A snapshot of melting Arctic sea ice during the summer of 2018

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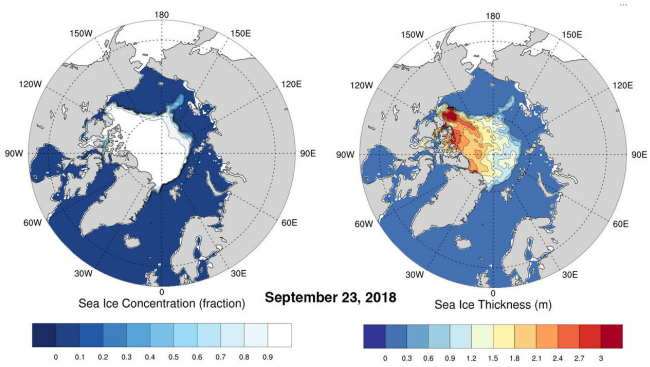

This figure shows the sea ice concentration and thickness in the Arctic on September 23rd 2018. Credit: Juhi Yadav

As sea ice in the Arctic retreats further and melts faster every decade, scientists are racing to understand the vulnerabilities of one of the world's most remote and unforgiving places. A study appearing July 29 in the journal *Heliyon* details the changes that occurred in the Arctic in September of 2018, a year when nearly 10 million kilometers of sea ice were lost over the course of the summer. Their findings give an overview at different timescales of how sea ice has receded over the 40 years of the satellite era and show how the summer's extensive decline is linked to global atmospheric processes as far south as the tropics.

At the peak of its melting season, in July 2018, the Arctic was losing sea ice at a rate of 105,500 square kilometers per day—an area bigger than Iceland or the state of Kentucky. "On the ground, I am sure it would have looked like an excellent summer month in the Arctic, in general, but over the past four decades, September sea-ice loss has accelerated to a rate of 12.8% per decade and 82,300 square kilometers per year," says co-author Avinash Kumar, a senior scientist at the National Centre for Polar and Ocean Research (NCPOR) in India.

The researchers followed the warm water currents of the Atlantic north to the Arctic Ocean and tracked the ice as it subsequently retreated through the Chukchi, East Siberian, Laptev, Kara, and Barents seas. Thanks to higher temporal resolution and greater satellite coverage than had previously been available, they could also measure the ice's decline through variables such as its thickness, concentration, and volume in addition to its extent throughout the Arctic. This dramatic loss of sea ice culminated at the end of the boreal summer, when in September, the ice had been reduced to a mere third of its winter extent.

Then, the team compared the decline to the previous four decades of data. "In the summer of 2018, the loss of sea ice was three times higher than the reported loss at the beginning of the satellite era," says Kumar. "Our study shows that both the minimum sea-ice extent and the warmest September records occurred in the last twelve years."

"Every year, news pops up of a new record of high temperature or fastest loss of sea ice in the Arctic region, but in the global system, each portion of the planet receiving climate feedback will lead to changes in the other parts as well," Kumar says. "If the sea-ice decline continues at this pace, it can have a catastrophic impact by raising air temperatures and slowing down global ocean circulation." These global impacts are partly why he became interested in trying to decipher the mysteries of the polar regions as a doctoral student studying the coastal zone in India. Now, he works at NCPOR, whose scientific programs, he says, are "truly trans-hemispheric, cutting across from north to south."

The researchers also turned their attention to the atmosphere, where they were able to gain insight into the processes that contribute to the loss of

Arctic sea ice. They found not only that September of 2018 was the third warmest on record, but that there was a temperature difference within the Arctic itself: the temperature of the air above the Arctic Ocean (~3.5°C) was slightly higher than that of the Arctic land (~2.8°C).

Their findings provide further evidence that ocean warming around the globe has influenced the natural cycle of the wind and pressure patterns in the Arctic. El Niños, or warm phases in long-term temperature cycles stemming from tropical regions, have long been known to drive extreme weather events around the world and are occurring with greater frequency as the world warms. El Niño cycles in the equatorial Pacific Ocean can carry warm air and water from tropical circulations to the Arctic, spurring the sea ice to melt. As the ice retreats, it cascades the Arctic into a positive feedback loop known as Arctic amplification, whereby the reduced ice extent gives way to darker ocean waters that absorb more of the sun's radiation. As it retains more heat, temperatures rise and more ice melts, causing the Arctic region to heat up faster—about four times so—than the rest of the world.

"If the decline of sea ice continues to accelerate at a rate of 13% per decade in September, the Arctic is likely to be free of ice within the next three decades," Kumar says. And just as sea-ice retreat is largely the result of anthropogenic pressures from across the globe, its impacts will be felt worldwide: this work adds to the mounting body of evidence that changes in the Arctic sea ice could be detrimental to weather patterns spanning the globe. He says, "The changes taking place in the Arctic can lead to other changes in lower latitudes, such as extreme weather conditions. The world should be watching tropical countries like India, with our research center saddled close to the beaches of Goa, and trying to understand—even in a small way—more about climate change and the polar regions."

More information: *Heliyon*, Kumar et al.: "Global warming leading to alarming recession of the Arctic sea-ice cover: Insights from remote sensing observations and model reanalysis" www.cell.com/heliyon/fulltext/ …

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