Contributing to the future

Dr Ralf Döscher provides details of his current project, which looks into the integration and improvement of Arctic climate change models, including the EC Earth global Earth System Model

To begin, could you provide an overview of the central themes and objectives of the 'Advanced Simulation of Arctic Climate Change and Impact on Northern Regions' (ADSIMNOR) project and what inspired its creation?

The key motivation of our work is to provide process understanding and improved climate change scenarios for the Arctic area. As regional Arctic questions are closely related to global changes, we figured we should integrate both aspects into one project. At the same time, the need to integrate traditional climate modelling – eg. that of atmosphere, ocean and sea ice – with other climate system components, such as vegetation and permafrost, became imminent. That approach is required to address the needs of climate change impact communities, so ADSIMNOR is a very broad project with the ambition to integrate disciplines focusing on Arctic change.

What are the projected economical, geo-political and societal benefits of this research effort?

Our ambition is to make a significant contribution to quantifying possible future climate change in the Arctic. At the same time, ADSIMNOR will contribute to and utilise international efforts such as the Coupled Model Intercomparison Project (CMIP) for global climate projections, and the Coordinated Regional climate Downscaling Experiment (CORDEX) for regional climate downscaling. Examples for using resulting climate model output will be given within the project and the potential user community will be involved through workshops, organised partly by ADSIMNOR but also by utilising other information infrastructure such as Sveriges Meteorologiska och Hydrologiska Institut, (Sweden's Meteorological and Hydrological Institute – SMHI) and the Abisko research station. As an additional component, a geographic information system (GIS) system for the user and stakeholder community has been developed.

Could you describe some of the modelling technology that you will be employing in your investigations and how you will be utilising it?

Part of the ADSIMNOR resources are devoted to developing the EC Earth global Earth System Model (ESM) with respect to Arctic performance, and to developing a new version of the Rossby Centre Atmosphere Ocean climate model (RCAO), including a module for vegetation. The effort necessary for technical development is often underestimated. New computer technologies, together with the need for higher resolution and better physical performance, requires permanent adjustment of model codes. In our case, the code structure of the regional atmosphere model has been completely revised together with the technical way of coupling to the ocean and sea ice models. Portability and applicability as well as computational performance have been raised to meet the needs of repeated century scale calculations.

What upgrades have you made to these modelling systems to develop understanding of Arctic climate processes and influences?

Major model improvements have been carried out in most model components in order to better describe processes, with the potential for a better representation of Arctic climate. An example is the sea ice model, which has been extended with multiple sea ice classes to allow a more realistic description of sea ice concentration and thickness. Vegetation modelling has made major progress due to the introduction of vegetation dynamics, hydrology, soil thermal dynamics and permafrost for peat land ecosystems. The model systems are now better suited to serve impact studies.

How do you propose to downscale the results of the regional climate results to provide a focused local view? Moreover, how localised can these scenarios be while still providing accurate results?

As a general rule, regionalisation can only be as good as the large scale signal. Thus, the complete chain from global simulations to local downscaling needs to be covered. Each instance of downscaling needs to take uncertainties into account. This results in probabilities for certain changes. When it comes to the local scale of several hundred metres, there is the option of statistical downscaling, which uses empirical knowledge from observations. Non-hydrostatic dynamical modelling is an upcoming alternative which will be tested. The method uses a more accurate approach to basic air flow laws.

Your website flags interdisciplinary synthesis as a considerable challenge in this project. What efforts have been made to encourage cross-disciplinary collaboration and what problems have you encountered on this front?

The direct links from global scenario via dynamical downscaling to statistical interpretation for the local scale is pretty clear conceptually. The challenge is to bring the complete chain to work. The full scale collaboration including appropriate interpretation of results can only be achieved by utilising additional resources of the project participants, such as user networks, user support functions and impact workshops. Also, modelling efforts as a spinoff from other projects need to be closely linked with ADSIMNOR. As an example, we are collaborating with a high resolution modelling project for northern Sweden.

New projections of **Arctic change**

Climate change is a global issue that affects us all. While initiatives all over the world attempt to address this burgeoning issue, the **ADSIMNOR** project brings a more integrated approach to Arctic climate study

WITH EVERY YEAR that passes, climate change research grows in importance. This importance is held by almost everyone across the globe from science communities and health organisations to education authorities, political groups and environmental stakeholders. The more we learn about climate change, the effects it brings and how we as a global community may be instigating these effects, the better prepared we can be for any situation it brings.

Climate change research initiatives operate from many corners of the Earth. One location in particular, where we can clearly see climate change altering our environment, is within the Arctic region. The Arctic climate is connected to global climate through exchange of heat, salt, air, water and ice. For many years, using various observations, theoretical considerations and numerical modelling, experts have demonstrated how the Arctic region is warming and how it is facing a decreasing supply of ice.

Recognising the importance of climate change study within the Arctic region, oceanographer and Arctic climate researcher Ralf Döscher and colleagues set up the project 'Advanced Simulation of Arctic Climate Change and Impact on Northern Regions' (ADSIMNOR), which Döscher now coordinates. ADSIMNOR aims to improve the integrated understanding of Arctic climate processes and their impacts. The project looks to achieve this goal via a number of connected methods, including analysis of large scale observation, improvement of process understanding and simulation capabilities, regional pan-Arctic climate scenarios and local impact studies concerning vegetation and permafrost.

SEARCHING FOR UNDERSTANDING

While the science world strongly agrees to a warming Arctic region, there is still plenty of uncovered information that could aid our understanding. Döscher believes that in order to successfully prepare ourselves for climate effects resulting from the Arctic region, we must gain a more realistic knowledge of the processes involved. This relates to both global Arctic interaction and regional Arctic processes and their impacts on both a regional and local scale. "Process understanding is key when improving models for coming scenario projections and even for decadal forecast efforts," Döscher adds.

Based out of the Sveriges Meteorologiska och Hydrologiska Institut (Sweden's Meteorological and Hydrological Institute)'s Rossby Centre, and Stockholm University's Department of Meteorology, the ADSIMNOR project has already started providing contributions to climate change studies. The project recently demonstrated evidence for a control of rapid Arctic sea ice loss by hemisphere scale air circulation changes. In addition, heat transference from lower latitudes has also contributed greatly to Arctic warming as well as regional self-amplifying mechanisms such as the 'sea ice albedo feedback'.

ARCTIC LANDSCAPE WITH VARYING SURFACE

With a view to gaining better understanding and projecting a more physical projection of coming climate events, Arctic climate models are constantly being developed. ADSIMNOR looks to improve many of the model components by integrating research groups and allowing for a more efficient sharing of knowledge.

FUTURE IMPROVEMENTS

The project is aiming to integrate better models for sea ice, land surface and vegetation into the Arctic model. In addition, it is working to improve ocean mixing and apply a higher resolution for both the pan Arctic simulation and a local northern Sweden domain. In order to improve the sea ice model, the project team incorporates sea ice classes, resulting in a more realistic sea ice distribution. The project holds a similar plan for the land surface model, intending to merge improved physiography with better formulations for snow albedo and soil moisture, while an updated vegetation model would include new implementations of vegetation dynamics, hydrology, soil thermal dynamics and permafrost for peatland ecosystems.

A CHANGE OF SCENE

Crucially, the ADSIMNOR project is not solely confined to department walls. In order to affirm simulations made through their models, the team orchestrates field work in Abisko, a valley area of northern Sweden. Coupled with this field observation, global and regional models can then be better verified and used to develop new scenario projections of future Arctic climates.

An integral component of the Arctic climate system is the ocean freshwater reservoir. This is also important to lower latitudes as freshwater

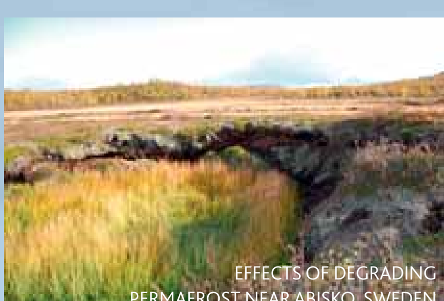
from the Arctic is exported to the Atlantic Ocean. However, the regularity of this export can vary and, while much progress has been made in Arctic climate science, it is still not fully understood what is controlling the freshwater dynamics inside the Arctic region, the release of freshwater and how sensitive it is to future changes.

ADSIMNOR intends to concentrate more on the freshwater issue by analysing the changes in heat and freshwater fluxes in future scenario simulations. Further project studies will focus on the sensitivity of freshwater dynamics within the Arctic by marking up the relevant sources and sinks with a number of passive tracers within the model. If this method is met with success, the ADSIMNOR team will carry out additional sensitivity experiments based on climate scenarios to study how possible future changes in the sources or sinks might impact the Arctic Ocean freshwater reservoir.

Focusing on the project's land surface and vegetation models, ADSIMNOR has already started to conduct studies relating to the effects of sea ice reduction on land climate around the Arctic Ocean. This task will be addressed by using a set of sensitivity tests that look at sea ice reduction in specific areas.

EXPLORING FROM ALL ANGLES

In collaboration with CORDEX, an international regional climate modelling project, and by utilising the Abisko research station, members of ADSIMNOR are addressing specific climate questions of local importance. These questions look at statistical downscaling of large-scale



EFFECTS OF DEGRADING PERMAFROST NEAR ABISKO, SWEDEN

REINDEER FACING CHANGING SNOW AND SOIL CONDITIONS

change projections, permafrost and reindeer herding. The results from statistical downscaling alone offer valuable input for studies on ecosystem structure changes.

The reasoning behind the focus on reindeer herding is to allow analysis of previous climate changes and then relate them to expected land surface change. These future projections will come as a result of climate scenarios and downscaling. Members of ADSIMNOR will run information events and conduct interviews with reindeer herders in the northern village of Gabna to ascertain perception of climate change from some of the most affected communities. Other climate change impact communities such as the health sector, local planning and tourism will be served via existing communication channels of ADSIMNOR partners.

Döscher believes that his team's work with Arctic climate change represents real benefit for northern nations and for the global climate research community. This is especially evident due to the integration that ADSIMNOR has fostered between different initiatives, from climate modelling to impact research. However, rather than providing the definitive answer, Döscher feels that his team's work will set the foundations for further projects in the future. "The project will end at some point, but the network established now will have a legacy and hopefully drive the development towards a tighter integration between classical Arctic climate modelling and impact work even further," he explains.

INTELLIGENCE

ADSIMNOR

ADVANCED SIMULATION OF ARCTIC CLIMATE CHANGE AND IMPACT ON NORTHERN REGIONS

OBJECTIVES

This project aims at understanding and advancing simulation of climate change in the Arctic including its impact on land areas, and incorporating interaction between simulation results and a wide stakeholder community. The goal is to establish a chain of knowledge starting from the global climate change signal and its Arctic amplification with a special emphasis on local impact in the Abisko area in Northern Sweden.

PARTNERS

Sveriges Meteorologiska och Hydrologiska Institut, (Sweden's Meteorological and Hydrological Institute – SMHI), Rossby Centre and Oceanography research group

Department of Meteorology, **Stockholm University** (MISU)

Department of Earth and Ecosystem Sciences, **Lund University**

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RALF DÖSCHER, oceanographer and Arctic climate researcher, is coordinating ADSIMNOR and is involved in developing coupled climate models. After a dissertation at the University of Kiel, postdoctoral work at the Alfred Wegener Institute for Polar Research (AWI) and the University of Washington, he turned to Rossby Centre/SMHI were he has been responsible for several EU projects. He co-coordinated EU-DAMOCLES.

SMHI

LUND UNIVERSITY

Abisko Research Station