UC SANTA BARBARA

THE Current

November 7, 2024

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Atmospheric rivers are shifting toward the poles, possibly following a long-term cycle

Against the backdrop of global warming, sea level rise and extreme weather, it's reassuring to learn that not all climatic changes are solely due to human activities. There are still natural rhythms in the oceans and atmosphere that influence our weather patterns. Understanding how these interact with anthropogenic climate change is crucial to forecasting.

A pair of researchers at UC Santa Barbara investigated major migrations in global weather patterns. "Atmospheric rivers are shifting poleward in both hemispheres," said Zhe Li, who recently earned his doctorate, "bringing heavy rain and storms to higher latitudes, which could reshape precipitation patterns globally." But Li and his advisor, Qinghua Ding, didn't see this trend reflected in current climate models, so they set out to discover why it's happening and how that will influence weather.

Their results, published in Science Advances, suggest this poleward shift is part of a natural cycle in sea surface temperatures in the Tropical Eastern Pacific. This change has already brought drought and water shortages to subtropical areas. "Understanding these changes will help us make better predictions about future rainfall patterns and water availability," Li said.

Rivers in the sky

More than just strong storm systems, “atmospheric rivers are like highways of moisture in the sky,” Li explained. They’re hundreds of kilometers wide and thousands of kilometers long, transporting moisture from the tropics to higher latitudes. These systems can carry more water than the Amazon River.

Li and Ding have noticed that atmospheric rivers were becoming more frequent at higher latitudes over the past two decades. But this shift isn’t predicted by current climate models, so they set out to interpret the discrepancy.

“A discrepancy doesn’t always mean the model is wrong,” said Ding, a climate scientist in the Department of Geography. “It just means our perspective needs to be adjusted.”

Li and Ding cataloged the location and frequency of atmospheric rivers over the past 40 years and then compared this to simulations from the climate models. To understand the differences, they began to investigate the influence of different climate variables.

They found that the effect of anthropogenic climate change was smaller, and much different, than natural factors affecting these systems. “Based on that, we hypothesize that this observed shift is not totally due to anthropogenic forcing,” Ding said. The poleward migration of atmospheric rivers strongly correlated with changes to sea surface temperature and a metric called Z200, a measure of atmospheric pressure that tells scientists how and where the wind will blow.

Image

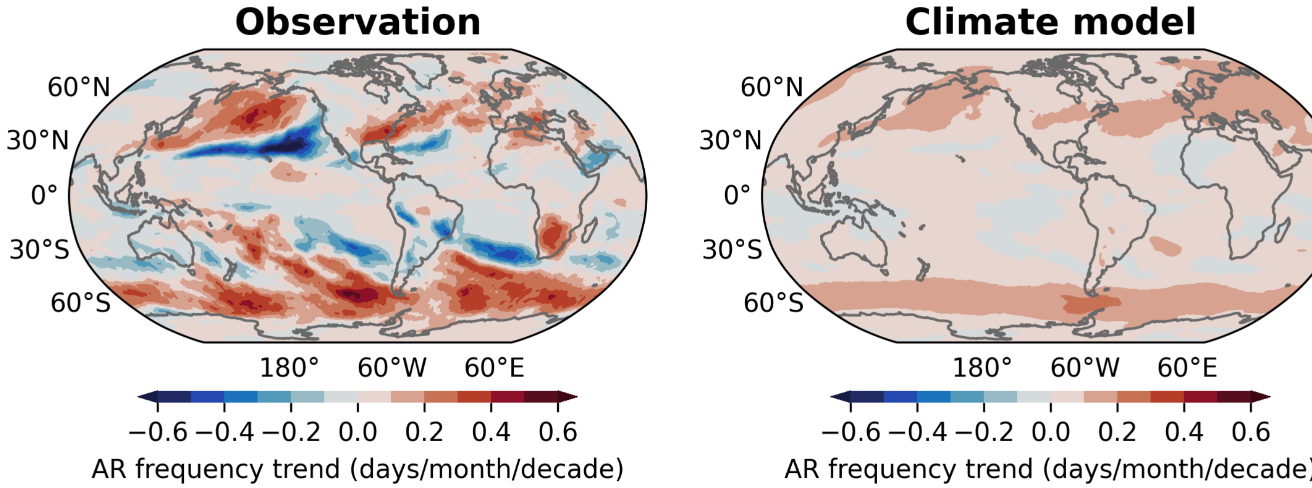

Photo Credit
Zhe Li and Qinghua Ding
Observations suggest that atmospheric rivers are shifting poleward. Meanwhile, models predict that they are simply becoming more frequent at higher latitudes. Li and Ding suspect it's a bit of both.

Human actions and natural cycles

A whole slew of complex factors and feedback loops influence the location, intensity and frequency of atmospheric rivers, but a few major contributors are well known to scientists. One major factor is the El Niño-Southern Oscillation (ENSO), an atmospheric and oceanographic fluctuation that occurs in the deep tropics (between 10º S and 10º N), with a period between two and seven years. There's also the Pacific Decadal Oscillation (PDO), a hot-cold cycle in the northern Pacific basin with a longer period of 10–20 years.

Many people are familiar with ENSO, if not by name. When warm surface water pools in the Tropical Eastern Pacific — off the western coast of the Americas — it causes El Niño conditions that often bring rain to California. The reverse is called La Niña, which generally brings drier conditions to the American West.

During La Niña, warm surface water moves to the Tropical Western Pacific. This is significant because this region generates a lot of convection. La Niña strengthens what is called the Walker Circulation, which cycles moist air back across the Pacific. This expands the tropical belt by raising the pressure in the mid-latitudes. As a result, all weather patterns get pushed toward the poles. Hence, more frequent atmospheric rivers at higher latitudes.

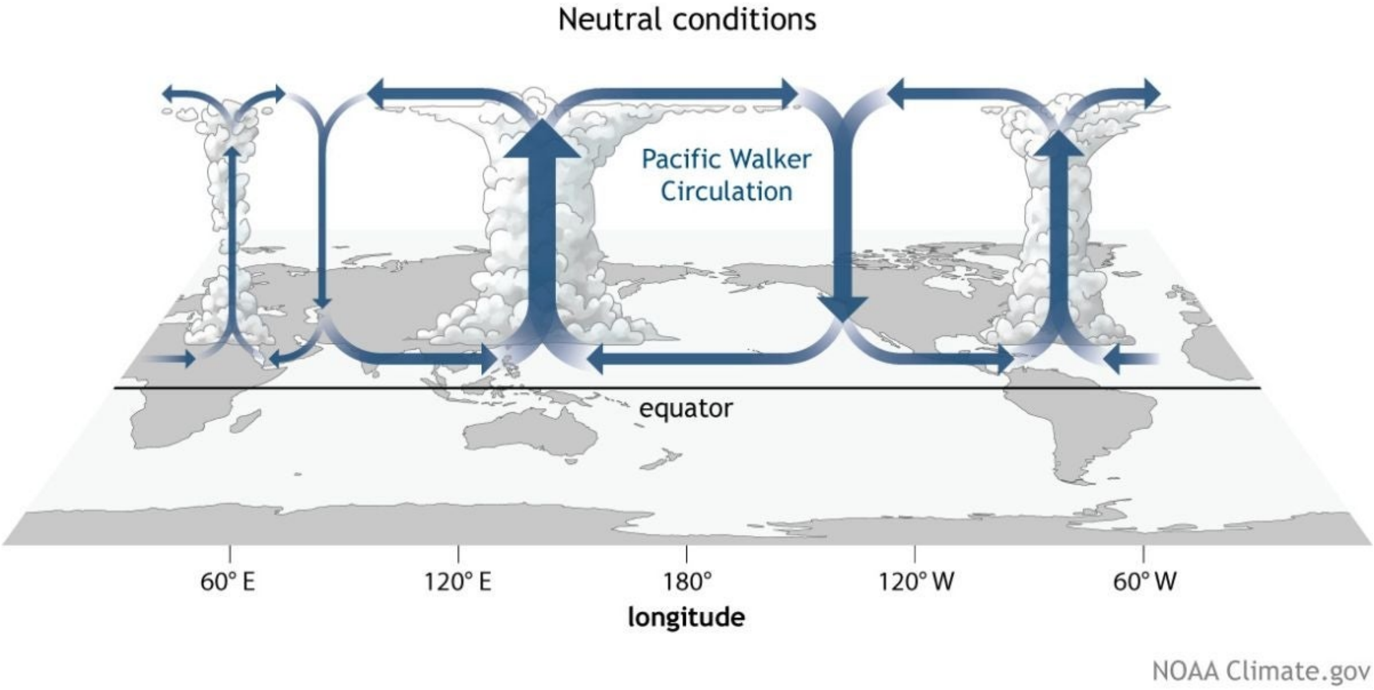

Photo Credit
Fiona Martin
The Walker Circulation drives air currents in the Pacific, which then affect weather conditions across the globe.

Reinterpreting the models

Li and Ding's data comes from the European Centre for Medium-Range Weather Forecasts, ERA5, one of the most accurate reconstructions of the past global climate. The organization combines data from satellites and terrestrial instrumentation with models that assimilate this data, blending simulations and observations into an integrated account of the global climate called a reanalysis.

The center's fifth-generation reanalysis covers the period from January 1940 to the present. Li and Ding use data beginning in 1979, when satellite observations began. Both cover sizable timespans, but they may still be too short for scientists to recognize long-term patterns. Perhaps these poleward shifts are followed by a shift back toward the equator, "but just by chance, over the most recent 40 years we've only observed this polar shift," Ding said.

Likewise, scientists aren't certain why the Eastern Pacific has been cooling. It could be part of a larger rhythm that simply extends beyond the timeline of the data. But

Ding stresses that it’s not just a matter of whether the models are right or wrong. If the cooling and shifts are driven by natural processes, then the models wouldn’t predict them since the models focus on anthropogenic factors. But if these changes are caused by human activity — an unlikely scenario, according to this study — then the models may need some adjustment to increase their accuracy.

A larger ebb and flow

More consistent La Niña conditions over the past decade have contributed to the droughts in the Western U.S., but if this is a periodic process, then the situation isn’t permanent — wetter winter conditions could return in the next decade.

Ding is particularly interested in learning how recent cooling in the Eastern Pacific and the poleward shift of atmospheric rivers have affected California over the last 20 years. He also plans to investigate the paleoclimate record to learn more about this phenomenon.

Still, he added, we’ll likely see more extreme weather as the climate crisis continues. Since warm air can hold and transport more moisture, models predict that dry areas will become drier and wet areas will become wetter. But this paper serves as a reminder that climate change is not the only factor influencing weather patterns — we still need to consider the role of natural cycles. Scientists know about some of these but are just now uncovering others.

Tags
Climate Change

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