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Background on Weather Modification and Cloud Seeding

April 2008

Planned vs. inadvertent modification

Humans can modify the atmosphere, both intentionally and unintentionally.

Planned weather modification generally refers to such activities as cloud seeding to enhance rainfall or snowfall or suppress hail.

Inadvertent weather modification refers to the impacts of pollution, which can range from the global -scale, long-term effects of warming produced by greenhouse gases to the local effects on rain or snow caused by particles of sulfates and other pollution in the atmosphere.

Cloud seeding techniques

Cloud seeding, the main type of intentional weather modification, began in the late 1940s. The basic idea was to use aircraft or rockets to inject silver iodide or another substance into the atmosphere to mimic ice nuclei. The amount of rain or snow a cloud can produce depends on a balance between the number of ice nuclei inside it and the amount of water available to grow around those nuclei. Clouds often lack naturally occurring ice nuclei, so injecting them with silver iodide particles (which are very similar in structure to ice) increases the number of nuclei. This makes the clouds more efficient at generating ice crystals that either fall as snowflakes or melt to produce raindrops, depending on temperatures in and beneath the cloud. Cloud seeding is also used to disperse fog banks near some airports.

A more recent cloud-seeding technique is to use *hygroscopic* (water-attracting) *particles* such as potassium/sodium chloride to create larger raindrops that fall more quickly, colliding with smaller droplets on the way and stimulating rainfall.

Does cloud seeding work?

Although the principles behind it are well established, it is difficult to prove that a given round of cloud seeding produced a particular effect, because it is difficult to know what would have happened otherwise due to natural variability. Major research projects from the 1950s through the 1970s—including the National Hail Research Experiment, operated in northeast Colorado by the National Center for Atmospheric Research (NCAR) failed to confirm the effectiveness of cloud seeding in increasing precipitation or reducing hail.

Since the 1980s, U.S.-sponsored research on weather modification has been minimal. However, NCAR scientists carrying out research projects in a number of other nations, often using the hygroscopic approach, have found some new intriguing results. Such projects have been conducted in Argentina, Australia, Italy, Mali, Mexico, Saudi Arabia, Mexico, South Africa, and Thailand, among other countries.

NCAR is also collaborating with the state of Wyoming on a five-year project to examine whether cloud seeding can stimulate snowfall over the Sierra Madre/Medicine Bow mountains east and west of Laramie and in the Wind River mountains.

In order to be effective, cloud-seeding studies must include a significant number of days when rain or snow might or might not occur so that the usefulness of seeding can be verified statistically. The

choice of days on which to seed is typically determined at random and kept secret to help ensure the project's validity.

National Academies report

Despite the lack of hard, consistent and repeatable evidence to support it, many government agencies and private firms continue take part in cloud seeding. In its 2003 report, "Critical Issues in Weather Modification Research," a panel of the National Academies found that 10 U.S. states were conducting at least 66 cloud-seeding programs. "We know that human activities can affect the weather, and we know that seeding will cause some changes to a cloud," noted the report. "However, we are still unable to translate these induced changes into verifiable changes in rainfall and hail fall, and snowfall on the ground, or to employ methods that produce credible, repeatable changes in precipitation."

The report did note progress in some areas. Research suggests that cloud seeding is most likely to succeed over ski areas and other mountainous regions, where upslope winds can help induce clouds and snow.

In addition, the hygroscopic seeding of summertime convective clouds shows some promise to enhance rainfall. However, in times of serious drought, weather modification may be of little use. When the skies are clear, there are often no clouds to seed.
