S.E. Atlantic Tidal Flood Factors: Sea Level Rise and Gulf Stream Effects

Effects of Gulf Stream Variations on Sea Levels along the Eastern Coast
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1. SLR increases perennial inundation
   • difficult to sense “mean” changes
     ... tides and storms dominate

2. Exacerbates extreme probabilities
   • obscured by rarity of events

3. Exacerbates high-tide flooding
   • more intuitive indicator of climate change-related SLR
Global Sea Level Rise (SLR)

NOAA Altimeter & Interagency Global Sea Level Rise Scenarios (Sweet et al., 2017)

- Low
- Int. Low
- Int
- Int High
- High
- Extreme
  - Topex
  - Jason-1
  - Jason-2
Regional-Local Relative Sea Level Rise

\[ \Delta \text{Relative Sea Level (RSL)} = \Delta \text{GMSL} + \Delta \text{RSL}_{\text{climatic}} + \Delta \text{RSL}_{\text{non-climatic}} \]

Virginia Key Sea Level and Future Scenarios
(Sweet et al., 2017)
Regional-Local Relative Sea Level Rise

Thermal Expansion and Oceanographic Effects in Intermediate (1 m) Scenario

$m = \Delta GMSL + \Delta RSL$
Gulf Stream (measured by AOML Undersea Cable)
Induced Changes in Sea Level

Adapted from Sweet et al. (2009)
South Florida Tidal Flood Probabilities

Location (time)
(SLR, Gulf Stream)

Sep 2015
~0.6 m Flood

Local Water Level Height

Probability of Occurrence
(e.g., daily highest tide in a year)

Slowing GS trans.
**South Florida Tidal Flood Probabilities** (Sweet et al., 2016)

Monthly Maximum WL (m, MHHW)

\[ y = -0.02x + 0.68 \]

\[ R^2 = 0.18 \]

- 0.2
- 0
  0.2
  0.4
  0.6
  0.8

15  20  25  30  35

Monthly Minimum FC Transport (Sv)

Sep-Nov

- Nuisance Flooding
- Gordon, Irene, Wilma, Rita, Sandy
Time dependent probabilities are quantified:

- with monthly highest water levels
- using a generalized extreme value (GEV) distribution
- Assessing co-variability w/ Florida Current monthly min. transport
- parameters \((\mu, \psi, \xi)\) estimated using maximum likelihood method

GEV cumulative distribution for a level \((z)\) is described by a \textbf{location} \((\mu)\), \textbf{scale} \((\psi)\) and \textbf{shape} \((\xi)\) parameter:

\[
F(z) = \exp \left\{ -\left[ 1 + \xi (z - \mu(t)/\psi) \right]^{-1/\xi} \right\}
\]

\[
\mu(t) = \beta_0 + \mu_{\text{Seasonal}}(t) + \mu_{\text{Nodal}}(t) + \beta_{\text{trend}}(t) + \beta_{\text{Gulf Stream}}(t)
\]
South Florida Tidal Flood Probabilities

(September) Exceedance Probability Curve for Miami

Location Parameter

Sep 2015 Event (~0.6 m)
Time Dependencies Affecting Tidal Flooding
Gulf Stream Effect: 0.9 cm water level increase in monthly max water level per 1 Sv decline (total collapse~0.3 m)

During a September, if Gulf Stream at higher transport, 30-year event (350% change) instead of 6-yr event

Trend (~SLR) in monthly max of about 11 cm since 1994: 40-yr event in 1994 (500% increase).

- Trend in Gulf Stream location parameter: 2.1 cm

Sea level rise scenarios (e.g., Sweet et al., 2017) capture AMOC slowdown, but magnitude is much higher north of Cape Hatteras. Variability south of Hatteras is apparent in high-tide flooding probabilities.

Under Intermediate Scenario, 0.6 m flood ‘event’ will occur 10+ times per year within about 30 years.