Transitioning from probing to droning: Improving spatial representation of snow processes and reducing personnel risks

USDA Agricultural Research Service

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OBJECTIVES

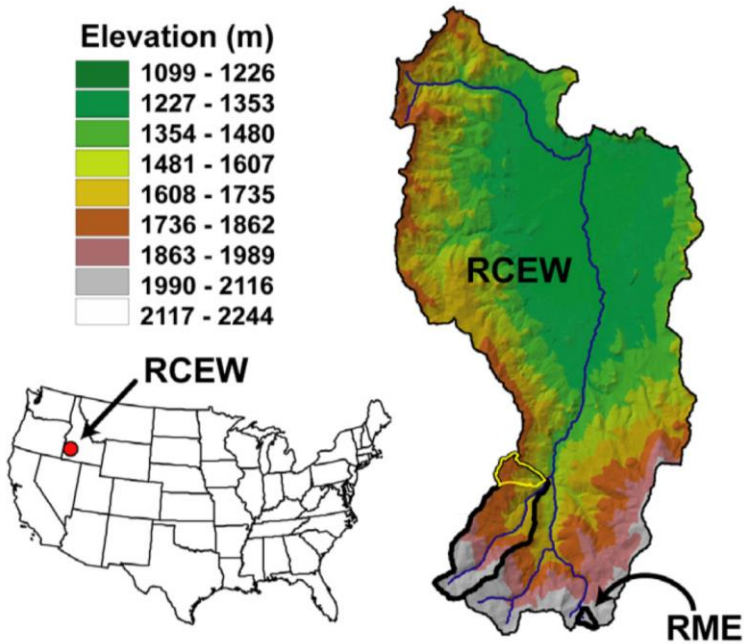
1. Present an overview of the Reynolds Mountain East intensive snow survey program (2001–present)
2. Describe how the Northwest Watershed Research Center is leveraging new technologies to improve surveys and reduce risks to field personnel.

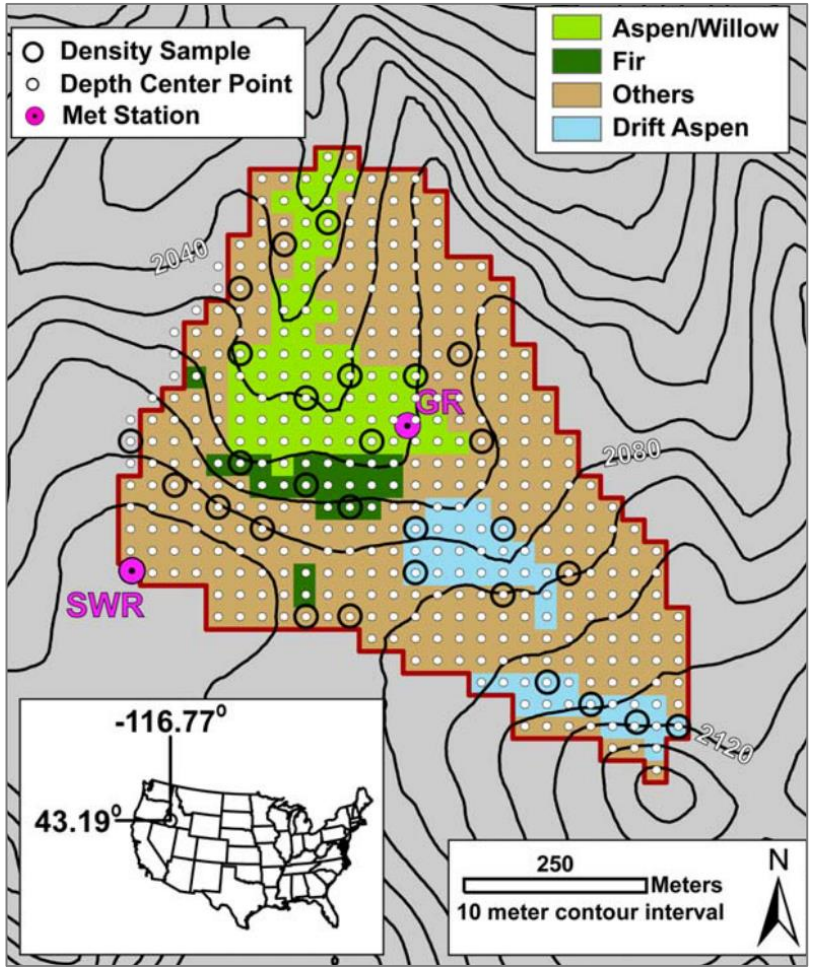
The Reynolds Mountain Yeti


Reynolds Mountain East snow pillow site (December 15, 2022)

Reynolds Mountain East

A densely instrumented sub-alpine outdoor laboratory (0.38 km^2; 2027 – 2137 m asl)





Reynolds Mountain East

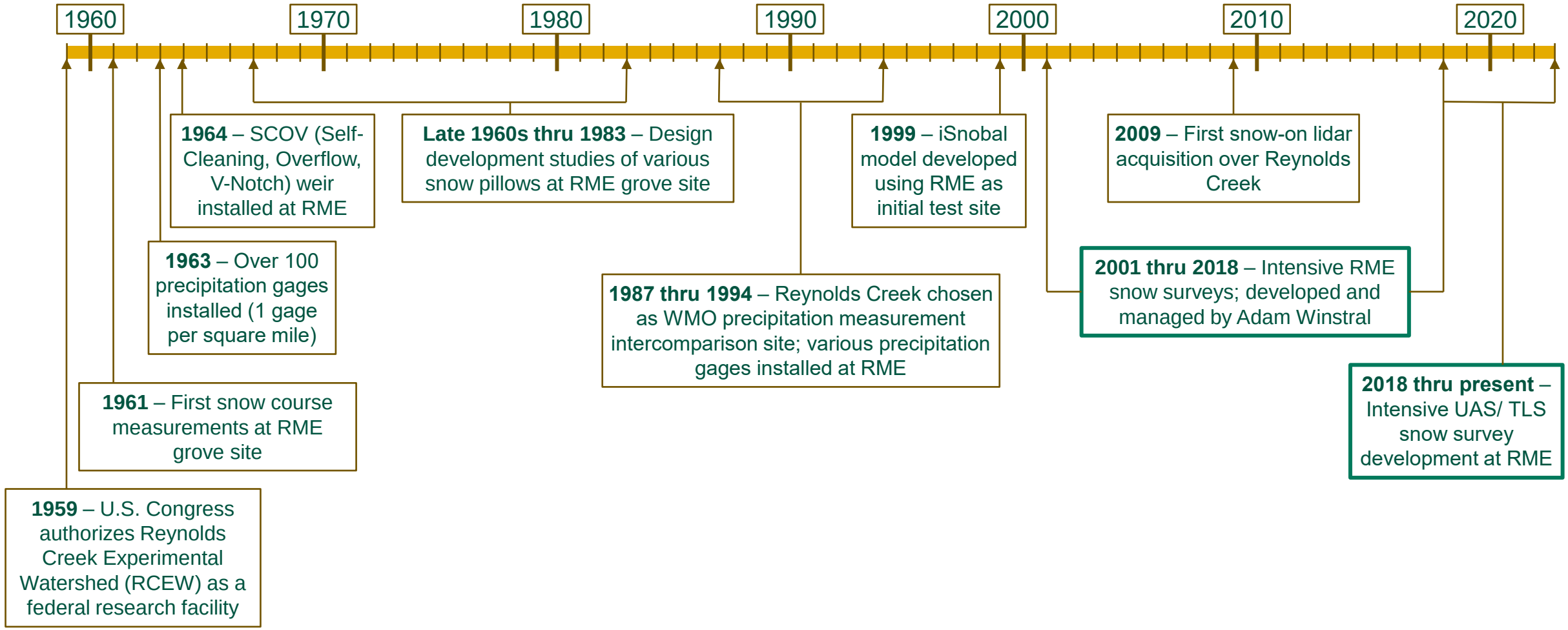
Intensively monitoring hydrology and climate since 1959

Spring 1964 – Newly installed upper Reynolds Creek weir house (site 166). Structure suffered catastrophic fire March 2023, rebuilt October 2023.

Reynolds Mountain snow pillow site (Summer 1968)

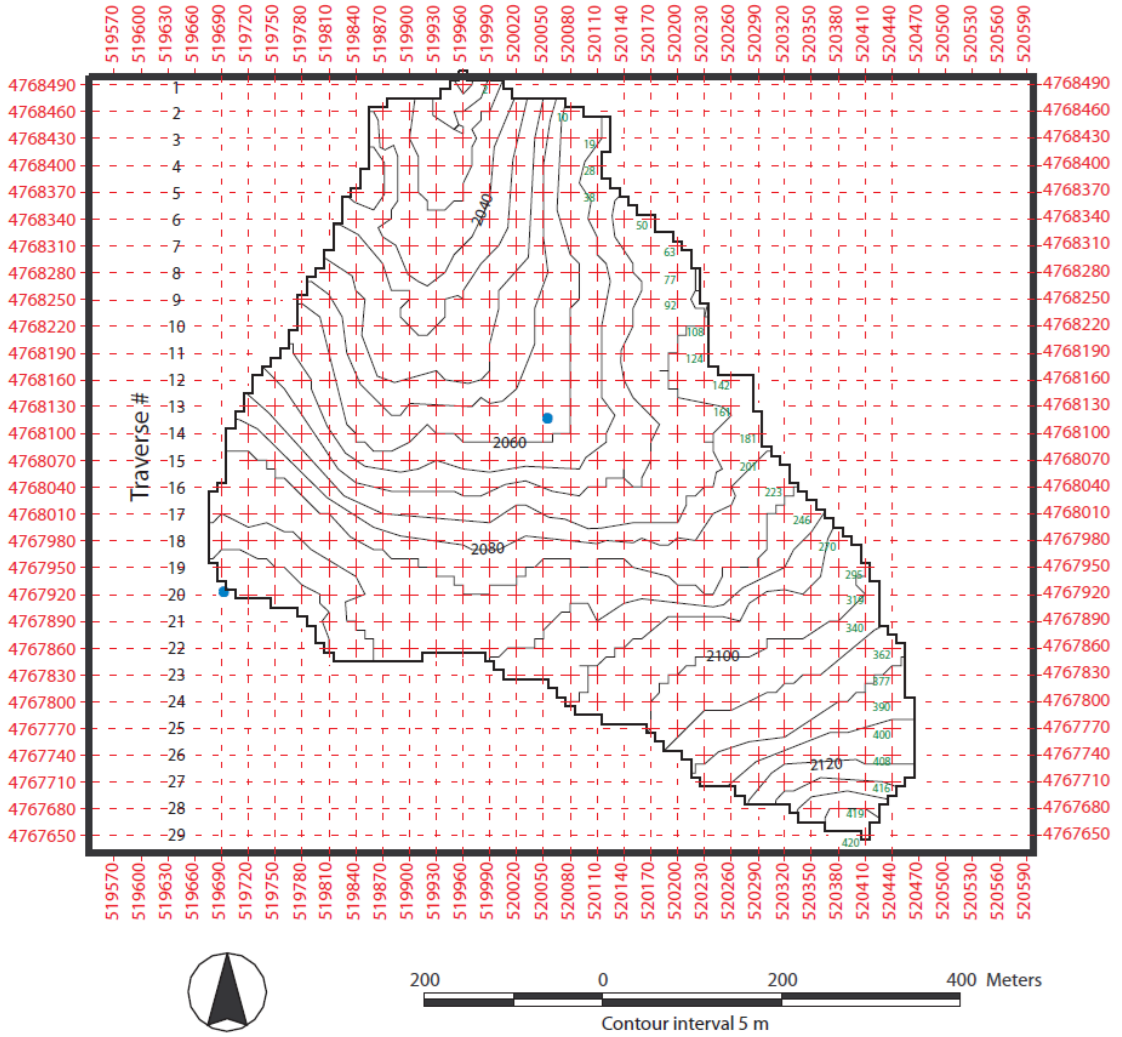
Fluid-filled snow pillow development circa mid-1960's

RME Timeline



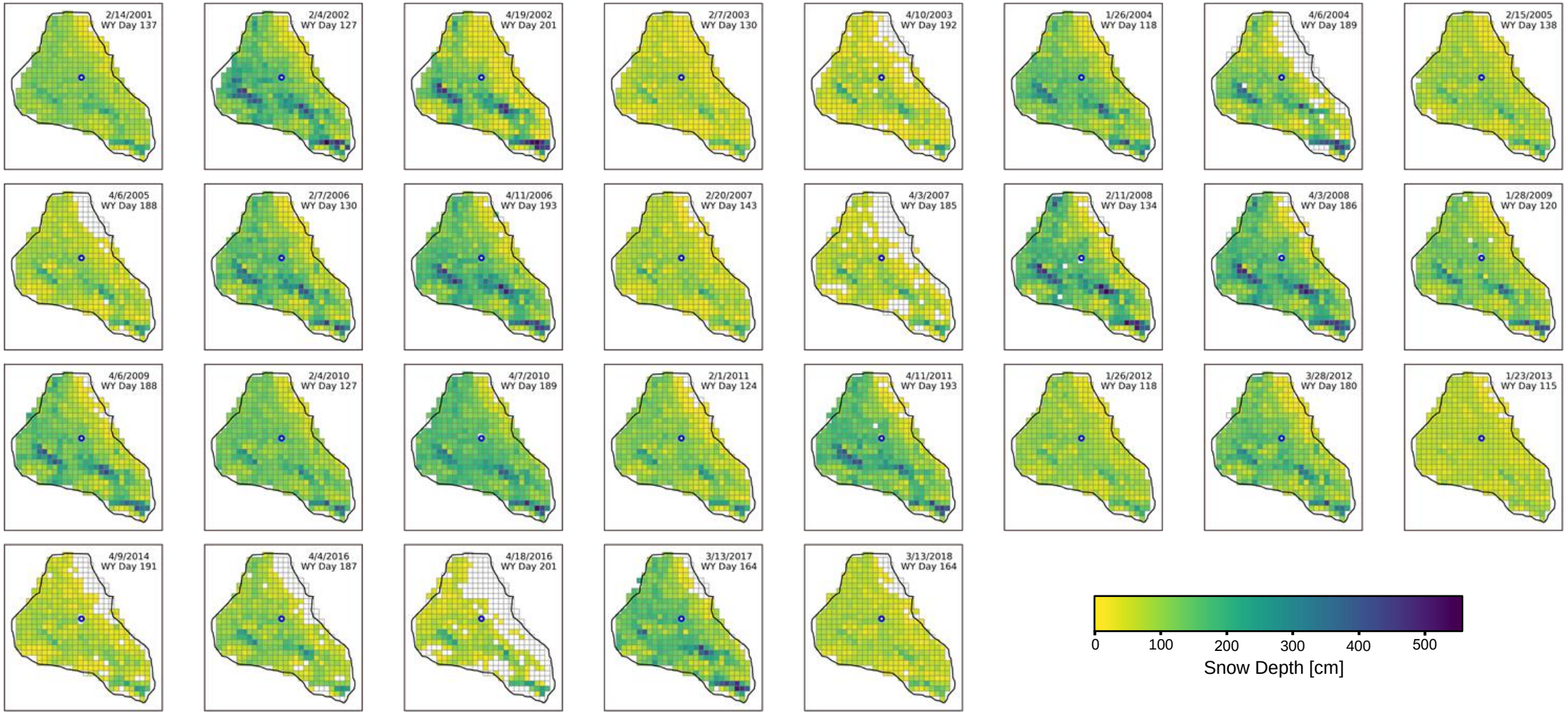
RME Snow Surveys (2001–2018)

- Quantify total basin surface water storage at or around peak SWE
- Stratified random snow density measurements w/ Federal SWE Sampler
  - ~20 points, 3 measurements / point
- Snow depths measured on 30-meter grid + random 10-meter offset from each grid center.
  - 420 grid centers + 420 offsets = 860 measurements
- Requires 3-5 people, overnight stay in luxurious RME Cabin

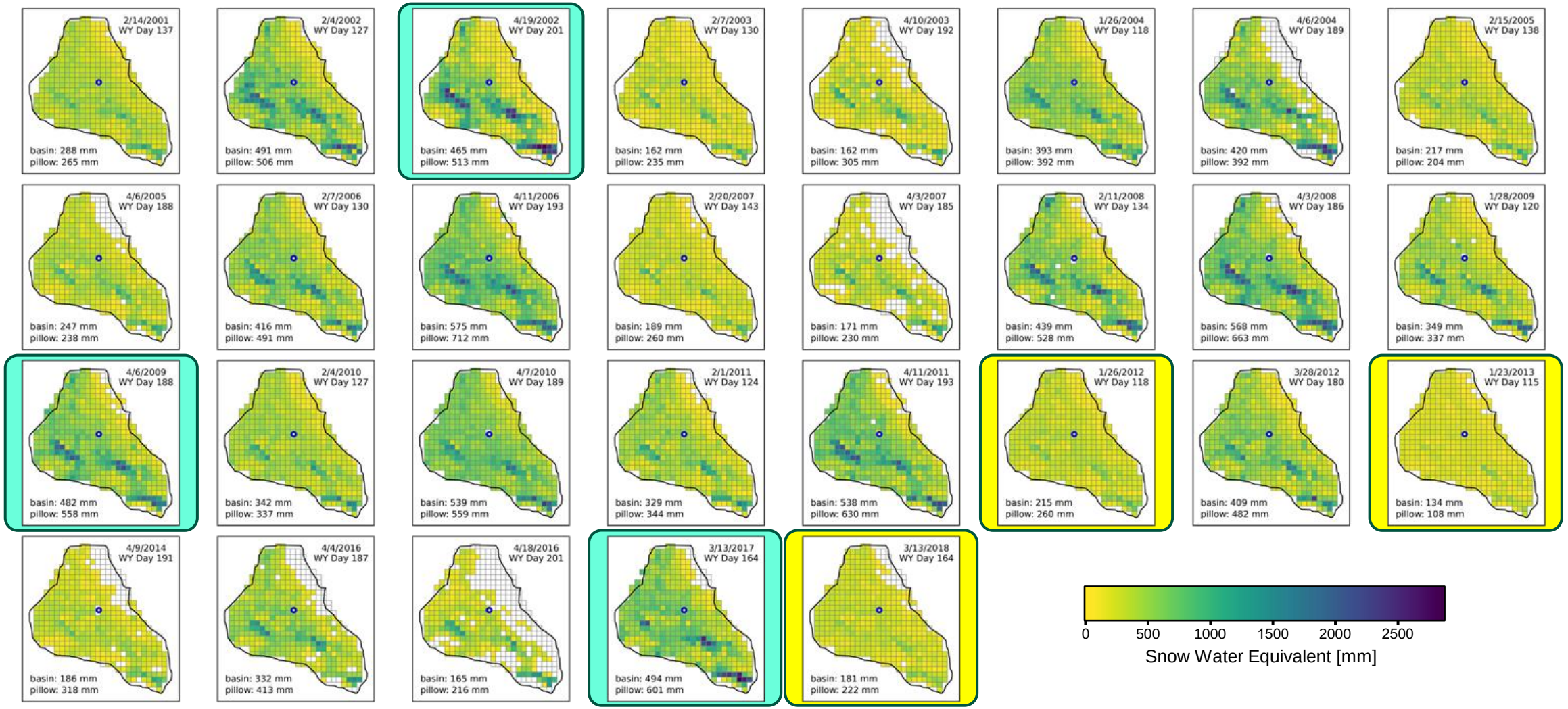


RME Snow Surveys (2001–2018)

RME Snow Depths (2001 – 2018)

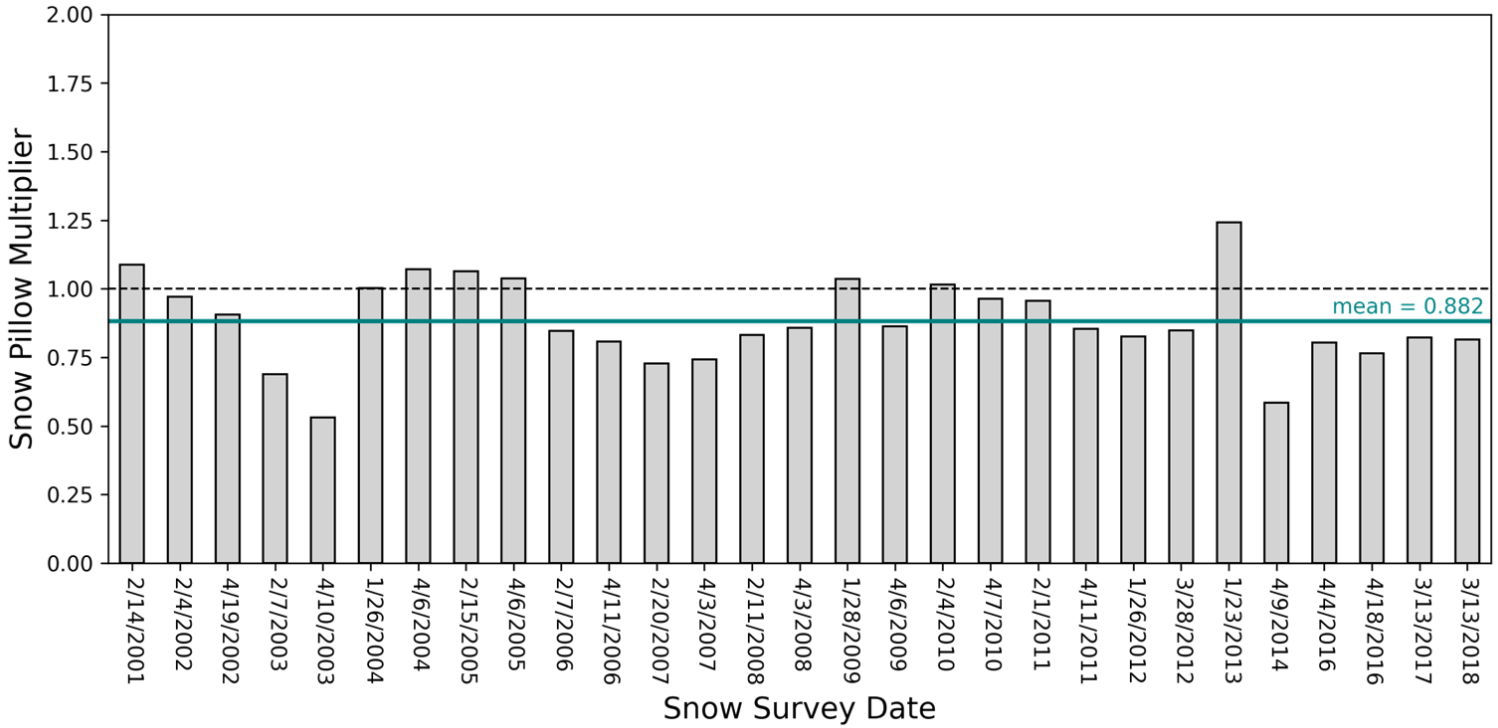


RME SWE (2001–2018)



Snow pillow relation to basin survey

Snow Pillow Multiplier = SWE_{basin} / SWE_{pillow}



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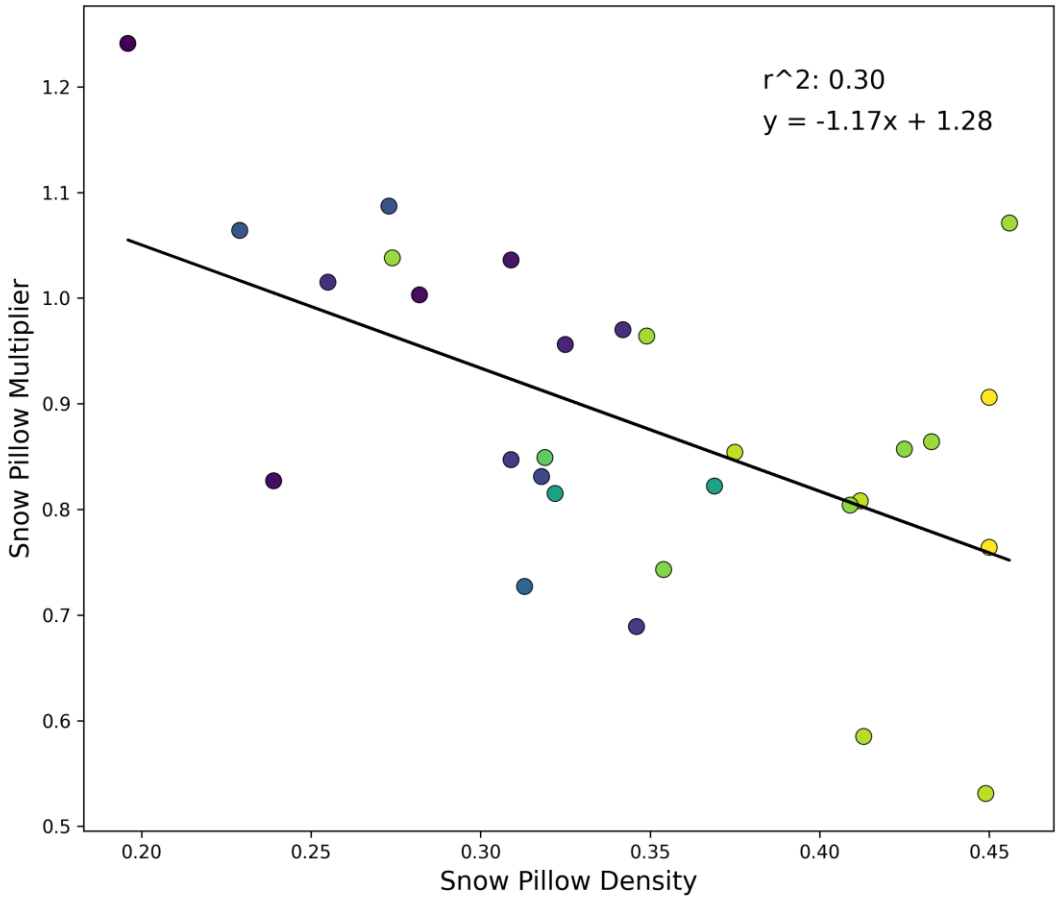
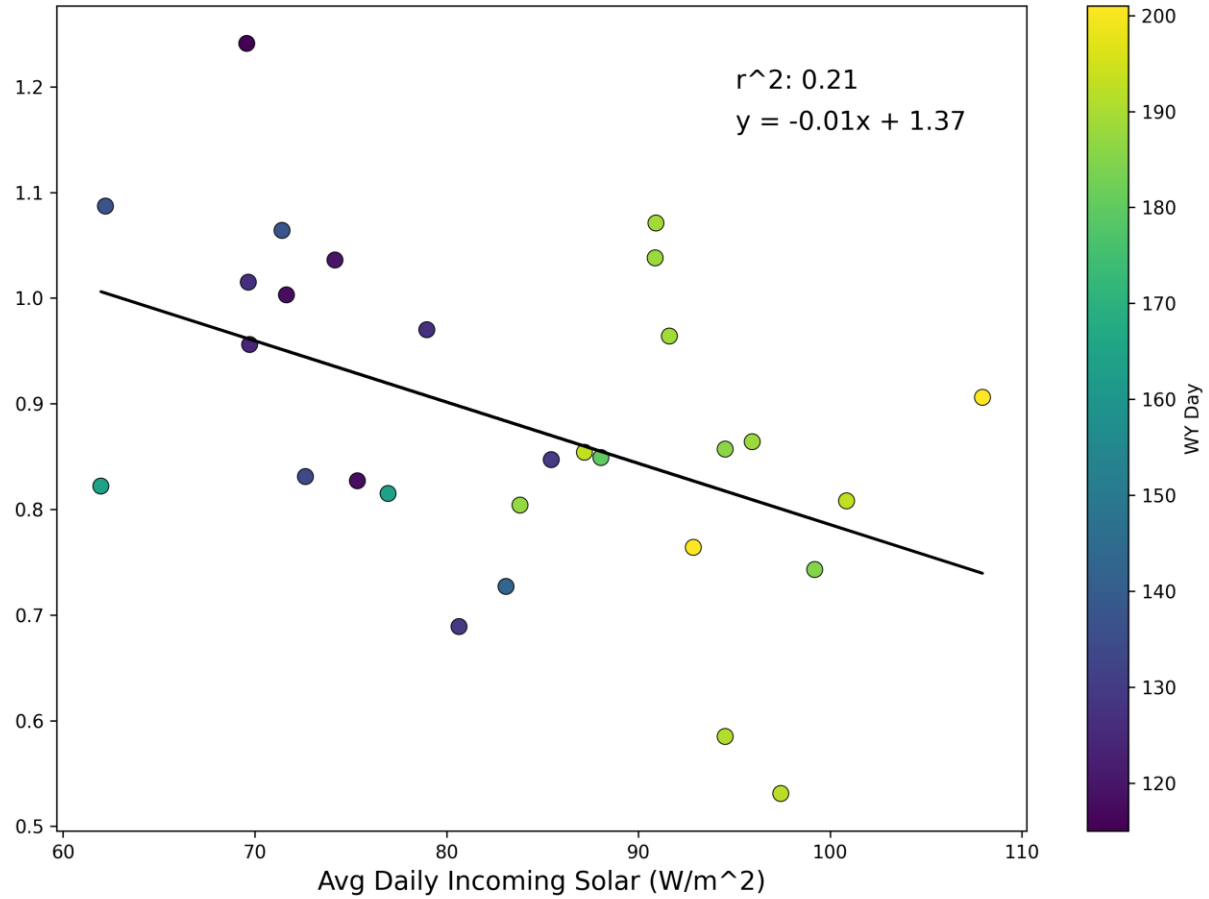
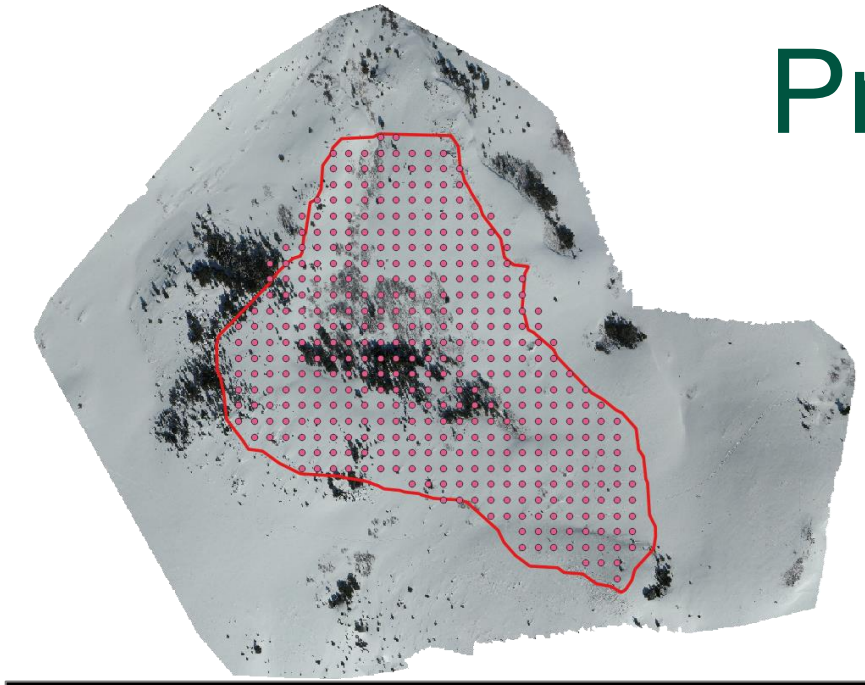




Is there an easier way?

Can we improve measurements while also reducing number of man-hours in the field?

- In 2019, began testing feasibility of using drones (UAS) and Terrestrial Laser Scanning (TLS) to measure basin snow depths
- Pros:
  - Complete survey in 1 day with 3 people
  - Increase spatial resolution from 30 m to ~10 cm
- Cons:
  - Poor coverage under canopy
  - More post-processing time per survey
- Still requires manual SWE sampling to obtain density



Progress so far…

- 2020 survey (SnowEx):
  - Tinkering with Ground control points (GCPs) to make visible in DJI Phantom IV imagery
  - Substandard imagery overlap
  - TLS scans of eastern portion of basin
- 2021 – 2022:
  - COVID-19 paused field activities
- 2023 (3 surveys):
  - January – Tablet battery died after 3rd of 4 required flights -> incomplete coverage
  - March and April – Smooth acquisitions!
- Still need a UAS snow-free, leaf-free elevation survey (fingers crossed for next week!)

Future Work

- Continue honing SOPs for Drone snow surveys
- Combine with TLS depths under canopy for whole-basin high resolution SWE
- Use legacy intensive surveys to validate precipitation-scaled iSnobal modeling approach
  - *See Ernesto Trujillo's presentation later today
- Moving forward, increase survey frequency to three surveys per year
- Update relationships between measured SWE and runoff
- We would love to learn how others are using UAS in their research catchments.