Project Summary

The Verification of the Origins of Rotation in Tornadoes Experiment (VORTEX) is a multi-agency field program to investigate (i) tornadogenesis, maintenance, and demise, (ii) tornado near-ground wind field, (iii) relationships among tornadoes, their parent thunderstorms, and the larger-scale environment, and (iv) numerical weather prediction of supercells and tornadoes. The second field experiment of VORTEX (VORTEX2) is proposed in the United States Great Plains region during the months of April–June, 2009–2010. It will be conducted as a two-phase experiment. A "tethered" phase, utilizing an adaptable observation network tethered to fixed observing facilities in central Oklahoma and conducted in each April and early May, will address foci related to storm-environment and storm-storm interactions, as well as numerical predictability. A "fully mobile" phase will take place in mid-May through June over a broad region of the central United States, with a focus on tornadogenesis and tornado wind fields.

Results from the first VORTEX experiment (VORTEX1), conducted in 1994–1995, advanced our understanding of the kinematic similarities between tornadic and nontornadic supercell thunderstorms and the implied sensitivity of supercell evolution and tornadogenesis to fine-scale heterogeneity, both pre-storm and storm-induced. Recent improvements in National Weather Service warning statistics may be attributable in part to the application of VORTEX1 findings pertaining to the role of the near-storm environment (e.g., enhanced low-level vertical wind shear, cloud base height, mesoscale boundaries) in determining the potential for tornado formation.

Despite (and because of) the broad successes of VORTEX1, many new questions have emerged regarding the circulation sources for tornadoes, the role of downdrafts and their thermodynamics and microphysics in tornadogenesis, the relationship between tornadoes and larger scales of motion, and the relationship between tornadic winds and damage. Furthermore, technological advances that have occurred since VORTEX1 (e.g., advances in ground-based mobile radar technology and improvements in our ability to obtain thermodynamic and microphysical observations) will allow investigators to explore aspects of tornadoes and their formation that they could not pursue in VORTEX1. These advances have increased both our ability to resolve small spatial and temporal scales within thunderstorms and our mobility while collecting these data. VORTEX2 will take full advantage of cutting-edge remote and in situ mobile and fixed observing systems, as well as data assimilation techniques that can improve analyses by combining the dense observations with governing dynamical equations.

The four foci of VORTEX2 are summarized below:

Tornadogenesis. Role of downdrafts in tornadogenesis; sensitivity of tornadogenesis to microphysical and thermodynamic characteristics; role of vorticity maxima along gust fronts in tornadogenesis and/or maintenance; modes for the development of significant tornadoes in supercells.

Near-ground wind field in tornadoes. Range of observed tornado characteristics, such as vertical, radial, and swirling velocity profiles, asymmetries, multiple vortices, and angular momentum budgets; relationships between damage and wind speed, acceleration, and duration.

Relationships between supercell storms and their environments. Interactions among storms that are/are not favorable for tornadogenesis; effects of environmental heterogeneity on supercells and tornadogenesis.

Storm-scale numerical weather prediction (NWP). Analysis and prediction of supercells, mesocyclones, and tornadoes; assessment of parameterization errors for storm-scale models and data assimilation methods for the storm scale; optimal use of observations; analysis and prediction of the pre-storm mesoscale environment.

Intellectual merit. VORTEX2 is designed to improve our understanding of tornadogenesis, which ultimately will better allow us to assess the likelihood of tornadoes in supercell thunderstorms and possibly even tornado intensity, longevity, and cyclic behavior. Moreover, VORTEX2 is expected to improve vastly our understanding of the range of tornado structures and the relationships between tornado structure and characteristics of the parent thunderstorm.

Broader impacts. VORTEX2 is expected to lead to further improvements in tornado warning skill. It is believed that storm-scale numerical weather prediction must play a prominent role in the initiative to improve short-term forecasts of severe weather; multi-sensor and multi-scale VORTEX2 datasets will serve as a testbed for numerical storm-scale prediction experiments. VORTEX2 will better our understanding of the relationships between tornadoes, their parent convection, and the larger-scale environment. Better insight into these relationships is essential if reliable long-term predictions are to be made of changes in the frequency and geographical distribution of tornadoes due to climate change. Quantification of the actual temporal and spatial distribution of winds impacting structures will enable better engineering standards to be developed. Lastly, VORTEX2 includes an innovative educational component in which students will participate in a series of scientific seminars presented in the field by the many participating severe storm expert PIs.