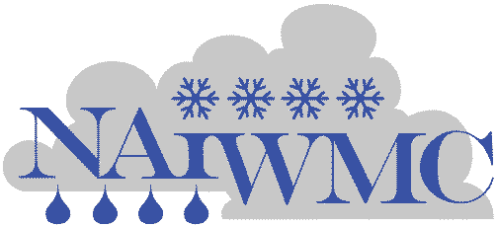

North American Interstate Weather Modification Council
www.naiwmc.org

Cloud Seeding FAQs

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Cloud seeding, often called weather modification, is not something most people know much about, yet it is a multi-million dollar industry in the Western United States. This document addresses the most common questions about the technology and provides the interested reader with some ideas where more information can be found.

1. For what purposes is weather modification practiced?
Weather modification, commonly referred to as cloud seeding, is currently used to increase precipitation from clouds, reduce hail from thunderstorms and eliminate fogs that reduce visibility, usually at busy airports.

2. How does cloud seeding work?
Cloud seeding improves a cloud's ability to produce precipitation by adding tiny particles called ice nuclei (which water needs to freeze) to a cloud. These nuclei help the cloud produce precipitation by acting on supercooled liquid water (SLW), the raw material from which precipitation is formed. These artificial ice nuclei promote freezing of SLW at warmer temperatures than it would naturally, accelerating the precipitation process and making more efficient use of the water in the cloud.

3. Can all clouds be seeded effectively?
No. Only clouds that meet certain criteria are suitable for seeding. Summer clouds must possess a sustained updraft of moist air, a lack of natural ice, and grow to heights cold enough to contain supercooled liquid water. Winter clouds must also be supercooled and persist long enough to grow snowflakes large enough to fall to the ground. Criteria for fog seeding are very similar to the conditions required for winter clouds.

4. What are clouds seeded with?
Clouds can be seeded with a number of different types of agents: silver iodide, liquid propane, dry ice (solid carbon dioxide), and various salt compounds.

5. How long after seeding before a treated cloud starts to change?
Seeding effect can vary from almost immediate to around 30 minutes depending on the seeding delivery method and the type of cloud seeded. Directly placing seeding material in a cloud typically works more quickly than releasing the material below the cloud and allowing the cloud to ingest it.

6. Who decides if and when clouds are seeded?
Typically, a meteorologist is the director of operations for cloud seeding missions. A number of factors play a part in the decision-making process which includes local atmospheric conditions, weather forecasts, seeding suspension criteria and aircraft safety concerns.

7. What methods are used to deliver seeding material to suitable clouds?
Seeding is typically done either by specially-equipped aircraft or via ground-based "generators" at higher elevations in mountainous areas.

8. Does rain or snow from a seeded cloud taste or smell different than natural precipitation?
No. There is no discernible difference between precipitation from a seeded cloud versus precipitation from a non-seeded cloud.

9. Can cloud seeding change weather patterns?
No. Cloud seeding may change individual clouds or groups of clouds, but weather patterns are determined by large-scale atmospheric conditions which cloud seeding cannot affect.

10. Can cloud seeding end droughts?
Though drought is sometimes the impetus for implementing a cloud seeding program, cloud seeding is not generally advocated for such purposes. The reason for this is that droughts are typically characterized by prolonged periods with a lack of precipitation-producing clouds. Therefore, cloud seeding opportunities during these periods would be very limited and the results likely marginal. A long-term and well designed cloud seeding program can potentially soften the impact of drought, however, as increased precipitation production before and after drought could temper the shortfall of precipitation during the drought period.

11. How do we know what happens inside clouds?
A number of scientific research experiments have been conducted from which we have learned much about the basic processes of precipitation initiation and development. Much of that knowledge has been applied to cloud seeding technology, thereby making cloud seeding more effective now than ever before. However, additional research is still needed to answer remaining questions and further improve cloud seeding practices.

12. How can seeding effects be measured?
Seeding effects and benefits can be demonstrated in a number of ways. The most direct method would be to conduct a project over several years in which half of the storms were randomly selected for seeding and the resulting precipitation from the seeded and unseeded storms were compared. The problem with this method, however, is that project sponsors usually want all of the seedable clouds treated (not half) to attain the maximum benefit possible from the program.

Evaluations of precipitation data, streamflow data, crop insurance data and crop yield data are useful if done properly. These evaluations require long term climatological elationships to be established between seeded and unseeded areas, and a long period of operations for comparison purposes, but do not require that only half of the suitable clouds be treated.

Recently developed methods include snow trace-chemistry analysis, objective radar-based analysis, evaluation of satellite data and even numerical modeling to help discern the effects of cloud seeding.

13. What are the typical benefits of cloud seeding?
Numerous evaluations have indicated that cloud seeding, when properly applied, can produce precipitation increases up to 10% or greater (AMS, 1998). Studies of hail suppression seeding indicate hail damage reductions up to 45% (Smith et al., 1997). Agricultural wheat production in seeded areas has increased by 5.9% in North Dakota (Smith et al., 1992).

14. What are the economic benefits of cloud seeding?
Evaluations indicate runoff from additional snowpack in the range from $1 to $15 per acre foot (Kansas Water Office, 2001). Benefit to cost ratios on summer season agricultural economic production approach 40 to 1 (Sell and Leistritz, 1998).

15. Who else is doing weather modification?
The latest data from the World Meteorological Organization compiled in 2000 listed 74 projects ongoing in 23 countries worldwide (WMO, 2000). In 2001 the National Oceanic and Atmospheric Administration (NOAA) documented 66 projects conducted in the western U.S. Project objectives included fog dispersal, snowpack and rainfall enhancement, and hail suppression.

16. Who performs cloud seeding operations?
On most U.S. programs, a company specializing in cloud seeding is hired to conduct seeding operations. Other programs are conducted by universities, private companies, or even local weather modification or water management entities.

17. What kind of training is required for weather modification personnel?
Prior experience in weather modification operations is a tremendous advantage to cloud seeding programs. Private contractors typically employ experienced personnel.

Pilots-in-command must meet certification and flight time requirements, while meteorologists must typically possess a Bachelor's degree in Meteorology or Atmospheric Science. Many programs conduct pre-project training classes prior to project startup covering all pertinent aspects of the program.

A unique intern training program is sponsored by the North Dakota Atmospheric Resource Board. An intern pilot program, in cooperation with the University of North Dakota's aviation program, trains pilots in summer convective cloud seeding each

summer in North Dakota, while a parallel program for meteorology interns performs the same purpose for radar operators.

The Weather Modification Association maintains a certification program for meteorologists in the weather modification field. Certified Operator (CO) and Certified Manager (CM) status is available to those who meet specific operational and educational criteria.

18. What safeguards are in place during cloud seeding operations?
Safety measures are typically employed on cloud seeding projects in the U.S. These may include seeding suspensions in the event of specified snowpack thresholds, flooding potential, severe weather such as tornadoes or funnel clouds, and aircraft safety concerns such as severe icing or turbulence.

19. Who sponsors cloud seeding in the U.S.?
A wide range of entities sponsor cloud seeding programs in the U.S. They include municipal, county and state governments; irrigation, water resource and water conservation districts; airports; ski resorts; and private industry.

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