Today's global climate models do not capture the effects of climate change on islands' aridity

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Aerial photo of the town of Jabor on Jaluit Atoll (169.5E, 6N), Republic of the Marshall Islands taken by a drone during recent fieldwork in the western tropical Pacific. Credit: Kris Karnauskas / CIRES

Island nations could be forgiven for feeling slighted. They already face the brunt of the effects of climate change: Rising sea levels, dwindling resources, threats to infrastructure and economic foundations. But to add insult to injury, thousands of these islands are too small to be accounted for in the global climate models (GCMs) used by scientists to measure the effects of climate change.

In a new study published in the journal *Nature Climate Change*, a new way of modeling the effects of climate change on islands shows that previous analyses underestimated the number of islands that would become substantially more arid by mid century-73 percent, up from an estimate of 50 percent. That leaves the population of those islands—approximately 18 million people—in the position of being what CIRES Fellow Kris Karnauskas, the paper's lead author, and his coauthors refer to as "computationally disenfranchised."

It also means that what's known about the effects of climate change on islands' freshwater systems may have been woefully incomplete. GCMs show 50 percent of all small islands becoming wetter and 50 percent becoming drier, as far as rainfall goes. But those models by themselves don't take into account what happens on the surface of these unaccounted-for islands and, in fact, Karnauskas and his coauthors found that 73 percent of islands will actually become more dry as a result of increased evaporation. "Islands are already dealing with sea level rise," says Karnauskas, also a professor of atmospheric and oceanic sciences at the University of Colorado Boulder. "But this shows that any rainwater they have is also vulnerable. The atmosphere is getting thirstier, and would like more of that freshwater back."

The problem stems from the fact that GCMs aren't all that fine-grained. These models divide the planet into a grid and each grid box is approximately 240 km by 210 km. That's a pretty big space and if there's a tiny island—or even an island chain like French Polynesia—alone in one of those grid boxes, it makes it impractical to include them in the model. "Think of pixels," says Karnauskas. "If they're too big to resolve the freckles on someone's nose, you won't be able to see those freckles. You have to have super fine pixels to resolve it, and frankly that's not what global climate models were designed to do."

The "pixels" of the GCMs are too big and scientists don't have the computer resources yet to do something on a more refined scale. Take, for example, an island like Easter Island, which is 3,512 kilometres off the coast of Chile in the South Pacific. Easter Island is small and it's the only spot of land in its GCM grid box. Essentially, it's a freckle and the GCM can't get down to that level of detail. So, in the current GCMs, Easter Island doesn't exist—that whole grid square is just considered open ocean.

That's the case with islands all over the globe and it's a real problem when it comes to knowing what climate change will do to islands' freshwater supplies. Unlike continents or larger islands, the effects of climate change on freshwater for these smaller, isolated islands aren't being calculated. "Paper after paper in my field show changes in drought or aridity," says Karnauskas. "But my eye always looks at the maps and graphs in those papers and I wonder why we can't see islands. Using models, it turns out, is much less straightforward for islands than for places where there are big chunks of land."

To understand how climate change will affect freshwater, scientists have to understand what's happening with precipitation and evaporation. The first part is easier: Current GCMs can tell you all about precipitation over land or over the ocean. Even in a grid square like the one that's home to Easter Island, they can estimate how much precipitation is likely falling from the sky.

But evaporation is another matter. When it comes to those same small islands, the models don't show how much water is evaporating because those islands don't exist in the models—it's all ocean there. Nor can it be calculated using the amount evaporating off the ocean, as ocean evaporation follows different physical principles than water evaporating off land. Without knowing how much water is evaporating off these islands, there's been no way to know exactly how the freshwater supplies are being affected. So Karnauskas and his former colleagues from the

Woods Hole Institute in Massachusetts developed a way to get the information needed to know what's happening on islands.

Karnauskas draws a diagram of a cube on a white board. "This is a 3-D picture of an ocean grid cell," he explains. "Say there's an island in here. The climate model doesn't have the island but let's go to the location where there ought to be an island and use the information on the model atmosphere from directly over that cell." Essentially, they're looking at the climate above the surface of the island to make an approximation of the island's actual climate. They can do this because many of the islands are so small that climate above the island isn't much different from climate above the ocean, especially averaged over a day or longer. That's been verified even on islands as large as Maui, where data from weather stations at airports shows surprisingly little difference from data from weather stations moored hundreds of kilometers offshore.

"We called it the blind pig test," explains Karnauskas with a grin. "If you were a blind pig flying in this area, would you know there was an island here? Could you feel a difference in the heat or the humidity?" A "successful" blind pig test means you can't tell if you're over land or over ocean. If that's the case, scientists don't need to know anything from the land itself to predict evaporation; they just need to know what's happening in the atmosphere right near the surface. From that information, and some tools borrowed from the engineering field, they can glean how much water is evaporating and, thus, get a more accurate picture of the ratio of precipitation to evaporation in a particular area.

Karnauskas sees this work as extremely important, both for understanding climate change in these regions and in considering human health and safety. A vast majority of the people living on these remote island rely on rainwater as the source of their drinking water. And for those that already have health issues due to water quality, increased pressure on freshwater systems will only exacerbate the problem.

Already someone from the Cook Islands, an archipelago in the South Pacific Ocean, saw mention of his research online and reached out for more details. "There's an opportunity to get important information out there," Karnauskas says. "This is a framework to provide more accurate information on what to expect."

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