Simulations predict more supercell thunderstorms in the Alps as climate warms

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A supercell thunderstorm over Lake Maggiore, photographed from Locarno Monti. Credit: MeteoSwiss, Luca Panziera

Supercell thunderstorms are among the most impactful weather events in Europe. They typically occur in summer and are characterized by a rotating updraft of warm, humid air that brings strong winds, large hail and heavy rain. The impact is significant and often leads to property damage, agricultural losses, traffic chaos and even threats to human safety.

The collaboration between the Institute of Geography, the Oeschger Center for Climate Change Research and the Mobiliar Lab for Natural Risks at the University of Bern and the Institute for Atmospheric and Climate Science at ETH Zurich has enabled a detailed simulation of these storms. Their high-resolution digital storm map allows a precise representation of individual storm cells and thus surpasses previous possibilities.

The study, published in *Science Advances*, shows that the Alpine region and parts of Central and Eastern Europe can expect a significant increase in storm activity—up to 50% more on the northern side of the Alps with a temperature increase of 3 degrees Celsius compared to pre-industrial values.

Simulations in line with reality

While European supercell thunderstorms are tracked via weather radar, differences in the countries' radar networks make a comprehensive analysis difficult. "This makes cross-border storm detection more difficult," explains corresponding author Monika Feldmann from the Mobiliar Lab for Natural Risks and the Oeschger Center for Climate Change Research at the University of Bern. For the first time, a new type of climate model simulates supercell thunderstorms with a precision of 2.2 kilometers, developed as part of the scClim project.

The team carried out an eleven-year simulation and compared it with real storm data from 2016 to 2021. "Our simulation largely reflects reality, although it captures slightly fewer storms," notes Feldmann. This is to be expected, as the model only captures storms larger than 2.2 kilometers and lasting longer than an hour, leaving out smaller, shorter-lived events.

Alpine region: A constant 'thunderstorm hotspot'

The simulation underlines the Alps as a hotspot for supercell thunderstorms, as Feldmann points out. The simulation shows around 38 supercell thunderstorms per season on the northern side of the Alps and 61 on the southern slopes.

With an increase of 3 degrees Celsius, these storms will continue to be concentrated in the Alpine region, with up to 52% more storms north of the Alps and 36% more in the south. In contrast, the Iberian Peninsula and southwest France could see a decrease. Overall, an 11% increase in supercell thunderstorms is expected across Europe. "These regional differences illustrate the diverse effects of climate change in Europe," explains Feldmann.

Few storms, big impacts

This project improves the accuracy of forecasts of supercell thunderstorms. Despite their rarity, these storms account for a significant proportion of thunderstorm-related hazards and financial losses.

"The inclusion of supercell thunderstorms in weather risk assessments and disaster strategies is crucial," emphasizes Feldmann. The rise of these storms poses growing challenges to society, increasing potential damage to infrastructure, agriculture and private property and increasing risks to the public. "Understanding the conditions that favor these storms is key to better preparedness."

More information: Monika Feldmann, European supercell thunderstorms - a prevalent current threat and an increasing future hazard, *Science Advances* (2025). DOI: 10.1126/sciadv.adx0513.
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