Simulations of the May 20 MC3E Squall Line Case: Impacts of Evolving Ice Habits on the Transition Region and Stratiform Precipitation

Anders A. Jensen[1], Edwin L. Dunnavan[2], Jerry Y. Harrington[2], and Hugh Morrison[1]
[1]National Center for Atmospheric Research, [2]The Pennsylvania State University

Benefits of evolving ice habits

•A new adaptive habit (AHAB) bulk ice method is used to study the impacts of ice habit evolution on squall line structure.

•The AHAB method predicts ice habits and shape evolution during riming and better predicts mass and fall speed evolution compared to traditional mass-dimensional (m-D) methods.

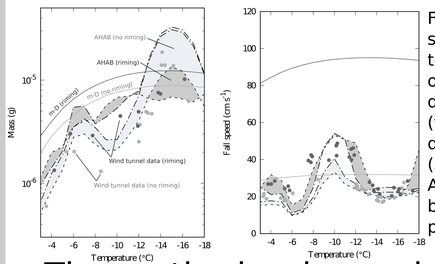


Figure 1 (left). Mass and fall speed as fuctions of temperature for 15 minutes of growth from wind tunnel data (dots), the AHAB model (filled regions), and mass-dimensional relationships (sold lines). Results from the AHAB model show a range of bulk distribution shape parameters.

•The method reduces riming growth errors across a range of temperatures compared to the tradional m-D method

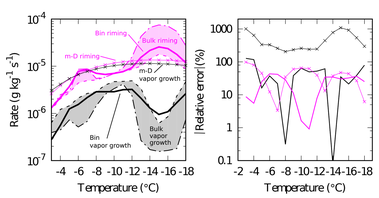


Figure 2 (above). a) Vapor depositional growth rates for the bulk model (gray shaded region), bin model (solid black), and using m-D relationships (black 'x'). Riming rates for the bulk model (magenta shaded region), bin model (solid magenta), and using m-D relationships (magenta 'x'). b) Absolute value of the relative errors for bulk (solid) and m-D relationships ('x') relative to the bin model for vapor growth (black) and riming (magenta).

Parcel comparision

•Simple parcel model simulations show that the AHAB approach captures ice particle shape evolution for both planar and columnar ice, as well as other particle properties compared to a bin model

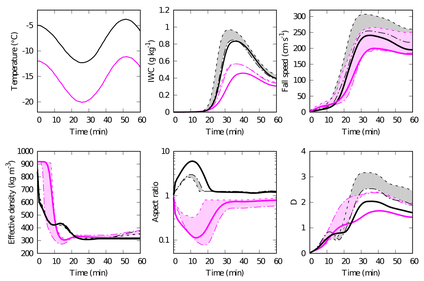
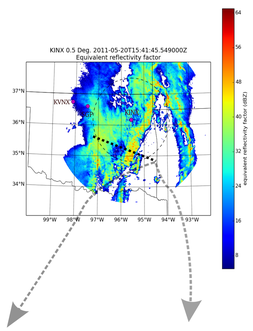


Figure 3 (left). Bulk (shaded regions) and bin model (solid lines) parcel simulation output with riming for planar (magenta) and columnar (gray) ice. Shown is parcel temperature, ice water content, fall speed, density, aspect ratio, and mass-weighted maximum diameter.

Structure of Leading-Line/Trailing-Stratiform MCS

•Most Bulk microphysical schemes have difficulty modeling the reflectivity structure of this type of MCS.

•These figures from KINX show the three different regions of the system: The Convective Region, the Transition Region, and the



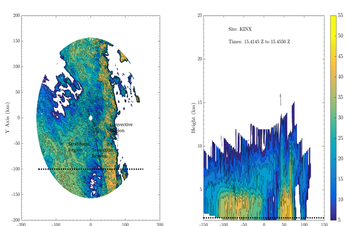
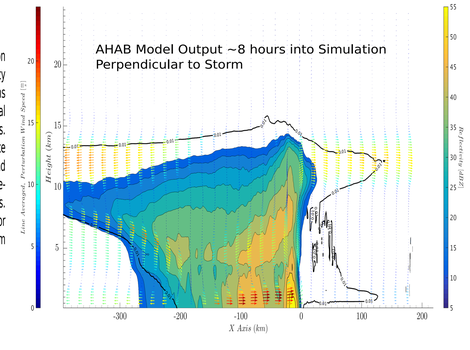


Figure 4.a) (Upper right) PPI scan from KINX that shows the structure of the MCS over Oklahoma at 15.5 Z, May 20 2011. Figure 4.b) (Lower right) Gridded, rotated, and interpolated PPI scan so that a cross section can be made along the X-Axis. The far right plot seems to show evidence of ice particles being advected from the convective updraft into the stratiform region.

Comparison Results

Figure 5 (right). Vertical cross section of calculated line-averaged reflectivity from integrated size distributions (simple) for i.) Rain, ii.) Ice crystal plates, and iii.) Ice crystal columns. Cloud and hydrometeor condensate are contoured in black at 0.01 g/kg and wind vectors are storm relative, line-averaged height perturbation winds. The "z" component of the wind vector was multiplied by 100 to show storm dynamics.

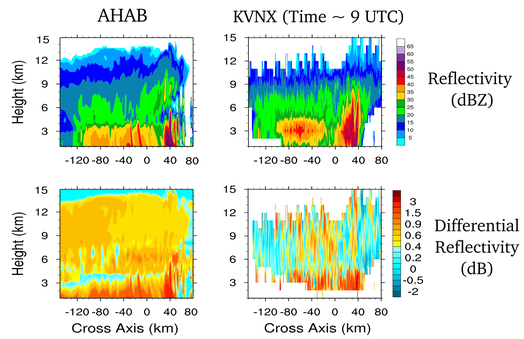


•The mature AHAB squall line shows all three regions and consistent dynamical structure
•AHAB Model shows planar ice descending into stratiform region

Present and Future Work

•Forward modeling of Dual Polarization radar variables such as ZDR with AHAB will help us compare the model's microphysics with reality.

•Interpolation of PPI scans can be used to grid radar observations however dual polarization variables do not plot well at lower levels (See figure below).



Acknowledgements

This research was supported by the U.S. Department of Energy's Atmospheric Science Program Atmospheric System Research, an Office of Science, Office of Biological and Environmental Research program, under Grants DE-SC0012827. We thank Matt Kumjian for his radar analysis.