Recent efforts from NOAA/AOML towards monitoring and improving the understanding of changes in the Florida Current: relationships with sea level along the east U.S. coast

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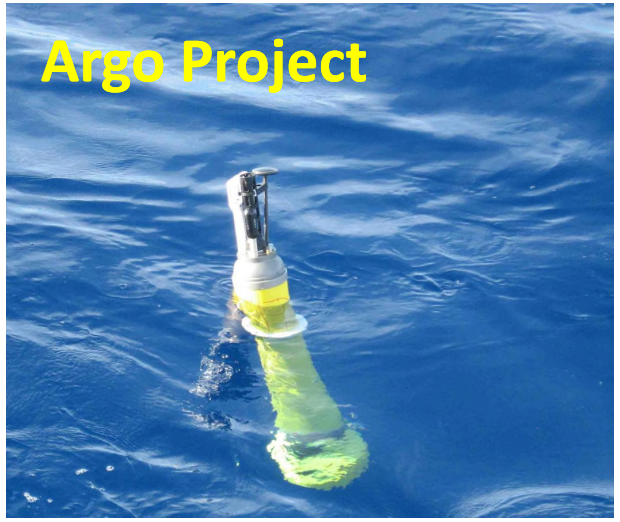
Gulf Stream: Variations in SLR along the Eastern Coast, West Palm Beach-FL, May 09 2017

AOML contribution to the Global Ocean Observing System



Improve the understanding on the role that the ocean plays on climate, extreme weather events, ecosystems, and sea-level changes

South Florida vs. Sea Level changes

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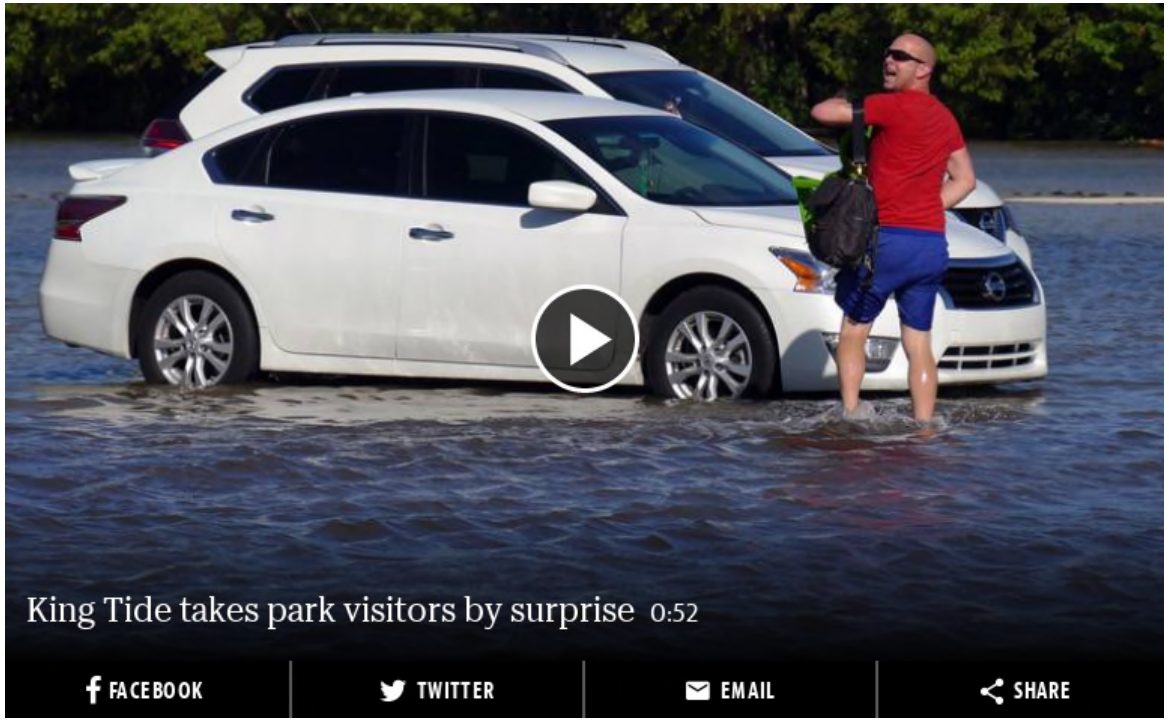
APRIL 24, 2017 7:24 PM

The Arctic is melting and guess who faces more flooding — that's right, South Florida

BY JENNY STALETOVICH
jstaletovich@miamiherald.com

A new assessment of polar ice melt could mean bad news for South Florida: higher sea rise than previously thought.



www.miamiherald.com/news/local/environment/article146511584.html

Sources of Sea Level Changes

$$\mathbf{Obs.\,SL} = \overline{\mathbf{SL}} + \Delta\mathbf{SL_{tides}} + \Delta\mathbf{SL_{waves}} + \Delta\mathbf{SL_{weather}} + \Delta\mathbf{SL_{land}} + \Delta\mathbf{SL_{GL}} + \Delta\mathbf{SL_{Ocean\ Currents}}$$

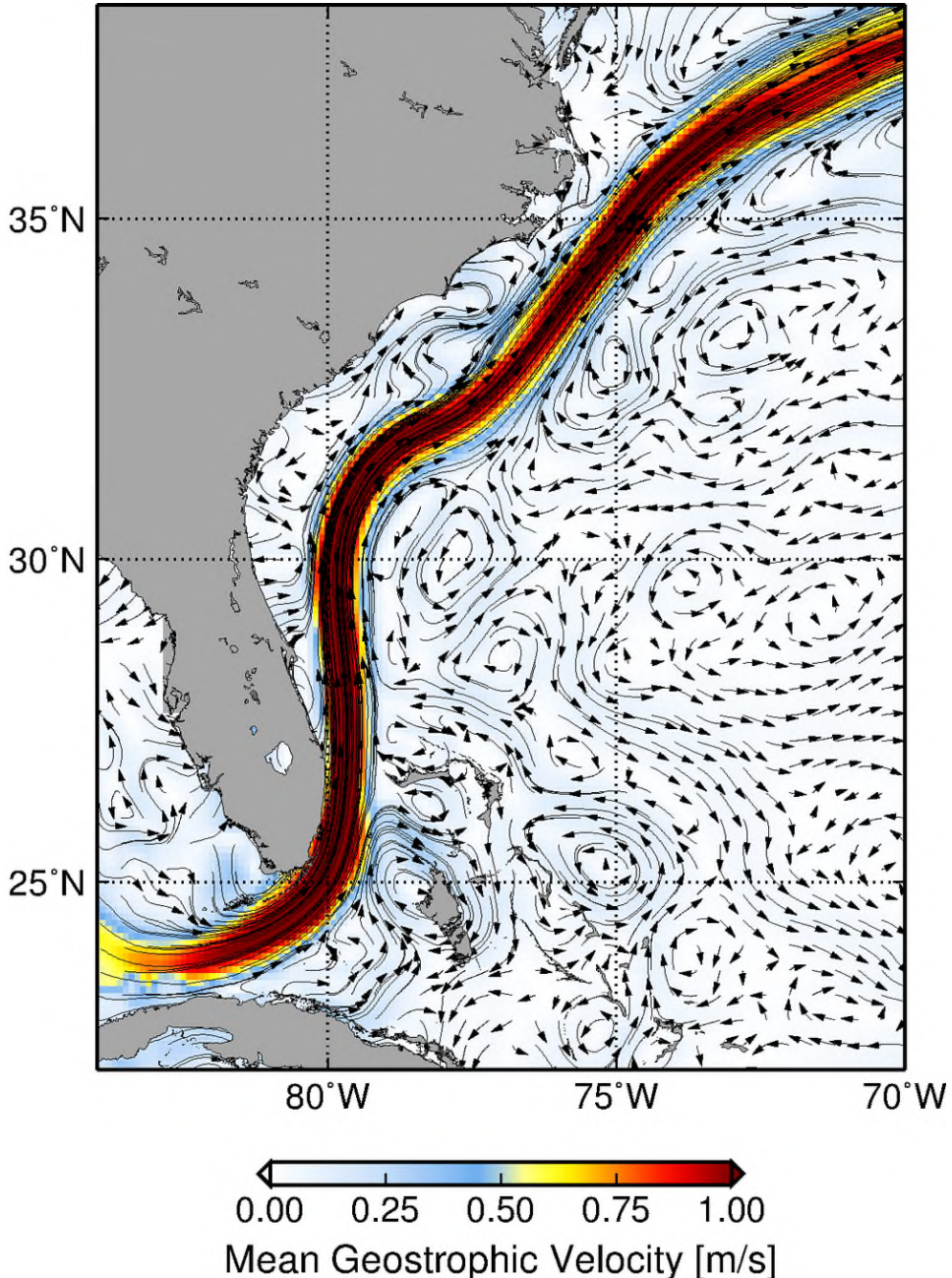
$\overline{\mathbf{SL}}$	mean sea level
$\Delta\mathbf{SL_{tides}}$	effect of astronomical tides
$\Delta\mathbf{SL_{waves}}$	local effect of waves
$\Delta\mathbf{SL_{weather}}$	effect of local winds and atm. pressure changes
$\Delta\mathbf{SL_{land}}$	effect of land subsidence
$\Delta\mathbf{SL_{GL}}$	effect of global changes in ocean mass and density

$\Delta\mathbf{SL_{Ocean\ Currents}}$ effect of Ocean Currents in sea level changes

Florida Current and Gulf Stream Effect on Sea Level along east U.S. coast

$\Delta SL_{\text{Ocean Currents}}$

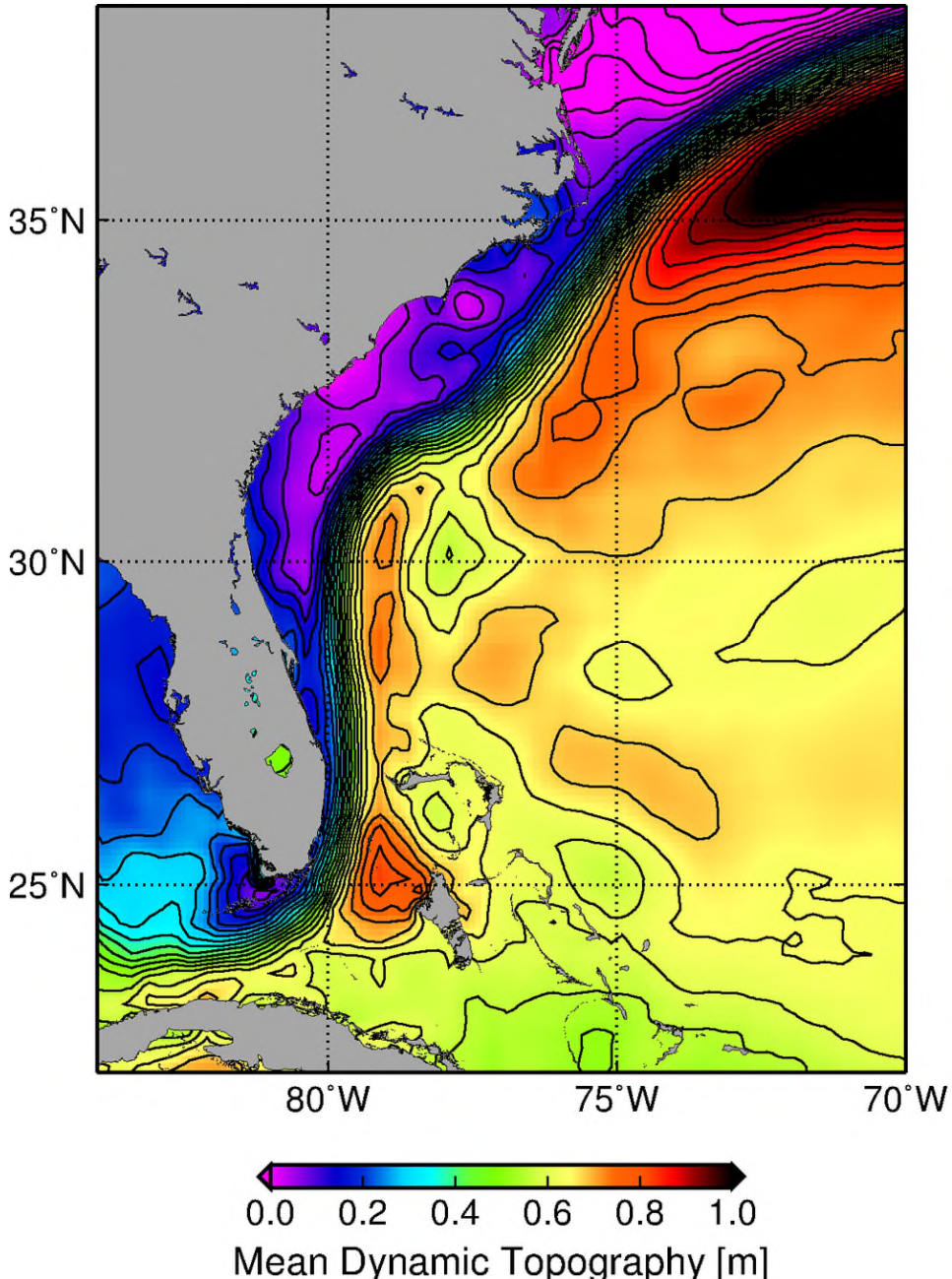
Intense Ocean Current Flowing very close to U.S. east coast



Florida Current and Gulf Stream Effect on Sea Level along east U.S. coast

$\Delta SL_{\text{Ocean Currents}}$

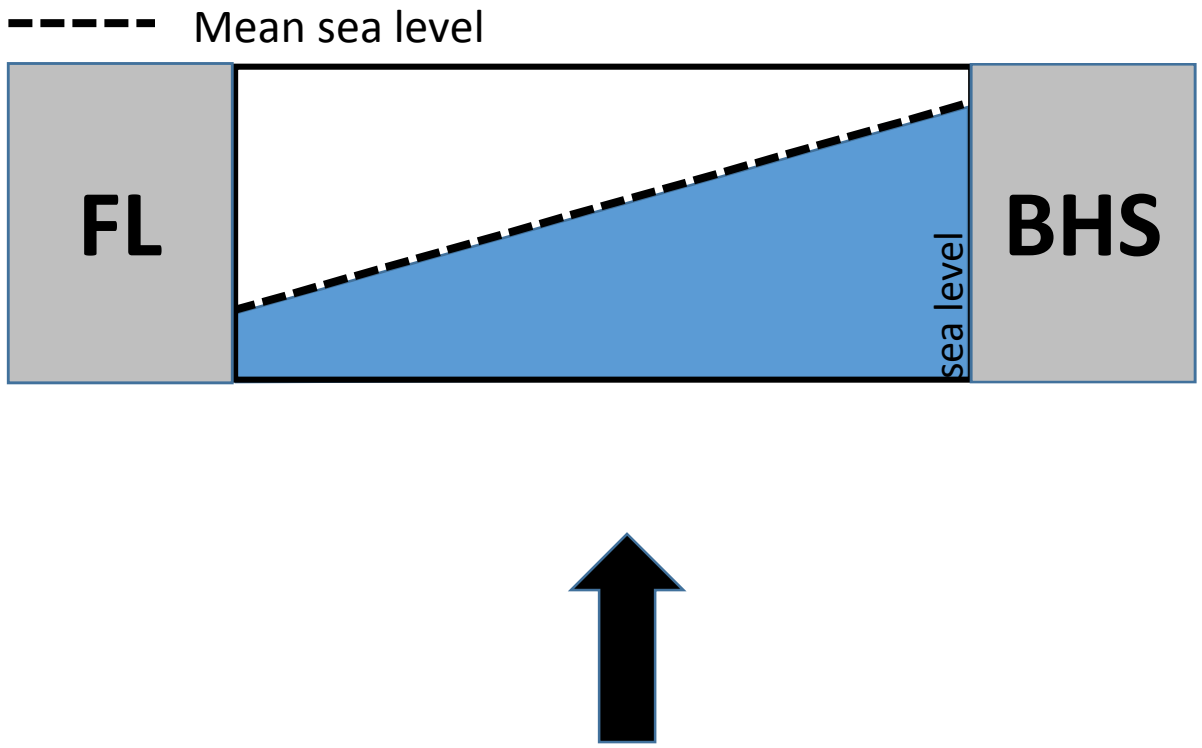
The Florida Current sustain a sea level difference between south Florida and the Bahamas of almost **1m**



Florida Current and Gulf Stream Effect on Sea Level along east U.S. coast

$\Delta SL_{Ocean\ Currents}$

Changes in the intensity of the Florida Current and Gulf Stream are, therefore, associated with sea level changes along the east coast of U.S.



FL - Florida
BHS - Bahamas

Florida Current and Gulf Stream Effect on Sea Level along east U.S. coast

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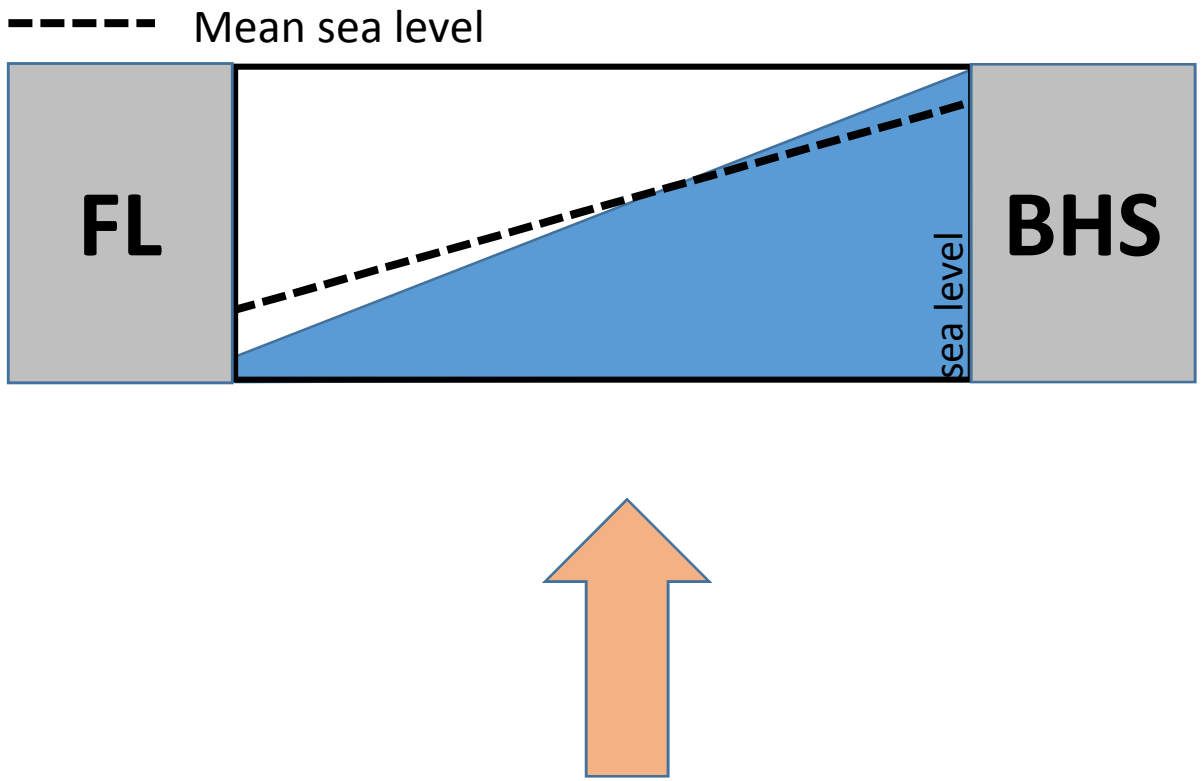

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Florida Current and Gulf Stream Effect on Sea Level along east U.S. coast

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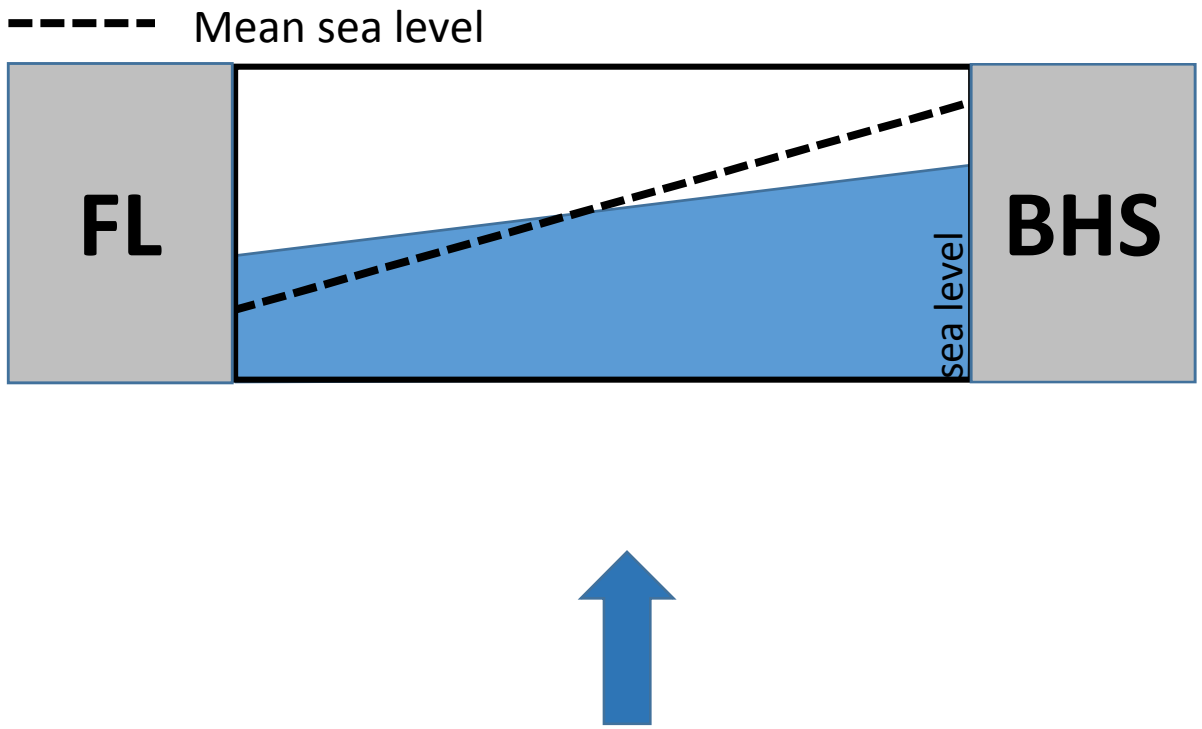
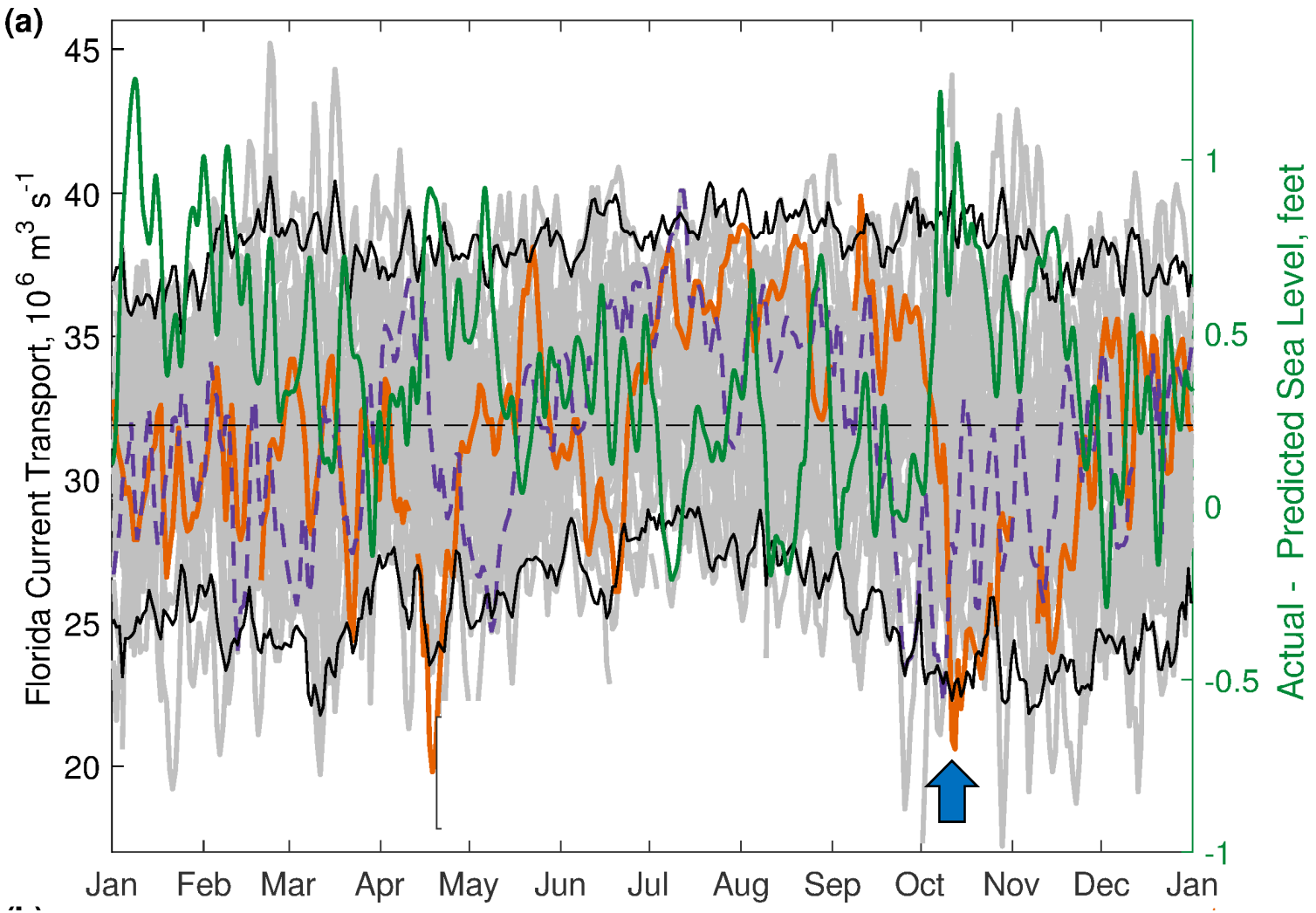


Weak Florida Current flow

FL - Florida
BHS - Bahamas

Increase in sea level at Florida
Decrease sea level at the Bahamas

Observed Florida Current changes and potential links with coastal sea-level



Daily FC transport

Observed – Predicted sea level 2016 (Lake Worth)

2016 FC transport

Low FC transport coincided with observed king tide events in October 2016

Baringer et al. (2017), Meridional overturning and oceanic heat transport circulation observations in the North Atlantic Ocean, State of the Climate in 2016, Bulletin of the American Meteorological Society, in press

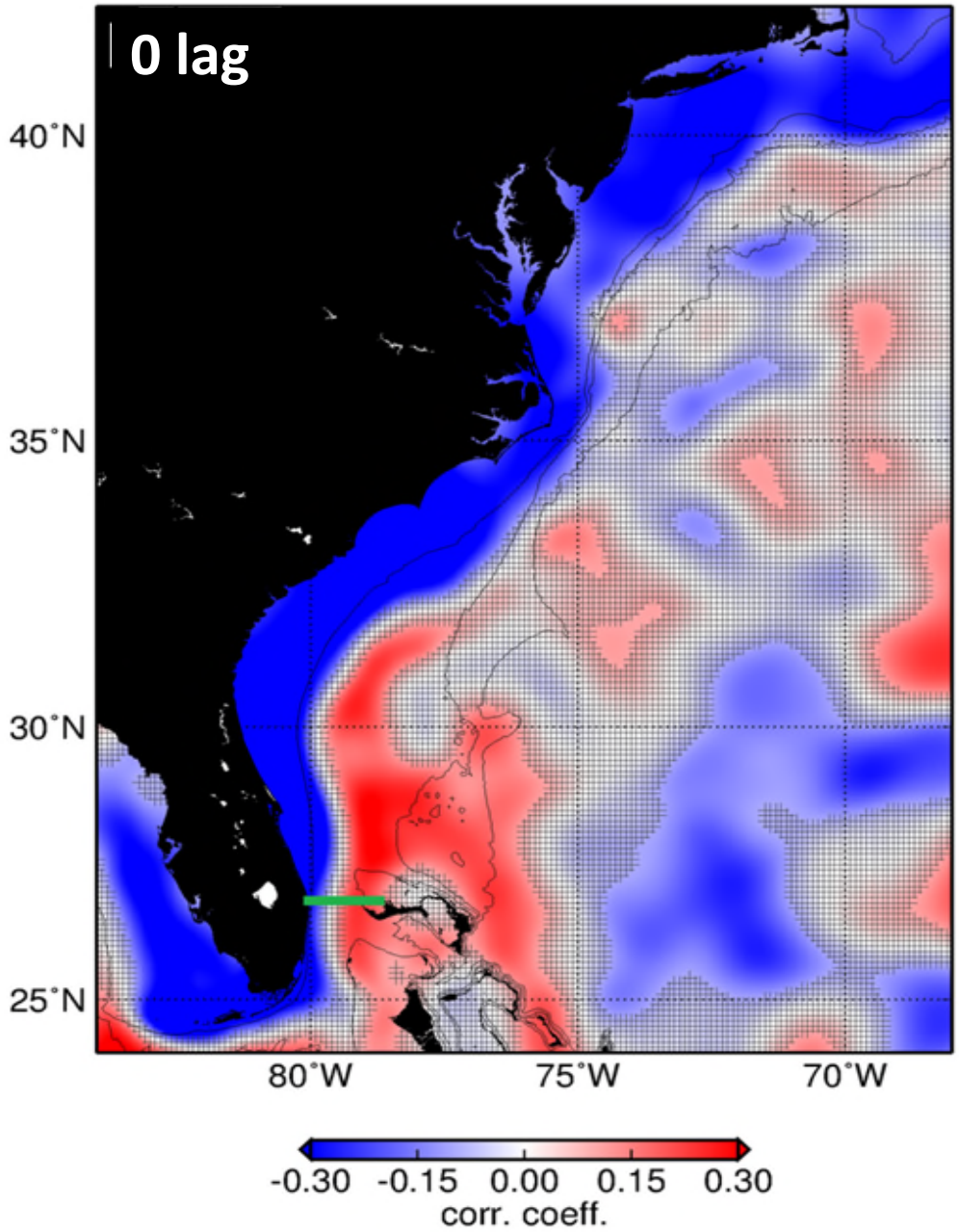
Florida Current and Gulf Stream Effect on Sea Level along east U.S. coast

$\Delta SL_{Ocean\ Currents}$

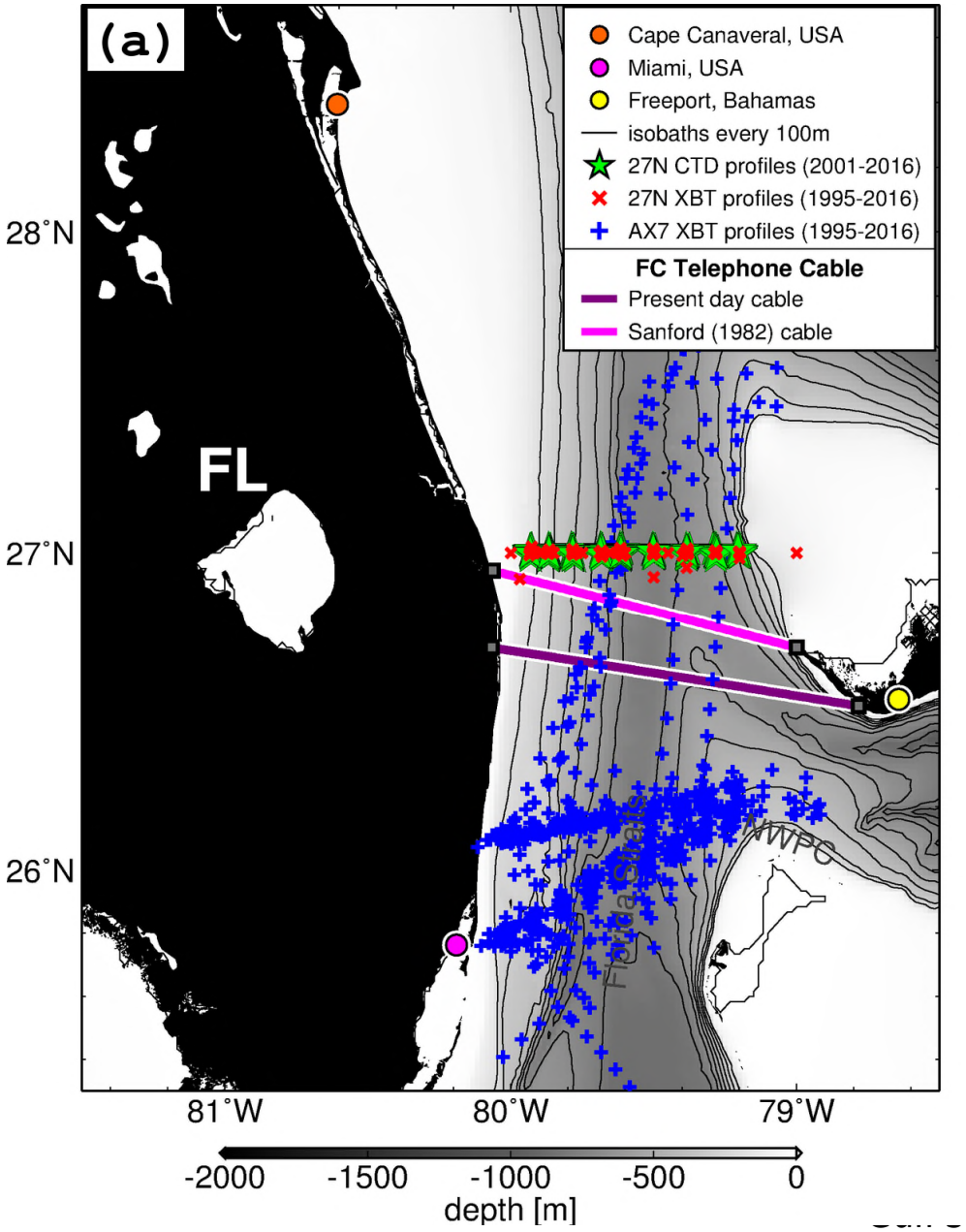
For every 1 Sv decrease in FC transport on seasonal time-scales:

- ✓ **~5 cm increase** in coastal sea-level in most locations between 25N-42N
- ✓ **~10 cm increase** in coastal sea-level in locations at the mid-Atlantic bight (SLR hot spot, Ezer et al., 2012)
- ✓ **5 cm decrease** in coastal sea-level at the Bahamas

1 Sv = 10^6 m^3 s^{-1}



Current efforts by AOML to monitor the Florida Current



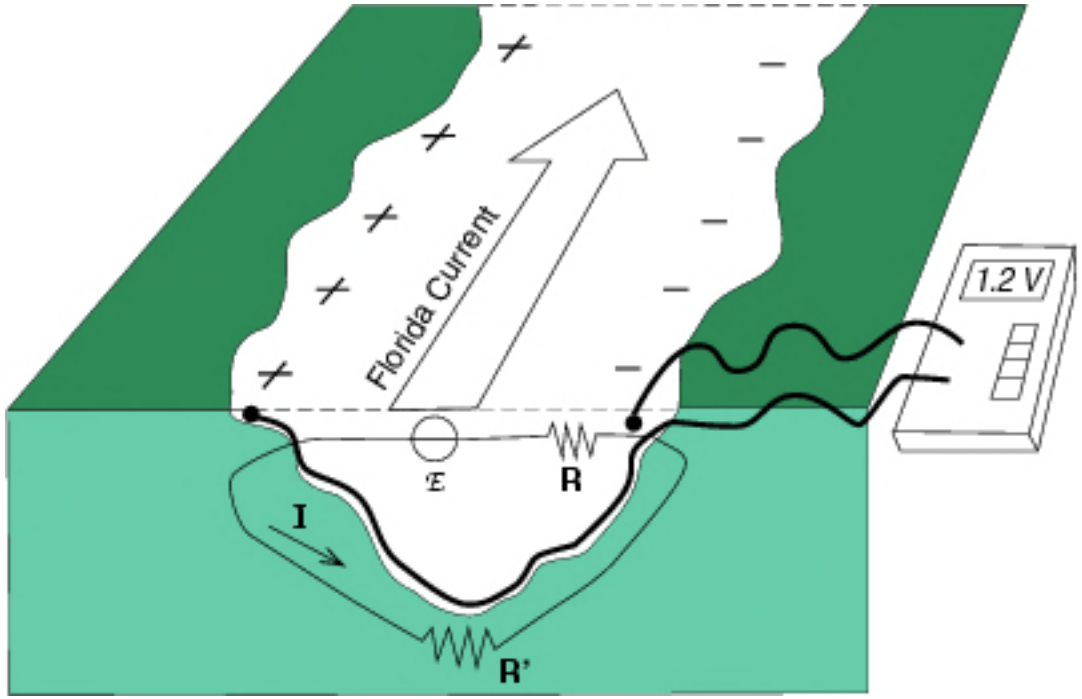
➢ XBT Project

- Approximately 10 XBT transects across the FC per year

➢ Western Boundary Time Series Project

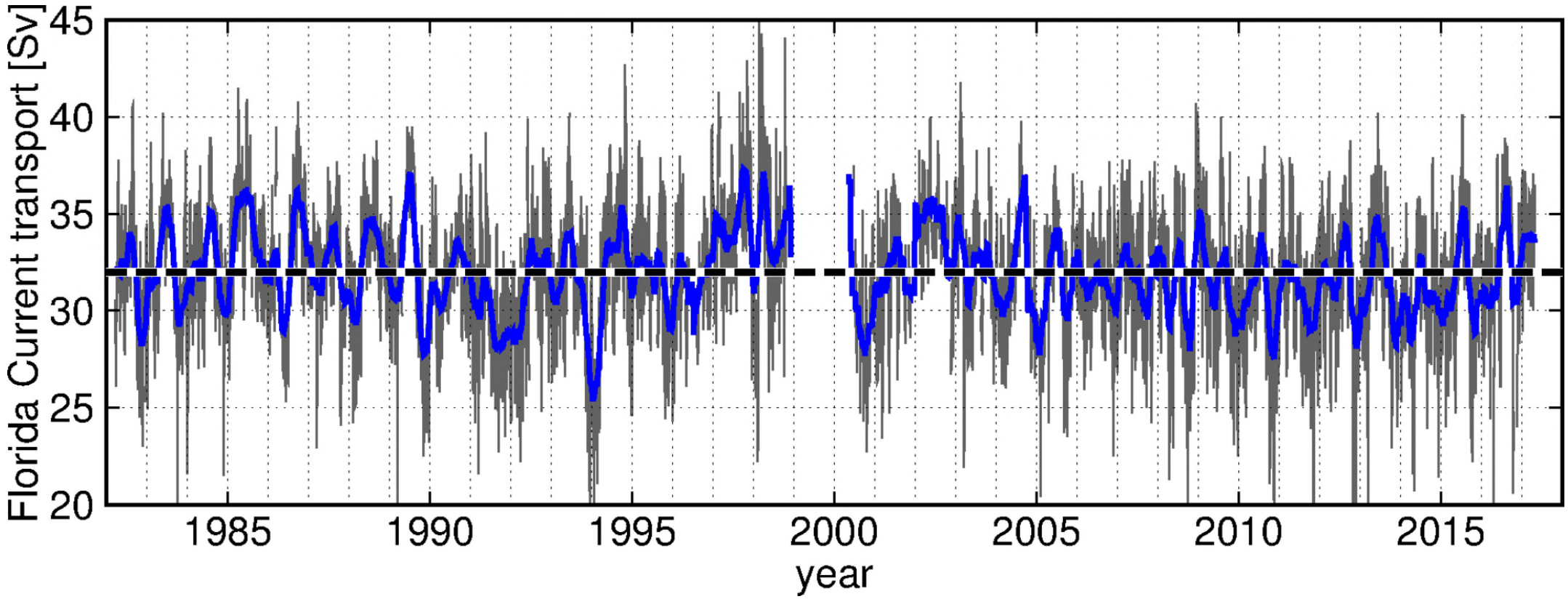
- At least 5 complete hydrographic surveys at 27N aboard the R/V Walton Smith from the University of Miami
- Continuous record of Florida Current flow starting in 1982

Continuous measurements of the Florida Current flow using telephone cables



Continuous measurements of the Florida Current flow using telephone cables

Daily record of the Florida Current flow since 1982



1 Sv = 10^6 m^3 s^{-1}

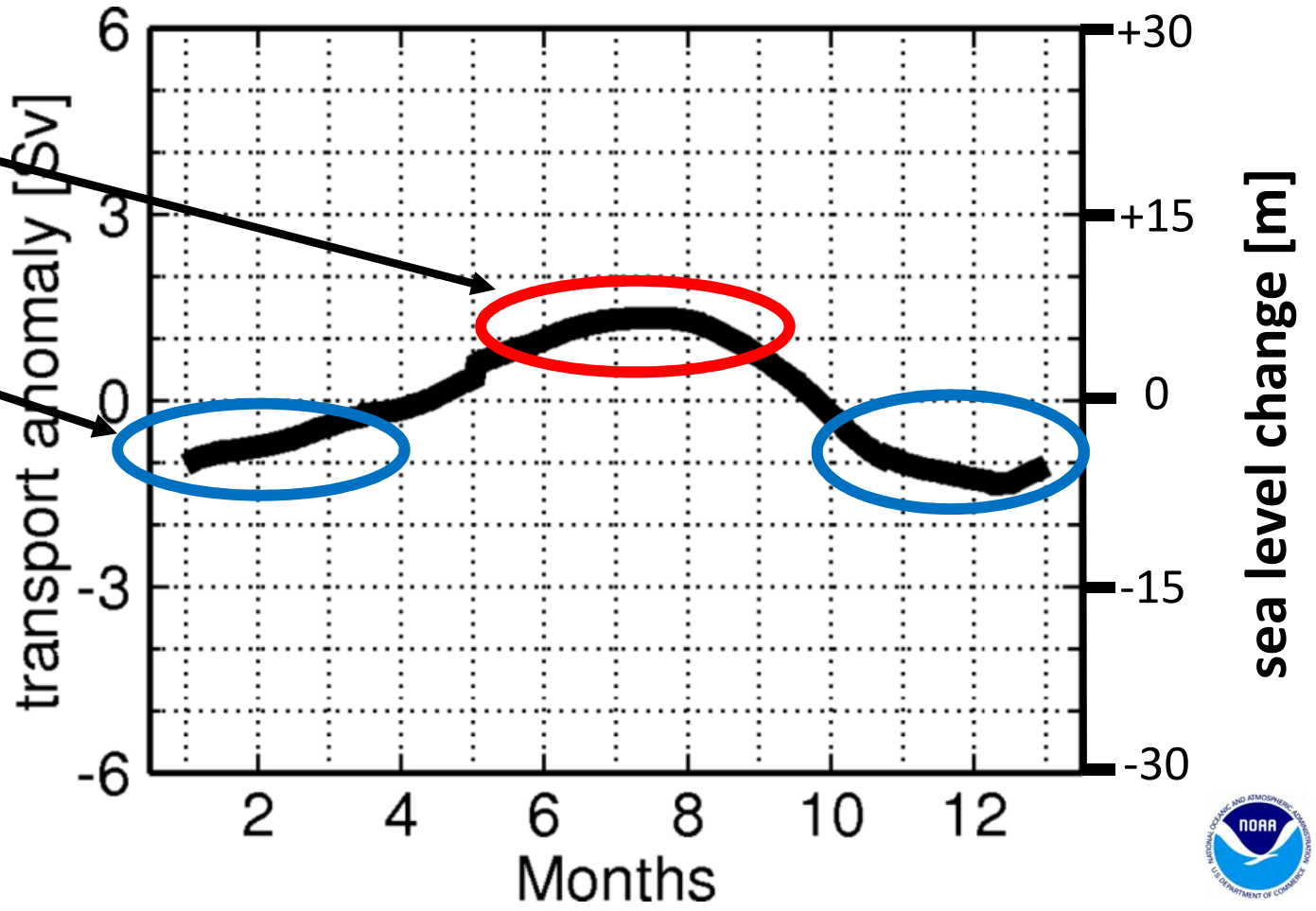
Seasonal changes in Florida Current flow

The FC annual variability

High during late spring to summer

Low during fall to winter

Niiler and Richardson (1973);
Leaman et al. (1987)
Schott et al., (1988)
Baringer and Larsen (2001);
Meinen et al., (2010)



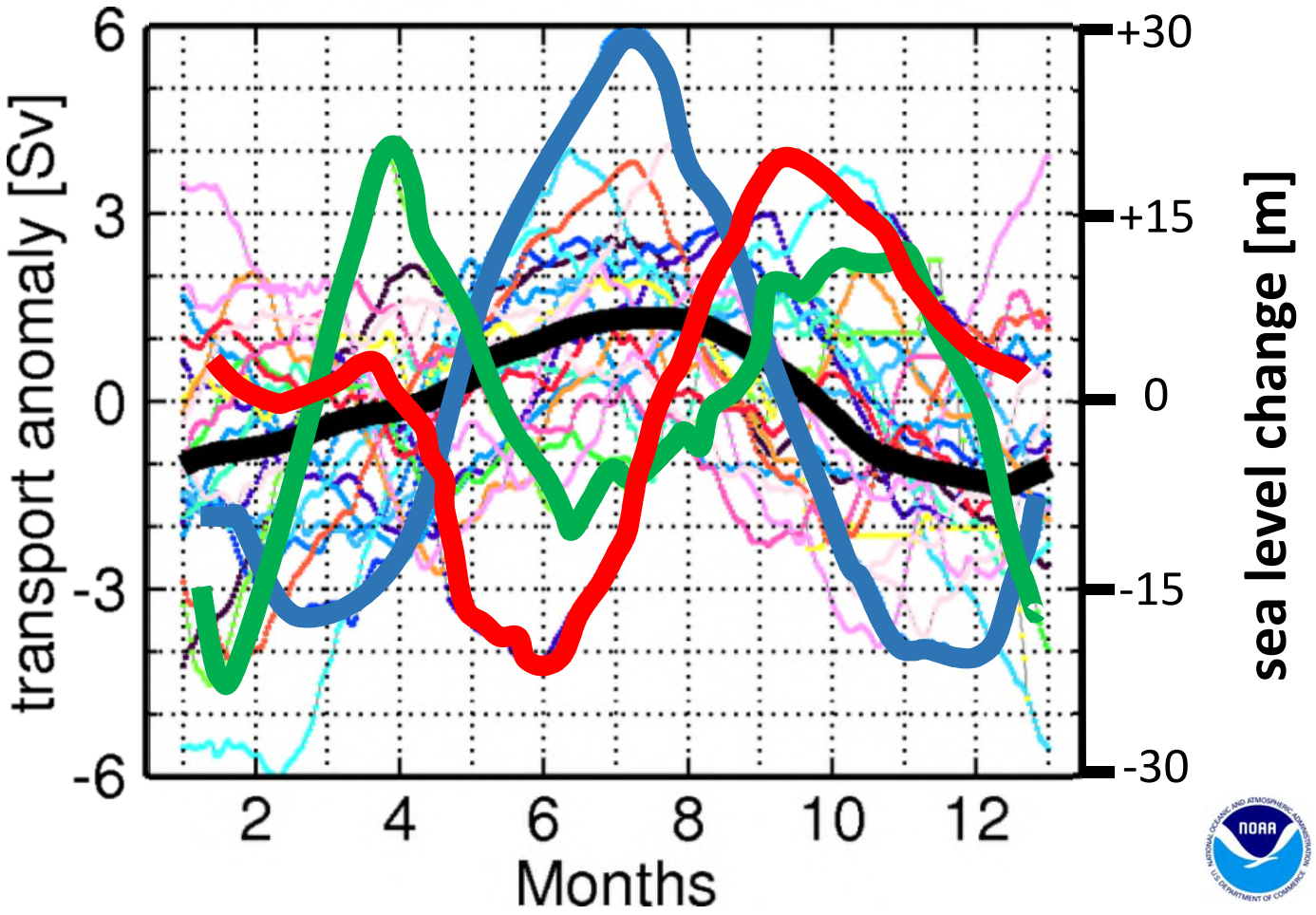
± 5 cm expected sea level change associated with the mean FC annual cycle

Seasonal changes in Florida Current flow

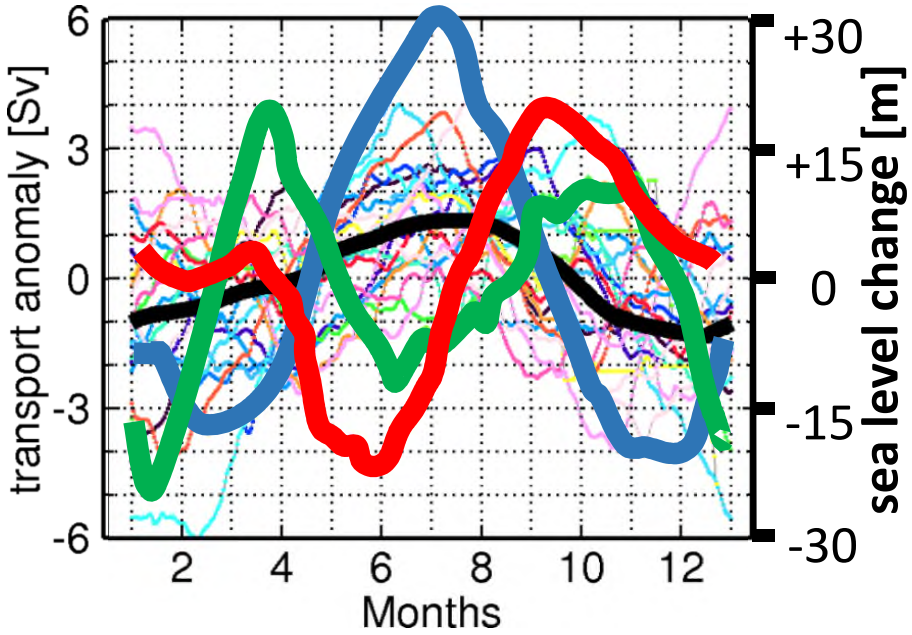
Significant changes in the Florida Current annual variability from one year to the next

± 20 cm sea level changes usually associated with the seasonal FC flow

The FC annual variability



Seasonal changes in Florida Current flow



- **Average annual cycle**

  Along-channel wind stress + Upstream/Downstream wind stress curl (Schott et al., 1988)

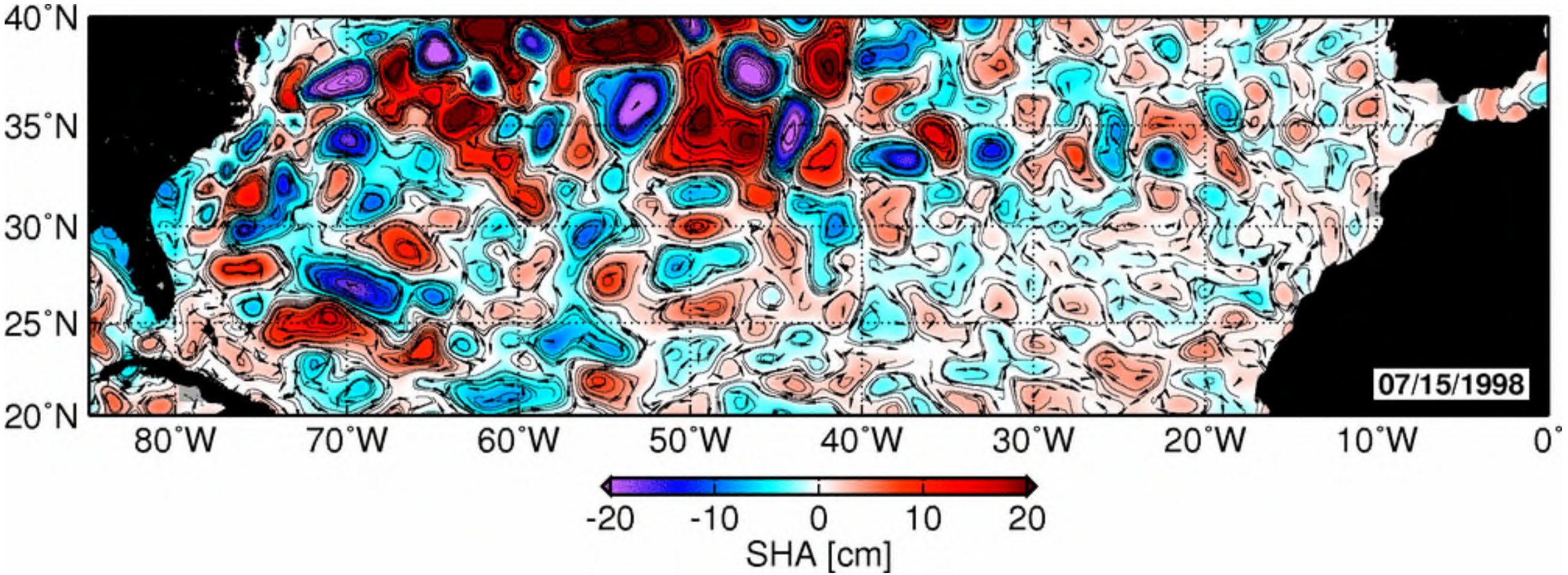
- **Year-to-year changes in the Florida Current seasonality**

  What drives the year-to-year changes in the Florida Current annual variability?

  - Domingues, R., Baringer, M., & Goni, G. (2016). Remote sources for year-to-year changes in the seasonality of the Florida Current transport. Journal of Geophysical Research: Oceans, 121(10), 7547-7559.

Seasonal changes in Florida Current flow

Satellite Altimetry – Westward propagating signals

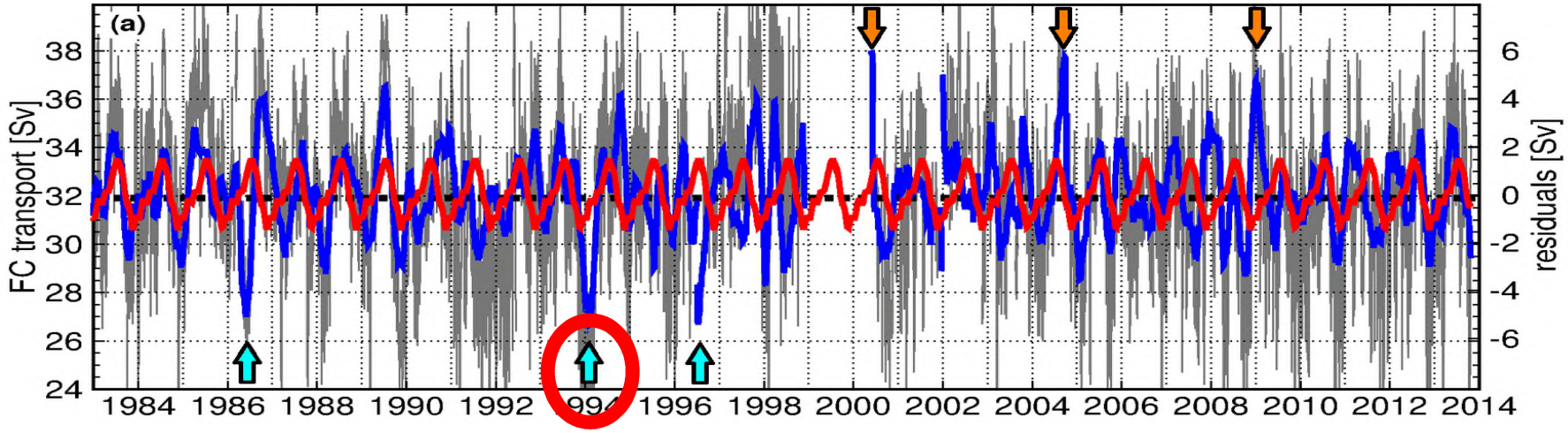


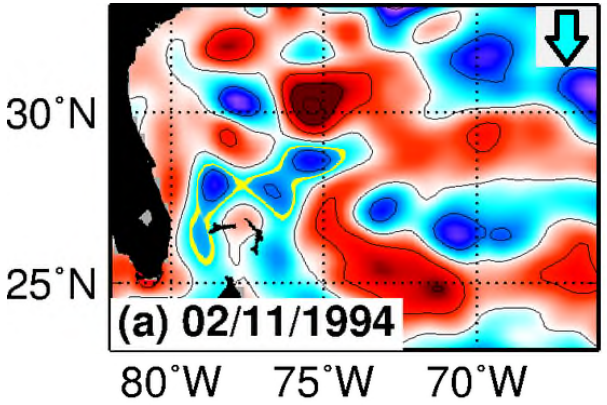
SHA – sea height anomaly measured by satellite altimetry

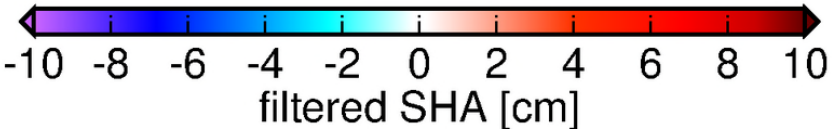
*displayed data is filtered for the 73-525 days band, after removal of average annual cycle

Year-to-year changes in the Florida Current seasonality: links with coastal sea-level changes

Satellite Altimetry vs. Florida Current transport

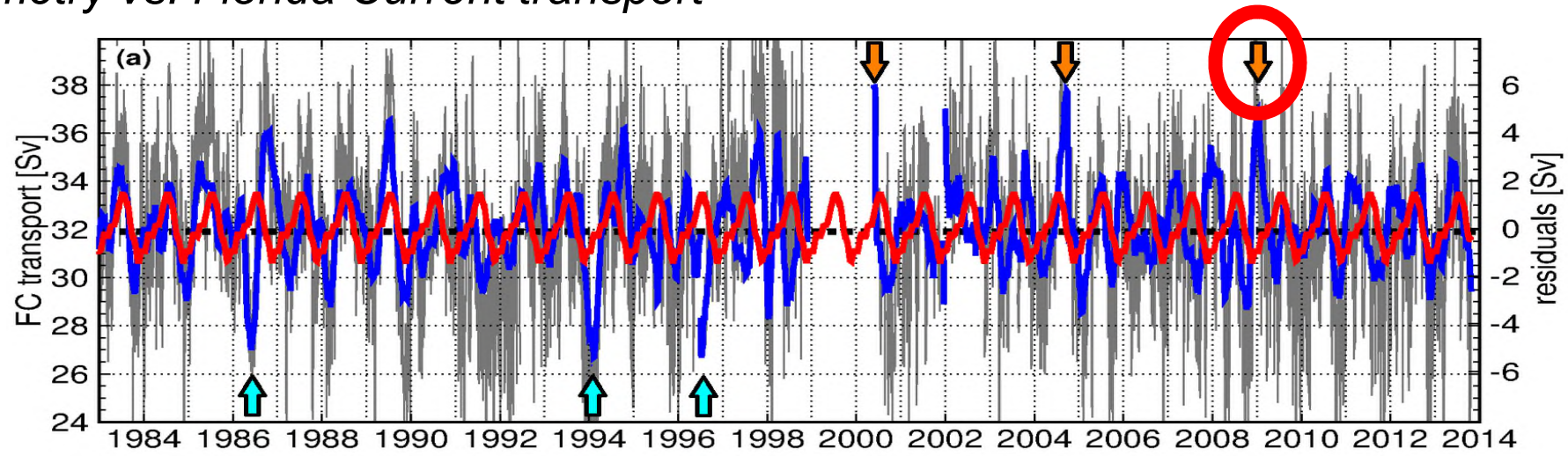


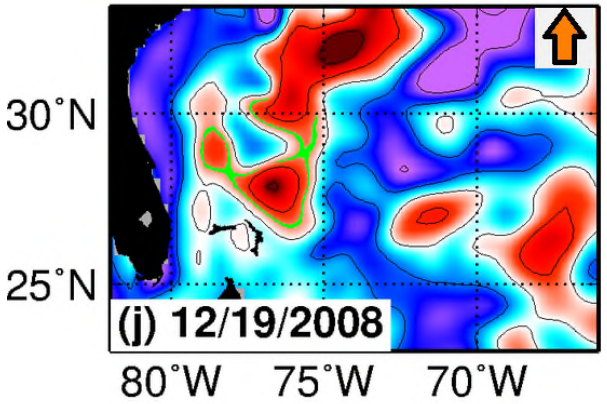


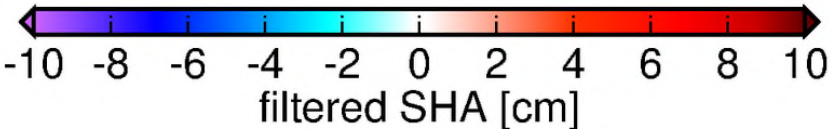


Year-to-year changes in the Florida Current seasonality: links with coastal sea-level changes

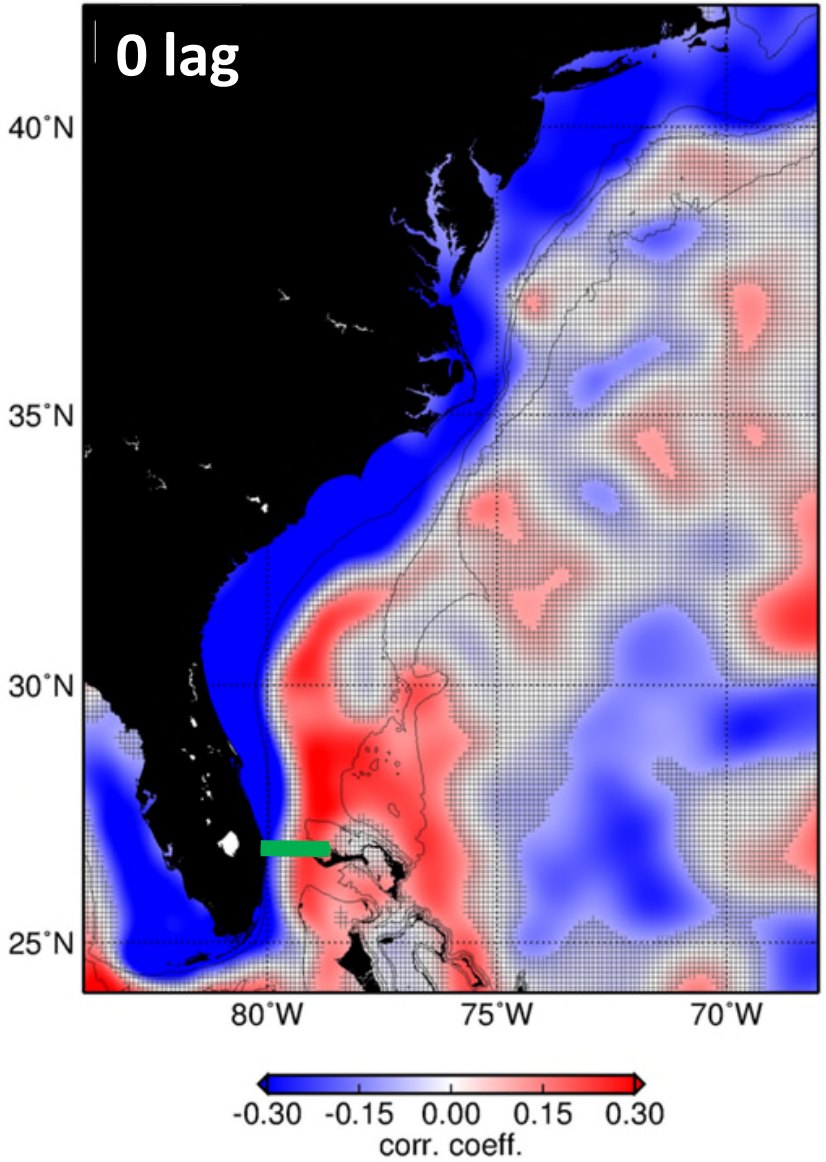
Satellite Altimetry vs. Florida Current transport



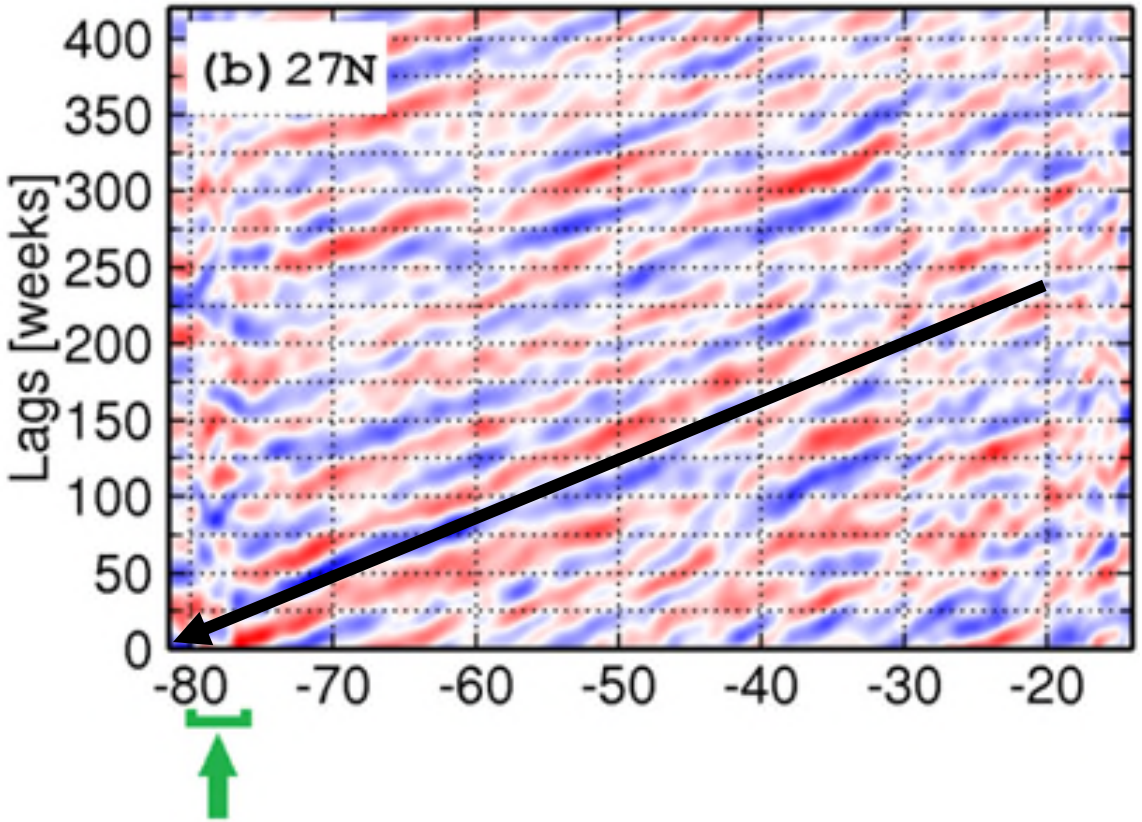




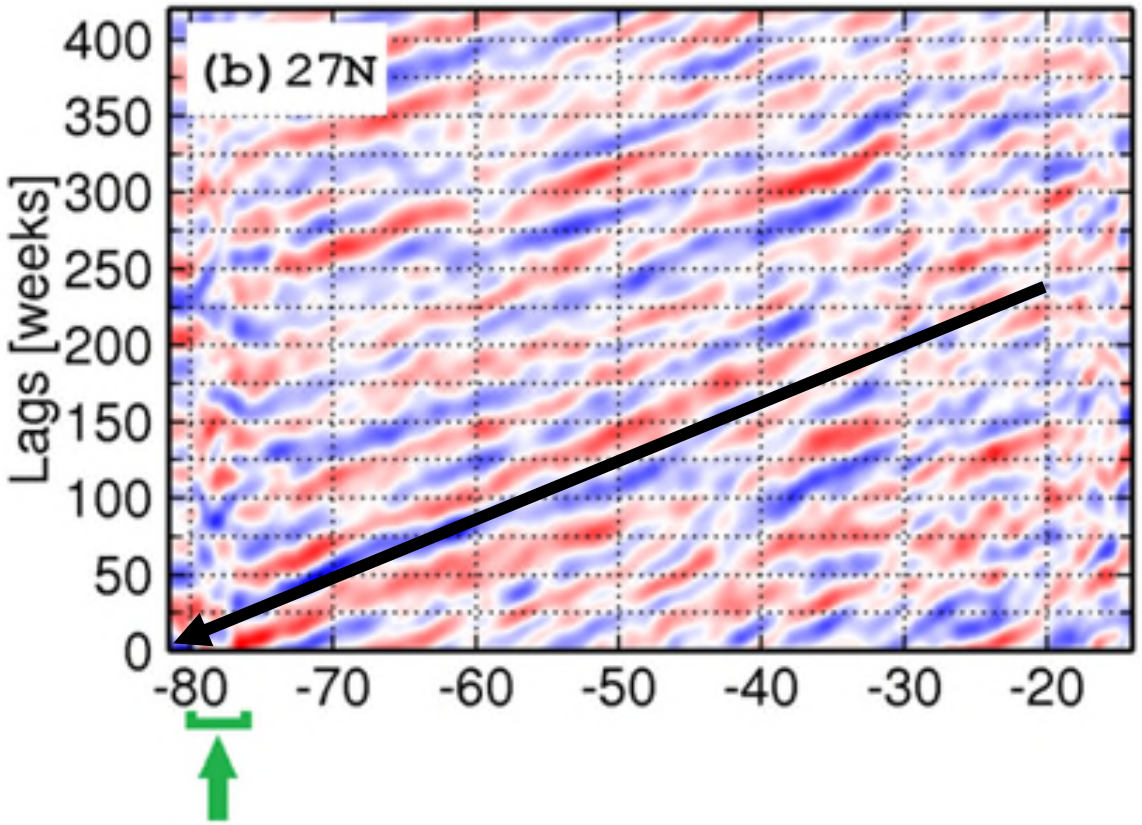
Seasonal changes in Florida Current flow



Lagged correlation between FC transport and SHA data along 27N



Year-to-year changes in the Florida Current seasonality: links with coastal sea-level changes



SHA signals propagate westward at an approximate fixed rate at 27N

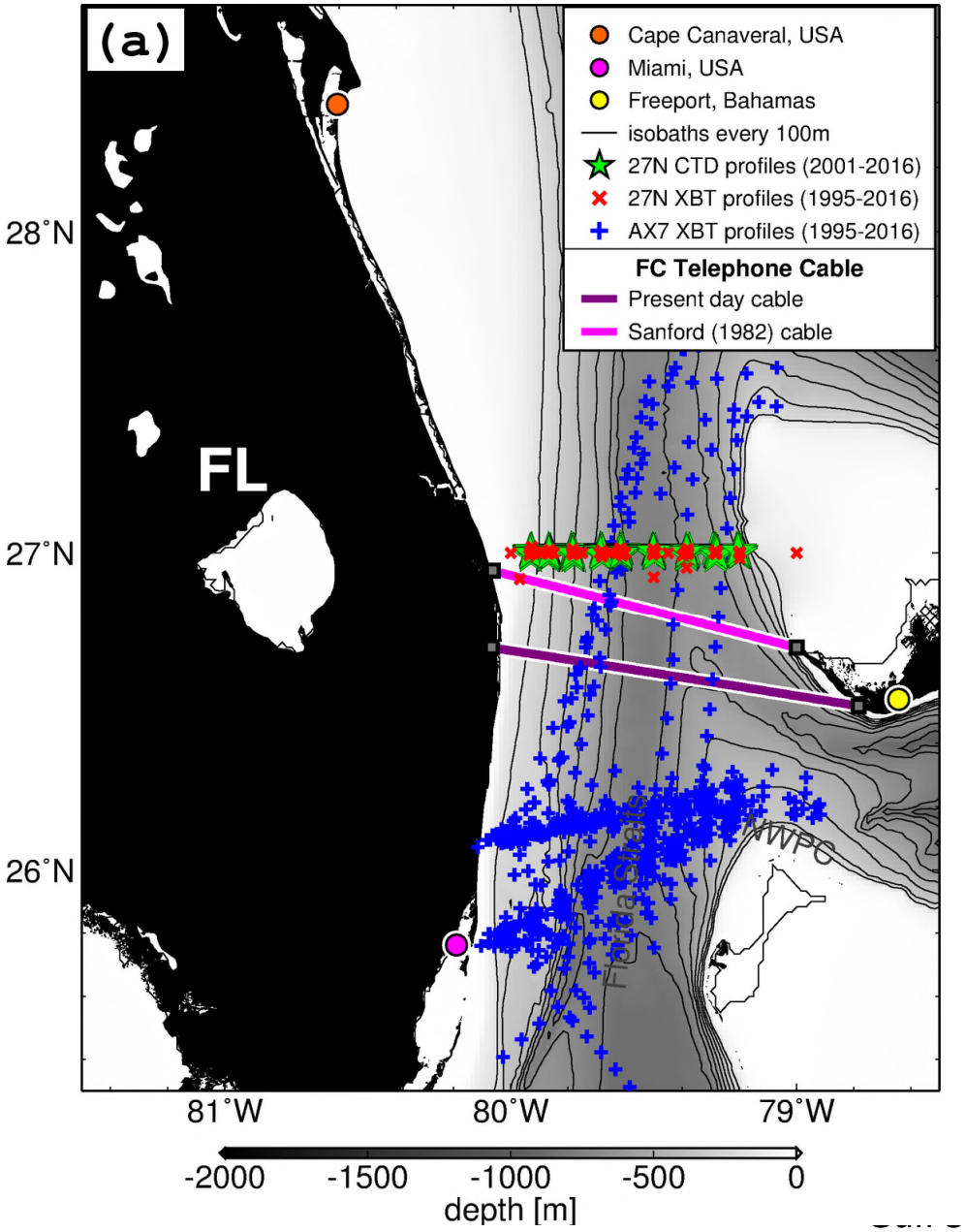
Potential for producing seasonal outlook indicators for the FC transport and for coastal sea-level changes

Reference: Domingues, R., Baringer, M., & Goni, G. (2016). Remote sources for year-to-year changes in the seasonality of the Florida Current transport. *Journal of Geophysical Research: Oceans*, *121*(10), 7547-7559.

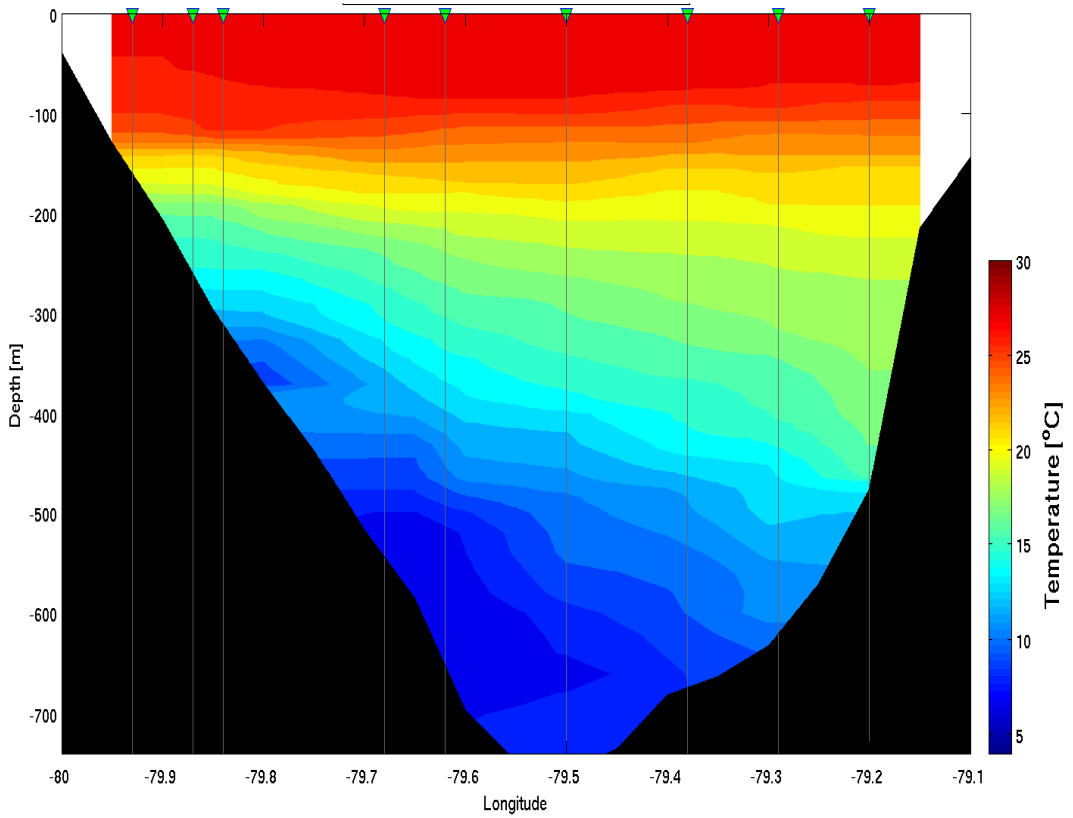
Recent Florida Current warming anomalies: potential links with coastal sea-level signals at the east coast of U.S.

Preliminary results

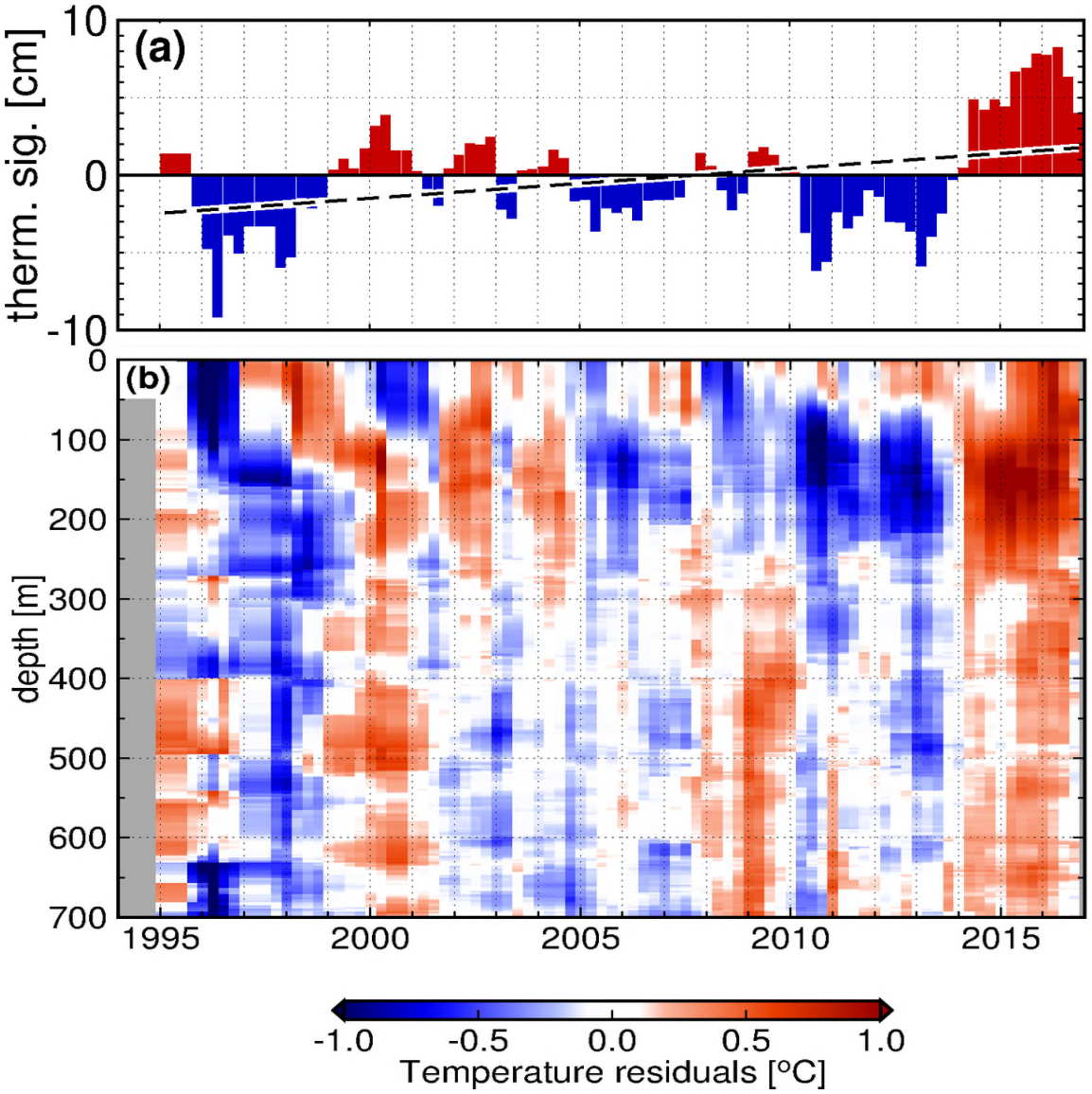
Recent Florida Current warming: potential links with sea-level rise at the east coast of U.S.



Over 250 in situ surveys since 1995



Recent Florida Current warming: potential links with sea-level rise at the east coast of U.S.



Temperature anomalies associated with:

- **Thermosteric height anomalies ranging between:**
  - -10 and 10 cm
  - Trend of 2 cm / decade
- **The 2014-2017 event:**
  - Thermosteric anomalies generally above 5 cm.
  - Peak in late 2015 coincided with
    - Low FC transport
    - Coastal flooding events during late September 2015

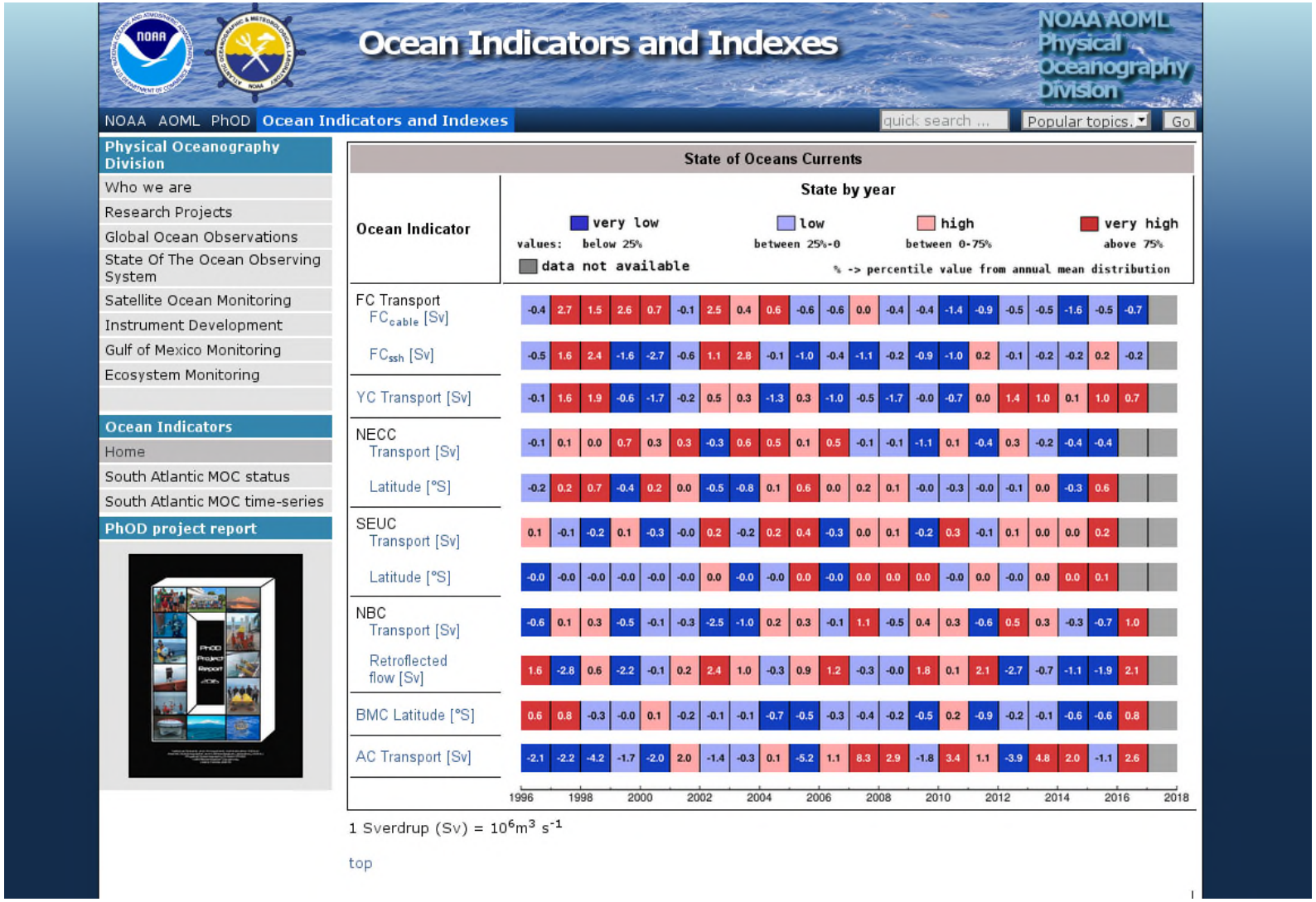
    Sweet et al., (2016)

FC warming and transport changes likely contribute and independently to coastal sea-level variability

Domingues et al., (in preparation). Recent changes in sea level along the Eastern U.S. coast: potential links with the Florida Current flow and heat content.

AOML Ocean Indicators Webpage

www.aoml.noaa.gov/phod/indexes



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