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Projecting future stream temperature in the Greater Yellowstone Ecosystem using observations and regional climate models

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Overview

- Motivation: ‘How will stream temperatures change in the future in the GYE and how will those changes impact aquatic species (ie Yellowstone Cutthroat Trout)?’
- Part I: Use observations to develop air-stream relationships and apply to future air temperatures simulated by Regional Climate Models (RCMs) to model future stream temperatures
- Part II: Apply temperature based growth models using derived future stream temperatures

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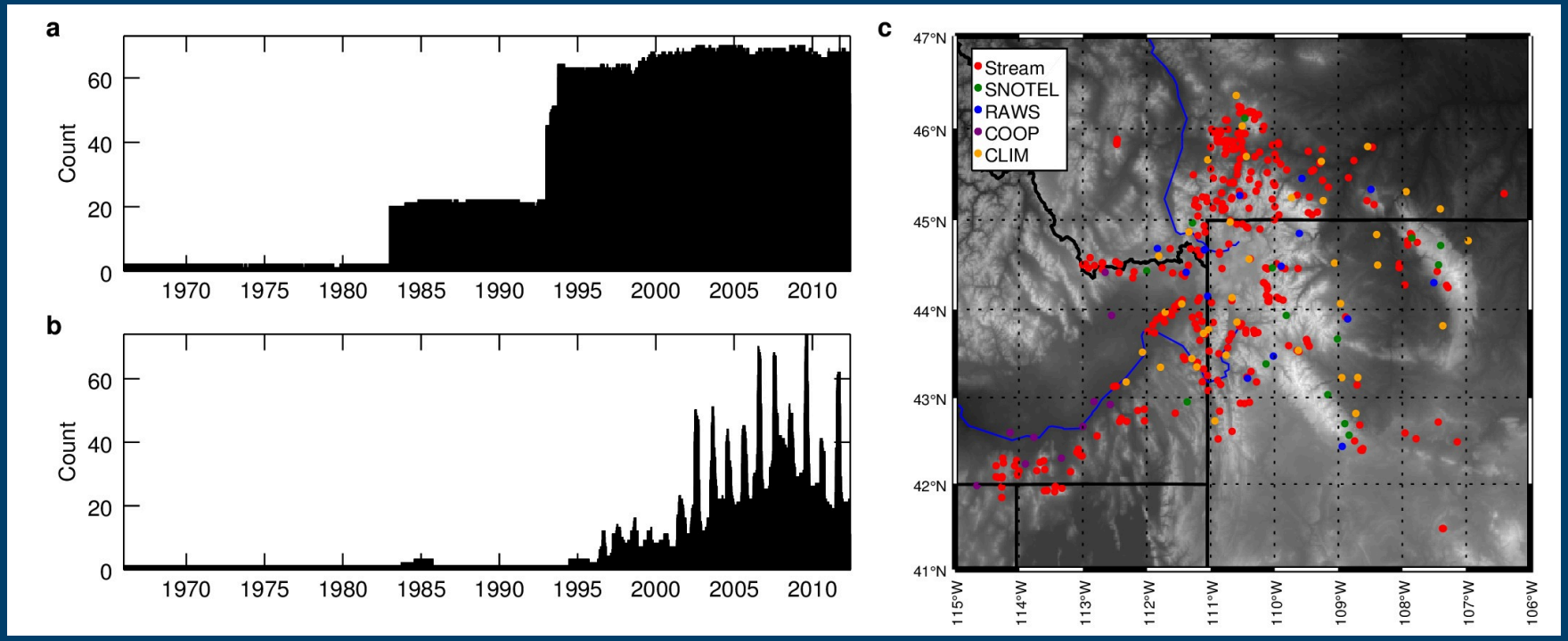
Spatiotemporal data coverage



- 76 air temperature stations (556,411 records)
- 338 stream temperature sites (152,539 records)

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Pairing air-stream temperatures

- Weekly air temperature is interpolated using IDW to each stream site and lapse rate adjusted for differences in elevation

- Only May – September data are used
  - No freezing
- A minimum of 8-weeks of paired air-stream temperature data is required
- Leaving 272 valid sites

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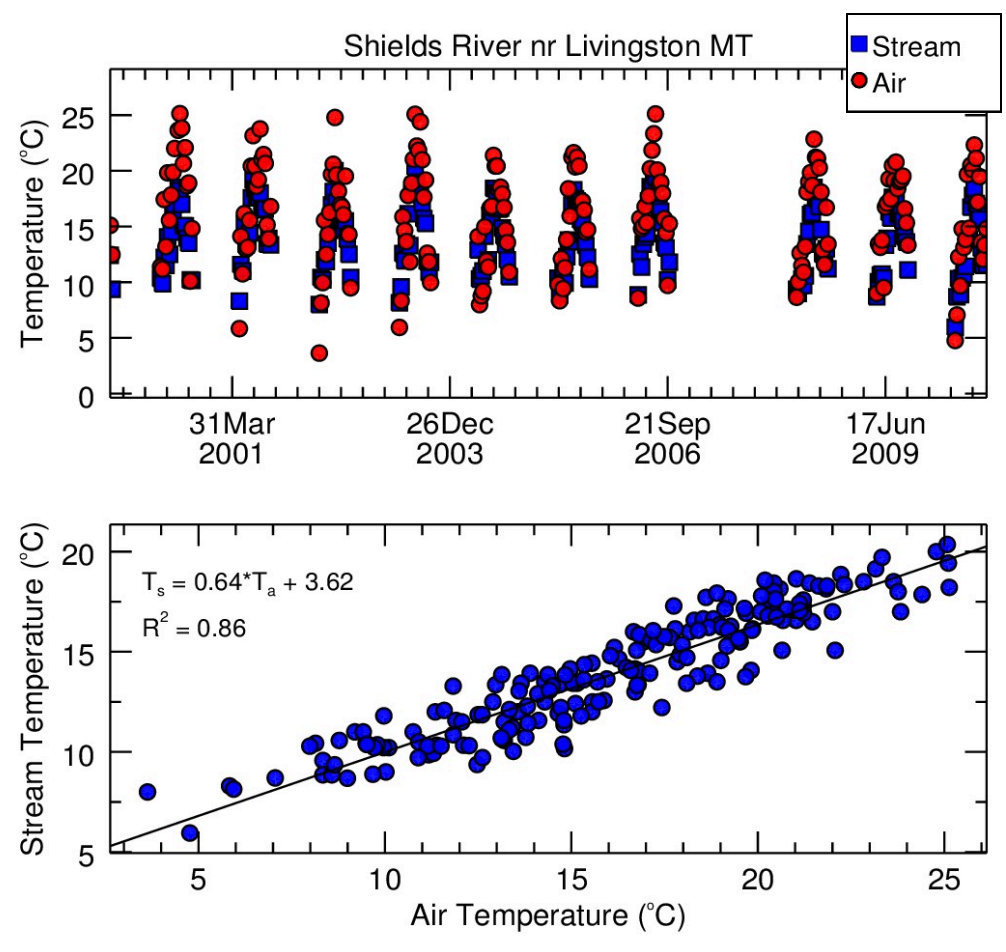
Air-stream temperature regression

- Simple linear regression is applied per stream site to the air-stream temperature pairs

$$T_{stream} = \beta_1 T_{air} + \beta_0$$



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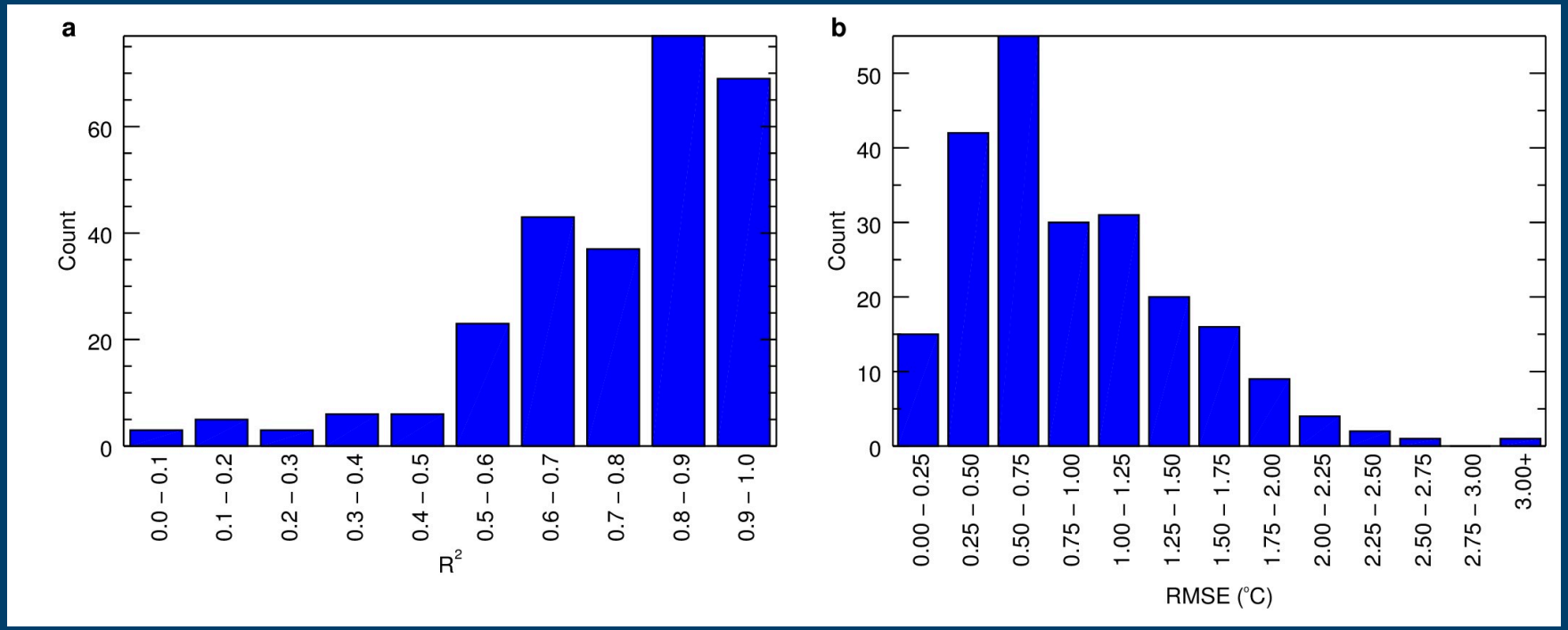
Error assessment

All sites (N=272)

Sites with $R^2 > 0.6$ (N=226)



- **The average slope coefficient of the 226 regressions is 0.56 ± 0.20 °C/°C**

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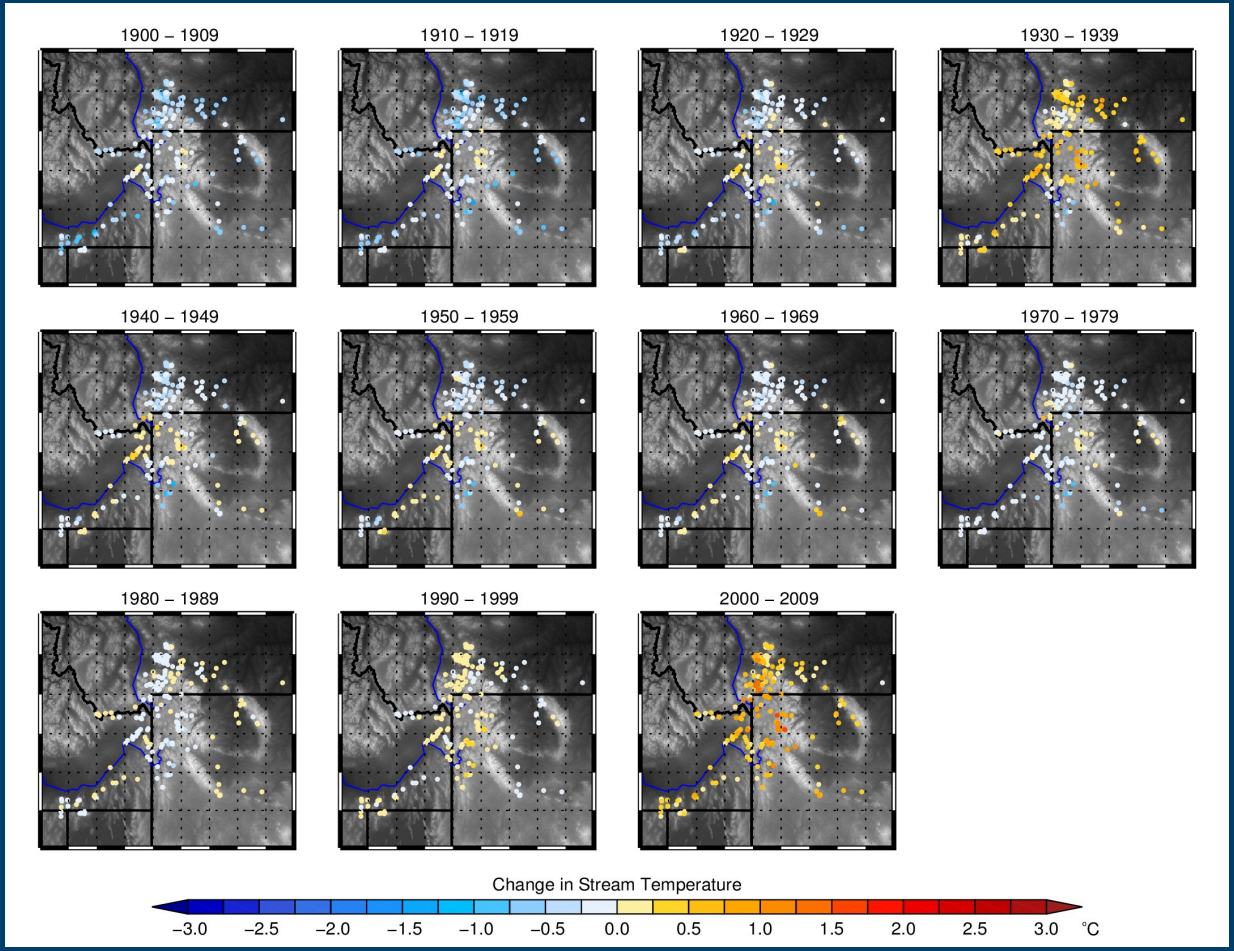
Changes in historical temperature

Derived by applying regressions to PRISM historical air temperature



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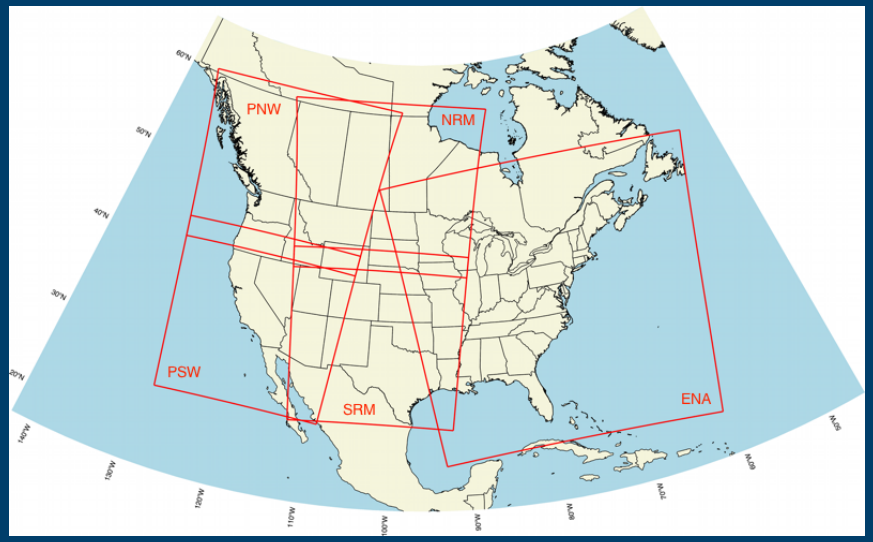
Anomalies vs. 1980-1999 climatology

Regional Climate Model dataset

- Dynamically downscaled regional climate model (RegCM3) simulations provide daily air temperature on a 15km grid
- Downscaled GCMs:
  - NOAA NCEP
  - MPI ECHAM5
  - GFDL CM2.0
  - GENMOM



-Hostetler et al, 2011
http://regclim.coas.oregonstate.edu

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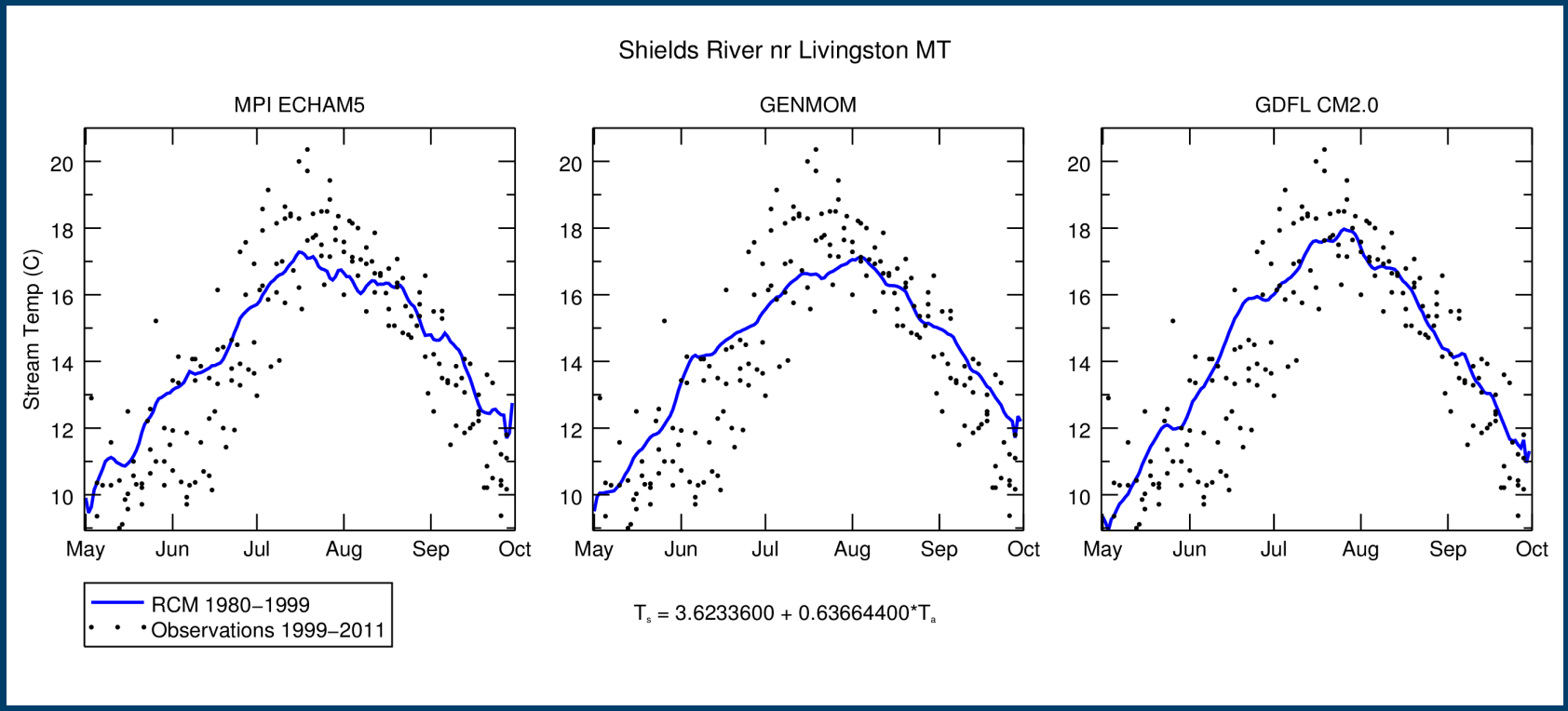
Applying simulated air temperature



- Linear regressions are applied to 1980-1999 air temperature
- Each model is bias corrected by PRISM to have the same May – September mean

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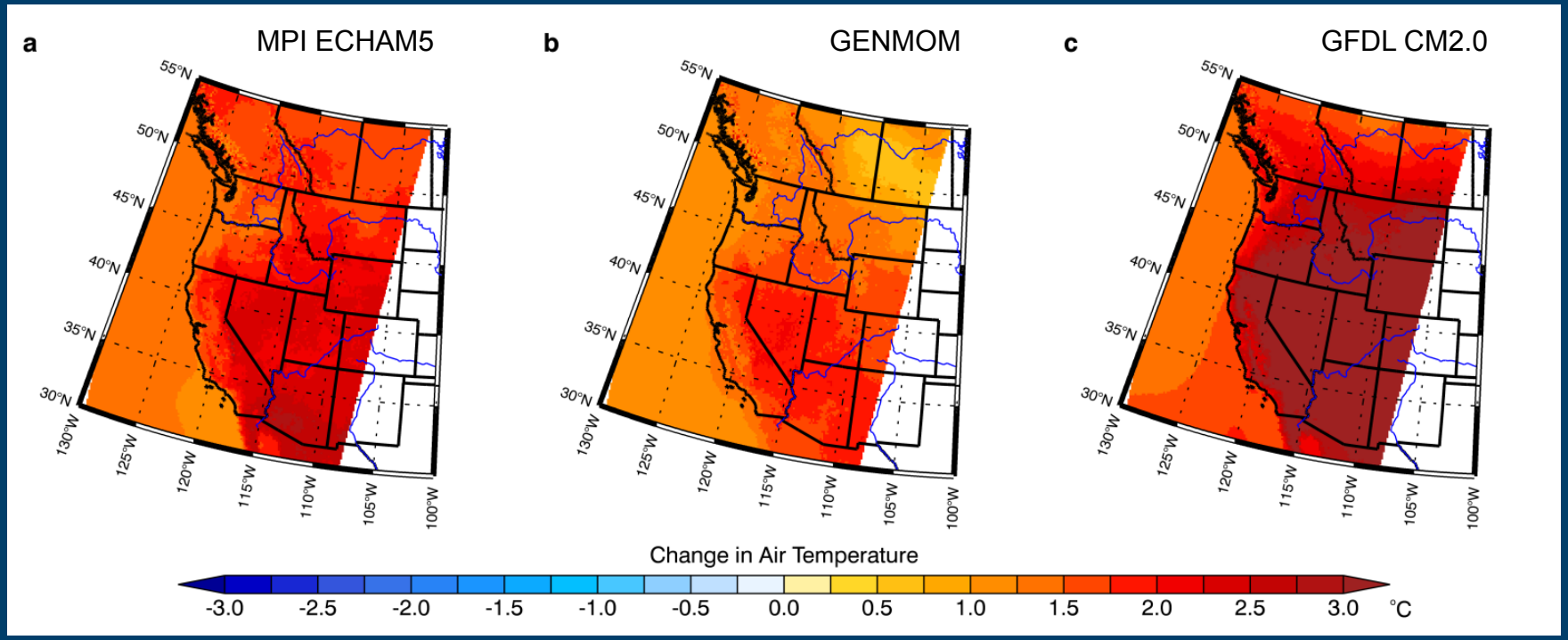
Simulated May-September changes in air temperature



- May – September air temperature anomalies (2050-2069 vs 1980-1999) for the Pacific Northwest and Pacific Southwest model domains (SRES A2 Emission Scenario)

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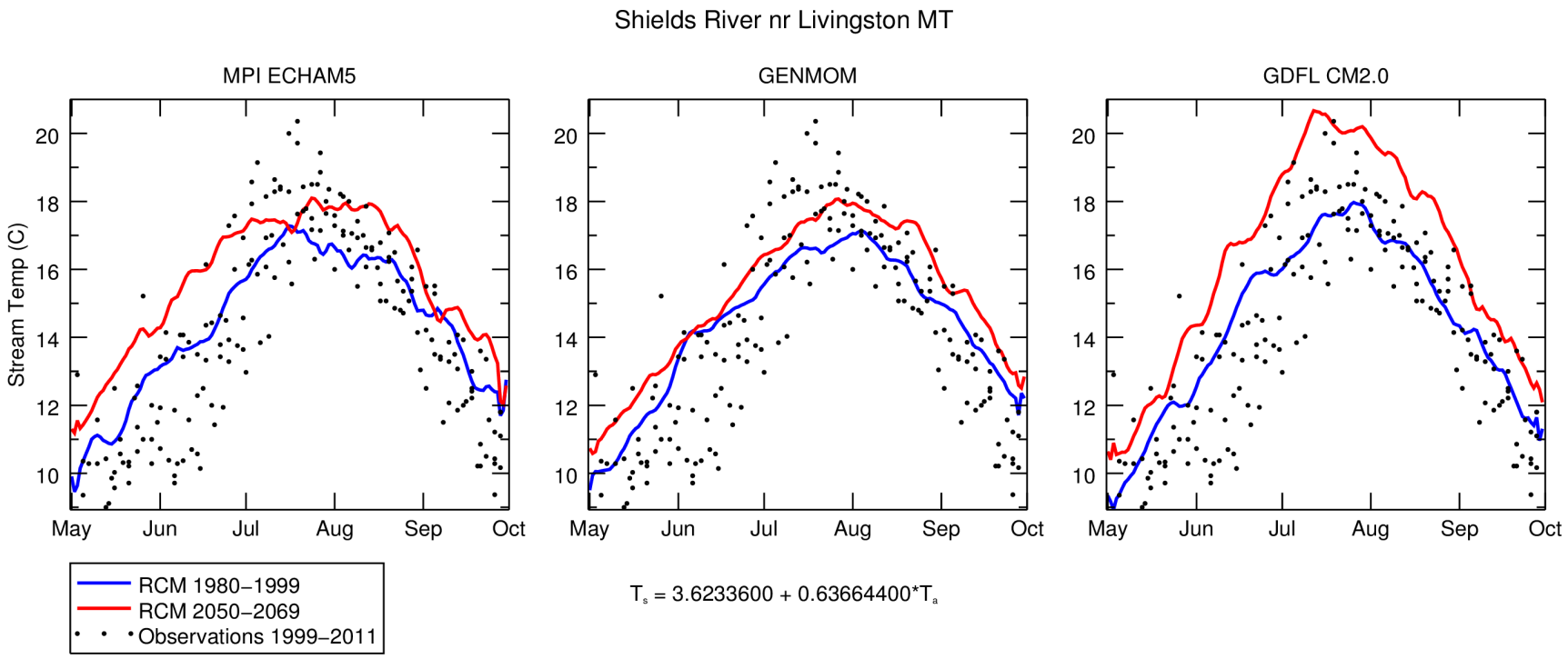
Modeling future stream temperature



- **MPI ECHAM5 and GENMOM warm the shoulder seasons whereas GFDL CM2.0 has the most warming in the peak summer months**

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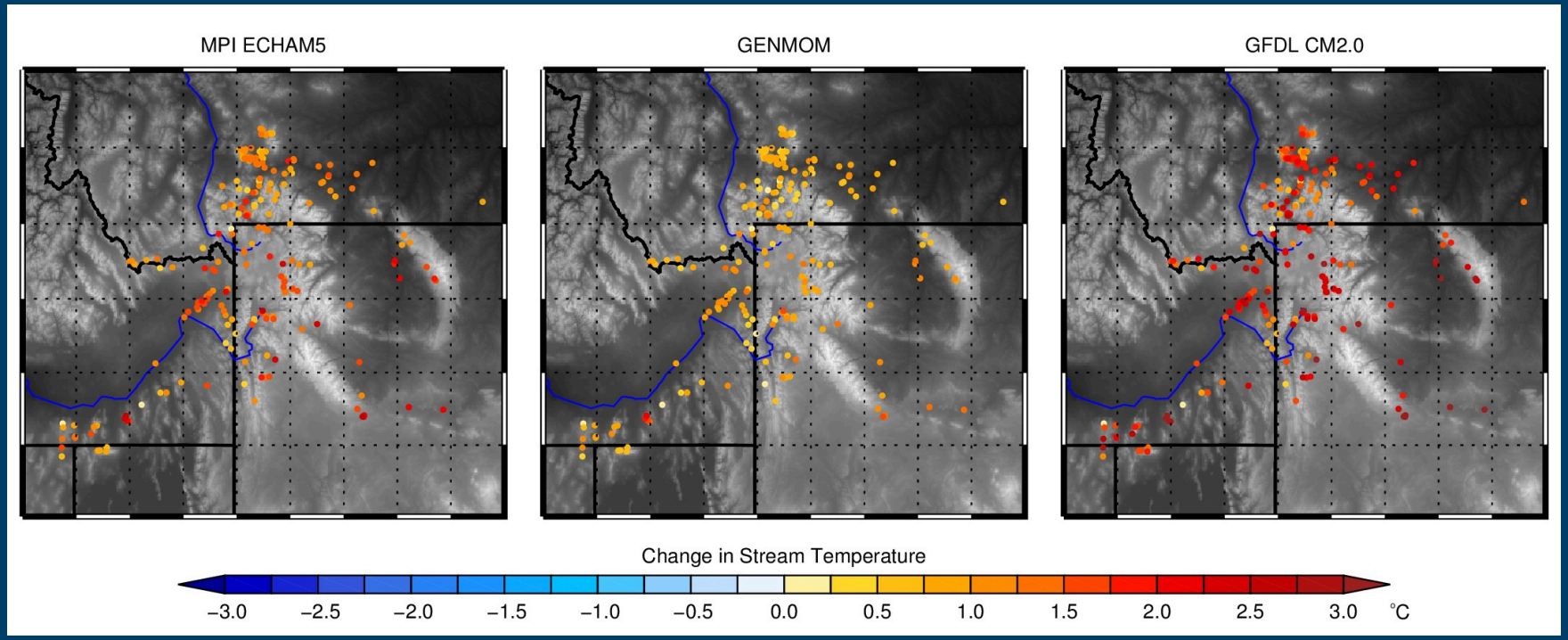
2050-2069 changes in GYE stream temperature



- MPI ECHAM5: 1.2 ± 0.5 °C
- GENMOM: 0.8 ± 0.3 °C
- GFDL CM2.0: 1.8 ± 0.7 °C

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Summary

- Stream temperatures are found to change by 0.5 – 2.5 °C in the GYE by 2050-2069
- The seasonal timing of the warming varies between different models
- Limitations
  - Simple linear regression doesn't capture all stream energy balance processes
  - Does not account for change in flow volume or timing/amount of snowmelt
  - Evaporative cooling above 25°C (nonlinear)

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Thank you

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