Mountain events could improve safety with ultra-high resolution weather models

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In late May of 2021, 172 runners set out to tackle a 100-kilometer (62-mile) ultramarathon in northwestern China. By midday, as the runners made their way through a rugged, high-elevation part of the

course, temperatures plunged, strong winds whipped around the hillslopes and freezing rain and hail pummeled the runners. By the next day, the death toll from the sudden storm had risen to 21.

A new study revisits the deadly event with the goal of testing how hyper-local modeling can improve forecast accuracy for mountain events. The runners ran into trouble because hourly weather forecasts for the race underestimated the storm. The steep mountain slopes had highly localized effects on wind, precipitation and temperature at too small a scale for the weather forecasts for the event, according to the new study, which is published today in the *Journal of Geophysical Research: Atmospheres* .

Hourly forecasts for the 2021 race were based on relatively large-scale atmospheric processes, with models running at a resolution of three kilometers—sufficient for most regional predictions, but too coarse to capture the "hyper-local" weather like the storm that struck the course, says Haile Xue, a climate scientist at China's CMA Earth System Modeling and Prediction Centre and lead author of the new study. Even though a wind and cold temperature advisory had been issued the night before, it lacked the resolution required to pinpoint the danger zones on the course.

"An apparent temperature forecast based on a high-resolution simulation may be helpful" in addition to general regional forecasts, Xue says. Conditions like the 2021 storm are common in mountains with extremely high elevations, such as Mount Everest and Denali, the paper states. While less frequent at lower elevations, when such storms do occur, they can strike suddenly and lead to injuries and loss of life.

The new study uses topographic data from the course, at tens of meters of resolution rather than kilometers, to model the hyper-local weather conditions created by the mountains. With a resolution two orders of

magnitude finer than the original forecasts for that weekend, as well as detailed considerations of mountainous topography, the model accurately recreated the storm conditions from the race and even offered greater insight into what may have happened that day.

The original forecast included a large-scale cold front, which would have led to temperature drops and stronger—but not extreme—winds, with only a low-level wind advisory issued. The new study found the apparent temperature could have dropped as low as -10 degrees Celsius (14 degrees Fahrenheit), about 3 degrees Celsius cooler than what the original models predicted.

The model also generated an "impact forecast," including apparent temperature, which could have dropped even lower as it considers humidity and would ideally include the effect of wet clothes or skin on body temperature. Including these in forecasts, Xue says, could help mitigate the risk of hypothermia.

Along with the weather, planning for the race and gear requirements for the runners were discussed following the event. Many endurance events require ample layers for warmth and rain protection; these were suggested but not required, which could have contributed to the loss of life. Both accurate weather forecasts and gear requirements are essential for an event to be safe.

More information: Haile Xue et al, Simulation of the Effect of Small-Scale Mountains on Weather Conditions During the May 2021 Ultramarathon in Gansu Province, China, *Journal of Geophysical Research: Atmospheres* (2022). DOI: 10.1029/2022JD036465

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