Ocean temperature patterns drive the West's wintertime storm tracks

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Waves crashing along a rocky shore in the Pacific Northwest. Credit: Hatham/Unsplash

About 20,000 years ago, large ice sheets loomed over North America, and researchers thought the ice, itself, pushed storms south, drenching the Southwest and leaving the Pacific Northwest dry. Now, a new CIRES-led study finds that ocean temperatures are the real culprit behind the dramatic shift in atmospheric circulation. The work, published in *Earth and Planetary Science Letters* suggests that West Coast precipitation patterns are tightly linked to changes in Pacific Ocean temperatures.

"Although there is no chance that a 3-km-tall ice sheet will suddenly appear over North America, modern climate can produce similar changes in North Pacific ocean temperatures that could temporarily swap the climates of the Southwest and the Pacific Northwest," said Dillon Amaya, a former CIRES Visiting Fellow and lead author on the paper.

Amaya, now a NOAA research scientist with the Physical Sciences Laboratory, and his colleagues used a climate model to evaluate the impact of Northern Hemisphere ice sheets on West Coast atmospheric dynamics during the Last Glacial Maximum, when today's arid Southwest was moist and the wet Pacific Northwest was dry. This major shift in storm tracks is supported by geologic evidence and previous modeling work, but the underlying cause remained less clear.

Researchers long hypothesized ice sheets acted as a physical barrier during the last ice age, forcing the North Pacific jet stream and wintertime storms south. But more recently, scientists began looking closer at another characteristic of the ice. "There's also the thermodynamic effect of having a really bright ice sheet that reflects a lot of sunlight," Amaya explained. "That creates cooling that also adjusts atmospheric circulation."

To better understand the differences between the two effects, the team used a climate model that also simulated the response of the ocean to the ice sheets and its interactions with the atmosphere.

Surprisingly, their model results suggest that ice sheets play a key, but behind-the-scenes role. In their climate model experiments, when they deliberately oversimplified the ways the ocean and atmosphere interact, ice sheets did appear to physically force the jet stream south. But when they allowed their model to account for air-sea interactions more realistically, the ice sheet's brightness triggered a change in North Pacific Ocean temperature patterns. The change altered the atmosphere's circulation and shifted west coast precipitation south.

The work shows that ocean temperatures, not ice sheets themselves, are directly responsible for the reorganization of North Pacific atmospheric circulation and West Coast precipitation patterns during the Last Glacial Maximum. The distinction is important, Amaya said, because the pattern of ocean temperatures is not unique to the Last Glacial Maximum, nor does it require the presence of an ice sheet to occur.

"This study highlights the need for a holistic view of the climate system, especially when modeling its past and future behavior," said coauthor and CIRES Fellow Kris Karnauskas. "Without accounting for the interaction between the atmosphere and ocean, you can end up with the right answer for the wrong reason, which is of course risky when you try to extrapolate that information to future concerns like freshwater availability."

"It is distinctly plausible that we could get an ocean temperature pattern in the North Pacific that looks very much like what we saw during the Last Glacial Maximum," Amaya said. "This could lead to dramatic changes in West Coast hydroclimate over a relatively short period of time, like decades.

More information: Dillon J. Amaya et al, Air-sea coupling shapes North American hydroclimate response to ice sheets during the Last Glacial Maximum, *Earth and Planetary Science Letters* (2021). DOI: 10.1016/j.epsl.2021.117271

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