



Arctic Ocean sea ice melt as seen from the U.S. Coast Guard icebreaker Cutter Healy. NASA/KATHRYN HANSEN

The Global Impacts of Rapidly Disappearing Arctic Sea Ice

BY PETER WADHAM'S · SEPTEMBER 26, 2016

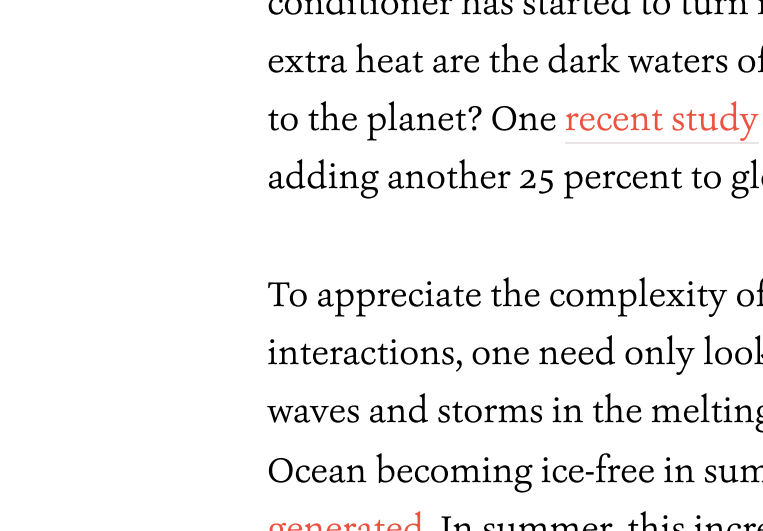
The top of the world is turning from white to blue in summer as the ice that has long covered the north polar seas melts away. This monumental change is triggering a cascade of effects that will amplify global warming and could destabilize the global climate system.

The news last week that summer ice covering the Arctic Ocean was **tied for the second-lowest extent** on record is a sobering reminder that the planet is swiftly heading toward a largely ice-free Arctic in the warmer months, possibly **as early as 2020**.

After that, we can expect the ice-free period in the Arctic basin to expand to three to four months a year, and eventually to five months or more.

Since my days measuring the thickness of Arctic Ocean ice from British nuclear submarines in the early 1970s, I have witnessed a stunning decline in the sea ice covering the northern polar regions – a more than 50 percent drop in extent in summer, and **an even steeper reduction in ice volume**. Just a few decades ago, ice 10 to 12 feet thick covered the North Pole, with sub-surface ice ridges in some parts of the Arctic extending down to 150 feet. Now, that ice is long gone, while the total volume of Arctic sea ice in late summer has declined, **according to two estimates**, by 75 percent in half a century.

The great white cap that once covered the top of the world is now turning blue – a change that represents humanity’s most dramatic step in reshaping the face of our planet. And with the steady disappearance of the polar ice cover, we are losing a vast air conditioning system that has helped regulate and stabilize earth’s climate system for thousands of years.



DISAPPEARING ARCTIC SEA ICE: THE GLOBAL CLIMATE IMPACTS
The rapid disappearance of Arctic sea ice is having profound regional climatic impacts and is beginning to affect the global climate. This graphic illustrates those repercussions in the Arctic Ocean leads for a largely ice-free state in summer, which some scientists say could occur in as little as five years.

1 ALBEDO EFFECT
The melting of Arctic sea ice is turning the top of the world from white to blue. Since dark surfaces absorb far more heat than white ones, the loss of ice and snow on sea and land is increasing regional and global temperatures.

2 METHANE RELEASE
The retreat of Arctic sea ice, and the resulting warming, is triggering a flow of methane gas that contains large amounts of frozen methane, a potent greenhouse gas. Continued Arctic Ocean ice loss and rising temperatures could cause massive methane releases.

3 MELTING THE GREENLAND ICE SHEET
Rising Arctic air temperatures, in part caused by the disappearance of sea ice, are leading to widespread surface melting of Greenland’s massive ice sheet. This melt is adding some 72 cubic miles of water to the ocean annually, leading to sea level increases.

4 INCREASE IN WATER VAPOR
Warmer air holds more moisture, so rising Arctic air temperatures mean that the once-foggy polar atmosphere is holding more water vapor. Water vapor is itself a greenhouse gas, trapping outgoing long-wave radiation, so this further heats up the Arctic.

5 WARMING RIVERS
As snow cover disappears, causing Arctic terrestrial regions to absorb more heat, the runoff and snowmelt from watersheds flow through warmer lands, increasing the temperature of large north-flowing rivers in Siberia and Canada. These warmer rivers expect even more heat into the Arctic Ocean.

MAP SOURCES: NATIONAL CLIMATE DATA CENTER AND ICE DATA CENTER. ICE EXTENT AS OF SEPTEMBER 2015. **YALE ENVIRONMENT 360**

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Few people understand that the Arctic sea ice “death spiral” represents more than just a major ecological upheaval in the world’s Far North. The decline of Arctic sea ice also has profound global climatic effects, or feedbacks, that are already intensifying global warming and have the potential to destabilize the climate system. Indeed, we are not far from the moment when the feedbacks themselves will be driving the change every bit as much as our continuing emission of billions of tons of carbon dioxide annually.

So what are these feedbacks, and how do they interact? The most basic stem from turning the Arctic Ocean from white to blue, which changes the region’s albedo – the amount of solar radiation reflected off a surface. Sea ice, in summer, reflects roughly 50 percent of incoming radiation back into space. Its replacement with open water – which reflects roughly 10 percent of incoming solar radiation – is causing a high albedo-driven warming across the Arctic.

When covered almost entirely by ice in summer – which the Arctic was for tens of thousands of years – water temperatures there didn’t generally rise above freezing. Now, as the open Arctic Ocean absorbs huge amounts of solar radiation in summer, water temperatures **are climbing by several degrees Fahrenheit**, with some areas showing increases of 7 degrees F above the long-term average.

Such changes mean that a system that was once a vast air conditioner has started to turn into a heater. Just how much extra heat are the dark waters of Arctic Ocean in summer adding to the planet? One **recent study** estimates that it’s equivalent to adding another 25 percent to global greenhouse emissions.

To appreciate the complexity of these feedbacks and interactions, one need only look at the growing role played by waves and storms in the melting Arctic. With more of the Arctic Ocean becoming ice-free in summer, **more waves are being generated**. In summer, this increased wave action breaks up large ice floes into smaller fragments and hastens their melt. Then, in autumn, larger storms fed by open water cause wave-induced mixing of the Arctic Ocean, which brings up heat absorbed during the summer. This warms the water, making it harder for ice to form in the fall. I observed this phenomenon last September and October aboard the University of Alaska research vessel Sikuliaq in the western Arctic Ocean. After the warm summer of 2015, the advance of winter ice was slow and sporadic, apparently held back by the quantity of heat in the water column.

Yet another albedo-related effect with important global climatic repercussions is now unfolding in the Arctic. As ice-free Arctic waters have warmed, in turn warming the air above them, these rising temperatures **have spread over land**. This is an important factor in the increased melting of snow in Arctic terrestrial regions. Today, in midsummer, the Arctic land area covered by snow has **decreased by several million square miles** compared to five decades ago. These now-dark lands absorb more heat and further warm the Arctic – and the planet.

Also, as the tundra and boreal forests heat up, runoff from snowmelt and waterways runs through warmer land, **increasing the temperature of the great Arctic rivers** such as the Mackenzie in Canada and the Ob, Lena, and Yenisei in Siberia. The warmer waters of these north-flowing rivers discharge into the Arctic basin, injecting more heat into the polar ocean.

By my calculations, the terrestrial warming in the Arctic is roughly equivalent to a 25 percent boost in global CO2 emissions. This, combined with the warming caused by the loss of Arctic sea ice, means that the overall ice/snow albedo effect in the Arctic could add as much as 50 percent to the direct global heating effect of CO2. Scientists can debate the potential magnitude of such increases. But there is no doubt that they will be significant – vividly illustrating how the Arctic can become a driver of, rather than just a responder to, global climate change.

The most worrisome feedback involves the release of seabed methane from the continental shelves of the Arctic Ocean.

The list of feedback effects on the global climate from diminishing Arctic sea ice goes on. As ocean and air temperatures in the Arctic rise, this adds **more water vapor to the atmosphere**, since warmer air holds more moisture. Water vapor is itself a greenhouse gas, trapping outgoing long-wave radiation and holding heat closer to the surface of the earth. With air temperatures rising in many parts of the Arctic **by several degrees F** in recent decades, water vapor concentration has gone up by more than 20 percent, adding to Arctic warming.

Rising air temperatures over open Arctic waters in summer are also heating up the Greenland ice sheet. Until the 1980s, the Greenland ice sheet did not experience extensive summer melt. The melt then began at low altitudes, and in recent years has spread to the whole ice sheet. In July 2012, for example, **97 percent of the Greenland ice cap** experienced surface melting, according to remote sensing by satellite.

The meltwater does not just remain on the surface to refreeze in autumn. It plunges down into the ice sheet through large holes called moulins, lubricating the ice sheet bed and causing glacial advance to accelerate, doubling in speed in some cases as glaciers calve more icebergs into the ocean. Greenland is now the **largest single contributor to global sea level rise**, its melting ice cap adding some **300 cubic kilometres (72 cubic miles) of water** per year to the ocean. The low estimates of sea level rise by the end of the century – two to three feet according to the Intergovernmental Panel on Climate Change (IPCC) – are being revised upwards, with serious implications for policymakers who must plan the defense of low-lying cities like Miami, New Orleans, London, Venice, and Shanghai, or of defenseless coastlines like Bangladesh.

But the most worrisome feedback, which could lead to catastrophic effects in the near future, involves the release of seabed methane – a potent greenhouse gas – from the continental shelves of the Arctic Ocean.

The Arctic Ocean is unusual in that, while its abyssal depths are great (13,000 feet or more), it is surrounded by wide continental shelf seas only 150 to 300 feet deep. Most of these – the East Siberian, Kara, Laptev, and Barents seas – lie to the north of Siberia. Until this century, most of these Arctic continental shelves were covered with sea ice even in summer, and this prevented the water temperature from rising above 32 degrees F. During the last decade, however, the summer sea ice has retreated from the shelves, allowing the water to warm up into the high 30s. The warmer water, extending to the seabed, thaws the offshore permafrost that has been in place since the last Ice Age. Underneath it is a thick layer of sediment containing large amounts of methane in the form of solid methane hydrates; these have a cage-like crystal structure in which methane molecules are surrounded by ice.

The release of the overlying pressure allows the hydrates to disintegrate and turn into gaseous methane, which bubbles up through the water column in intense plumes and is released to the atmosphere. This release is already causing global methane levels to rise after being flat through the early years of this century. The fear is that a larger portion of the methane will be released from the sediments. And although methane only remains in the atmosphere for a decade or so (unlike CO2, which can linger for centuries), it traps heat 23 times more efficiently per molecule than carbon dioxide.

These changes represent a spiritual impoverishment of the earth, as well as a catastrophe for humanity.

The Russian scientists investigating the offshore plumes (joined recently by German and Swedish expeditions) fear that a pulse of up to 50 gigatons of methane – some 8 percent of the estimated stock in the Arctic sediments – could be released within a very few years, starting soon. If this happened, model studies show that there would be a **virtually immediate warming of 1 degree F**, with accompanying massive costs to the planet.

What is the risk of such an outbreak? Many scientists say it is low, although those who regard it as high are the very scientists who have actually done the observational work in the East Siberian Sea. The IPCC ignores this risk, but does go into the likely result of a total methane emission of a similar magnitude, albeit spread over decades.

Other feedbacks from the loss of Arctic Ocean ice – ranging from a possible **slowdown of the so-called “global ocean conveyor belt”** to major **shifts in the northern hemisphere’s jet stream** – could also have serious climatic impacts.

What I am trying to offer in this tale of apparently unremitting gloom is a wake-up call rather than a statement of despair. What is taking place in the Arctic reinforces the conclusion of many scientists that last year’s Paris agreement to limit global warming to 2 degrees C is unrealistic so long as it only involves the reduction of CO2 emissions. As the various Arctic climate feedbacks show, we are fast approaching the stage when climate change will be playing the tune for us while we stand by and watch helplessly, with our reductions in CO2 emissions having no effect in the face of, say, runaway emissions of methane.

What is needed today is a widespread global campaign to actually remove carbon dioxide from the atmosphere using techniques like **direct air capture**. In my view, initiatives to devise economically acceptable methods for carbon dioxide removal from the atmosphere should be the most important concern of science and technology. The success of these efforts will mean the difference between the prospect of a positive future for mankind and the certainty of a descent towards climate-driven chaos.

In the human lifetime, I have witnessed the transformation of the top of the world from a beautiful ice-bound expanse of wilderness to a region now characterized by warming and melting on all fronts. These changes represent a spiritual impoverishment of the earth, as well as a practical catastrophe for humanity. The time for action has long since passed.

Peter Wadhams, professor emeritus of ocean physics at Cambridge University, is a sea ice specialist with 46 years of research on sea ice and ocean processes in the Arctic and Antarctic. In more than 50 expeditions to both polar regions, he has worked from ice camps, icebreakers, and aircraft. He also has traveled six times on Royal Navy submarines under frozen north polar seas to conduct research. His new book is “**A Farewell to Ice: A Report from the Arctic.**” **MORE →**

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