

High-resolution coupled climate modeling for hydrometeorology and terrestrial hydrology in Alaska and Yukon

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NSF Navigating the New Arctic Project – The climate impacts on Alaskan and Yukon rivers, fish, and communities as told through co-produced scenarios (Multi-institution effort under Indigenous guidance)

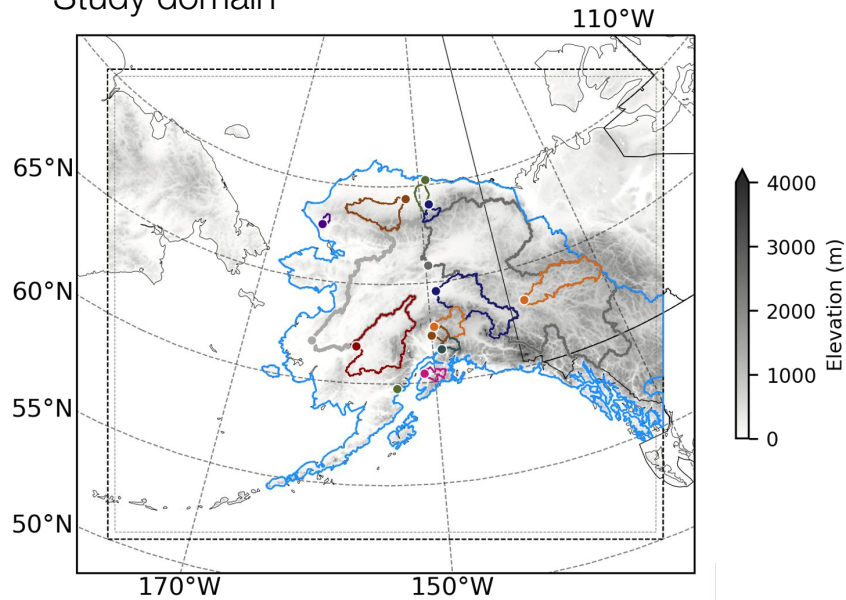


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- The Arctic is rapidly changing:
 - Large increases in temperature and decreases in sea ice
 - Increases in annual precipitation and rain versus snow amounts
 - Changes in seasonal snowpack
- Indigenous Alaskans heavily rely on the inland river systems for essential subsistence fishing as well as transporting fuels and supplies

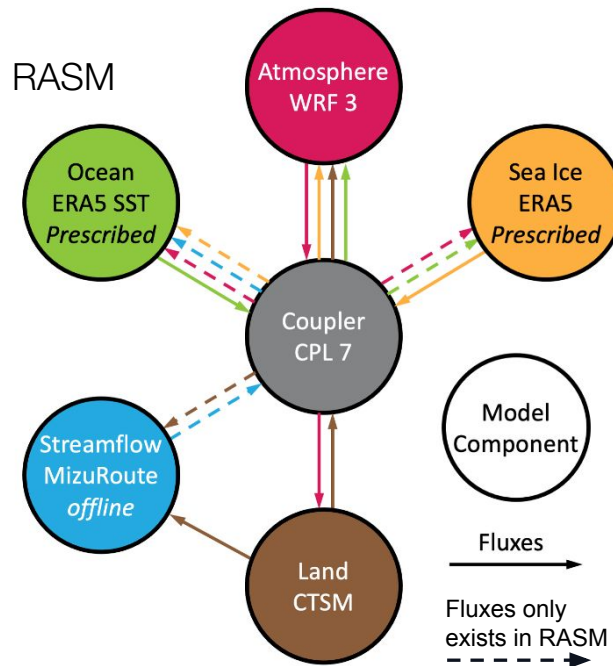
Study domain



High-resolution coupled land and atmospheric modeling

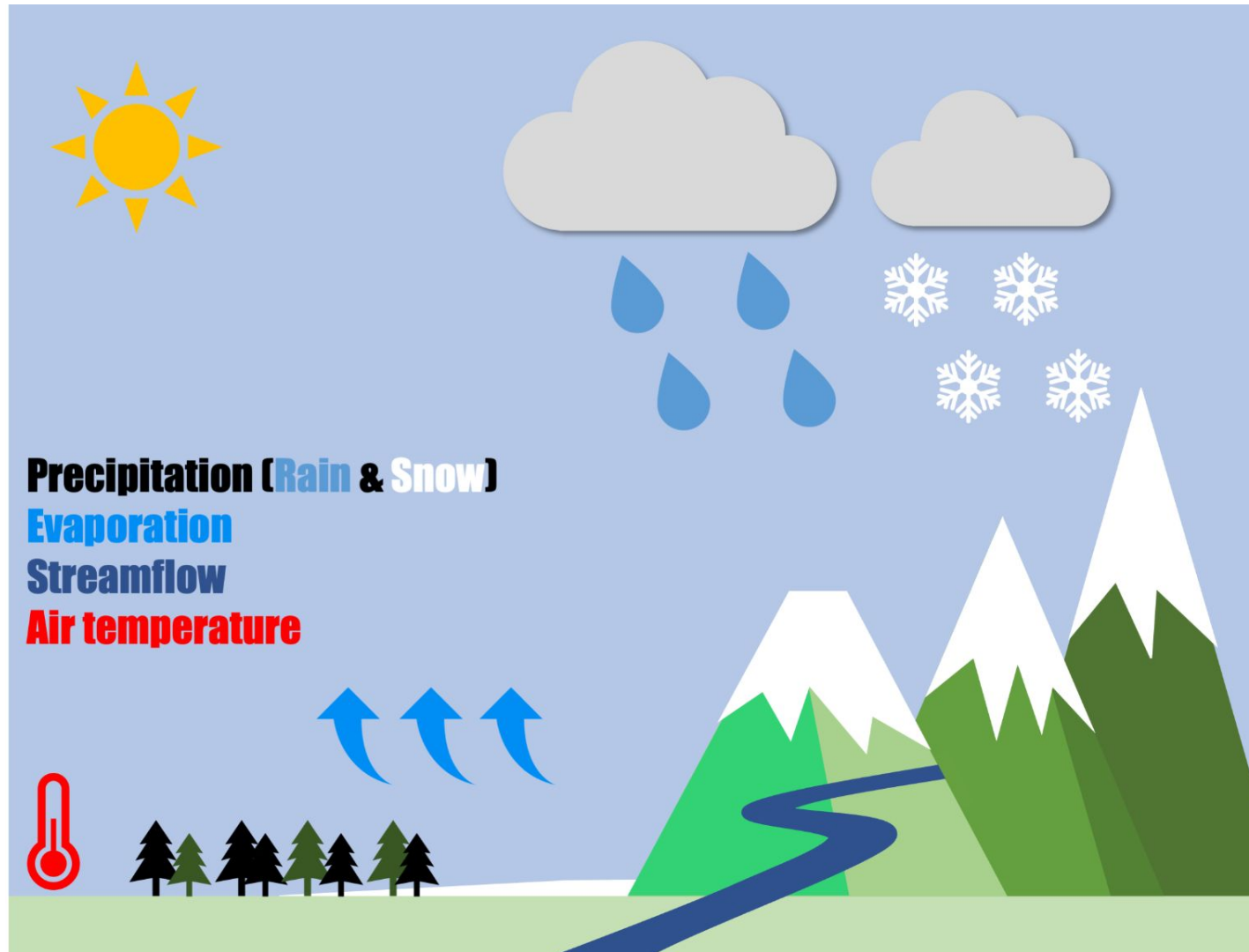
Regional Arctic Systems Model (RASM)

- Land Model
 - We optimized parameters for CTSM and used them in the coupled run (Cheng et al., 2023)
- Atmospheric Model
 - Manually test WRF namelist
 - Explore physics options in WRF
 - Make sure that optimized CTSM parameters will not deteriorate the performance of coupled simulations
- Historical WRF-CTSM simulation for WY1990-2020
 - Spatial resolution: 4km



Cheng et al. (2023) Moving land models towards more actionable science: A novel application of the Community Terrestrial Systems Model across Alaska and the Yukon River Basin. WRR

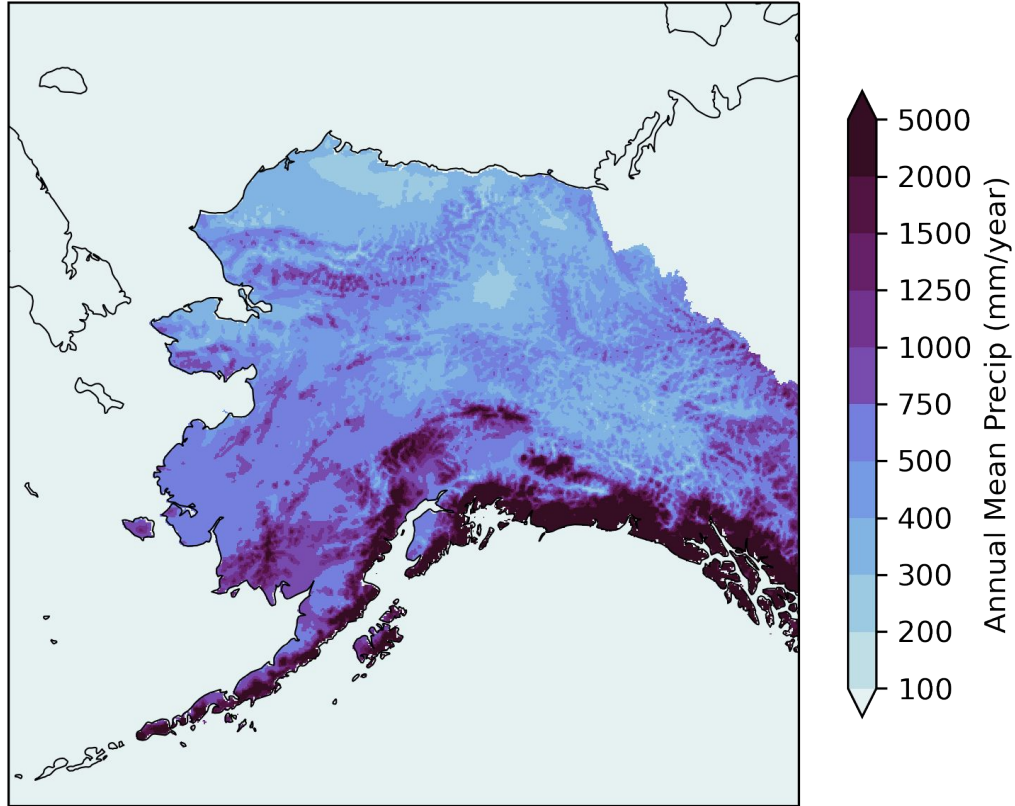
Examine hydrometeorology and terrestrial hydrology simultaneously



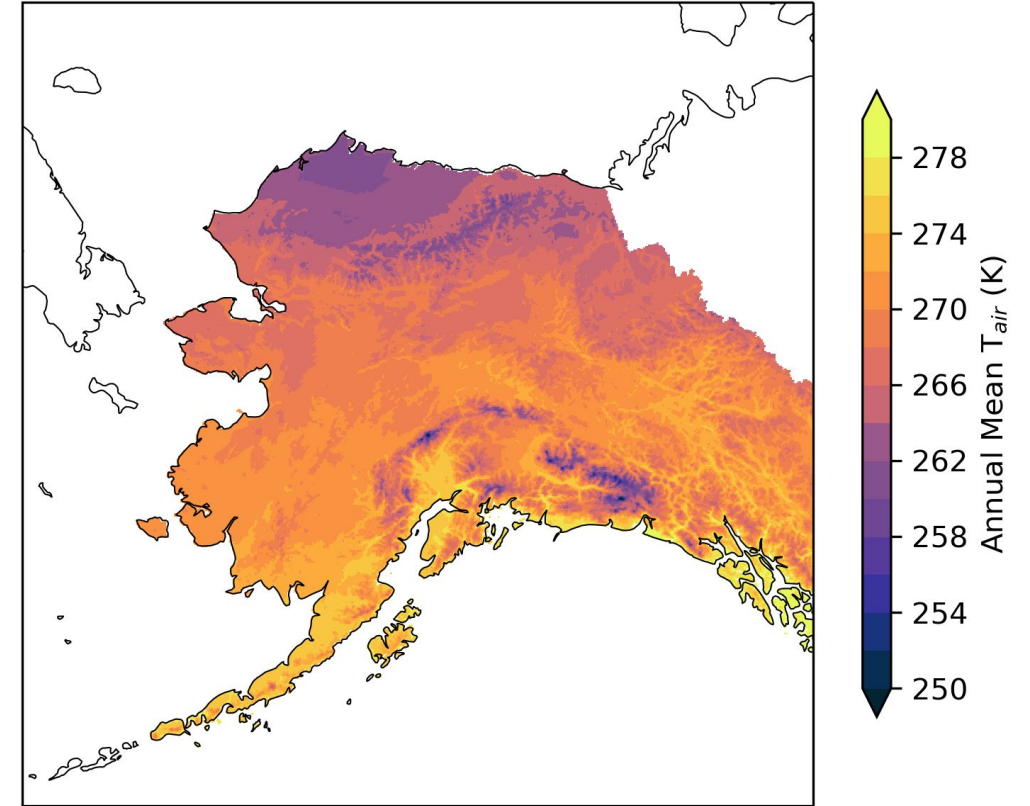
Total Precipitation
2-m air temperature
E/P ratio
Snow-to-precipitation fraction
Terrestrial snow
Streamflow

Simulated precipitation and air temperature from coupled WRF-CTSM modeling

Mean annual precipitation

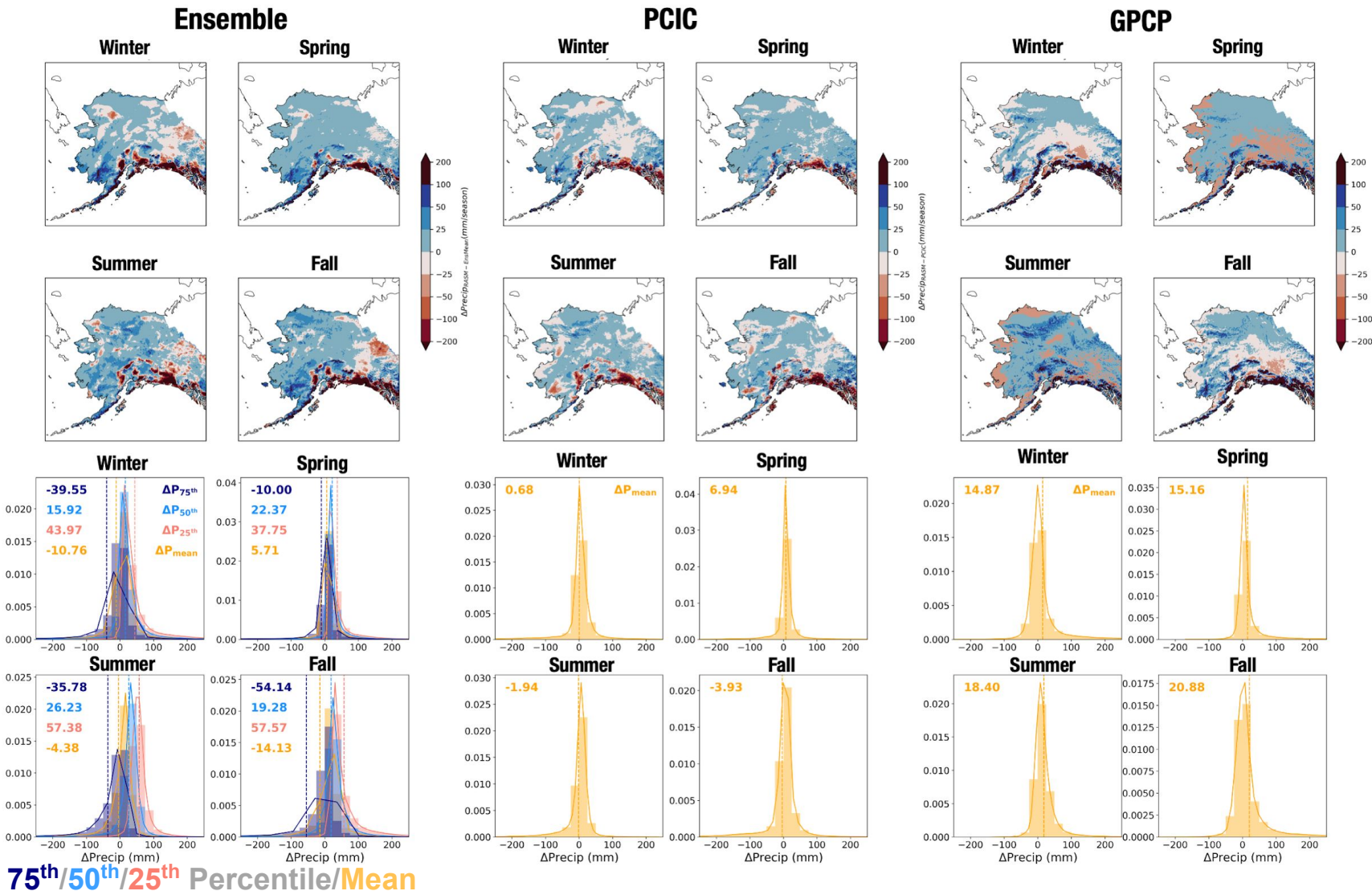


Mean annual air temperature



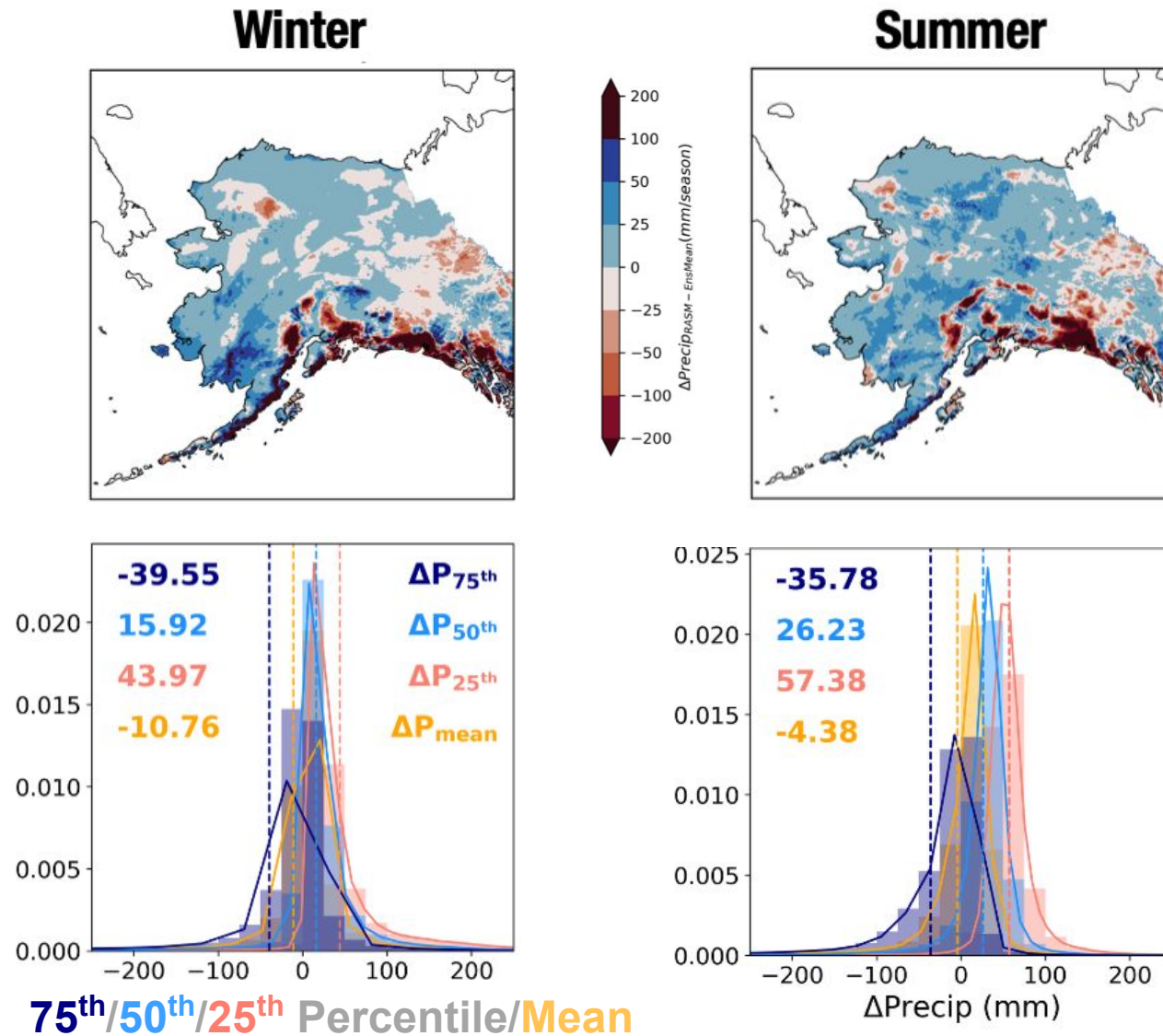
- Plots above show clear complex ridge-valley patterns and orographic impacts on precipitation and air temperature distributions

Our simulation captures the spatial distribution and quantity of precipitation well



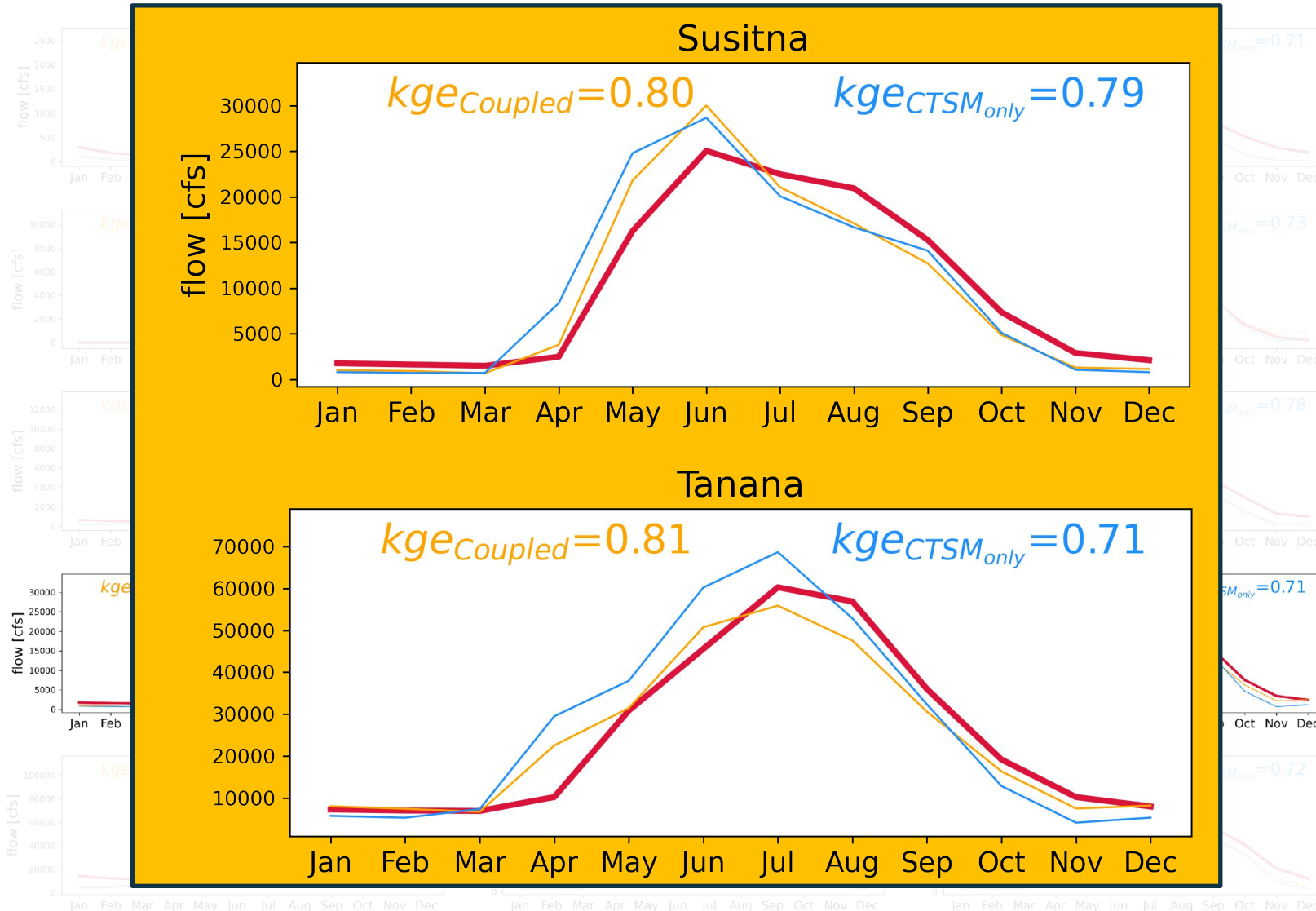
- Precipitation data products shows discrepancies over Alaska and Yukon River Basins
- Our simulation well captures the spatial distribution of mean seasonal precipitation with seasonal biases smaller than 50 mm/season
- Mean regional biases are mostly within 20 mm/season for PCIC, GPCP, and ensemble mean estimate.

Our simulation captures the spatial distribution and quantity of precipitation well

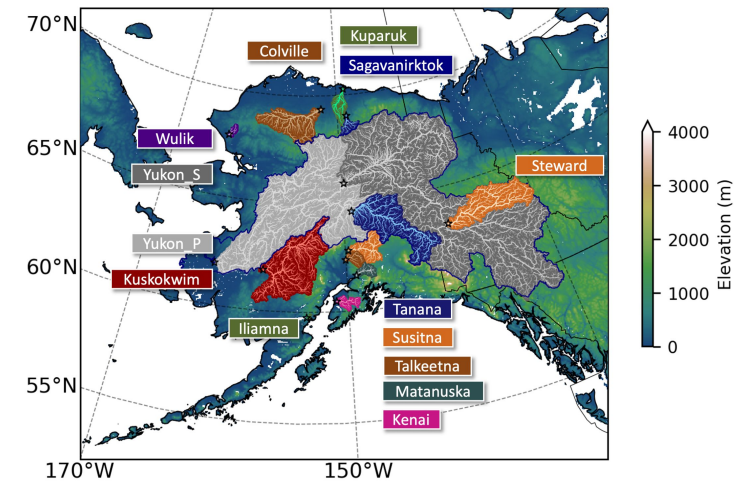


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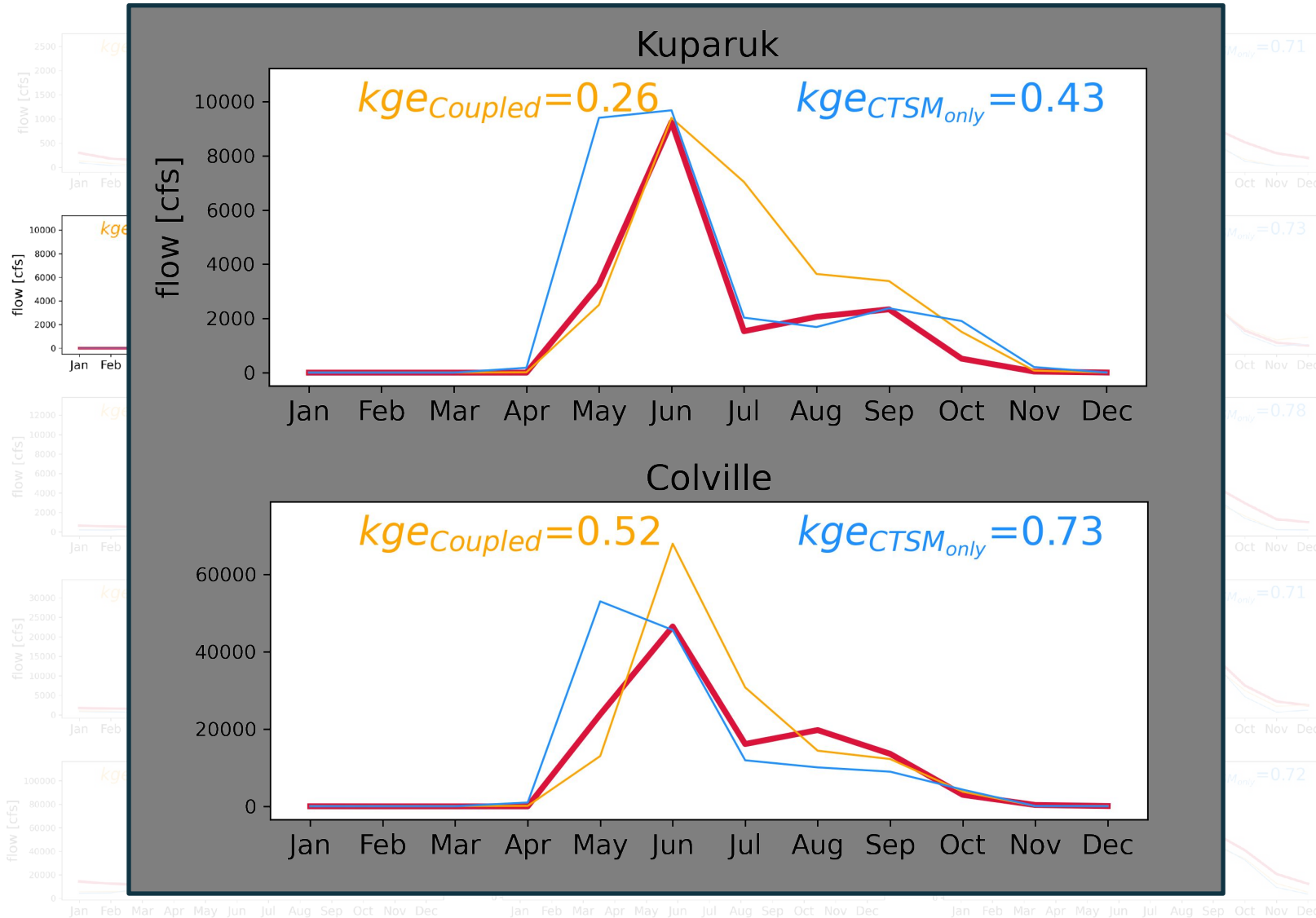
Streamflow (Evaluated against *USGS observations*)



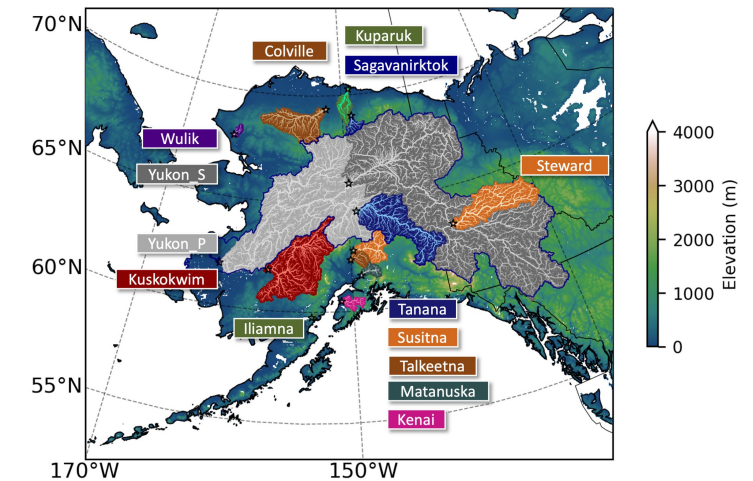
- Some basins show **better** flow performance (evaluated using Kling-Gupta Efficiency) in coupled run than **CTSM only**



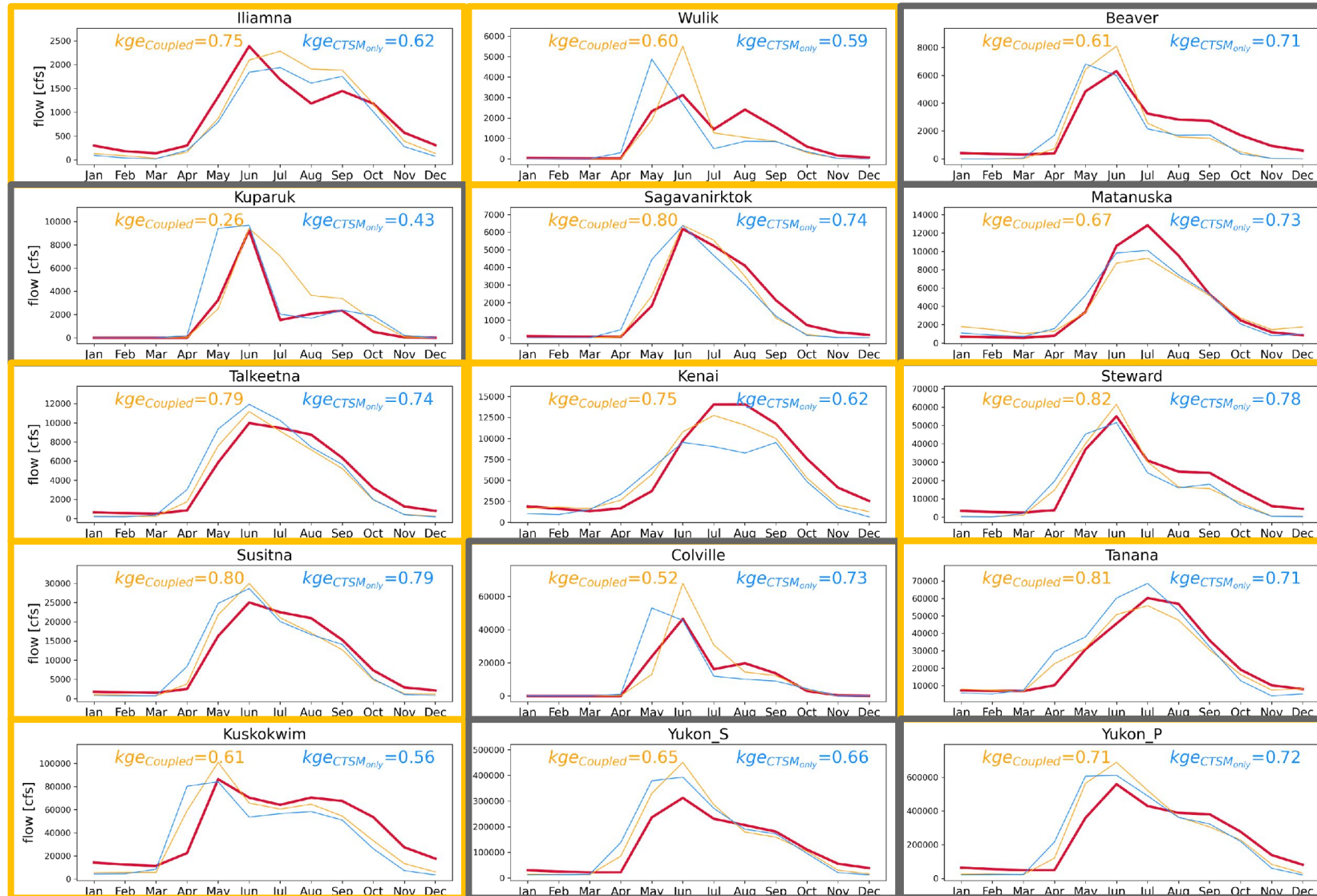
Streamflow (Evaluated against *USGS observations*)



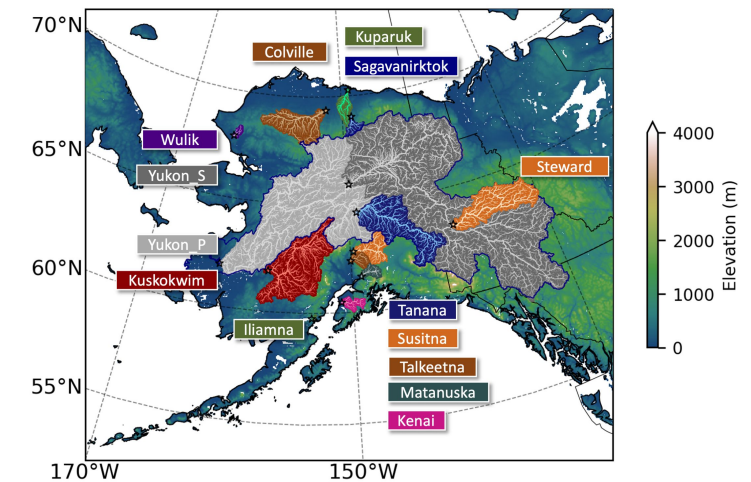
- ...while some basins show **worse** flow performance (evaluated using Kling-Gupta Efficiency) in coupled run than **CTSM only**



Streamflow (Evaluated against *USGS observations*)



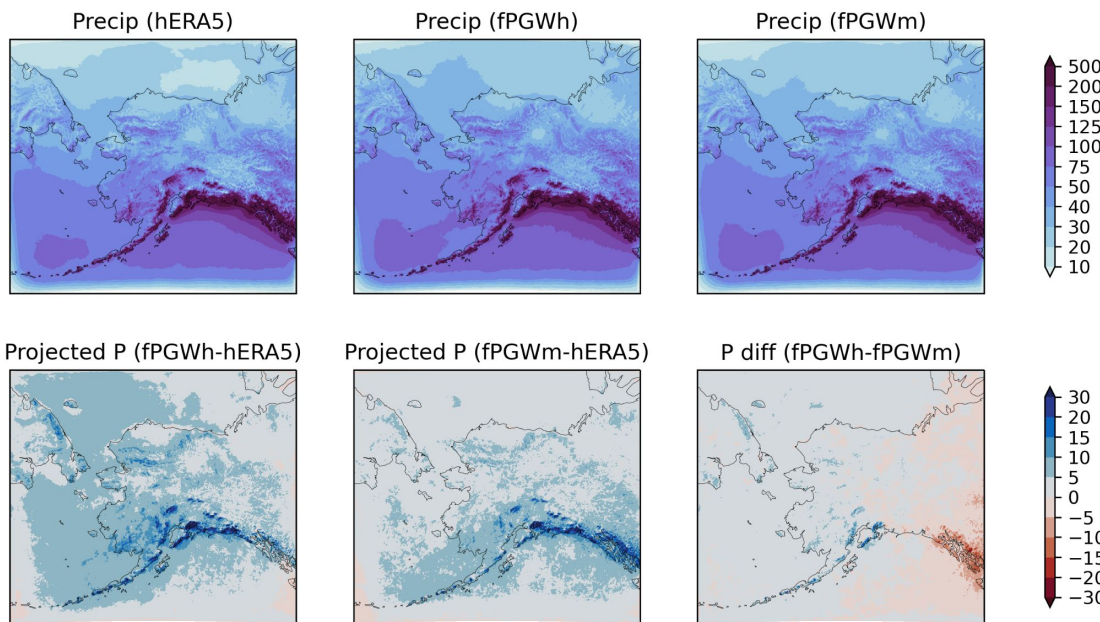
- **9** out of 15 basins show better flow performance (evaluated using Kling-Gupta Efficiency) in coupled run than **CTSM only**



Quantify the climate impacts?

Pseudo Global Warming - 2 scenarios Ongoing

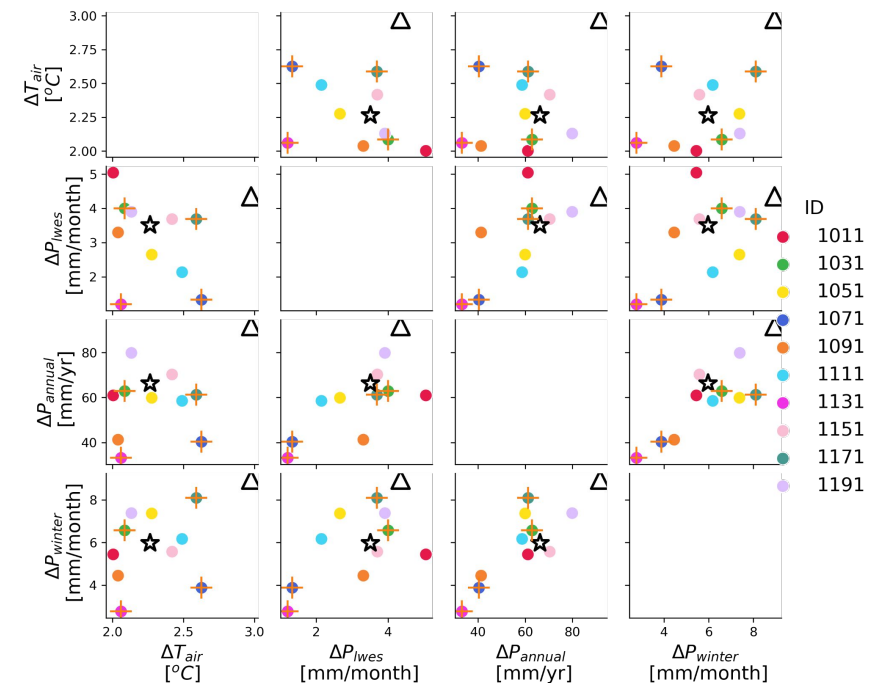
- Flexibility in future scenario design, interpretability, and avoiding biases from GCMs
- We selected two future scenarios, i.e., *median* and *high*, which are ensemble means across different GCMs from SSP2-4.5



Dynamic Downscaling - 4 members In Prep

- Better for understanding the changes in weather, storms, and extreme weather events
- Four members were selected from CESM2-LENS
- Derecho ASD allocation (71 million cpu hours)

△: high PGW
☆: median PGW
+: Selected CESM2-LENS2 ensemble members



Takeaway

- We actively engage Indigenous participation in this project to ensure that Indigenous Knowledge is included, valued and protected. Their knowledge also guide the study design and modeling decisions.
- An optimization workflow is designed for CTSM
 - [Workflow is available on Github \(https://github.com/NCAR/ctsm_optz\)](https://github.com/NCAR/ctsm_optz)
- We are working on making our climate data more accessible back to Indigenous communities.
- We will provide this coupled WRF-CTSM climate and hydrology dataset to the community with variables available from sub-daily to monthly from 1990 to 2021.
- Next Steps
 - [Finish up the PGW runs](#)
 - [More high-resolution regional runs \(Derecho HPC ASD program\)](#)



Interdisciplinary Project Team



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