Analysis of Cloud Seeding Potential in the Lemhi River Basin of Idaho

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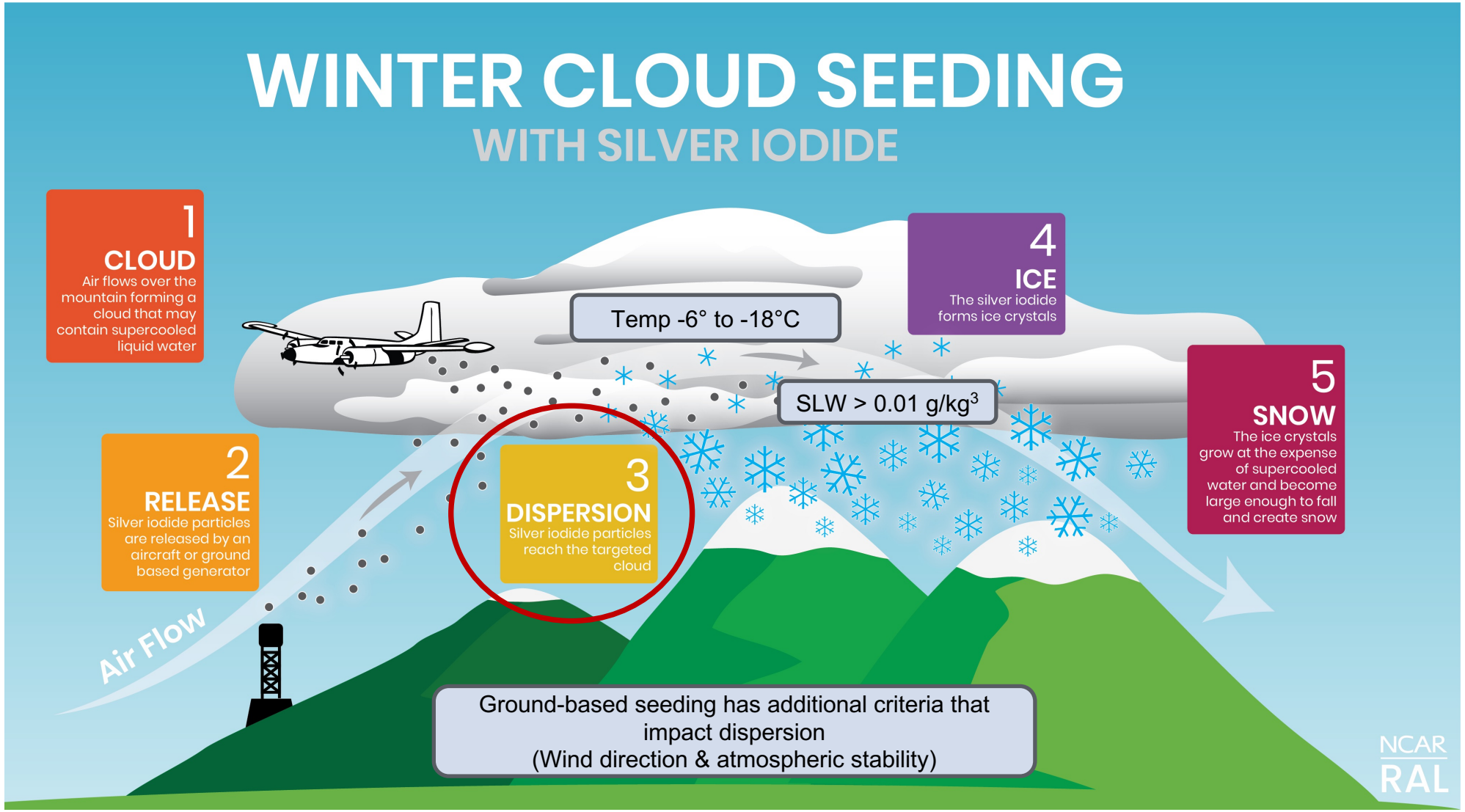
Study Goals

1. Investigate the potential for cloud seeding to supplement the snowpack and runoff in Idaho's Lemhi River Basin.

2. Evaluate cloud seeding potential in current and future climate scenarios for both ground and airborne seeding operations.

Lemhi Range Image courtesy of www.kingmoutainglіderpark.com

Cloud Seeding Overview & Criteria



Datasets

Current Climate

CONUS404

- 40 year dataset (1980 – 2021)
- Includes seeding criteria variables (SLW, cloud water) not available in reanalysis data
- Reproduces precipitation over complex terrain

CONUSI

- 13 year dataset (2000 – 2013)

Future Climate

CONUSI - PGW

- Pseudo Global Warming (PGW)
- High resolution WRF climate change simulation dataset (4km)
- Simulates the thermodynamics of storms in a warmer climate
  - Changes temperature and moisture characteristics
  - Does not impact storm tracks or frequency

Weather Research and Forecasting (WRF) CONUS Domain

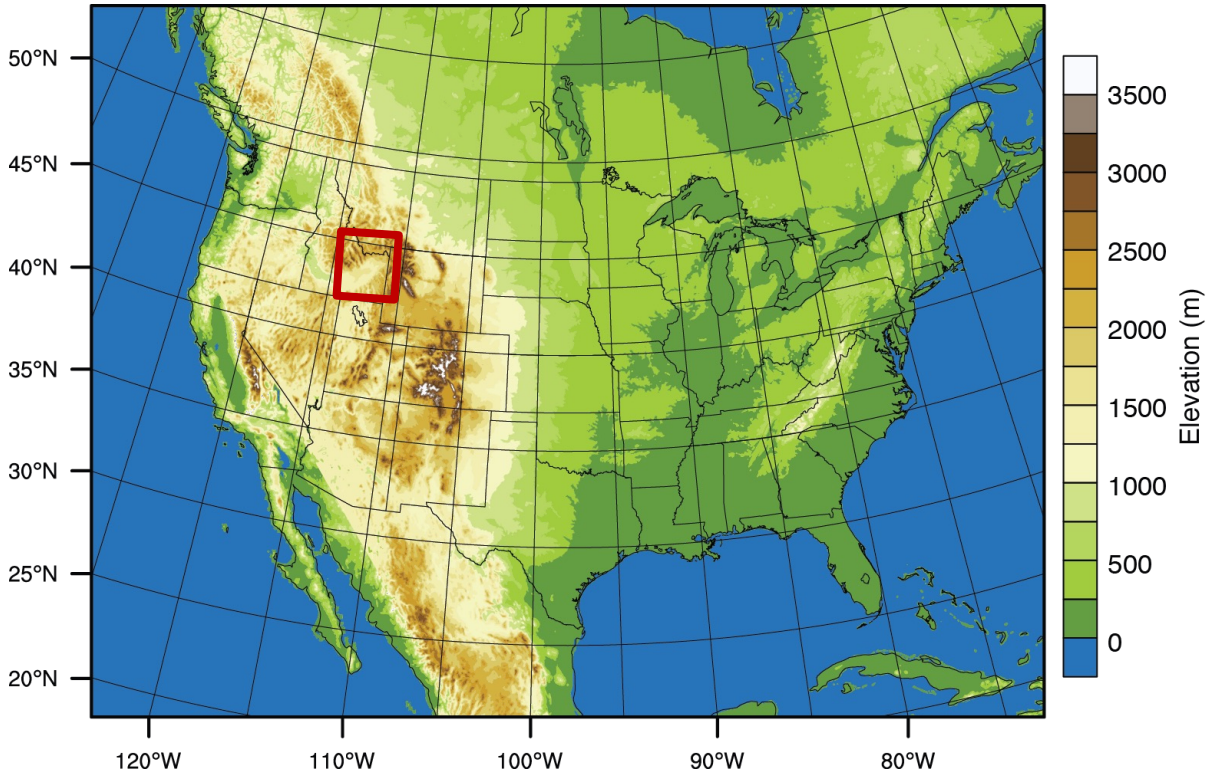
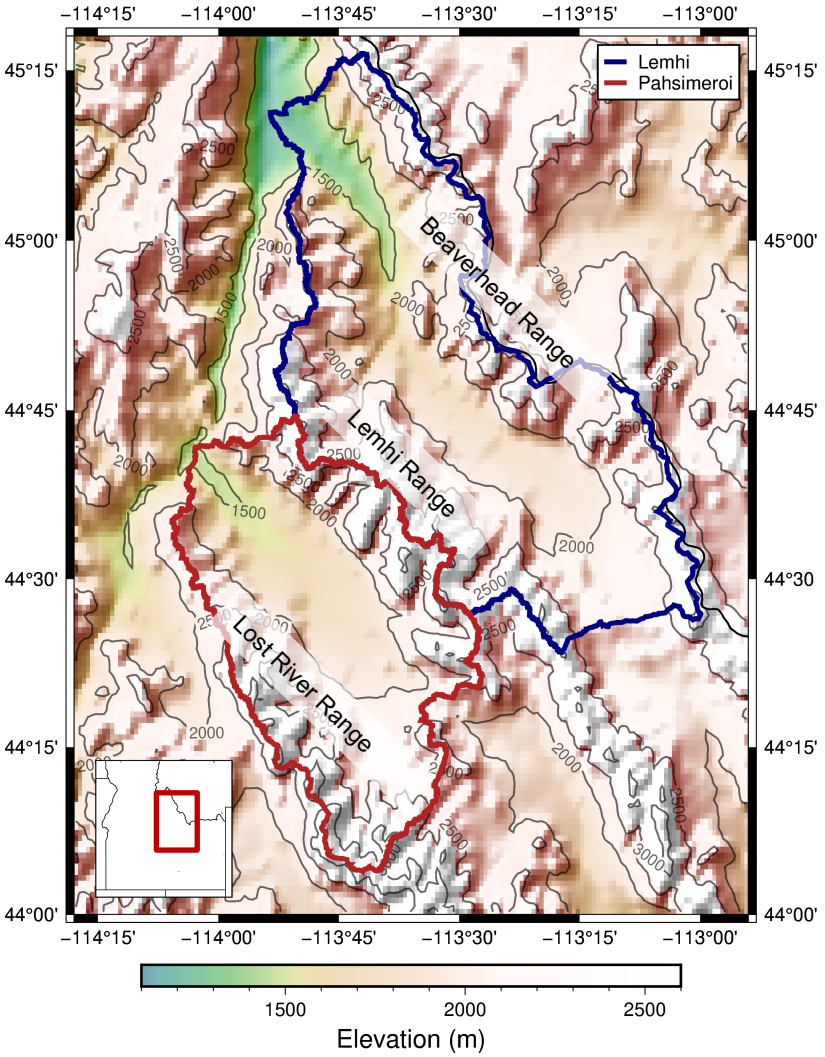
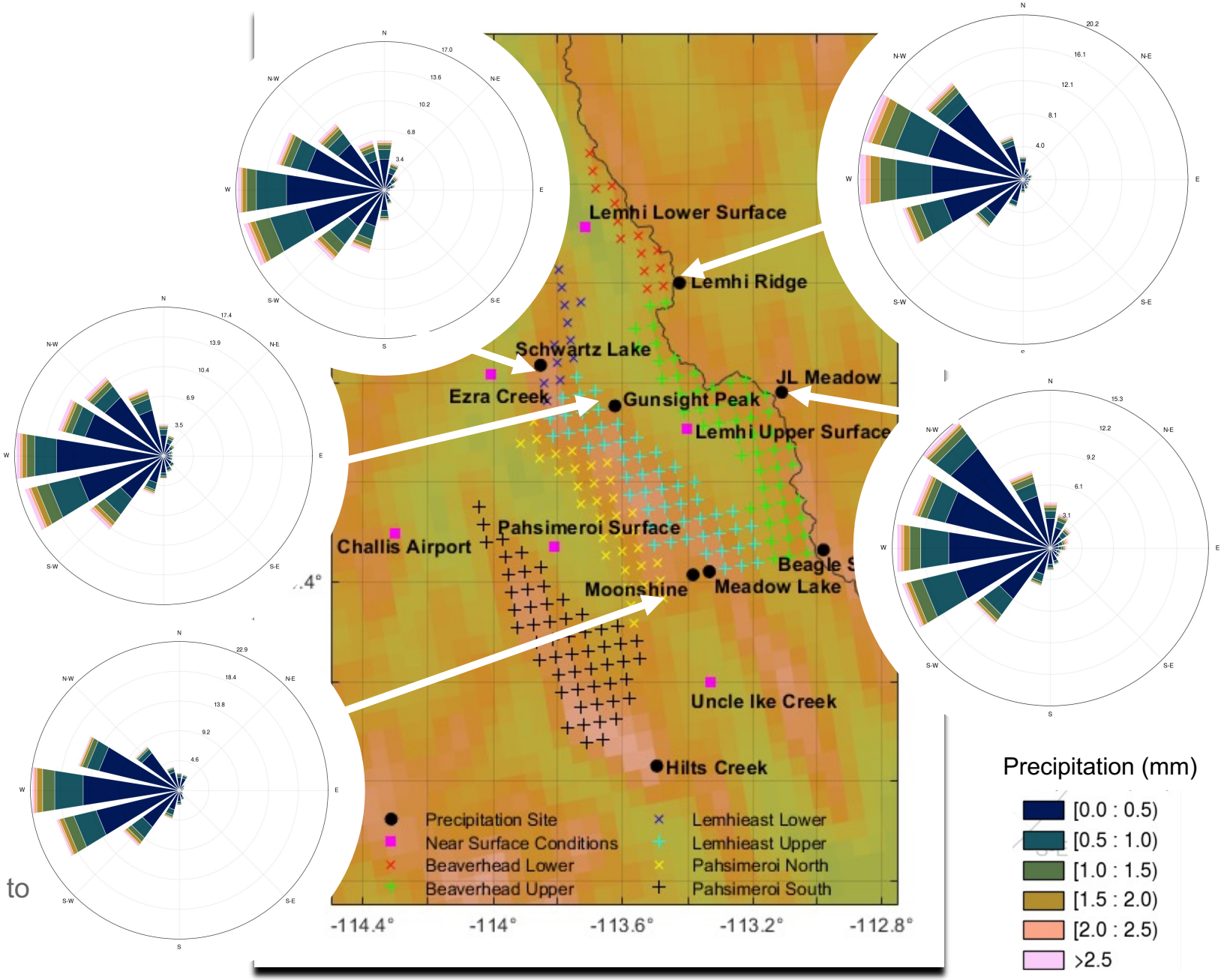


Image courtesy of NCAR Research Data Archive

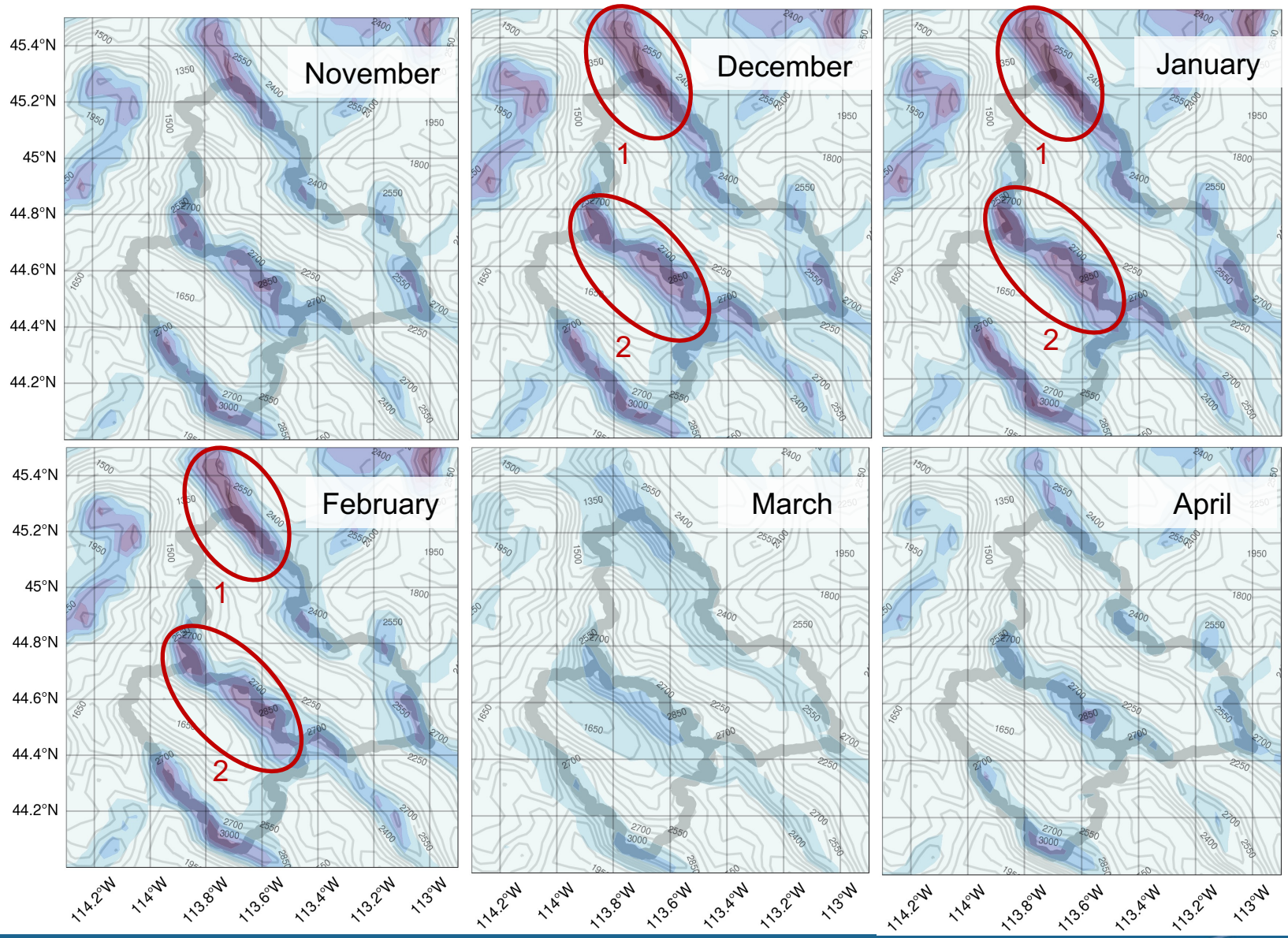
Domain

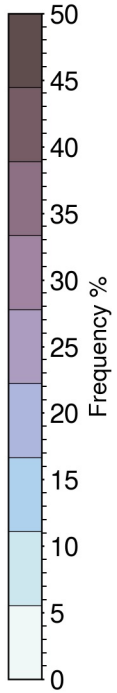




- Predominant wind directions are southwesterly to northwesterly
- Wind direction influences seeding dispersion

CONUS404 Frequency of Ground-Based Seeding Opportunities

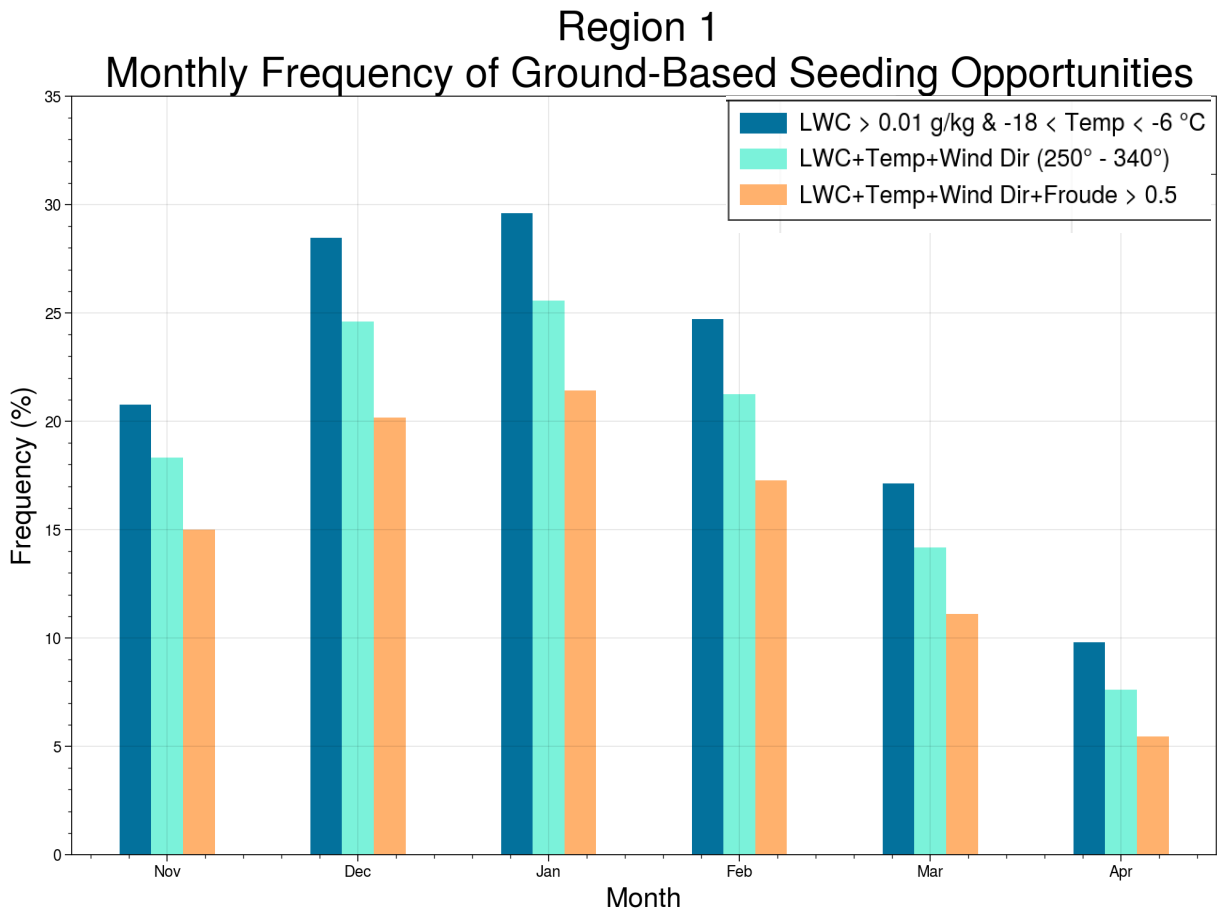


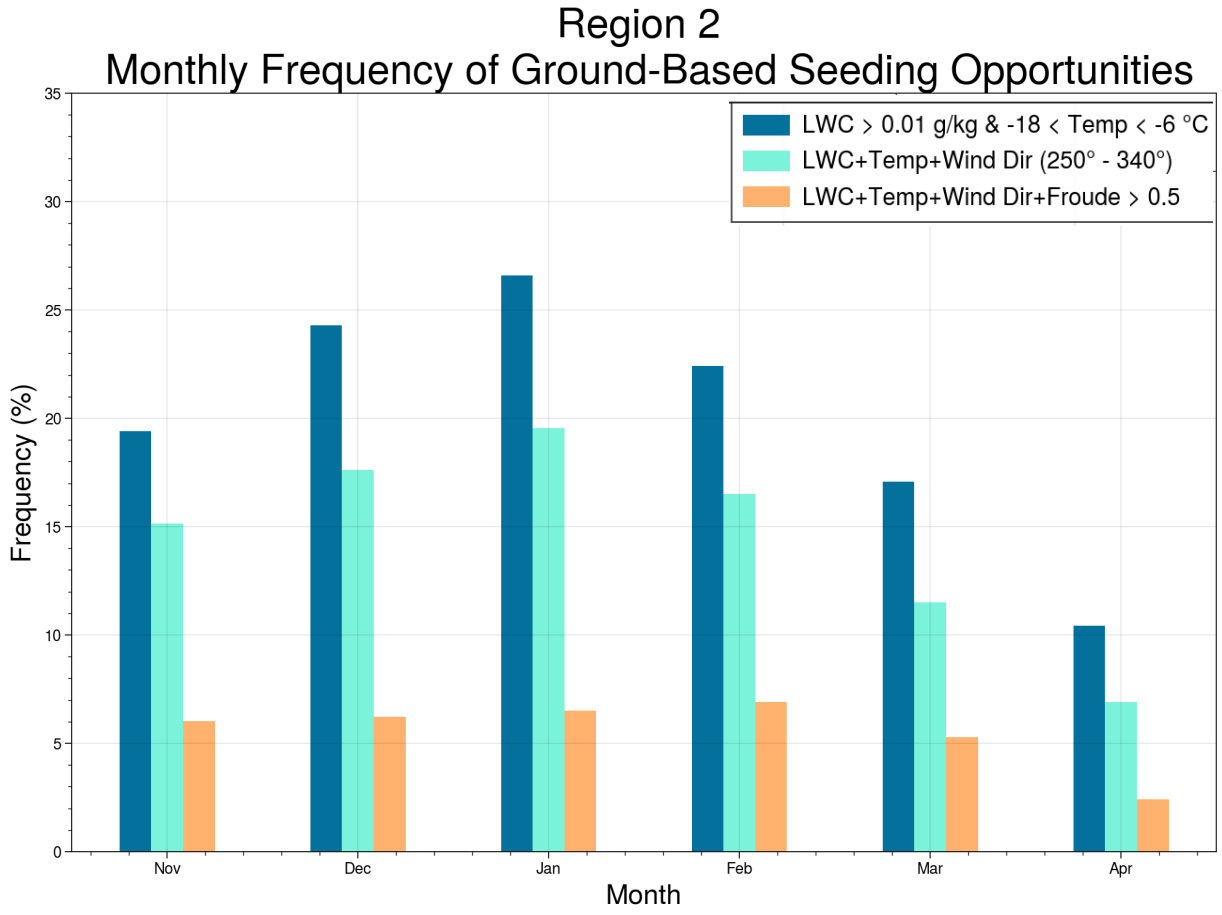


Frequency of SLW > 0.01 g/kg^3 present at temperatures between -6° C and -18° C

- Regions 1 and 2 show the greatest frequency for ground-based seeding conditions
- December – February have similarly frequent for ground-based seeding opportunities

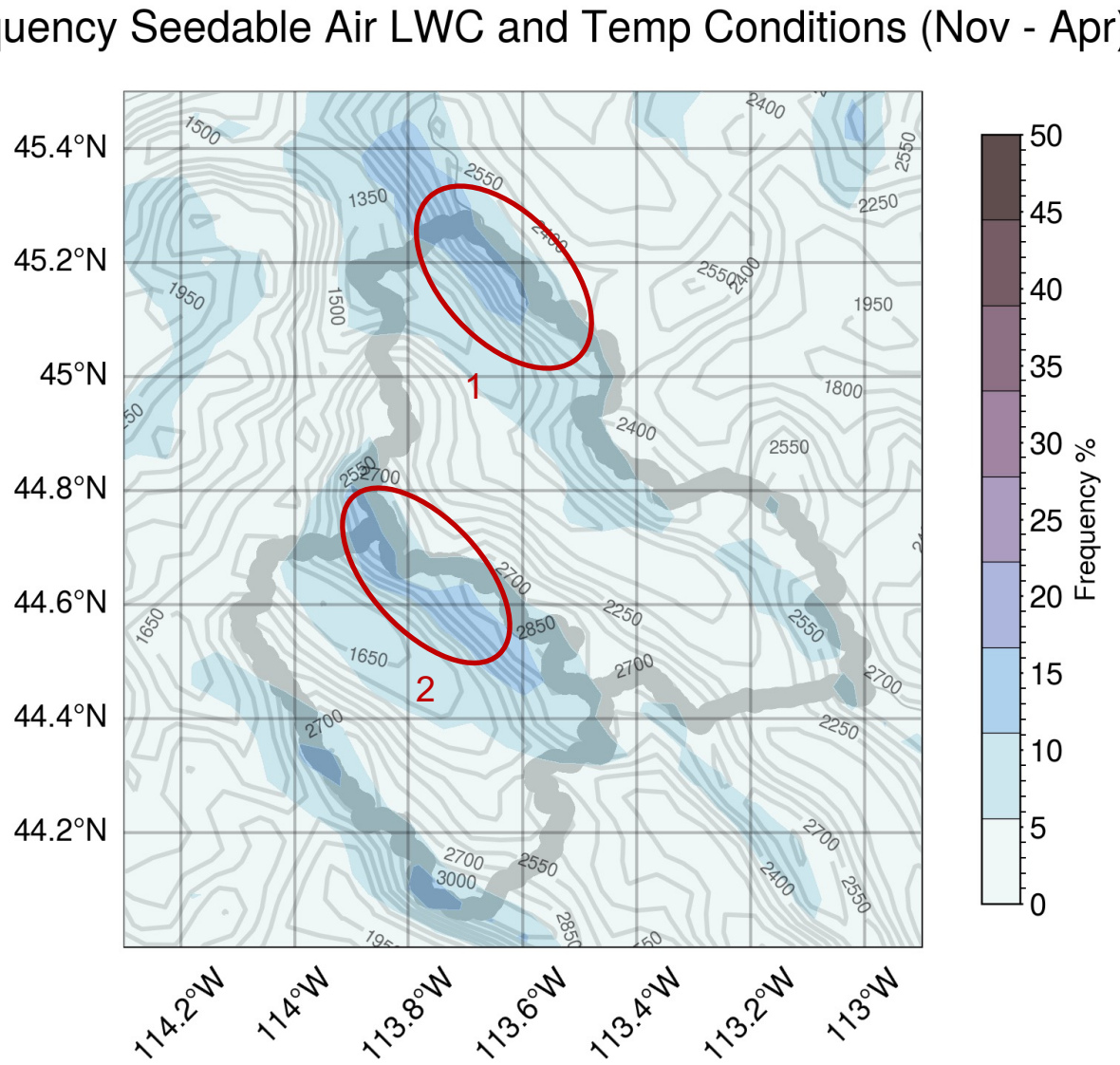
CONUS404 Frequency of Ground-Based Seeding Opportunities





- Wind direction and blocking decrease ground-based seeding potential
- Region 1 maintains ~15-20% seeding frequency even with the inclusion of wind and blocking parameters
- Region 2 substantially decreases in seeding frequency to ~ 5% due to atmospheric blocking
- December through February have the highest frequency of ground-based seeding opportunities

CONUS404 Frequency of Airborne Flight Layer Seeding Opportunities

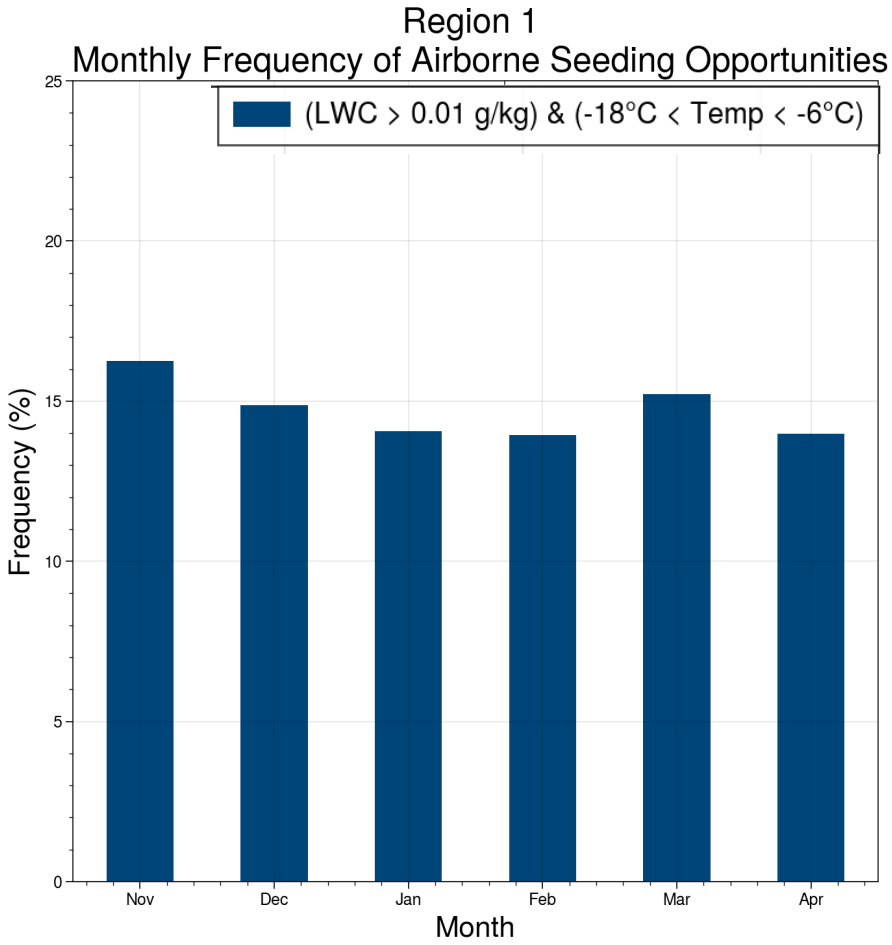


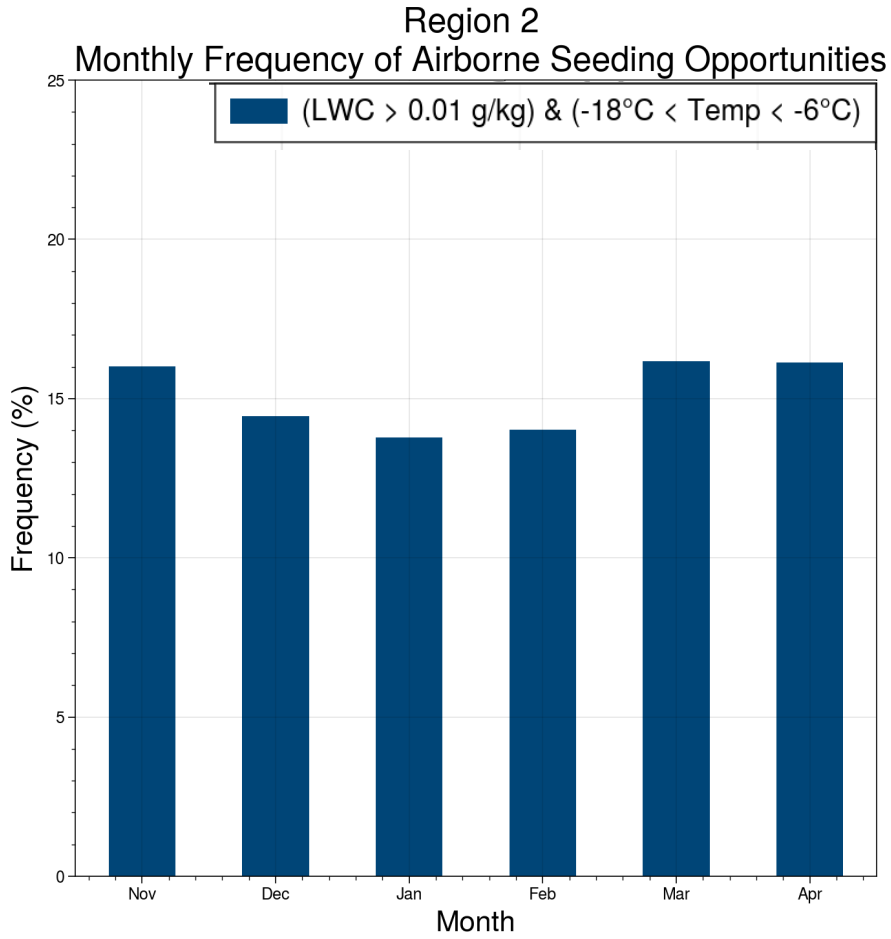
Frequency of SLW > 0.01 g/kg^3 present at temperatures between -6° C and -18° C

- Airborne seeding frequency does not vary substantially through the Nov-April seeding season
- Regions 1 and 2 are approximately equal for airborne seeding opportunity frequency

CONUS404 Frequency of Airborne Flight Layer Seeding Opportunities

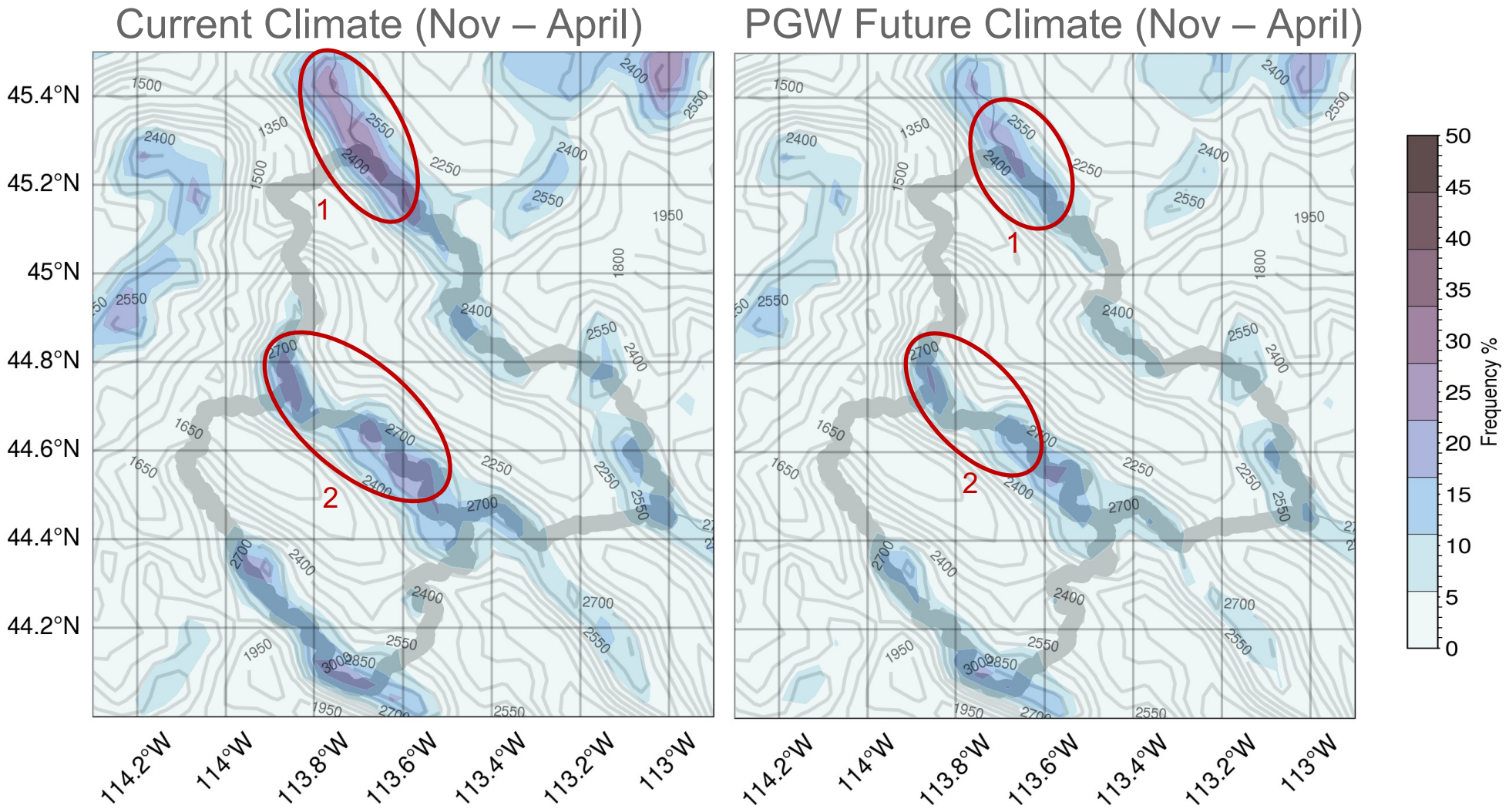
- Airborne seeding opportunities are only limited by LWC and temperature parameters
- Airborne seeding frequencies stay around 15% across the entire seeding season for both regions





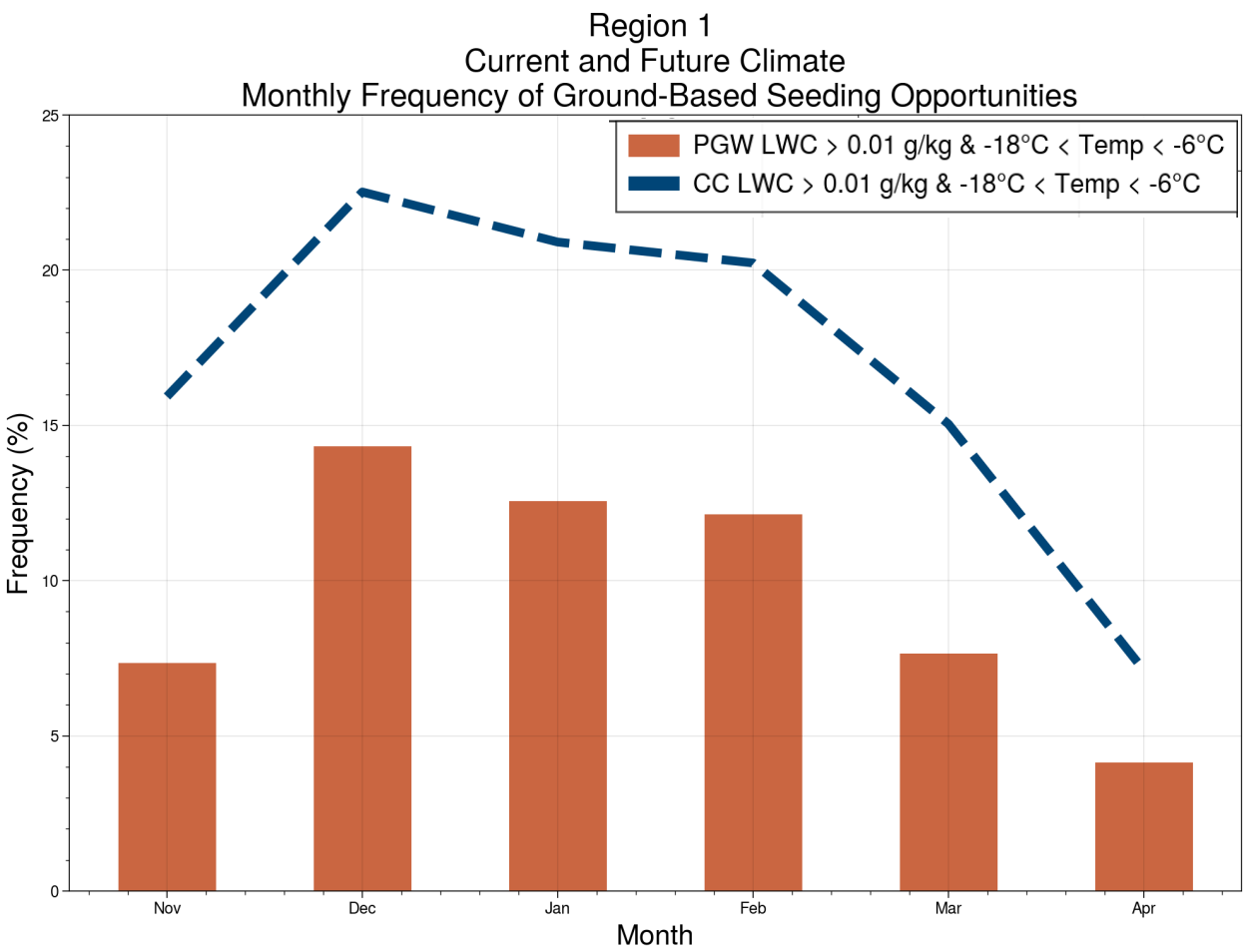
CONUSI Current and Future Climate Frequency of Ground-Based Seeding Opportunities

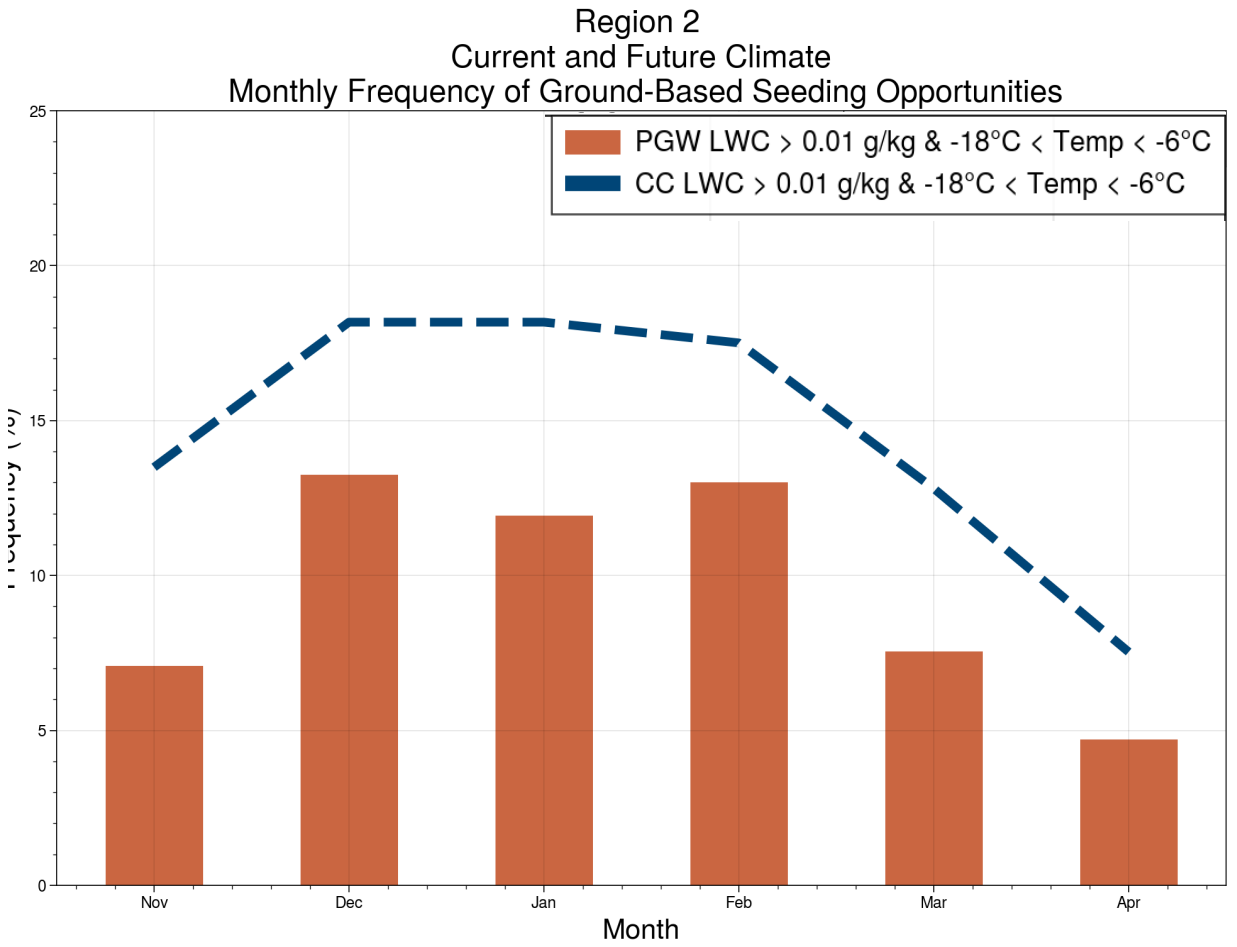
- Frequency of ground-based seeding opportunities decreases in future climate scenarios due to warming surface temperatures



Frequency of liquid water > 0.01 g/kg^3 at temperatures between -6° and -18°C

CONUSI Current and Future Climate Frequency of Ground-Based Seeding Opportunities

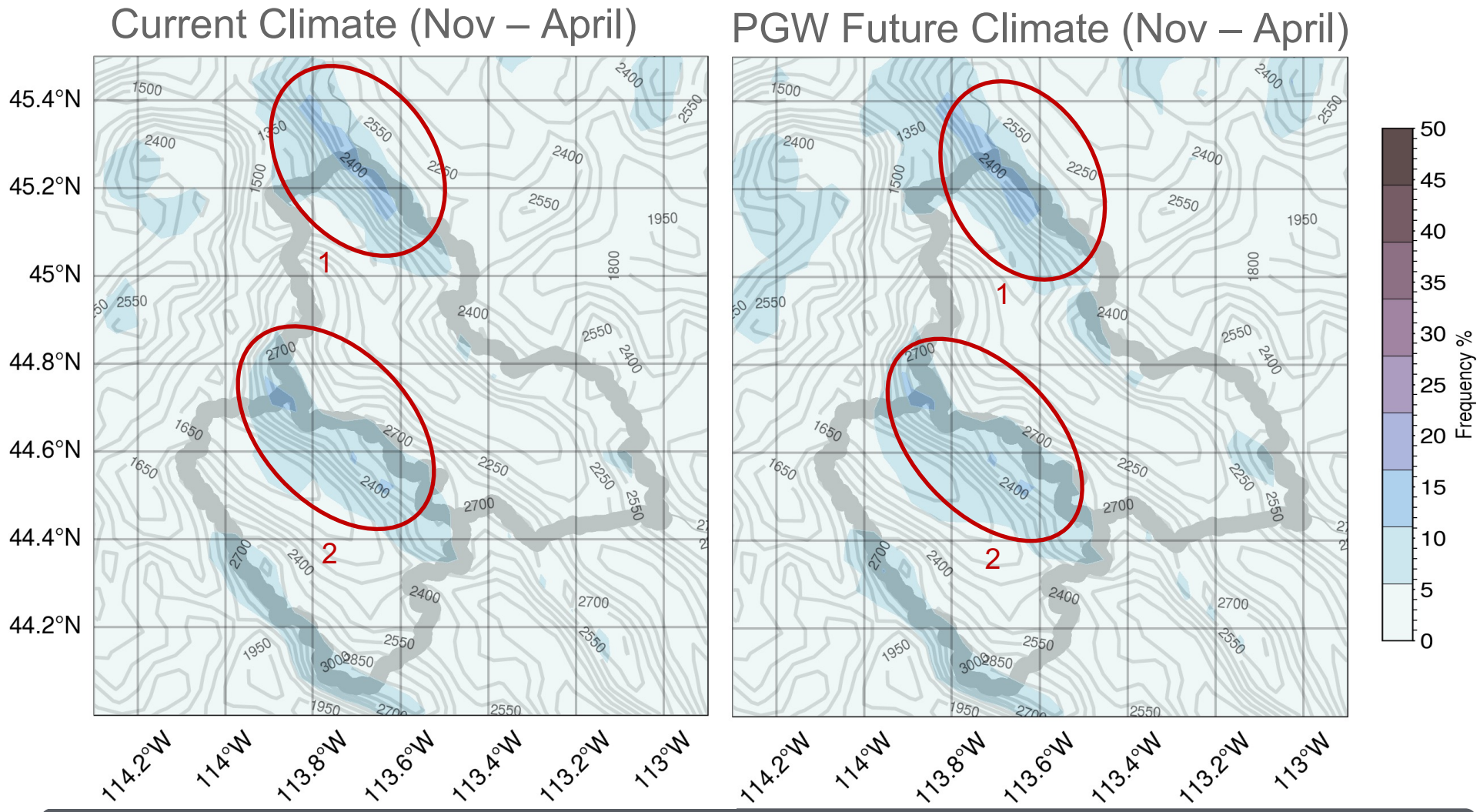




- In both regions the seeding frequency is reduced across all months between current climate and PGW
- December through February are still the months with highest seeding frequency

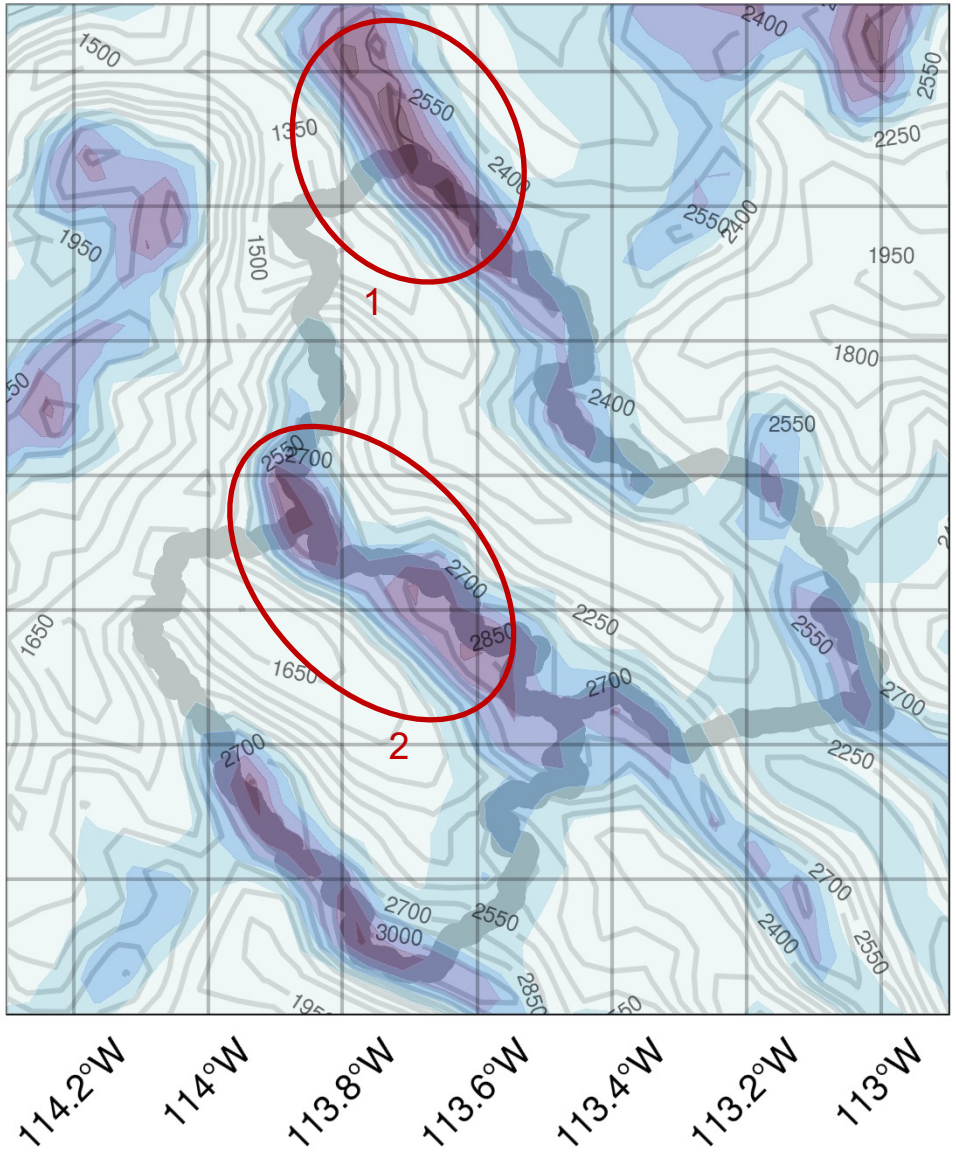
CONUSI Current and Future Climate Frequency of Airborne Flight Layer Seeding Opportunities

- Frequency of airborne seeding opportunities are similar in PGW and current climate indicating that PGW does not substantially impact airborne seeding



Frequency of liquid water > 0.01 g/kg^3 at temperatures between -6° and -18°C

Summary & Conclusions



- The Region 1 in the Beaverhead Range and Region 2 in the Lemhi range show the greatest seeding potential for both airborne and ground-based seeding in current and future climate scenarios.

- Current climate analysis:
  - December – February are the months with highest frequencies for ground-based seeding
  - All months have similar frequencies for airborne seeding opportunities.
  - Blocking makes Region 2 have much reduced frequency for ground-based seeding than Region 1
- Future climate analysis:
  - Ground-based seeding opportunities decrease due to warming temperatures limiting the seeding season for ground-based operations
  - Airborne seeding opportunities are not as impacted by PGW