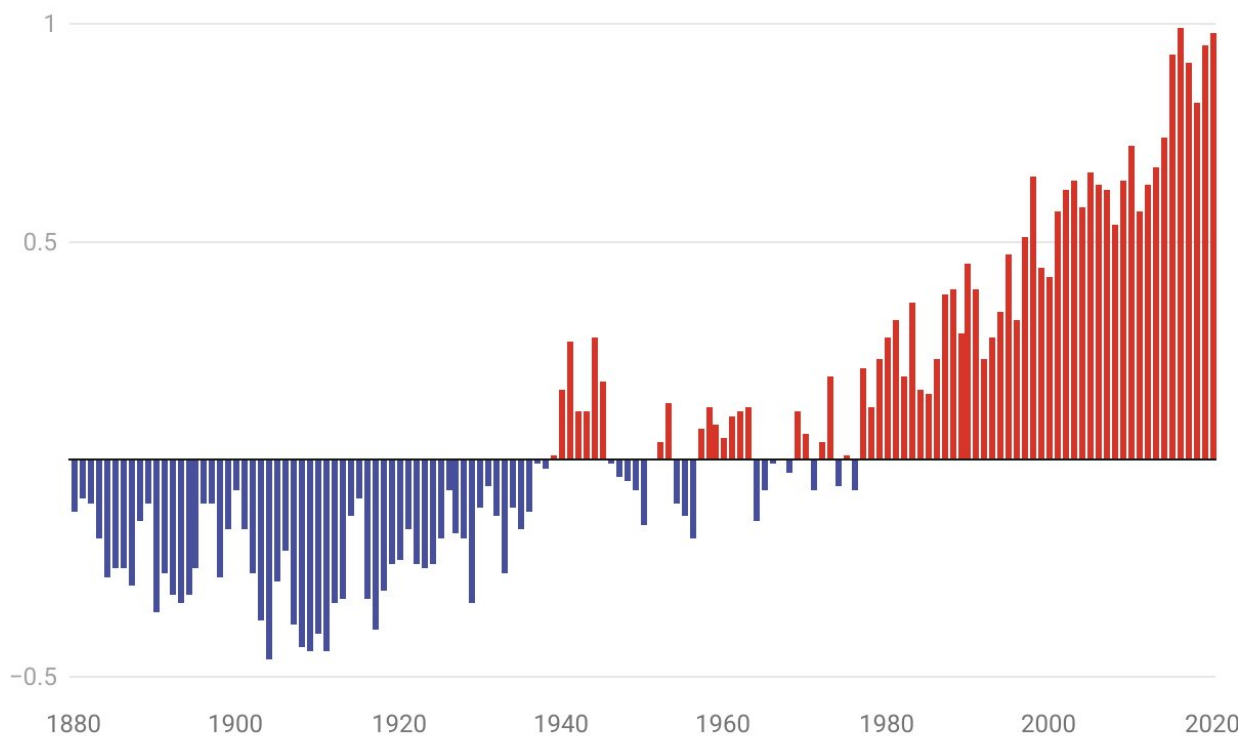# Global evidence links rise in extreme precipitation to human-driven climate change

July 7 2021, by Gavin D. Madakumbura, Alex Hall, Chad Thackeray and Jesse Norris

Global temperatures are rising

The average global temperature, including both land and sea surface, is now nearly 1 degree Celsius (1.8 F) warmer than the 20th century average.

Difference between average annual temperature and 20th century average in degrees Celsius, through 2020

Chart: The Conversation/CC-BY-ND • Source: NOAA

Human activities, such as burning fossil fuels for transportation and electricity, have worsened the intensity of extreme rainfall and snowfall over land in recent decades, not just in a few areas but on a global scale, new research shows.

Past studies were able to attribute individual extreme events and long-term changes in some regions to climate change, but global assessments have been more difficult. We used a new technique to analyze precipitation records from around the world and found conclusive evidence of human influence on extreme precipitation in every one.

Scientists have been warning that rising global temperatures will lead to more extreme precipitation in the future, mainly because warm air "holds" more water vapor in the atmosphere, fueling storms.

With Earth already about 1 degree Celsius (1.8 F) warmer since the start of the industrial era, we wanted to find out if that change had already started.

Past attempts to detect the human influence in historical precipitation records typically required long time series with many consecutive years of data. But precipitation is difficult to monitor over long periods from land or space, so those records are rare. We found another way.

We used artificial neural networks, a type of machine learning, to find patterns of extreme precipitation in weather records. Once those neural networks understood what to look for, we could analyze shorter and more disparate observational records.

The result is multiple lines of evidence that human activity has intensified extreme precipitation during recent decades. Even when the data sets were widely different, we were able to see the human influence.

[The findings](#) were published July 6, 2021, in the journal *Nature Communications*.

Understanding how humans influence extreme precipitation is important for interpreting climate events today and for preparing cities and protective infrastructure for the changing world ahead.

In recent years, devastating flooding has made headlines after extraordinary rainfall that historically would have been extremely rare. The [2017 hurricane season in Texas, Florida and Puerto Rico](#) and the [extreme monsoon rains over India and Bangladesh in 2017](#) are two examples. Our results indicate that, as a general rule, precipitation has become more extreme around the world in recent decades.

> [#Harvey](#) in perspective. So much rain has fallen, we've had to update the color charts on our graphics in order to effectively map it. [pic.twitter.com/Su7x2K1uuz](#)
>
> — National Weather Service (@NWS) [August 28, 2017](#)

Perhaps more importantly, our results indicate that further warming of the planet through the 21st century is likely to continue to intensify the most extreme precipitation events. [Climate models project such an intensification](#) will happen this century, and they suggest that a similar but [less-rapid intensification occurred in the 20th Century](#), based on how much the planet has already warmed. Our results validate that finding.

With greenhouse gas levels in the atmosphere still increasing, the planet is projected to continue [warming through the 21st century](#). How much it warms will depend on choices made today about [fossil fuel use](#) and other major contributors to [climate change](#). That 1 degree of warming could be [4 degrees](#) by the end of the century if emissions continue at a high rate.

While we clearly identified the influence of humans on extreme precipitation in the past, we haven't yet isolated how much each type of human activity has contributed. Greenhouse gas emissions, aerosols and changes in land use can all have an influence. We plan to modify our machine learning method in the future to home in on those sources.

The machine learning method we used is also currently learning from data alone. We can take this up a notch by bringing climate physics into the algorithm. By doing that, the machine would learn the physical processes that lead to intensifying extreme precipitation. Other climate variables could be included, such as winds, clouds and radiation, helping to answer not just whether extreme precipitation is intensifying, but why.

More information: Gavin D. Madakumbura et al, Anthropogenic influence on extreme precipitation over global land areas seen in multiple observational datasets, *Nature Communications* (2021). DOI: 10.1038/s41467-021-24262-x

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