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Sketch for an Arctic Council project on the impacts of reduction in sea ice, a changing Greenland ice sheet and varying snow cover and permafrost conditions

Climate Change and the Cryosphere

Introduction

The last 5-6 years, the rate of loss of sea ice in the Arctic Ocean has increased considerably. If this accelerated loss of sea ice continues, the Arctic Ocean could be ice-free during summer earlier than projected in the ACIA report. The local and regional impacts of reduced sea ice could consequently be more imminent than previously thought. This situation makes the need for more detailed and thorough knowledge about the impacts, and more accurate projections about the future sea ice extent, more urgent. Further, IPCC (AR4) points to a possible thinning of the Greenland ice sheet as one of the major unknowns in the Arctic climate system and with severe global consequences (i.e., rising sea level). Also, changing in precipitation, snow cover conditions and a thawing of the permafrost will affect the hydrological situation and thereby have widespread consequences. For example, this will have an affect on vegetation, the food availability for animals as well as and altering the runoff from large Arctic rivers. Thawing permafrost causes release of the greenhouse gas methane as well as impacts on infrastructures previously built on more stable permafrost conditions.

Current situation

Sea ice

The Arctic Climate Impact Assessment (ACIA, 2004) concluded that the sea ice distribution in the Arctic the last 30 years until 2002 had been reduced by 8%. The decadal loss rate was estimated to be 3-4%, and it was bigger in summer than in winter. Five Global Circulation Models (GCMs) were run by ACIA to project the future fate of the sea ice. In average, the models projected a 50-60% loss of sea ice by the end of this century. One of the models projected that summer sea ice would be gone by 2070. ACIA indicated that the rate of sea ice loss had increased in recent years. The rate of loss of sea ice in summer (September) since 1979 has increased to 8% per decade when the last years are taken into account. Several models now indicate that summer sea ice may disappear before the end of this century. Some models even project that sea ice could be reduced abruptly and reach near ice-free September conditions already by 2040 (Holland, et al. 2006). The interaction between freshening of the Arctic Ocean, through melting of sea ice, glaciers and increased runoff from rivers, and ocean circulation is crucial to understand the climate processes in these areas. Monitoring of ocean currents, especially

in the North Atlantic, should be a prominent task. Updated knowledge about the consequences of future reductions in sea ice will be of outmost importance for indigenous peoples, for biodiversity conservation as well as for a range of economic activities that will have to adapt to these changes.

Greenland ice sheet

The large ice masses on land that represent key players with respect to potential major global sea level rise in future are Antarctica (representing 91.8% of the land ice on Earth) and Greenland (representing 7.9%). Until recently, the current understanding was that the ice mass in Antarctica most likely would increase (i.e. lowering the sea level) in a warming scenario, Greenland would have a moderate reduction in ice mass (i.e. increasing the sea level) while the largest contribution from melting ice would come from other glaciated areas (representing 0.3% of the Earth's land ice). Recent results question these assumptions because new observations indicate that ice streams draining large areas of the Antarctic and Greenland ice sheets have accelerated. As a consequence of increased ice stream velocities, substantial thinning of some areas of Antarctica and Greenland has been observed. Thus, glacier dynamics, which may efficiently drain large ice masses, seems to play a more important role in reduction of land ice masses than previous thought. In this picture, it is critical to understand the processes that occur and their consequences for the Greenland ice sheet related to global sea level. The IPCC AR4 has clearly addressed this.

Thawing of permafrost, changing snow cover and hydrological conditions

Terrestrial changes in the cryosphere are also expected due to increased precipitation, snow cover conditions and thawing of the permafrost with consequences for the hydrology. First, the snow covered area in the Northern Hemisphere has been reduced since the late 1970ies. This trend is expected to continue. For Arctic regions, more unstable weather conditions will also change snow cover characteristics, e.g. creating layers of crust and ice in the snow pack more frequently due to temperatures around zero. Such changes will be negative for reindeer herding and directly affect indigenous people. Also, changes of snow cover properties and the duration of the snow-covered season will affect vegetation and animals adapted to current climate. Further, the ACIA report quantified the reduction of days with snow on ground in Alaska that enable transportation over land. Reduction of permafrost areas have been observed, especially in North America. Negative consequences of reduced permafrost for infrastructure and coastal erosion are obvious. Additionally, thawing of the permafrost in Arctic regions will release methane. This will be a positive feedback, largely with an unknown affect. Finally, changes in precipitation, snow and permafrost conditions influence on the hydrological cycle where changes in runoff from large Arctic rivers will be a particular area of interest. Many local communities depend on these rivers for their living and will have to adapt to future changes.

Potential regional and global impacts

The changes described above will have widespread impacts. Some of the major global effects are:

- Strengthen the global warming through the snow and sea ice albedo feedback.
- Potentially affect the thermohaline circulation (THC) which may change the large scale ocean currents and distribution of heat on the Earth's surface
- Alter the CO₂ uptake of the Arctic Ocean
- Affect the global sea level
- Positive feedback process due to increased release of methane stored in the permafrost

And some examples of regional impacts are as follows:

- Affect the culture of indigenous peoples
- Affect local peoples economies and livelihood
- Change marine and terrestrial biodiversity and productivity
- Increase the accessibility to the continental shelves of the Arctic Ocean and for instance make exploitation of their petroleum resources easier.
- Potentially change shipping routes between some of the continents
- Change the hydrological cycle, incl. runoff characteristics of large Arctic rivers
- Make jurisdictional conflicts more urgent

Proposed project idea

The objective of the proposed project is to provide the Arctic Council with updated and synthesised scientific knowledge about present and future regional and global consequences of rapid changes in sea ice, melting of the Greenland ice sheet, changes in snow cover and permafrost conditions. The project should mainly be based on existing scientific knowledge, but could also be supplemented by new research where there are significant gaps in knowledge. The scenarios for future projected reductions in sea ice should be strengthened and developed further based on new research achievements, including natural climate variability that is pronounced in the Arctic. To improve the quality of the climate scenarios, it is necessary to improve the quality of the input parameters. Further, global models provide too low resolution for precise studies of consequences on regional scales, e.g. of the annual sea ice cover fluctuations. Thus, it is important to focus on downscaling from global models in order to provide regional studies of high accuracy. This is fundamental for choosing the best possible adaptation strategies. Then, based on a set of scenarios for future changes in the cryosphere, scenarios of the consequences for local peoples, ship transport and petroleum activities, ecosystems and biodiversity, and the global consequences should be developed. Updated knowledge about potential consequences of reductions in sea ice, melting of the Greenland ice sheet and changes in snow cover, permafrost and hydrological conditions will be invaluable for establishing sustainable adaptation strategies and measures.

A possible structuring of this project could be as follows; 1) data availability and understanding of processes to improve input to climate models, 2) monitoring, 3) climate model runs – new scenarios, 4) regional consequences, 5) global consequences and 6) data collocation and management.

The project could be conducted by AMAP, CAFF, PAME and WGSD in collaboration by appointing a steering committee with representatives from the four WGs, strengthened with scientists.

Time frame: The different modules described above could be started sequentially or simultaneously. Preliminary results should be presented to the ministerial meeting in 2009. A final report should be ready and delivered to the ministerial meeting in 2001.