

Arctic Sea Ice and Climate Stability

THE CASE FOR PRIORITIZING SEA ICE RESTORATION



The Role and State of Arctic Sea Ice

The Arctic is an integral component of the global climate system. Its vast, reflective frozen surfaces, including sea ice, ice sheets, and land-based snow, play a critical role in regulating Earth's climate. For centuries, Arctic summer sea ice has been a lynchpin keeping the Arctic frozen.

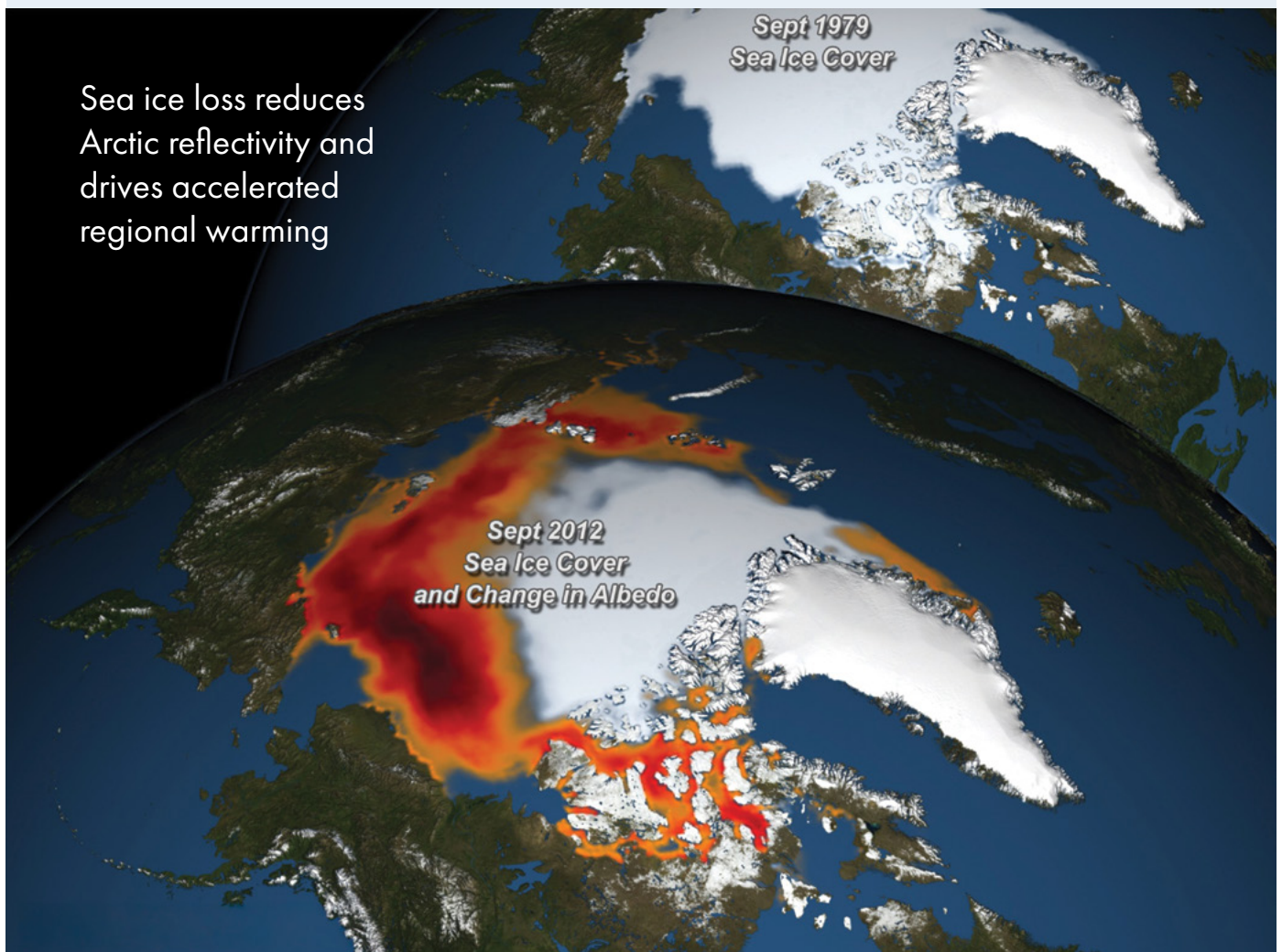
The Arctic Ocean is covered by sea ice during the winter when the Arctic is mostly dark. As winter transitions to summer, conditions shift from near-constant darkness to near-constant sunlight. For most of human history, some of the winter sea ice would naturally melt, but most would persist. In high summer, with the sun shining on the Arctic 24 hours a day, the ice's bright surface reflected most of this huge amount of incoming heat energy back out to space, keeping the Arctic mostly frozen in summer.

This historic dynamic has been dramatically disrupted by anthropogenic climate change. Increases in air and sea

temperature in the Arctic have led to a 50 percent decline in the spatial extent of summer sea ice over the last four decades^{1,2,3,4} and sea ice has also lost its mass: thicker multi-year sea ice (at least five years old) has decreased by 90 percent¹. This drives further loss because thicker ice has a higher albedo (reflectivity) than thinner, newer ice and is also less vulnerable to seasonal melting⁵.

As summer sea ice shrinks, an increasing amount of heat energy is absorbed by the darker ocean, rather than being reflected. This phenomenon is a significant part of the reason the Arctic region has warmed three to four times faster than the global average^{6,7,8,9}. This accelerated pace of warming in the Arctic relative to the global average is known as "Arctic Amplification," and it has fueled a self-reinforcing feedback loop: Higher temperatures in the Arctic drive more sea ice loss, which further increases warming in the region.

Sea ice loss reduces Arctic reflectivity and drives accelerated regional warming



Arctic Sea Ice and Earth System Tipping Points

Amplified Arctic warming carries many risks for both the region and the global climate, one of the most dangerous of which is the risk of crossing tipping points. Tipping points refer to key components of the climate system that have thresholds which when exceeded¹⁰ can lead to self-perpetuating, widespread, abrupt, and often irreversible impacts.



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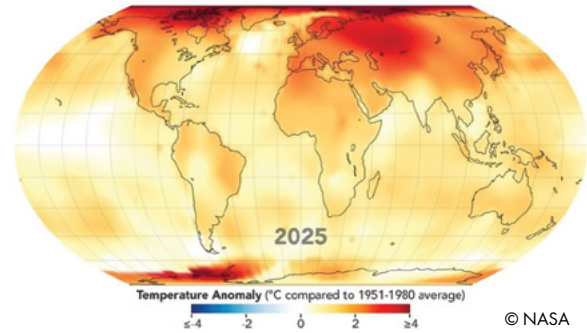
The Global Tipping Points report, published in 2023¹⁰ and updated in 2025¹¹, reports that “multiple tipping elements in the Earth system are already showing signs of destabilization under current warming levels.” Currently, global average temperature is around 1.3-1.4°C^{12,13} above preindustrial temperatures, and the best estimates from the 2025 UNEP Emissions Gap report

suggest that, based on current policy commitments, warming will reach 2.7°C by 2100, which is well above the tipping temperatures of a number of critical earth system functions.

Three of the five tipping points identified in the Global Tipping Points report as being at highest risk at current levels of temperature change are in the Arctic.

Loss of Arctic summer sea ice, and resulting Arctic amplification, is a predecessor to and an accelerator of melting of the Greenland Ice Sheet¹⁴, thawing northern permafrost¹⁵, and tipping of the sub-polar gyre¹⁰. If exceeded, these tipping points represent high risks to all of humanity and nature:

- The Greenland Ice Sheet contains enough ice volume to cause 7.42 m of global sea level rise¹⁶. The cold climate in the Arctic historically kept the ice sheet stable, locking in that store of freshwater¹⁷. However, as the Arctic has warmed, melting of the Greenland Ice Sheet is accelerating and it is now losing mass at a rate six times that of the rate in the 1980s¹⁷. This meltwater alone is expected to increase global sea levels by ~20 cm by 2100 in a scenario where the world reaches 2.7°C of warming¹⁸, an amount similar to the overall sea level rise Earth has experienced to date since 1900.
- 25 percent of the Northern Hemisphere is currently covered by permanently frozen ground, known as permafrost¹⁹. This frozen ground contains twice as much carbon as the atmosphere²⁰ as well as large stores of methane, a very powerful greenhouse gas that traps about 85 times more heat than carbon dioxide over a 20-year period, and 30 times more over 100 years. Cold temperatures in the



Arctic warming is 3-4 times greater than the global average

Arctic keep these greenhouse gases locked in the ground. As permafrost thaws, the gases are released into the atmosphere, which in turn drives further global warming¹⁷. Permafrost area is expected to decrease by a quarter of its pre-industrial extent at 2°C²¹ of warming. If global warming reaches 2.7°C at the end of the century, that thaw is estimated to release 80–117 billion tons of CO₂e (approximately two years-worth of total global emissions)²⁰.

- The subpolar gyre (SPG) tipping point refers to the collapse of deep convection in the Labrador and Irminger Seas when warming and freshening of the ocean stops dense water from sinking. It is a tipping risk that could trigger abrupt regional climate shifts, including cooler North Atlantic conditions, harsher northwestern European winters, disrupted rainfall patterns, lower agricultural yields, and marine ecosystem changes¹¹. Because deep convection is also an oceanic process that draws down atmospheric carbon and stores it in the deep ocean, SPG tipping could impact the ocean’s role in carbon sequestration.

Both the SPG and the Greenland Ice Sheet are also linked to another tipping point with enormous consequences—the Atlantic Meridional Overturning Circulation (AMOC). The SPG’s convection drives cold salty water into the depths of the ocean, which helps sustain AMOC circulation. SPG tipping would further weaken the AMOC. The continuing melt of the Greenland Ice Sheet is adding very significant increases of freshwater input to the Arctic Ocean^{10,22,23} which is directly contributing to observed weakening or slowing of the AMOC.

Concerted action to prevent crossing of tipping points is critical and prudent, as changes become irreversible once tipping points are crossed, even if temperatures are lowered in the future.¹⁰

Arctic Sea Ice and Overall Global Warming

At the planetary scale, what we refer to as global warming is an enormous quantity of excess solar energy trapped in the Earth system—a phenomenon referred to more accurately as Earth’s “energy imbalance.” While this energy imbalance is caused primarily by rising concentrations of greenhouse gases in the atmosphere, declines in the Earth’s overall albedo have also been a significant contributor²⁴.

Within this latter category of albedo-driven warming, sea ice decline has contributed a significant fraction to planetary albedo loss: The excess heat trapped in the Earth system from Arctic sea ice loss is equal in magnitude to around 25 percent of the total excess heat trapped by rising atmospheric CO₂ concentrations between 1979 and 2011²⁵.

And this trend will continue without new actions. Summer sea ice is expected to disappear²⁶ in at least one month each summer by the middle of this century, if not earlier^{27,28,29} under even the most ambitious emissions reduction trajectories³⁰. Continuing loss of Arctic summer sea ice will continue to increase overall global warming.

- If global warming reaches 2.7°C by 2100, which is the current forecast for warming based on existing country-level pledges to reduce carbon emissions, the Arctic Ocean will be ice free every summer for multiple months¹⁷.

- An earth system model-based study estimates that the complete loss of summer sea ice will contribute >1.5°C of the warming in the Arctic and 0.19°C of the global temperature increase³¹.

Associated permafrost thaw is estimated to contribute 0.04-0.11°C of the warming globally by 2100 under our current warming trajectory (RCP4.5)³².

Taken together, these Arctic feedback loops represent additional warming on the order of 0.23–0.3°C. Worse, the currently projected level of 2.7°C of warming may be an underestimation, both if humanity fails to meet stated policy commitments, and/or if we have underestimated other warming feedback loops driven by increased warming³³.

Sea Ice Loss and Arctic Biological Diversity

Declines in sea ice extent in the Arctic are also causing a major shift at the base of the Arctic food web, with a decline in organisms associated with sea ice and an increase in organisms associated with open water³⁰.

During periods of ice melt, algae that are living on the underside of ice sink, providing food for organisms on the sea floor such as sea stars and shellfish, which in turn sustain marine mammals such as walrus and gray whales, and some fish species. As ice is lost and open water area increases, the base of the food web shifts to open water organisms, such as phytoplankton. These

ARCTIC SEA ICE LOSS AND GLOBAL TIPPING POINTS

A rapidly warming Arctic is triggering changes that will reverberate around the planet

Greenland Ice Sheet Collapse

Loss of sea ice amplifies warming and ocean heat uptake, accelerating Greenland melt and adding to planetary sea level rise.

© NASA

Boreal Forest Shift

Changes to the jet stream and warmer winters increase wildfire risk, shifting forests from carbon sink to source.

© USGS

Permafrost Thaw

Arctic warming thaws permafrost, releasing methane and CO₂ and accelerating global warming.

© USGS

Atlantic Ocean Circulation Slowdown

Freshwater from ice melt can weaken vital ocean circulation, disrupting climate and ecosystems across the North Atlantic.

© WHOI

floating plankton are more likely to be consumed in the upper ocean, so less organisms reach the seafloor, reducing food for benthic species that larger animals at the top of the food chain, like walruses and gray whales, depend on.

The shift from ice to open water has altered Arctic marine food webs, with changes observed in zooplankton movements³⁴, fish abundances, and the food sources and hunting behaviors of marine mammals^{30,35,36}.

- Shrinking summer sea ice and related Arctic marine food webs have led to increased mortality and behavioral shifts of Arctic species^{30,37} such as ringed seals, harp seals, beluga whales, and polar bears^{30,35,37,38}.
- Arctic seabirds are particularly vulnerable to warming, in part due to shifts in timing of prey abundance and reproductive cycles, resulting in low chick survival rates and population declines¹⁷.
- As the ocean warms across latitudes, Arctic fish ranges are contracting, while non-Arctic species are expanding into the region²⁸.
- Warmer temperatures have also been shown to lead to increased pathogens, which could have catastrophic impacts on some Arctic species³⁹.

Sea Ice Loss and Arctic Coastal Communities

Climate change in the Arctic has had dramatic impacts on Arctic Indigenous Peoples and northern communities⁴⁰. Loss of sea ice has led to increased coastal erosion^{41,42} and higher impacts from sea level rise for coastal communities^{30,43}. Thinning sea ice has led to increasingly unstable conditions that pose a safety risk when traveling on the ice, causing decreased access to important resources for Arctic Indigenous Peoples and communities^{30,40}, e.g. in Greenland⁴⁴ and Canada⁴⁵. Diminishing sea ice cover has altered the seasonal migrations of whales⁴⁶ and walruses in ways that increase the expense and danger associated with hunting by Indigenous Peoples⁴³, e.g. in Alaska⁴⁷ and Canada⁴⁵. Permafrost thaw, in conjunction with other effects of global warming, has already caused communities in Alaska and Greenland to relocate due to damage to infrastructure⁴⁰, and more of this is likely to be expected.

Continued loss of sea ice will lead to further changes in the ways that Indigenous Peoples and northern communities travel, hunt, and acquire resources due to their reliance on sea ice^{17,39}. These changes will likely lead to increased food insecurity and risk of injury and mortality^{17,48}. As traditional subsistence hunting and harvesting methods are reduced, Indigenous Peoples will be forced to import more expensive food, which will increase the

rate and severity of food insecurity⁴⁰ and poverty. Permafrost thaw will increase coastal erosion and damage to infrastructure from ground subsidence¹⁷. Sea level rise from the melting of the Greenland Ice Sheet will increase coastal erosion, flooding, and saltwater intrusion¹⁷.

Sea Ice Loss and Geopolitics

Melting Arctic sea ice is fueling a race for resources, with a number of implications. Loss of ice is:

- Opening access to new shipping routes in the Arctic^{49,50} and increasing shipping traffic, with increased risk of accidents and pollution
- Fueling a race for new areas for fishing
- Driving increased oil and gas exploration and a hunt for mineral resources⁵⁰
- Spurring increased militarization and risk of conflict in the Arctic⁵¹

Increased demand on the Arctic for fishing, shipping, military, tourism, and other activities is also exposing governance weaknesses and challenges⁵¹.

Continued accelerated warming in the Arctic has much wider geopolitical implications as well. Sea level rise from a melting Greenland Ice Sheet impacts coastal countries around the world¹. As it continues, this will lead to displacement and migration of people living near the coast or on low-lying islands¹.

Arctic summer sea ice loss also impacts global weather. The Arctic is connected to weather patterns in other regions of the world through ‘teleconnections,’ or linked pressure systems and currents of air spanning long distances. These connections mean that changes in the Arctic—like warming or melting ice—can influence weather far away, affecting things like storms, heatwaves, and rainfall in other parts of the world.

Arctic sea ice loss is predicted to affect the timing, precipitation, and/or strength of the monsoons in West Africa⁵², East Asia⁵³, and India^{54,55}, and it is expected to affect temperature and precipitation in the tropics⁵⁶. Arctic sea ice loss has also been observed to impact mid-latitude weather, although findings on its specific role are still inconclusive.

Warming in the Arctic and loss of sea ice and land ice also changes the density of the Arctic Ocean, which in turn disrupts ocean mixing and globally important ocean circulation systems⁵⁷. Taken together, these Arctic-driven changes to atmosphere and ocean circulation will have world-wide repercussions for access to food and water resources, and impact globally traded goods.

Restoring Sea Ice and Climate Stability: Will Current Approaches Work?

The only *permanent* way to slow and stop the loss of summer sea ice, and ultimately enable it to rebuild, is to reduce Earth’s energy imbalance and bring global temperature down. And the only durable way to do that is by drastically cutting emissions of greenhouse gases, removing legacy greenhouse gases from the atmosphere, and restoring albedo.

However, society’s current trajectory of emission reductions and greenhouse gas removals is not projected to keep temperatures below thresholds at which most summer ice in the Arctic will be lost¹⁷.

- Ceasing greenhouse gas emissions alone would stabilize global temperatures but not reduce them⁵⁸.
- Carbon dioxide removal of hundreds of billions of tons over the coming decades is also necessary to reduce global temperatures⁵⁸—but we are many years from reaching the scale needed to be impactful⁵⁹.
- Methane emissions reductions would be one of the fastest paths to slowing rates of warming⁵⁸ but methane emissions are still increasing from both anthropogenic sources and feedbacks in the earth system⁶⁰.
- Methane removal (atmospheric destruction) approaches are an important research priority, but they have significant technological hurdles to overcome before they will be able to be considered for implementation⁵⁹.

So, while continued emissions reductions and greenhouse gas removals are fundamental, their limitations in the near term highlight the importance of pursuing other approaches to slow the loss of Arctic ice and to rebuild sea ice.

Prolonging and rebuilding Arctic sea ice could protect Arctic communities and livelihoods; maintain Arctic biological diversity; reduce global weather disruptions; help slow overall planetary warming; and reduce the risks of passing tipping points that would have devastating impacts to people and nature around the world.

For all these reasons, Ocean Visions believes it is critical and prudent to advance responsible research on all potential approaches that may slow the loss of Arctic sea ice.

The Path Forward

Protection and restoration of Arctic sea ice is an ambitious goal for the conservation of Arctic and global ecosystems, as well as to maintain critical Earth system functions that sustain communities around the world.

A number of approaches have been proposed to pursue this goal, and we are just beginning to assess their potential and to develop research pathways to explore the most promising of them. These include approaches that reduce the amount of sunlight that reaches Earth’s surface or increase the amount of heat that leaves the atmosphere; approaches that reflect more sunlight into space by increasing the reflectivity of Earth’s surface; and approaches with the goal of directly increasing ice or slowing the melting of ice.

Ocean Visions assessed 21 different approaches in our [Arctic Sea Ice Road Map](#). The Road Map highlights the different characteristics of these approaches and outlines first-order priorities for critical research to answer fundamental questions that will allow determinations to be made about whether to continue to investigate these pathways.

Since publication of the map, Ocean Visions has been working to catalyze and support responsible research on some of the least-studied, high-potential approaches. Through our [Arctic Sea Ice Restoration Research Fund](#), in early 2026 we awarded \$2.5 million dollars to six research teams for early-stage research into three such approaches.

Given the rapid pace of melting ice in the Arctic, and the potentially positive impacts on global temperature, global weather, earth system tipping points, human welfare, and Arctic biological diversity, ***now is the time to accelerate this research on new approaches.*** Research provides the foundational information needed for informed decision-making about whether we can, and how to, slow the loss of Arctic summer sea ice as a critical component of overall climate stabilization and recovery.



Ocean Visions believes it is critical and prudent to advance responsible research on all potential approaches that may slow the loss of Arctic sea ice.

TO GET ENGAGED WITH THIS IMPORTANT WORK, please reach out to repair@oceanvisions.org

Endnotes

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**Ocean Visions pursues bold solutions,
guided by science, to stabilize the climate
and regenerate the ocean.**

