Impacts of Sea Level Rise on Compound Fluvial and Coastal Flooding

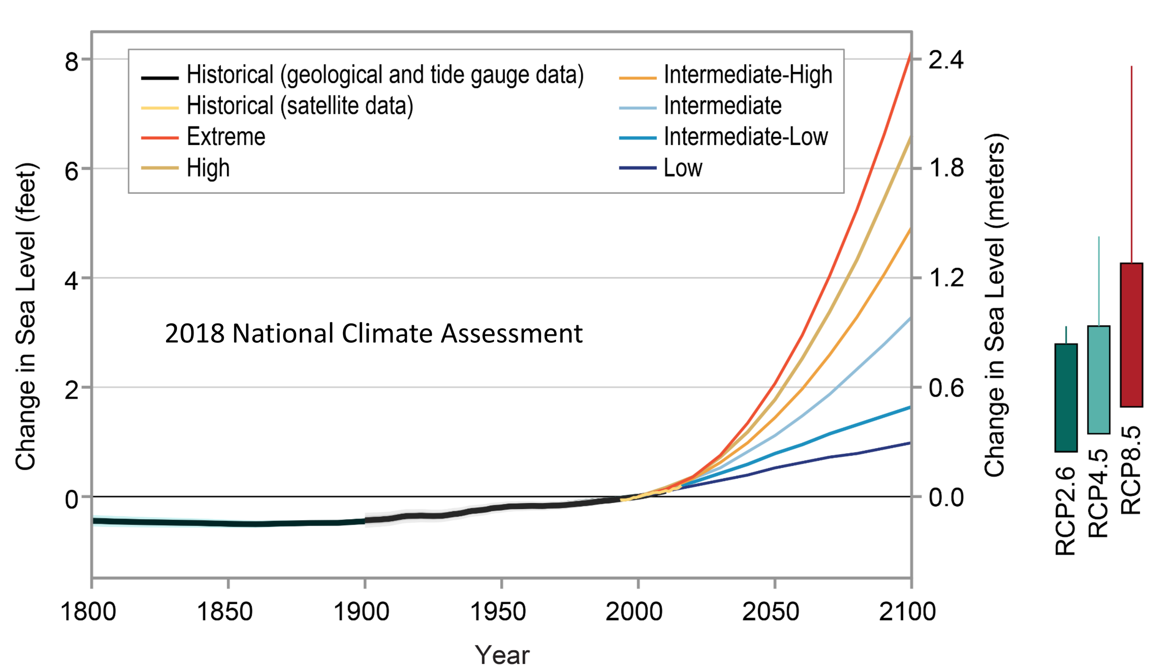
Mahshid Ghanbari[1], Mazdak Arabi[1],
Colorado State University, Civil and Environmental Engineering

H11M-1691

Introduction

Coastal cities are exposed to storm surge events from hurricanes as well as pluvial flooding (direct runoff) and fluvial flooding (increased river discharge) due to heavy precipitations → Compound flooding events.

Sea level has been rising from the 20th century and as a result of climate change, the rate of global mean sea level rise accelerate through 21st century.

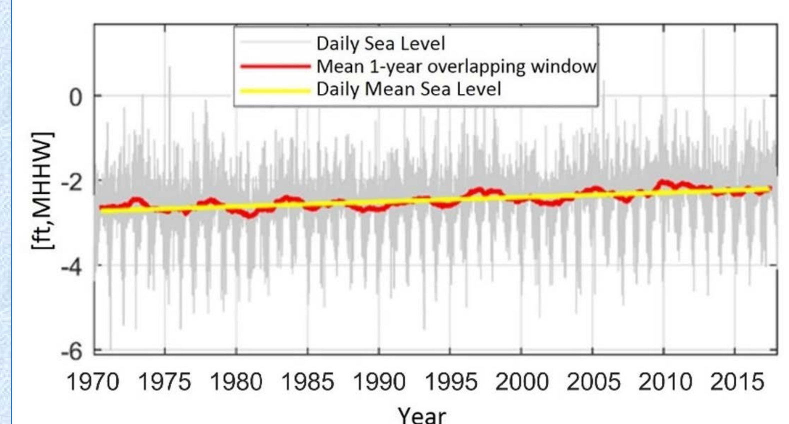


It is important to examine compound risk from coastal and fluvial/pluvial flooding with consideration of **impacts of sea level rise.**

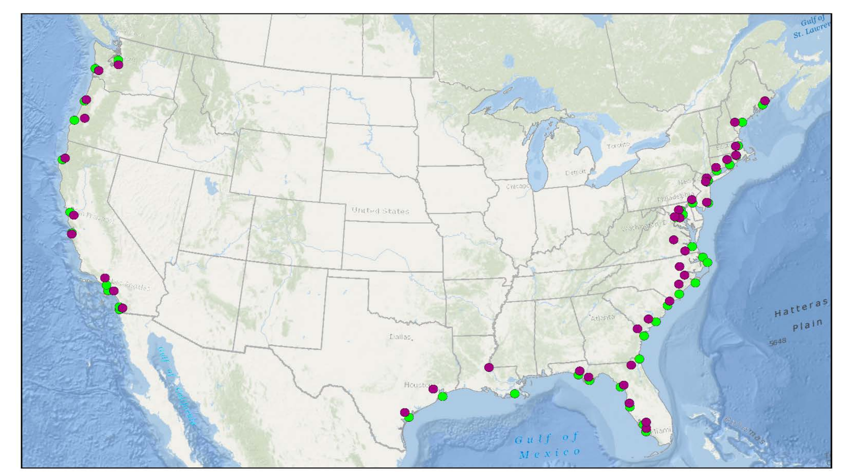
Objectives

- Develop a bivariate nonstationary flood hazard assessment that accounts for compound flooding from fluvial and coastal events with consideration of impacts of SLR.
- Estimate the future annual risk of compound coastal and fluvial flooding along the coastal U.S.

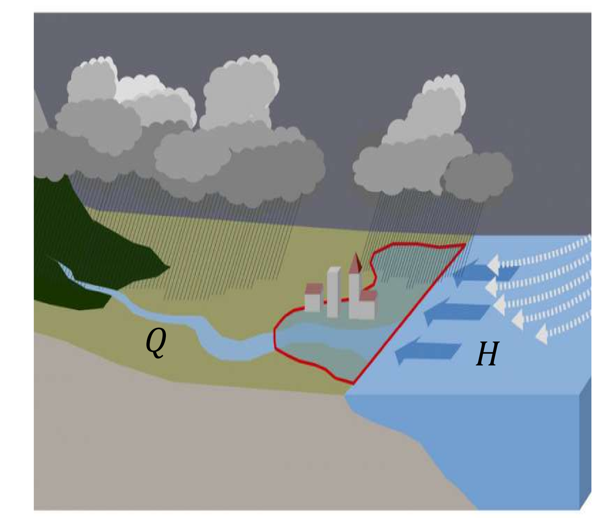
Materials and Methodology

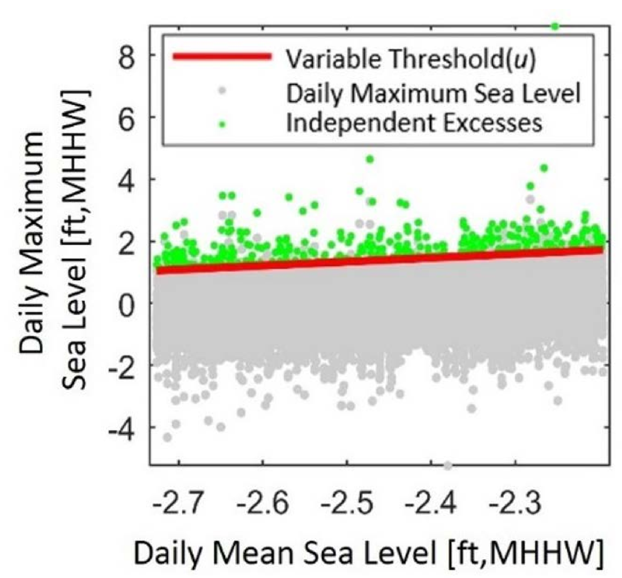


Daily mean sea level calculated using linear function fitted to the daily sea levels (Battery [NY] tidal station)



River stations Tidal stations





Variable threshold estimated using Quantile regression method and independent excesses over threshold (Battery [NY] tidal station)

The bivariate model should be applied only to the pairs of extreme values.

Extreme sea water level data are identified using peak over variable threshold method.

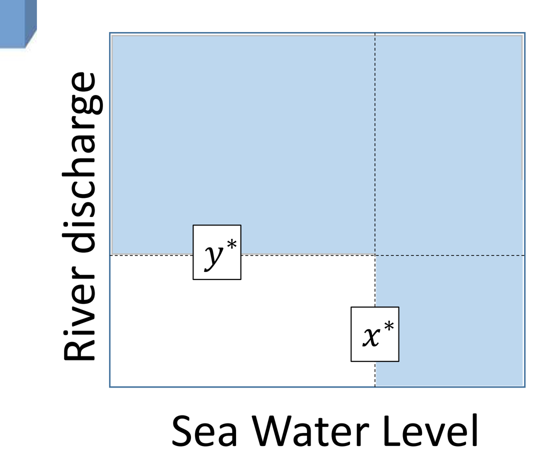
Extreme sea water level data are paired with the corresponding highest river discharge within ±1 days of these data.

$(H_{ext}, Q|H_{ext})$

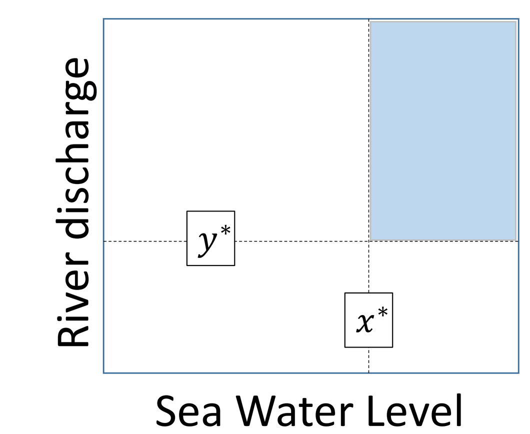
Copula Method

$$F_{XY}(x,y) = \Pr(X \le x, Y \le y) = C(F_{X_t}(x), F_Y(y))$$

Appropriate univariate distributions should be fitted to the marginals :
Nonstationary GPD for high sea water level data $F_{X_t}(x)$
Best fitted univariate distribution for river discharge data $F_Y(y)$



$$P_{OR} = 1 - C(F_X(x^*), F_Y(y^*))$$

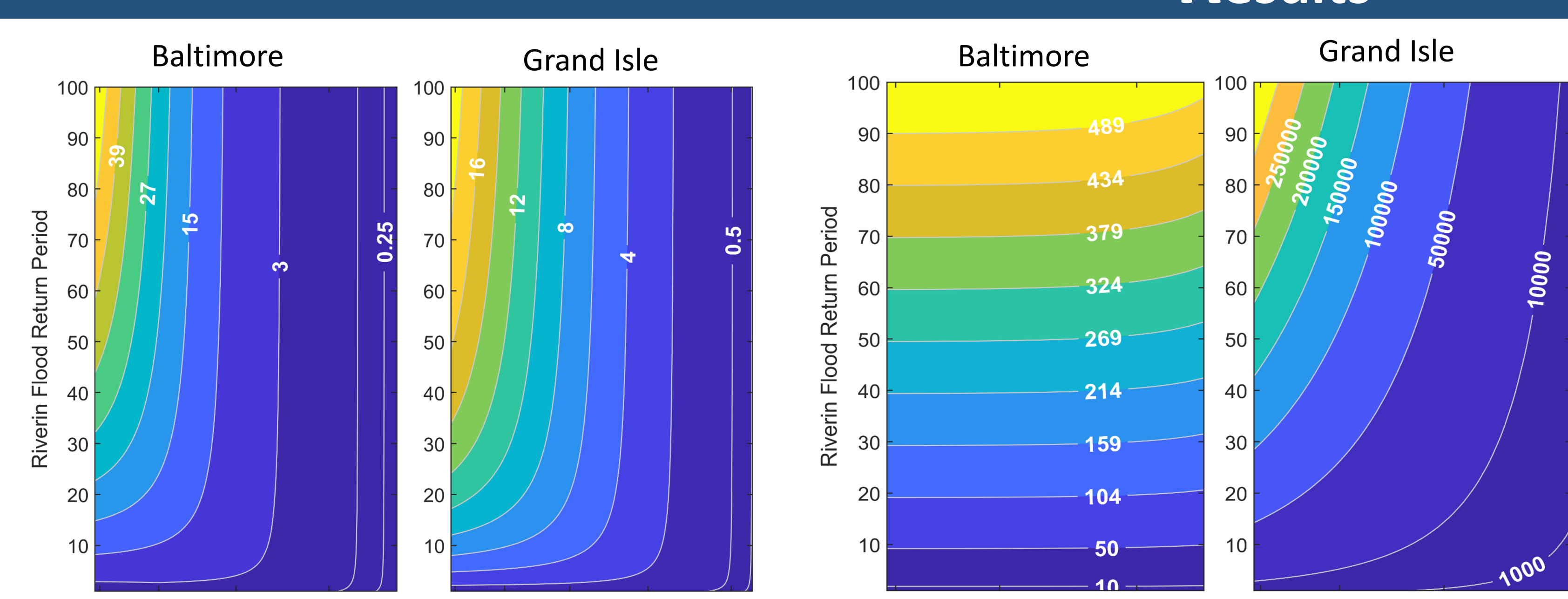


$$P_{AND} = 1 - F_X(x^*) - F_Y(y^*) + C[F_X(x^*), F_Y(y^*)]$$

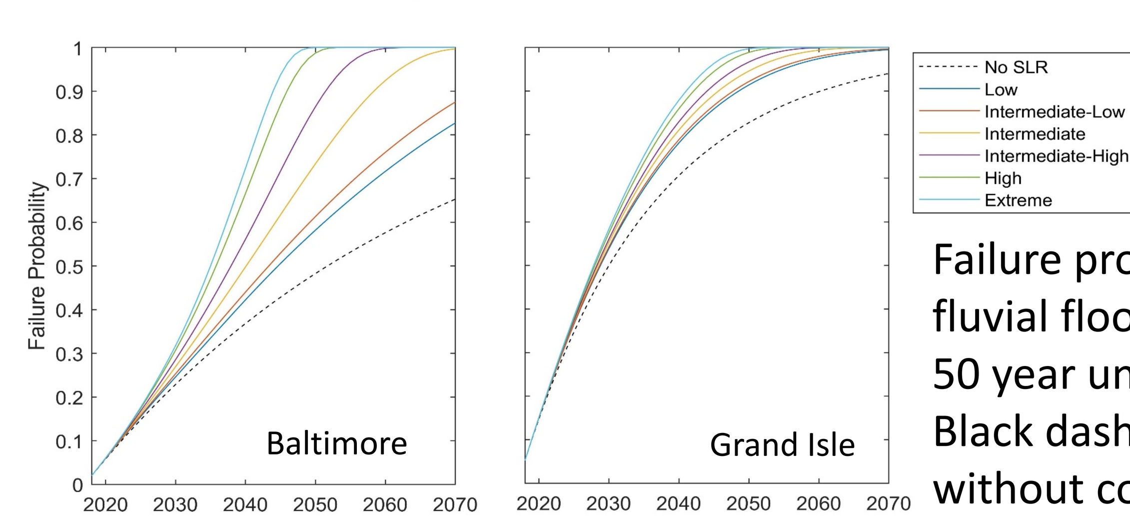
$$Failure\ Probabilty = 1 - C(F_X(x^*), F_Y(y^*))^n$$

$$Failure\ Probabilty = 1 - \prod_{t=1}^{n} (C(F_{X_t}(x^*), F_Y(y^*))$$

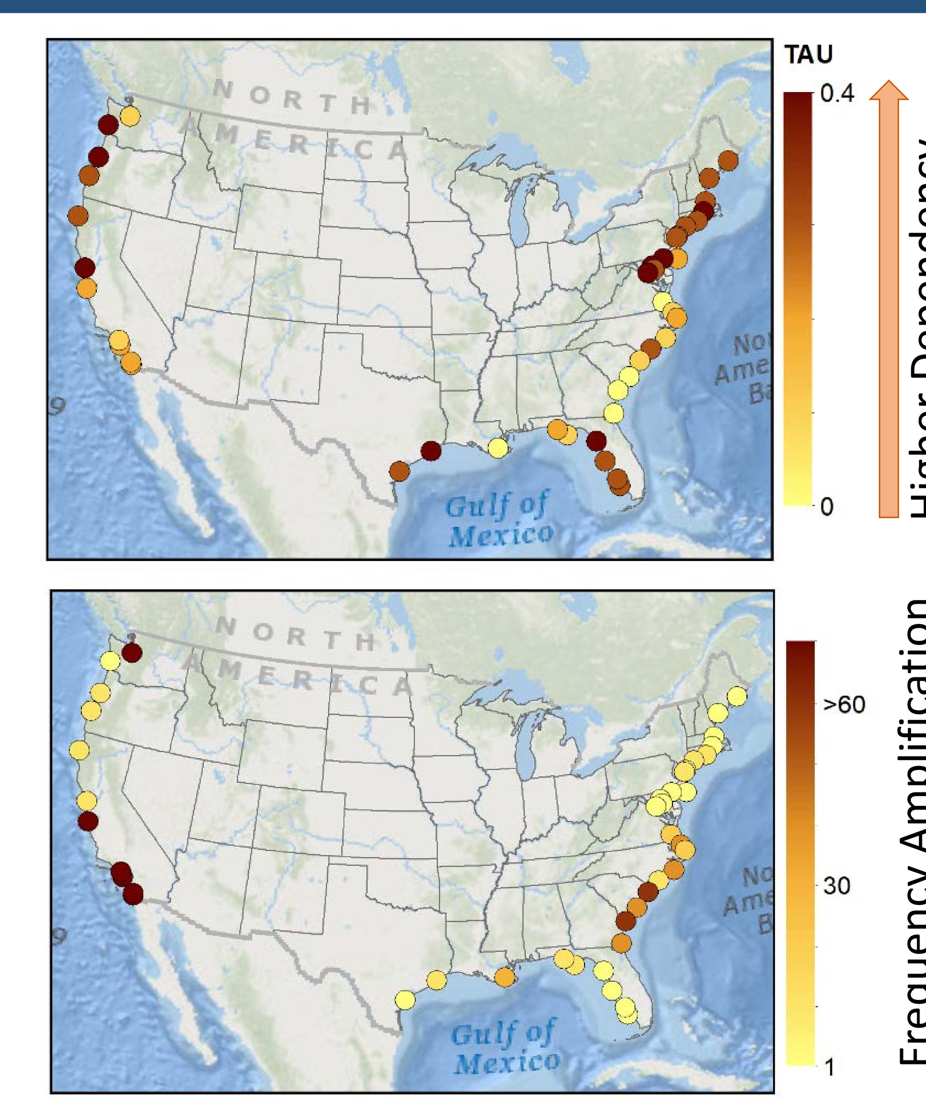
Results



Joint Probability of major coastal flooding and river flooding (Left) OR scenario (Right) AND scenario (Intermediate sea level rise scenario)



Failure probability due to major coastal or fluvial flooding for a temporal horizon of 50 year under 6 sea level rise projections. Black dashed line is failure probability without consideration of sea level rise.



(Up) dependence between extreme sea water level and river discharge$(H_{ext}, Q|H_{ext})$, (Bottom) Compound major coastal and fluvial flood frequency amplification (2050)

References

Ghanbari, M., Arabi, M., Obeyesekera, J., & Sweet, W. (2019). A coherent statistical model for coastal flood frequency analysis under nonstationary sea level conditions. Earth's Future, 7, 162–177.

Sweet, W. V., Kopp, R. E., Weaver, C. P., Obeyskera, J., Horton, R. M., Thieler, E. R., & Zervas, C. (2017). Global and regional sea level rise scenarios for the United States

Acknowledgment

This study is supported by NSF Sustainability Research Network (SRN) Cooperative Agreement 1444758.

ONE WATER SOLUTIONS INSTITUTE
NSF
UWIN