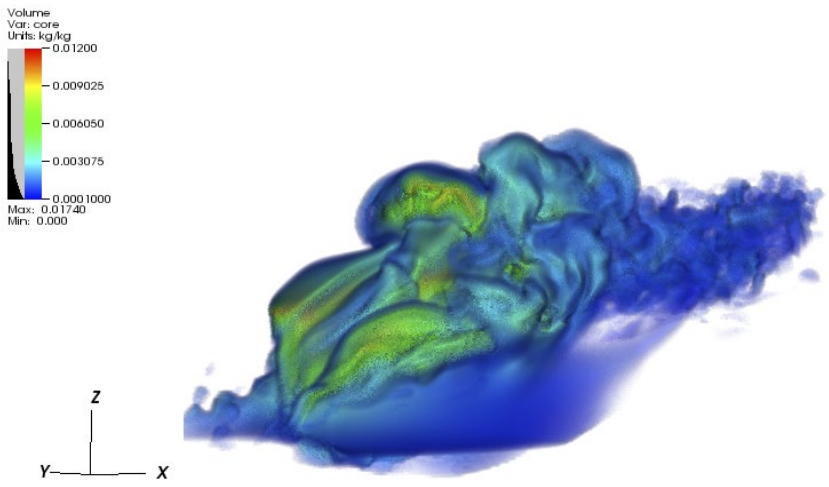
BLUE WATERS
SUSTAINED PETASCALE COMPUTING

Allocation: BW Professor/275 Knh
PI: Sonia Lasher-Trapp
University of Illinois at Urbana-Champaign
Geoscience

"BREATHING" CLOUDS AND STORMS: INFLOW AND ENTRAINMENT, OUTFLOW AND PRECIPITATION

Research Challenge

"Entrainment" is the process by which the turbulent motions within clouds bring dry air from outside the cloud inward. In time, entrainment can limit storm development and precipitation, but is not always effective in doing so. Long-standing problems in meteorological models have been to understand why they tend to predict rain formation too early, and/or in excessive amounts, and why models often miss predicting outbreaks of storms. This project investigates if these deficiencies in past models are related to poor representation of entrainment, and its influence upon precipitation production of storms.



Precipitation mass in a thunderstorm developing in an environment where the wind speed increases greatly with height. Much of the mass from the older part of the cloud (blue colors on right side) was depleted by entrainment.

Methods & Codes

- NCAR's CM1 model was used to simulate convective clouds and storms at high resolution.
- The NSSL microphysical scheme within CM1 was used to model the details of precipitation formation.
- Entrainment was evaluated with a project-developed code that calculates mass fluxes into the core of the storm as it evolves.

Results & Impact

The latest results from this project suggest that:

- Developing thunderstorms growing in a scenario where the winds increase strongly with height, initially, entrain three to five times more dry air.
- Storms developing closer together may precipitate less initially, but if they do precipitate, their outflow can force new storms that precipitate much more.
- The amount of large ice particles that fall from storms appears to be most important for strengthening their outflows, rather than the evaporation of rain, as is sometimes assumed.

Why Blue Waters

Blue Waters has been essential for achieving the high resolution required within a given simulation to properly represent the smaller cloud motions that are important for entrainment and precipitation development over the larger spatial and temporal domains required for thunderstorms and their outflows. As a result of its huge number of nodes, its high speed, large memory, and its large storage capability for high-resolution model output and analysis, Blue Waters enables the team to conduct detailed calculations over millions of grid points. The hardware needed to run these simulations quickly supersedes the limits of most computers.