Dramatic transformation

Climate changes will result in a dramatic transformation of nature in Northeast Greenland. In a worst case scenario, this could affect the global climate through the so-called »global feed-back« mechanisms

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■ *Zackenbergimi sulianut tamanut qitiusoq tassaavoq silasiorfik isumaminik ingerlatitaq, ukioq kaajallugu silap pissusaanut tunngasunik arlalissuarnik nalunaarsuisartoq.*

■ *Centeret for alt arbejdet i Zackenberg er en automatisk vejrstation, som året rundt registrerer en lang række klimatiske parametre.*

■ *The centre for all the work at Zackenberg is an automatic weather station that registers a long series of climatic parameters all year round.*

The impact of global warming is felt most strongly in the Arctic regions. New climate models indicate that the temperature in the Arctic could increase by up to eight degrees over the next 100 years. The results of 10 years of research at Zackenberg in Northeast Greenland show that there will be far-reaching consequences for the Arctic eco-systems and that these consequences could have a dramatic effect on the climate in the rest of the world. There are two major factors involved.

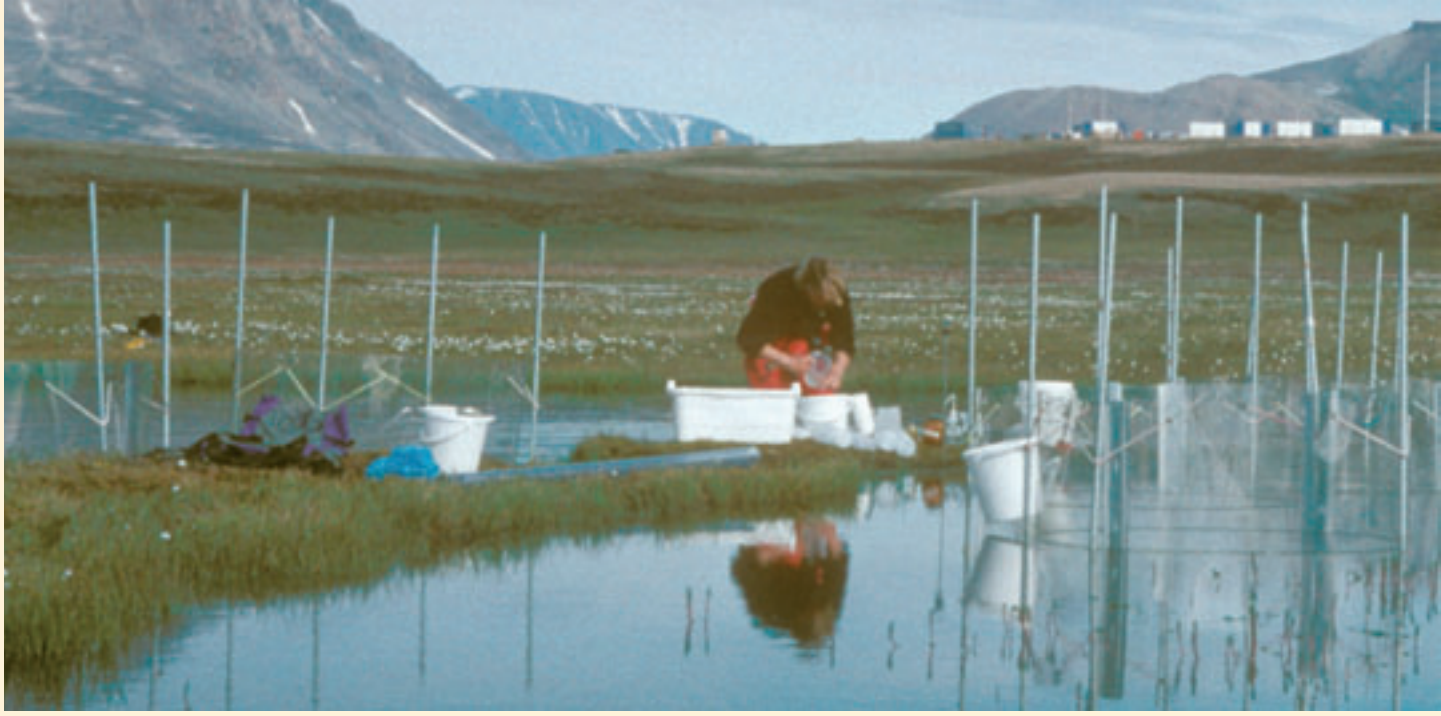
First and foremost, enormous quantities of cold sea water sink in waters off Northeast Greenland. This sinking, which is called »the cold heart of the oceans«, drives ocean currents all over the globe and is therefore responsible for much of the transportation of warmth from south to north. Think of the Gulf Stream which ensures the mild climate in North West Europe. But the sinking is highly dependent on the temperature off Northeast Greenland and on the formation of sea ice. If the temperature increases and less ice is formed, the pump's action will slow down and the currents will become weaker. The question is, how much weaker?

The other great unknown factor is what will happen with the enormous amount of peat that is accumulated in the Arctic. It has been calculated that 20 per cent of the world's biologically bound carbon is contained in these peat layers. When the temperature increases, the peat will start to decay releasing the bound carbon into the atmosphere in the form of carbon dioxide and methane. This will exacerbate the greenhouse effect, which will result in even more global warming and so on and so on. Just as with most other ecological processes in the Arctic, melting snow is a decisive factor for the carbon balance, as the start of the growing season to a high degree determines how much carbon dioxide and methane is exchanged between the tundra and the atmosphere during the summer.

The time when the snow melts is a key factor in the understanding of not only the effects on plant and animal life, but also the effects of future climate changes in the Arctic. The melting snow has therefore been the subject of targeted research and we will subsequently take a closer look at the results.

Several climate zones

The Arctic is divided into a high Arctic and a low Arctic zone. The low Arctic zone is often fertile, with bushes and other knee-high plants, whilst the high Arctic zone only has ankle-high plants. Here, the mean temperature for the warmest month does not usually



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rise above plus six degrees. In addition, much less snow falls in the high Arctic. The south tip of Greenland gets 100 times more snow than northern Greenland where there is a »desert climate« with as little as 25 mm of annual precipitation.

The whole of West Greenland is low Arctic whilst North and Northeast Greenland, including the entire National Park in North and Northeast Greenland, is high Arctic. The reason for this is that the sea ice often covers a several hundred kilometre wide belt off the coast. During periods with a lot of sea ice, the continental climate in Northeast Greenland is dry, whilst during periods with less sea ice there is a coastal climate with lots of snow in the winter and a lot of fog in the summer. The amount of sea ice that drifts down past the coast of East Greenland is therefore crucial for the climate of Northeast Greenland.

Feedbacks

From the end of the 1800's, when Denmark's Meteorological Institute (DMI) starting recording data along Greenland's west coast, the temperature increased until about 1940. This was followed by a period with comparatively low temperatures until 1965 and since then, there have been regional increases up to today. Warming over the last 40 years has been greatest in East Greenland, where the temperature has increased by one to two degrees Celsius each decade.

The increased concentration of greenhouse gasses in the atmosphere will have a greater impact on the Polar regions than the on the rest of the world because of various »feedbacks« such as the so-called snow-ice albedo feedback. Snow and ice reflect a great deal of the sun's energy back into space, but as it gets warmer, more of the snow and ice will melt, exposing ground and seawater. Since ground and seawater are much darker than snow and ice, they absorb a greater part of the sun's energy and this gives rise to further warming, which again melts more snow and ice and so on and so on. In addition, the local climate will change drastically when the sea ice melts and there is open water. This is precisely what we are expecting in Northeast Greenland during the next century.

Severe increase

Calculations using a very elaborate climate model show that the temperature in Greenland up to 2080 will increase drastically, precisely in those areas where the ice and snow disappear. We expect an increase in temperature over the next 60-70 years in the range of 7-8 degrees along the west coast, up to 12 degrees along the east coast and a whole 18 degrees in the Svalbard region! The increase in temperature will predominantly take place in the winter and spring, whilst changes will be milder in autumn and especially in the summer.

The models predict more precipitation throughout the entire area. Whilst there will be an increase of about 30 per cent in South Greenland, 60 per cent more precipitation is expected in the northern part of Greenland – in some places even three times as much. Combined with higher temperatures, this means that there will be more rain and less snow everywhere along the coasts south of Ilulissat/Jacobshavn and Ittoqqortoormiit/Scoresbysund, respectively with more frequent, storm-like showers.

Spring snow cover

Most scientists come to the Arctic when the snow has gone and the plants are in full bloom. But by this time, many of the most important processes in nature in the Arctic have long since finished. Our studies show that the time when the snow melts is by far the most significant factor for the high Arctic ecosystems. The time and progress of the snow melt is determined by a combination of the winter's precipitation, the re-distribution of snow by storms and the spring temperature. All three conditions will change dramatically in the future, since they are affected both by the North Atlantic climate system and by the prevalence of sea ice off Northeast Greenland.

■ *Tatsini taseqqanilu uumasoqassutsimut qaqugukkut aputip aannera sunniutilerujussuusarpoq. Matumani qeriuaannartup masarsoqarfiani taseqqami qaleruallit assigiinngitsut akornanni sunniivigeqatigiinneq misissorneqarpoq.*

■ *Livet i søer og damme påvirkes stærkt af, hvornår isen smelter. Her undersøges samspillet mellem de forskellige krebsdyr i en dam på tundraen.*

■ *The time when the ice melts has a strong effect on life in the lakes and ponds. Here, the interaction between the various crustaceans in a pond on the tundra is studied.*

The time when the snow cover melts away combined with the temperatures is crucial for the start of plant growth and for the time when the plants bloom. Since the snow doesn't melt until June, when the sun is highest in the sky, it has great bearing how early the plants start growing. The earlier they start growing and blooming, the more they benefit from the full energy of the sun. In years with a late snow melt, there are many plants that do not produce mature seeds.

Similarly, the emergence of flying insects in spring and life in lakes and ponds is completely dependent on the time when the snow and ice melts. The egg-laying of wading birds can be delayed for up to 2-3 weeks in years with particularly widespread snow cover. In such years, the young are hatched correspondingly later and therefore have less time to grow big and strong before, at the age of just 6 - 10 weeks, they must undertake the long migration across the North Atlantic to their winter quarters in Europe and Africa.

Snow and the musk-oxen

The time of the snow melt has also great significance for the musk-oxen's exploitation of the countryside, although periods with thaw in winter are a serious threat to the population. In the period during which we have knowledge of the conditions in Northeast Greenland, the musk-oxen have almost been eradicated several times in large parts of the country when glaze ice has covered the countryside and the vegetation. This has prevented the musk-oxen from obtaining food and they have starved to death.

The amount of winter precipitation and thereby the thickness of the snow cover will increase significantly in the future, but this factor will, to a certain extent, be counteracted by the higher spring temperatures which will cause a faster snow melt. It is very likely that there will be greater fluctuations from year to year in the amount of snow cover and at the same time there will be a greater variation between years with an early snowmelt and years with an extremely late snowmelt. In years with large amounts of snow and a cold spring there could be an almost total lack of reproduction on the part of many plants and animals. All this means that Northeast Greenland's nature is facing big changes, but it also means that conditions could originate here, that could have dramatic consequences for the ocean currents and thereby the global climate.

Zackenberg

The research station at Zackenberg is centrally situated in the National Park in Northeast Greenland and it is here that one of the most comprehensive and cohesive research programmes in the Arctic is being carried out under the leadership of the Danish Polar Centre, Copenhagen University, the National Environmental Research Institute at Århus University and the Greenlandic sector research institutes Asiaq and the Greenland Nature Institute. Zackenberg, which is owned by the Greenland Home Rule Government and run by Danish Polar Centre, is a modern research station with a total of 10 big and small houses and its own runway. The station is normally open from the end of May until around September 1st.

Since 1995, several hundred Danish and foreign researchers and scientists have documented every observable corner of the high Arctic nature at Zackenberg. Their research has now been collected in its entirety in the book »High-Arctic Ecosystem Dynamics in a Changing Climate – Ten years of Monitoring and Research at Zackenberg Research Station, Northeast Greenland« which is published by Academic Press.