New Study Hints at Bespoke Future of Lightning Forecasting

Researchers used machine learning to develop a model that can predict lightning strikes to within 30 minutes of their occurrence and within 30 kilometers of a weather station by using just four simple atmospheric measurements.

New research outlines how a machine learning algorithm using data from 12 weather stations in the Swiss Alps created a model that can take local atmospheric measurements and produce real-time lightning nowcasts, accurate to within 30 minutes of a lightning incident. Credit: Tobias Van Der Elst, CC BY-SA 2.0

By Jon Kelvey 13 February 2020

On 14 November 1969, the Apollo 12 Moon mission rode the fiery exhaust of a massive Saturn V rocket upward to pierce a cloudy, rainy sky.

Just 36 seconds into the flight, the sky struck back.

The spacecraft was struck by lightning (https://appel.nasa.gov/2019/11/12/this-month-in-nasa-history-lightning-strikes-apollo/), twice, tripping circuits and triggering a blinding constellation of warning lights in the command module. Responding to the situation, John Aaron, a flight controller at NASA Kennedy Space Center, suggested to the control room manager, "Flight, try SCE to AUX (https://www.kennedyspacecenter.com/blog/18/sce-to-aux-nasa-acronyms)." The phrase has since become a synonym for coolness under pressure. The rocket's guidance systems were not affected, and the astronauts were able to bring the command module systems back online. Still, the incident had a lasting impact on NASA and atmospheric scientists.

"The entire branch of lightning forecasts, or even in a more general sense thunderstorm warnings, came from the Apollo 12 launch lightning strike incident," said Yoav Yair (http://portal.idc.ac.il/faculty/en/pages/profile.aspx?username=yoav.yair), dean of the School of Sustainability at the Interdisciplinary Center Herzliya in Israel and a scientist whose research focuses on atmospheric electricity. "That was the main motivation that actually drove or propelled this field very far and very fast forward, because people realized that you don't want your rocket to be hit by lightning."

The nowcasts are accurate to within 30 minutes of a lightning incident.

Weather forecasting has come a long way since the days of the Apollo program, but new work by researchers at the Swiss Federal Institute of Technology Lausanne represents a significant leap forward, according to Yair.

In a paper published in *npj Climate and Atmospheric Science* (https://www.nature.com/articles/s41612-019-0098-0), professor Farhad Rachidi (https://people.epfl.ch/farhad.rachidi), doctoral assistant Amirhossein Mostajabi (https://people.epfl.ch/amirhossein.mostajabi?lang=en), and their colleagues describe training a machine learning algorithm on data from 12 weather stations in the Swiss Alps to create a model that can take local atmospheric measurements and produce real-time lightning nowcasts. The nowcasts are accurate to within 30 minutes of a lightning incident.

To say that's a good performance is a major understatement, according to Yair.

"I think it's much more than just good. This is a brilliant degree of prediction," he said. To forecast with 80% assurance for 30 minutes of lead time for an area 30 kilometers around the measuring station, "that's absolutely formidable. I think they should be commended."

Twelve Stations, Four Input Parameters, and Machine Learning

Rachidi and his team gathered meteorological data from 2006 through 2017 from 12 weather stations in Switzerland, aiming for variations in terrain and location. "Among the stations, six are located in urban areas inside cities with altitudes ranging between 273 and 776 meters above sea level," Rachidi wrote in an email to *Eos*, noting that one station is at the Geneva airport. "Five out of the 12 stations are located in mountainous regions with three of them having an altitude of more than 1000 meters above sea level."

The team then used machine learning algorithms to train a model on these historical data, a model they found could be used to predict future lightning strikes within 30 kilometers of the 12 stations given the input of current meteorological parameters.

The team is able to make its nowcasts based on just four basic meteorological parameters: air pressure, wind speed, relative humidity, and air temperature.
To Yair, the simplicity of the input parameters really stands out. Rachidi and his team are able to make their nowcasts based on just four basic parameters: air pressure, wind speed, relative humidity, and air temperature. They "can use those really almost trivial parameters…to reach a very high accuracy of lightning occurrence," Yair said.

Although those four parameters may not represent what's going on in the upper atmosphere, Rachidi wrote, they have the advantage of being more directly and continuously measurable than upper atmosphere parameters such as convective cloud top height and the vertical distribution of water vapor. Nevertheless, he added, "the selected set of parameters may not be sufficient in some of the cases. We are now working on another lightning-predictive scheme [that uses] upper-atmosphere parameters as the input to the model."

Any such modeling would have been impossible without the new computational capabilities that made machine learning on big data a reality over the past decade, according to Rachidi, and the very large volumes of meteorological data available to feed into such analysis form a potential gold mine. "It offers great opportunities for the big data–spun revolutions seen in other fields to be duplicated in climate and atmospheric science," he wrote. "This paper tries to continue the same trend but for lightning nowcasting."

Laser Focus on Lightning

Lightning nowcasting per se wasn't the original impetus behind the work, however. Rachidi and his colleagues are part of the European Laser Lightning Rod project (http://llr-fet.eu/), which aims to use lasers to trigger lightning and safely discharge the atmospheric electric field to lightning rods away from sensitive sites like airports and spaceports—echoes of the Apollo 12 lightning strikes still being heard today.

"The initial motivation of this study," Rachidi wrote, "was the investigation of the conditions that are propitious to the occurrence of lightning so that the laser can be activated at an appropriate instant to maximize the likelihood of triggering lightning."

"Tailor-made, site-specific short-range lightning prediction, which can save lives, money—that's exactly the future."

But because the research shifted to such accurate and timely lightning forecasts, could this be turned into a publicly available forecasting service? A consumer smartphone app to take along to a sporting event?

"We're not there yet, but I think conceptually they showed that it's possible," Yair said. "I would be very curious to see if the same algorithm can work in the Indian monsoon or in winter Mediterranean thunderstorms."

Despite the topographic variance at the 12 sites used to build the model, Rachidi agreed that working on other locations is a step—one of several—necessary before the model could make for a practical warning system. "For example, the lead time ranges should be extended for many practical cases," Rachidi wrote. "We are working on a conference paper to explain the challenges for this technique."

But deploying this model for real-world operations around rocket launches, airports, or sporting events is not necessarily that far off either. It could happen within 4 years' time, in Yair's opinion.

"Tailor-made, site-specific short-range lightning prediction, which can save lives, money—that's exactly the future," he said.

—Jon Kelvey (@JonKelvey (https://twitter.com/@JonKelvey)), Science Writer

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