North Central Climate Adaptation Science Center

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Future Streamflow Estimates Suggest a Shift in Streamflow Magnitude and Timing by the End of the Century - Preliminary Results from the Tongue River 2100 Project

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Outline

- Project Goals
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- Approach
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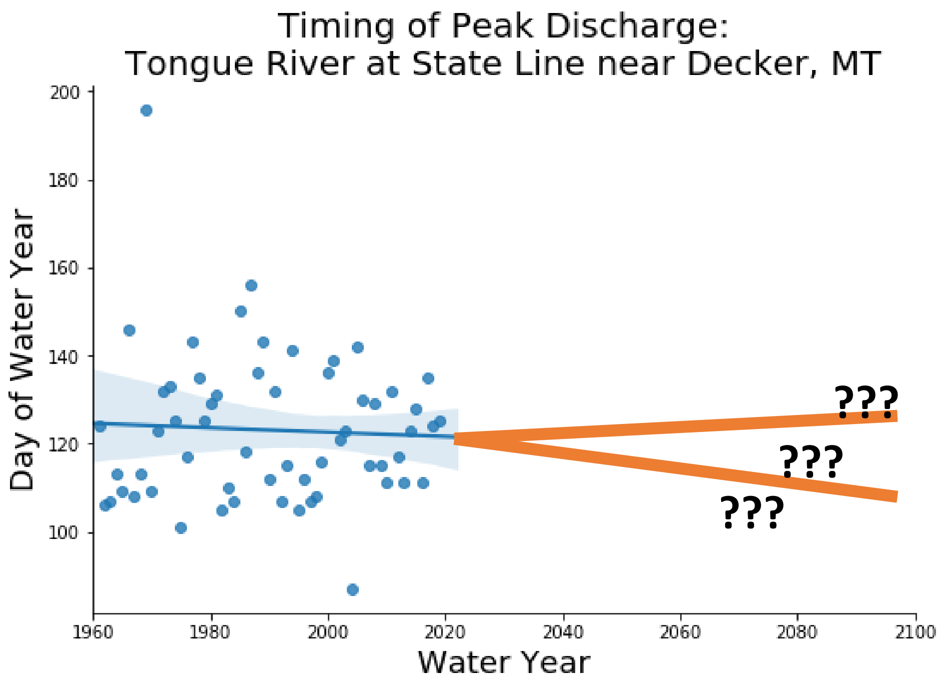
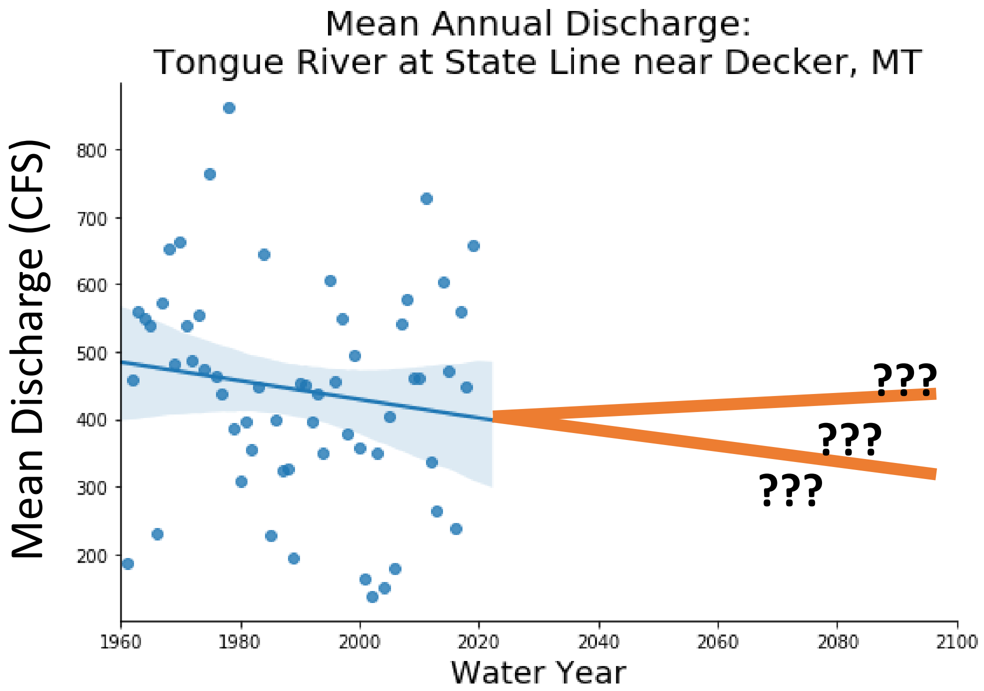
- Results
  - Watershed sub-catchments
  - Bias Correction
  - Future Streamflow
- Conclusions and next steps

Project Goals

- Co-produce knowledge with the Northern Cheyenne Tribe (NCT) and other project partners.
- Identify locations within the Tongue River watershed that are of interest.
- Construct and calibrate a river system model.
- Produce and analyze future streamflow estimates in conjunction with NCT and project partners.





Partner Engagement

Primary Indigenous Partnership

- Northern Cheyenne Citizens
- Northern Cheyenne Resource Managers

Water Resources

- Yellowstone River Compact Commission
- Montana Department of Natural Resources and Conservation
- Wyoming State Engineer's Office

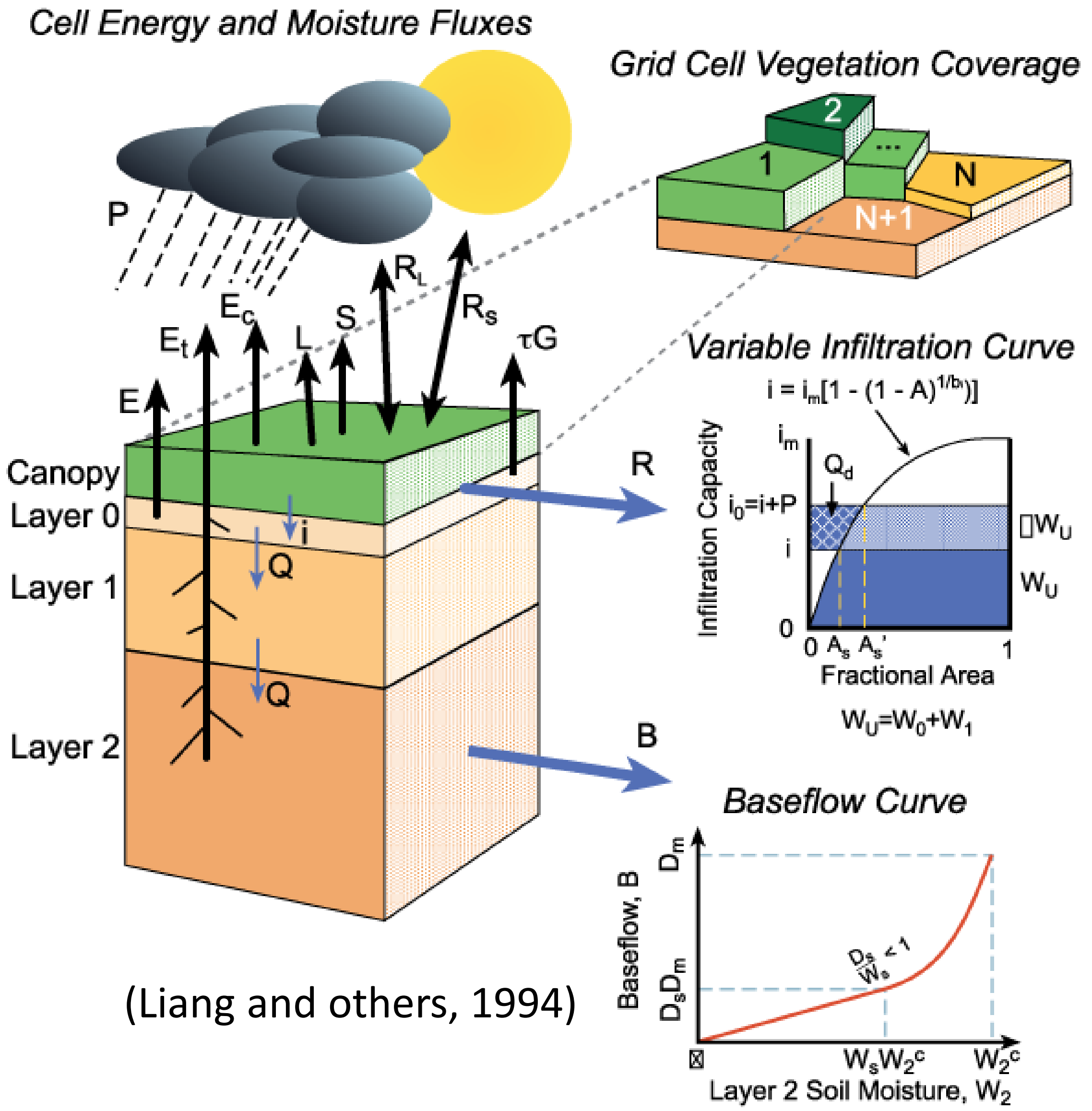
Irrigation

- Tongue River Water Users Association

Approach

- Use an existing future hydrology dataset (Vano et al., 2020):
  - Downscaled climate data using Localized Constructed Analogs (Pierce et al., 2014).
  - Two future climate scenarios considered (2006-2099):
    - RCP4.5 – moderate emissions (32 models)
    - RCP8.5 – business as usual (32 models)
  - Historical simulation period was 1950-2005.
  - Hydrologic outputs produced using VIC (Liang et al., 1994).

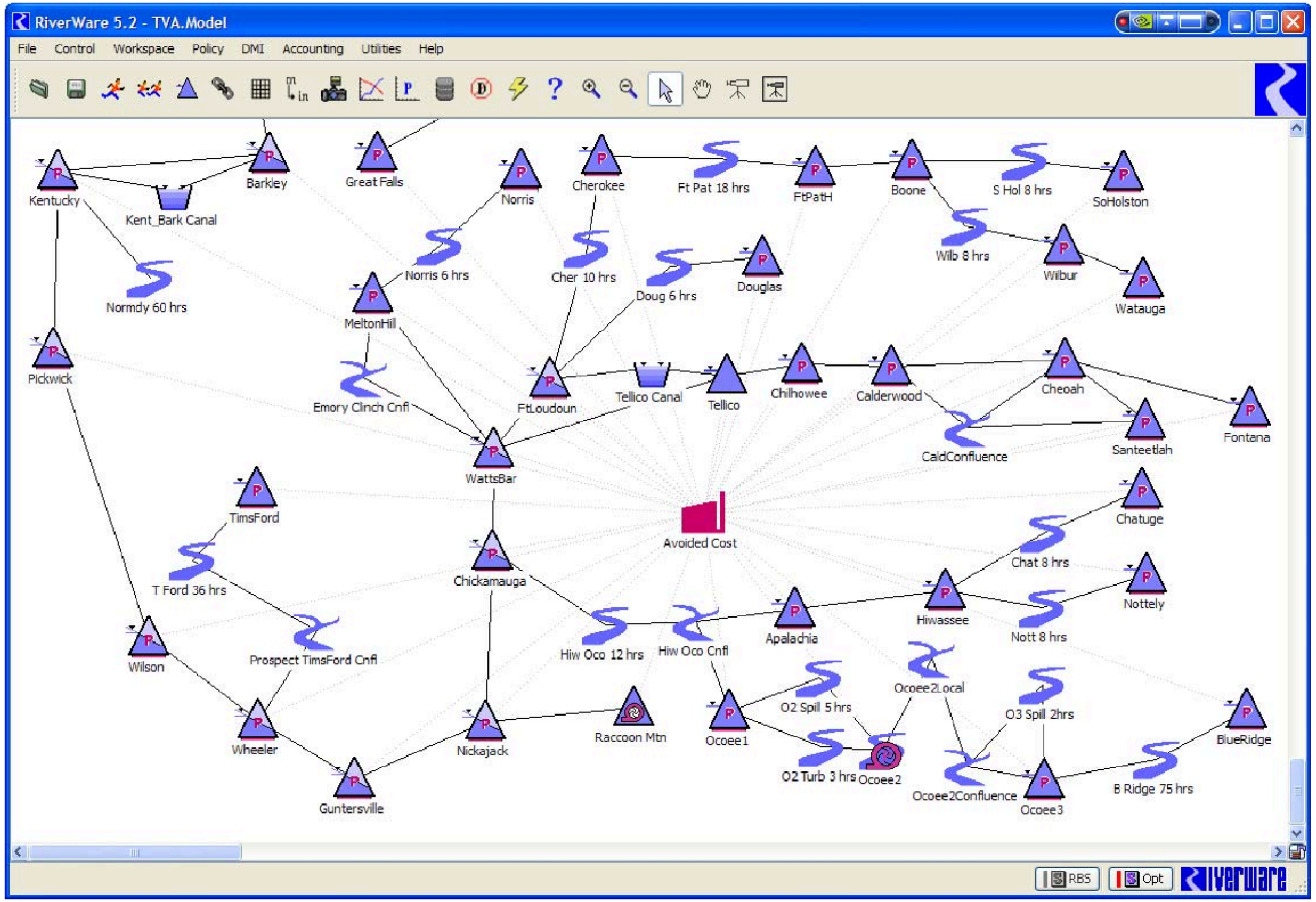
Variable Infiltration Capacity (VIC) Macroscale Hydrologic Model



(Liang and others, 1994)

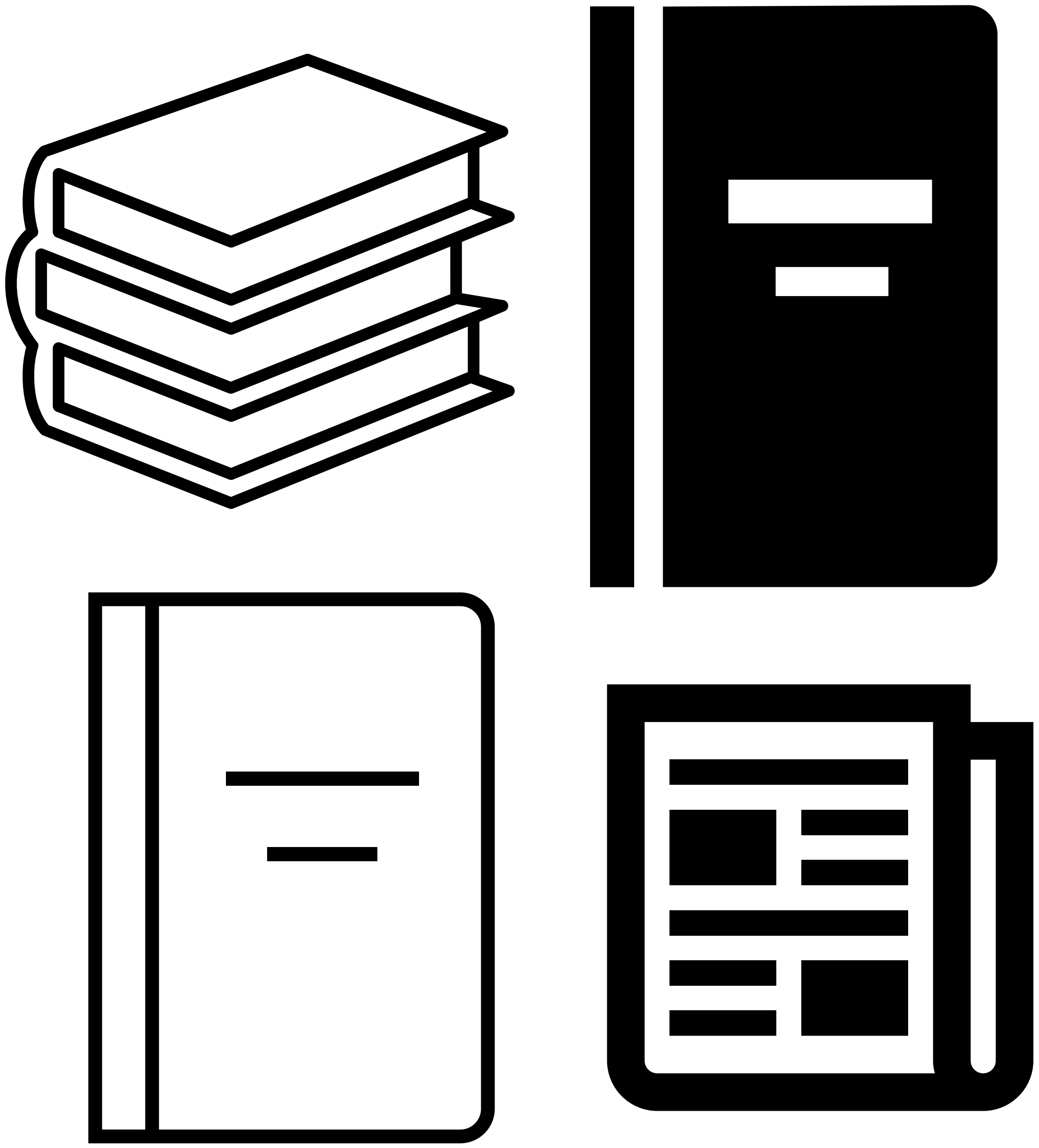
Approach

- Build and calibrate a RiverWare simulation (Zagona et al., 2001).
  - Represents irrigation and reservoir operations in the watershed.
- Use future-climate scenarios as inputs to RiverWare to produce future streamflow estimates.
- Produce analyses comparing historical to future streamflow estimates at points of interest.



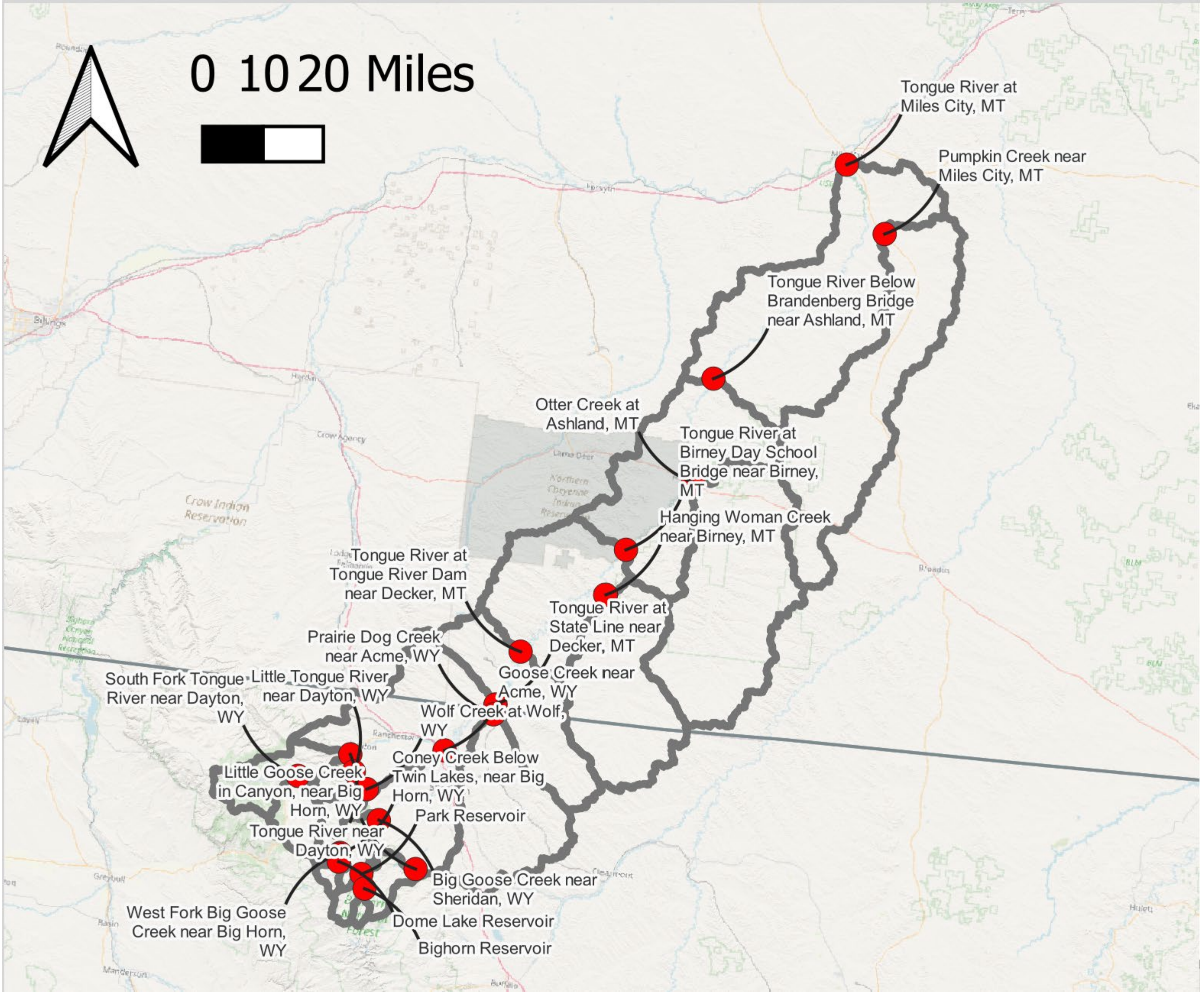
Planned Deliverables

1. Presentations to project partners summarizing findings.
2. A database of future streamflow estimates throughout the Tongue River watershed delivered by USGS ScienceBase.
3. A scientific paper detailing methods and results.



Results: Sub-Catchments

- The watershed has been divided into 21 catchments.
- This will allow the future hydrology estimates to work with the river system model.



Results: Focus Catchments

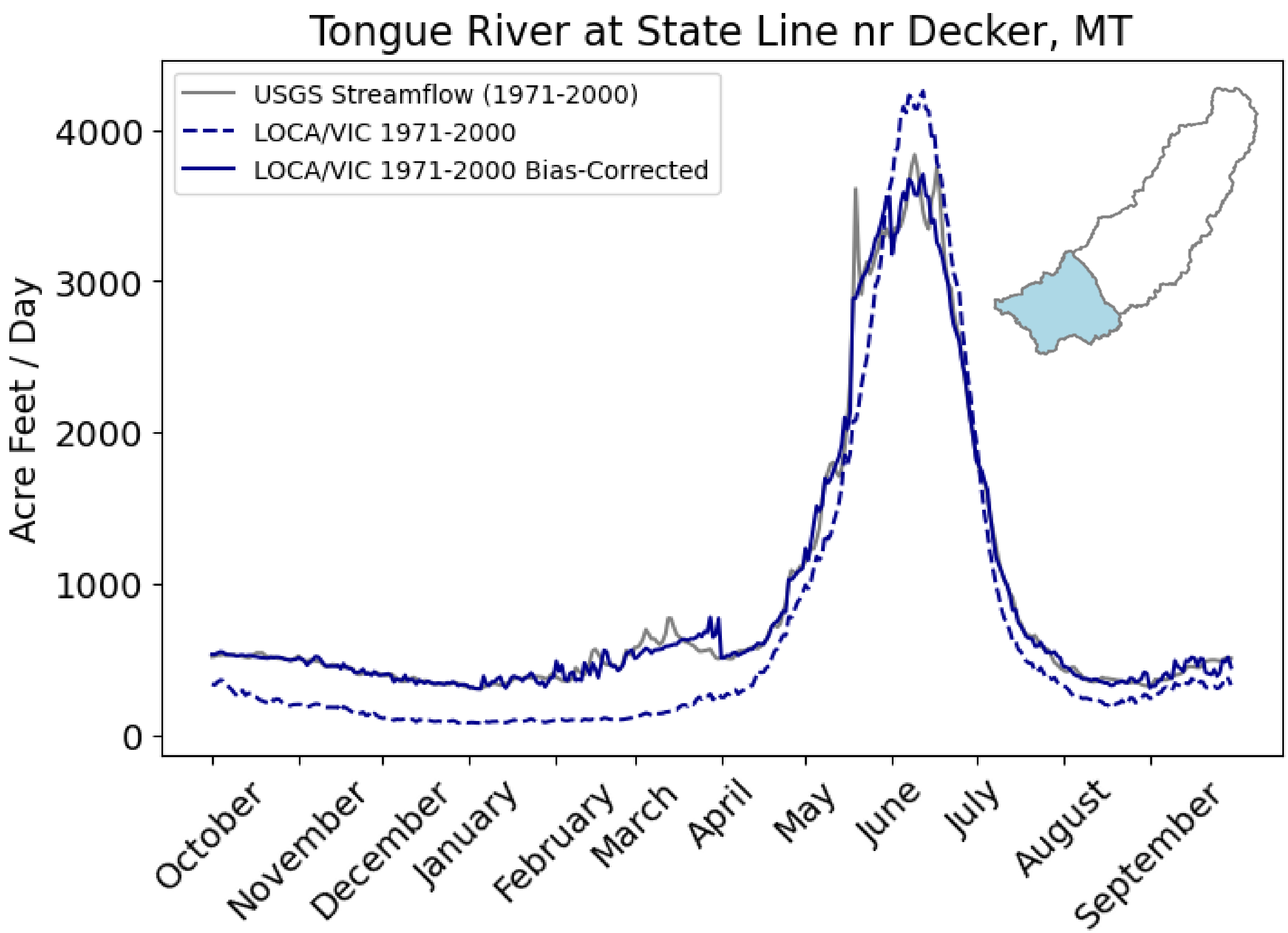
Tongue River at State Line Near Decker
(Headwaters)

Otter Creek Near Ashland
(Lowlands)

South Fork Tongue River
(High-Elevation)

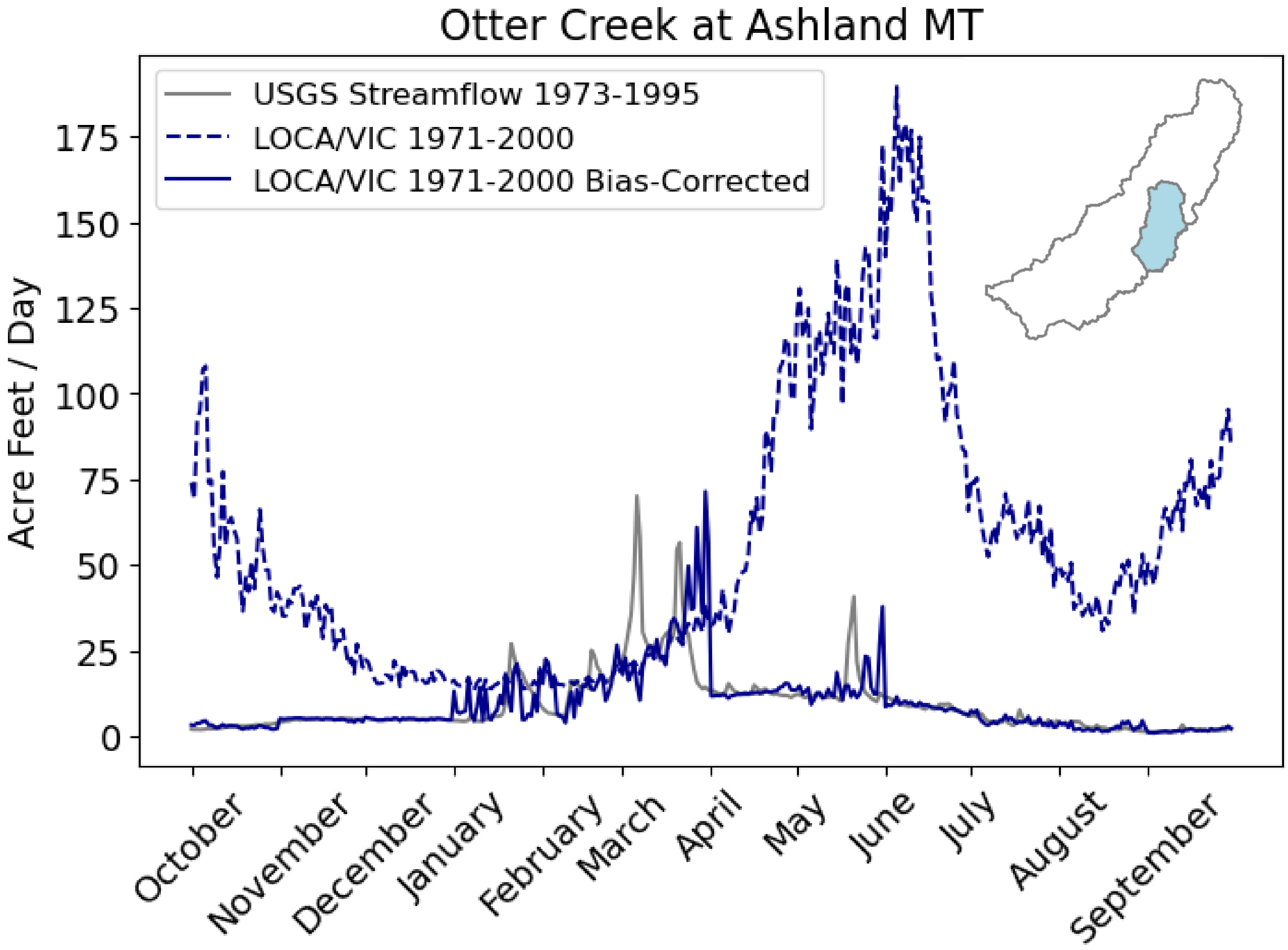
Results: Streamflow Bias Correction

- We bias-corrected historical VIC data using stream gage data following Farmer et al. (2018) via GEOGloWS (Sanchez Lozano et al., 2021).
  - This is done using monthly flow duration curves.
  - Rescales simulated streamflow based on observations.
  - Preserves temporal sequencing of streamflow.



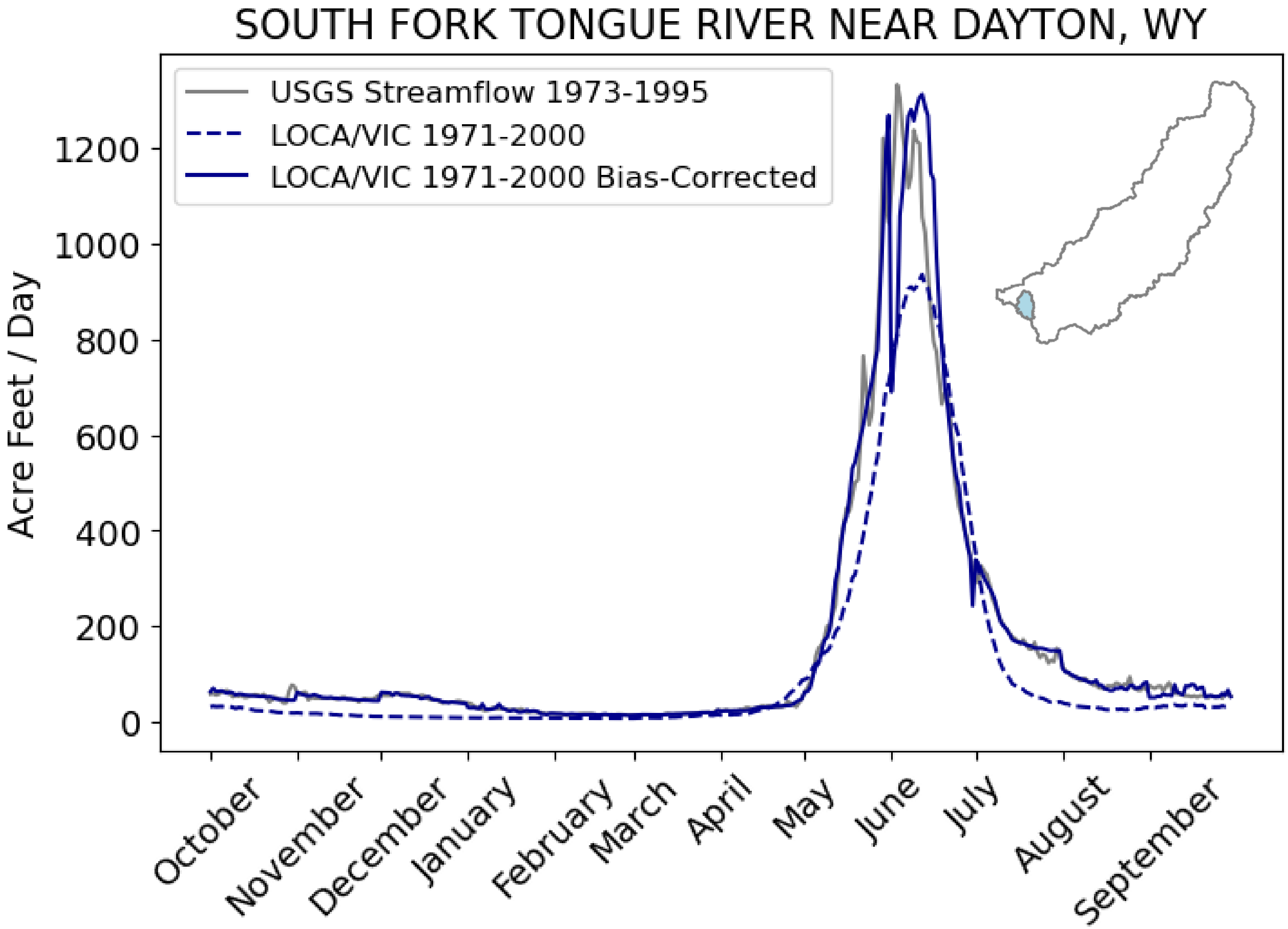
Results: Streamflow Bias Correction

- In the lowlands VIC and USGS streamflow do not match well.
- After bias correction the simulation matches the streamflow much better.
- This suggests that bias correction and RiverWare will be very important in the lower portions of the watershed.



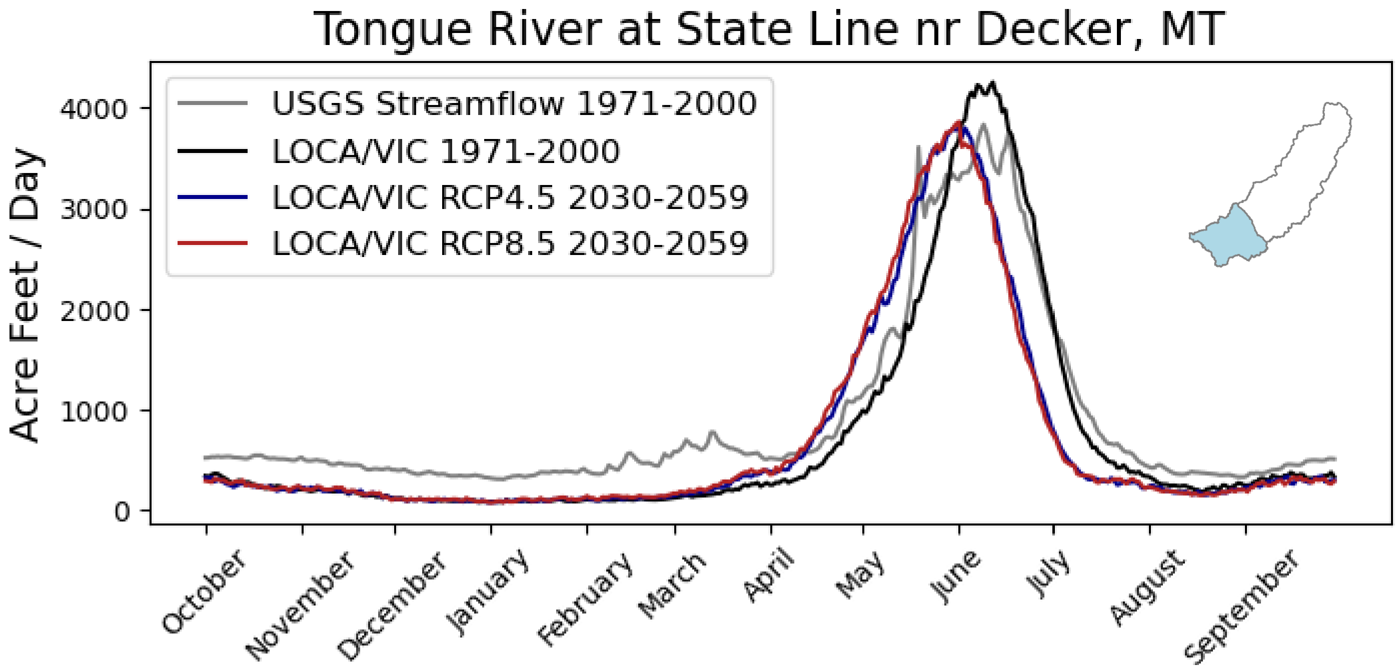
Results: Streamflow Bias Correction

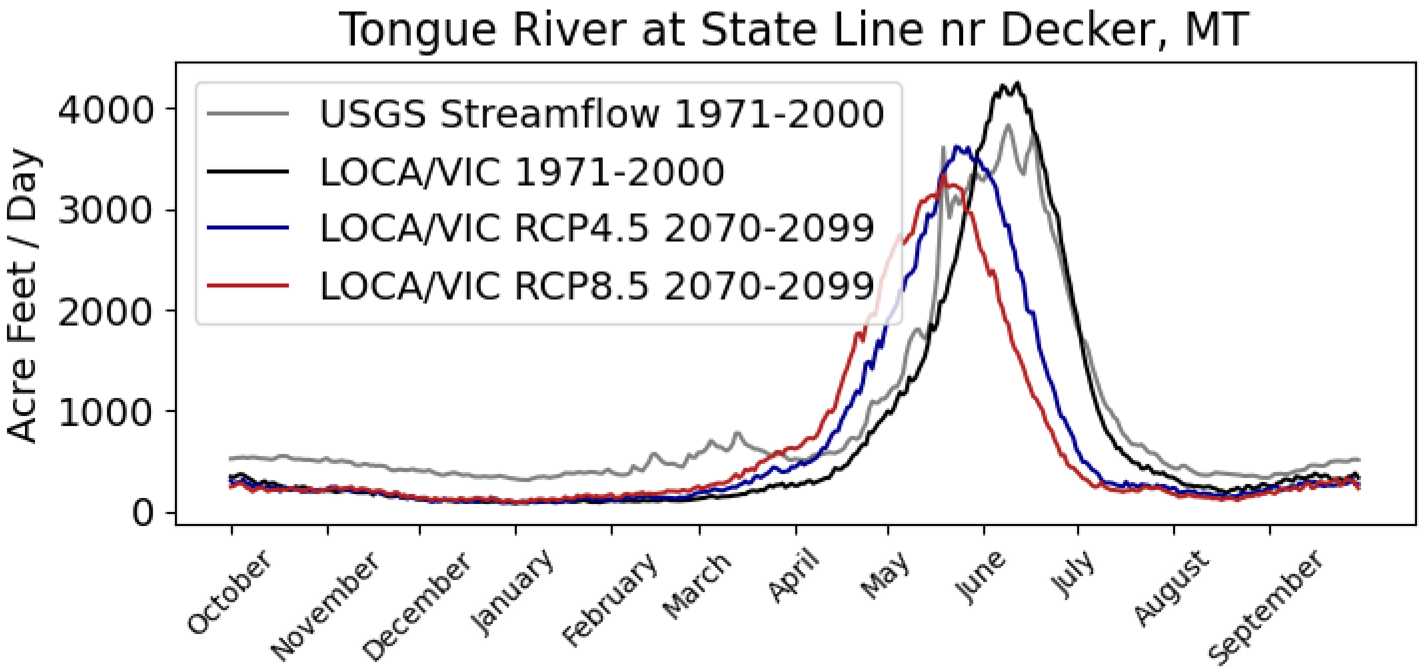
- In the high-elevation portion, simulated streamflow is biased low so bias correction is needed to correct this.



Results: Future Streamflow

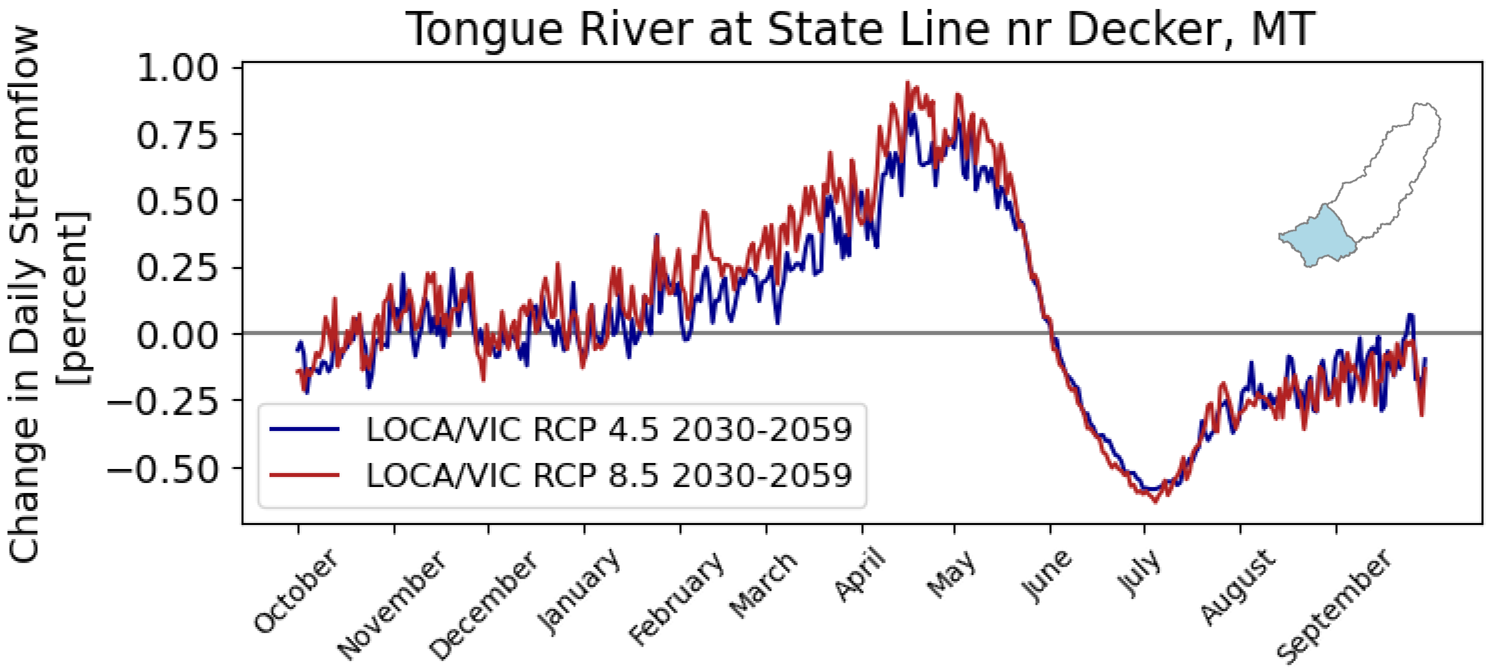
- At mid-century, both scenarios are similar and show earlier peak streamflow and a lower peak compared to historical VIC output.
- By end of century, RCP4.5 and 8.5 have diverged with 8.5 showing earlier and lower streamflow relative to 4.5.

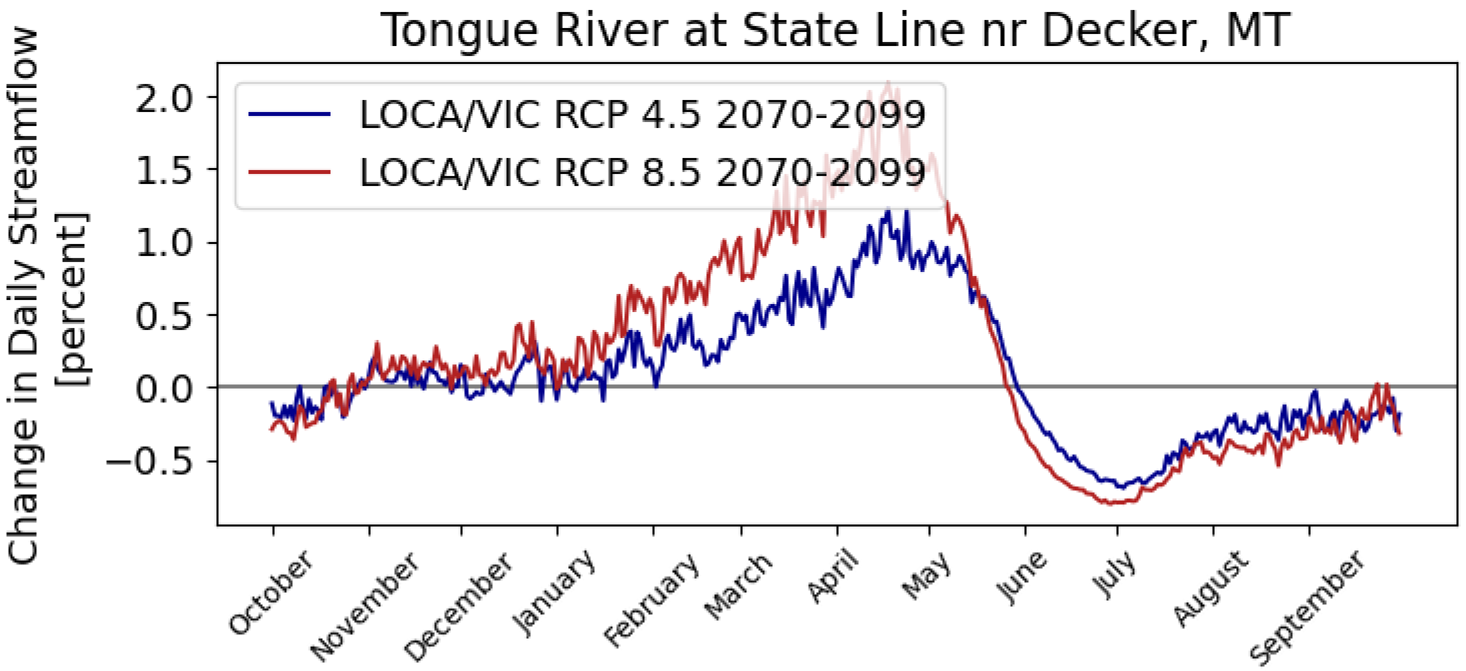




Results: Future Streamflow

- At mid-century there was little difference between both scenarios but there was increased streamflow in the winter and spring and then decreased streamflow in the summer.
- By end of century RCP8.5 showed much greater winter and spring streamflow compared to RCP4.5





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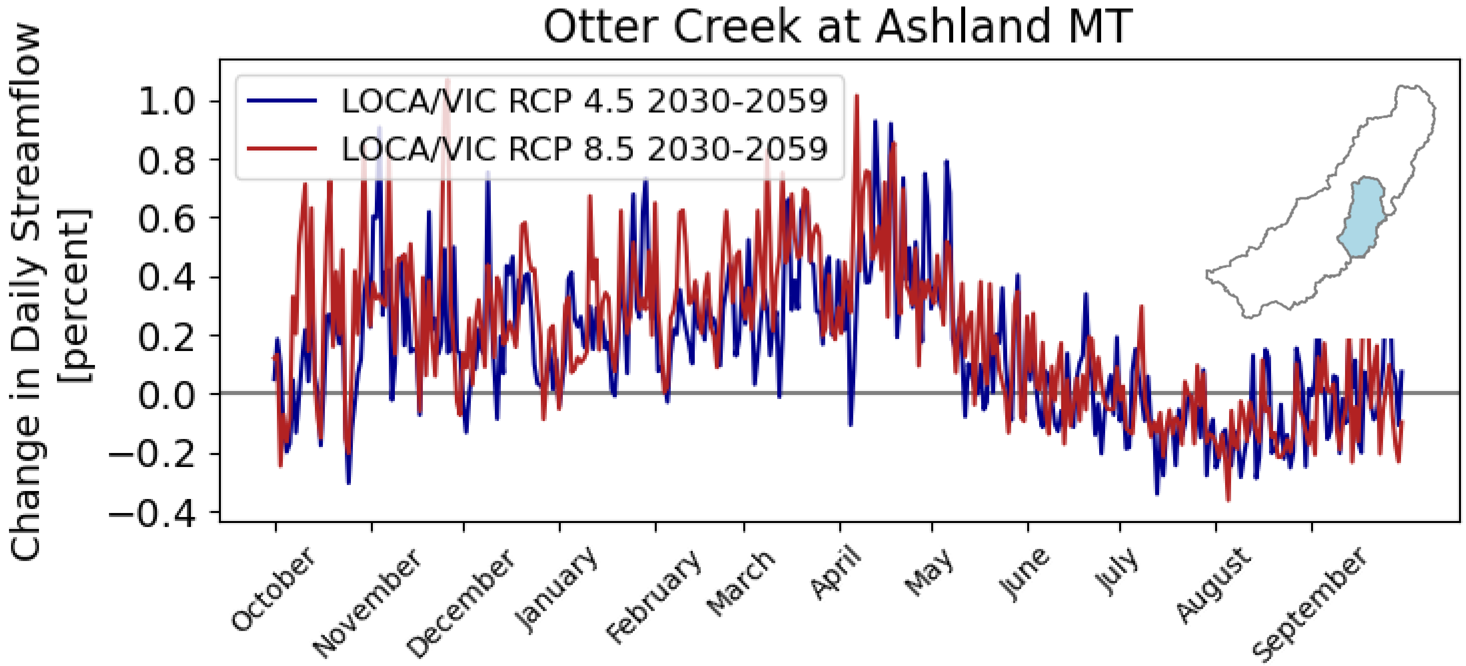
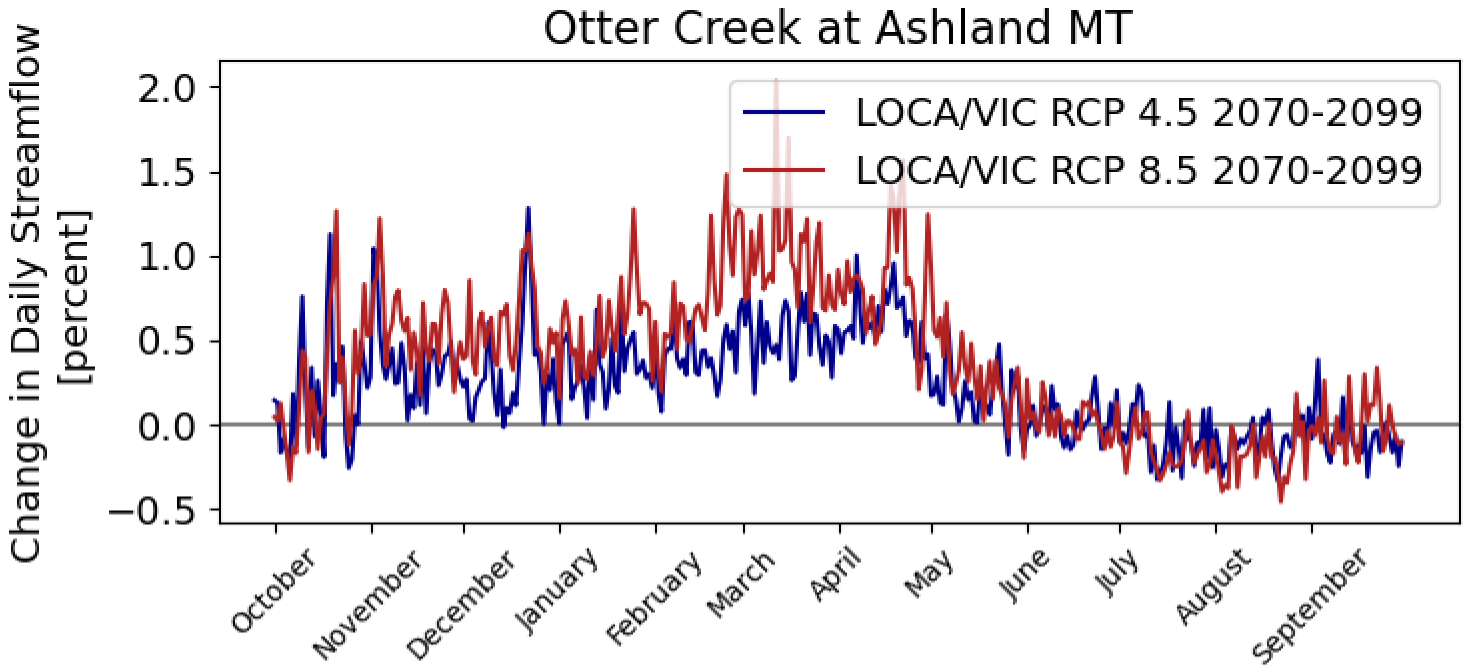
Results: Future Streamflow

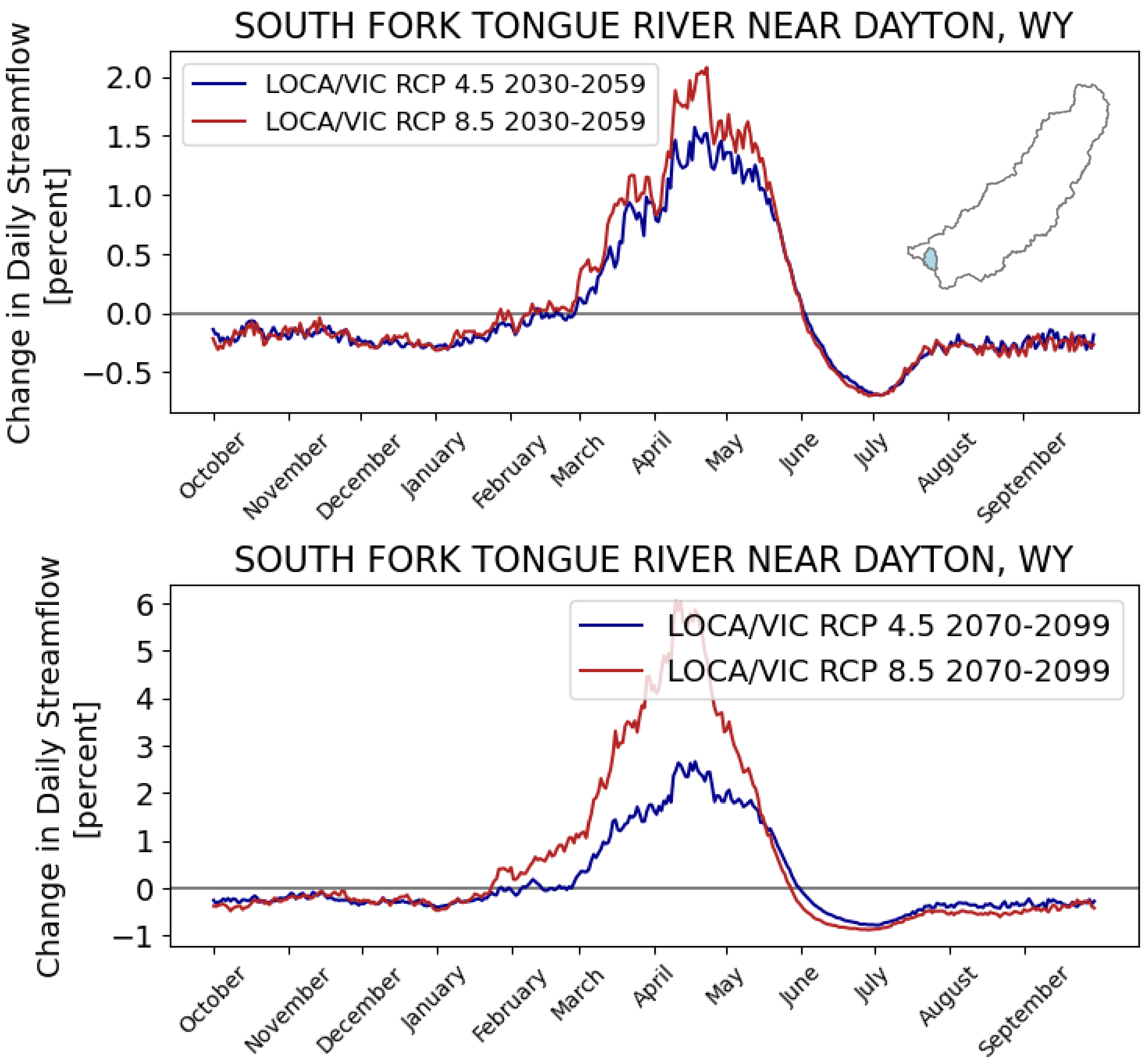
- RCP4.5 and 8.5 are similar mid-century.
- Wetter fall-spring and then a bit drier in the summer.
- By end of century there is some divergence between RCP4.5 and 8.5 in the winter.





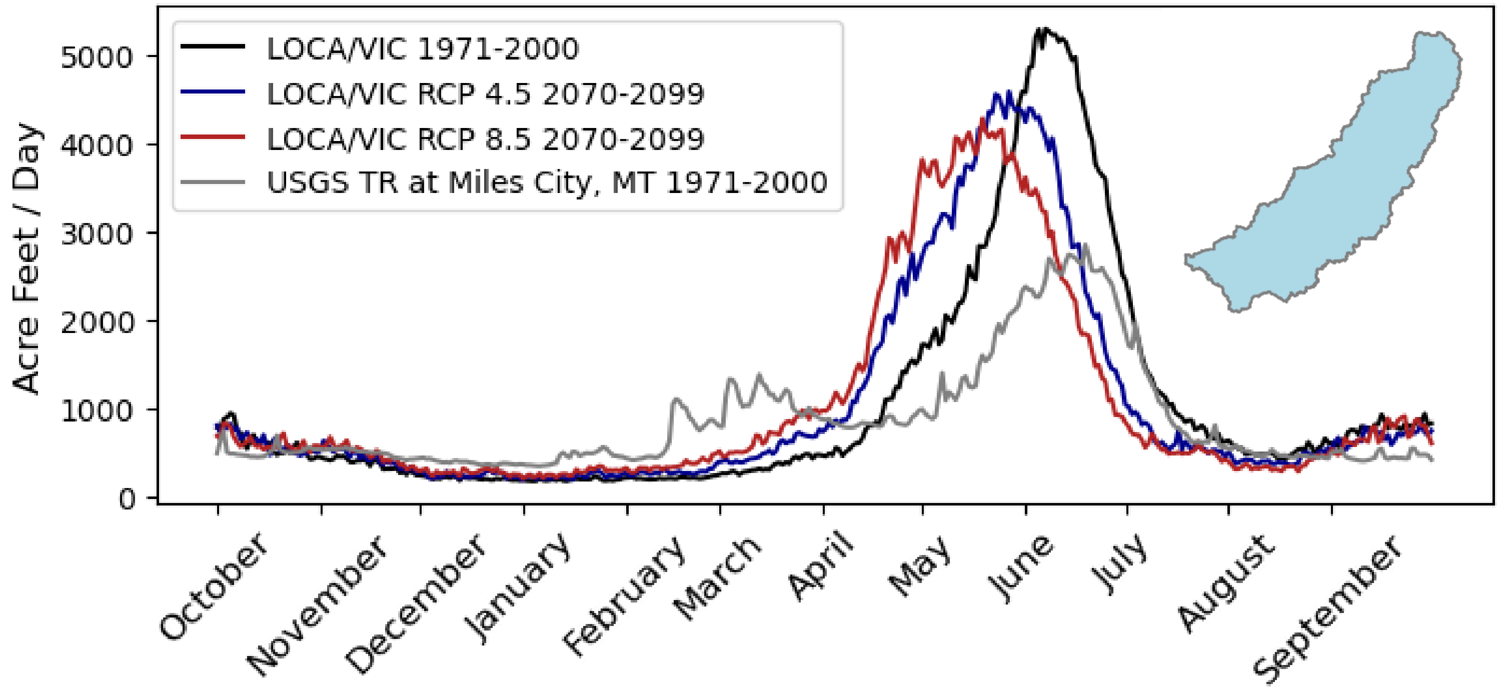
Results: Future Streamflow

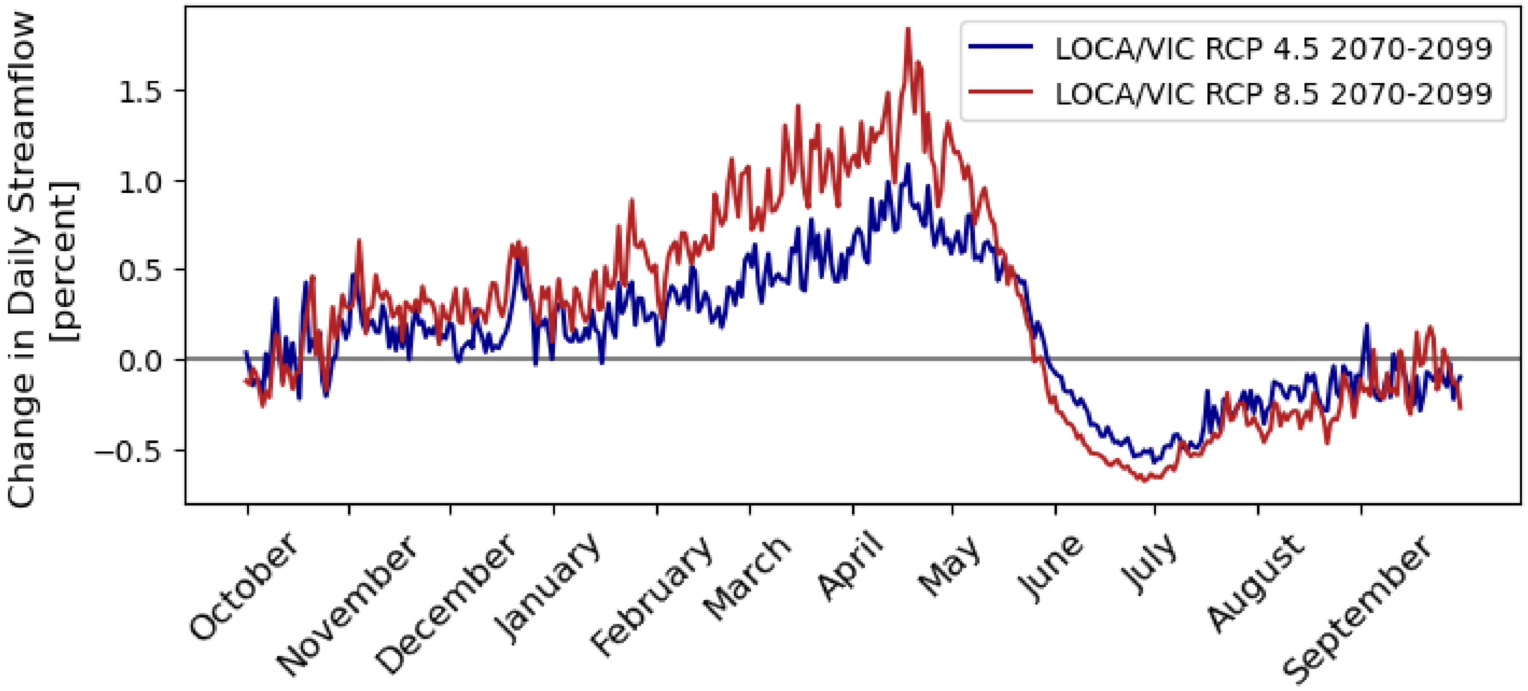
- Increased spring streamflow but decreased summer and fall streamflow by mid-century for RCP4.5 and 8.5.
- By end of century winter spring streamflow is much greater for RCP8.5 and both scenarios show decreased streamflow in fall and summer.



Results: Future Streamflow

- Across the whole watershed end of century streamflow is expected to shift earlier in the year with a lower peak, particularly for RCP8.5





Conclusions and Next Steps

- Preliminary results suggest earlier streamflow timing across the domain and lower peak streamflow.
- Bias correction needed in all catchments, particularly in the low-elevation portions of the domain.
  - Bias correction methods need to be extended to future time periods in the LOCA/VIC output.
- Analysis needs to be extended for annual streamflow volumes and low flow changes.
- RiverWare model is under construction to compute naturalized flow (for bias correction) and for future climate streamflow estimates.

Questions?

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Project Web Page

Contact Information

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