**WEATHER MODIFICATION – ARTIFICIAL RAIN MAKING AND CLOUD SEEDING**

Weather modification refers to willful manipulation of the climate or local weather. Research done in this field goes back to as far as the early 1940s when the US military experimented with cloud seeding to stimulate rain. Today, private corporations have joined the weather modification research effort to protect people, cities and assets from the damage extreme weather brings.

**Principles of rainmaking**

Clouds are classified into warm and cold clouds based on cloud top temperature. If the cloud temperature is positive these clouds are called warm clouds and if it is negative they are called as cold clouds. The nucleus needed for precipitation differs with type of clouds. Hygroscopic materials are necessary as nucleus for warm clouds

**History of Cloud Seeding**

Cloud seeding experiments started with the work of a scientist from General Electric named Vincent Schaefer who discovered that ice crystals can induce precipitation. Since ice crystals are difficult to transport and spread over an area, silver iodide, a compound with similar properties, was used as a substitute. The experiments continued until the 1970's when the program was shelved because of lack of usable results.

**Cloud seeding**

Cloud seeding is one of the tools to mitigate the effects of drought. It is defined as a process in which the precipitation is encouraged by injecting artificial condensation nuclei through aircrafts or suitable mechanism to induce rain from rain bearing cloud. The raindrops are several times heavier than cloud droplets. These mechanisms are different for cold and warm clouds.

**How it Works**

Cloud seeding involves the use of water-absorbent materials to encourage the formation of clouds and rain so that there could be increased crop production in areas where there's little water. This practice has already been implemented in some areas like Texas and Utah, though not without its share of controversies. The effectiveness of cloud seeding cannot be proven and some worry that it may actually cause harm.

**Cloud seeding useful in the following applications**

**Increasing Precipitation**

The most common application of cloud seeding is to increase precipitation, possible with both warm and cold clouds. There are two primary methods employed to stimulate precipitation. One, hygroscopic seeding, affects warm cloud processes. The other, glaciogenic seeding initiates cold cloud processes.

Though occasionally both techniques may be helpful, in most cases one can be utilized more effectively than the other. In addition, either technology can be applied from the surface (ground-based) or from an aircraft. Weather Modification, Inc. can help you decide which method will be most effective.

**Augmenting Snowfall**

Glaciogenic seeding can also be used to increase precipitation from stratiform and orographic clouds. In such cases, seeding may be accomplished through either ground-based or airborne modes. By increasing snowpack and resultant spring runoff, subsequent water supplies for hydropower are increased. In addition to alleviating the need for alternative costly power supplies, cloud seeding increases the water availability for municipal, recreational, and environmental interests.

**Enhancing Rainfall**

Efforts to increase rainfall during the warm seasons are typically aimed at convective clouds. While it is theoretically possible to seed such clouds using ground-

based equipment, targeting from aircraft is much more efficient and accurate. It is usually possible to affect the cloud through releases of a seeding agent in sub-cloud updrafts, or by dropping the seeding agents directly into the upper regions of the clouds. Warm season glaciogenic seeding is typically applied to treat supercooled cumulus congestus clouds, either by releasing the ice-forming (nucleating) seeding agent in the updraft beneath the actively-growing cumulus, or by dropping the nucleating agent directly into the supercooled cloud top. The seeding agents can produce ice at significantly warmer temperatures than the natural process. This is how glaciogenic seeding gives the treated cloud a head start in producing precipitation.

When clouds do not grow tall and cold enough to produce precipitation through the Bergeron process, it may be possible to stimulate precipitation growth by seeding these warm clouds with hygroscopic seeding agents. This approach can be quite successful through stimulation of the warm cloud precipitation processes. Hygroscopic seeding is normally done from aircraft flying in the sub-cloud updrafts, in order to affect the initial cloud droplet development which occurs in this zone.

**Mitigating Hail Damage**

Cloud seeding can be used as a tool to help mitigate hail damage and protect crop yields, homes and other property, thus reducing the economic harm from disastrous storm damage. Since hail is itself ice that is produced only by vigorous convective clouds, it is certain that such clouds are cold enough to be amenable to glaciogenic seeding techniques. Hail develops when excess supercooled liquid water develops within strong updrafts. However, if the excess might be induced to freeze into large numbers of small particles rather than much smaller numbers of large particles, the ice that does precipitate may melt during its transit through the warm sub-cloud layer, or if it doesn't it will reach the surface as much smaller, less-damaging, ice.

**Dispersing Fog**

Another useful application for cloud seeding is the treatment of ground-based clouds, also known as fog. Supercooled fogs, comprised of water droplets at temperatures cold enough to permit ice development, can easily be cleared by glaciogenic seeding. This can be done either from the ground or from airborne application. Your choice between the two will depend on characteristics such as local infrastructure, topography, and wind.

**Seeding of cold clouds**

This can be achieved by two ways (1. Dry ice seeding and 2. Silver Iodide seeding).

**1. Dry ice seeding**

- Dry ice (solid carbon-dioxide) has certain specific features. It remains as it is at –80$^{o}$C and evaporates, but does not melt. Dry ice is heavy and falls rapidly from top of cloud and has no persistent effects due to cloud seeding.
- Aircrafts are commonly used for cloud seeding with dry ice.
- Aircraft flies across the top of a cloud and 0.5 – 1.0 cm dry ice pellets are released in a steady stream.
- While falling through the cloud a sheet of ice crystals is formed.
- From these ice crystals rain occurs.
- This method is not economical as 250 kg of dry ice is required for seeding one cloud. To carry the heavy dry ice over the top of clouds special aircrafts are required, which is an expensive process.

**2. Silver Iodide seeding**

Minute crystals of silver iodide produced in the form of smoke acts as efficient ice-farming nuclei at temperatures below –5⁻C. When these nuclei are produced from the ground generators, these particles are fine enough to diffuse with air currents. Silver

iodide is the most effective nucleating substance because; its atomic arrangement is similar to that of ice. The time for silver iodide smoke released from ground generator to reach the super cooled clouds was offer some hours, during which it would draft a long way and decay under the sun light. The appropriate procedure for seeding cold clouds would be to release silver iodide smoke into super cooled cloud from an aircraft. In seeding cold clouds silver iodide technique is more useful than dry ice techniques, because, very much less of silver iodide is required per cloud. There is no necessity to fly to the top of the cloud, if area to be covered is large.

**Seeding of warm clouds**

**1) Water drop Technique**

Coalescence process is mainly responsible for growth of rain drops in warm cloud. The basic assumption is that the presence of comparatively large water droplets is necessary to initiate the coalescence process. So, water droplets or large hygroscopic nuclei are introduced in to the cloud. Water drops of 25 mm are sprayed from aircraft at the rate of 30 gallons per seeding on warm clouds.

**2) Common salt technique**

Common salt is a suitable seeding material for seeding warm clouds. It is used either in the form of 10 per cent solution or solid. A mixture of salt and soap avoid practical problems. The spraying is done by power sprayers and air compressors or even from ground generators. The balloon burst technique is also beneficial. In this case gunpowder and sodium chloride are arranged to explode near cloud base dispersing salt particles.