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How is sea ice in the Arctic and Antarctic changing?

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How is sea ice in the Arctic and Antarctic changing?

Sea ice is the frozen portion of the polar oceans[i], covering roughly 3 to 6% of Earth's surface area at any given time[ii]. Earth hosts major sea ice systems at both poles, i.e. one in the Arctic Ocean and another in the Southern Ocean around Antarctica, here simply referred to as Antarctic sea ice. Ice forms in local autumn/winter and melts in local spring/summer, driven by exchanges of heat between the sea ice, ocean, and atmosphere. Sea ice is typically bright (snow-covered ice can reflect away more than 80% of incoming solar radiation[iii]). As sea ice melts, it exposes the darker (less reflective) water beneath it, and the planet's surface becomes darker and warmer overall. By this mechanism, sea ice can amplify changes in the climate system (e.g. warming leads to melt, exposing darker surfaces, which leads to additional absorption of incoming sunlight and therefore more melt). In addition to its direct relevance for climate, sea ice has a large impact on ocean biology and serves as a home and/or hunting ground for some large animals (for example, polar bears in the Arctic Ocean and emperor penguins around Antarctica).

Since 1979, satellite surveys have provided reliable, continuous, year-round measurements of sea ice extent. This long, unbroken record shows that sea ice is constantly changing, with variations over seasons, years, and decades. Arctic sea ice typically covers an area roughly the size of Australia in summer (about 7 million km^2) and grows to an area roughly the size of Russia by late winter (about 16 million km^2). Similarly, Antarctic sea ice covers an area roughly the size of India in the summer (3 million km2) and grows to nearly twice the size of Antarctica in the winter (17 to 20 million km^2). In addition to these seasonal variations, satellite surveys have revealed decades-long trends in both Arctic and Antarctic sea ice.

Over the period 1979-2012, Arctic sea ice extent decreased by about 4% per decade, and perennial sea ice (i.e. sea ice that is more than one year old) decreased at a little over 10% per decade[iv]. A record low September sea ice extent occurred in 2012. Between 1980 and 2008, the average winter sea ice thickness within the Arctic basin decreased (likely between 1.3 and 2.3 m), and the total volume of Arctic sea ice has also decreased.

Antarctic sea ice extent, however, has slightly increased by about 1.5% per decade overall, with strong regionalvariations (i.e. more sea ice in some areas and less in others). Research suggests that this increase in ice extent may be due to winds, i.e. stronger cold winds from Antarctica can (a) push sea ice further northwards, exposing more open water where new sea ice can form and (b) encourage sea ice formation by lowering air temperatures.

Arctic and Antarctic sea ice are physically similar[v], but they exist in different land/ocean/atmosphere configurations. A large portion of Arctic sea ice cover sits in a nearly closed basin, with relatively restricted movement and only small openings to the other ocean basins. Antarctic sea ice, however, is influenced by distinct climate regimes in the Atlantic, Pacific, and Indian oceans and by winds from the Antarctic continent.

Because of these differences, and because climate involves exchanges of heat (e.g. through sunlight and infrared radiation) and momentum (e.g. through winds and ocean currents) between the ocean, atmosphere, and sea ice, one would not necessarily expect the Arctic and Antarctic to respond to climate change in the same way.

Future prospects and implications

Sea ice is influenced by a combination of human-driven (e.g. greenhouse gases, ozone depletion) and natural factors (e.g. the configuration of the continents). As fossil fuel burning increases the concentration of carbon dioxide in the atmosphere, more energy is directed towards the Earth's surface and sea ice is put at risk. Climate model studies project declining Arctic and Antarctic sea ice extents in the 21st century, with the Arctic likely to be ice free (less than 1 million km^2) by 2050, assuming high future emissions of greenhouse gases[vi]. However, these projections depend on sea ice thickness, which is much better known in the Arctic than the Antarctic.

Notes, further reading and references:

i) Sea ice is distinct from icebergs, which ultimately come from land-based ice sheets.

ii) J. Comiso (2010), Polar Oceans from Space, Atmospheric and Oceanographic Sciences Library 41, DOI 10.1007/978-0-387-68300-3_7

iii) Perovich, D. K., and C. Polashenski (2012), Albedo evolution of seasonal Arctic sea ice, Geophys. Res. Lett., 39, L08501, doi:10.1029/2012GL051432

iv) IPCC AR5 Working Group 1, Chapter 4 (http://www.ipcc.ch/report/ar5/wg1/).

v) On average, Arctic sea ice is thicker and less snow-covered than Antarctic sea ice.

vi) IPCC AR5 Working Group 1, Chapter 12 (http://www.ipcc.ch/report/ar5/wg1/). There is more confidence in Arctic projections than in Antarctic projections.