Met Office Hadley Centre Climate Briefing Note

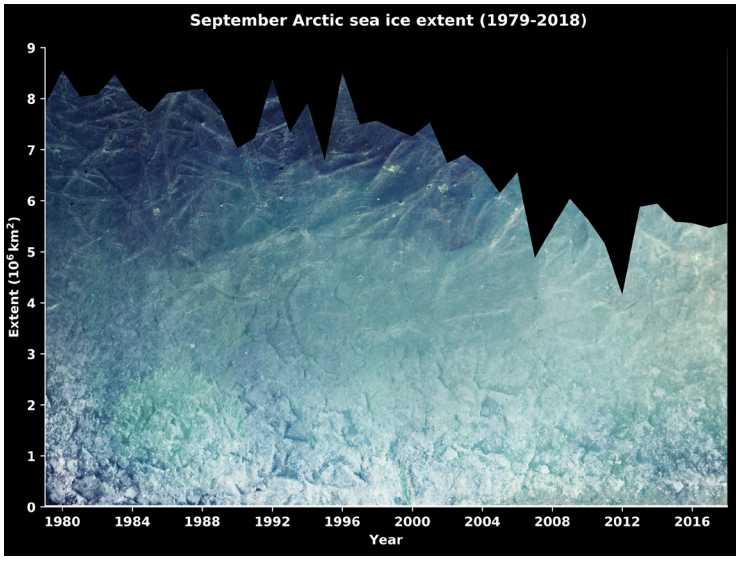
How is sea ice affected by climate change?

- Arctic sea ice September extent has declined by about 12% per decade since satellite records began in 1979. Research suggests this decline is unprecedented in at least the last 1000 years.
- Antarctic sea ice extent over the satellite record has shown no discernible trend. Huge differences in geography between the Antarctic and Arctic mean we wouldn't expect them to respond to climate change in the same way.
- The Arctic could see ice free summers by the middle of this century if we fail to curb greenhouse gas emissions. Reducing emissions is likely to slow the rate of decline over this century.
- It is not clear how Antarctic sea ice will respond in future as there is little agreement between climate models.

What has happened to Arctic sea ice in recent decades?

One of the most visible indicators of climate change in recent years has been the rapid loss of Arctic sea ice cover. Satellite observations, which started in 1979, show Arctic sea ice extent[1] has declined in all seasons – with the largest losses in summer.

Arctic sea ice extent at the September summer minimum has declined at an average rate of almost 12% per decade[2] since satellite records began in 1979. This equates to an average loss each year of over 87,000 km^2 - an area greater than Scotland or more than four times the size of Wales. Extent at the winter maximum in March has declined by almost 44,000 km^2 per year on average over the same period.



Around half of the observed Arctic summer sea ice loss has been linked with increased concentrations of atmospheric greenhouse gases such as CO_2, with the remainder attributed to natural variability within the climate system. Observations and reconstructions of past climate using things like tree-rings and ice cores suggest this decline is unprecedented in at least the last 1000 years.

As well as observed reduction in the extent of Arctic sea ice, the thickness and the age of the ice has also decreased with the Arctic now predominantly comprised of first-year-ice.

Figure 1: September Arctic sea ice extent evolution from 1979 to 2018 from the HadISST.2.2.0.0 dataset

[1] Sea ice extent is the total area of ocean for which at least 15% of the surface in the immediate vicinity is ice-covered.
[2] Relative to the 1981-2010 long-term average of 7.27 million km^2 (Source: HadISST.2.2.0.0 dataset).

What has happened in the Antarctic?

Antarctic sea ice extent over the satellite record has, on average, shown no discernible trend. The small (but significant) positive trend in mean annual Antarctic sea ice extent during 1979-2015 – and reported in previous IPCC reports – has not continued. Antarctic sea ice has seen three consecutive years of below-average sea ice cover following a large-scale loss of ice in November 2016. There is currently no agreement as to the exact causes of this decline.

The geography of the Antarctic and Arctic are very different and so we would not expect them to both respond in the same way to changes elsewhere in the climate system. Whilst the Arctic is an ocean surrounded almost entirely by land, the Antarctic is a very cold continent surrounded entirely by ocean.

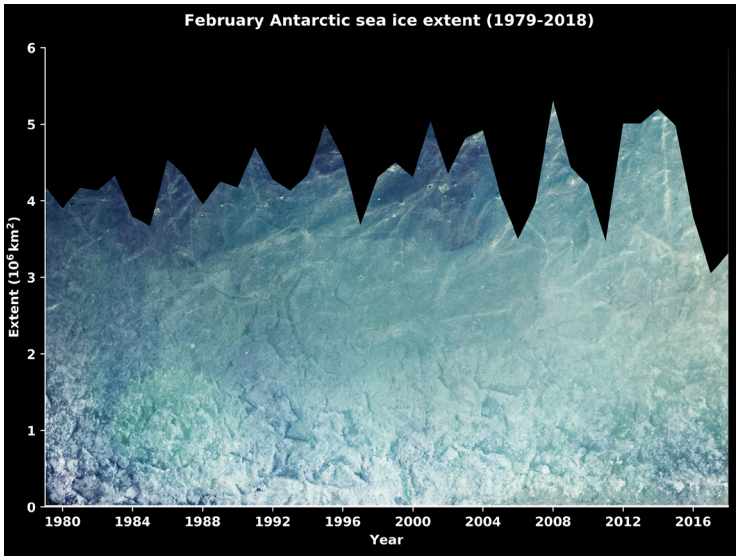


Figure 2: February Antarctic sea ice extent evolution from 1979 to 2019 from the HadISST.2.2.0.0 dataset.

What do climate models say about the future of sea ice?

Climate models agree Arctic sea ice will continue to decline over the 21st Century in response to increasing global temperatures. However, the rate of decline, and whether the Arctic becomes ice-free in summer at some point this century, will depend on the scenario of future greenhouse gas emissions and resulting rate of warming.

Under a low emissions scenario – consistent with keeping global temperature rise to below 2°C above pre-industrial levels – some sea ice is projected to remain, whereas higher emissions scenarios could result in the Arctic becoming nearly ice-free[3] in late summer by the middle of the 21st Century. Research also suggests there is a high likelihood summer sea ice will remain in the Arctic if global temperature rises are limited to 1.5°C in line with the ambition of the 2015 Paris Climate Agreement. Arctic sea ice loss is expected to be broadly reversible if the underlying warming were reversed.

When it comes to sea ice in the Antarctic, there is little agreement between climate models as to what will happen in the future and scientists are focusing research to improve understanding in this area.

The current understanding on future sea ice is based on analysis of the models (CMIP5) used for the Intergovernmental Panel on Climate Change's (IPCC) 5th Assessment Report in 2012. A new generation of climate models (CMIP6) are now available and experiments using them are currently underway.

These new models have numerous improvements of relevance for modelling sea ice, which include higher resolution ocean and atmosphere, improved representation of processes including sea ice and snow thermodynamics, and improved coupling between the different components of the Earth system. CMIP6 also sees a considerable increase in the number of model experiments and process-based model diagnostics, both designed to improve our understanding of potential changes to the Earth's climate.

The impact of this improved realism for projections of sea ice will need to be better understood, and work on this is underway now as part of the IPCC's next assessment report, due out in 2021.

[3] The Intergovernmental Panel on Climate Change (IPCC) define 'nearly ice-free' conditions in summer as having sea ice extent less than 1 million km^2 in September. In this situation the remaining ice would be confined to the regions near the northern coast of Greenland and the Canadian Arctic archipelago, leaving the central Arctic Ocean virtually free from ice.