P6.2 Development and testing of a dual-pol-based surface precipitation type algorithm

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1. Introduction

Accurate remote diagnosis of precipitation type at the surface in real-time can be of great benefit to aviation interests. A surface precipitation type algorithm has been developed that integrates temperature data from surface sensors, thermodynamic model output from numerical weather prediction models, and dual-polarimetric radar hydrometeor classification algorithm output. The algorithm has been initially tested on three archived cases and shows promise in accurately depicting regions of freezing rain, snow, and rain at the surface, potentially aiding aviation ground operations during winter storms.

The key component in improving surface precipitation type diagnosis is dual-polarimetric radar. The WSR-88D at the National Severe Storms Laboratory (KOUN) was upgraded in 2002 to include polarimetric capabilities. Dual-pol radars are capable of remotely diagnosing hydrometeor types in sampled areas aloft with a high degree of certainty. In addition, polarimetric radar has been found to be useful in differentiating between meteorological and non-meteorological scatterers. Dual-pol KOUN data were provided in real-time to forecasters at the National Weather Service for their evaluation during the Joint Polarization Experiment (JPOLE) in 2003. The data analysis period included several winter storms. Forecasters found polarimetric characteristics helped in their interpretation of surface precipitation type (Miller and Scharfenberg 2003, Scharfenberg et. al 2005a).

A hydrometeor classification algorithm (HCA) will be included with the national upgrade of the WSR-88D. This algorithm uses fuzzy logic to determine the most likely type of scatterer sampled based on the polarimetric characteristics, as described by Ryzhkov et al. (2005). Recent data analysis suggests the melting layer can be automatically detected using polarimetric radar variables (Giangrande et al. 2005). This will further aide the HCA in differentiating between liquid and frozen hydrometeors aloft. However, many areas of the United States have little or no radar coverage between the surface and ~1 km above ground level. Simple extrapolation of precipitation type from the lowest radar elevation angle to the surface will not always be reliable.

To more accurately depict surface precipitation type, the HCA output derived from fuzzy logic at each radar tilt is combined with model thermodynamic data and surface temperature reports in the surface precipitation type algorithm (SPTA). This algorithm has been developed and tested using the National Severe Storms Laboratory's Warning Decision Support System – Integrated Information (WDSS-II; Hondl 2002) as described by Scharfenberg et al. (2005b).

2. Case studies

Three data sets were studied using KOUN dual-pol radar data, surface temperature data at 5-minute resolution from the Oklahoma Mesonet, and thermodynamic data aloft from a 20-km version of the operational Rapid Update Cycle (RUC) model. The cases chosen had different sensible weather reported at the surface – light snow on 16 January 2003, a rain event with a very low melting layer level on 2 May 2005, and widespread freezing rain and rain on 5 January 2005.

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a. Light snow on 16 January 2003

One hour of data, from 1400 to 1500 UTC, was chosen for this study. During that time period, light snow was being reported over a wide area, particularly near and north of the KOUN radar site. The radar showed small patches of light precipitation, with relatively weak reflectivity.

The dual-pol hydrometeor classification algorithm (Fig. 1) misidentified the precipitation as light rain. This is because light rain and light snow have similar dual-pol characteristics and no melting layer was observed. Because of the HCA misidentification, and surface temperature reports below freezing, the SPTA incorrectly assigned freezing rain at the surface (Fig. 2).

The HCA was re-run incorporating the RUC model temperature data aloft, and correctly identified the precipitation particles aloft as dry snow. The resulting SPTA output (Fig. 3) correctly identified the primary precipitation type at the surface as dry snow.

b. Rain with a low melting level on 2 May 2005

Multi-sensor data from 1400 to 1500 UTC on 2 May 2005 were tested. During this event, rain was the only precipitation type reported at the surface, but a very low melting level was observed. In the dual-pol fields at the lowest elevation angle, much of the melting layer was sampled, leading to identification of melting, melted, and frozen hydrometeors over a wide range.

Despite the highly varied particle types identified aloft by the HCA, the SPTA (Fig. 4) correctly classified rainfall at the surface throughout the coverage area. Surface temperature reports and low-level RUC thermodynamic information ingested into the SPTA suggested any frozen or melting hydrometeors aloft would be completely melted before impacting the surface.

c. Rain and freezing rain on 5 January 2005

A significant freezing rain event struck the northwestern half of the KOUN coverage area on 5 January 2005. Data from 1000 to 1100 UTC were examined for this study. Surface temperature and precipitation type reports at 1000 UTC (Fig. 5) showed freezing rain and sub-freezing temperatures confined to an area west through north of KOUN, with rain and surface temperatures above freezing near and southeast of the radar. An objective analysis of Oklahoma Mesonet data (Fig. 5) well-depicted the freezing line at the surface.

The SPTA output (Fig. 6) showed very good agreement with the surface precipitation type reports, even at long ranges from the radar, where the HCA output on the lowest radar tilt showed snow.

3. Discussion and Conclusions

This technique shows potential in providing real-time mapping of surface precipitation type. Unfortunately, it is not possible with standard data sets to construct a complete surface verification map. Dual-pol hydrometeor classification on radar elevation data surfaces serve as the basis for determining surface precipitation type. Below the lowest radar elevation angle, surface temperature reports and numerical model thermodynamic information can be used to estimate how the observed precipitation changes (if at all) before reaching the surface.

Because radar cannot differentiate between rain and freezing rain, this is the only method to provide an accurate real-time map of freezing rain at the surface. In addition, if dual-pol information is not available to accurately map precipitation type aloft, numerical model data may be incorporated to assist in classification.

It is hoped this algorithm will be tested in real-time mode during a future dual-pol winter weather study, coincident with an intensive verification effort.

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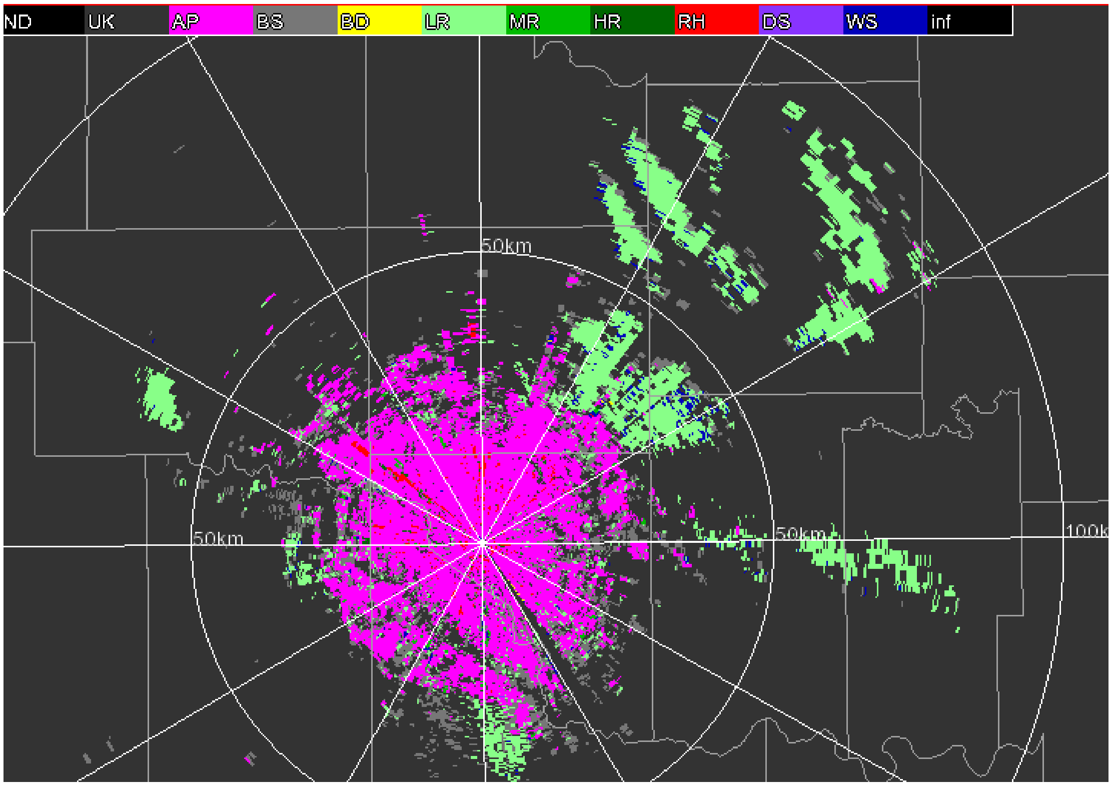

Fig. 1. Hydrometeor classification algorithm output from the KOUN dual-pol radar 0.5 degree elevation angle on 16 January 2003 at 1400 UTC.

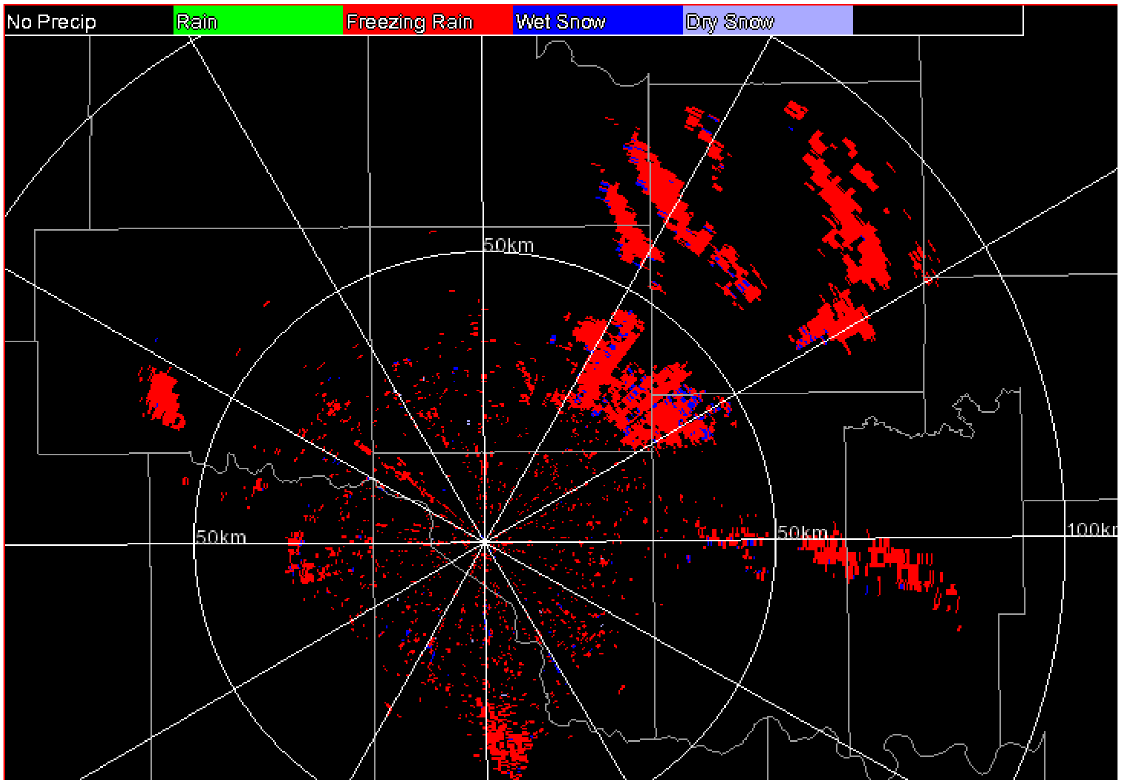

Fig. 2. Surface precipitation type algorithm output on 16 January 2003 at 1400 UTC including only surface temperature data.

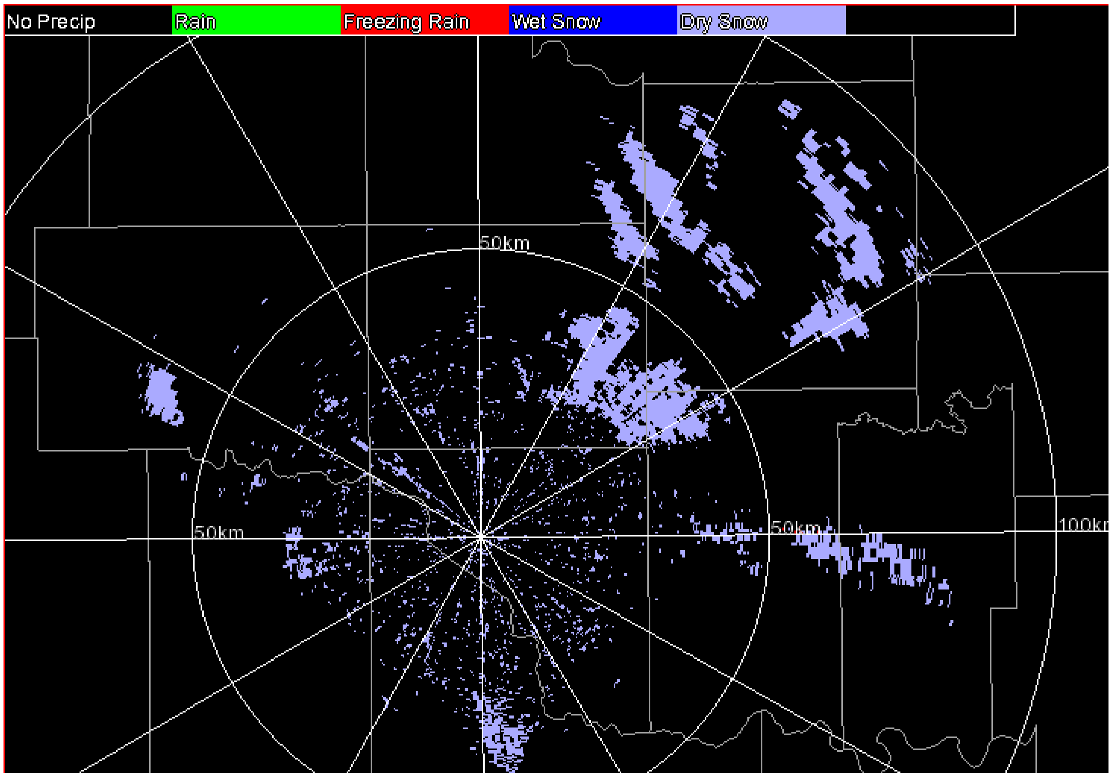

Fig. 3. Surface precipitation type algorithm output on 16 January 2003 at 1400 UTC using both RUC model thermodynamic data aloft and surface temperature reports.

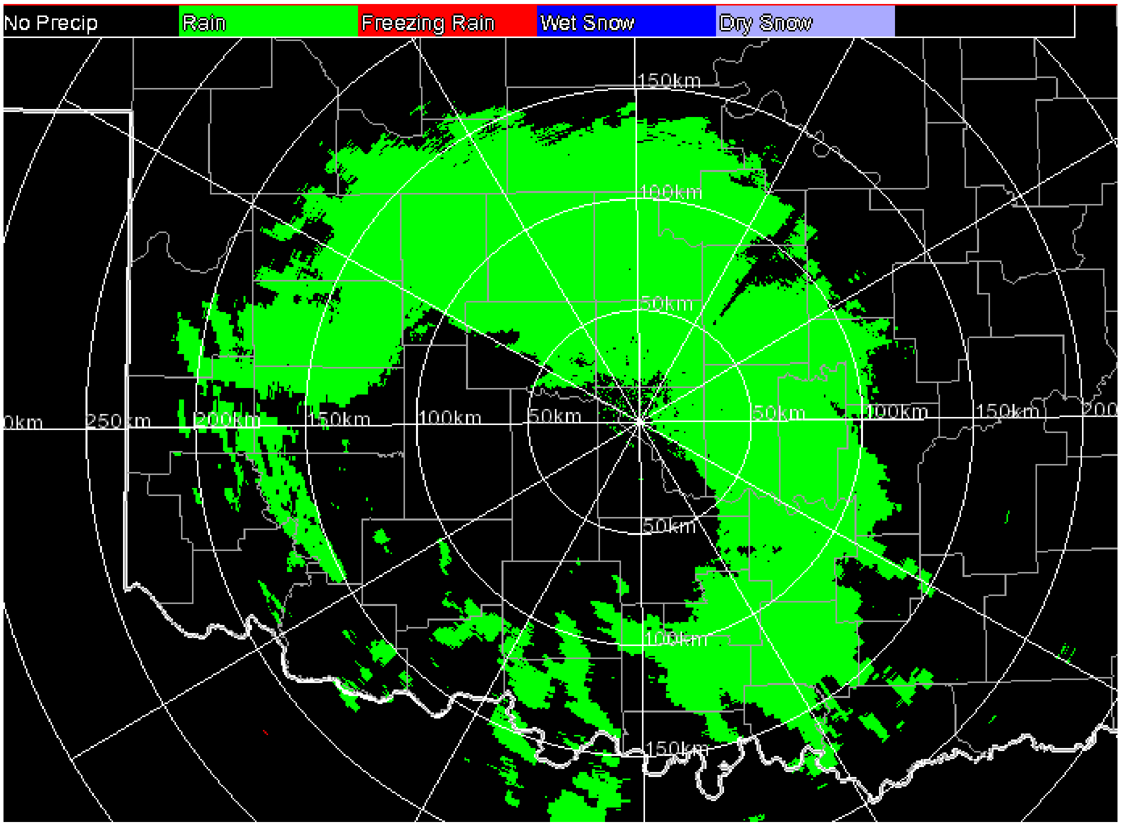

Fig. 4. Surface precipitation type algorithm output on 2 May 2005 at 1400 UTC.

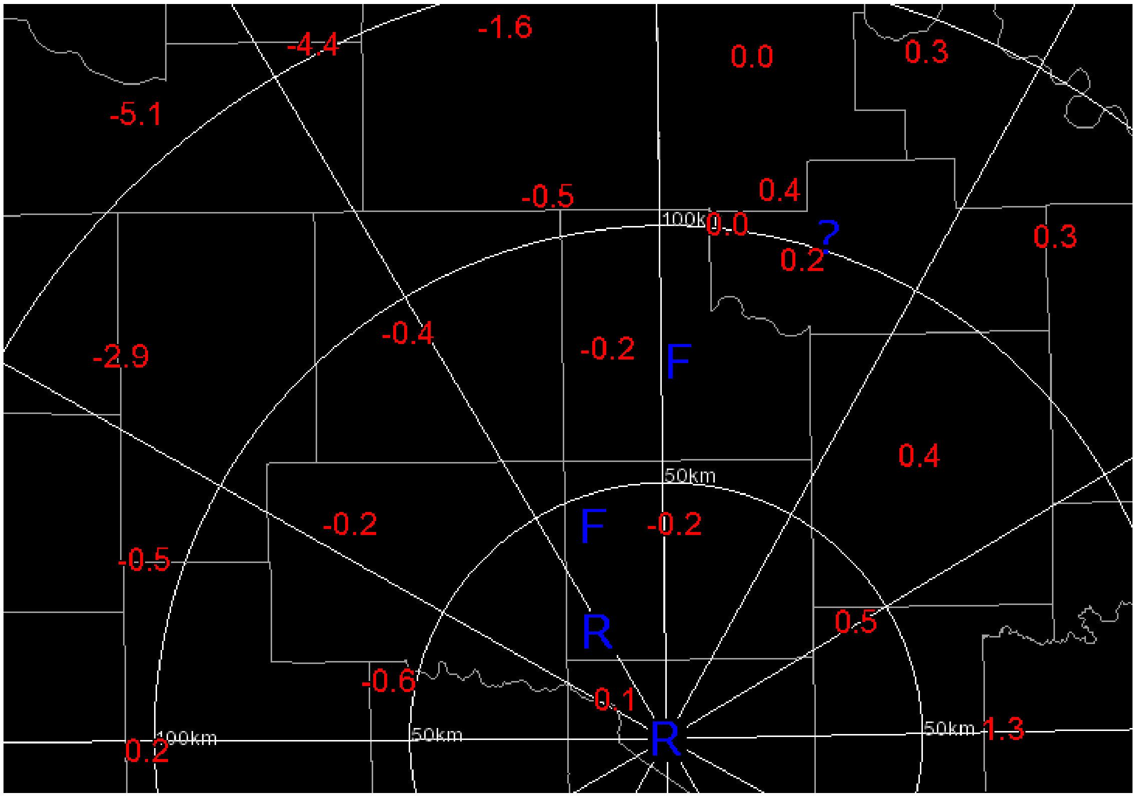

Fig. 5. Surface temperature (°C) and observed precipitation type reports ("F" for freezing rain, "R" for rain, and "?" for unknown) at 1000 UTC on 5 January 2005.

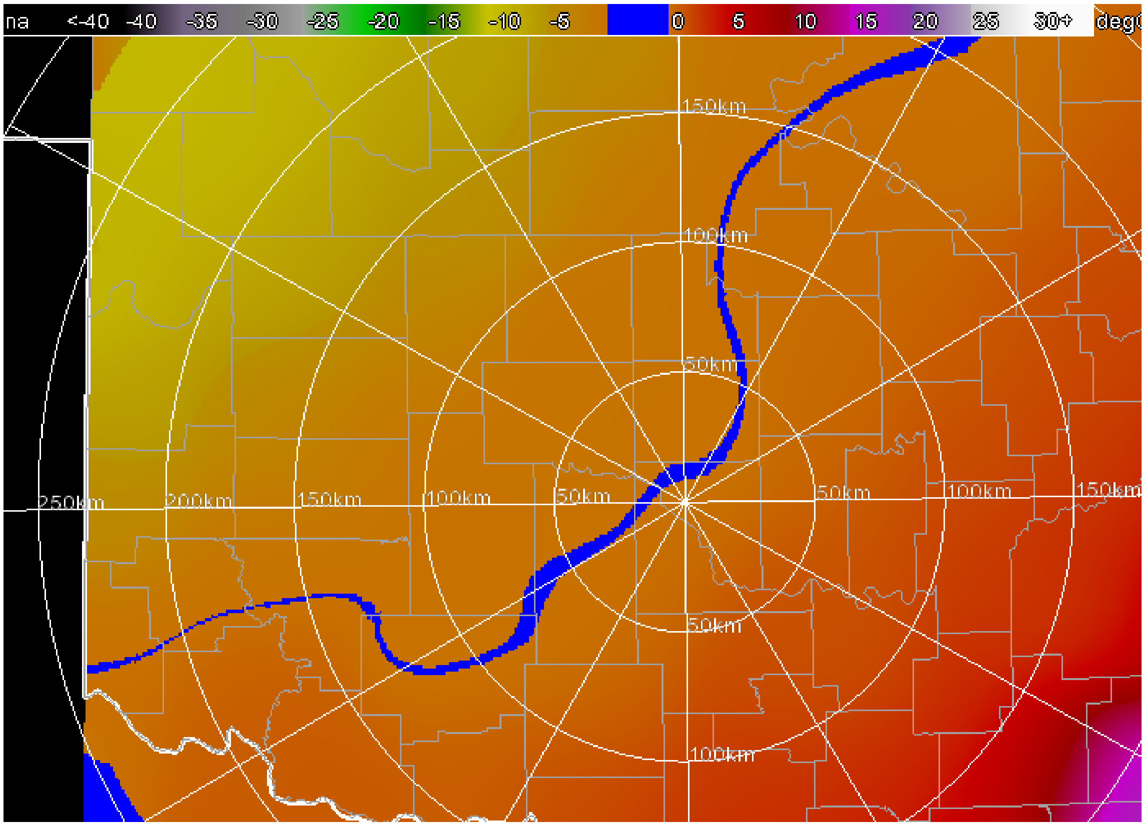

Fig. 6. Objective analysis of Oklahoma Mesonet temperature reports at 1000 UTC on 5 January 2005. A temperature analysis near 0°C is marked by the blue line.

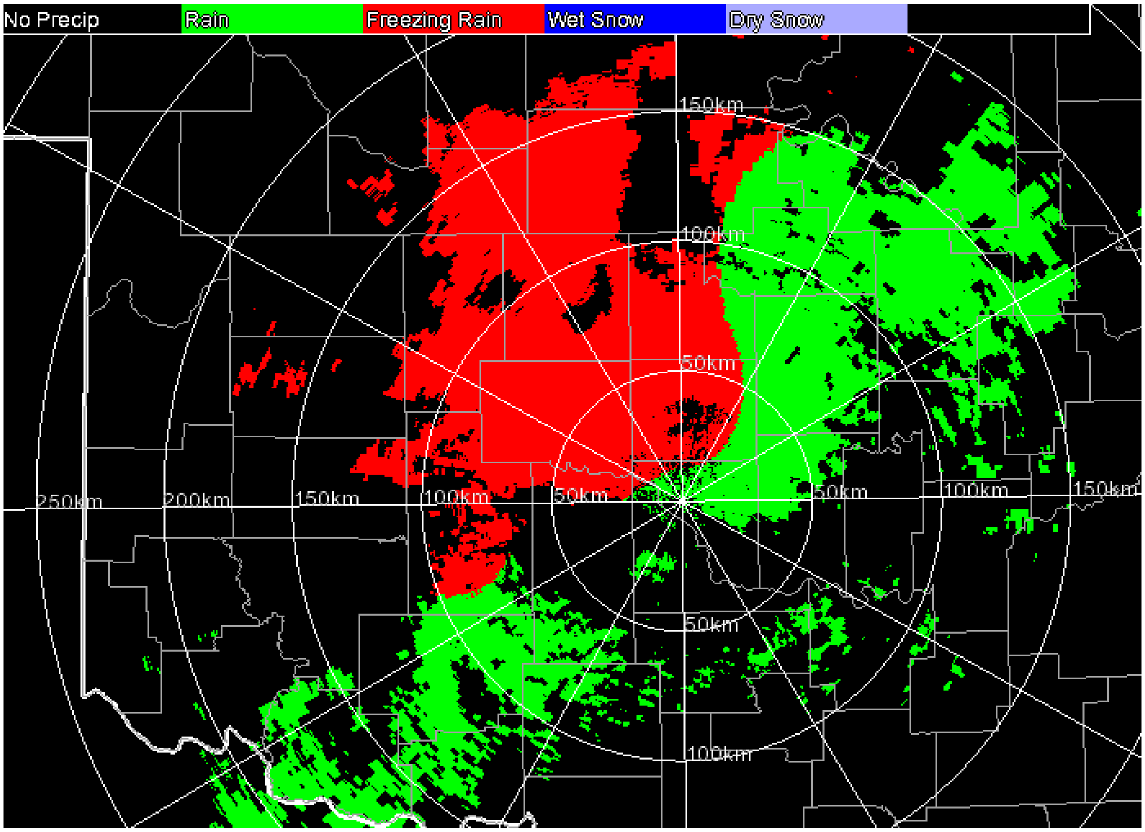

Fig. 7. Surface precipitation type algorithm output at 1000 UTC on 5 January 2005.