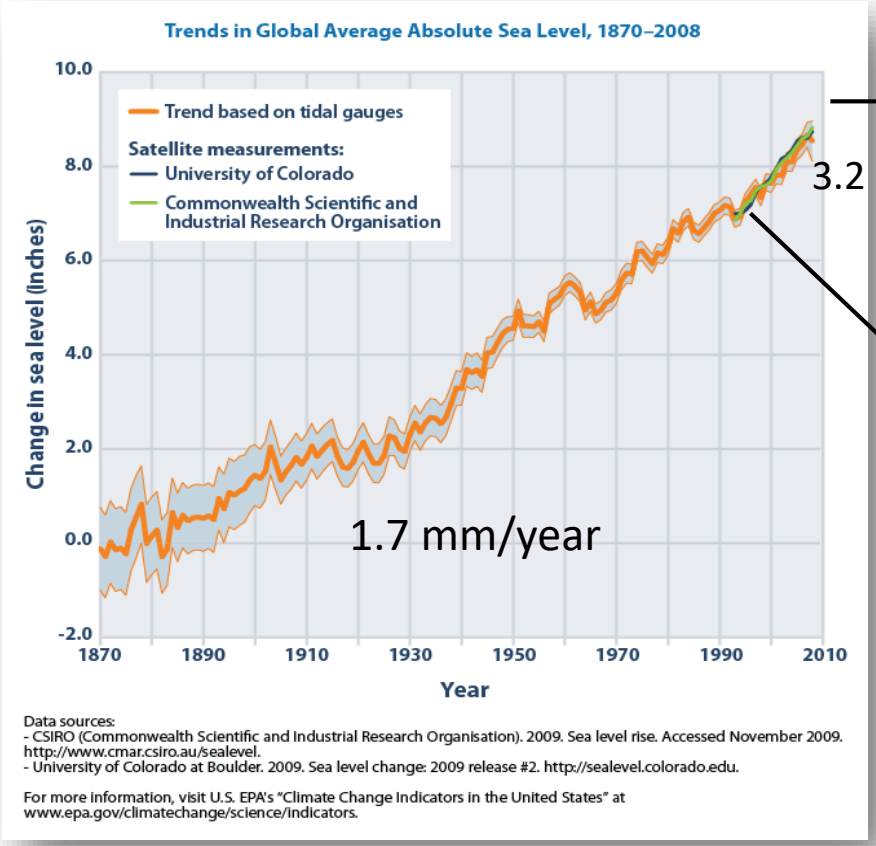
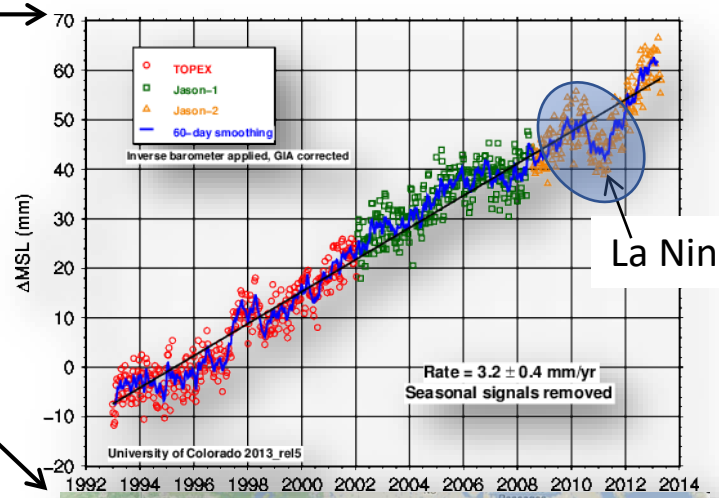
Regional Sea Level Projections

Jayantha Obeysekera ('Obey'), Ph.D.,P.E., F.EWRI
Shimon Wdowinski, Ph.D.
Sea Level Solutions Center
GEER Conference 2019

Global Average Sea Level Rise & Relative Sea Level Rise along US Coastline



3.2 mm/year



La Nina

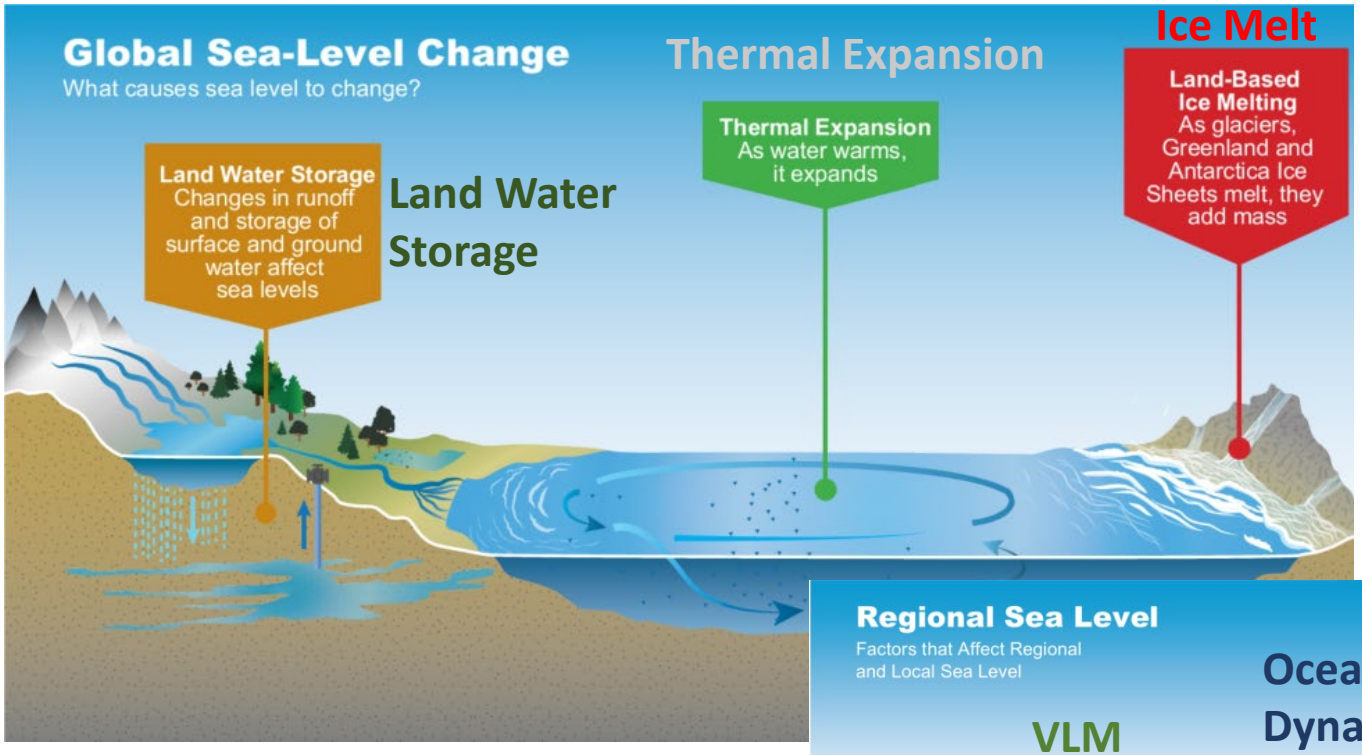
Global Mean SLR Projections

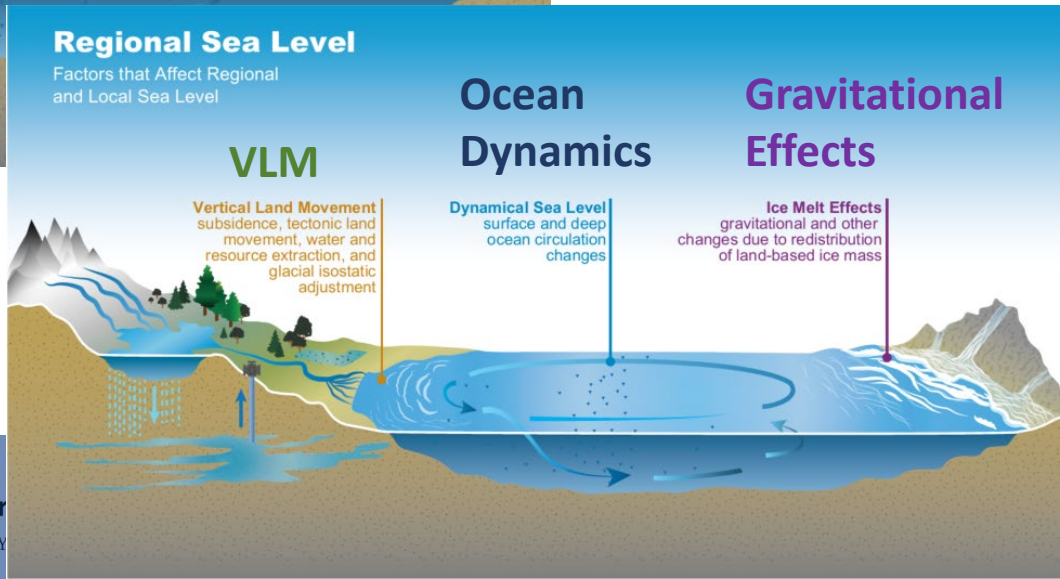
- **IPCC AR5 (2013, 2014)**

  The median projection for 2100 for the RCP 8.5 scenario is 0.73 with a range of 0.53 to 0.97 (Table AII 7.7)- "median confidence" (range has a probability of 66%.). There is a 33% probability the range could be larger.

  "Only the collapse of the marine-based sectors of the Antarctic ice sheet, if initiated, could cause GMSL to rise substantially above the likely range during the 21st century. This potential additional contribution cannot be precisely quantified but there is medium confidence that it would not exceed several tenth of a meter of sea level rise."

Sources of Global and Regional Sea Level Change

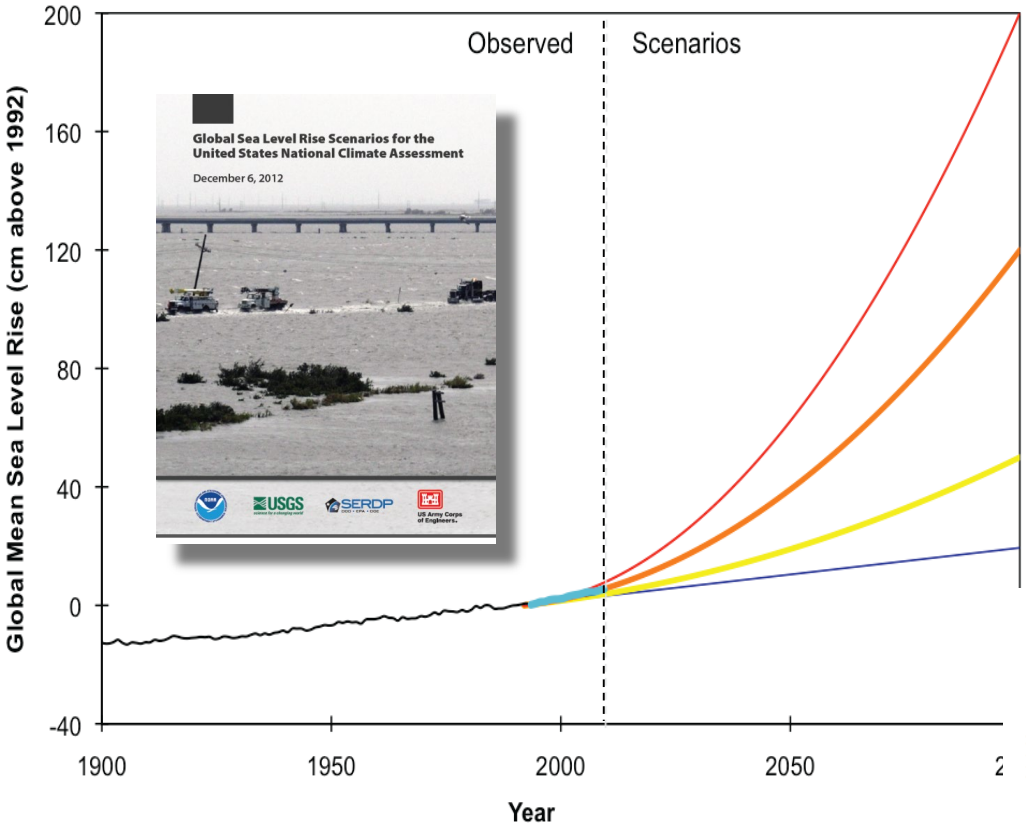


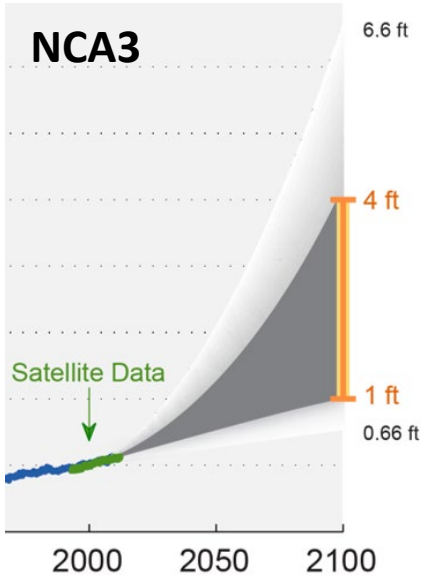


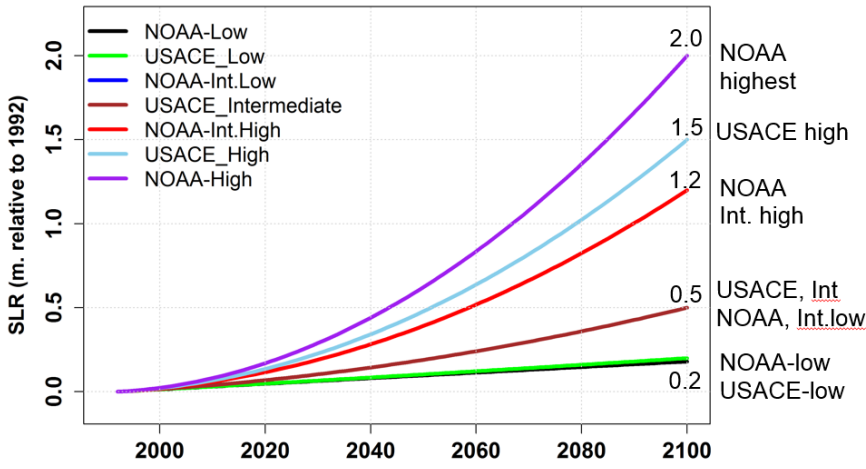
FIU Institute of Water and Environment
Florida International University

FIU Sea Level Solutions Center
Florida International University

Scenario approach (NOAA, 2012) for 3rd National Climate Assessment







Confidence (>90%) was assigned to the range as bounding possible futures, with no likelihoods assigned to individual scenarios.

FLORIDA INTERNATIONAL UNIVERSITY

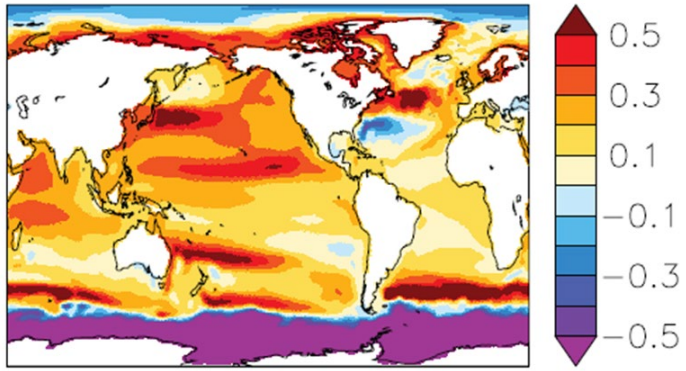
Regional/Local Sea Level Change (DoD)

- **Change in Relative Sea Level (RSL):**

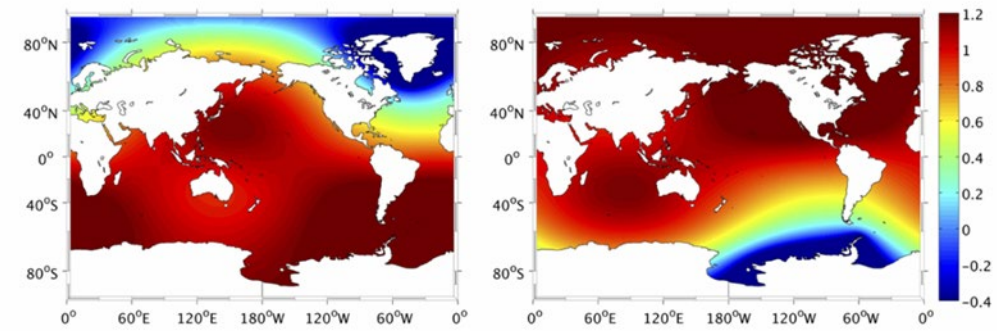
$$\Delta RSL = \Delta SL_G + \Delta SL_{RM} + \Delta SL_{RG} + \Delta SL_{VLM}$$

Global

Ocean Dynamics



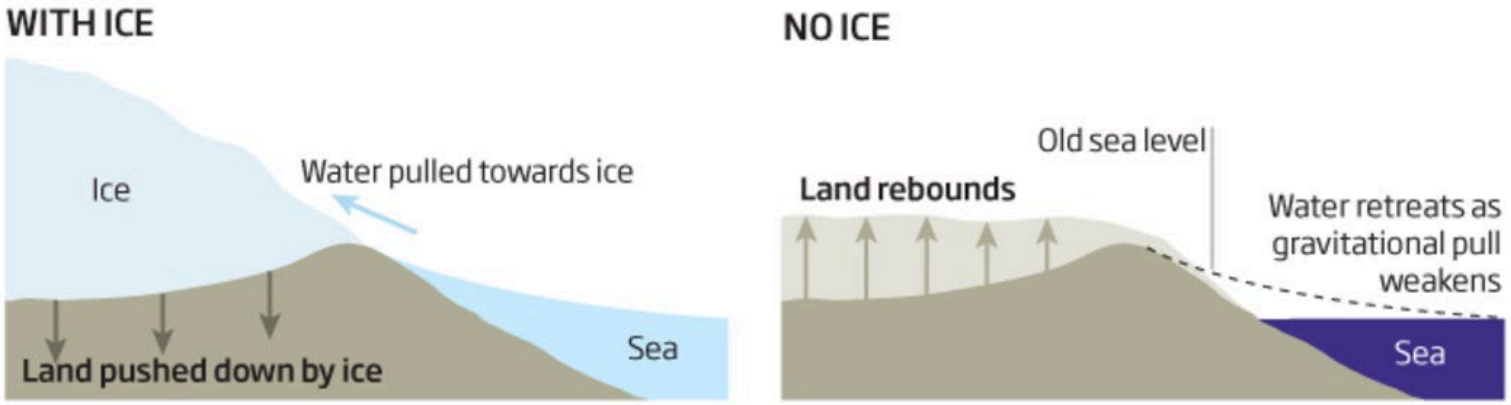
Gravitational Effects (Glaciers, Ice Sheets)



Vertical Land Movement (Uplift/Subsidence,GIA)

*As suggested in Nicholls et al., 2011

Regional changes due to sea level finger printing (Gravitational effect)

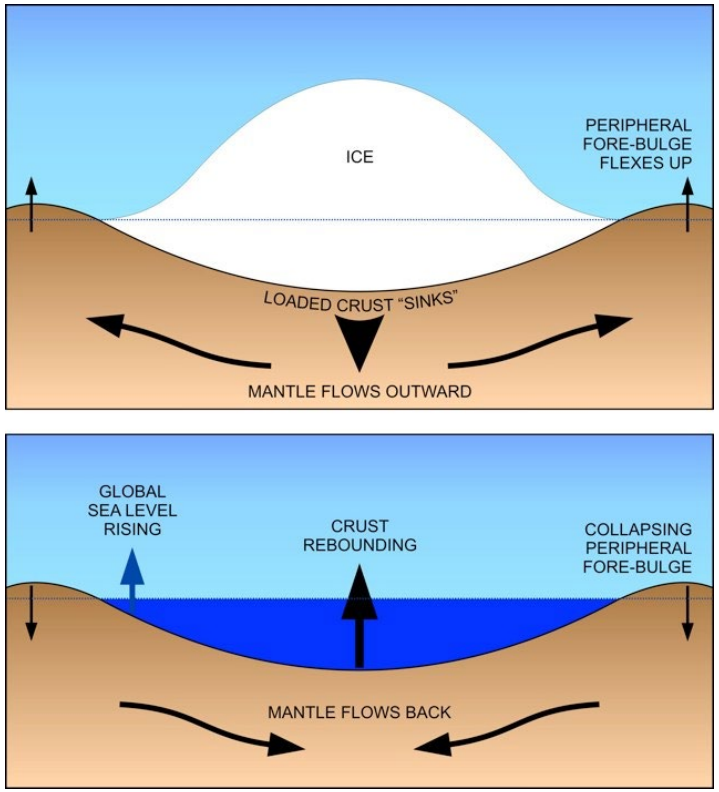


The large mass of ice sheets exert gravitational attraction of seawater towards the ice sheets.

Mass decrease due to ice melt reduces the Gravitational attraction. Consequently, sea level falls at the vicinity of the ice sheet and increases further away.

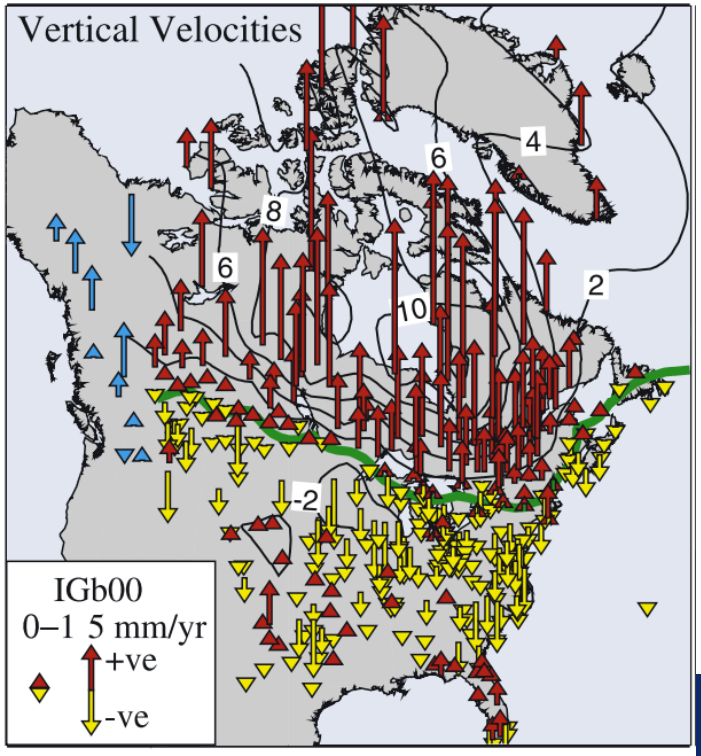
Source: NewScientist

Regional changes due to Glacial Isostatic Adjustment (GIA) – Vertical Land Movements



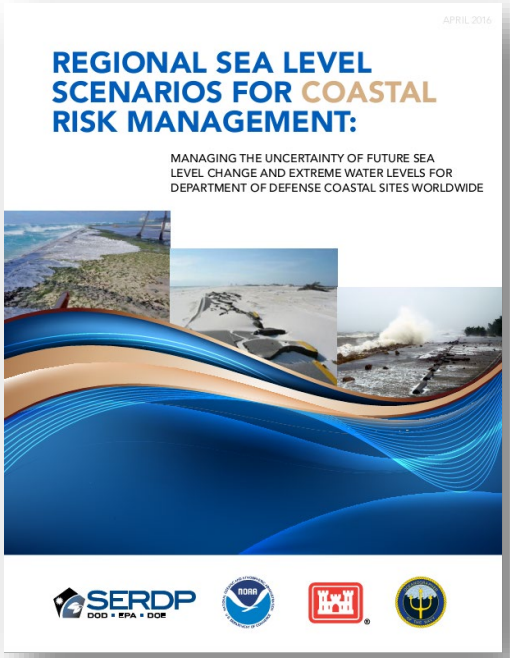
Source: Canadian Geodetic Survey

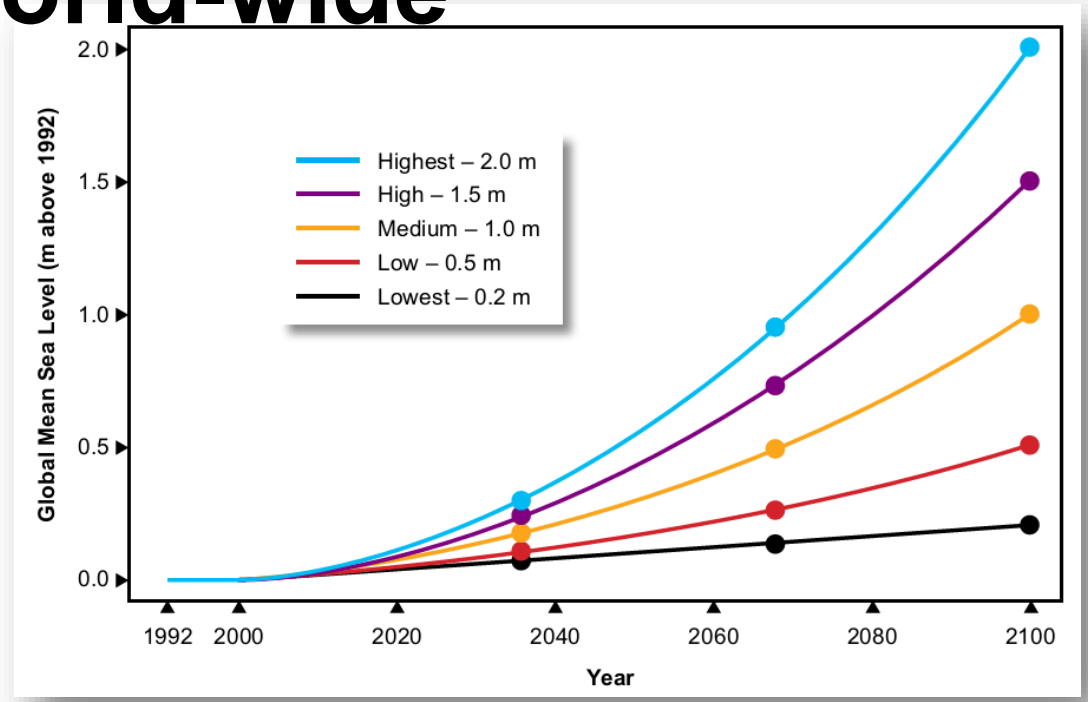
Regional-scale uplift and subsidence due to viscous (time dependent) mantle flow in response to past ice melt.



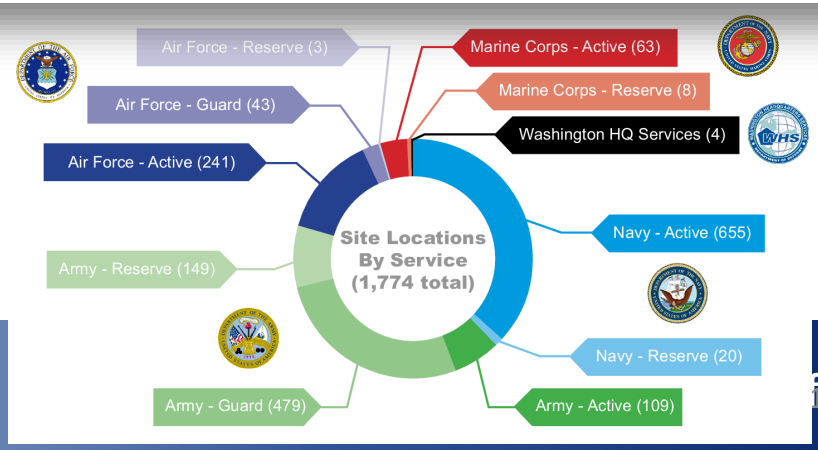
Sella et al. (2007)

DoD Project (Hall et al. 2016): GMSL Scenarios for installations world-wide





- Scenario approach, no probabilities
- Risk-based framing
- Upper limit still based on Pfeffer (2008)



Δ Relative Sea Level (RSL) of Sweet et al. (2017):

following probabilistic framework of Kopp et al. (2014)

$$\Delta RSL = \Delta GMSL + \Delta RSL_{climatic} + \Delta RSL_{non\text{-}climatic}$$

Global Mean Sea Level (GMSL) Scenarios for 2100:

Low (0.3)
Intermediate-Low (0.5 m)
Intermediate (1.0 m)
Intermediate-High (1.5 m)
High (2.0 m)
Extreme (2.5 m)

1) Δ Ice Mass w/ gravity 'fingerprints' of Mitrovica et al. (2011):

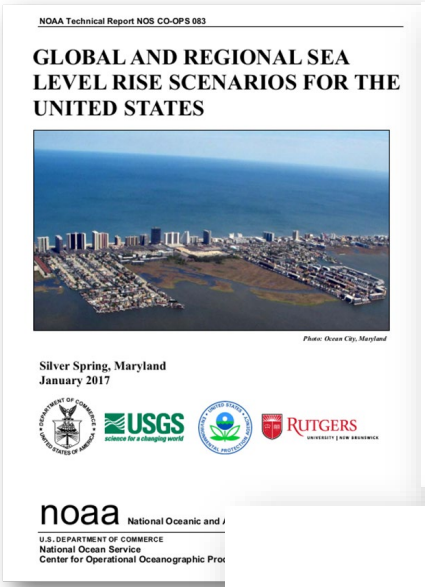
2) Δ Oceanographic Processes (thermal expansion, dynamics from CMIP5 models)

3) Land-water storage based upon empirical relationships

GIA, tectonics, sediment compaction, anthropogenic factors:

- Spatiotemporal model of tide gauge data with 3 modes: 1) globally uniform sea level change, 2) **a constant-rate average, long-term, regionally varying trend**, and 3) temporally and spatially varying regional sea-level contributions

NOAA (Sweet et al. 2017) for 4th National Climate Assessment


NOAA Technical Report NOS CO-OPS 083

GLOBAL AND REGIONAL SEA LEVEL RISE SCENARIOS FOR THE UNITED STATES

Photo: Ocean City, Maryland

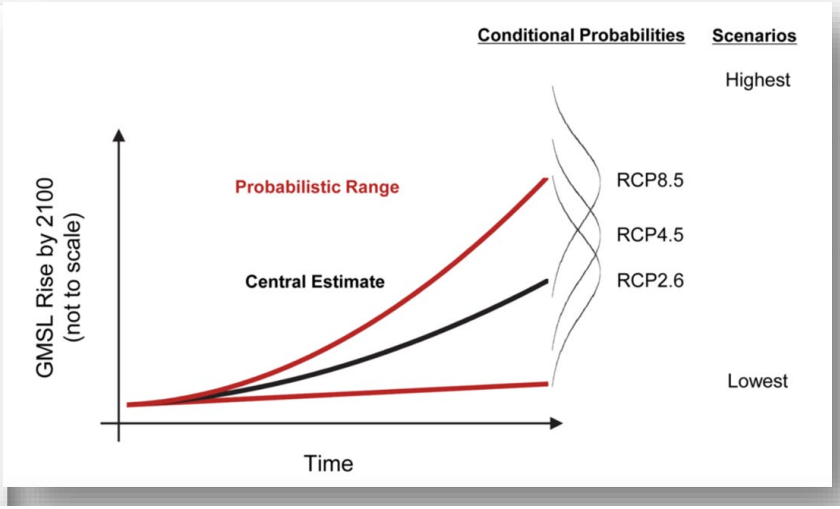
Silver Spring, Maryland
January 2017

USGS science for a changing world

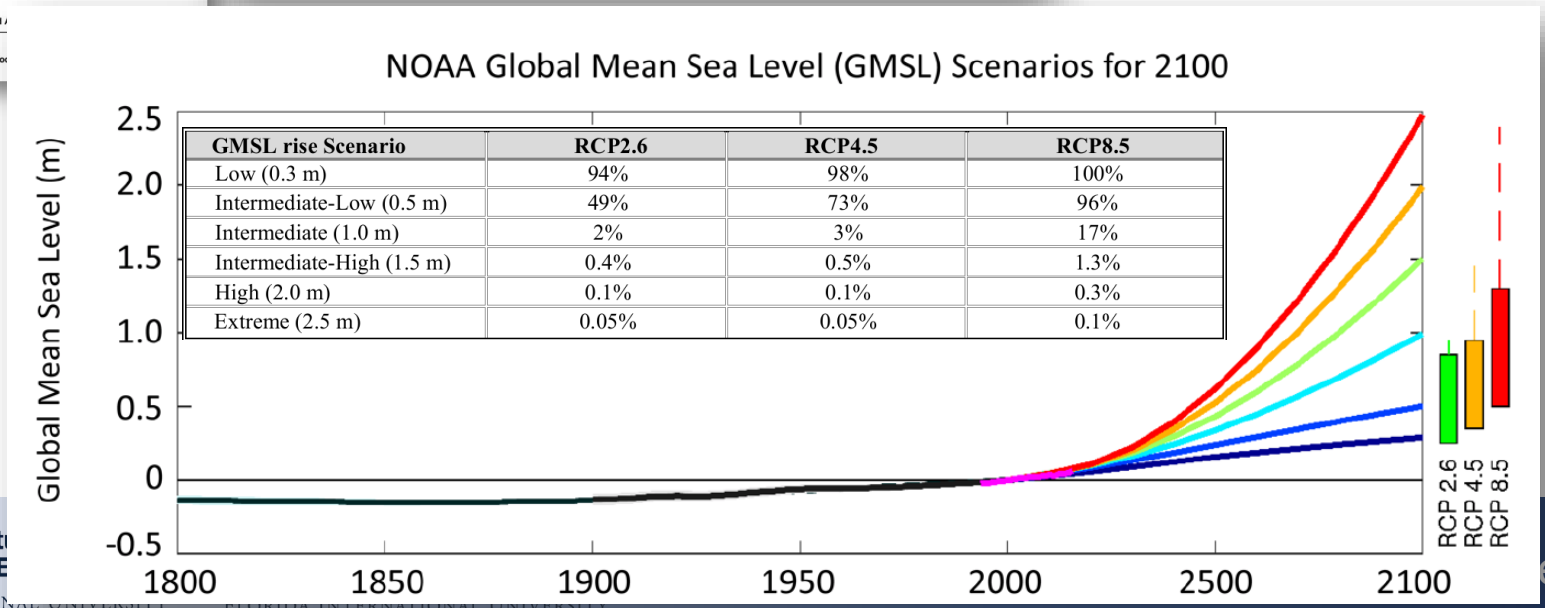
RUTGERS

noaa National Oceanic and

U.S. DEPARTMENT OF COMMERCE
National Ocean Service
Center for Operational Oceanographic Prod



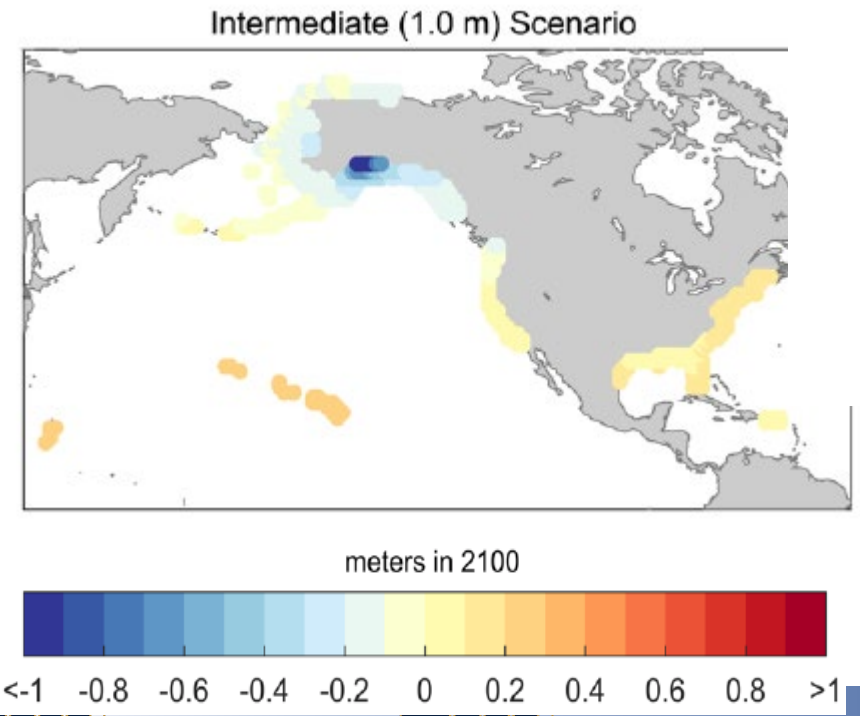
- Kopp et al. (2014)
- Conditional Probabilities
- Expert elicitation to get the tails
- **DeConto & Pollard (2016)**
  - Antarctica can contribute more, hence 2.5 m scenario

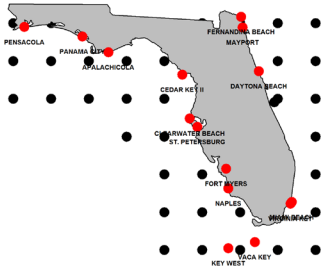


GMSL rise Scenario	RCP2.6	RCP4.5	RCP8.5
Low (0.3 m)	94%	98%	100%
Intermediate-Low (0.5 m)	49%	73%	96%
Intermediate (1.0 m)	2%	3%	17%
Intermediate-High (1.5 m)	0.4%	0.5%	1.3%
High (2.0 m)	0.1%	0.1%	0.3%
Extreme (2.5 m)	0.05%	0.05%	0.1%

Regional Sea Level Projections

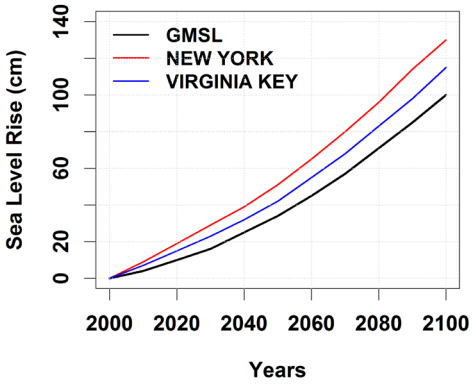
- **Both Hall et al. (DoD 2016) and Sweet et al. (NOAA 2017) accounted for all components**





Florida

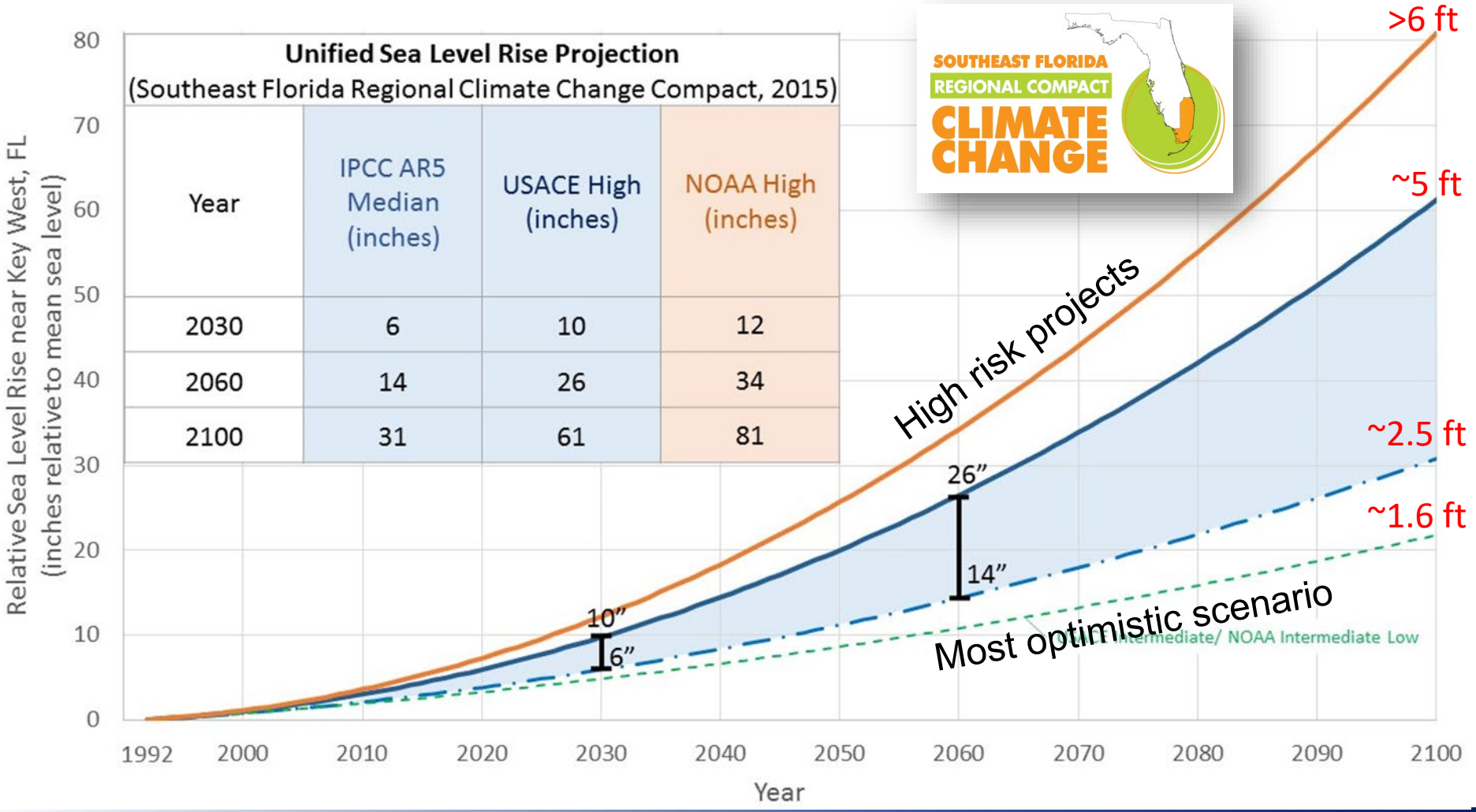
Regional Sea Level Curves



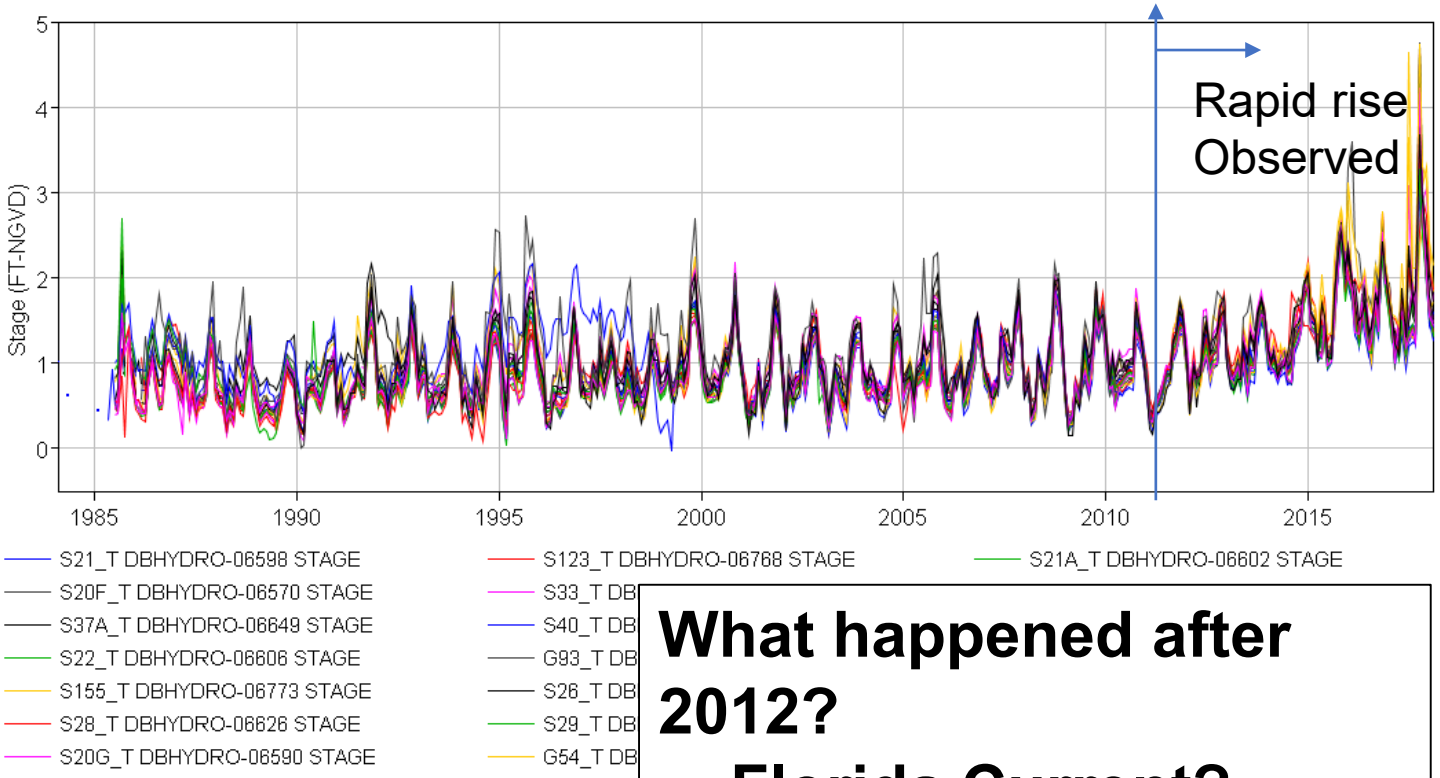
Regional Sea Level Projections

Unified Sea Level Rise Projection
(Southeast Florida Regional Climate Change Compact, 2015)

Year	IPCC AR5 Median (inches)	USACE High (inches)	NOAA High (inches)
2030	6	10	12
2060	14	26	34
2100	31	61	81



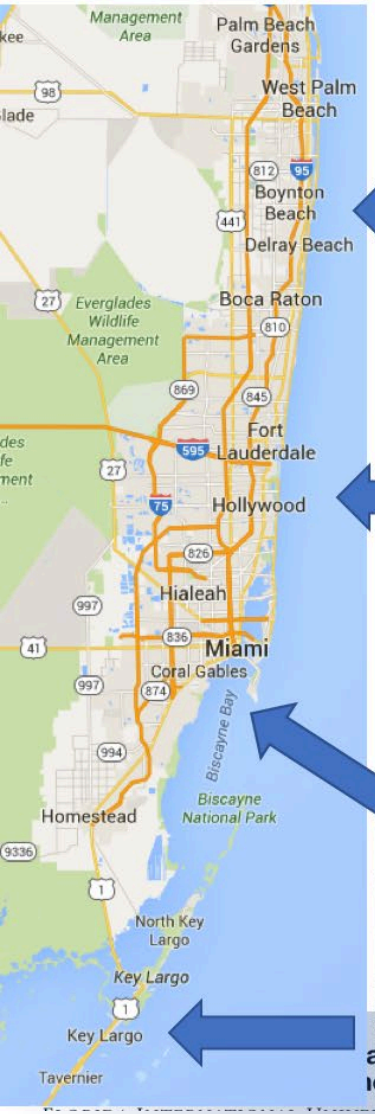
Coastal Discharge Structures in South Florida

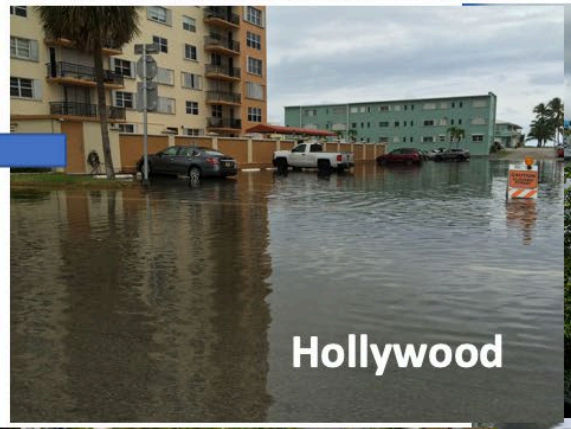


What happened after 2012?

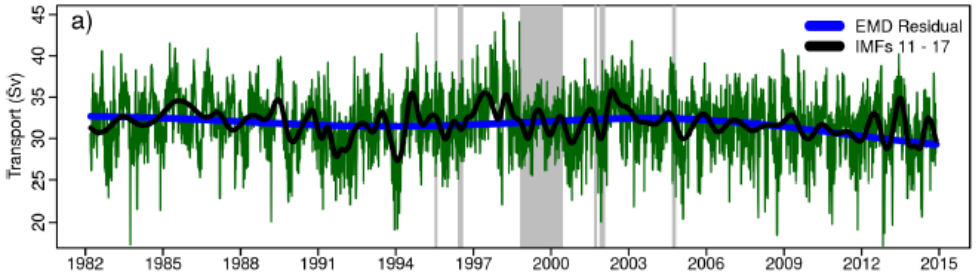
- **Florida Current?**
- **Ocean Warming?**
- **ENSO, NAO?**

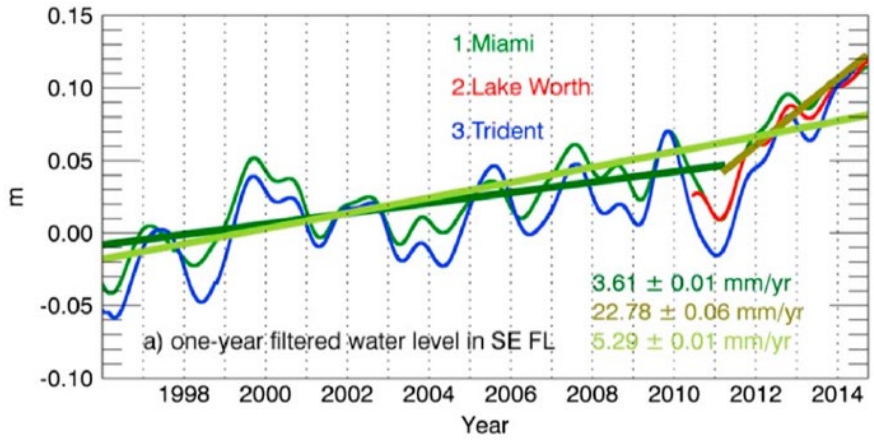
King Tide Flooding in South Florida (2015)





Decline in Florida Current Transport or NAO/ENSO Influence?

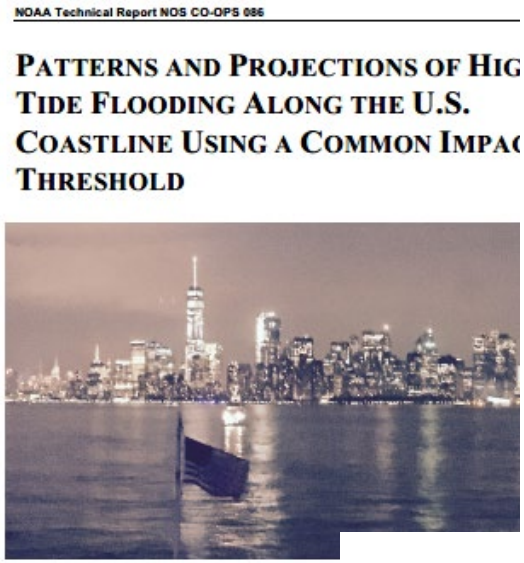


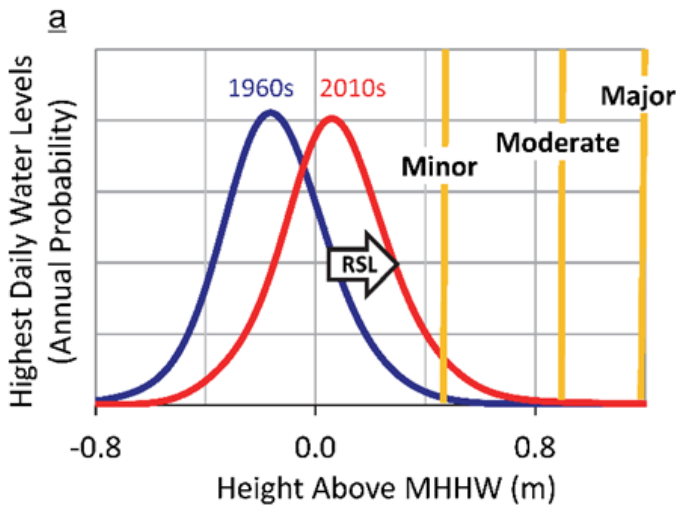


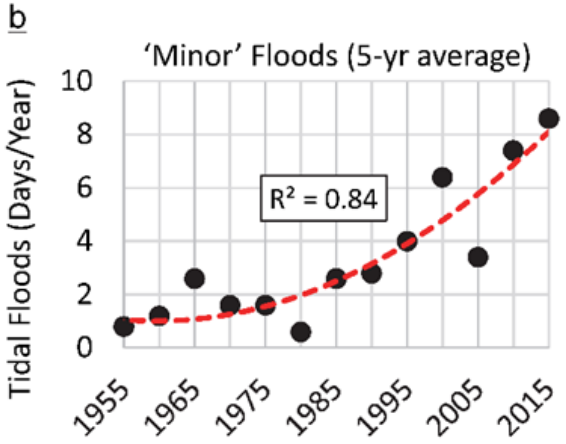
Spatial and temporal variability of sea level rise hot spots over the eastern United States

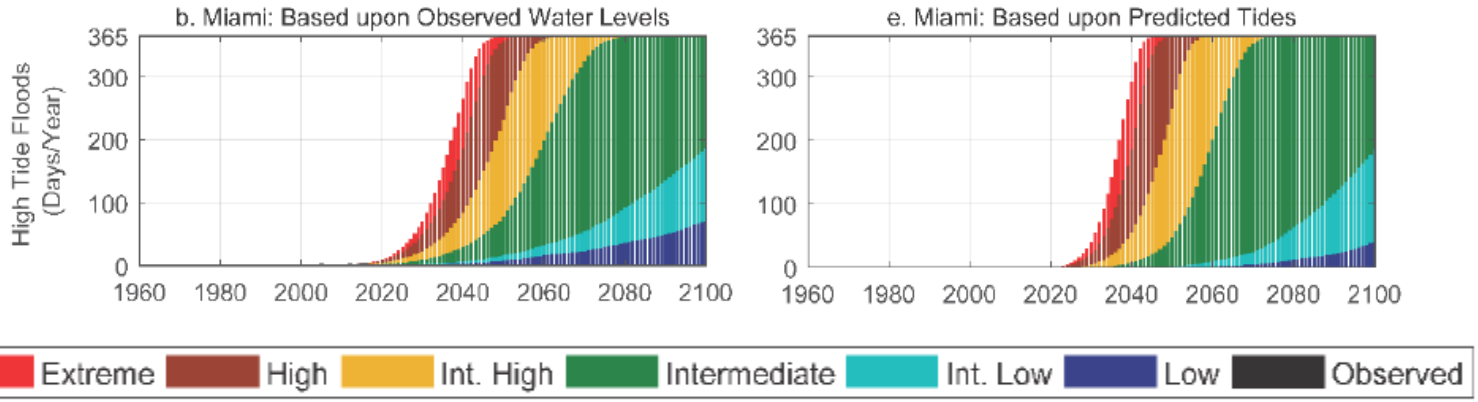
Arnoldo Valle-Levinson[1], Andrea Dutton[2], and Jonathan B. Martin[2]

Nuisance Flooding to Chronic Flooding









Sea Level Extremes

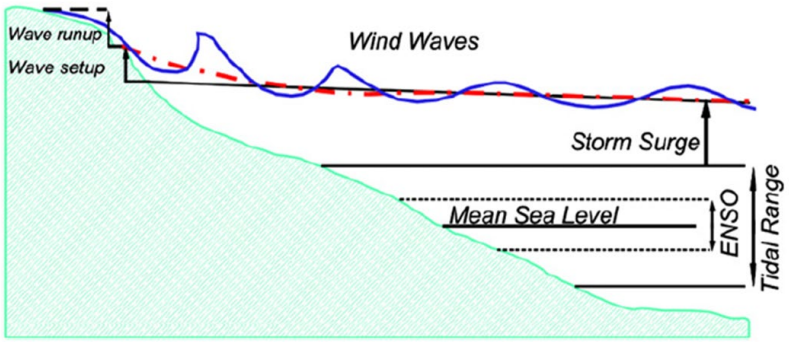
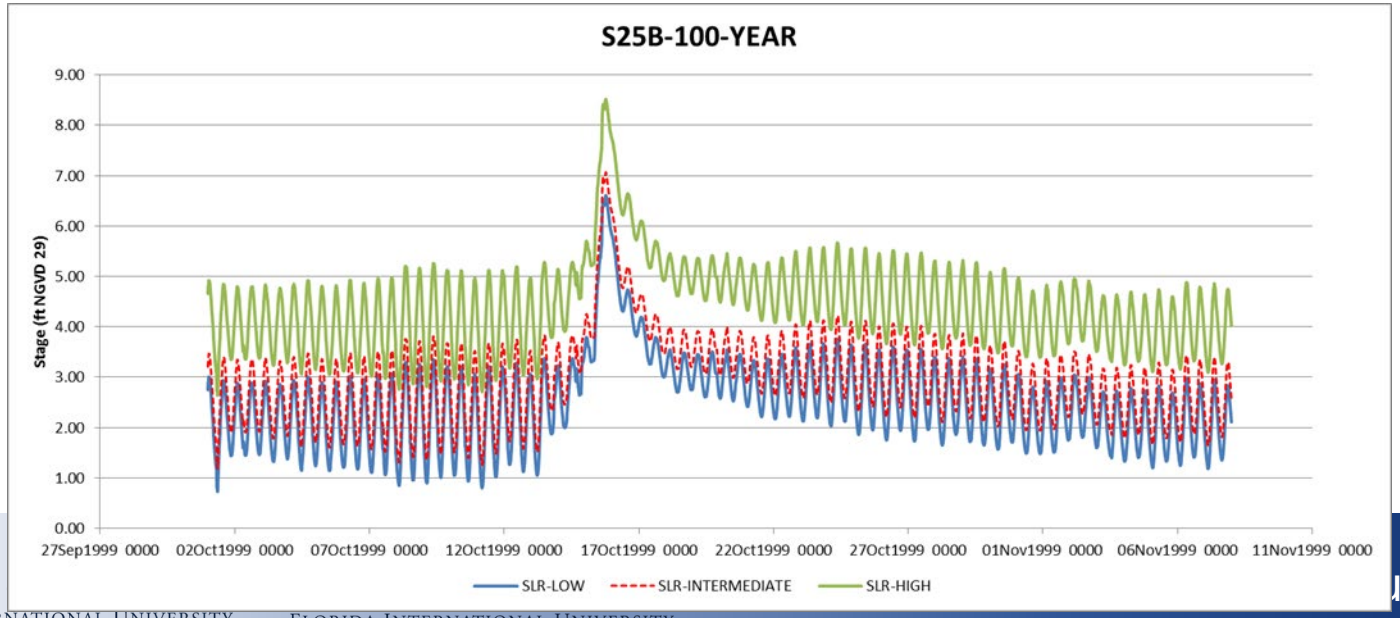


Fig. 2. Diagram illustrating the contributions to sea level due to tides, storm surge and wind-generated waves.

- General agreement that extremes vary primarily with the mean
- SFWMD currently uses an **Empirical Simulation Technique** (Goring et al. 2011)



Conclusions

- Global sea level changes occur due to thermal expansion, land-based ice melt, and land water storage changes.
- Regional sea level changes occur due to ocean dynamic, vertical land movements, and gravitational effect
- Global Mean Sea Level (GMSL) Scenarios
  - depend on assumed Representative [greenhouse gas] Concentration Pathways (RCPs), which vary in the range of 400-1,250 CO2-equivalent ppm by the end of the century (2100).
  - Project changes of 0.3-2.5 meter (1-8 feet) by 2100.
- Regional Scenarios typically adapt curves calculated by GMSL models.
- Extreme situation, mainly, **collapse of the marine-based sectors of the Antarctic ice sheet,** could cause GMSL to rise substantially above the likely range during the 21st century.