



The University of Vermont

Warmer winters drive snowpack declines and runoff increases in a headwater region of the northeastern United States

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Kate Hale^{1,2}, Andrew Schroth³, James Shanley⁴, Beverley Wemple³

¹Department of Geography, University of British Columbia, Vancouver, British Columbia, Canada

²Institute of Northern Engineering, University of Alaska Fairbanks, Fairbanks, AK, USA

³Department of Geography and Geosciences, University of Vermont, Burlington, Vermont, USA

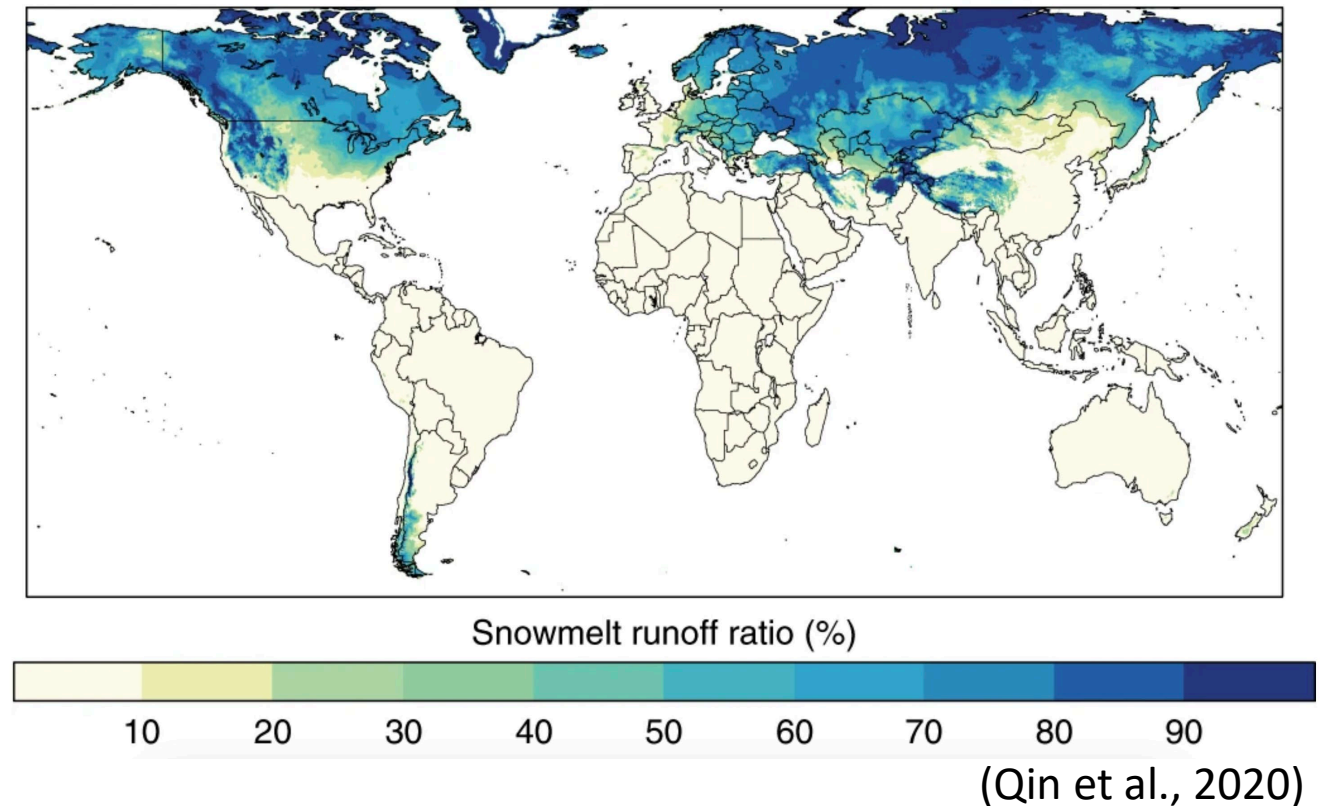
⁴U.S. Geological Survey, New England Water Science Center, Montpelier, Vermont, USA

Snow as a water resource

One-sixth of the global population relies on seasonal snowpack and glacier-derived runoff as a primary water resource (Barnett et al., 2005)

Value of snow estimated in trillions of dollars (Sturm et al., 2017)

The seasonal snowpack accumulation and ablation cycle delays the timing of water availability (Stewart et al., 2004; 2005)



Snow as an integral part of northeastern USA hydrology

The seasonal snowpack accumulation and ablation cycle delays the timing of water availability (Stewart et al., 2004; 2005)

Climate change is altering the snow season, resulting in a phase change (Cho et al., 2021)



January 2023



April 2023

Snow as an integral part of northeastern USA hydrology

Economic Stability



Hazardous Events

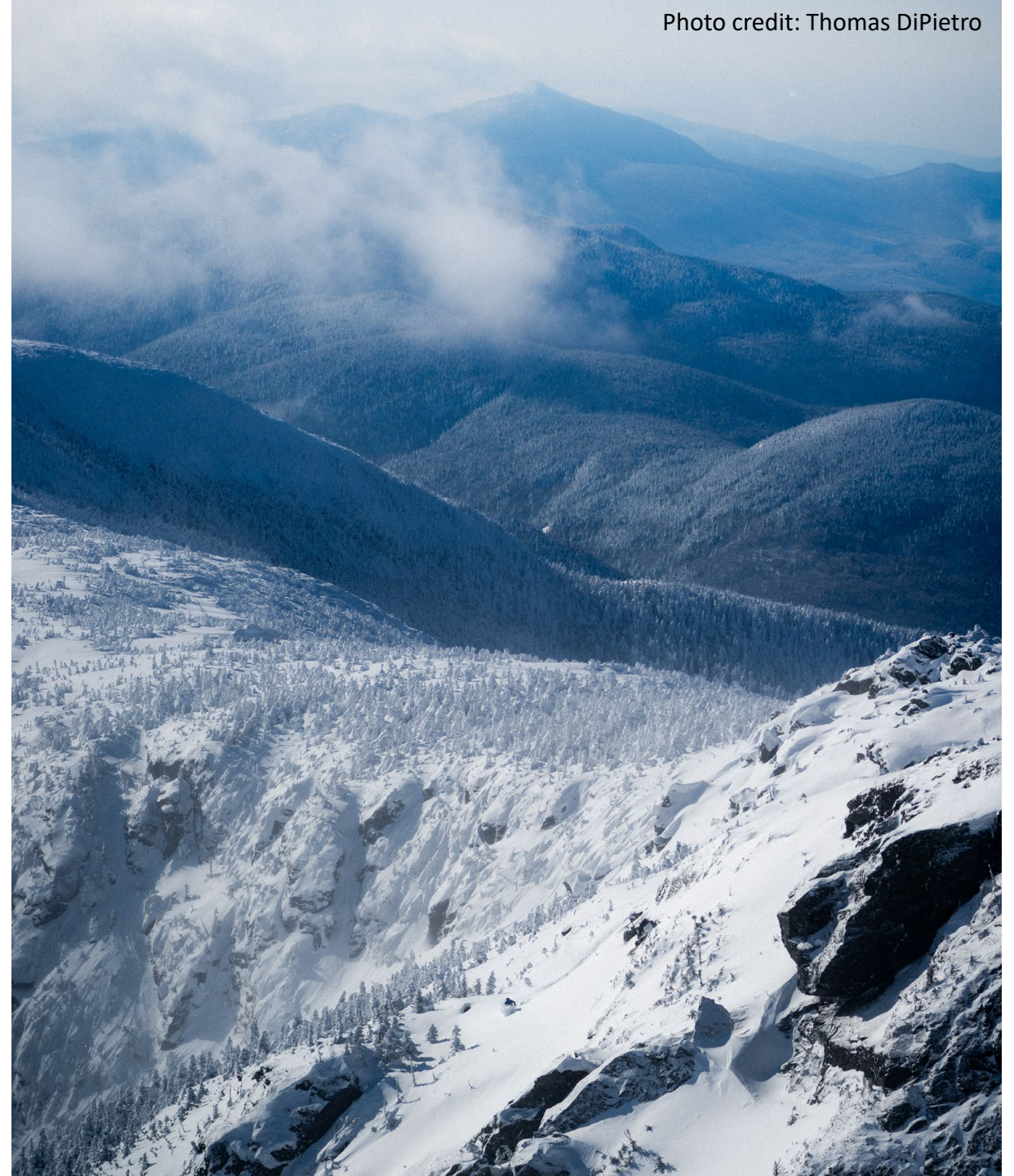


Forecasting

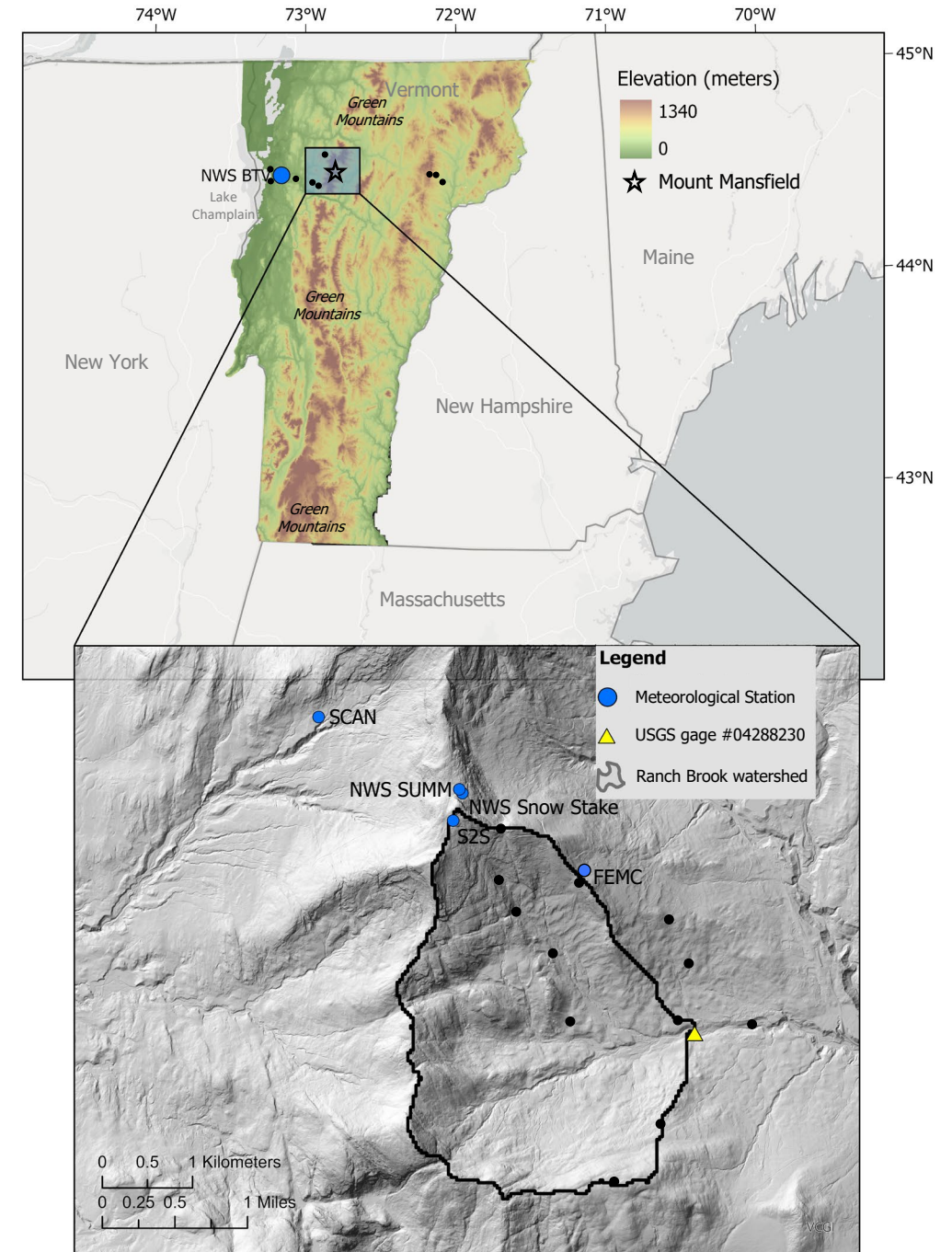
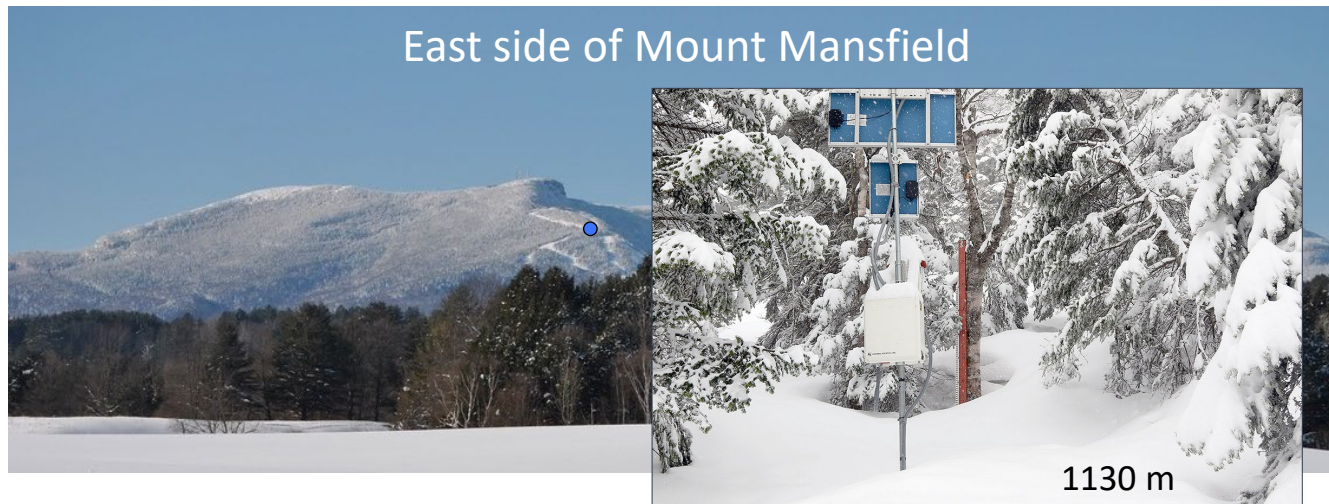
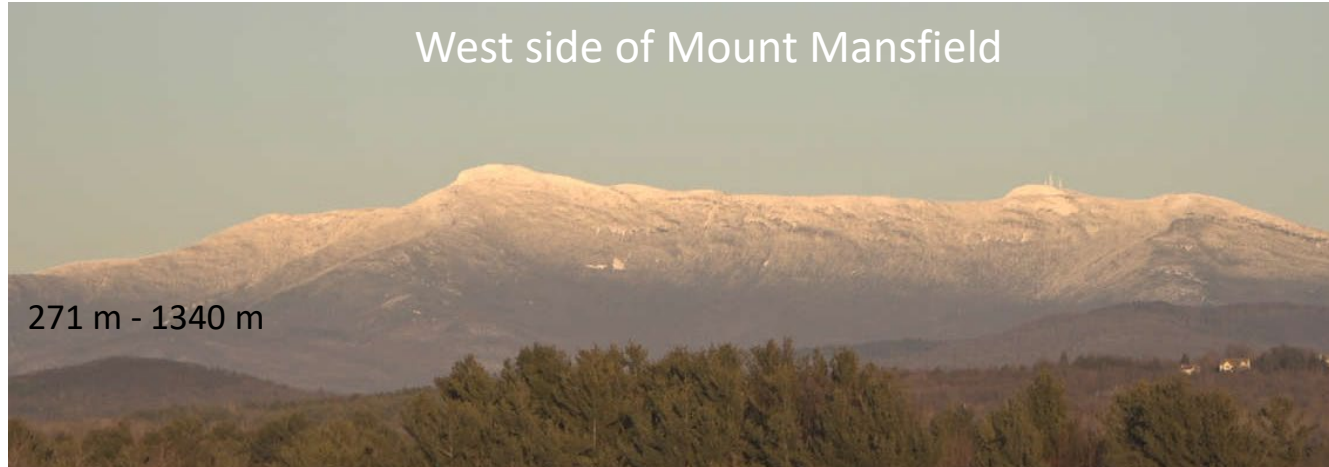


Unknown changes and hydrologic implications

Snowpack trends and relations have only been recently explored in the northeast, in part due to scarce observations

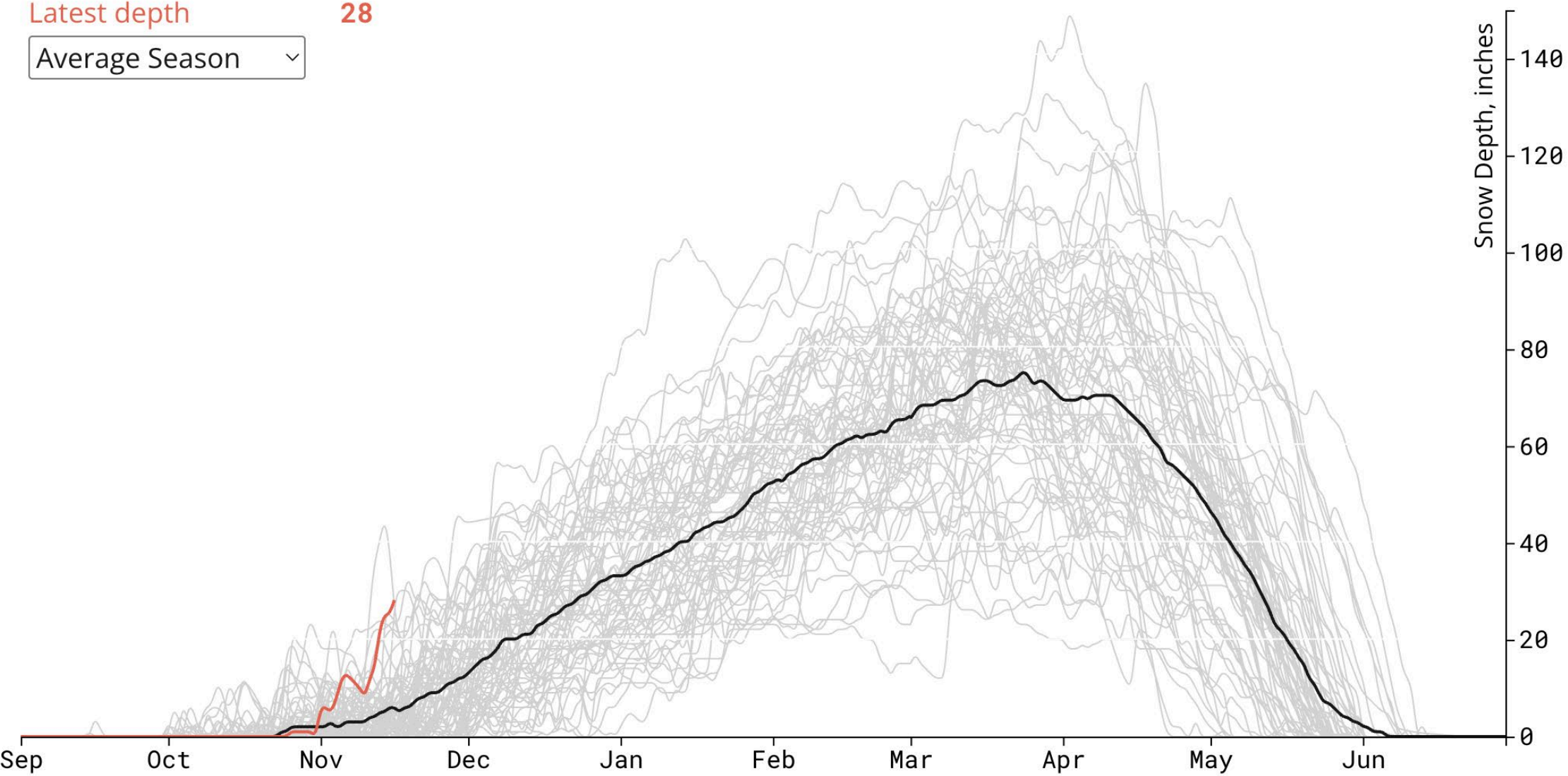


Snow monitoring in Vermont



(Hale et al., 2025, *Hydrological Processes*)

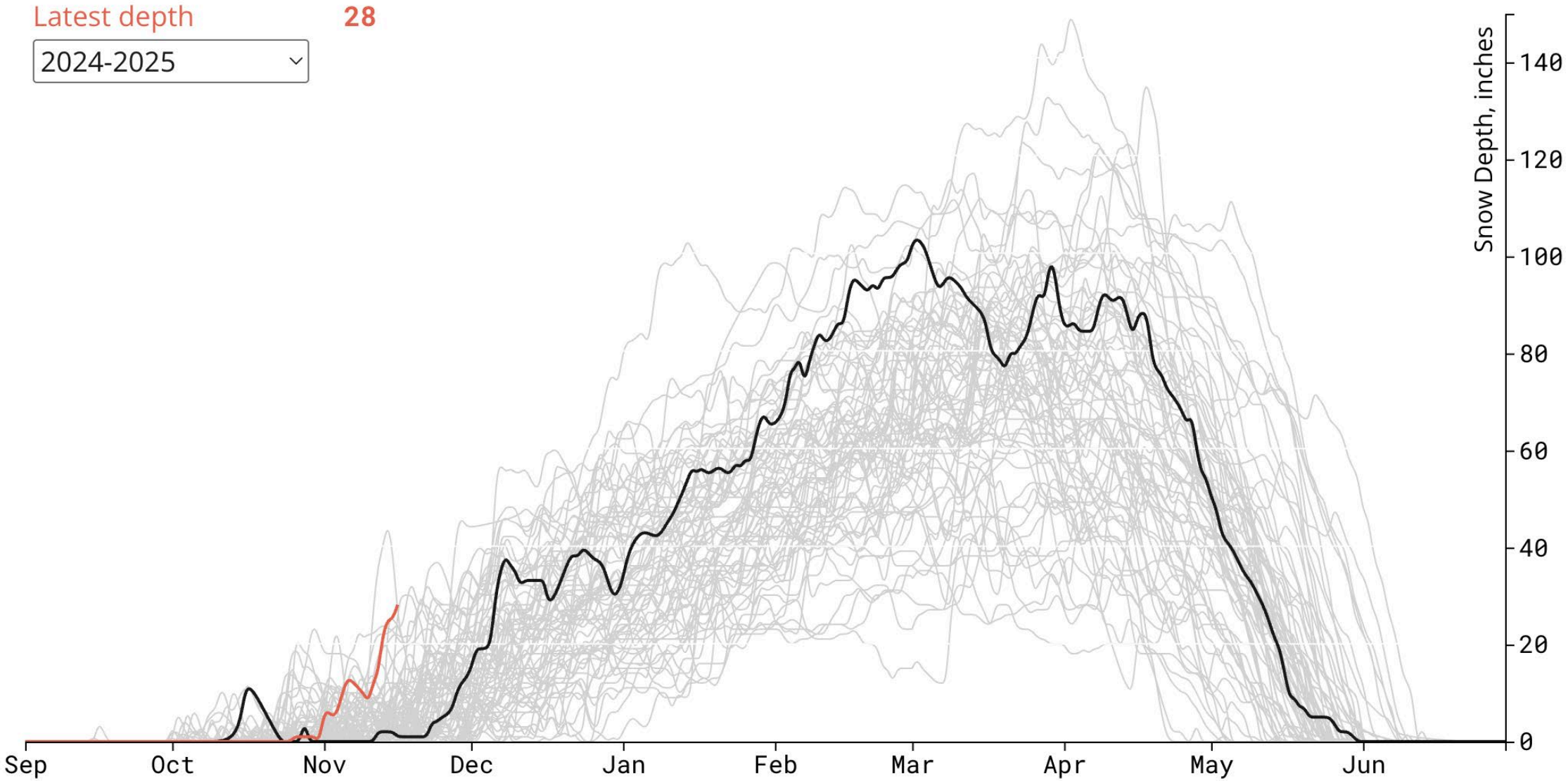
Variability in daily snow depth at Mount Mansfield snow stake (1965-present)



Last reported by NWS on: 11/16/2025

Figure credit: Matt Parrilla

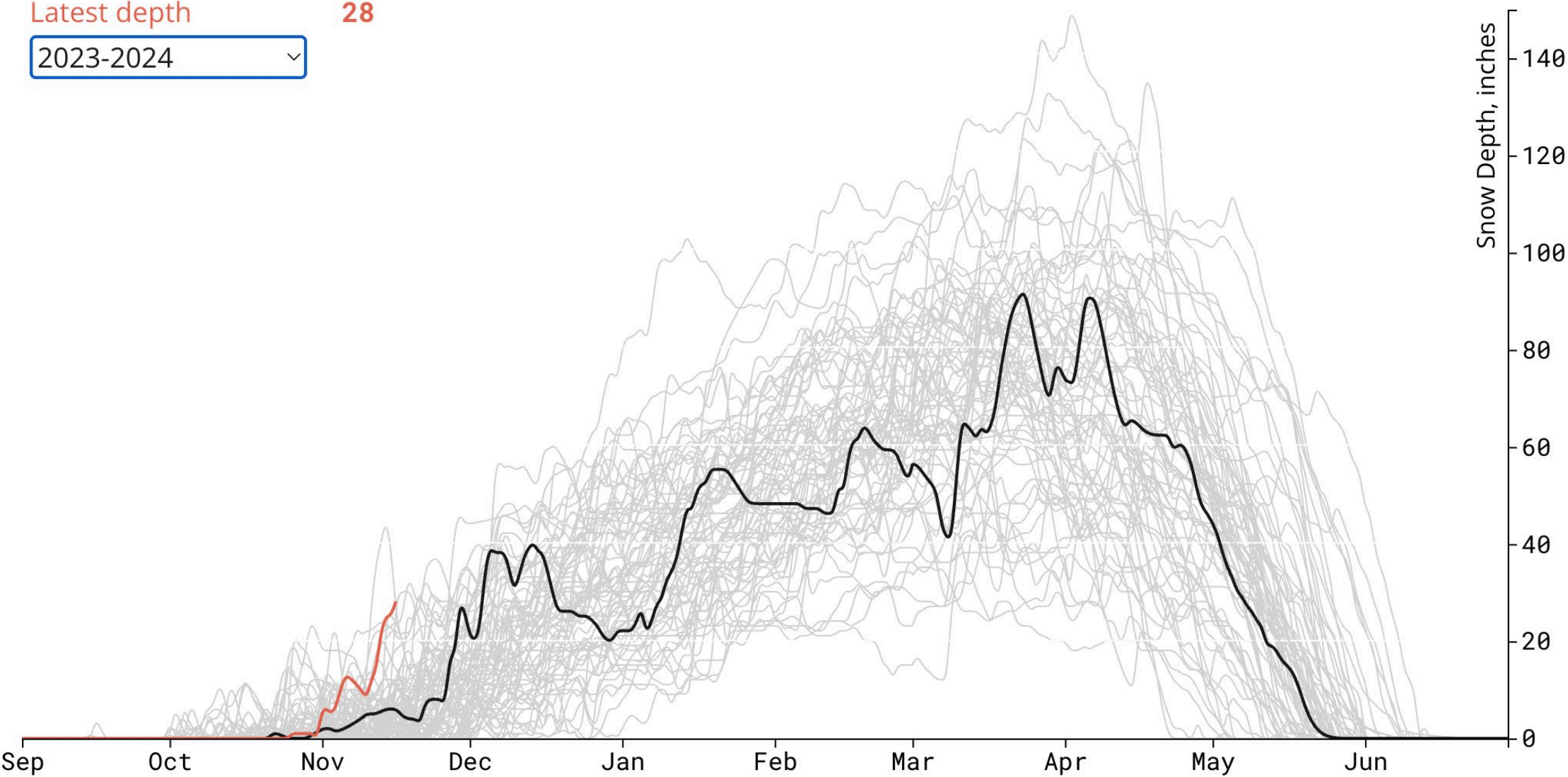
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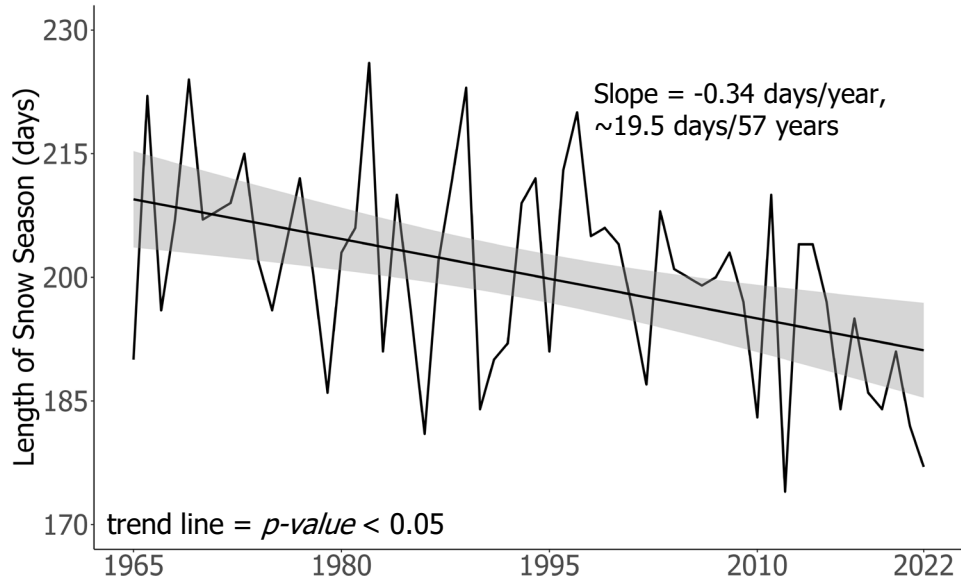
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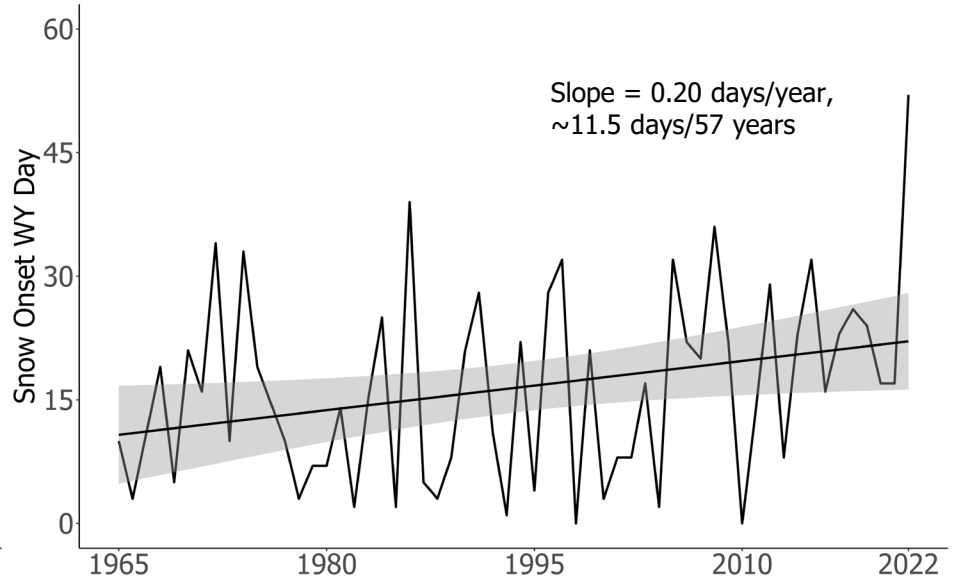
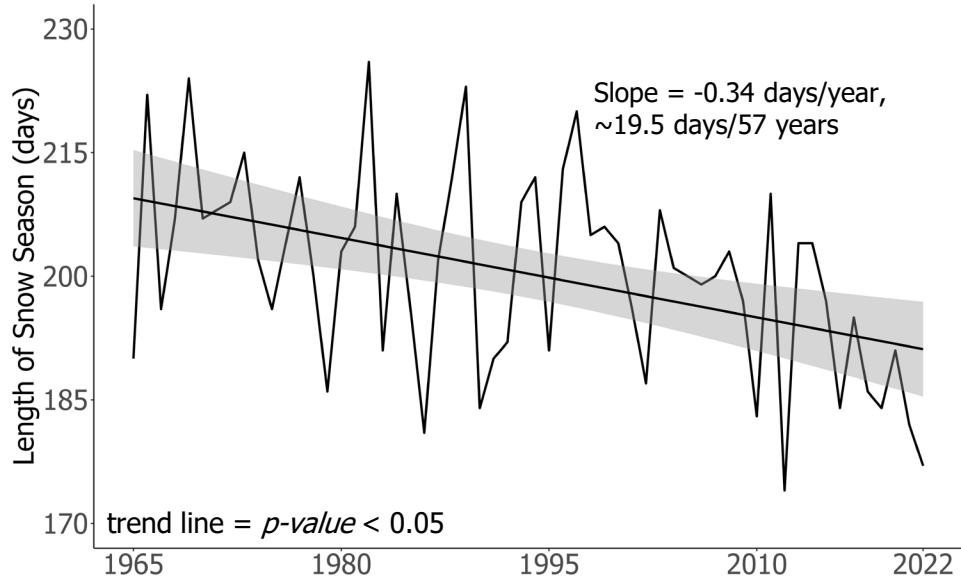
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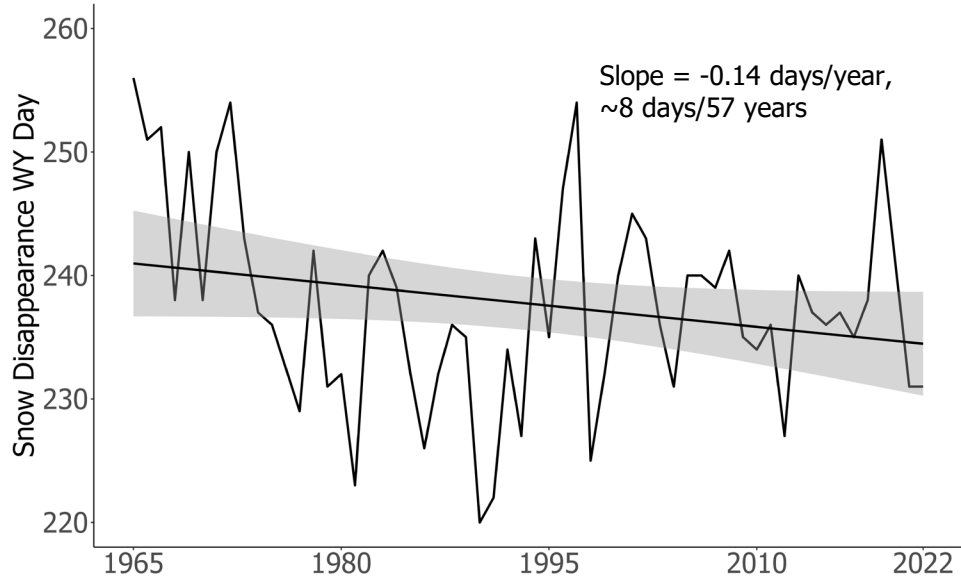
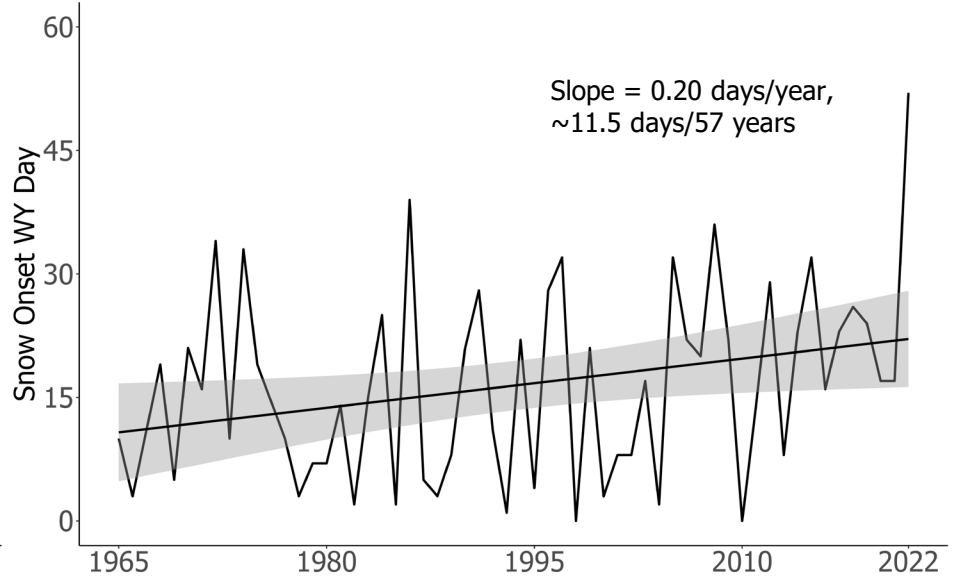
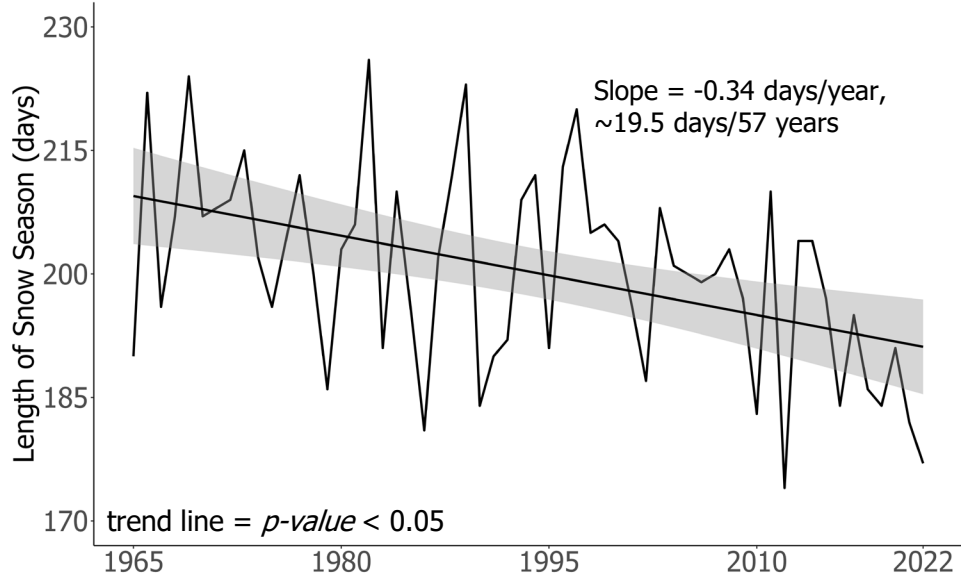
Shorter snow season, later snow onset, earlier snow off, more rain-on-snow (Hale et al., 2025, *Hydrological Processes*)



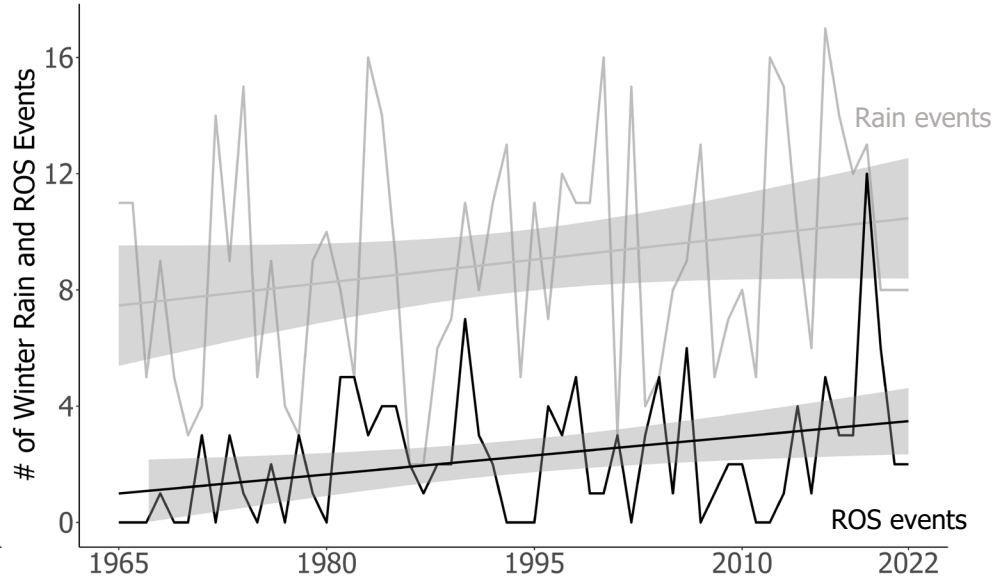
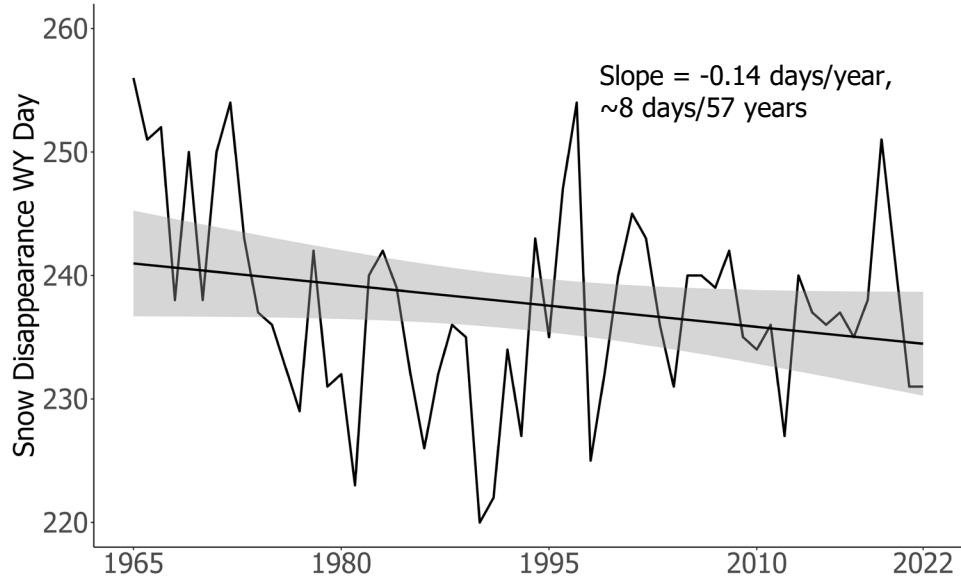
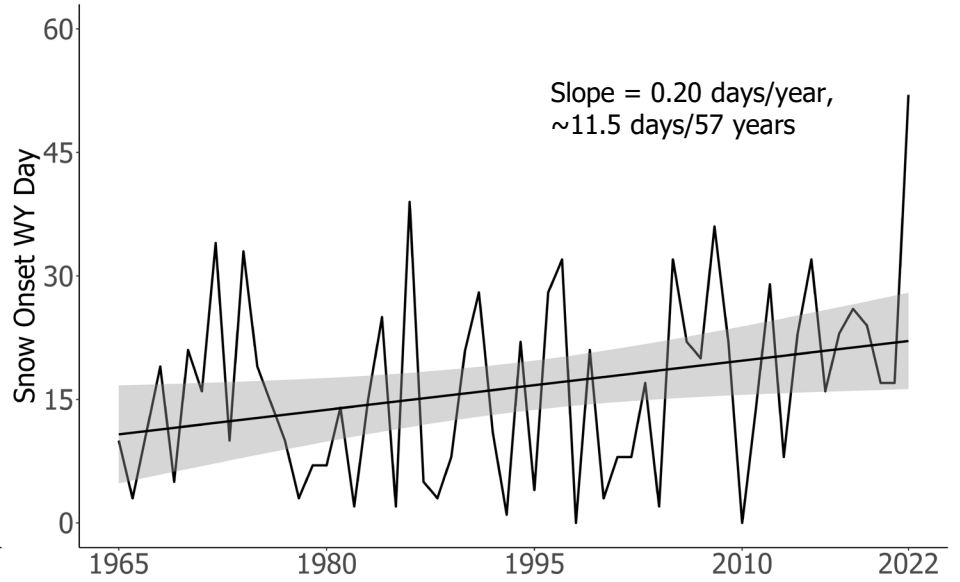
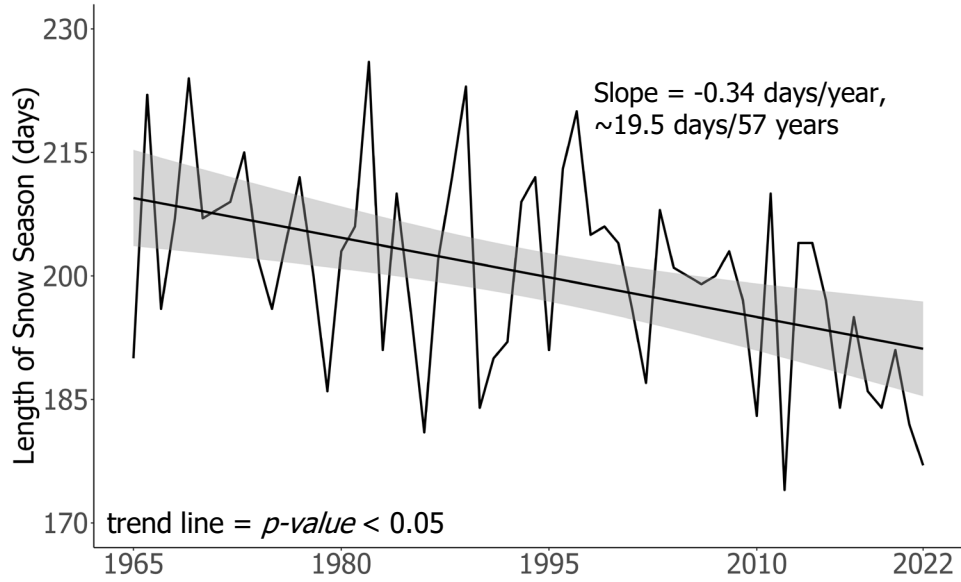
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NWS SUMM



Snow stake

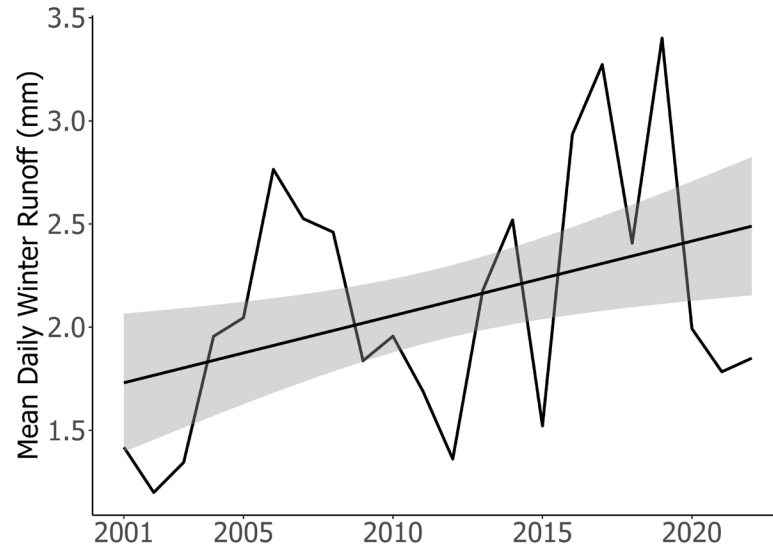


FEMC

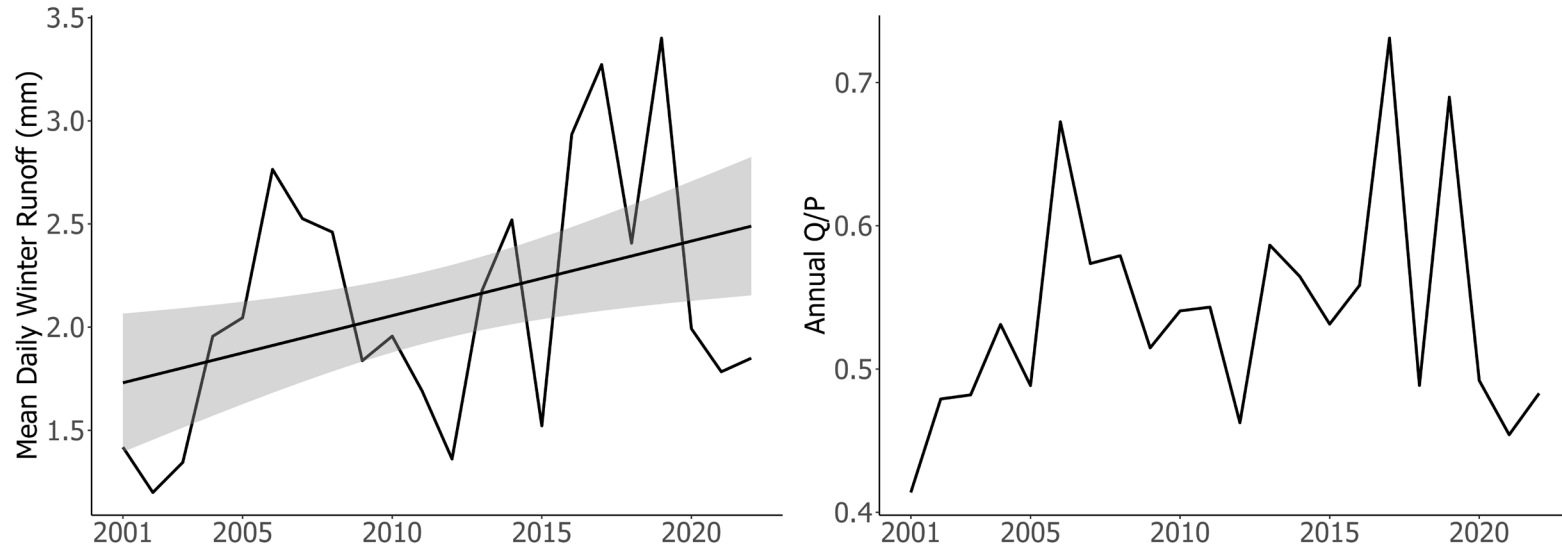
Ranch Brook Watershed
9.6 km², 295 m – 1166 m
USGS gage #04288230

How does the snowpack influence
downstream runoff?

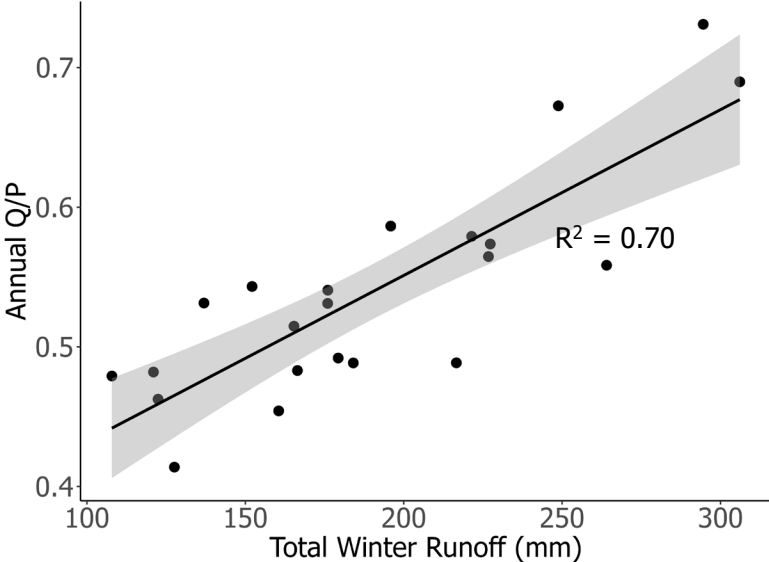
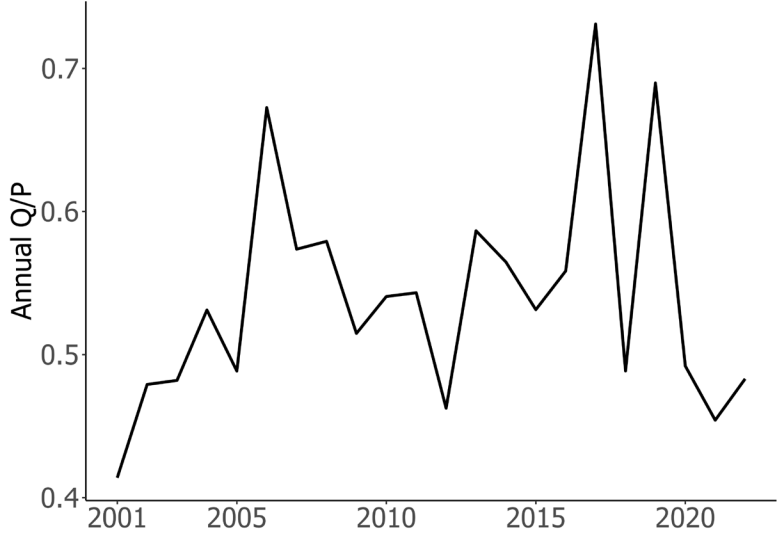
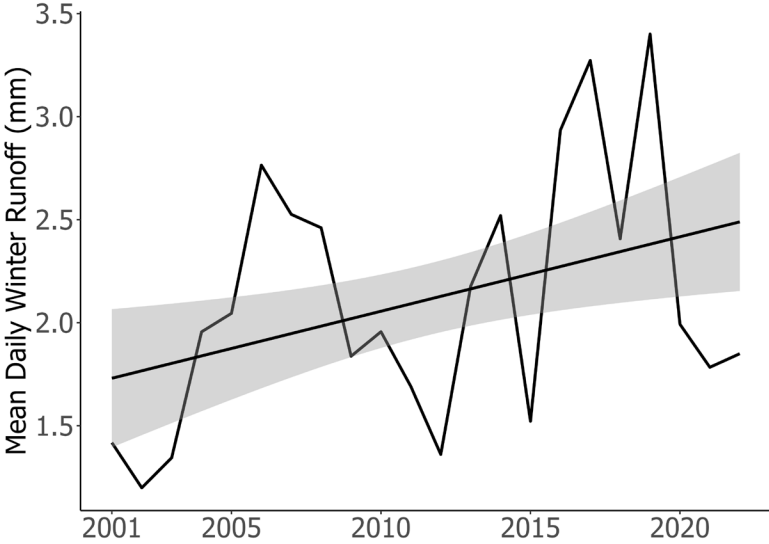
Increases in winter runoff, related to rain-on-snow, driving increased annual runoff ratios



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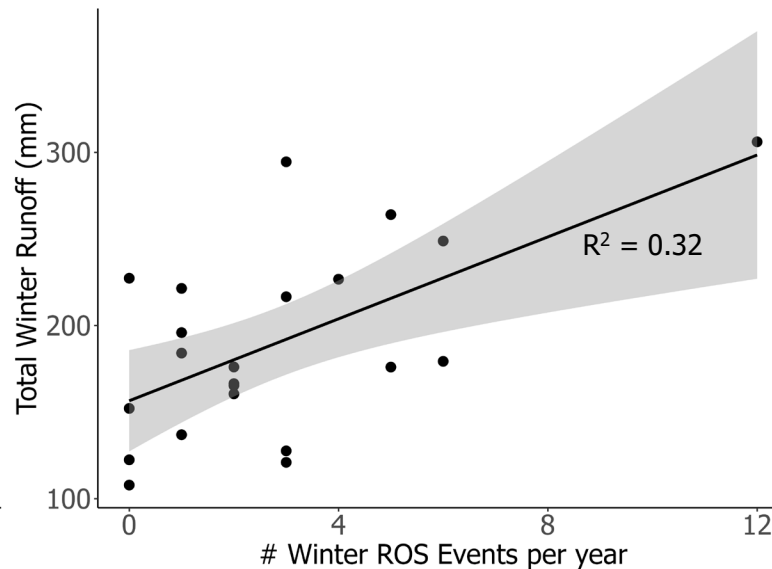
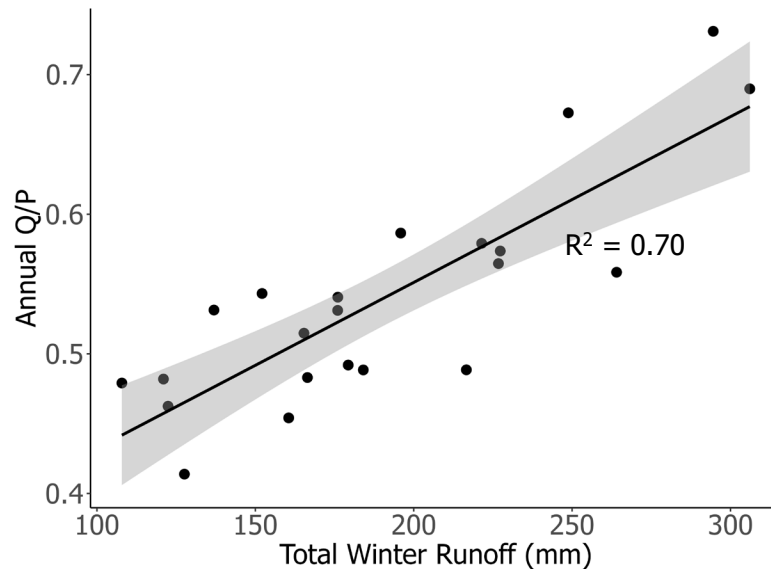
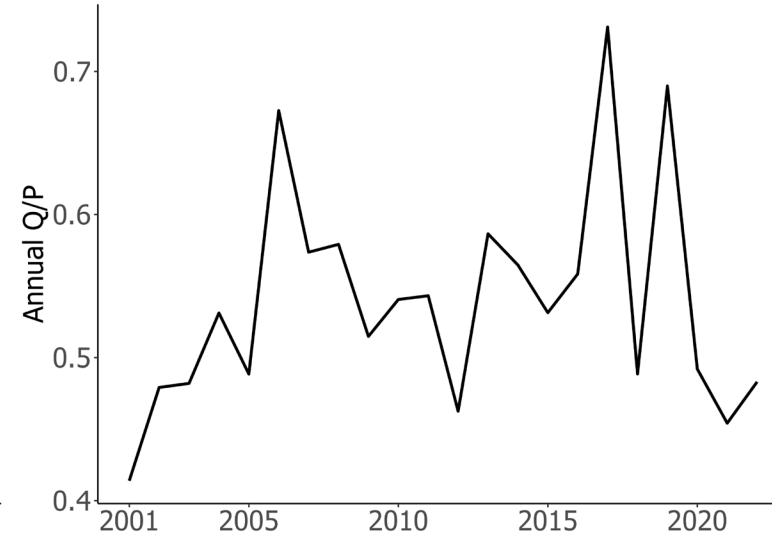
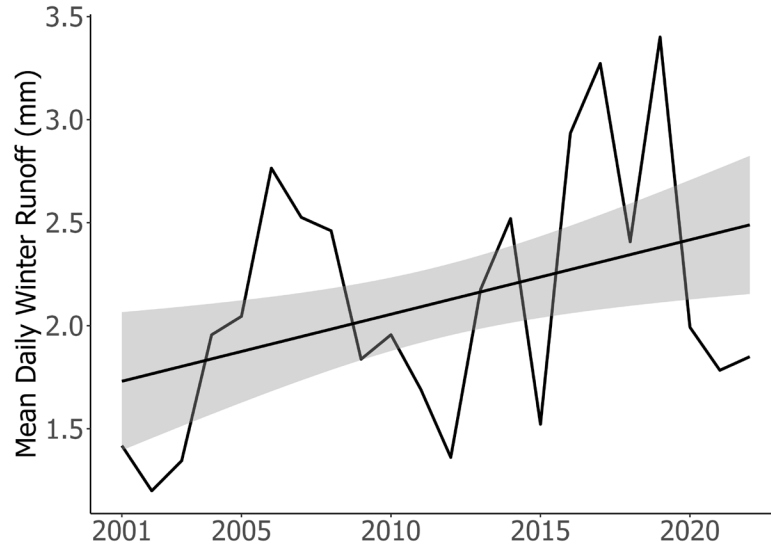


Increases in winter runoff, related to rain-on-snow, driving increased annual runoff ratios



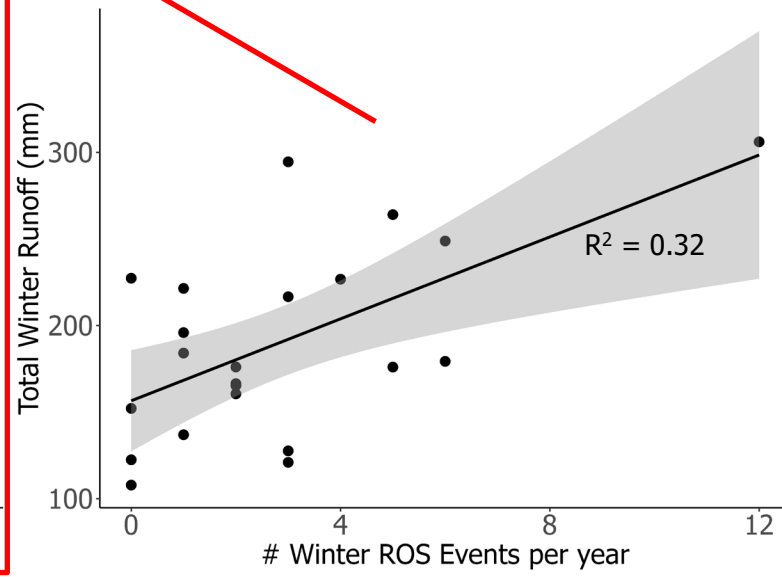
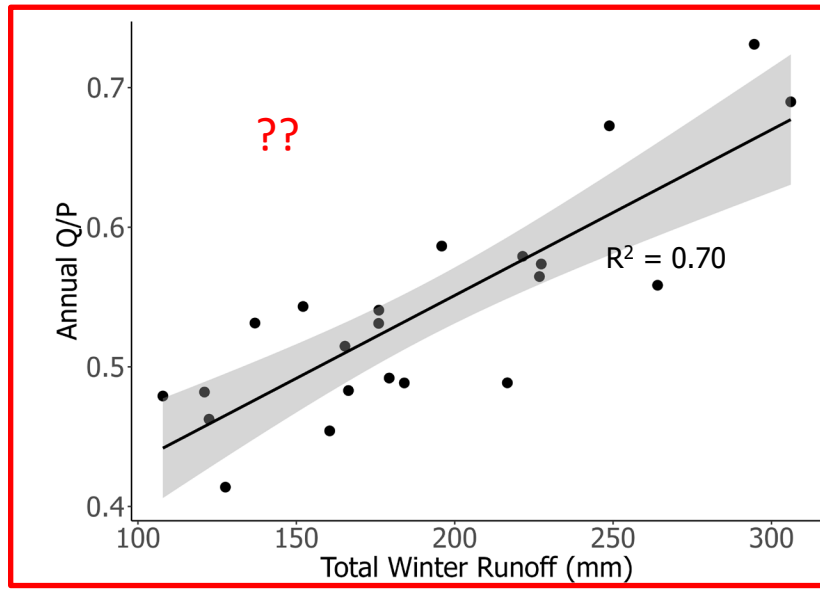
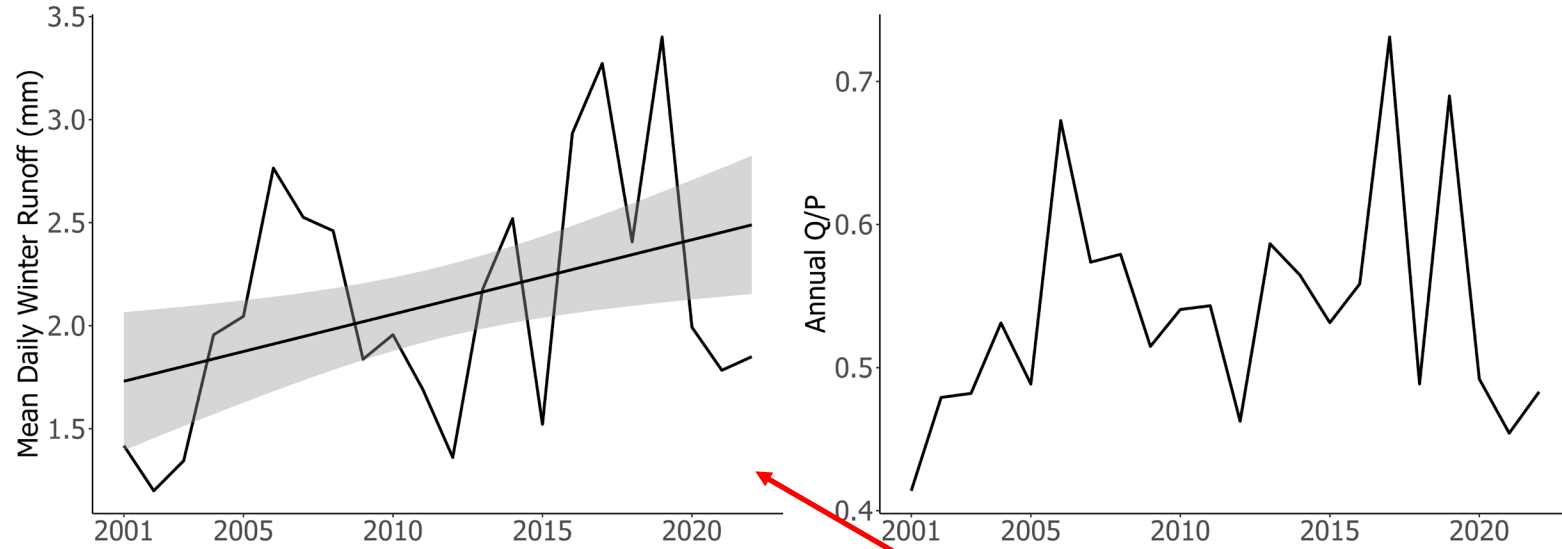
(Hale et al., 2025, *Hydrological Processes*)

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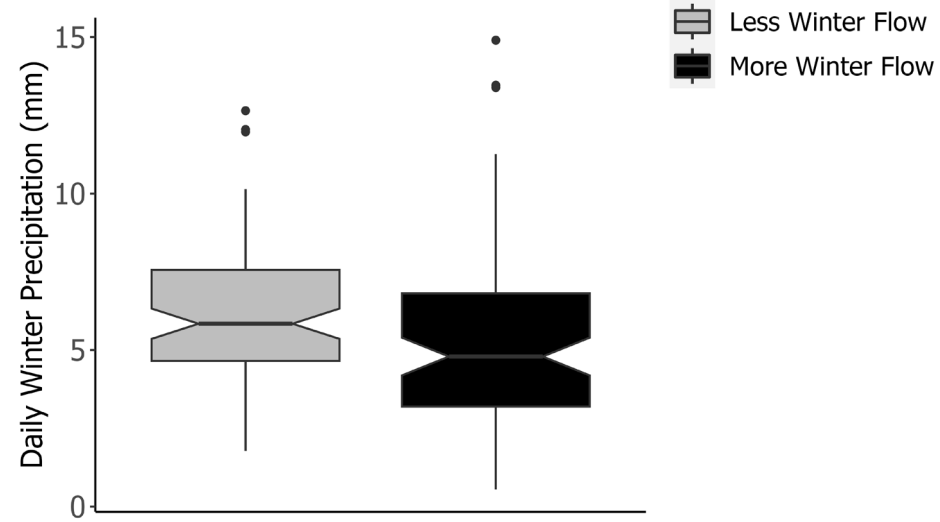
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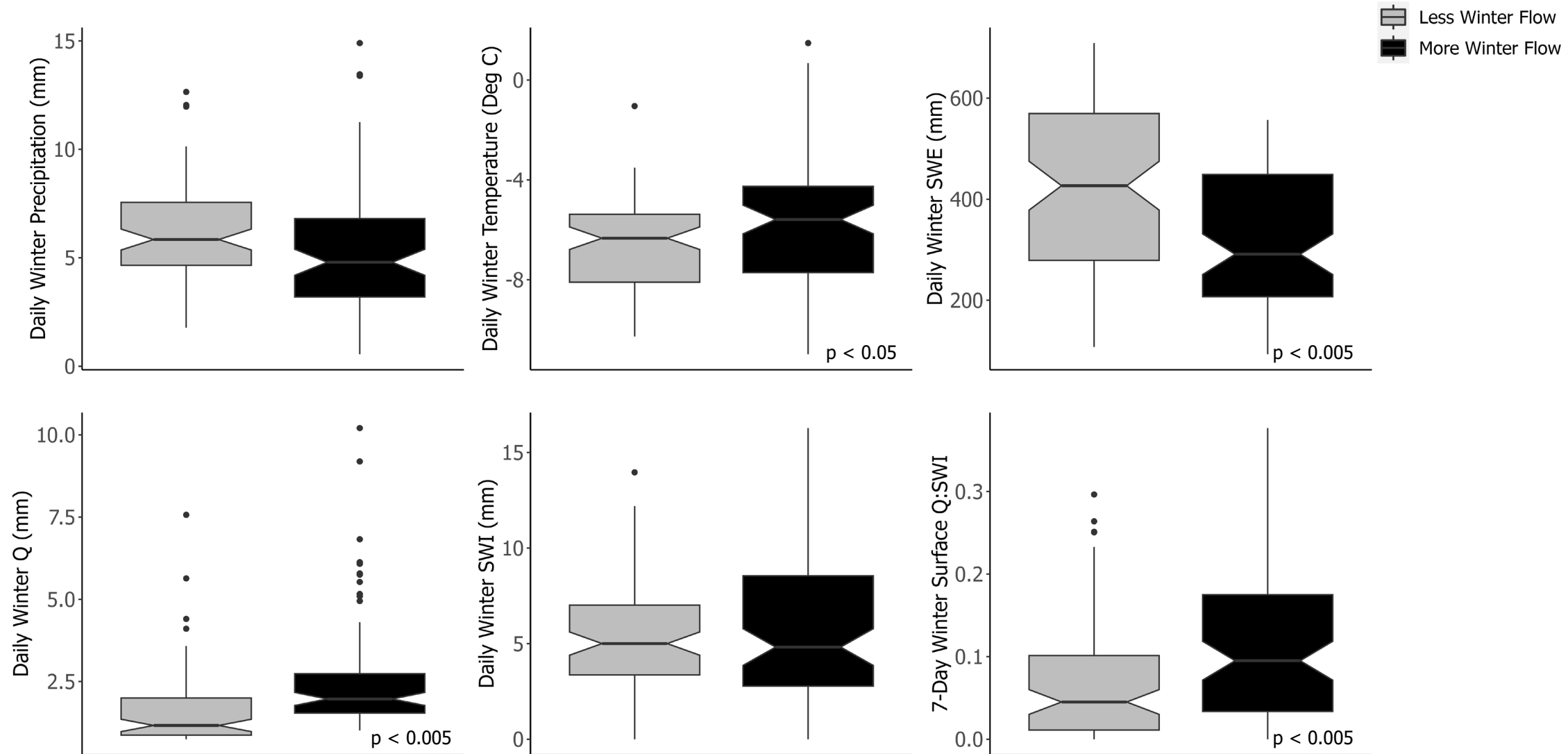


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Years with more winter runoff are warmer and experience less snowfall but efficiently partitioning SWI to runoff in winter months

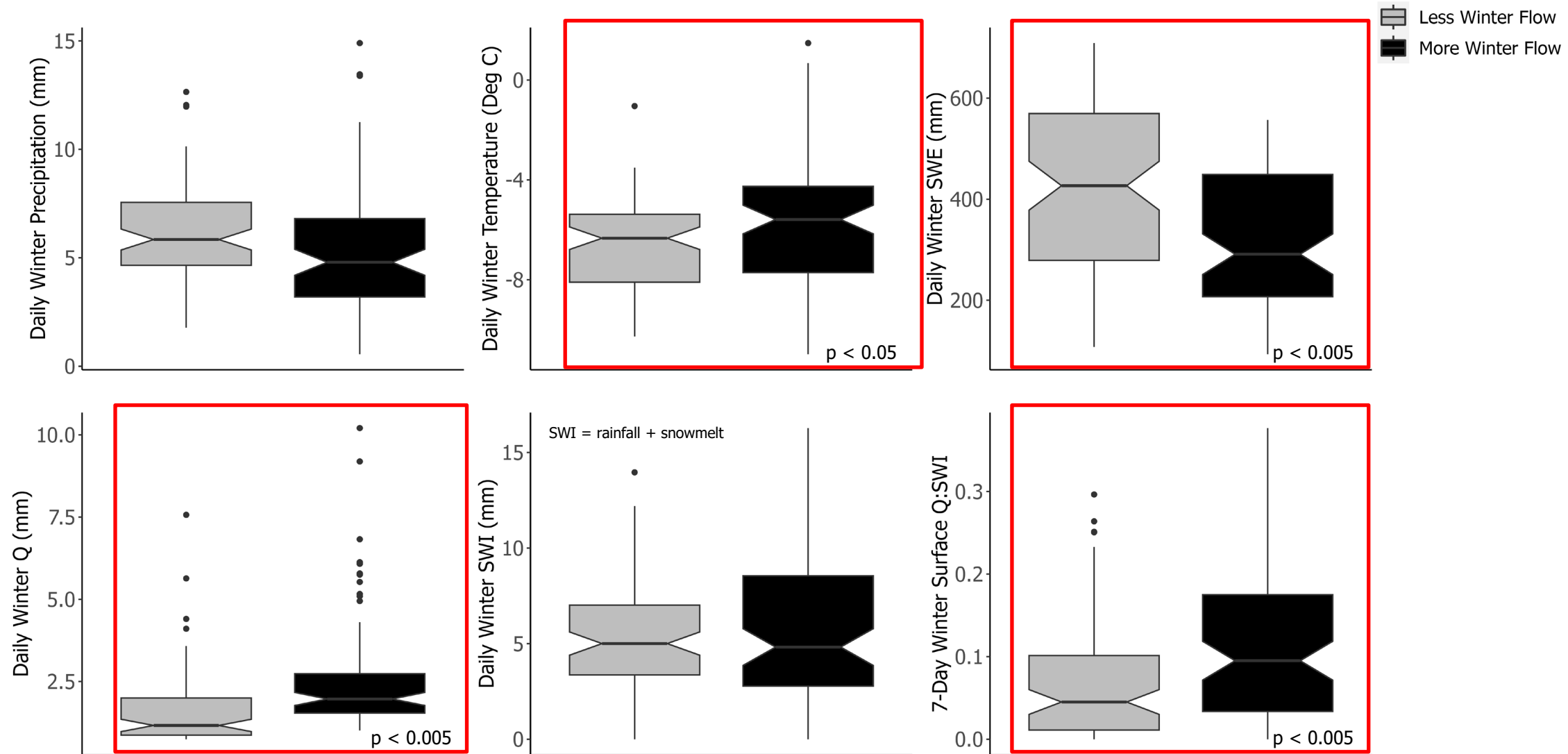


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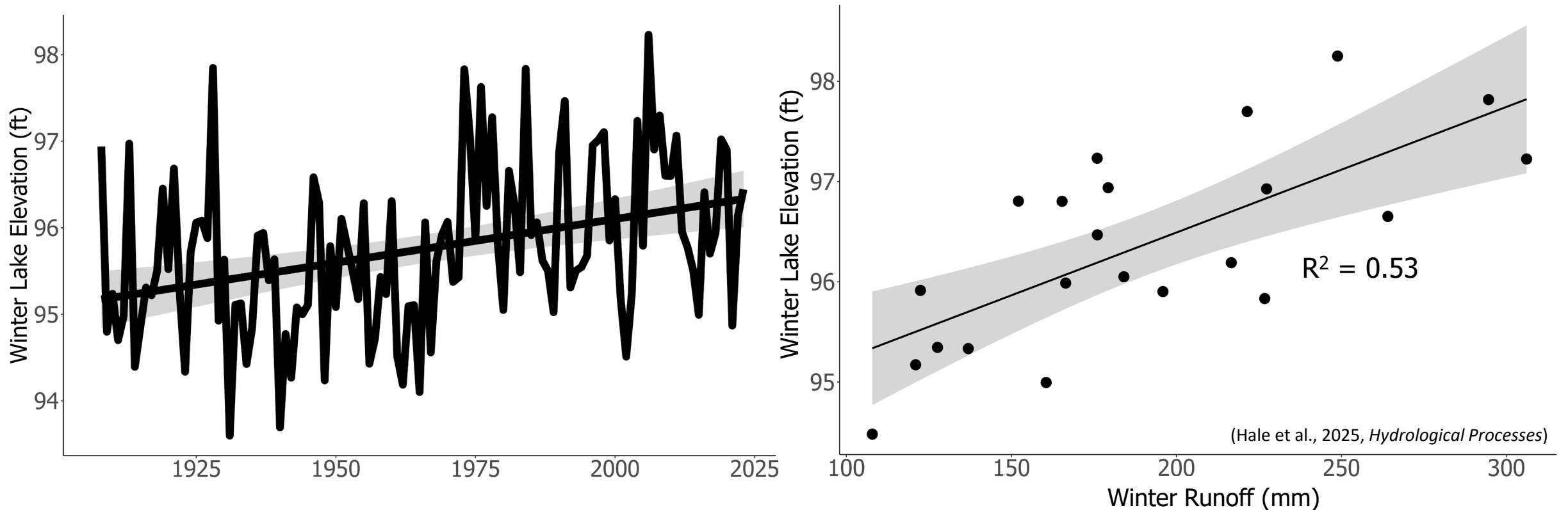
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Downstream implications:

Increases in winter season Lake Champlain levels, explained in part by winter runoff generation

Spring evapotranspiration, vegetation green-up, summer chlorophyll-a concentrations, and forest tree growth (Czikowsky and Fitzjarrald, 2004; Hrycik et al., 2021; Khodae et al., 2022; Reinmann et al., 2019)

“February flow” often used as a metric by water managers (Gong et al., 2010)



Thank you.
Questions?
kate.hale@ubc.ca



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