Annual Report for 2014-2015 Blue Waters Allocation: Robert J. Trapp

- **Project Information**
    - *Petascale modeling of convective storms under climate change and variability*
    - Robert J. Trapp, Department of Atmospheric Sciences, UIUC
    - jtrapp@illinois.edu

- **Executive summary (150 words)** The current focus of this research regards the basic question of how current-day extreme tornadic storm events might be realized under human-induced climate change. The "pseudo-global warming" (PGW) methodology was adapted for this purpose. Modified atmospheric states drawn from global climate model (GCM) output were used to constrain WRF model simulations of the events at high resolution. Comparison of an ensemble of these simulations with control simulations facilitated assessment of PGW effects. We have concluded thus far that a more intensely rotating tornadic storm and, by extension, a more intense tornado, is one potential effect of PGW. This is due largely to the PGW-modified thermodynamics. However, other PGW modifications of the convective environment precluded storms from forming: the combined effects of increased convective inhibition and decreased forcing led to a failure of convection initiation in many of the ensemble members. Additional simulations using other GCMs will help us identify the predominant effect.

- **Description of research activities and results**
    - *Key Challenges:* The overarching theme of this research is the morphology and intensity of severe thunderstorms and tornadoes, which have obvious impact on society. What makes the particular research challenging and unique is that the simulations are done under the weather and climate conditions projected in the future, owing to human-enhanced greenhouse gasses as well as to the natural variations of the Earth system. Hence, a component of the research project addresses critical yet unresolved questions about the possible effects of human-induced climate change on weather hazards such as severe thunderstorms and tornadoes.
    - *Why it Matters*: As just alluded to, the research addresses atmospheric phenomena that have a significant impact on society. Besides an improved understanding on how convective phenomena connect to climate change and variability, the anticipated results have application towards long term planning and adaptation.
    - *Why Blue Waters:* The episodic nature yet relatively small size of thunderstorms and tornadoes necessitates a research approach that can account for temporal scales that range from decades to minutes, and spatial scales ranging from thousands of kilometers to hundreds of meters. The Blue Waters allocation will provide us with the resources needed to achieve this unprecedented level of climate simulation.
    - *Accomplishments:* This year's efforts were focused mostly on building the WRF model code on Blue Waters. Despite the fact that this model is open source and has been deployed worldwide, and also despite my experiences with WRF on multiple other high-performance computing platforms, this

initial task was a protracted struggle. One issue was the loss of WRF expertise at NCSA (due to retirement). Nonetheless, after a significant investment of time, my research group now has a fully functional modeling system, and has been able to complete a number of relatively modest runs for the project described above. These runs have put us in a good position to move forward with a set of computationally intensive production runs, which are planned for the next couple of months.

- **List of publications and presentations associated with this work**

Trapp, R. J., and K. H. Hoogewind, 2015: The realization of extreme tornadic storm events under future anthropogenic global warming. *Journal of Climate*, in revision.

- **Plan for next year**

As noted, my research group here (which will include a post-doc who will begin her/his term in early 2016) is now ready to begin with a set of production runs with WRF as a dynamical downscaler. These runs will require an allocation comparable to the 2014-2015 level. The specific runs (and associated experiments) regard: (1) quantification of WRF-modeled thunderstorm occurrences as projected under late 21^{st} Century climate conditions; (2) development of a climate-change (and variability) attribution method, as applied to extreme convective events; and (3) evaluation of land-falling hurricane structure and hazard implication under pseudo-global warming.