An intro to the wolverine glacier and surrounding watershed research

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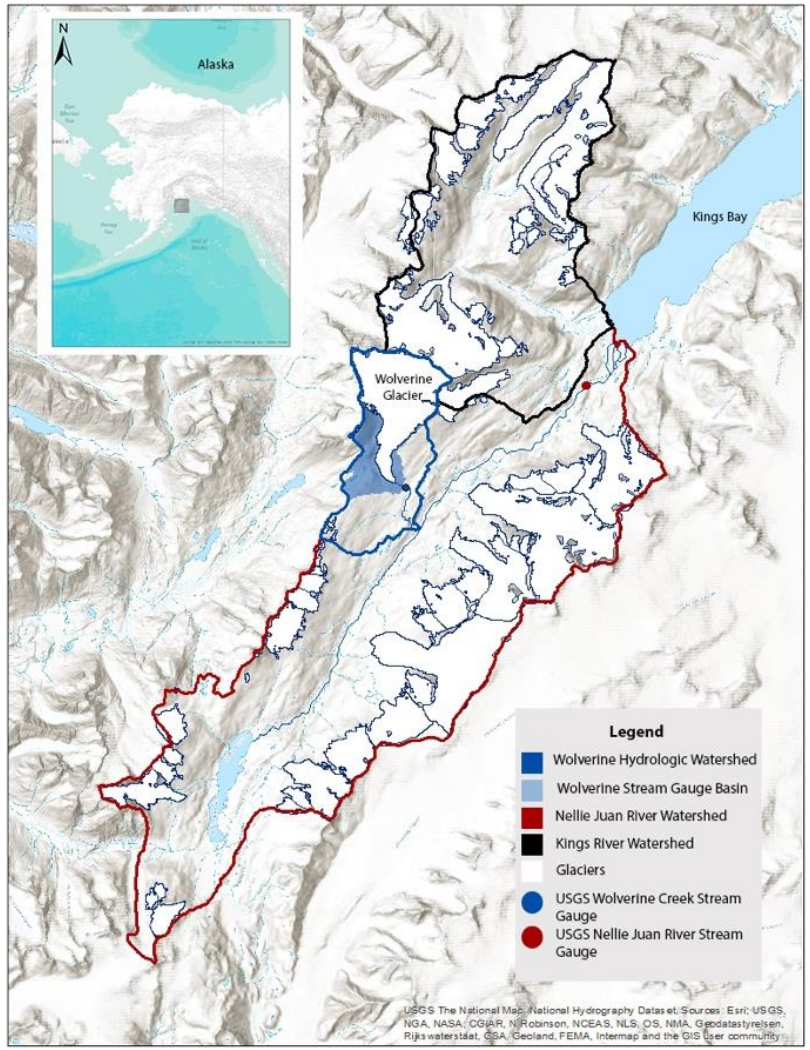
USGS science for a changing world

Legacy of USGS glaciology research

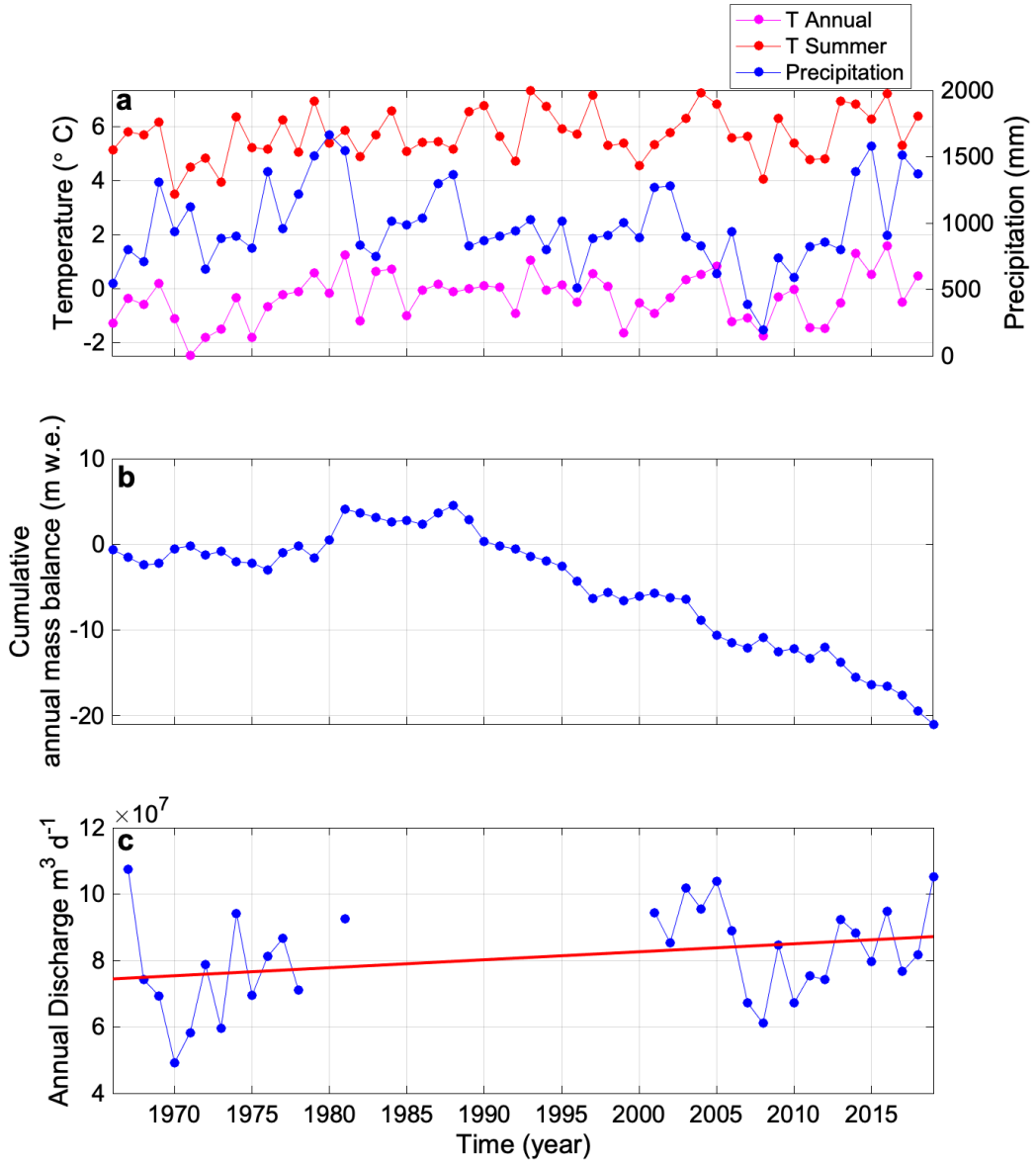
- Established as a Benchmark Glacier in 1966
  - Mass balance
  - Streamflow
  - Meteorology
- Weather station at 990 m
  - Mean annual temp: -0.2 C
  - Mean annual Precip: 1 m w.e. 75% snow
- Wolverine Glacier Watershed:

  24.6 km2, 60% glacierized, 350 – 1739 m a.s.l.
- Nellie Juan Watershed:

  450 km2, 40% glacierized, 0 -1782 m a.s.l.



Wolverine Glacier is thinning and retreating



Since measurements began:

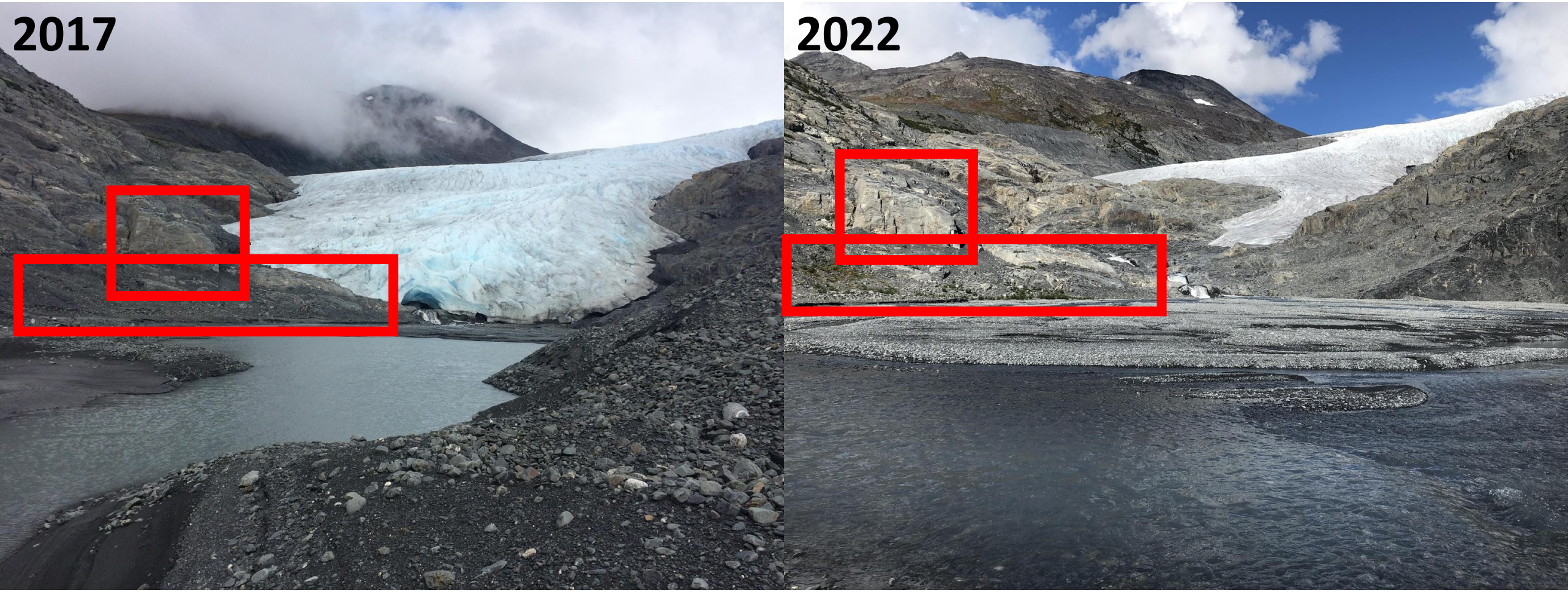
Significant decrease in winter precipitation, and warming of 1° C (half of regional trend)

The glacier has lost over 20 m w.e.

Last positive mass balance year was 2011-12

Annual flow at the Wolverine gage appears to be increasing

Wolverine Glacier terminus



Vegetation change across the landscape

Establishment of alders on LIA moraines

Establishment of mosses and vascular plants on new moraines

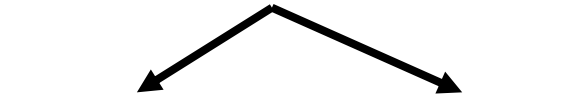
Alders getting taller, denser, possible forest establishment at middle elevations

What are the hydrologic and biogeochemical impacts of the rapidly changing landscape?

1. Water Balance 2. Mixing Model 3. Continuous Monitoring

1. Water Balance

$$\Delta S_{total} = Input - Output$$



Terrestrial Storage

Glacier Storage

$$\Delta S_{terr} = P_{tot} - Q - ET - B_a$$

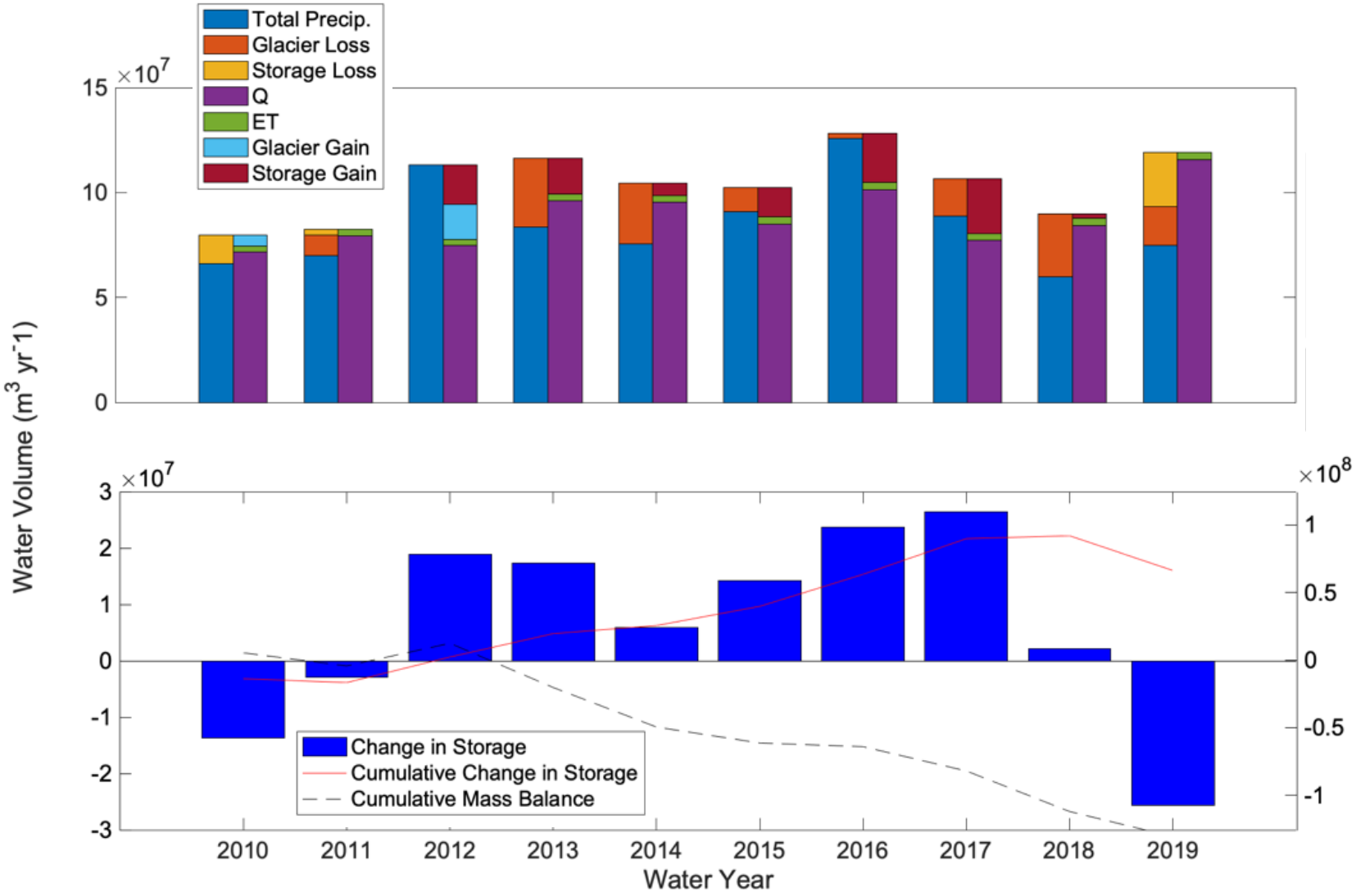
P_{tot} – Explored several models including data from nearby stations

Q – From USGS stream gage, assumed a low winter Q and interpolated

ET – MODIS MOD16A3 – summed to annual

B_a- Glacier mass balance - stake measurements

1. Water Balance



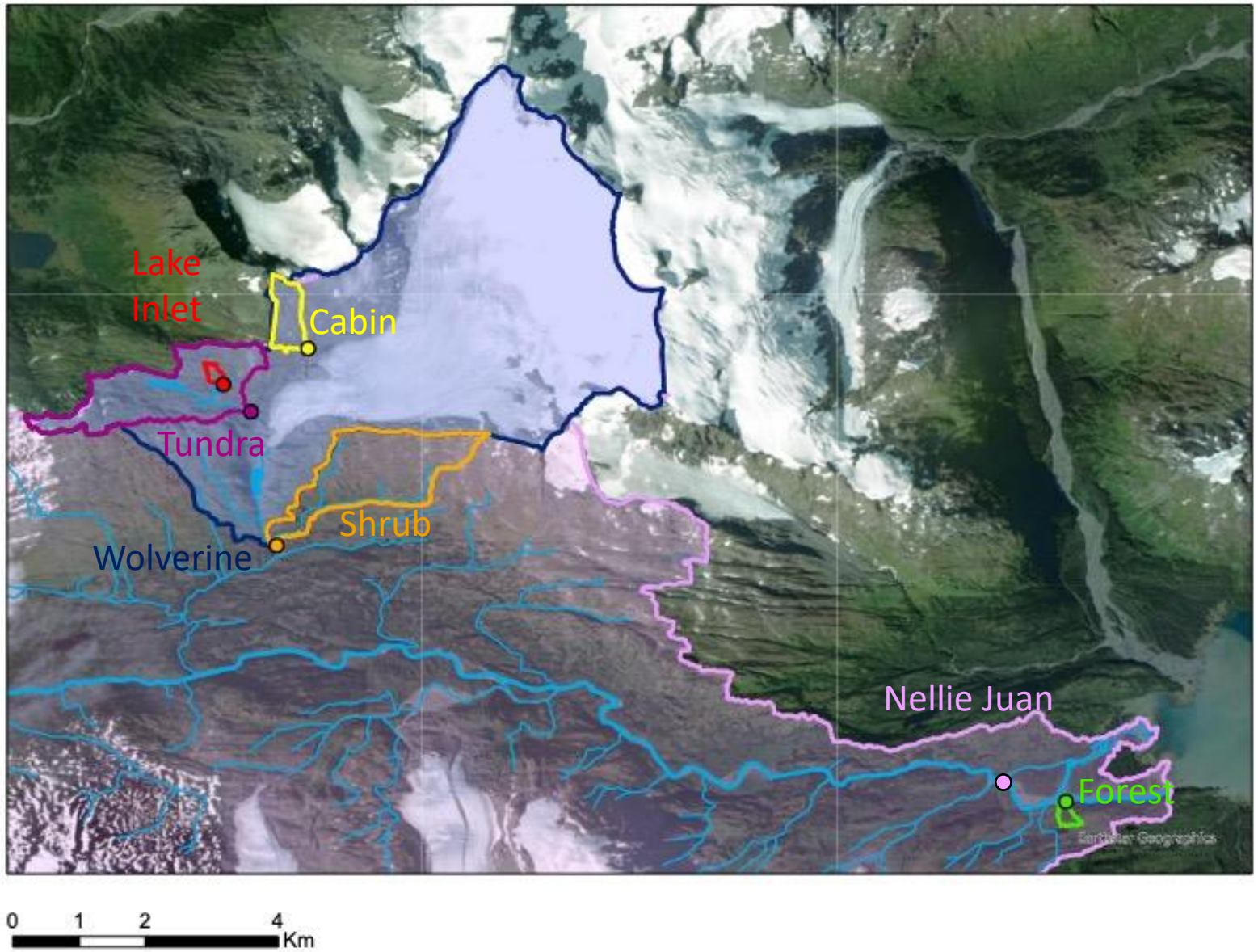
On average precip is ~90% of Q, Glacier mass loss is ~20%

Precip uncertainty is very large, wind redistribution is huge.

ET very small but increasing over record

Storage – closure error, firn storage, groundwater

2. Mixing Model



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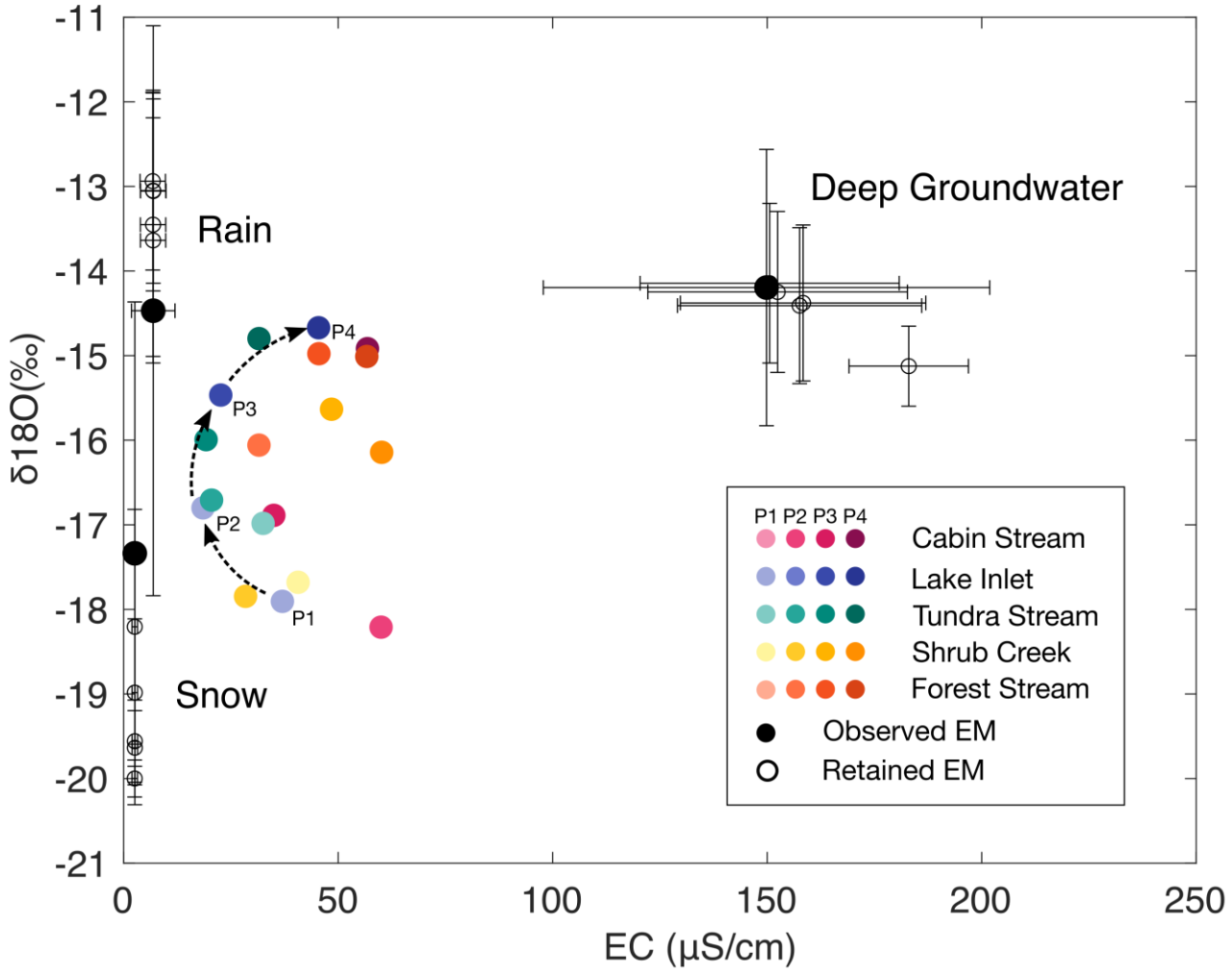


Cannot separate snow and ice, used one end member

Monte Carlo simulation of end members aided in issues with fractionation during snow melt

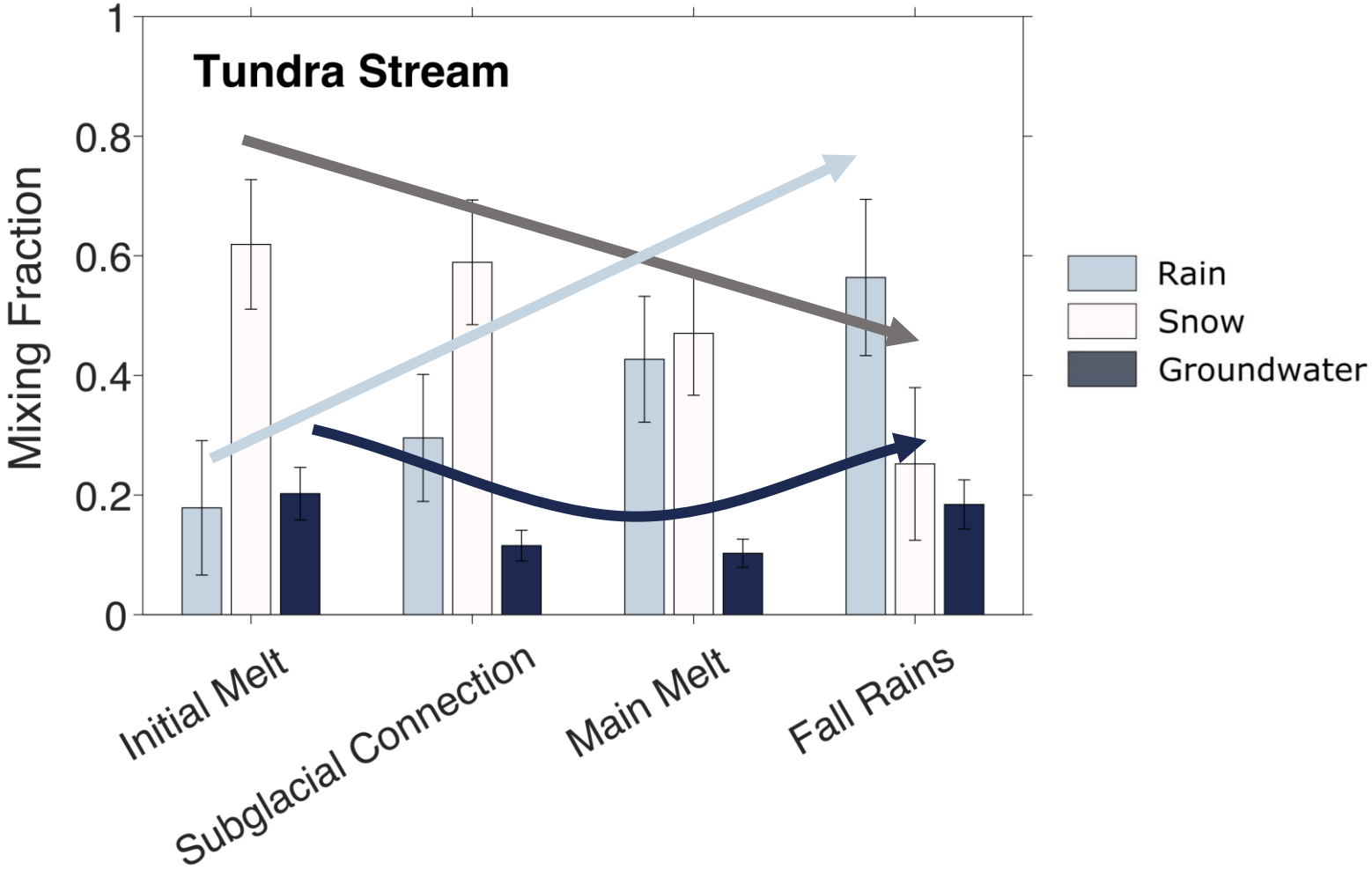
Streams are moving from snow dominated to rain and groundwater dominated through the season

2. Mixing Model

Across locations:

Up to ~45% of flow is derived from groundwater

Generally increasing GW at lower elevations – but bedrock controled



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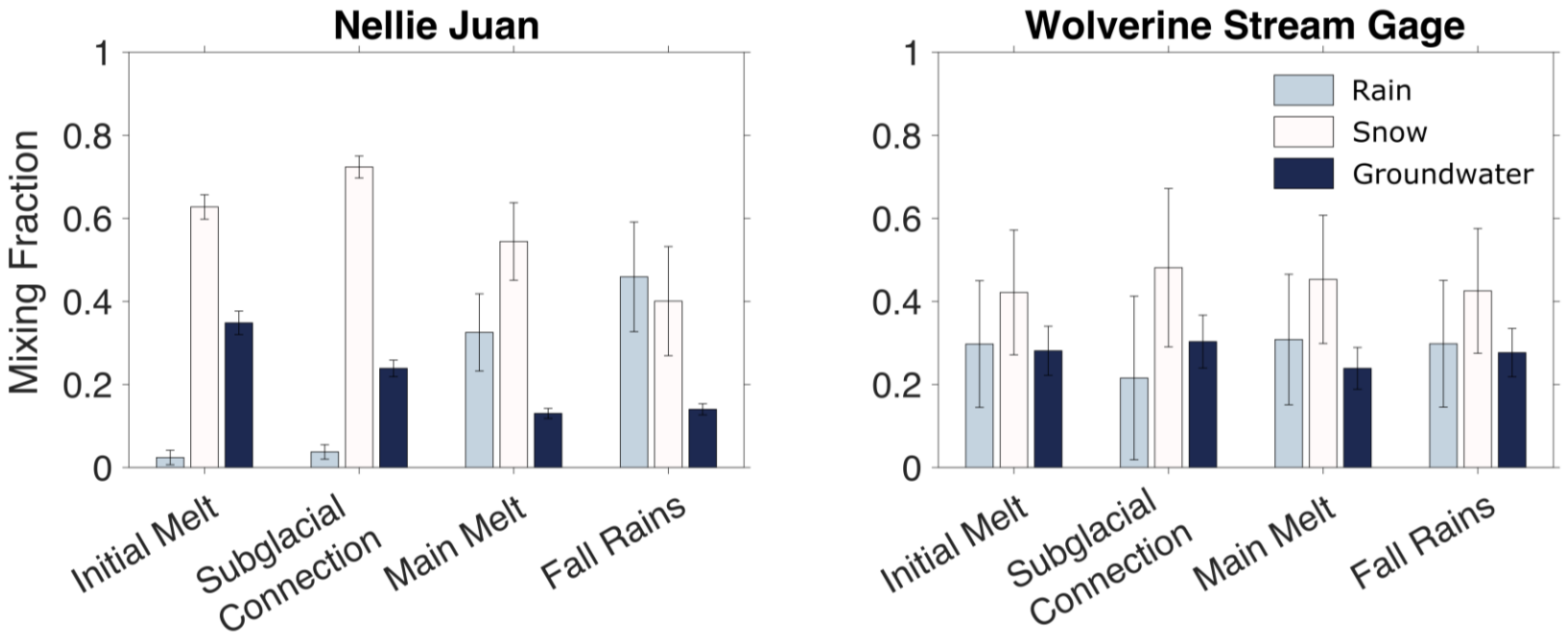


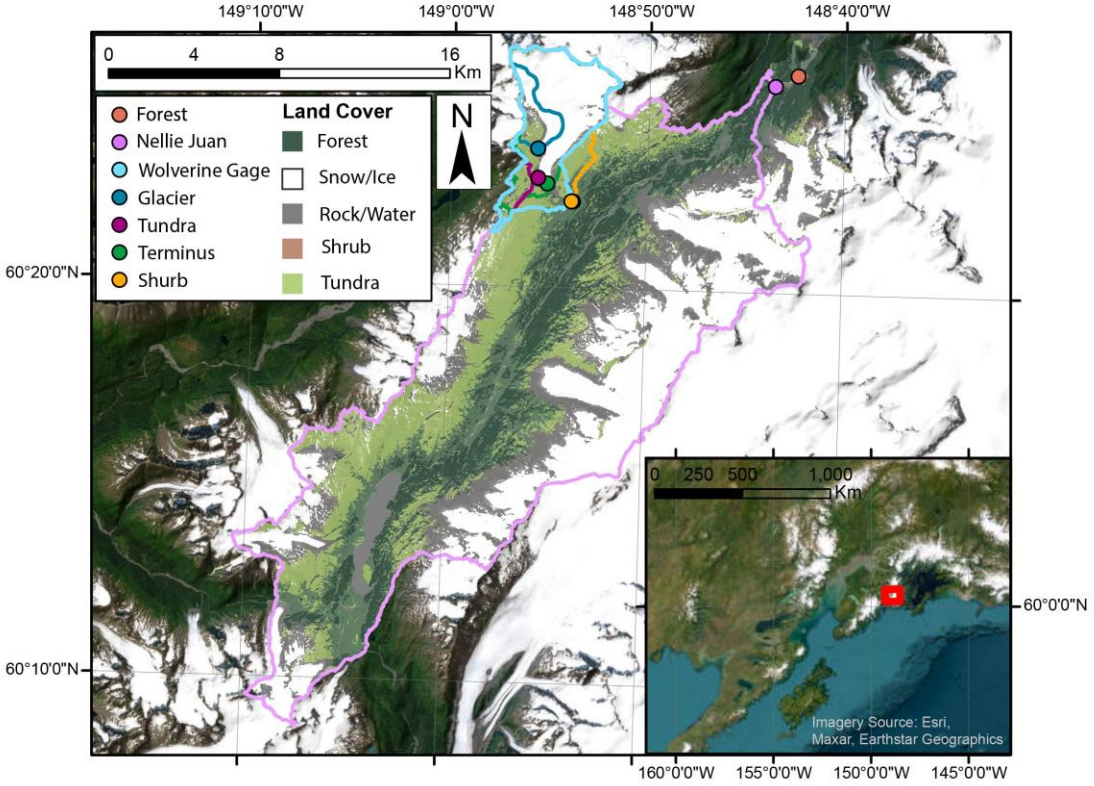
Glacier watersheds- Still high groundwater

Snow/ice melt consistently higher

Wolverine is more stable over the season

3. Continuous Monitoring

- Installed YSI EXO2 – water quality sondes at 5 locations
  - Temp
  - EC
  - pH
  - DO
  - Turbidity
  - FDOM
- Watersheds capture dominant landscape types, scaling



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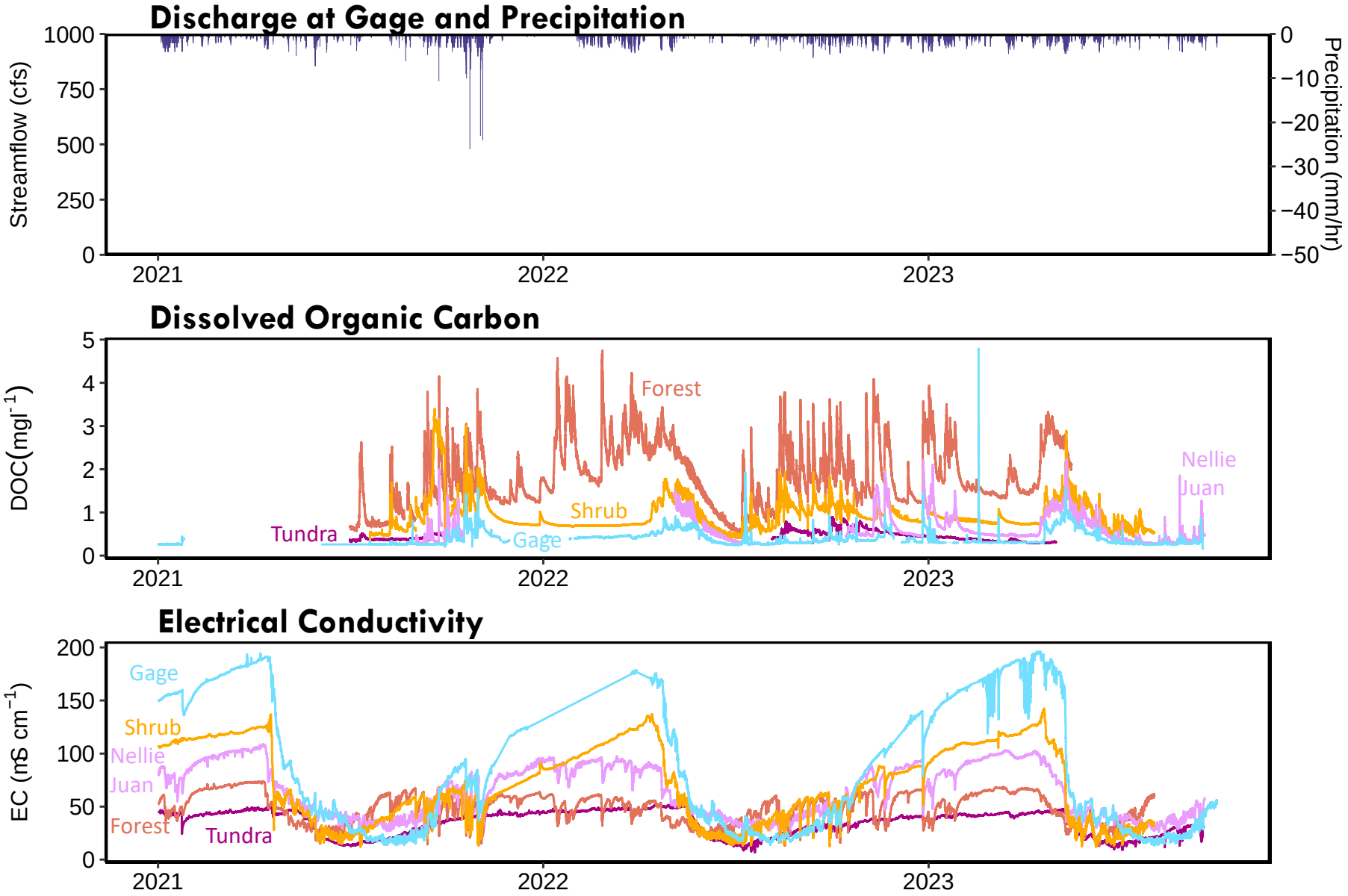
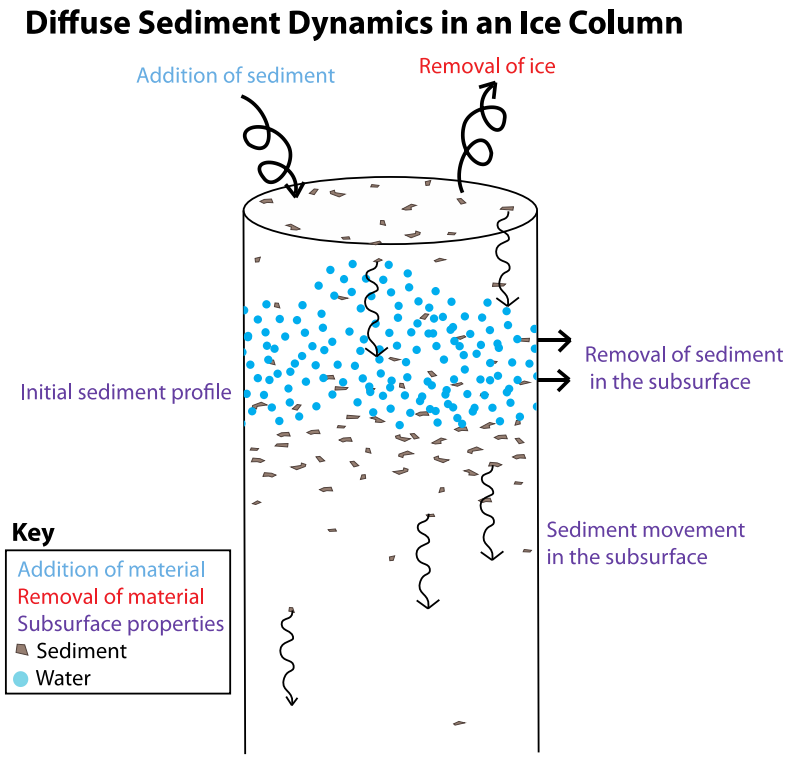
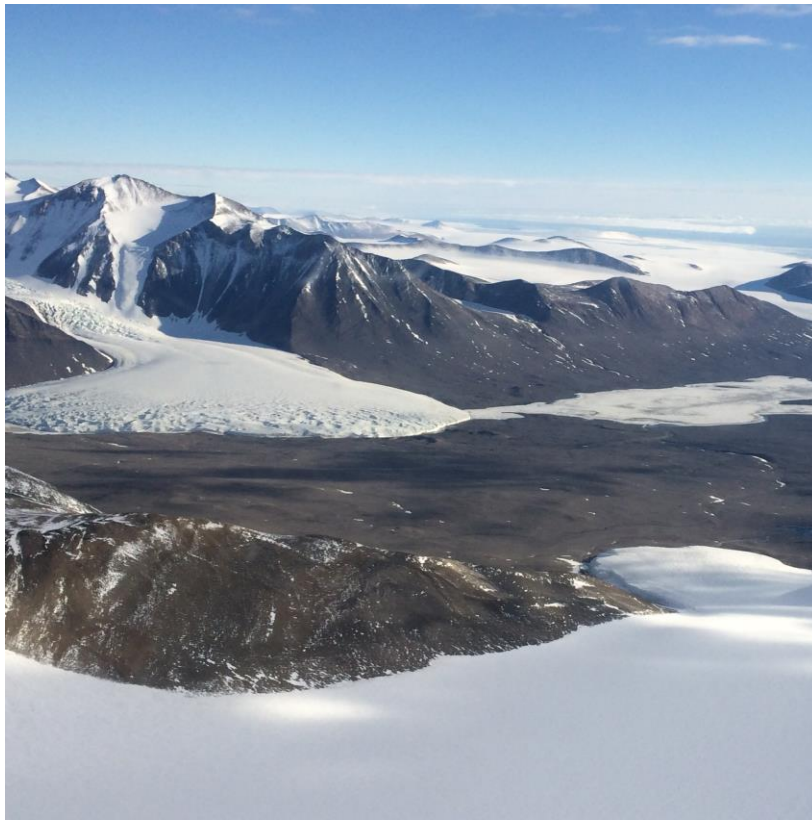


- Precipitation is exceedingly hard to measure
- Groundwater is contributing to storage and streamflow
- Winter melt/rain events are observed in geochemical record, even at high elevation
- All of this will become increasingly important/pronounced as climate change continues

I'm hiring!





Modeling of sediment – ice energy balance interactions

McMurdo Dry Valley Glaciers, Antarctica

Thanks for your attention
Thanks to collaborators and field personnel

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