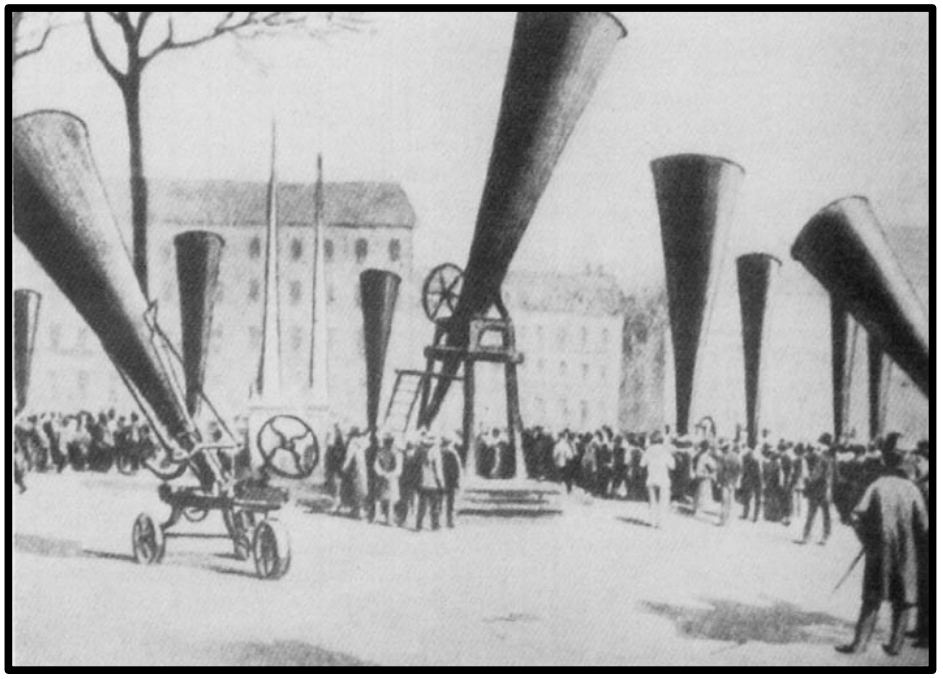
Early History of Weather Modification

- 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.



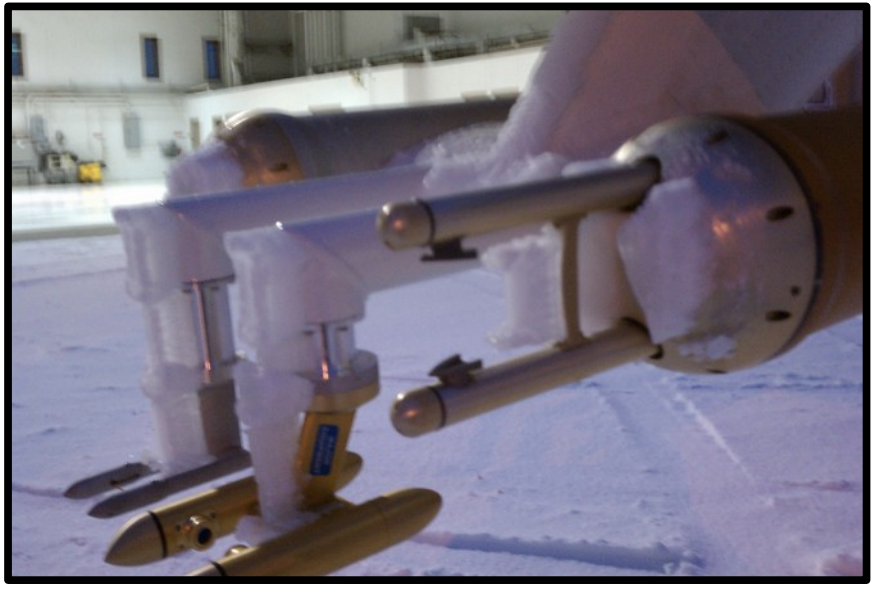
Hail cannons at an international congress on hail shooting held in 1901.

General Electric Research

- Experiments during World War II were conducted dealing with aircraft icing.
- Aircraft icing experiments directed by Irving Langmuir.
- Additional group involved 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).

Aircraft Icing: Still a Research Topic



Icing of Cloud Probes on the Citation Research Aircraft after November 24, 2010 flight.

Rosemount Icing Detector probes on the fuselage and on hot-wire boom under the left wing of P-3 aircraft for NASA IMPACTS 2023 field project.

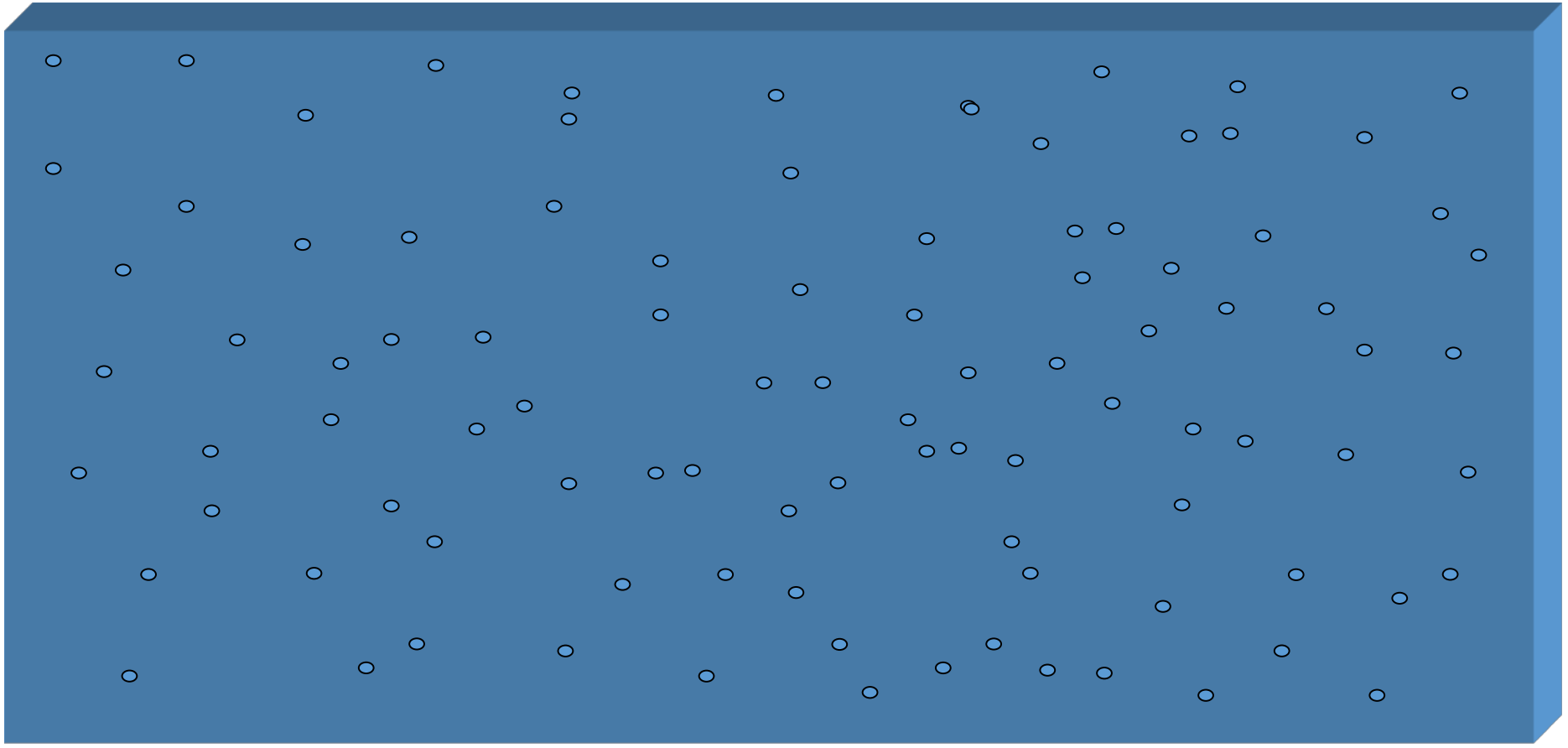
Important Early Results

- Concept of Supercooled Liquid Water (important as for 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



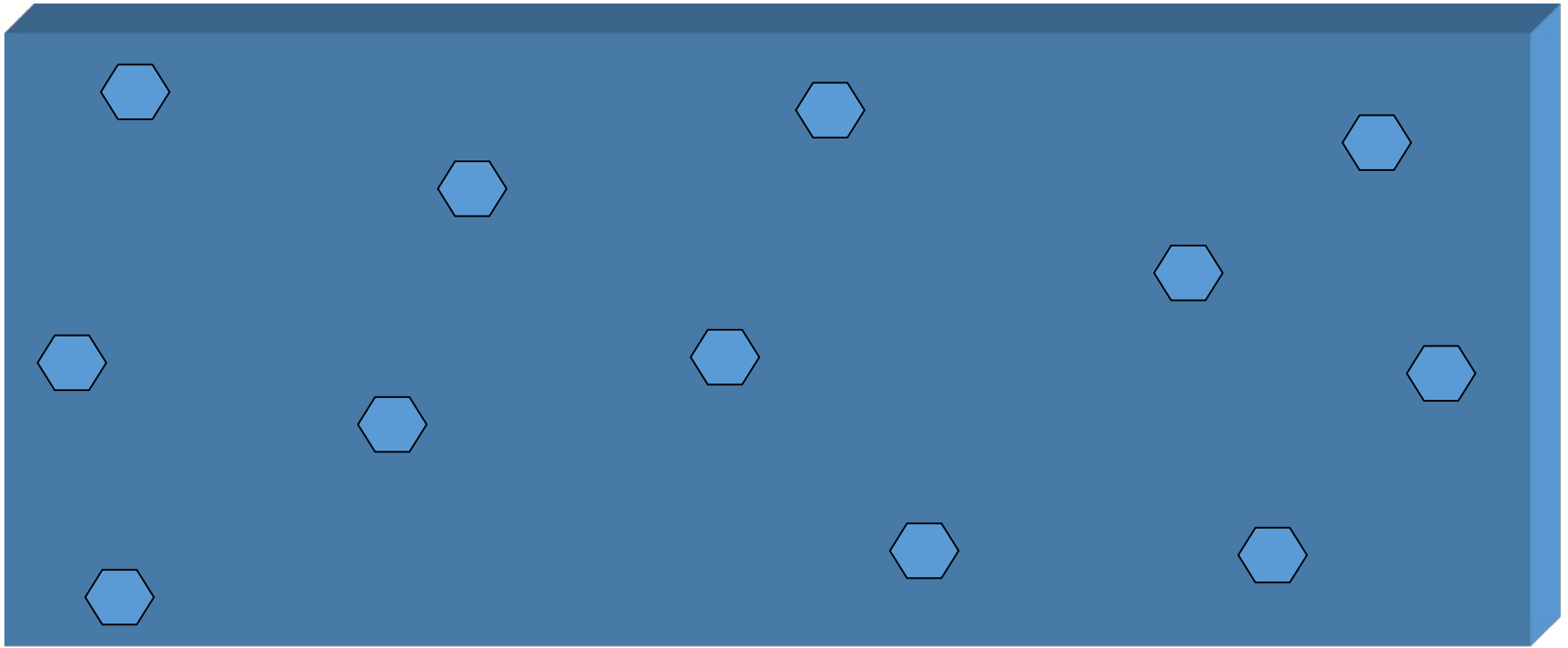
- Droplets

Dry Ice Introduced to the Supercooled Cloud

Droplets

Small Ice Crystals

In time, Water Droplets Disappear and Ice Crystals Grew Large



Large Ice Crystals

After more time has pasted,
the large ice crystals fell out,
leaving only the ice at the bottom and no cloud.

Pi Cloud Chamber Experiment

Videos Website Link

June 21, 2018 – **3:14**

0:23 - Injection starts.

1:14 - Start to see some ice.

2:16 - More turbulent eddies.

2:33 - Ice is becoming more prevalent.

3:52 - In the upper right corner, a large dark area.

5:22 - Ice continue to increase.

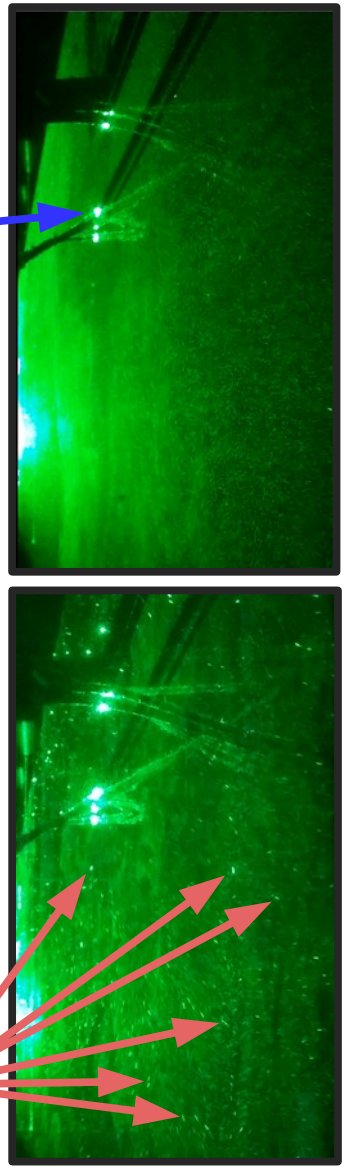
7:00 - Water drops depleting as more dark spots apparent

8:37 - Very little super cooled drops left.

9:06 – Lot of the ice particles apparent.

9:33 - Water drops increasing.

10:15 - Chamber mainly ice particles.



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 in the great racetrack demonstration

What likely is the cause of the hole observed in the image above?

What was the result of putting dry ice into stratiform cloud in western Massachusetts?

- 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.

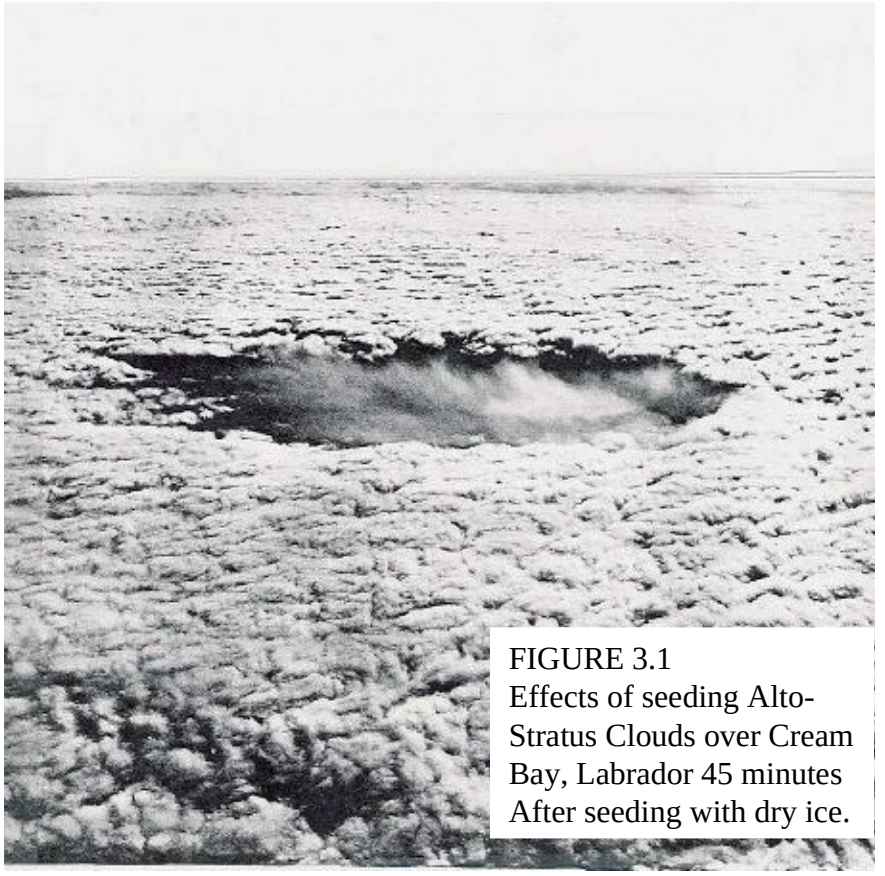


FIGURE 3.1
Effects of seeding Alto-Stratus Clouds over Cream Bay, Labrador 45 minutes After seeding with dry ice.

Meanwhile, back at in the laboratory

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

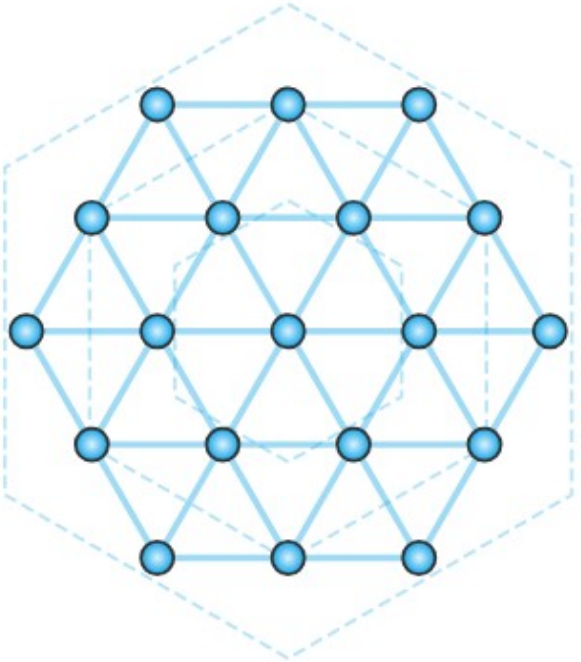
What alternative method for cloud seeding did Bernard Vonnegut propose?

Early History: Summary of the Concept

- Supercooled water droplets can exist to -40 °C.
- Once an ice crystal formed, it would continue to grow.
- If a crystal is introduced that looks like an ice, the ice will continue to grow on that “seed” crystal.

Are there any substances with crystal structure similar to ice?

Ice (Ih)

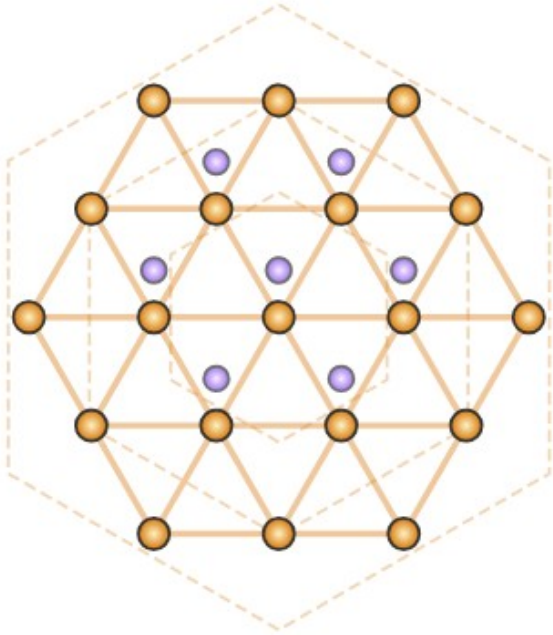


Oxygen (O) Hexagonal Lattice
a=4.52 Å c=7.36 Å

Silver Iodide Structure

- **Lattice Match:** The 'a' parameter differs by only 1.3% (4.52 Å vs 4.58 Å)
- **Hexagonal Symmetry:** Both structures share the same hexagonal crystal system crystal.
- **Surface Template:** AgI provides an ideal template for ice crystal formation at temperatures as warm as -5 °C.

Silver Iodide (β-AgI)



Silver (Ag) Iodide (I^-)

Hexagonal Lattice

a=4.58 Å c=7.49 Å