September Arctic sea ice predicted to disappear near 2°C global warming above present

Irina Mahlstein[1,2] and Reto Knutti[2]

[1] NOAA, Earth System Research Laboratory, Boulder, CO, USA

[2] Institute for Atmospheric and Climate Science, ETH Zurich, Switzerland

irina.mahlstein@noaa.gov

Arctic sea ice extent shows large interannual variability due to the numerous factors, but on longer time scales the total sea ice extent is approximately linearly related to Arctic surface air temperature in models and observations. Overall, models however strongly underestimate the recent sea ice decline.

A recalibration of an ensemble of global climate models using observations over 28 years provides a scenario independent relationship and yields about 2°C change in annual mean global surface temperature above present as the most likely global temperature threshold for September sea ice to disappear.

1. The linear relationship

The linear realationship between Arctic sea ice and global surface temperature shown in Figure 1 can be used to recalibrate the CMIP3 models and to get a best estimate on at what global temperature increase (ΔT) the September sea ice will be melted in the future (SI_f):

$$SI_f = SI_{1980\text{-}1999} + ((\Delta \text{Sea ice}/\Delta T_{Arctic}) \cdot (\Delta T_{Arctic}/\Delta T_{Global})) \cdot \Delta T$$

Observations provide all of the numbers used in the equation, models are only used to test the linear relationship in the future and to assess the uncertainties which are associated with the best estimate.

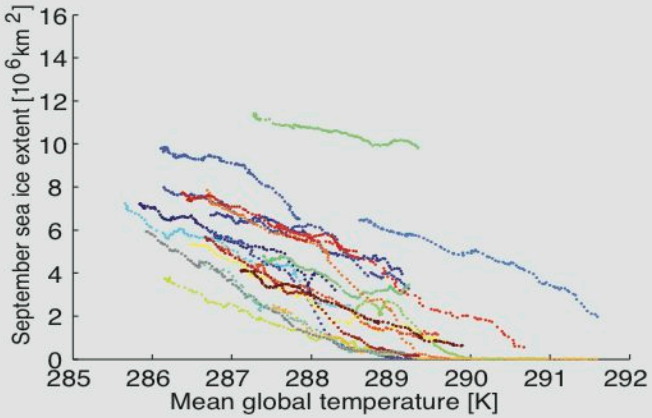

Figure 1: Linearity of Arctic sea ice and global temperature of model data for the time period 1980-2099. Shown are results for A1B scenario based on a 10yr running mean. Each color indicates a different model.

2. The best estimate

Two different observational periods (1980-2007 and 1960-2009) are used and hence give two different estimates. However, as observations are of poorer quality before 1980, the red line in Figure 2 is our best estimate. This estimate suggests that at a global temperature increase of 2°C the Arctic will be nearly ice-free in September.

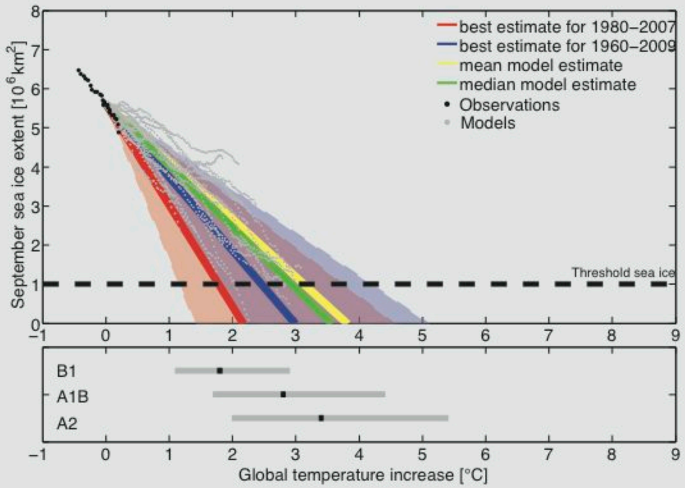

Figure 2: Predicted decline of Arctic September sea ice extent. Shaded areas depict the uncertainty range (red based on observations from 1980-2007 and blue from 1960-2010). Warming in 2090-2099 and associated uncertainties for three SRES non-intervention emission scenarios are indicated at the bottom.

3. Spatial representation of September sea ice cover

The models can now be forced to follow the red line in order to get a spacial representaiton of the sea ice reatreat in a warming world, which is shown in Figure 3.

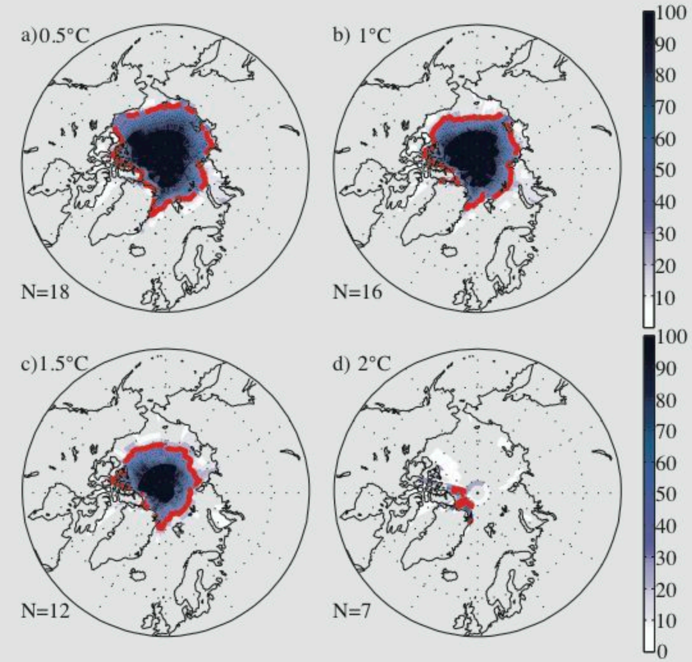

Figure 3: Shown is the percentage of climate models with sea ice in a specific grid cell for 0.5°C, 1°C, 1.5°C and 2°C above present (a-d, respectively). The red line shows the 33.3% isoline. The area outside the red line is therefore likely to be ice-free.

If global temperature increase was to be stabilized at **2°C above preindustrial (1.2°C above present)** the Arctic could likely be **prevented from becoming ice-free** and about half of the current sea ice extent could remain during summer.