

Trends in Lower Columbia and Willamette River Water temperatures over the past 170 years

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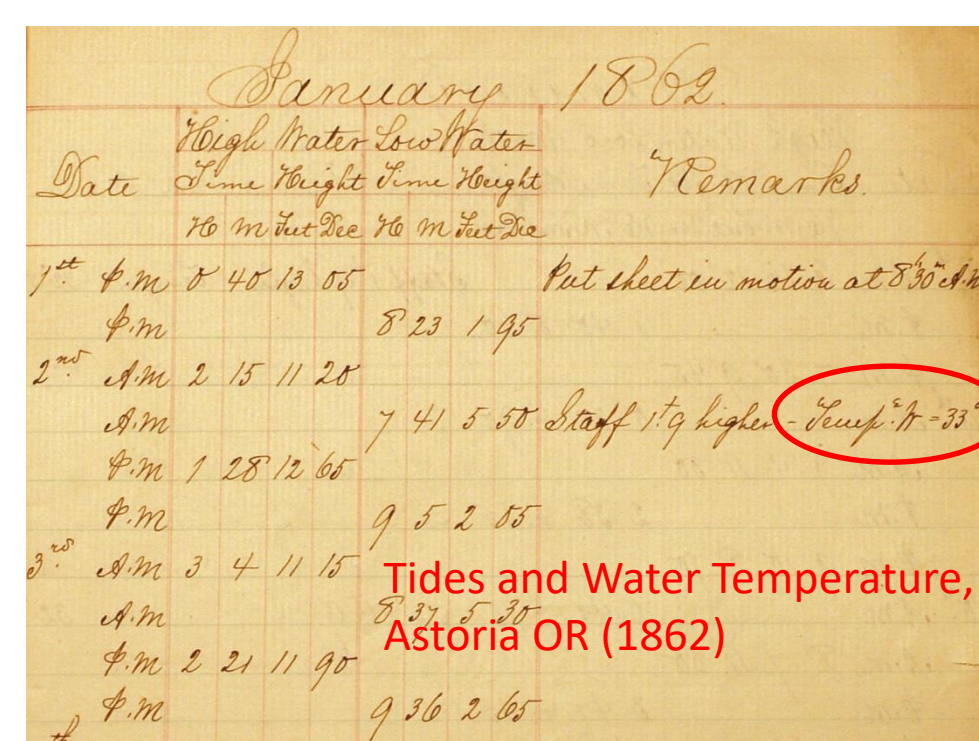
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Introduction

Increases to water temperature pose a critical stress on lower Columbia River ecosystems and the survivability of salmon and other species. Questions:

1. Do trends in water temperature continue back to the 19th century?
2. What is the cause: Climate change or Landscape/River system changes?

Approach

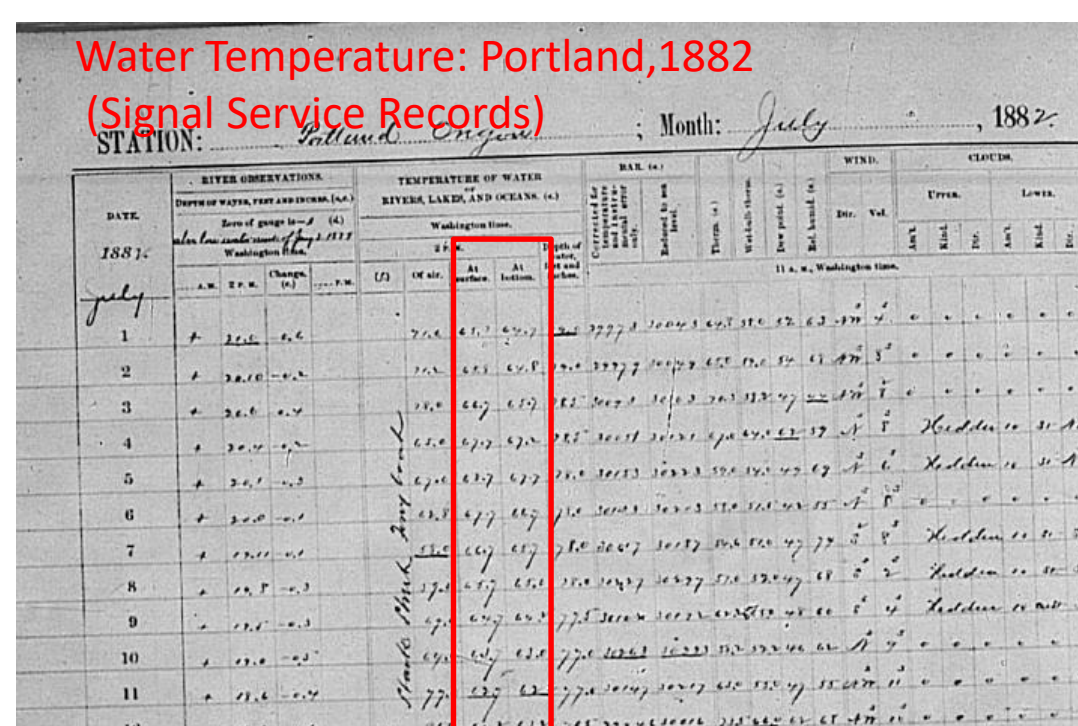
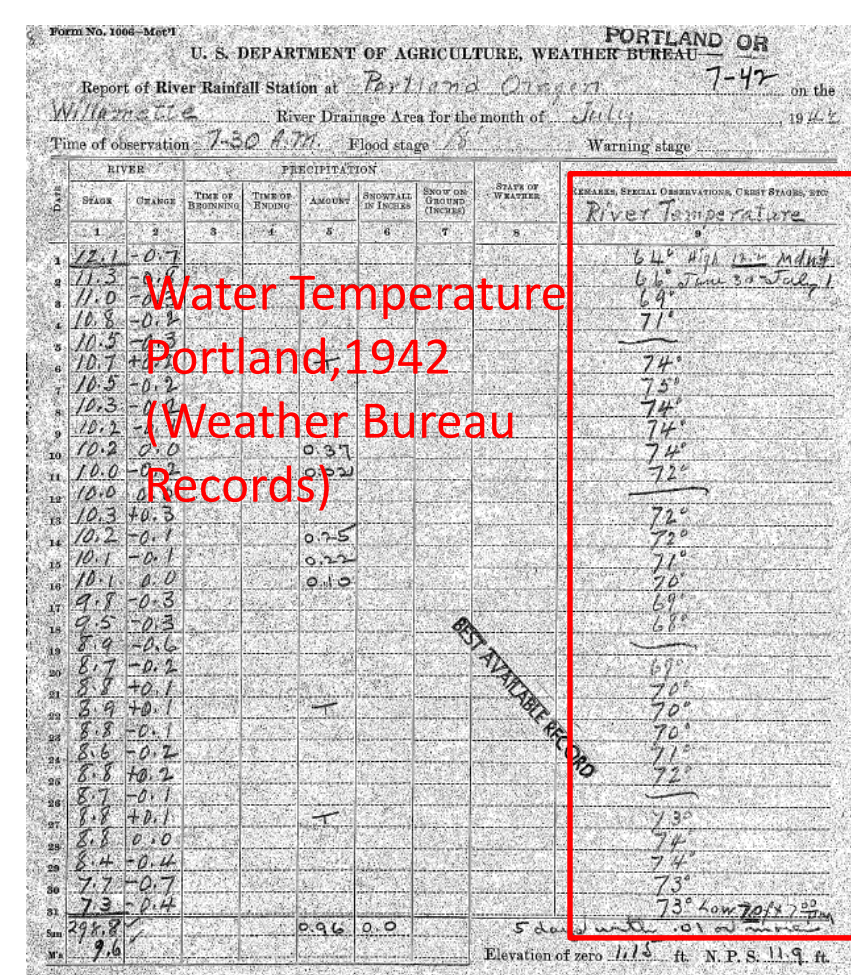
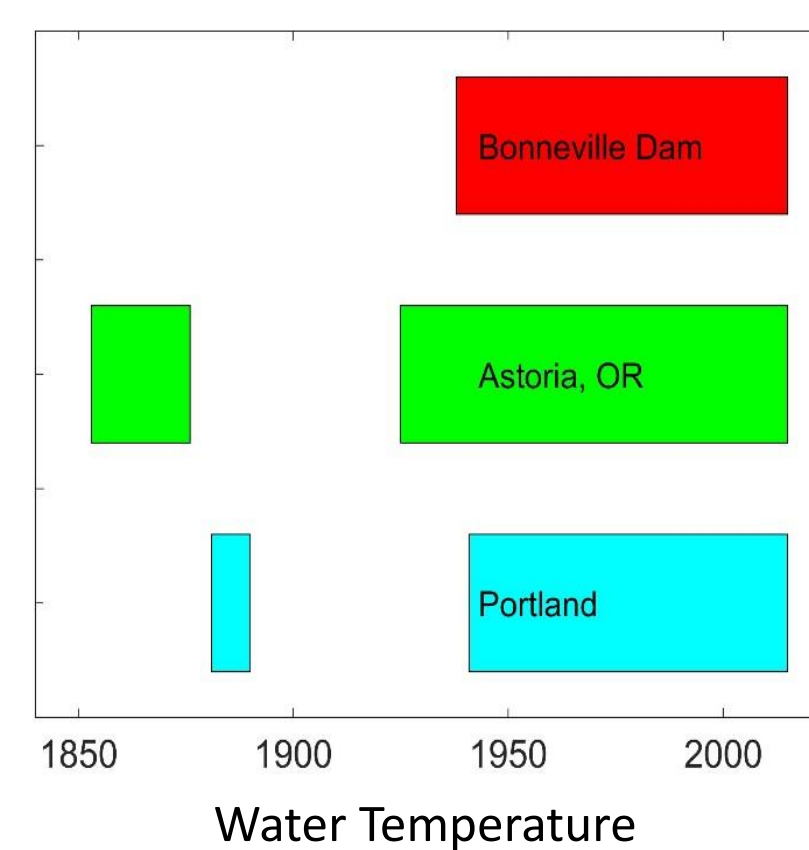


Archival water temperature records recovered:

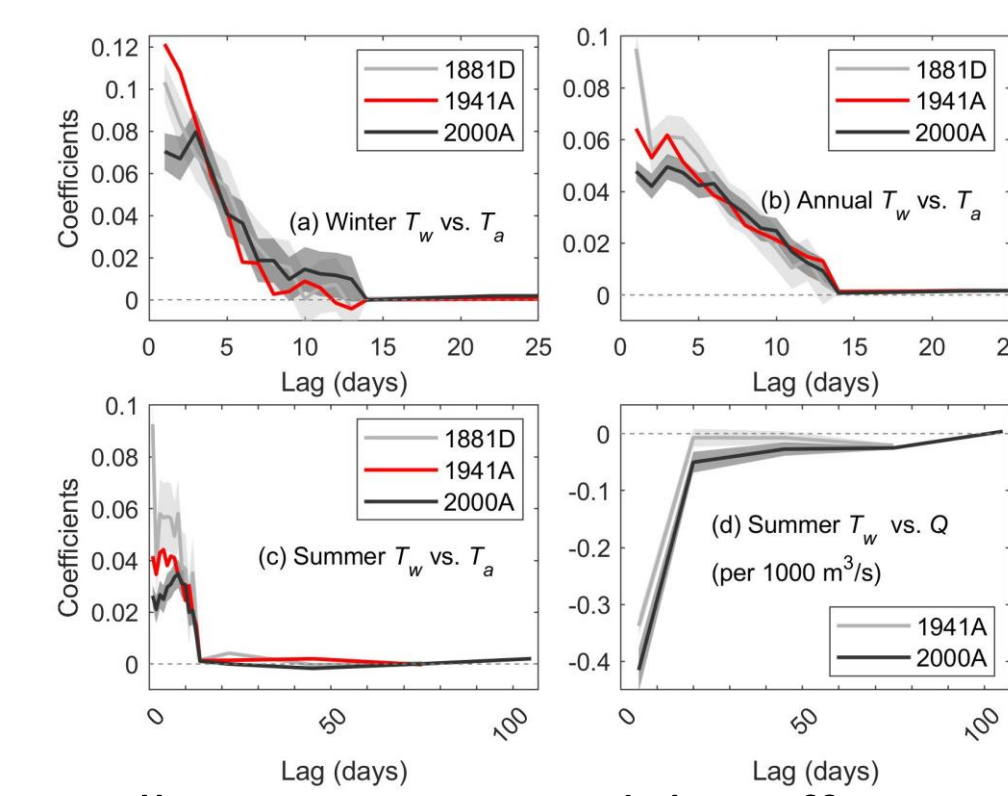
- US Coast Survey
 - Astoria (1854-1876)
- US Signal Service
 - Portland (1881-1890)
- US Weather Bureau
 - Vancouver, 1941-1947
 - Portland, 1941-1961

Additional Records Used:

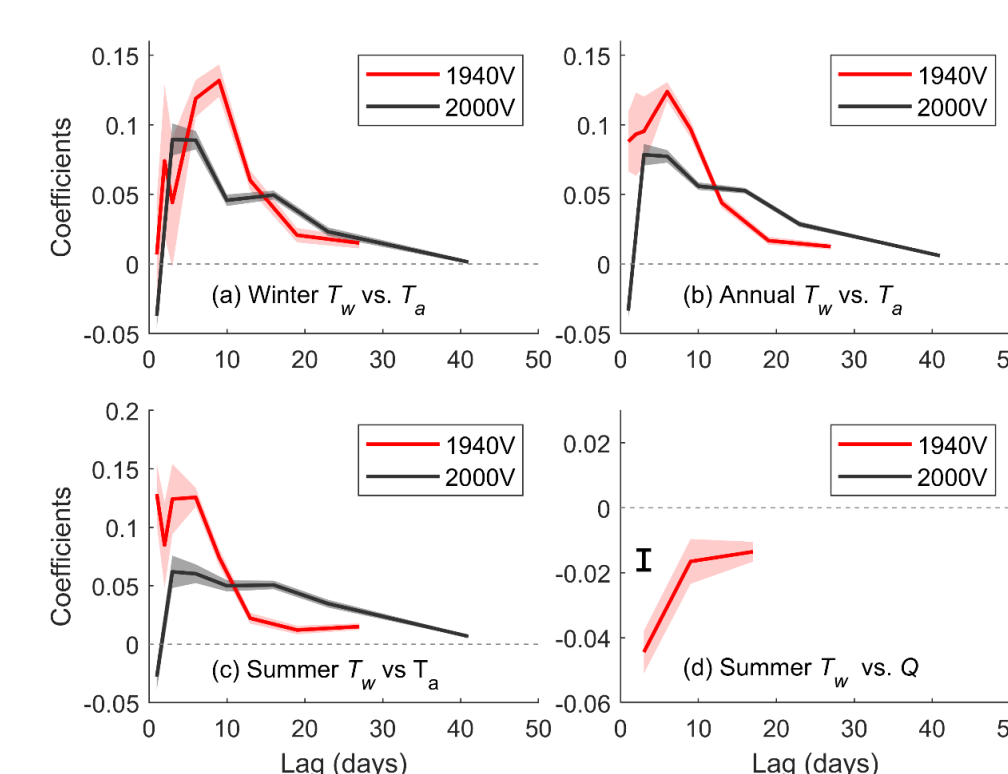
- Bonneville Dam
 - (1939-present)
- USGS, City of Portland, OR DEQ
 - (1961-present)



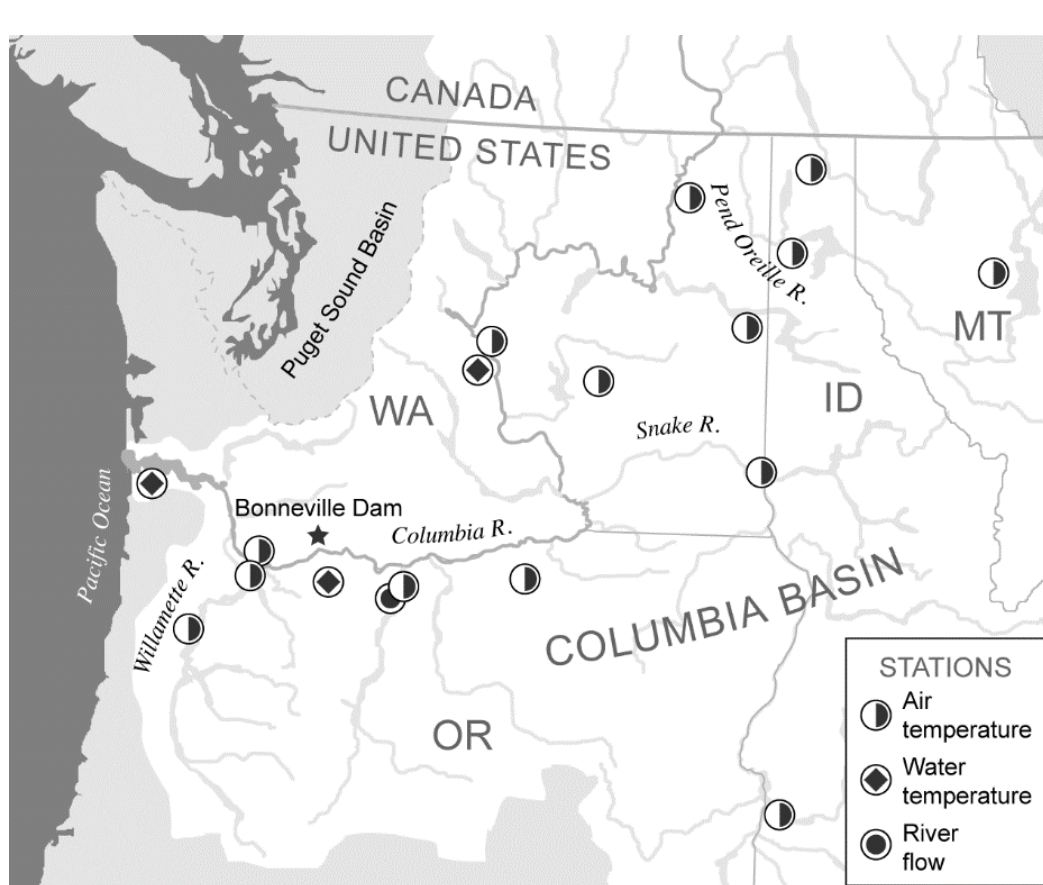
Statistical Model



Willamette River Model Coefficients



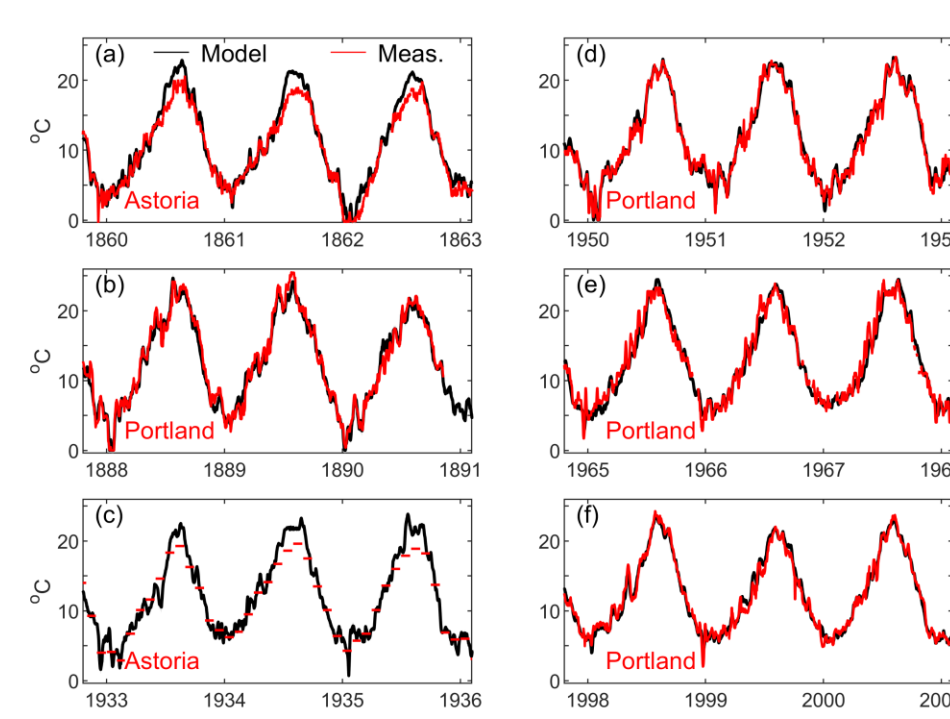
Columbia River Model Coefficients



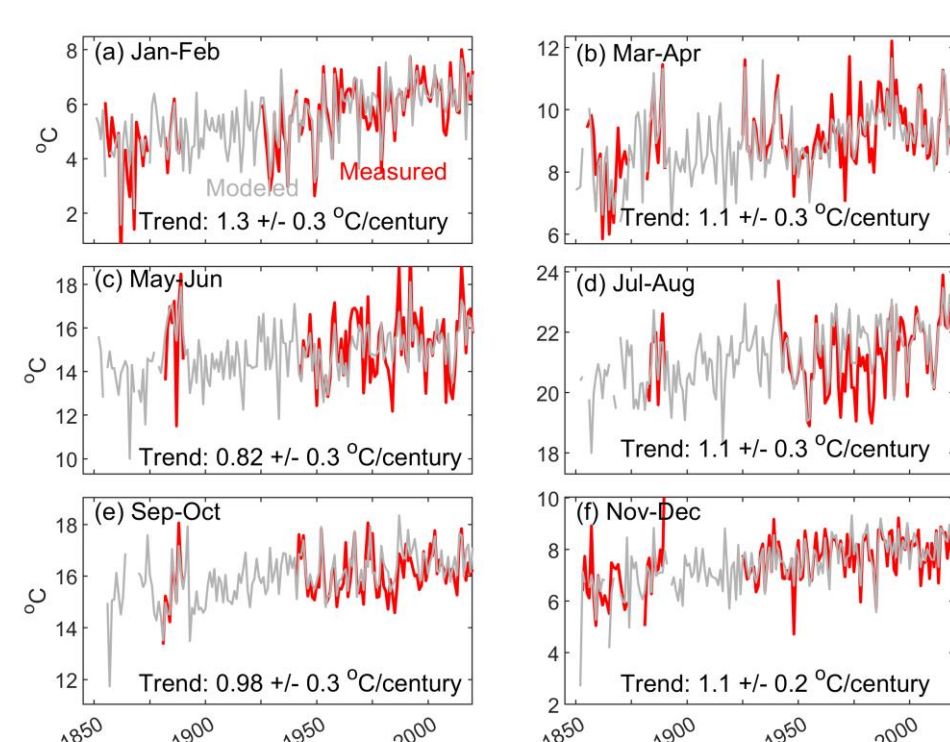
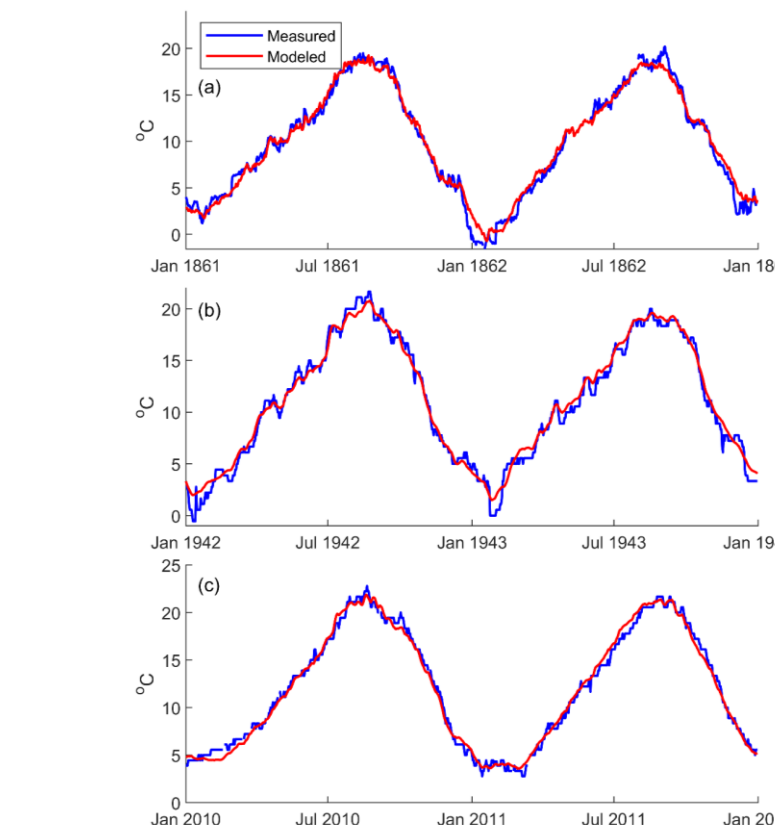
Daily water temperature at Portland and Bonneville Dam is estimated as a function of time-lagged air temperature and river flow.

1. Models developed from 3 different eras: late 1800s, mid 20th century, and present
2. Further, sub-models are developed for all data, winter, and summer
3. Daily water temperature hindcast from 1850-present, using daily air temperature

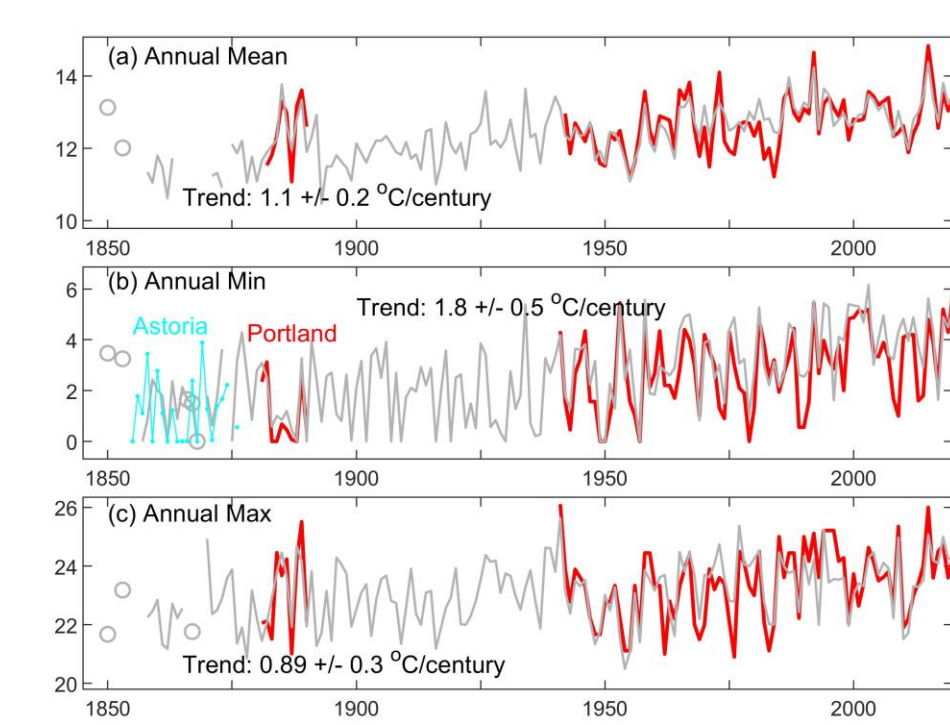
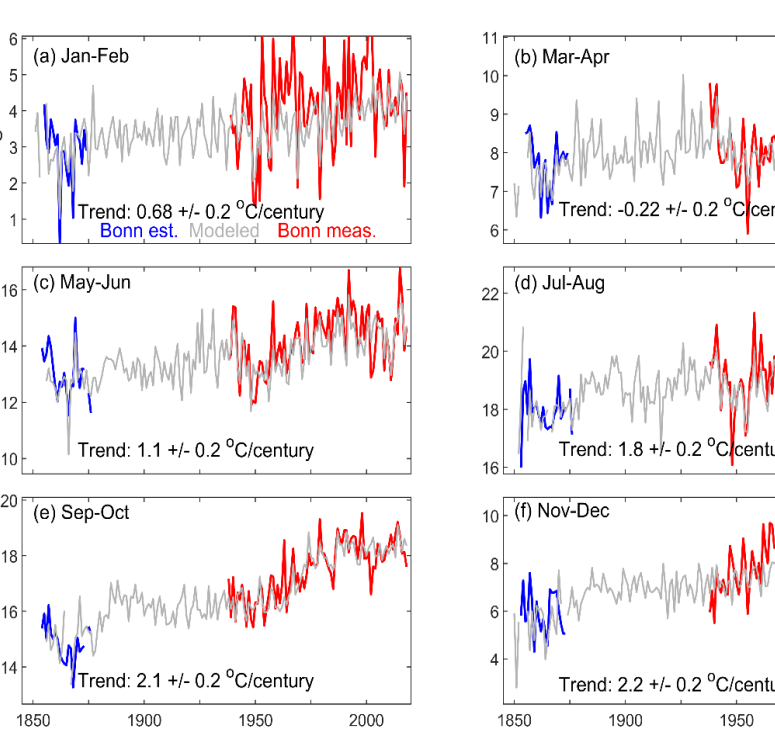
Willamette R. Columbia R.



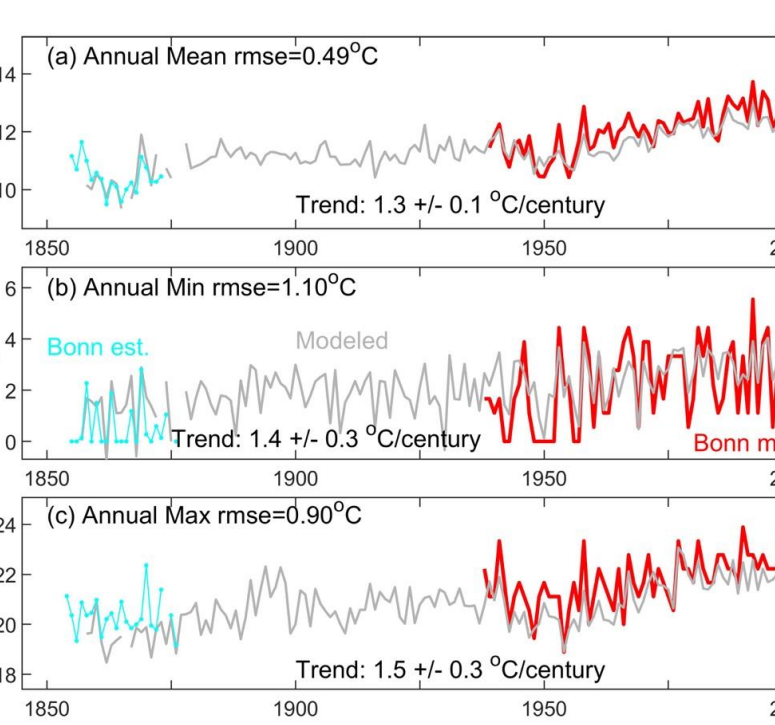
Daily Time Series: model vs. measurement comparison



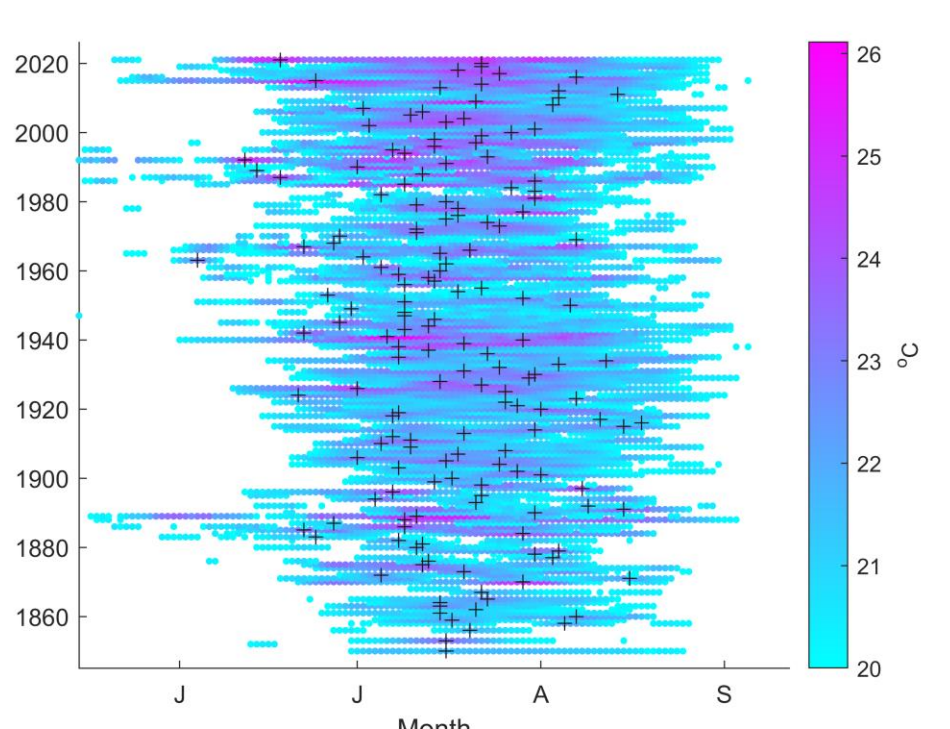
Bimonthly averages



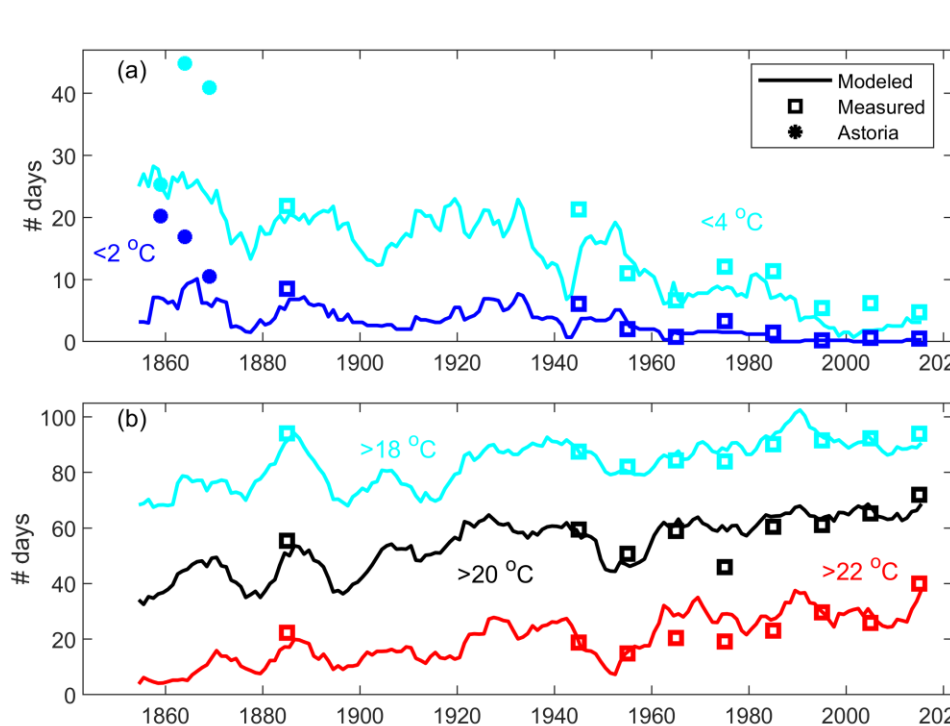
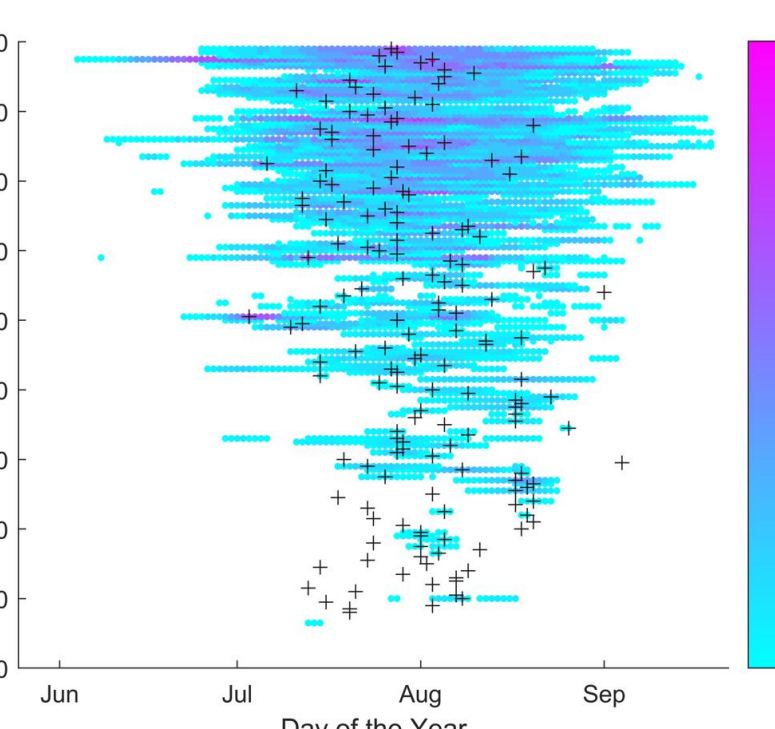
Annual Statistics



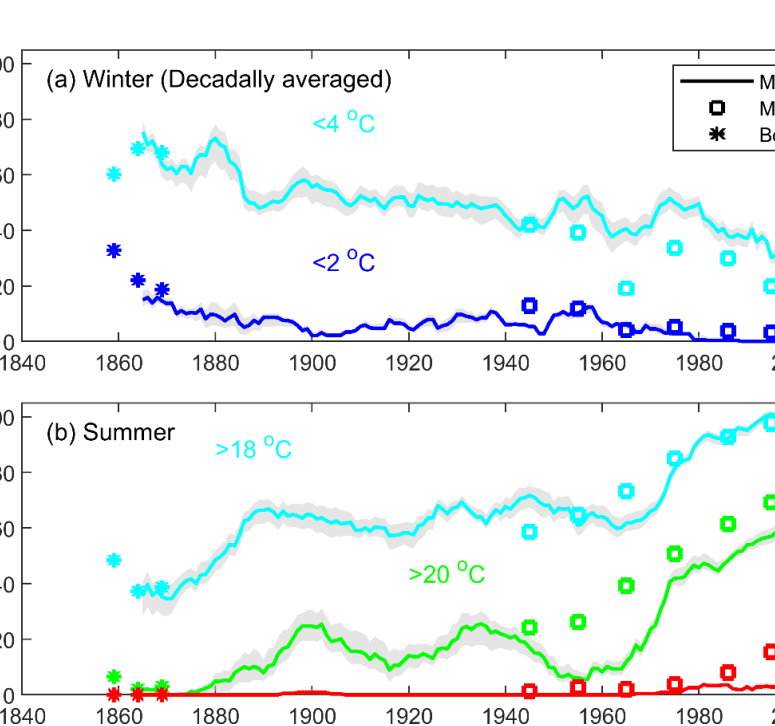
Long Term Shifts in Exceedence



Days per year over 20°C



days below threshold

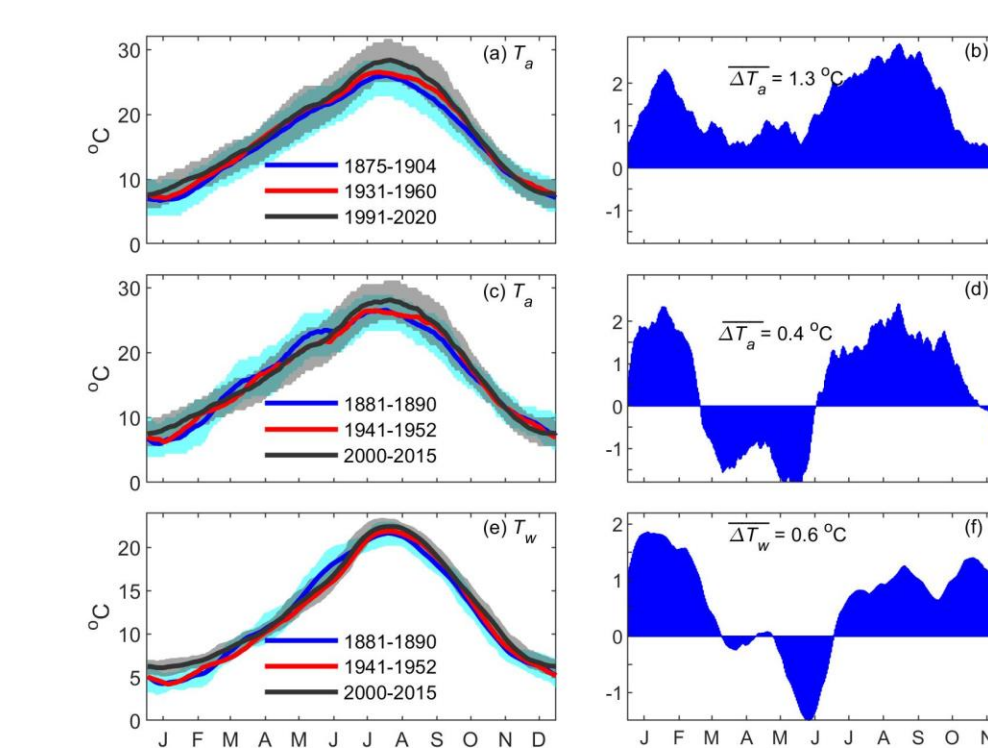


days above threshold

Willamette River

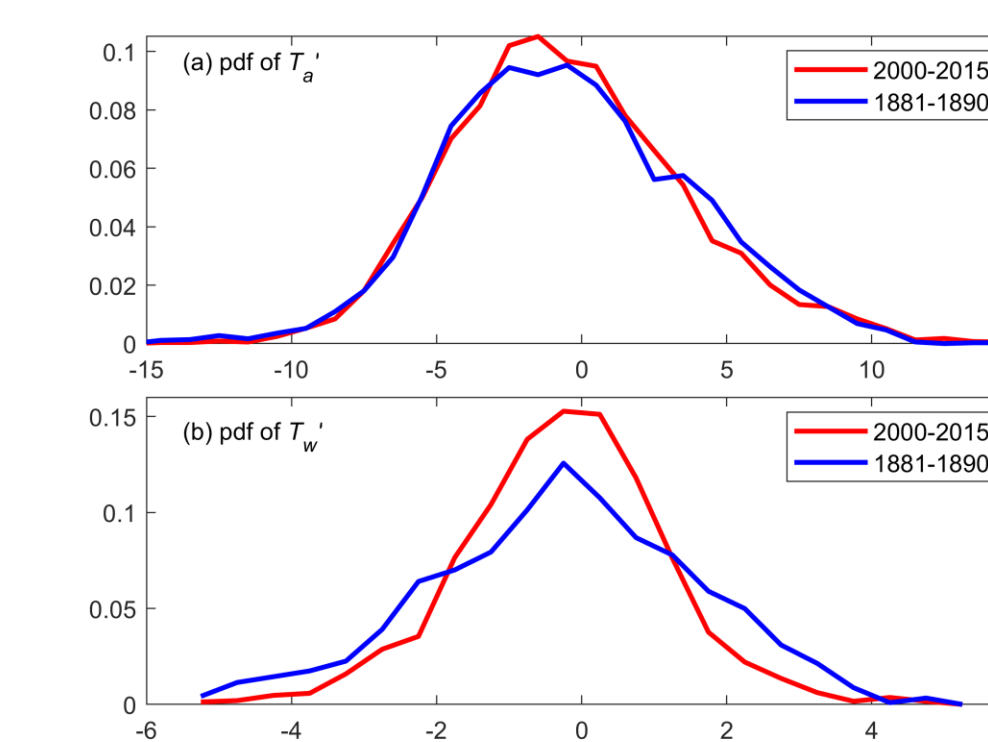
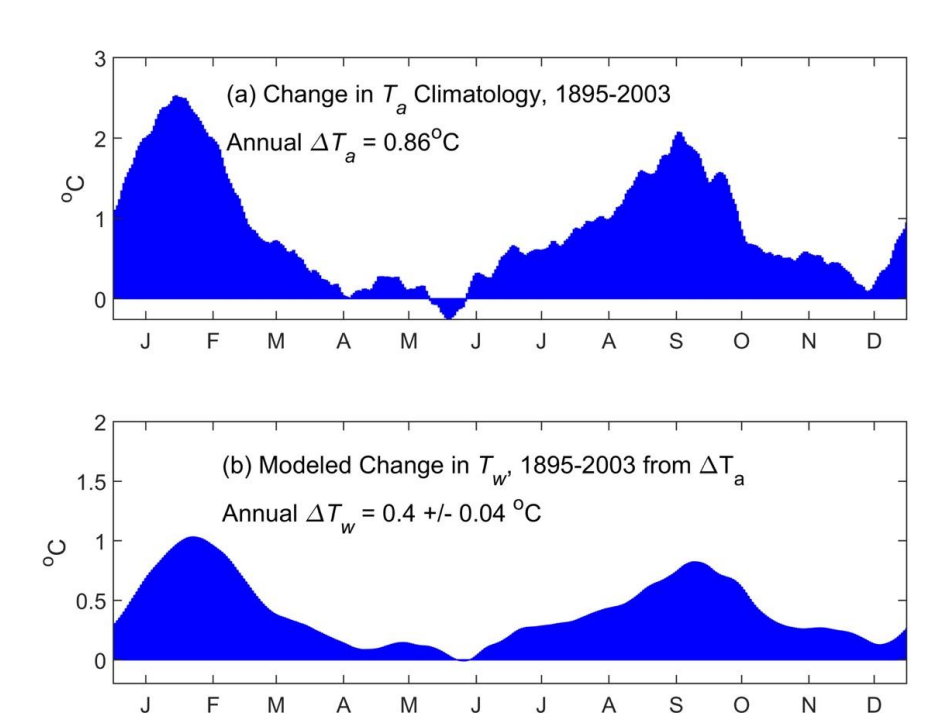
Columbia River

Willamette R. Columbia R.

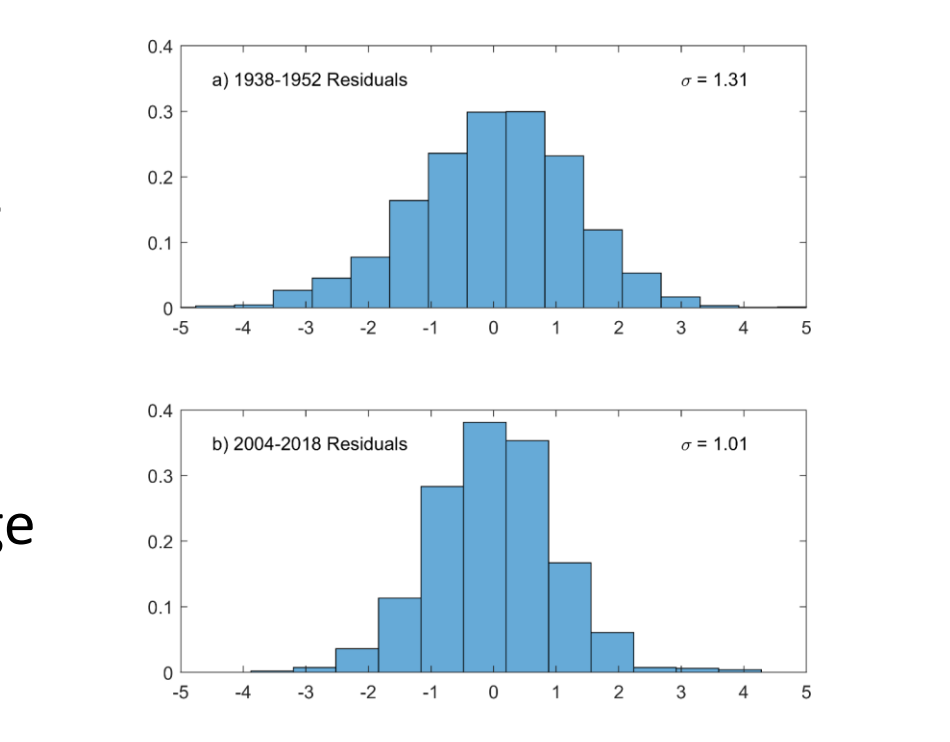


Comparison of air temperature and water temperature.

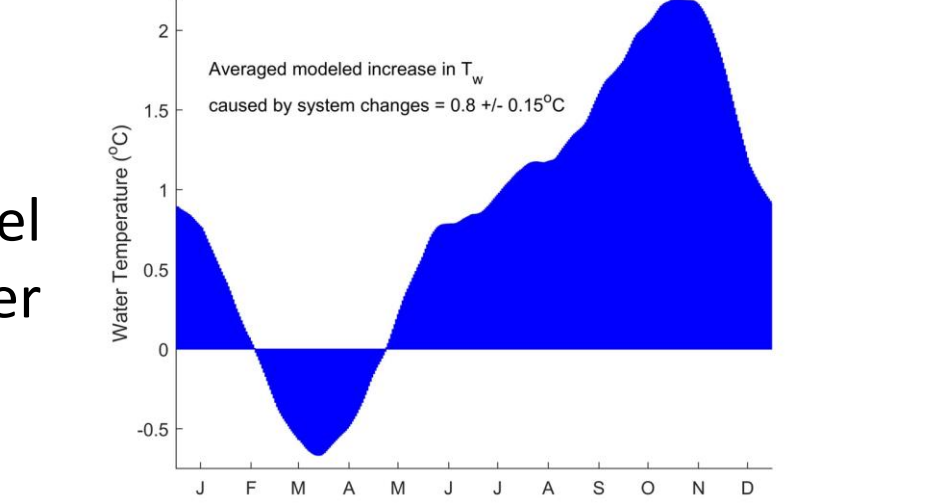
Left uses Portland air temperature, right uses Berkeley Earth estimates for Vancouver



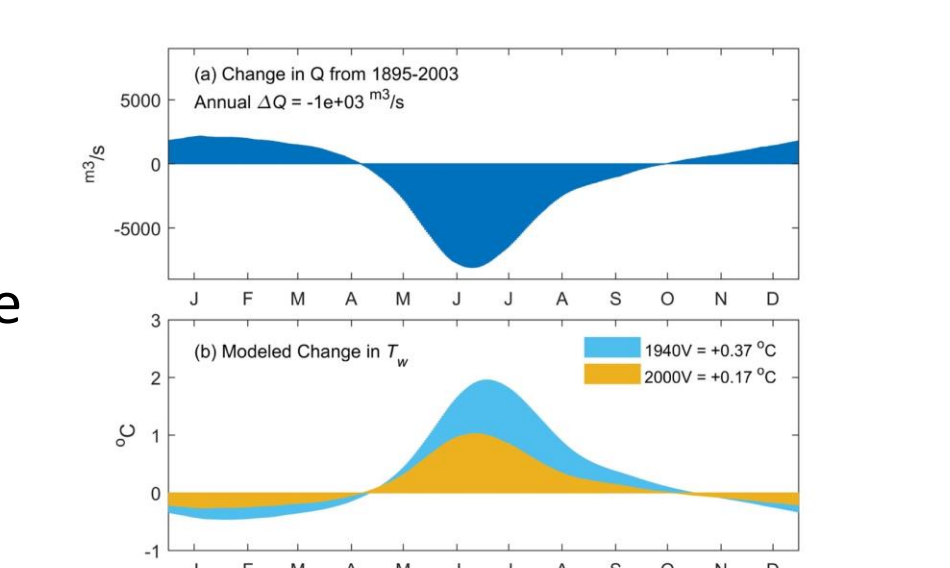
Distribution of water temperature and air temperature anomalies from climatological average



Left: Influence of climate change, system change (model coefficients), and river flow change on temperature



Right: Influence of system coefficients (model coefficients) and river flow change



Conclusions

- Average Water Temperatures rising by **1.1°C/century** (Willamette) and **1.3°C/century** (Columbia)
- The number of days exceeding 20°C has increased by 20 days (W.R.) and 60 days (C.R.)
- **Columbia River:** Greatest increases from **July-Dec**
- **Willamette River:** **Largest increases** in **winter** (especially Jan-Feb)
- The response of both rivers to short-term meteorological forcing has been reduced.
 - *Temporal Refugia*—summertime periods below 20°C—are decreasing
- Causes of water temperature increases:
 - Columbia R.: Primarily system changes (e.g., depth); flow and climate change important
 - Willamette R.: Dominated by Climate Change, augmented by system change in winter, reduced by river flow changes in summer.

References

1. Talke, S.A., A. Mahedy*, D.A. Jay, P. Lau*, C. Hilley*, A. Hudson* (2020). Sea level, tidal and river flow trends in the Lower Columbia River Estuary, 1853-present. *Journal of Geophysical Research-Oceans*. <https://doi.org/10.1029/2019JC015656>
2. Scott, M., Talke, S.A., Jay, D.A., Diefenderfer, H. (2023). Warming of the Columbia River, 1853-2018. Submitted to *River Research & Applications*, submission RRA-22-0262, September 2022. Returned with minor revisions, Apr 2023
3. Talke, S.A., Jay, D.A., & Diefenderfer, H. (2023). Warming of the Willamette River, 1850-present: the effects of climate change and river system alterations. Resubmitted to *Hydrology and Earth System Science*, resubmitted May 2023. EGUsphere [preprint, version 1], <https://doi.org/10.5194/egusphere-2022-792>

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