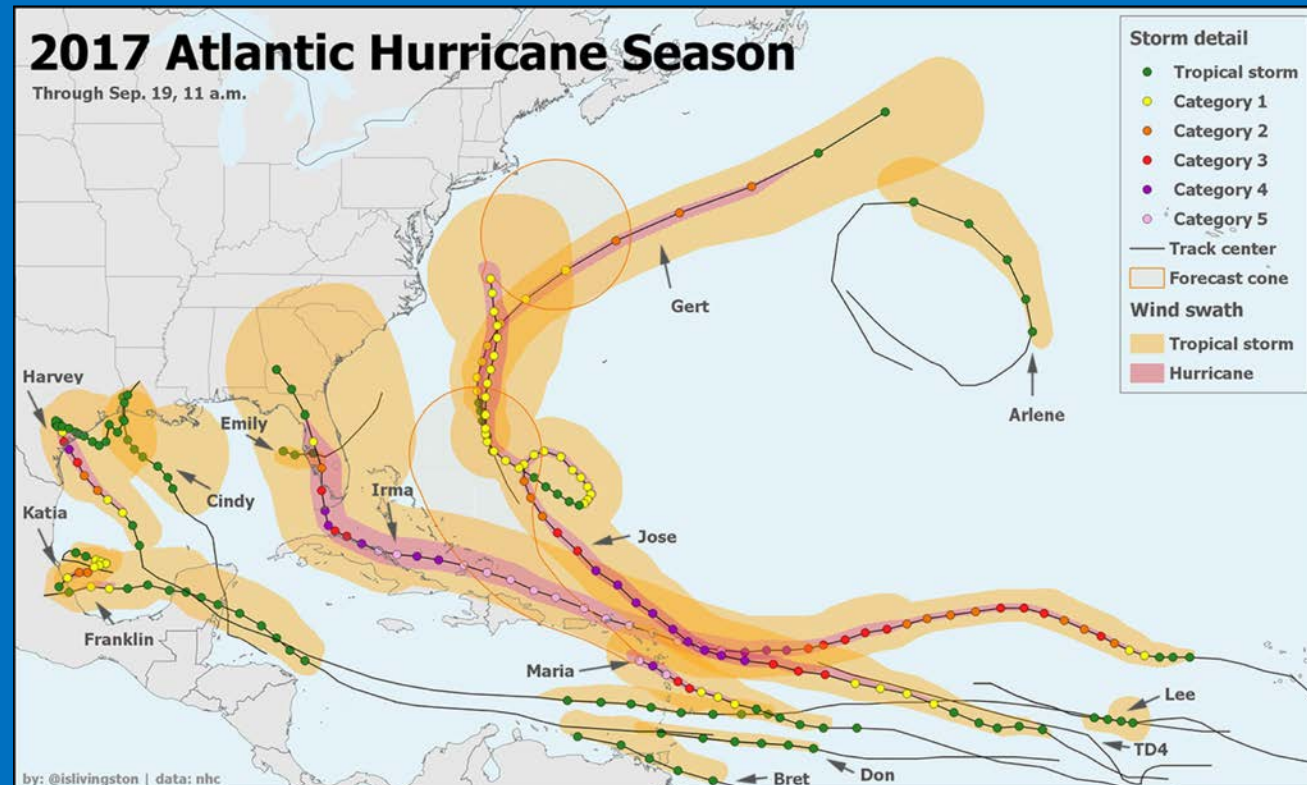
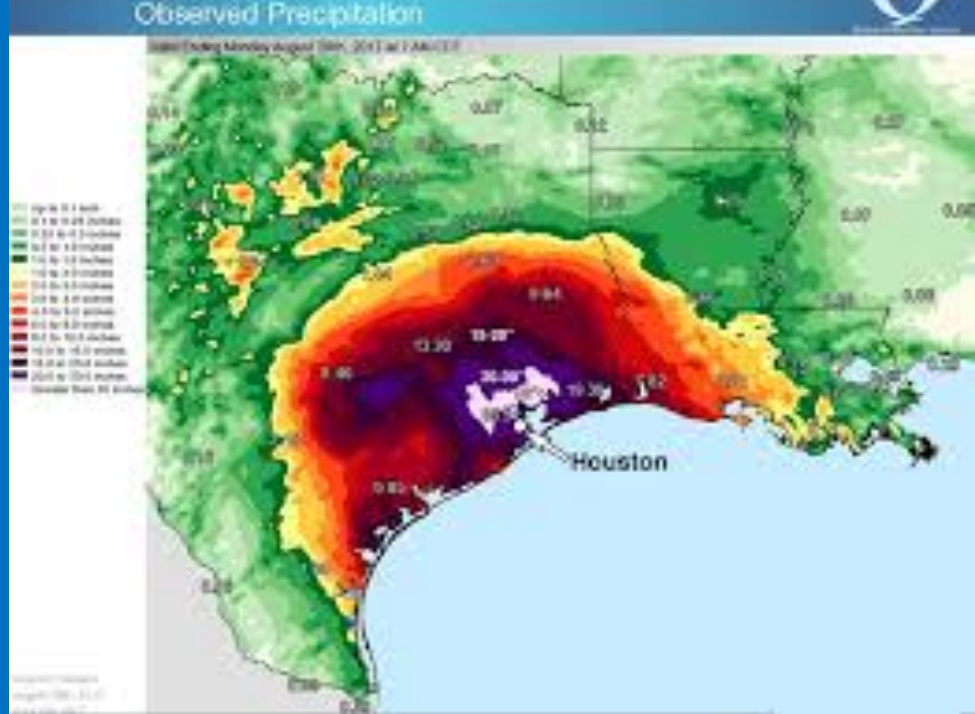
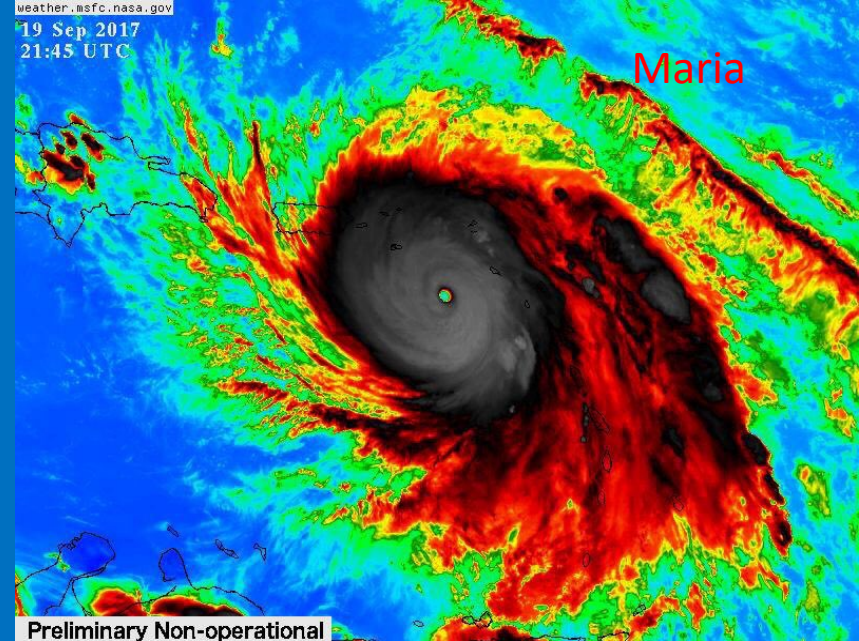
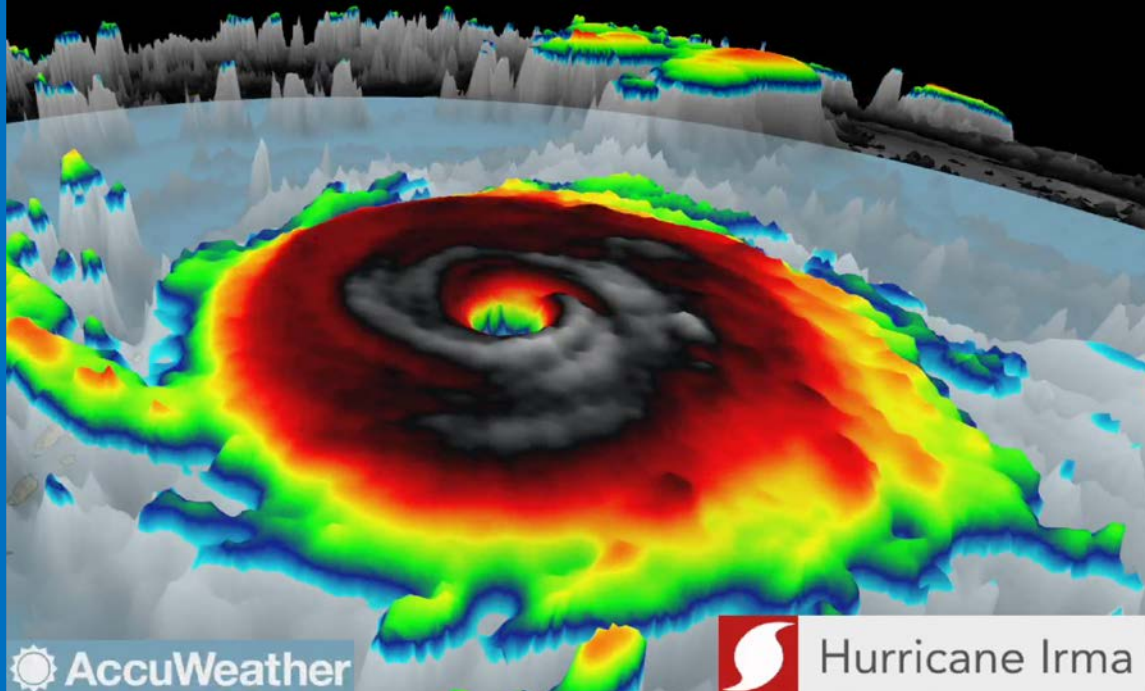


Hurricanes, storm surge, and climate change

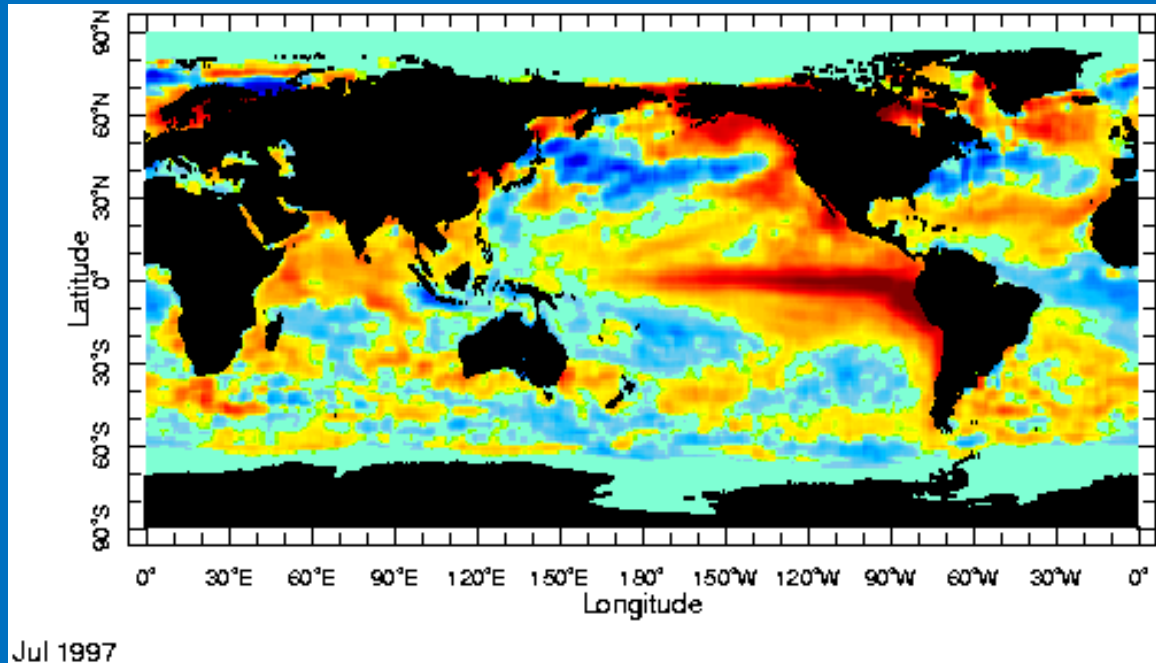
Suzana J. Camargo

Climate Science and Investment Conference
Ice Sheets and Sea Level Rise: Implications for Coastal Property
May 4th, 2018, New York, NY

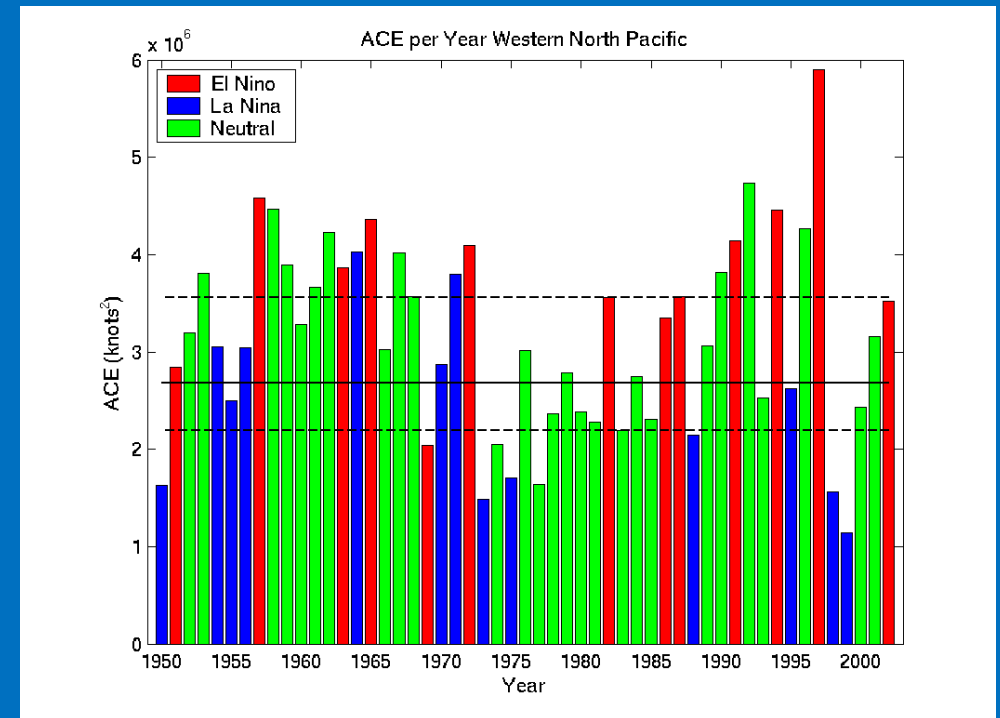


Tropical Cyclones and Climate

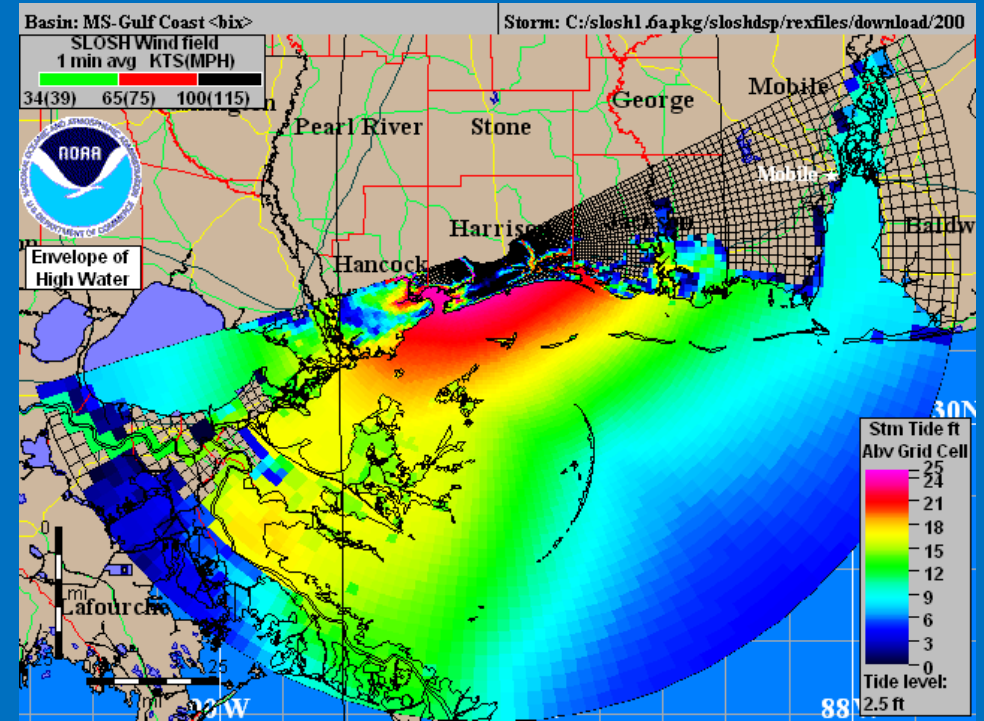
El Niño-Southern Oscillation



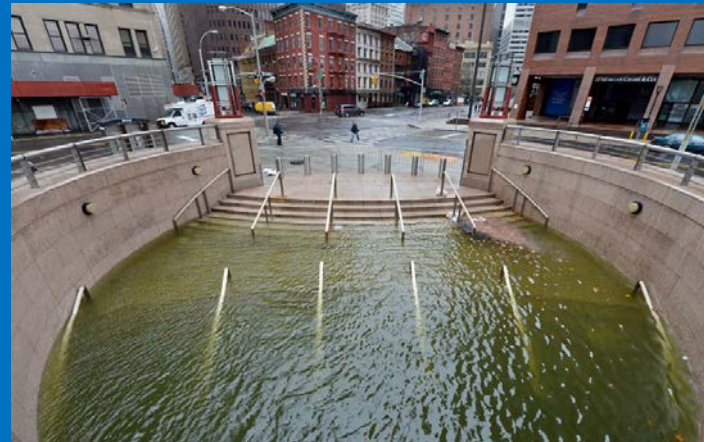
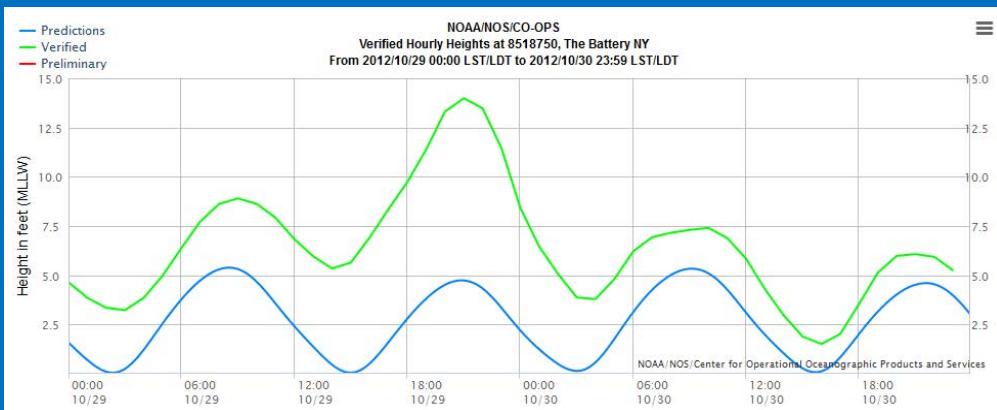
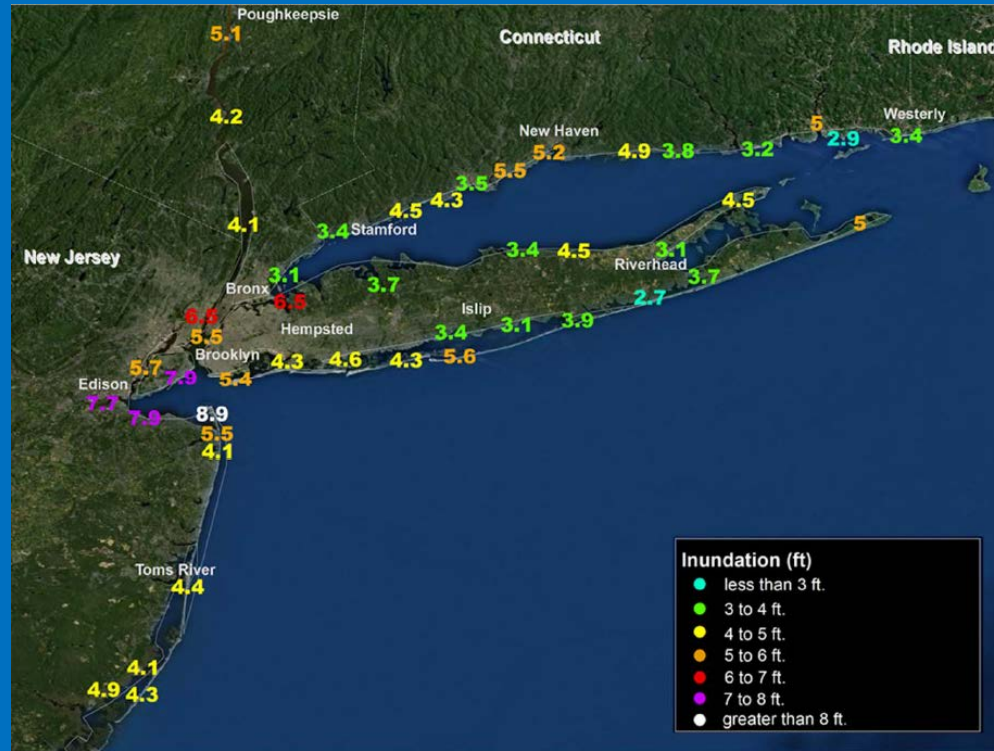
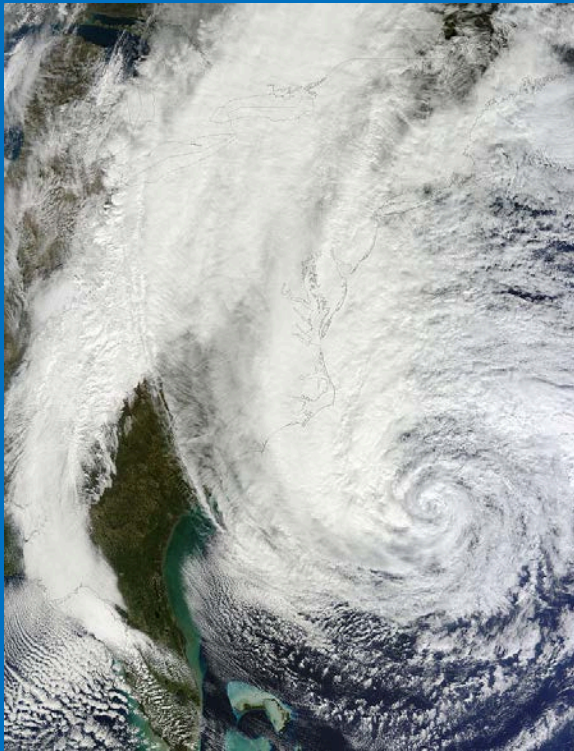
- El Niño events:
 - Stronger typhoons
 - Longer-living typhoons



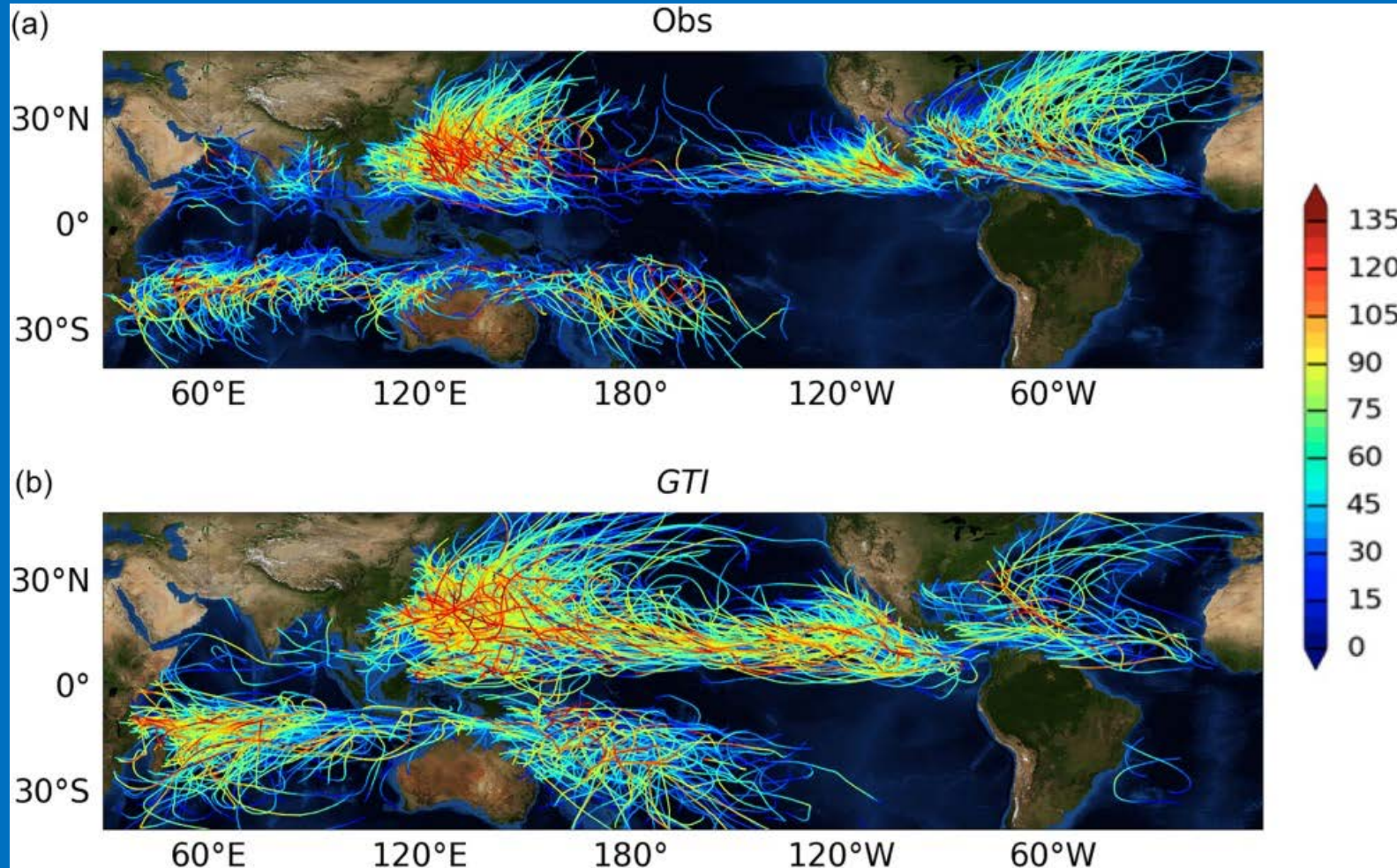
Hurricane Katrina



Hurricane Sandy



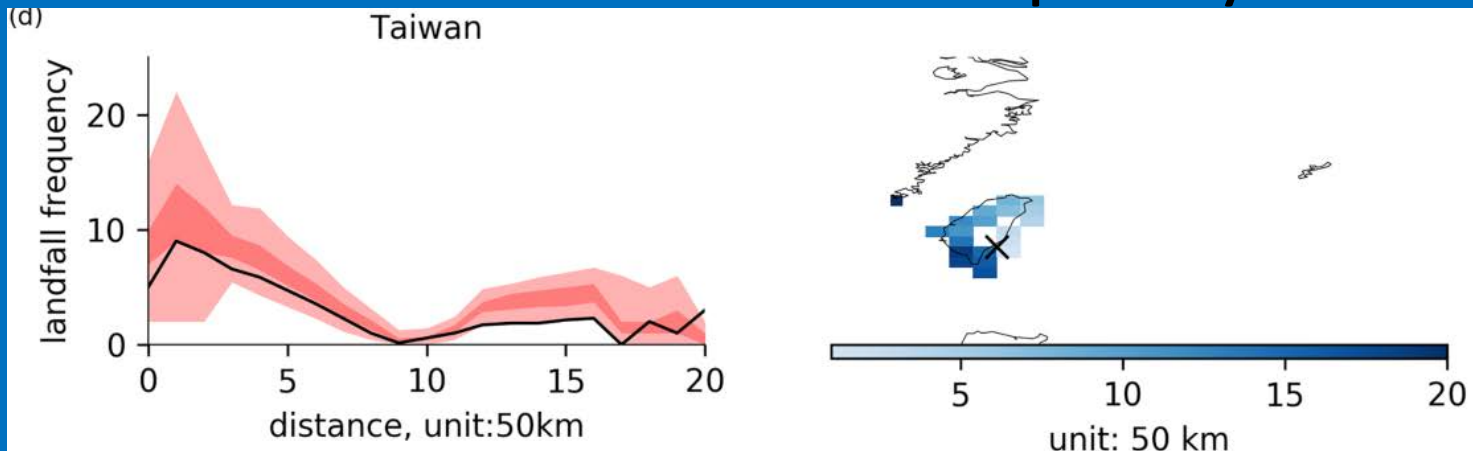
Tropical Cyclone risk: Columbia HAZard model (CHAZ)



Lee, Tippett, Sobel & Camargo, 2018

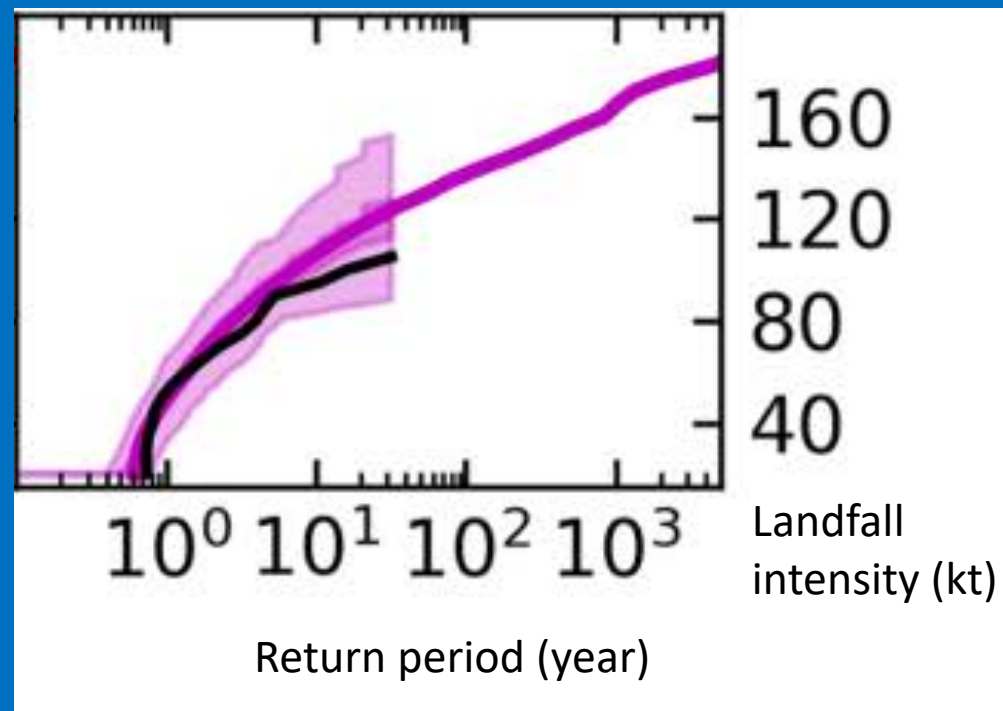
Columbia HAZard Model - CHAZ

Taiwan - Landfall Frequency



Lee, Tippett, Sobel & Camargo, 2018

Japan - Landfall return period



Lee, Tippett, Sobel & Camargo, 2018

Mumbai, Mumbai, $r = 150$ km

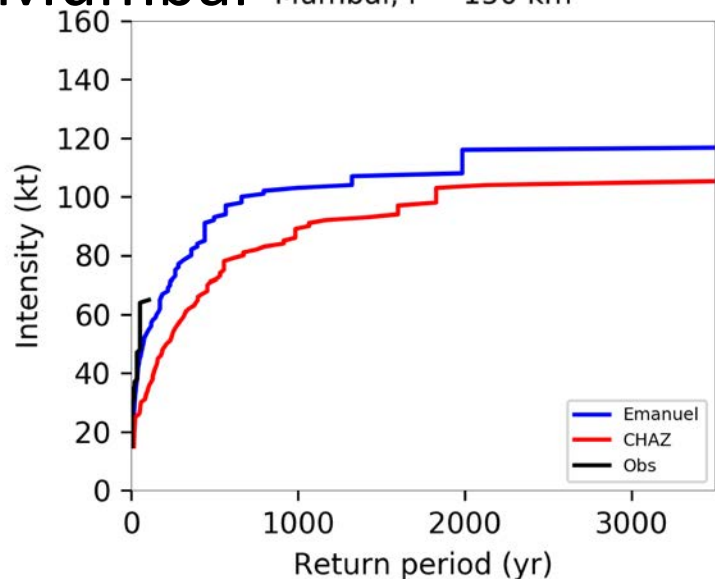
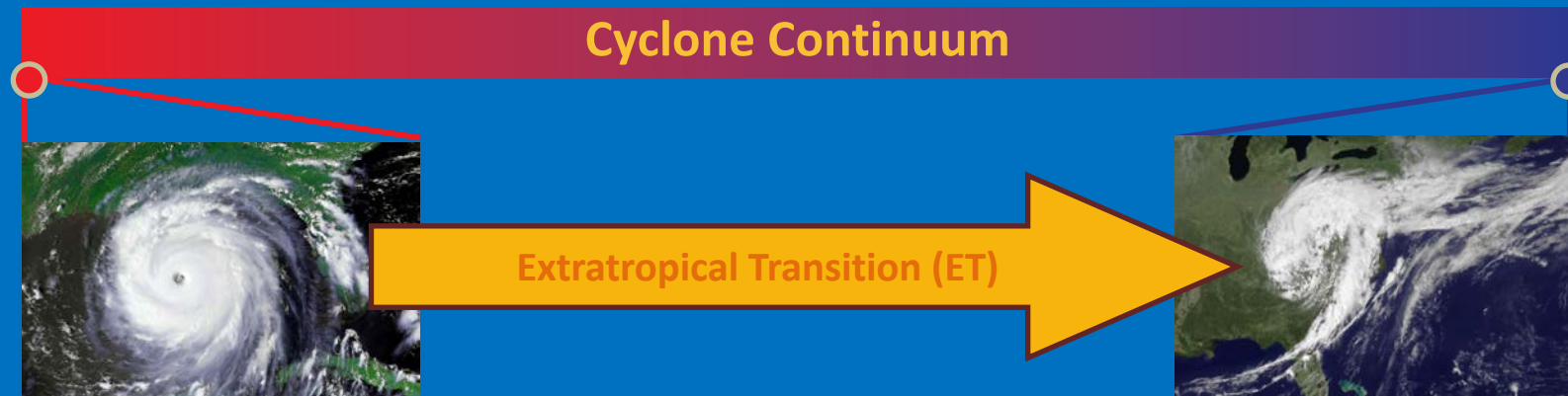


Figure by C.-Y. Lee
Sobel et al., in prep.

Extratropical transition (ET)



Tropical Cyclone:

- Warm Core
- No fronts
- Radially symmetric
- Fuel: Latent heat release

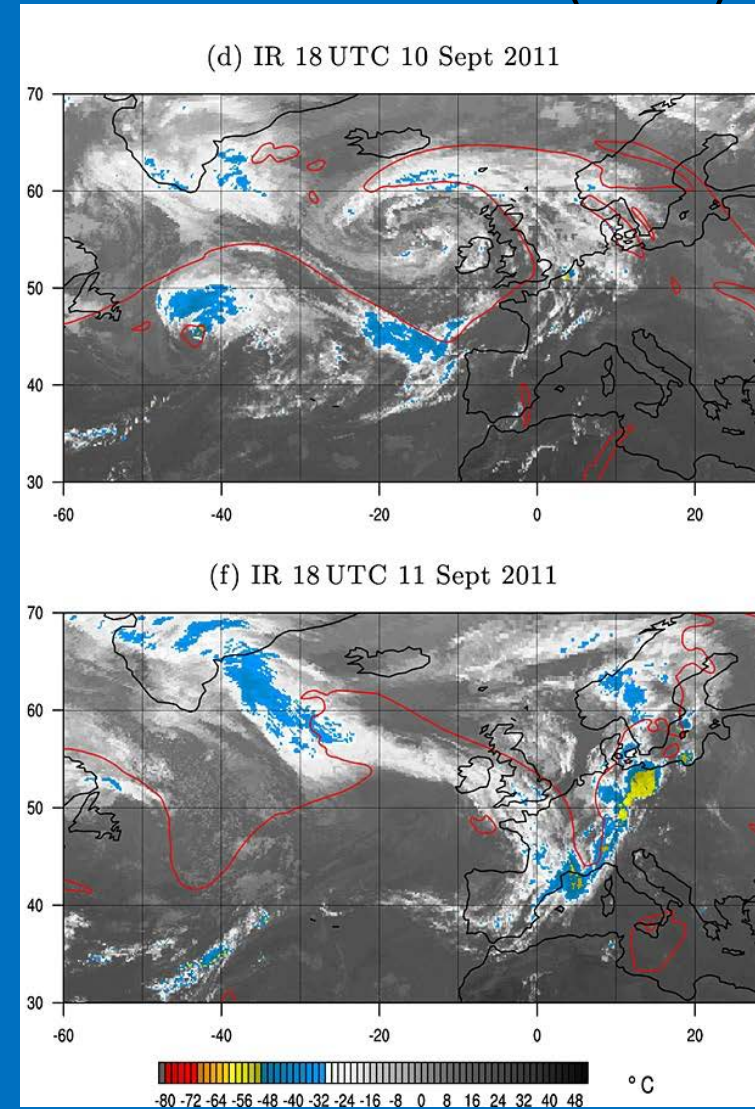
Extratropical Cyclone:

- Cold core
- Fronts
- Asymmetric (“comma”)
- Fuel: Baroclinicity

- Super-Storm Sandy



- European Impacts
 - Hurricane Katia (2011)



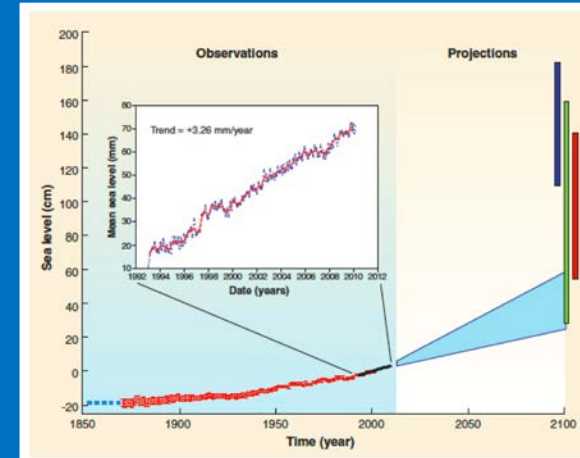
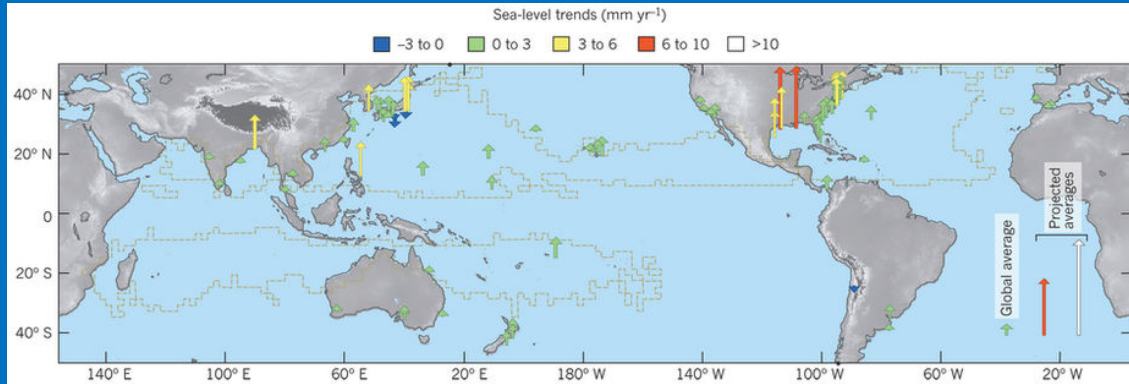
Grams & Blumer (2015)

Tropical Cyclones and Climate Change - 1

- Based on theory and models
- Globally averaged **intensity** of TCs shift towards **stronger** storms – 2-11% by 2100
- **Increases** of ~ 20% of the **precipitation rate** within 100km of the storm center.
- Globally averaged **frequency** of TCs **decreases** on the order of 6-34%
- Projected changes for individual basins – uncertain.

Sea Level Rise and Tropical Cyclones

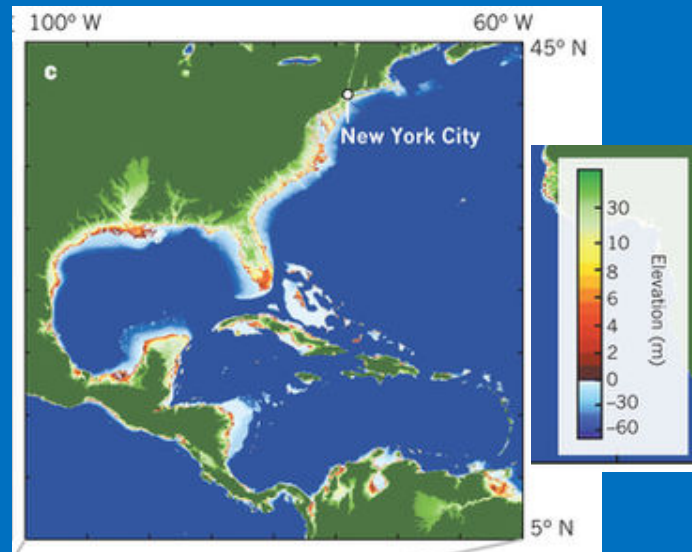
Sea Level Rise Trends



Nicholls & Canzenave 2010

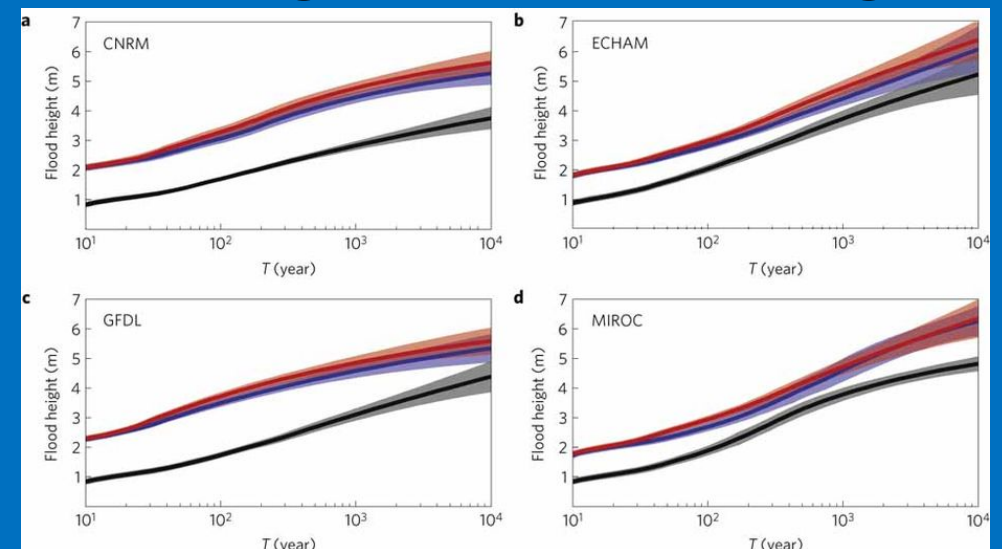
Storm surge risk enhanced:

- Shallow depths offshore
- Low-lying regions



Woodruff, Irish & Camargo 2013

Flooding due to Storm Surge



Lin et al. 2012

Tropical Cyclones & Climate Change - 2

- Sea Level Rise: probably more important than what climate change does to the storms!
- Risks will change over time
- Large impact will be felt in coastal real state due to sea level rise
- Increase of population & infrastructure on coastal areas

BRIEFLY

Stuff that matters

LOOMING LEXICON



'Climate gentrification' is coming to Miami's real estate market. Prospective homeowners often evaluate nearby schools, public parks, and public transportation options. But future homeowners in coastal cities might want to consider another factor before making a down payment: climate change.

Summary

- Risk of tropical cyclone disasters: events are too rare to evaluate using historical data only.
- Hazard/catastrophe models are one way to evaluate risk, but they don't address all issues: e.g. climate change.
- Columbia developed a new Hazard model - open source
- Plan to develop new aspects of the model: full wind field, storm surge, precipitation, flooding.
- Potential to collaborate with industry in risk assessment.