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Study reveals link between Tibetan Plateau heat and record rain in California

The discovery could transform winter forecasting and explains why severe floods hit the US west coast when dry weather was expected

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The Tibetan Plateau has been heating up in recent years as a result of climate change. Photo: Getty Images

Abnormally high temperatures across the Tibetan Plateau in early winter can trigger catastrophic rainstorms in California, according to a new study revealing a previously unidentified climate connection.

In the winters of 2016-2017 and 2022-2023, record-breaking rain swept across the US state and surrounding areas, causing billions of dollars in damage and several deaths during years when drier weather was expected in the region.

A study led by researchers from the University of California, Los Angeles (UCLA) found that these rain events happened shortly after periods of unusually high land surface temperatures on the Tibetan Plateau in early winter.

As the planet heats up and the world braces for what could be a record-strength El Nino event, understanding climate and weather connections over long distances could be the key to better weather forecasting and preparedness.

The record rain caused “extraordinary damage and severe societal impacts”, according to the paper published in the peer-reviewed journal Science Advances on Wednesday.

Rainfall in the winter of 2016-2017 effectively ended California’s five-year drought, with property damage reaching around US$2 billion. Heavy precipitation in the winter of 2022-2023 brought severe flooding, killing several people and causing around US$4.6 billion in damage.

These winter events happened during La Nina years – the cold phase of the El Nino-Southern Oscillation (Enso) global climate pattern, when California typically experiences less precipitation.

The extreme flooding that occurred during both seasons was not forecast in advance, nor was it recreated by computer simulations after the storms happened, according to the researchers from institutes in the US, China, France and India.

“With more similar, though less severe, events occurring in recent years and drawing widespread public concern, it has become imperative to adequately address this scientific challenge,” they said.

Using Earth system models, the team found that anomalous early winter heating over the Tibetan Plateau helped drive the extreme precipitation across the Pacific Ocean.

The study was part of an international collaboration called GEWEX/LS4P that aims to study how land surface temperature and snowpack affect precipitation predictions.

Xue Yongkang, study author and a distinguished professor at UCLA, said that through the collaboration, researchers were working with major meteorological institutions to integrate their findings into forecasting systems.

“Because our paper presents a breakthrough discovery, it will take some time for relevant agencies to formally adopt it,” Xue wrote in an email on Wednesday.

The Tibetan Plateau, which lies mainly in southwestern China and is the largest and highest plateau in the world, has been heating up rapidly in recent years as a result of climate change.

The world is bracing for what has been dubbed a “super El Nino” – a particularly strong warm phase of the Enso cycle. The event, which could be the strongest on record, has raised concerns about the impact on land and ocean temperatures, as well as the potential for extreme weather events.

Xue said the underlying mechanism of the Tibetan Plateau-California connection was “driven by general dynamic and physical principles, rather than depending specifically on Enso”.

“Historically, general statistical relationships suggest that an upcoming strong El Nino should bring increased rainfall. However, a past El Nino event was paradoxically associated with an extraordinary California drought,” Xue said.

“While we wait to see how the current event unfolds, we must also closely monitor early winter surface temperatures on the Tibetan Plateau.”

Before 1980, there was no statistically significant relationship between early winter Tibetan Plateau temperatures and late winter precipitation in California. Xue said this was “largely because extreme hydroclimate events were far less frequent”.

“However, the rise of unprecedented extremes in recent decades points to a shifting climate dynamic that warrants further investigation. Quantifying the exact scale of these future changes will require targeted, rigorous research.”

Xue said early warning systems could be improved by shifting to a comprehensive, multi-variable approach that integrates data from the Tibetan Plateau.

This could fill a critical gap in winter forecasting for the US west coast, which has traditionally relied heavily on sea surface temperatures. It would also improve winter preparedness by giving more weight to land temperature and extending warning windows.

“Tracking Tibetan Plateau surface temperatures in early winter allows meteorologists to enhance early warning systems. This gives west coast communities vital extra time to prepare for devastating atmospheric rivers,” Xue said, referring to narrow bands of highly concentrated water vapour high in the atmosphere that can release large amounts of rain or snow when they make landfall.

In control simulations, the team found that the models initially failed to reproduce the link between the Tibetan Plateau and California, leading to the need for model adjustments.

Xue said that all weather forecast models used in the GEWEX/LS4P project, including those from the world’s major weather prediction centres, struggled to accurately simulate land temperature anomalies on the plateau and the link with California.

“While we are working to enhance simulations in these areas, achieving substantial improvements will take time,” he said.