

## Arctic sea ice extent small as never before

Alerting message from the Arctic: The extent the the Arctic sea ice has reached on Sep. 8 with 4.240 million km<sup>2</sup> a new historic minimum (Figure 1). Physicists of the University of Bremen now confirm the apprehension existing since July 2011 that the ice melt in the Arctic could further proceed and even exceed the previous historic minimum of 2007. It seems to be clear that this is a further consequence of the man-made global warming with global consequences. Directly, the livelihood of small animals, algae, fishes and mammals like polar bears and seals is more and more reduced.

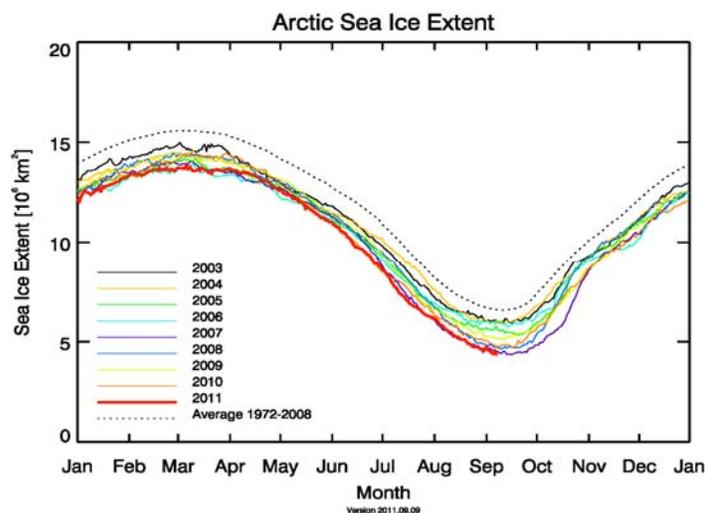


Figure 1: Sea ice extent of the years 2003 to 2011 with minima in September and Maxima in March.

The work group of Georg Heygster at the University of Bremen has been observing the the sea ice at both poles for many years. With the support of the ESA/GMES project Polar View, daily maps of the sea ice extent are publicly provided at <http://www.iup.uni-bremen.de/seaice/amsr/>. The retreat of the summer sea ice since 1972 amount to 50%. For algae and small animals living at the lower side of the ice, less and less living environment remains since they need a certain time to settle there. They are at the beginning of the food chain for fishes, mammals and also man.

The extent of the Arctic sea ice shows a pronounced yearly cycle, with about 15 million km<sup>2</sup> in March and five million km<sup>2</sup> in September. In 2007 however, it was only 4.267 million km<sup>2</sup>, the previous smallest value since start of satellite observations in 1972, and most probably since the last climate optimum about 8000 years ago. The current value is 27,000 km<sup>2</sup> or 0.6% lower and could even be undercut in the next weeks. The ice maps of the University of Bremen show also that in this year, the Northwest and Northeast passages are ice free simultaneously (Figure 2). This had happed for the first time in 2008, and in 2009 the German shipping company Beluga has traveled it commercially for the first time. Recently, it

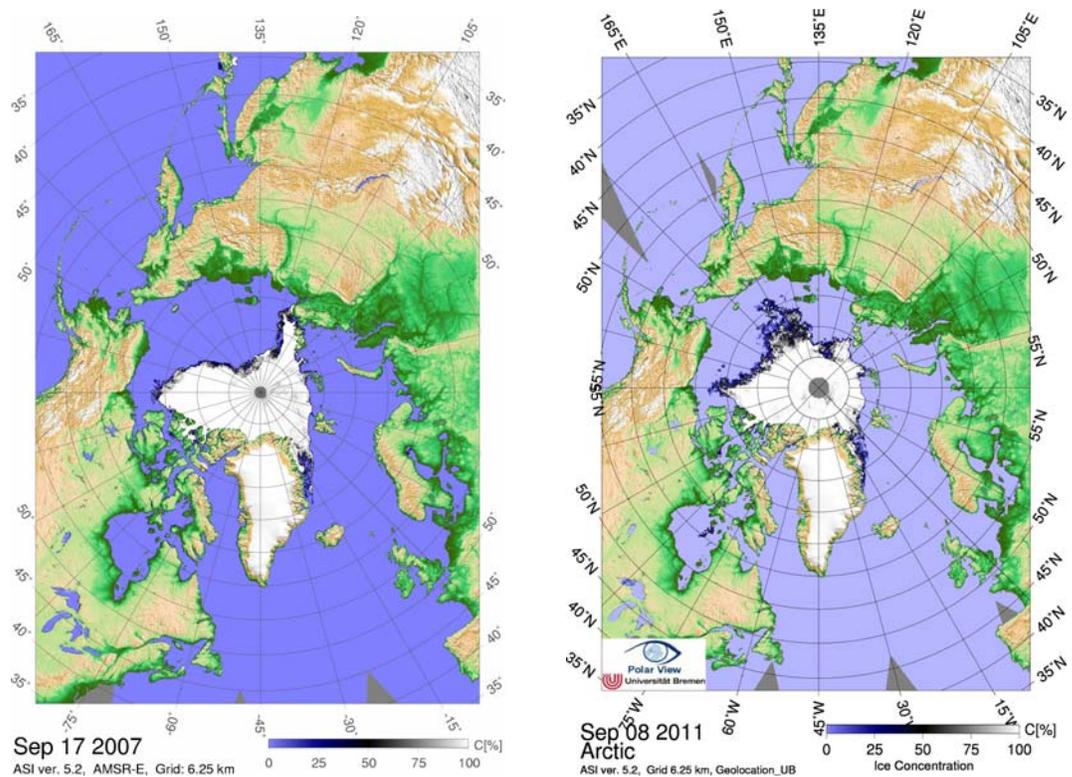


Figure 2: Sea ice concentration maps of the minimum 2007 and of the first day of historic minimum in 2011. The 2011 sea ice area could reduce further in the next days.

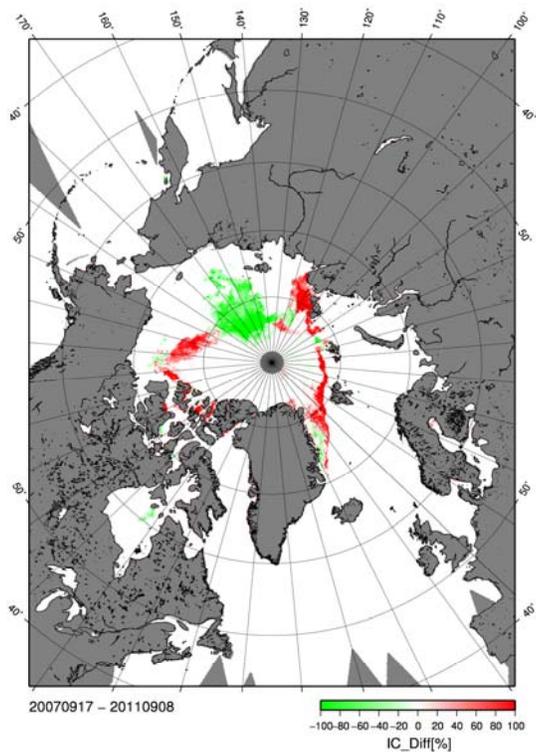


Figure 3: Differences of ice concentrations of the minima in 2007 and 2011. Green: ice covered in 2011, not in 2007, red vice versa.

was crossed in the record time of only 8 days by a tanker, traveling from Houston, Texas to Map Ta Phut, Thailand.

Already in July the new record minimum had been expected because in this month the sea ice extent was minimum, compared with the same month in other years. Due to the high sun elevation and long days in July, the sea ice extent in this period is climatologically more important than that of September. The increased insolation into the open water heat it up, leading to an additional sea ice melt from the bottom and delays formation of new ice in autumn. Moreover, the sea ice retreat can no more be explained with the natural variability from one year to the next, caused e.g. by weather influence. Climate models show rather that the reduction is related to the man-made global warming which, due to the ice albedo effect, is particularly pronounced in the Arctic: an ice area melted by a small temperature increase will then as open water have a much darker surface, absorb more solar radiation than before, which causes additional heating.

In contrast to the minimum in September, the yearly maximum in March has been decreasing less rapidly (Figure 4): despite the reduced in in summer, in winter large areas of the arctic ocean freeze up. However, this first-year ice is clearly thinner than multiyear ice having survived one summer. Therefore, in summer first-year ice melts much easier than multiyear ice and after a historic minimum, the ice cover needs several years to fully recover, even in an unchanged climate. Observation of the last years show further, that the sea ice thickness reduces, so that the total mass of Arctic sea ice decreases even more drastically than the sea ice extent.

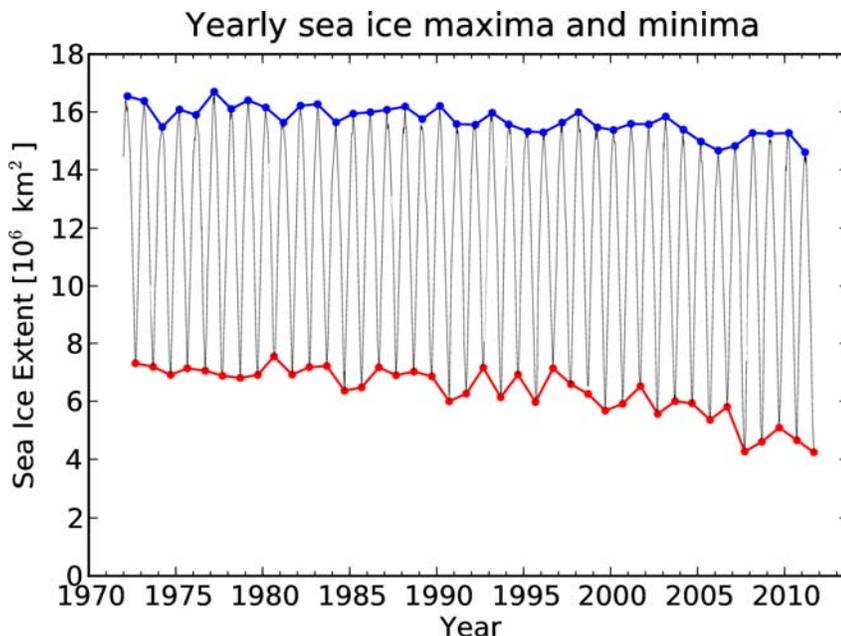


Figure 4: Yearly Arctic sea ice minima and maxima.

The daily sea ice maps of the University of Bremen are based on observations of the Japanese microwave sensor AMSR-E, in orbit on board the NASA spacecraft Aqua since 2002. The institute receives the data from two servers in the US and Japan and produces the maps based on these observations. The sea ice concentration retrieval is based on the ASI

(ARTIST Sea Ice) algorithm using the 89 GHz channels of AMSR-E. Other centers may use data from other satellite instruments, e.g. the NSIDC uses SSMIS. Both sensors are passive microwave sensors measuring at similar wavelengths.

Also the retrieval methods are different. While, again as an example, NSIDC uses the NASA Team algorithm working at 19 and 37 GHz (about 15 and 8 mm wavelength), the University of Bremen uses the channels at 89 GHz (about 3 mm wavelength). The latter observations have a higher spatial resolution (about 6 km), but they are more influenced by weather (water vapor, clouds).

Different methods may find slightly different sea ice extent values. The difference of the sea ice extent between the two mentioned data sets is in the order of 2 percent which at the same time may be considered as an uncertainty margin of the retrieval methods.

Another important aspect of time series analysis is that it is essential to consider consistent data. Here, this means that all data need to be derived using the same method. But even then, because of the inherent uncertainty, there may be slight differences in the results. The sea ice minimum 2011 is such a case. University of Bremen find the minimum 2011 about 1% lower than that of 2007. But finding the 2011 minimum with another sensor and retrieval method slightly higher than that of 2007 is just within the statistical variation.

The common and important point to our understanding is that all methods find consistently that all minima since 2007 have been lower than all minima before, i.e. the last five minima (2007-2011) are the four lowest on record, see Figure 4.

The data in the time series of Figure 4 cover 32 years. They stem from several different satellite sensors and have been harmonized carefully based on the overlap periods of the different sensors.

#### Further information:

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