Nordic Working Paper

Downscaling climate projections – towards better adaptation strategies in the Nordic countries

Report from a workshop organized by the Nordic Council of Ministers on
20 November 2020

This working paper was funded by the Nordic Council of Ministers.
However, the content does not necessarily reflect the Nordic Council
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NA2021:901
ISSN 2311-0562
<http://dx.doi.org/10.6027/NA2021-901>

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Summary

On 20 November 2020 the Nordic Council of Ministers' Working Group on Climate and Air (NKL) arranged a digital workshop focusing on downscaling of climate projections, different user needs and the implications for climate adaptation. The aim of the workshop was to explore the user needs and enhance the science-policy interface with regard to climate modelling and climate adaptation in the Nordic countries. In total, the workshop gathered 32 participants from all Nordic countries, representing national authorities, research institutes and other organisations from both the scientific and policy level. The participants concluded that Nordic co-operation on downscaling of climate models is essential. Enhanced communication between producers of climate models and end users is needed, and different types of co-creation processes should be developed.

1. Introduction

Climate models help us to better understand how the climate changes on different time scales. The models also reflect the causes of changes, including natural variability and human influence, and are often used to predict future climate conditions. Climate models are also important from the climate adaptation perspective. Access to reliable, relevant and up-to-date climate data and models would promote the development of strategies for adaptation to climate change. For instance, better predictions of unexpected and heavy rainfalls could make it easier to prepare and launch counteractive measures to protect vulnerable infrastructure and peoples' health. Recently, the importance of information of high local resolution for modelling has been demonstrated. *Convection-permitting climate models* provide a tool to improve the quality of simulations of phenomena not resolved in climate models with coarser resolutions.

The national weather services in Denmark, Finland, Norway and Sweden have initiated a research collaboration to further develop and apply high-resolution regional climate models. The co-operation in the framework of HCLIM¹ builds on the numerical weather prediction model used operational in these countries. The HCLIM model has so far been used for downscaling a global reanalysis and 20-year time slices from two global climate model projections to 3 km resolution.

It is still necessary to better understand the potentials and limitations of models for downscaling of climate projections. At the same time, it is crucial to improve the dialogue between researchers producing climate information, and policymakers working with climate adaptation. Looking more in depth into various user needs could bring valuable insights not only for collaboration on climate

modelling, but also for adaptation work at various geographical scales.

On 20 November 2020 the Nordic Council of Ministers' Working Group on Climate and Air (NKL) arranged a digital workshop focusing on downscaling of climate projections, different user needs and the implications for climate adaptation. The aim of the workshop was to explore the user needs and enhance the science-policy interface with regard to climate modelling and climate adaptation in the Nordic countries. In total, the workshop gathered 32 participants from all Nordic countries, representing national authorities, research institutes and other organisations from both scientific and policy level. The issues raised in the first sessions were elaborated on in the second, more interactive part with discussions in five break-out groups and a concluding session in plenary (Annex 1, workshop programme). This report summarizes the three main presentations of the workshop and conclusions of the discussions in the break-out groups.

2. User needs

What are the user needs – a Norwegian perspective

Aurora Stenmark, Norwegian Environment Agency

In Norway, the report "**Climate in Norway 2100 – a knowledge base for climate adaptation**" was published in 2015. The report summarizes the historical development of the climate in Norway as well as projections of the future climate. A few years earlier the Norwegian Centre for Climate Services (NCCS) (<https://www.klimaservicesenter.no/>) was established. NCCS has compiled regional descriptions of the climate, i.e. regional or downscaled climate profiles for each county. The regional climate profiles include useful

¹ <https://www.geosci-model-dev.net/13/1311/2020/gmd-13-1311-2020.pdf>

information for climate adaptation, and are widely used by different groups such as municipalities, regional authorities and governmental agencies. In addition to the regional profiles, NCCS published a report on sea level rise and a special report focusing on Svalbard. Furthermore, the material on climate adaptation includes an online visualization tool. NCCS will issue the next nationwide report on climate in Norway in 2023.

In order to find out more specific user needs the Norwegian Environment Agency (NEA) carried out a survey in 2020. Interviews were made with about 20 national and regional authorities as well as municipalities and other local users of climate data. As a result, specific topics of interest of different user groups could be identified, covering topics like drought, extreme precipitation, wind, wave height, sea level rise, snow cover, avalanches, landslides and storm surges. Many of the interviewed people expressed their interest in similar types of topics or phenomena. However, some of the topics had not been highlighted earlier, such as water temperatures in rivers and lakes, the number of zero degree crossings wintertime as well as combined impacts of strong rain and wind. The survey also revealed that different users need different type of local information. For instance, local municipalities were often interested in extreme weather events on the local level whereas people working in the agriculture sector rather preferred climate data and predictions related to specific vegetation zones. People working with biodiversity were more interested in an ecosystem approach, having for instance focus on certain nature types like wetlands and forests. The survey also demonstrated the need to communicate climate information in a transparent and clearly understandable manner. Some of the users would like to have specific layers depicting climate data integrated into maps already in use. The web site of NCCS is an important source of information.

Downscaling of low emissions scenario (RCP 2.6) will be possible, in line with the goals of the Paris agreement. It is not yet clear what scenarios, especially in the high emission end, will be relevant for downscaling.

Discussion:

A part of the results of "Climate in Norway 2100" builds on results generated by modelling done outside Norway. One participant asked whether the data would be available also in 2023. Norway will start working with an extended ensemble from CMIP5 (In the last round only 10 EURO-CORDEX simulations were available). For CMIP6 Norway will use empirical statistical downscaling. EURO-CORDEX will probably deliver some simulations as well also in 2023.

Another question focused on the regulatory needs, i.e. whether there is a regulatory framework in place allowing or requiring downscaling. The situation depends on the country but one conclusion was, that there usually is a framework. Municipalities are probably facing the biggest challenges as the planning regulations in some cases may be insufficient to react on the needs, for instance regarding sea level rise and storms.

The question of the knowledge base and needs of different local users was discussed. The amount and quality of data have improved. However, for instance in Norway, one bottleneck is how to reach all the relevant users, and especially those that would need very local information. There may also be some challenges in understanding the data, and to use it as a basis for decision-making.

Link to a project funded by European Union Civil Protection:

<http://fmispace.fmi.fi/index.php?id=tamir>

Some reflections on climate knowledge transfer and the impact of climate model resolution

Jonas Olsson, Swedish Meteorological and Hydrological Institute

Transfer of climate knowledge

The flow of information or transfer of climate knowledge from the producers of raw data to the actual end users could be expressed as a “value chain”, linking different users. Raw data, big data or the outputs of climate models could be regarded as the first link in the chain. As the following step, the first users, generally well informed about climate modelling, develop and apply specific impact models, for instance related to air, sea level and hydrology. In the next phase, intermediate users analyze and interpret the results from these models for different, often strategic purposes. Ministries and governmental agencies are examples of intermediate users that use the results to provide background and support for political decision makers. Media and for instance regional authorities are also important users but still not actual end users. The last link in the chain are the end users, i.e. people for instance working in planning offices of municipalities, rural advisers, companies etc. The end users do by definition not transfer the data any further but use it directly for decision-making related to their services.

In many processes (and projects) we make shortcuts from the first users to the end users. Disregarding the intermediate users and only having a direct co-operation between the both ends of the chain may involve some risks with regard to the outcome. For instance, there is a risk that the information or tools developed become too tailored, i.e. too difficult for other end users to understand and use practically. One possible way to avoid this problem is to include “independent” end users in the process.

There is a wide range of users involved in the transfer of climate knowledge, from first to end users. This should be taken better into account

when designing research and development projects.

Case: Pluvial flooding

Predictions of pluvial flooding, i.e. flooding caused by local and high-intensity rainfall with a short duration, would highly benefit from climate models with a higher resolution. For instance, a heavy rainfall in August 2014 caused substantial damage to infrastructure in Malmö. The damage was a direct consequence of the considerable small-scale variability of the extreme rainfall, peaking in the morning hours. This type of small-scale variability is not properly reflected in the (relatively speaking) coarse-resolution regional climate models used so far, and therefore the climate impacts on e.g. urban flooding are highly uncertain. Until approx. five years ago, a grid of 50 x 50 km was generally used for regional climate projections. Today, EuroCORDEX with a grid of 12 x 12 km is largely in use. However, the convection-permitting climate modelling (CPM) with a grid of 3 x 3 km would enable more precise projections of local short-duration rainfall extremes and their consequences. The Swedish Meteorological and Hydrological Institute is at the moment using a national hydrological model S-HYPE with a resolution very close to the one used applied in convection-permitting climate modelling. Adaptation to flooding is critically dependent on reaching the resolution of CPMs.

Discussion

Before climate model outputs are used in subsequent impact models, it is generally required to bias adjust the outputs, to reduce systematic errors. One question concerned to which degree bias adjustment of regional climate model are scalable, i.e. can methods applied on for example 50 x 50 km resolution also be applied on 3 x 3 km resolution. This depends on the bias adjustment method used and its assumptions. For example, some

methods assume certain probability distributions, which may only be valid for a certain resolution. However, currently multi-resolution methods are being developed.

3. Convection-permitting climate modelling

Convection-permitting climate modelling in the Nordic countries

Andreas Dobler, Norwegian Meteorological Institute

Atmospheric convection is a phenomenon caused by differences in air pressure and subsequent transport of air. For instance, on summer days the air over land is often warmer than the air over sea, and as warm air rises and cold air sinks, this leads to a vertical transport of heat and moisture. Convection in the atmosphere becomes visible as towering clouds, and can cause thunderstorms, heavy rainfall, hail showers and tornadoes.

There are two methods of downscaling, dynamical downscaling and statistical downscaling. Nowadays the methods are applied in a complementary manner. The models work with grid cells. On a regional scale, and for instance in Europe, the length of the grid is usually approx. 12 kilometres. Convection occurs on a smaller scale, and model cells therefore need to be smaller, usually having a length of approx. 5 kilometres. Convection-permitting climate models reduce the degree of uncertainty in the projections. An example from Sweden illustrates this – global models could only provide a coarse prediction of extreme precipitation whereas convection-permitting climate models produced results much closer to the actual observations. Models with a resolution of approx. 12 kilometres, i.e. regional models, can provide rather accurate projections of for instance seasonal mean precipitation and precipitation intensity in

wintertime. Extreme rainfalls, severe wind gusts and the intensity and duration of summertime rainfall can only be predicted using convection-permitting climate models. Higher resolution may also be required regarding phenomena like fog, hail showers and lightning.

Nordic Convection Permitting Climate Projections (NorCP) is a collaboration of the four national meteorological institutes in Denmark, Finland, Norway and Sweden. It is coordinated by SMHI. NorCP is part of a larger consortium that develops HARMONIE as a climate model (HCLIM). HARMONIE is a model providing weather forecasts to many European regions. HCLIM – NorCP focuses on the development of the HCLIM model, provides high-resolution data for the Nordic region, and studies the science behind the models. The collaboration has carried out several simulations covering almost 200 years. Data produced by NorCP will for instance be utilized in “Climate in Norway 2100” (2023) and the Danish Climate Atlas (2021). The data has also for instance been used for predictions of insect outbreaks in Norway and as support for urban planning. It is also used for impact modelling. It would not be possible to carry out the modelling at one single institution, i.e. Nordic co-operation has made it possible to share resources including computer resources and data facilities. However, simulations covering larger geographical areas and long time periods are very demanding in terms of resources, and the data also has to be converted to an understandable format for different type of users. Funding is also a big challenge, for instance when it comes to downscaling of global projections.

Discussion:

One participant raised the question whether other research groups in Europe working on regional models could contribute to the modelling of the Nordic countries. The overall view was that this is not likely to happen.

Another question pointed at the challenge of securing a continuity in the modelling work. At the moment, much of the funding is based on project funding. One possibility could be to create a Nordic consortium. It also seems like there are many other Nordic co-operation networks in related fields, such as the Nordic Framework for Climate Services, and it would be important to create and maintain a forum for exchange of views on research topics and modelling.

Link to the article "Benefits and added value of convection-permitting climate modeling over Fenno-Scandinavia"

<https://link.springer.com/article/10.1007/s00382-020-05359-3>

4. Do user needs and climate modelling meet?

In the second part of the workshop the participants continued the discussions in five break-out groups. The starting point for the discussion was the question: *which question or challenge do you find as most important to elaborate on with regard to convection-permitting climate modelling ?* Participants representing the climate modelling community and policymakers exchanged information and views on ongoing work and the interface between science and policy. Some main conclusions were drawn from the discussions:

- Nordic co-operation on downscaling of climate models is essential. In fact, the Nordic countries are at the moment paving the way even globally, and we have to make use of this opportunity. Co-operation is crucial, as for example the computational power is limited, and co-operation enables us to make simulations and projections that otherwise would not be possible for a

single organisation or country. However, the long-term funding is a challenge.

- There is still a discrepancy between the user needs and the predictions produced by climate modellers. Users often ask for predictions on a rather local scale, and end users would need as few scenarios as possible to make practical decisions on adaptation measures. Sometimes, the end users do not have the background or capacity to ask for projections that are actually needed. It is also important to recognise that more detailed projections doesn't necessarily mean greater accuracy. This underlines the need for *enhanced communication* between the producers of climate models and various users. The projections should be translated to the users, and we should communicate clearly what information the models actually produce. However, we should also consider the needs of different users, eg. how to design products that are needed by the end users. Robust platforms for communication and decision-making are needed. One important step could be to identify the users more in detail. Lastly, we also have to accept that uncertainty is a part of the process.
- In communication, there is no single recipe for success. However, different co-creation processes are probably a key to better understanding between producers and users. We need to include users early in the process, but also for instance build connections between different communities of climate modellers. The production of the Climate Atlas in Denmark is one example of a process, where stakeholder involvement has been successful, and also generated funding and future research.

Annex 1. Programme of the Nordic workshop on 20 November 2020

PART 1		
10.00 - 10.15	Welcome words and introduction by Ministry of the Environment, Finland	Juhani Damski , <i>Permanent Secretary</i> Kaarle Kupiainen , <i>Chairman of the Nordic Working Group on Climate and Air (NKL)</i> Bo Storränk , <i>facilitator of the workshop</i>
10.15 - 11.00	Climate modelling and climate adaptation – do they meet?	What are the user needs? Presentations from the Nordic countries – the challenge of linking policy and science. Aurora Stenmark <i>Norwegian Environment Agency</i> Jonas Olsson <i>Swedish Meteorological and Hydrological Institute SMHI</i>
11.00 - 11.30	Convection-permitting climate modelling in the Nordic countries	State-of-the-art presentation: introduction to the concept of convection-permitting climate modelling, ongoing research and some of the main methodological and institutional challenges Andreas Dobler <i>Norwegian Meteorological Institute</i>
11.30-11.45	Questions and comments	All participants

11.45-12.30 LUNCH BREAK

PART 2		
12:30-13.15	Introduction to part 2 of the workshop Discussions in break-out groups	Bo Storränk 5 groups
13.15-13.55	Presentations and discussions in plenary	by each group and all participants
13:55-14.00	Concluding remarks	Kirsi Mäkinen <i>Ministry of Agriculture and Forestry, Finland</i>