Combining satellites, radar provides path for better forecasts

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Every minute counts when it comes to predicting severe weather. Combing data from cutting-edge geostationary satellites and traditional weather radar created a path toward earlier, more accurate warnings, according to Penn State researchers who studied supercell thuderstorms in the Midwest.

"We know satellites have an advantage in producing forecasts earlier, and radar has more confidence in where clouds should be and where thunderstorms will be moving," said Yunji Zhang, assistant research professor in meteorology and atmospheric sciences at Penn State. "The question was whether these two types of observations would complement each other if combined together. We found, for at least one severe weather event, assimilating satellite and radar simultaneously leads to the best forecasts."

Data assimilation is a statistical method used to paint the most accurate possible picture of current weather conditions, important because even small changes in the atmosphere can lead to large discrepancies in forecasts over time.

The scientists assimilated satellite and radar data separately and simultaneously to see which combination could best recreate conditions during a large storm system that struck Wyoming and Nebraska in 2017. The best results came from combining infrared brightness temperature observations from satellites, and radial wind velocity observations from radar, the scientists reported in the American Meteorological Society journal *Monthly Weather Review*.

"Our results suggest that each sensor provides unique information about the storm," said David Stensrud, head of the Department of Meteorology and Atmospheric Science at Penn State. "While these results need to be evaluated across a large spectrum of cases, they point to a path forward that could extend lead times for severe weather events, thereby providing improved information to the public when severe weather strikes."

The researchers were previously the first to use data from the new U.S. Geostationary Operational Environmental Satellite, GOES-16, to predict severe thunderstorms through the all-sky radiance method.

The all-sky method, developed by Penn State's Center for Advanced Data Assimilation and Predictability Techniques, can assimilate data from all weather conditions, including cloudy and rainy skies. Forecasting previously relied on clear-sky observations, due to challenges in diagnosing the complex physical processes within clouds, the scientists said.

Instruments on GOES-16 can see storm clouds as they form, tens of minutes earlier than traditional Doppler radar, which senses storms only after rain begins to fall, the scientists said. Satellites can also detect important surrounding environmental conditions, like how much water vapor is in the air.

But satellites also have limitations. Those same infrared sensors can only scan the tops of clouds and may miss details about what is happening underneath. Doppler radar observations provide 3-D scans of the storms, leading to more accurate information about the storm's structure and potentially cutting down on false alarms, according to the researchers.

The scientists found they could increase warning times by up to 40 minutes, which supports the findings of their previous work. According to the researchers, current warning times for tornadoes average about 14 minutes.

"Say you have severe weather heading toward a football game or a large event," Zhang said. "If you can have a longer forecast lead time of 20 to 40 minutes, you have more time to evacuate. I believe that more human lives can be saved by increasing forecast times."

More information: Yunji Zhang et al, Simultaneous Assimilation of Radar and All-Sky Satellite Infrared Radiance Observations for Convection-Allowing Ensemble Analysis and Prediction of Severe Thunderstorms, *Monthly Weather Review* (2019). DOI: 10.1175/MWR-

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