THE PHYSICAL BASIS FOR SEEDING CLOUDS

WEATHER MODIFICATION (CLOUD SEEDING) is the intentional treatment of individual clouds or storm systems for the purpose of achieving a beneficial effect without harming people or the environment. Dr. Vincent J. Schaefer, the father of modern weather modification, conducted the first field experiments following his basic discoveries in 1946 at the General Electric Laboratory in Schenectady, New York. Since 1946, various inorganic and organic materials have been known to alter the physical processes which lead to the formation and growth of water droplets and ice crystals in clouds. In more recent years, extensive scientific experiments and the application of scientific concepts have led to the development of techniques which can provide predictable results when applied under proper supervision. Cloud and storm-related events which are often the target for cloud seeding programs include rainfall, snow, fog, lightning, hail and devastating winds from severe storms.

To some degree, all air contains moisture (water vapor). The meteorologist calls this degree of moisture relative humidity, and it is extremely important to the formation of clouds. The colder the air, the less water vapor it can hold before clouds form. If a parcel of air at 80°F (27°C) has a relative humidity of fifty percent, it means the air contains half the water vapor it can hold at that temperature. If this air parcel cools, the relative humidity increases and at 60°F (16°C) it reaches 100%. If further cooling takes place, the water vapor may condense and form cloud droplets.

These cloud droplets are formed around microscopic particles—dust, smoke, salt crystals, soil and other materials that are always present in the atmosphere. Scientists classify these particles as cloud condensation nuclei and without them there would be no clouds. Among the total particles in the atmosphere, there are a few special kinds known as ice nuclei, on which cloud droplets freeze or ice crystals form directly from the water vapor. Generally, there is an abundance of condensation nuclei in the air, but a scarcity of the special ice-forming nuclei.

Clouds are made up of billions of these tiny water droplets or ice crystals and sometimes combinations of both. The cloud droplets are so small it may take a million or more to produce a single raindrop. Millions of tons of water in the form of water vapor, liquid droplets and ice particles constantly flow in the atmosphere around the world.

Sometimes precipitation only occurs in small amounts, or not at all, because certain required conditions are not present. Of prime importance for determining both the initiation and amount of precipitation from the cloud system are (1) the vertical and horizontal dimensions of the clouds, (2) the lifetime of the

clouds and (3) the sizes and concentrations of cloud droplets and ice particles. Under proper conditions, one or more of these three factors can be favorably modified by seeding the cloud with appropriate nuclei.

There are two basic mechanisms by which precipitation forms in clouds. These are called the "warm rain" and the "cold rain" processes. The term "warm rain" was derived after scientists noticed that rain in tropical regions often fell from clouds with temperatures never colder than 32°F (0°C). Rain is formed in these warm clouds when larger droplets collide with and absorb smaller cloud droplets in a process known as coalescence.

The "cold rain" process occurs when temperatures in all or parts of the clouds are colder than 32°F. In these colder regions the clouds are usually composed of both ice crystals and liquid water droplets. The ice crystals which form in this supercooled region grow rapidly, drawing moisture from the surrounding cloud droplets, until their weight causes them to fall. These falling ice crystals may melt and join with small liquid cloud droplets, growing to raindrops in a manner similar to the warm rain process. If the ice crystals do not melt, they may grow to large snowflakes by agglomeration and reach the ground as snow.

Compared to the amount of water that is visible as clouds or that falls to the ground as precipitation, the atmospheric reservoir of water above the earth is large. The sizes, types and concentrations of nuclei present in the atmosphere play an important role in determining the efficiency with which a cloud system forms and ultimately produces rain or snow. For instance, salt crystals acting as giant condensation nuclei are abundant in the oceanic regions. These allow larger cloud droplets to form and the subsequent coalescence process initiates rainfall well within the lifetime of the clouds. Conversely, the atmosphere over continental regions usually contains much smaller and more numerous condensation nuclei. Medium-sized clouds formed in these regions normally dissipate before the coalescence mechanism has had a chance to initiate rain. Likewise, many regions have only a few ice nuclei in the atmosphere which further reduces the efficiency of the cold rain process. The technology may best be described as simply lending Nature a helping hand.

Man can assist nature by furnishing appropriate types and numbers of nuclei through "seeding" the clouds at the proper time and place. Seeding with very large condensation nuclei (hygroscopic particles such as salt crystals) can be done to accelerate the warm rain process. Seeding with proper ice nuclei (such as silver iodide or dry ice) to supply naturally deficient clouds with the proper concentration of ice crystals will increase rainfall through the cold rain process.

Following is a list of some primary equipment supplied and operated by Atmospherics Incorporated in support of our weather research programs and mission-oriented cloud seeding projects.

- Weather Radar Systems
- Special Cloud Seeding Aircraft
- Airborne Seeding Equipment
- Pyrotechnic Seeding Devices
- Cloud Physics Instrumentation
- Data Acquisition Systems
- Meteorological Measurement Systems
- Airborne Instrumentation
- GPS Navigation & Tracking
- Rawinsonde Equipment
- Photographic Equipment
- Communications Systems