GLOBAL WARMING

The Greenhouse Is Making the Water-Poor Even Poorer

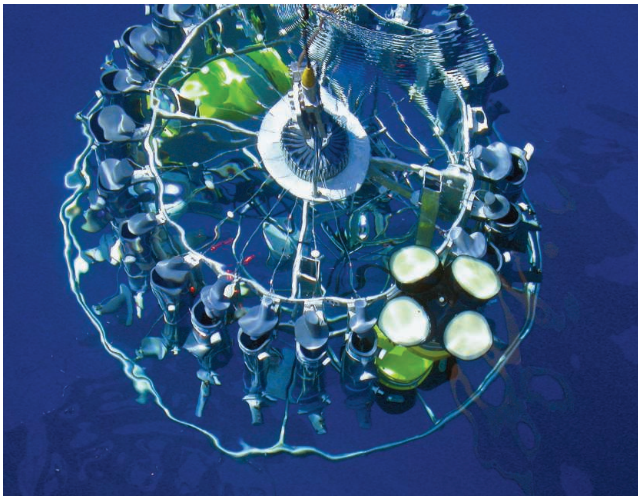
How bad will global warming get? The question has long been cast in terms of how hot the world will get. But perhaps more important to the planet's inhabitants will be how much rising greenhouse gases crank up the water cycle. Theory and models predict that a strengthening greenhouse will increase precipitation where it is already relatively high—tropical rain forests, for example—and decrease it where it is already low, as in the subtropics.

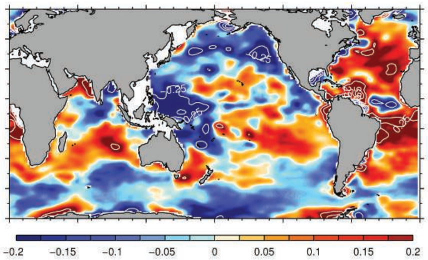
A new study of the ocean's changing salinity on page 455 confirms that this "rich get richer" mechanism of water-cycle amplification has been operating for the past half-century. "It's a pretty striking result," says oceanographer Raymond Schmitt of Woods Hole Oceanographic Institution in Massachusetts. The result also suggests that the water cycle is intensifying quickly under global warming—twice as fast as climate models have been predicting.

Several studies of how fast water has been evaporating and falling back as rain on a global scale had suggested an acceleration of the water cycle, but they had their limitations. Using rain gauges on land was tricky given that heavy rains can be sporadic and gauge networks have been sparse. Satellites can survey the globe, but they have been at it for only a couple of decades.

So oceanographer Paul Durack of Lawrence Livermore National Laboratory in California and colleagues from the Commonwealth Scientific and Industrial Research Organisation's Marine and Atmospheric Research division in Australia looked to the ocean. After all, "that's where the water is," as Schmitt puts it. The oceans cover 71% of the globe, hold 97% of its water, and receive 80% of its precipitation. And gauging the oceans' changing salinity provides a way of tracking water as it cycles between atmosphere and ocean. If more rain falls over an ocean than water evaporates from it, surface salinity drops proportionately. If evaporation outpaces rain, salinity rises.

Oceanographers were not surveying global salinity intensively until 1999, when they started releasing instrumented subsurface floats under the Argo program. Argo floats now number about 3500. But because the ocean smoothes out rainfall's patchiness, even pre-Argo measurements reflect changes in the global water cycle more accurately than the denser data available over land. Durack and colleagues used the Argo observations to help correct for shortcomings in the salinity measurements made from research vessels between 1950 and 2000, such as oceanographers' understandable reluctance to brave the stormy wintertime high latitudes.





Saltier or less so. Ship-borne instruments (*top*) showed that places already saltier than average got saltier (reds) and those less salty got even more so (blues).

When Durack and colleagues analyzed the 1.7 million salinity measurements made worldwide in the second half of the 20th century, they found that the water-rich had indeed been getting richer and vice versa (see figure). High-latitude and equatorial parts of the oceans, where greater precipitation keeps surface waters less salty than average, became even less salty; the central regions of ocean basins, where evaporation dominates and turns water saltier, became even saltier. Because 80% of the water cycle operates over oceans and much of the water falling as rain over land comes from the ocean, the water cycle over land no doubt is behaving the same way.

After comparing the magnitude and geographical pattern of salinity change in models and in the real world, Durack and colleagues concluded that the water cycle had sped up roughly 4% while the surface warmed 0.5°C. That 8% increase per degree of warming is about the rate of acceleration expected on the basis of how much more water vapor warmer air can hold. The more moisture air can hold, the faster water can make the circuit of the water cycle, like building a bigger pipe in a plumbing system. But the warming seems to have intensified the real world's water cycle twice as much as the typical global climate model does. At least some of the models, it seems, do not properly simulate the water cycle's response to warming.

The new analysis "has provided decisive evidence for a surprisingly rapid acceleration of the global water cycle," Schmitt says. "This is the first time we're seeing this for the hydrological cycle," adds oceanographer Sydney Levitus of the U.S. National Oceanic and Atmospheric Administration (NOAA) in Silver Spring, Maryland. The pattern and rate of the change "represents yet another 'fingerprint' of global change."

So wet places have been getting wetter while dry places got drier. But worse is yet to come. If the world warms 2°C to 3°C by the end of the century, as currently projected, and the past is any guide to the future, the water cycle will accelerate 16% to 24%, Durack and colleagues point out. "That's a pretty amazing projection," says ocean modeler Stephen Griffies of NOAA's Geophysical Fluid Dynamics Laboratory in Princeton, New Jersey, "and it just might be close to reality."

Such a revved-up water cycle would have "a lot of implications for how extreme events would change in a warming climate," says meteorologist Brian Soden of the University of Miami in Florida. Water cycling from the surface to the atmosphere carries heat energy that can ultimately fuel violent storms, from tornadoes to tropical cyclones. The faster water cycles, the more abundant and more violent those storms might be. And wet places getting wetter can lead to more severe and more frequent flooding. Dry places getting drier would mean longer and more intense droughts. The Argo flotilla should have an interesting tale to tell in the years to come.

–RICHARD A. KERR

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