Could Lightning Provide Earlier Tornado Warnings?

New technology that tracks lightning frequency may offer advance warning of twisters
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Flickr/Cordey

On the day the devastating tornado hit Moore, Okla., Robert Marshall sat glued to the news, watching images of the deadly twister on CNN while he also monitored it on his computer.

Marshall, the energetic CEO of Earth Networks, a company that owns and operates an enormous network of weather sensors, was looking for one thing in particular: lightning. But he didn't see it.

"These tornadoes from a couple weeks ago were probably the most videotaped tornadoes in history. If you just watched the video, there's almost no lightning," Marshall said.

Visible lightning, that is. In fact, as Marshall explained, there actually was lightning, a whole lot of it, in the storm that caused the Moore tornado. It's just that most of it didn't hit the ground and was thus unseen by humans.

Earth Network's "Total Lightning Network" saw it, though. That's because this network, which consists of about 600 stations across the United States, has instruments that can track in-cloud lightning, the flashes that occur within a cloud and never make it to the ground.

Storms can have a lot of this type of lightning, and researchers have been working hard to understand how surges in it are related to severe weather events like tornadoes. What they are learning holds considerable promise to improve weather forecasters' ability to issue severe weather and tornado warnings earlier and more accurately.

"It's really clear that lightning data is very helpful for both our models and our forecasters," said Alexander MacDonald, director of the National Oceanic and Atmospheric Administration's Earth System Research Laboratory in Boulder, Colo.

Meteorologists still don't understand exactly how lightning relates to severe weather, but they know there is a strong correlation.

Telltale signs of growing strength

As a storm builds and more ice particles collide in a cloud, the rate of lightning flashes increases. This increase is often tied to a future growth in a storm's intensity.

Eric Bruning, an assistant professor of atmospheric science at Texas Tech University, said the flashes of in-cloud lightning might be few and far between as a storm gets organized, but as it gathers energy and moisture, that can change quickly.

"As it really taps into that deep moisture source, that flash rate will go up substantially, and it's a really sensitive indicator of that storm becoming more established," Bruning said.

Lightning researchers call this a "jump." In the Moore tornado, Marshall watched it happen on the Earth Networks' lightning network in real time.

"That Moore tornado ... that particular tornado went from no lightning and really no storm to like 50 flashes per minute," Marshall said. "It's a very classic scenario where you have a significant rise in lightning well in advance of the tornado."

On May 20, when the tornado hit Moore, his network saw its first spike in lightning to around 33 flashes per minute at 2:13 p.m., which is when it would issue a warning.

At 2:35, the in-cloud lightning hit 50 flashes per minute. The tornado touched down in Newcastle, Okla., at 2:56.

Not all jumps mean the storm is going to strengthen or a tornado is going to form. Figuring out that relationship between a jump and the severe weather that can follow is what Chris Schultz, a NASA scientist and a doctoral student at the University of Alabama, Huntsville, is working to figure out.

Schultz's doctoral work focused on developing an algorithm that relates lightning jumps to severe weather.

If he can do this -- and his formula is currently being tested at NOAA's Hazardous Weather Testbed in Norman, Okla. -- he could help forecasters improve their lead time on tornado warnings.

Adding seven crucial minutes of warning

"The average lead time on tornadoes is currently about 13 minutes," Schultz noted. "The average lead time using lightning jump to severe weather is about 20.5 minutes."

That seven and a half minutes of extra warning could save lives.

Earth Networks' Marshall is also focused on improving the time between warnings and the severe weather to follow. In January, his team presented the results of a study using its lightning network to issue severe weather warnings at the American Meteorological Society annual meeting.

Using data from the 2011 hurricane season, team members found that the tornado warnings issued from their system based on the total lightning network resulted in warning lead times of 27 minutes on average.

NOAA's MacDonald is eager to test Earth Network's system with the National Weather Service. He's excited about a program the company has developed to turn the lightning pulses it senses into predictions of where severe weather is going to occur, a sort of parallel to the National Weather Service's warning system.

MacDonald hopes to run a trial with the National Weather Service where they integrate that program into a number of weather forecasting centers, although he is waiting for project funding.

"They have software that will determine how much lightning is occurring and which direction it's moving, and then they in effect make a forecast of the areas that are threatened in the next couple hours. So that was the product that we wanted to test out," he said.

Potential lifesaver

Some Weather Service offices have already had the chance to test out lightning data as a resource for severe weather prediction. That's because they have access to local lightning monitoring networks.

One such network is in Huntsville, Ala.

Brian Carcione, the science and operations officer at the National Weather Service station in Huntsville, said his office has had access to lightning data for nearly a decade, but it has taken the office a while to figure out just how it fits into its forecasts.

"I personally think it has the potential to be a game changer, but it's very different from what we are used to," Carcione said. "As forecasters, we are getting more and more data

that we have to sift through ... so one thing being discussed already is what's the most efficient way to get this information in front of the forecaster so that it helps them make the decision better."

It's not as simple as just giving forecasters the lightning data, explained Kristin Calhoun, a research scientist with the National Severe Storms Laboratory and the Cooperative Institute for Mesoscale Meteorological Studies in Oklahoma.

Forecasters already have to sift through a huge volume of information when making their decisions and issuing things like tornado and severe weather warnings.

That's why Calhoun took Schultz's algorithm and put it into the hands of meteorologists at the Hazardous Weather Testbed. There, she got their feedback on the best way to present them with that information.

"What we are developing right now is the visualization of the lightning jump. Some forecasters like to be alerted; a bell will go off or a banner will come up. Some forecasters like to see it as a grid," Calhoun said.

Calhoun and Carcione stressed that lightning jump information is not a tool to be used in isolation, but in combination with the other data forecasters use, like Doppler radar, it has the potential to give them an extra edge.

Which storm will be the killer?

"You may be watching a number of storms at the same time, and the lightning can help you figure out that one may be more important or strengthening more than the others," Carcione said.

In Alabama, Carcione added, tornadoes are often associated with storms that are not particularly large. Lightning jumps are particularly useful in those situations and may help a forecaster see that severe weather is coming as much as five to 10 minutes before the radar sees it.

While there is no national lightning network for the Weather Service right now, the next set of geostationary satellites NOAA is scheduled to launch, beginning in late 2015, will have an instrument called a geostationary lightning mapper.

This mapper, once it is operational, will have the ability to see lightning over the entire United States and much of the Atlantic and Pacific oceans, where ground-based lightning networks cannot reach.

NASA's Schultz is actually building his algorithm with this instrument in mind, even though it is a few years away from going live.

The satellite mapper is unlikely to put ground-based lightning sensors out of business, though, because it has limitations on its ability to differentiate between cloud-to-ground lightning and in-cloud lightning, Schultz said.

"That is the beauty of the ground-based systems," he said.

In the meantime, Marshall of Earth Networks continues his quest to improve lead times for tornado warnings using the network his company already has in place.

He hopes to improve tornado warnings to the point where people don't just have enough advance notice to huddle in their basement; he wants to give them enough time to get out of the way.

"If you only have 10 to 15 minutes' warning, there is not much you can do. You can try and get in the safest location that you have, but in big tornadoes it doesn't matter," Marshall said.

"If we could get to the point where people have a half-hour warning time, then you can actually leave. You can get in your car."

Comments

IMO, having grown up in TX, OK & KS, this idea seems to be unfounded speculation. Not all violent thunderstorms produce tornadoes, even in Moore, OK, and there's a great distinction between the damage that is most often produced by high winds, hail & rain and that which is produced by tornadoes. That's why the NWS distinguishes between tornado warnings and thunderstorm warnings. It's not at all clear that what's being described here is the potential for predicting violent thunderstorms or tornadoes, but it seems to me that only the ability to predict violent thunderstorms is actually being discussed, with tornadoes being thrown in to spice things up, given the public's current heightened level of interest...

The NWS has to protect against issuing false tornado warnings - for reasons that should be obvious. Perhaps articles like this hyperbole will produce some research funding - let me know when this method can reliably predict the impending development of a tornado, especially in areas like Alabama, where tornadoes are not quite as frequent as in the lower plains states!

@JTDwyer - While I agree that a spike in cloud-to-cloud lightning does not predict tornado formation, it very well might indicate that a thunderstorm is changing to a super cell, the precusor of a tornado. I was born and bred in Kansas - I've seen more tornados than you can shake a stick at, and every one was accompanied by massive quantities of cloud-to-cloud lightning. But what I've noticed is the hail that seemed to always preceed

a tornado. Don't know if that is related or not ... just throwing that out there for consideration.

> That's the point, though - it seems that tornado formation cannot be predicted earlier solely from an increase in cloud-cloud lightning - as seemed to be suggested in this article. Or was it? Much of the article seemed to indicate that in-cloud lightening could be used to predict violent storms:
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> "Meteorologists still don't understand exactly how lightning relates to severe weather, but they know there is a strong correlation."
>
> As I said, I suspect the scientists are saying thunderstorms and the journalists are hearing tornadoes...
>
> In-cloud lightning might well be useful in predicting violent storms but, as you know, if tornado warnings are issued every time there's a thunderstorm, the number of casualties produced by tornadoes will increase because no one will take cover.
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> Your mention of hail is important: as I understand one of the critical factors in the formation of tornadoes is a mass of cold air moving over hot land. This fundamental factor may result in vertical air motions, producing supercell storms, hail, and often, tornadoes.
>
> IMO, tornado predictions must be based on detection of actual causal factors rather than indirect correlations - to improve both the accuracy of alerts and warning time. Improving warning time while increasing the number of false alarms will not save lives.

jack.123 June 4, 2013, 8:38 PM

> I have long suspected that super cell storms and tornadoes are electromagnetic in nature,a huge spinning dynamo that builds on itself,increases wind speeds.Looking at the EM features of these storms may answer why some produce tornadoes and others don't.Lightning studies are a good start.Further studies of iron ore deposits and EM field lines of the Earth may give some insight