Resolving spatial variability in SWE using a ground based GPR system

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And many, many collaborators (Ryan Webb, HP Marshall, Noah Molotch, Chris Hiemstra, Shad O’Neel, Louis Sass, Emily Baker, Chris McNeil and SnowEx ground team)
Example Transects

\[ v = 0.24 \text{ m/ns} \]

\[ r^2 = 0.61 \]
Travel Time [ns]
0.4 0.6 0.8 1.0 1.2 1.4 1.6 1.8

MagnaProbe depth [m]
0.247941 0.892162

Data Fit Confidence bounds

Shrub Meadow

v=0.24 m/ns
r²=0.89
Land cover control on SWE variability
USGS Alaska Benchmark Glaciers

- Eureka Gulkana
- Valdez
- Scott
- Wolverine

- Wolverine Glacier:
  - long-term sites
  - additional sites
  - 1975 sites
  - 2017 sites

- Gulkana Glacier:

**Graphs:**
- **Wolverine Glacier**
  - Graph showing mass balance (m) over time (years) with data points for glaciological and calibrated data.
- **Gulkana Glacier**
  - Graph showing mass balance (m) over time (years) with data points for glaciological and calibrated data.

**Legend:**
- Green: glaciological
- Orange: calibrated
From \( n = 3 \) to \( n = 200,000 \)

\[ v = 0.23 \text{ m/\text{ns}} \]

\[ r^2 = 0.96 \]
GPR Observations – 2013 – 2017

- Extensive surveys across both glaciers (~25 km)
- Consistent tracks to avoid known crevasse and avalanche hazard; possible bias
• Develop multi-variable stepwise regression, with a threshold for parameter inclusion, between terrain parameters and our SWE observations.
Model Performance – 2013 – 2017

- Terrain parameters do a decent job explaining the variability in the observations
- Radar derived winter balance exceeds stake derived estimates
- Dominance of elevation
- Sx and curvature → capture wind redistribution
- Quite variable
Year to Year Consistency (CoVs)
Thanks!
Small glaciers, big SWE
High rates of mass turnover