Quantifying Snowfall from Orographic Cloud Seeding

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Motivation: How much snow can be produced through cloud seeding?

Why is it so difficult?

- **Statistical comparison of snowfall** during seeded versus non-seeded events or times as well as target and control regions (Rauber et al. 2019 JAMC)
  - Repeatability of the experiment; changing atmospheric conditions
- **Simulate the microphysical impacts** of cloud seeding using numerical models - ensemble approach (Rasmussen et al. 2018 JAMC)
  - Accuracy of numerical models
- **Physical process studies** identifying and tracking seeding plumes and associate enhancements in snowfall
  - Identifying and tracking

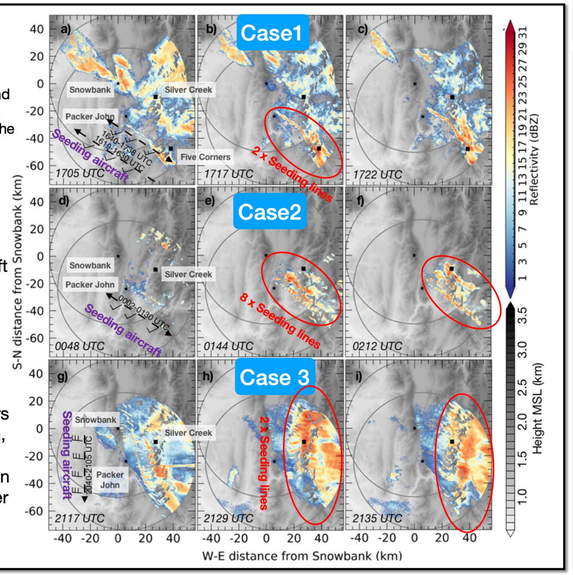
Significance: radar returns are unambiguously the result of cloud seeding in regions with light or no natural precipitation

Data

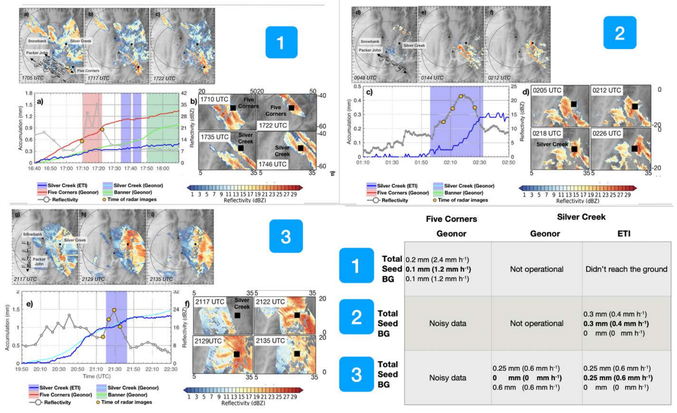
SNOWIE (Seeded and Natural Orographic Wintertime Clouds: The Idaho Experiment)

Jan-March 2017 in Idaho

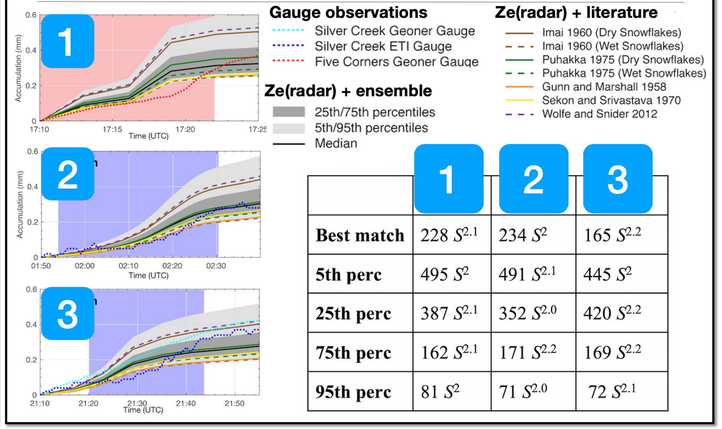
- Seeding aircraft flew legs perpendicular to the wind upwind of domain
- 2 x X-band scanning radars @ Packer John, Snowbank
- 2 x precipitation gauges @ Silver Creek, Five Corners



How did we quantify snowfall? Step 1: Snow gauges



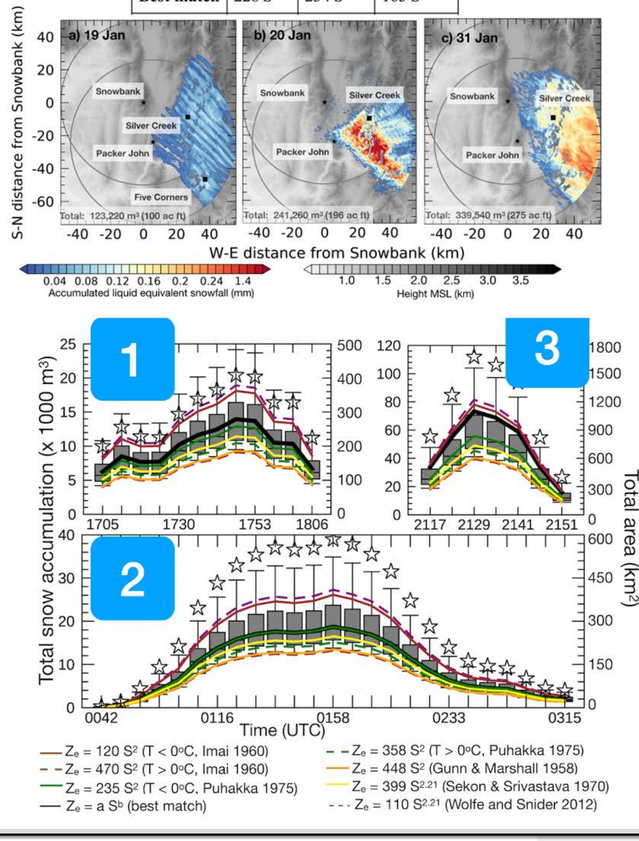
How did we quantify snowfall? Step 2: Deriving Ze-S relationship



	1	2	3
Best match	228 $S^{2.1}$	234 S^{2}	165 $S^{2.2}$
5th perc	495 S^{2}	491 $S^{2.1}$	445 S^{2}
25th perc	387 $S^{2.1}$	352 $S^{2.0}$	420 $S^{2.2}$
75th perc	162 $S^{2.1}$	171 $S^{2.2}$	169 $S^{2.2}$
95th perc	81 S^{2}	71 $S^{2.0}$	72 $S^{2.1}$

How did we quantify snowfall? Step 3: Applying the Ze-S relationship to radar obs

	1	2	3
Best match	228 $S^{2.1}$	234 S^{2}	165 $S^{2.2}$



Conclusion

Gauge Analysis

- Snow accumulation from seeding 0.05-028 mm over few minutes (rate 0.4-1.2 mm h-1).

Radar Analysis (best-match Ze-S relationship)

339,540 m3 = **136 Olympic-size swimming pools** (25 min of seeding),

123,220 m3 – **50 pools** (20 min of seeding),

241,260 m3 – **96 pools** (86 min of seeding).

More info

Friedrich et al. PNAS 2020

Will be covered by controls if you define slides