**Tornadoes & Severe Storms**

*Improving forecasts, warnings, and response*

Spring 2013

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### I. Description

An intense tornado can kill dozens of people and inflict more than $1 billion in damage in a matter of minutes. With support from the National Science Foundation and partners, NCAR (the National Center for Atmospheric Research) and collaborating institutions are gathering new kinds of data on the atmosphere in and near tornadic storms, plus using high-end computer simulations to diagnose the factors that determine where the highest tornado risk will be on a given day. This research lays the foundation for enhanced longer-range outlooks that could specify the areas of greatest risk as much as 24 hours in advance. Scientists are also examining how people receive, interpret, and respond to warning messages and how to enhance the effectiveness of these critical alerts.

### II. Stage of Research

NCAR is a leader in developing comprehensive systems to simulate tornadoes and the thunderstorms that generate them. These include advanced computer forecast models that can now track weather every few miles, allowing them to simulate individual thunderstorms and determine what risks (tornadoes, hail, heavy rain) are most likely.

Field campaigns are essential for gathering detailed data on severe thunderstorms, which are too small-scale and fast-evolving for standard observing networks to fully capture. NCAR is lead organizer of the 2013 MPEX study, which is using enhanced early-morning observations collected by aircraft to improve the computer model forecasts of thunderstorms later that afternoon and evening. By comparing the quality of forecasts made with and without the extra data, MPEX will help determine how enhanced observations can be used to clarify the areas where tornado risk is greatest. The project is also collecting data with parachute- and balloon-borne instrument packages, sampling the conditions that precede and surround severe storms—including the one that produced the Moore, Oklahoma, tornado. The data are crucial for assessing how such storms develop and interact with the surrounding atmosphere.

NCAR was also a leading participant in the Verification of the Origin of Rotation in Tornadoes Experiments (VORTEX in 1994–95; VORTEX2 in 2009–10). Scientists are now analyzing data from VORTEX2, which used portable radars and other mobile equipment to study tornado-producing storms in detail. NCAR is prototyping the Airborne Phased
Array Radar (APAR), which will be able to gather high-resolution data on winds, precipitation type, and other important aspects of severe storms.

### III. Advantages

- **Severe storm researchers** are studying the processes that shape tornadoes with idealized simulations that capture detail every few yards.
- **NCAR's Data Assimilation Research Testbed** is a leader at bringing varied types of data into computer models, which maximizes the quality of storm predictions.
- **A fleet of aircraft- and ground-based measuring systems**, operated by NCAR on behalf of NSF for the nation’s university researchers, gathers vital detail on tornadic storms during field campaigns.
- **The NCAR-Wyoming Supercomputing Center** conducts high-resolution modeling of severe thunderstorms and the surrounding atmosphere.
- **NCAR’s ground-based velocity track display** (GBVTD) allows the evolution and 3-D structure of tornadoes to be deduced from Doppler radar data.
- **NCAR’s interdisciplinary team of social scientists** includes experts in meteorology, economics, and risk communication, addressing fundamental questions about how people interpret and respond to information on severe weather risk.

### IV. Applications

- **Longer-range forecasts** to identify areas at greatest risk of tornadoes (such as a major city and its surroundings) as much as 24 hours in advance.
- **Identifying the most cost-effective observing systems and techniques** to support more accurate storm forecasts from computer models.
- **Improving the NWS watch/warning system**, including longer lead times and more precise warning areas.
- **Evidence-based practices** for communicating severe weather risk and eliciting the responses most likely to save lives.

### V. Funding and IP Status

Primary: National Science Foundation (core funding), NOAA, others

**Additional funding could:**
- Improve the speed and accuracy of forecast systems, including those that identify the risk of tornadic thunderstorms on a given day.
- Improve observing capabilities through lidar, airborne phased-array radar (APAR), and GPS-based tools, including more detailed 3-D mapping of the atmospheric moisture that fuels storms.
- Support interviews, surveys, and analysis to explain variations in warning response, such as how people’s past experience with tornadoes and severe storms affects how they act during future threats. This will enable scientists to craft and test more effective forecast and warning messages.

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