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The Impact of Vertical Wind Shear on Hail Growth in Simulated Supercell Storms

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Research Summary

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The increase in losses resulting from severe convective storms continues to outpace advances in detection, forecasting and mitigation. Hailstorms account for a large percentage of these losses; however, research activities focused on improving the ability to detect, forecast and mitigate against this hazard have lagged behind those for hurricanes and tornadoes. The rapid advancement in high-performance computing has opened the door to new research into hailstorms through simulations of individual thunderstorms and their internal processes. As a result of this research, IBHS member companies have the opportunity to leverage new strategies for hail forecasting and more accurately simulating potential loss scenarios. The following research summary provides a brief synopsis; additional information can be obtained by contacting Ian Giammanco at igiammanco@ibhs.org.

Several computer simulations of a hail-producing thunderstorm were conducted by Dr. Matthew Kumjian and his student, Eli Dennis, at Penn State University. Support was provided in part by the Insurance Institute for Business & Home Safety (IBHS) hail field research program, which facilitated the acceleration of this work. The goal of this study was to investigate how the environmental vertical wind profile influenced hail production within the modeled supercell thunderstorm. Supercells, which exhibit a rotating updraft, are responsible for a significant percentage of large hail events each year.[1] For the 20 simulations conducted in this study, only the vertical wind profile was altered to determine how hail production changed with each variation. The outcome of this research can be applied to output from current weather forecast models and will foster new research avenues to improve and provide more detailed hail forecasts.

The study was recently accepted for publication in the Journal of Atmospheric Sciences and yielded the following results:

- Changes in the vertical wind profile influence the size, shape and strength of the thunderstorm updraft. This affects the thunderstorm's ability to produce and sustain large hail.
- Increased vertical wind shear (i.e., the change in the direction and magnitude of the wind with increasing altitude) oriented in a west to east direction is more favorable for hail production in a given supercell than a wind shear vector oriented more south to north.
- Strong low-level wind shear (below 3 km altitude) in a south to north direction, while favorable for tornadoes, is not ideal for very large hail growth.
- The model was successful in producing a simulated hail swath based on real-world thunderstorm processes.
- Local maxima in hail content were observed along the southern extent (storm-relative right) of the hail swath; this region may be favorable for larger hail. This tendency has been qualitatively observed during the IBHS hail field research program. Low concentrations of large hail near the updraft region are typically not well captured in conventional (non-dual-polarized) radar-based hail swath products.

[1]Smith, B.T., R.L. Thompson, J.S. Grams, C. Broyles, and H.E. Brooks, 2012: Convective modes for significant severe thunderstorms in the contiguous United States. Part I: Classification and climatology, *Wea. Forecasting*, **27**, 1114-1135.

- Future idealized simulations and those of well-observed thunderstorms in the field will support and advance the findings of this study.

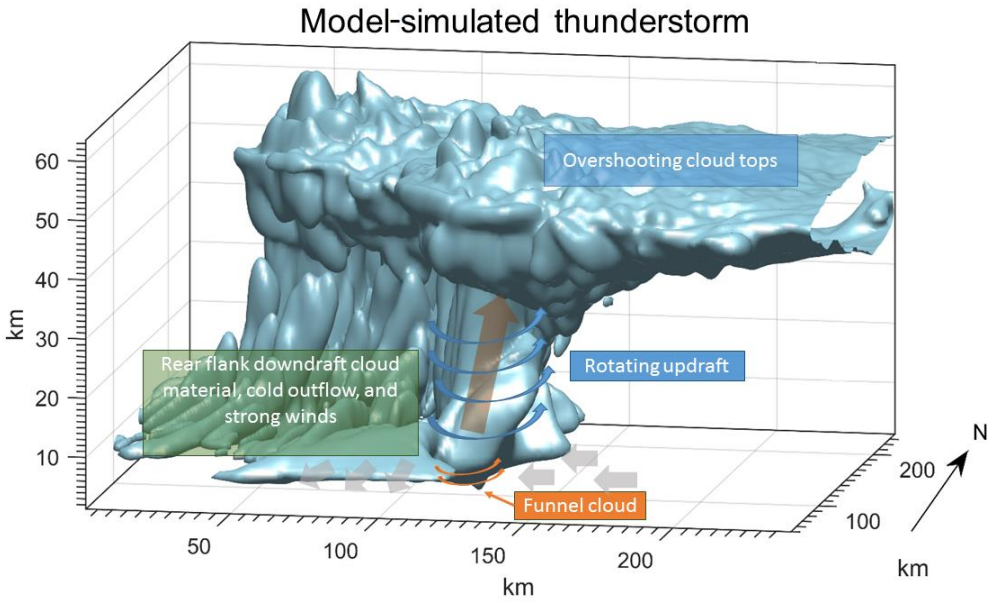

Figure 1. Cloud surface from one of the simulations conducted by Dennis and Kumjian in the study. The image is annotated to note features that are typically observed in the field.

Next Steps

The results of the study open an exciting avenue to future research that will provide substantial improvements to hail forecasting. For example, the results can be leveraged with regards to existing weather forecast model output. Identifying the environmental controls within a generally favorable environment for severe storms will allow for an improved assessment of the threat for large and damaging hail. The National Oceanic and Atmospheric Administration's (NOAA) Storm Prediction Center has already begun to explore ways to integrate these results into current hail forecasting methods. The study was also successful in producing realistic simulated hail swaths. This type of output could be coupled with statistical damage relationships and underlying land-use datasets to more accurately simulate potential losses. In addition, idealized simulations over large population centers can be used to explore different loss scenarios using accurate real-world conditions at a very granular level. IBHS member companies are encouraged to explore how these results and the vast amount of available weather data can be leveraged to help reduce the impact of hazardous weather.

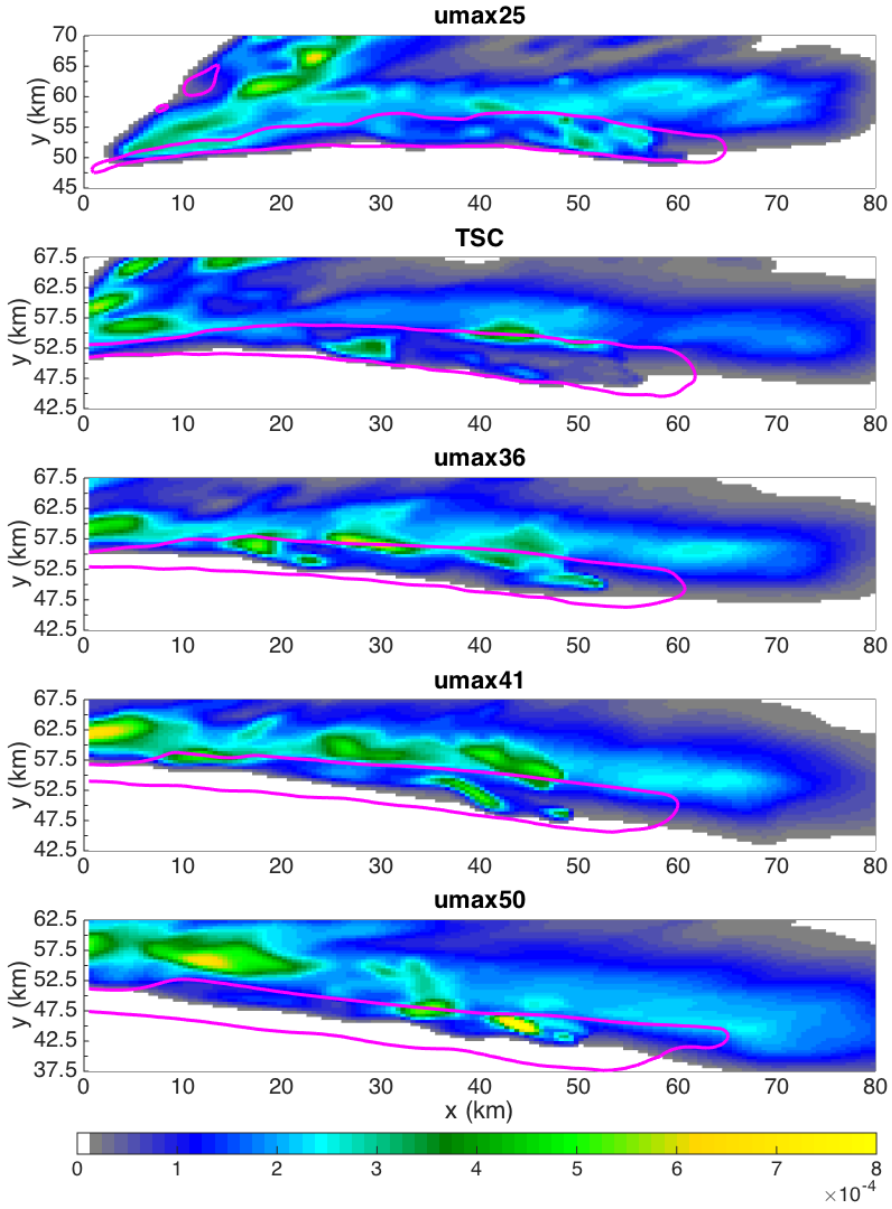

Figure 2. Simulated hail swaths for 5 of the 20 simulations conducted in the study. The warmer colors indicate regions of larger total hail content within the model. For these simulations, this can be interpreted as larger hail sizes. The magenta contour denotes the approximate track and width of the thunderstorm updraft.

Full Study

Dennis, E.J., and M.R. Kumjian, 2017: The impact of vertical wind shear on hail growth in simulated supercell storms, *J. Atmos. Sci.*, DOI: http://dx.doi.org/10.1175/JAS-D-16-0066.1