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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AOML contribution to the Global Ocean Observing System

The Global Drifter Program

Argo Project

The XBT Network

WBTS Project

PIRATA

Underwater Gliders

Improve the understanding on the role that the ocean plays on climate, extreme weather events, ecosystems, and sea-level changes
The Arctic is melting and guess who faces more flooding — that’s right, South Florida.

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

\[ \text{Obs. SL} = \overline{SL} + \Delta SL_{\text{tides}} + \Delta SL_{\text{waves}} + \Delta SL_{\text{weather}} + \Delta SL_{\text{land}} + \Delta SL_{\text{GL}} + \Delta SL_{\text{Ocean Currents}} \]

- \( \overline{SL} \) mean sea level
- \( \Delta SL_{\text{tides}} \) effect of astronomical tides
- \( \Delta SL_{\text{waves}} \) local effect of waves
- \( \Delta SL_{\text{weather}} \) effect of local winds and atm. pressure changes
- \( \Delta SL_{\text{land}} \) effect of land subsidence
- \( \Delta SL_{\text{GL}} \) effect of global changes in ocean mass and density
- \( \Delta SL_{\text{Ocean Currents}} \) effect of Ocean Currents in sea level changes
Florida Current and Gulf Stream Effect on Sea Level along east U.S. coast

$\Delta S_L$ Ocean Currents

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

ΔSL<sub>Ocean Currents</sub>

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.

Mean Florida Current flow

FL - Florida
BHS - Bahamas

Mean sea level
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

**Intense Florida Current flow**
- Decrease in sea level at Florida
- Increase sea level at the Bahamas
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.

**Weak Florida Current flow**

- Increase in sea level at Florida
- Decrease in sea level at the Bahamas
Observed Florida Current changes and potential links with coastal sea-level

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

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

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

\[ \Delta S L_{\text{Ocean Currents}} \]

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

$1 \text{ Sv} = 10^6 \text{ m}^3 \text{ s}^{-1}$
Seasonal changes in Florida Current flow

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
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?

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

![Graph and map showing year-to-year changes in the Florida Current seasonality and links with coastal sea-level changes.](image)
Year-to-year changes in the Florida Current seasonality: links with coastal sea-level changes

Satellite Altimetry vs. Florida Current transport

![Graph showing satellite altimetry vs. Florida Current transport](image)

![Map showing filtered SHA at 30°N and 25°N](image)
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

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.
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