Request for NSF Highlight

National Science Foundation
Computer and Information Science and Engineering Directorate (CISE)
Information and Intelligent Systems Division (IIS)

Please save a copy of this form (and a completed version) with a file name created by concatenating your award number with the PI's last name as follows:

Award_numberPI_Last_name.doc
Example: 0599999Smith.doc

Return this completed form and image file(s) as attachments to an email message addressed as follows:

Subject: Highlight: Zemankova, Award_number, PI_Last_name, Institution
Send To: mzemanko@nsf.gov
Cc: ddigiova@nsf.gov

Award Information

Program Director: Maria Zemankova, III

Award Number:	0746816 and supplements: 0840956 and 0938138
PI's Last Name:	McGovern
PI's First Name:	Amy
PI's Institution:	University of Oklahoma
PI's email address:	amcgovern@ou.edu
PI's Telephone Number:	405-325-5427

Project's Title:

NSF CAREER: Developing Spatiotemporal Relational Models to Anticipate Tornado Formation

If you are describing a collaborative award, please enter the award information below for the "Lead" award and numbers for **all** affiliated "Non-lead" awards.

NSF-	NSF-	NSF-	NSF-	NSF-
NSF-	NSF-	NSF-	NSF-	NSF-

Is this project funded under ARRA? "Yes" or "No": No

NSF Press Release Number Associated with this Highlight *(if applicable)*:_____

Enter Highlight

NOTE: Insert *only* text. ***Do not paste in images.*** Instructions on how to send images are provided in the highlight request letter under the "Highlights Guidelines."

Please write the highlight with sufficient information to describe the research, its significance, and its results in terms that the general public can understand. Refer to the highlights request letter for additional guidance.

REQUIRED:
Highlight Title:
(Catchy, newspaper story-style title; not necessarily the award title)

Supercomputers identify supercell storms and tornadoes

*Please enter your Highlight text in ***300- 400 words***. *Text box will expand while typing.*

After a long winter, many people look forward to spring. In the Midwest, spring also brings tornado season. The very word tornado is enough to scare some people, especially those who have personally experienced one of these violent storms. Others, including researchers at the University of Oklahoma, see tornadoes as a puzzle to be solved. Dr Amy McGovern, an Assistant Professor in Computer Science at the University of Oklahoma in Norman Oklahoma, studies tornadoes using advanced data mining techniques.

While approximately 80% of tornadoes are warned before they touch down, nearly 80% of the time that the tornado siren goes off, there is no tornado at all. Dr McGovern and her students are studying storms from their birth until they die out with the goal of identifying the critical triggers for a tornado. With such triggers identified, false alarms will be reduced significantly.

Because data on both the actual tornadoes and the corresponding lifetime of the storm that spawned the tornado is rare, Dr McGovern and her students are studying tornadoes through high-resolution computer simulations of supercell thunderstorms. Supercells are severe thunderstorms with a rotating center and they generate the most violent tornadoes. Using one of the world's most powerful supercomputers, Dr McGovern and her students are generating several hundred computer simulations of these storms. Simultaneously, they are also developing novel spatiotemporal data mining techniques that can identify common patterns occurring in a storm 15-30 minutes prior to a tornado.

Image #1 shows simulated radar reflectivity of one of the high-resolution simulations. Red regions have more intense precipitation including hail. Blue regions have no precipitation. There is a tornado in the left middle portion of the image, where the reflectivity appears to swirl. Image #2 simultaneously maps the corresponding pressure and an instantaneous measure of spin. The tornado is seen by the small donut of pressure lines with high spin inside it.

Image #3 shows the track of all supercell storms that generated tornadoes in Oklahoma over a ten year period. Image #4 shows the frequency of these same tornadic supercells superimposed on a map of Oklahoma where red means tornadic supercells occur more frequently. Dr. McGovern and her students are studying this data and correlating it with the findings from the simulated storms.

Not only does this project benefit society through improved prediction of tornadoes, but it brings authentic learning experiences to all levels of Computer Science students.

Add Image(s)

IMAGES ARE IMPORTANT, IF NOT CRITICAL, FOR HIGHLIGHTS

IMPORTANT: Please refer to the letter sent with this template for instructions on images.
We cannot accommodate more than four images.

Image #1 File name: _McGovern_0746816_1.JPEG_____
Image #1 Caption: __Simulated radar reflectivity 7200 seconds into a storm simulation. The swirling region in the middle of the image is a tornado. _____

Email address of the person who provided the image: __Timothy.A.Supinie-1@ou.edu _____
Has NSF been granted permission to use this image? Yes_X_ No___
If "yes," please enter the image credit: _Timothy Supinie_____

Image #2 File name: __McGovern_0746816_2.JPEG_____
Image #2 Caption: ___Superimposed spin and pressure at the surface of the simulation showing the tornado inside the donut of pressure. _____

Email address of the person who provided the image: __Timothy.A.Supinie-1@ou.edu _____
Has NSF been granted permission to use this image: Yes_X_ No ___
If "yes," please enter the image credit: _Timothy Supinie____

Image #3 File name: __McGovern_0746816_3.JPEG_____
Image #3 Caption: __Tracks of all supercell storms in Oklahoma that generated a tornado over a ten year history._____

Email address of the person who provided the image: __djgagne@ou.edu___
Has NSF been granted permission to use this image? Yes_X_ No___
If "yes," please enter the image credit: _David John Gagne II____

Image #4 File name: __McGovern_0746816_4.JPEG_____
Image #4 Caption: ___Frequency of tornadic supercells occurring in each location in Oklahoma over a ten year history._____

Email address of the person who provided the image: __djgagne@ou.edu_____
Has NSF been granted permission to use this image? Yes_X_ No__
If yes, please enter the image credit: __David John Gagne II_____

Select Primary (and Secondary) Strategic Outcome Goals

Below are two tables entitled **Primary Strategic Outcome Goals** and **Secondary Strategic Outcome Goals**.

All NSF projects have "Primary" Strategic Outcome Goals and *possibly* have "Secondary" Strategic Outcome Goals. In the PRIMARY Strategic Outcome Goal table please choose **one category** (i.e., one column: Discovery, Learning or Research Infrastructure) that BEST DESCRIBES your project's highlight. Within that column, check one or more boxes that apply. If your project also has clear Secondary Strategic Outcome Goals, decide on the appropriate column in the *second table* labeled "Secondary Strategic Outcome Goals." Check as many boxes within that column that best describe your project. For example, if your Primary Strategic Outcome Goal was *Discovery*, your Secondary Goal may be *Learning*.

Primary Strategic Outcome Goals

Decide whether your project's *Primary Strategic Outcome* Goal addresses Discovery, Learning ***or*** Research Infrastructure. Within that column check one or more boxes that best describe your project.

Discovery	Learning	Research Infrastructure
Fostering research that advances the frontiers of knowledge, emphasizing areas of greatest opportunity and potential benefit and establish-	Defined in the NSF Strategic Plan 2006-2011 as "Cultivate a world-class, broadly inclusive science and engineering workforce, and expand	Defined in the NSF Strategic Plan 2006-2011 as "Build the nation's research capability through critical

ing the nation as a global leader in fundamental and transformational science and engineering.

Please Note:
If you are reporting an outcome from an **EPSCoR** Research Infrastructure Improvement grant, or a research grant co-funded with the EPSCoR Program, please check the EPSCoR box under DISCOVERY, as well as the box that represents the area of science, engineering, or education for the project.
2) If you are reporting an outcome of research conducted at an NSF-funded large facility and check a category under Discovery for the PRIMARY goal, please also check the **Major Multi-User Facilities** category under Research Infrastructure for the SECONDARY goal.

Research Grants

- ☐ Biological Sciences
- **XXX** Computer & Information Science and Engineering
- ☐ Cyberinfrastructure (excluding Shared Cyberinfrastructure Tools; see Research Infrastructure)
- ☐ Engineering Research
- ☐ Small Business Innovation Research/Small Business Technology Transfer
- ☐ Geosciences: Earth, Atmosphere, and Ocean Sciences
- ☐ Mathematical & Physical Sciences
- ☐ Social, Behavioral, & Economic Sciences
- ☐ Polar Sciences: Arctic and Antarctic Research
- **XXX** CAREER: Faculty Early Career Program
- **XXX** EPSCoR: Experimental Program to Stimulate Competitive Research
- ☐ International Collaborative Research
- ☐ Education Research and Evaluation to Improve STEM Learning and Teaching

NSF Centers

- ☐ Centers for Analysis & Synthesis
- ☐ Centers for Chemical Innovation

the scientific literacy of all citizens."

Please Note:
1) If you are reporting an outcome from an **EPSCoR** Research Infrastructure Improvement grant, or a research grant co-funded with the EPSCoR Program, please check the EPSCoR box under DISCOVERY, as well as the box that represents the area of science, engineering, or education for the project.

- ☐ K-12 Education
- ☐ Teacher Education and In-service Professional Development
- ☐ Undergraduate Education and Undergraduate Student Research
- ☐ Graduate Education and Graduate Student Research
- ☐ International Research Experiences for Undergraduate & Graduate Students
- ☐ Postdoctoral Education, including International Postdoctoral Fellowships
- ☐ Public Understanding of Science and Lifelong Learning
- ☐ Broadening Participation to Improve Workforce Development
- ☐ Promoting CyberLearning Strategies to Enhance STEM Education
- ☐ Professional and Career Development (i.e., ADVANCE, Course, Curriculum, and Laboratory Improvement (CCLI) Program, & Advanced Technological Education (ATE) Program)

investments in advanced instrumentation, facilities, cyber-infrastructure and experimental tools."

Please Note:
1) If you are reporting an outcome from an **EPSCoR** Research Infrastructure Improvement grant, or a research grant co-funded with the EPSCoR Program, please check the EPSCoR box under DISCOVERY, as well as the box that represents the area of science, engineering, or education for the project.
2) If you are reporting an outcome of research conducted at an NSF-funded large facility and check the **Major Multi-User Facilities** category under Research Infrastructure for the PRIMARY goal, please also check the appropriate category under Discovery for the SECONDARY goal.

Major Multi-User Facilities

- ☐ Academic Research Fleet
- ☐ ATLAS - A Toroidal Large Angle Spectrometer
- ☐ CMS - Compact Muon Solenoid
- ☐ Cornell Electron Storage Ring
- ☐ Gemini Observatory
- ☐ IRIS - Incorporated Research Institutes for Seismology
- ☐ Integrated Ocean Drilling Program
- ☐ Large Hadron Collider
- ☐ Laser Interferometer Gravitational Wave Observatory (LIGO)
- ☐ MREFC Projects: ALMA, Earthscope, IceCube Nutrino Observatory, SODV (Scientific Ocean Drilling Vessel), South Pole Station Modernization, NEON, OOI, ARRV, ATST
- ☐ National Astronomy and Ionosphere Center (NAIC)
- ☐ National Center for Atmospheric Research (NCAR)
- ☐ National High Magnetic Field Laboratory
- ☐ National Nanofabrication Infrastructure Network
- ☐ National Optical Astronomy Observatory (NOAO)
- ☐ National Radio Astronomy Observatory (NRAO)
- ☐ National Solar Observatory
- ☐ National Superconducting Cyclotron Laboratory

☐ Engineering Research Centers ☐ Materials Research Science & Engineering Centers ☐ Nanoscale Science & Engineering Centers/Networks ☐ Science & Technology Centers ☐ Science of Learning Centers		☐ Network for Earthquake Engineering Simulation (NEES) ☐ Polar Facilities & Logistics ☐ Major Research Instrumentation (MRI) Program ☐ Shared Cyberinfrastructure Tools ☐ Other Infrastructure and Research Resources

Secondary Strategic Outcome Goals

Complete this table **only** if your project has clear *Secondary Strategic Outcome Goals*. For example, if your *Primary* Strategic Outcome Goal is "Discovery," then your *Secondary* Strategic Outcome Goal can be either "Learning" or "Research Infrastructure." Please check one or more boxes within that column that describe your project's Secondary Strategic Outcome Goals:

Discovery

Fostering research that advances the frontiers of knowledge, emphasizing areas of greatest opportunity and potential benefit and establishing the nation as a global leader in fundamental and transformational science and engineering.

Please Note:
If you are reporting an outcome from an **EPSCoR** Research Infrastructure Improvement grant, or a research grant co-funded with the EPSCoR Program, please check the EPSCoR box under DISCOVERY, as well as the box that represents the area of science, engineering, or education for the project.
2) If you are reporting an outcome of research conducted at an NSF-funded large facility and check a category under Discovery for the PRIMARY goal, please also check the **Major Multi-User Facilities** category under Research Infrastructure for the SECONDARY goal.

Research Grants

- ☐ Biological Sciences
- ☐ Computer & Information Science and Engineering
- ☐ Cyberinfrastructure (excluding Shared Cyberinfrastructure Tools; see Research Infrastructure)
- ☐ Engineering Research

Learning

Defined in the NSF Strategic Plan 2006-2011 as "Cultivate a world-class, broadly inclusive science and engineering workforce, and expand the scientific literacy of all citizens."

Please Note:
1) If you are reporting an outcome from an **EPSCoR** Research Infrastructure Improvement grant, or a research grant co-funded with the EPSCoR Program, please check the EPSCoR box under DISCOVERY, as well as the box that represents the area of science, engineering, or education for the project.

- ☐ K-12 Education
- ☐ Teacher Education and In-service Professional Development
- **XXX** Undergraduate Education and Undergraduate Student Research
- ☐ Graduate Education and Graduate Student Research
- ☐ International Research Experiences for Undergraduate & Graduate Students
- ☐ Postdoctoral Education, including International Postdoctoral Fellowships
- ☐ Public Understanding of Science and Lifelong Learning
- ☐ Broadening Participation to Improve Workforce Development

Research Infrastructure

Defined in the NSF Strategic Plan 2006-2011 as "Build the nation's research capability through critical investments in advanced instrumentation, facilities, cyber-infrastructure and experimental tools."

Please Note:
1) If you are reporting an outcome from an **EPSCoR** Research Infrastructure Improvement grant, or a research grant co-funded with the EPSCoR Program, please check the EPSCoR box under DISCOVERY, as well as the box that represents the area of science, engineering, or education for the project.
2) If you are reporting an outcome of research conducted at an NSF-funded large facility and check the **Major Multi-User Facilities** category under Research Infrastructure for the PRIMARY goal, please also check the appropriate category under Discovery for the SECONDARY goal.

Major Multi-User Facilities

- ☐ Academic Research Fleet
- ☐ ATLAS - A Toroidal Large Angle Spectrometer
- ☐ CMS - Compact Muon Solenoid
- ☐ Cornell Electron Storage Ring
- ☐ Gemini Observatory

☐ Small Business Innovation Research/Small Business Technology Transfer	☐ Promoting CyberLearning Strategies to Enhance STEM Education	☐ IRIS - Incorporated Research Institutes for Seismology
☐ Geosciences: Earth, Atmosphere, and Ocean Sciences	☐ Professional and Career Development (i.e., ADVANCE, Course, Curriculum, and Laboratory Improvement (CCLI) Program, & Advanced Technological Education (ATE) Program)	☐ Integrated Ocean Drilling Program
☐ Mathematical & Physical Sciences		☐ Large Hadron Collider
☐ Social, Behavioral, & Economic Sciences		☐ Laser Interferometer Gravitational Wave Observatory (LIGO)
☐ Polar Sciences: Arctic and Antarctic Research		☐ MREFC Projects: ALMA, Earthscope, IceCube Nutrino Observatory, SODV (Scientific Ocean Drilling Vessel), South Pole Station Modernization, NEON, OOI, ARRV, ATST
☐ CAREER: Faculty Early Career Program		☐ National Astronomy and Ionosphere Center (NAIC)
XXX EPSCoR: Experimental Program to Stimulate Competitive Research		☐ National Center for Atmospheric Research (NCAR)
☐ International Collaborative Research		☐ National High Magnetic Field Laboratory
☐ Education Research and Evaluation to Improve STEM Learning and Teaching		☐ National Nanofabrication Infrastructure Network
		☐ National Optical Astronomy Observatory (NOAO)
NSF Centers		☐ National Radio Astronomy Observatory (NRAO)
☐ Centers for Analysis & Synthesis		☐ National Solar Observatory
☐ Centers for Chemical Innovation		☐ National Superconducting Cyclotron Laboratory
☐ Engineering Research Centers		☐ Network for Earthquake Engineering Simulation (NEES)
☐ Materials Research Science & Engineering Centers		☐ Polar Facilities & Logistics
☐ Nanoscale Science & Engineering Centers/Networks		☐ Major Research Instrumentation (MRI) Program
☐ Science & Technology Centers		☐ Shared Cyberinfrastructure Tools
☐ Science of Learning Centers		☐ Other Infrastructure and Research Resources

Please answer the following questions:

1.) Does this highlight represent transformative or potentially *transformative research*?
The National Science Board has defined **Transformative Research** as "Research that has the capacity to revolutionize existing fields, create new subfields, cause paradigm shifts, support discovery, and lead to radically new technologies."

Yes_X_ No__ If Yes, please explain why in 100 words or less: *

This research is transformative in both data and approach. By studying the causes of tornadoes through hundreds of simulated high-resolution tornadic storms using all the atmospheric variables, Dr McGovern and her students aim to revolutionize the understanding of tornadoes. A few years ago, generating such simulations would have been impossible. In addition, Dr McGovern and her students are developing novel spatiotemporal relational data mining techniques. This is a unique subfield within data mining.

2.) In terms of *intellectual merit*, why is this research outcome notable and/or important? Please explain in 100 words or less:*

The intellectual merit of this research spans two fields. First, in Computer Science, the creation and real-world experimentation of novel spatiotemporal relational data mining techniques is a significant contribution. These techniques must work in very large data sets and on real-world data, making their applicability quite broad. The models are all human-readable which enables strong interdisciplinary research with meteorologists (or other domain scientists for other applications). Second, by revolutionizing the understanding of tornadoes, Dr McGovern will contribute significantly to the field of Meteorology. The current contributions include the high-resolution simulations, which are unique in the field.

3.) What are the *broader impacts* of this activity? Please check one or more of the categories below and provide one explanation covering the categories: *

___ How well does the proposed activity broaden the participation of underrepresented groups (gender, ethnicity, disability, geographic, etc.)?

_X_ What may be the benefits of the proposed activity to society?

_X**_** How well does the activity advance discovery and understanding while promoting teaching, training and learning?

___ To what extent will it enhance the infrastructure for research and education, such as facilities, instrumentation, networks and partnerships?

_X_ Will the results be disseminated broadly to enhance scientific and technological understanding?

In 100 words or less in the context of *Broader Impacts* as described above, please describe what is notable/important about your project here:

Improved prediction of tornadoes will directly benefit society by reducing both the monetary impact of severe weather and potentially saving lives. This research also strongly incorporates undergraduates (the figures in this highlight were all from the undergraduates), thus promoting research and learning at the undergraduate level. Dr McGovern also brings the weather data directly to the classroom, thus bringing authentic learning experiences to all levels of Computer Science students. The results have been disseminated at both Computer Science and Meteorology conferences. In future years, Dr McGovern will also bring the results to the National Weather Service for field testing.

NSF Investments (Existing and Proposed) -- select all that apply: The purpose of identifying one or more NSF investments is to provide guidance for NSF staff selecting highlights for publication in the annual budget, the annual performance report, and other public documents. These investments represent major cross-foundation initiatives.

- ☐ Adaptive Systems Technology
- ☐ American Competitiveness Initiative (ACI)
- ☐ Climate Change
- ☐ Cyber-enabled Discovery and Innovation (CDI)
- ☐ Cyberinfrastructure
- ☐ Environment (including the importance of fresh water and dynamics of water processes)
- ☐ Homeland Security
- ☐ Human and Social Dynamics

☐ International Polar Year (IPY)

☐ National Nanotechnology Initiative (NNI)

☐ Networking and Information Technology Research Development (NITRD)

☐ Science and Engineering Beyond Moore's Law

☐ Science of Science and Innovation Policy (SciSIP)

☐ Sensor Research

☐ Understanding Complex Biological Systems (including the interfaces of life, physical, and computational sciences)

XXX None Applicable