9A.13 MOBILE MICRO RAIN RADAR DEPLOYMENTS IN NORTH CAROLINA

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1. INTRODUCTION

The state of North Carolina is one of a small number of states that has had over 21 billion dollars in climate and weather related disaster events since 1980 (Lott and Ross, 2006). Because of this high incidence of costly disasters, the Renaissance Computing Institute (RENCI) is working with other groups across the state to use technology to solve disaster and emergency management related problems. Solving these problems, which range from a lack of environmental observations to data sharing and communication issues will help in lessening the impact of future events such as ice storms and hurricanes.

This paper concentrates on the use of the Micro Rain Radar (MRR), a radar technology being tested for its utility during ice and heavy rain events. In this paper data from an MRR, including reflectivity and fall velocity of precipitation, are presented and the utility of this data to the state of North Carolina for better managing winter weather events is discussed. The purpose of this radar is to collect information on the vertical structure of precipitation during winter weather events that is not otherwise accessible. The case study for this paper is a winter storm event that occurred on 1 February 2007 in North Carolina.

2. MICRO RAIN RADAR CHARACTERISTICS

The MRR, manufactured by METEK, Elmshorn, Germany, is a vertically pointing, K-band (λ=1.25 cm) radar with an offset, 60 cm parabolic dish antenna that measures the profiles of drop size distribution. Rain rate, liquid water content, and characteristic fall velocity can be derived from the drop size distribution. For a detailed discussion of these parameters, their retrieval procedures, and technical issues refer to Peters et al. (2005).

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The radar uses the frequency modulated-continuous wave (FM-CW) for volume filling targets technique described by Strauch (1976) to measure height-resolved drop size distributions. Normally, FM-CW radars need to use two separate antennas, one for transmitting and one for receiving (Peters et al., 2005). However, the MRR transmits a small amount of power (50 mW) and which allows for a common antenna to be used. This simplification in MRR design eliminates problems with beam overlap (Peters et al., 2005).

The MRR uses a frequency-modulated gunn-diode-oscillator with an integrated mixing diode. The backscattered radiation and the transmitted signal produce two different frequencies in the mixing diode. This frequency shift is dependent on two variables: the distance of the target from the radar and the fall velocities of the particles (Löffler-Mang et al., 1999). Additional characteristics of the MRR can be found in Table 1.

Beamwidth (two way, 6 dB)	2°
Wavelength	1.25 cm
Frequency	24.1 GHz
Transmit power	50 mW
Parabolic dish diameter	60 cm
Modulation	FM-CW
Number of range gates	30
Adjustable height range	10…1000 m
Adjustable averaging time	10…3600 s

Table 1: MRR characteristics from MRR User Manual (2005)

3. RESULTS

This paper examines a minor winter storm that occurred on 1 February 2007 in North Carolina. The goals of the deployment were to collect data that showed a recognizable bright band aloft during the storm and to compare the type of precipitation that was falling on the ground to the type that could be deduced by real-time MRR data. Such data would be useful for forecasters, utility companies, emergency managers, and others, as it provides a profile of precipitation that otherwise is not available.

Data collection began at 9Z on 1 February at the Guilford County Office of Emergency Management in Greensboro, NC. The storm was not expected to result in a major winter storm event, as the parent high pressure system responsible for the cold air was located well off the Virginia coast. This setup usually leads to “in-situ” cold air damming (Bailey et al. 2003) which depends on diabatic processes to generate the cold air needed to support frozen precipitation. In this case, these diabatic processes were insufficient to sustain a significant amount of frozen precipitation.

The MRR reflectivity and fall velocity plots collected for the 1 February event are present in Figure 1 and 2, respectively. Data was collected using one minute averaging at height steps of 150 m from the surface to 4500 m above the ground. Precipitation began to fall aloft at approximately 1015Z, but evaporated at about 1800 m above ground (Figure 1) due to a dry layer. As this dry layer moistened precipitation began to descend over time towards the ground with precipitation reaching the surface at approximately 12Z and lasting until about 13Z. Snow was reported on the ground during this time and the measured fall velocities of 1 m/s (Figure 2) concur with Nakaya and Terada’s measured terminal velocities of ice crystals (Fletcher,1962). A brief snow shower occurred just after 1330Z. Snow began to fall steadily again at about 1550Z.

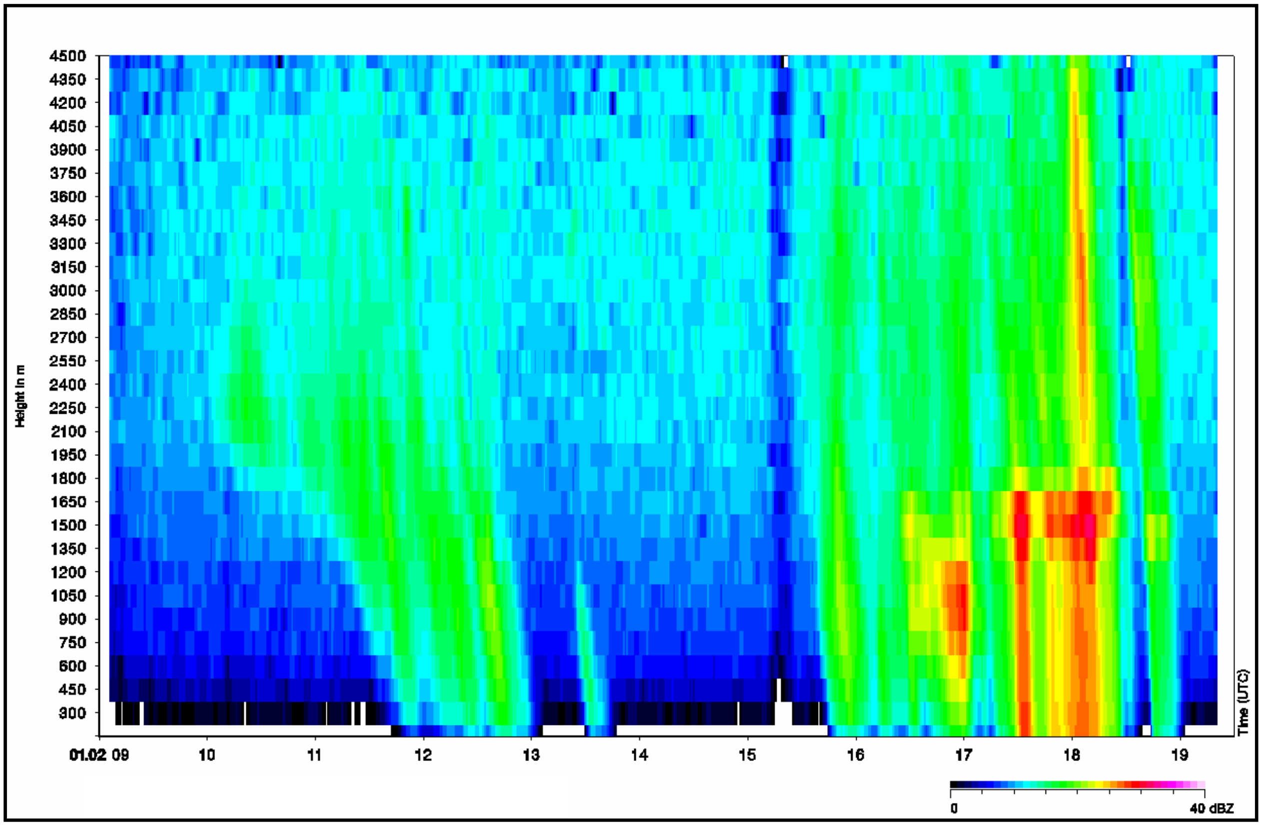

Figure 1: MRR reflectivity plot of height (m) vs. time (UTC) for 1 February 2007 deployment.

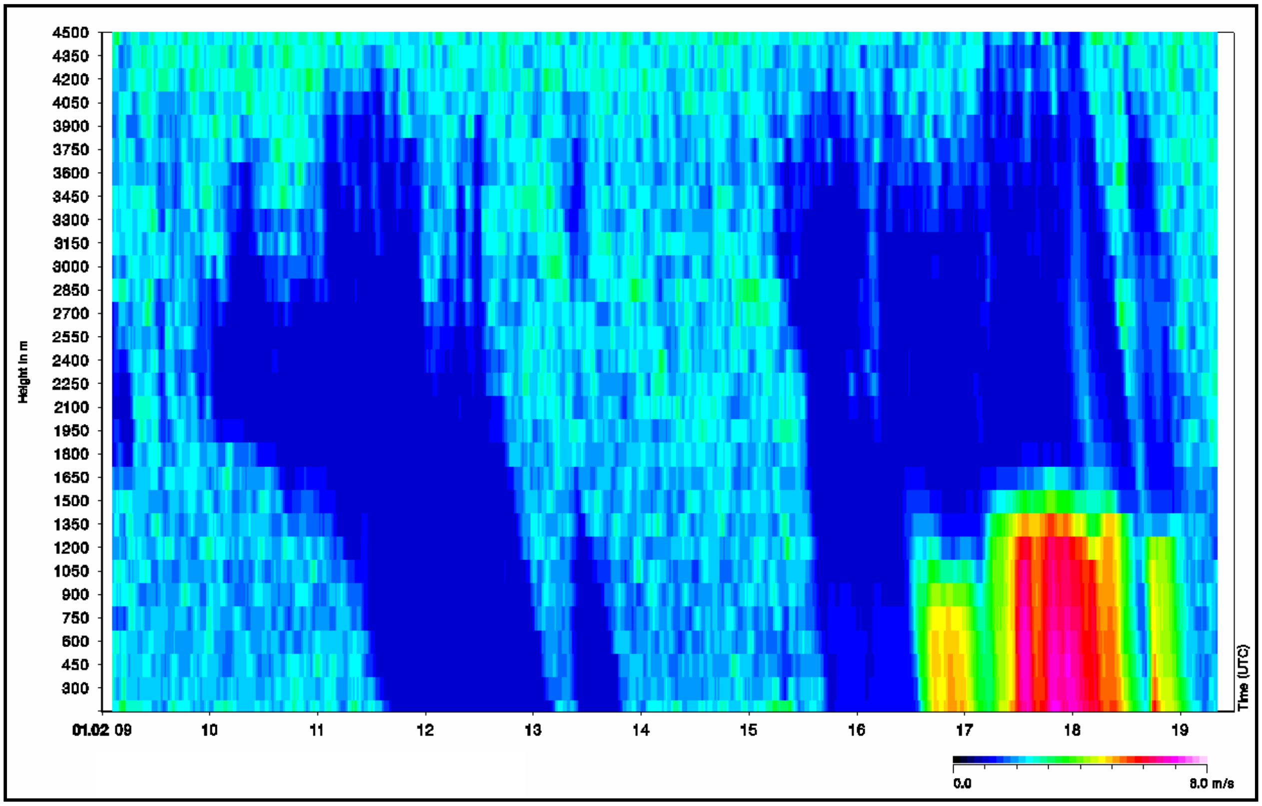

Figure 2: MRR fall velocity plot of height (m) vs. time (UTC) for 1 February 2007 deployment.

From 1645Z until 17Z significant increases in both reflectivity and fall velocity from the ground to 1500 m can be seen, suggesting that the bright band, or the level at which melting of frozen precipitation is occurring, is located at an altitude of about 1200 m. The bright band appears in the radar data because the snowflakes have begun to melt or are partially melted at this height. During melting, the snowflakes maintain their relatively large diameter but their liquid coating causes the drops to be highly reflective. As evidenced by the increase in fall velocities (Figure 2) during this time, the precipitation does not recover from the partial melting before hitting the ground and is reported at the surface as a wet snow. Another brief period of frozen precipitation falls from 1710Z to 1720Z.

Finally, just before 1730Z there is one final transition to heavy rain that lasts the remainder of the data collection period. This transition is clear from Figure 1 and especially Figure 2, as there is a dramatic change in colors representing the bright band at 1500m. During this transition, the melting is complete, as rain is falling at the surface with a maximum fall velocity of about 7.1 m/s. Even if no observer is present, it can be deduced from this fall velocity value that rain, with an approximate diameter of 2.3 mm, is falling (Gunn and Kinzer, 1949).

Based on this and other MRR datasets it is thought that MRR data, when used in conjunction with other datasets such as WSR-88D radars and surface observations, can be an excellent resource for forecasters (Blaes, 2007). It provides data about the vertical profile of precipitation that otherwise would not be known and gives forecasters a snapshot of changes in a storm that are imminent, such as the height of the bright band or the moistening of a dry layer above ground.

4. FUTURE WORK

A unique feature of the RENCI MRR not available during the 1 February deployment is its current mounting on a small trailer to enhance transportability. This mobility allows the radar to be moved to various locations around the state as determined by an approaching weather event. The trailer has a leveling system so that the radar remains vertical when sampling. Electronic components and an onboard computer are enclosed for protection during precipitation. The trailer also includes a camera, a compact weather station called the Vaisala

Weather Transmitter WXT510 that measures six variables, an OTT laser optical disdrometer, an infrared temperature sensor to measure the temperature of the ground, and a GPS to determine the location and elevation of the radar. All data collected by the sensors on the trailer is sent back to RENCI in real-time using wireless broadband. This winter the MRR trailer is collecting data in Chapel Hill and will be deployed to other sites in the state if a winter weather event occurs in North Carolina. .

Although the MRR provides useful data, it is limited to a single vertical data point. Combining this data point with the two NWS balloon launches in the state fails to provide a complete picture of what is happening aloft in North Carolina. To understand a dynamic, 3-dimensional vertical structure, we are exploring the possibility of creating a network of MRRs that would give snapshots of vertical precipitation profiles aloft across a large area of the state.

In addition to winter weather events, the mobile MRR has been and will continue to be deployed along the southeastern coast of North Carolina during the summer and fall in anticipation of a tropical event. Data collected during a tropical event from the MRR would provide information such as the current rain rate as well as the rain rate at which the MRR attenuates. Also, the MRR could be used to improve the Z-R relationship of the NWS radar that samples the southeastern part of North Carolina. Finally, the MRR can be used during rain events, although due to the drought across the southeastern United States we have only a very limited data set.

5. CONCLUSION

Reflectivity and fall velocity data from a Micro Rain Radar have been presented for a winter weather case study from 1 February 2007. This case study demonstrates the utility of an MRR to observe the vertical structure of precipitation. Features such as the bright band are easily observed on both the reflectivity and fall velocity data and can be helpful to forecasters during an event.

The MRR provides data about the vertical profile of precipitation that otherwise would not be known. Also, the data gives forecasters a snapshot of changes in a storm that are imminent, indicated by such features as the height of the bright band or the moistening of a dry layer above ground. Used in conjunction with other observations, the MRR can be a valuable resource for forecasters.

6. REFERENCES

Bailey, C.M., G. Hartfield, G.M. Lackmann, K. Keeter, and S. Sharp, 2003: An objective climatology, classification scheme, and assessment of sensible weather impacts for Appalachian cold-air damming. *Wea. Forecasting*, **18**, 641-661.

Blaes, J., 2007: A new weather too: the upward-pointing “Micro Rain Radar.” *National Weather Service Raleigh Changing Skies Newsletter Fall/Winter 2007-08*, **5**, 9. [Available online from http://www.erh.noaa.gov/rah/newsletter/RAHnewsletter_Nov07.pdf].

Fletcher, N.H., 1962: *The Physics of Rainclouds.* Cambridge University Press, 386 pp.

Gunn, R., and G.D. Kinzer, 1949: The terminal velocity of fall for water drops in stagnant air. *J. Meteor*., **6**, 243-248.

Löffler-Mang, M., M. Kunz, and W. Schmid, 1999: On the performance of a low-cost K-band radar for quantitative rain measurements. *J. Atmos. Oceanic Technol.*, **16**, 379-387.

Lott, J.N., and T. Ross, 2006: Tracking and evaluating U.S. billion dollar weather disasters, 1980-2005. Preprints, *AMS Forum: Environmental Risk and Impacts on Society: Successes and Challenges,* Atlanta, GA, Amer. Meteor.Soc.

METEK, 2005: *Micro Rain Radar User Manual*. Elmshorn, Germany, 41 pp.

METEK, 2005: *MRR Physical Basics Version 1.9.0*. Elmshorn, Germany, 22 pp.

Peters, G., B. Fischer, H. Münster, M. Clemens, and A. Wagner, 2005: Profiles of raindrop size distributions as retrieved by Microrain Radars. *J. Appl. Meteor.,* **44**, 1930-1949.

Strauch, R.G., 1976: Theory and application of the FM-CW Doppler radar. Ph.D. thesis, University of Colorado, 97 pp.