P4B.5 OPERATIONAL USE OF A HYDROMETEOR CLASSIFICATION ALGORITHM TO DETECT THE SNOW MELTING LEVEL

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1. INTRODUCTION AND WEATHER SYNOPSIS

On 3-4 December 2002, a winter storm moved across Oklahoma, producing a variety of precipitation types. The National Severe Storms Laboratory's (NSSL) experimental hydrometeor classification algorithm (HCA, based upon Zrnic et al. 2001) was used on polarimetric radar data and made available to National Weather Service forecasters as part of the Joint Polarization Experiment (Schuur et al. 2003). The HCA was run in real time on PPI data collected at a 0.5 degree elevation angle by the NSSL's polarimetric WSR-88D, KOUN.

The algorithm output helped forecasters evaluate the altitude, slope, and evolution of the snow melting level, improving the forecast of precipitation type across the region. This event marked the first operational use of polarimetric radar data by the National Weather Service during a winter storm. Another such case study is documented by Miller and Scharfenberg (2003) in this volume.

The HCA methodology for discrimination between rain and snow is described in Ryzhkov and Zrnic (2003) and is based upon polarimetric concepts outlined in Ryzhkov and Zrnic (1998). This presentation discusses the verification of the algorithm output in this particular case, and how the output was used in an operational setting.

The precipitation type forecast for this storm system was somewhat challenging. A cold front moved through Oklahoma on 2 December, bringing cooler air to the region. Surface temperatures decreased throughout the day on 3 December as the cold air mass continued to deepen across the state. Meanwhile, a middle- and upper-level low pressure moved out of New Mexico and across the Southern Plains, causing a warm air advection pattern to develop ahead of the storm system. This pattern brought moisture to the mid levels and enhanced lift over Oklahoma.

The precipitation began as rain, but eventually changed to freezing rain, sleet, or snow over large parts of Oklahoma as the cold air mass continued to deepen and cool. The melting level first intersected the surface in northwest Oklahoma early in the event, where the reported snowfall totals were the highest. The melting level sloped upward toward the southeast across the state; southeast Oklahoma only received rain. Meanwhile, locations across southwest, central, and northeast Oklahoma received rain, freezing rain, and sleet, before the precipitation changed to snow.

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2. RADAR AND SOUNDING OBSERVATIONS

Figure 1 shows an example of the HCA output, taken at 1655 UTC on 3 December. Note the melting level is generally depicted at a lower altitude to the north and west (1100 m to 1470 m) than to the south (up to 1830 m).

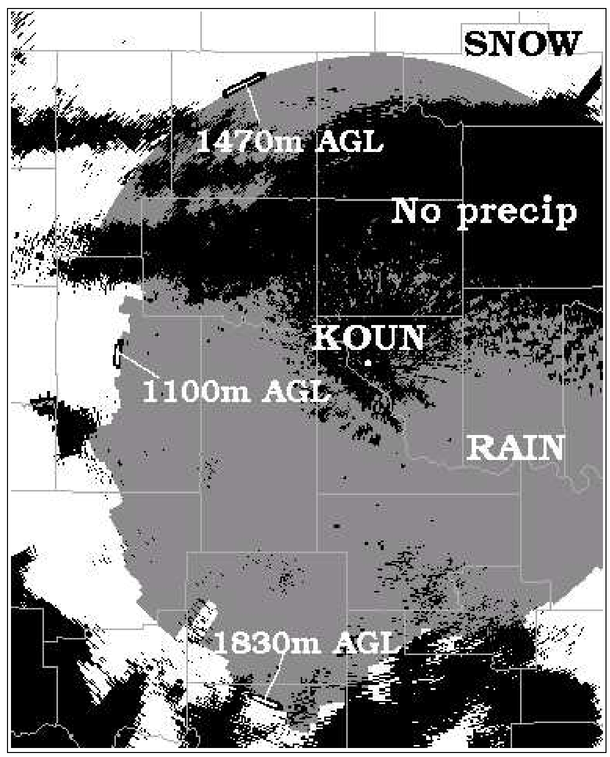

FIGURE 1. The NSSL Hydrometeor Classification Algorithm output at 1655 UTC on 3 December 2002 for KOUN polarimetric WSR-88D. Black shading represents regions of no precipitation. The gray region depicts areas of rain, and the white region depicts snow. Three beam height altitudes discussed in the text are shown.

A special sounding was released at the Norman, Oklahoma office of the National Weather Service (co-located with KOUN radar) at the time of the radar image in Figure 1. This sounding was used to verify the actual melting level altitude. The sounding (Figure 2) found the melting level to be about 2400 m AGL. At first glance, this may appear inconsistent with the KOUN measurement of the rain-snow line between 1100 and 1830 m AGL. However, note that the sounding indicates the layer of air just below the melting level is subsaturated.

Observational studies indicate snow falling below the melting level into subsaturated air may fall more than 500 meters before melting, and the snow melt layer often extends as low as the 5°C isotherm (Pruppacher and Klett 1998). Therefore, the KOUN measurement is reasonable, and is also consistent with reports in northwestern Oklahoma of light snow falling with surface temperatures as high as 3°C.

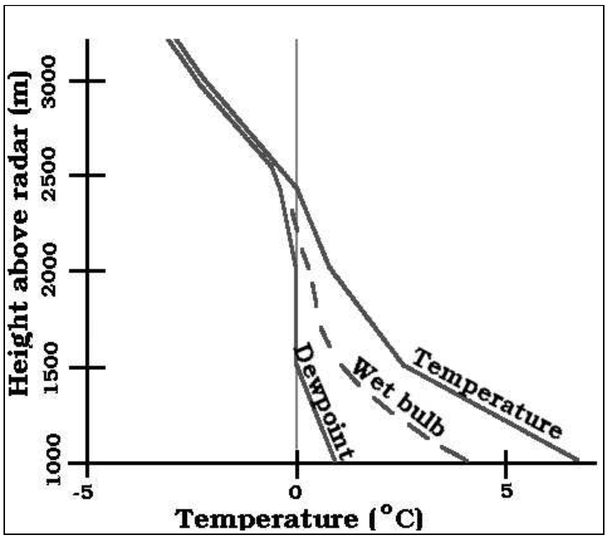

FIGURE 2. Partial profile of temperature, dewpoint, and wet bulb temperature from a sounding launched near KOUN radar at 1700 UTC on 3 December 2002.

The KOUN reflectivity image (Figure 3) corresponding to Figures 1 and 2 has two important implications. First, note that there is no well-defined "bright band", or enhanced region of reflectivity corresponding to the melting level. This is typically the only method available to find the melting level using a non-polarimetric radar.

Second, the reflectivity image shows the precipitation is more intense to the west of the radar, where the HCA indicated the melting layer to be nearest the ground. This is a reasonable observation, as heavier precipitation would be expected to cool the

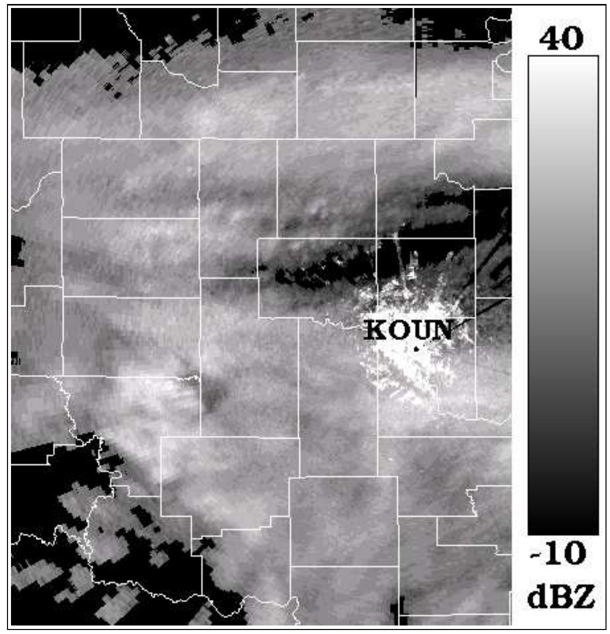

FIGURE 3. KOUN reflectivity image at 1655 UTC, 3 December 2002.

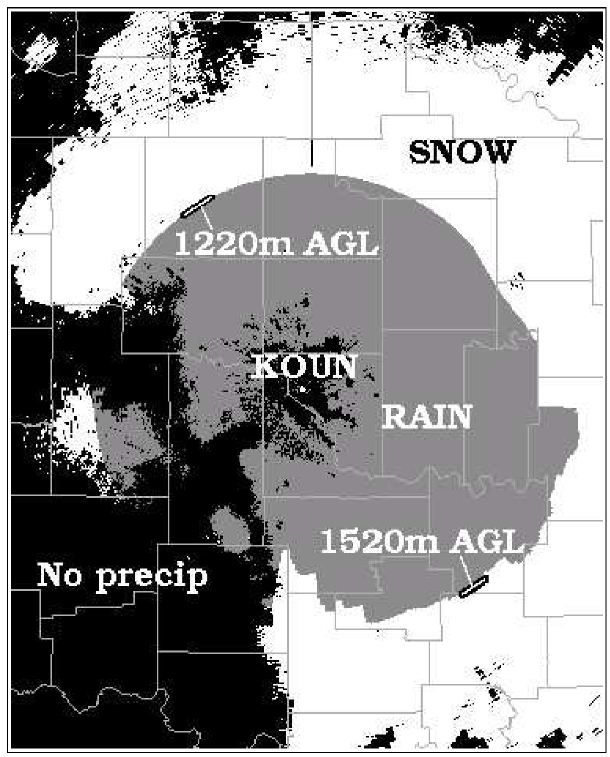

FIGURE 4. The NSSL Hydrometeor Classification Algorithm output at 0428 UTC on 4 December 2002. Black shading represents regions of no precipitation. The gray region depicts areas of rain, and the white region depicts snow. Two beam height altitudes discussed in the text are shown.

subsaturated lower atmosphere more rapidly to the wet bulb temperature.

Later in the event, temperatures had cooled and the rain/snow line had moved slowly to the southeast. Correspondingly, the altitude of the melting layer had lowered (Figure 4) to 1220 m to 1520 m AGL. The upward slope of the melting level toward the southeast remained evident.

The 2300 UTC sounding (Figure 5) confirmed that the melting layer had lowered over the region, and also showed that the entire layer had become saturated. The melting level on the sounding (1600 m AGL) is still higher than depicted in the HCA product, however, the difference was considerably less than earlier in the event. This is consistent with observational studies that indicate falling snow melts more readily in a saturated environment than in a subsaturated environment (Pruppacher and Klett 1998).

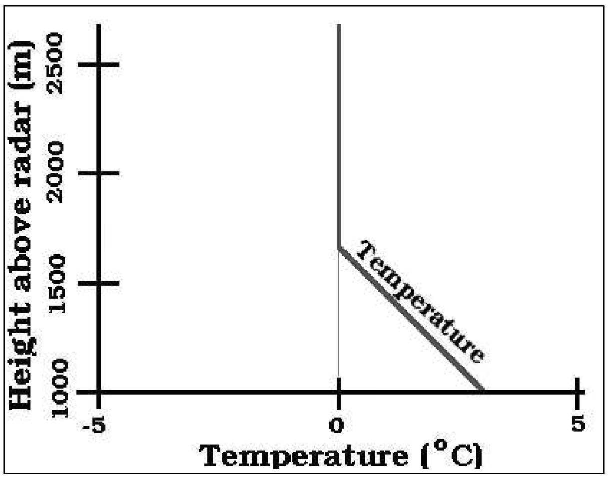

FIGURE 5. Partial profile of temperature, dewpoint, and wet bulb temperature (saturated) from a sounding launched near KOUN radar at 2300 UTC on 3 December 2002.

3. OPERATIONAL IMPLICATIONS

Using the KOUN polarimetric radar and HCA output, forecasters were able to determine the melting level was sloped toward the southeast as soon as precipitation began, and throughout the event. In addition, forecasters observed the melting level gradually lower as the cold air mass deepened. Finally, the more rapid cooling of the air column in the heavy precipitation west of the radar early in the event was made evident by the lower melting level in that area.

These observations gave forecasters increased confidence in forecasting a northwest-to-southeast transition in precipitation type from rain, to mixed phase, to snow. The time evolution in the HCA output allowed the forecasters to better anticipate the change in precipitation types as the cold air mass strengthened.

4. ACKNOWLEDGEMENTS

National Weather Service forecaster Mike Branick provided much of the weather data collected during this event. This case study would not have been possible without the dedicated work of the scientists who maintain, operate, and collect data from KOUN radar.

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5. REFERENCES

Miller, D.J., and K.A. Scharfenberg, 2003: The use of polarimetric radar data in the winter weather warning decision making process: A case study. *Preprints, 31st Intl. Conf. on Radar Meteor.*, Seattle, WA, Amer. Meteor. Soc., in this preprint volume.

Pruppacher, H.R., and J.D. Klett, 1998: *Microphysics of Clouds and Precipitation, 2nd ed.* Kluwer Academic Publishers, 954 pp.

Ryzhkov, A.V., and D.S. Zrnic, 1998: Discrimination between rain and snow with a polarimetric radar. *J. Appl. Meteor.*, **37**, 1228-1240.

Ryzhkov, A.V., and D.S. Zrnic, 2003: Discrimination between rain and snow with a polarimetric Nexrad radar. *Preprints, 31st Intl. Conf. on Radar Meteor.*, Seattle, WA, Amer. Meteor. Soc., in this preprint volume.

Schuur, T.J., D.W. Burgess, and A.V. Ryzhkov, 2003: The Joint Polarization Experiment – An operational demonstration of the polarimetric KOUN WSR-88D radar. *Preprints, 31st Intl. Conf. on Radar Meteor.*, Seattle, WA, Amer. Meteor. Soc., in this preprint volume.

Zrnic, D.S., A. Ryzhkov, J. Straka, Y. Liu, and J. Vivekanandan, 2001: Testing a procedure for automatic classification of hydrometeor types. *J. Atmos. and Oceanic. Technol.,* **18,** 892-913.