

Modeling Flood Risk in the Portland, OR Metro Area

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Overview

- Research Questions
- February 96 Flood
- Scenario Development
- Model Development
- Results
- Conclusions

http://www.travelandleisure.com/travel-guide/portland-oregon

Research Questions

- What is the current vulnerability of flood risk along the mainstem of the Willamette River
- Where are the areas of peak vulnerability and what are potential damages with changes in flood inundated areas under different scenarios
- How do flood water level and spatial extent of floods shift under different flow and sea level rise scenarios?

Scenario Development

Ocean Studies Board and National Research Council projects up to 0.5 -1.4m Sea-Level Rise by 2100

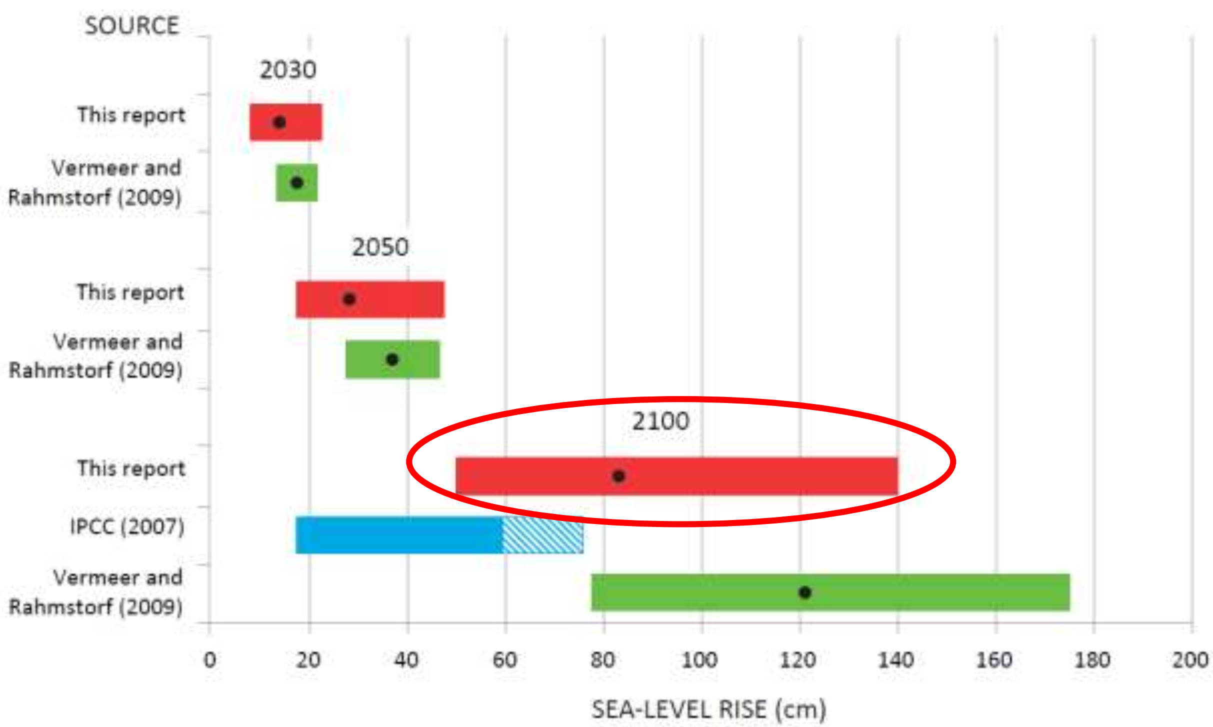
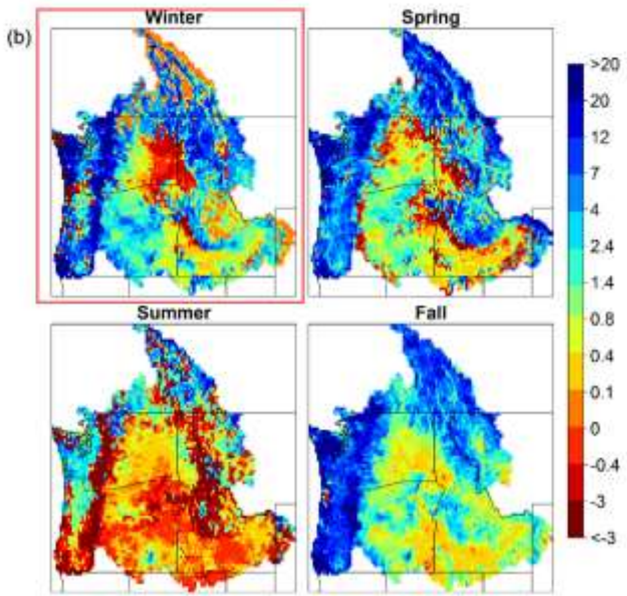


FIGURE 5.6 Global sea-level rise for 2030, 2050, and 2100 projected by this committee (red), Vermeer and Rahmstorf (2009; green), and IPCC (2007; blue). The dots are the projected values and the colored bars are the ranges. The IPCC value includes the sea-level projection (blue) plus the scaled-up ice sheet discharge component (blue diagonal lines).

Taken from *Board, O.S. and National Research Council* [2012]

Scenario Development



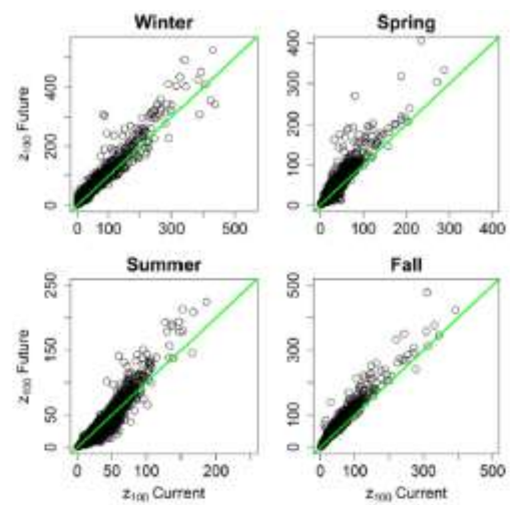


Fig. 8. Bayesian model average results of the estimated 100-year return level runoff (in mm) obtained from the hierarchical Bayesian model for the current versus future time periods; circles are representing the 6392 grid cells in the Columbia River basin.

Future climate projections show ~10% increase in Winter 100-yr return level run-off

Table 2
Calculated scaling factors based on the linear regression model of the future (Y) and historical (X) simulations.

Season	Mean	2.5% CI	97.5% CI
Winter	1.112	1.1	1.118
Spring	1.31	1.3	1.32
Summer	1.051	1.044	1.058
Fall	1.242	1.237	1.248

Future – historical of 100-yr return level run-off [mm].
***Najafi & Moradkhani* [2015]**

Future vs historical run-off for 100-yr return level runoff
***Najafi & Moradkhani* [2015]**

Scenario Development

Changes in run-off [*Najafi & Moradkhani*, 2015] and SLR [*Pachauri et al*. IPCC, 2014].

Run-off Increase (%)	Sea Level Rise (m)
A – no increase	**0 – no change**
B – 10% projected increase	**1 - 0.6m rise**
	2 - 1.5m rise

Model Development

Simulation on Delft3D depth averaged model

Model Sources

Tides

- Oregon State University
  Tidal Prediction Software (OTPS)

Discharge

Columbia River Inputs

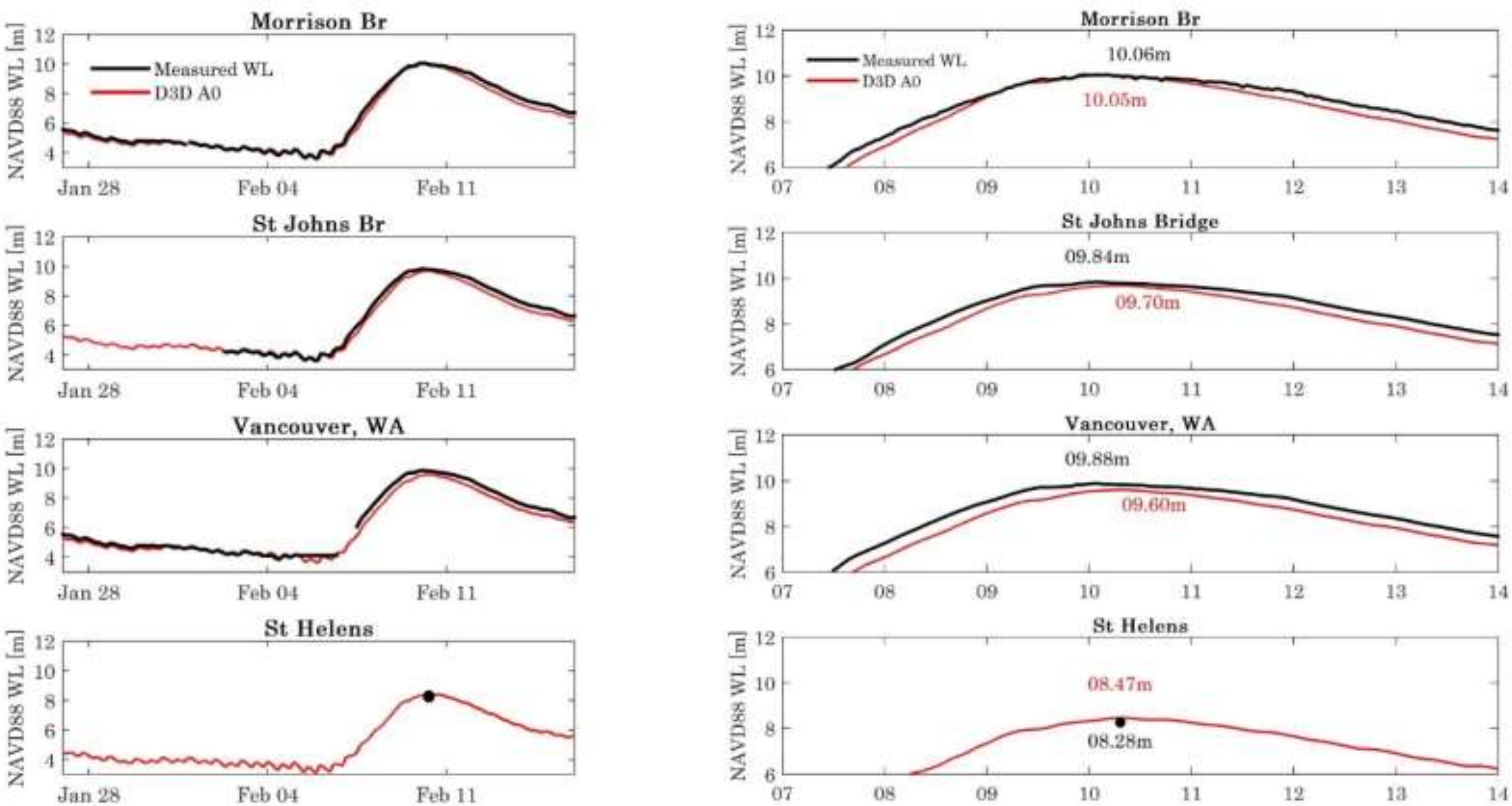
- Columbia River @ Bonneville
- Washougal River @ Washougal, WA
- Sandy River @ Bull Run
- Lewis River @ Ariel, WA
- East Fork of the Lewis River @ Heisson, WA
- Cowlitz River @ Castle Rock, WA
- Ungauged Columbia River Gorge

Willamette River Inputs

- Willamette River @ Morrison Br

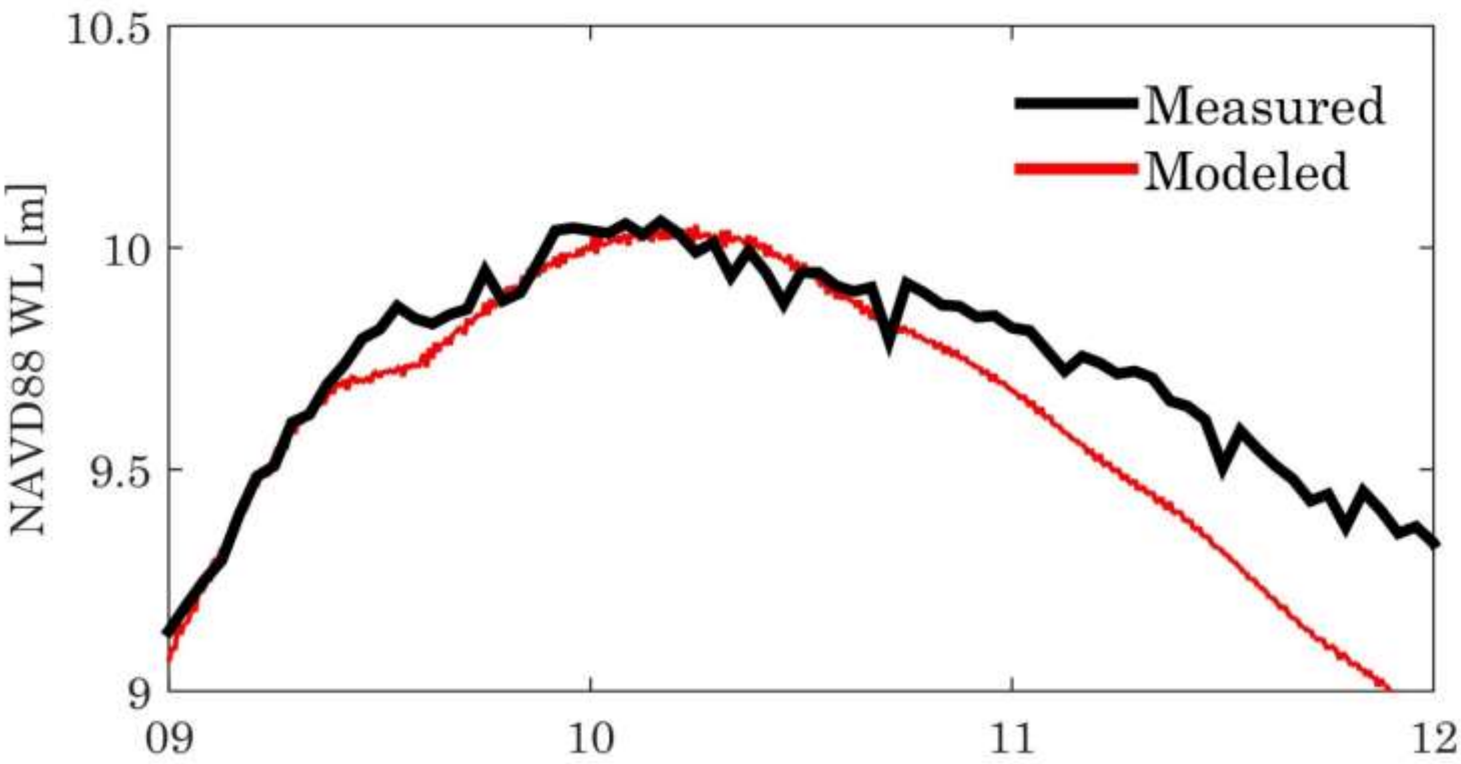
Results: Feb 1996 Calibration/Validation

Modeled water level match closely at Morrison model diverges from measured peak downstream
Morrison Br = +0.01m, St Johns Br = -0.14m, Vancouver = -0.18m

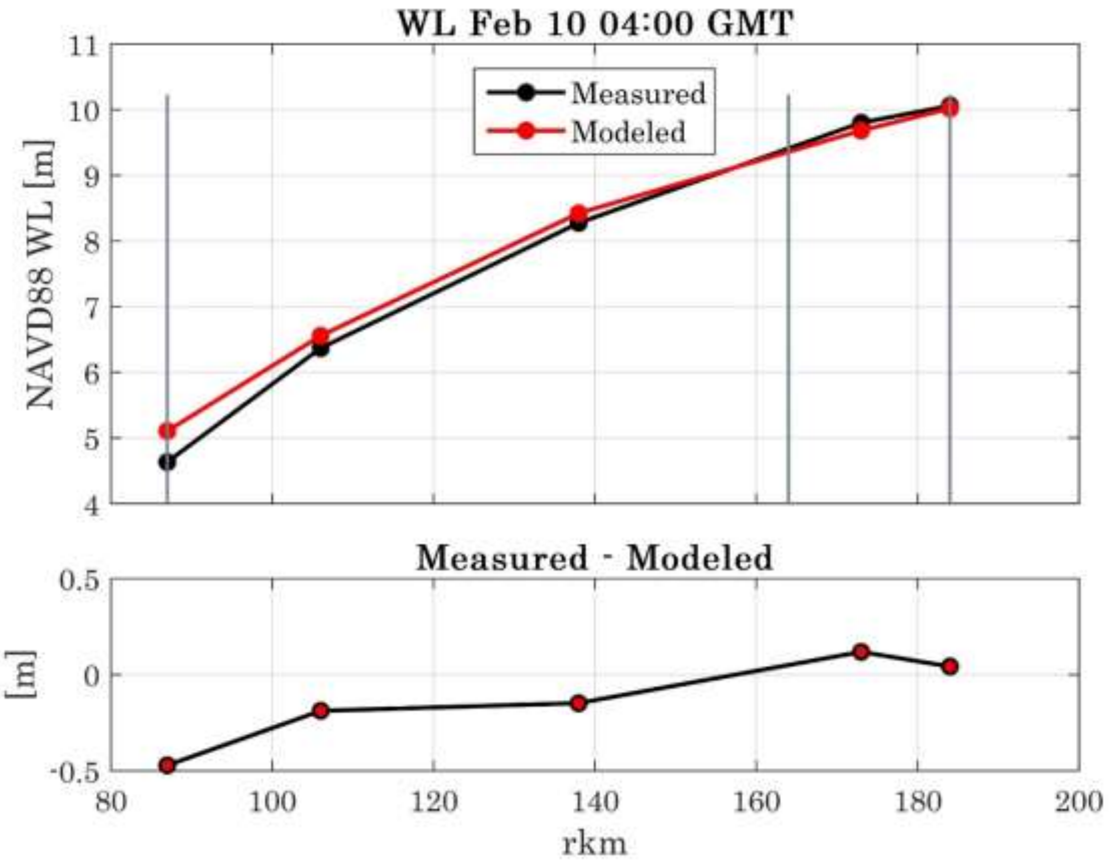


Results: Feb 1996 Calibration/Validation

Closeup of water level at Morrison Bridge during peak of the flood

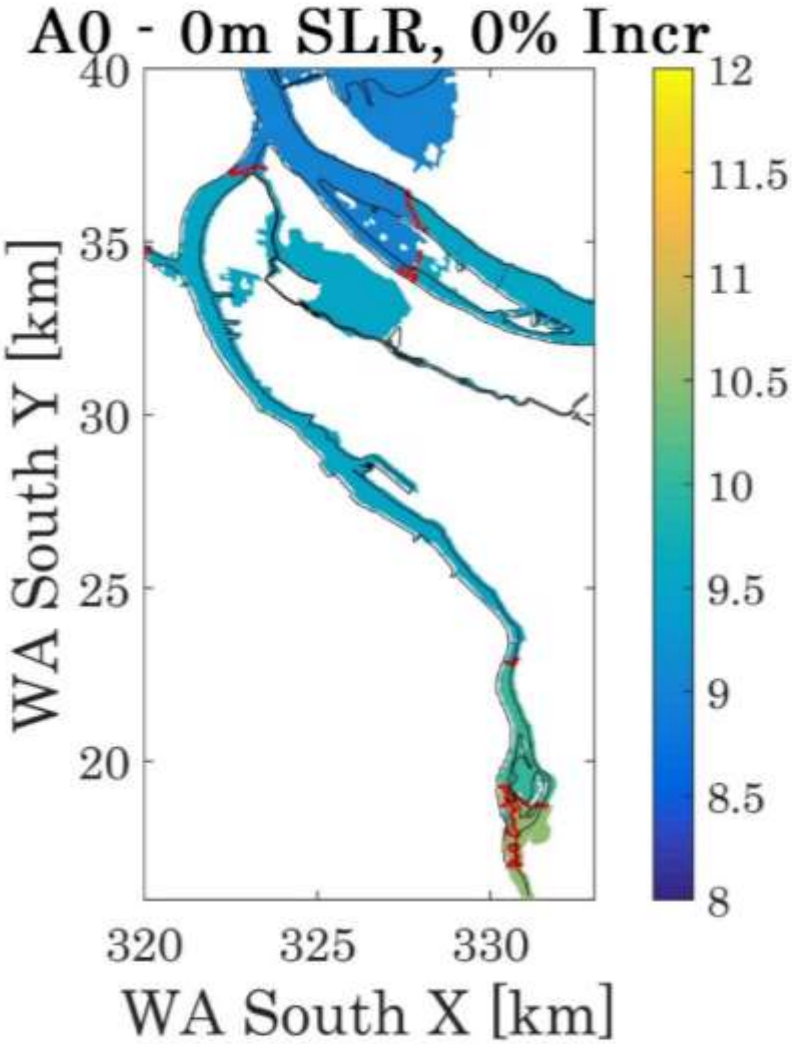


Results: Feb 1996 Calibration/Validation



Measured and Model elevation at Morrison Bridge peak water level

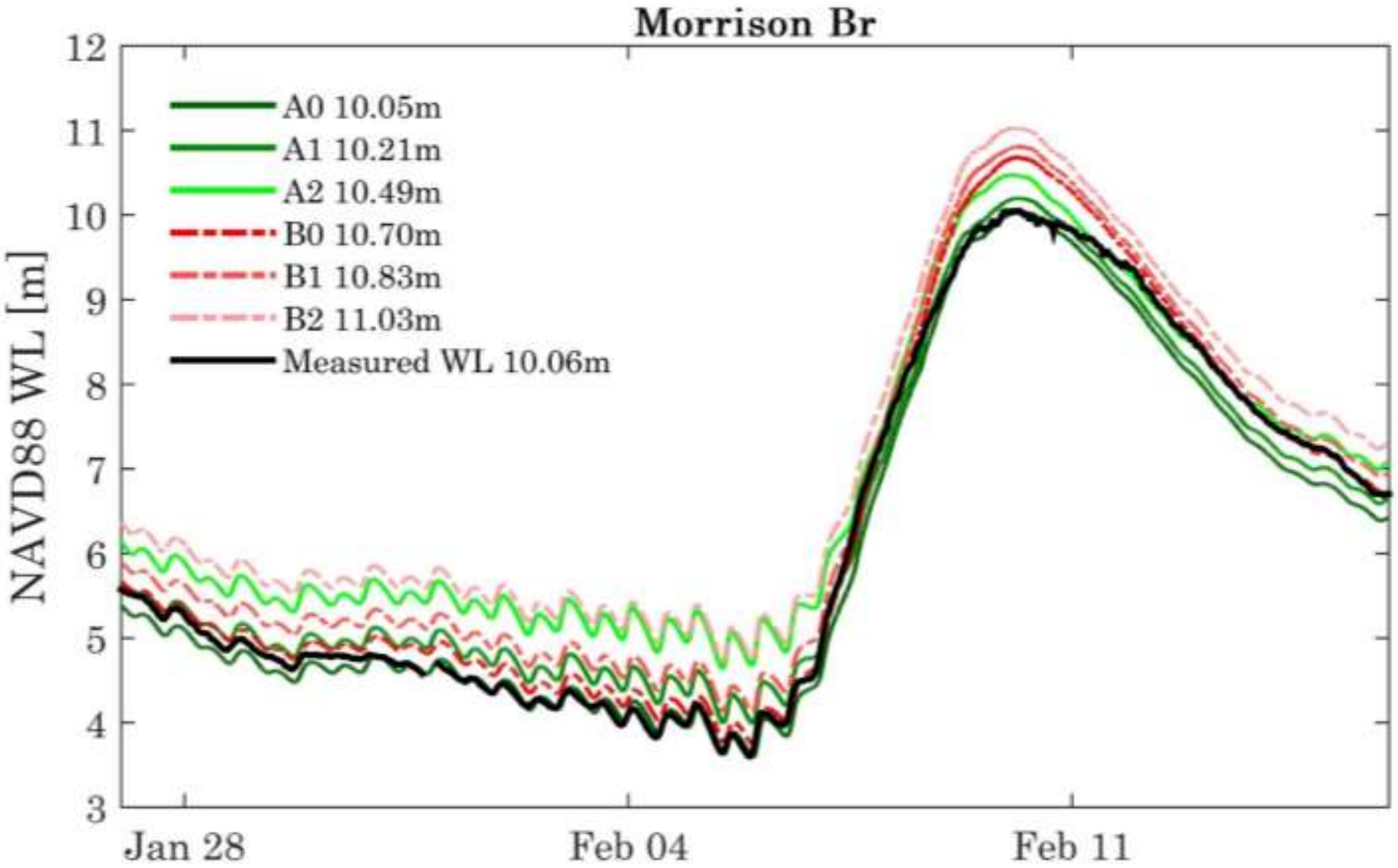
Results : Feb 1996 Calibration/Validation



Landsat 11 Feb 1996

Results: Future Scenarios

Measured and modeled water level at Morrison for all six scenarios



Results: Future Scenarios

55% of the increase in most severe scenario due to run-off. B2 – A2

Sea Level Rise Scenario

Run-off Scenario

	0m	0.6m	1.5m
0%		0.16	0.44
10%	0.66	0.78	0.98

25-30% of the increase in sea level reaches Portland

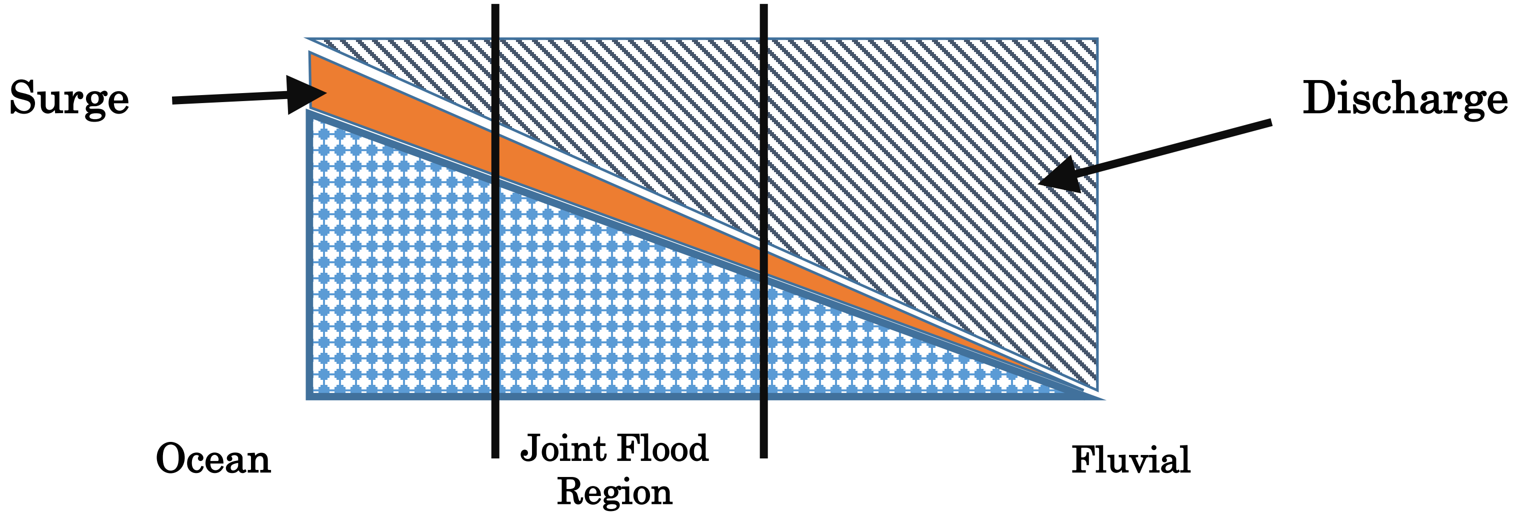
0.66m increase (79%) in peak water level at Morrison Br in combined (SLR+climate) scenario

0.54m increase (55%) in peak water level at Morrison Br in combined (SLR+climate) scenario

Spatial Variability

Spatial Differences in Flood Risks

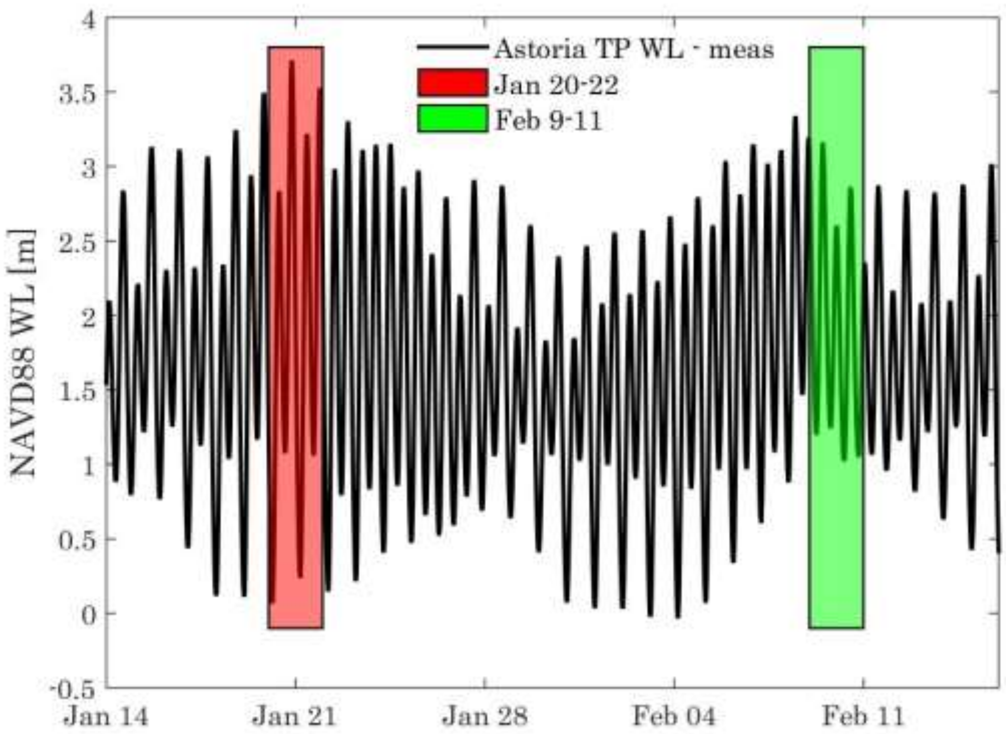
- Flood varies spatially from nearly total discharge dependent (Portland and upstream) to sea-level and storm surge driven (Astoria and downstream)



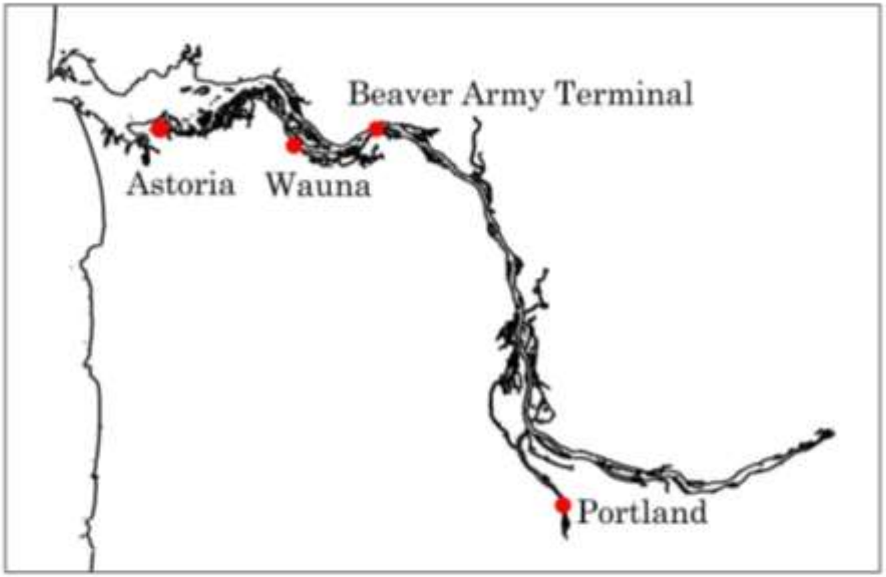
Results: Timing (tide) effects

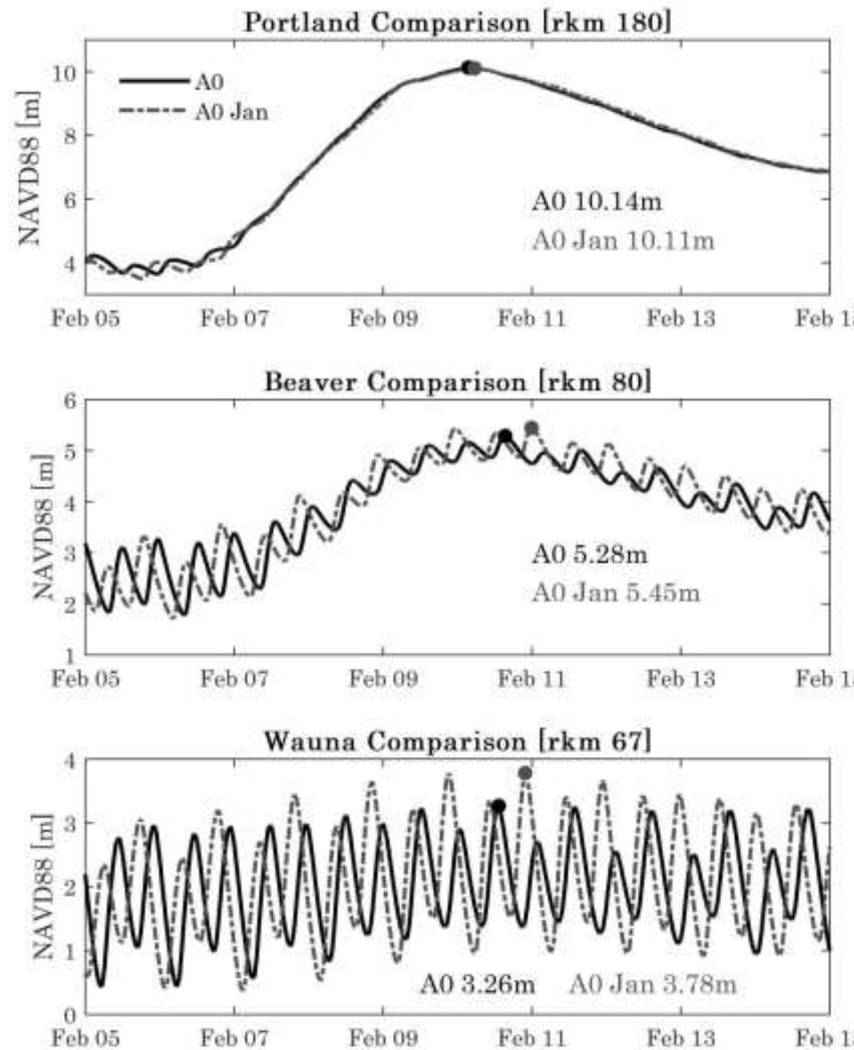
Spring tide Jan 20-22, 1996 created large tide range in Astoria

A simulation is run from Dec 31, 1995 – Jan 27, 1996 so that peak water level coincide with spring tide



Results: Spatial Difference (Spring/Neap)





The effect of shifting the flood increases downstream of Portland

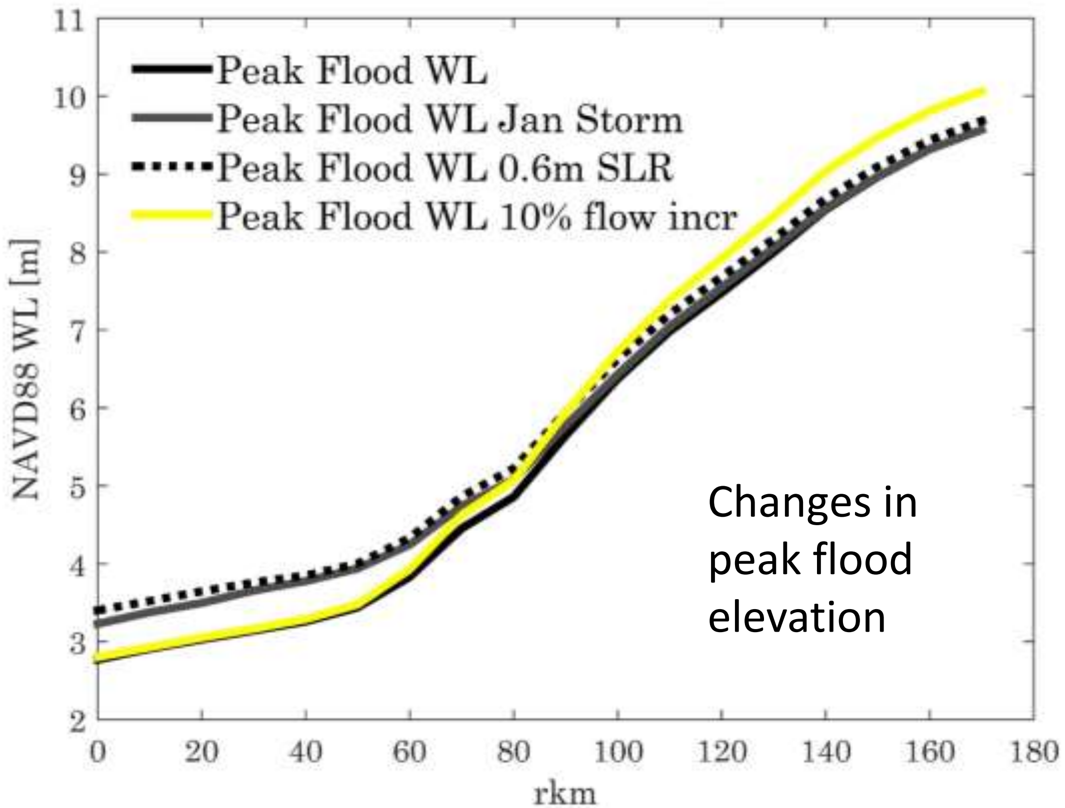
PDX (rkm 180) – 0.03m increase
Beaver (rkm 80) – 0.27m increase
Wauna (rkm 67) – 0.52m increase

Results: Spatial Difference

Coastal process (tides, surge, SLR)
- Propagate upstream
- Effect diminished far upstream (i.e. Portland)

Fluvial process (floods)
- Propagate downstream
- Effect diminish in the estuary (i.e. Astoria)

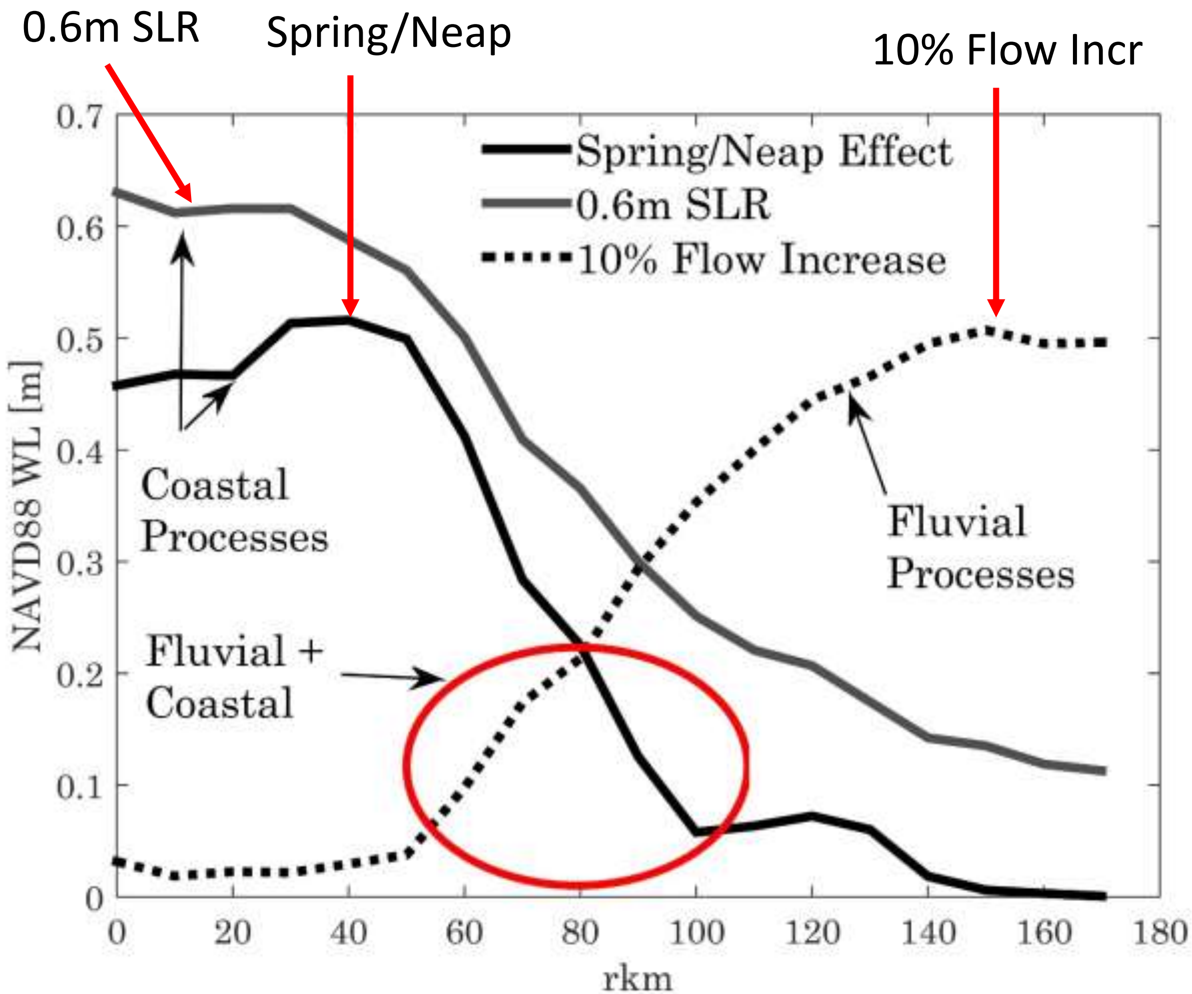
Is there an area where both processes can be significant?



Results: Spatial Difference

From rkm 60 – 100, coastal and fluvial processes are significant

This is an area of joint flood risk



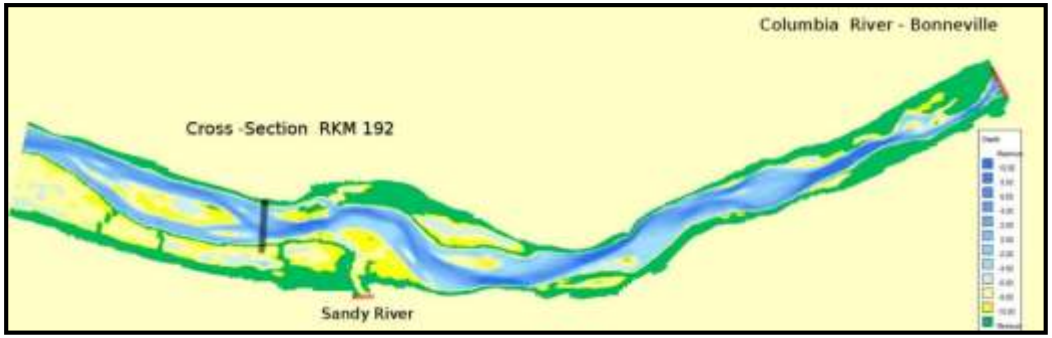
Conclusions

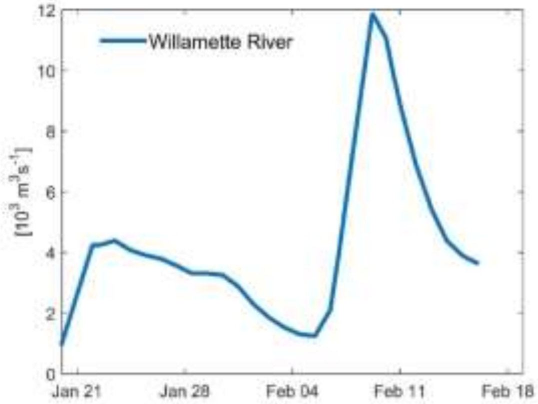
1. February 1996 Flood was 50 – 100 yr event in peak winter water level at Morrison Bridge
2. Fluvial domain (i.e. Portland) is more sensitive to changes in run-off than rising sea-level
3. Changes in the timing flood produced significant results in the mid-river section. Up to 0.5m difference in Wauna due to spring/neap effect
4. Between the estuary and the fluvial domain, middle section of the river may be subject to significant coastal and fluvial processes
5. Future research will focus on assessing joint flood risk

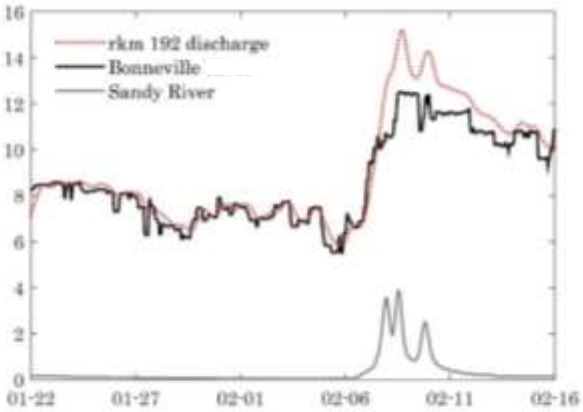
References

- Najafi, M.R. H. Moradkhani (2015) Multi-model ensemble analysis of runoff extremes for climate impact assessments, *J. Hydrol. 525*, 352-361
- Board, Ocean Studies, National Research Council (2012) Sea-level rise for the coasts of California, Oregon and Washington : past, present and future, National Academies Press
- Pachauri, R.K., et al. IPCC (2014) Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, IPCC

Model Development







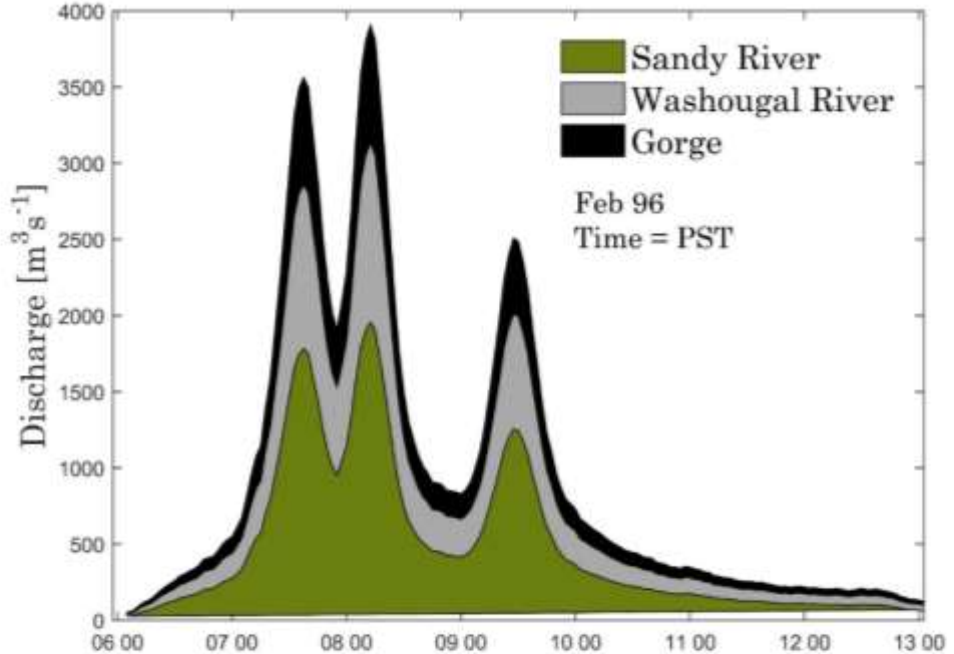
Revised Discharge Boundary

- Apply discharge boundary at Bonneville (measured hourly flow)
- Apply contribution from Sandy, Washougal and Gorge at the confluence with Sandy River
- Monitor discharge at CR transect near rkm 192
- Used filtered discharge for boundary on refined grid

Model Development

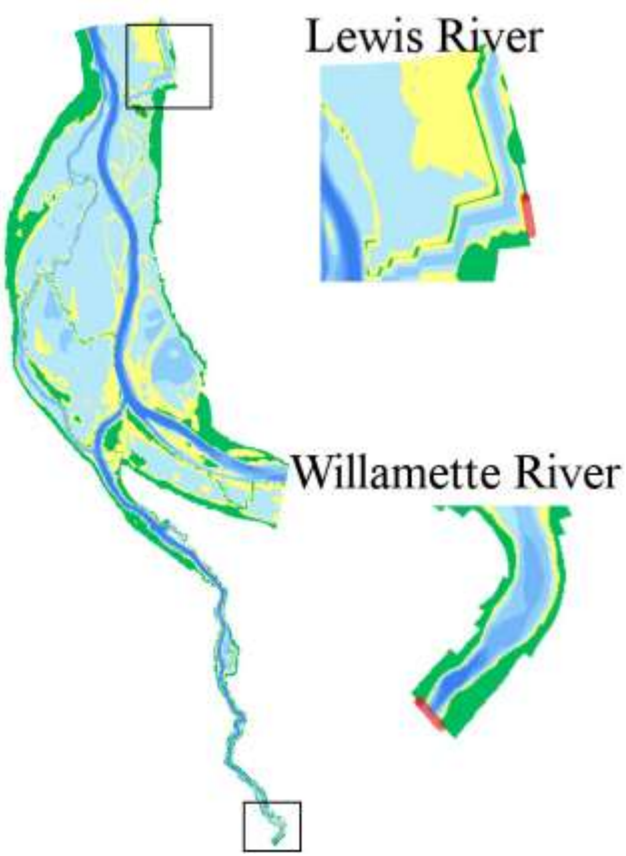
Detailed 30 min discharge available only for the Sandy River. Following assumptions made for other tributaries

- Washougal River and Sandy River have same similar discharge ratio throughout flood
- Timing of Washougal River and Sandy River are correlated
- Discharge from the City of Washougal/Gorge has same ratio of discharge to drainage area as Washougal River
- Timing of City of Washougal/Gorge and Sandy River are correlated



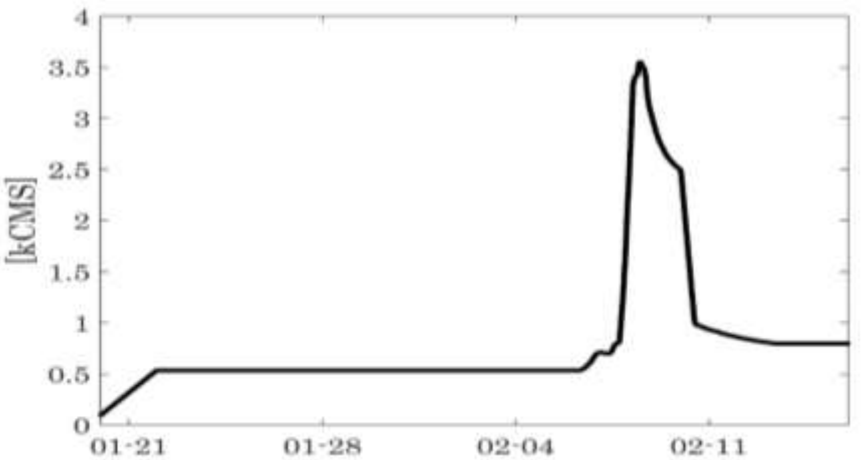
	Drainage (sq km)	Peak Discharge (m^3s^{-1})
Sandy River	1115	1940
Washougal River	279.7	767
City of Washougal/Gorge	427	1171

Model Development



Lewis River

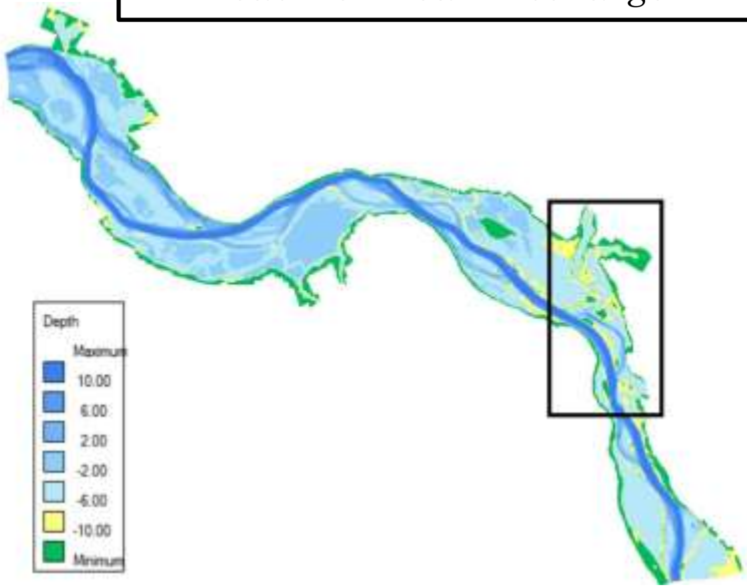
- Discharge is combination of Lewis River and East Fork Lewis River
- Daily Average discharge and peak measured discharge determine total discharge volume during flood
- Shape of hydrograph is inferred from recent flood events

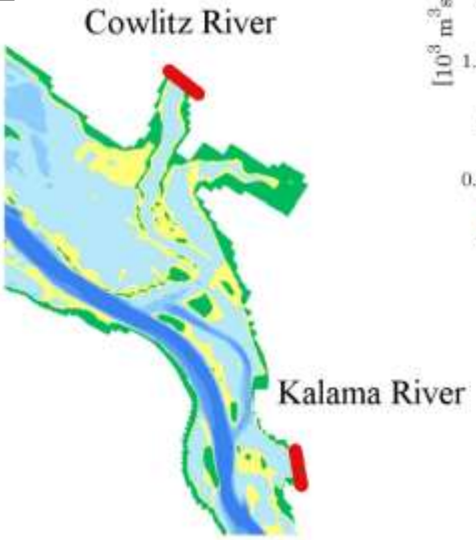


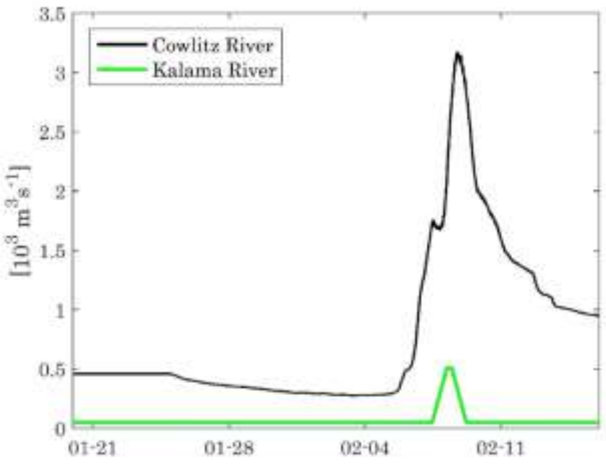
Model Development

Cowlitz River
- USGS 15min Discharge

Kalama River
- Measured Peak discharge





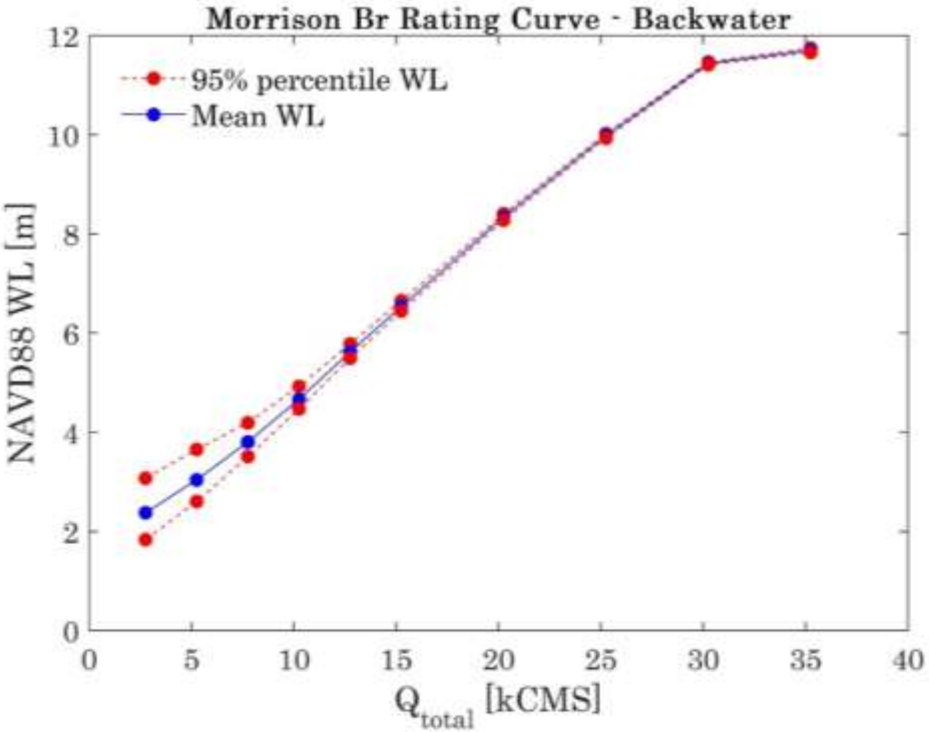


Model Development

Delft3D Constant Flow Simulation

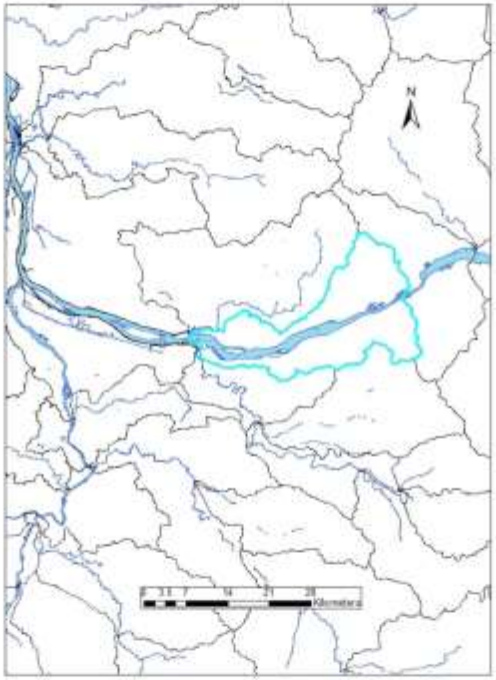
Wil Rvr (kCMS)	Col Rvr (kCMS)
0.25	2.50
0.25	5.00
0.25	7.50
0.25	10.00
0.25	15.00
0.25	20.00
0.25	25.00
0.25	30.00
0.25	35.00

Rating Curve of Columbia River backwater flow



Model Development

City of Washougal/Columbia River HUC10 1708000108

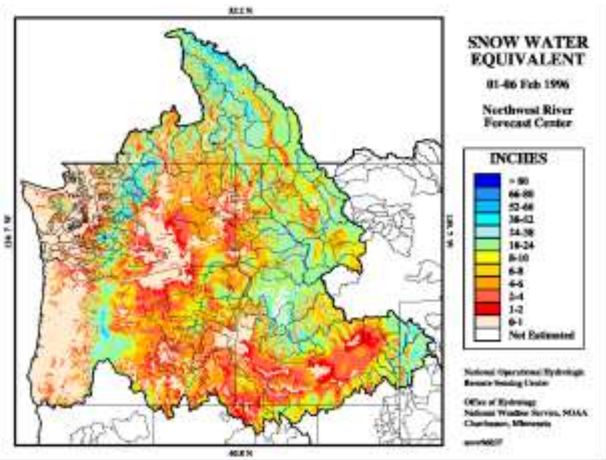


Columbia River Gorge is known for areas of high rainfall and snowfall due to orographic effect.

There are no discharge gages in watershed.

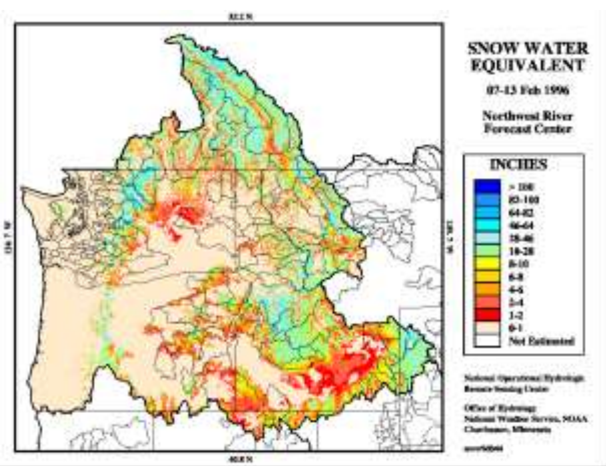
Feb 1996 Flood

Heavy snow followed by a warmer temperatures and intense rain combined to create produced disastrous floods



06-Feb 1996

13-Feb 1996



Between 06-Feb and13-Feb a large portion of the snowpack converted to streamflow

http://www.nwrfc.noaa.gov/rfc/

https://upload.wikimedia.org/wikipedia/commons/9/97/Flood_in_Portland_Feb_1996_-_area_NW_of_Steel_Bridge.jpg

Scenario Development

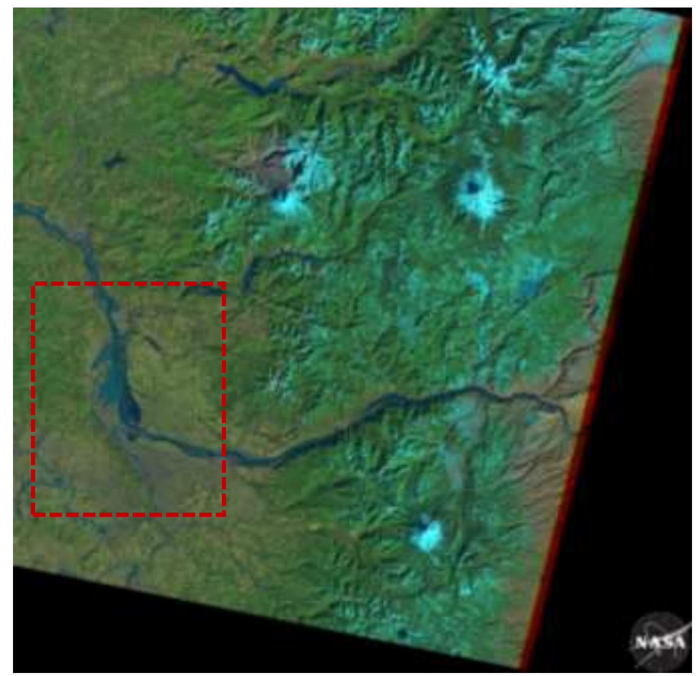
Landsat 2 Feb 1996

Prior to flood rivers within banks and snowpack on hills

Heavy snow followed by a warmer temperatures and intense rain combined to create produced disastrous floods

Landsat 11 Feb 1996

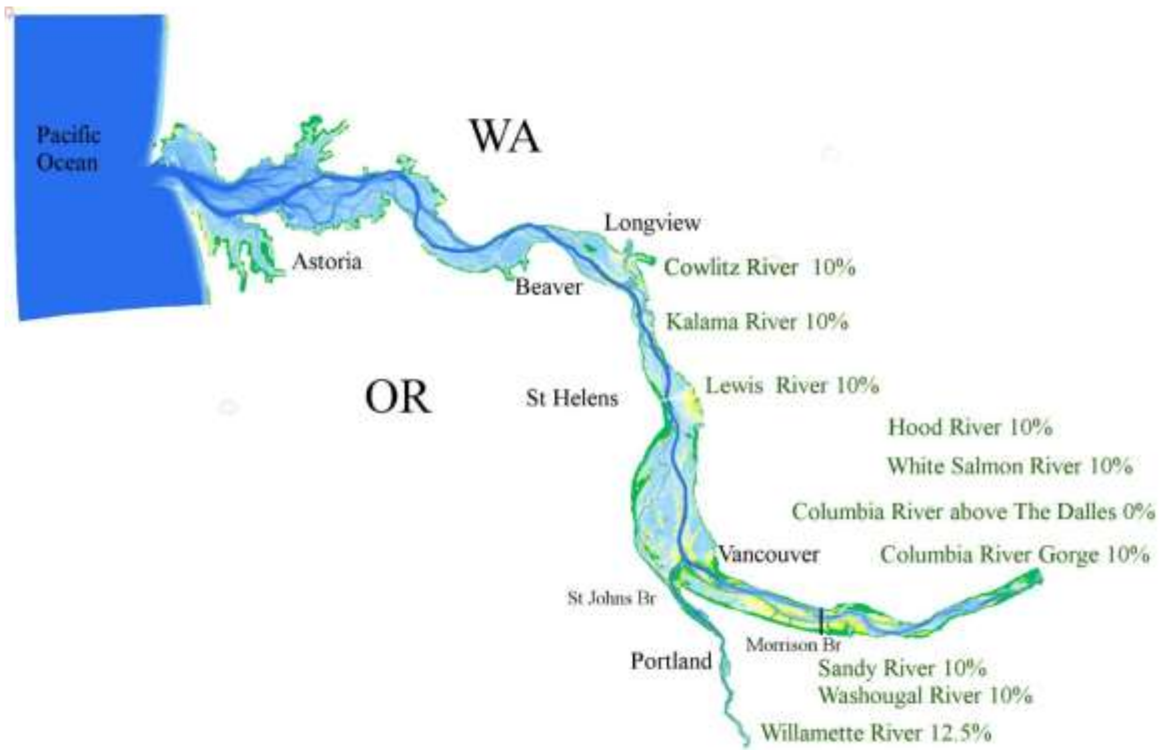
After flood peak on 10 Feb, snow only at higher elevation and overbank flooding



Future Scenarios

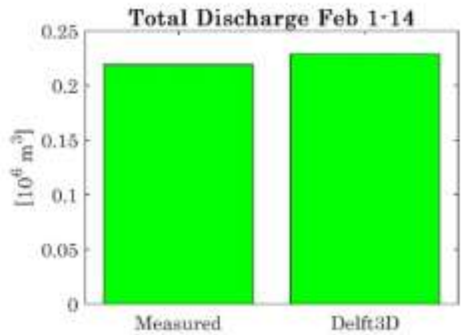
Willamette River
Assume ~25% from Feb 96 event was regulated. Assume no increase in storage, run-off increased by **12.5%**

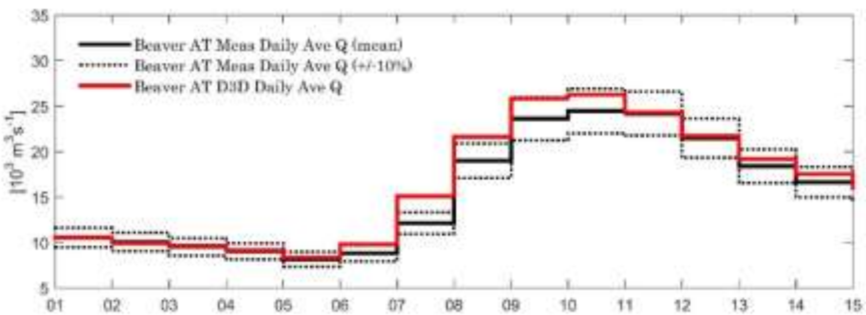
Columbia River
No increase in run-off upstream of The Dalles. Tributaries downstream of The Dalles increase by **10%**

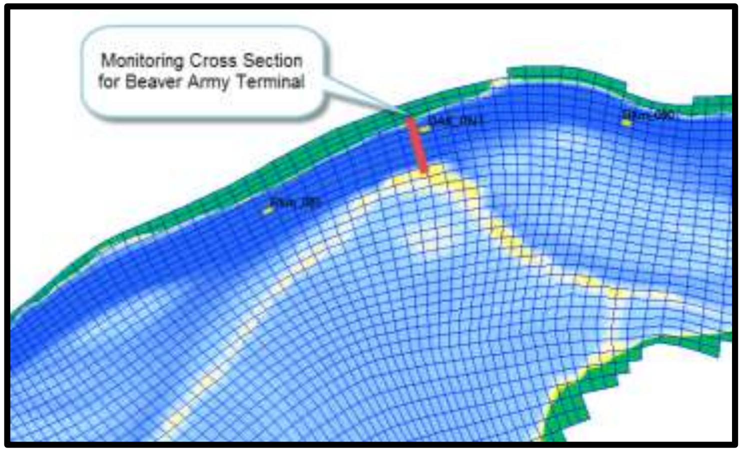


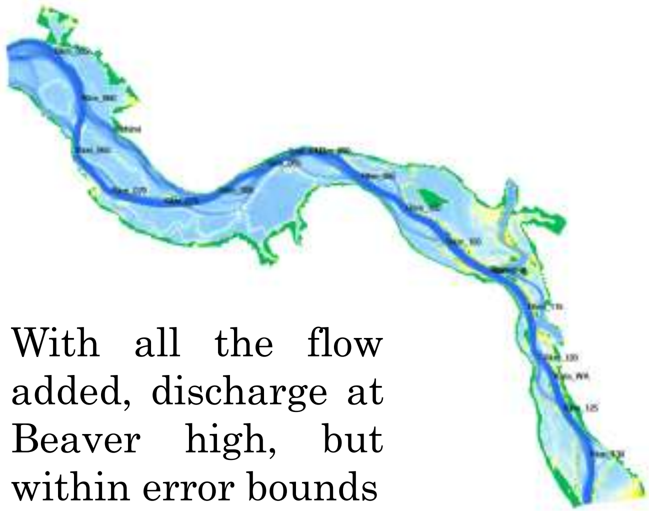
Results : Feb 1996 Calibration/Validation

Model discharge monitored at Beaver Army Terminal and compared to measured discharge









With all the flow added, discharge at Beaver high, but within error bounds

Results: Future Scenarios

Inundation in baseline and combined sea-level rise, climate scenario

Downtown Portland starts to flood at 10.5m NAVD88