Arctic ice cap melt: when will we reach the tipping point?

Recent climate research points to grim prospects for the Arctic ice cap. Vanessa Spedding reports on current scientific opinion.

It's hardly news to say that things are changing quickly at the Arctic ice cap. Since the start of research for this article there have been a dozen or so announcements of new results, each updating the understanding of the state of the region.

The idea that the rate of change of a 15 million km^2 swathe of ice might be outpacing the rate at which our finest minds and instruments can observe it sends a very strong message. It also makes it hard to glean a simple overview of what's going on, especially given the variety of approaches and models being deployed to assess the situation.

This article attempts to summarise the prevailing understanding about the speed of melt at the North Pole, the predictions for the first ice-free Arctic summer, and the implications of this dramatic change.

Arctic ice loss to date

According to satellite data from the US National Snow and Ice Data Center (NSIDC), the averaged Arctic sea ice extent during March 2013 (the month at which it reaches its annual maximum), at 15.04 million km^2, was 710,000 km^2 below the 1979-2000 average extent. The linear rate of decline for March ice extent is 2.5% per decade, relative to the 1979-2000 average, representing an average rate of decrease of 39,800 km^2 per year; roughly twice the area of Wales.[1]

The trends for summer ice decrease are even more alarming. The September figures, for when Arctic sea ice at its annual minimum, show the sea ice extent declining at a rate of 11.5% per decade, relative to the 1979-2000 average.[2] The decline in the annual minimum of Arctic sea ice *volume* is more alarming still – see Figure 1.

There is overwhelming scientific agreement that the cause of this dramatic retreat is the amplified warming in the Arctic region due to its enhanced sensitivity to the effects of greenhouse gas emissions from human activities. However, there is a range of opinion about the implications of this melt. Are we past the point of no return on the road to an ice-free Arctic? When might such a situation prevail? Will such a state change represent a tipping point in the global climate system? Is anything we can do about it?

When will the Arctic ice cap disappear?

The most conservative ice-melt predictions come from computer simulations, and give us another 40 or so years under current conditions before we can expect ice-free Arctic summers (defined as a September ice extent of 1 million km^2 or less). The prediction from the UK Met Office is slightly more pessimistic, suggesting "an earliest plausible date for an ice free summer in the Arctic [of] 2025-2030".[3]

More pessimistically still, Peter Wadhams, Professor of Ocean Physics at Cambridge University, suggests we should expect ice-free Arctic summers by 2015.[4]

Prof Wadhams uses a different approach, basing his predictions on trends in the measured retreat of the total volume (not just area) of Arctic ice; he has spent many summers in submarines tracking its ever diminishing thickness. His predictions come from an extrapolation of the plots of sea-ice volume as a function of time. These are mirrored by outputs from a new, regional Arctic climate computer model written by Wieslaw Maslowski of the Naval Postgraduate School, Monterey, USA, which simulates future values from trend data, incorporating couplings between ocean, atmosphere and sea ice in the same way that global climate models do. Maslowski predicts an ice-free Arctic summer by 2016, plus or minus three years.[5]

Other research groups propose dates somewhere between these two extremes (of 2015 and 2060) for ice-free summers, and the variation appears to be roughly correlated with the modelling method used. Professor James E. Overland, at the National Oceanic and Atmospheric Administration (NOAA) in the USA, investigated three methods of predicting the point at which the Arctic will be nearly ice free in summer.[6]

He defines the first of the three methods, the 'trendsetters' approach, as that using observed sea ice trends. Results from these investigations show the total amount of sea ice to have decreased rapidly over the previous decade – faster than computer models had predicted – and extrapolate on average to a nearly sea ice-free Arctic by 2020.

The second method, termed the 'stochasters' approach, is based on assumptions of future multiple, randomly timed, large sea ice loss events such as occurred in 2007 and 2012. Research using this method suggests an ice-free Arctic by about 2030, but with large uncertainty.

Finally, the 'modellers' approach refers to the use of global climate models to simulate geophysical conditions over time. These models show the earliest

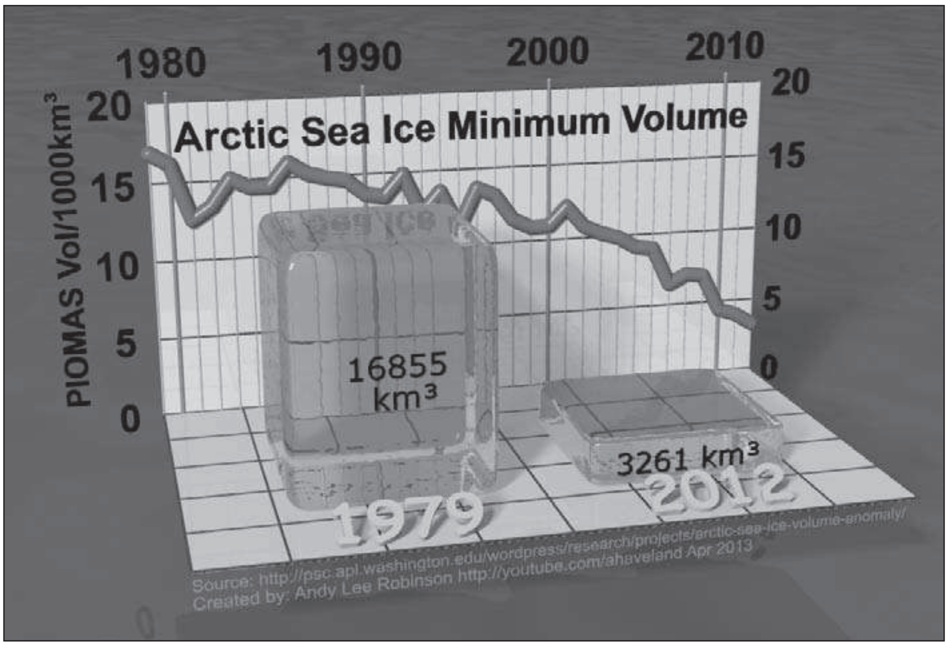

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Figure 1. Decline in Arctic sea-ice minimum volume, 1979-2012

loss of the ice cap to be around 2040 with a median time closer to 2060. Overland believes this to be too late but nonetheless values the importance of the modelling approach because of its ability to take account of a wide variety of factors.

A version of the 'stochaster' approach is used by Professor Tim Lenton, Chair in Climate Change and Earth Systems Science at the University of Exeter, and his team. Their research, currently in press, uses sophisticated statistical analysis and time-series propagation methods and suggests we will see regularly and consistently ice-free Arctic summers in the 2030s. But Prof Lenton told SGR: "I wouldn't claim our model is any sense the 'right' one, and I would not rule out Peter Wadhams and others being correct."

Have we passed a tipping point?

While the finer detail is still to play out, the majority of research points clearly to ice-free summers before the middle of the century, and very likely within the next decade or two. Given the sense of inevitability, and the fact that it will be the first time it's happened in 13 million years, quibbling over the most likely particular year seems increasingly academic.

The inevitability issue brings up the question of tipping points. There has been some debate as to the significance of this transformation, not to say some confusion over the definition of the term tipping point.

Prof Wadhams told SGR that he uses the definition shared by the Intergovernmental Panel on Climate Change (IPCC). "A tipping point for an element of a system is passed when the forcing on that element has taken a parameter so far from its original value that if you remove the forcing, the parameter does not return to its original value but assumes a different state," he explained.

"So the question is, if you remove the forcing on the ice-melt, will it come back? I think it won't. I think we are past the tipping point. Even if we took CO_2 back to 280ppm, the changes we've set in motion will produce warming for another 100 years. And as the climate does come gradually back, the Arctic Ocean will be more firmly established as an ice-free summer ocean; the water structure will be changed."

While some models show that the ice cap could refreeze given the right external conditions,[7] other research suggests otherwise, including some by Prof Lenton and his team. "I have been arguing for a while that the loss of summer sea-ice could involve a tipping point in a scientific sense," he explained, referring to a recent paper.[8]

Overall there appears to be increasing agreement among scientists that we are committed to a fast trajectory of sea-ice loss by virtue of our emissions to date, whether or not ice returns at some distant future time. The broader question is whether the Arctic ice cap is itself a key element in the global climate system, such that its state change will cause the latter to pass through a tipping point of its own. Some claim the whole tipping point debate is a distraction from more pressing issues but many hold the view that, even if the ice-melt were reversed, its state change will have pushed other parameters out of their equilibrium range such that the whole climate system will move to a new state.

The implications of these dramatic developments and their potential global effects are cause for great consternation. Jennifer Francis, Research Professor at the Institute of Marine and Coastal Sciences at Rutgers University, USA, argues that rapid warming at the Arctic is altering the jet stream over North America, Europe, and Russia to produce more persistent and extreme weather.[9]

In a commentary in *Nature Climate Change*, Professors Lenton and Wadhams set out the evidence for a number of 'discontinuities' in the system that will be triggered by the Arctic melt, and the catastrophic effects these will have.[10] As well as the reduced albedo effect, these discontinuities include the destabilisation of the Greenland ice sheet, peat-fires in the sub-Arctic region, methane emissions from thawing methane hydrates, slowed global thermohaline circulation and reduced oceanic CO_2 uptake. Each of these has further destabilising effects on the climate, and between them they are leading us into a time of dangerous change, say the authors, which will be characterised by unpredictable ecosystem shifts, disrupted food webs, rapidly declining ocean life, more extreme weather, risks to unique ecological and social systems and likely a global food crisis.

Prof Wadhams is on record as recommending geo-engineering to help avert these catastrophes, but his views on this have since shifted. "I do still think we need urgent research into geo-tech but I don't think anything will bring back the Arctic ice. And it is very difficult to see how there could be international agreement on geo-engineering. So I'm pessimistic about that as well, and there really isn't anything else in the locker."

There is little if anything heartening to be taken from this survey of Arctic science, except for those motivated by the short-term economic gains resulting from the new shipping and extraction opportunities. However, Prof Lenton did make the point that this dramatic and visible planetary change might wake us up to the delicacy and importance of our climate system. "I do think that the loss of summer ice cover will be a tipping point in public and policy perception of climate change," he said.

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References

1. NSIDC Arctic Sea Ice News and Analysis (2013). http://nsidc.org/arcticseaicenews/2013/04/spring-has-sprung-in-the-arctic/
2. NASA. http://climate.nasa.gov/key_indicators
3. Met Office (2012). http://www.metoffice.gov.uk/research/news/sea-ice-2012
4. The Guardian (2012). Arctic expert predicts final collapse of sea ice within four years. 17 September. http://www.guardian.co.uk/environment/2012/sep/17/arctic-collapse-sea-ice
5. Maslowski et al (2012). The Future of Arctic Sea Ice. Annual Review of Earth and Planetary Sciences Vol. 40: 625-654. http://www.annualreviews.org/eprint/wuwatQenfcpJFiP2g6ux/full/10.1146/annurev-earth-042711-105345
6. Overland J E and Wang M (2013). When will the summer arctic be nearly sea ice free? Geophysical Research Letters. Published online 21 May. DOI: 10.1002/grl.50316
7. Environmentalresearchweb (2009). Arctic summer sea ice loss may not 'tip' over the edge. http://environmentalresearchweb.org/cws/article/news/37591
8. Lenton T M and Livina V N (2013). A recent tipping point in the Arctic sea-ice cover: abrupt and persistent increase in the seasonal cycle since 2007. The Cryosphere, 7, 275-286. http://www.the-cryosphere.net/7/275/2013/tc-7-275-2013.html
9. Yale environment 360 (2012). Linking Weird Weather to Rapid Warming of the Arctic. http://e360.yale.edu/feature/linking_weird_weather_to_rapid_warming_of_the_arctic/2501/
10. Duarte et al (2012). Abrupt Climate Change in the Arctic, Nature Climate Change 2, 60–62. http://www.nature.com/nclimate/journal/v2/n2/full/nclimate1386.html

Update

Since this article was written, the 2013 Arctic ice minimum was reached (on 13th September). While not as low as in 2012, it still rates among the lowest ever recorded and is consistent with the trend of long-term decline.

Reference

National Snow and Ice Data Center (2013). http://nsidc.org/arcticseaicenews/charctic-interactive-sea-ice-graph/