Seasonal soil freeze/thaw variability across North America via ensemble land surface modeling

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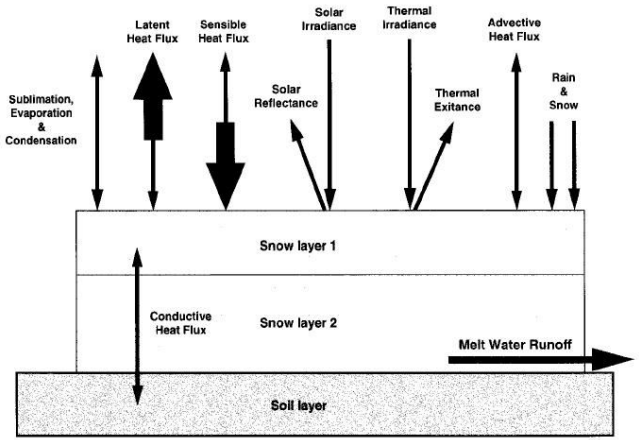
Background:

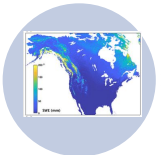
- Soil thermal regime modulates regional climate and land-atmospheric boundary processes by controlling surface and subsurface energy, water and nutrition fluxes.

- The complex interaction between soil and overlaying snowpack makes soil state estimation challenging.

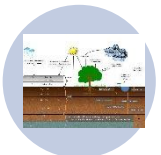


Goal: To understand LSMs' performance and consistency in modeling cold season soil characteristics

Snow Ensemble Uncertainty Project (SEUP) (Kim et al., 2021)



Study area: North America (spatial resolution: 0.05°)



LSMs: JULES, Noah 2.7.1, and Noah-MP 3.6

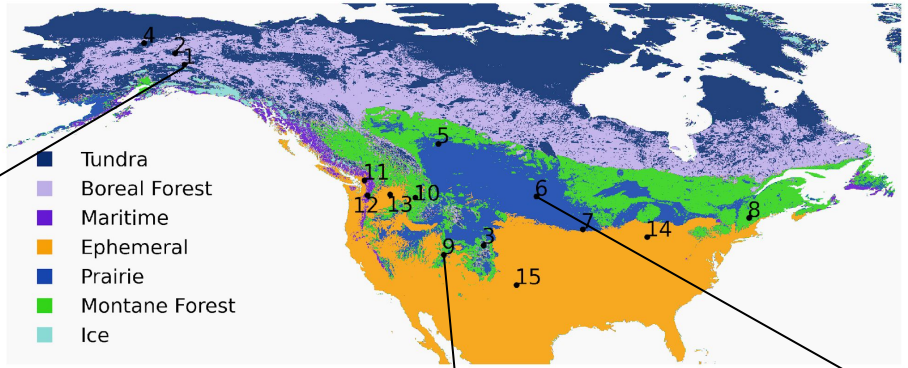
Forcing datasets: ECMWF, GDAS, MERRA2

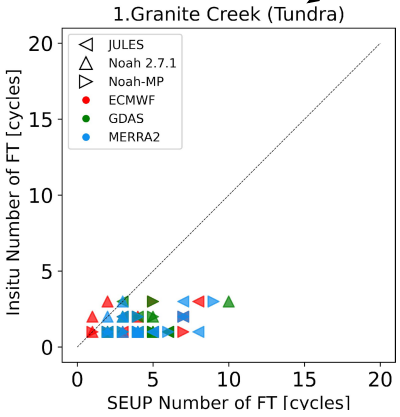
3 Hourly from 2010 to 2017 (spin up: 2000–2009)

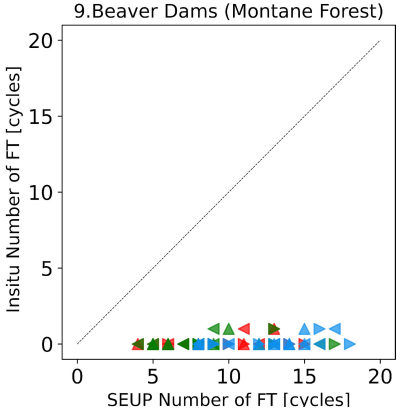
Kim, R.S., Kumar, S., Vuyovich, C., Houser, P., Lundquist, J., Mudryk, L., Durand, M.,Barros, A., Kim, E.J., Forman, B.A., Gutmann, E.D., 2021. Snow Ensemble Uncertainty Project (SEUP): quantification of snow water equivalent uncertainty across North America via ensemble land surface modeling. Cryosphere 15 (2),771–791.

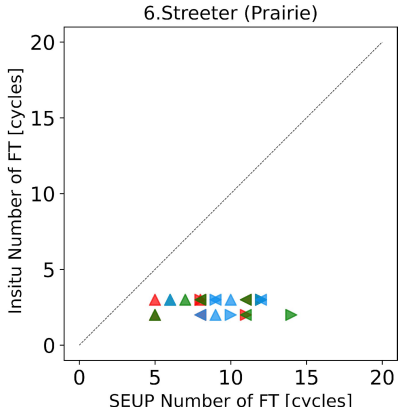
Findings:

- Notable overestimation in simulated number of FT cycles comparing to in-situ observations



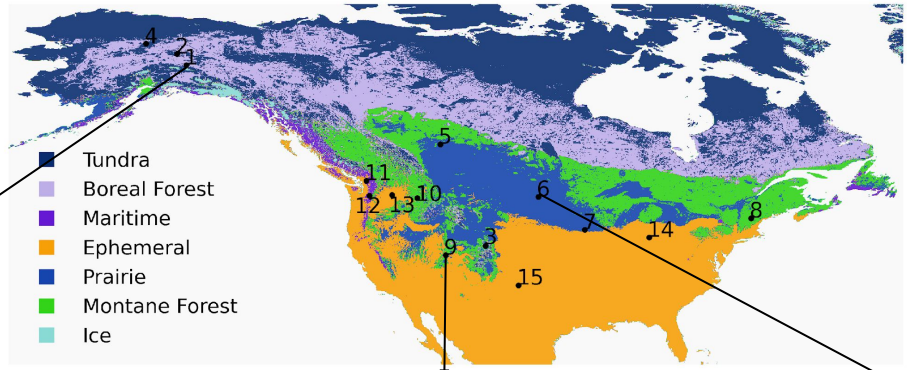


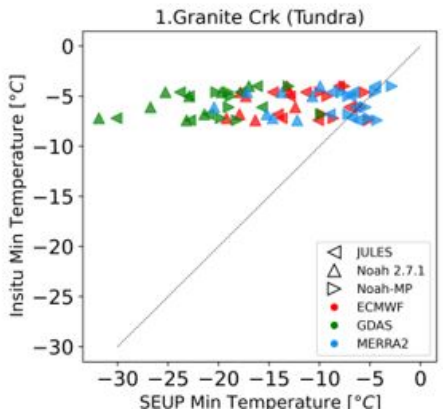


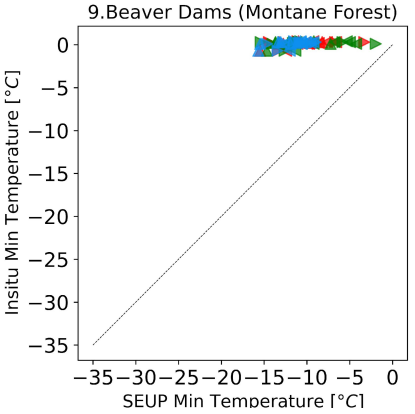


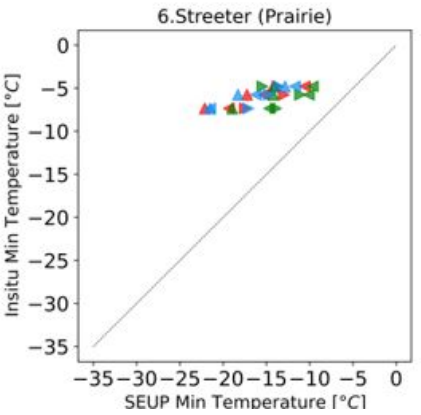
Findings:

- Considerable underestimation in simulated annual minimum soil temperatures comparing to in-situ observations





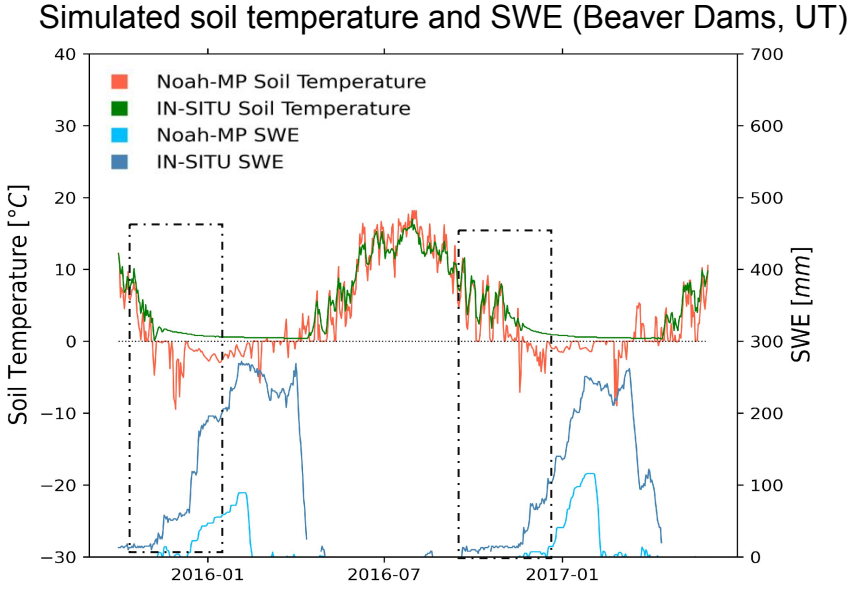




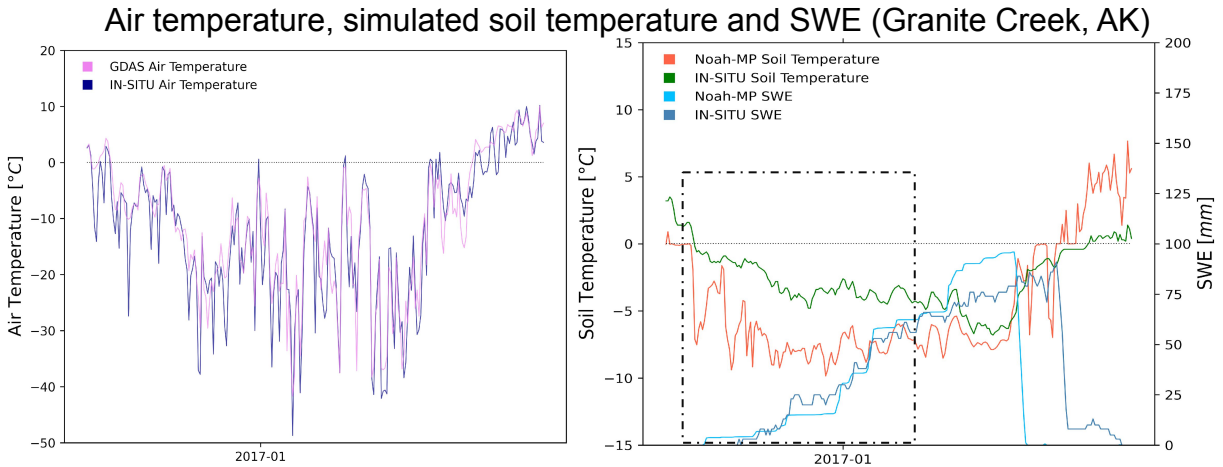
Findings:

Possible sources of biases in soil simulations:

- Biases in snow processes, specially at the beginning of winter season
  - limited insulation
  - cooling impact due to high albedo of snowpack



Findings:

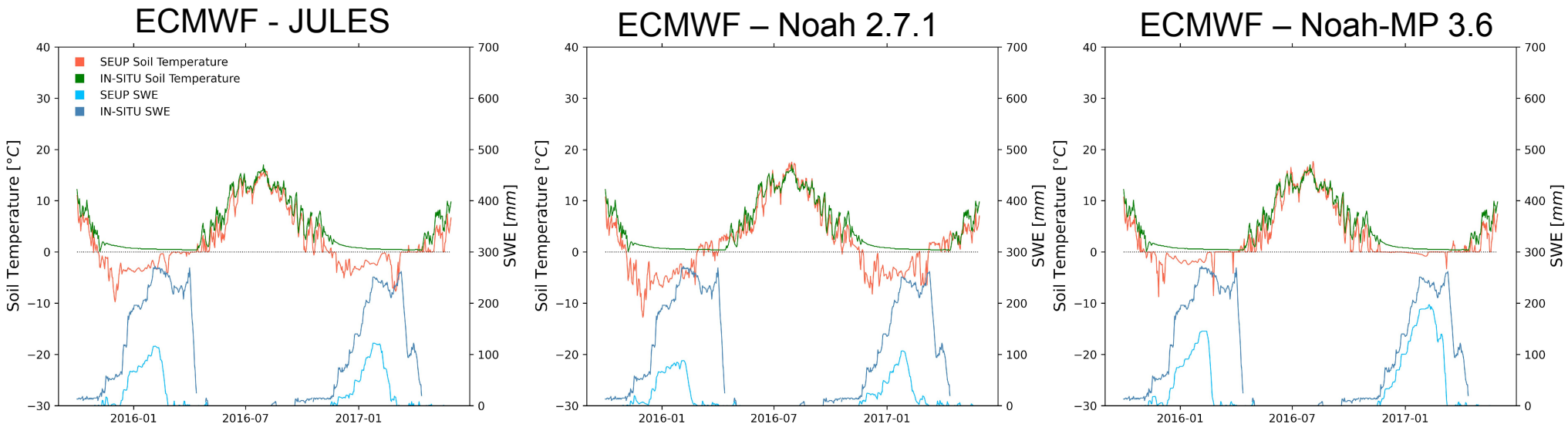


Possible sources of biases:

- Overestimation of snow thermal conductivity (less snow thermo-insulation)
- Overestimation of snow albedo
- Misrepresentation of thermal processes in soil layer

Findings:

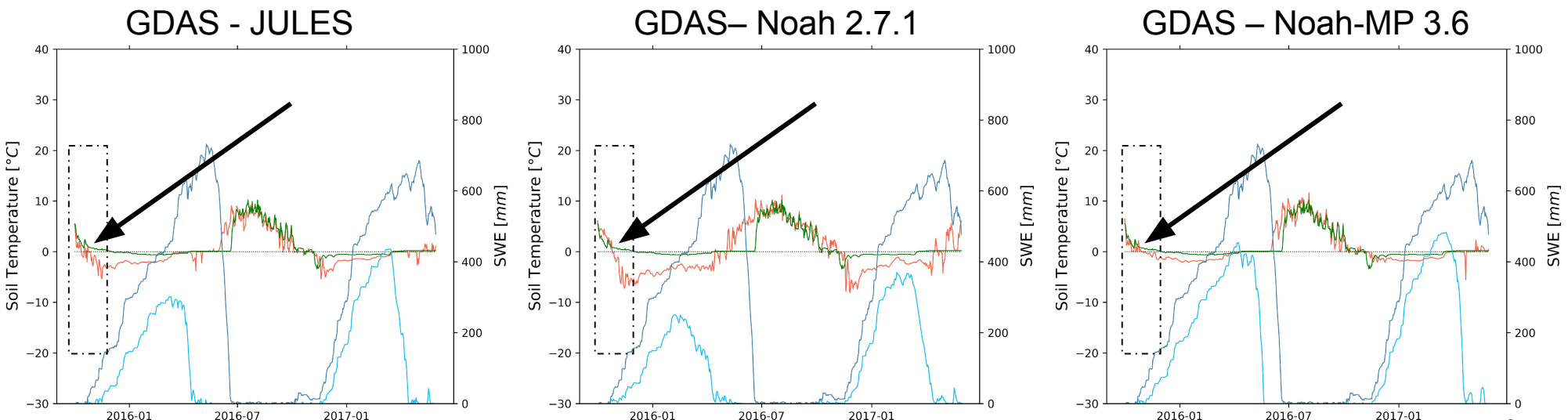
- Higher SWE values estimated by Noah-MP resulted in lower day-to-day variations in soil temperatures.



Simulated soil temperature and SWE (Beaver Dams, UT)

Findings:

- Noah-MP's soil temperatures had a smoother transition and less dramatic decrease at the beginning of winter



Simulated soil temperature and SWE (Arapaho Ridge, CO)

Summary:

Notable biases were found in the Noah-MP's simulated soil characteristics during cold seasons.

The magnitude and fluctuations of the Noah-MP's soil temperatures were in much better agreement with observations than the other models.

More in-depth assessments are required to identify the sources of biases in winter soil temperature simulated by Noah-MP.

Thank you!

Questions?

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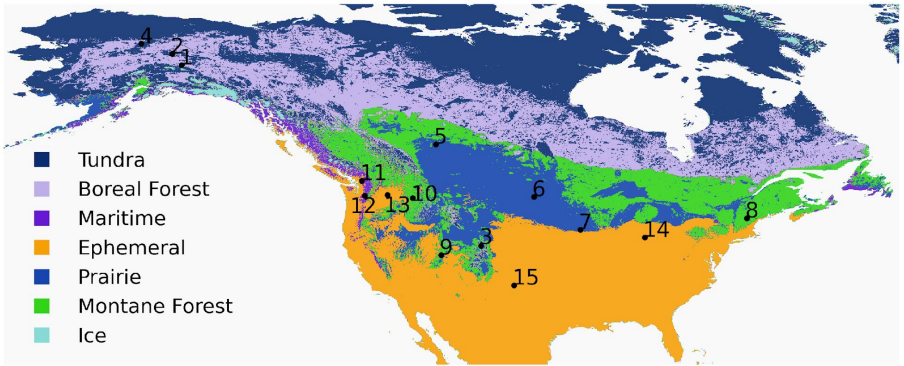
Tundra
Boreal Forest
Maritime
Ephemeral
Prairie
Montane Forest
Ice
1
2
3
4
5
6
7
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11
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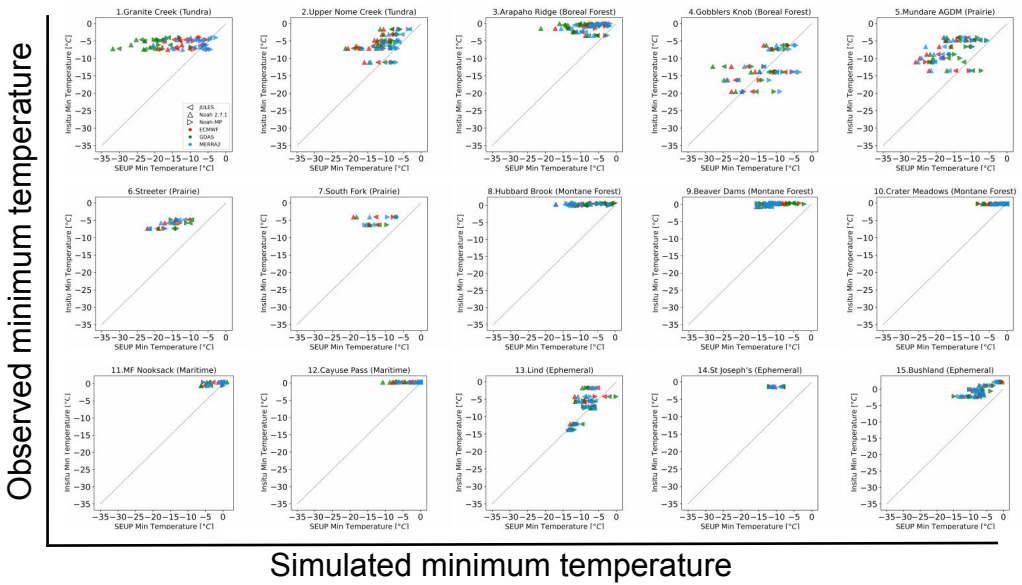
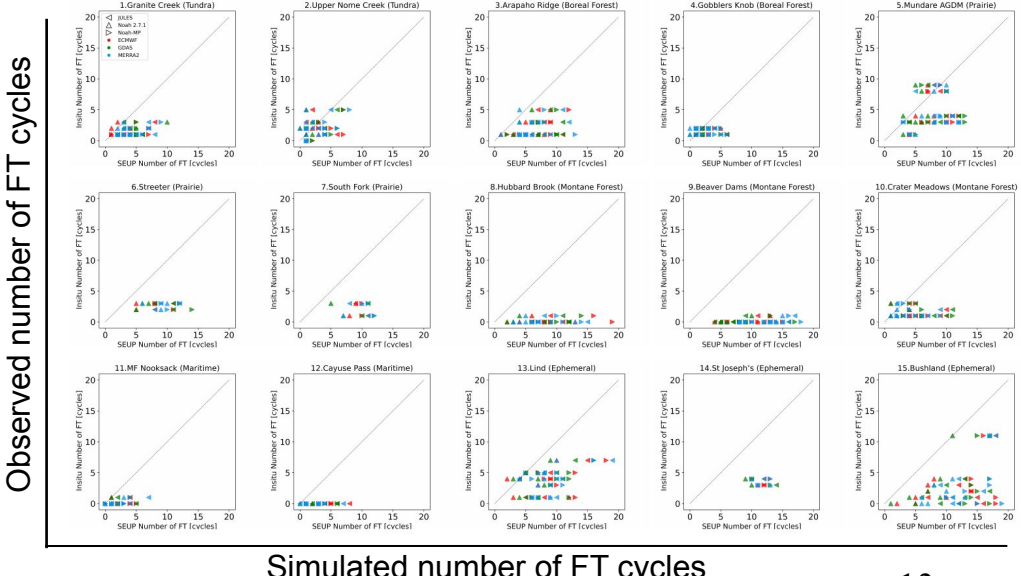

Observed minimum temperature
Simulated minimum temperature
1.Granite Creek (Tundra)
2.Upper Nome Creek (Tundra)
3.Arapaho Ridge (Boreal Forest)
4.Gobblers Knob (Boreal Forest)
5.Mundare AGDM (Prairie)
6.Streeter (Prairie)
7.South Fork (Prairie)
8.Hubbard Brook (Montane Forest)
9.Beaver Dams (Montane Forest)
10.Crater Meadows (Montane Forest)
11.MF Nooksack (Maritime)
12.Cayuse Pass (Maritime)
13.Lind (Ephemeral)
14.St Joseph's (Ephemeral)
15.Bushland (Ephemeral)
JULES
Noah 2.7.1
Noah-MP
ECMWF
GDAS
MERRA2


Observed number of FT cycles
Simulated number of FT cycles
1.Granite Creek (Tundra)
2.Upper Nome Creek (Tundra)
3.Arapaho Ridge (Boreal Forest)
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