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Guidelines for Operational Hail Suppression Programs

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PREFACE

This standard is a revision of the 2015 *Guidelines for Operational Hail Suppression* and represents the current consensus of the ASCE EWRI Atmospheric Water Management Standards Committee.

This standard provides a general overview of the science and technology of hail suppression combined with specific strategies and procedures required to design, conduct, and evaluate hail suppression operations. Users of this standard must give particular attention to use of the mandatory "shall" and advisory "should" terms within the text of the standard. The body of this standard is supplemented with appendixes, which provide nonmandatory information or material that is an essential part of projects but too lengthy to place in the text.

Revisions to the mandatory requirements of this standard include

- Improvements to the strategy, practice, technologies, and techniques used to implement the standard;
- Improved figures and text to better express the latest science and its practice; and
- Updated sections on abbreviations, definitions, notation, and symbols.

The document is to be a standard guide to water resource, agricultural, energy and insurance managers as well as others who design, operate, or evaluate hail suppression projects. If this standard is used as part of an agricultural, energy or water security/sustainability program, the environmental and cost aspects of such interdisciplinary efforts should be considered.

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CHAPTER 1
SCOPE

This standard describes a process through which hail suppression operations should be designed, organized, and conducted. The information contained herein is intended to be helpful to those persons wishing to implement operational hail suppression activities (described interchangeably in this document as programs or projects). The standard provides information on the design, operation, and evaluation of such efforts. Operational activities addressed by this standard include airborne, ground-based, and rocket and artillery delivery systems. Hail cannons, though used for hail mitigation in some areas, are not included in this standard because there is currently no scientific evidence that they may affect hail development. The standard is to guide the water resource, agricultural, energy, and insurance managers, and others with the standard approach/guidelines for designing, operating, and evaluating a decision on hail suppression projects.

The International System of Units (SI) is used throughout, with English/customary equivalents also provided. Exceptions are the use of the Celsius (°C) temperature scale and, where appropriate, centimeters (cm) in lieu of meters (m). Appendix A provides all conversion factors used herein. Italics denote special emphasis.

1.1 GLOSSARY OF TERMS AND ACRONYMS

Definitions are from the *Glossary of Meteorology* (AMS 2000) and where applicable ASCE (2003, 2015).

Accumulation Zone: Hypothetical, relatively small regions within mature updrafts of hailstorms where supercooled liquid water drops have accumulated, creating a region well suited to the rapid development of large hail. Although such zones have been encountered by research aircraft on rare occasions, their true role, if any, in hail development is uncertain. Also used to indicate azimuth, especially in radar manuals.

AgI: *See* Silver Iodide.

AMS: American Meteorological Society

ANELFA: Association Nationale d'Etude et de Lutte contre les Fléaux Atmosphériques. *(Association to Suppress Atmospheric Plagues),* http://www.anelfa.asso.fr/

ASCE: American Society of Civil Engineers, http://www.asce.org/

Attenuation: In physics, any process in which the flux density (or power, amplitude, intensity, illuminance, etc.) of a "parallel beam" of energy decreases with increasing distance from the energy source; for example, attenuation in the atmosphere, often caused mostly by precipitation, reduces the intensity of the electromagnetic wave (radar signal) along its path from and back to the radar. Attenuation thus lessens the ability of radar to sense all clouds and precipitation, such that the depicted information becomes inaccurate or incomplete.

Broadcast Seeding: The release of seeding agent, either from aircraft or from the ground, in conditions thought favorable for the development of treatable convective storms but either before such storms have developed or at some distance from the storms (i.e., not within the storm or in its immediate proximity). *Compare* Direct Targeting. Broadcast seeding is also a routine practice to increase precipitation within winter clouds in mountainous areas.

Buffer Zone: The area between the target area and control area that buffers the control from the possible effects of seeding within the operational area.

Burn-in-Place Flare: A pyrotechnic device burned in a fixed position, such as the trailing edge of an aircraft wing. *Compare* Ejectable Flares.

C-Band Radar: A radar system operating at a wavelength of approximately 5 cm (2 in.).

CaCl: *See* Calcium Chloride.

Calcium Chloride: The salt commonly used in hygroscopic cloud seeding pyrotechnics.

CCN: Cloud condensation nuclei. The tiny particles, either liquid or solid, upon which condensation of water vapor first begins, necessary for the formation of cloud droplets.

CD-ROM: Compact disk, read-only memory. Much of the project data today is archived to CD-ROMs because most modern computers can read them.

Cell: A convective element (cloud) that, in its life cycle, develops, matures, and dissipates, usually in about 30 min.

Certified Manager: Person with certification of weather modification project managerial experience and skills granted by the Weather Modification Association.

Certified Operator: Person with certification of weather modification project operational experience and skills granted by the Weather Modification Association.

Cloud Droplet: A particle of liquid water from a few micrometers to tens of micrometers in diameter, formed by condensation of atmospheric water vapor and suspended in the atmosphere with other droplets to form a cloud. These liquid water droplets are too small to precipitate.

Cloud Model: Physical description of cloud processes programmed into a computer to simulate cloud development and evolution. Useful in understanding the relative importance of the many factors that influence cloud development, and the only way in which exactly the same cloud can be both seeded and unseeded.

CO_2: *See* Dry Ice.

Coalescence: In cloud physics, the merging of two water drops into a single larger drop. This merging occurs through the collision of two drops, which then unite.

Conceptual Model: A theoretical model, for example, of storm and hail development, based upon current knowledge and scientific concepts. *See also* Cloud Model.