Understanding Clouds and Rain

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Understanding

Knowing how things work is important!

- Grew up in Northern Michigan
- Attend Michigan Technological University & University of Wyoming
- At the University of North Dakota since 2001







Activities

• Research

- –Improve our understanding of how cloud system produce rain.
- Education
 - -Teach about theory and tools.
 - -Discuss what we know about precipitation formation.

Publication

- –Publish observation, software, and papers.
- –Journal of Weather Modification Editor.

Physical Process Experiments

Sample environmental and cloud micro-physical using aircraft and surface based instruments to measure properties of clouds and particles to enable evaluation of suitability of North Dakota for hygroscopic seeding.



View from Seeding Aircraft on July 8, 2012

View of Cumulus Cloud on July 12, 2012

Statistical Experiments

Characterization of cloud seeding effects using robust statistical analysis of a randomized experiment that includes observations of important atmospheric conditions.





Hygroscopic Cloud Seeding



Summary and Conclusions

• Science

- -Strong scientific support that particles affect clouds.
- -Clouds typically lack certain particles (nuclei).
- -Cloud seeding releases critical particles to enhance the precipitation formation process.

• Operations

- -Weather modification is conducted in many states and around the world.
- Research
 - -Weather modification and cloud physics research is on-going.



Questions



Effectiveness of Hygroscopic Seeding

- Hygroscopic cloud seeding in South Africa, Mexico City and Thailand had positive statistical results (Mather et al. 1997; Terblanche 2005).
- Convective clouds only transform approximately 10 percent of ingested water vapor into precipitation (Langhans et al. 2015).
- Scientific studies indicate that enhancement of water supplies may be possible by modifying the micro-structure of cumulus clouds using aerosols (Levin and Cotton 2008).
 - It is important to determine if North Dakota is similarly to locations where hygroscopic seeding seems to work.

References

Delene, D. J., Suitability of North Dakota for Conducting Effective Hygroscopic Seeding, Journal of Weather Modification, 48, 43-67, 2016, URL:

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Aerosol Importance

- Scatter and Absorb Radiation
- Media for Chemical Reactions
- Serve as Cloud

Condensation Nuclei CCN)





Types of Operational Cloud Seeding Glaciogenic and Hygroscopic

Ejectable



Agl Generator



Burn-in-Place







Cessna 340 EquipmentCCN CounterFSSPFlare Rack





PCASP





Temperature and Hot Wire Probe



M300 Display





Dew Point Temperature Sensor Head

POLCAST4 CESSNA340 N98585 INSTRUMENT CONFIGURATION



UND NorthPol Radar

- C-band (5 cm wavelength) Doppler radar
- Dual-polarized Antenna Mounted Receiver
- 28 m Antenna Above Ground
- SIGMET IRIS and TITAN Analysis Software
- Operated Mostly in Full-Volume Mode during POLCAST3



Aircraft Flight Tracks 2010 POLCAST3 2012 POLCAST4



MODIS Visible Images



July 8, 2012 July 9, 2012 Grand Forks, North Dakota

North Dakota Project Area





July 8, 2012

July 9, 2012