WRF SIMULATIONS OF THE NOVEMBER 11, 2003 AIRS II FIELD EXPERIMENT.

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1 Introduction

There has been a considerable amount of research on the modeling of micro-physical processes that lead to the formation of precipitation within meso-scale and cloud-scale dynamical models. This research has been concerned with many time and spatial scales, and physical mechanisms. While the most general theme often is to understand the role of natural and anthropogenic aerosols on precipitation formation, other purposes such as the prediction of specific physical phenomena such as rain, snow, and hail on the ground, aircraft icing conditions aloft, and precipitation enhancement potential remain important goals. During the last few years several wintertime field studies have provided comprehensive data sets that can use used to validate meso-scale forecast models and the micro-physical parameterizations. This paper present preliminary results of the meso-scale model simulations of the AIRS2 November 11, 2003 field experiment using the nested WRF-ARW model and including the micro-physical parameterization of Thompson et. al. (2004). The present micro-physical parameterization scheme has been designed to represent the major physical process characteristics of precipitation development in wintertime mid-latitude storms with the particular emphasis on the problem of predicting freezing drizzle events.

2 Model Description and Set-Up

The present dynamical framework is the non-hydrostatic Weather Research and Forecast Model (WRF), (WRF,2003). Initial and time dependent lateral boundary conditions are created by the WRF-ARW Standard Initialization program (SI) using the NCEP ETA model GriB 3 hourly output. The model domain includes 3 interactive grids of horizontal resolutions of 27, 9, and 3 km with grid points (x,y,z) (106,106,82), (181,181,82), and (181,181,82) centered over the observational area between Ottawa Ontario and Montreal Quebec. This model configuration allows for the simultaneous investigation of the larger scale storm system and also to focus on the smaller scale physical processes and storm structures that can be directly compared with the in-situ observations. The three nested domain grids were initialized at 00Z November. 11, 2003 and run for 24 hours with the period of interest being from 16Z to 24Z.

3 November 11, 2003 AIRS2 Field Study

On this day between 19 UTC and 23 UTC a NW-SE oriented precipitation cloud band moved through the field study area. This band was associated with warm air advection ahead of a developing surface low pressure system over Wisconsin. Figures 1 through 4 present a series 1.0 KM CAPII radar images from the McGill radar site from 18 UTC to 21 UTC as the storm moved into the observational area. Shown in figure 5 is a data time series plots from the NCAR C-130 taken along a east west line centered over the Mirabel Ontario airport (YMX). The flight legs were taken along the solid line in figures 6 through 7. Figure 5 reveals a week inversion just below 4 KM with an associated secondary liquid water maxima and the predominate precipitation changing from snow to drizzle at altitudes 1 KM to 4 KM during

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this period. At 19:30 UTC the PMS-2DC probe saw mostly snow between 1 and 5 KM altitude levels and by 22:30 the probe saw predominately freezing drizzle between 1 and 2 KM.

4 Model Simulation Results

The model output was matched to the radar by over plotting the radar range circles. WRF model simulation results from the fine grid (3 KM resolution) horizontal plots at 1.08 KM of the rain, and snow at 20:00 UTC are shown in figures 6 and 7. A secondary band that appears to the east of the main band in the radar did not appear in the simulation. Figures 8 through 11 show vertical cross-sections of model results at 20:00 UTC as the main cloud system passes over the observation area. In the plots of cloud water, rain or drizzle water and snow also contain plots of temperature (red) and equivalent potential temperature (black). The cloud system is caused by rising warm air being forced over colder air within the warm frontal system. The equivalent potential temperature illustrates how the warm air advection is causing the vertical motion within the cloud system. These cross-sectional plots depict how the cloud system changing from predominate snow to rain (drizzle) at the Mirabel location in time. Note the simulated cloud water field has a secondary maxima near 4 KM near the frontal inversion as seen by the aircraft observations. Several available warm rain parameterizations have been tested with the current model framework. Not all of the parameterizations produced freezing drizzle. The talk will focus on why some of the micro-physical parameterizations were successful and other were not and the importance of the background aerosol assumptions to the model solution.

5 Future Work

Further data analysis from the AIRS 2 field project are in progress from other aircraft platforms that collected data on this day.

It is the goal of this work to examine the suitability of using explicit bulk parameterization schemes to predict the characteristics of precipitation that lead to freezing drizzle events in wintertime mid-latitude storms. Work continues to test the hierarchy of bulk micro-physical schemes for cases where verification observational data are available. Further testing and modifications of the various spectral distribution functions that represent each cloud physical field are planed.

6 REFERENCES

Thompson, Gregory, R. M. Rasmussen, K. Manning, 2004: Explicit Forecasts of Winter Precipitation Using an Improved Bulk Microphysics Scheme. Part 1: Description and Sensitivity Analysis. *Mon. Wea. Rev.*, **132**,519-542.

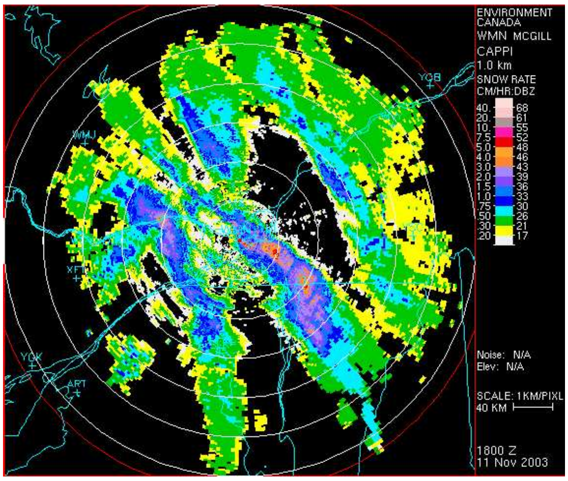

Figure 1: McGill Radar CAPPI 1 KM at 18 UTC.

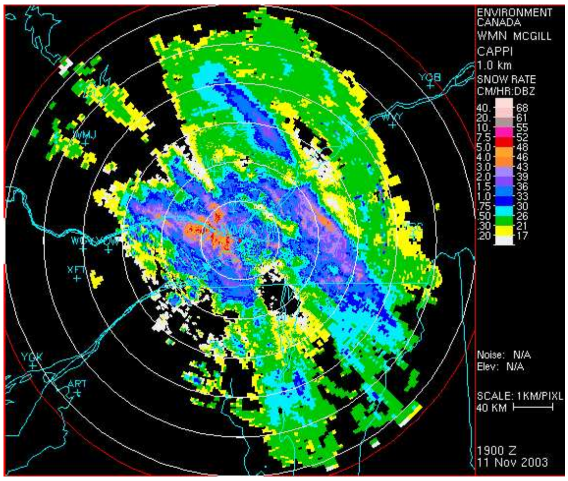

Figure 2: McGill Radar CAPPI 1 KM at 19 UTC.

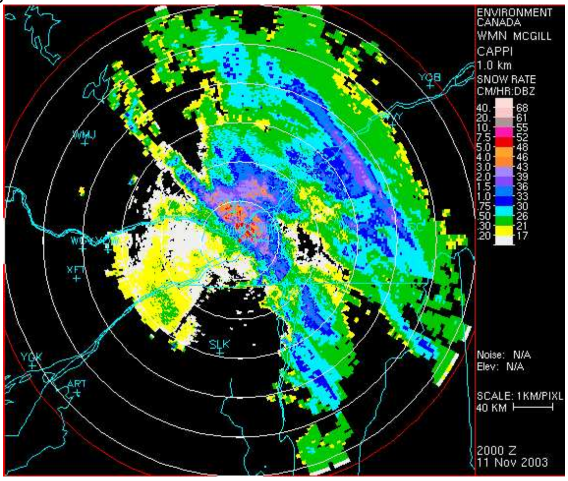

Figure 3: McGill Radar CAPPI 1 KM at 20 UTC.

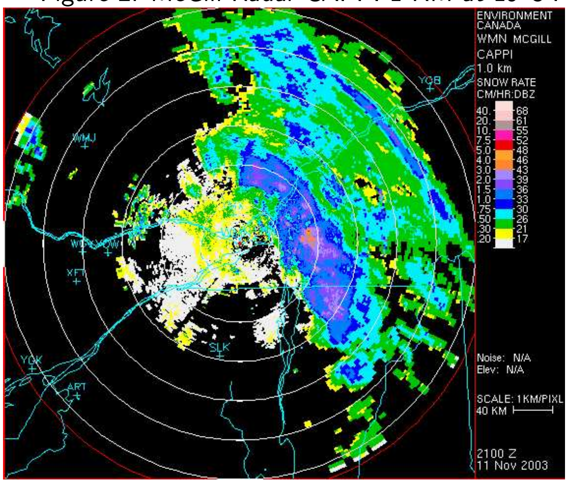

Figure 4: McGill Radar CAPPI 1 KM at 21 UTC.

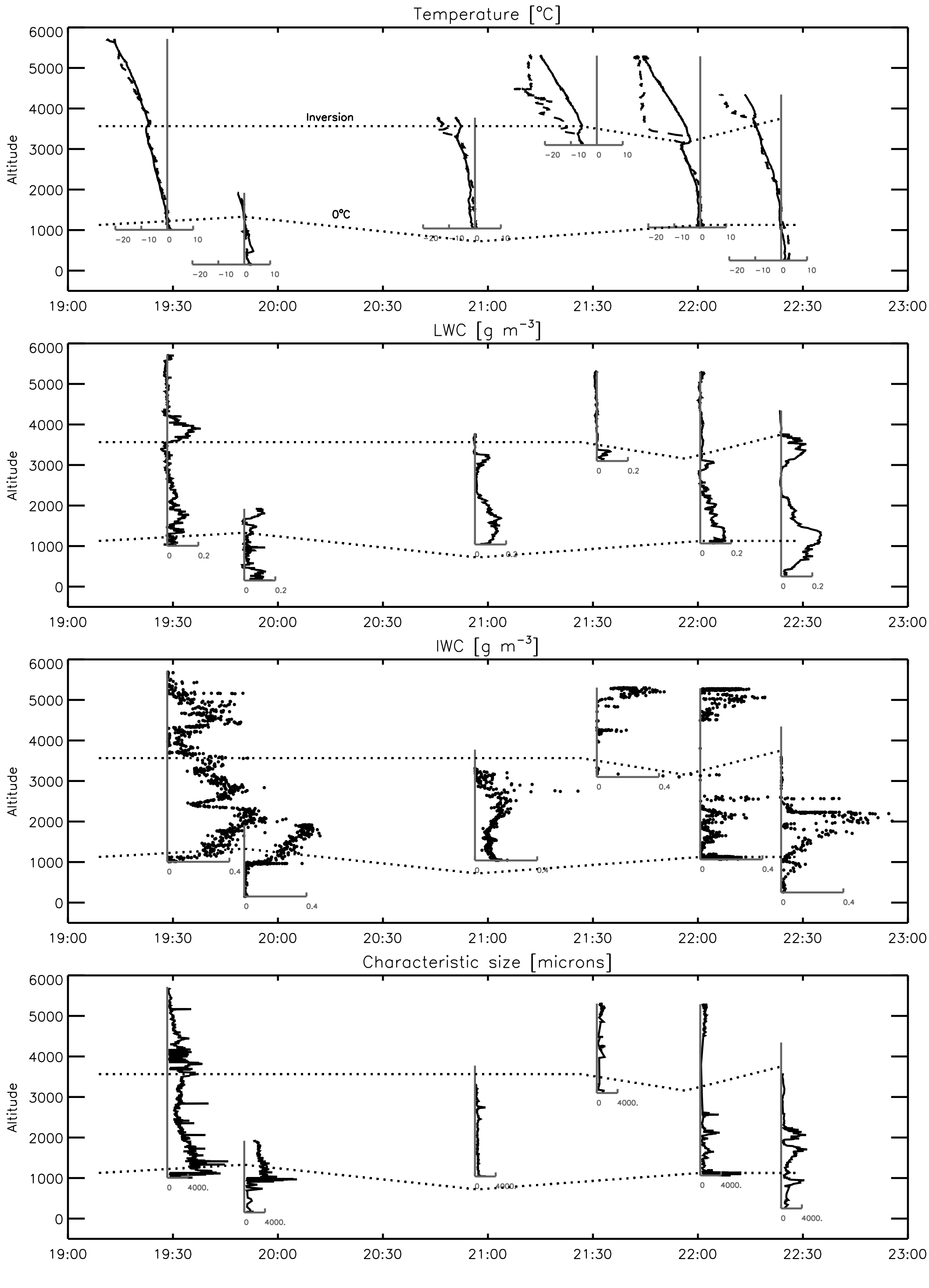

Figure 5: Plots of temperature, liquid water content, ice water content, and characteristic ice size as seen by the PMS-2DC probe from data collected by the NCAR C-130 flying over the observational area between 19 UTC and 23 UTC.

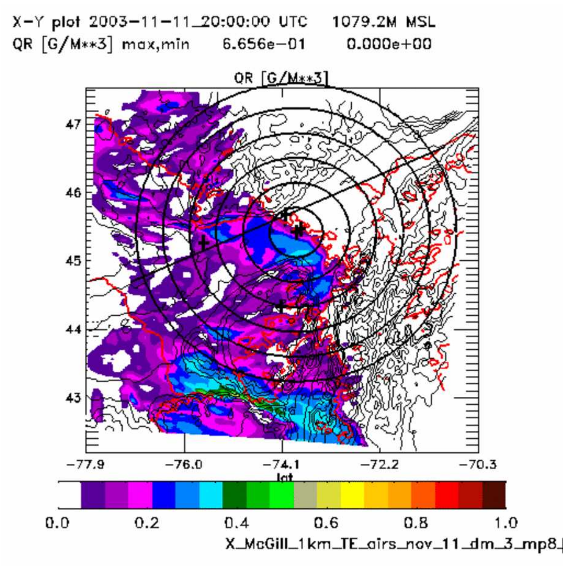

Figure 6: Rain and Drizzle at 1.08 KM at 20:00 UTC.

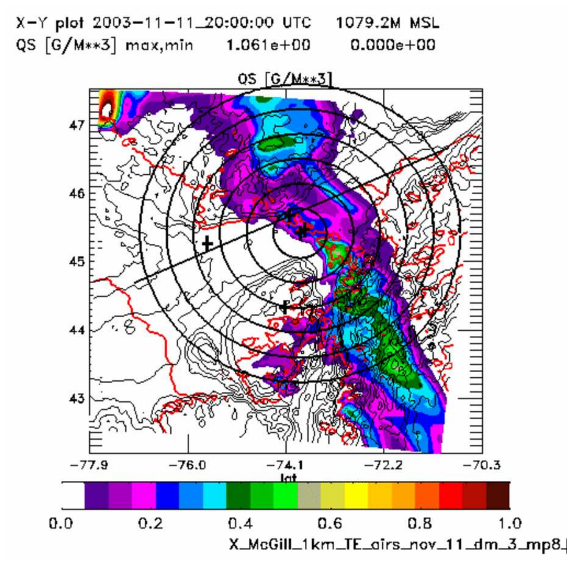

Figure 7: SNOW at 1.08 KM at 20:00 UTC.

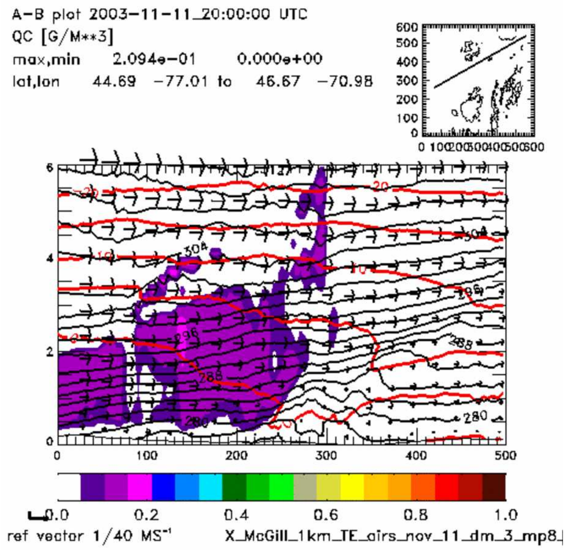

Figure 8: Cross-section of Cloud water at 20:00 UTC

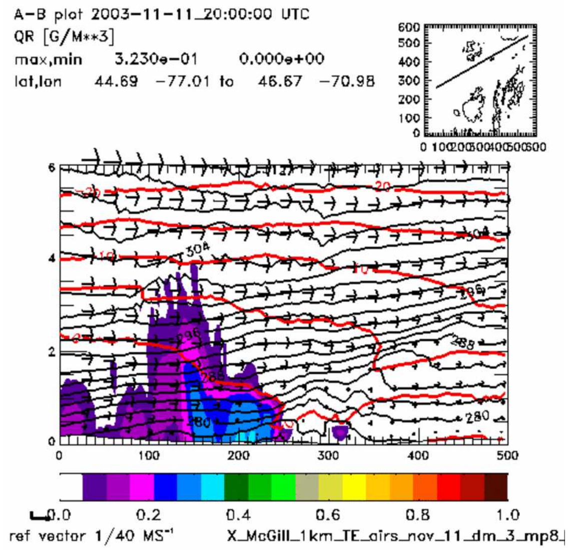

Figure 9: Cross-section of Rain and Drizzle water at 20:00 UTC.

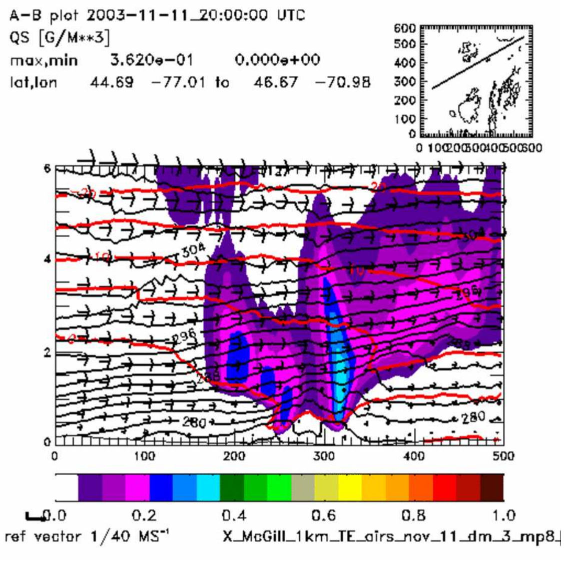

Figure 10: Cross-section of Snow at 20:00 UTC.