




Summary of Weather Modification

 [Observations / Forecast / Blogs](#)

 [Vitae \(pdf\) / NSF-Bio \(pdf\)](#)


 [Peer Reviewed Publications](#)

 [Archives & Technical Papers](#)

 [Guides, White Papers/Slides](#)


 [Talks & Presentations](#)


 [Videos & Audio Recordings](#)

 [Research Interests](#)

 [Projects / NSF-CPS \(Positions\)](#)

 [ADPAA Software Gateway](#)

 [Teaching \(Catalog\)](#)

 [Dissertation Research](#)

 [Master Thesis \(pdf\)](#)

Dr. David J. Delene ([News](#))
([orcid 0000-0002-3733-6021](#))



Research Professor ([University Page](#))

[University of North Dakota](#) ([Directory](#), [Faculty Success](#))

[John D. Odegard School of Aerospace Sciences](#)




[Atmospheric Sciences Department](#) ([Wiki](#), [Gallery](#))

[Clifford Hall](#) 420, [4149 University Avenue](#)



Grand Forks, North Dakota 58202-9006 ([VCard](#))

 Email delene@aero.und.edu ([Public Key](#))

 [Mobile](#) 507-533-5363  Office 701-777-4847 

 Department 701-777-2184  Fax 701-777-5032 


 [Skype](#) User Name: [david.delene](#)

 [Zoom](#) ([Invite](#), [365-040-0756](#)  [Meeting ID](#))

 Zotero: [delene](#) Frequent [Logins](#)

 [Google Scholar Profile](#)

 [Linkedin Profile](#)

 Calendar: [View My Schedule](#)

Dr. David J. Delene, Research Professor

Atmospheric Sciences Department, University of North Dakota

Start of Weather Modification Research

- Experiments during World War II built on aircraft icing work at General Electric.
- 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).

Weather Modification Class Goals

- To learn the theoretical basis for weather modification.
- To learn how cloud weather modification projects are established and conducted
- To learn how to effectively participate in operational programs.



Extent of the Weather Modification

- History of Weather Modification
- Critical Thinking & Legal Aspects
- Environmental Concern
- Sociological Issues
- Economic Impacts
- Unintended Weather Modification
- Statistical Evaluations
- Atmospheric Aerosols
- Atmospheric Water Vapor
- Particle Nucleation
- Droplet Growth
- Ice Crystal Growth



Extent of the Weather Modification

- Basic Clouds and Cloud Formation
- Precipitation Processes
- Cloud Dynamics
- Conceptual Models
- Precipitation Conceptual Models
- Hail Suppression Conceptual Models
- Cloud Modification Project Model
- Seeding Materials, Dry Ice as Seeding Agent
- Seeding Agent Dispersal: Equipment and Methods
- Radar for Weather Modification
- Weather Forecasting and SkewT Basics



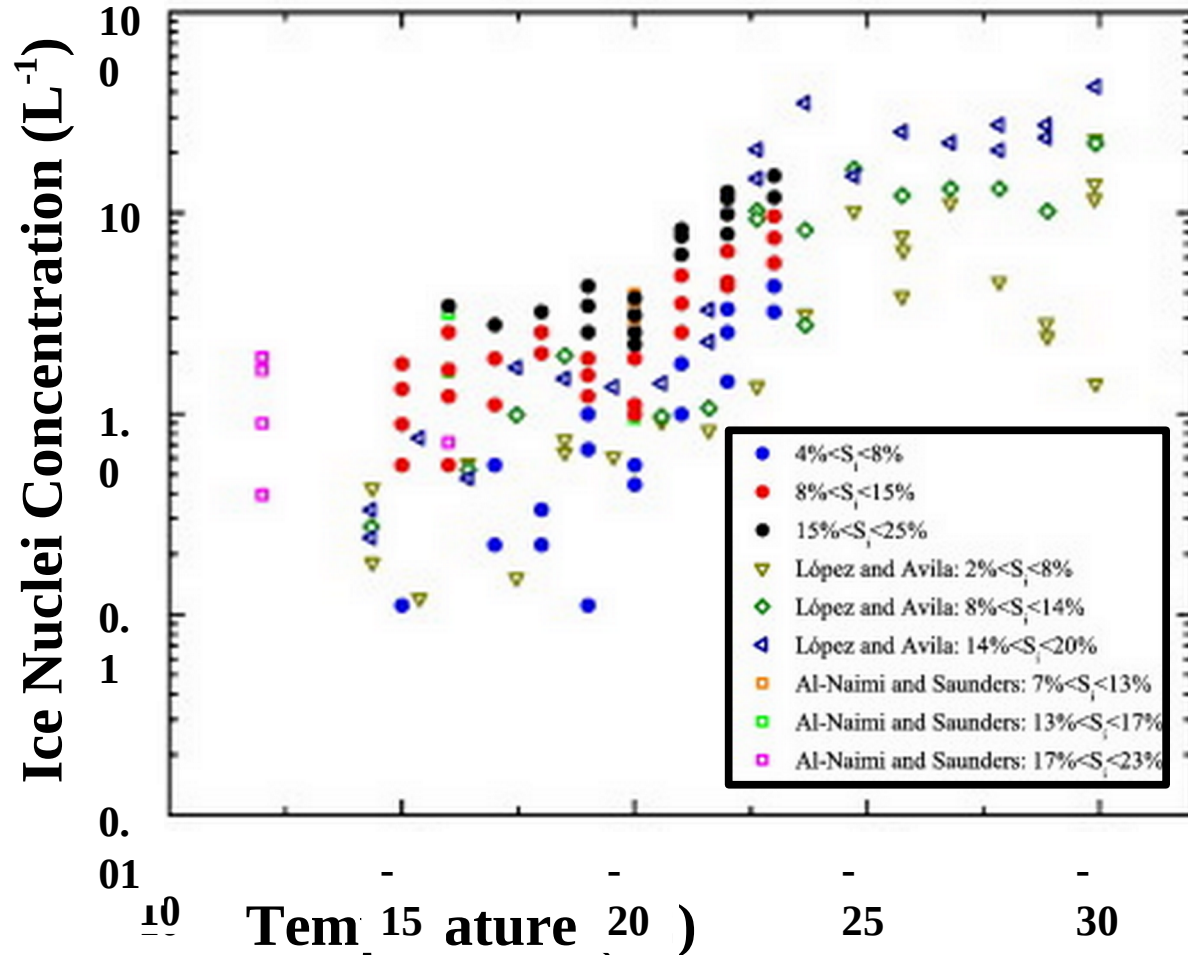
Extent of the Weather Modification

- Record Keeping
- Daily Operations
- Opportunity Recognition
- Flight Safety
- North Dakota Cloud Modification Internship Program
- Case Example: Put All Together



Glaciogenic (Silver Iodine) Cloud Seeding

- Effectiveness is often measured by “threshold temperature”.
- Threshold temperature is when 1 in 10,000 produce an ice crystal.
- Different substances have different threshold temperatures ranging from about -5 to -40 °C.
- Silver Iodine (AgI) threshold temperature is -5 °C.



Hygroscopic Cloud Seeding

Condensation from
Vapor

Coagulation of
Aerosols

Mechanical
Generation

Wind Blown Dust
Sea Spray
Volcano
Plant Particles

Coagulation

Rainout
And
Washout

Sedimentation

.002 .01 .1 1 2 10 100

Particle Diameter [μm]

Transient Nuclei or
Aitken Nuclei Range

Accumulation
Range

Mechanically Generated
Aerosol Range

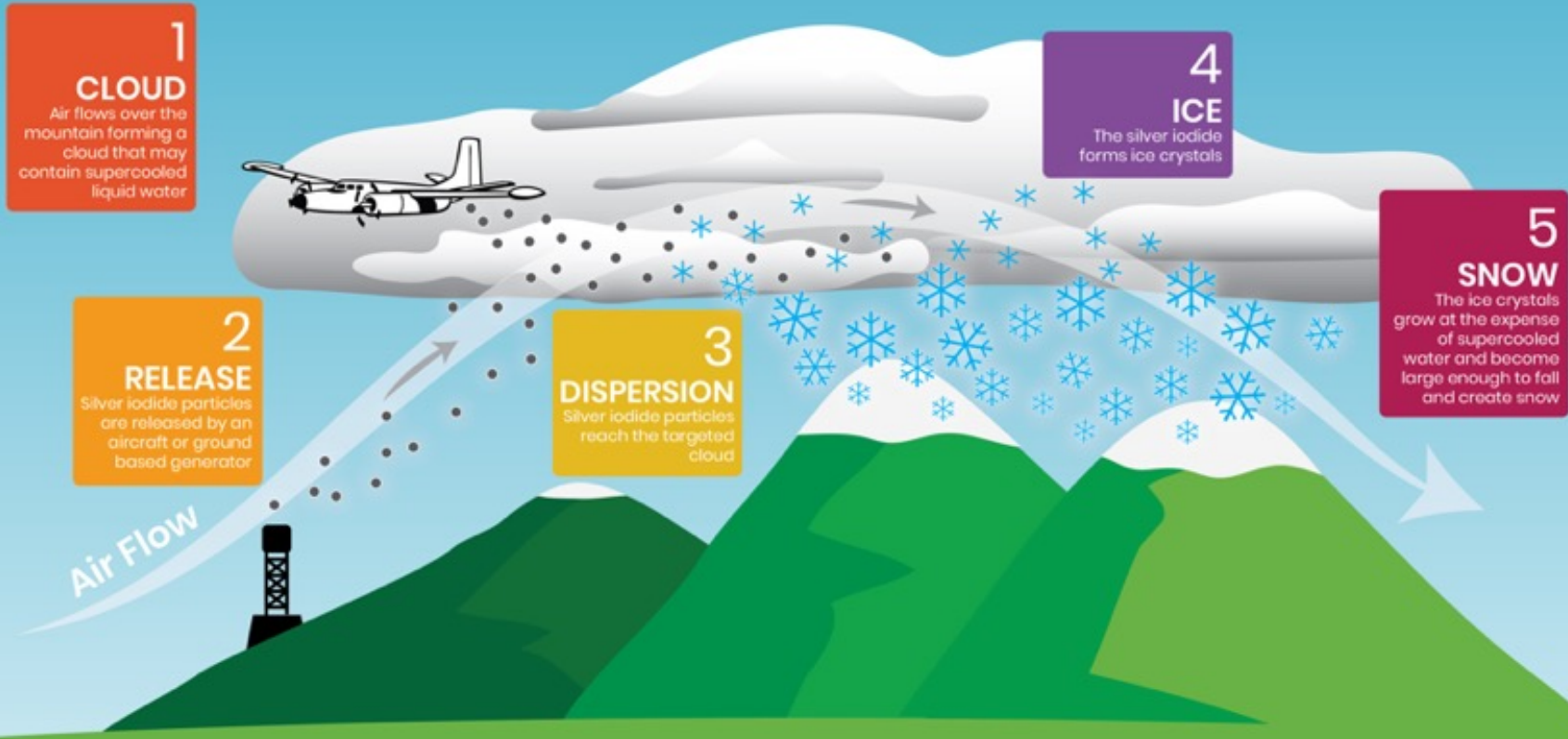
Fine Particles

Coarse Particles

- Few number of large sized atmospheric particles.

Snowfall Enhancement

WINTER CLOUD SEEDING WITH SILVER IODIDE

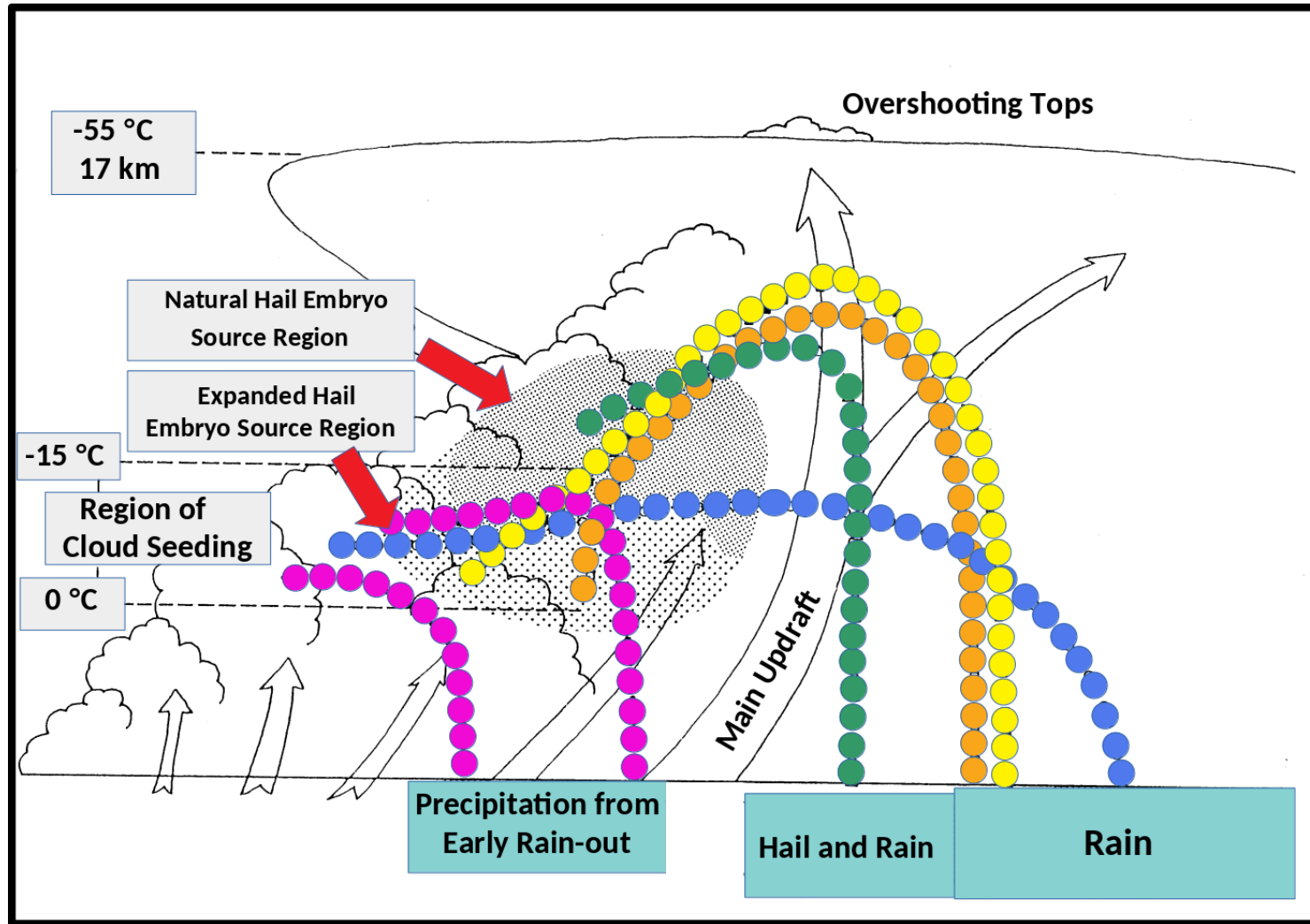


Precipitation Augmentation

- Enhancing the cold rain process through addition of ice particles.
- Enhancing the warm rain process by addition of giant Cloud Condensation Nuclei (CCN).
- Increasing the cloud depth by release of latent heat of fusion.
- Promoting the merger of small clouds into larger clouds through release of latent heat of fusion.



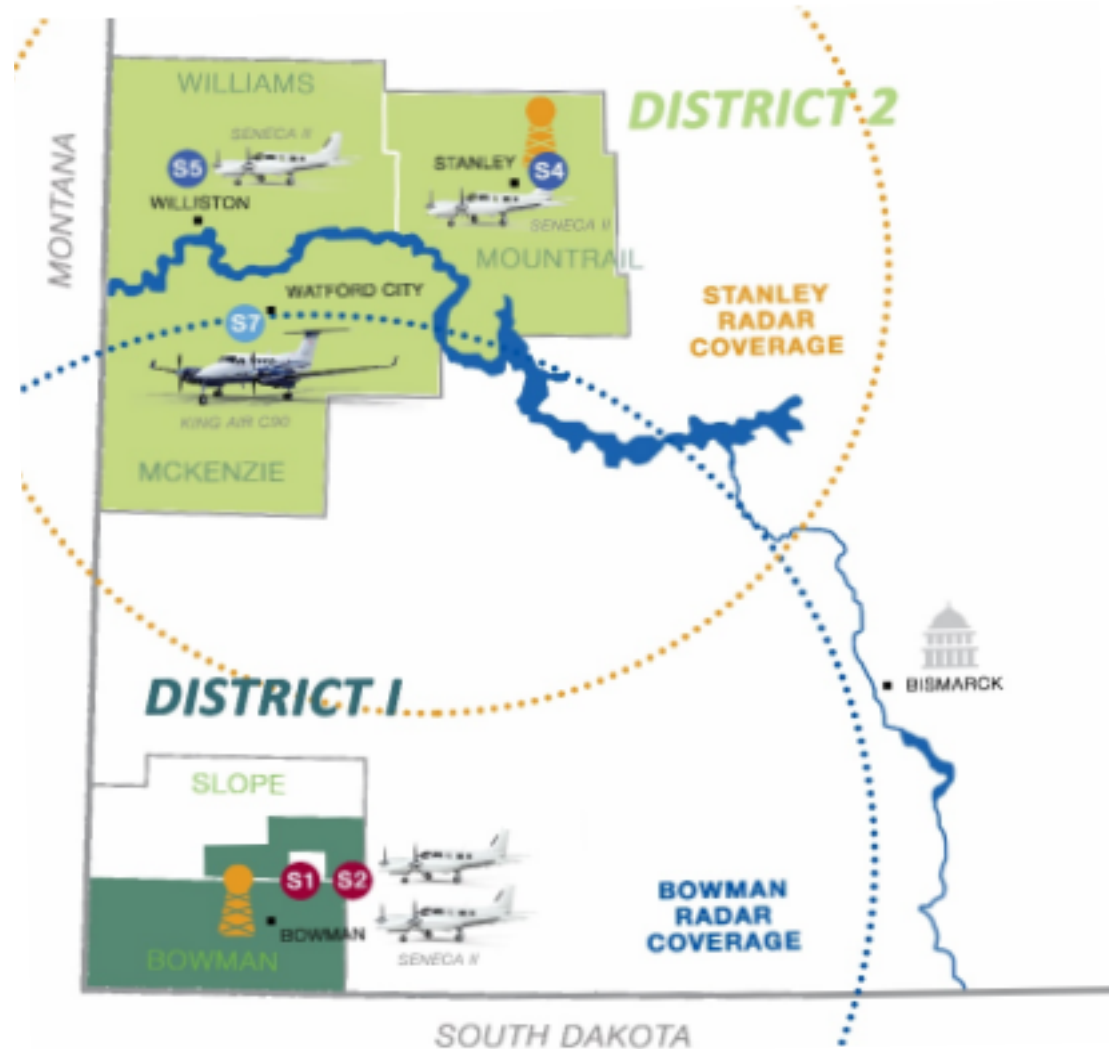
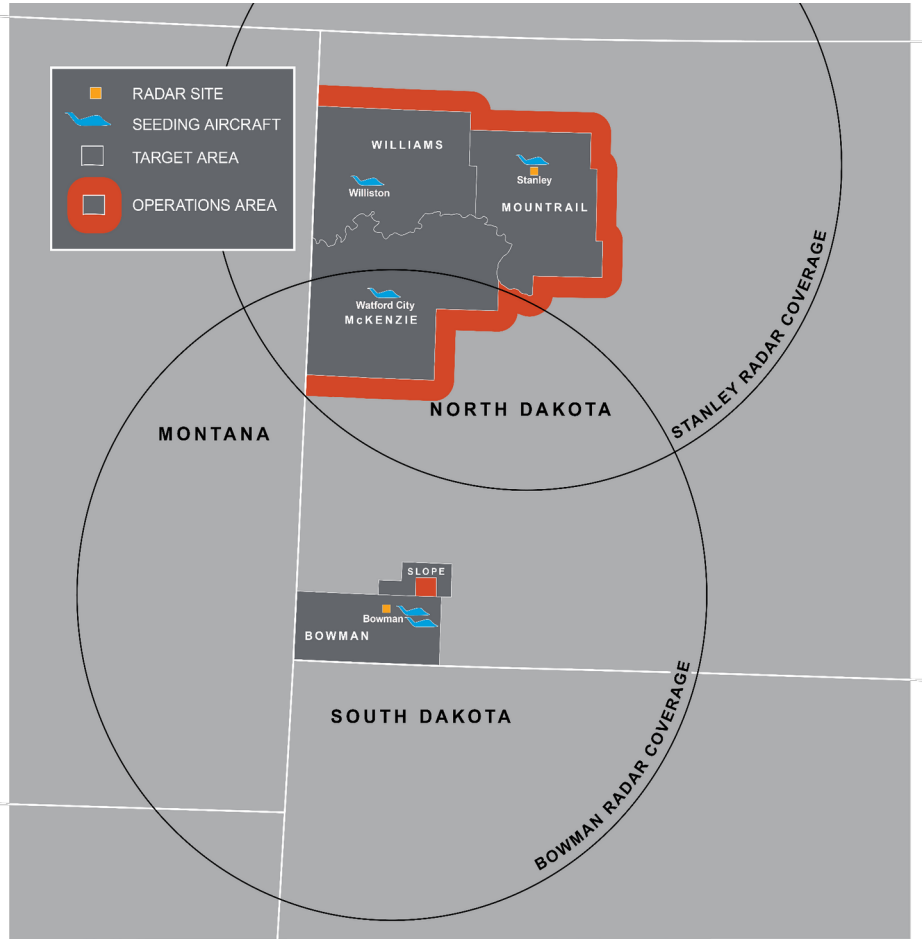
Hail Suppression Conceptual Models



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

Current North Dakota Cloud Modification Program

- Program started in 1977.



North Dakota Cloud Modification Program Internship

- Students have the opportunity to be project meteorological interns.
- UND students can obtain co-pilot internships due to our MOU.
- 400+ student pilots have participated in the internship program.



Weather Modification Operational Program

