PLANNED WEATHER MODIFICATION THROUGH CLOUD SEEDING

An Information Statement of the American Meteorological Society

(Adopted by the AMS Council on 2 November 2010)

INTRODUCTION. Increasing population, urbanization, and the impacts of a changing climate require that water resources be managed to most effectively alleviate the shortages that manifest themselves, from time to time, in various geographic settings. At the other extreme, precipitation processes on occasion may be so intense and prolonged that damage results to crops and structures, and there can be injuries and loss of life. In addition, nonprecipitating clouds may obscure visibility to the extent that transportation and other human activities are significantly hindered. One tool available for mitigating some of these weather impacts is planned weather modification through cloud seeding. In its most common form, specially formulated aerosols or very cold materials are dispersed in targeted locations within clouds to achieve precipitation enhancement, hail damage mitigation, fog clearing, and other intentional effects. Cloud seeding techniques have been developed over nearly 70 years through experimentation and trials. In this statement, we focus on the policy issues that pertain to local-scale application of these techniques covering areas from a few to several hundreds of square kilometers. Larger-scale efforts to intentionally modify weather and climate using these or other techniques are discussed in a separate AMS policy statement on geoengineering.

UNCERTAINTY. Planned weather modification programs benefit from a comprehensive understanding of the physical processes responsible for desired modification effects. Recent improvements in the composition and techniques for dispersion of seeding agents, observational technology, numerical cloud models, and in physical understanding of cloud processes permit evermore detailed design and targeting of planned weather modification effects, and more accurate specification of the range of anticipated responses. While effects are often immediately evident in simple situations, such as when cloud seeding is used to clear supercooled fog and low stratus cloud decks, in more complex cloud systems it is often difficult to determine a seeding effect on a cloud-by-cloud basis. In these more complex situations, large numbers of events must be analyzed to separate the response to cloud seeding from natural variability in cloud behavior. Rigorous attention to evaluation of both operational and research programs is needed to help develop more effective procedures and to improve understanding of the effects of cloud seeding. Research and operational programs should be designed in a way that will allow their physical and statistical evaluation. Any statistical assessment must be accompanied by physical evaluation to confirm that the statistical results can be attributed to the seeding through a well-understood chain of physical events. It should be noted, though, that in practice large potential benefits can warrant relatively small investments to conduct operational cloud seeding despite some uncertainty in the outcome.

RISK MANAGEMENT. Unintended consequences of cloud seeding, such as changes in precipitation or other environmental impacts downwind of a target area, have not been clearly demonstrated, but neither can they be ruled out. In addition, cloud seeding materials may not always be successfully targeted and may cause their intended effects in an area different than the desired target area. This brings us to the ethical

concern that activities conducted for the benefit of some may have an undesirable impact on others. At times unintended effects may cross political boundaries. Weather modification programs should be designed to minimize negative impacts. International cooperation may be needed in some regions.

Precipitation augmentation through cloud seeding should be viewed cautiously as a drought-relief measure. Opportunities to increase precipitation are reduced during droughts. A program of precipitation augmentation is more effective in cushioning the impact of drought if it is used as part of a water management strategy on a long-term basis, with continuity from year to year, whenever opportunities exist to build soil moisture, to improve cropland, and to increase water in storage.

From time to time methods have been proposed for modifying extreme weather phenomena, such as seeding severe thunderstorms with aerosols to diminish tornado intensity, or seeding tropical cyclones to cause changes in their dynamics and steer them away from land and/or diminish their intensity. Some experimentation has taken place in these areas, but current knowledge of these complex weather systems is limited, and the physical basis by which seeding might influence their evolution is not well understood.

Weather modification techniques other than cloud seeding have been used in various areas of the world for short periods of time to achieve goals similar to those of cloud seeding. Much less is known about the effects of these other techniques, and their scientific basis is even further from being demonstrated, either statistically or physically, than it is for cloud seeding. Application of weather modification methods that are not supported by statistically positive results combined with a well-understood physical chain of processes leading to these results, and that can also be replicated by numerical cloud modeling, should be discouraged.

RECOMMENDATIONS. As with weather forecasting, significant progress has been made in the science of weather modification in the last half-century. There remain limits to the certainty with which desired changes in cloud behavior can be brought about using current cloud seeding techniques. Continued effort is needed toward improved understanding of the risks and benefits of planned modification through well-designed and well-supported research programs.

In particular, the following specific recommendations are made:

- Efforts should continue to improve understanding of the targeted cloud and precipitation processes in planned modification.
- Because predictability is a limiting factor in the assessment of weather modification efforts, well-designed (randomized) and well-supported research programs should be conducted that improve the predictability of the undisturbed weather and the magnitude of weather modification effects.
- It is necessary to comprehensively address the risks, benefits, and ethical issues associated with planned weather modification and to develop policy approaches that can help the implementation and conduct of future experiments and operations.
- Research into modification of extreme weather systems, such as tornadic thunderstorms, tropical cyclones, etc., should be limited to numerical simulations until such time as there is sufficient knowledge to lay the foundation for safe experimentation in the atmosphere.

[This statement is considered in force until November 2013 unless superseded by a new statement issued by the AMS Council before this date.]