Water Acquisition and Management Subcommittee
Position Paper: Weather Modification – Cloud Seeding Water

Introduction

- Cloud seeding is also termed weather modification.
- The fundamental technology development started in the 1940s.
- Today, the technology is applied most commonly and, apparently, most successfully to reduce cold fogs at airports using, predominately, dry ice dropped through or compressed gases released into the fog.
- The second most accepted use is treatment of winter clouds rising over mountains to increase snowfall (commonly estimated to increase snowfall by 10 to 15%).
- The third generally recognized approach is the seeding of summer clouds to reduce hail damage and, secondarily, increase local precipitation.
- Cloud seeding of summer clouds over flatter terrains to increase precipitation appears to be least reliable.
- Cloud seeding is commonly portrayed as not reducing downwind precipitation volumes, ostensibly because the amount of water typically removed by cloud seeding is, at most, only 10% of the cloud water available before seeding. (The question of whether multiple, sequential seeding operations could produce a downwind decrease in precipitation is not commonly addressed.)
- Chemicals used in cloud seeding, especially silver iodide, is reported to produce no significant adverse environmental impacts or to accumulate above background concentrations in seeding areas (very dilute in-cloud concentrations result from seeding).

Example Cloud Seeding Programs Today

- At least ten states have active (aggressive) cloud seeding programs for precipitation enhancement and/or hail suppression.
- For the Winter of 2002-2003, Denver is proposing to contract $700,000 for Year 1 of an ongoing cloud-seeding program, adding 41 new ground-based generators to augment snowpack and streamflow around reservoirs. Denver Water estimates that 35,000 to 50,000 AFY can be generated at a cost of $12-23/AF.
- In October 2002, Colorado public hearings were listed for 12 cloud-seeding permits to augment snowpack, suppress hail, and augment precipitation.
- In 2002, Texas had 11 listed weather modification projects covering 52 million acres.
- In 1994, $645,000 was spent on cloud seeding in Tasmania, which was estimated to produce 55 mm (2.2 in) of rain over 6 months, at a benefit cost ratio of 13:1.
- In a 1997 report, Nevada estimated that augmented water produced by cloud seeding varied from 35,000 to 60,000 AFY for 10 years of seeding; estimates of percent increases in total water yield varied between 4 and 10% per year, with the greatest production in drought years; costs ranged from $8 to $15/AF.
- In a 2000 report, Utah estimated an annual increase in runoff of 249,600 AF due to its cloud seeding program, an average increase of 13% at an average cost of $1.20 /AF.
- North Dakota reports that for that state cloud seeding, particularly for hail suppression, results in a 45% reduction in crop loss (worth $34.4M), a 15% increase in rainfall (worth $52.5M) for a $3.2M investment in cloud seeding, offset by $5.1M increase in taxes.

A Conservative View (Prof. William R. Cotton, http://rams.atmos.colostate.edu/gkss.html)

- [The most compressive review of the scientific literature on cloud-seeding apparently available on the Internet and one pointed to by several other web sites.]
- "Often the decision to apply cloud seeding technology to a particular country or state is a prescription of a *political placebo* or a decision that it is better to do something than to sit idly by and do nothing as reservoirs dry up and crops wither and die due to the absence of water."
- " ... there are only a few limited examples of where cloud seeding has been scientifically [i.e., statistically] shown to be effective in enhancing rainfall."
- "The window of opportunity for cloud seeding appears to be limited to:
  - "clouds which are relatively cold-base and continental;
  - "clouds having top temperatures in the range of –10 to –25 C;
  - "a time scale limited to the availability of significant supercooled water before depletion entrainment and natural precipitation processes."
- " ... the success of cloud seeding experiment or operation, therefore, requires a cloud forecasting skill that is far greater than is currently in use."
- In a 2002 article in the Colorado State Collegian he is quoted as, "The increase [in cloud seeding rainfall augmentation] could be between 5 to 10%. "[Cloud seeding] may increase precipitation, but it is very modest. It's not going to be a drought breaker." [Note similarity to estimated runoff benefit of 4-10% from cloud seeding presented in the 1997 Nevada report]

Jemez y Sangre Water Plan 2002 Alternatives Assessment (www.dbstephens.com/jemez.html)

- Recognized that disagreement exists in the scientific community on cloud seeding benefits.
- Noted that scientific societies have guardedly optimistic policy statements on the benefits from cloud seeding.
- Report recommendations:
  - Form partnerships with local entities to conduct a pilot program
  - Share costs with NMISC
  - Establish a public information/education program
  - Review recent experiments by NMISC in the Pecos Valley and elsewhere
  - Model predicted runoff distributions and potential volumes
- 3,000 to 6,000 AFY may result from cloud seeding in the Jemez y Sangre Project area.

NMISC and cloud seeding in NM

- State of New Mexico has provided, on average, approximately $100,000 per year for the past 5 years to support a cloud seeding demonstration project in eastern NM. Funding for this activity was administered through a Joint Powers Agreement between the NMISC and local NM Soil and Water Conservation Districts. The west Texas underground conservation districts in conjunction with the NM Soil and Water Conservation Districts conducted the cloud seeding operations.
- Over the last two years, NMISC has taken a greater interest in the administration of the cloud seeding activities and as a result, reporting and assessment activities have increased, and better weather data is being compiled. Better methods are being implemented to allow calibration of radar to estimate precipitation volume.
- At this time, the question of whether cloud seeding produces or does not produce new water in NM lacks adequate data for a scientific/statistical evaluation.
- NMISC have contracted with both Dr. Conrad Keyes and additional support from Dr. Bill Woodley to aid the ISC in the assessment of these and future funded efforts in NM.
- The Llano Estacado Weather Modification Association with assistance from the NMISC is prepared "Proposal for Eastern New Mexico Precipitation Enhancement Program, January 2002"

that request legislative/Water Trust Board funding of approximately $1M per year for the next five years in support of a "expanded, State Managed Cloud Seeding Program."

- The annual total dollar amount may be larger than that, if the State is successful in tapping into BOR matching funding.
- This bulk of program will include a summer cloud seeding program using aircraft based out of Roswell. The program will include the purchase of perhaps two used aircraft the first year, and perhaps a fleet of 4 or 5 aircraft by the end of the first five years. The program will include a statistical/scientific based seeding program with the intent of developing a data set to allow an adequate assessment of the success of the seeding program in reducing irrigation demands.
- About 10-15% of the budget will be devoted to conducting a winter demonstration, ground-based seeding program, first, in the upper Pecos Watershed for 2 years, then in the Sacramento Mountains for 2 years. The goal of this seeding would be to increase snowpack, surface yield, and base flow.
- No seeding has been planned in the Rio Grande watershed.

Additional observations:

- NCAR scientist seeded clouds in Mexico during a 3-year randomized experiment ended in 2000 that showed that rainfall from seeded clouds *statistically* lasted longer, the rainfall area was larger, and total precipitation was greater (sometime even double) than output from similar non-seeded clouds.
- Important to recognize the high degree of difficulty in designing a statistically rigorous, adequately replicated and randomized weather modification experiment, lacking a precipitation area bias or confounding factors ("standard clouds" don't exist).
- Science/statistics is best equipped to disprove rather than prove relationships exist (i.e., use of "null hypothesis").
- Ultimately, the final basis for determining for or against cloud-seeding benefits will likely be based on a "weight-of-evidence support" producing deductive conclusions, rather that statistically based inductive conclusions.

WAM Conclusion and Recommendations to the Program InSC:

1. The Collaborative Program should establish a Program priority to monitor the findings of the NMISC seeding program, both in terms of success in reducing potential irrigation demands by seeding and increasing spring runoff production from seeding.
2. The Collaborative Program should establish a Program priority to provide a cost-share expansion of the NMISC winter seeding pilot program into the upper Rio Grande watershed, south of the CO-NM Stateline, to assess the potentials for cloud seeding to increasing snowpack and Spring runoff potentials. The WAM suggests that ground-based seeding to enhance snow pack water volumes may be the most cost-effective method to increase stream flow and a useful 3- to 5-year pilot program in north central NM could likely be undertaken at a cost of $150,000 to $250,000 per year.
3. Proposals developed in response to any such RFP for clouding seeding pilot study should include provisions for matching funding, to augment the Programs support, from ski areas in the upper Rio Grande watershed of New Mexico, who are likely to also benefit from such a program.