UCF | National Center for Integrated Coastal Research

UNIVERSITY OF CENTRAL FLORIDA

SEA LEVEL RISE, COASTAL IMPACTS, AND ADAPTATION


Credit: USGS

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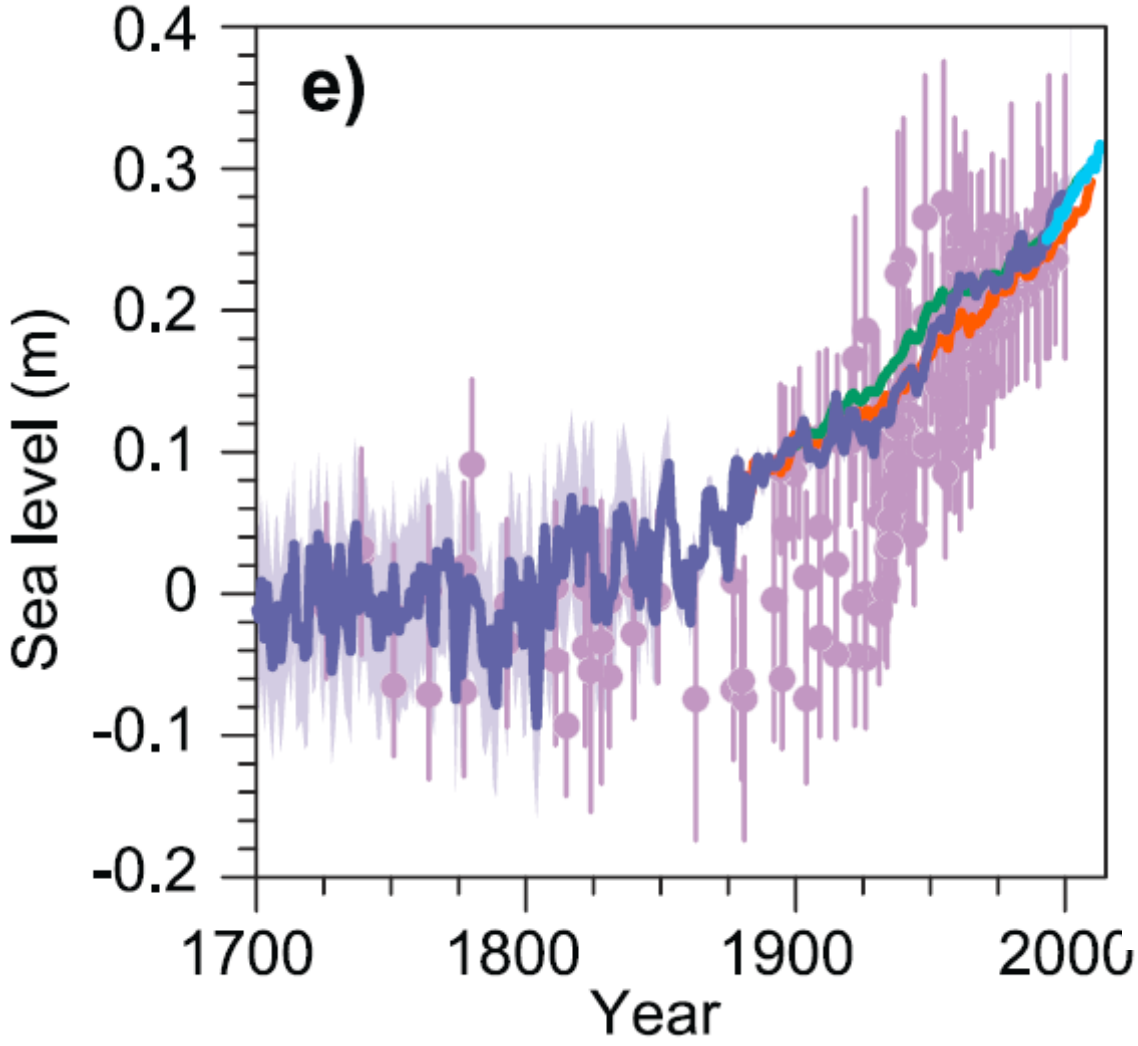
Civil, Environmental and Construction Engineering & UCF Coastal

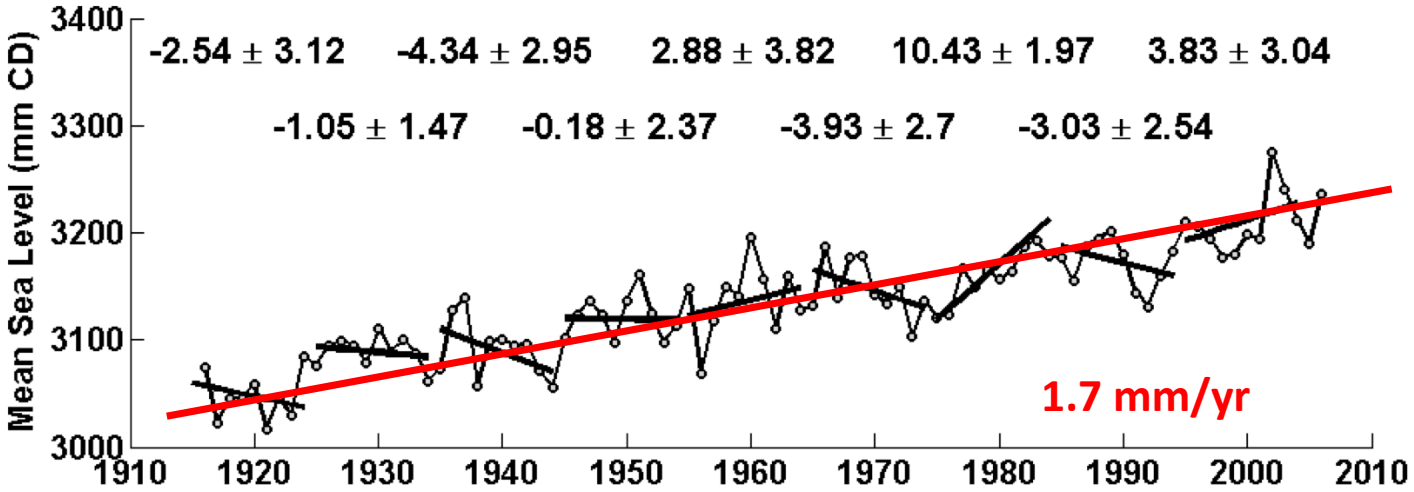
Modern sea level rise

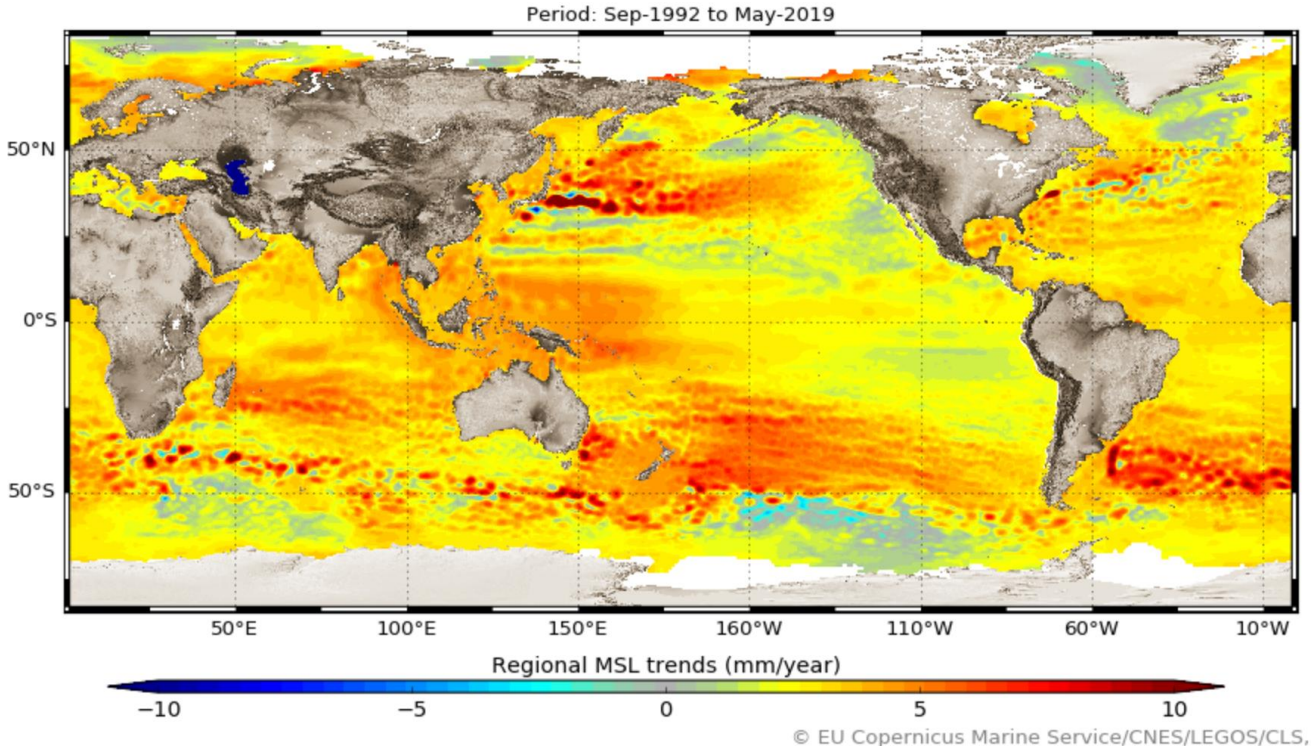
Sea level rise rates observed over the last century are very likely unprecedented over any of the previous 27 centuries.



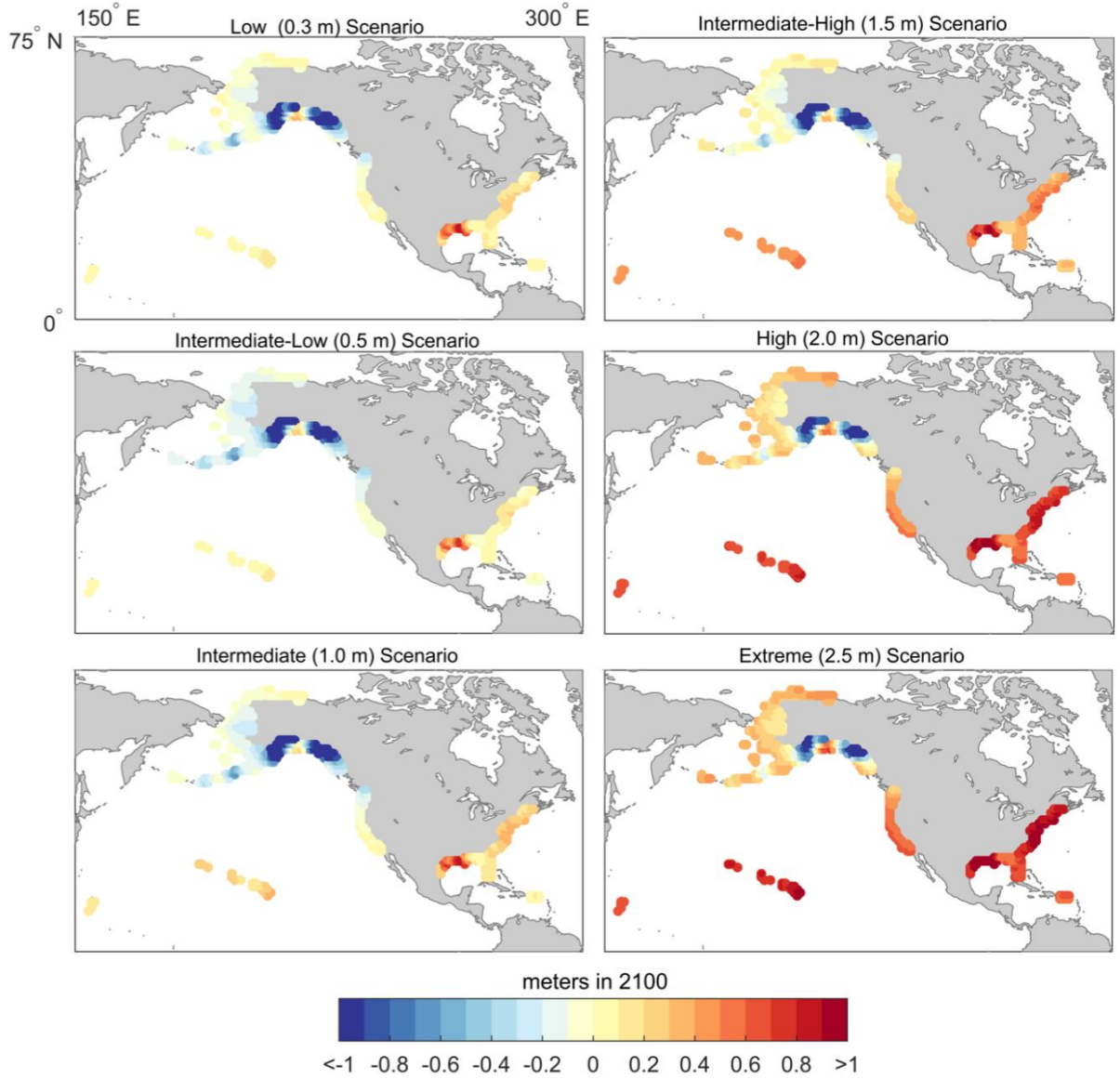
Church et al. [2013], AR5

Spatial/temporal variability





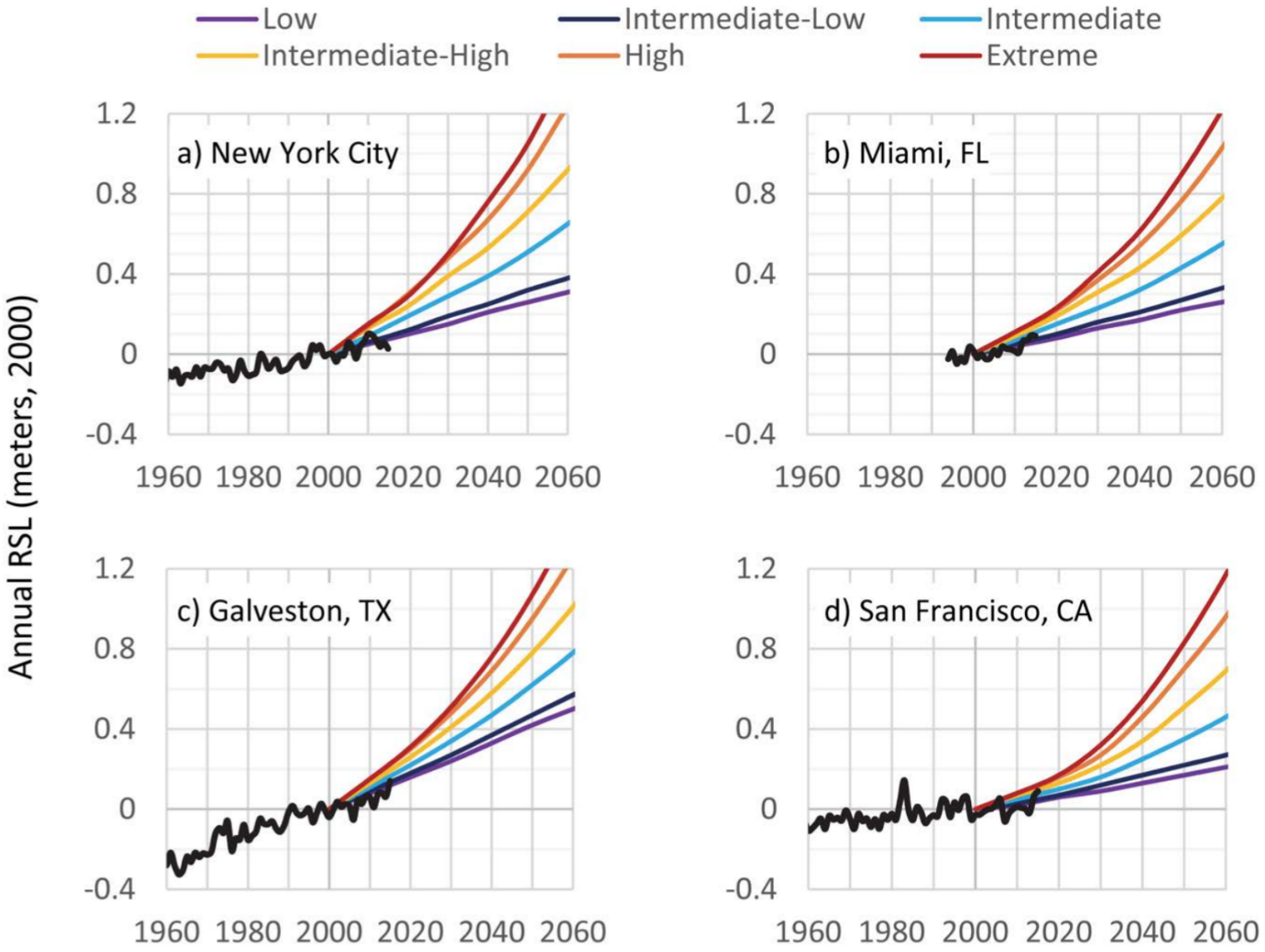
Relative SLR projections for the coast



NOAA (2017)

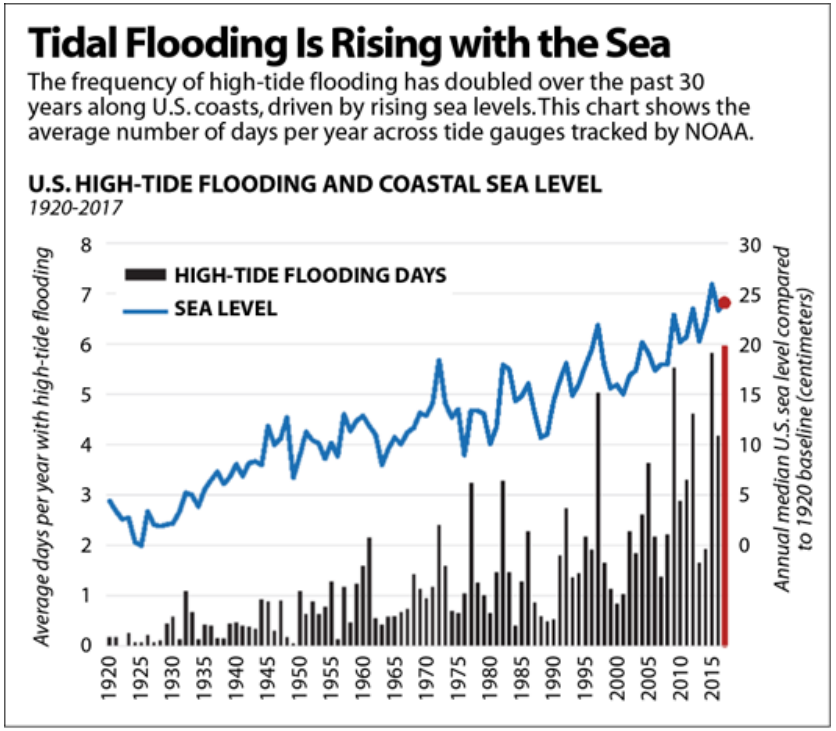
Figure 13. Total RSL change at 1-degree resolution for 2100 (in meters) relative to the corresponding (median-value) GMSL rise amount for that scenario. To determine the total RSL change, add the GMSL scenario amount to the value shown.

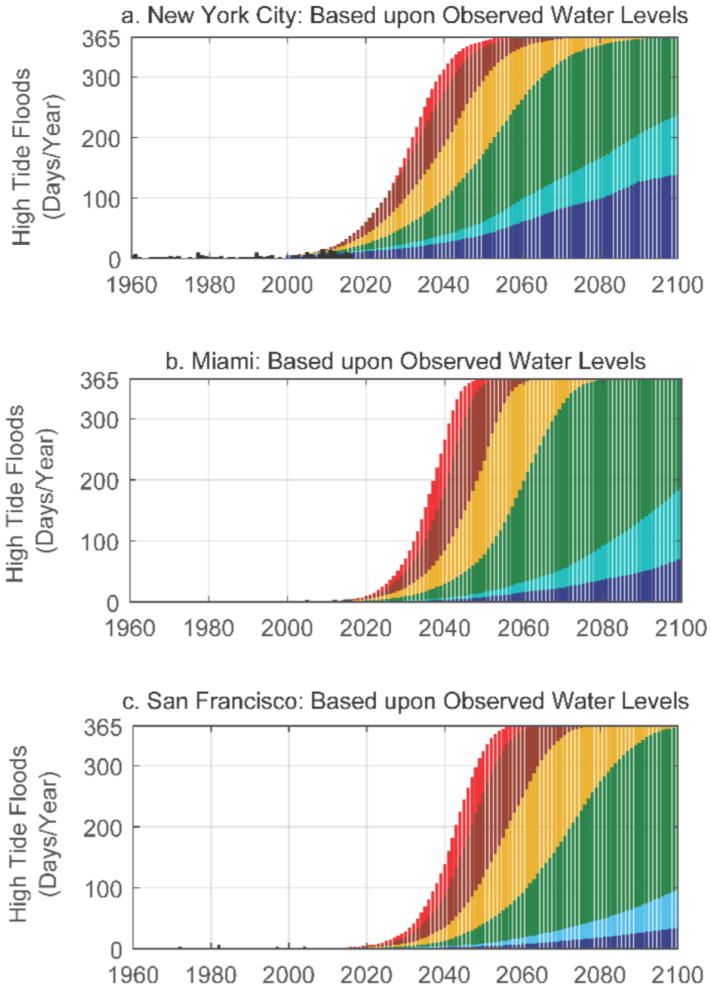
Relative SLR projections for the coast



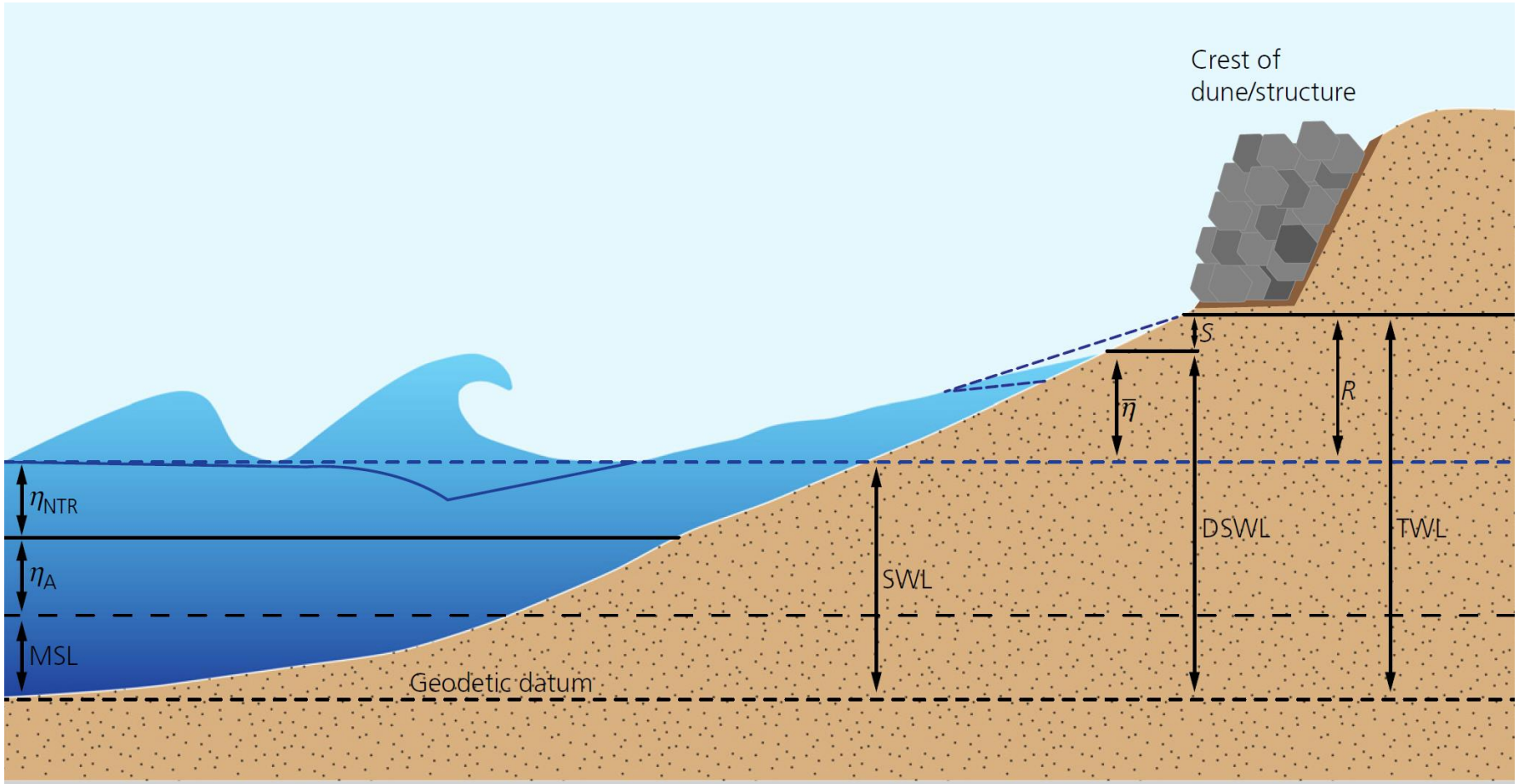
NOAA (2017)

Past/future nuisance flooding





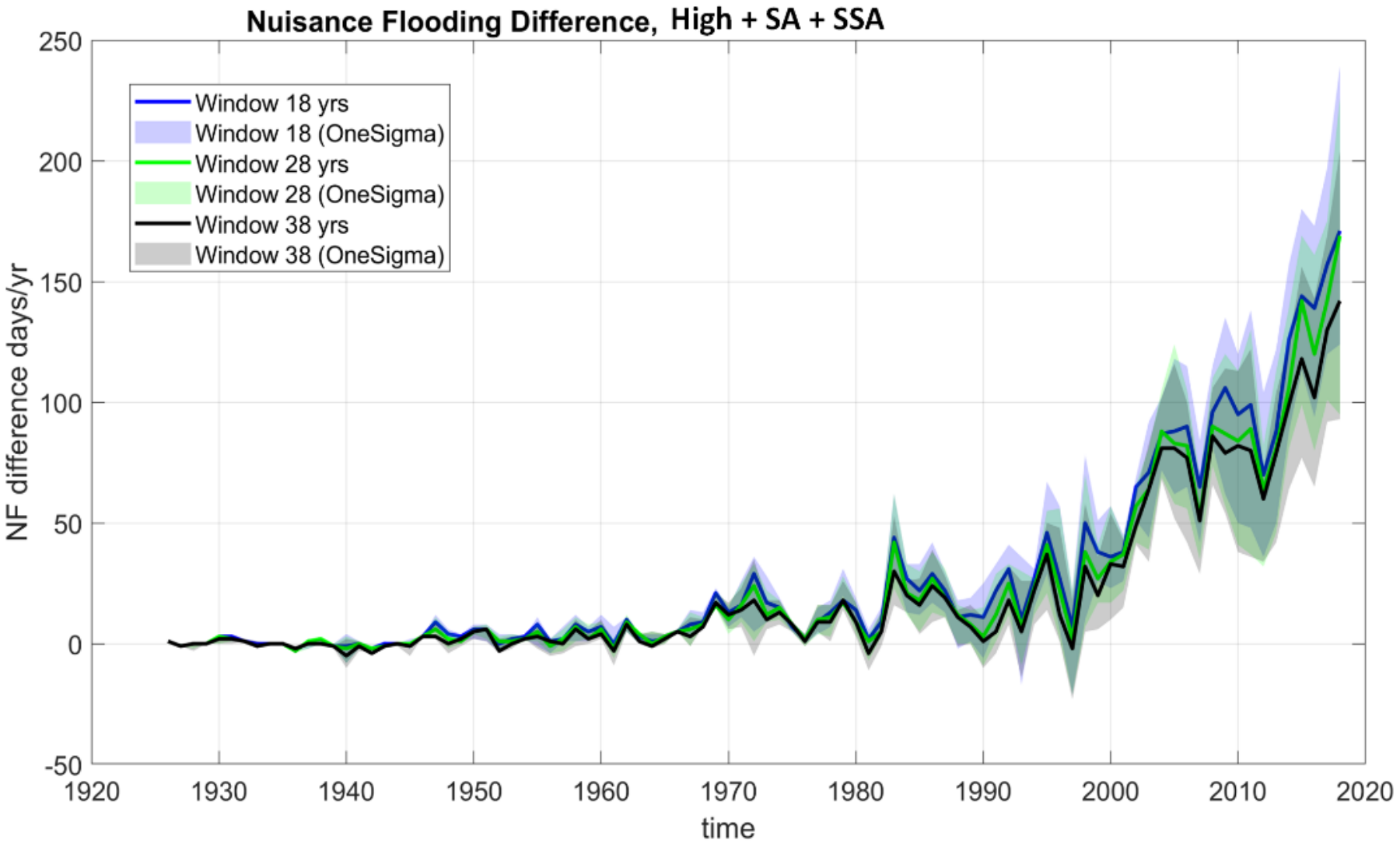
Other sea level components matter



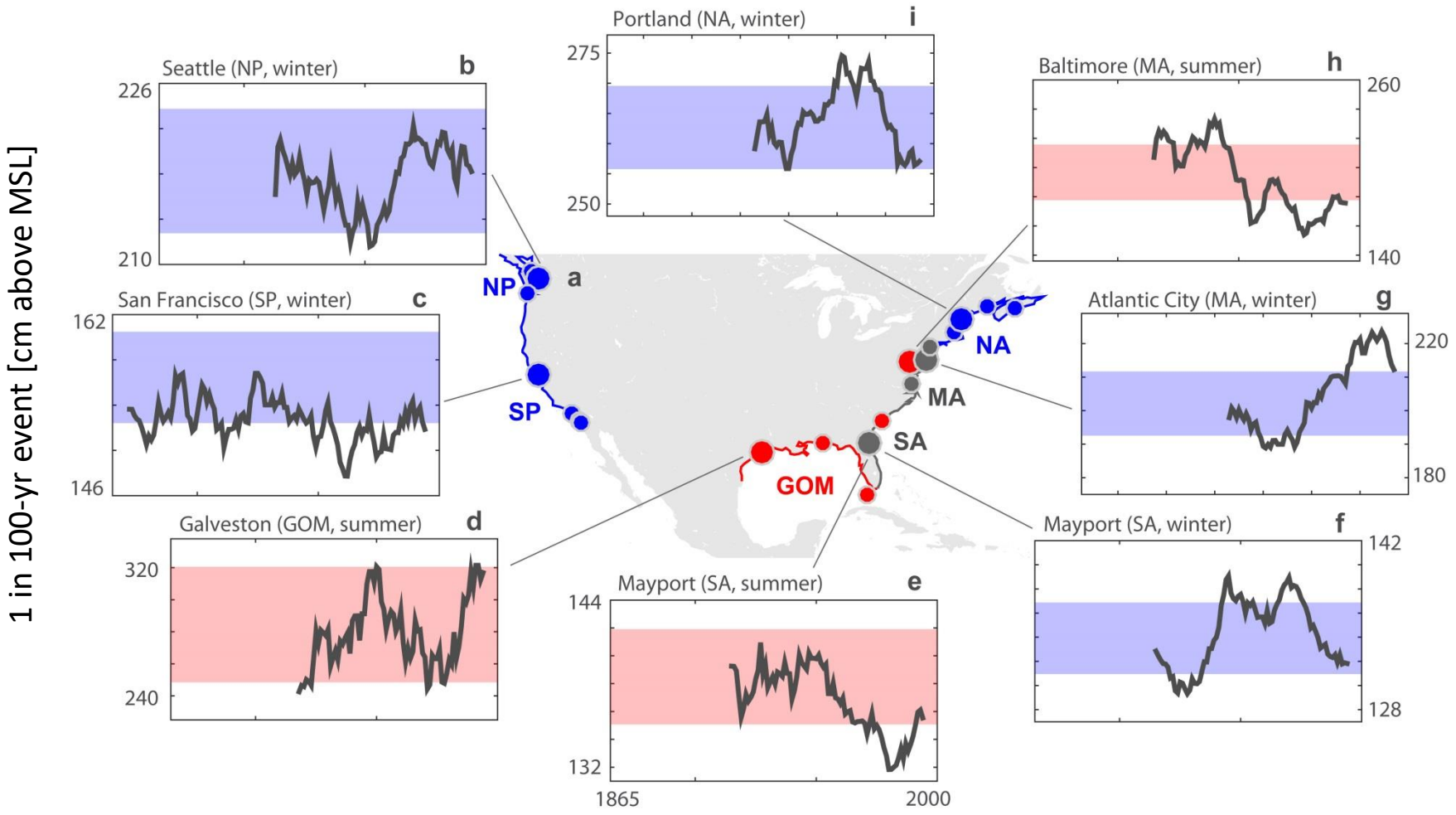
η_{NTR}	Non-tidal residual	MSL	Mean sea level	DSWL	Dynamic still water level
η_A	Astronomical tide	SWL	Still water level	R	Wave run-up
$\overline{\eta}$	Wave set-up	S	Swash	TWL	Total water level

Moritz et al. (2016)

Tidal changes vs nuisance flooding

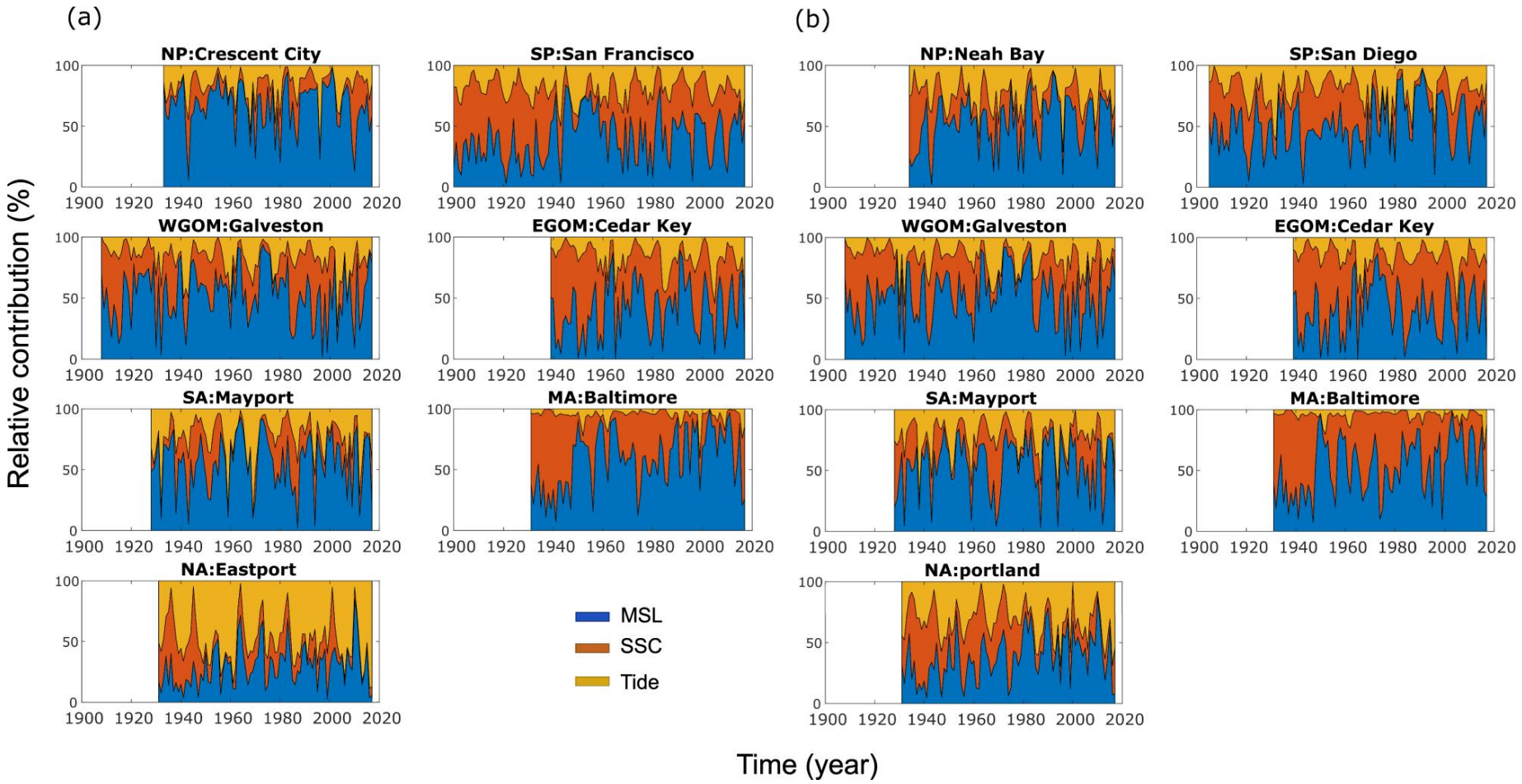


Temporal variability – storm surge



Wahl, T., Chambers, D.P. (2015). Evidence for multi-decadal variability in US extreme sea level records, *Journal of Geophysical Research Oceans*, 120, 1527–1544.

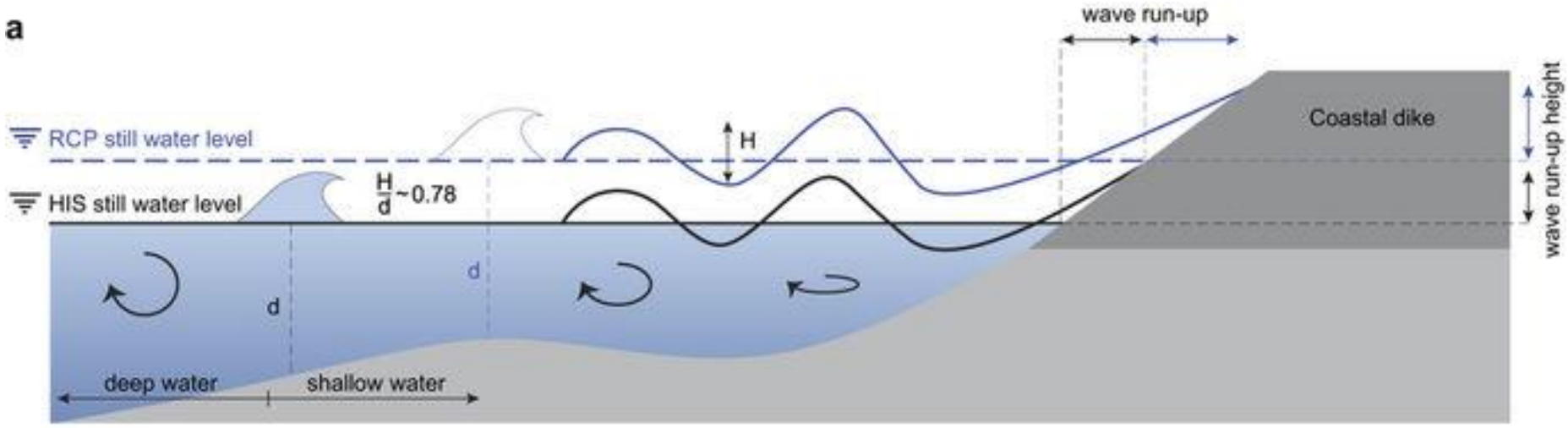
US extreme sea level indicator



Rashid, M.M., **Wahl, T.**, Chambers, D.P., Calafat, F.M., Sweet, W.V. (2019). An extreme sea level indicator for the contiguous United States coastline, *Nature Scientific Data,* 6, 326, doi:10.1038/s41597-019-0333-x.

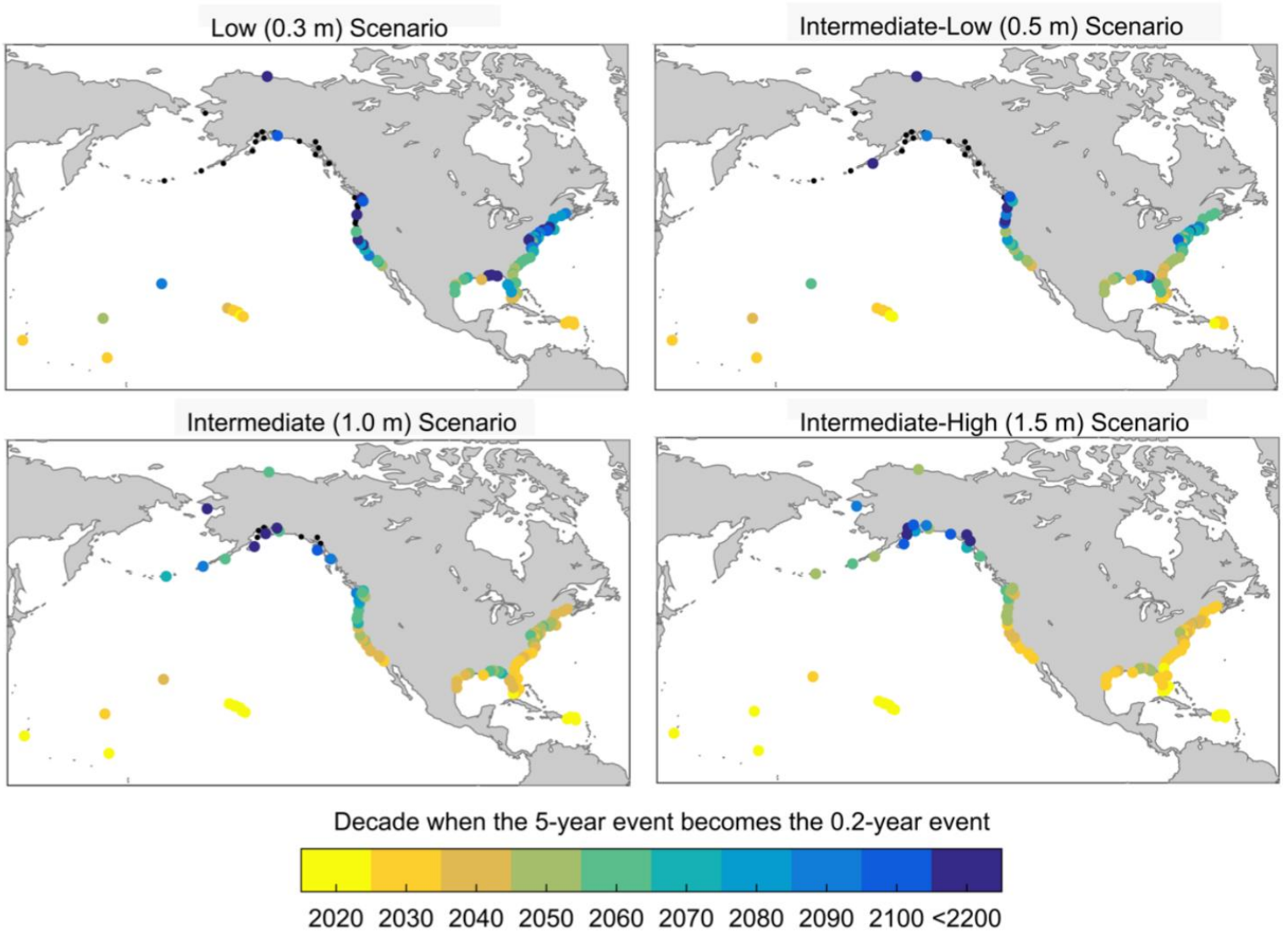
SLR vs waves

Sea level rise relaxes the breaking criterion, resulting in larger waves approaching the shore.



Arns et al., 2017

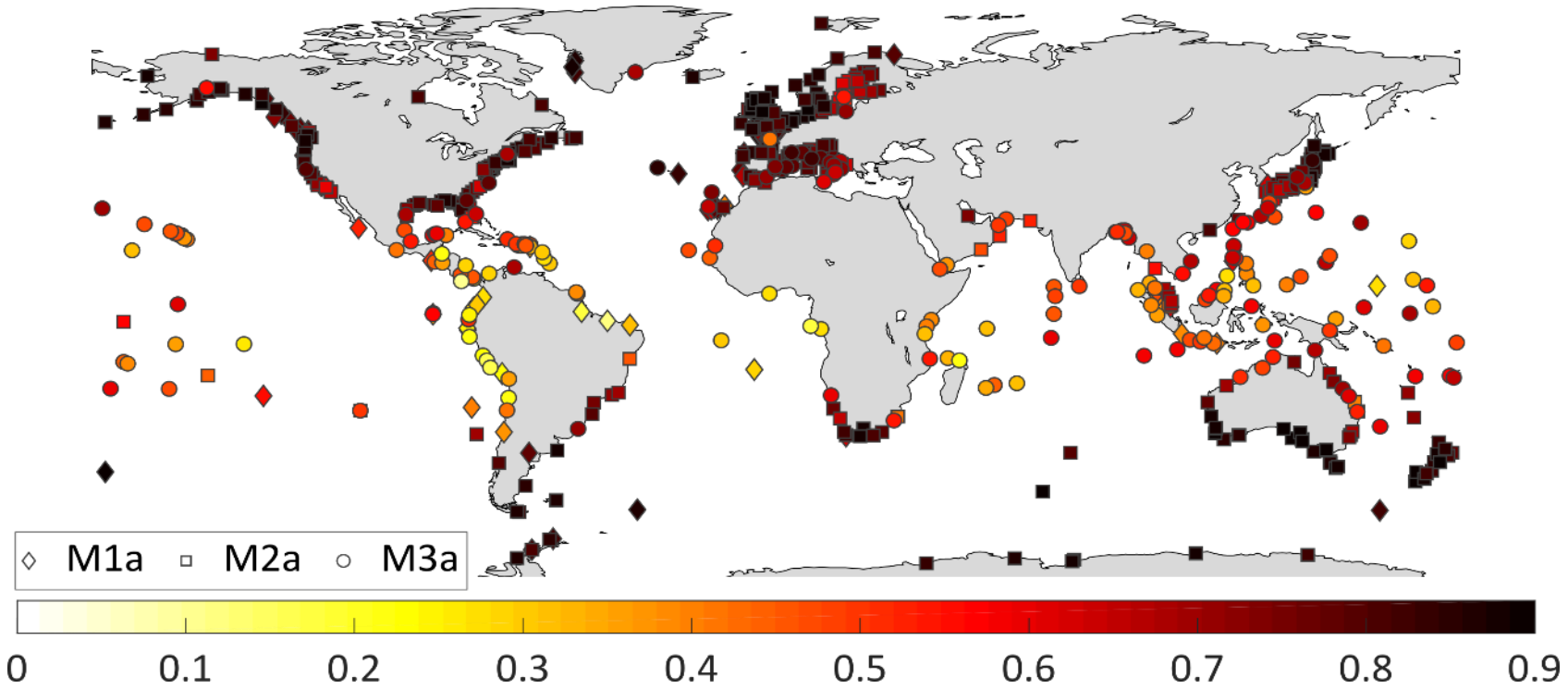
Storm surge flooding



NOAA (2017)

Storm surge flooding

For robust statistical analysis and we need long surge records, can statistical models/machine learning help?

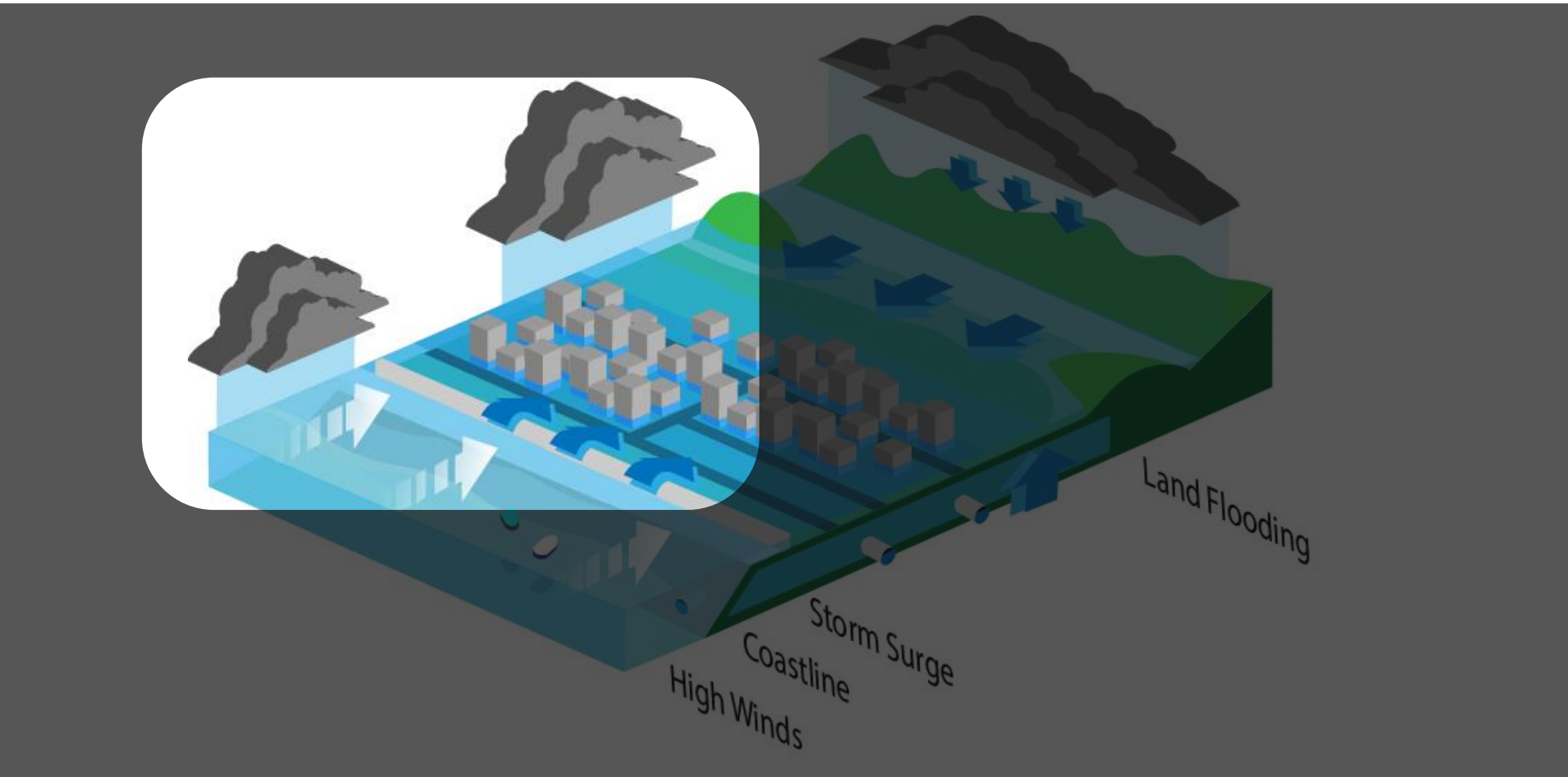


Correlation of modelled vs observed daily max. surge

Tadesse, M., **Wahl, T.**, Cid, A. (under revision). Data-driven modeling of global storm surges, *Frontiers in Marine Science*.

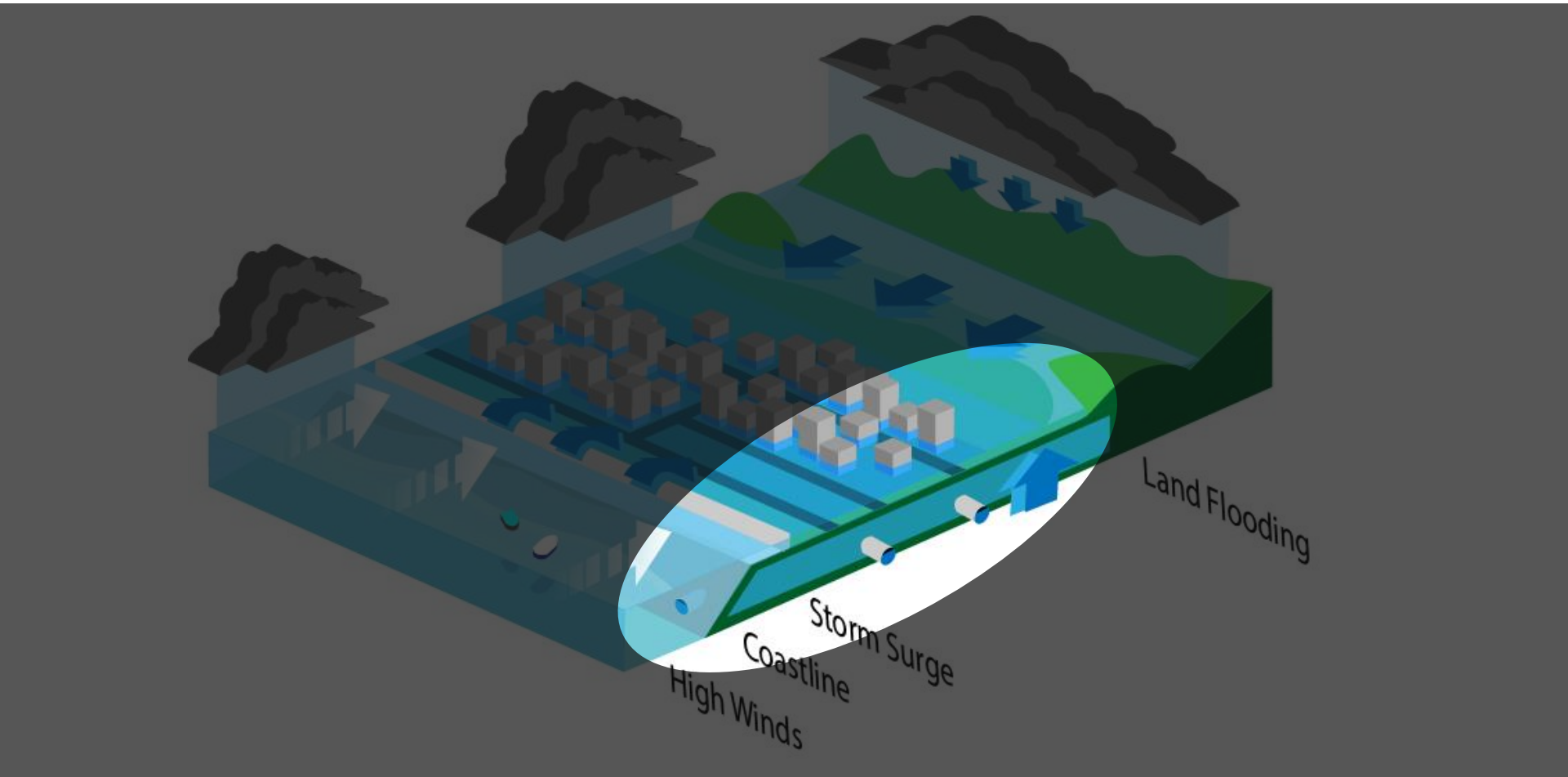
Compound flooding

1) Storm surge causes flooding, rainfall on top increases the impacts



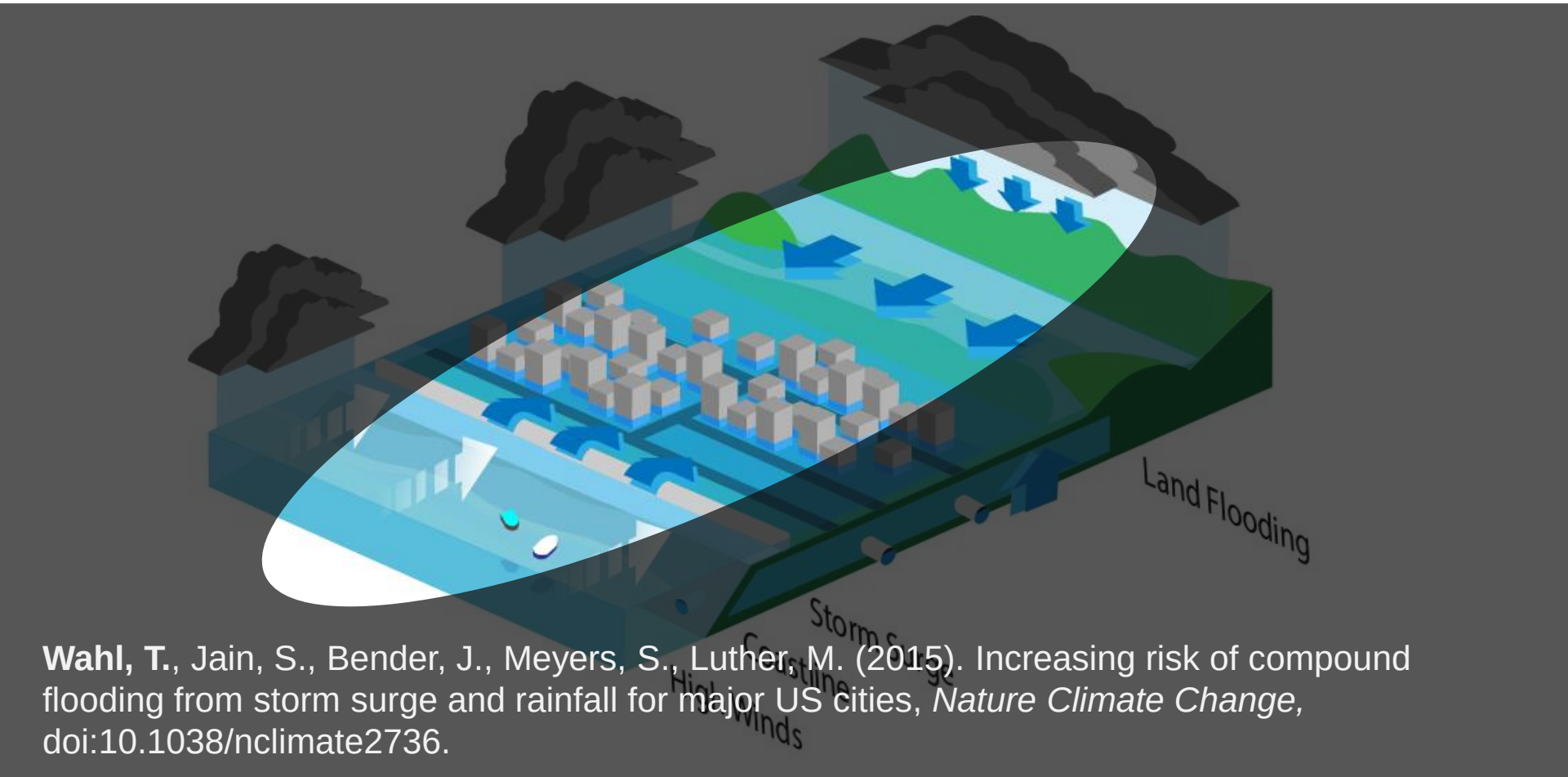
Compound flooding

1) Storm surge causes flooding, moderate rainfall on top increases the impacts
2) Moderate storm surge blocks drainage, heavy rainfall causes flooding



Compound flooding

1) Storm surge causes flooding, moderate rainfall on top increases the impacts
2) Moderate storm surge blocks drainage, heavy rainfall causes flooding
3) In estuaries/deltas storm surge interacts with river discharge

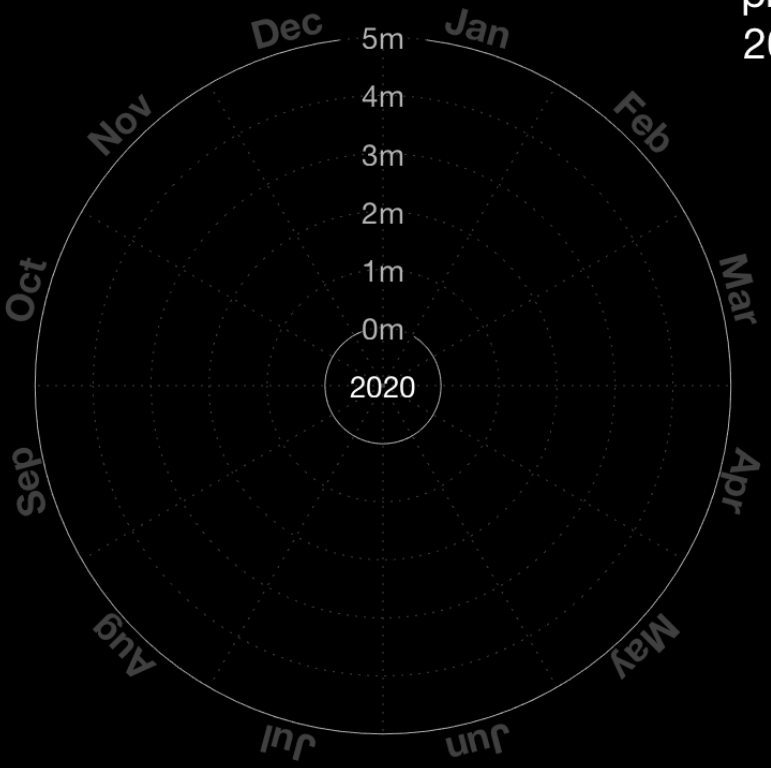


Wahl, T., Jain, S., Bender, J., Meyers, S., Luther, M. (2015). Increasing risk of compound flooding from storm surge and rainfall for major US cities, *Nature Climate Change,* doi:10.1038/nclimate2736.

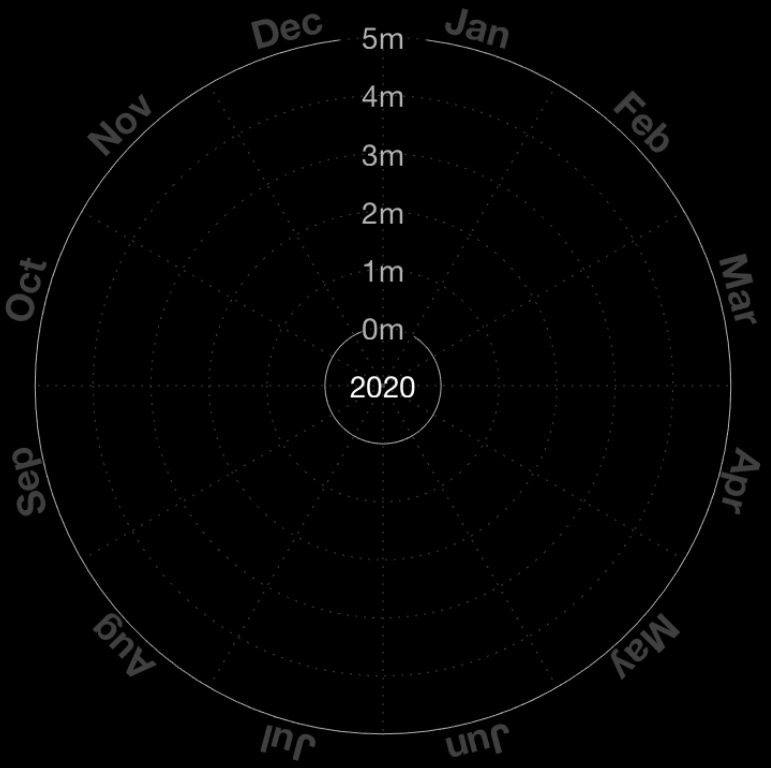
Odds are getting worse

Sea level projections 2020-2300

Paris Agreement 1.5 deg C



High emission scenario



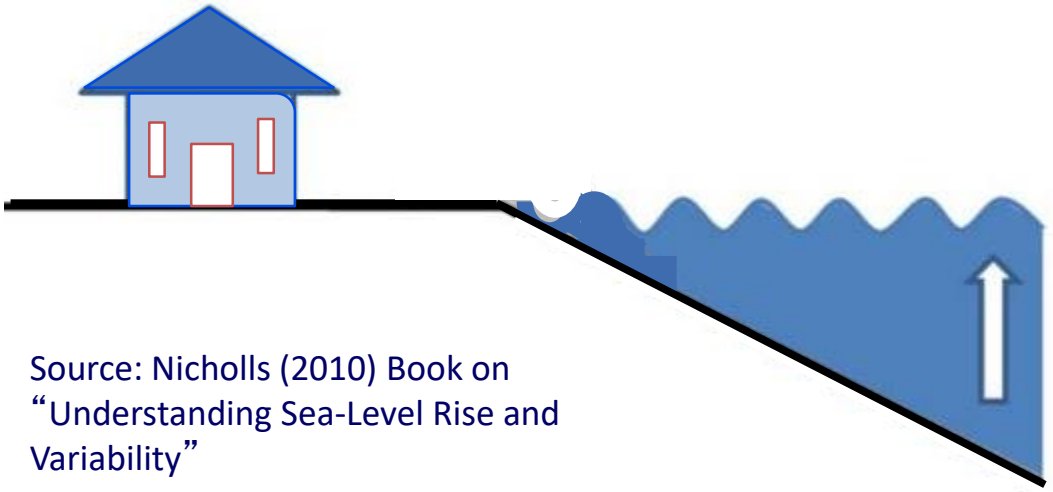
@ivanhaigh

Sea level projections from Goodwin et al. (2018), Earth's Future, 6(3), 601-615

Managing sea level rise impacts

Option 1: No active intervention

- no planned investment in defending against flooding or erosion
- cost benefit analysis doesn't justify the expense of building or maintaining defenses (i.e. farm land or for a few houses) on a natural coast with little development
- shoreline will continue to evolve naturally
- can also apply to areas that are currently defended but may not be defended in the future (may include an increased risk of flooding or coastal erosion)



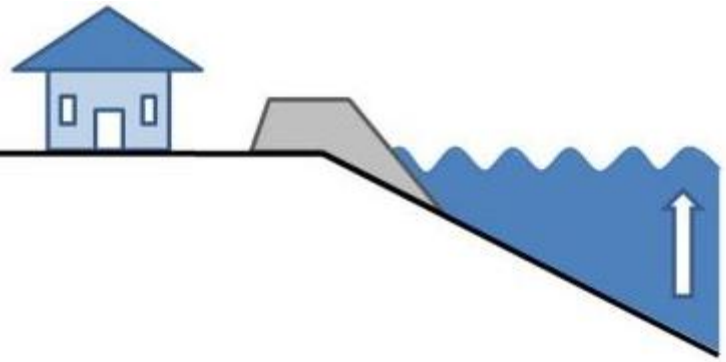
Source: Nicholls (2010) Book on "Understanding Sea-Level Rise and Variability"

http://www.islay.org.uk/2013/08/13/bagh-an-da-dhoruis-and-the-north-coast-of-islay/

Managing sea level rise impacts

Option 2: Hold the line

- build or maintain artificial defenses so that the position of the shoreline remains
- example is the Thames Barrier and associated defenses in London
- this approach is taken for all major coastal cities and settlements



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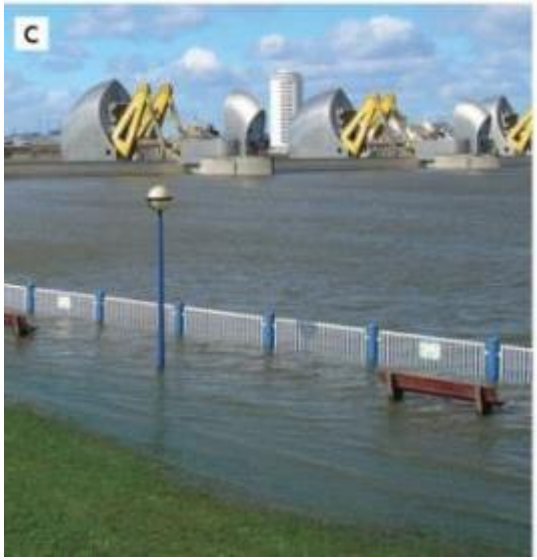


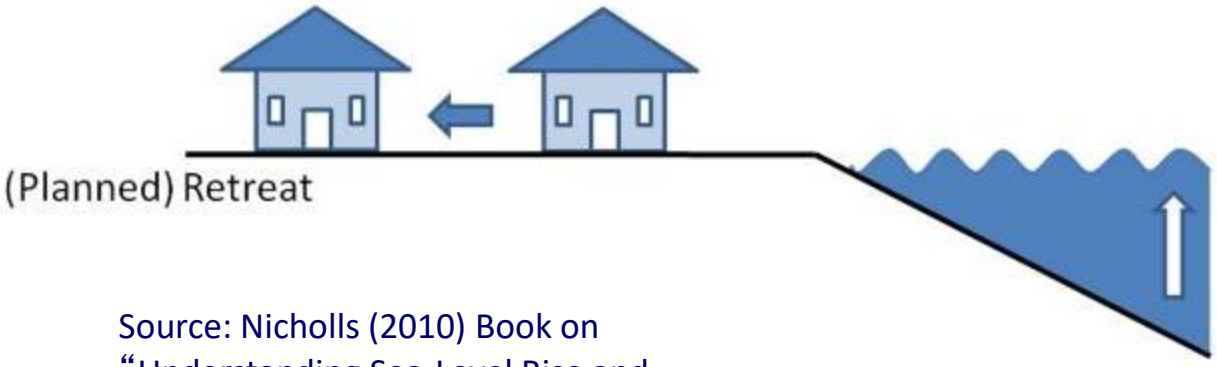
Thames Barrier
London

Maeslantkering
Netherlands

Managing sea level rise impacts

Option 3: Managed realignment

- allowing the shoreline to move naturally, but managing the process to direct it in certain areas
- done in low-lying areas (occasionally applied to cliffs)
- usually done where a cost benefit analysis doesn't justify the expense of building or maintaining defenses or near to areas of flood rise
- also known as 'managed retreat' or 'planned retreat'.

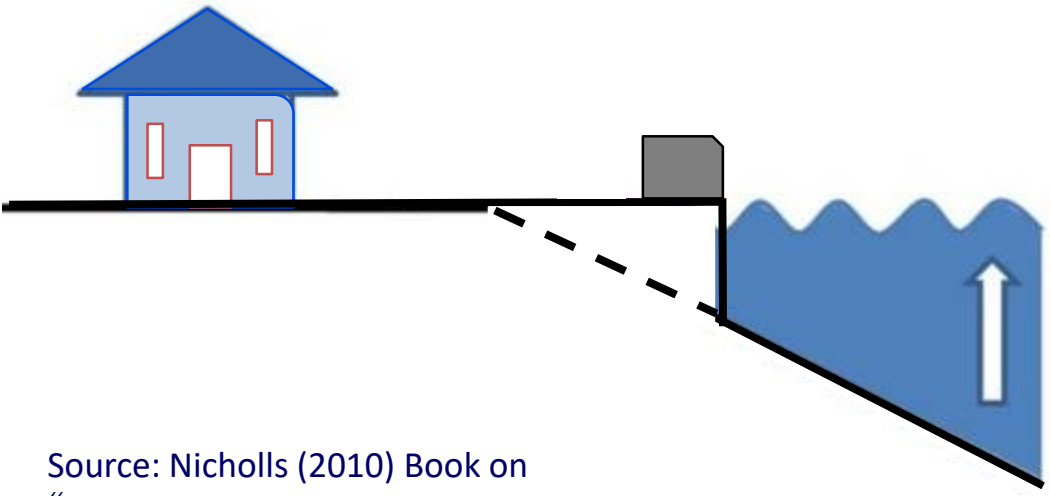


Source: Nicholls (2010) Book on "Understanding Sea-Level Rise and Variability"

Managing sea level rise impacts

Option 4: Advance the line

- new defences are built on the seaward side
- done where there is a shortage of land (i.e. Maldives, Singapore)
- extensively done in Dubai

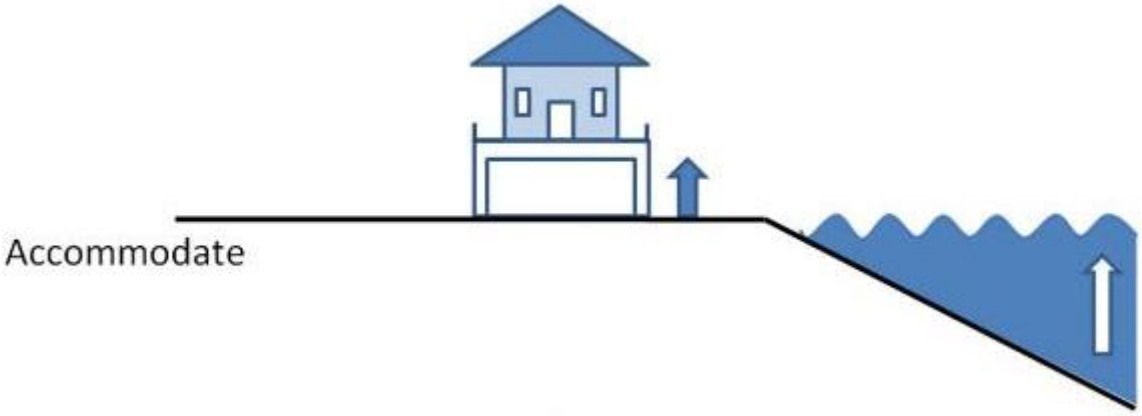


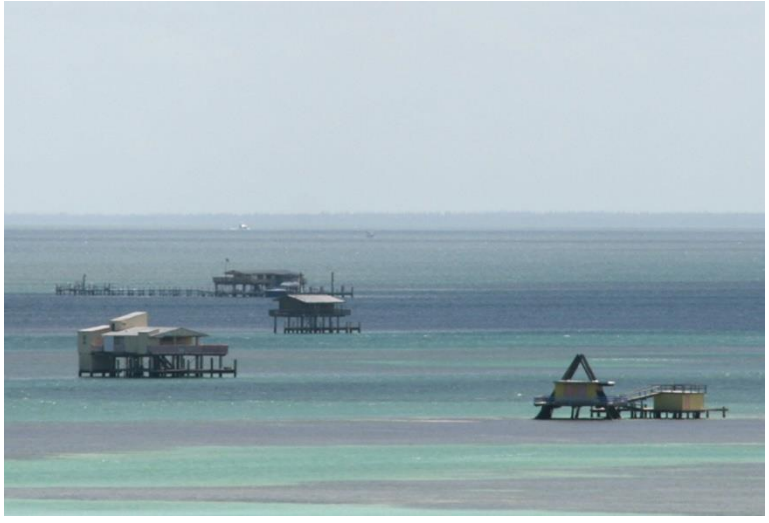
Source: Nicholls (2010) Book on "Understanding Sea-Level Rise and Variability"

Hulhumalé - Maldives

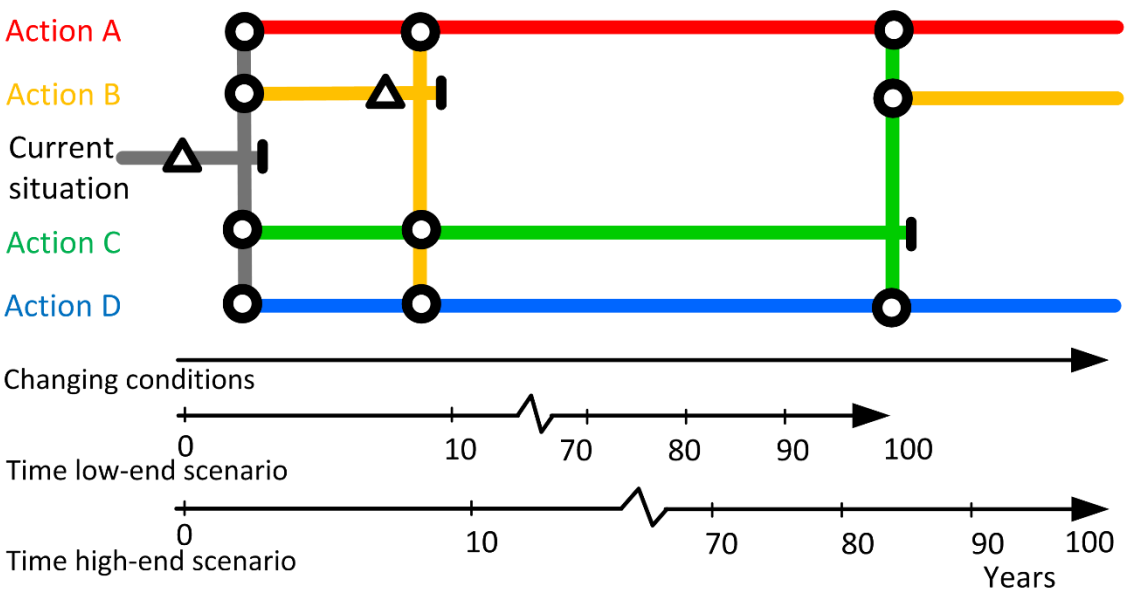
Managing sea level rise impacts

Another option is to ‘accommodate’. This can be done by raising houses or building floating houses.





Adaptation Pathways Map



Transfer station to new policy action

Adaptation Tipping Point of a policy action (Terminal)

Policy action effective

Decision node

Costs and benefits of pathways

Time horizon 20 years

Time horizon 50 years

Time horizon 100 years

Pathway	Costs	Benefits	Co-benefits
1	+++	+	0
2	+++++	0	0
3	+++	0	0
4	+++	0	0
5	0	0	-
6	++++	0	-
7	+++	0	-
8	+	+	- - -
9	++	+	- - -

Pathways that are not necessary in low-end scenario

Questions?