Idea318

DK-Proposal 37

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The changing ice in the Arctic and its coupling to weather, climate and carbon cycling

Disciplines:
Multi-disciplinary

Motivation:
The observed retreat of the sea ice around Greenland is likely to be important for a number of interconnected climate issues. The reduced ice cover will influence the weather and Climate at and around Greenland, due to the changed surface fluxes induced by the increased surface area with open water. Multiple effects on the Carbon balance can also be foreseen, the retreat of glaciers will free more terrestrial surface to enter into the carbon cycling (methane and CO_2), while the ice free waters will change the air-sea exchange of CO_2 for the area. It should be noted that the Greenland Sea – together with the Labrador Sea - is considered to have a large importance for the global ocean uptake of CO_2, due to its cold water and sinking water masses. It is proposed to initiate a multidisciplinary study of these phenomena, benefiting from the fact that the international presence in the Arctic during the IPY will enhance the international cooperation on the subject.
Research:
Thinning of sea ice and smaller ice coverage in the Arctic Ocean over the last few decades has been observed. In addition the sea ice off the East coast of Greenland is showing a tendency to retreat during both summer and winter. Sea ice plays an important role in regulating ocean-heat and CO_2 transfer, controlling the (phyto)-plankton productivity as well as the ecology of marine mammals. Moreover, a potential reduction will have considerable repercussions on commercial shipping and fishery. The development of the sea ice cover should be closely monitored using the best available satellite measurements. Part of the recent decrease may be related to multidecadal natural variability. Theoretical studies and the best available historical records of sea ice will be used to investigate the relative importance of such variability.

Ice Sheets and glaciers
The ice sheets and glaciers in the Arctic contribute to the freshwater input to the Arctic North Atlantic Ocean via summer melting of their marginal zones. During the last decade the climate of North East Greenland and other parts of the Arctic has shown a warming trend. Speculations as to the causes of this warming are focused on the global anthropogenic greenhouse effect, but irrespective of the cause, increased sum-mer temperatures in the Arctic will lead to higher freshwater contributions to the Arctic North Atlantic. This will affect sea ice conditions, which in turn will affect the North Atlantic deep water formation. Weakening of the latter may then lead to a number of influential changes in the weather, climate, carbon dioxide cycling and mass-balance of the ice sheets and glaciers in the Arctic. It is known from previous studies, that the ice masses in North East Greenland are especially sensitive to warming e.g. the Hans Tausen Ice Cap in Peary Land, which presently covers an area similar to the Danish island of Fyn, melted away 5-8 kyrs ago. The latter period is called the Holocene Climatic Optimum and was a few degrees warmer, than today. Our present

knowledge on the sensitivity of ice sheets and glaciers to a warming climate is, however, crude: It is therefore recommended, that studies of ice mass balance in the North East Greenland area becomes an important part of a Danish IPY contribution.

Sediment

Recent research suggests that in the Arctic multi-decadal climate variability is larger than the level of climate variability at lower latitudes, where climate-proxy data and historical records have indicated natural interdecadal and century-scale climate oscillations. Spectrum analysis of global-mean temperature records has identified a temperature oscillation with a period of 65-70 years. Recent research has provided evidence for similar oscillations in the East Greenland Current activity, which has controlled in the past 1000 years the export of ice and Polar Water from the Arctic into the North Atlantic and its respective regions crucial for deep-water formation. Model simulations suggest that this oscillation arises from predictable internal variability of the ocean-atmosphere system. Studying of (Holocene) sediment core records from the Arctic Ocean and gateway areas will contribute in improving our understanding of multi-decadal sea ice variability and provide data for a long-term prediction model.

Atmosphere / Ocean

Generally higher temperatures over the continents at high latitudes except over NE Canada have been observed in the last decades. One result is the melting of permafrost in part of the area, another is the thinning and shrinking of the Arctic sea ice cover. This is believed to be a result of global warming in general. But specific processes at local and regional scales are probably also contributing to the evolution and need to be explored better. Large-scale meteorological flow dynamics are also playing an important part in the processes. During the 80’s and 90’s the pressure, temperature and wind distributions resemble those of a high NAO index situation. This distribution favours higher than normal temperatures at high latitudes extending from the Atlantic region of Europe over central parts of Russia to the western parts of North America. The anomaly chart looks very much like the simulated global warming signals from increased GHG concentrations making it difficult to separate the actual event in an internal phenomenon (in fact a coupled phenomenon) and an externally forced response. In addition to the suspected impact described above it is generally thought that the warmer and more humid weather in Europe during the same period can lead to a substantial reduction in deep water formation at high latitudes in the Atlantic ocean if the warming continues much longer.

It is of great interest to the scientific community and to the decision makers to get a more realistic evaluation of these phenomena. It is proposed to put focus on the meteorological processes involved in the forming of the observed pattern. One possibility is to study to what extent polar lows have a measurable impact on the deep water formation through an enhanced wind induced mixing (and cooling of the water column) in the upper layers of the ocean. It may be of great importance that over the last two decades the number of polar lows have declined dramatically due to changes in the overall weather pattern. Another interesting fact is the occasionally strong vortices developing over northern Canada with very low temperatures in the inner core. Often these vortices move through the large-scale atmospheric flow towards southeast and affect the weather in a large area around the North Atlantic Ocean. Finally it is proposed to perform at study on the potentially changed character of atmospheric meridional heat transport in a warmer climate with reduced oceanic meridional overturning. Key questions in this regard are: Why is simulated high latitude warming particularly strong despite the fact the simulated oceanic heat transport in the North Atlantic is considerably reduced? Can this be explained entirely by the radiative impact of changing arctic cloud and sea ice or is changed atmospheric meridional latent heat transport more important?

Carbon

The changing ice conditions will cause several changes in the terrestrial carbon budgetFor dwarf shrub heath growing on the coarse and dry soil found all over the NE Greenland continuous measurements of CO_2 flux measurements shows an increase in summertime net carbon uptake with increasing temperatures. The general validity of these observations should be investigated and especially the winter conditions should be considered. For the wetlands (such as fens and bogs) with deep organic soils a few degrees of temperature increase would most likely turn these systems from a carbon sink to carbon source. A partly melting of the permafrost as already observed in Northern Scandinavia would increase the decomposition of the organic soil thus leading to increase carbon emission. To what extent this would take place in form of CH_4 or CO_2 would depend on the water balance and thereby on the melting of snow and ice. Melting of the ice will also change the water balance and thus the increase the discharge and the associate soil erosion in total leading to lateral transport of dissolved carbon Arctic change and human adaptation. Archaeological evidence demonstrates human adaptation to extreme Arctic climate during the past many thousands of years. Recent research comparing population groups from the Arctic region with people living more to the south shows that genetic differences in energy metabolism may play an important role for humans to be able to adapt to cold climate. Abrupt and drastic climate change or extreme climate variability at shorter time-scales may be a factor to be considered when trying to explain the disappearance of several early Inuit cultures and Norse settlements from Greenland. As outlined before, a large-scale change of sea ice conditions affecting the marine ecosystem in the Arctic can be concluded also to have a fundamental effect on future living conditions of people in this region.