Characterizing the deep uncertainties surrounding coastal flood hazard projections: A case study for Norfolk, VA

Kelsey L. Ruckert[1], Vivek Srikrishnan[2], & Klaus Keller[1,2]

Earth & Environmental Systems Institute[1], Penn State University, University Park, PA, USA

Department of Geosciences[2], Penn State University, University Park, PA, USA

Contact: klr324@psu.edu

Problem

Many coastal communities are vulnerable to flooding from sea-level rise (SLR) and storm surge. However, designing risk management strategies based on flood hazard projections poses problems for coastal planners. Coastal planners face a potentially confusing array of flood hazard projections that can differ.

Research questions

- **What causes flood hazard projections to diverge?**
- **Which projection(s) should a coastal planner adopt for planning purposes?**

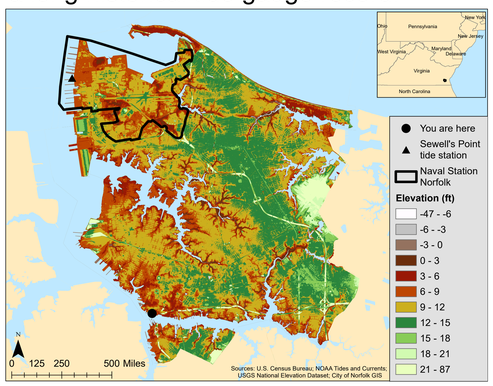
Why does this matter?

Hazard projections inform risk management strategies such as how high to build a levee or elevate a building. In Norfolk, a difference of < 1 ft in coastal flood estimates can be the difference of millions of dollars in potential damages[a].

Why Norfolk, VA?

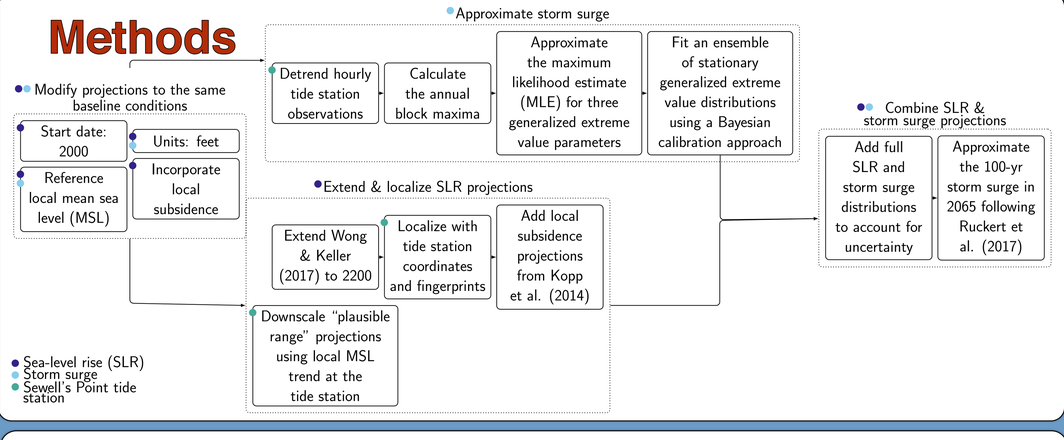
We study the city of Norfolk, VA because preparedness planning and risk management strategies are typically made on a local scale, and because Norfolk:

- is prone to impacts from SLR and flooding from high tides, heavy rainfall, and (extra-) tropical storms,
- is home to the world's largest naval base (Naval Station Norfolk), and
- has a long historical tide gauge record.



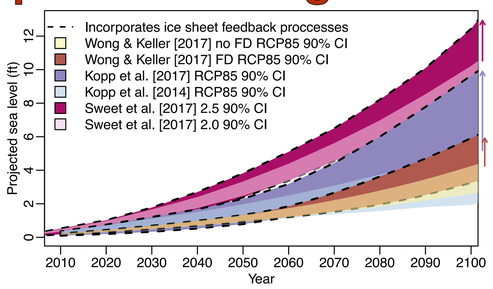
✦ This study can provide useful insights to the broader community interested in local coastal protection.

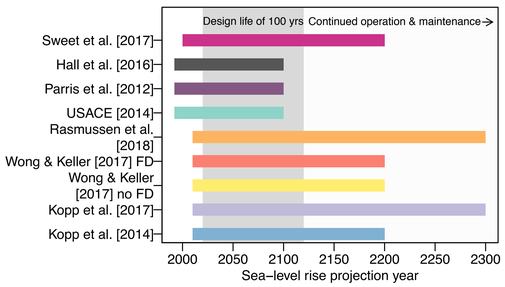
Methods



Ice-sheet dynamics & projection time can impact long-term adaptation strategies

Assumptions about **the complex behavior of ice sheets drive flood hazard diversity** and lead to a difference of roughly 1.7 - 4.5 ft by 2100 (comparing 95th percentiles).

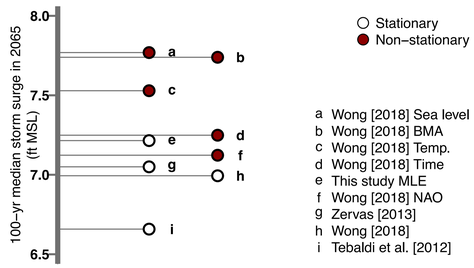




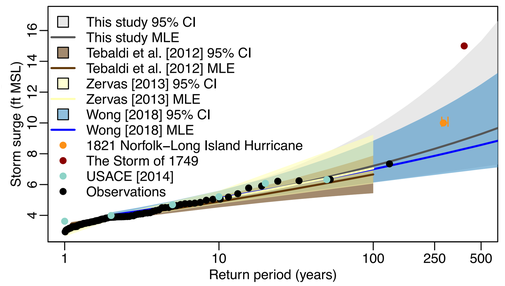
The design life (20 - 100 years) of **infrastructure built for long-term adaptation strategies** today **can exceed projection timescales**[b].

Considering storm surge information reveals overconfidence

Few studies resolve return periods past the 100-yr event, yet **critical infrastructure is suggested to be built to withstand the 500-yr event**[c,d] and past storms show these **rare events can and do occur.**

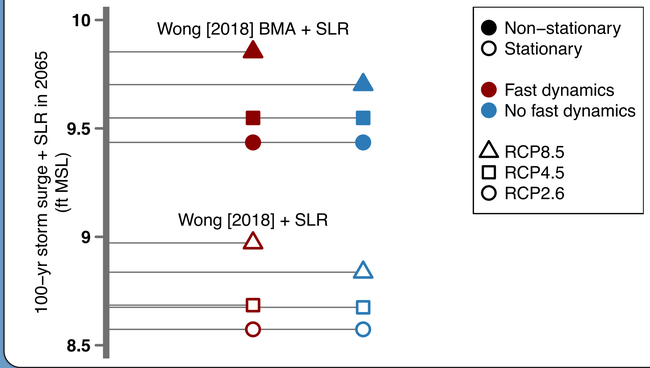


a Wong [2018] Sea level
b Wong [2018] BMA
c Wong [2018] Temp.
d Wong [2018] Time
e This study MLE
f Wong [2018] NAO
g Zervas [2013]
h Wong [2018]
i Tebaldi et al. [2012]



In 2065, almost all **non-stationary 100-yr storm surge values are up to 1 ft greater than the stationary storm surge values.**

Considering a single "best" estimate of local flood hazard projections can lead to poor outcomes



Key message

Scientists can improve how useful flood hazard projections are to informing risk assessments and coastal planning by:

- **representing complex ice sheet behavior,**
- **covering decision-relevant timescales beyond this century,**
- **resolving low probability storm surge events (e.g., the 500-yr event),**
- **considering that storm surge projections may deviate from the historical record, and**
- **communicating the considerable deep uncertainty**

References & Acknowledgements

a) Fugro Consultants, Inc. Lafayette river tidal protection alternatives evaluation. Tech. Rep. Fugro Project No. 04.8113009. Fugro Consultants, Inc. (2016). City of Norfolk City-wide Coastal Flooding Contract, Work Order No. 7. Retrieved from https://www.norfolk.gov/DocumentCenter/View/25170.

b) U.S. Army Corps of Engineers. Procedures to evaluate sea level change: Impacts, responses, and adaptation. Tech. Rep. ETL 1100-2-1, U.S. Army Corps of Engineers (2014). Retrieved from https://www.publications.usace.army.mil/Portals/76/Publications/EngineerTechnicalLetters/ETL_1100-2-1.pdf.

c) U.S. Army Corps of Engineers. Final integrated City of Norfolk coastal storm risk management feasibility study / environmental impact statement. Tech. Rep., U.S. Army Corps of Engineers (2018). Retrieved from https://usace.contentdm.oclc.org/utils/getfile/collection/p16021coll7/id/8557.

d) FEMA. Making critical facilities safe from flooding. In Design guide for improving critical facility safety from flooding and high winds, 1–102 (Risk Management Series, Washington, DC, USA, 2007). FEMA 543.

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