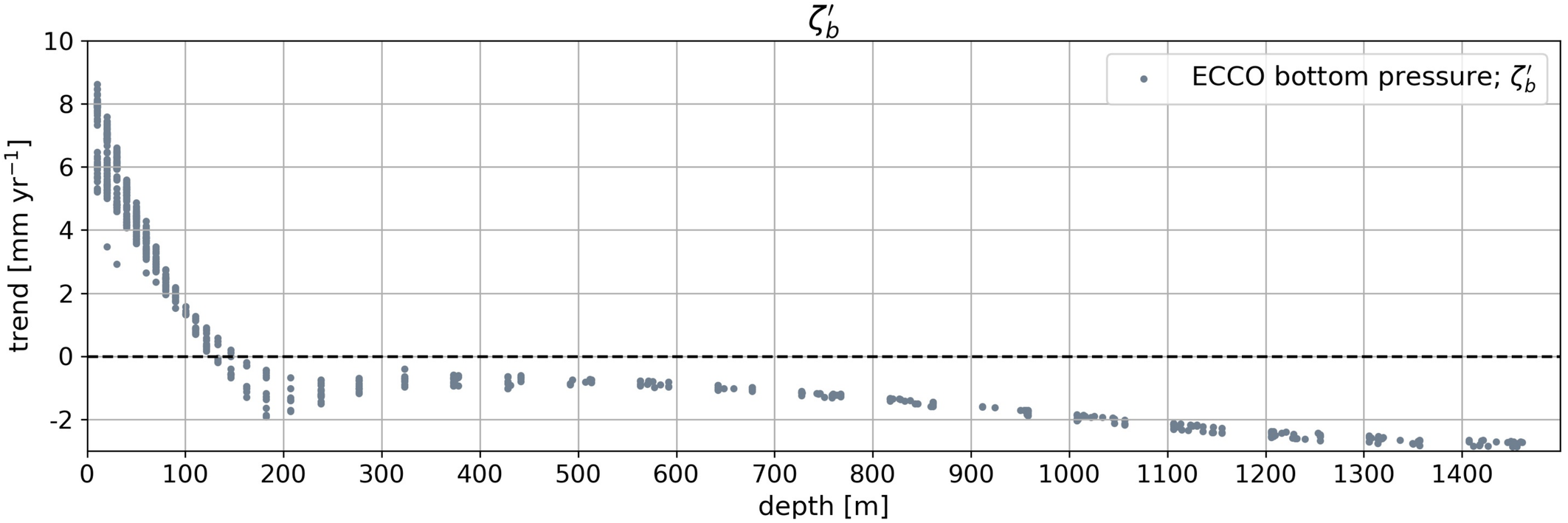
Landerer et al. 2007



bottom pressure change ✓

we expect a change in bottom pressure following this warming-driven redistribution of mass


$\zeta_b - \overline{\zeta_b}$ trend: 2008
32°N
30°N
28°N
26°N
24°N
22°N
20°N
97.5°W
92.5°W
87.5°W
82.5°W


ζ_b'
ECCO bottom pressure; ζ_b'
trend [mm yr^{-1}]
depth [m]
10
8
6
4
2
0
-2
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400

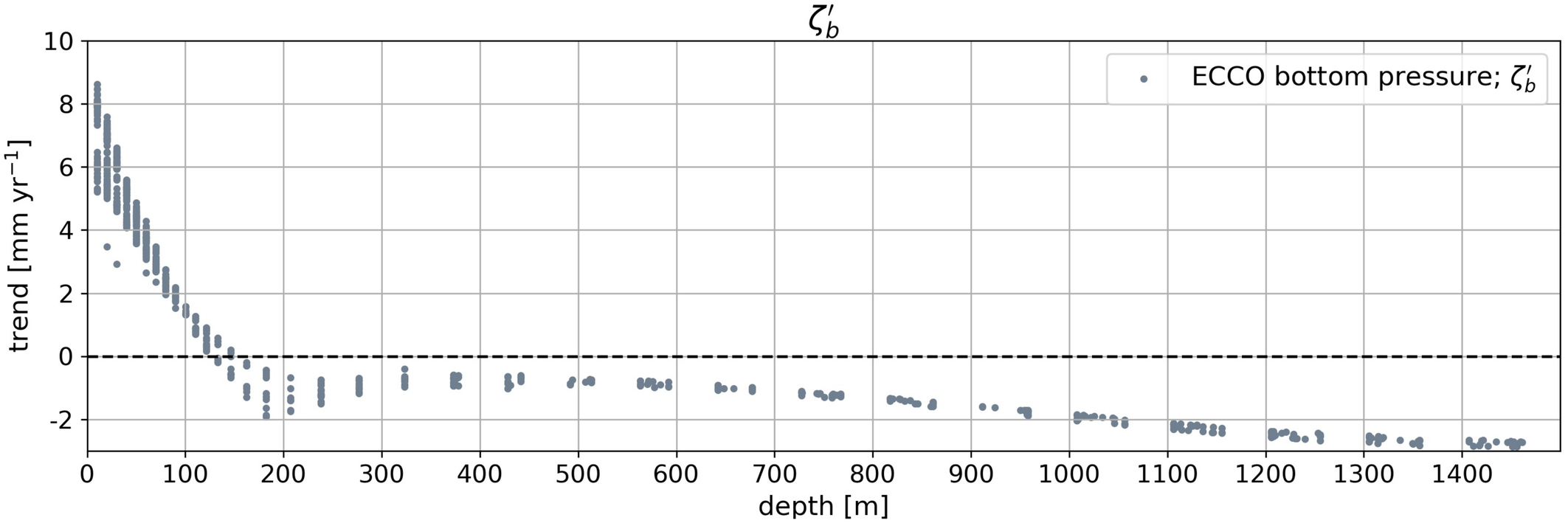
Framework

Landerer et al. 2007

$$\zeta_b^* = \frac{p_b}{g\rho_0} = \frac{1}{\rho_0}\sum_{i=1}^{i}\left(1 - \frac{A_i}{A_s}\right)\rho_i' h_i - \frac{1}{\rho_0}\sum_{i+1}^{N}\frac{A_i}{A_s}\rho_i' h_i$$

predicted bottom pressure change from:

- density change (ρ_i)
- model layer thickness (h_i)
- model layer areas (A_i , A_s)



Framework

Landerer et al. 2007

$$\zeta_b^* = \frac{p_b}{g\rho_0} = \frac{1}{\rho_0}\sum_{i=1}^{i}\left(1 - \frac{A_i}{A_s}\right)\rho_i' h_i - \frac{1}{\rho_0}\sum_{i+1}^{N}\frac{A_i}{A_s}\rho_i' h_i$$

predicted bottom pressure change from:

- density change (ρ_i)
- model layer thickness (h_i)
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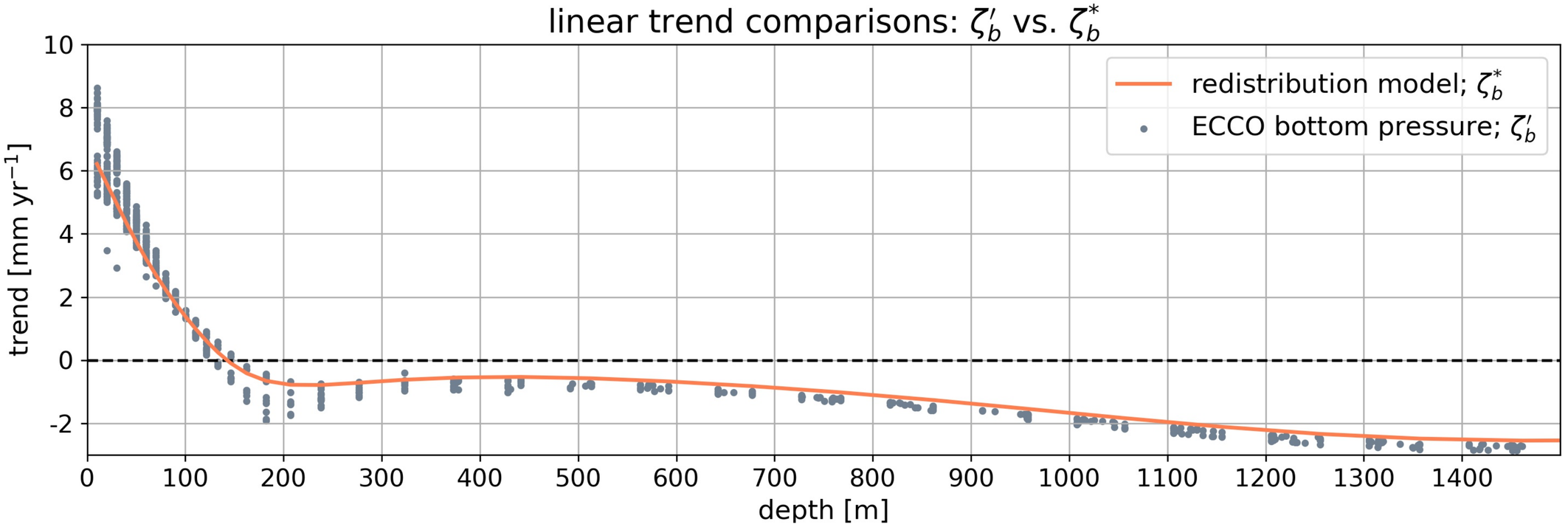
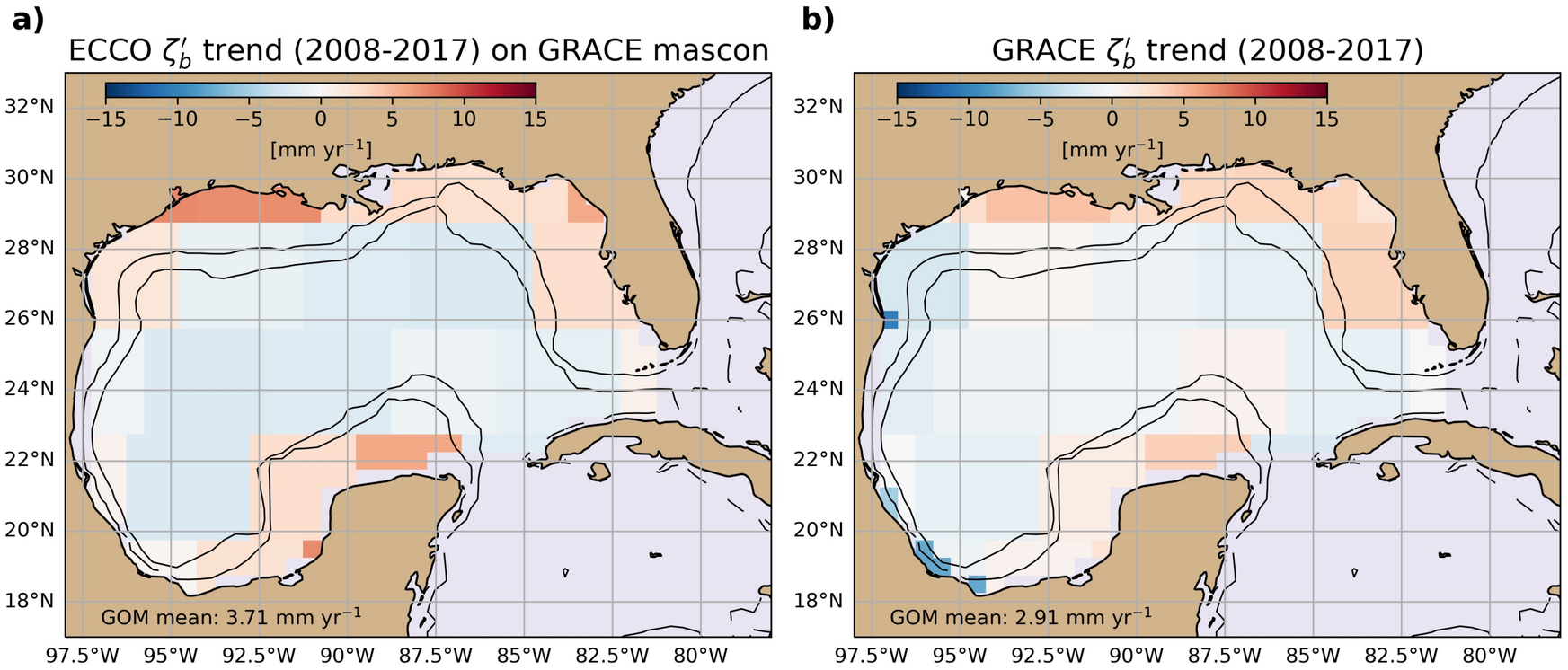
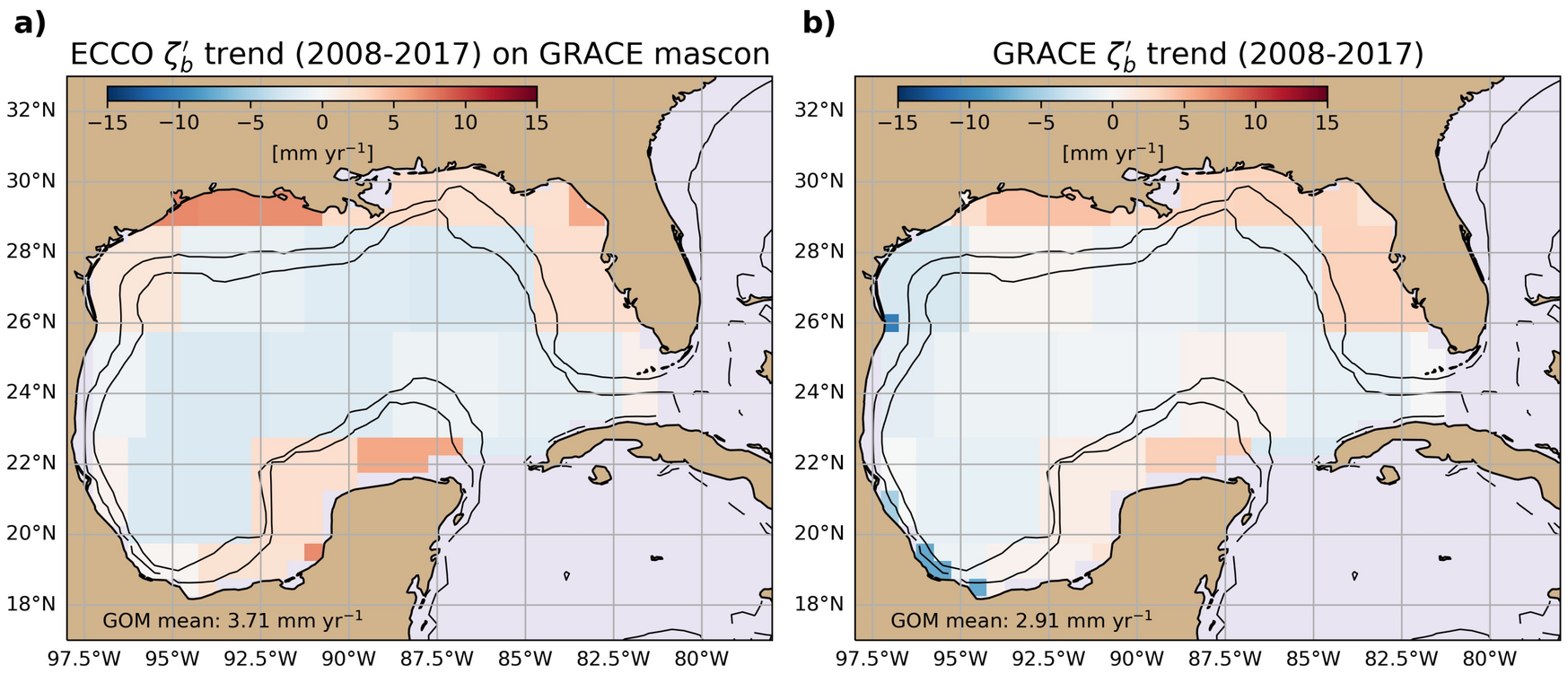


bottom pressure trends: ECCO —> GRACE/GRACE-FO

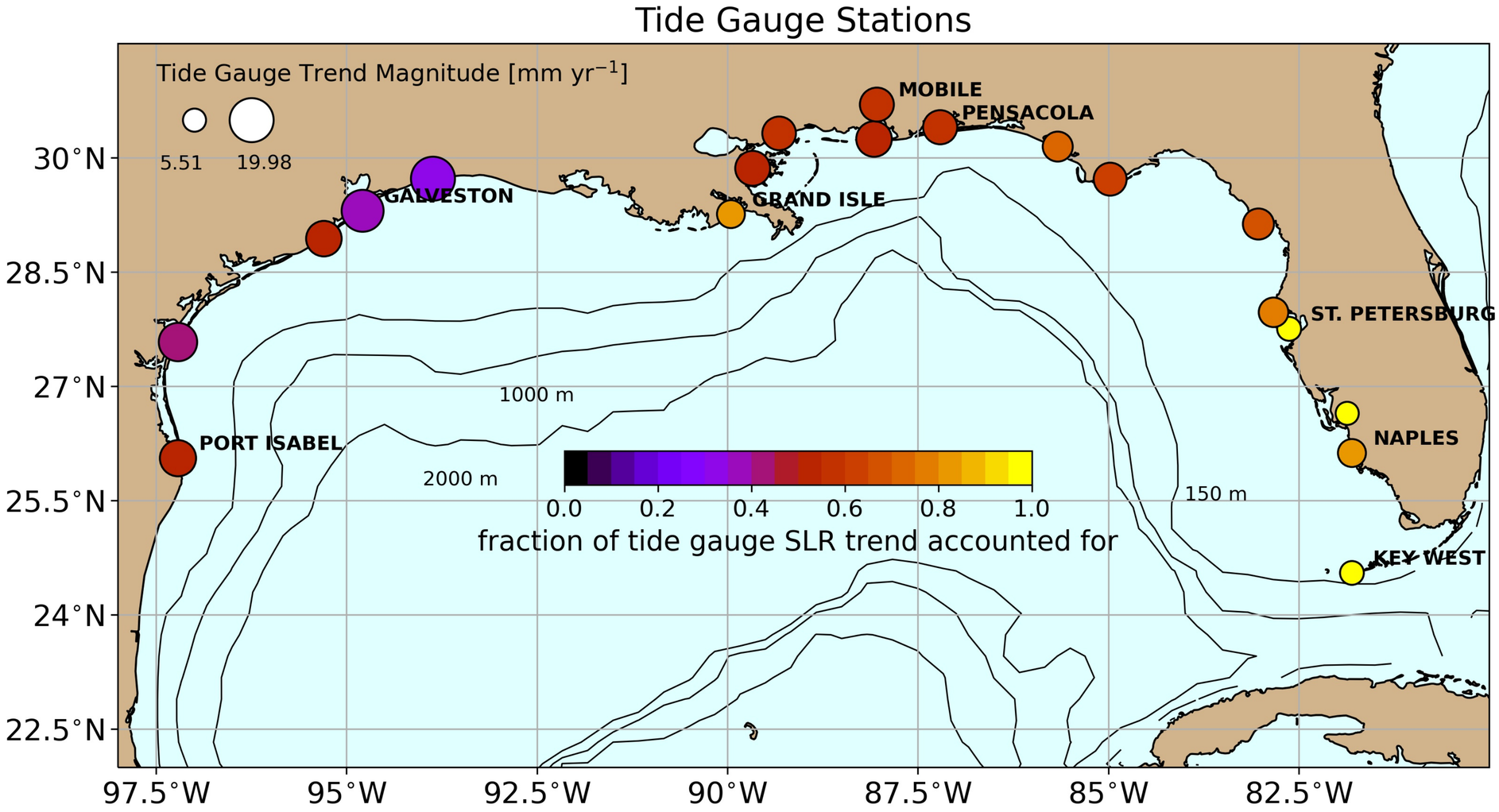


<u>bottom pressure trends</u>: ECCO —> GRACE/GRACE-FO

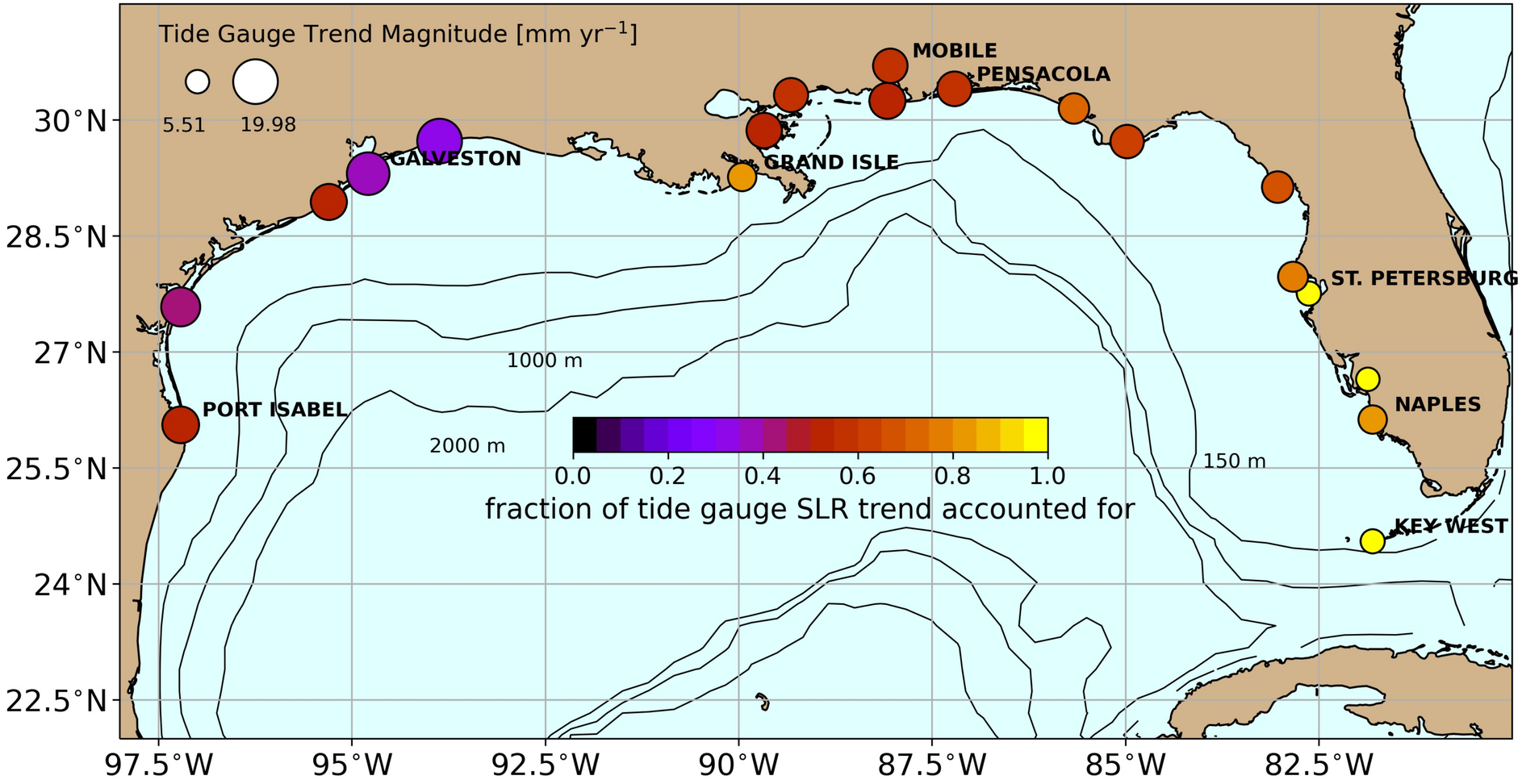


motivation:
- can we mechanistically explain sea level rise observed in tide gauge records of sea level? (decadal trends)

observational needs:
- vertical land motion trend
- Gulf of Mexico area-mean trend [GRACE/GRACE-FO]
- subsurface warming driven mass redistribution (Landerer et al. 2007) [Argo]


Tide Gauge Stations
Tide Gauge Trend Magnitude [mm yr^{-1}]
5.51
19.98
MOBILE
PENSACOLA
GALVESTON
GRAND ISLE
ST. PETERSBURG
NAPLES
KEY WEST
PORT ISABEL
1000 m
2000 m
150 m
0.0
0.2
0.4
0.6
0.8
1.0
fraction of tide gauge SLR trend accounted for
30°N
28.5°N
27°N
25.5°N
24°N
22.5°N
97.5°W
95°W
92.5°W
90°W
87.5°W
85°W
82.5°W

Tide Gauge Stations



<u>Conclusions:</u>

decadal trends in coastal sea level can largely be explained by

- import of mass to the Gulf of Mexico (due to land ice melt & terrestrial water storage loss)
- subsurface warming driven mass redistribution onto the continental shelf

Thanks! Questions?!