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Projected changes to the hydroclimate in the Pacific Northwest and implications for coastal hazards and compound flooding

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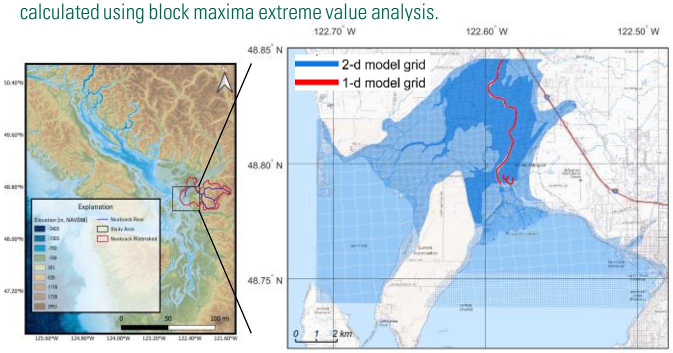
1. Introduction

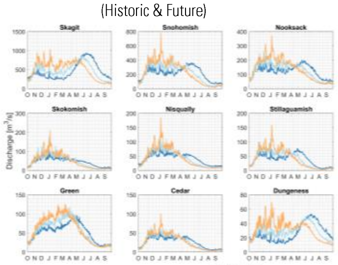
- Higher winter streamflow's coupled with rising seas across the Pacific Northwest, are expected to threaten low lying coastlines and floodplains of the Salish Sea (Snover et al., 2019).
- We developed a model to evaluate the extent that compound flooding associated with recent 10-yr and 25-yr floods on the Nooksack River near Bellingham, WA will change under the RCP 8.5 GHG emissions scenarios in the 2040s and 2080s.
- An assessment of flood exposure accounting for higher sea level and stream flooding with and without identified engineered floodplain alternatives show potential benefits of projected extreme water levels for planning and how habitat restoration can reduce flood exposure (depth and time) in the future.

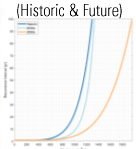
2. Methods

A Delft3D Flexible Mesh model was constructed for the lower Nooksack River extending from Ferndale, WA into Bellingham Bay using a 1D network of grid cells in the mainstem of the river and an unstructured 2D mesh covering the floodplain and marine waters. The model was calibrated and validated against observed water levels at 3 site in the Nooksack River and 1 in Bellingham Bay. Ensemble mean and daily flows from 1950 – 2099 (Chegwidden et al., 2017) were computed for the Nooksack River and extreme flow statistics for three-time frames (historic, 2040s, 2080s) from 10 different GCMs and 4 different hydrology models. Extremes were calculated using block maxima extreme value analysis.



The *mean* and *maximum* change in the 10-yr and 25-yr stream flow along with the 50% and 1% probabilistic SLR projections from the WCRP (Miller et al., 2018) were simulated with and without identified Nooksack Floodplain Integrated Planning (FLIP) engineering alternatives.





References

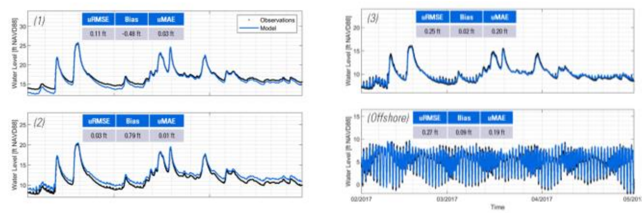
Chegwidden, O. S., B. Nijssen, D. E. Rupp, P. W. Mote, 2017: Hydrologic Response of the Columbia River System to Climate Change [Data set]. Zenodo. doi:10.5281/zenodo.854763.

Miller, I.M., Morgan, H., Mauger, G., Newton, T., Weldon, R., Schmidt, D., Welch, M., Grossman, E. 2018. Projected Sea Level Rise for Washington State – A 2018 Assessment. A collaboration of Washington Sea Grant, University of Washington Climate Impacts Group, University of Oregon, University of Washington, and US Geological Survey. Prepared for the Washington Coastal Resilience Project. updated 07/2019

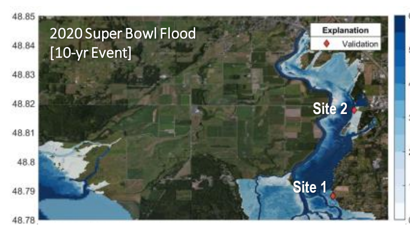
Snover, A.K., C.L. Raymond, H.A. Roop, H. Morgan, 2019. No Time to Waste. The Intergovernmental Panel on Climate Change's Special Report on Global Warming of 1.5°C and Implications for Washington State. Briefing paper prepared by the Climate Impacts Group, University of Washington, Seattle. Updated 02/2019.

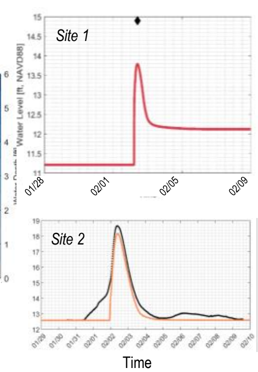
3. Results

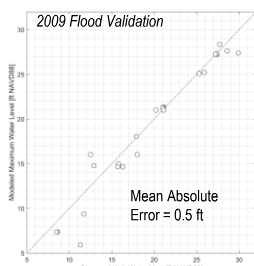
Validation showed an average uRMSE of 0.17 ft across the 4 stations over a three-month period in 2017 when detailed observations were made.

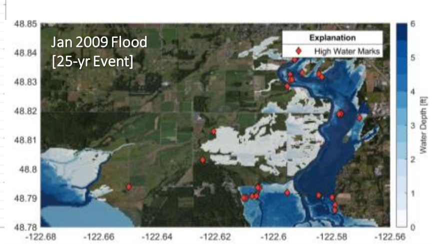


The model showed high skill in simulating the 2020 Super Bowl Flood, a 10-yr stream flood event and the January 2009 Flood, a 25-yr stream flood event. Modeled flood extent and flood depth agreed well with aerial imagery, GPS surveys of flooded area, and measured flood depths. Based on the GEV analysis, we found the 10-yr river flood is expected to increase in magnitude by 20%, 32%, 52%, and 72% for the 2040 mean and max scenarios and the 2080 mean and max scenarios, respectively.

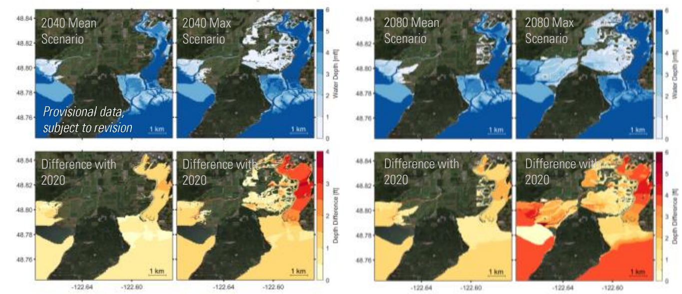




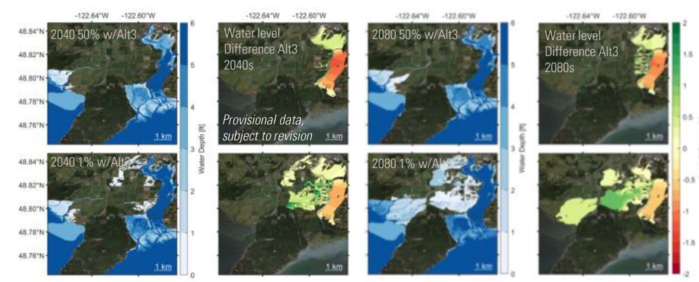




The model indicates that a significant portion of the western floodplain will be under water in the 2040s and 2080s during a 10-yr flood relative to today. 25% and 50% of the western floodplain is expected to be flooded by at least 1′ of water for the maximum 2040s and 2080s scenario. The average scenarios for the 2040s and 2080s showed 6% and 13% of the floodplain will be inundated with water greater than 1′ deep.



The proposed alternative design (Alt3) showed an overall net benefit in reducing river stage during a 10-yr flood today by 1.9 ft and up to 0.5 ft through all scenarios in 2040s and 2080s. Alt3 reduced the exposure of the west floodplain to flooding today and to 7% of the area for the 2040 scenarios and the 2080 average scenario. For the 2080 maximum scenario Alt 3 reduced the flooded area of 1′ or greater from 59% to 39% and for areas deeper than 3′ from 16% to 3%.



4. Conclusion

A new compound flood model indicates that projected changes in stream flow and sea level position will have significant impacts on the lower Nooksack River. Model results indicate that much of the western floodplain will be inundated with flood waters towards the later half of the century with nearly 50% expected to be underwater from a 10-yr river flood, assuming a maximum change scenario. Mitigation efforts, however, are assessed here to be beneficial in reducing the stage in the Nooksack River as well as flood extents and depths across the west floodplain important to valued land uses and ecosystem functions. The proposed floodplain alternative design helps mitigate flood hazards rerouting flood waters across the eastern floodplain proposed for wetland and wildlife habitat restoration. It is important to note that these results assume a static river and delta bathymetry, and results not shown indicate potential significant sediment aggradation to occur in response to the higher stream flows and sea level rise. Next steps for the modeling are to include morphologic change to assess sediment effects.

5. Contact

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