Utah Division of
Water Resources

Rev. May 2024

Cloud Seeding Frequently Asked Questions

What is cloud seeding?

- A form of weather modification.
- Improves the efficiency of a cloud's ability to produce rain or snow.
- Sends a high number of ice nuclei into a cloud similar to their natural counterparts like soils and bacteria.

Why cloud seed in Utah?

- Snowpack generates up to 95% of Utah's annual water supply.
- Increasing the snowpack leads to additional water.
- Winds upsloping along the mountains allow for the rapid creation of supercooled liquid water, or water that is below freezing and does not grow large enough to fall as precipitation.

When does cloud seeding take place in Utah?

- November through April.
- During the winter because the goal is to augment the snowpack.
- During precipitation events over targeted mountain ranges (see Figure 1).
- Not during clear conditions with no precipitation occurring.
- Cloud seeding efforts are not responsible for condensation trails from aircraft. Cloud seeding operations take place in or above clouds at altitudes below 13,000 feet and only during precipitation events.

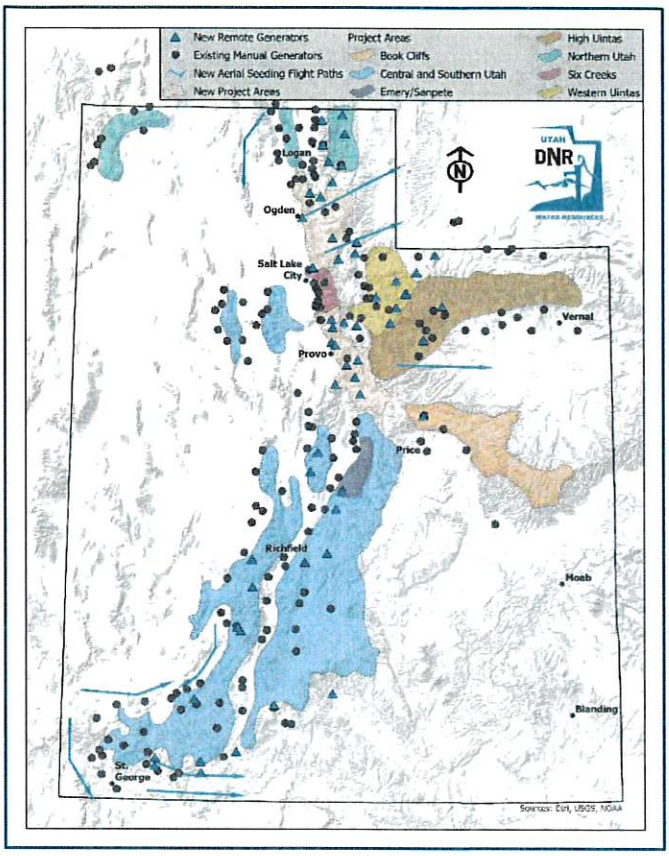

Figure 1. Cloud seeding target areas with manual and remote generator locations and aerial flight paths.

How effective is cloud seeding in Utah?

- Target and control evaluation provides estimates of a 6-12% increase in precipitation.
- Per Water Resources, an increase of streamflow of 180,000 acre-feet to 200,000 acre-feet during spring runoff, which is more water than Deer Creek holds (147,000 acre-feet).
- Other programs across the U.S. and the world show an upwards to 10-15% increase per 2016 Weather Modification Association statement on capabilities.

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How is cloud seeding conducted in Utah?

Cloud seeding in Utah uses both ground-based and aerial techniques. The goal is to release a material into the cloud that interacts with the small, supercooled cloud droplets resulting in the development of ice particles allowing for more efficient growth. Ice particles then become heavy enough to fall as additional snowfall.

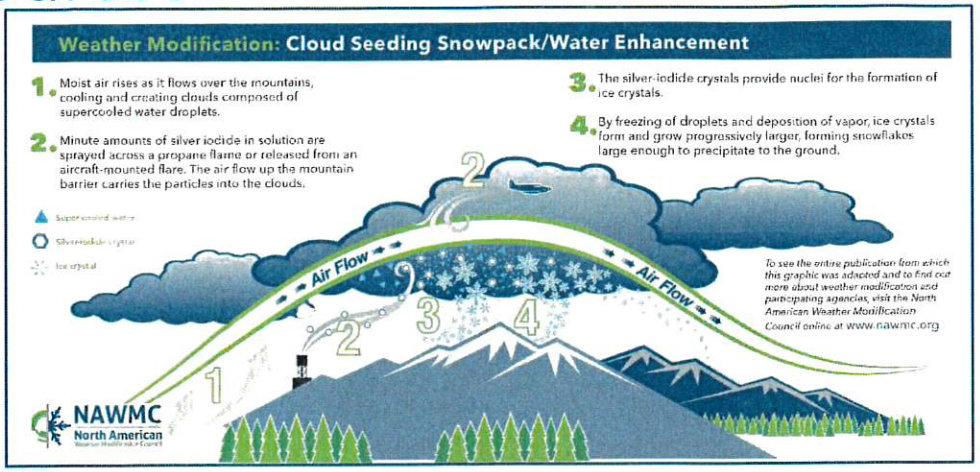

Figure 2. Cloud seeding graphic from the North American Weather Modification Council.

Ground-Based

- Ground-based generators sit on foothills or at high elevations (6,000-9,000 feet).
- Wind flows perpendicular to the mountain ranges, which lifts and disperses the seeding material throughout the cloud.
- Generators run for the seedable duration of a storm.

Aerial

- Flight paths are filed at 12,000-13,000 feet.
- The pilot chooses a predetermined flight path where temperatures are favorable for cloud seeding.
- A meteorologist watches cloud parameters for the best seeding area.

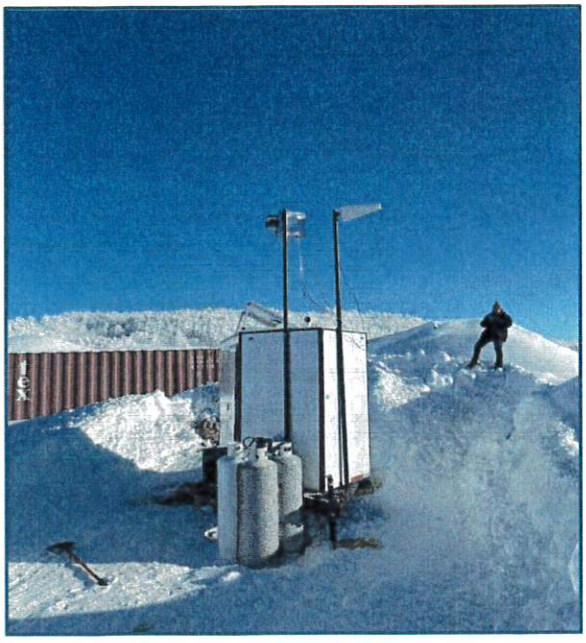

Figure 3 (left). Cloud seeding remote generator.

Figure 4 (top). Cloud seeding aircraft with burn in place flares in the wing racks, one on each side of the aircraft.

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What materials are used in cloud seeding?

Both silver iodide and liquid propane are used in Utah. Silver iodide is structurally very similar to an ice crystal. This allows for cloud droplets that are below the freezing level but not yet able to freeze a mechanism to freeze upon. Meanwhile, liquid propane creates intense evaporative cooling that cools the surrounding air, making all liquid particles freeze instantaneously. Both methods are effective for seeding clouds along mountain ranges in Utah. Silver iodide has greater dispersion, but liquid propane can target warmer clouds in thinner columns.

Silver Iodide

- Structurally resembles an ice crystal.
- Converts supercooled liquid water into ice at temperatures from -23°F to -4°F.
- Generators run during seedable conditions, typically for long time periods. The seeding plume disperses both in the horizontal and vertical dimensions with time.

Liquid Propane

- Intense evaporative cooling converts liquid water into ice at temperatures from 32°F to -40°F.
- Must be dispersed in-cloud.
- The effectiveness of this method is being further researched.

Silver iodide particles from ground-based generators and aircraft are in the 0.3-3 micrometer range so they cannot be seen with the naked eye. These particles are released when winds are blowing towards the mountains, so they are not responsible for "black snow" or unnatural flakes over the valleys.

Is cloud seeding safe?

The amount of silver iodide released for cloud seeding in Utah represents 0.33% of all silver released by cloud seeding programs across the world per year. Additionally, the silver released in Utah for cloud seeding is 0.01% of all silver released into the atmosphere (Eisler 1996) across the world. Silver and iodine have a strong covalent bond which makes silver iodide unable to dissolve in water, one reason why it is so effective since the particles are exposed to saturated environments. However, this bond keeps the free silver ion from dissolving away and becoming toxic. The maximum concentration of soluble (dissolved) silver in water is 0.984 µg/L (micrograms-liter), which is far below the standards for safe drinking water (100 µg/L), impacts to aquatic life (4.1 µg/L), algae (2-7 µg/L) and terrestrial plants (10-10,000 µg/L). This is also below the natural background levels of natural silver which in Utah, Idaho and the Sierra Nevada Mountains are anywhere from 2-6 µg/L.

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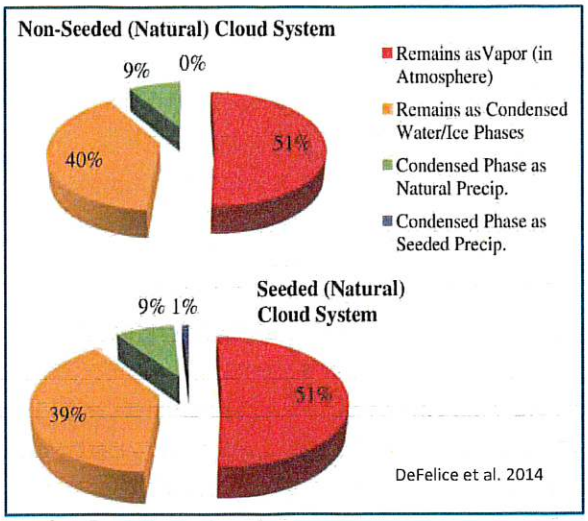

Figure 2. Amount of condensed water vapor in a seeded cloud vs. an unseeded cloud showing plentiful moisture available.

Does cloud seeding deplete moisture downwind of a project area?

When liquid water changes to ice, heat is released within the cloud, allowing it to expand both vertically and horizontally. This results in continued augmented precipitation outside of targeted areas, which is referred to as Extra Area Effects (DeFelice et al. 2014). Even with cloud seeding, the amount of precipitation falling is a minimal amount of the overall moisture available (Figure 2). For example, most thunderstorms produce rainfall at 19% efficiency. A study conducted by Solak et al. (2003) showed an 8% increase in precipitation east of the target areas in Utah, which was further confirmed by a later study in 2011 by North American Weather Consultants. Further research into downwind impacts is reviewed by DeFelice et al. (2014).

How is cloud seeding regulated?

Cloud seeding activities in Utah must be licensed and permitted. The Cloud Seeding Act of 1973 gives the Division of Water Resources authority to approve licenses and permits if an applicant meets the requirements. All cloud seeding projects also must report to the National Oceanic and Atmosphere Administration annually before and after a cloud seeding project is conducted. There is also suspension criteria in place for potential flooding, severe weather along with potential avalanche concerns.

Cloud seeding is a long-term water management strategy that is being used across the world to augment water supply. States such as Utah, Texas, Idaho, Colorado and California have been cloud seeding for over 30 years. Research shows it is an effective water management tool, and that it is safe, inexpensive and non-invasive.

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