P6R.1 **DEVELOPMENT OF A HIGH RESOLUTION PRECIPITATION RESEARCH FACILITY IN THE NORTHERN PLAINS**

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1. INTRODUCTION

The Department of Atmospheric Science at the University of North Dakota has developed a high resolution precipitation research facility in the northern plains. The site consists of a C-Band polarimetric Doppler radar located in Grand Forks, North Dakota and high resolution atmospheric observing facility located about 65 km to the south-southeast of the radar. The radar and atmospheric facility compliments an array of other meteorological instrumentation including cooperative rain gauge sites, mesonet stations, and the nearby WSR-88D radar (KMVX) located 47 km to the SW of the UND in Mayville, North Dakota. A regional map showing the locations of the UND radar, the atmospheric observing facility (Glacial Ridge Field Site), and the cooperative rain gauge sites is displayed in Figure 1.

The atmospheric observing site is ideally located to provide surface-based precipitation observations for both the UND C-Band radar and the KMVX WSR-88D radar. This close proximity between the two radars with allow for detailed intercomparison between C-Band polarimetric observations and conventional measurements from the S-Band WSR-88D radar. As the planned polarimetric upgrades are implemented around the country, the precipitation facility could serve as a test bed for improving polarimetrically based algorithms in a northern climate regime. Even though the WSR-88D scanning strategies are not ideal for dual-Doppler studies, limited Doppler analysis maybe possible between the UND and KMVX radars (see dual-Doppler lobes in Fig 1).

The UND radar has been in operation with polarimetric capability for over a year and the field site has been in operation for almost a year. This relatively short time period has provided many opportunities to observe both warm and cold season precipitating systems. The unique datasets have already provided new insights on the characteristics of weather events that occur in the northern plains.

2. PRECIPITATION NETWORK

2.1 UND Polarimetric Radar

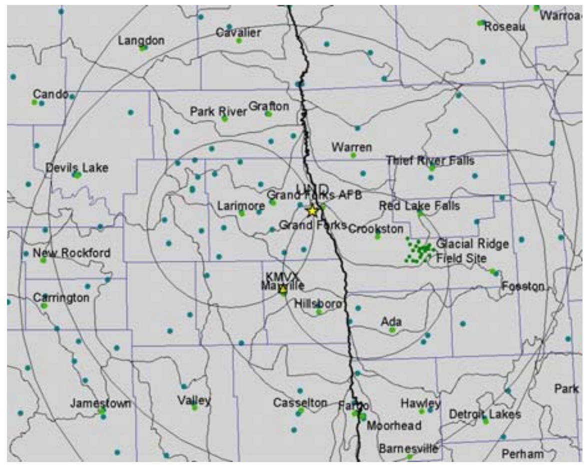

Figure 1: Coverage area of the UND polarimetric Doppler radar and the NWS WSR-88D radar located in Mayville, ND. The inner circles represent dual-Doppler regions. The filled circles indicate cooperative rain gauge locations. The proposed Glacial Ridge dense rain gauge network is located 64 km SE of the UND radar (densely populated circles). A zoomed in view of the network is shown in Figure 2.

The original components of the UND radar were built by Enterprise Electronics Corporation (model: Weather Surveillance Radar - 1974 C-band: WSR-74C). In January 2003, the radar was upgraded with a SIGMET, Inc. digital receiver and signal processor (RVP8), radar antenna controller (RCP8), and radar control, analysis and display software (IRIS). In January 2004, the radar was upgraded to a dual-polarized system with the installation of an antenna mounted receiver (AMR) and has been operating in support of the research and academic programs in the Department of Atmospheric Sciences since the upgrade. A summary of the radar specifications are shown in Table 1. Besides collecting the traditional fields of radar reflectivity, mean Doppler velocity, and Doppler spectrum width, the upgrade provides the opportunity to collect a subset of the full matrix of polarimetric parameters which include: differential reflectivity, depolarization ratio, the phase, and correlation between the horizontal and vertical channels. The radar is currently co-located with the Atmospheric Sciences Department on top of Clifford Hall at the west end of the UND campus. A more complete description of the facility along with near real-time quick look images is available on the UND radar website http://radar.atmos.und.edu.

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Table 1: Technical specifications of the UND C-Band radar.

Radar Parameter	Value
Peak Output Power (kW)	250
Wavelength (cm)	5.4
Pulse Width (microsecond)	0.6, 2.0
Antenna Gain (dB)	43.75
Elevation Range (°)	-0.5 – 90
Antenna height Above Ground (m)	28
Beam width (degree)	0.99
Minimum Detectable Signal (dB)	-106.5
Maximum Scan Speed (°/sec)	20
PRF (Hz)	250-1200
Polarization	Linear Horizontal & Vertical
Variables	Z_H, V_R, σ, ZDR, KDP, Φ_{DP}, ρ_{HV}
Data System	SIGMET IRIS

2.2 Glacial Ridge Atmospheric Observatory

The atmospheric observing facility resides on the Nature Conservancy (http://www.tnc.org) Glacial Ridge Prairie Restoration Project, a 24,000 acre property that is currently being restored to native tall prairie grasses and wetlands from existing farm and graze land. The extensive area of the property provides a unique opportunity to study precipitation variability over temporal scales ranging from instantaneous to seasonal time scales and spatial scales ranging from meters to tens of kilometers. For surface observations, the research facility currently has a small network of rain gauges, several video disdrometers, snow gauges, a surface meteorological station, a microwave radiometer, and a variety of pyrometers. Also, a dense rain gauge network has been designed and sited at Glacial Ridge. The spatial distribution of rain gauges is shown in Figure 2. This rain gauge network is planned for deployment in Spring 2006. It will provide high spatiotemporal observations of rainfall variability that will improve the understanding radar rainfall uncertainty and improve the hydrological cycle in the northern plains.

In collaboration with the NOAA Aeronomy Laboratory, a 915 MHz wind profiler has been deployed at Glacial Ridge in efforts to measure boundary layer wind fields and the vertical structure of precipitation. The wind fields are currently available in near real-time from the NOAA Profiler Network website: http://www.profiler.noaa.gov/npn/profiler.jsp Photos showing the locations of several of the instruments and the climate-controlled research trailer is displayed in Figure 3. The atmospheric observing facility is designed to complement existing hydrologic research activities currently being conducted at Glacial Ridge. A detailed description of the facility along with a link to real-time data is available and the Glacial Ridge Atmospheric Observatory website: http://glacialridge.atmos.und.edu.

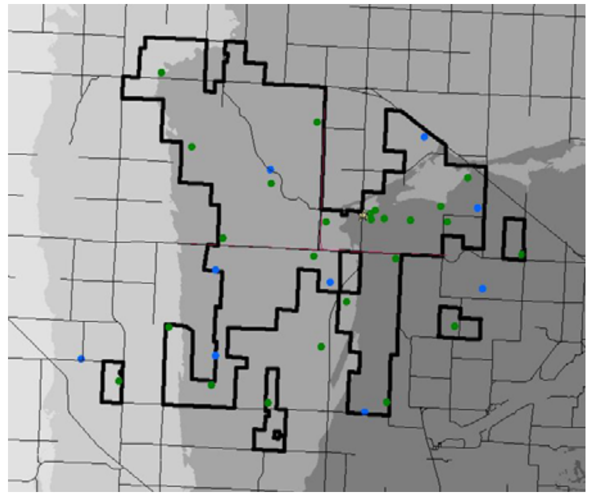

Figure 2: A zoomed in view of the proposed dense rain gauge network located on the Nature Conservancy Glacial Ridge site (boundary indicated by the bold black line). The green dots indicated proposed UND rain gauge sites and the blue dots indicate the existing USGS rain gauge sites.

Figure 3: Photos of the Glacial Ridge Field Site. The photos show the locations of the profiler, met tower, disdrometers, pyrometers, and research trailer.

3. EXAMPLE OBSERVATIONS

Since the Glacial Ridge Atmospheric Observing facility has been in operation (December 2004), a variety of storm events have been captured by the precipitation facility and are currently being analyzed. In particular, a snow event was observed in March 2005. This event was a typical Alberta Clipper snow storm. However, the polarimetric observations in combination with surface observations showed a unique transition of the snowfall type and fall orientation. From the ZDR measurements (not shown), a distinct transition from a positive ZDR to a slightly negative ZDR was observed from the front to backside of the snowband. A more detailed analysis of the storm event and observations can be seen in the paper (P11R7) by Newman et al. (2005).

The example observations that are shown in this section were observed from a series of storm events that past over the Grand Forks area during 11-14 June 2005. During this time, the UND radar and instruments at the field site were in almost continuous operations. Storm total rainfall accumulations estimated from the UND radar are shown in Figure 4 for the event that occurred on 13-14 June. The plot shows that total rainfall accumulations ranged from a minimum of about 2 mm in the northern half of the network to a maximum of about 25 mm the SW of the UND radar. The radar rainfall rates were generated using a ZH, ZDR, KDP blended algorithm for each instantaneous observation (10 min interval) and then accumulated for the entire storm event. Qualitative comparisons of the radar rainfall estimates were in good agreement with the rain gauge observations.

A time series of the vertical profiles of precipitation observed by the 915 MHz profiler for the same storm event is shown in Figure 5. The plot shows the main portion of the storm moved over the Glacial Ridge site starting at 14 UTC (9 AM LT) 13 June and ended near 00 UTC (7 PM LT) 14 June. The observations show the classical leading edge convective precipitation followed by a long-lasting stratiform precipitation event.

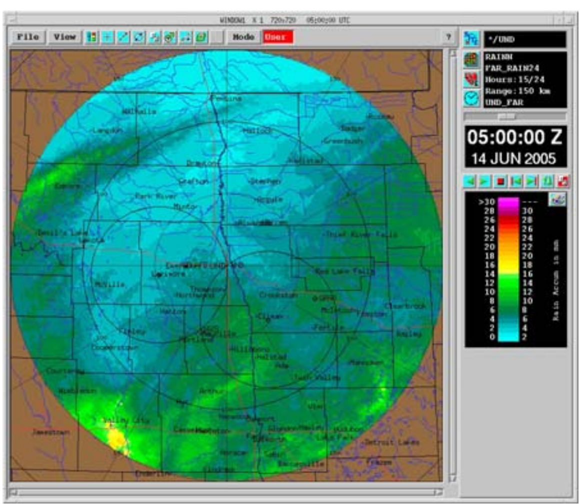

Figure 4: Radar rainfall storm accumulation for 13-14 June 2005 event. The radar estimate was 7.5 mm at the Glacial Ridge field site.

Drop-size distributions (DSDs) observed by the video disdrometer during stratiform portion of the storm (22 UTC) is shown in Figure 6. The plot shows the variability of DSD's for an hour in 5-min integration intervals. The observations indicate the precipitation was mostly composed of small drops with the maximum dropsize size being about 2 mm in diameter.

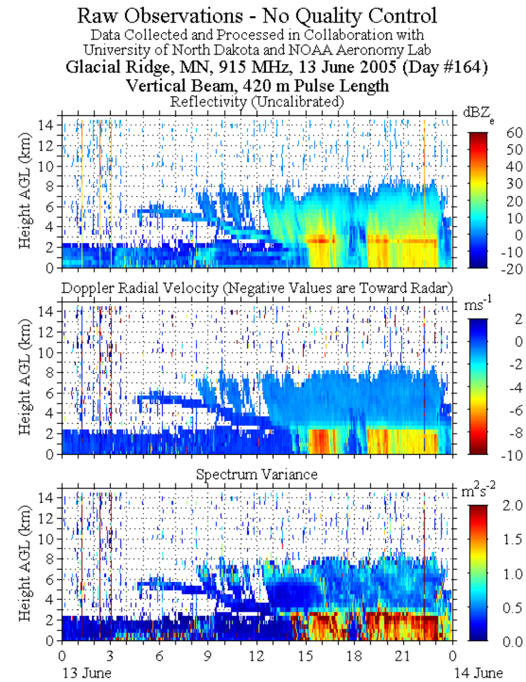

Figure 5: Time series of reflectivity, vertical velocity and spectral width from the Glacial Ridge 915 MHz wind profiler for the 13-14 June 2005 storm event.

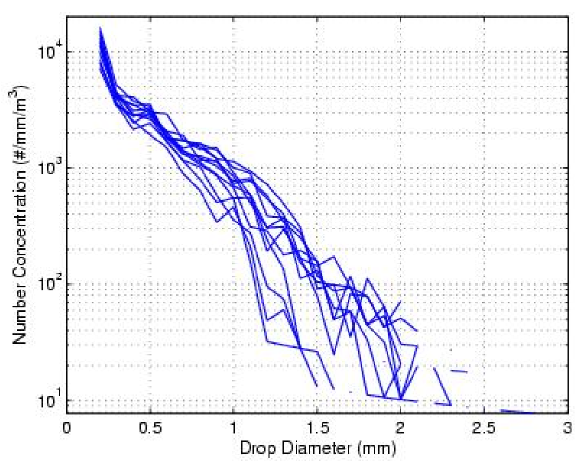

Figure 6: Dropsize distributions observed by the video disdrometer located at 22 UTC 13 June 2005.

A time series comparing reflectivity derived from the video disdrometer and the near surface profiler reflectivity is shown in Figure 7. The plot shows that the disdrometer and the profiler are in good agreement in characterizing the variability of precipitation. The disdrometer and profiler observations are currently being analyzed for intercomparison studies with the UND and KMVX radar observations.

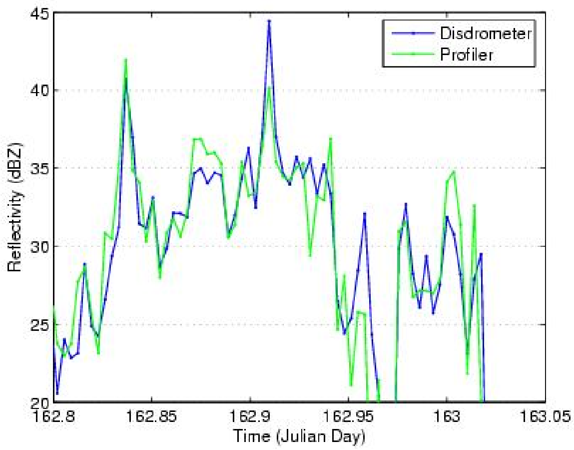

Figure 7: Time series of radar reflectivity observed by the video disdrometer (blue line) and the profiler (green line) for the storm event that occurred on the 11 June 2005.

The last example provided in this paper is hydrometeor retrievals using the UND polarimetric observations for the event that occurred at 2335 UTC 11 June 2005. Figure 8 captures the hydrometeor identification at an altitude of 0.5 km. The bottom panel shows a vertical cross section of the retrieval for the location given by the black line on the top panel. The retrievals are based on the hydrometeor identification algorithm developed by Liu and Chandrasekar (2000). The plot shows that the storm was mostly composed of drizzle (light rain) and rain at the lowest altitudes and composed of mostly dry snow and some vertical ice about the 0° isotherm which was located about 3 km for this event.

4. SUMMARY

The implementation of the precipitation facility will help improve the understanding of the spatial and temporal characteristics of cold and warm season precipitation, which is a key component of the hydrologic cycle in the climate region of the Northern Plains. This facility with the combination of polarimetric radar observations, vertical profiler measurements, and surface observations of microphysical properties of precipitation will provide an unprecedented database for a multitude of quantitative precipitation studies. An example study could be the precipitation algorithm development in the Northern Plains for the planned polarimetric upgrades of the WSR-88D or possible future upgrades of the C-band radars in the TDWR network.

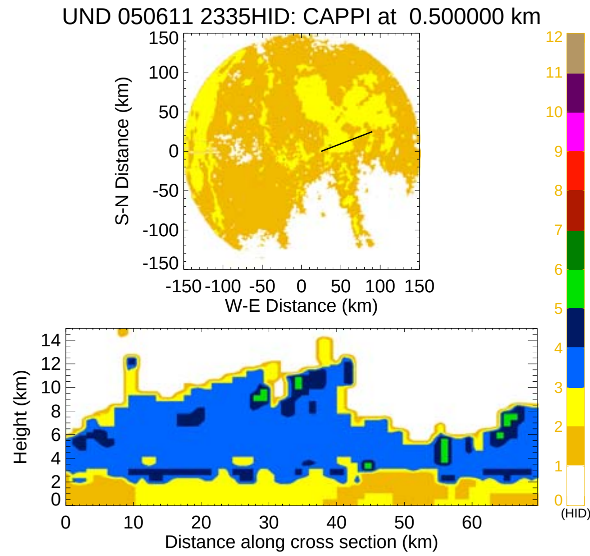

Figure 8: Example hydrometeor identification retrieval. The numbers in the color table represent the following hydrometeors: 1=drizzle; 2=rain; 3=dry snow; 4= wet snow; 5=vertical ice; 6=dry graupel; 7=wet graupel; 8=small hail; 9=large hail; 10=small hail with rain; 11= large hail with rain.

5. ACKNOWLEDGMENTS

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6. REFERENCES

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