For weather forecasting, precise observations matter more than butterflies

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A thunderstorm in Owens Valley, California. The butterflies superimposed on this photo would not matter for the forecast. Credit: Dale Durran/University of

Washington

In the 1970s, scientist Edward Lorenz famously asked whether the flapping of a butterfly's wings in Brazil could lead to a tornado in Texas.

During the decades since, the butterfly effect and chaos theory have sparked countless debates and pop culture references. But the question also holds practical importance: What do small, unpredictable events mean for the future of weather prediction?

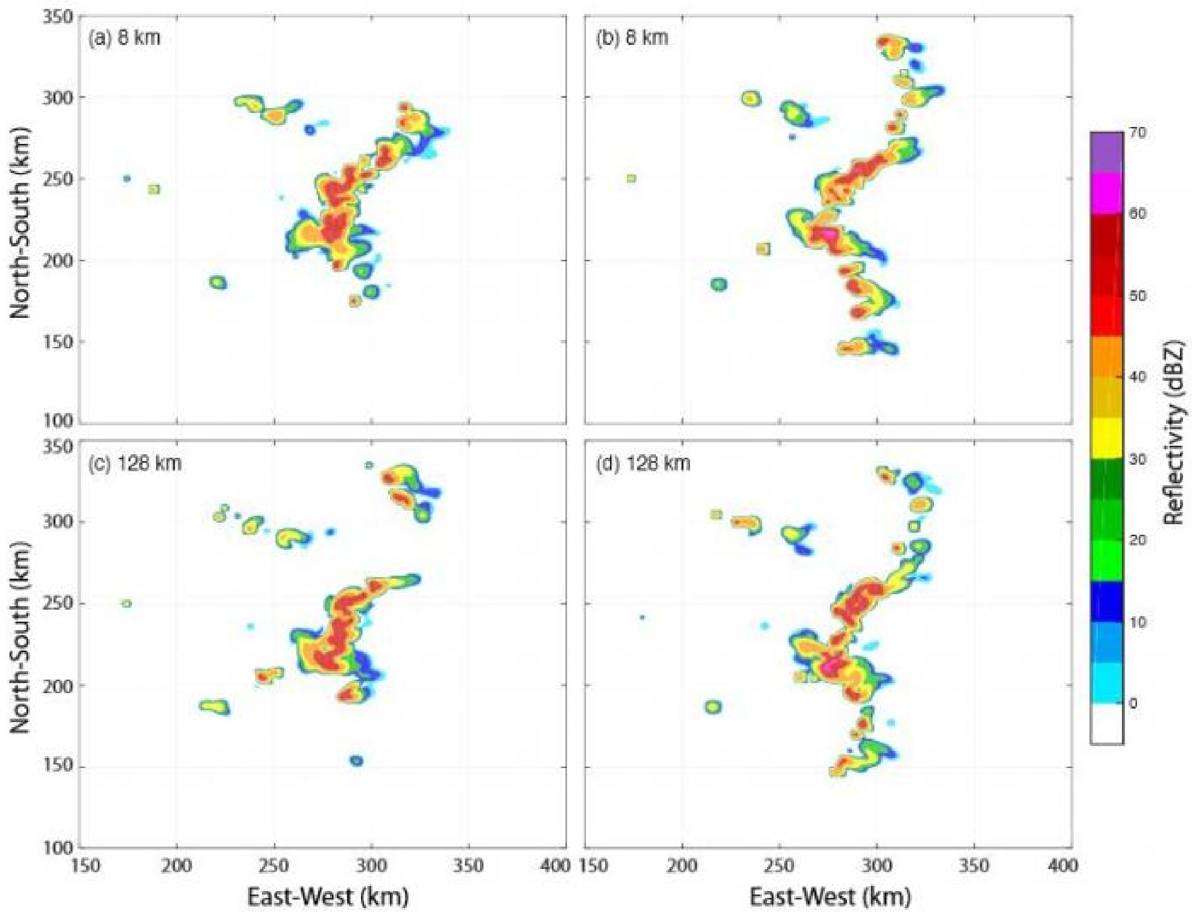
A University of Washington study asks whether unobserved, minuscule disturbances—like those from butterfly wings—actually affect weather forecasts. Luckily for those who rely on the weather report, the answer is no.

"The butterfly effect is important, as an example of how errors might theoretically spread to larger scales, but actual butterflies don't matter for forecasts," said Dale Durran, a UW professor of atmospheric sciences.

He is lead author of "Thunderstorms Don't Get Butterflies," published in the February issue of the *Bulletin of the American Meteorological Society*.

What matters, he says, is getting the bigger picture right.

"The uncertainty in a meteorological forecast generated by ignoring the flapping of a butterfly's wings—or even broader circulations 1 mile wide—is less than that produced by very-small-percentage errors in our observations of much larger-scale motions," Durran said. Thunderstorms can grow rapidly from a small cloud to a huge storm, and are notoriously difficult to forecast. The researchers used this as their test case.



Simulated radar images from two thunderstorms. The top panels included initial errors at the 8-km horizontal scale, but give similar results to the bottom panels, which had more minor errors, only a quarter the size, at the larger 128-km scale. Credit: Dale Durran/University of Washington

"The evolution of thunderstorms is thought to be particularly sensitive to small-scale disturbances," Durran said.

The study used computer simulations of squall lines, the row of thunderstorms that can form ahead of a cold air front. The authors looked at the effect of beginning the simulation with modest errors at different horizontal scales. Minor errors at large scales of about 80 miles (128 kilometers) mattered as much for the forecast as more significant errors at a smaller scale of about 5 miles (8 kilometers). On the one hand, this is good news, since small-scale motions, which are almost impossible to observe routinely, don't matter so much, confirming Durran's earlier paper on the meteorological irrelevance of butterflies. On the other hand, it's bad news, because even little mistakes in the large-scale observations can throw off a forecast for a thunderstorm or a snowstorm.

"Perhaps counterintuitively, you have to know the large scale with a great deal of precision to get the small scale right," Durran said. "There's a lot of energy in the larger scales, so if you make a small fraction of a percent error there, it might not seem like much at the start, but a couple hours into the forecast, it makes a difference."

It's not necessary to create a dense network of observing stations to measure the atmosphere at finer and finer scales, Durran said.Instead of sweating the small stuff, he says, scientists need to improve the way they assimilate, or input, existing observations of the atmosphere on horizontal scales between 100 and 300 miles (160 to 480 km) in order to start local-area forecasts with the best possible description of the air circulating.

"It's going to be difficult, but not impossible, to improve the larger scales," Durran said The other co-author is Jonathan Weyn, a UW doctoral student in atmospheric sciences. The research was funded by the U.S. Office of Naval Research.

More information: Dale R. Durran et al. Thunderstorms Don't Get Butterflies, *Bulletin of the American Meteorological Society* (2015). DOI: 10.1175/BAMS-D-15-00070.1

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