HYDROMETEOR IDENTIFICATION FROM W-BAND POLARIMETRIC MEASUREMENTS

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Introduction

Automatic classifications of radar polarimetric measurements into hydrometeor types using fuzzy-logic or other similar algorithms are now routinely done using ground-based cm-wavelength polarimetric radars (e.g., Vivekanandan et al. 1999; Lim. et al. 2005). In most of these algorithms, the polarimetric thresholds for various hydrometeor types are based on computational studies. A comprehensive review of polarimetric thresholds used for hydrometeor identification from cm-wavelength radar is given by Straka et al. (2000). Most of the cm-wavelength based algorithms are focused on large-scale systems and typically lump ice crystals into 2-3 broad categories. However, as both observational and computational studies for mm-radar show (e.g., Wolde and Vali, 2001; Tang and Aydin 1995), ice crystals have diverse polarimetric signatures that depend on crystal shape, size, density and fall patterns. By using near coincident in-situ and airborne radar data, it is possible to refine the threshold obtained from computational studies and add more classes (mixed phase, mixed particle types, rimed vs. pristine crystals etc). This paper uses near-coincident (within 100 m) W-band polarimetric radar and in-situ cloud microphysics measurements in developing fuzzy-logic based hydrometeor classification beyond what has been reported in the past.

Data and Methodology

The W-band and in-situ microphysical measurements used in this study were obtained during the second Alliance Icing Research Study (AIRS II). AIRS II was conducted between November 2003 and February 2004 over the Mirabel airport near Montreal, Canada and the surrounding regions in Ontario and Quebec (**http://airs-icing.org/**).

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During AIRSII, the University of Wyoming Cloud Radar (WCR) was installed on the National Research Council of Canada Convair-580 (CV580) research aircraft (Fig. 1) during the first Intensive Operational Period (IOP1) of AIRS II. During this period, the CV580 sampled clouds consisting of glaciated, mixed phase and supercooled clouds. W-band radar polarimetric signatures of ten hydrometeor types (irregular crystals, dendrites, plates & stellar types, needles, supercooled drops, supercooled drizzle, mixed phase, melting crystals, drizzle and rain) were identified using the near-coincident radar and in-situ measurements. The near-coincident W-band radar and in-situ data were used to determine thresholds of radar equivalent reflectivity factor (Z_e), differential reflectivity factor (ZDR) and Linear Depolarization Ratio (LDR) for the different hydrometer types. The poalrimetric thresholds and the flight level temperature are then used as an input for the fuzzy-logic based algorithm.

Figure 1: The Wyoming W-band Cloud Radar installation inside the NRC Convair-580

Result

Figs 2-3 show examples of the fuzzy logic output of hydrometeor types based on the W-band radar measurement in two different cloud conditions sampled during AIRSII. Samples of in-situ particle shapes measured by one of the sensors (PMS 2D-C) are also shown as reference. In the first example (Fig. 2), the hydrometeor types changed from small ice crystals (irregular shape) to supercooled drops. The algorithm clearly captured the transition from ice phase to supecooled cloud regions. The second example (Fig. 3) was obtained from a flight through pristine planar crystals (plates and dendrites) with pockets of supercooled drops. Again there is a good agreement between the in-situ sensor data and the fuzzy-logic output.

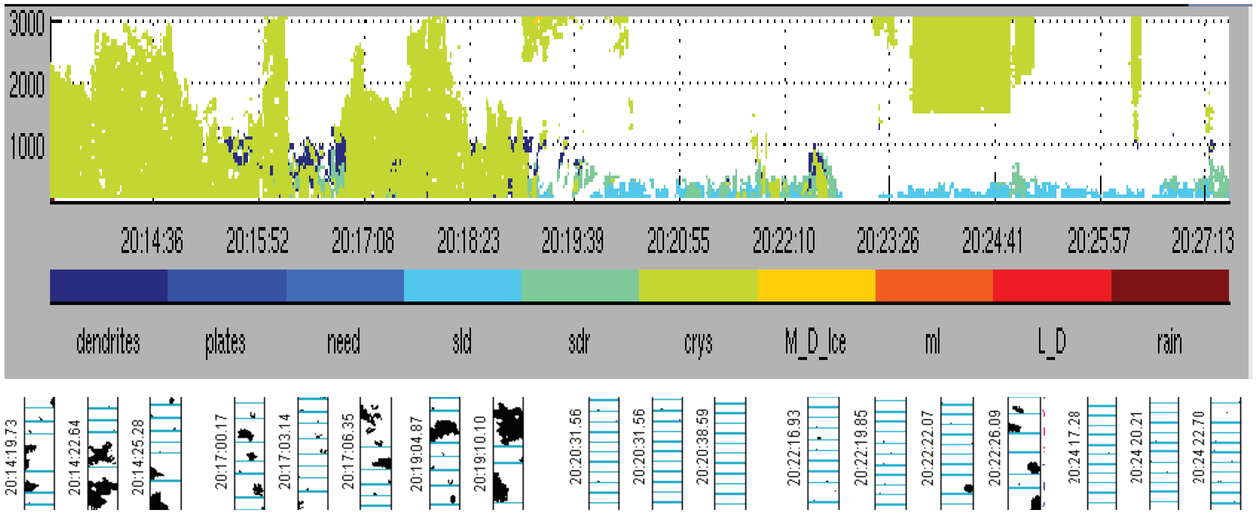

Figure 2. Top: Fuzzy-logic hydrometeor classification output. The bottom images show samples of PMS-2DC images during the flight. The horizontal bar represents 800 µm in size.

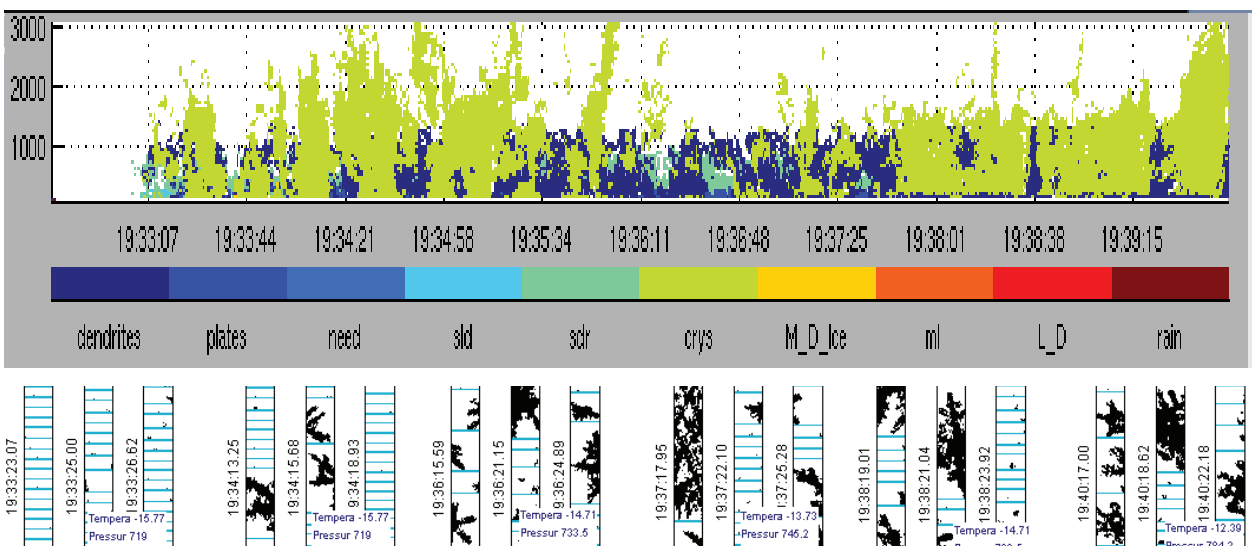

Figure 3: Same as Fig. 2 except for a flight segment through pristine planar crystals and supercooled clouds.

Concluding Remark

The paper presents an analysis of a large in-situ and airborne W-band radar polarimetric measurements obtained during AIRSII in winter clouds. The analysis done so far show a good agreement between the in-situ measurements and the fuzzy-logic based hydrometeor classification. As more coincident in-situ and radar data become available, this approach can be improved and more hydrometeor types can be added in the classification.

References

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