ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

FACT SHEET

THE INFLUENCE OF ARCTIC SEA ICE ON WEATHER AND CLIMATE IN EUROPE

Climate

What do the changes in the Arctic have to do with us?

The atmosphere and the ocean are able to transport signals over long distances. That means climate anomalies at one place may have impacts on the weather and climate in distant regions. The El Niño phenomenon unfolds the best known remote impacts in the tropical Pacific. It has been shown that El Niño even has an influence on the winter climate in Europe.

The southern boundary of Arctic sea ice is no more than 3,000 kilometres away from Berlin. The fact that presumably the greatest climate change worldwide – the decline in Arctic sea ice – takes place in nearby regions north of Europe gives rise to the question as to what consequences climate change will have for the weather and climate in Europe.

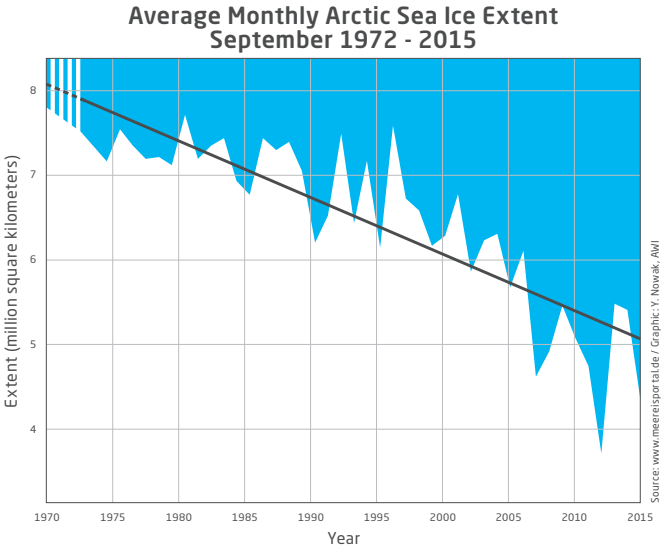
What specific changes do we observe?

Arctic sea ice has undergone a fundamental change in the past decades:

- Sea ice thickness has diminished by half in the past 50 years (see in this connection: AWI Fact Sheet Sea Ice).

- The extent of Arctic sea ice in the month of September (sea ice minimum at the end of summer) has also declined by 50% since 1979.

- The past 6 summers were the summers with the lowest extent of sea ice since the beginning of satellite observations.



This graph is based on the most recent sea ice data. However, the final data for the sea ice minimum of September 2015 was not yet available at the editorial deadline of this fact sheet, which is why the minimum is indicated as a range of values.

Projections with climate models indicate that the Arctic will be practically ice-free during the summer months by the middle to end of the 21st century.

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Whereas winters in Europe during the period from 1960 to 1990 tended to be milder, we have observed the reverse development in the past years: European winters are becoming colder again. The winters in the years 2005/06, 2009/10 and 2012/13, for example, were among the coldest in Central Europe since the 1960s.

The simultaneous severe decline in Arctic sea ice in the past years and increased occurrence of cold winters in Europe at the same time give rise to the question as to whether there is a causal connection. Furthermore, there is the question of whether the occurrence of cold winters is inconsistent with anthropogenically induced climate warming.

Why is that and what is known about the reasons?

The observed decline in Arctic sea ice during recent decades can be primarily explained by climate change due to increased greenhouse gas concentrations. However, it cannot be ruled out that natural climate fluctuations have contributed to the observed changes, particularly with regard to the rapid decline in ice since the turn of the millennium.

The mechanism of how Arctic sea ice influences the weather and climate across Europe has yet to be fully understood. A plausible explanation is based on the fact that in winter Arctic sea ice shields relatively warm water (approx. 0°C) from very cold air (down to −40°C). A decline in sea ice therefore means that the sea substantially warms the atmosphere from below. A large-scale decrease in sea ice will thus result in reduction of the temperature difference between the low and high latitudes – the main forcing factor for atmospheric wind systems.

The retreat of the sea ice edge to the north also has an influence on the main paths of low pressure areas, which are influenced by the edge of the sea ice, and thus on the general weather patterns in the neighbouring regions (see also figures on right).

Overall, we therefore expect that a decline in Arctic sea ice will lead to an increase in the occurrence of Scandinavian and Siberian high pressure areas that push cold air of Russian origin to Europe.

By the way

The idea that a decrease in sea ice may lead to colder winters across Europe is not new. Such a hypothesis was formulated with the help of model experiments back in the 1970s. It is thus not a new attempt to explain the seeming contradiction between the greenhouse effect and the increased occurrence of cold winters in Europe since the turn of the millennium in retrospect.

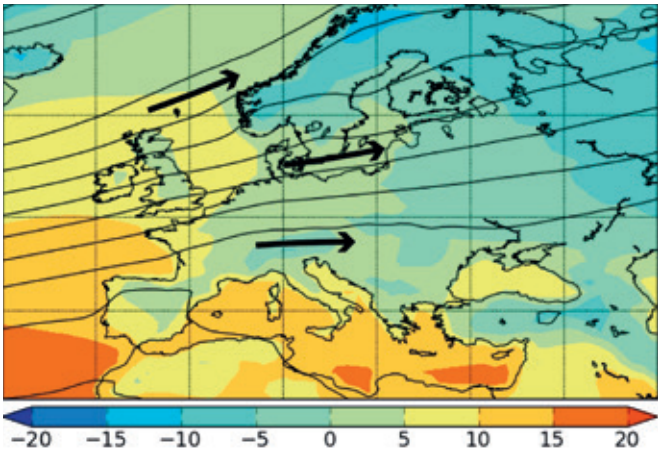

Figure 1: The winter weather situation in Europe under normal ice conditions in the Arctic. This map shows the present mean temperature distribution in Europe in winter (December, January and February) expressed in °C. It indicates that the coldest temperatures prevail in northeast Europe and the mildest in the southwest. The temperature over the sea tends to be milder than that over the continent. The black lines with arrows show the mean wind direction in winter. They indicate that in winter there is an inflow of predominantly mild air from the North Atlantic that influences in particular the temperatures in central and northern Europe. (Figure: AWI)

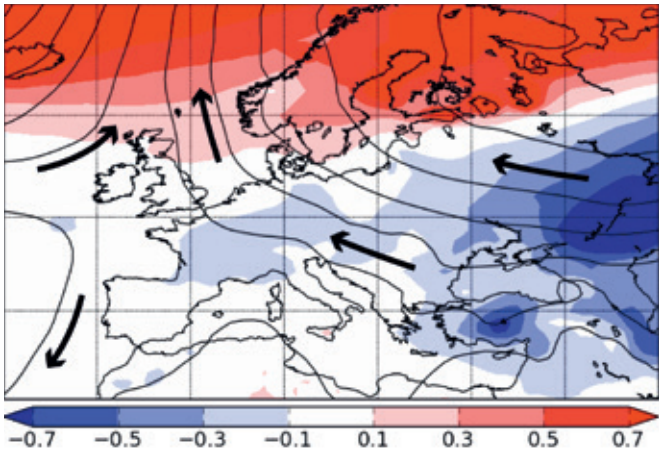

Figure 2: Possible changes. This map shows how the winter weather pattern in Europe could change if the thickness of Arctic sea ice diminished by half. Parts of northern Europe would get more than 0.7°C warmer – indicated here by the deep red colour. This temperature rise would be brought about by virtue of the direct influence of the warmer Arctic. Over Eastern Europe and, to a certain extent, over Central Europe as well, on the other hand, temperatures would drop. This would result from changes in the prevailing winds.
The black lines with the arrows indicate the wind difference between present-day conditions and conditions with diminished sea ice thickness. The wind difference shows an easterly to southeasterly direction over Eastern and Central Europe. This means that the mean westerly wind would get weaker, thus making cold air outbreaks from Eastern Europe more probable.
As a matter of fact, we have experienced cold winters in recent years in which the extent and thickness of Arctic sea ice were extremely low. For Central Europe, however, the modelled cooling is weaker than the warming created by increased greenhouse gas concentrations in the atmosphere. Overall, the decline in sea ice would therefore merely moderate the warming due to the direct greenhouse effect in winter. (Figure: AWI)

How substantial are the uncertainties?

The uncertainties are definitely still significant. However, various climate models agree in terms of their results that a decline in the ice tends to lead to colder winters in Europe. Nevertheless, this connection is relatively insignificant in climate models or to put it in another way: there are other mechanisms that have a greater influence on the weather and climate in Europe. Furthermore, the decline in sea ice is accom-panied by processes in the boundary layer between sea ice and the atmosphere that it has not been possible to represent precisely enough in climate models yet.

Although observations show a simultaneous decline in sea ice and an increase in cold winters, we cannot conclude more than the possibility of a connection from them at the moment.

What do we expect for the future? (development of research and climate)

In the coming decades we expect a further decline in Arctic sea ice. For this reason it is important to gain a better understanding of the consequences this will have for the weather and climate in Europe. Observing and modelling scientists are therefore working jointly in national and international research programmes to understand processes at high latitudes better and, with the help of this knowledge, to improve the quality of climate models with which controlled experiments can be conducted.

The question of whether the winter temperatures in Europe can be predicted several months or even years in advance is a focal point of climate research at present. Current studies from Great Britain give rise to optimism in this context. In spite of all optimism, however, the quality of these forecasts will, in all likelihood, not be able to attain the forecast reliability for the El Niño phenomenon in the tropical Pacific.

What aspects of these research questions are AWI climate scientists working on?

Members of the Climate Sciences research division staff at AWI are currently attempting to gain a better understanding of the mechanism regarding how Arctic sea ice influences the weather and climate in Europe. They carry out and analyse climate model simulations, both with normal and reduced sea ice, for this purpose. To obtain the most meaningful results possible, the models are further improved using observation data. In future investigations will also focus more intensively on the influence of the ice conditions on ocean circulation, e.g. the location and intensity of the Gulf Stream. Finally, all this work is aimed at enabling reliable forecasts for sea ice and thus for weather events in Europe as well.

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