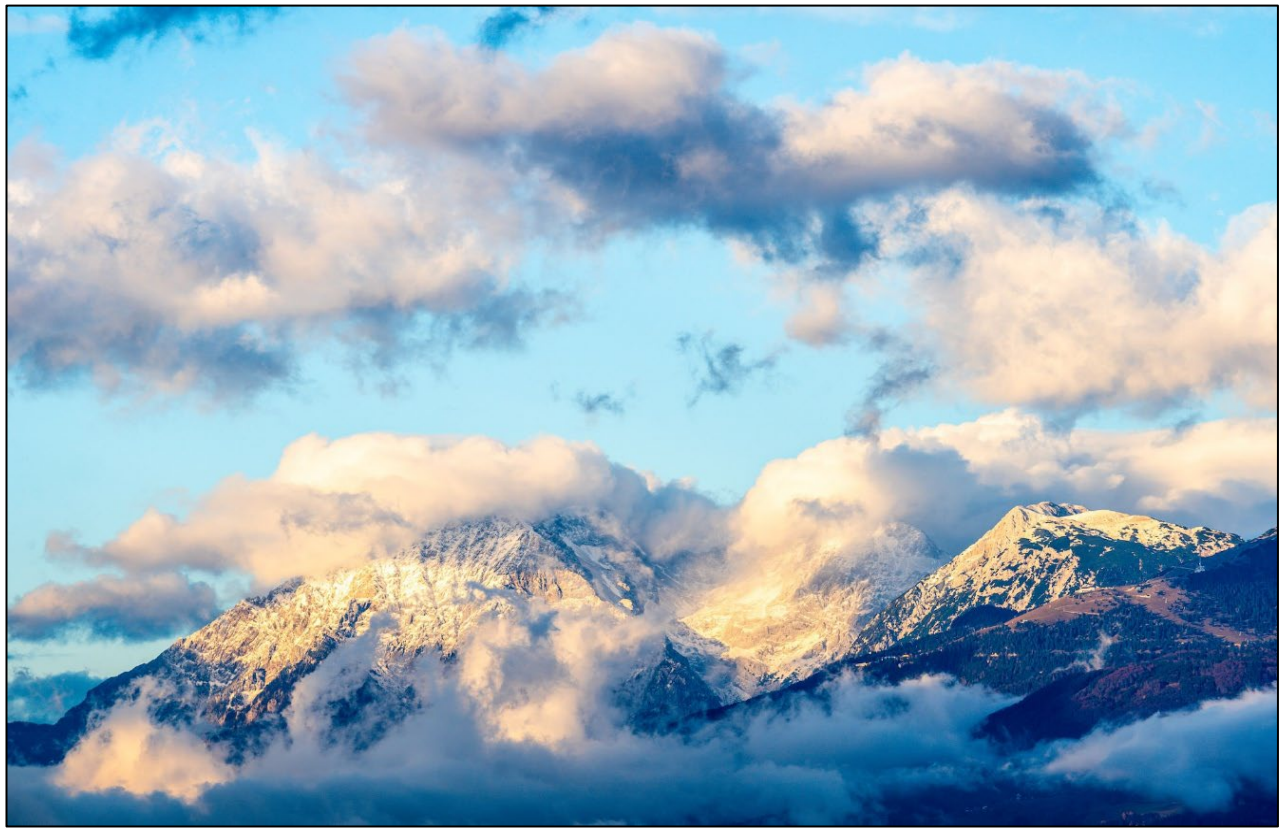
Cloud Seeding Feasibility Study

Water Policy Interim Committee

October 20, 2025

Michael Downey – Drought Program Coordinator

Montana Department of Natural Resources (DNRC)



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Cloud Seeding in Montana – A Brief History

- 1967 – 40th Montana Legislature passes the Atmospheric Weather Modification Act
- 1970's – Bridger Range Experiment, High Plains Cooperative Research Program (HIPLEX), Miles City
- 1970's – 1980's North Dakota operates summer cloud seeding along Montana border
- 1982 – 1987 Bridger Bowl Weather Modification Project
- 1993 – 53rd Montana Legislature passes HB72 establishing weather modification permitting & licensing
- 2019 – 66th Montana Legislature passes HJ40 – Weather Modification Study
- 2021 – SB29 Overhaul of Weather Modification Act dies in House on 2nd reading
- 2023 – 68th Montana Legislature appropriates funding in HB2 for Cloud Seeding Feasibility Study

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Cloud Seeding Feasibility Study

- April 2023 – House Bill 2 Appropriation directs the Montana Department of Natural Resources and Conservation (DNRC) to complete a cloud seeding feasibility study in southwest Montana
- December 2023 – DNRC contracts with the National Science Foundation - National Center for Atmospheric Research
- May 2025 – Study Completed

Study Goals:

- Goal #1: Assess the potential for cloud seeding to augment snowpack and subsequent streamflow in select target mountain ranges in southwestern Montana. Early analysis favored the Big Hole watershed.
- Goal #2: Complete a preliminary cost/benefit analysis and preliminary program design based upon weather/climate analysis.
- Goal #3: Support development of public engagement and education activities and materials related to cloud seeding.

Cloud Seeding Feasibility Study

Study Deliverables:

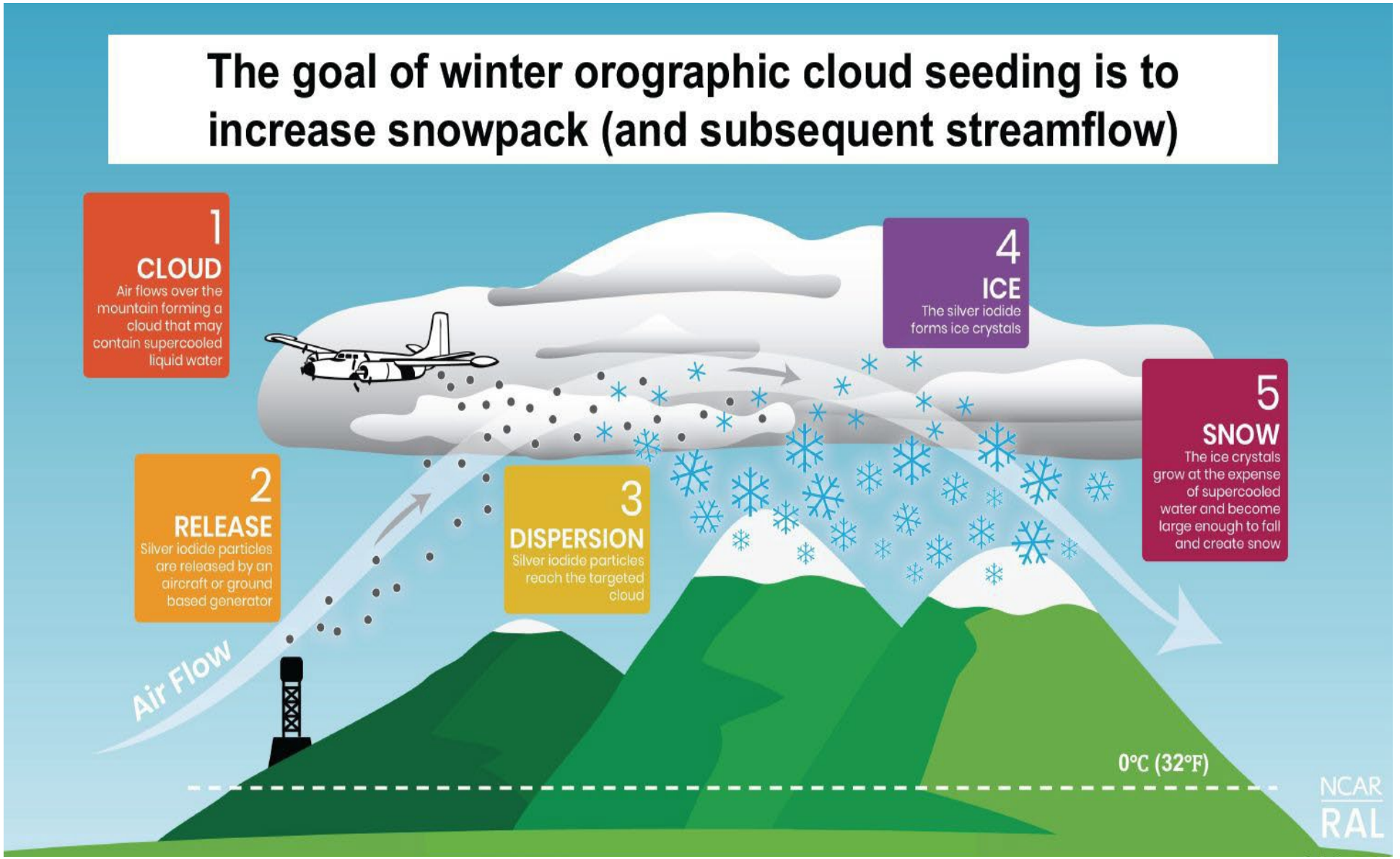
- Preliminary report including results of the feasibility analysis for current and future climate scenarios and a summary of design options that will be tested with model simulations.

- Final report including modeling results and identification of cloud-seeding program design(s) with associated cost-benefit analysis.

- Program design guidance for a 3 to 5-year cloud seeding pilot project.

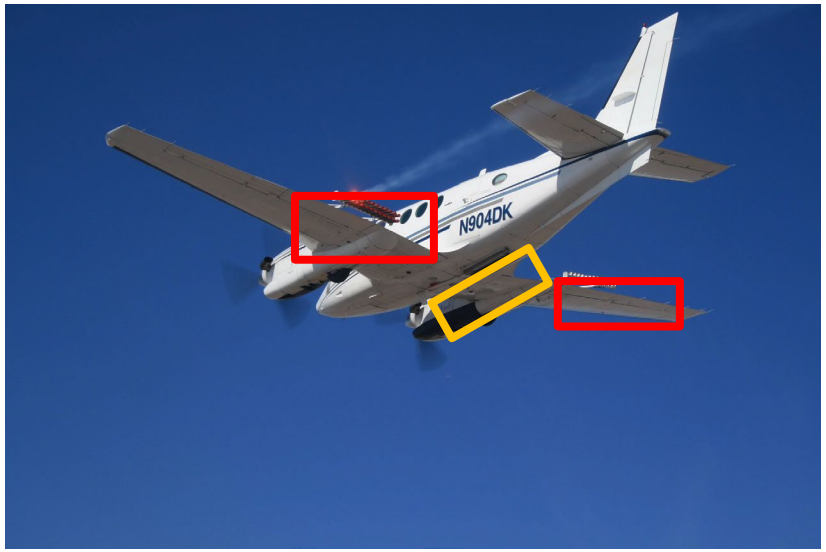
What is cloud seeding?

- Clouds are made up of tiny water droplets or ice crystals that form when water vapor in the atmosphere cools and condenses around a tiny particle of dust or salt floating in the atmosphere.
- Without these particles, raindrops or snowflakes cannot form and precipitation will not occur.
- Cloud seeding is a process of adding tiny ice nuclei into clouds that **contain super-cooled liquid water but lack the impurities (dust, ice, salt) necessary for precipitation**. These nuclei provide a base for snowflakes to form.
- Cloud seeding is **not** a process used to create clouds.



Graphic by the National Center for Atmospheric Research

Aircraft Seeding



Demonstration of flare ignition, actual dispersion occurs in cloud

- Burn-in-Place (BIP) flares are released in cloud. Plane flies through cloud when conditions are sustainable for the aircraft.
- Ejectable (EJ) flares are released above cloud. Plane flies above cloud when conditions are too hazardous.

Wing mounted “Burn-in-Place” (BIP) flares

Belly Mounted Ejectable (EJ) flares

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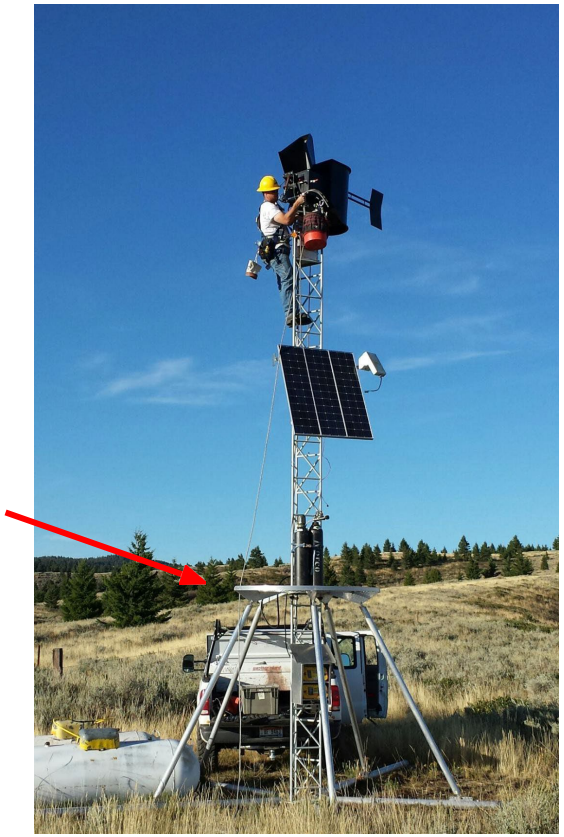
Images Courtesy of Idaho Power Co and Ice Crystal Engineering

Remote Ground Generators

Base Platform ~9 feet from ground



Images Courtesy of Idaho Power Company

How much water are we talking about?

- Clouds form when invisible water vapor in the air condenses into visible water droplets or ice crystals (Example: contrails form when a combination of hot exhaust, water vapor and particulates condense to create a vapor trail).

- Nature will condense roughly 20% of the total available water vapor as moist air rises over a mountain barrier.

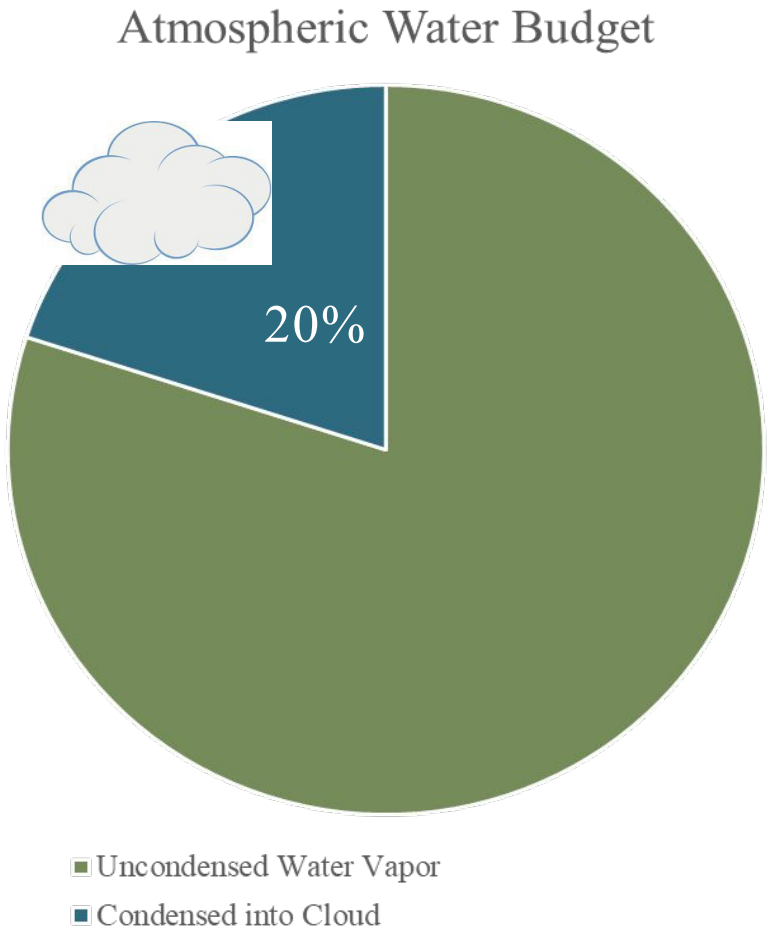


Figure Courtesy of Idaho Power Company

How much water are we talking about?

- Winter storms are typically about 30% efficient.
- This means only about 30% of the condensed water contained in a cloud will fall to the ground as precipitation.
- That's equal to roughly 6% of the total water content in the atmospheric water budget

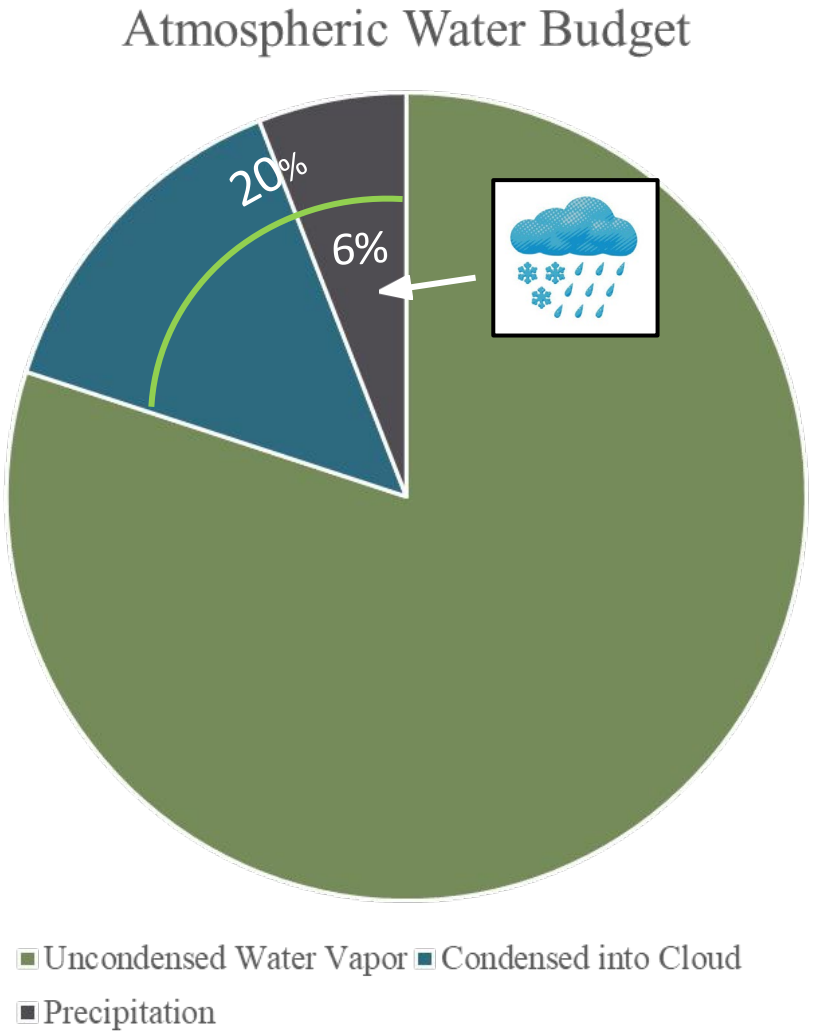


Figure Courtesy of Idaho Power Company

How much water are we talking about?

- Clouds = 20% of Total Water Vapor in Atmosphere
- Precipitation = 30% of water vapor in a cloud = 6% total available
  - Cloud seeding enhances the storm's efficiency by an average of 10% to 15%.
  - That amount is equal to <1% of the total amount available in the atmospheric water budget.

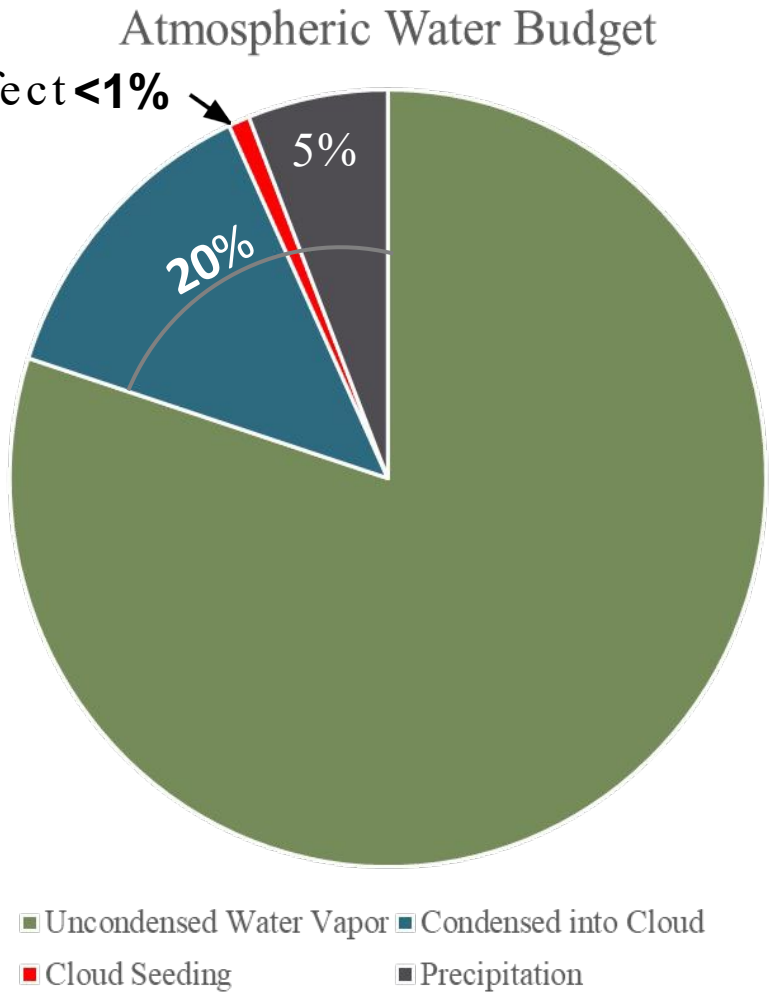


Figure Courtesy of Idaho Power Company

Silver Iodide in the Environment

- Silver (AgI) is a toxic pollutant. World Health Organization, EPA and most state government water quality standards is 100 ppb total silver (AgI).
- Silver Iodide (Ag+) is an insoluble salt that does not breakdown in water.
- Silver iodide primarily accumulates in soils or streambed sediments and is typically found at parts per trillion (30 -50 ppt) background levels. Ag+ concentrations in snow vary between 1-20 ppt after seeding events.
- Environmental sampling of cloud seeding operations have found no detectible increase in total AgI concentrations above background levels in soil, streams or aquatic species in seeded areas.

Final Report on

Cloud-Seeding Feasibility and Preliminary Program Design for Southwest Montana

prepared for

Montana Department of Natural Resources and Conservation (DNRC)

by

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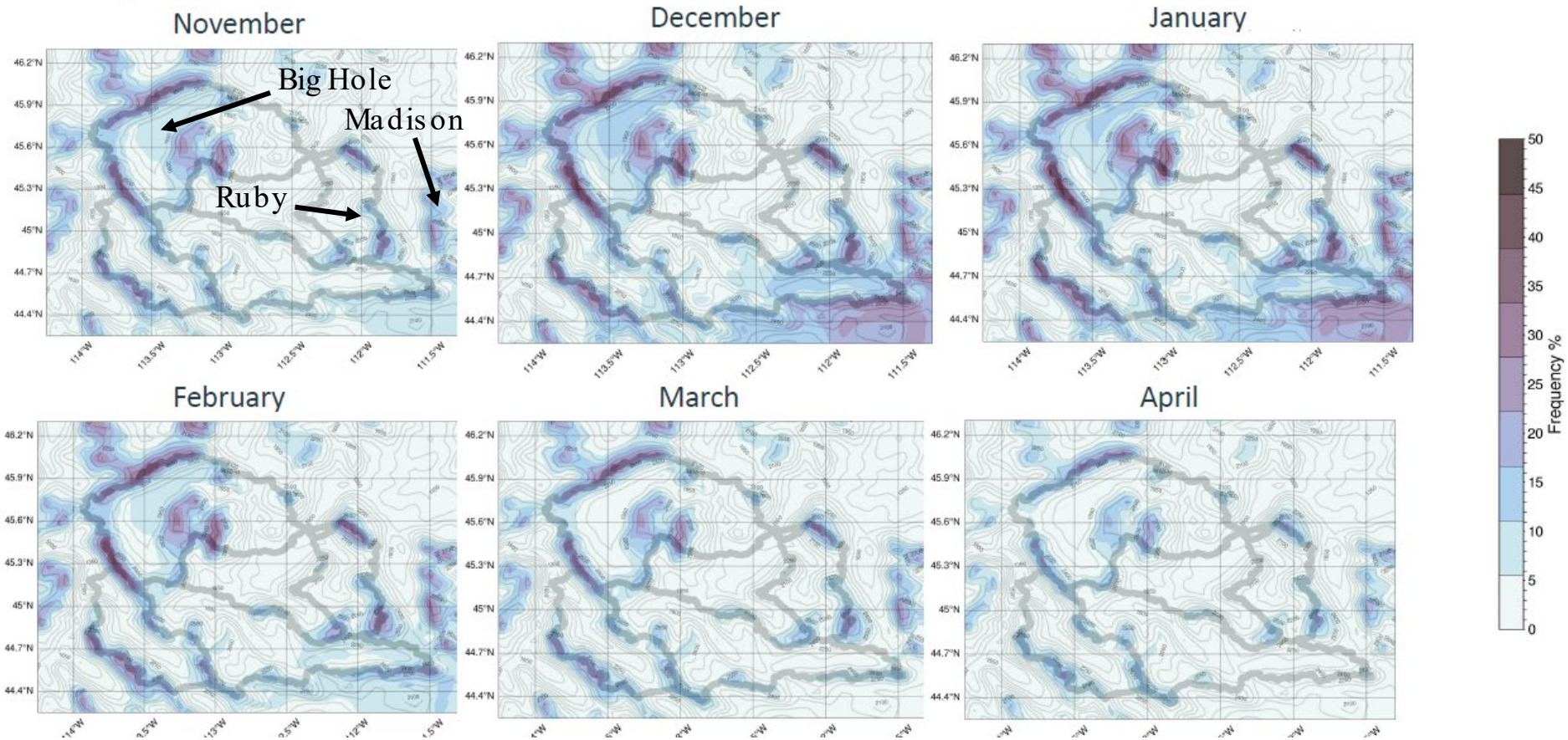
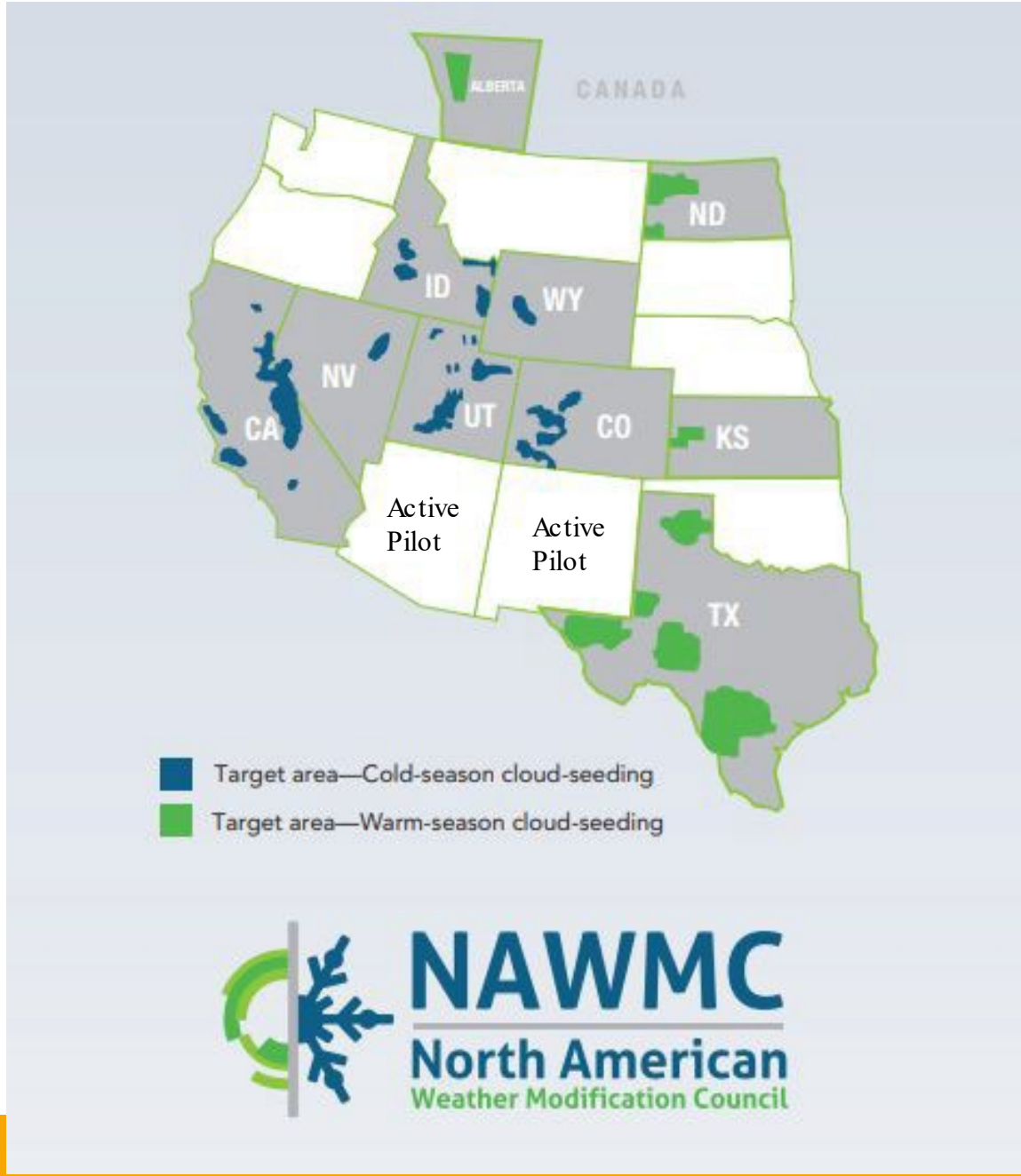
SCLW frequency in SW Montana by Month

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



CLOUD SEEDING IN NORTH AMERICA



NAWMC
North American
Weather Modification Council

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What's Next?

- If the State wants to pursue cloud seeding in the Big Hole, the next step would be a 3-to-5-year pilot project to confirm study conclusions.
- A pilot project would require legislative action appropriating funds ($400,000 to $1,000,000 annually).
- No statutory changes would be necessary to operate a pilot project. Implementation of an ongoing program would require changes in statute.

Questions /Comments

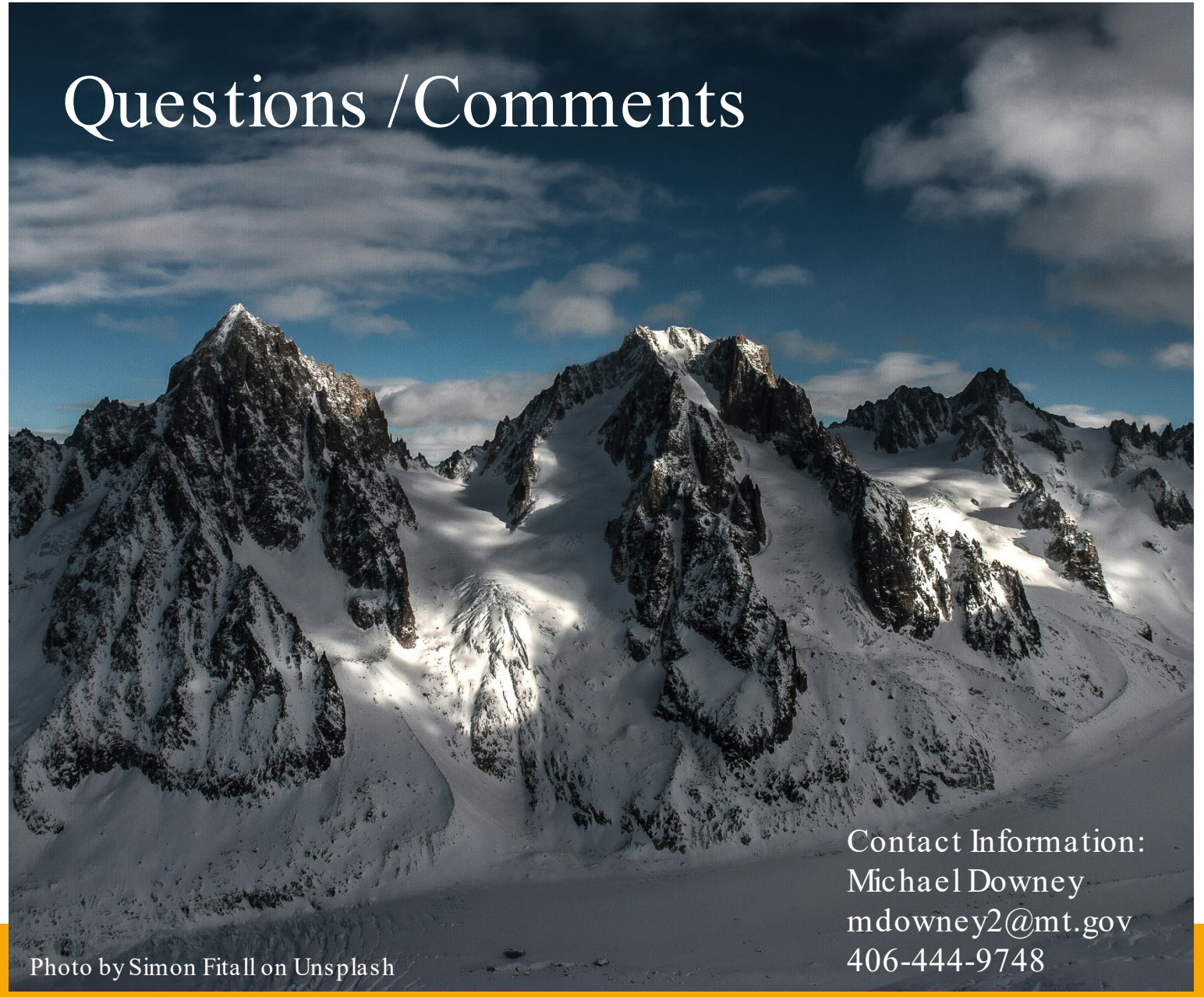

Photo by Simon Fitall on Unsplash

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