

Developing Actionable Regional Climate Models and Data for Communities and Decision-makers Across Alaska and Northwestern Canada

CESM Workshop, High-resolution cross-working group, 11 June 2025

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Overview



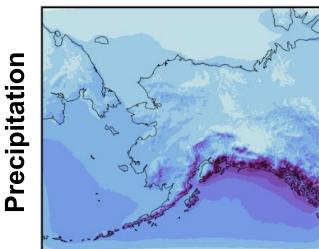
- The Arctic is rapidly changing:
 - Large increases in temperature and decreases in sea ice Increases in annual precipitation and rain versus snow amounts Changes in seasonal snowpack
- Inland river systems are essential for subsistence fishing as well as transporting fuels and supplies

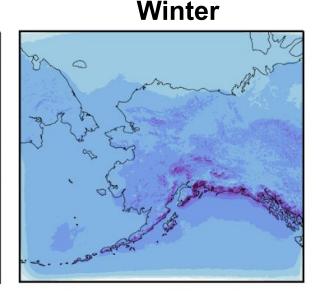


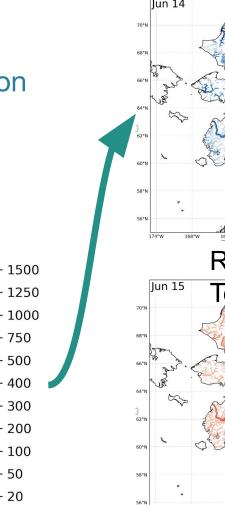
Regional Climate Model Development

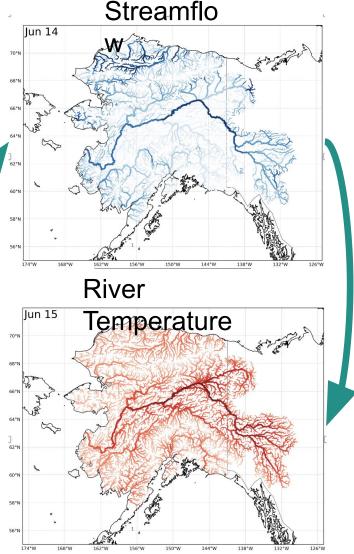
- NSF Navigating the New Arctic Arctic Rivers project
 - Assessing the climate sensitivity of Alaskan & Yukon rivers and fish to support resilient communities
- Partnership with YRITWC informed the initial proposal motivation and conceptual approach

Summer







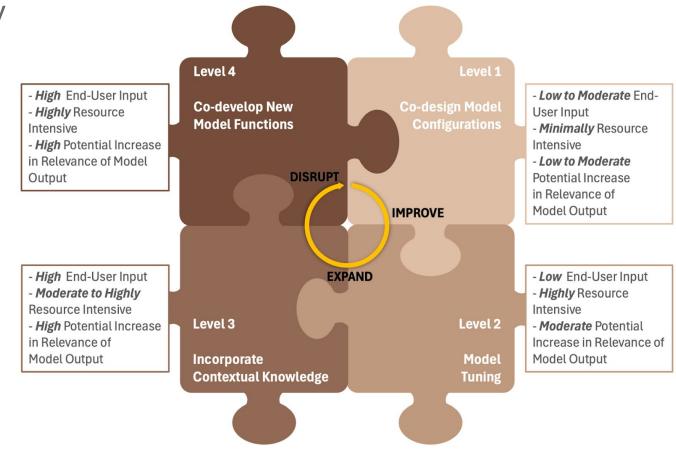




Historical

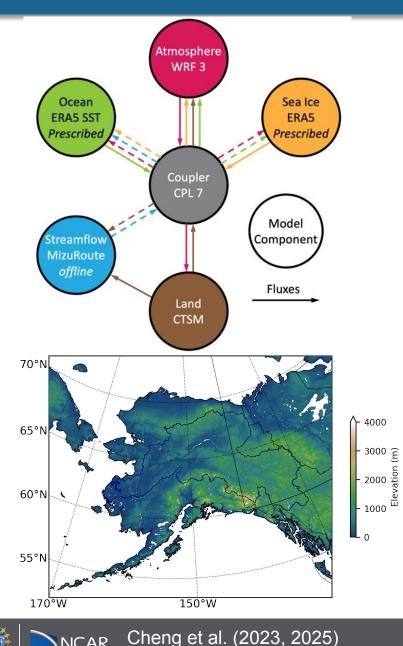
Regional Climate Model Development

- Model (and projection) co-design is a spectrum ranging from none to very deep integration
- In our project, we worked across levels of co-design
 - Ranging from 2 (co-designing model configuration) to 3 (local knowledge informed model localization)
- Level of effort, skills, partner questions and capacity, other considerations all influence our research
 - Types of impact models
 - Probabilistic versus storylines



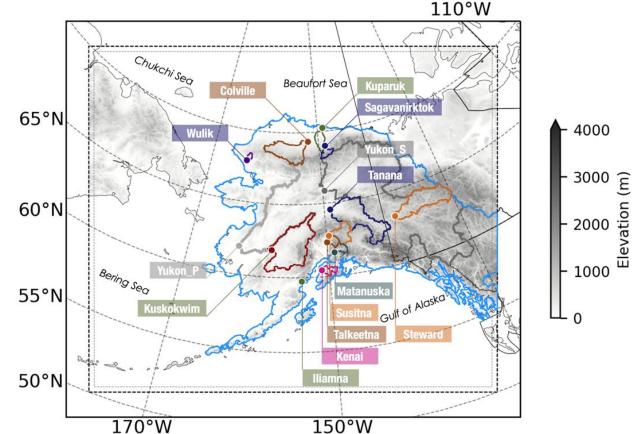


Regional Climate Model Development



- Co-design can help mitigate built-in assumption risk
- Our model: Regional Arctic Systems Model (RASM)
 - A regional ocean-land-atmosphere-ice coupled model
 - WRFv3.7.1 atmospheric model
 - Community Terrestrial Systems Model (CTSM)
- All models have a world view (assumptions)
- What are the key limitations for your application?
 - Move to Community Terrestrial Systems Model (CTSM) in RASM, include hydrologic optimization
 - RASM and CTSM configurations
 - E.g. 4 km grid spacing, hillslope hydrology
 - Future climate experiments (number and time span)
 - Follow-on impact models, data dissemination

- Nearly all of Alaska, and all of the Yukon River basin
 - 4 km grid spacing
 - Formal optimization applied to CTSM, river routing, stream temp
- Simulations:
 - 30 year historical (ERA5 forced)
 - Two 30 year Pseudo Global Warming (PGW) (2035-2065)
 - Four CESM2-LE members
 - 30 historical and mid-century time slices matched to other runs





Historical Simulation Verification

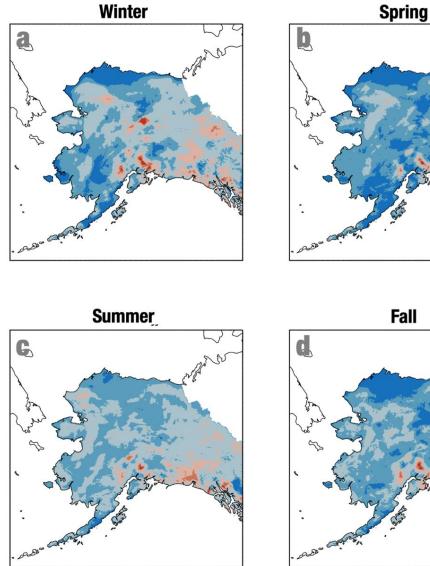
90th percentile

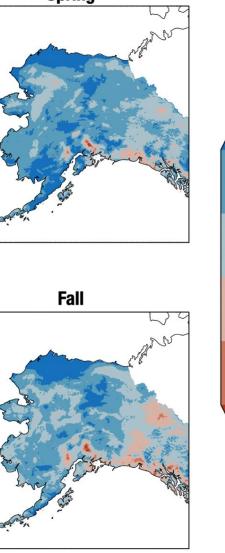
75th percentile

25th percentile

10th percentile

50th percentile

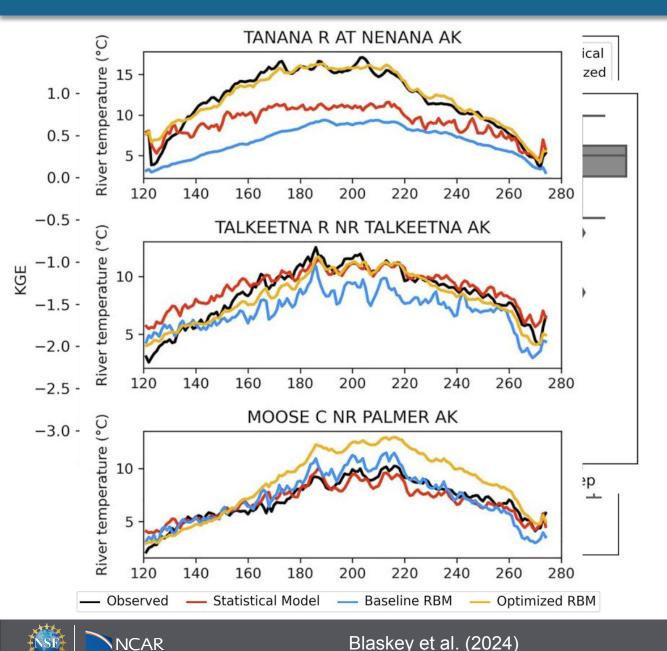




- Use of performance benchmarks and other meaningful performance descriptors
- Observations have uncertainty, use it to guide validation
 - Precipitation often falls within range of observational uncertainty (from Newman et al. 2020)
 - Arctic is challenging for quantitative validation
 - Few observations, complex spatial features
 - Consistent wet bias on north slope
 - Potential dry bias along SE AK



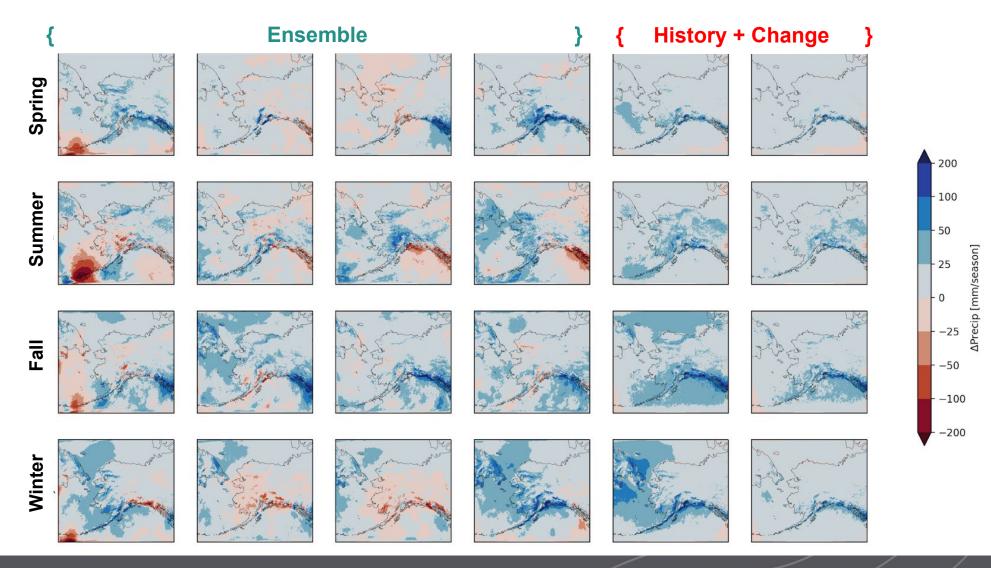
Historical Simulation Verification



- Offline (not shown) and coupled streamflow improved over baseline
 - Offline model has NSE > 0.5 in majority of validation basins (usefulness metric)
 - Coupled model daily streamflow median KGE of 0.47
- Daily stream temperature estimates also improved
 - Compared to default and simple statistical model (benchmark)
 - Site to site variance

Future Change Signals

Seasonal precipitation – long-term circulation changes matter in Alaska





Newman et al. (2025), submitted to BAMS

Data Distribution and Post-processing

- Releasing datasets through traditional pathways
 - NSF NCAR Research Data Archive
 - NSF Arctic Data Center
 - Zenodo
- Archiving model code, namelists, restart files
- Also working on post-processed and interactive inquiry
 - Working with UAF, SNAP, and IARC
 - Northern Climate Reports
 - Rising Voices, Changing Coasts
 - Multiple spatial aggregations
 - Plain language summaries

Research Data Archive Datasets ~ Resources ~ Support ~ News



Home / Datasets / D614000



Multi-decadal historical regional hydroclimate simulation with two mid 21st century Pseudo-Global Warming futures over Alaska and the Yukon at 4 km resolution

d614000 | DOI: 10.5065/ZPSB-PS82 ☆

NORTHERN CLIMATE REPORTS ECOLOGICAL FUTURES IN STORIES, CHARTS, and DATA

A changing climate is altering Northern landscapes. Explore these changes with easy-to-understand climate model projections.

Locations matching 64.99°N, -146.91°E

The map on the left shows hydrological units (HUC-8, HUC-10) and protected areas near the point you selected. Additional areas of interest (ethnolinguistic regions, fire management units, climate divisions and Native corporation are not shown on the map because they are large, but are included in the list of matching areas below.

Chena River State Recreation Arec

- Doyon, Limited NATIVE CORPORATION LANDS
- Fairbanks Area FIRE MANAGEMENT UNIT
- Fairbanks North Star Borough BOROUGH
- GMU 20A GAME MANAGEMENT UNIT
 GMU 20B GAME MANAGEMENT UNIT
- GMU 20B GAME MANAGEMENT UNIT
 GMU 25C GAME MANAGEMENT UNIT
- Military Zone FIRE MANAGEMENT UNIT
- Northeast Interior CLIMATE DIVISION
- Southeast Interior CLIMATE DIVISION
- Steese National Conservation Area
 Tanana ETHNOLINGUISTIC REGION
- Tanana Valley State Forest
- Upper Yukon Zone FIRE MANAGEMENT UNIT
- White Mountains National Recreation Area

Hydrological units (HUCs)

- Banner Creek-Tanana River HUC10 ID1908030709
- Bear Creek HUC10 ID190804020



Top: NSF NCAR RDA landing page

Bottom: northernclimatereports.org

- Successful initial co-design of a regional climate model
 - Lessons learned for future efforts
 - Data, models, and methods for applications and fundamental research
 - Future physical model improvements and process studies
- Information beginning to be used across communities and agencies
 - Focus of remaining project is on storylines and generation and dissemination of useful and usable data
- Much work remains to distill these massive, complex datasets
 - Initial data releases are not readily accessible by communities, so we are helping distill information

