ASCE's Standard Practice Provides Procedures Overview

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The American Society of Civil Engineers' (ASCE) *Standard Practice for the Design and Operation of Precipitation Enhancement Projects*, published in 2004, provides a useful overview of the topic and is intended to inform water managers and others who may be considering such a project. The roughly 50-page publication does not provide specific standards so much as a description of how cloud seeding ("precipitation enhancement") works from both scientific and practical perspectives.

The first two sections cover the historical and scientific background of cloud seeding. U.S. cloud seeding experiments date back to the 1940s, when dry ice was used as the seeding agent. The current state of the technology is addressed by four major organizations: ASCE, the Weather Modification Association, American Meteorological Society, and World Meteorological Organization. Sections on cloud condensate, the growth of precipitation, and concepts of precipitation augmentation provide an informative tutorial on how precipitation forms and what factors influence its formation.

The bulk of the document focuses on project design, which should consider the geographic and temporal scope of the project, the method of seeding, selection of the seeding agent, data collection, siting of equipment, and legal and environmental concerns. The geographic extent of the project should include both target and control areas with very similar geography, climatology, and use. Seeding can be performed by both aerial and ground-based methods; the advantages and disadvantages of each are addressed. Typical seeding agents include silver iodide, dry ice, organic substances, and hygroscopic agents such as finely ground salt particles.

Data collection is critical both for determining the timing of seeding and evaluating its effectiveness. Real-time data used for decision-making are available from several networks and use radar, satellites, instrumented observatory stations, rawinsondes (balloon-borne instruments), gauges, computer models, and specially designed instruments such as for measuring the supercooled liquid water content of clouds. Data from precipitation and stream gauges, remote sensing techniques, snow chemistry, and cloud models are used to evaluate the results of seeding activities.

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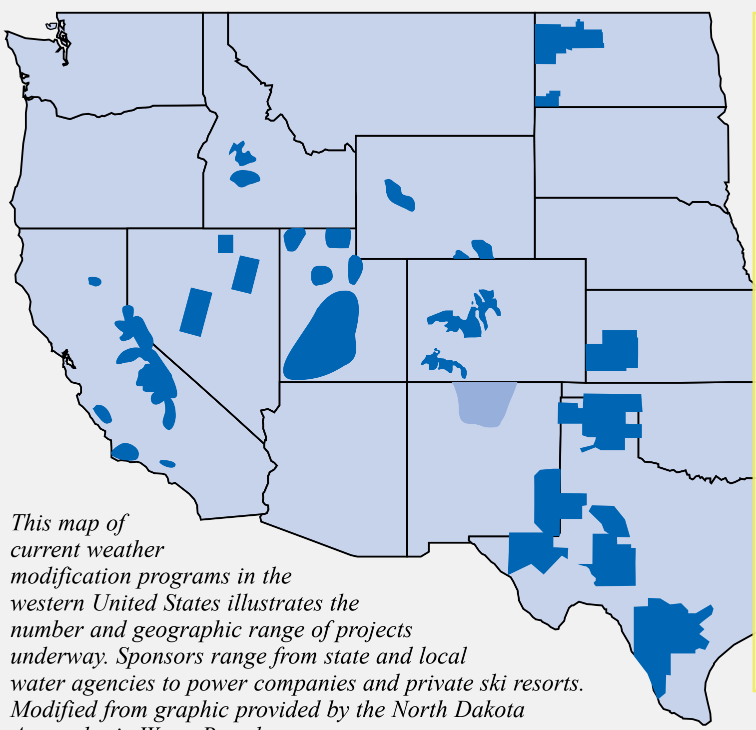
Where Is Weather Modification Occurring?



This map of current weather modification programs in the western United States illustrates the number and geographic range of projects underway. Sponsors range from state and local water agencies to power companies and private ski resorts. Modified from graphic provided by the North Dakota Atmospheric Water Board.

CALIFORNIA
Precipitation augmentation
www.dwr.water.ca.gov

COLORADO
Snowpack augmentation
Various ski areas and water districts

IDAHO
Snowpack augmentation
www.idahopower.com

KANSAS
Hail suppression
www.kwo.org

NEVADA
Precipitation augmentation
www.cloudseeding.dri.edu

NEW MEXICO
Precipitation augmentation
(lighter blue = proposed project)
www.just-clouds.com

NORTH DAKOTA
Hail suppression, rainfall augmentation
swc.nd.gov/arb

OKLAHOMA
(program suspended)
Rainfall augmentation, hail suppression
www.owrb.state.ok.us/hazard/weather/wx_mod.php

TEXAS
Rainfall augmentation, hail suppression
www.license.state.tx.us/weather/weathermod.htm

UTAH
Snowpack augmentation
www.water.utah.gov/cloudseeding/

WYOMING
Snowpack augmentation
www.rap.ucar.edu/projects/wyoming

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Operational aspects of cloud seeding are covered next. Key project personnel include meteorological staff, pilots specifically trained in cloud seeding, a director of operations, and support personnel. Decision-making requires close coordination and communication among these and others, such as local weather officials. Safety considerations include protection of personnel from hazards related to microwave radiation, seeding agents and dispensers, severe weather, and aircraft safety. In addition, operators must monitor for conditions that warrant suspension of operations, such as flooding, severe weather, avalanche conditions, or full reservoirs.

The final section briefly addresses evaluation of cloud seeding projects. Although much knowledge is to be gained over the long term from project evaluation, a strong evaluation requires target areas to be randomly seeded or not, so as to develop two unbiased classes of storms for comparison. Unfortunately, most sponsors of cloud seeding projects want to maximize the immediate benefits and not forego any opportunity to enhance precipitation, thus randomized programs are rare. Alternative approaches are to compare the target area to a nonseeded control area, or to compare storm measurements from within and outside of the project area prior to and during the project to see if the relationship changed during the seeding program. Both direct and indirect measurements are used for evaluation. Direct measurements include precipitation and radar data, whereas indirect measurements may include crop yield changes, stream runoff data, or chemical analyses using various tracers.

The document concludes with a glossary of terms and an extensive list of references. Although anyone seriously considering initiating a cloud seeding project would need to consult with trained scientists and practitioners as to the feasibility and cost of the method in the desired area, *Standard Practice* provides water managers and others with a strong base of information about how the process works, decisions that would need to be made, and other important considerations.

See American Society of Civil Engineers, 2004. Standard Practice for the Design and Operation of Precipitation Enhancement Projects, *ASCE/EWRI 42-04.*

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