Hail Suppression Conceptual Models



July 8, 2013 - Courtesy of NWS Gaylord.

Calgary, August 2, 2018 Courtesy of Darren Howard and Dan Gilbert

Vivian Hail Stone (Largest in the World)

- Diameter:
 - 8 inches (20.32 cm)
- Weight:
 - 1.94 pounds (0.88 kg)
- Location:
 - Vivian, South Dakota
- Habitat:
 - July 23, 2010



Source: https://largest.org/nature/hailstones/

Hail Formation Processes

- Formed by riming an ice crystal over an extended time period.
- Hail particle needs to remain in cloud to continue to accumulate supercooled liquid water.
- Hail particle must remain in substantial updraft in order to remain in cloud for the necessary time for growth.



Soft rime form white ice deposition from droplets. http://atmosgallery.atmos.und.edu/TreeIcing_120203



Structure of Updraft in a Convective Cloud



Hail Formation

As hailstone grows, it falls to a region of higher updraft speed, where it remains in balance with its terminal velocity.



Updraft Speed

Unsuccessful Hail Formation

Growing hailstone cannot remain suspended in cloud below the point of maximum updraft.



Updraft Speed

Hail Formation Requires

- Large updrafts.
- Supercooled liquid water in upper parts of storm.
- Very few ice particles in upper parts of storm.

Aurora, Nebraska 7 inches 1.33 pounds



Source: https://largest.org/nature/hailstones/

Hail Formation

Precipitation Development Zones



Thunderstorm – Strong Updraft



Hail Embryo



Wet Growth



Dry Growth



Hailstone Growth Types



Growth Type Regions





Final Descent



Melting



Hail Suppression

- Not much attention paid to hail suppression until 1960s.
- Russians claimed great success with a hail suppression program.
- This started the National Hail Research Experiment (NHRE) in the US.



Coffeyvlle, Kansas: 5.7 inches, 1.67 pounds Source: https://largest.org/nature/hailstones/

Soviet Hail Suppression Program

- Utilized artillery shells targeted by weather radar.
- Many questions regarding how the operations were carried out and the statistics that were reported.



Southwest Germany: 5.5 inches, 0.79 pounds Source: https://largest.org/nature/hailstones/

National Hail Research Experiment (NHRE)

- Attempt to replicate the Soviet results.
- A number of things were different, including the seeding material used and the manner in which the seeding material was dispensed.
- Was a dismal failure, as far as getting the same results as were reported by the USSR.



Colorado 4.83 inches, 0.53 pounds

https://www.weather.gov/gld/8132019CORecordHailstone

Hail Suppression Conceptual Models

- Why does hail cause damage?
- What might be done to reduce hailstorm damage?



Conceptual Models for Hail Suppression

- Complete Glaciation of Cloud Water
- Competing Embryos.
- Trajectory Lowering.
- Promotion of Coalescence.
- Dynamic Effects.



Complete Glaciation of Liquid Water?

- Attempt to deplete all liquid water so that riming cannot occur.
- Elimination of all supercooled liquid is virtually impossible.
- This is especially true of very large storms (supercells).



Summary of Hail Suppression Model Types

- Natural Hail Trajectory
- Early Rain-out
- Beneficial Competition
- Trajectory Lowering
- Promotion of Coalescence



Courtesy of Bruce Boe, Weather Modification International

Beneficial Competition (Competing Embryos)

- Attempt to create more hail particles, but smaller ones (the ice is split up into more, smaller packages).
- Hailstones travel to a greater height.
- This is also difficult to do with super-cells.



A Super-cell Thunderstorm in Kansas

Trajectory Lowering

- Attempt to get growth started lower in the cloud, below the point of maximum updraft.
- As hailstone starts to grow, it cannot be supported by the updraft and will fall out while it is relatively small.



Promotion of Coalescence

• Attempt to get raindrops falling out of the cloud at low elevations in the cloud, depleting the liquid water in the upper portions of the cloud.



Low-precipitation Super-cell Storm Photograph by Roger HIII

Dynamic Effects

- This is a different type of dynamic seeding than was discussed in the case of precipitation augmentation.
- One approach is to weaken the updraft earlier in its life cycle.
- Another approach is to encourage growth in regions that will cut off moisture supply.

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