We know the Arctic is warming—what will changing river flows do to its environment?

March 5 2024, by Daegan Miller

Michael Rawlins collecting data samples from an Arctic stream. Credit: University of Massachusetts Amherst

Scientists at the University of Massachusetts Amherst recently combined satellite data, field observations, and sophisticated numerical modeling to paint a picture of how 22.45 million square kilometers of the Arctic will change over the next 80 years.

As expected, the overall region will be warmer and wetter, but the details—up to 25% more runoff, 30% more subsurface runoff, and a progressively drier southern Arctic, provide one of the clearest views yet of how the landscape will respond to climate change. The results were published in the journal *The Cryosphere*.

The Arctic is defined by the presence of permafrost—the permanently frozen layer on or under the Earth's surface. It's that permafrost that drives everything from seasonal runoff to the freshwater dumping into coastal lagoons to the amounts of soil carbon that wind up flowing into the ocean.

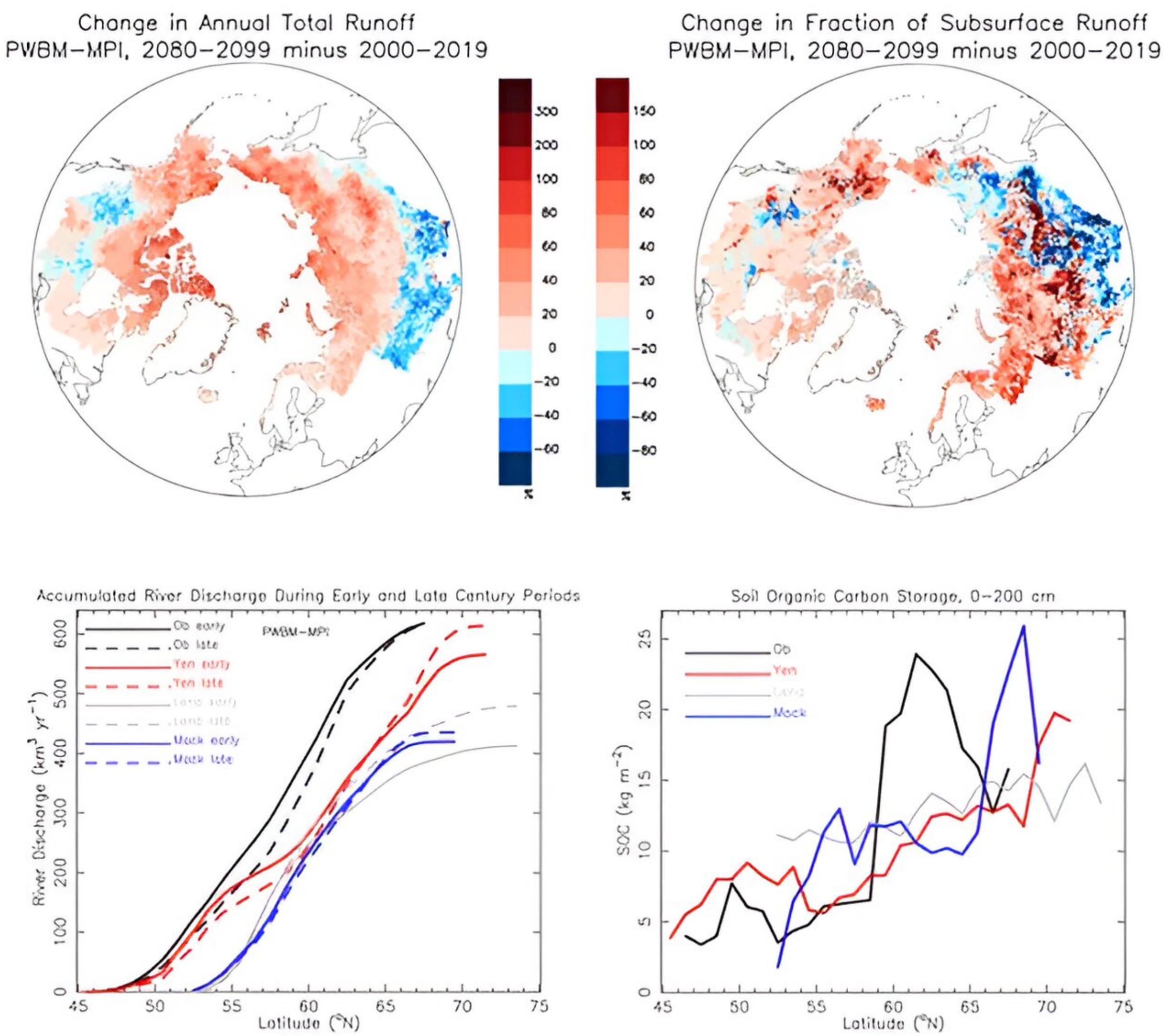
But the Arctic is warming two-and-a-half to four times faster than the global average, which means that massive amounts of carbon-rich soils in permafrost regions are thawing, releasing their carbon to rivers and the atmosphere every year. The thawing is also intensifying the Arctic's water cycle—the continuous loop of precipitation, runoff, and evaporation that, in part, determines a region's environment.

The upper part of the permafrost that thaws each summer is called the active layer, and it has been of particular interest to Michael Rawlins, associate professor in the Department of Earth, Geographic and Climate Sciences at UMass Amherst and the paper's lead author. As the Arctic warms, the active layer is getting thicker, and Rawlins wanted to know how that thickening, combined with warming and an intensified water cycle, would affect the terrestrial Arctic environment.

Rawlins has spent the last 20 years building and refining his Permafrost Water Balance Model, which accounts for the seasonal thawing and freezing of permafrost and how it influences runoff, subsurface water pathways, river flows and other aspects of the region's hydrology.

To do this, Rawlins teamed up with the U.S. National Science

Foundation, the U.S. Department of Energy, NASA and Ambarish Karmalkar, a research assistant professor at UMass Amherst when he completed the research and now an assistant professor of geosciences at the University of Rhode Island.



Credit: University of Massachusetts Amherst

Karmalkar is an expert in the use of global climate models, and he and

Rawlins used precipitation and temperature scenarios from two of them to envision two different possibilities for the future: a moderate case in which greenhouse gas emissions, and so global temperatures, are curbed; and a high emissions and warming scenario.

Rawlins then fed the climate-model data into his Permafrost Water Balance Model, and what he discovered is that the thawing permafrost and associated thickening of the active layer which, Rawlins says, "acts like a giant bucket," will fundamentally alter the region's hydrology.

"A thicker active layer creates a bigger bucket for storing water," says Rawlins. "Our work shows that as precipitation intensifies, the water will be stored longer in thawed soils and released at a later time via subsurface pathways, instead of running off immediately into rivers and streams, as much of it does now."

The study demonstrates how thawing soils will increase runoff to rivers in fall because the ground won't freeze as early in a warmer world. Between now and 2100, the yearly proportion of subsurface runoff will increase by up to 30%.

Moreover, this increased runoff will happen mainly in the northern parts of the Arctic. Some of the additional water will originate from evaporation caused by an increasingly ice-free Arctic Ocean. And southern portions of the Arctic will warm so much that evaporation and plant transpiration will send much of the additional precipitation back to the atmosphere, resulting in an overall drying out of the landscape.

All of this has a number of implications for the Arctic: northern rivers, especially the region's largest, the Ob, Yenesey, Lena, and Mackenzie, will see proportionally more water coming from their northern reaches. Because there's more soil carbon in the northern Arctic, it is likely that more of it, some frozen for thousands of years, will wind up flowing through rivers to the Arctic Ocean.

The increased discharge will affect the dynamics of coastal sea ice, change the ecology of the biodiverse Arctic lagoons, and affect ocean freshwater storage, potentially slowing the Atlantic meridional overturning circulation (AMOC), which is responsible for maintaining the temperate climate of Northern Europe.

There's more work to be done, Rawlins says. "More field observations are needed from the small- and medium-sized rivers near the Arctic coast to understand better how warming will alter the land-to-ocean transport of freshwater and, in turn, impact Arctic environments and the flora, fauna and Indigenous populations that call the region their home."

More information: Rawlins, M. A. et al, Regime shifts in Arctic terrestrial hydrology manifested from impacts of climate warming, *The Cryosphere* (2024). DOI: 10.5194/tc-18-1033-2024. tc.copernicus.org/articles/18/1033/2024/

Provided by University of Massachusetts Amherst

Citation: We know the Arctic is warming—what will changing river flows do to its environment? (2024, March 5) retrieved 27 April 2024 from https://phys.org/news/2024-03-arctic-river-environment.html