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

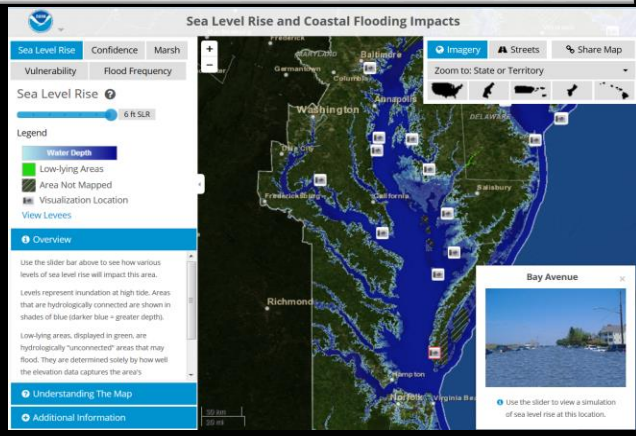



Effects of Gulf Stream Variations on Sea Levels along the Eastern Coast
Florida Atlantic University's Center for Environmental Studies
May 9, 2017

William Sweet
NOAA CO-OPS Oceanographer

The Problem: Sea Level Rise (SLR) High Tide Flooding

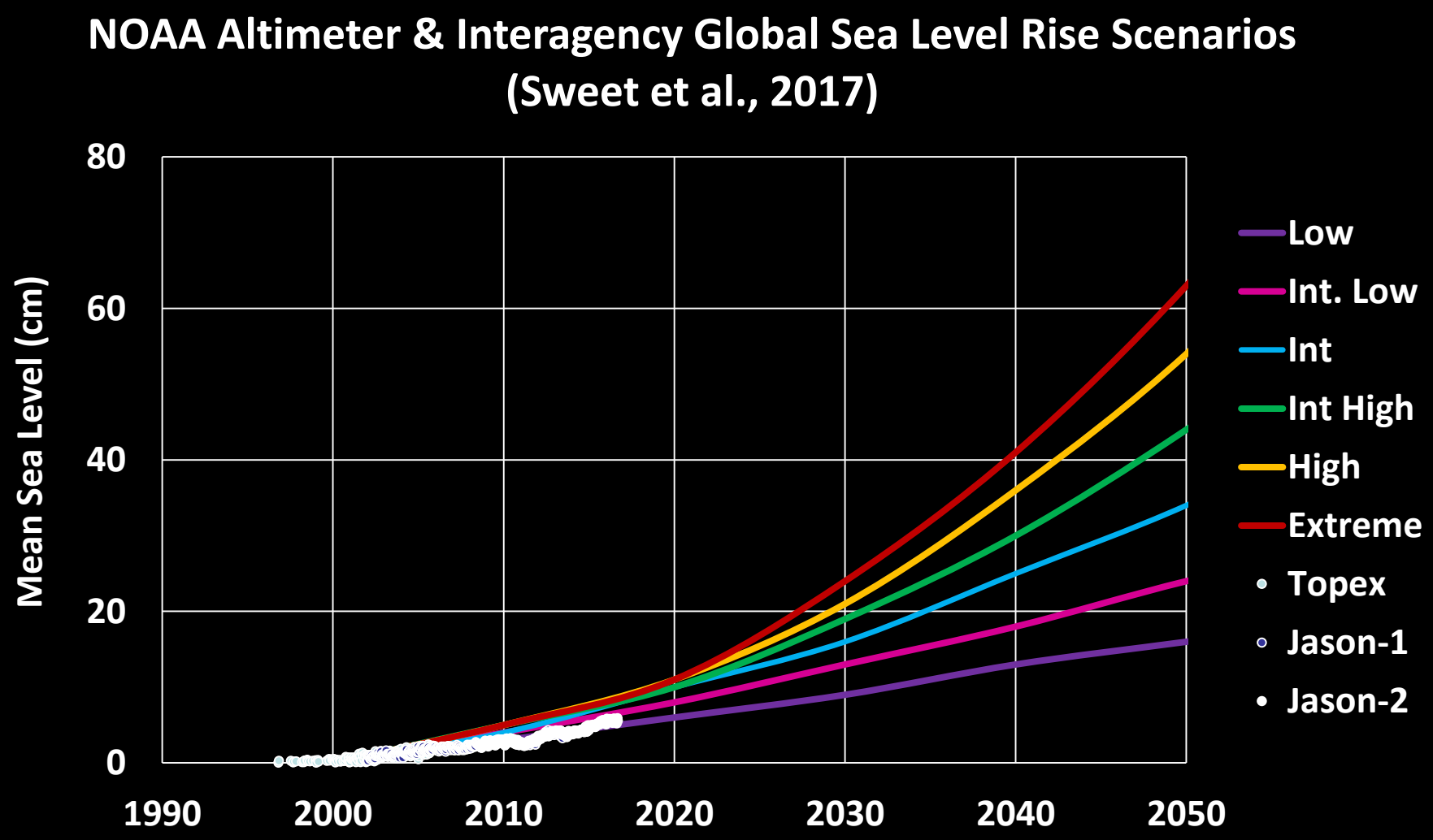
1. SLR increases perennial inundation
   - difficult to sense "mean" changes … tides and storms dominate



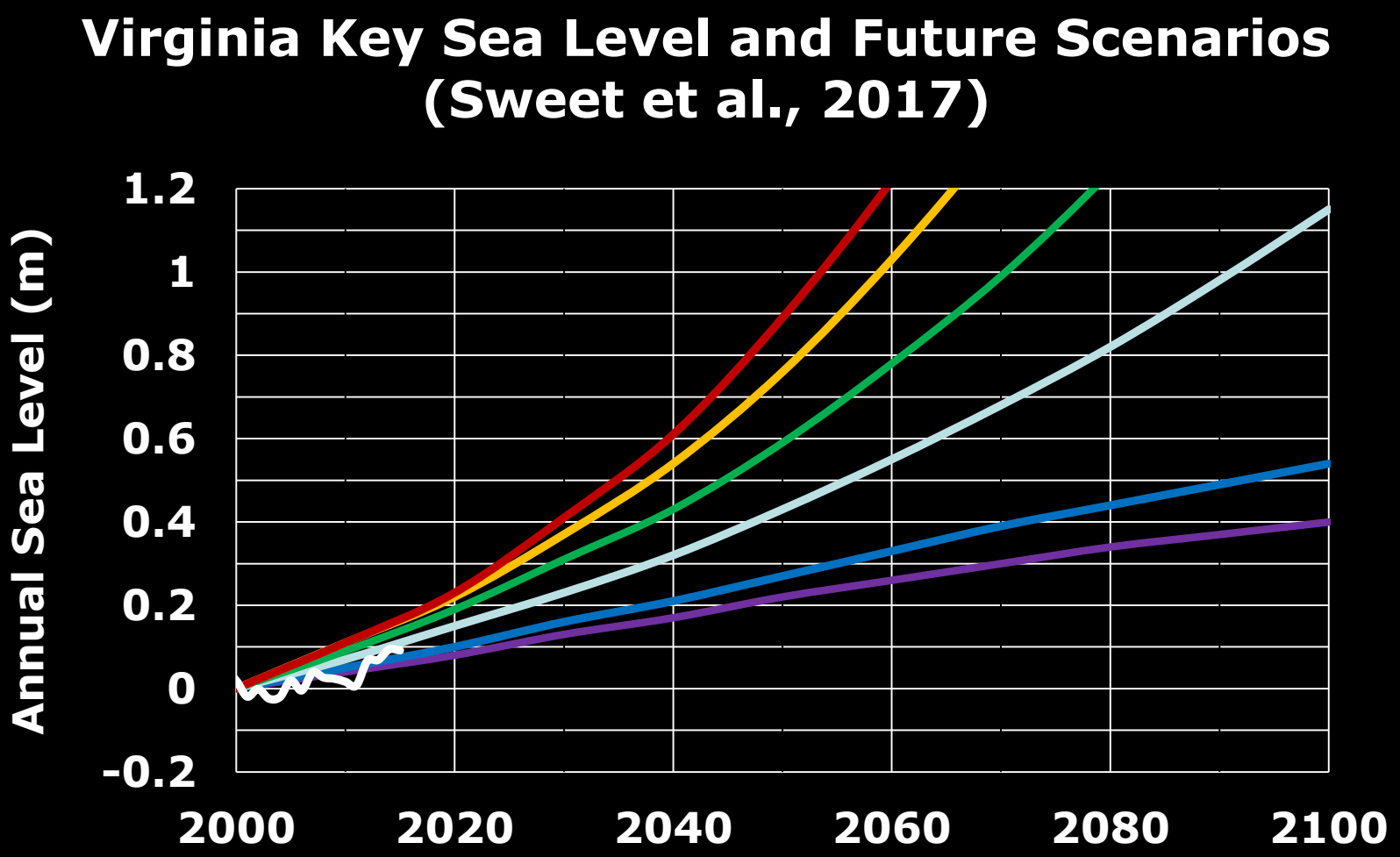
2. Exacerbates extreme probabilities
   - obscured by rarity of events

3. Exacerbates high-tide flooding
   - more intuitive indicator of climate change-related SLR

Global Sea Level Rise (SLR)



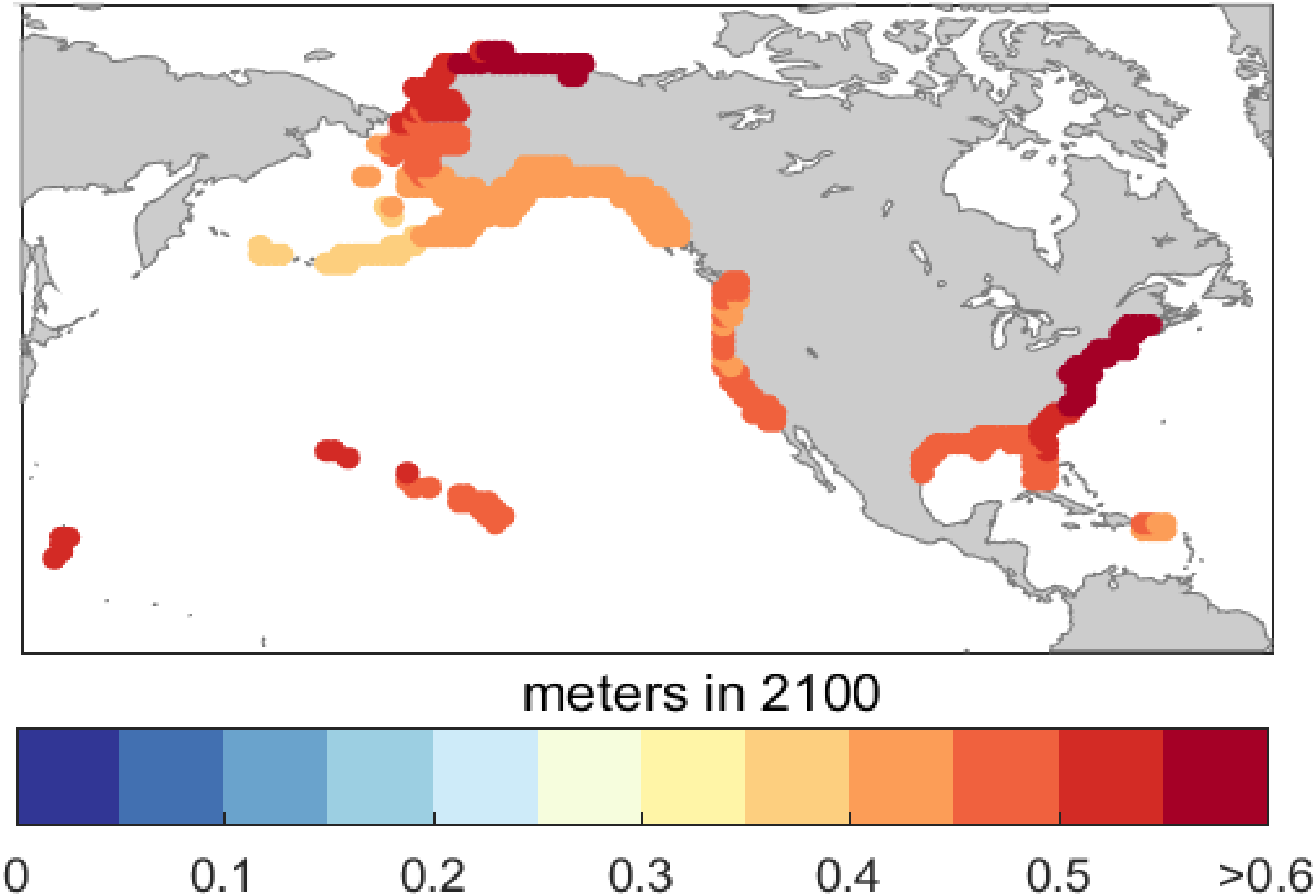
Regional-Local Relative Sea Level Rise



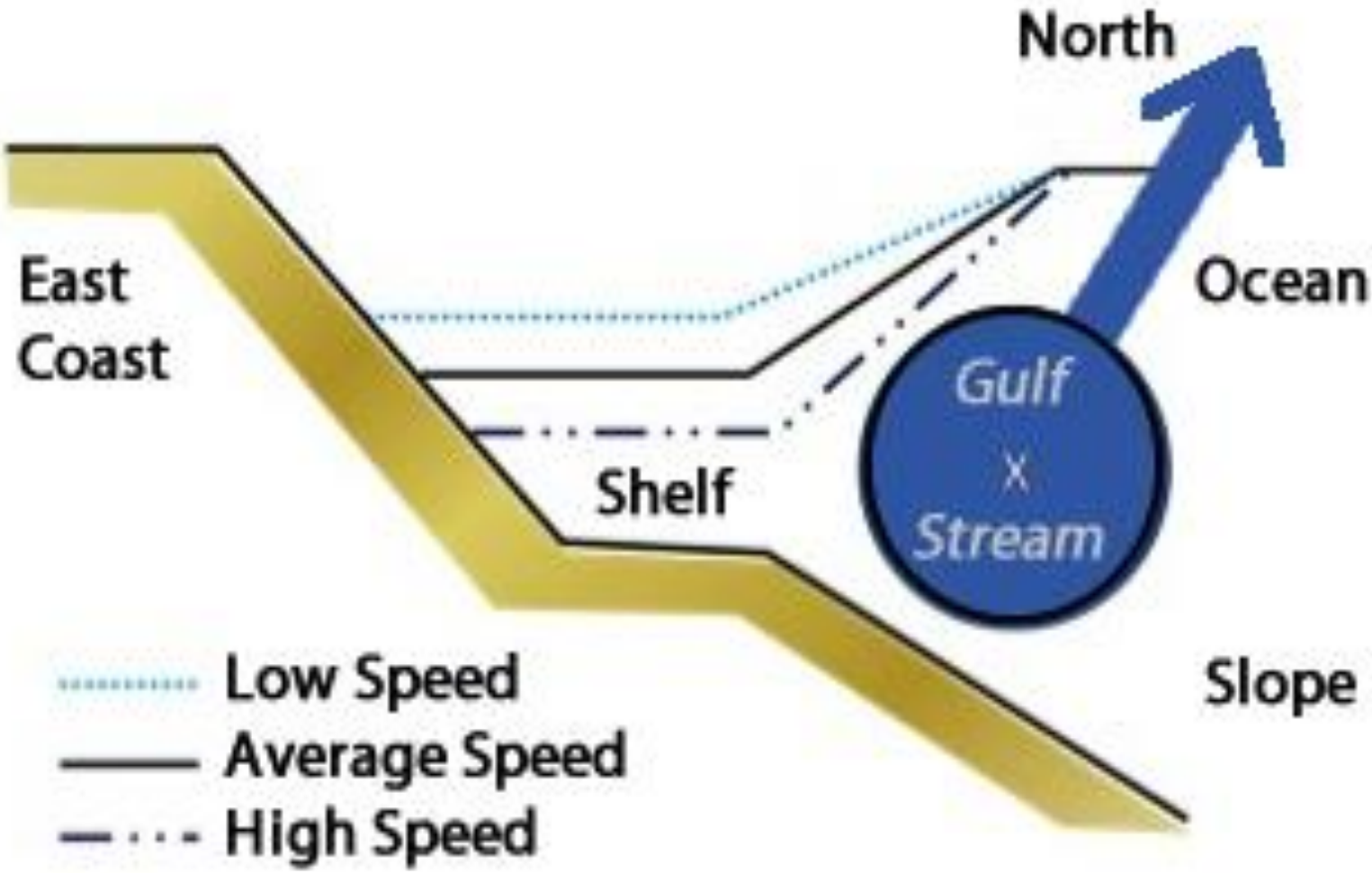
$$\Delta \text{ Relative Sea Level (RSL)} = \Delta\text{GMSL} + \Delta\text{RSL}_{\text{climatic}} + \Delta\text{RSL}_{\text{non-climatic}}$$

Regional-Local Relative Sea Level Rise

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

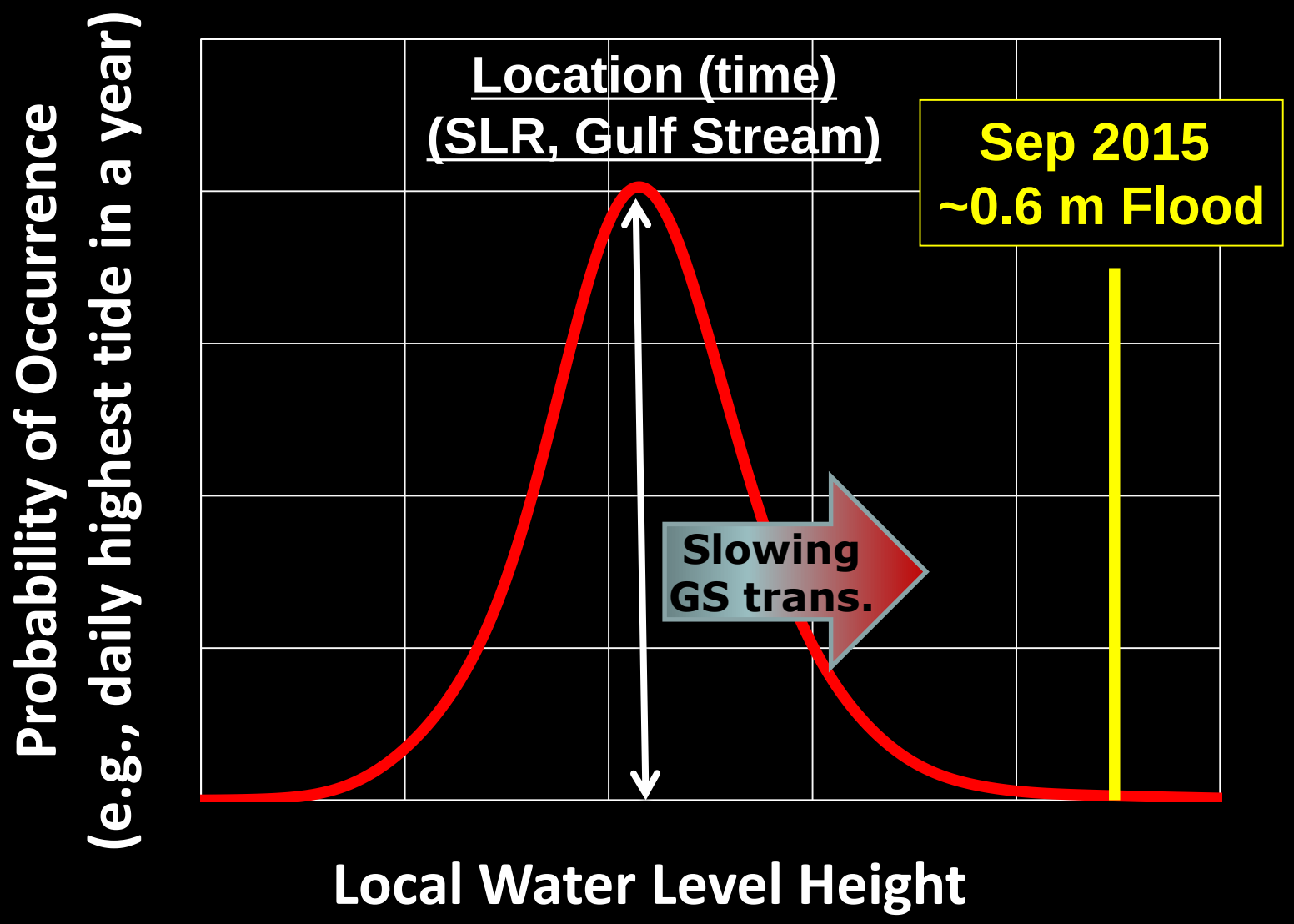


Gulf Stream (measured by AOML Undersea Cable) Induced Changes in Sea Level

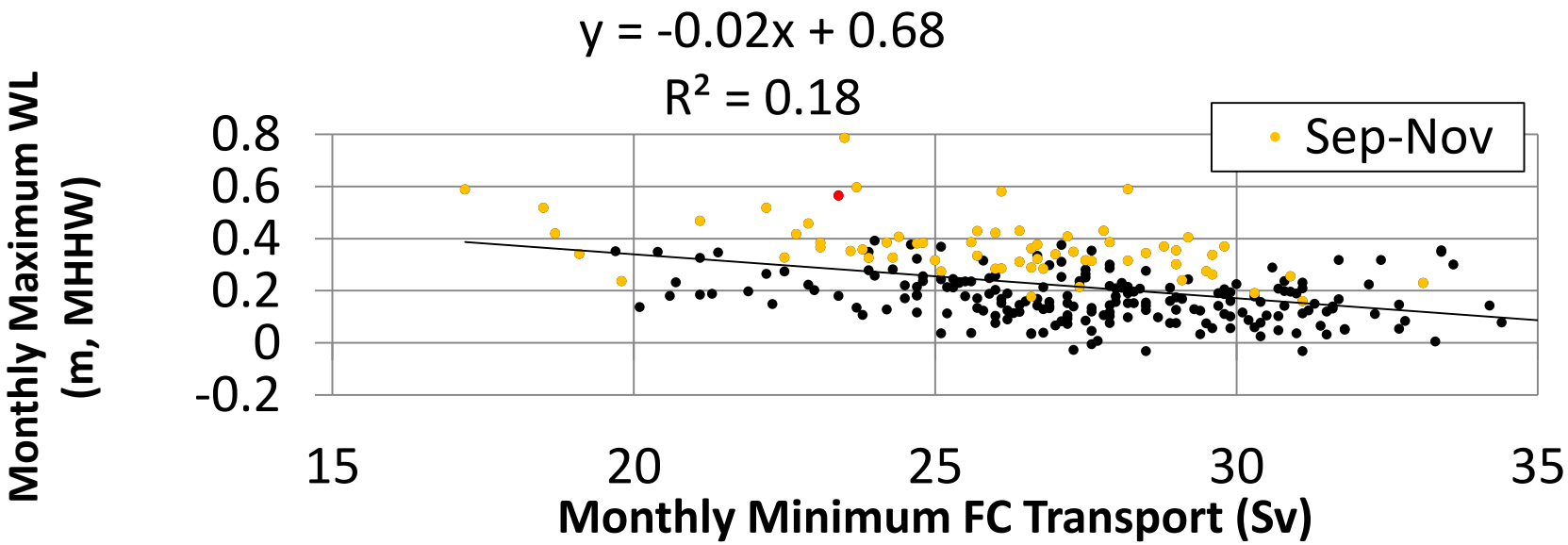


Adapted from Sweet et al. (2009)

South Florida Tidal Flood Probabilities



South Florida Tidal Flood Probabilities (Sweet et al., 2016)



Vol. 97, No. 12, December 2016

South Florida Tidal Flood Probabilities

Time dependent probabilities are quantified:

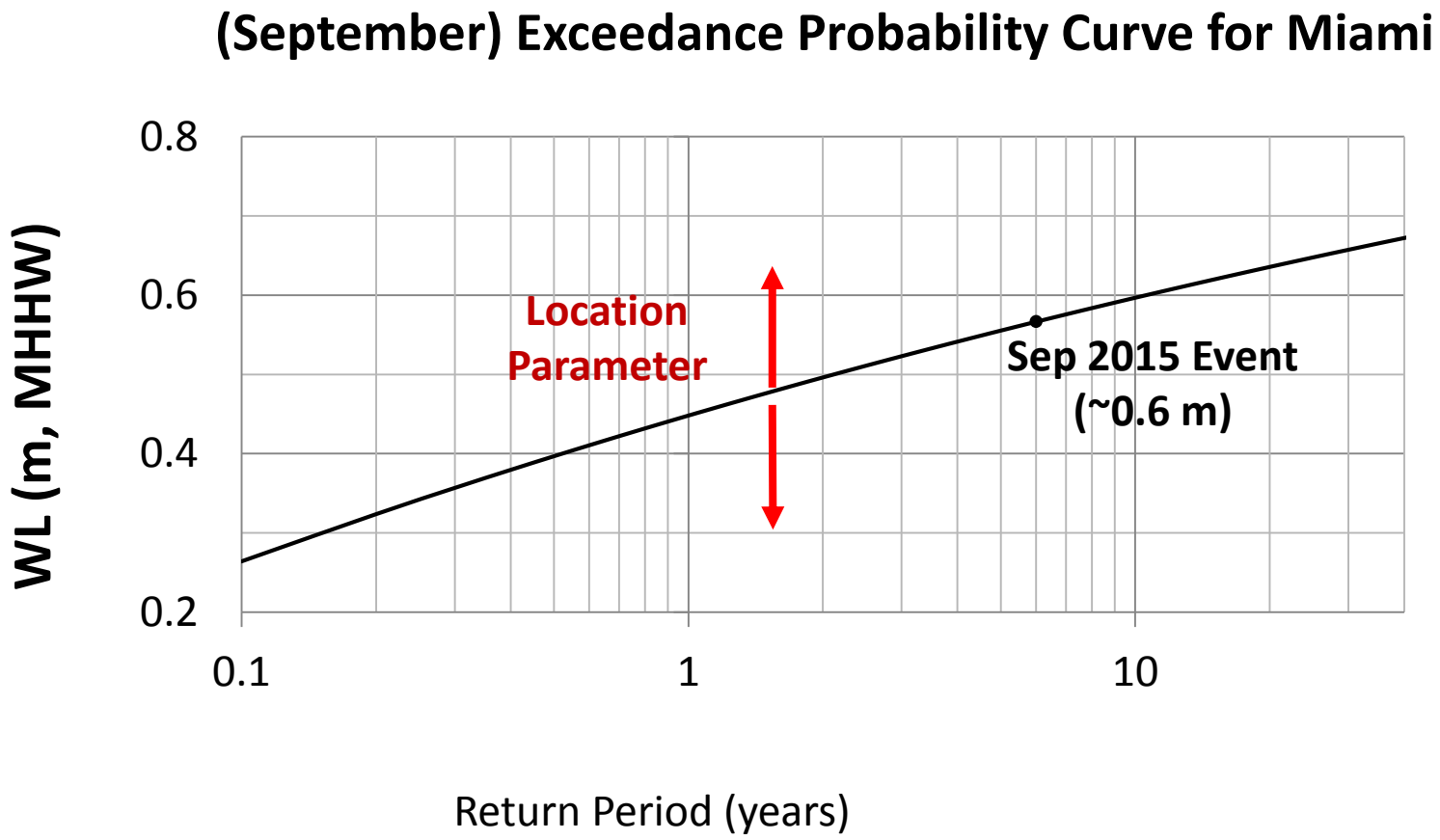
- with monthly highest water levels
- using a generalized extreme value (GEV) distribution
- Assessing co-variability w/ Florida Current monthly min. transport
- parameters (μ, ψ, ξ) estimated using maximum likelihood method

GEV cumulative distribution for a level (z) is described by a location (μ), scale (ψ) and shape (ξ) parameter:

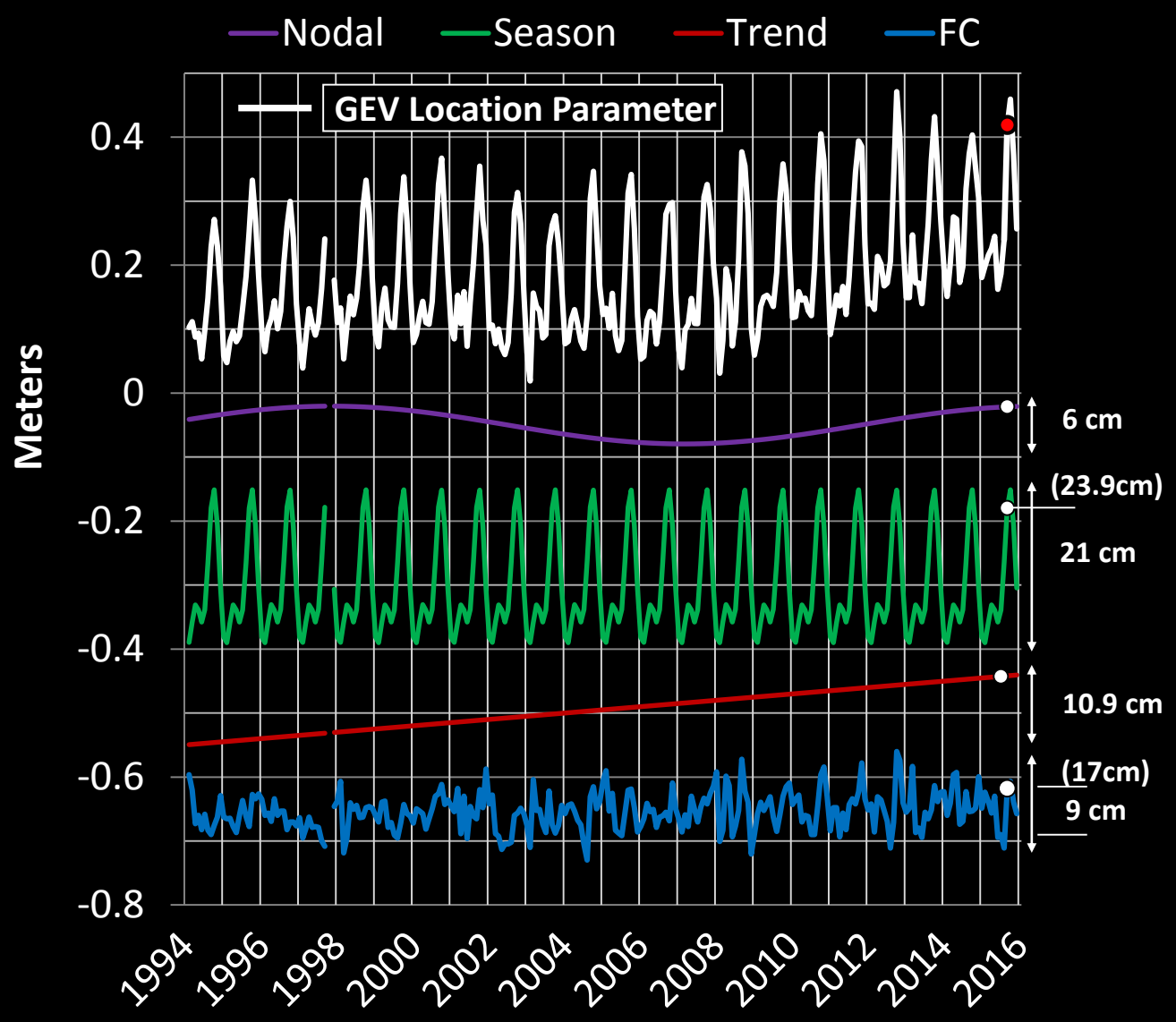
$$\mathbf{F(z) = \exp\left\{-[1 + \xi(z - \mu(t)/\psi)]^{-1/\xi}\right\}}$$

$$\mu(t) = \beta_0 + \mu_{Seasonal}(t) + \mu_{Nodal}(t) + \beta_{trend}(t) + \beta_{Gulf\ Stream}(t)$$

South Florida Tidal Flood Probabilities



Time Dependencies Affecting Tidal Flooding



Take Away

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.