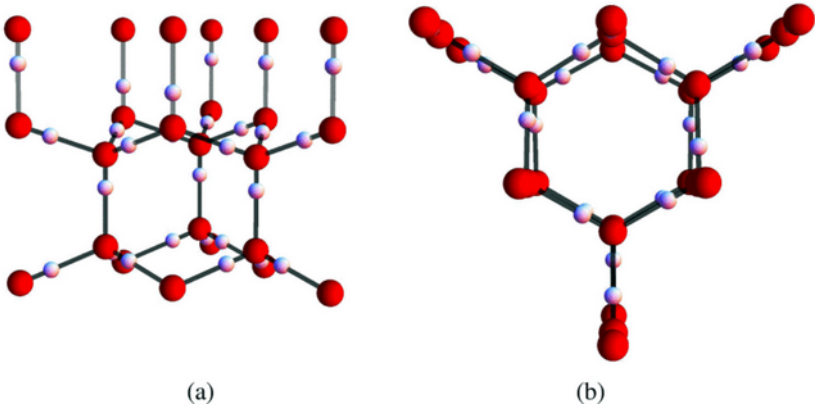
More Recent History of Weather Modification

- Silver Iodide (AgI) is very close.
- AgI has a hexagonal crystal lattice structure.
- The spacing between molecules in AgI is very close to the spacing between molecule in ice.

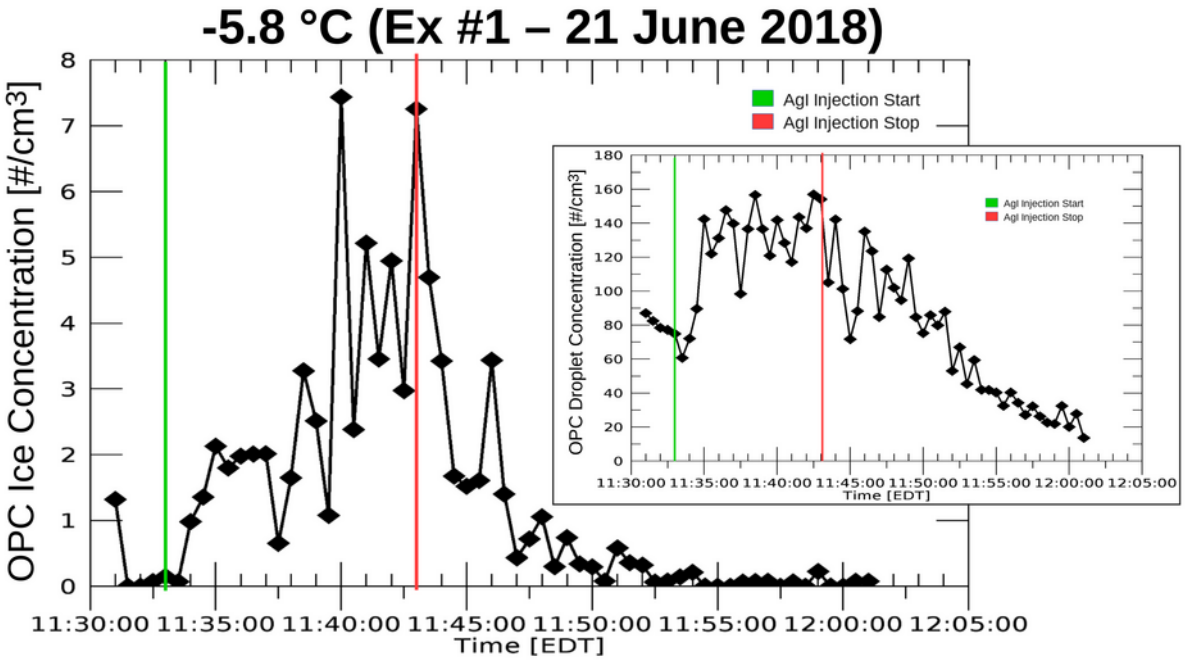


Crystal structure of hexagonal (Ih) water ice. Water ice can be viewed as a frozen configuration of water molecules, satisfying the Bernal-Fowler “ice rules” [1, 2], in which each oxygen (red sphere) forms two short, covalent bonds, and two long, hydrogen bonds with neighboring protons (white spheres). Oxygen atoms form an ordered lattice, belonging to the hexagonal space group P63/mmc, with a four-site primitive unit cell. Protons do not show any long-range order. (a) Structure viewed perpendicular to the hexagonal symmetry axis (the crystallographic c axis). (b) Structure viewed along the hexagonal symmetry axis.

Benton, Owen & Sikora, Olga & Shannon, Nic. (2015). Electromagnetism on ice: classical and quantum theories of proton disorder in hexagonal water ice. Physical Review B. 93. 10.1103/PhysRevB.93.125143.

Does it Work?

- AgI turned out to be quite effective as a nucleating agent.
- AgI would form ice crystals in the cloud at temperatures as warm as -5 degrees Celsius.



Results from an experiment designed to test ice nucleation of Silver Iodide cloud seeding flares using the Pi Cloud Chamber.

Delene, David J., Kyle Pederson, Bruce Boe, and Charlie Harper, An Experiment Designed to Test Ice Nucleation of Silver Iodide Cloud Seeding Flares using the Pi Cloud Chamber, Presentation given (2:00 pm on Wednesday 24 April 2019) at the 2019 Weather Modification Association Annual Meeting in Phoenix, Arizona.

The “Big Three”

- Foreground: Vincent Schaefer
- Left: Irving Langmuir
- Right: Bernard Vonnegut

Summary of the Results

Can We Make Rain?

Certainly, but it may not be cost-effective.

Can We Make Rain Cost-Effectively?

This is a lot more difficult.

It can be done if there is a weak link in the process that we can change with a small amount of effort.

The Weakest Link for Precipitation Formation?

- The early Schaefer experiments identified a potential weak link in the rain-making process.
- The existence of supercooled liquid water in clouds could be changed to precipitation with the addition of a small amount of “seeding material”.

The Answer to Water Shortages

- The development of AgI as a seeding agent made it possible to release material from the ground and influence large volumes of air.
- Hence, seeding could be done economically on a large scale.

Off to the Races

- Everyone (almost) started getting into the cloud seeding business.
- By 1950, about 10 % of the land area of the U.S. was under contract to cloud seeding firms.
- Great claims were being made about the effectiveness of the operations.

The Periodic Seeding Experiment

- Project Cirrus, a research project at GE Research Labs.
- Seeding from the ground in New Mexico several days each week.
- Analysis of rainfall patterns across the U.S. indicated a seven-day periodicity in various weather elements.

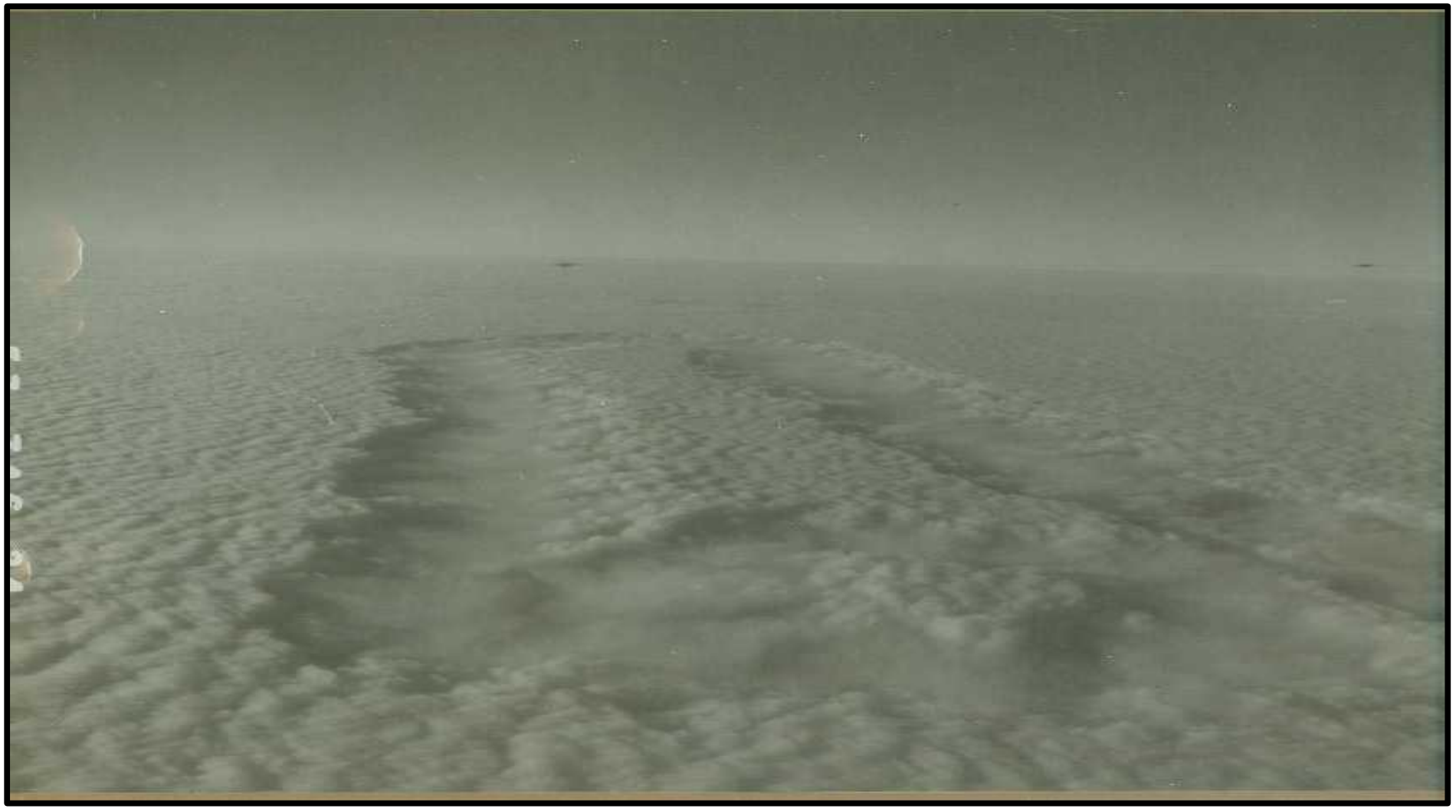
The Skeptics

- How do we know that these alleged seeding effects would not have happened naturally?
- Do we know that Schaefer's original cloud experiment was the result of the dry ice or something different?

The Skeptic Carneades

https://factsanddetails.com/world/cat56/sub401/entry-6219.html

The Answer → Great Racetrack Demonstration



Quasi-believers

- Generally, even the most skeptical came to believe that the microphysical properties of the clouds could be changed by seeding.
- However, the question of additional precipitation at the ground had not been clearly demonstrated.

Experiments, and More Experiments

- The periodicity experiment was brought into question since seven-day periodicities in weather elements had been observed with data prior to this experiment.
- The claims of additional precipitation in seeded areas were not regarded as proof due to the high rainfall variability.
- Needed to demonstrate the effects clearly.

Delene, David J., Kyle Pederson, Bruce Boe, and Charlie Harper, An Experiment Designed to Test Ice Nucleation of Silver Iodide Cloud Seeding Flares using the Pi Cloud Chamber, Presentation given (2:00 pm on Wednesday 24 April 2019) at the 2019 Weather Modification Association Annual Meeting in Phoenix, Arizona.

The Hydro-illogical Cycle

"Interest in weather modification is soluble in water." (Archie Kahan)

Drought Response