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 storm structures and physical processes that can be directly compared with the in-situ observations. The three domain model was initialized at 00Z November. 11, 2003 and run for 24 hour with the period of interest being from 14Z 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. Figure 1 is shown a 1.5 KM CAPII radar image from the Franktown, Ontario radar south west of the observational area at 16:10 UTC before the cloud band passed the observational area. At this time the cloud band was centered over the radar site. In figure 2 are several time series 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. Shown here are 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 this period.

‘ 4. Model Simulation Results

Corresponding to figure 1 in figures 3 through 6 are plotted WRF model simulation results from the fine grid (3 KM resolution) at 1.58 KM of the cloud, rain, snow, and graupel fields at 16:10

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UTC. Note the modeled cloud system is directly over the Franktown radar and has a NW-SE orientation as seen in the radar data. A secondary band that appears to the east of the main band in the radar did not appear in the simulation. Figures 7 through 10 show the same modeled fields at 20:30 UTC as the main cloud system passes over the observation area. The solid line is centered over Mirabel Airport and extends 1.°in longitude to the west-south-west and east-north-east marking the region of the cross-sectional plots that follow. The cloud system is caused by rising warm air being forced over colder air. Figure 11 shows the chosen cross-section of equivalent potential temperature illustrating how the warm air advection is causing the vertical motion within the cloud system. In Figures 12 through 15 are show in the same cross-sectional plane the fields of cloud water, rain water, snow, and graupel. These plots depict the cloud system changing from predominate snow to rain (drizzle). Note the cloud water field has a secondary maxima near 4 KM as seen by the aircraft observations. Little super-cooled drizzle droplets are present in the model in contrast to the aircraft observations. The model appears to have predicted graupel where the super-cooled large liquid droplets should have been.

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Reasons for the differences between the model simulation and observations remain a research subject. Possible problems include the lack of cloud fields at the initial starting time of the model, improper assumptions of the cloud condensation nuclei and ice forming nuclei with the model, and incorrect rain and snow size spectra assumptions used by the micro-physical parameterizations. 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 continue examining 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.

5. 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.

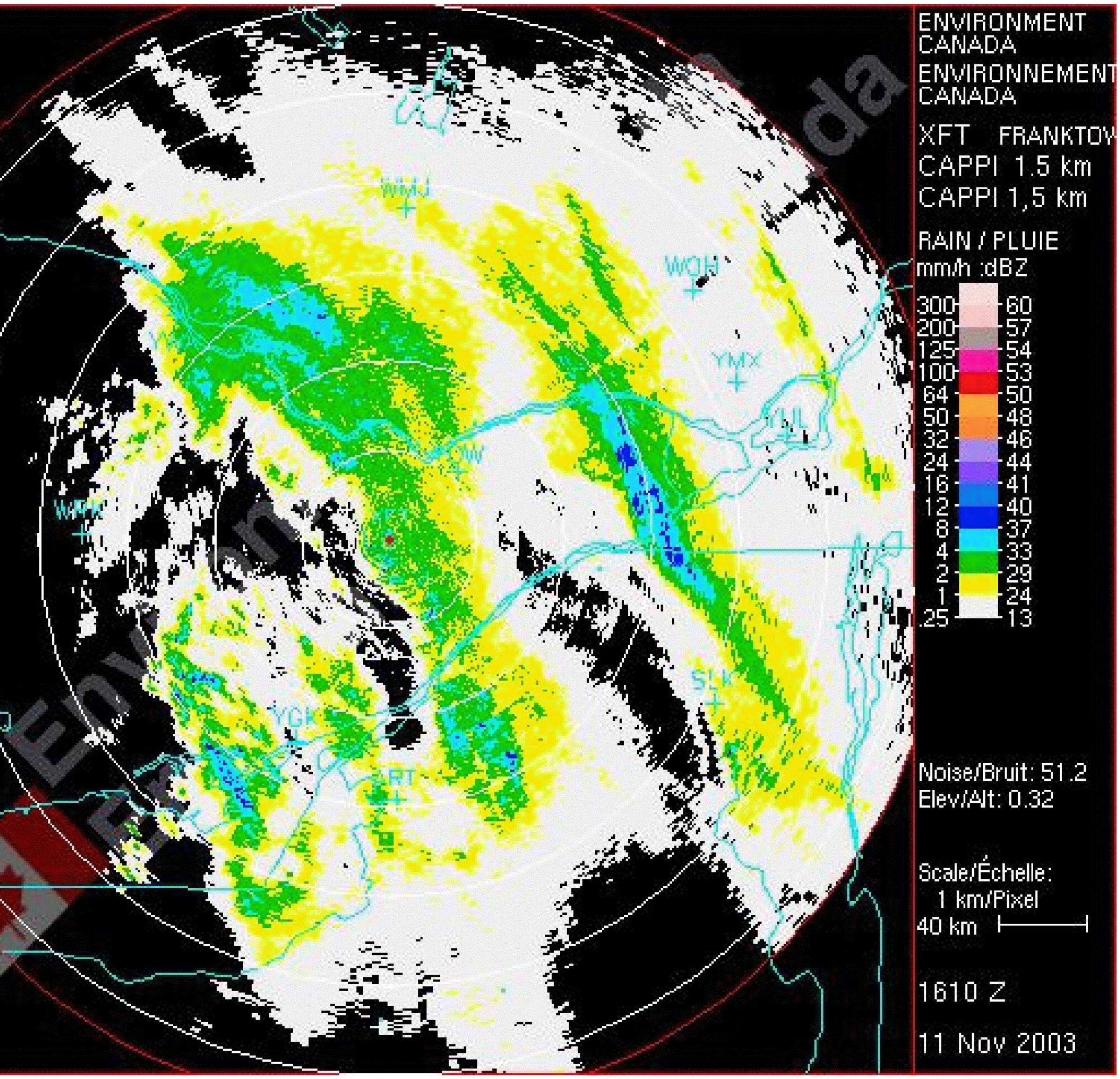

Figure 1: Franktown Radar 1.5 KM CAPI.

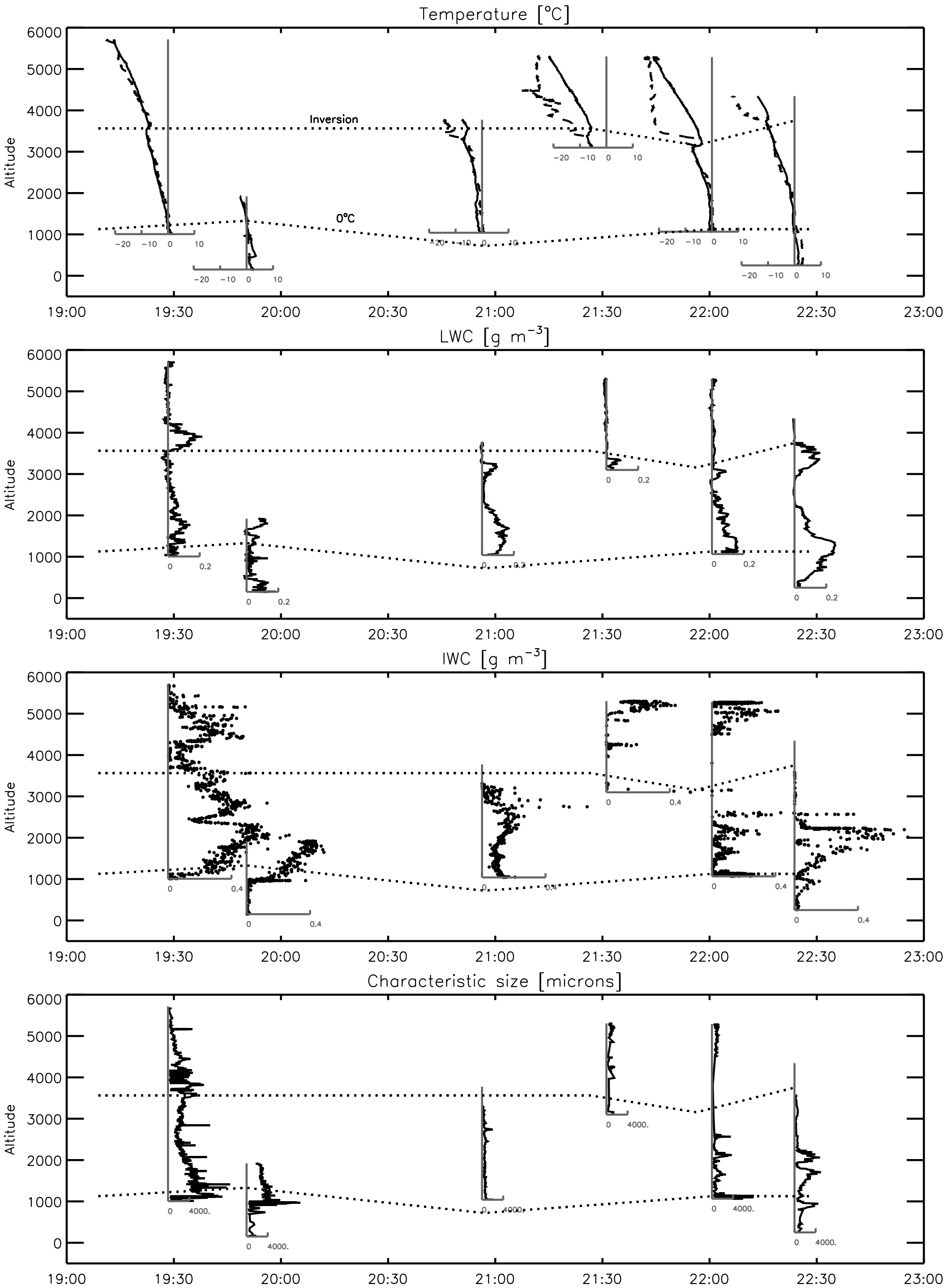

Figure 2: Aircraft ice and liquid water observations from the NCAR C-130.

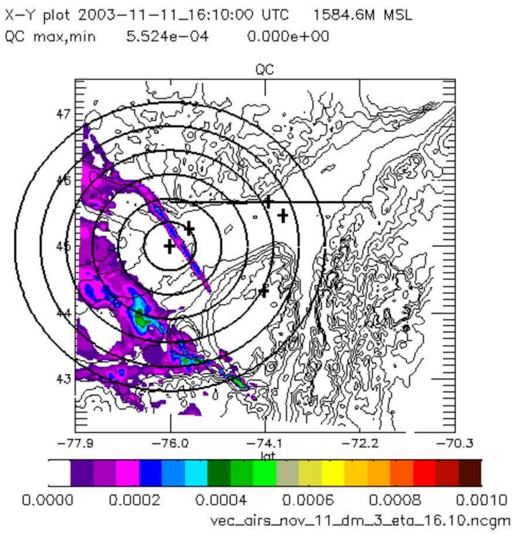

Figure 3: Cloud water at 1.58 KM.

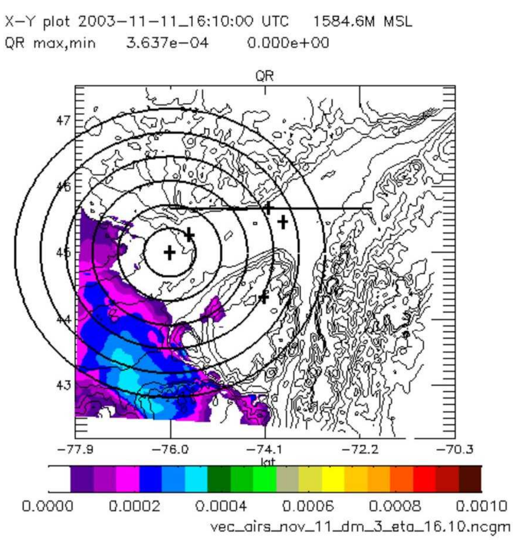

Figure 4: Rain of Drizzle water at 1.58 KM.

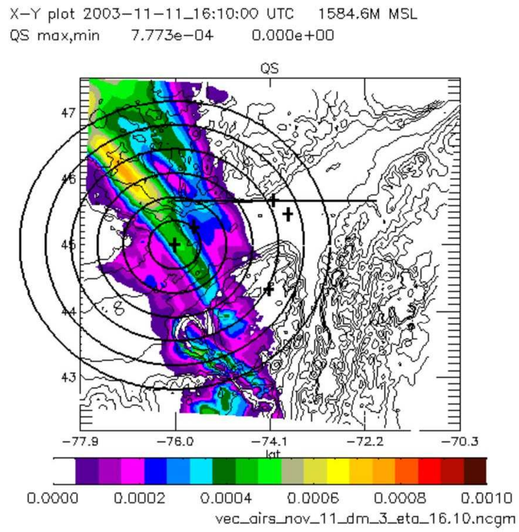

Figure 5: Snow at 1.58 KM.

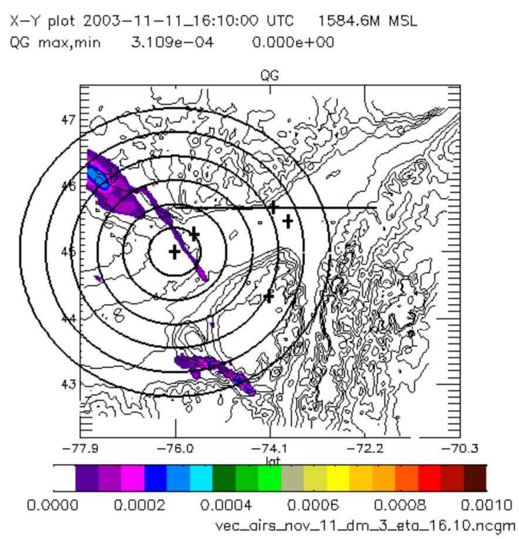

Figure 6: Graupel at 1.58 KM.

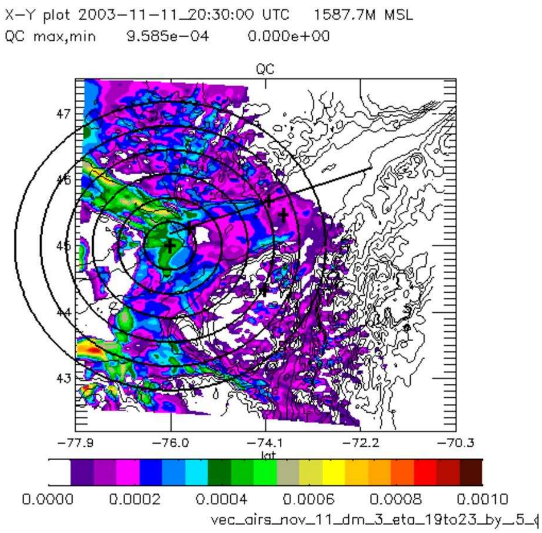

Figure 7: Cloud water at 1.58 KM.

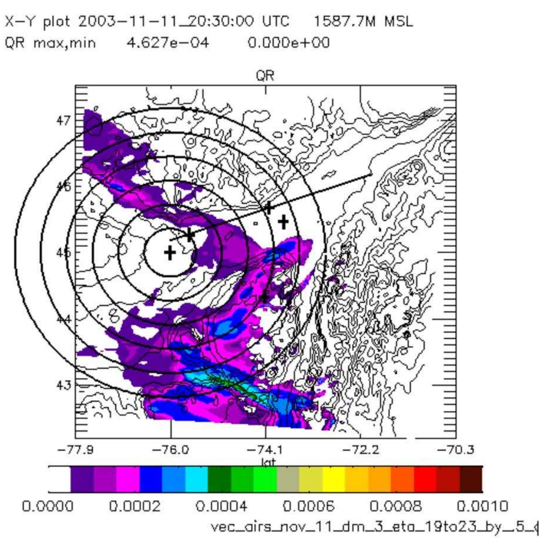

Figure 8: Rain of Drizzle water at 1.58 KM.

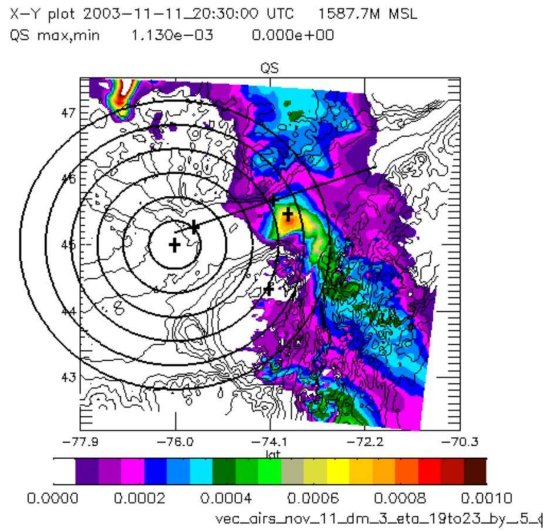

Figure 9: Snow at 1.58 KM.

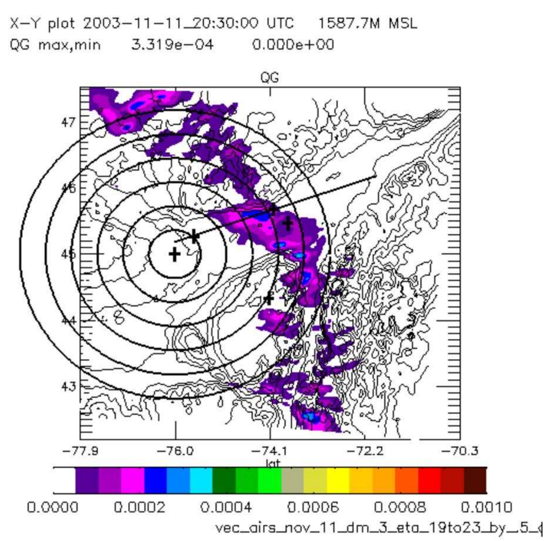

Figure 10: Graupel at 1.58 KM.

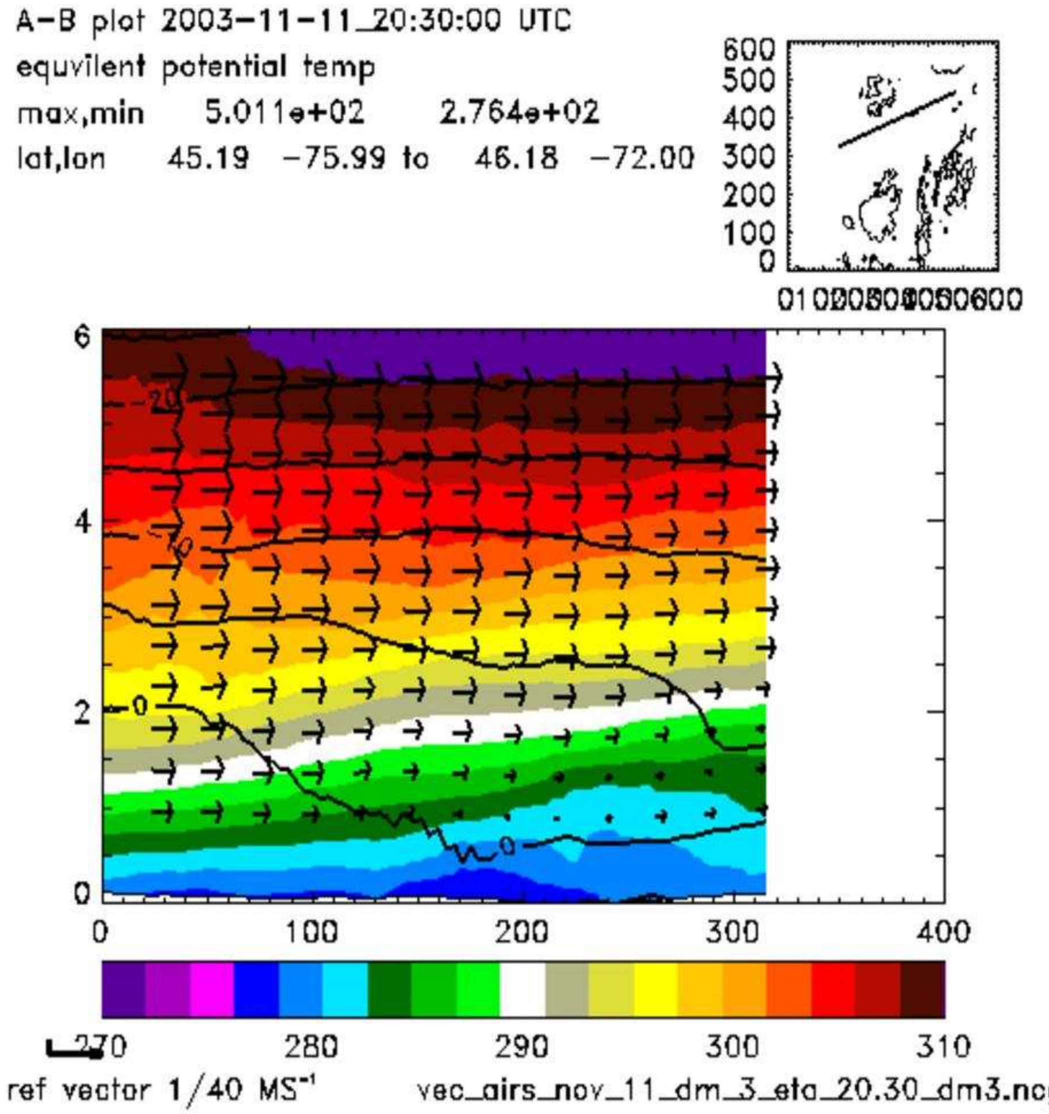

Figure 11: Cross-section of equivalent potential temperature at 20:30 UTC.

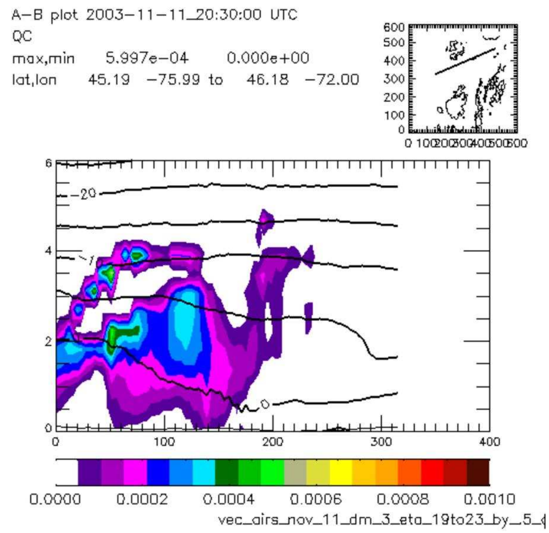

Figure 12: Cross-section of Cloud water at 1.58 KM.

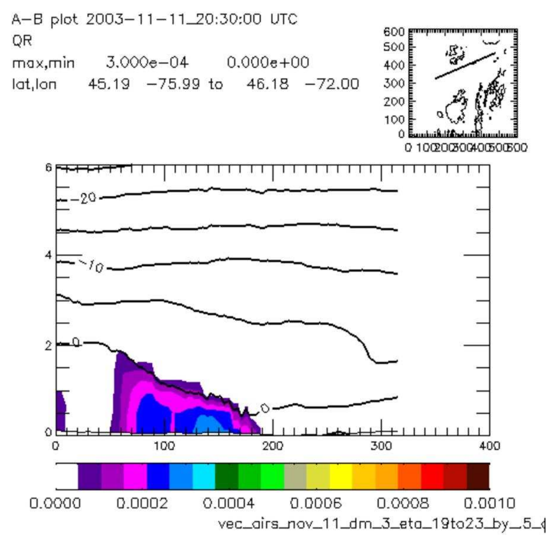

Figure 13: Cross-section of Rain of Drizzle water at 1.58 KM.

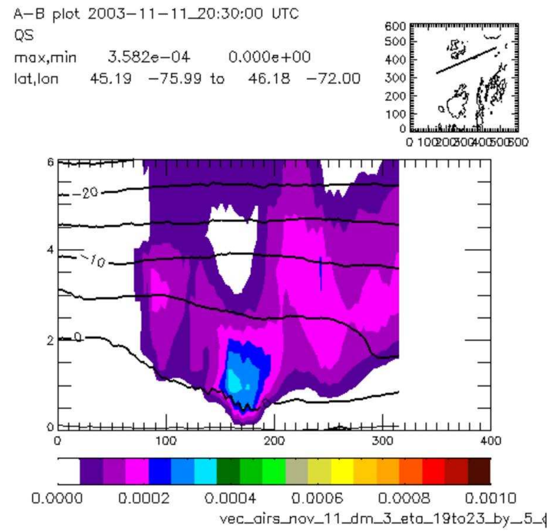

Figure 14: Cross-section of Snow at 1.58 KM.

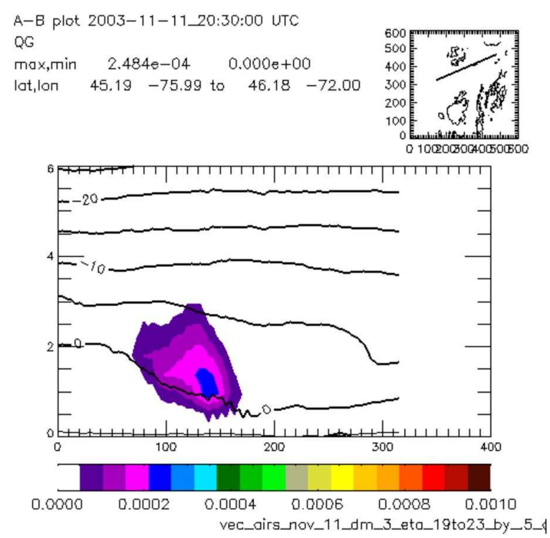

Figure 15: Cross-section of Graupel at 1.58 KM.