Comparing Field Observations from MC3E with Numerical Model Simulations

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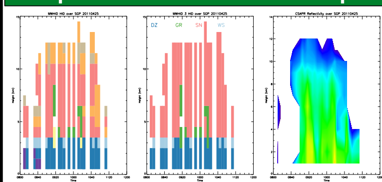
Introduction

During the Midlatitude Continental Convective Clouds Experiment (MC3E), S-, C-, and X-band radars located near the DOE Southern Great Plains (SGP) observation site provided the opportunity to examine microphysical and kinematic interactions across a wide variety of spring weather. These radars were ideally positioned to collect data that could be used in 3D wind analysis using dual-Doppler techniques. An over-determined dual-Doppler solution was used to constrain the retrieval due to the number of radars present. These results were then compared to data from an S-band profiler to check performance. Furthermore, the polarimetric data collected provided by these co-located radars provided enhanced microphysical information for the validation of cloud resolving models through a multi-wavelength hydrometeor classification (MWHID), which uses the strengths of each different wavelength to improve the classification of hydrometeors. Both wind and hydrometeor classification data were then compared with simulations from the WRF Spectral Bin Model.

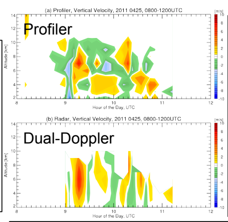
MC3E Instrument Configuration
- 3 X-bands
- 1 C-band
- 2 S-band (NPOL/ Vance AFB)
- Profiler (S-band, located at SGP circled in purple)

Comparison with Profiler – 25 April 2011



Time-height series of HID and CSAPR reflectivity over SGP

- Vertical time series of the MWHID over the SGP was used to subtract fall speed from the S-Band profiler data using 4 fall speed relationships from Giangrande et al. (2013) to obtain vertical air motions.



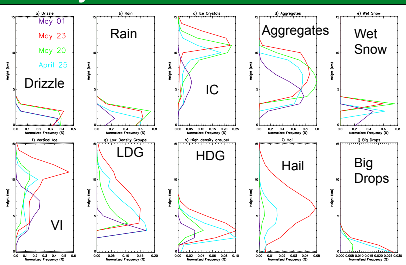
Time-height series of vertical motion over SGP

- Positive up, neg down
- Consistent on major updrafts;
- Profiler indicates more downward motion compared to radar-derived w

MC3E Multi-Case Comparison

	25 April, 2011	1 May 2011	20 May 2011	23 May 2011
Classification of Storm	Scattered storms	MCS Large stratiform region	Strong squall line (Analysis period associated with widespread stratiform)	Multiple tornadic supercells
Time Period of Data Analyzed	0800 - 1100 UTC	1100 – 1330 UTC	0600 – 0900 UTC	2100 – 2400 UTC

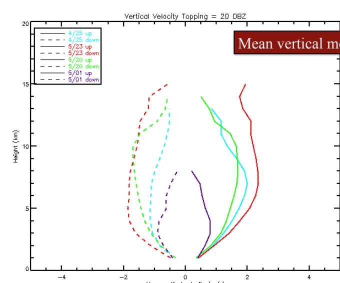
Hydrometeor Classification



Mean hydrometeor frequency as a function of height

- 25 April and 23 May saw the largest amount of big drops
- 1 May had the lowest melting layer, with wet snow showing up at the surface (sleet reported at SGP)
- 23 May saw the most hail and vertical ice aloft

Mean Dual-Doppler Wind Comparison



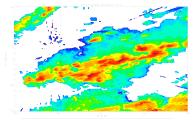
Mean vertical motion

- 25 April and 23 May both had updraft peaks at about 8 km.
- 20 May peaked higher (~11 km); May 1 peaked at 4 km.
- 23 May had the strongest vertical motion and the highest storms
- Downdrafts peaked closer to the surface for 3 of the cases (4 km), but at 10 km for 20 May

25 April, 2011 Model Comparison

Case Overview

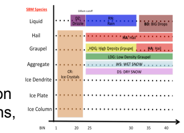
- Overnight case ~08-11 Z
- Cool sfc temps
- Moderate humidity
- Low cape
- Big drops noted in both radar data and surface 2DVD observations



CAPPI of composite reflectivity in our domain at 9Z

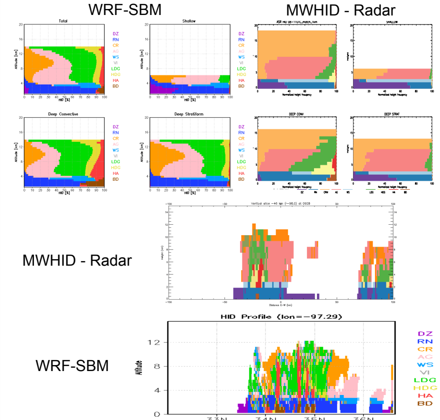
Model Overview

WRF-SBM was used to solve complex microphysical phenomena in different environments. In order to better evaluate the simulation in relation to polarimetric radar observations, a hydrometeor profile was simulated, and confidence levels were calculated.



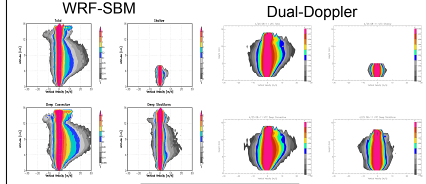
Relationship between WFR-SBM categories/bins and MWHID categories

Hydrometeor Classification



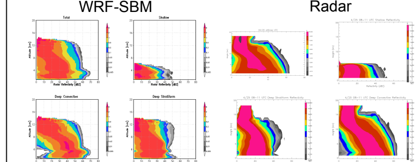
- The model performs quite well, but in general sees much more low density graupel throughout the depth of the storm than the radar based on observations. Shallow echoes (<6 km) compare well between the model microphysics and MWHID.

Vertical Velocity



CFADs of Vertical Velocity

Reflectivity



CFADs of Reflectivity

- General shapes of both velocity and reflectivity CFADS agree
- Observations see a wider downdraft region in vertical velocities.

Conclusions

When comparing the microphysical and kinematic analyses, the structure of each case is different. 23 May had the most hail aloft due to its large updraft speeds (fall-speeds removed), and a large number of big drops present from melting hail. The 23 May case also showed the distributions of ice hydrometeors shifted upward in height compared to the other cases, again due to the intensity of the storms illustrated by the dual-Doppler derived winds. The 20 May and 25 April cases had similar mean updraft strengths, but the 25 April case had significantly more graupel and big drops compared to the time period analyzed for the 20 May case. The 1 May case was weaker and behaved more like a winter event, with a dual-structure melting layer at 1.2 and 3 km, with low vertical velocities, low cloud top heights, and winter precipitation being reported at the surface. More cases will be added and future comparisons will include HIWRAP and Citation data.

Conclusions

Overall, there was a general agreement between the observations on 25 April 2011 and model simulations of hydrometeor classification, vertical velocity, and reflectivity. Statistics were done instead of point-comparisons as the model has a much larger domain than the radars' used during MC3E are able to see. Observations saw taller storms than the model, with less low density graupel and a broader CFAD in the downdraft region, but the comparisons provide confidence in the winds and HID derived from the data as well as in the model itself. Comparisons will continue to include more cases.

Acknowledgements

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