Arctic Freshwater Cycle is Intensifying Consistent with Climate Warming, say UMass Amherst Researcher and International Team

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AMHERST, Mass. – The amount of fresh water flowing through the Arctic as snow or rainfall, in rivers and other cycles is increasing, in agreement with model projections under a warming climate, according to a new study by University of Massachusetts Amherst hydrologist Michael Rawlins and colleagues from 18 other institutions in the United States, Norway and Finland.

The multi-year, multi-investigator synthesis of available data caps a five-year effort known as the Freshwater Integration study (FWI), funded by the National Science Foundation, which sought to answer fundamental questions about the Arctic system, foremost of which: Is the Arctic freshwater cycle accelerating or intensifying? Findings appear in the current, online issue of the Journal of Climate.

As Rawlins, manager of the Climate System Research Center at UMass Amherst explains, “The balance of evidence suggests that Arctic freshwater cycle intensification is occurring across the terrestrial Arctic. These observations are consistent with what models have suggested should occur with climatic warming.” Intensification is related to the atmosphere’s ability to hold more moisture as it warms.

However, he adds that though this study used the best available data, because of uncertainties such as sparse observing networks and “considerable variability” in the Arctic freshwater system, confidence in the overall conclusion must be seen as “somewhat limited.” Nevertheless, the study provides an important benchmark.

As the authors point out, “direct observations of the Arctic freshwater cycle are continually being updated and made available as well. Future analysis to update the assessments presented here will be an important contribution to the emerging body of evidence documenting Arctic hydrologic change.”

The analysis, which focused on changes over the past few decades, involved a synthesis of data collected over recent years. Specifically, Rawlins and colleagues found that five of six terrestrial precipitation data sets showed a trend toward increased precipitation, two being statistically significant. Also, all five evapotranspiration (the sum of water evaporated from water bodies and transpired from vegetation) data sets showed a positive trend, of which three were significant. Finally, all five of the Arctic river discharge records showed an increasing trend. These were significant for Eurasia, North America excluding the Hudson Bay drainage and the Arctic as a whole, defined as all land areas that drain to the Arctic Ocean.

The researchers note that, “Among all components, the long-term increase in river discharge from large Eurasian rivers is perhaps the most consistent trend evidencing Arctic freshwater cycle intensification.” Their analysis builds on a groundbreaking 2002 study which found the combined flow of the six largest Eurasian rivers increased by about 7 percent from 1936–1999. Rawlins and
colleagues say recent positive trends in North American river flows suggest that riverine intensification “may now be pan-Arctic in extent.”

While the available data show intensification on the terrestrial side, no clear evidence suggests intensification in flows or the amount of freshwater within the Arctic Ocean. However, many processes control ocean freshwater content including circulations which cyclically build up and export the water. Overall, Rawlins notes, the Arctic Ocean is predicted to become fresher as precipitation and river flows to the ocean increase, and as sea ice melts, but available data do not confirm this.

Freshwater cycle intensification could have important implications for processes and cycles not only in the Arctic, but beyond. Changes in terrestrial Arctic hydrology may alter land-surface flows of carbon dioxide and methane, both of which are potent greenhouse gases. And, as Rawlins notes, “Freshening of the Arctic Ocean could potentially slow down the global thermohaline circulation, which is understood to be an integral component of Earth’s climate system.” Thermohaline refers to water temperature and salt concentration, which help to determine sea water density.

Future studies of the Arctic system should benefit greatly from better data sets and models, Rawlins says. “The science is constantly improving,” he notes. “Where we worked with nine models, we'll soon be able to repeat this analysis with twenty or more. And the models are getting more accurate all the time, with improved representations of key physical processes and higher spatial resolutions.”

In particular, as a terrestrial hydrologist, Rawlins is interested to break down the data by season and by region to confirm suspicions about how snowfall increases and recent losses of sea ice may be contributing to the observed freshwater trends.

More Information

Graphic of Arctic hydrologic system (photo credit Arctic-CHAMP / ARCUS)