Research forecasts increased chances for stormy weather

December 4 2007

This is an image of a severe thunderstorm that occurred on June 7, 2005, near Murdo, S.D. Credit: Karen A. Kosiba

Researchers who study severe weather and climate change joined forces to study the effects of global warming on the number of severe storms in the future and discovered a dramatic increase in potential storm conditions for some parts of the United States.

The Purdue University-led team used climate models to examine future weather conditions favorable to formation of severe thunderstorms - those that produce flooding, damaging winds, hail and sometimes spawn tornadoes.

"It seems that areas in the U.S. prone to severe thunderstorms now will likely have more of them in the future," said Robert Trapp, the Purdue associate professor of earth and atmospheric sciences who led the research team. "We can't predict individual storms, but we can project the number of days with conditions conducive to storm formation."

The study found that by the end of this century the number of days that favor severe storms could more than double in locations such as Atlanta and New York. The study also found that the increase in storm conditions occurs during the typical storm seasons for these locations and not during dry seasons when such storms could be beneficial. The findings will be published online this week in the *Proceedings of the National Academy of Sciences.*

"Hopefully, the results of this work will help raise awareness of the changing weather and increase long-term preparations for severe weather, such as emergency response plans," Trapp said. "Areas close to the main sources of humidity, primarily the Gulf of Mexico and the Atlantic, show the most significant increases in potential for storms."

Noah Diffenbaugh, who collaborated with Trapp on this study, said the research findings illustrate how a relatively small increase in temperature can have a dramatic effect on day-to-day weather.

"It is easy to look at global warming just in terms of the average increase in temperature, but the effects are much more far-reaching," said Diffenbaugh, who is a member of Purdue's Climate Change Research Center. "We know from the past that extremes in weather and individual severe storms can be devastating. This study makes a strong statement that a few degrees of global warming could make these severe events much more common than they are today."

The study results were compared to current environmental conditions

and past environmental conditions shown to produce severe thunderstorms.

Harold Brooks, a member of the research team and researcher at the National Severe Storms Laboratory in Norman, Okla., said bringing together experts in climate modeling with experts in severe storms to examine how climate change may affect weather was a new approach to a problem important to both groups of researchers.

"Identifying the environmental conditions that favor certain weather has been at the heart of forecasting research," Brooks said. "We applied that forecasting model to the data from climate change research. It is the same way your local forecaster predicts tomorrow's weather, but we took it out over a long time period. Although we can't say if a storm will occur, we can tell from the data how severe a storm will be if it occurs."

Brooks said individual storms were not examined in this study because they are too small for the current climate models to analyze and, in addition to certain environmental conditions, a trigger is needed to initiate a storm.

"We know the basic ingredients for making a severe thunderstorm are warm, moist air near the ground, cold, dry air higher above the ground, winds that increase in intensity from the ground up and a storm trigger," he said. "We have most of the recipe, and this is a good first look, but whether or not storms will initiate is an unknown."

Some triggers, such as topography, will remain constant. Others, such as storm fronts, could be changed by future global weather conditions, he said.

Research suggested global warming would lead to an increase in humid air that fuels severe thunderstorms, however, it also suggested global

warming would reduce strong winds that contribute to the storms.

"This study was the first to include both of these key factors in order to see which would have a greater influence on overall environmental conditions," said Diffenbaugh, who also is an assistant professor of earth and atmospheric sciences at Purdue. "The result was a general increase in days more favorable to storm creation. It appears that the increase in warm, humid air near the surface outweighs the reduction in strong winds higher in the atmosphere."

In addition, the study showed a strong seasonal and regional variation in the effects of climate change.

"Some areas were only affected slightly, while others more than doubled the chance for severe thunderstorms," Diffenbaugh said. "Also, the storm-favorable conditions appear to occur during the same seasons as they do today, with an extension of the season in some areas. This increases the seasonal extremes, as opposed to more storms spread throughout the year. It is essentially a longer, more intense storm season - sort of a feast or famine."

The team, which also included Michael Baldwin, a Purdue assistant professor of earth and atmospheric sciences, and Purdue research assistant Eric Robinson, looked at weather conditions over the U.S. landmass from the middle to latter part of 21st century, using the regional climate model and three global climate models.

Diffenbaugh said the team used multiple climate models to achieve thorough research results and to reduce the impact of an idiosyncrasy of an individual model.

"The fact that there is so much agreement between the different models increases our confidence in the findings," he said.

Pairing the high resolution of the regional model with multiple global climate models achieves a greater depth of research results, Diffenbaugh said.

Climate models are sophisticated computer programs that incorporate as many details about the complex workings of the environment as possible. Hundreds of dynamic processes, such as ocean currents, cloud formations, vegetation cover and the increase in atmospheric greenhouse gases, are included. The models produce data of the net effects for square-shaped plots over the Earth's surface. The smaller these squares are, the better the resolution the model can provide.

A model must factor in so many changing variables that a full analysis can require months of nonstop computational effort. The Rosen Center for Advanced Computing on Purdue's campus provided the powerful computing required for this study.

Jeremy Pal, one of the lead developers of the regional climate model used in this study and a co-author of the paper, said the regional climate model offers the most detailed picture available today of what is happening across the United States.

The regional model divides the landmass of the United States into a grid of cells spaced 25 kilometers, or 15.6 miles, apart and provides information about the conditions occurring for each cell. This adds detailed information to the data from the global models.

"For example, for Indiana the regional model gives information for specific counties, while a global model would have one set of average data for the entire state," said Pal, who also is a professor of civil engineering at Loyola Marymount University and a member of the Intergovernmental Panel on Climate Change and the Abdus Salam International Centre for Theoretical Physics in Trieste, Italy. "The

regional model has a higher resolution and provides information on the tens-of-miles scale. Global models give data on the hundreds-of-miles scale. The use of four different models in this study makes the results more robust."

Trapp said the next step is to use even higher-resolution models to explicitly study thunderstorms, which can address some of the limitations of the current research.

"One question is whether severe storms in the future will be stronger than those of today," he said. "Another is how often the future storms will spawn tornadoes."

Source: Purdue University