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Man vs. Nature:

Weather Modification in the 21st Century

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Since the beginning of civilization, weather has played a pivotal role in human history and development. The desire to influence this powerful force has given rise to both science and science fiction. Recently, however, the concept of controlling the weather has become a viable and perhaps widely beneficial possibility. Ideas like cloud seeding—stimulating precipitation by dropping crystals into developing storm clouds—have been practiced since the 1940's. The advancement of scientific technology has given rise to new ideas for manipulating the climate, from stopping hurricanes and earthquakes to using the weather as a military asset. With weather phenomena such as El Niño and several major hurricanes and floods occurring in the past few years, weather modification has re-emerged as a hot topic of interest. Like many new developments, weather manipulation has rallied scientific attention, but not without criticism and ethical speculation.

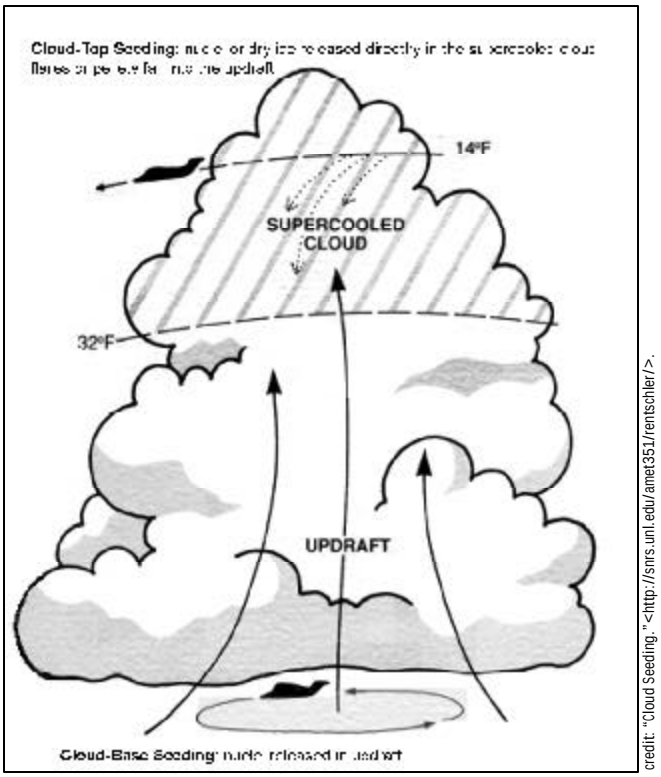
Cloud Seeding

Borne out of the desperation of droughts, the main purpose of cloud seeding has been to provide increased precipitation for crops. While still being implemented in states such as Utah and Texas, cloud seeding has been highly controversial due to varied results regarding its effectiveness and possible harm. However, recent interest in cloud seeding has expanded to a variety of applications including mitigating earthquakes and volcanoes, and even prevention of military fighter planes from flying over certain areas.

To understand cloud seeding, one must understand how rain forms and falls in the first place. There are two basic ways in which precipitation forms in clouds: the "warm rain" and the "cold rain" processes. The "warm rain" process occurs in clouds with temperatures above 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, on the other hand, occurs in clouds that have regions with temperatures below 0°C. Both ice crystal and liquid water droplets tend to form in these supercooled regions. The ice crystals rapidly grow larger by drawing moisture from surrounding cloud droplets until their weight causes them to fall. These falling ice crystals may melt and join with 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 clustering together and reach the ground as snow (1).

In 1946, a scientist named Vincent Schaefer made a startling discovery in his General Electric laboratory. While trying to induce precipitation in a cold cloud chamber (a modified freezer), he placed a block of dry ice inside because he worried the temperature was getting too warm. He was stunned to find that the ice crystals formed a cloud around the dry ice. This startling discovery paved the way for the science of cloud seeding, the artificial formation of precipitation in clouds. Ice crystals however, would be difficult to transport and disseminate in the sky. Schaefer's colleague, Bernard Vonnegut, addressed this problem when he found out that silver iodide has a molecular structure very similar to ice crystals and can be carried and applied more easily. Their research prompted the first experimental trials of cloud seeding in which planes would fly above clouds and scatter silver iodide upon them (2).

The first application of this technology was in farming. The United States and Russian governments used cloud



credit: "Cloud Seeding." <http://snrs.unl.edu/amet351/rentschler/>.

Figure 1. A diagram illustrating the method of cloud seeding

seeding to try to relieve droughts by stimulating precipitation in agricultural areas. These operations continued in full-force until the 1970's, when scientists began to become critical of the programs because the technology's effectiveness could not be proven. Cloud seeding for farming purposes is still used sparingly, however, with 29 states having appropriate project licenses (1).

Mitigating Hurricanes

The concept of weather manipulation expanded in the 1960's when Robert Simpson, then director of the U.S. Hurricane Research Program, suggested that cloud seeding could possibly be used to weaken hurricanes. The theory was that if a hurricane's band of thunderstorms were seeded appropriately, the eye of the hurricane would enlarge and if "the eye grows larger across, the winds spiraling into it would slow, much in the way a spinning ice skater slows when she holds her arms out" (3). This concept is based on the theory that when an area is seeded, the increased moisture is gained from surrounding areas. Thus, seeding the hurricane in appropriate places might remove moisture from the eye, expand its diameter, and hence slow down its wind speeds.

To test this theory in the field, Project Stormfury was created in 1961. Several experiments were done with real hurricanes that showed promising results, the most notable being Hurricane Debbie, which was seeded over five trials in August 1969. During these trials, the peak wind speed decreased from 115 mph to about 80 mph, a 30% reduction, and although the winds eventually returned to their original speeds, repeated seeding continued to have a positive effect (3). Despite these results, the scientists could not be sure that Debbie wouldn't have weakened without seeding, so Project Stormfury eventually died in 1980 with a collection of inconclusive evidence.

Innovations in Storm Dissipation

Storm dissipation has jumped back into the limelight due to a Florida-based company called Dyn-o-Mat. They claimed to have successfully tested a formulated polymer called "Dyn-O-Storm," that is capable of removing clouds from the sky. Dyn-O-Storm works by absorbing water from the storm and turning it into a gel that drops to the ocean. On July 16, 2001, twenty thousand pounds of the storm-busting product were loaded onto a C-130 jet in Palm Beach. That day, team members completely removed a gathering thunderstorm from the atmosphere, the first time such a feat had ever been accomplished (4). The company now hopes to use Dyn-O-Storm to weaken dangerous hurricanes by spreading the powder in cloud layers just outside the eye of the storm. By precipitating moisture out of these outer layers, moisture and energy could be sucked from the eye of the storm, weakening its overall power.

MIT researchers have also joined in on recent storm dissipation efforts. They have proposed spreading a thin layer of vegetable oil on the surface of the ocean. This slick patch would theoretically hamper the exchange of water between sea and air, reducing evaporation and basically cutting the engine of a developing hurricane. Others have suggested that massive mirrors in space might be used to redirect sunlight and alter weather patterns by heating cool pockets (5).

Vladimir Pudov, a Russian scientist, secretly did extensive work on this topic in the 1980's. Recently declassified documents reveal that he sought a substance to dissolve in the ocean and cool the water temperature. He claims to have developed the ideal compound: a low-cost, ecologically safe, fine white powder called carmidol. "Carmidol suppresses evaporation by no less than sixty-five percent," he says. "This leads to a decrease of water-air temperature difference and a decrease of the energy flow into the hurricane" (6).

Using Weather as a Weapon

Besides humanistic goals like drought relief and storm dissipation, governments have also been interested in using weather manipulation as a tactical military weapon. In fact, the U.S. government used cloud seeding to try to flood out critical paths in the Ho Chi Minh trail during the Vietnam War (7). The British Ministry of Defense led its own research efforts with "Operation Cumulus" in the early 1950s. Their list of possible uses for cloud seeding included "bogging down enemy movement", "incrementing the water flow in rivers and streams to hinder or stop

enemy crossings", and clearing fog from airfields (8). Declassified documents also talk of rainmaking having a potential "to explode an atomic weapon in a seeded storm system or cloud. This would produce a far wider area of radioactive contamination than in a normal atomic explosion" (9).

Even as recently as 1996, the United States Air-Force commissioned a report entitled "Weather as a Force Multiplier: Owning the weather in 2025" to forecast the technology needed to maintain US air and space leadership into the next century. The report concludes, "Over the course of the next century, the weather will be our most powerful weapon. Weather modification can provide battlespace dominance to a degree never before imagined. By 2025 it will be within the realm of possibility" (6). According to ABC News, "by creating rain that turns battlefields into mud baths, the military could immobilize enemies. Triggering lightning over airfields would keep hostile aircraft on the ground. Burning through a heavy fog would give U.S. fighter pilots a better view of enemy targets" (7). These ideas are still concepts at best. Furthermore, military advancements into weather manipulation are, of course, classified.

Projects in Development

Weather manipulation has also been used to try to control all other sorts of natural weather phenomena. Eleven countries have done research on using cloud seeding to suppress hailstorms. The National Center for Atmospheric Research in the United States has dedicated $25 million to fund a hail suppression project (10). Other weather manipulation applications still in the theoretical realm include mitigating earthquakes and volcanic eruptions. With respect to earthquakes, rain from cloud seeding can increase the groundwater pressure in an area, reducing the friction along a fracture and thereby inducing small earthquakes in order to prevent a larger one. In addition, dangerous lava flows can be doused with the rain provided by cloud seeding. This rain would cool the lava and force it to spread sideways, slowing or halting the flow altogether. The United Kingdom has even done preliminary research into using weather manipulation for fog dispersal, an idea that would make London a very different place in December (11).

Challenges Ahead

Despite all these promising results and intriguing ideas, the scientific verification of weather manipulation has always been, and will likely remain, its largest critic. This problem is only natural when one thinks of the enormous scale in which this type of research must take place. Collecting weather data across an entire hurricane is both difficult and dangerous. Furthermore, the earth's weather is influenced by an enormous number of factors, which has made it difficult to gain insight into the field of climatology. These variables also make it difficult to prove that weather manipulation is actually causing the changes that eventually ensue. Thus, the scientific research on weather modification projects like cloud seeding continues to be a conglomeration of arguments for and against its actual effectiveness.

A broader issue is whether we want to manipulate our weather in the first place, an issue involving both ethical and practical dilemmas. Trying to manipulate something as ubiquitous as the weather rallies opponents that tout the scientific principle of "The Butterfly Effect." Simply put, this is the idea that small changes can have global impacts. The thought is that "the simple fluttering of a butterfly's wings in, say Singapore, can trigger a chain of events to change the weather thousands of miles away in New York City" (5). Due to the fact that the consequences of weather manipulation are so uncertain, many wonder if it is such a wise idea in the first place. The current benefits might be far out shadowed by future possible harm.

A Stormy, Yet Promising Future

Even though weather manipulation has long been a topic of science fiction, research efforts have come a long way in turning this concept into a reality. The proposed efforts and applications of this technology are as widespread and diverse as the earth's weather itself, and hold a conglomeration of powerful possibilities. From controlling rainfall for a variety of purposes to stopping destructive storms, the benefits to the world are extremely promising. However, many obstacles, be they ethical, logistical, or economical must first be dealt with. In light of the potential benefits of weather manipulation , the scientific community and the public must proceed with both current costs and future impacts in mind.

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