Alaska thunderstorms may triple with climate change

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Warming temperatures will potentially alter the climate in Alaska so profoundly later this century that the number of thunderstorms will triple, increasing the risks of widespread flash flooding, landslides, and lightning-induced wildfires, new research finds.

In a pair of new papers, a research team led by scientists at the Paris Sciences and Letters University and the National Center for Atmospheric Research (NCAR) show that the sea ice around Alaska could largely give way to open water in the warmer months, creating an ample source of moisture for the atmosphere. This moisture, combined with warmer temperatures that can hold more water vapor, would turbocharge summertime storms over Alaska by the end of the century under a high greenhouse gas emissions scenario.

"Alaska can expect three times as many storms, and those storms will be more intense," said NCAR scientist Andreas Prein, a co-author of the new papers. "It will be a very different regime of rainfall."

The thunderstorms would extend throughout Alaska, even in far northern regions where such storms are virtually unheard of. In more southern regions of the state that currently experience occasional thunderstorms, the storms would become far more frequent and peak rainfall rates would increase by more than a third.

The scientists used a suite of advanced computer models and a specialized algorithm to simulate future weather conditions and to track the sources of moisture in the atmosphere. They noted that the impacts in Alaska could be significantly reduced if society curbed emissions.

The findings have far-reaching implications for the 49th state. Flooding is already the most expensive type of natural disaster in central Alaska, and wildfires ignited by lightning strikes are a major hazard.

"We suspect that the increasing number of thunderstorms might have significant impacts, such as amplifying spring floods or causing more wildfire ignitions," said Basile Poujol, a scientist with the Paris Sciences and Letters University and lead author of both studies. "Further studies are necessary to determine whether these impacts are likely to occur and,

if so, their potential effects on ecosystems and society."

The studies, published in *Climate Dynamics*, were funded by the National Science Foundation, which is NCAR's sponsor, and by the European Research Council.

A major climate shift

Alaska is expected to warm by 6-9 degrees Celsius (about 11-16 degrees Fahrenheit) by the end of the century if society pumps out high amounts of greenhouse gases. The vast state is already experiencing damaging impacts from warmer temperatures, including longer wildfire seasons, record heat waves, and landslides and sinkholes caused by melting permafrost.

If thunderstorms become more common in Alaska, it would represent a major shift in the state's climate.

Organized convective storms, including powerful systems of thunderstorms, are a frequent occurrence in the tropics and midlatitudes, where the atmosphere is moist and solar heating creates instability and rapidly rising parcels of air. In contrast, the colder Arctic provides an inhospitable environment for high-impact thunderstorms.

For the first paper, which focused on how Alaskan thunderstorms may change later this century, the authors compared computer simulations of Alaska's current-day climate with the conditions expected at the end of the century. They fed data from global climate models into the higher-resolution NCAR-based Weather Research and Forecasting (WRF) model, which enabled them to generate detailed simulations of Alaska's weather and climate. They then applied a specialized storm-tracking algorithm, focusing on large thunderstorm clusters in the simulations that extended for dozens to hundreds of miles and unleashed more than an

inch of rain per hour—the type of event that could lead to far-reaching flash flooding and landslides.

To confirm that the models were realistic, the authors compared the simulations of recent atmospheric conditions with observations of actual conditions from radar, satellite, lightning sensors, and other sources.

The results showed that thunderstorm frequency south of the Yukon River increased from about once a year to every month during the warm season. Hourly rainfall rates increased noticeably, ranging up to 37% higher in the cores of storms. In addition, thunderstorms began appearing in regions that had not previously experienced them, such as the North Slope and West Coast.

The second paper focused on the reasons for the increase in thunderstorms. After using WRF and other models to develop a detailed representation of the atmosphere over Alaska, including temperature, water vapor, and seasonal sea ice cover, the research team applied a specialized model to trace air parcels back to their sources.

"Our goal was to determine the sources of moisture and associated changes that would fuel such a significant increase in thunderstorms over Alaska," said NCAR scientist Maria Molina, a co-author of the second study.

The results showed that moist air masses from ice-free regions of the Gulf of Alaska, Bering Sea, and Arctic Ocean will provide abundant fuel for storms. The warmer atmosphere will experience increasingly powerful thunderstorms that are more likely to organize and form large-scale clusters, increasing the potential for heavy rain and lightning.

Prein said the effects of increased storms in Alaska could be particularly severe because the landscape will be reshaped by melting permafrost and

the northerly migration of boreal forests.

"The potential for flash flooding and landslides is definitely increasing, and the Arctic is becoming way more flammable," he said. "It's hard to grasp what the ecological changes will be in the future."

These modeling results from the two studies are in agreement with observed increases in thunderstorm activity in Arctic regions. The authors urged more research into other high-latitude regions to understand if they will experience similar changes.

"There's a lot of value in doing targeted regional climate model simulations that can capture smaller-scale events like thunderstorms and open the door for us to begin to understand more of the complex ways that climate change will impact many aspects of life all over the globe," said NCAR scientist Andrew Newman, a co-author of the first paper. "These two studies show the potential for the Arctic to experience previously unseen weather events in addition to traditionally highlighted changes such as sea ice loss."

More information: Basile Poujol et al, Dynamic and thermodynamic impacts of climate change on organized convection in Alaska, *Climate Dynamics* (2021). DOI: 10.1007/s00382-020-05606-7

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