

Increase in extreme precipitation in the northeast caused by Atlantic variability and climate change

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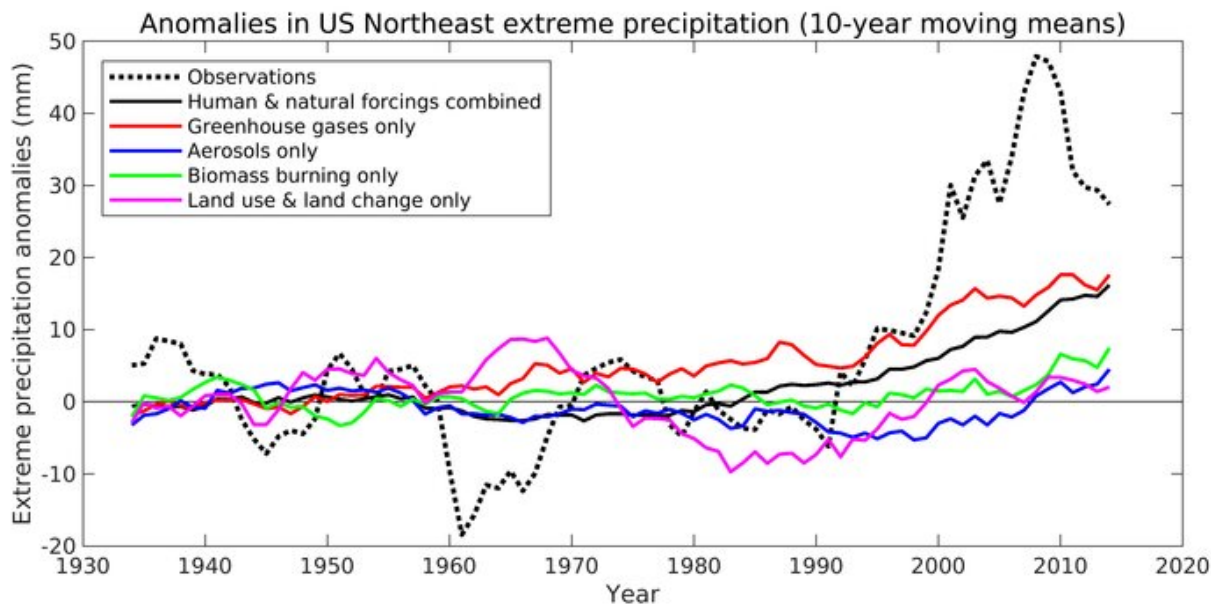
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Recent record-breaking rainfall across the northeastern United States is part of a larger trend. From Maine to West Virginia, the Northeast has seen an abrupt increase in extreme precipitation—heavy rain and snow resulting in about 1 to 2 inches of water in a day depending on location

since 1996, which has coincided with warming sea surface temperatures in the North Atlantic. Northeast extreme precipitation is typically caused by tropical cyclones, thunderstorms along fronts, and extratropical cyclones like Nor'easters. A recent study published in *Weather and Climate Extremes* finds that the increase in extreme precipitation after 1996 was caused by greenhouse gases from human activity and surface temperature variability of the North Atlantic Ocean, known as Atlantic variability.

"Our previous work has shown that Northeast [extreme precipitation](#) has increased dramatically over the past 25 years, but this study is among the first to demonstrate that this rise is partially due to [anthropogenic climate change](#)," said lead author Huanping Huang, a former graduate student in earth sciences and an alumnus of the Applied Hydroclimatology Group at Dartmouth. Huang is currently a postdoctoral fellow in the Climate and Ecosystem Sciences Division at Lawrence Berkeley National Laboratory.

This study builds on earlier work by Huang and co-authors, which found that the Northeast has experienced a [53% increase in extreme precipitation](#) since 1996, and that the primary driver of the increase is enhanced heavy rainfall from tropical cyclones. The team linked the enhanced heavy [precipitation](#) from tropical cyclones to both a warmer atmosphere, which increases the amount of water air can hold, and a warmer Atlantic Ocean, which creates stronger and more frequent hurricanes. "Our results demonstrate that multidecadal variability in Atlantic [sea surface temperatures](#), an important driver of warming in the Atlantic, alongside anthropogenic [greenhouse gases](#) and aerosols, also contributed to the increase in Northeast extreme precipitation after 1996," added Huang.



Anomalies in U.S. Northeast extreme precipitation (10-year moving means).
Credit: Huanping Huang.

To determine the causal factors of increased extreme precipitation in the Northeast and the warming of Atlantic sea surface temperatures from 1929 to 2018, the research team used two large sets of global [climate](#) model simulations provided by the National Center for Atmosphere Research, as well as precipitation data from U.S. weather stations from the Global Historical Climatology Network compiled by the National Oceanic and Atmospheric Administration's National Centers for Environmental Information.

To isolate the causes of the extreme precipitation increase, the team used one set of global climate model simulations that reproduce historical climate by including the evolution of all natural and anthropogenic forcings. Natural forcings include solar radiation and volcanoes, while anthropogenic forcings include greenhouse gases, industrial aerosols

(particulates from the burning of fossil fuels), aerosols from the burning of biomass, and land use and land change. In the other set of simulations, all of the forcings were included except for one of the four anthropogenic forcings. Through this "leave-one-out" approach, the researchers could isolate the effects of external forcings and internal variability (naturally occurring climate variations) on the observed changes of North Atlantic sea surface temperatures and Northeast extreme precipitation. The researchers then applied a statistical method called "optimal fingerprinting" that is frequently used in climate change research, to determine the extent to which external forcings have influenced regional climate.

The findings revealed that the extreme precipitation increase observed after 1996 was caused by greenhouse gases from [human activity](#) and a warmer North Atlantic Ocean. The North Atlantic Ocean warming since the 1990s, can be attributed to multidecadal variability, decreased industrial aerosols, and increased greenhouse gases. As air quality improved due to the Clean Air Act of 1970, aerosols that polluted the atmosphere and reflected sunlight, decreased. This reduced cooling from fewer aerosols, combined with warming from increased greenhouse gases from human activity, warmed the North Atlantic.

"Our analysis illustrates that decreased aerosols and increased greenhouse gases from human activity have contributed to both the rise in Northeast extreme precipitation and North Atlantic sea surface temperatures," said co-author Jonathan Winter, an associate professor of geography and principal investigator of the Applied Hydroclimatology Group at Dartmouth. "Our research team has been exploring this dramatic increase in extreme precipitation for several years now, and this study confirms that humans are in fact, partially responsible for the increase in heavy rain events that we have been experiencing over the past two and a half decades."

More information: Huanping Huang et al, Rise in Northeast US extreme precipitation caused by Atlantic variability and climate change, *Weather and Climate Extremes* (2021). [DOI: 10.1016/j.wace.2021.100351](https://doi.org/10.1016/j.wace.2021.100351)

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