Interannual Sea Level Variability Along the U.S. East Coast during Satellite Altimetry Era: Local versus Remote Forcing

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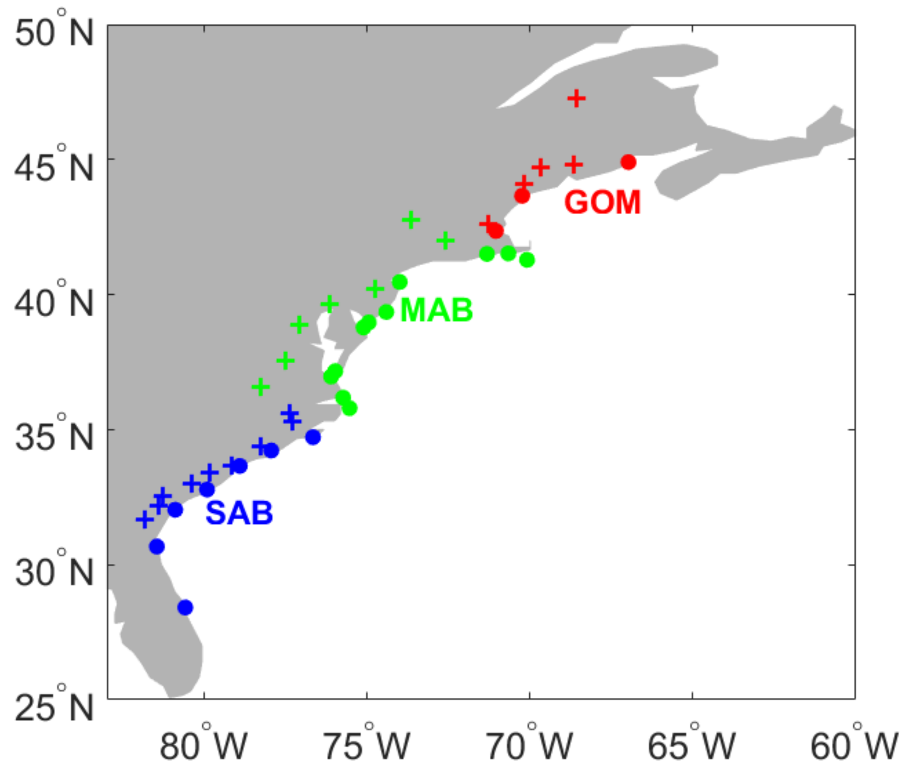
Background

❖ *Existing studies have shown that interannual sea level variability along the U.S. east coast (USEC) are affected by both local and remote forcing*

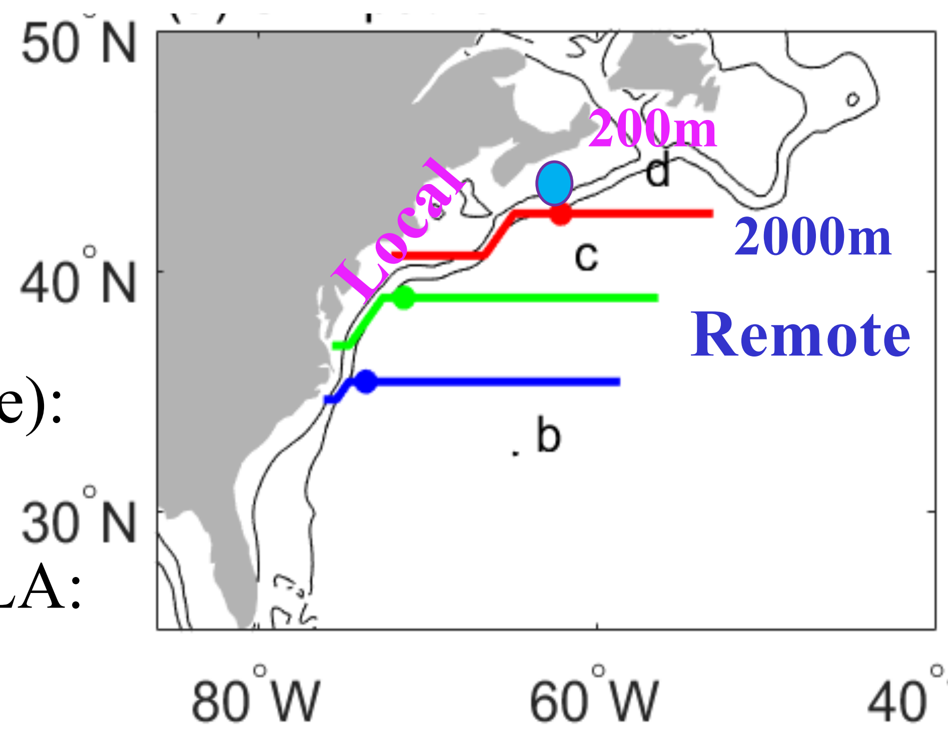


❖ *Their relative roles, however, have not been systematically quantified*

❖ **Goal: Quantify local vs remote forcing on interannual SLAs** along USEC in the Gulf of Maine (**GOM**), Mid-Atlantic Bight (**MAB**) & South Atlantic Bight (**SAB**) **since 1993**, when satellite altimetry data have become available

Approach

❖ **Apply analytic models combined with empirical method**



Local forcing:

- Longshore wind stress:

$$\frac{\partial \eta^{\tau}}{\partial s} + \lambda \eta^{\tau} = \frac{\tau^{S}}{\rho g H},$$

- IB effect (atmos. sea level pressure):

$$\eta^{IB} = -\frac{P_a - \overline{P_a}}{\rho g},$$

- River runoff induced halosteric SLA:

$$\eta^{R} = \left(\frac{2 f \alpha S_0 Q_F}{g}\right)^{\frac{1}{2}},$$

Remote forcing:

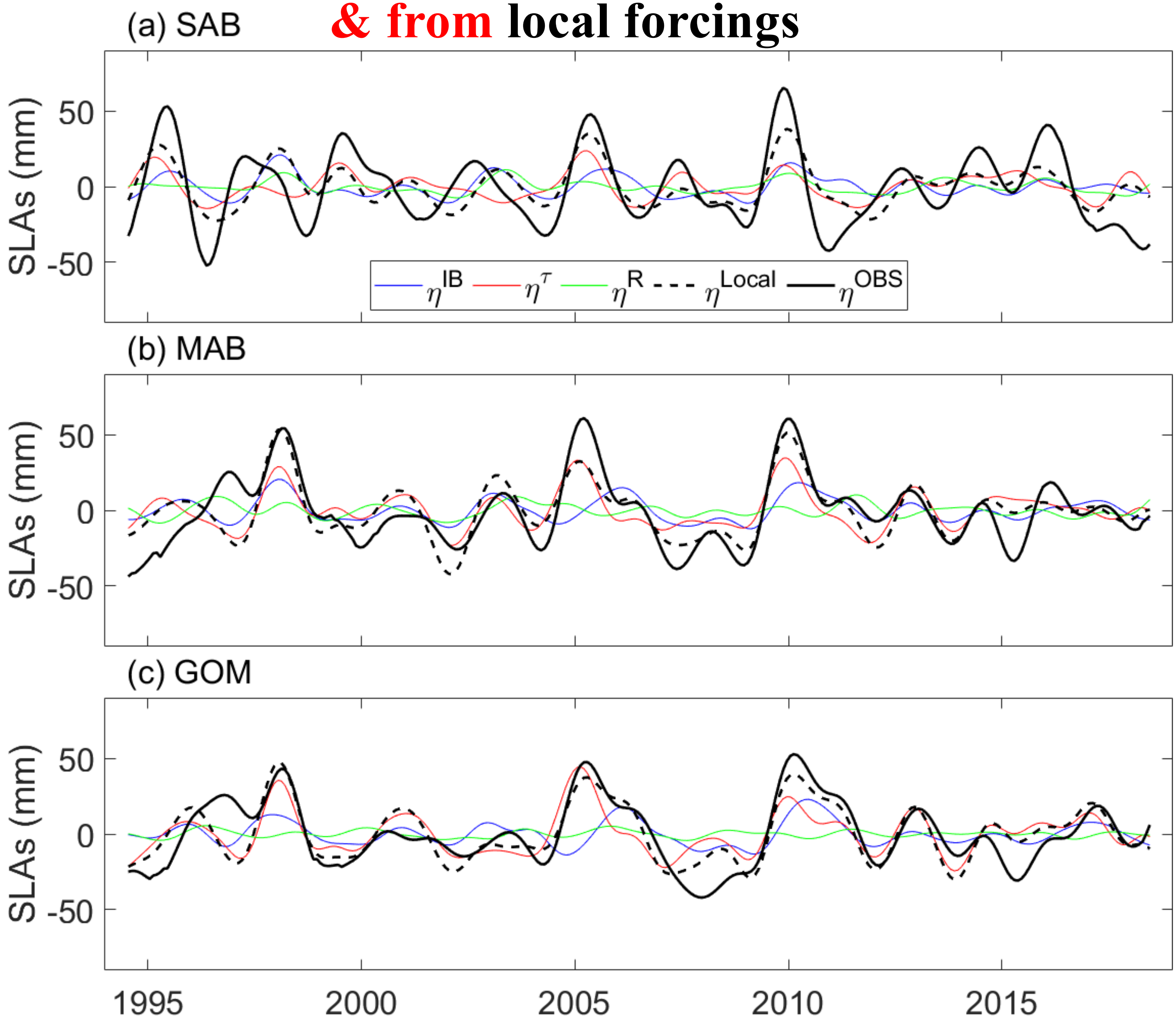
- Open ocean from east & north: 0.25x0.25deg satellite SLAs

$$\eta(y,t) = \underbrace{\frac{f(y)}{f_P}\eta(y_P,t)}_{\eta^N} + \underbrace{f(y)\int_{y}^{y_P}\frac{\beta}{f^2}\eta_I\big(x_I(y'),y',t-\delta(y')\big)dy'}_{\eta^W},$$

- Effect of Gulf Stream (GS): $\eta^{Residual} = b_0 + b_1 GS^{up} + b_2 GS^{down} + e,$

Results

Interannual SLAs from tide gauge obs (solid black) & from local forcings



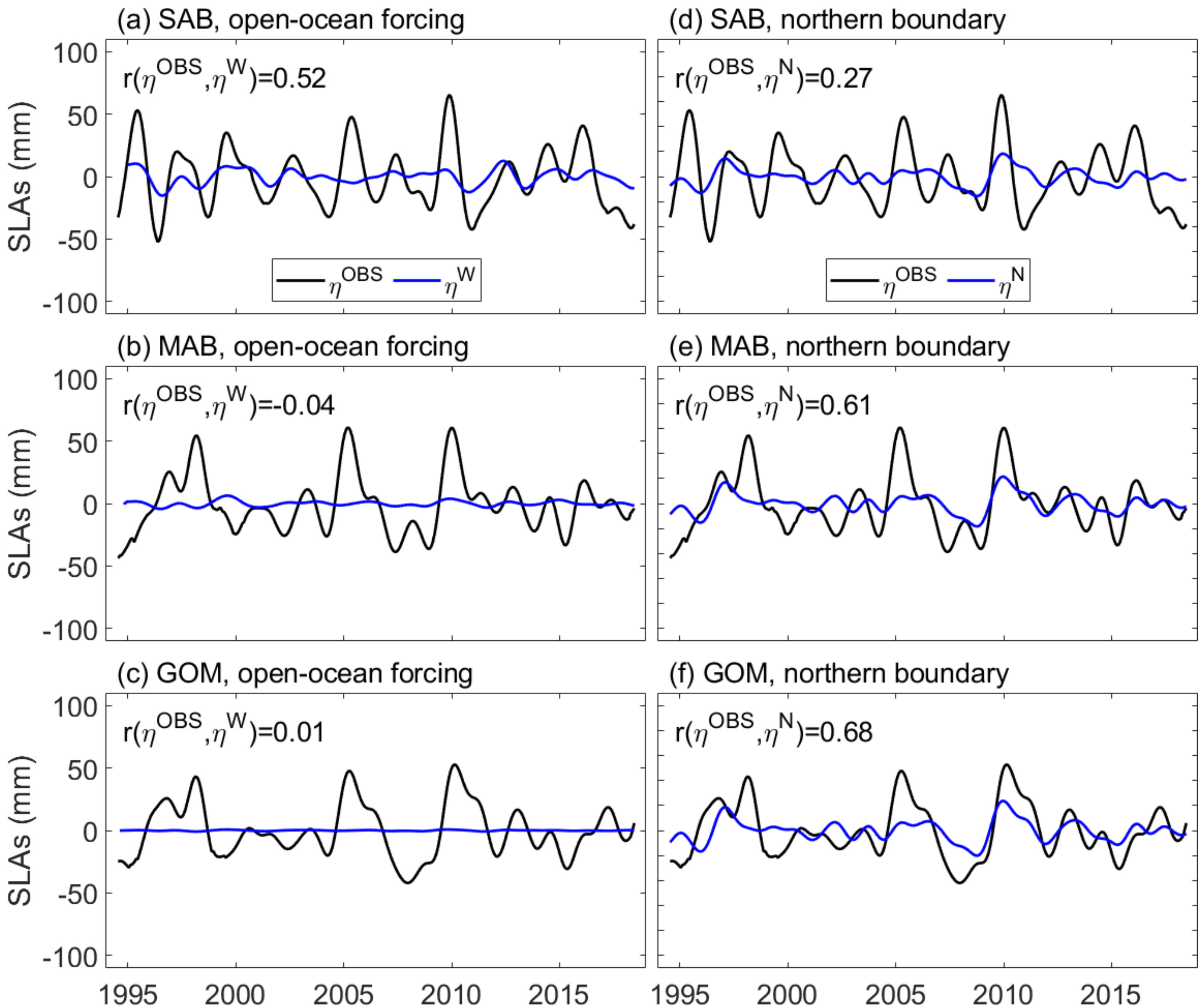
47% obs variance

60% obs variance

67% obs variance

Wind largest;
River weak

Interannual SLAs from tide gauge obs & from remote forcing



46% obs variance

W+N+ GS (23%)

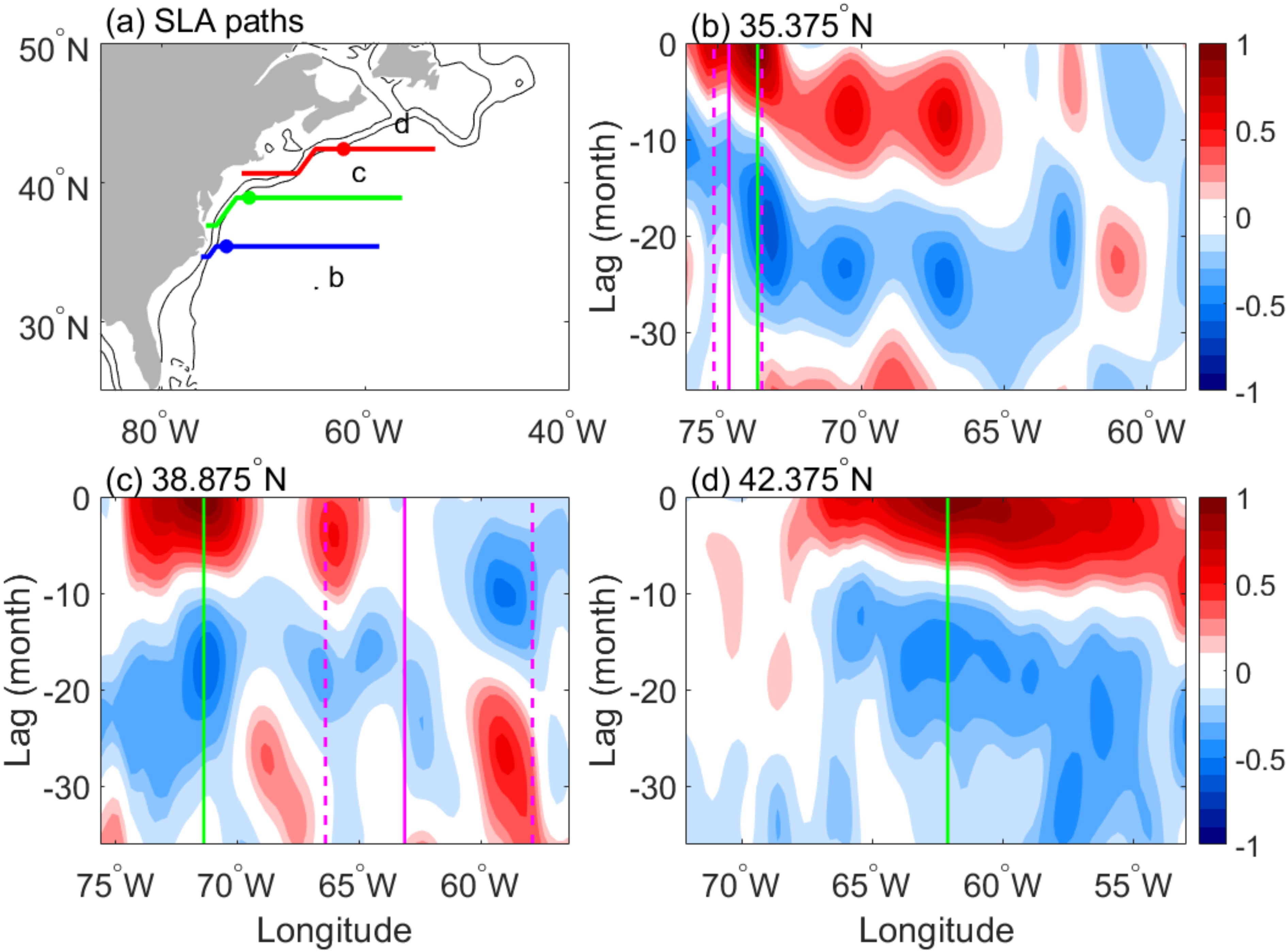
29% obs variance

W+**N**

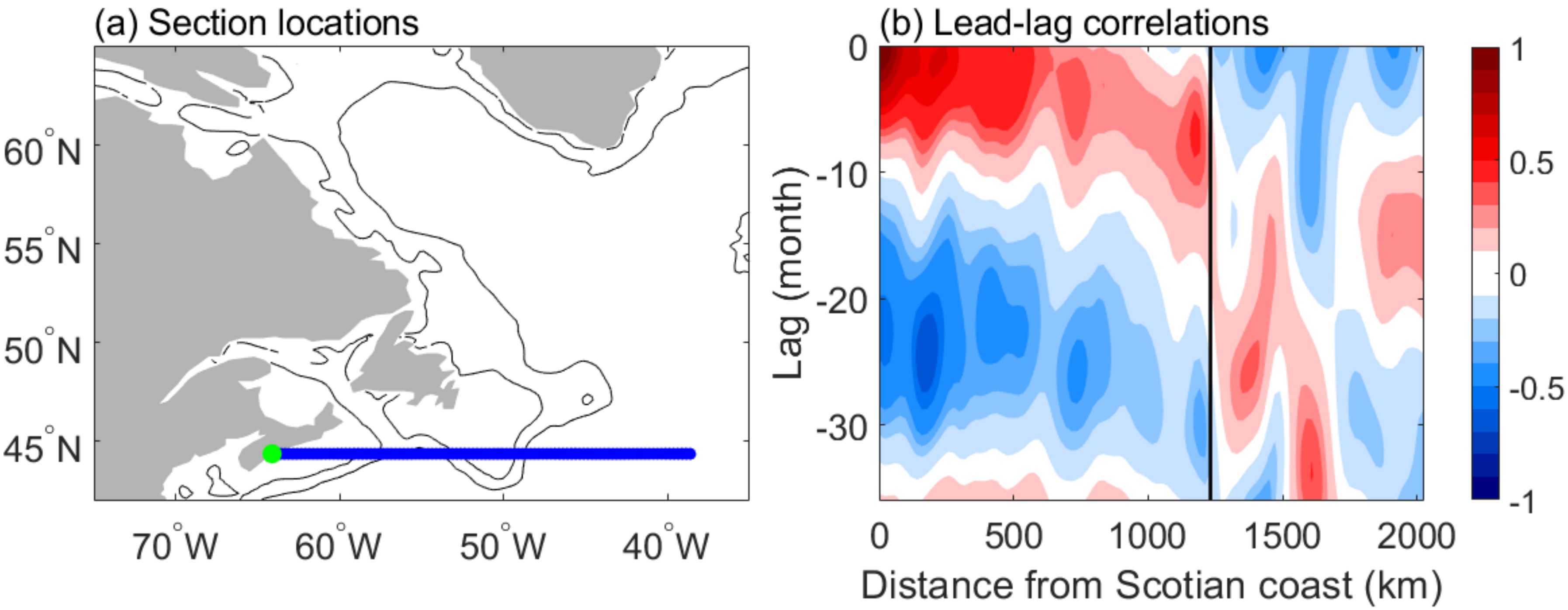
38% obs variance

W+**N**

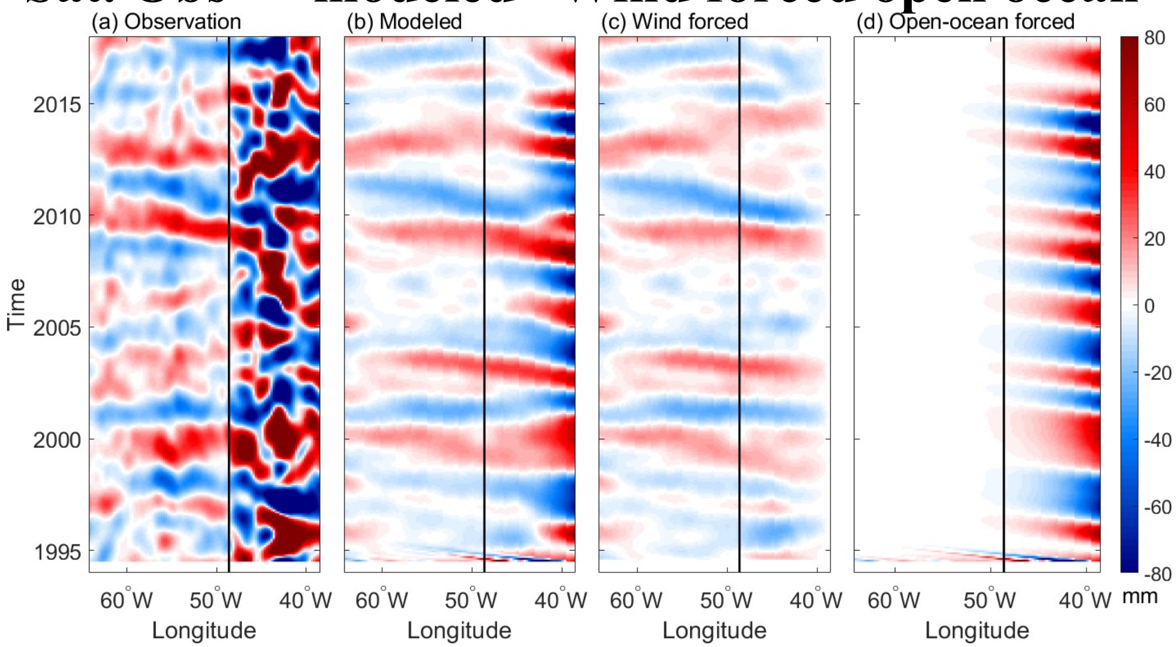
Regression of Altimeter SLA at open ocean points & along paths



Regression of Altimeter SLA at north (green dot) & along path



Sat. Obs modeled Wind forced open ocean



$$\frac{\partial h}{\partial t} - c_r \frac{\partial h}{\partial x} = -\frac{g' \mathbf{k} \cdot \nabla \times \boldsymbol{\tau}}{\rho_0 g f} - \epsilon h,$$

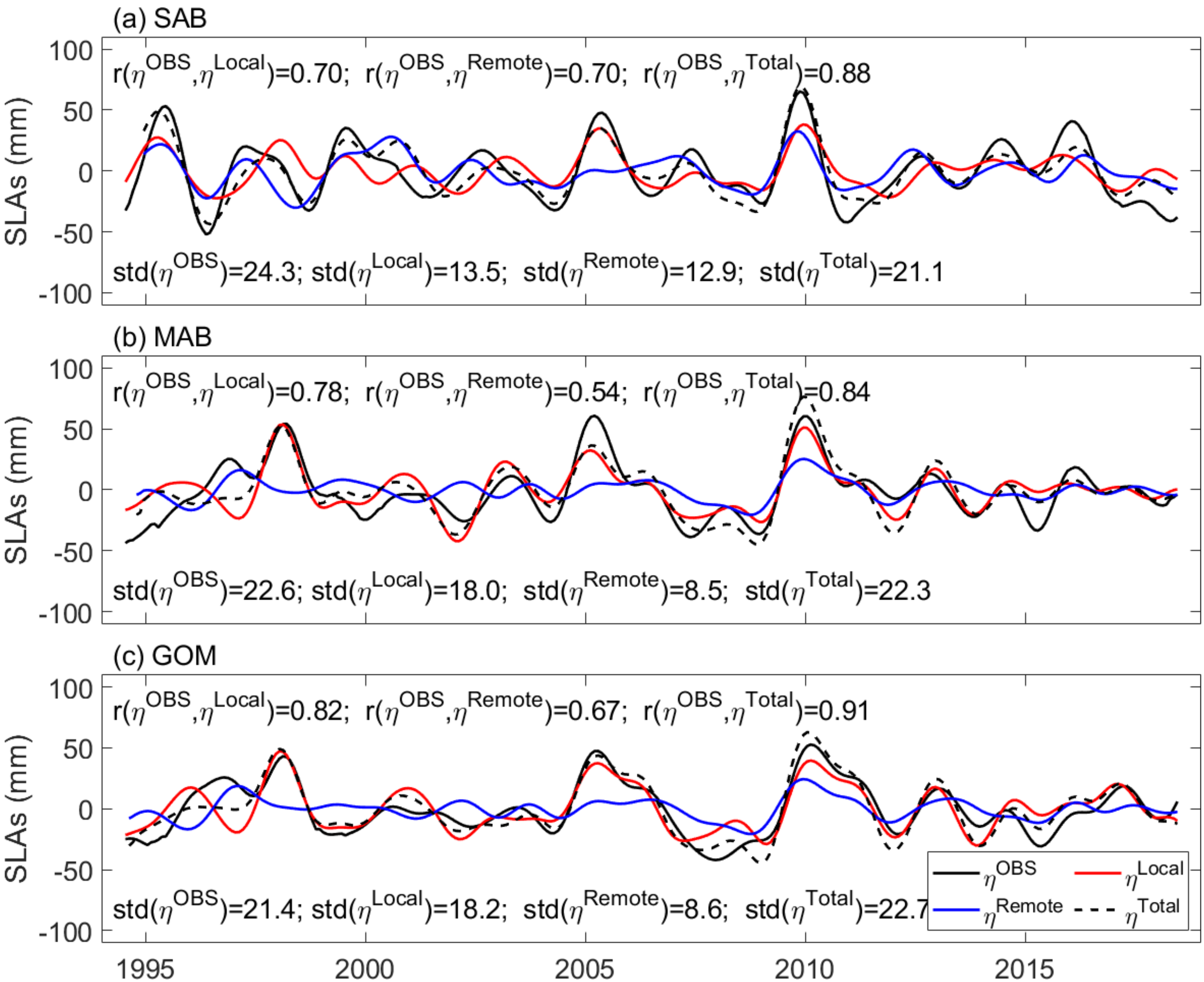
Summary & conclusions

During satellite altimetry era since 1993, for interannual coastal SLAs:

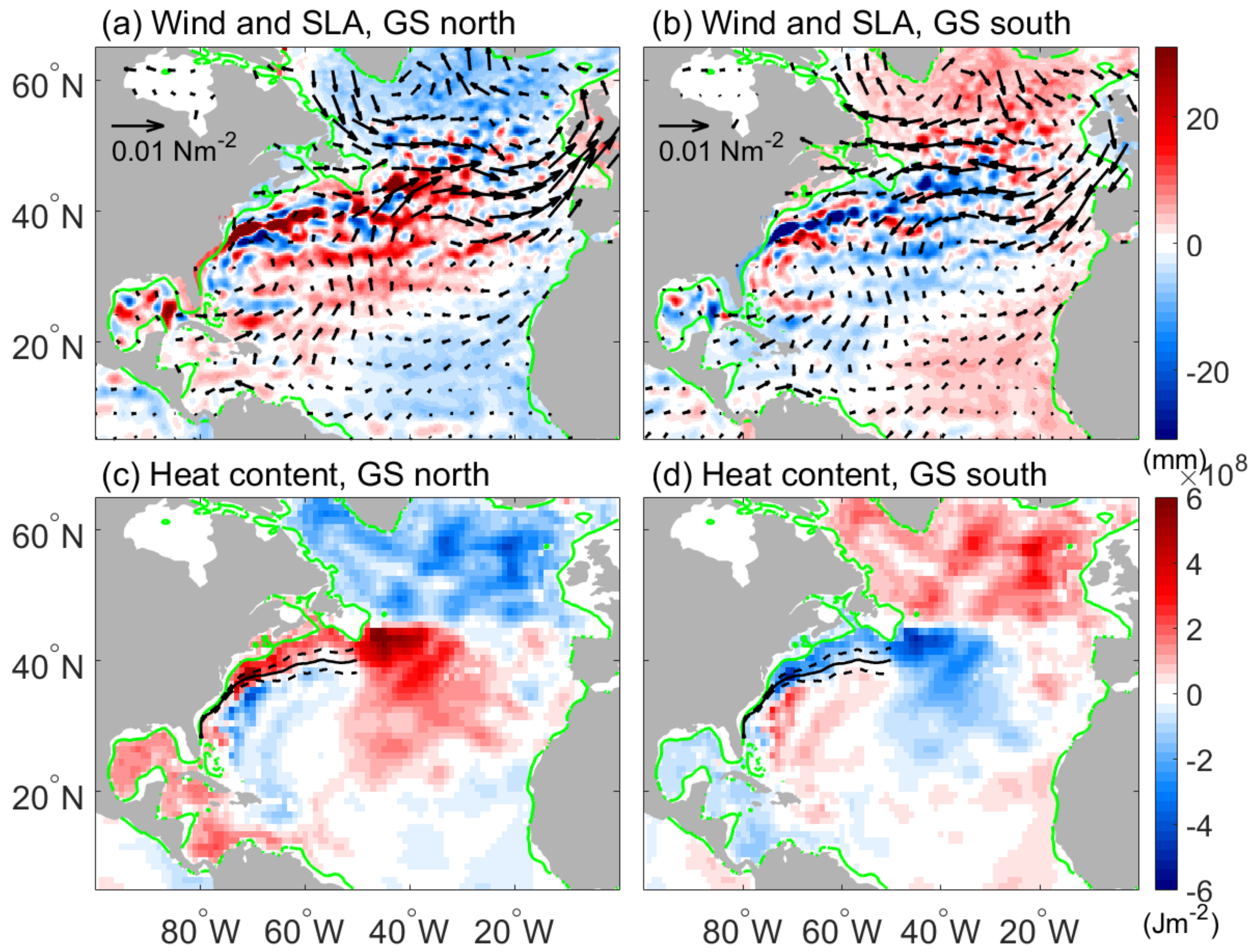
- **In SAB, local forcings** mainly from alongshore wind stress & IB effect **(remote forcing) explain ~47% (46%) SLA variance–** ***comparable role*****;** remote forcing from open ocean in the 35°N-38°N band and upstream GS strength strongly influence coastal SLAs;
- **In MAB, local forcings -** mainly from alongshore wind stress & IB effect - **(remote forcing) explain ~60%/29% SLA variance-** ***local larger than remote*****;** remote forcings from the subpolar North Atlantic and wind stress curl over the Grand Banks exert significant influence on coastal SLAs in GOM & MAB.

- **In GOM, local forcings -** mainly from alongshore wind stress & IB effect - **(remote forcing) explain ~67%/38% coastal SLA variance –** ***local larger than remote.***

Thank you!



(a) SAB
r(η^OBS,η^Local)=0.70; r(η^OBS,η^Remote)=0.70; r(η^OBS,η^Total)=0.88
std(η^OBS)=24.3; std(η^Local)=13.5; std(η^Remote)=12.9; std(η^Total)=21.1
(b) MAB
r(η^OBS,η^Local)=0.78; r(η^OBS,η^Remote)=0.54; r(η^OBS,η^Total)=0.84
std(η^OBS)=22.6; std(η^Local)=18.0; std(η^Remote)=8.5; std(η^Total)=22.3
(c) GOM
r(η^OBS,η^Local)=0.82; r(η^OBS,η^Remote)=0.67; r(η^OBS,η^Total)=0.91
std(η^OBS)=21.4; std(η^Local)=18.2; std(η^Remote)=8.6; std(η^Total)=22.7
SLAs (mm)
100
50
0
-50
-100
1995
2000
2005
2010
2015
η^OBS
η^Local
η^Remote
η^Total



(a) Wind and SLA, GS north
(b) Wind and SLA, GS south
(c) Heat content, GS north
(d) Heat content, GS south
0.01 Nm^-2
0.01 Nm^-2
60°N
40°N
20°N
60°N
40°N
20°N
80°W
60°W
40°W
20°W
80°W
60°W
40°W
20°W
20
0
-20
(mm)
×10^8
6
4
2
0
-2
-4
-6
(Jm^-2)