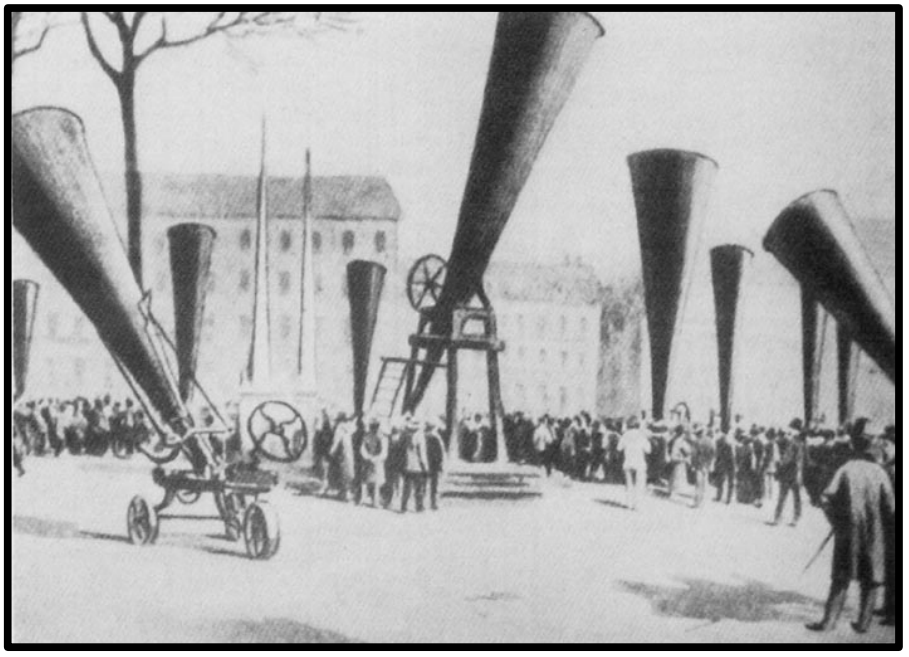
# History of Weather Modification

- Many early attempts at modification of the weather.
- Generally, no scientific basis until 1940's.
- Work done at General Electric Research Labs in New York.



Hail cannons at an international congress on hail shooting held in 1901.

# General Electric Research

- Experiments during WWII dealing with Aircraft Icing
- Directed by Irving Langmuir
- Also in the group were Vincent Schaefer and Bernard Vonnegut

Wilson Hunter, the Head of the Icing Research Section is shown demonstrating the dangerous icing of the propellers of a P-39 after a wind tunnel test. General Arnold (left) and George Lewis (far left).

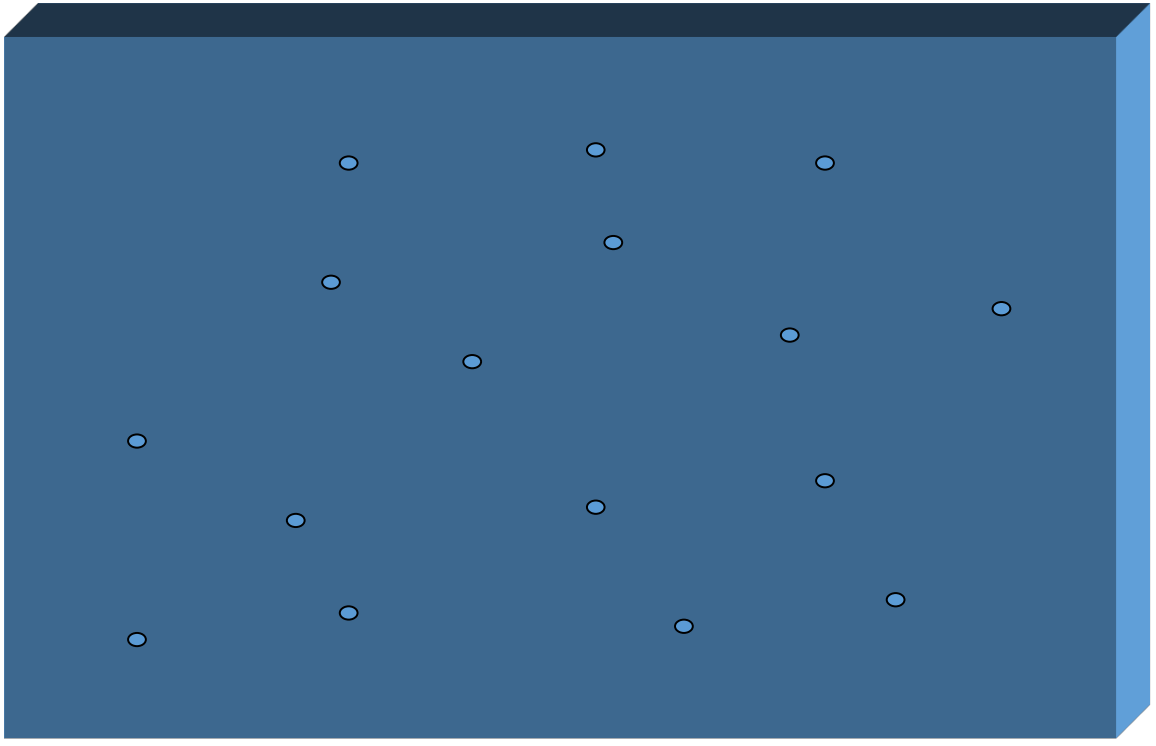
# Important Results

- Concept of Supercooled Liquid Water (important component of aircraft icing)
- Cold Box Experiments

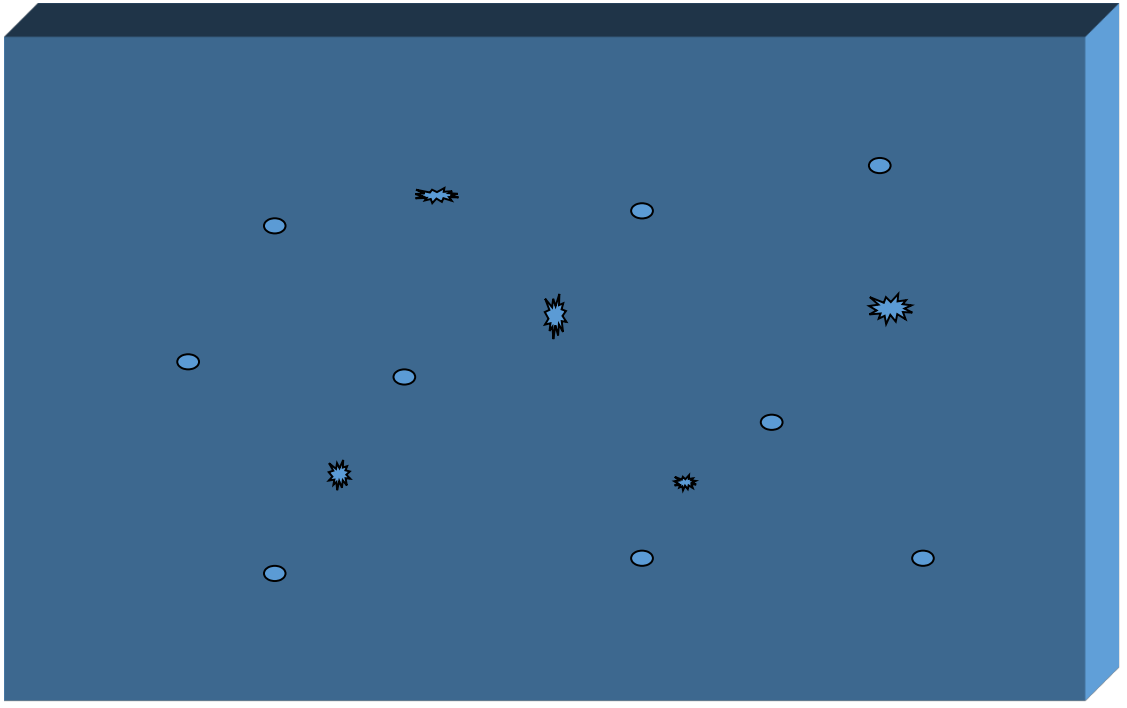
How cold can supercooled liquid droplets be in the atmosphere?

Photo of a hole punch cloud and the associated fall streaks, taken on the east side of Madison, WI, at 11:20 AM CST on Sunday, November 7th. By Tim Wagner

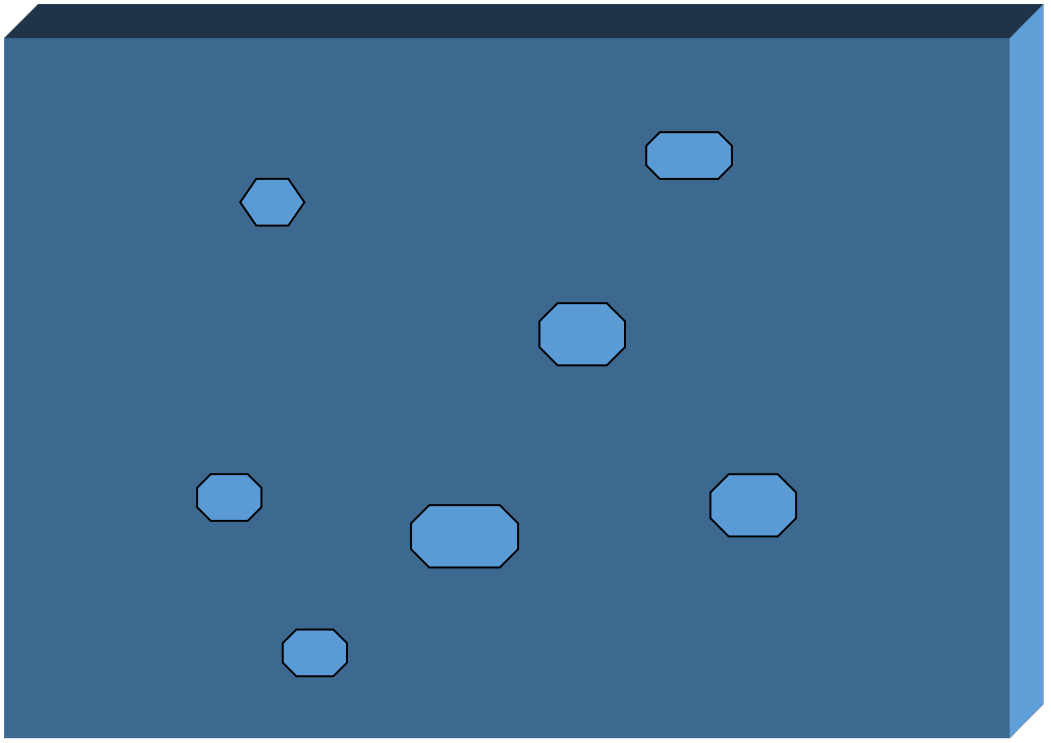
# Supercooled Cloud Formed in Chest Freezer



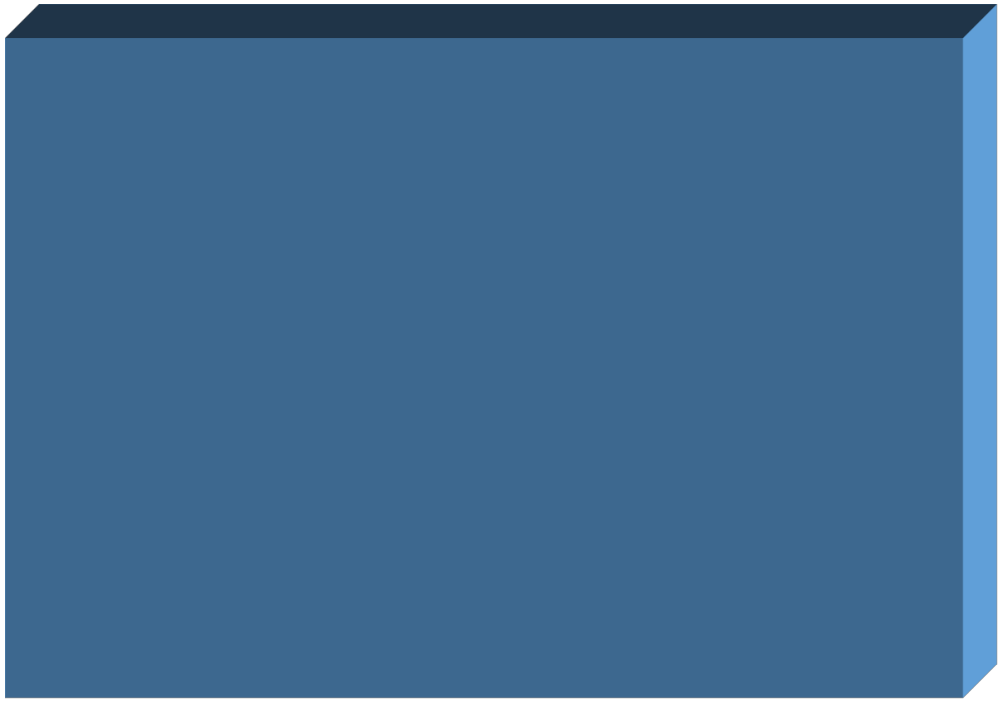
# Dry Ice Introduced to the Supercooled Cloud



**In time, the water droplets disappeared and the ice crystals grew large.**



**As time continued, the large ice crystals fell out, leaving only the ice at the bottom of the box and no cloud**



# So What?

- Why did this happen?
- Could I make this work to my advantage?

# Would this happen in a real cloud?

- This question was addressed and finally tried November 13, 1946.
- Vincent Schaefer dropped about 1.5 kg of dry ice into stratiform cloud in western Massachusetts.

# What Happened?

- A hole appeared in the cloud
- Ice crystals fell from the base of the cloud
- Ice crystals fell about 600 m below cloud base before sublimating in the dry air below cloud base.

# Meanwhile, back at the Ranch...

- The mechanism causing this phase change was being investigated
- Bernard Vonnegut proposed a different method to achieve the same result**s**

# The Concept

- Once an ice crystal formed, it would continue to grow
- If a crystal is introduced that looks like an ice crystal, ice would continue to grow on that crystal
- Are there any substances that have a crystal structure similar to that of ice?

# YES

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

# 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

# The “Big Three”

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

# 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?

- 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

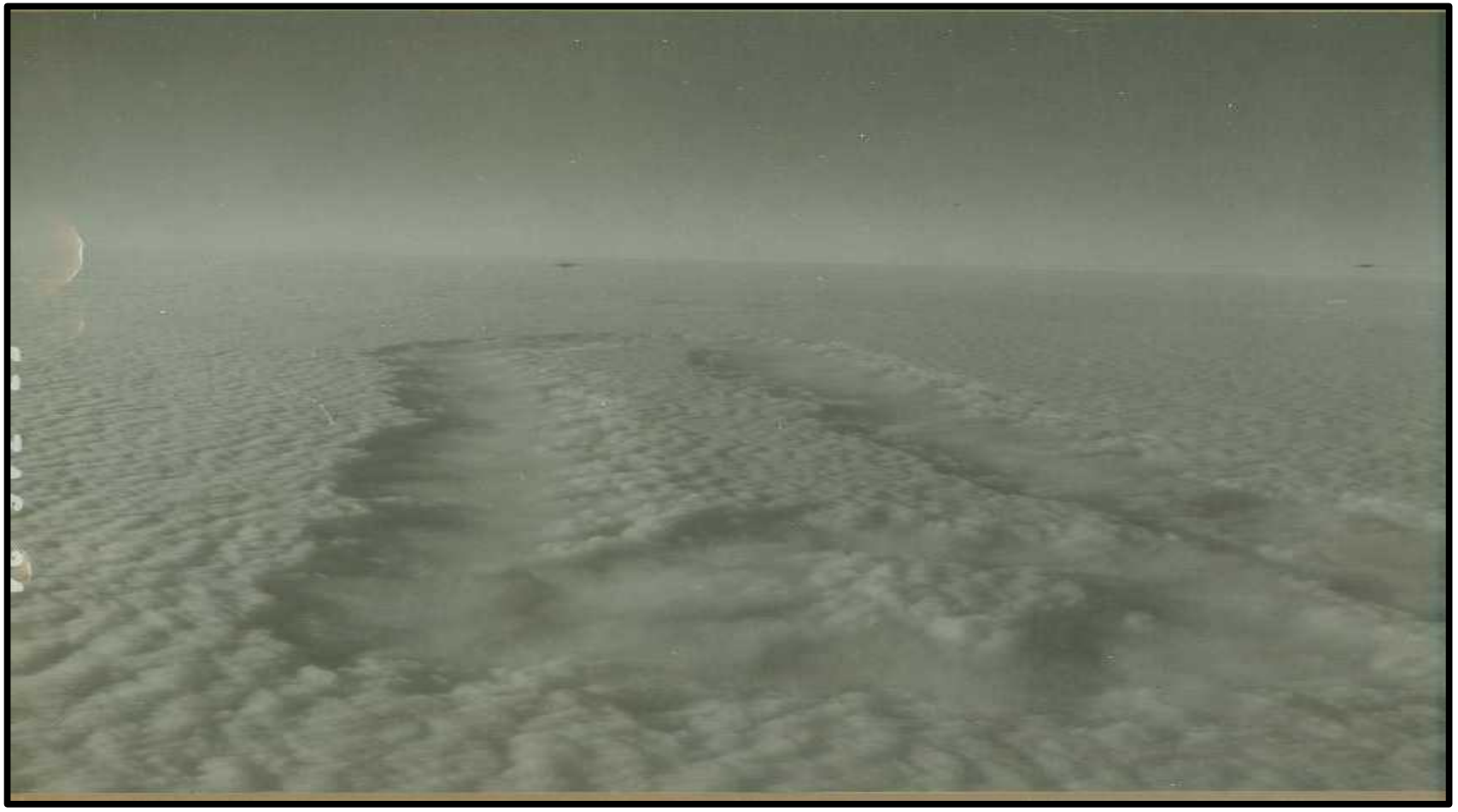
# The Periodic Seeding Experiment

- 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 Answer



**The 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, 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 wild variability of rainfall.
- Needed to demonstrate the effects clearly.

# The Hydro-illogical Cycle

- “Interest in weather modification is soluble in water.” (Archie Kahan)

## Drought Response