Why climate models underestimate Arctic sea ice retreat?

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According to a recent study, the disappearance of Arctic sea ice could occur more quickly than predicted by climate models. © Lucas Girard

In recent decades, Arctic sea ice has suffered a dramatic decline that exceeds climate model predictions. The unexpected rate of ice shrinkage has now been explained by researchers at CNRS, Université Joseph Fourier and Massachusetts Institute of Technology. They argue that climate models underestimate the rate of ice thinning, which is actually about four times faster than calculations. This model bias is due to the poor representation of the sea ice southward drift out of the Arctic basin through the Fram Strait. When this mechanism was taken into account to correct the discrepancy between simulations and observations, results from the new model suggested that there will be no Arctic sea ice in summer by the end of the century. This work was published in the

Journal of Geophysical Research on 29 September 2011.

The Arctic has been losing about 10% of its permanent ice layer every ten years since 1980. Melting of Arctic sea ice has also reached record heights: in mid-September 2007, at the point when sea ice reaches its annual minimum extent, perennial ice covered an area of 4.14 million km^2(1). This record low level was nearly reached again in September 2011 (4.34 million km2). Climate simulations conducted for the IPCC(2) simulate the decline in Arctic sea ice resulting from global warming. They predict that summer ice will disappear altogether at the end of this century. However, when compared with 30 years of detailed satellite observations, these models appear optimistic. Arctic sea ice has thinned on average four times faster over the period 1979-2008 than in the climate simulations. True observations are therefore not correctly reproduced by these climate models, which were mainly calibrated using global variables, such as world average rather than “regional” temperature.

An explanation for this difference has been put forward by a Franco-American team, involving in particular the Laboratoire de glaciologie et géophysique de l'environnement (CNRS / Université Joseph Fourier). It may be due to a misrepresentation of the mechanical behavior of pack ice and the drift of sea ice in the models. To demonstrate this, the researchers examined the mechanisms of sea ice drift with respect to their physical state (thickness and concentration), then analyzed the model predictions in combination with field data. In 2009, these same scientists demonstrated that there had been a significant acceleration of ice drift in recent decades. This can now be explained by ice thinning, which has accelerated. Sea ice has become thinner and more fragile. Because it breaks up more easily, its mobility is increased, as is its export from the Arctic Ocean through the Fram Strait between Greenland and the Svalbard archipelago, followed by its melting. This mechanism may be exacerbating the present decline in Arctic sea ice.

The drift of sea ice is poorly described by the models, which do not take drift acceleration or southward evacuation of the ice into account. "Modeled" sea ice behaves as though it drifts freely, without any mechanical interaction between ice fragments, whatever the season, period or ice thickness. There is no link in the models between the thinning of the ice and the further acceleration of its drift.

To close this gap between simulations and observations in terms of Arctic sea ice thinning rates and decline, the models should take into account an acceleration of ice export through the Fram Strait. This mechanism suggests that, well before the end of the century, the Arctic Ocean will be devoid of sea ice in late summer. The disappearance of Arctic sea ice will probably occur in the next few decades, with far-reaching consequences for ecosystems, sea routes and off shore exploitation of resources.

More information: IPCC climate models do not capture Arctic sea ice drift acceleration: Consequences in terms of projected sea ice thinning and decline, P. Rampal, J. Weiss, C. Dubois, J.M. Campin. J. Geophys. Res. 29 Septembre 2011

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