Interannual Sea Level Variability Along the U.S. East Coast

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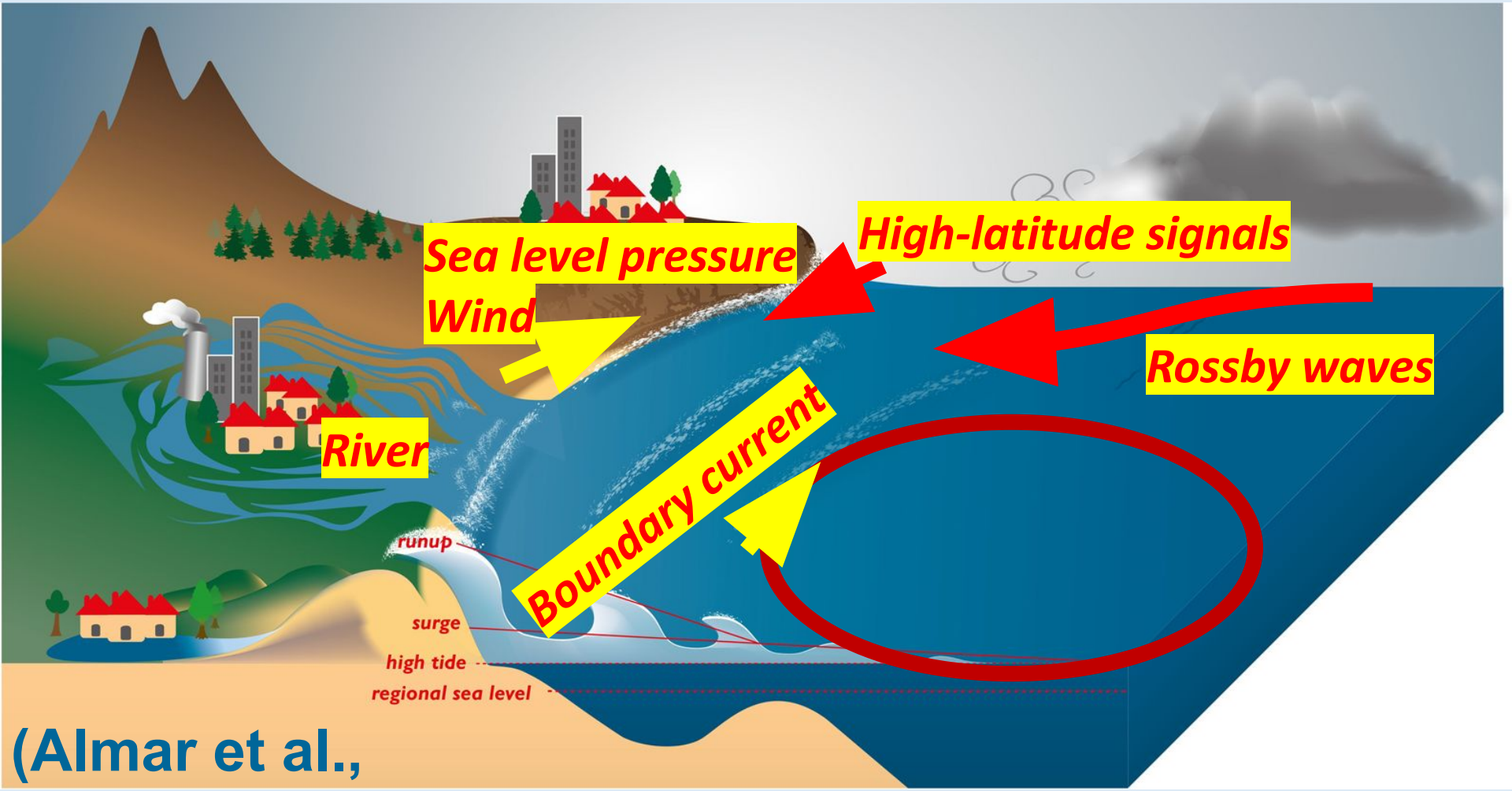
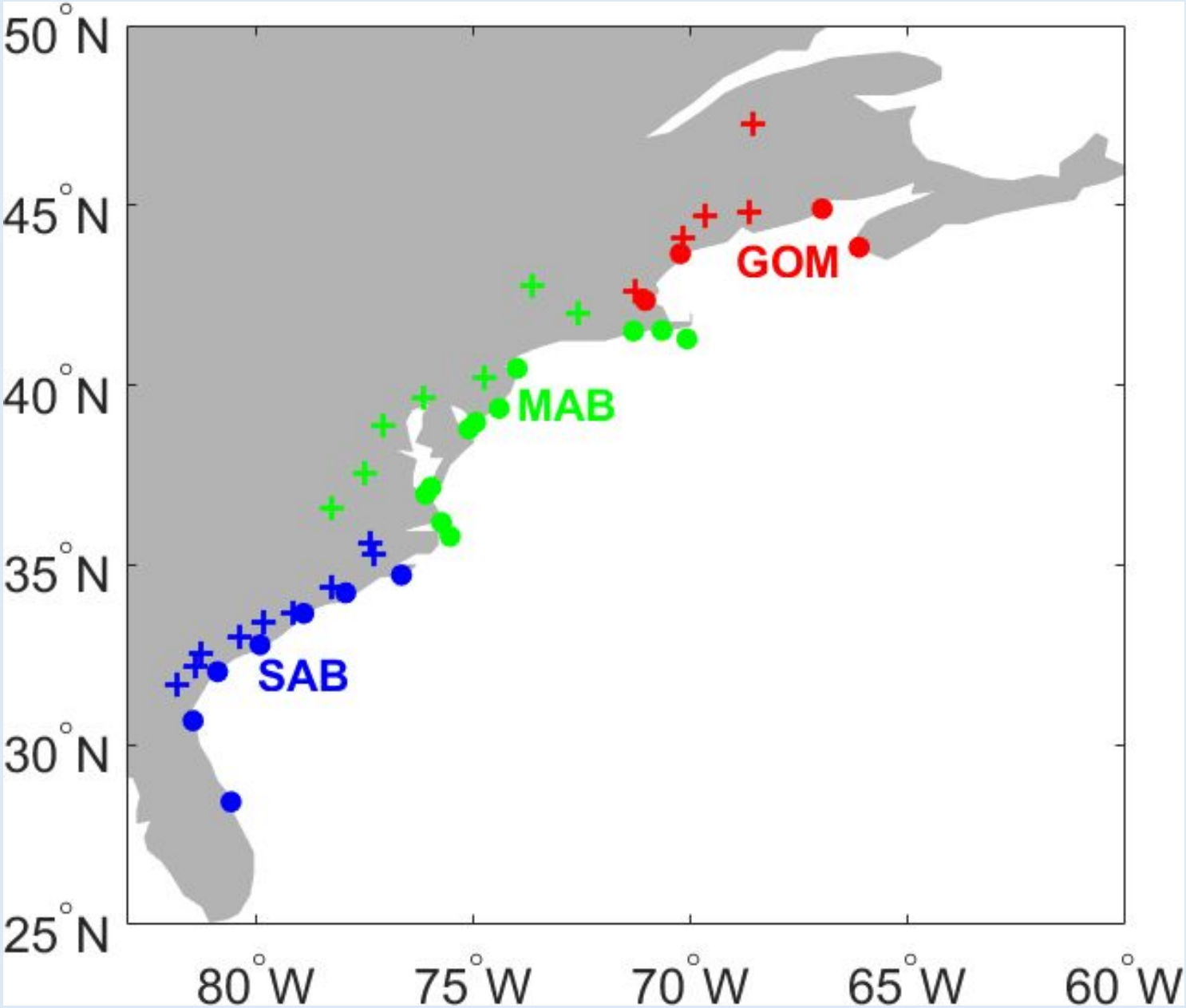
Drivers of interannual sea level variability along the coast



(Almar et al., 2021)

1. What are the relative contributions of local and remote forcings ?
2. Is the role of local and remote forcings changing with time?

Data



Methods: Local forcings

1. Sea level pressure

$$\eta^{IB} = -\frac{P_a - \bar{P}_a}{\rho g}$$

2. Alongshore wind stress

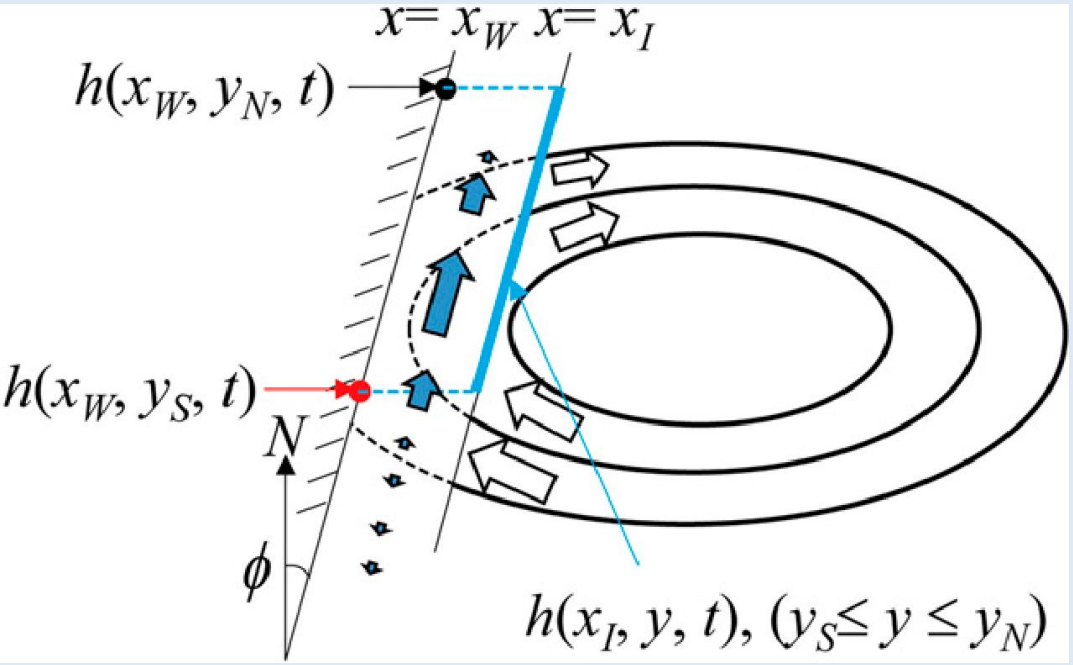
$$\frac{\partial \eta}{\partial s} + \lambda \eta = \frac{\tau^{s}_{top}}{\rho g h}$$

3. River runoff

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

Methods: Remote forcings

1. High-latitude signals and Rossby waves (Minobe et al., 2017)



High-latitude forcings: $\frac{f(y)}{f_P}\eta(y_P, t)$

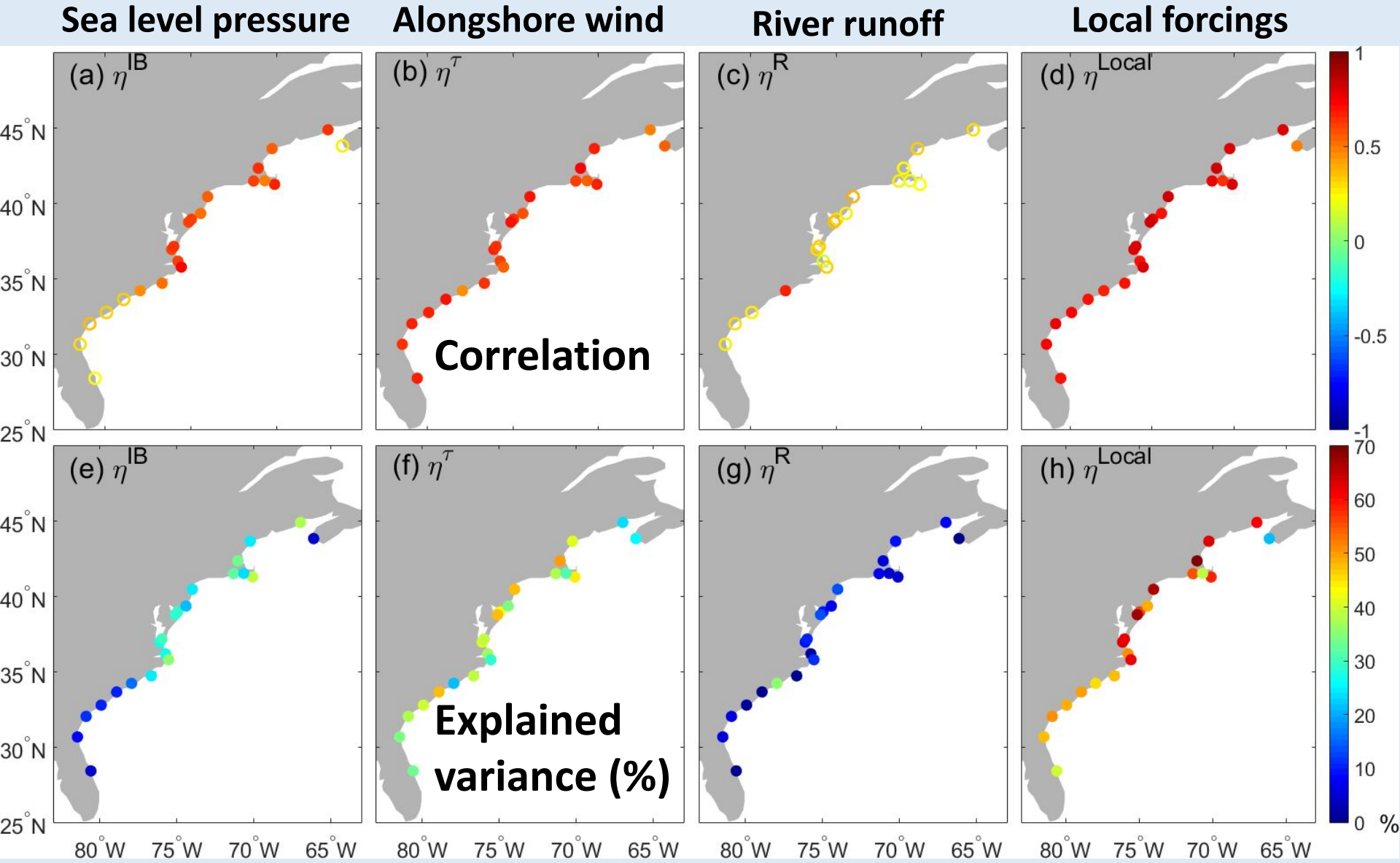
Rossby waves:

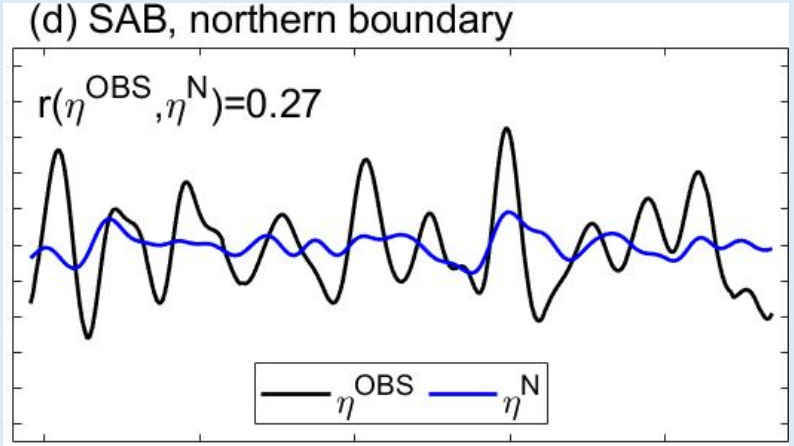
$$\mathbf{f}(y)\int_{y}^{y_P}\frac{\boldsymbol{\beta}}{f^2}\eta_I\left(x_I(y'), y', t-\boldsymbol{\delta}(y')\right)dy'$$

2. Role of Gulf Stream

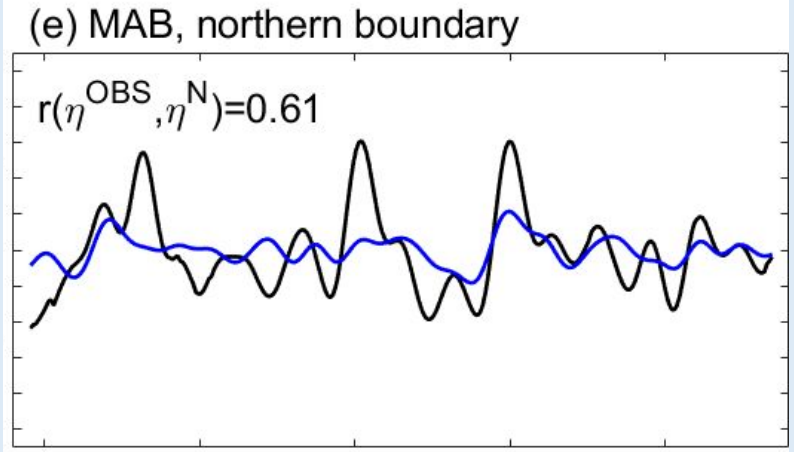
$$\eta^{Residual} = b_0 + b_1 GS^{up} + b_2 GS^{down} + e$$

Relative contribution of local forcings

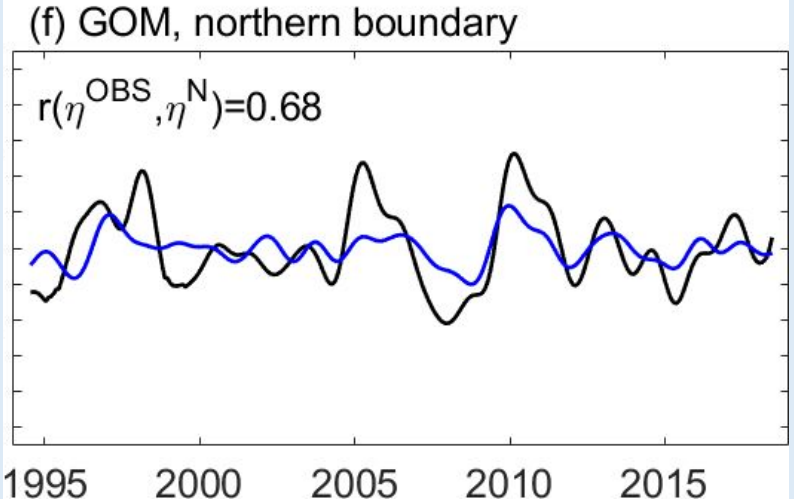




SAB



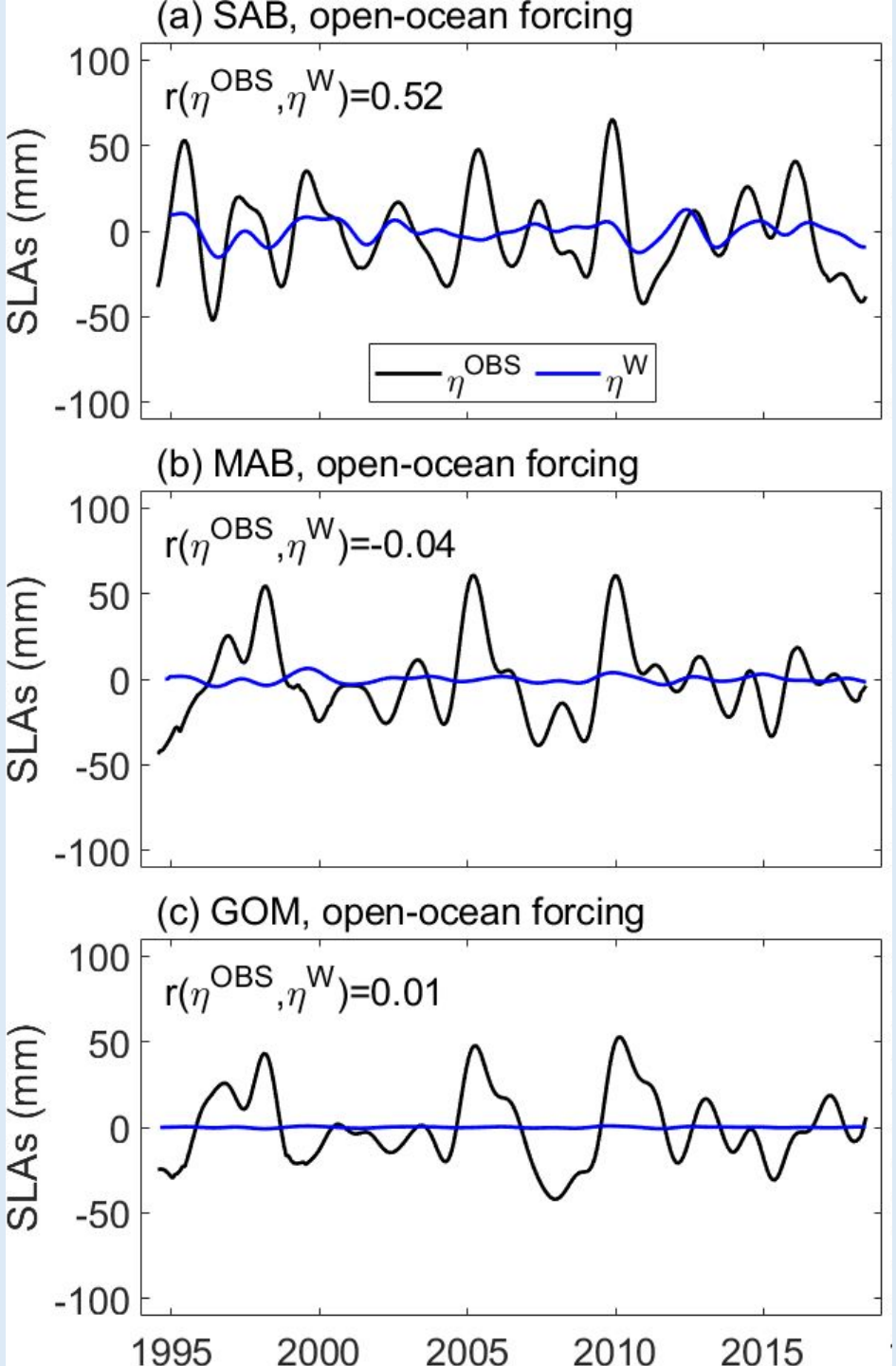
MAB



GOM

Role of high-latitude forcings:

most important in the MAB and GOM



SAB

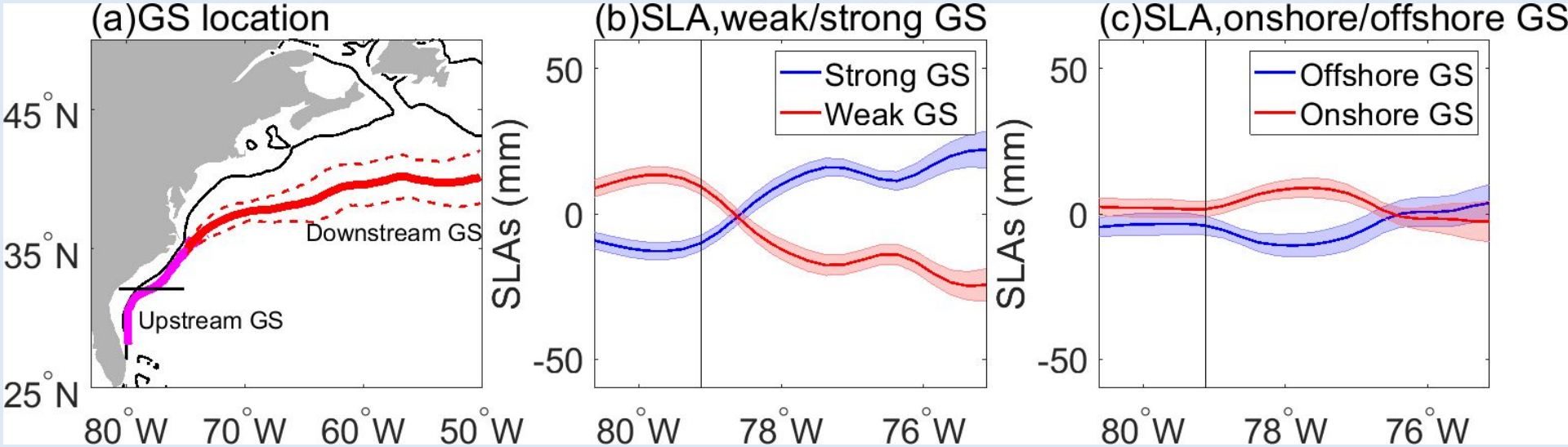
MAB

GOM

Role of Rossby waves:

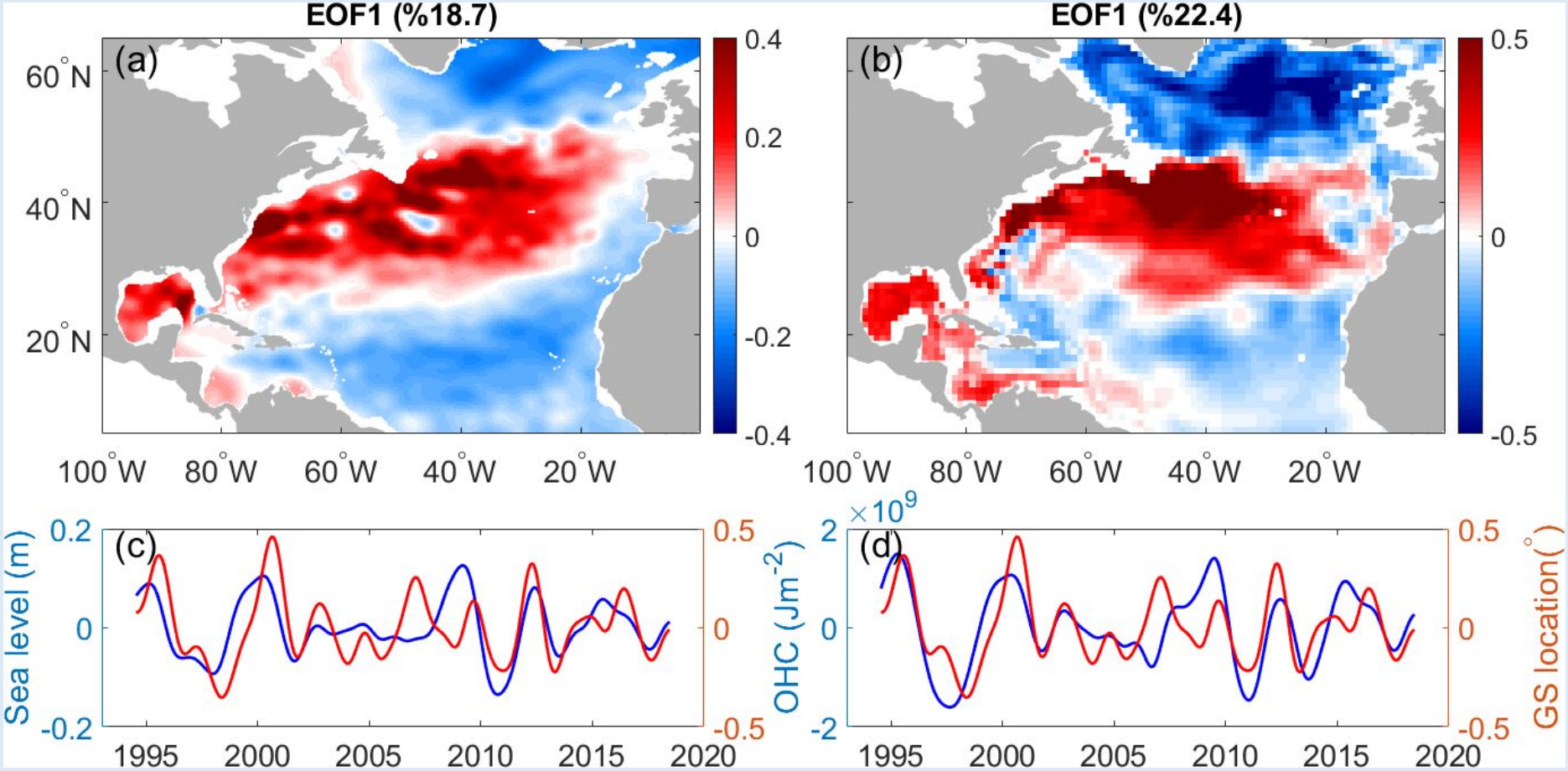
most important in the SAB

Role of upstream Gulf Stream on coastal sea level



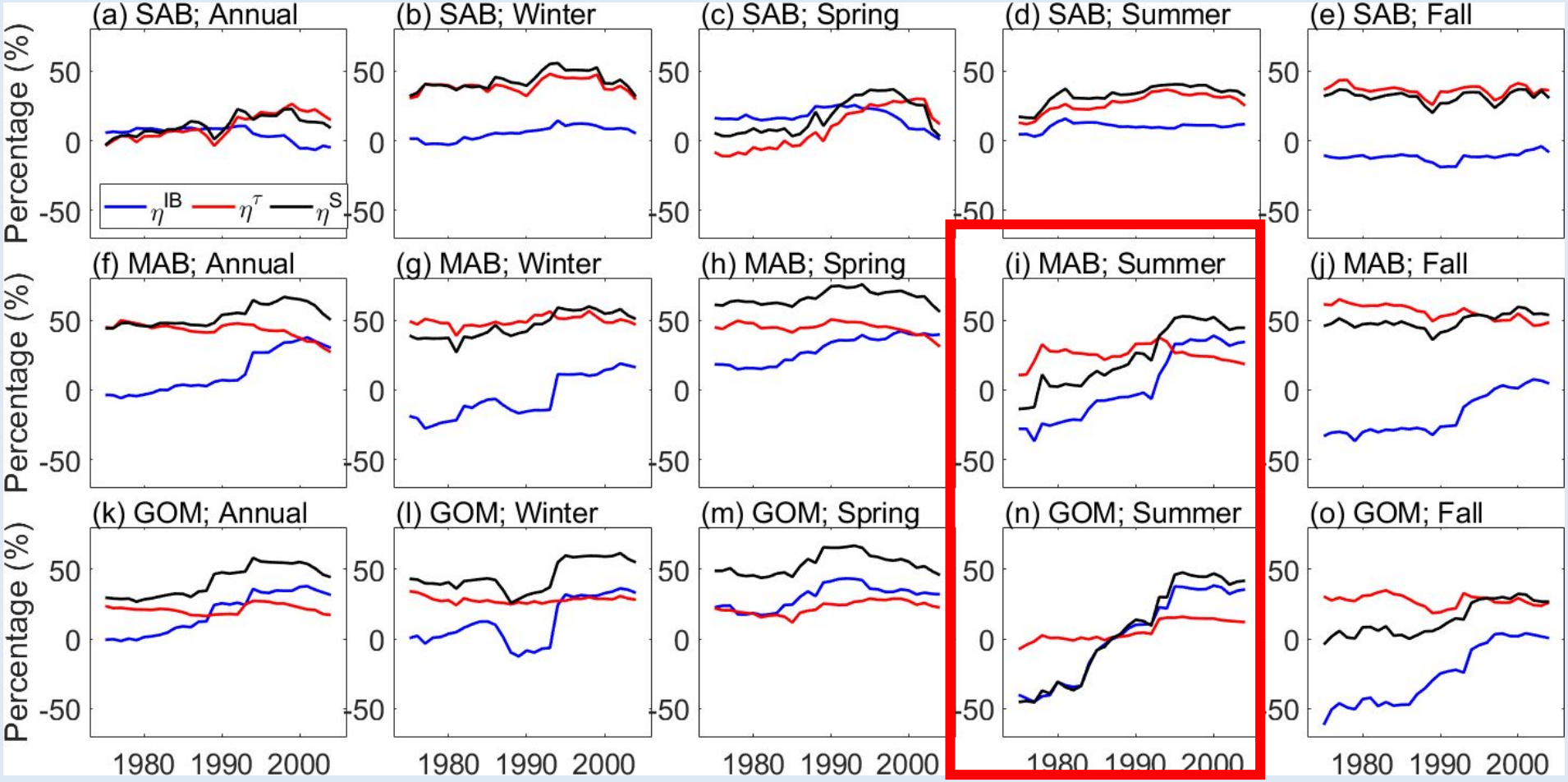
The upstream Gulf Stream strength is the most important

Role of downstream Gulf Stream

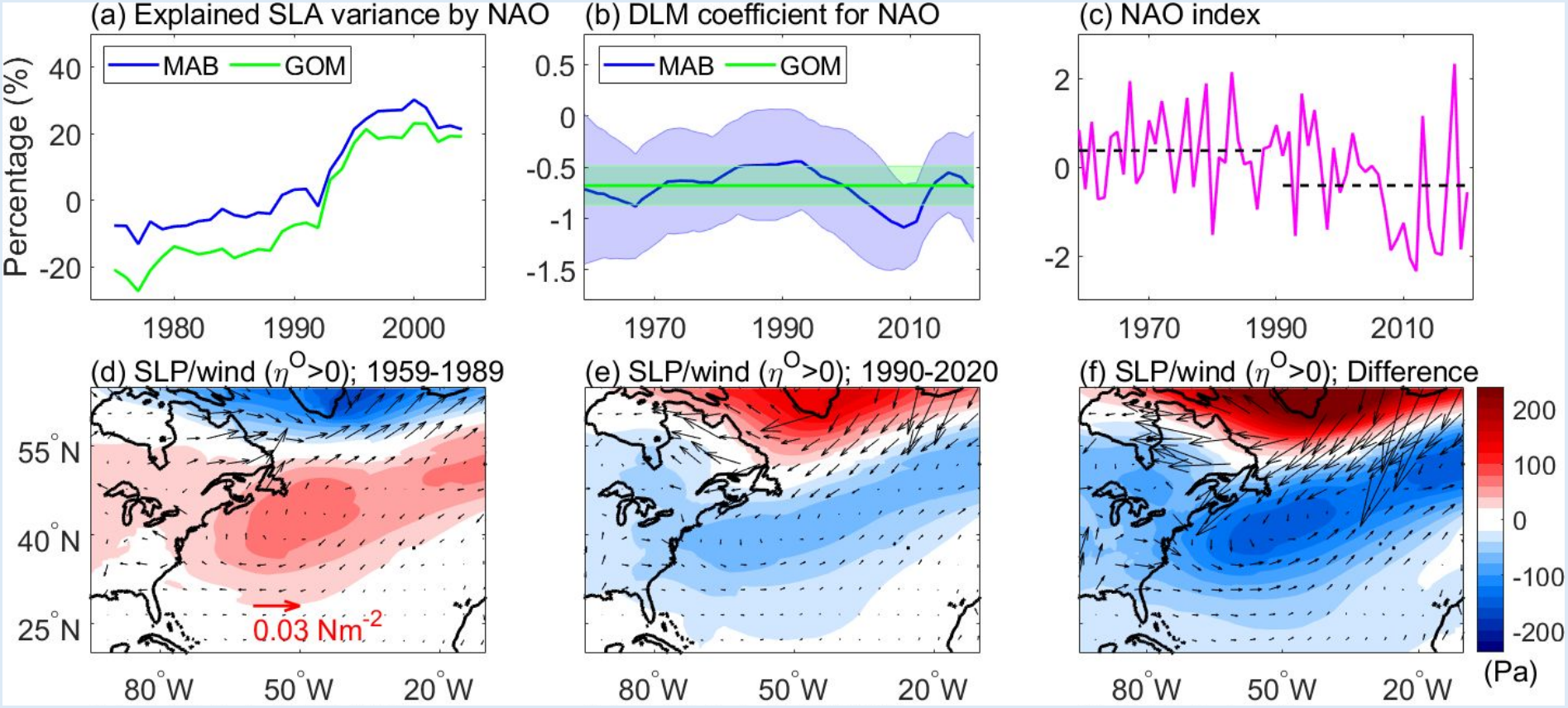


The downstream Gulf Stream location is the most important

Sea level variance explained by local forcings over 31-year moving windows



Roles of NAO


(a) Explained SLA variance by NAO
Percentage (%)
MAB
GOM
40
20
0
-20
1980
1990
2000
(b) DLM coefficient for NAO
MAB
GOM
0.5
0
-0.5
-1
-1.5
1970
1990
2010
(c) NAO index
2
0
-2
1970
1990
2010
(d) SLP/wind (η^O>0); 1959-1989
0.03 Nm^{-2}
(e) SLP/wind (η^O>0); 1990-2020
(f) SLP/wind (η^O>0); Difference
55°N
40°N
25°N
80°W
50°W
20°W
200
100
0
-100
-200
(Pa)

Summary

What are the relative contributions of local and remote forcings？

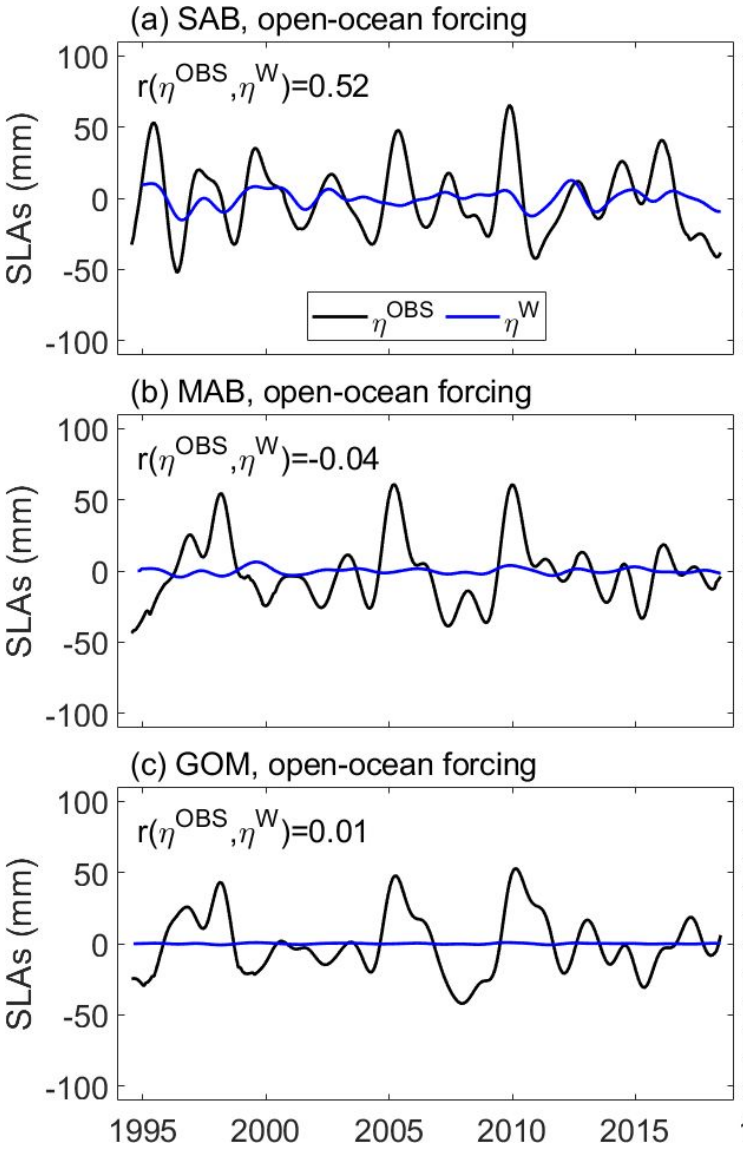
- **Local and remote forcings are the most important for the interannual sea level variability in the northeast and southeast U.S. coast, respectively.**
- **Rossby waves, upstream Gulf Stream strength, and downstream Gulf Stream location are the most important along the southeast coast, while remote forcings from the high latitudes are the most important along the northeast coast.**

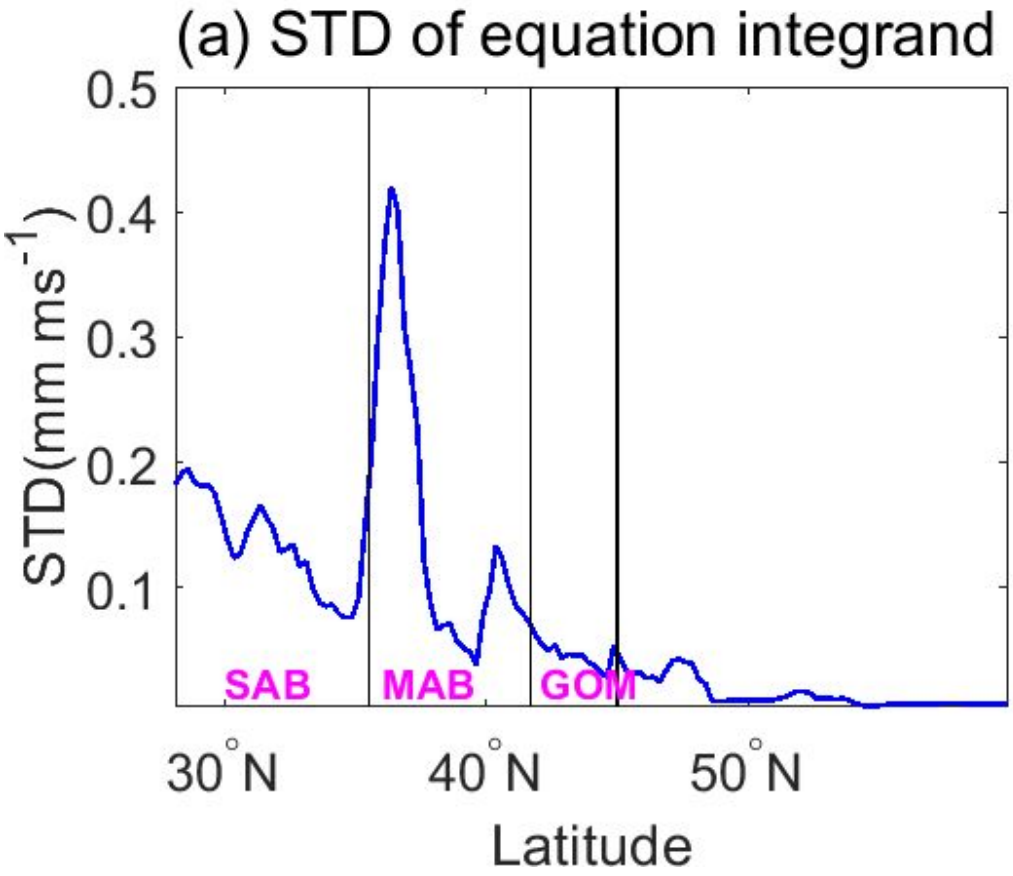
Is the role of local and remote forcings changing with time?

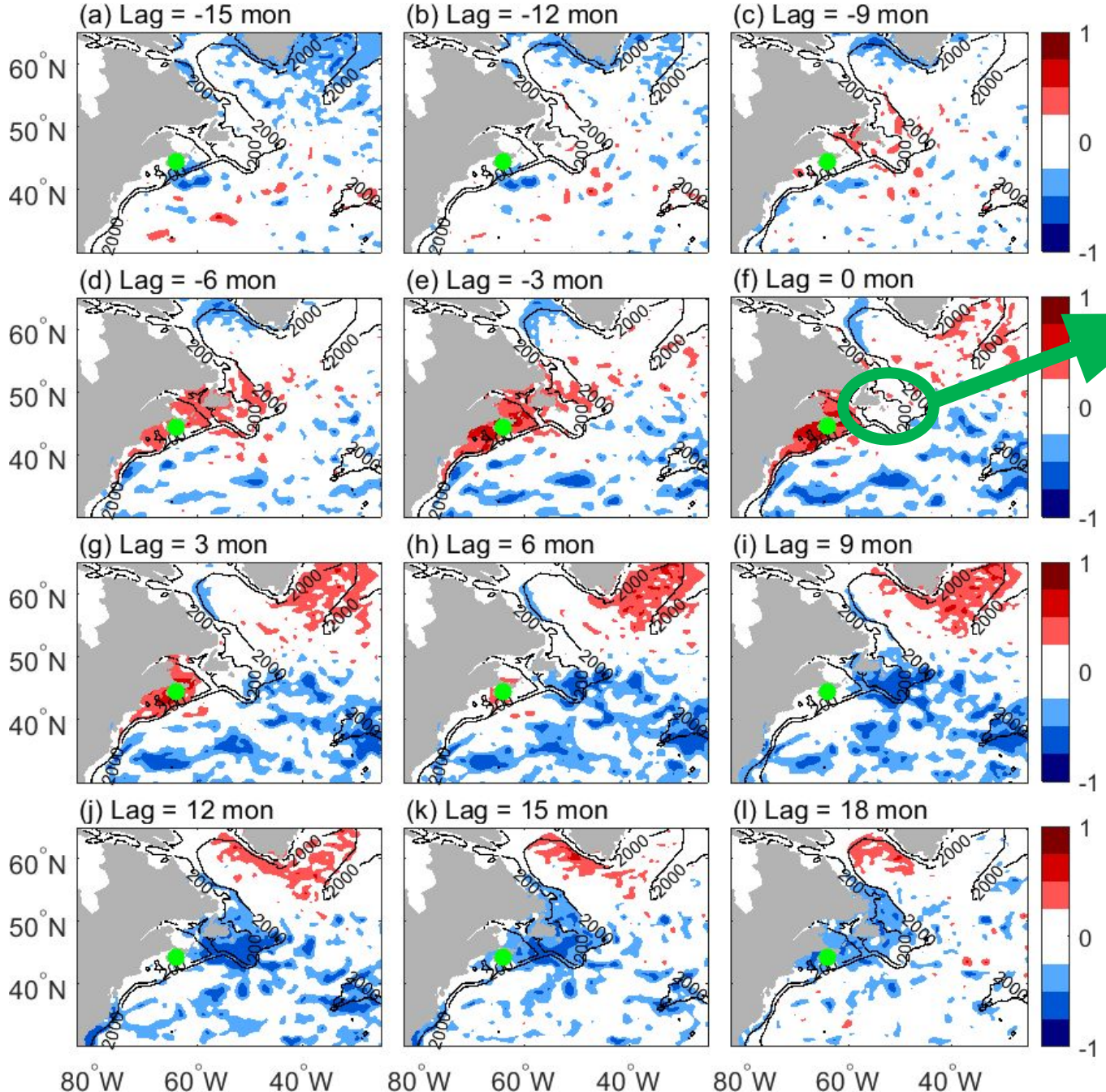
- **The role of sea level pressure in driving interannual sea level variability along the northeast U.S. coast significantly increases in recent 30 years, which is related to the summer NAO.**

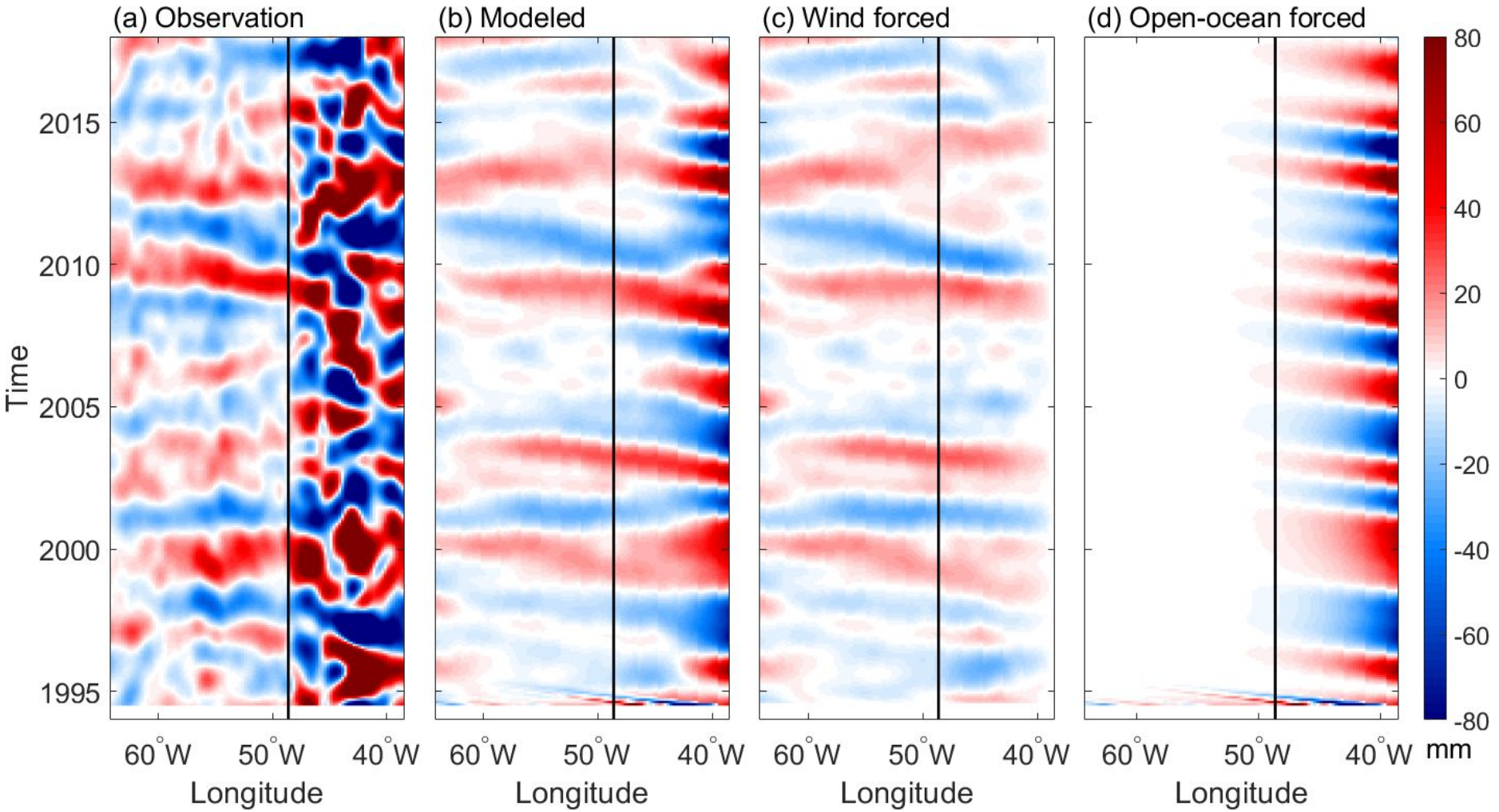
Thank you

Role of Rossby waves






(a) Lag = -15 mon
(b) Lag = -12 mon
(c) Lag = -9 mon
(d) Lag = -6 mon
(e) Lag = -3 mon
(f) Lag = 0 mon
(g) Lag = 3 mon
(h) Lag = 6 mon
(i) Lag = 9 mon
(j) Lag = 12 mon
(k) Lag = 15 mon
(l) Lag = 18 mon
60°N
50°N
40°N
80°W
60°W
40°W
1
0
-1
2000
Grand Banks



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

Winds along the Grand Banks