Rapid Intensification, Storm Merging, and the 2011 Joplin Tornado

The rapid intensification of low-level vertical wind shear leading to tornado formation (tornadogenesis) may have a source in the interaction of cells merging with a parent storm. Our research uses high-resolution (sub-1 km) Weather Research and Forecasting Model (WRF) simulations to analyze the significance of storm mergers in the subsequent intensification of the parent circulation (mesocyclone) and tornadic vortex in the devastating 22 May 2011 Joplin, Missouri case. This event was noted for the rapid evolution of the storm, in association with storm mergers, from tornadogenesis to its peak EF-5 intensity in approximately four minutes according to the National Weather Service's Event Assessment. By identifying the connection between the merger(s) and rapid intensification, a better understanding of tornadogenesis can be achieved.

Approaching this event from a modeling perspective, we used real-data WRF simulations to reproduce the observed behavior in a controlled environment. Current simulations have replicated many aspects of storm structure and evolution observed on this day. The simulation results in tornadic-strength surface rotation shortly after the occurrence of a storm merger. Increased precipitation loading from the merging cell precedes a descending reflectivity core (DRC), which recent studies have found may play a role in the intensification of low-level rotation through increased convergence along the rear-flank gust front. The exact process leading to intensification will be the topic of forthcoming research.

One opportunity afforded by modeling is the ability to test hypotheses by altering the environment or physical processes. Identifying if the storm would have been as intense without the presence of cell mergers is essential to quantifying the effect of these mergers. Our evolving research involves utilizing higher-resolution (~100 meters) simulations and modifications of the storm environment to address this and many other questions resulting from this evolving research. –Kevin W. Van Leer (University of Illinois at Urbana-Champaign), B.F. Jewett, R.B. Wilhelmson, "Rapid Intensification Mechanisms Including the Role of Storm Mergers in the 22 May 2011 Joplin, MO Tornadic Storm." Presented at the 26th Conference on Severe Local Storms, 5-8 November 2012, Nashville, Tennessee.

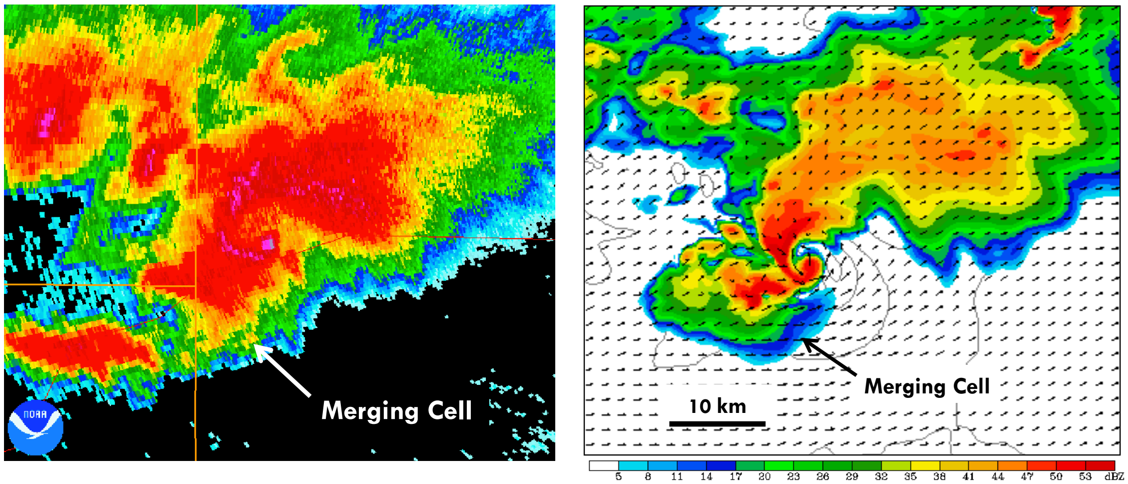

Figure title: **Thunderstorm Mergers**

Figure caption) Left: Base reflectivity from the KSGF WSR-88D radar at 2243 UTC on 22 May 2011. A weaker cell is merging with the primary storm along the NW Arkansas-SW Missouri border. Right: Surface wind and reflectivity at 2km AGL in the same area, from the WRF simulation.

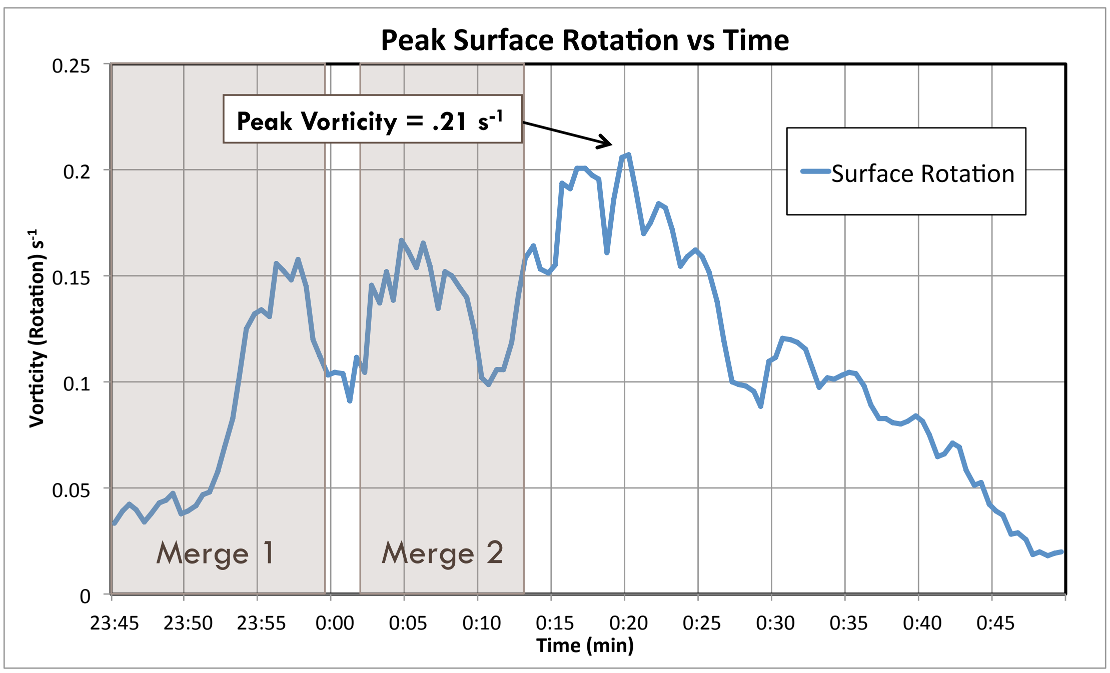

Figure title: **Rapid Intensification**

Figure caption) Rotation (surface vorticity, s^{-1}) response vs. time (UTC, hour:minutes) associated with 2 cell mergers in the simulation. The rotation in this simulation is on the same scale as a tornadic-strength vortex.

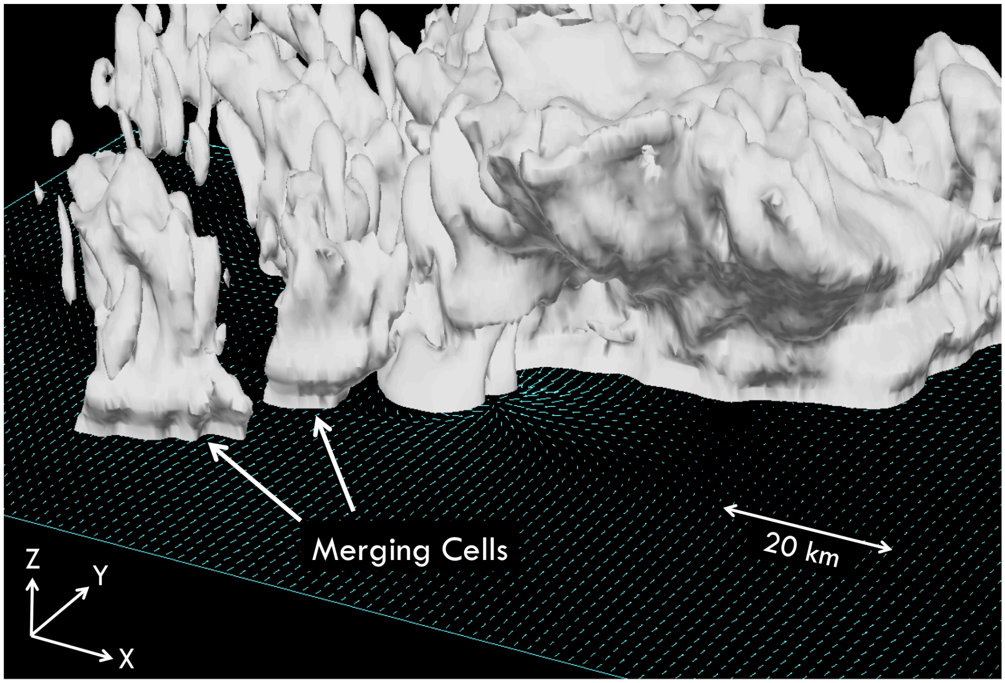

Figure title: **Simulated Cell Merger**
Figure caption) 3-D image of the simulation as seen from SE of the parent storm 30 minutes before peak intensity. The merging cells are noted. White shading is a 30 dBZ isosurface and blue arrows are surface wind vectors.

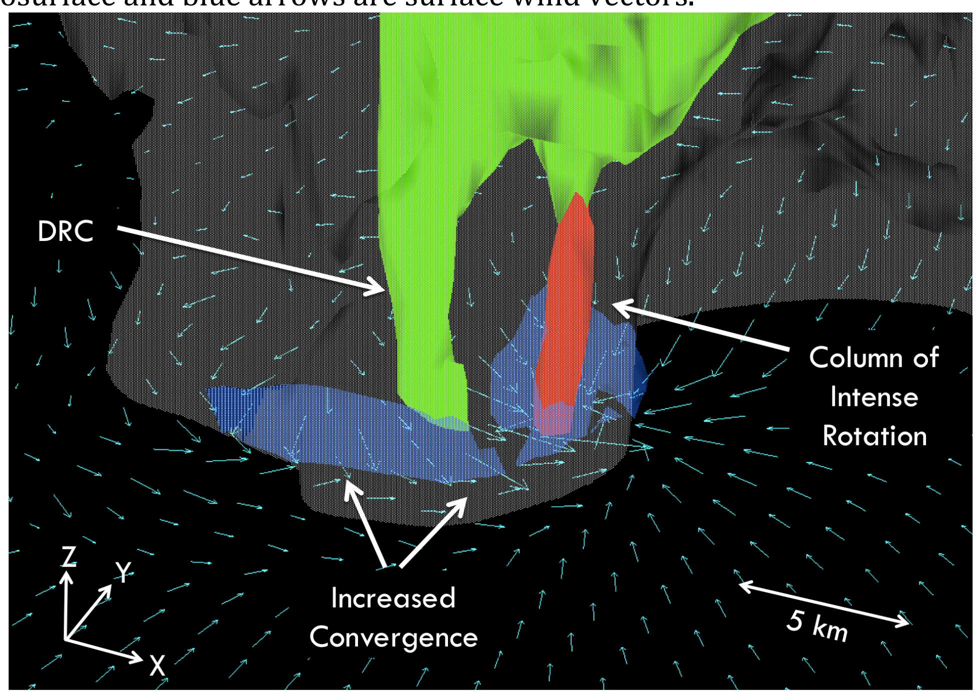

Figure title: **Powerful Rotation**
Figure caption) 3-D image as seen from SE of the surface circulation (blue vectors) during the time of peak intensity. Red is a 0.1 s^{-1} vorticity isosurface, blue is a 0.025 s^{-1} convergence isosurface, and reflectivity is gray (30 dBZ) and green (55 dBZ).