Climate models may underestimate future floods

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Climate models may be significantly underestimating how extreme precipitation will become in response to a rise in greenhouse gases in the atmosphere, a new Yale-led study finds.

It all comes down to raindrop physics, researchers Ryan Li and Joshua Studholme explain in the journal *Nature Climate Change*. Even a slight change in the percentage of each falling raindrop to reach the Earth's surface can mean the difference between a climate of light drizzles and one that creates unprecedented deluges.

Yet for now, many climate projections seem to be underestimating future floods, the researchers say.

"Whether the rain a cloud produces over its lifetime will increase or decrease in warmer climates is a research question from over half a century ago. We are still searching for the answer," said Li, a graduate student in Yale's Department of Earth and Planetary Sciences, and first author of the new study.

"What we've shown is that the answer to this seemingly isolated question in fact has a big role in projections of global climate change."

Recent years have brought a wave of large storms that exceeded expectations for precipitation severity. Such storms reached all-time global records for damages in 2021, costing the United States $65 billion, Europe $43 billion, and China $30 billion. These financial losses resulted from widespread destabilization of land in Germany, and flooded subway systems in New York City and Henan, China, among other impacts.

Many state-of-the-art climate models did not see the uptick in extreme storms coming, the authors of the new study say. For their study, they analyzed the models to understand if, and why, the impacts of greenhouse gases are being underestimated. They trace the problem to a central question: How much rain will reach Earth's surface from a given cloud as the planet continues to get warmer?

"Climate models used for current global warming projections are divided over this critical question," said co-author Studholme, a physicist and postdoctoral associate in the Department of Earth and Planetary Sciences in Yale's Faculty of Arts and Sciences.

"The answer corresponds to a staggering, two-times difference in projections of extreme rainfall," said Studholme, who was also a contributing author on the United Nation's Intergovernmental Panel on Climate Change sixth assessment report.

For the study, the researchers developed a novel way to measure precipitation efficiency (PE), the amount of rain that is re-evaporated as it falls from a storm cloud. A PE measurement of 0 would mean no rain reaches Earth's surface; a PE of 1 would mean all water from the cloud rained onto the surface. The researchers paid particular attention to the "drying" timescale of clouds—the time a cloud would need to drop all of its water.

The researchers found that atmospheric models using more detailed, higher-resolution information about clouds often use a higher PE—meaning more precipitation. "Unfortunately, the computational power to run these high-resolution models for global climate change projections doesn't exist yet," Studholme said. "But they can be used to contextualize conventional climate models."

They also found that the traditional climate models—the ones that predict increasing PE, like the high-resolution models—predict a two-fold increase in extreme precipitation events in the 21st century, compared to models with decreasing PE.

Co-authors of the study are Alexey Fedorov, a professor of oceanic and atmospheric sciences at Yale; and Trude Storelvmo, a former Yale professor who is now at the University of Oslo.

More information: Raindrop physics important for future tropical slowdown and extreme precipitation, *Nature Climate Change* (2022). DOI: 10.1038/s41558-022-01402-9

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