Evaluation of Mixed-Phase Microphysics Within Winter Storms using Field Data and In Situ Observations

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Introduction

- It is hypothesized that microphysical predictions have greater uncertainties/errors when there are complex interactions that result from mixed-phased processes like riming.
- Use Global Precipitation Measurement (GPM) Mission ground validation studies in Ontario, Canada to verify and improve parameterizations.

Motivating Questions

- How well do the various Weather Research and Forecasting (WRF) microphysical schemes predict snowband intensity and microphysics?
- What is the benefit of using a more sophisticated double moment ice/snow scheme as well as more advanced riming schemes?

Field Case Study – 18 February 2012

- Figure 1 shows the 9, 3, and 1-km WRF domains, and the case study location (red dot and inset).
- On 18 February 2012 there was a weak cyclone near Lake Huron and a weak warm front approaching from the southwest .
- Surface radar estimate and WRF underestimated precipitation during this event (Fig. 2).

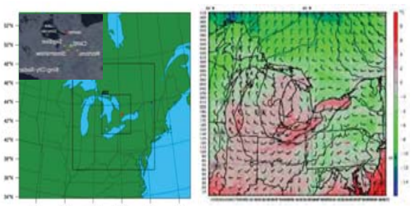

Figure 1. *(left) WRF model domains and the GCPEX field location site (red dot). (right) 11-h WRF forecast (at 1100 UTC 18 February 2012) showing SLP (every 2 hPa), surface temperature (shaded) and surface winds (full barb = 10 kts).*

- The observed snowband was associated with an enhanced area of reflectivity (25-35 dBZ) extending up to 3 km.
- The Goddard scheme most realistically predicted the structure of the narrow snowband (Thompson too weak).
- There were convective cells aloft that were predicted in the Goddard and Stony Brook (SBU-YLin) schemes.
- There was little cloud water (LWC) observed and simulated on the north (cold) side of the precipitation band (Fig 5).

Observed Versus WRF Radar Analysis

- WRF initial and boundary conditions from the 13-km RUC at 0000 UTC 18 February. Physics include: YSU PBL, GD CP scheme on 9-km only, and RRTM for LW, Dudhia scheme for SW Radiation.
- At 1100 UTC 18 February there was a warm frontal snowband observed near the field study site.
- Most of the 1-km WRF microphysical members realistically simulated this snowband, except the Thompson run was too weak.

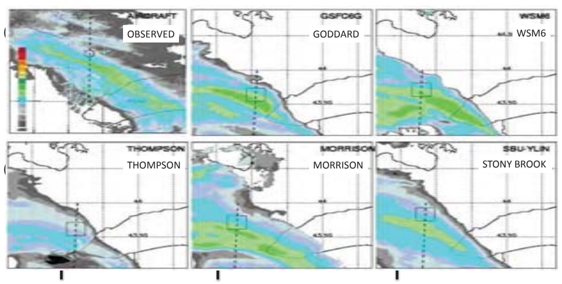

Figure 3. *Observed radar (0.5 deg) vs 1-km WRF (surface) reflectivity (shaded) at 1100 UTC 18 Feb 2012. North-south cross section locations (dashed) are band relative in order to compare radar and model.*

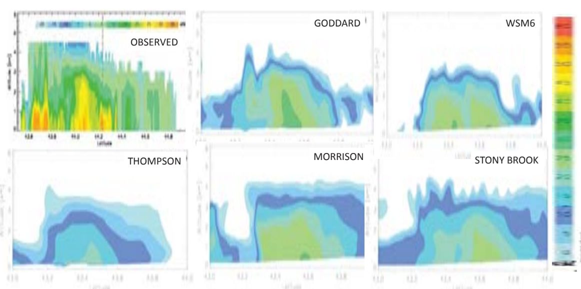

Figure 4. *Observed versus 1-km WRF-simulated radar reflectivity at 1100 UTC 18 Feb 2012 for the cross section locations shown in Fig. 2.*

- WRF microphysical predictions were averaged within the boxes in Fig. 3, which is location of aircraft spiral.
- At 1100 UTC (north side of band), all WRF schemes realistically predicted the ice water content profiles. The Thompson tended to underpredict, and Goddard/SBU-YLIN overpredict.

18 Feb 2012: Microphysical Verification

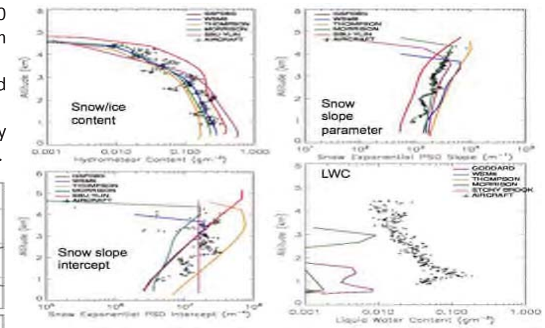

Figure 5. *Mean 1-km WRF profiles of ice water content, snow exponential PSD slope parameter and intercept, and liquid water content for the boxes in Fig. 3 in comparison to aircraft spiral.*

- Morrison best predicted the snow distribution (slope), but had difficulty with the intercept. The temperature dependent slope intercept schemes (SBU and WSM) had a closer intercept to the aircraft observations.

Microphysical Comparisons over Long Island, NY

- Reflectivity and Doppler velocity from four WRF BMPs (MORR, WSM6, THOM2, and SBU-YLIN) were compared to microwave rain radar (MRR) and surface riming/ice habit observations (from stereomicroscope) at Stony Brook, NY (100 km east of New York City) for nine snow events.
- WRFv3.5 was nested down to 1.33-km grid spacing using GFS analysis for initial and boundary conditions.

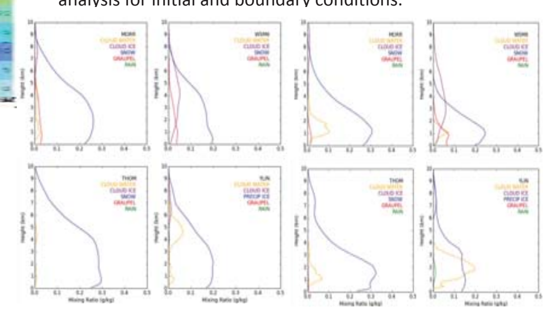

Figure 6. Mean snow, cloud water, graupel, and cloud ice mixing ratios (g/kg) during the (a) light and (b) heavy riming periods for the (a) MORR, (b) WSM6, (c) THOM2, and (d) SBU-YLIN schemes.

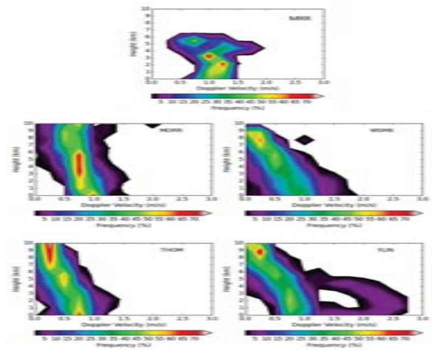

Figure 7. CFADs of Doppler velocity (m s^{-1}) for light riming periods given in Table 3. (a) from the MRR, (b) from OKX, (c) from the MORR scheme, (d) from the WSM6 scheme, (e), from the THOM2 scheme, and (f) from the SBU-YLIN scheme.

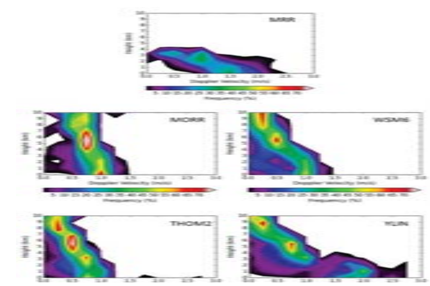

Figure 8. Same as Fig. 7 except heavy riming cases.

* All schemes underpredict fallspeeds for light riming, and this problem increases for heavy riming (except SBU-Ylin scheme (Figs. 6-8).

Summary and Conclusions

- The snowband structure is sensitive to the microphysical parameterization used in WRF.
- The Goddard and SBU-YLin most realistically predicted the band structure, but overpredicted snow content.
- The double moment Morrison scheme best produced the slope of the snow distribution, but it underpredicted the intercept.
- Fallspeeds and mixing ratios suggest that many BMPs underpredict cloud water and riming in winter storms.

Acknowledgements

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