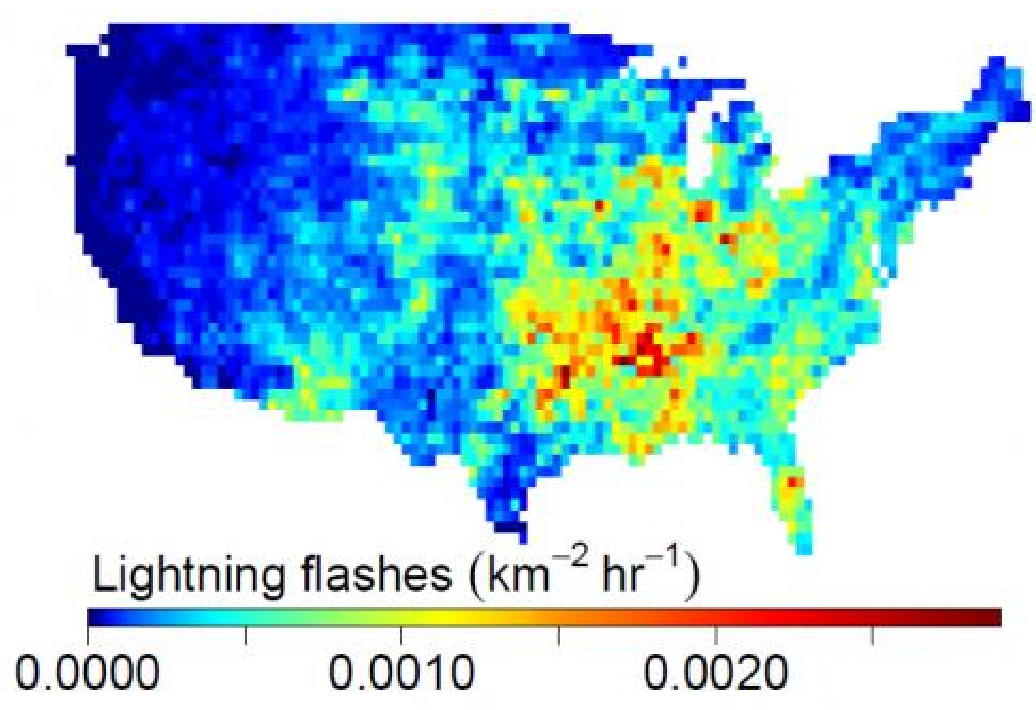
Lightning will increase by 50 percent with global warming, research says

November 13 2014



This graphic shows the intensity of lightning flashes averaged over the year in the lower 48 states during 2011. Credit: Data from National Lightning Detection Network, UAlbany, and analyzed by David Romps, UC Berkeley.

Today's climate models predict a 50 percent increase in lightning strikes across the United States during this century as a result of warming temperatures associated with climate change.

Reporting in the Nov. 14 issue of the journal *Science*, University of

California, Berkeley, climate scientist David Romps and his colleagues look at predictions of precipitation and cloud buoyancy in 11 different climate models and conclude that their combined effect will generate more frequent electrical discharges to the ground.

"With warming, thunderstorms become more explosive," said Romps, an assistant professor of earth and planetary science and a faculty scientist at Lawrence Berkeley National Laboratory. "This has to do with water vapor, which is the fuel for explosive deep convection in the atmosphere. Warming causes there to be more water vapor in the atmosphere, and if you have more fuel lying around, when you get ignition, it can go big time."

More lightning strikes mean more human injuries; estimates of people struck each year range from the hundreds to nearly a thousand, with scores of deaths. But another significant impact of increased lightning strikes would be more wildfires, since half of all fires - and often the hardest to fight - are ignited by lightning, Romps said. More lightning also would likely generate more nitrogen oxides in the atmosphere, which exert a strong control on atmospheric chemistry.

While some studies have shown changes in lightning associated with seasonal or year-to-year variations in temperature, there have been no reliable analyses to indicate what the future may hold. Romps and graduate student Jacob Seeley hypothesized that two atmospheric properties - precipitation and cloud buoyancy - together might be a predictor of lightning, and looked at observations during 2011 to see if there was a correlation.

"Lightning is caused by charge separation within clouds, and to maximize charge separation, you have to loft more water vapor and heavy ice particles into the atmosphere," he said. "We already know that the faster the updrafts, the more lightning, and the more precipitation, the more lightning."

Precipitation - the total amount of water hitting the ground in the form of rain, snow, hail or other forms - is basically a measure of how convective the atmosphere is, he said, and convection generates lightning. The ascent speeds of those convective clouds are determined by a factor called CAPE - convective available potential energy - which is measured by balloon-borne instruments, called radiosondes, released around the U.S. twice a day.

"CAPE is a measure of how potentially explosive the atmosphere is, that is, how buoyant a parcel of air would be if you got it convecting, if you got it to punch through overlying air into the free troposphere," Romps said. "We hypothesized that the product of precipitation and CAPE would predict lightning."

Using U.S. Weather Service data on precipitation, radiosonde measurements of CAPE and lightning- strike counts from the National Lightning Detection Network at the University of Albany, State University of New York (UAlbany), they concluded that 77 percent of the variations in lightning strikes could be predicted from knowing just these two parameters.

'Blown away'

"We were blown away by how incredibly well that worked to predict lightning strikes," he said.

They then looked at 11 different climate models that predict precipitation and CAPE through this century and are archived in the most recent Coupled Model Intercomparison Project (CMIP5). CMIP was established as a resource for climate modelers, providing a standard protocol for studying the output of coupled atmosphere-ocean general circulation models so that these models can be compared and validated.

"With CMIP5, we now have for the first time the CAPE and precipitation data to calculate these time series," Romps said.

On average, the models predicted an 11 percent increase in CAPE in the U.S. per degree Celsius rise in global average temperature by the end of the 21st century. Because the models predict little average precipitation increase nationwide over this period, the product of CAPE and precipitation gives about a 12 percent rise in cloud-to-ground lightning strikes per degree in the contiguous U.S., or a roughly 50 percent increase by 2100 if Earth sees the expected 4-degree Celsius increase (7 degrees Fahrenheit) in temperature. This assumes carbon dioxide emissions keep rising consistent with business as usual.

Exactly why CAPE increases as the climate warms is still an area of active research, Romps said, though it is clear that it has to do with the fundamental physics of water. Warm air typically contains more water vapor than cold air; in fact, the amount of water vapor that air can "hold" increases exponentially with temperature. Since water vapor is the fuel for thunderstorms, lightning rates can depend very sensitively on temperature.

In the future, Romps plans to look at the distribution of lightning-strike increases around the U.S. and also explore what lightning data can tell climatologists about atmospheric convection.

More information: "Projected increase in lightning strikes in the United States due to global warming," by D.M. Romps, et al. *Science*, www.sciencemag.org/lookup/doi/ … 1126/science.1259100

Provided by University of California - Berkeley