PRECIPITATION EVALUATION OF THE NORTH DAKOTA CLOUD MODIFICATION PROJECT (NDCMP) USING RAIN GAUGE AND RADAR OBSERVATIONS

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Committee Meeting 10/16/2018

IMPORTANCE OF STUDY

- This project is an overall evaluation of the effectiveness of the NDCMP.
- Results of this study can help determine the increase in rainfall due to the seeding in Western North Dakota, which in return can help determine the economic cost benefits of running the program.
- The most recent similar study was last done in 2005 and found a 6-9% increase in rainfall (Wise 2005).

PROJECT BACKGROUND

- NDCMP has ran a seeding operation in North Dakota for 41 years.
- C-Band radars are located in Bowman and Stanley, ND.
- Eight aircrafts have been used in recent years, with planes located in Bowman, McKenzie, Williams, Mountrail, and Ward County.



NDCMP Flight tracks for the entire length of 2017 field campaign.

METHODOLOGY

- Weighing rain gauge within radius of influence
- Single ratio test
- Double ratio test
- Radar derived rainfall totals compared to observed
 - TITAN (depending on if it works)
 - Uncertainty estimates

Rain Gauge locations 1977-2018



5

Rain Gauges 2018



6

WEIGHTED RAIN GAUGES

$$w = \frac{R^2 - d^2}{R^2 + d^2}$$

w = Weight of rain gauge to central location

R = Radius of influence (40km)

d = Distance of the gauge from grid point Reference: Wise 2005

COUNTY CIRCLE WEIGHTED RAINFALL AMOUNT

$$f_d = \sum_{i=1}^n w(i) * f_o(i)$$

- f_d = Calculated rainfall at grid point
- $f_o = 24$ hour measured rainfall
- w = Weighed calculation
- n = Number of gauges within radius of influence Reference: Wise 2005

STATISTICAL TESTS

- For the statistical tests, target and control regions will be used in calculated single and double ratios.
- McKenzie and Bowman Circles (target) will be compared to Billings Circle (control).
- Ward Circle (target) will be compared to Mercer Circle (control)



SINGLE RATIO TEST

• To calculate single ratio test the equation:

$$\frac{\sum_{n=1}^{41 (years)} f_d^{June, July, August, and all}(seeded circle)}{\sum_{n=1}^{41 (years)} f_d^{June, July, August, and all}(control circle)}$$

• Single ratio tests will be done for June, July, and August for each year between 1977 and 2018 using weighed rain gauge amounts

DOUBLE RATIO TEST

$$\frac{\sum f_d^{June,July,and August}(seeded circle)}{\sum f_d^{June,July,and August}(control circle)} / \frac{\sum_{n=1}^{41 (years)} f_d^{May}(seeded circle)}{\sum_{n=1}^{41 (years)} f_d^{May}(control circle)}$$

• Double ratio tests will compare 41 years of weighted May rainfall to weighted rainfall for each individual months of June, July, and August for 41 years.

RADAR ESTIMATED RAINFALL

- Level III radar data will be used to calculate 24 hr precipitation totals.
- The Z-R relationship will be calculated using the standard NEXRAD equation of: $Z = 300R^{1.4}$

Z= radar reflectivity

R= rainfall rate

- 24 hr precipitation observed by will be summed up and compared to the NDARBCON network.
- A correlation between radar and rain gauge will be calculated for years between 2009 and 2018
- To check if calculations are correct, some variability will be added to data to see if there are changes in ratios.

REFERENCES

- Wise, E., 2005: PRECIPITATION EVALUATION OF THE NORTH DAKOTA CLOUD MODIFICATION PROJECT (NDCMP). University of North Dakota, 63 pp. <u>http://www.swc.nd.gov/arb/ndcmp/pdfs/PrecipEvalNDCMP_2005.pdf</u>.
- Woodley, W. L., R. Drori, D. Rosenfeld, S. Orr, and G. Bomar, 2001: Results of Monthly and Seasonal Gauge vs. Radar Rainfall Comparisons in the Texas Panhandle. *Journal of Weather Modification*, **Volume 33**, 46–60.