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## **The Regulation of Geoengineering - Science and Technology Committee [Contents](#)**

### **Memorandum submitted by Dr James Lee (GEO 01)**

#### 1. SUMMARY OF MAIN POINTS

Cloud seeding is a geo-engineering tool that is widely used by more than 30 countries. With climate change, fresh water resources will be in decline in many parts of the world, particularly around the equator. One result may be an increase in the use of cloud seeding. As cloud seeding becomes more effective and widely disseminated, it may be a factor in conflict situations or a reason to precipitate conflict. Disputes over cloud seeding could fall under the Environmental Modification Treaty.

#### 2. BRIEF INTRODUCTION ABOUT ME

I currently hold administrative and faculty positions at American University. Prior to that, I have worked at the U.S. Trade Representative and U.S. Environmental Protection Agency.

#### 3. FACTUAL INFORMATION

Most recently, I am the author of *Climate Change and Armed Conflict* (Routledge, 2009), "Global Warming Is Just the Tip of the Iceberg", *Washington Post*, 4 January 2009, and "A Brief History of Climate Change and Conflict", *Bulletin of the Atomic Scientists*, 14 August 2009. I also run the website, *Inventory of Conflict and Environment*. <http://www1.american.edu/tesd/ICE/index.html>

#### 4. RECOMMENDATIONS

There needs to be a better understanding of the modes for cloud seeding and its impacts. A beginning point would be a multilateral registry of cloud seeding events with information and data collection on key characteristics.

##### 1. CLIMATE CHANGE AND CLOUD SEEDING

Countries will take measures to counteract and adapt to climate change, namely trends of declining precipitation and increasing temperature. There will be a great temptation and need to use cloud seeding, the oldest and most common form of environmental modification (a type of geo-engineering). Cloud seeding is an issue regarding fresh water resources, rights, and obligations. As with other water issues, cloud seeding can be a source of dispute. Climate change will cause differing regional impacts and thus a variety of motivations for cloud seeding.

It is important to distinguish between climate change and weather, since cloud seeding is more likely to affect the latter. Weather is a state of the atmosphere over the short-term and more likely at specific points and places. Climate is a long-term phenomenon expressed as average weather patterns over a long period. Cloud seeding could affect climate when carried out over a long period. Key measures of weather and climate are precipitation and temperature.

The line between hostile and peaceful uses of cloud seeding (and environmental modification in general) is extremely thin and at times ambiguous. One country in the

midst of a severe humanitarian emergency may perceive cloud seeding as a benevolent act. A neighbour country, encountering the same drought and humanitarian crisis, may perceive their lack of rain as being "stolen" by their neighbour. The key word here is "hostile", which of course is in the eye of the beholder.

## 2. THE ENVIRONMENTAL MODIFICATION (ENMOD) TREATY

During the Cold War, the United States and the Soviet Union explored differing Weapons of Mass Destruction (WMD) that included the use of nuclear, biological, and chemical devices. In 1945, the mathematician John von Neumann met with other U.S. scientists to discuss the possibility of deliberately modifying weather (a new WMD) as a tool of war (von Neumann, 1955). Weather modification was one way to destroy Soviet agricultural harvests, cause mass starvation, harm their economy, and incite internal dissension. The goal was to make the Cold War very cold.

There was widespread use of geo-engineering during the Vietnam War. Between 1967 and 1972, the United States ran Operation Popeye, a cloud seeding operation to disrupt transport of military supplies along the Ho Chi Minh trail and aimed at parts of South and North Vietnam, Laos and Cambodia. The operation occurred during the dry season when it was ordinarily easiest for the North Vietnamese to move men and materials south. While the program was successful in causing heavy rains out of season, it was not successful in stopping the flow of men and materials southward. Heavy rains attributed to the cloud seeding program led to catastrophic floods in 1971 that caused a poor harvest in North Vietnam.

The disclosure of Operation Popeye led many to realize that such a tactic took the idea of "all-out war" to a new level, and one that was disturbing. As a result, in 1977 countries agreed to the "Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques" (ENMOD). The treaty forbids the use of environment in hostile circumstances and supports the use of weather modification for peaceful purposes. Climate change is but one of a number of environmental phenomena covered by this treaty.

Earthquakes, tsunamis; an upset in the ecological balance of a region; changes in weather patterns (clouds, precipitation, cyclones of various types and tornadic storms); changes in climate patterns; changes in ocean currents; changes in the state of the ozone layer; and changes in the state of the ionosphere.

### (Convention on the Prohibition of Military or Any Other Hostile Use of Environmental

Modification Techniques 1978)

A re-confirmation of the ENMOD principles occurred at the Framework Convention on Climate Change (UNFCCC) and the 1992 Earth Summit in Rio de Janeiro. The statement suggests far-reaching implications in the jurisdiction of a nation's sovereign area.

"States have... in accordance with the Charter of the United Nations and the principles of international law, the (...) responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction." (UNFCCC, 1992)

Most techniques covered by the ENMOD treaty are quite speculative. Causing earthquakes or tsunamis is far beyond the capacity of current technology. Cloud seeding, on the other hand, is a technology that is often used.

No country has invoked ENMOD, but cases have been possible candidates. During the 1991 Gulf War Iraqi forces burned oil wells on a large scale, placing huge amounts of particulates in the air that may have affected weather patterns in neighbor countries. Iraq also polluted the Persian Gulf with oil that did cause environmental damage to other states, upset the ecological balance in a region, and led the mass sea life destruction.

## 3. A BRIEF HISTORY OF cLOUD sEEDING

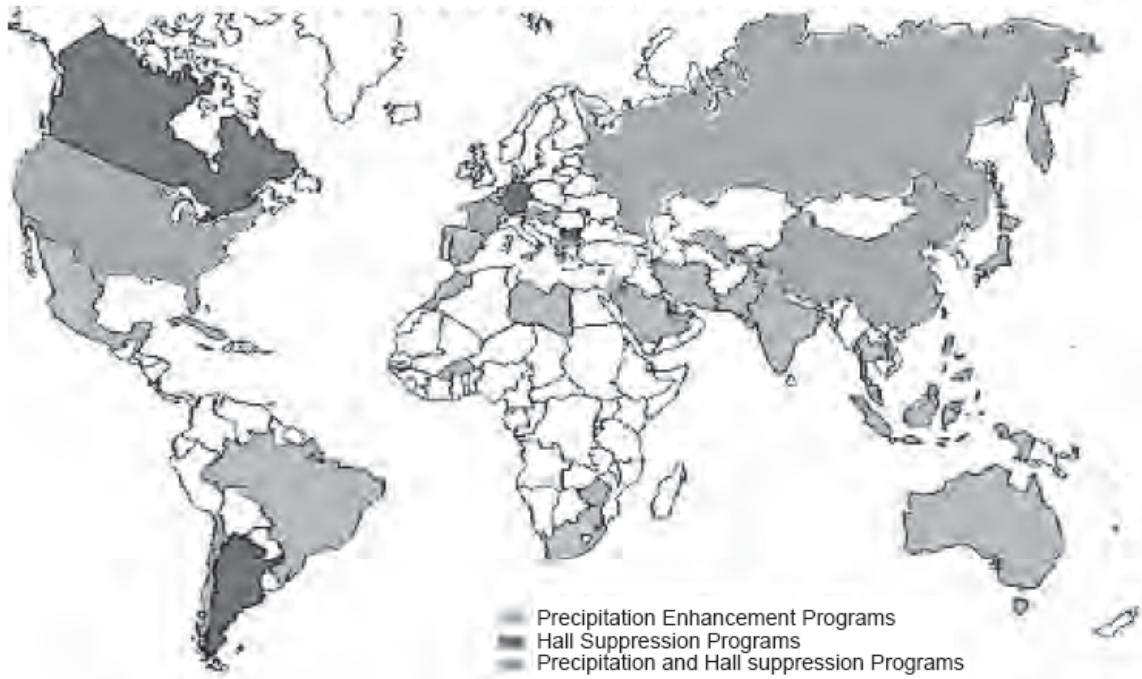
Cloud seeding is one of several rainmaking techniques. The first scientific demonstration of cloud seeding occurred in 1946 in the United States. The use of cloud seeding has substantially grown over the last half century.

There is nonetheless controversy over the efficacy of cloud seeding. While many countries report successes, the U.S. National Academy of Science, National Research Council, published a study in 2003 that questioned the utility of cloud seeding and the extent of impacts outside of local areas. The report called for greater research into practices for understanding and improving cloud seeding effectiveness. The reality is that many countries practice cloud seeding and believe it works. Regardless of the scientific debate, the perception of the viability of cloud seeding can lead to dispute.

Cloud seeding causes precipitation by introducing substances into cumulus clouds that cause condensation. Most seeding uses silver iodide, but dry ice (solid carbon dioxide), propane, and salt are also used. At least 30 countries have identified programs and some, like China and the United States, have extensive programs (See Figure 1). Most countries that practice cloud seeding are parties to the ENMOD treaty, but China is not.

### Figure 1

## Weather Modification Around the World

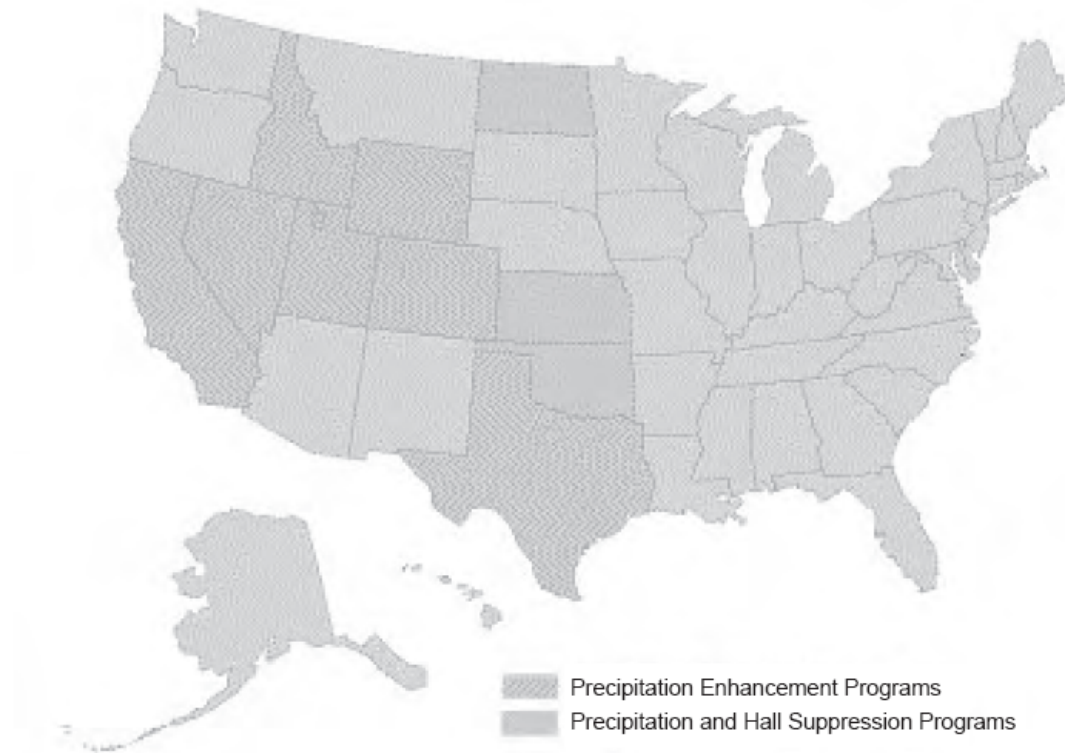


*("Overview of Weather Modification Programs Around the World", National Center for Atmospheric Research)*

There has been extensive use of cloud seeding in the United States (see Figure 2), largely in the southern states near the Mexican border. Programs concentrate on two geographical areas. First, there are several south central states, such as Texas, prone to dry conditions in the summer or during spring planting. Hail suppression is a concern in Kansas and Oklahoma. The other major nexus of use is the states in the Colorado River Basin, including Colorado, Wyoming, Utah, Nevada, and California, who use it to increase winter snowpack. North Dakota seeds clouds for hail suppression and Idaho for increasing fresh water resources.

**Figure 2**

### Weather Modification in the United States



*("Overview of Weather Modification Programs Around the World", National Center for Atmospheric Research)*

*("Overview of Weather Modification Programs Around the World", National Center for Atmospheric Research)*

The year that the Katrina and Rita hurricanes devastated the U.S. Gulf Coast, Senator Kay Bailey Hutchinson of Texas introduced S. 517 [109th Congress] the "Weather Modification Research and Development Policy Authorization Act of 2005". It calls for greater research and development into cloud seeding (Section 5, "Duties of the Board") with two key goals. (The measure has never become law.)

- (1) improved forecast and decision-making technologies for weather modification operations, including tailored computer workstations and software and new observation systems with remote sensors; and
- (2) assessments and evaluations of the efficacy of weather modification, both purposeful (including cloud-seeding operations) and inadvertent (including downwind effects and anthropogenic effects).

The United States began technical assistance on cloud seeding to the Mexican state of Coahuila in 1996. Canada uses cloud seeding for hail suppression while Brazil, Argentina and Cuba use it for precipitation enhancement. In November 2009, Venezuela began cloud seeding operations after El Niño conditions led to droughts and water rationing in Caracas. Cuba provided technical assistance to Venezuela in carrying out the program.

China's cloud seeding program is the largest in the world, using it to make rain, prevent hailstorms, contribute to firefighting, and to counteract dust storms. On New Year's Day in 1997, cloud seeding made snow in Beijing, for probably no other reason than popular enjoyment. During the 2008 Olympics, China extensively used cloud seeding to improve air quality. China sees cloud seeding as part of a larger strategy to lower summer temperatures and save energy.

The Soviet Union and later Russia use cloud seeding to assure good weather during political events, such as a rain-free May Day parade. To save money, the mayor of Moscow proposes use to lessen winter snowfall in the city.

Employing cloud seeding in emergencies illustrates how perceptions of impact may differ. Soviet air force pilots seeded clouds over Belarus after the Chernobyl nuclear disaster of 1986 to prevent radioactive clouds from reaching Moscow and other major populated areas. (Grey, "How we made the Chernobyl rain", 2007). While Moscow saw benefit, Belarus surely did not.

Many Middle Eastern countries are natural candidates for cloud seeding. France conducted tests in Algeria as early as 1952. Libya began testing in 1971, Jordan in 1986, Iraq under Saddam Hussein in 1989, and Syria in 1991. Israel has a long-standing cloud seeding program. Saudi Arabia has experimented with cloud seeding, beginning in 1990 and is increasing its programs, particularly in the southwest portion of the country near the Yemen border.

Iran has long experience with cloud seeding, especially around Yazd, the driest major city in Iran. "Statistical evaluation of the effectiveness of regular cold-cloud seeding operation, carried out over the project territory in the Central part of Iran during the period of operation, shows that from 0.7 to 1.9 km<sup>3</sup> of additional water was obtained about 22-40% of the natural seasonal precipitation annual." (Khalili, "Results of Cloud Seeding Operations", 2008)

#### 4. HOSTILE AND PEACEFUL USES OF ENMOD

Article I of the ENMOD treaty requires members "not to engage in military or any other hostile use of environmental modification techniques having widespread, long-lasting or severe effects as the means of destruction, damage or injury to any other State Party". The general intent of the treaty is to limit the use of ecology in a military context. It distinguishes between weather related actions (short-term) from those that are climate related (long-term). The key word of course is "or", meaning any one of the three is sufficient to cause a treaty violation. The "Understanding Relating to Article I" provides the three indicators of environmental modification covered by the treaty and *de minimus* levels of impact.

(a) widespread: encompassing an area on the scale of several hundred square kilometers;

(b) long-lasting: an act whose duration lasts months, or approximately a season; and

(c) severe: involving serious or significant disruption or harm to human life, natural and economic resources, or other assets.

The treaty is clear on what it forbids: widespread, long-lasting, or severe environmental modification. It is thus quite revealing to consider what the treaty allows. It does permit cloud seeding (or other actions) that may adversely affect a neighbour so long it is undertaken without a military or hostile intent. Further, military personnel could carry out a non-hostile action as long as it was without military intent. The treaty permits weather modification by the military even with a hostile intent when it is localized, short-term, and produces positive outcomes. These exceptions obviously can lead to ambiguity in real situations.

First, widespread refers to the geographic scope covered by the treaty. Treaty violations occur when impacts exceed 300 square kilometers (or 186.4 miles), so a square of roughly 17.3 kilometers (or 10.7 miles) in length and width. Washington, DC (a partial square city) is 177 square kilometers in comparison, so these are not extremely large areas but they could be home to millions of people.

The second concept is long-lasting, denoting time duration. One season corresponds to about three months. The chosen months however would produce differing impacts. If cloud seeding occurred during a planting season, it would mean the loss of an entire year of production. If cloud seeding occurred in the winter, to build snow pack for example, the impact may be benign or even positive.

The third premise focuses on a severe disruption to the environment and may be the most difficult concept to pinpoint. Specific indicators might use socio-economic indicators (such as income) or human health markers (such as infant mortality). A violation might significantly reduce ecological, economic or health indicators. A full understanding of impacts may not occur until long after the act occurred.

The treaty references assisting other countries in transferring technology related to the development of harmful or hostile ENMOD techniques. This implies the trade of materials, equipment, technology, or expertise. Export technology treaties cover materials that may have military application as dual-use technologies. The ENMOD Treaty suggests that exports of cloud seeding technologies may as well fall into such categories.

## 5. BUILDING A MULTILATERAL REGISTRY OF CLOUD SEEDING EVENTS

ENMOD Article III, 2. The States Parties to this Convention undertake to facilitate, and have the right to participate in, the fullest possible exchange of scientific and technological information on the use of environmental modification techniques for peaceful purposes.

Little scientific exchange seems to have resulted from the ENMOD Treaty. Exchanging information is of course a first step in a confidence building process in the development of a treaty and its understandings. In cases of environmental modification, collecting information on activities is a necessary beginning point, starting with cloud seeding. A multilateral cloud-seeding registry, that is voluntary, can begin to reduce possible future ambiguities over weather modification by compiling and releasing reports of country activity.

Registry information could include detail on the clouding seeding event, starting with the scope, intensity, and particular economic impacts on human health and economy. Countries might also report the type of chemical used to induce rain and the subsequent precipitation amounts in target and adjacent areas. The data collected might also include specific indicators of widespread, long-lasting, and severe impacts. The registry could be open to non-signatories. Countries that have not joined ENMOD Treaty include China, France, Nigeria, Indonesia, Spain, Mexico, South Africa, and Saudi Arabia.

As climate change and technology proceed, the desire and the ability to claim fresh water will extend into the atmosphere and far underground. The registry may be a means to offer transparency to uses of cloud seeding and avoid ambiguities that may be the basis for dispute.

## REFERENCES

Cotton, W R, and R A Pielke, Sr., 2007, *Human Impacts on Weather and Climate*. Cambridge University Press.

Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques 1978.

Richard Gray, "How we made the Chernobyl rain", 22 April 2007, Telegraph, <http://www.telegraph.co.uk/news/worldnews/1549366/How-we-made-the-Chernobyl-rain.html>.

Morteza Khalili Sr., M Seidhassani, F Golkar, and V Khatibi, "Results of Cloud Seeding Operations for Precipitation Enhancement in Iran during 1999-2007", *Planned and Inadvertent Weather Modification/Weather Modification Association*, 22 April 2008. [http://ams.confex.com/ams/17WMModWMA/techprogram/programexpanded\\_492.htm](http://ams.confex.com/ams/17WMModWMA/techprogram/programexpanded_492.htm).

National Academy of Science, National Research Council, *Critical Issues in Weather Modification Research*, 2003.

"Overview of Weather Modification Programs Around the World", National Center for Atmospheric Research [http://www.rap.ucar.edu/general/press/presentations/wxmod\\_overview/index.html](http://www.rap.ucar.edu/general/press/presentations/wxmod_overview/index.html)

UN Framework Convention on Climate Change, New York, 1992. [http://www.unfccc.de/resource/conv/conv\\_002.html](http://www.unfccc.de/resource/conv/conv_002.html).

Von Neumann, J, 1955, "Can We Survive Technology?" *Fortune*: 504-519.

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