Climate Change impacts on the Snow Hydrologic Cycle in the Western U.S.

Motivation

Climate change is altering snowpack magnitude and timing across much of the western U.S., with critical implications for water resources and ecosystems. Snow research in our group is united by a desire to understand how climate change is impacting snow hydrology and in turn altering water resources in the western U.S. Each project focuses on a different part of the snow cycle, including:

1. Hydroclimate (snow deluge)
2. Accumulation and melt patterns (wildfire impacts)
3. Consequences of snow change for streamflow (streamflow width)
4. Watershed modeling (sensitivity analysis).

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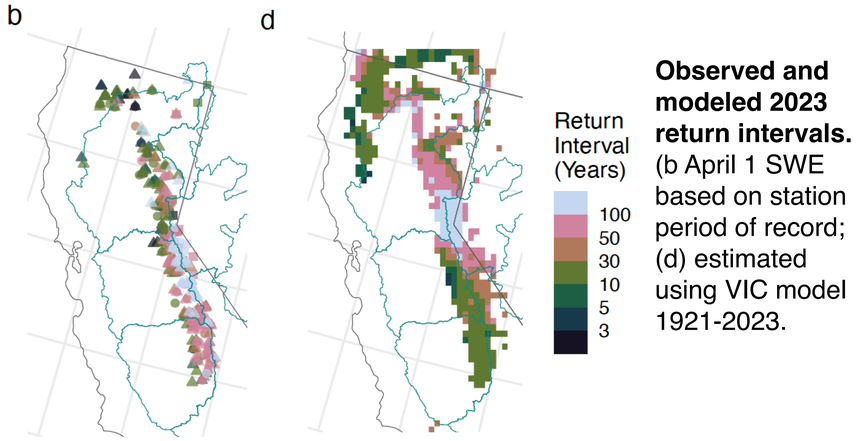
1. Snow Deluge

Lead: Marshall

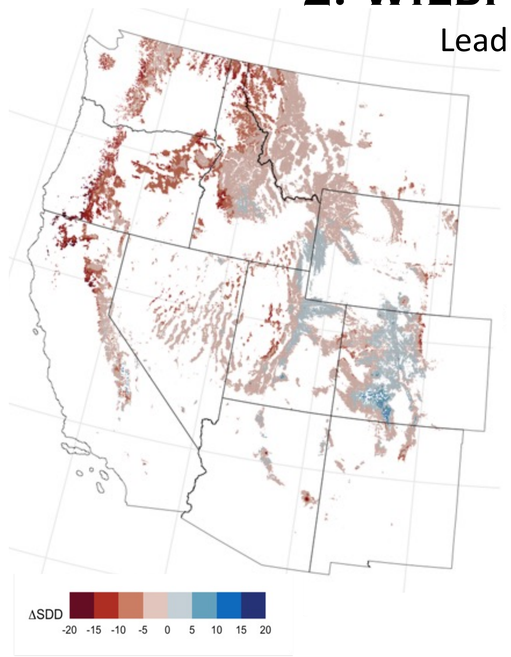
- California April 1 SWE in 2023 was exceptional, with a 54-year return interval aggregated over the state.
- Relative to only the last few decades, cool-season temperatures were a driver of the 2023 snow deluge.
- Snow deluge is projected to decline in future climates, but less so than median years.



Observed and modeled 2023 return intervals. (b April 1 SWE based on station period of record; (d) estimated using VIC model 1921-2023.

2. Wildfire Impacts

Lead: Koshkin

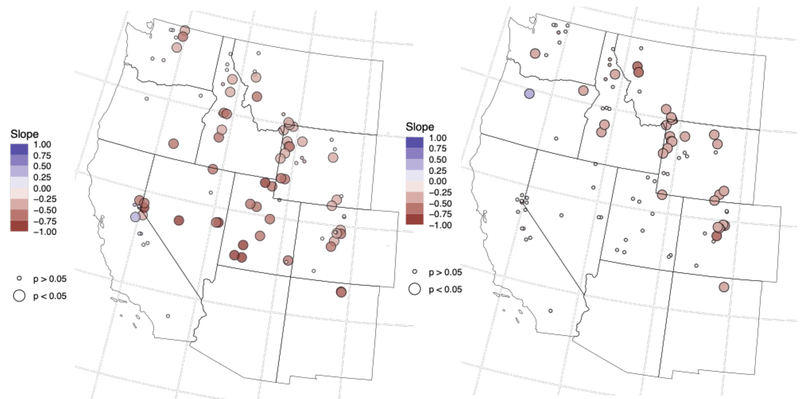


Modeled ΔSDD (unburned – burned) post-fire under average climate conditions

- Wildfires advance snow disappearance date (SDD) most in the relatively warm, low-elevation Pacific Northwest (PNW).
- SDD in the cold, sunny, higher-elevation Intermountain West has a smaller or even delayed melt response post-fire.
- Fire impacts on snowmelt timing could have spatially heterogeneous consequences for water resources.

3. Streamflow Width

Lead: Bazlen

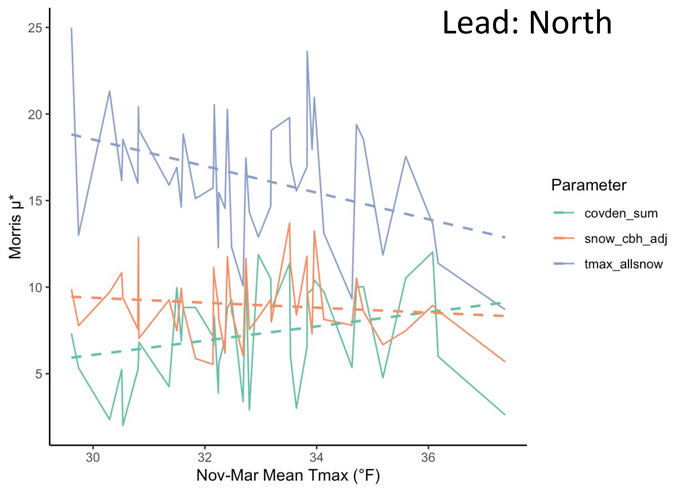


SDoT relationship with snowpack variables
(a) SDoT and peak SWE volume (b) SDoT and peak SWE DOWY

- Higher peak SWE is associated with narrower streamflow distribution (Standard Deviation of Timing, SDoT).
- Later peak SWE is associated with narrower SDoT in the Rocky Mountains.
- Results suggest that as watersheds become more rain dominated, the streamflow distribution could widen.

4. Sensitivity Analysis

Lead: North



Parameter sensitivity vs. winter Tmax
The 3 most sensitive pywatershed parameters with respect to simulated peak SWE in the East River watershed, CO from WY 1980-2022

tmax_allsnow: max air temp. for precip. as snow
snow_cbh_adj: adjustment to observed precip. by HRU
covden_sum: summer vegetation cover density of the major vegetation type by HRU

- Simulated snowpack is most sensitive to climate and canopy parameters.
- High sensitivity to snow_cbh_adj suggests high sensitivity to climate input uncertainty.
- Parameter sensitivity (μ*) varies interannually and exhibits mixed trends regarding winter temperatures.