Statistical Analysis of the 2008, 2010, and 2012 POLCAST Data Set

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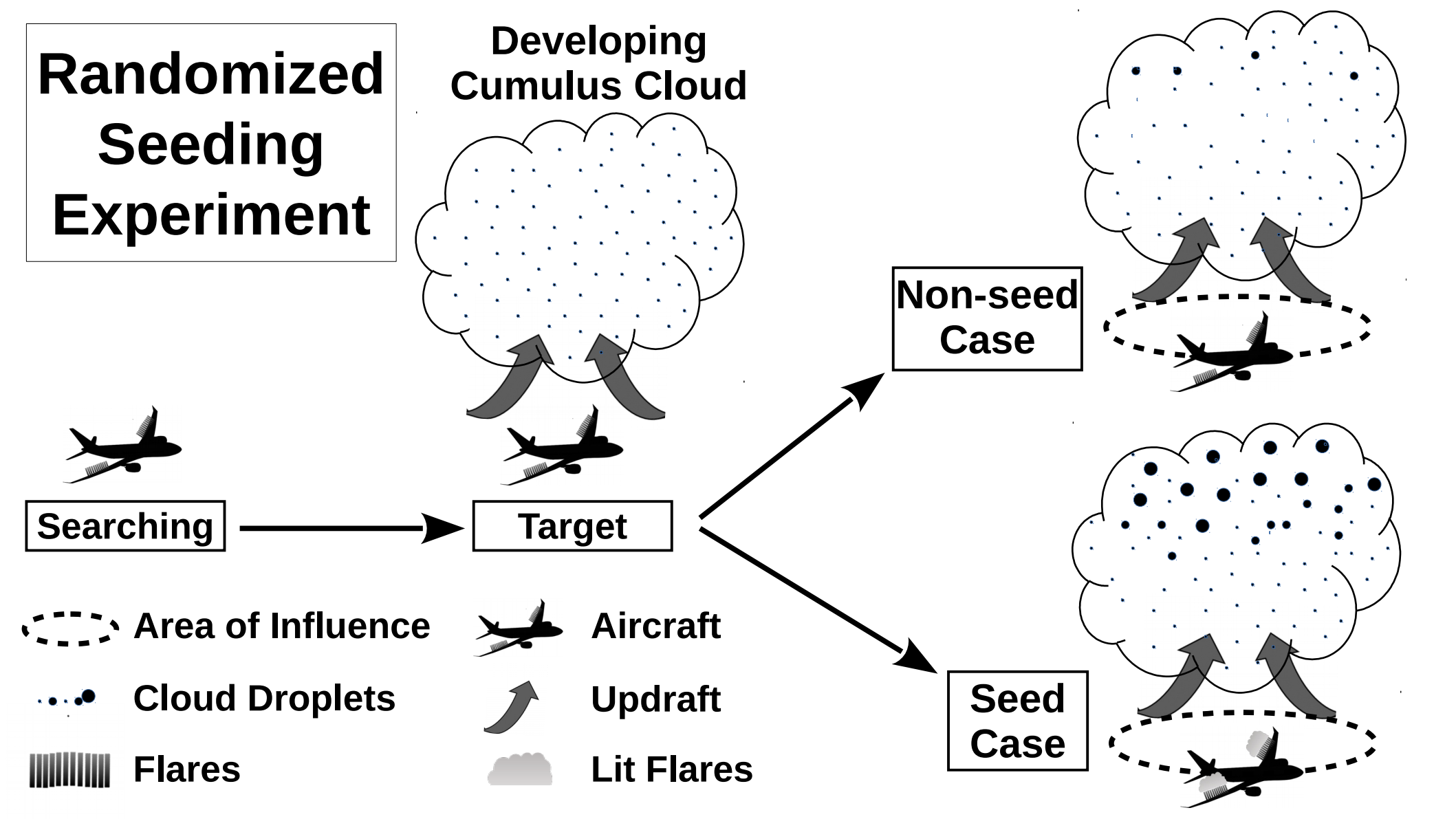
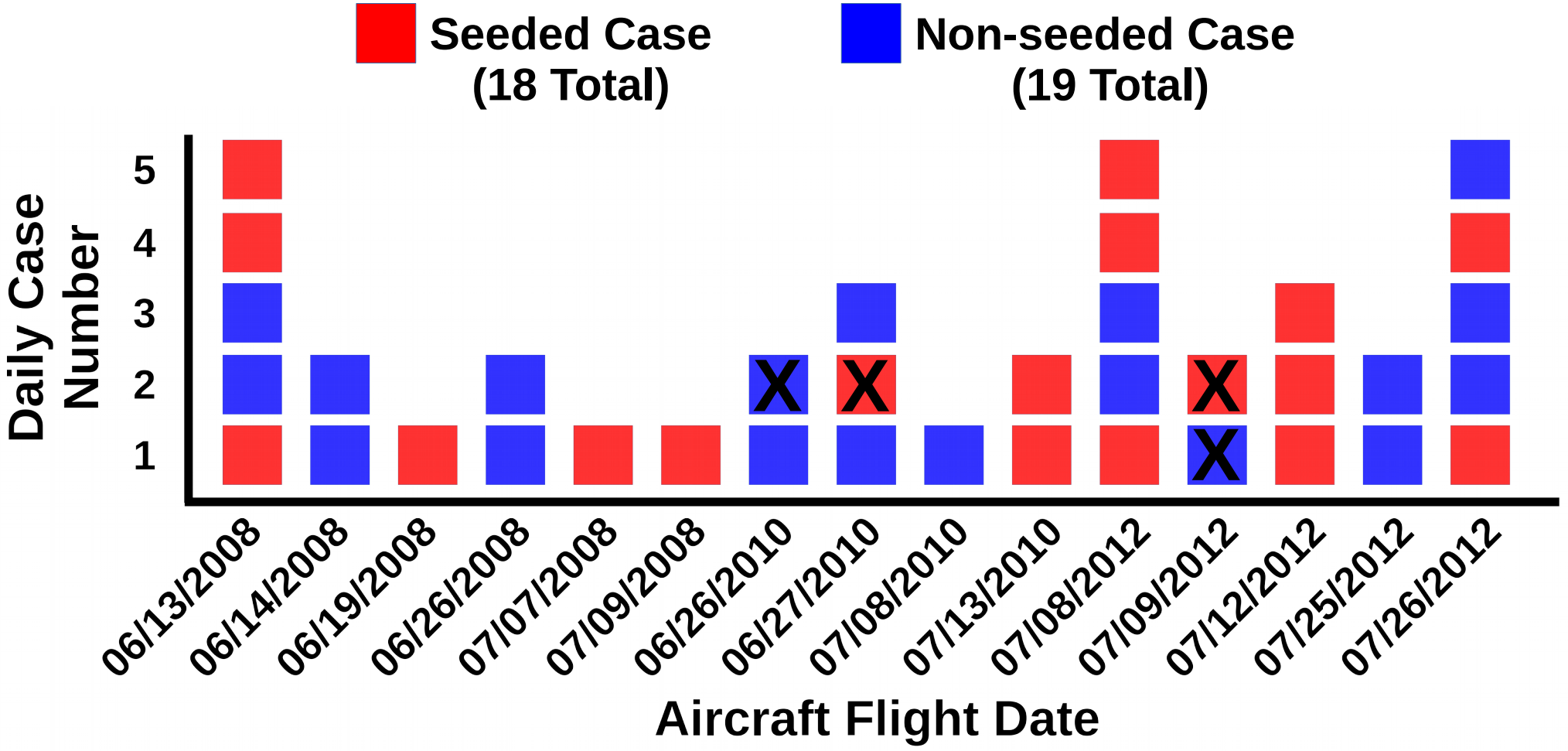
Objective and Overview

- Determine the effectiveness of hygroscopic seeding in North Dakota.
- The POLCAST field projects conducted randomized hygroscopic seeding while obtaining airborne and radar observations.
- The Thunderstorm Identification Tracking and Nowcasting (TITAN) program is used to analyze radar data from the POLCAST field projects (33 usable cases) to determine differences in rain rate and total rain amount between seeded and non-seeded clouds.


Randomized Seeding Experiment
Developing Cumulus Cloud
Searching
Target
Non-seed Case
Seed Case
Area of Influence
Cloud Droplets
Flares
Aircraft
Updraft
Lit Flares

POLCAST Targets Distribution (37 Total, 33 Usable)



Statistical Analysis Methodology: Single Ratio

$$Single\ Ratio = \frac{Seed_A^{0-60}}{Non-Seed_A^{0-60}}$$

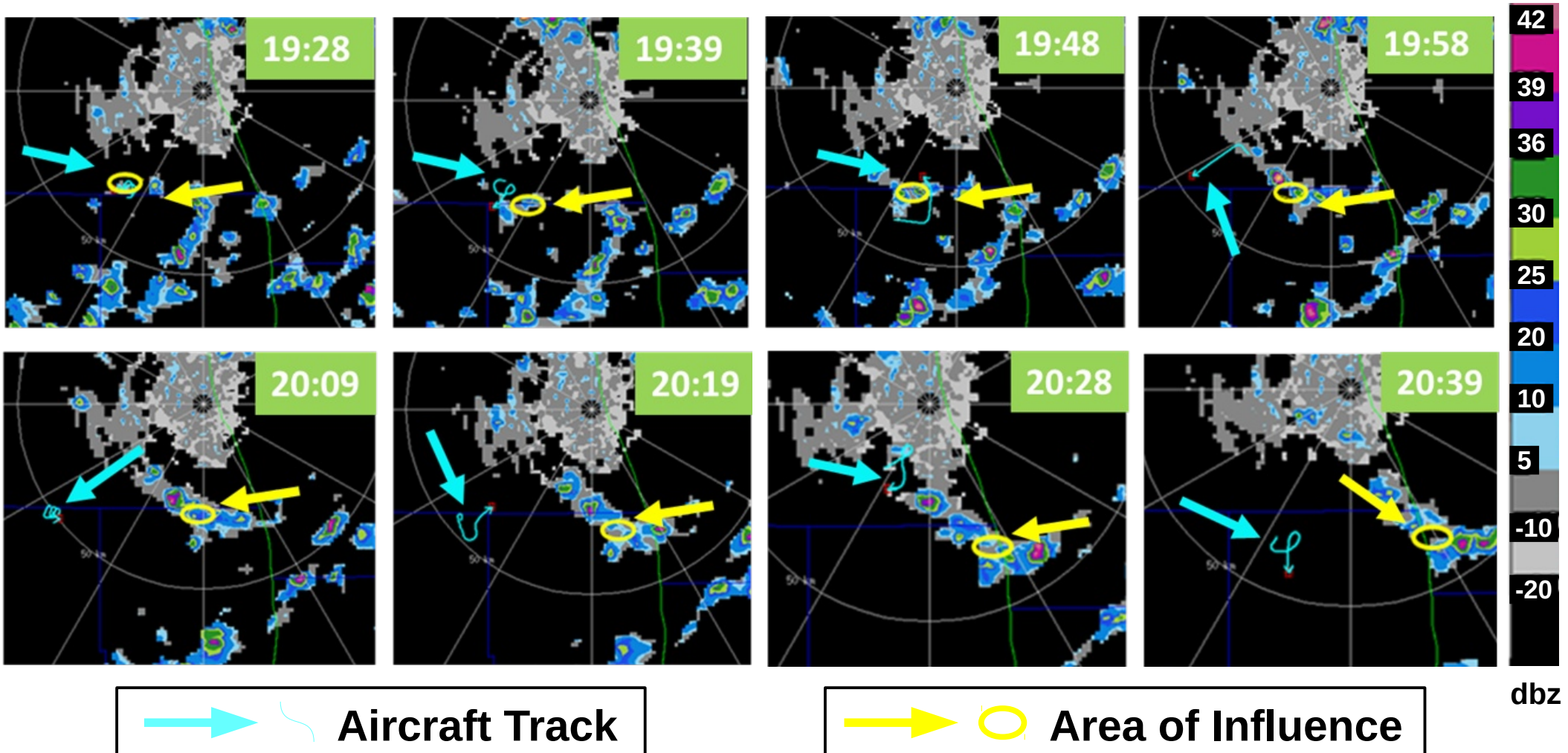
- *A* represents a given measurement of interest.
- $Seed_A^{0\text{-}60}$ and $Non\text{-}Seed_A^{0\text{-}60}$ represent the average of measurement A for the seeded and non-seeded cases, respectively.
- The average is over the area of influence defined by the aircraft circling over a 60 minute period (0-60) that begins 12 minutes after case type selection, which corresponds to the end of seeding for seed cases and the end of below cloud sampling for non-seed cases.

Statistical Analysis Methodology: Double Ratio

$$Doube\ Ratio = \frac{Seed_A^{20-60}}{Non-Seed_A^{20-60}} / \frac{Seed_A^{0-20}}{Non-Seed_A^{0-20}}$$

- *A* represents a given measurement of interest.
- $Seed_A^{20\text{-}60}$ and $Non\text{-}Seed_A^{20\text{-}60}$ represent the average of measurement A for the seeded and non-seeded cases, respectively within the area of influence for the 20 to 60 minute after case selection.
- $Seed_A^{0\text{-}20}$ and $Non\text{-}Seed_A^{0\text{-}20}$ represent the average of measurement A for the seeded and non-seeded cases, respectively within the area of influence for the 0 to 20 minute after case selection.

Radar Reflectivity: June 13, 2018 (Non-seed Case)



POLCAST Data Analysis using TITAN Scripts

Executable

Sigmet2Dsr
Dsr2Vol
ctrec
EsdAcingest
AcTrack2Polygon
Advect2Polygon
DrawFmq2Polygon
GridPointSelect
DrawFmqPolygon2Stats
Tracks2Ascii
GenPolyStats2Ascii
AcPolygonStats

Radar Data

Sigmet2Dsr

↓ **Converts raw data into DSR Format**

Dsr2Vol

↓ **DSR Beam-by-beam to MDV**

ctrec

↓ **Uses Cell Advection Vectors**

Wind Fields

Aircraft Tracks

EsdAcingest

↓ **Creates Aircraft Flight Tracks**

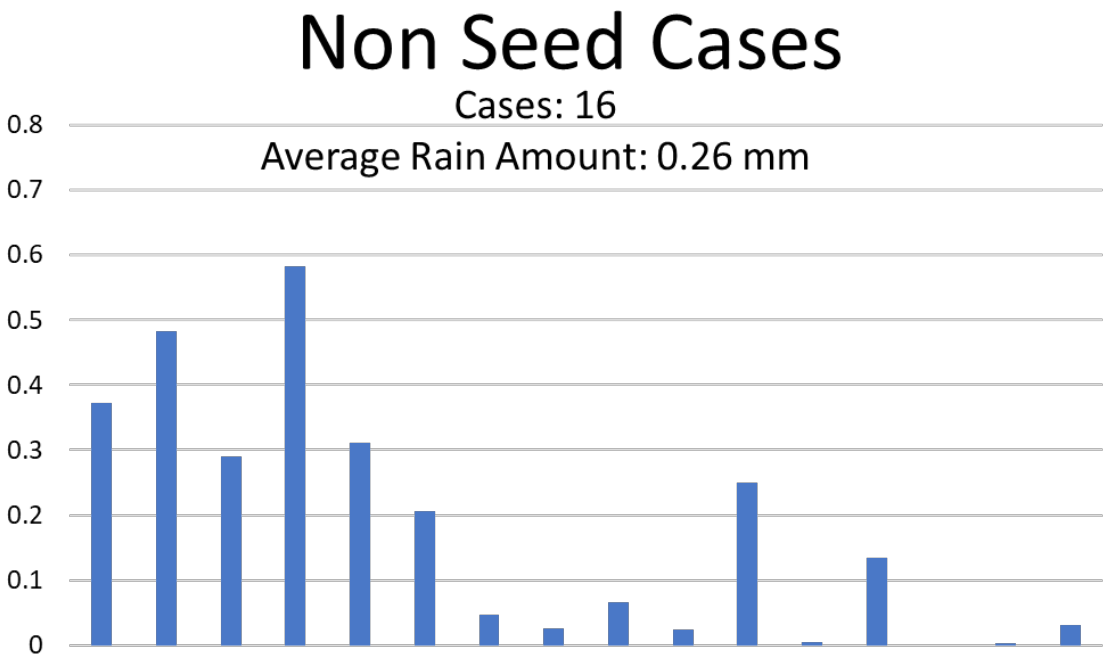
AcTrack2Polygon

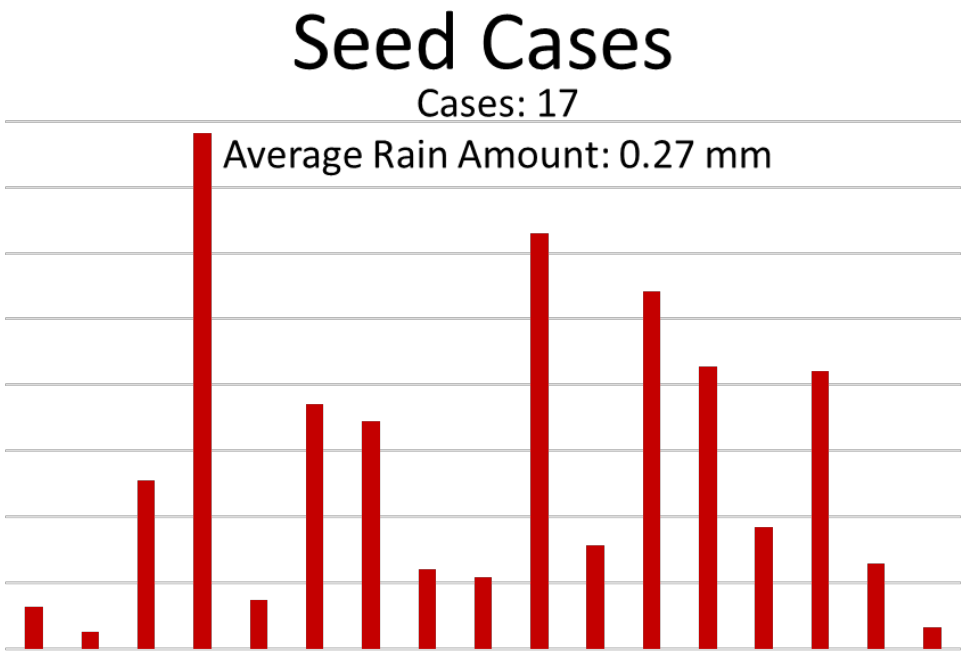
↓ **Fits Polygon to Flight Tracks**

Advect2Polygon

Advect Polygon and Calculate Parameters withing the Polygon

Rain Amount Total: First Hour after Decision





	Past 20 min	Past 30 min	Past40 min	Past 50 min	Past 60 min
Seeded	100 %	88 %	82 %	76 %	41 %
Non-seeded	88 %	62 %	56 %	31 %	25 %
Percent Difference	12 %	26 %	26 %	45 %	16 %

Summary and Conclusions: Ratio Statistics

- The single ratio of 1.56 is determined for seeded to non-seeded cases over the first 60 minutes rainfall amount after case selection.
- The increase for seeded cases is due mainly to storm lifetime increasing by 41 %.
- The single ratio results is collaborated by a 1.85 double ratio, which accounts for cloud system variability using the first 20 minutes of the storm.

Summary and Conclusions: Significance

- The Mann-Whitney test gives a significance (p-value) of 0.063 for the double ratio analysis of the POLCAST data set.
- Bootstrapping analysis (Ratio_RainAmt_POLCAST.py) indicates that 50 cases (+17 usable case) would provide a statistically significant (p-value < 0.05) double ratio.
- While the statistical analysis show an increase in North Dakota rainfall from hygroscopic cloud seeding, additional analysis is required to determine a seasonal increase and cost-benefit of an operational program.

Questions and Discussion

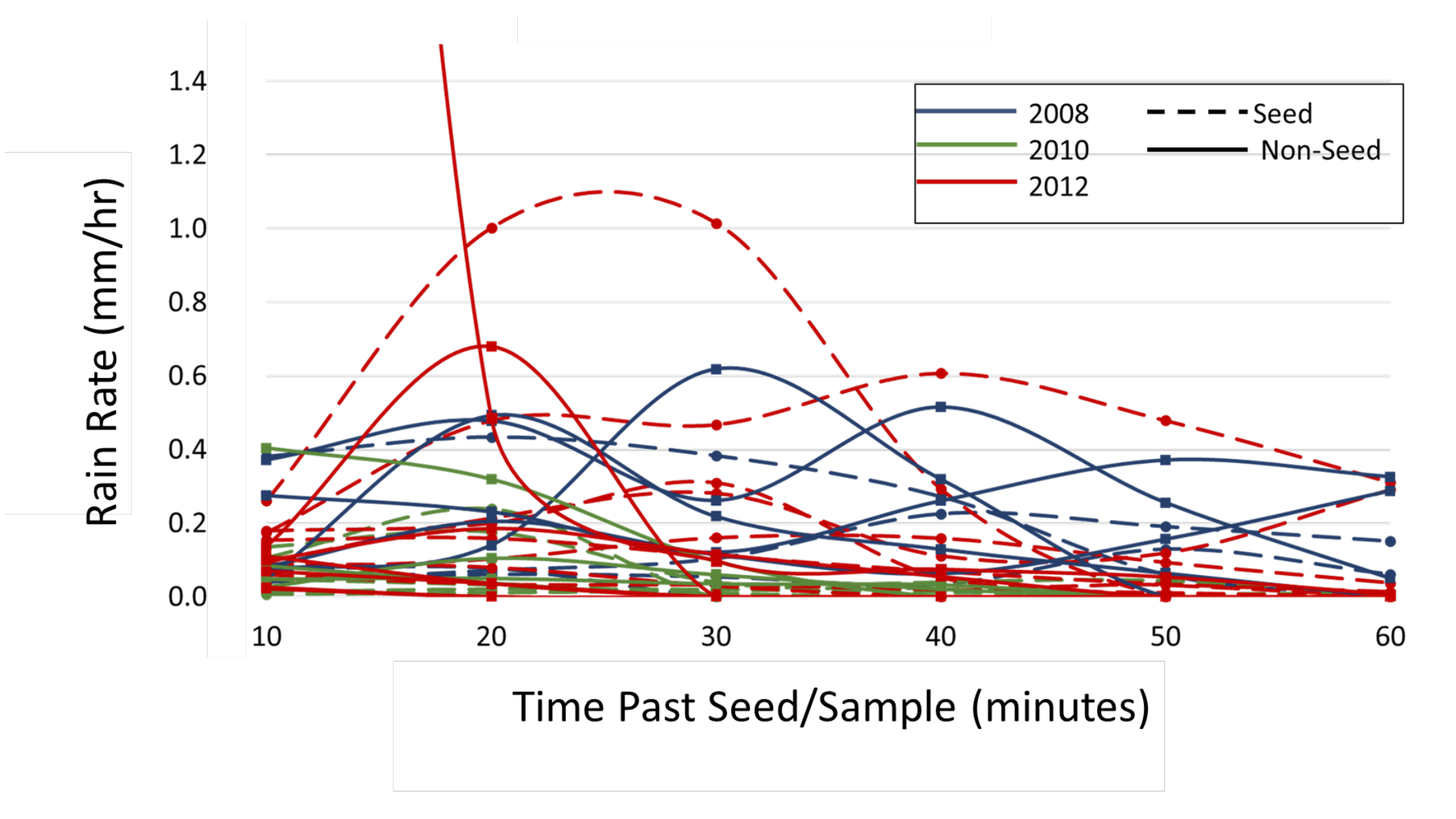
References:

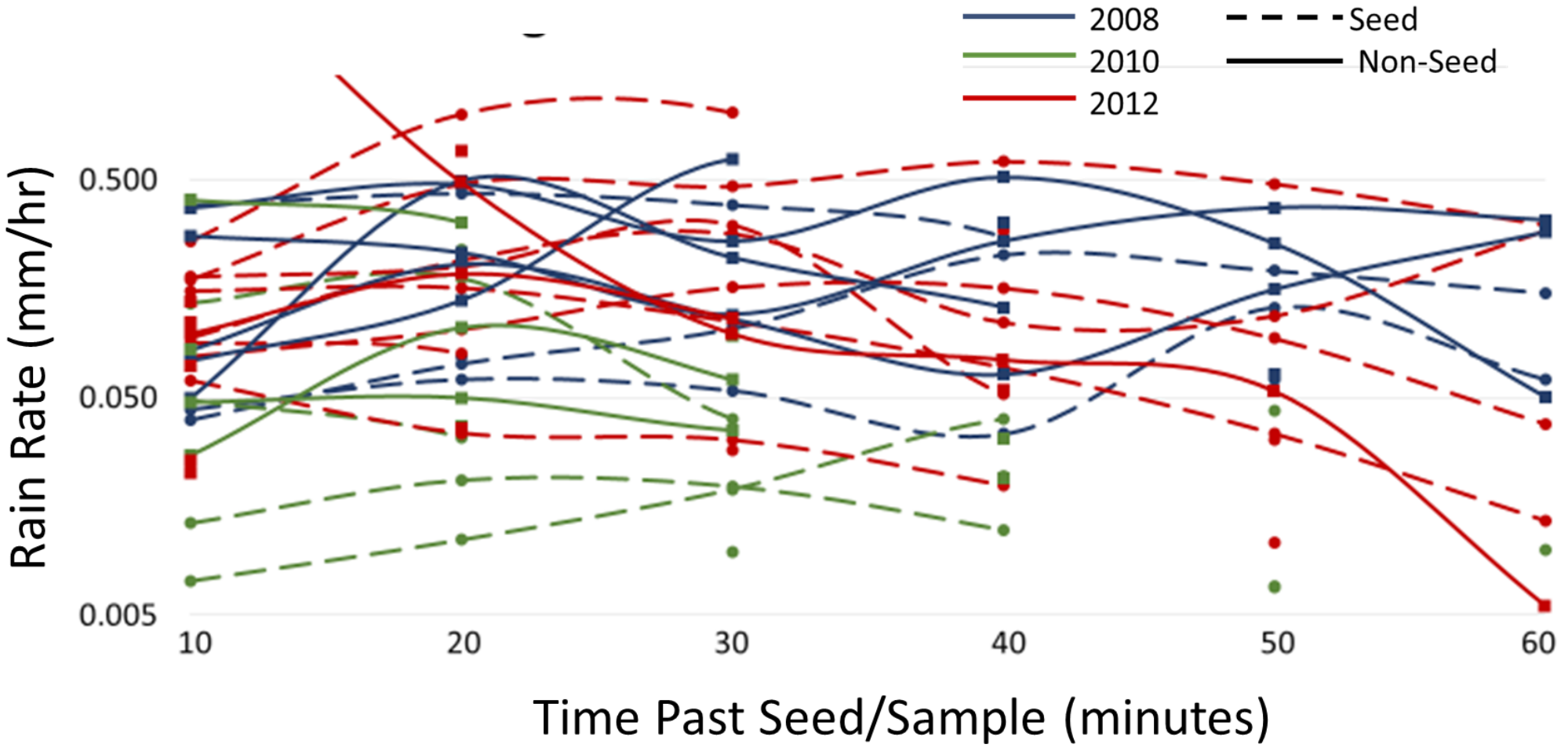
Ekness, Jamie Lynn, Gerry Dunnigan, David J. Delene and Paul Kucera, Analysis of the Randomized Hygroscopic Seeding conducted during the Polarimetric Cloud Analysis and Seeding Test (POLCAST) Field Projects, Atmospheric Research, in preparation, 2018.

Delene, D. J., Suitability of North Dakota for Conducting Effective Hygroscopic Seeding, Journal of Weather Modification, 48, 43-67, 2016, URL: http://www.weathermodification.org/publications/index.php/JWM/article/view/549.

Delene, D. J., C. Grainger, P. Kucera, D. Langerud, M. Ham, R. Mitchell, and C. Kruse, The Second Polarimetric Cloud Analysis and Seeding Test, Journal of Weather Modification, 43, 14-28, 2011, URL: http://www.weathermodification.org/publications/index.php/JWM/article/viewArticle/147.

Kucera, P., A. Theisen, and D. Langerud, 2008: Polarimetric Cloud Analysis and Seeding Test (POLCAST). J. Weather Modif., 40, 64–76.


Rain Rate (mm/hr)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
10
20
30
40
50
60
Time Past Seed/Sample (minutes)
2008
2010
2012
Seed
Non-Seed


2008
2010
2012
Seed
Non-Seed
Rain Rate (mm/hr)
0.500
0.050
0.005
10
20
30
40
50
60
Time Past Seed/Sample (minutes)