The Research Council of Norway

Norwegian climate research

An evaluation

Evaluation
Division for Energy, Resources and the Environment

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The Research Council of Norway
P.O.Box 2700 St. Hanshaugen
N–0131 OSLO

Telephone: +47 22 03 70 00
Telefax: +47 22 03 70 01
post@rcn.no
www.rcn.no

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Preface from the Research Council of Norway

Climate change is one of the greatest social, economic and environmental challenges of our time. Human activity is causing the climate to change, and our actions now will have impacts centuries into the future. The challenges are many and they are transnational. They cannot be solved by individual countries alone, but require a joint long-term effort. Norway has both the responsibility and the opportunity to make a significant contribution to the global community through the national and international development of climate knowledge and expertise.

We know that excellent work is being done in many areas of Norwegian climate research, but the knowledge needs are still many, and we need sound and solid research to help us become even better and to set the right priorities for the future.

This evaluation provides a critical review of Norwegian climate research in an international perspective and recommends measures to enhance the quality, efficiency and relevance of future climate research.

The evaluation does not review single institutions, but rather the total picture of Norwegian climate research. It provides an updated analysis of Norway's capacity and research needs and the ways in which Norway can contribute to the global effort against climate change.

Climate research extends across a wide range of subject areas, and an overall evaluation of these areas comprises more than the sum of the individual disciplines. Evaluating climate research requires a substantial multi- and interdisciplinary focus. This has been an enormous, complex task, and the Research Council of Norway would like to thank the nine members of the Evaluation Committee and the secretariat for their comprehensive efforts. Within a limited time frame, the Committee has delivered a sound, impressive report, with important conclusions and recommendations. These recommendations will be essential inputs to the Research Council of Norway's strategy for organizing future climate research.

The Research Council would also like to thank the 78 participating research units for their contributions to facts and information. The Committee has been totally dependent on the research units' involvement in compiling a comprehensive and reliable report. The Research Council appreciates their time, interest and contributions.

Oslo, Norway, June 2012

Fridtjof Unander
Executive Director
Division for Energy, Resources and the Environment

Executive Summary

Introduction
In early 2011, the Norwegian Research Council (RCN) appointed a committee to review Norwegian climate research. The aim of the evaluation was to provide a critical review of Norwegian climate research in an international perspective and to recommend measures to enhance the quality, efficiency and relevance of future climate research.

The Evaluation Committee met three times: in August and December 2011, and March 2012. RCN sent an invitation to 140 research organisations to participate by delivering background information on their climate research. Based on the initial response, 48 research units were invited to submit self-assessments and 37 research units responded. These were invited to hearings during the second meeting of the Evaluation Committee in December. In our judgement, a great majority of the most active research units are covered by this evaluation report. It should be emphasised that the evaluation concerned the Norwegian landscape of climate research rather than individual scientists or research units.

Bibliometric analyses and social network analyses provided additional information. We are aware of problems in making comparisons across disciplinary publishing traditions, especially with regard to the differences between the natural and social sciences and the humanities. The Evaluation Committee also reviewed a number of governmental and RCN policy documents and conducted interviews with the chairs of the NORKLIMA Programme Steering Board and the Norwegian IPY Committee, as well as with staff members of RCN.

Additional information was received from hearings organised by RCN with the science communities and various stakeholders in January 2012.

For the purpose of this evaluation, climate research was divided into three broad thematic areas:

1. The climate system and climate change: research on climate variability and change in order to improve our capability of understanding climate and of projecting climate change for different time scales with reduced uncertainty and increased spatial detail. Advances will provide climate information for national and international decision making. The focus is on physical, chemical and biological processes in the atmospheric, oceanic, terrestrial, and cryospheric systems that are relevant to the climate system.
2. The impacts of, and adaptation to, climate change and variability: insights into the impacts of climate change and variability on the natural environment and on society; i.e. research on how species and ecosystems will be affected and on how society will be affected through changes in food production, water availability, health, etc.
3. Institutions and instruments for response to climate change: research on national and international climate policy, institutions (norms, principles, organisations, strategies, measures and instruments) for reducing greenhouse gases and adapting to climate change. Analysis of how societal relations at multiple levels of governance need to change in order to deal with climate change. This includes issues related to economic growth and poverty reduction, migration, changes in the attitudes and behaviour of the population etc.

The Norwegian climate research landscape

Norway has developed internationally recognized top competencies in many of the scientific disciplines that are necessary for understanding the current climate and its development. In particular the comprehensive numerical climate and Earth system models are highly regarded. Norwegian climate research is in harmony with the mainstream of international climate science. However, more effort is needed to understand natural climate variability in order to better quantify the uncertainty in predicting future climate.

Norwegian scientists have successfully addressed the impacts of climate change on Norway's natural resource base. High quality research is being pursued, but there is a gap in research on climate change adaptation and ecosystem services. Opportunities to expand monitoring capacity have been investigated but need to be realized and should be tied in part to monitoring the changes in the capacity of biotic systems to continue to deliver crucial ecosystem services. Climate change research must also be more closely aligned with research on other global changes that may either mitigate or exacerbate the impacts of climate change when the latter are considered in isolation.

There is relatively little research on institutions and instruments for response to climate change, but it is very influential. It is important that this area of research not will be reduced to only an instrumental vision of how to address the various drivers of climate change, but that it makes space for critical and innovative thinking as well. The research arena is fragmented into small projects and a diversity of funders and there has been no attempt to collate results into a meta-analysis that adds up to more than the sum of the individual projects. This also means that there have only been limited opportunities to reflect on the big picture issues: the architecture of climate governance from the local to the global levels and how best to create a green, sustainable and equitable society over the same range of levels.

There are some excellent examples of integrated research that spans all themes, but the overall balance of research in the Norwegian landscape still has gaps and areas of relative weakness: e.g. the social sciences in general and research on adaptation to climate change. The engineering aspect of mitigation and disaster risk reduction also seem to require further study. Integration across all themes will have to go beyond the three traditional themes of climate system science, impacts of and adaptation to climate change, and response. It should be emphasised that interdisciplinary research is resource intensive and requires longer time horizons than monodisciplinary research, given the necessity of developing interdisciplinary understanding.

The number of Norwegian climate research papers is high: Norway produced the highest number of climate research papers per capita in the world. Over the last decade, an increased interest in climate research has triggered an increase in research articles on climate that vastly exceeds the increase in articles on other scientific topics, and this research spans many scientific disciplines and sub-fields. Norwegian scientists have also played important roles in international assessments, such as the IPCC. The impact of Norwegian climate research publications demonstrates a high visibility in the international research community. Norway has some very strong university departments and research institutes specialized in climate research and related issues, but many of its other research institutes has co-authored only a few climate research articles. This may imply a strong fragmentation of the research system. External funding for climate research came primarily from RCN, other national grants, Nordic sources and EU Framework Programmes. Of all external funding, 89 per cent came from Norwegian sources, with 74 per cent from RCN. The most important RCN activities in terms

of funding climate research were NORKLIMA, IPY, and the basic funding of research institutes.
Nordic programmes provided also important financial support: the Nordic Centres of Excellence funded by NordForsk and the Top-level Research Initiative (TRI). The most important EU FP6 programme was 'Sustainable development, global change and ecosystems' which provided about half of the funding volume, and the most important FP7 the programme was "Environment, (including climate change)".

Strategic focus of Norwegian climate research
The overall priority areas for Norwegian climate research can be summarized as follows:

- an improved knowledge of the climate system, including the development of climate scenarios with reduced uncertainty and a greater degree of detail, and an increased understanding of the Arctic climate;
- research on the consequences of, and adaptation to, climate change for nature and society, including public policy and technology;
- research on the development and implementation of policies and instruments to reduce greenhouse gas emissions, including research into behavioural changes for reduction of emissions.

The large scale Programme on Climate Change and Impacts in Norway (NORKLIMA; 2004-2013) has been a primary driver of climate research for almost a decade, with total funding of 721.6 MNOK. The objective was 'to generate vital new knowledge on the climate system, its past, present and future trends, and the direct and indirect impacts of climate change on environment and society in order to generate a new knowledge base to guide our adaptive response to these changes'.

The scientific focus of NORKLIMA was adjusted and steered throughout the lifetime of the programme with a higher proportion of social science towards the end. This was intentional and accomplished by issuing multiple funding calls. Partly as a result of and partly through a shortfall in anticipated funding, none of the programme elements of NORKLIMA were evenly funded throughout the course of the programme, and there was less continuity between the main themes of the programme than might have been envisaged. Though intended as a 10-year programme, NORKLIMA was not a long programme from the viewpoint of scientists.

The International Polar Year (IPY), which ended in 2009, was a major international research effort and represented about a 50% increase in the global funding of polar science. The Norwegian IPY programme was special in its 4-year span, its bi-polar scope, its built-in emphasis on outreach, and the resources devoted to it, and a synthesis phase has already been completed.

In the years 2006–2009, the Norwegian government issued several important policy documents that give high priority to climate change research. In particular, the Klima21 recommendations are still highly valid though poorly addressed in climate change research priorities.

Parallel to the Government's climate policy development, RCN has responded by developing a number of plans and including climate research in its annual budget requests to the Government. The overall picture is one of high expectations and well-developed plans for meeting the identified research needs, but the actual budget allocations have not met those

expectations. To date, few of the stated research priorities and needs have been adequately met, and much remains to be done.

NORKLIMA/IPY should be followed by a major new research programme taking into account the recommendations of KLIMA 21, which were developed in a fruitful dialogue with the Norwegian scientific community, and the accomplishments of NORKLIMA itself, once these have been properly assessed in a thorough synthesis phase.

Research partnerships

Nordic Centres of Excellence partners further strengthen Nordic climate change research and increase the international visibility of the Nordic research in global arenas. Therefore, it is also beneficial to Norwegian climate change researchers to participate in these Nordic activities. It is important that the research groups participating in joint Nordic research are supported with sufficient national co-funding. Although the research collaboration at the Nordic level is extensive, it is noteworthy that Nordic collaboration on research infrastructure is relatively poorly developed.

Norwegian scientists are actively participating in European collaboration, particularly though European Commission projects. Solid, national long-term base-funding and sensible national co-funding, e.g. for EC projects, are essential tools for a successful international research collaboration. Norwegian researchers have a history of important international publishing collaboration with many countries.

There is a willingness and motivation to collaborate internationally, and this includes developing and emerging countries. However, the projects in the NORKLIMA programme had only sporadic collaboration with developing countries, mainly supported by bi-lateral projects. RCN and Norad should explore mechanisms to increase the funding for climate research collaboration with developing countries.

There has been significant participation of Norwegian scientists in the international climate science assessments of IPCC and the Arctic Climate Impact Assessments.

Relevance of Norwegian climate research

On the whole, the research units in the Norwegian climate landscape are addressing research topics that are highly relevant for practitioners, programme planners, and policy-makers. To ensure effective communication with these users, RCN and the research institutions should provide sufficient support and guidance, and the research groups and individuals should prioritise communication as part of the research process. With few exceptions the universities and institutes lack professional communication expertise, and communication activities are often still seen as voluntary even if they are part of the mandate.

There is a growing need for the communication of scientific results, adapted to the audience in question. Good communication requires an appropriate level of resources and forethought. Dedicated funding of communication activities by the RCN should be seen as an integral part of achieving research outcomes, rather than as a separate activity.

A Global Framework for Climate Services (GFCS) has been established to promote climate services around the world. KLIMA-21 proposed the establishment of a Norwegian National Climate Service Centre (NCSC). With the broad range, unusual nature and high societal importance of climate issues in Norway, the Norwegian experience in the provision,

development and application of climate services is likely to provide unique examples and case-studies in an international context.

Recommendations

RCN has played a major role in stimulating Norwegian climate research, and research on climate issues has been funded by many RCN programmes. NORKLIMA and IPY have played an especially important role in funding dedicated climate research covering a wide range of scientific disciplines. However, NORKLIMA has been a funding programme rather than a research programme with (so far) a lack of adequate synthesis. On the other hand, as an important component of a major international effort on polar research, IPY has been a research programme with both national and international synthesis efforts. Energy and climate issues are very closely connected, and it is important that RCN provide mechanisms to enable energy and climate research to be mutually supportive, if financed through different RCN programmes. Based on our evaluation, we make six major recommendations and provide suggestions for how these might be implemented.

1. Establish a clear and coherent national strategy for climate research and its funding.
2. The Research Council of Norway should develop a new integrated long-term climate research programme.
3. Build on strengths and develop capacities in areas where Norway currently lacks sufficient scientific expertise.
4. Ensure societal relevance as well as inter- and transdisciplinarity in research.
5. Emphasise collaboration and cooperation as a basis for successful climate research.
6. Prioritise outreach and stakeholder interaction

1 Introduction

The evaluation of Norwegian climate research was initiated by the Research Council of Norway (RCN) in the spring of 2011. As defined in its mandate, the objective of the evaluation was "to assess Norwegian climate research in relation to research quality and capacity, strategic focus, communication and interaction, and relevance to society, and … to make recommendations regarding particular areas where Norway has special interests and needs but lacks sufficient capacity or expertise". In general, the evaluation covers the period 2001 to 2010, but with more emphasis on the second part of this period.

The appointed international Evaluation Committee started its work in July 2011. In the following sections, the evaluation process, the evaluation tasks and the main data sources are presented.

1.1 The Evaluation Committee and the Evaluation Process

The Evaluation Committee consisted of:

- Thomas Rosswall, Professor emeritus, France (chair)
- Michelle Colley, Senior Manager, ICF International, Canada
- Bob Dickson, Professor emeritus, CEFAS Lowestoft Laboratory, UK
- Katarina Eckerberg, Professor, Umeå University, Sweden
- Eigil Friis-Christensen, Professor emeritus, Technical University of Denmark, Denmark
- Joyeeta Gupta, Professor, VU University Amsterdam, The Netherlands
- Gordon McBean, Professor, University of Western Ontario, Canada
- Harold Mooney, Professor, Stanford University, USA
- Sanna Sorvari, Dr, Finnish Meteorological Institute, Finland

Antje Klitkou at the Nordic Institute for Studies in Innovation, Research and Education (NIFU) served as the secretary of the Evaluation Committee. Malin Lemberget Lund and Camilla Schreiner coordinated the project on behalf of RCN, with supported from Gørill Kristiansen and Herman Farbrot.

The Evaluation Committee had its first meeting in August 2011. As a result of this meeting the mandate of the evaluation was revised by RCN in October 2011 (Appendix 1.1). The second meeting was in December 2011 and included hearings with a selection of research institutions. The final meeting was in March 2012. In between these meetings the Evaluation Committee had several virtual conferences.

Before the publication of the report was published, a draft version was sent to all of the research units that participated in the evaluation for comments on factual matters.

1.2 The Evaluation Tasks

The mandate for the evaluation included a definition of the climate research that was to be covered by the evaluation:

"Climate research may be defined as research that is relevant in the long and short term, and at the global, regional and local levels, for predicting climate change and the impacts of these changes on the natural environment and society, and for identifying measures for adapting to climate change and reducing greenhouse gas emissions.

For the purpose of this evaluation, climate research was divided into three thematic areas:

- The climate system and climate change: Research into climate variability and change in order to improve capability in understanding climate and in projecting climate change for different time scales with reduced uncertainty and increased spatial detail. Advances will provide climate information for decision making in a national and international context. Focus is on physical, chemical and biological processes in the atmospheric, oceanic, terrestrial and cryospheric systems that are relevant for the climate system.
- Impacts of, and adaptation to, climate change and variability: Insights into the impacts of climate change and variability on the natural environment and society, i.e. research into how species and ecosystems will be affected and how society will be affected through changes in food production, water availability, health, etc.
- Institutions and instruments for response to climate change: Research on national and international climate policy, institutions (norms, principles, organisations, strategies, measures and instruments) for reducing greenhouse gases and adapting to climate change. Analysis of how societal relations at multiple levels of governance need to change in order to deal with climate change. This includes issues related to economic growth and poverty reduction, migration, changes in attitudes and behaviour of the population etc.

The above classification of thematic areas follows the classification by the Intergovernmental Panel on Climate Change (IPCC), but leads to some overlaps and challenges. However, this seemed to the evaluation committee to be the best of many choices.

The mandate also specified four topics to be addressed by the evaluation.

1. Research quality and capacity
    - Norway's contribution to advancing the research front;
    - The quality of Norwegian research groups in an international context;
    - Publication activity and scores on research quality indicators;
    - Basic and applied research, multi- and interdisciplinary research;
    - Capacity related to recruitment, infrastructure, investment, etc.
2. Strategic focus and interaction
    - Distribution of tasks, interaction and coordination between national instruments for climate research, both within and outside of the Research Council (large-scale programmes, action-oriented programmes, support for independent projects, infrastructure, independent research institutes, centres under the Centres of Excellence (SFF), Centres for Environment-friendly Energy Research (FME) and other schemes, other centres, etc.);

- Interaction between Norwegian and international instruments for climate research, e.g. in the Arctic Council countries, the Nordic countries and the EU.

3. The players involved in climate research – participation, communication and cooperation
    - National researcher cooperation and Norwegian participation in researcher cooperation in bilateral, Nordic, European and global arenas;
    - Interaction between national players, such as the Research Council, government ministries, agencies, directorates and research groups. Relevant players that are not mobilised;
    - Dissemination of knowledge to the public administration, industry players and participants in society at large.
4. Relevance to the challenges to society
    - Relevance of research for Norwegian and international climate policy priorities in light of what the evaluation committee views as key challenges in climate research and knowledge needs of industry players and others in society.

We considered these topics in our evaluation and our findings are presented in this report. However, we did not have an opportunity to explore "Interaction among national players, such as the Research Council, government ministries, agencies, directorates and research groups" as it relates to the interaction between relevant segments outside RCN and the scientific community. In addition, we did not have the possibility of engaging with the private sector ("industry players"). We were invited to hearings that RCN organised with government ministries, the private sector and other stakeholders in Oslo in March 2012, but unfortunately we were not able to participate in those hearings.

1.3 Data Sources

The evaluation was based on a broad set of data sources.

In September 2011, RCN sent out an invitation to 140 research organisations to participate in the evaluation by delivering background information on their climate research in fact sheets. The invitation to deliver fact sheet information, the outline of the fact sheets and the guidelines are included in the Appendices 1.2–1.4. A total of 78 research units delivered fact sheets (Appendix 1.5). Most of the fact sheets came from university departments (44) and research institutes (29). Four other institutions of higher education and a public agency participated as well. The fact sheet information was analysed by the secretariat. The thematic specialization of the research units was assessed based on this analysis and contributions of the Evaluation Committee.

In October 2011, RCN invited 48 research units (26 university departments and 22 research institutes) to deliver self-assessments and 37 research units responded. The self-assessment form is included in Appendix 1.6. The self-assessment also included a selection of the 5-10 most important international scientific articles. The self-assessments and publication lists gave the main background information for the interviews with the research units (hearings).

In November 2011, RCN invited all research units that had delivered self-assessments to participate in hearings with the Evaluation Committee. In December 2011, the Evaluation Committee had hearings with 39 research units or groups of different research units. The structure of the hearings is summarised in Appendix 1.7. Members also interviewed the chairs of the NORKLIMA Programme Steering Board and the Norwegian IPY Committee. The

hearings and interviews were summarised by the members of the Evaluation Committee and were a main information source for the evaluation report.

In January 2012, the chair of the Evaluation Committee participated in public dialogue meetings organised by RCN with Norwegian climate research groups in Bergen, Oslo, Tromsø and Trondheim. He summarised the experiences from these meetings so as to inform the other members of the Evaluation Committee.

The secretariat performed a bibliometric study of Norwegian climate research and several social network analyses of project collaboration at the national and international level.[1]

The Evaluation Committee had access to a number of policy documents[2] (Arbeiderpartiet at al., 2008; Miljøverndepartementet, 2007; Norwegian Government, 2006, 2009; Styringsgruppen for Klima21, 2010) and RCN reports relevant for assessing the political framework conditions and priorities for Norwegian climate research (RCN, 2007, 2008a, 2008b, 2008c, 2009a, 2009b, 2010, 2011b, 2011c, 2011e, 2011f, 2011g).

RCN provided the Evaluation Committee with data on the funding of Norwegian climate research, especially with regard to RCN's funding schemes, but also to funding under the 7th European Framework Programmes (EU FP7).

1.4 Data Limitations

The information on research funding provided by the research units had certain limitations. There were some differences between the total amount of funding resources for climate research reported by RCN and by the research units. Some research units did not report all funding for the first three years because their accounting system did not support such statistics. In addition, many research units reported projects funded by RCN outside the NORKLIMA programme as 100 per cent climate research, whereas RCN has weighted the share of climate research for projects outside the NORKLIMA programme. Some of them may still be 100 per cent climate research, but many are accounted for at a lower level.

The bibliometric analysis of climate research was based on a selection of core journals and keywords. This combination allowed a better coverage of the highly multidisciplinary research field. However, the selection of keywords and core journals was essential. Whereas the core journals were identified by RCN, the selection of keywords was based on the index of the 4th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007 a-d).

In some cases, it was difficult to distinguish between the three themes that were to be covered by this evaluation, and this also complicated the task of determining the breakdown of funding. Many research units carry out climate research on more than one theme, and the borders between the themes were not clear cut with regard to scientific disciplines. This was an issue in the analysis of the fact sheets (section 2.3), in the hearings (Appendices 1.2 and 1.4) and in the bibliometric analysis (section 2.2).

[1] The bibliometric analysis covered 2001-2010, whereas the fact sheets covered just the last five years and often even less.

[2] The chapter on policy documents cover documents issued in 2006–2010, with the exception of RCN where documents from 2011 were included.

We are certainly aware of the problems with making comparisons across disciplinary publishing traditions. In particular, some of social sciences and humanities frequently publish in journals and formats (e.g. books and book chapters) other than those covered by the ISI data base. Therefore, we urge the readers to interpret the comparative statistics in section 2.2 giving due consideration to this bias. An analysis of a more extended list of keywords covering social science research on climate revealed that social science articles are covered very well in the bibliometric analysis. The differences between the social sciences and the natural sciences can be explained by the different publishing traditions, not by the selection of the sample of articles included in the bibliometric analysis.

This evaluation does not cover all of the Norwegian research units that have been engaged in climate research over the last ten years. Of the 140 invited research units only 78 research units delivered fact sheets. However, we assess that the vast majority of the most active research units are covered by this evaluation report.

2 The Landscape of Norwegian Climate Research

2.1 Thematic Specialization of Norwegian Climate Research

2.1.1 Theme 1 The climate system and climate change

2.1.1.1 Background

The Earth is a complex system and can be divided into different components (atmosphere, biosphere, cryosphere, hydrosphere, lithosphere and recently also the anthroposphere). However, all of the components are strongly interlinked with many concurrent operating processes on a wide range of temporal and spatial scales. In addition, many natural processes are self-organising, giving rise to a high degree of variety and complexity in the system. It is not possible to understand the climate system by simply extrapolating one process or research aspect from the single units of which they are composed. A different approach is needed – a systems approach.

For the climate system, as for any system, the capacity to understand is predicated on the capability to describe. The ability to predict in satisfactory manner is dependent on the capacity to understand and in a scientific sense is a measure of that understanding. Intelligent control or mitigation must be firmly based on an ability to predict. By carefully studying past climate, the basic physical processes, modelling them, and validating the models by observations, new climate knowledge can be achieved. Therefore, the climate research that comes under Theme 1 is crucial for dealing with the research that comes under Theme 2, i.e. concerning the impacts of and adaptation to climate change and variability, and Theme 3, institutions and instruments for mitigation of and adaptation to climate change. On the other hand, there are potential thresholds of change that exceed biospheric resilience and these will need to be given special focus within the Theme 1 activities. In addition, Theme 3 research topics may call for specific investigations within Theme 1.

As concluded in the international evaluation of research on Earth Sciences in Norway (RCN, 2011d), Norway has many strengths in the field of Earth Science, which have been developed from a strong physical and natural science base. This applies in particular to climate research. Norwegian research on the climate system has a long tradition, and over time it has created a broad knowledge base and sound competence in climate research. Long-term investments and talented scientists have helped establish many Norwegian research groups as world leaders in their fields and important players in international climate research arenas. Compared to the other Nordic countries, for example, Norway plays a relatively substantial role in the preparation of the IPCC reports (see Table 4.5.1).

Norwegian climate researchers and research groups are typically strong in the field of marine research and oceanography, climate modelling, paleoclimatology, high latitude/polar research, atmospheric sciences, etc. and in recent years the fields of integrating process studies, modelling and theoretical work and system analyses have been added to this impressive list.

19 research units conducting research under Theme 1 submitted fact sheets, and 17 of these units were interviewed by the evaluation committee. The list of research units that indicated they were performing research in Theme 1 includes: the Norwegian Computing Centre, the Geological Survey of Norway (NGU), the Norwegian Meteorological Institute, the Bjerknes Centre for Climate Research partners (UiB – the Geophysical Institute, UiB – the Uni Bjerknes Centre, the Institute of Marine Research, the NERCS Nansen Centre), the Norwegian Polar Institute, the NVE Research Group, UiB – the Dept. of Biology, UiB – the Dept. of Earth Sciences, UiO – the Dept. of Geosciences, UNIS Biology, UNIS Geology, CICERO, NILU, NTNU – the Dept. of Geography, UMB – IMT.

As reported in the fact sheets, the amount of RCN research funding under Theme 1 came to about 56.5 MNOK in 2006 (18 per cent of the total RCN climate research funding) and 98.6 MNOK in 2010 (17 per cent). When Themes 1 and 2 and 1, 2 and 3 are included, the funding amounted to 270.7 MNOK in 2006 (88 per cent of the total RCN climate research funding) and that amount increased to 400.8 MNOK in 2010, i.e. a clear increase in the amount, but a much lower percentage of the total funding (69 per cent).

The bibliometric results for Theme 1 are shown in Figure 2.2.3 and indicate that the research has been widely distributed throughout all of Norway but with two regions, Bergen and Oslo, dominating the picture when it comes to publication activity.

2.1.1.2 Strategic focus and trends

Theme 1 has received stable basic funding over the last five years which has enabled Norwegian research organisations to build competence around their research focus areas. Many research groups have clearly identified their strategic focus areas, and they seem to be in good accordance with competence and national strategic focus. However, especially for small research groups, it is difficult to carry out long-term strategic research that demands a longer funding perspective than the standard 3-year contract from RCN.

There are two regions where most Norwegian scientists related to Theme 1 are located, namely Oslo and Bergen. The Oslo region comprises strong atmospheric research groups, including the Met office, whereas the Bergen school in addition to the atmospheric research plays a strong, internationally leading role in oceanography and paleoclimatology. RCN has been instrumental in encouraging collaboration rather than competition regarding the limited resources for climate research. Collaboration in the use of NORKLIMA funding through RegCLIM, NorCLIM and currently EarthCLIM has been an important factor in the creation and development of a suite of climate models, which form the essential competence at the core of Norwegian climate research, and this collaborative effort seems poised to continue with the further development of the Norwegian Earth System Model (NorESM) and the establishment of a distributed National Climate Service Centre (Section 5.2). Because of the dominant role of RCN in Norwegian research funding and the pre-eminence of NORKLIMA as its primary long-term climate-funding programme, we can sketch out a reasonably complete pattern of national collaboration in climate research solely based on the project collaborations in NORKLIMA (Section 4.1).

In a geographical sense there is a large but natural strategic focus on the Polar/Northern regions (mainly northern Europe and Russia, including Svalbard and Greenland). This is the basic framework for studies in atmospheric and ocean climate processes as well as integration of observations on Earth System modelling, past climate variability, and land surface processes. The strong marine component incorporates operational oceanography, marine microbiology, and chemical oceanography.

The trend in climate research is inevitably connected to the available funding, which in recent years is closely connected to the needs of society and to the political agenda aimed at decreasing the emission of anthropogenic greenhouse gasses. By assessing the magnitude and uncertainty of the various elements contributing to climate change, the IPCC provides a strong guide-line for identifying research areas where additional research may have the largest impact. Klima21, which adheres quite well to the IPCC results, was almost unanimously recommended in the interviews as the preferred direction for future climate research activities (see Section 3.1.3). Consistent with that is the fact that Norway, compared to the number of climate scientists, has acquired a relatively high profile in writing the scientific chapters of the IPCC reports measured in terms of lead authors and coordinating lead authors (see Section 4.4). This complies very well with the increased focus on climate and Earth system models, involving a relatively large number of Norwegian research groups and organisations.

The need for increased infrastructure for monitoring and observations as well as for international cooperation has directed the Norwegian climate research to some extent and will probably do so even more in the near future, in particular because of the continued large uncertainty in the model projections.

2.1.1.3 Capacity: students, personnel, infrastructure, etc

According to the fact sheets, Theme 1 constitutes about 36 per cent of the research personnel in Norwegian climate research, with 11 per cent and 9 per cent more in interdisciplinary research when Themes 1, 2 and 1, 2, 3 are respectively taken together. When measured by the number of researchers specialized in a theme, the largest research units in Theme 1 that we interviewed were: the Norwegian Meteorological Institute (87 researchers), the University of Bergen - Geophysical Institute (45 researchers), the Norwegian Polar Institute (28 researchers), the University of Oslo - Dept. of Geosciences (27 researchers), the Institute of Marine Research (IMR) (22 researchers), the Geological Survey of Norway (NGU) (16 researchers), the Centre for International Climate and Environmental Research – Oslo (CICERO) (13 researchers) and UMB, IMT`s section for geomatics (9 researchers).

Several of the large institutions like the Norwegian Meteorological Institute and the Institute of Marine Research rely on a large infrastructure which facilitates long-term research projects, whereas some of the smaller groups need to cooperate in order to do research at a competitive level.

2.1.1.4 Disciplinary strengths and weaknesses in the landscape

The climate projections of variability and change and the physical understanding of the system are developed by means of climate system models. The climate system is complex with so many interacting processes that projections are not possible without models. On the other hand, it is not possible to model all the physical processes that are involved, in particular because some of the processes take place on scales well below the grid-cell size that is feasible for the available computer power. Furthermore, many of the small-scale processes, for instance those related to the formation of clouds, which are one of the main constituents of the radiative forcing in the atmosphere, need to be better understood before they can be fully incorporated in the numerical models. Therefore some of the physical processes need to be parameterized – a procedure that needs to be validated by real observations.

The Norwegian climate research community is well-suited for carrying out many of the tasks necessary for this effort. It comprises a number of excellent groups that cover many of the necessary disciplines without too much overlap. The Earth System Model (NorESM) is a state-of-the-art enterprise combining various modelling efforts at different institutions in

Norway, and this is a tool that is not only providing a significant contribution to the next IPCC report but that also seems ideal for testing the various physical processes by making predictions that can then be tested by means of atmospheric, terrestrial, and marine observations.

The Norwegian combination of disciplinary expertise in oceanography, paleoclimatology and atmospheric science is an asset that Norway should be proud of. It should be used to improve the capability of the models and to validate the models with new and improved oceanographic observations, which have recently become possible and which have provided new, and in some cases surprising results, that the models are not yet capable of explaining. Norway has the necessary institutions and competence to make systematic observations of relevant atmospheric and oceanographic parameters to compare them with model calculations and thereby help quantify the uncertainty in the model predictions. This also illustrates the need to include in climate research the excellent competence in statistical analysis that is available in the scientific community at large, and which has also been applied, although perhaps not to the extent that it might have been.

The increased consciousness of the importance of natural climate variations has entailed a greater focus on past climate variations as a tool for understanding current climate change. In its scientific community, Norway has leading world experts in paleoclimatology, so using the Norwegian climate models in an attempt to simulate past climate variations may be further pursued.

The strong focus of RCN on supporting all three themes of climate research in a concerted way has obviously had some very valuable impact on the quality and extent of Norwegian climate research at large. For Theme 1, however, the coherent approach may not have attracted adequate attention to those aspects of the climate system that are currently not explained by numerical climate models.

An increased focus on basic research with regard to physical processes in the climate system as expressed in several interviews could possibly improve the models significantly.

2.1.1.5 Attitudes: disciplinary, interdisciplinary, transdisciplinary, national-international

Norwegian climate research rests on a strong disciplinary tradition and competence. Interdisciplinary efforts are necessary in climate science, and attempts by RCN to foster interdisciplinarity by providing funding for specific calls have been made. The establishment of RCN Centres of Excellence has proven to be a successful tool for building strong disciplinary competence while simultaneously enhancing the interdisciplinary research collaboration among research groups.

The establishment of the Bjerknes Centre for Climate Research – now approaching its 10th Anniversary – obviously provides such an opportunity, for it has enjoyed success, although it seems to suffer from lack of a co-location and from bureaucratic delays due to dependence on three different institutions.

The strong competence in Norwegian climate research is also seen in the strong leadership role that Norway plays in international collaborations. Among many new initiatives: 1) following the decision of the World Climate Conference 3 in 2009 to establish a Global Framework for Climate Services (GFCS), a Climate Services Partnership (CSP) was formed at the 1st International Conference on Climate Services (ICCS) in October 2011 in which the proposed Norwegian Climate Service Centre may play an important role; 2) over the past 4

years and for the most part under Norwegian Chairmanship, the Arctic Ocean Sciences Board (AOSB), now Marine WG, of the International Arctic Science Committee (IASC) has developed a series of reports on observing our Northern Seas during the International Polar Year, and these will form the basis for observing polar seas during the 'legacy Phase' of the IPY; 3) in addition to the NERSC outreach initiatives in setting up a Nansen-Zhu Centre in Beijing and the Nansen-Tutu Centre in Cape Town in 2010, and 4) important Norwegian influence in the leadership (Vice-Chair) of the Intergovernmental Oceanographic Commission (IOC) for 2011–13.

2.1.1.6 Future directions

For the research groups evaluated, the main motivation is to better understand the physical processes of the complex climate system. During the last decade, Norway has invested major resources in the research field and important results have been achieved. This has given Norway a prominent international position, in particular in relation to the IPCC. The building and developing of Norwegian climate and Earth system models and the development of climate services gives Norway a unique opportunity as a nation to tackle climate change related challenges.

Although the expressed political needs regarding science results primarily relate to the impact of anthropogenic greenhouse gasses, there is also a need for increased research on the impact of human activity on land cover and land-use change, especially in relation to the albedo and the biogeochemical and hydrological cycles. Furthermore, a good understanding of the climate system cannot be reached without a dedicated effort to understand the contribution to climate change from natural climate processes. The geological history very clearly documents a strong climate forcing associated with solar variability, although the exact mechanism has not been identified. This should call for a coherent international effort, but surprisingly, the worldwide scientific effort to increase our understanding of the natural variations is very limited, and this is most probably related to the limited funding available for basic, not agenda-driven research. Therefore, in addition to implementing the recommendations of Klima21, this committee recommends an increased effort in research on the natural causes of climate change, in particular the activity variations of the sun, the mechanism of cloud formation, and the multi-decadal variations in ocean current systems.

2.1.1.7 Summary of key findings

Largely funded by RCN, Norway has developed internationally recognised top competency in many of the scientific disciplines that are necessary for understanding current climate and its development. In particular, the numerical comprehensive climate and Earth system models are highly regarded. Less effort has been devoted to studying and explaining the natural causes of climate change because these have been regarded as having a relatively minor impact on the climate system and global temperature compared with the effect of man-made greenhouse gasses. In setting priorities, Norwegian climate research is in harmony with the mainstream of international climate science, but, taking into account the strong competencies in a wide spectrum of disciplines, an increased effort to understand the basic natural climate processes could be advantageous for Norwegian climate research.

2.1.2 Theme 2 Impacts of, and adaptation to, climate change and variability

2.1.2.1 Background

The great bulk of climate change science over the past decades has focused on accumulating evidence that climate change is indeed impacting biological systems, and the fourth IPCC

Assessment Report (IPCC, 2007a) concluded that "Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases".

Focusing specifically on high latitudes, an international effort produced a report on "The Impacts of a Warming Arctic" (ACIA, 2006) which concluded that "annual average Arctic temperature has increased at almost twice the rate as that of the rest of the world over the past few decades..". This study embraced the Subarctic in its analysis. The study concluded with the reminder that not only was there impressive climate warming but also, "The increasingly rapid rate of recent climate change poses new challenges to the resilience of Arctic life. In addition to the impacts of climate change, many other stresses often brought about by human activities are simultaneously affecting life in the Arctic, including air and water contamination, overfishing, increasing levels of ultraviolet radiation due to ozone depletion, habitat alteration and pollution due to resource extraction, and increasing pressure on land and resources related to the growing human population in the region. **The sum of these factors threatens to overwhelm the adaptive capacity of arctic populations and ecosystems"** (highlight added)**.**

Most recently, there has been a massive international study to enrich the basic understanding of the natural and physical characteristics of Polar Regions. Norwegian scientists were heavily involved in this International Polar Year (IPY) (Orheim and Ulstein, 2011) as they have been in the studies noted above. The studies specifically directed at global change in biotic systems focused mainly on the impacts of global warming. One study, "Community Adaptation and Vulnerability in the Arctic Regions" or CAVIAR did however focus on human populations. Its results reiterated the conclusions of ACIA and noted, "The research findings indicate that climate change is not necessarily the greatest challenge that communities in northern Norway and northeast Russia need to deal with. It is the interactions between social, political and economic factors, and the fact that their impacts are intensified by climate change, that together require adaptability and determine how vulnerable communities are" (Hovelsrud, 2011). A similar contribution to impacts on human populations and adaptation in the CAVIAR study was devoted to reindeer husbandry and the adaptation of human populations from the ice age to the present.

In sum, there has been a considerable recent investment in research on the Arctic in the larger sense. The great bulk of the climate change research has focused on the drivers of the climate system and on evidence that the climate is changing and that it is having wide-spread impacts on geophysical processes as well as on biotic systems. The scientists from Polar Regions have had a long history of international collaboration in science, and this has increased in recent times. Norwegian scientists have played an important role in all of the activities noted above.

This section, Theme 2, focuses on impacts and adaptation. From the above reports it appears that most work to date has focused on impacts rather than on adaptation. We examine these issues in more detail below for a number of specific Norwegian research entities. In this section, we also introduce a further element of analysis. The documented increasing losses of biotic diversity stimulated an international assessment of the consequences of these losses in terms of the capacity of ecosystems to provide benefits to human well-being; the Millennium Ecosystem Assessment (MA, 2005). The connection is that the functioning of natural and managed ecosystems, results in benefits to society such as food and fibre, as well as erosion control, water purification, climate and disease regulation as well as cultural services relating to wilderness, including recreation. The MA concluded that the capacity of ecosystems to

deliver services had been considerably degraded over the past 50 years. Ecosystem services are thus an important metric to assess because they provide information not only about the impacts of climate change on biotic systems but also information on the consequences of any mitigation or adaptation strategy in dealing with climate change. Any given area can be viewed as providing a bundle of services to society. In viewing the full bundle, assessments can be made about which services will be gained and which will be lost in the production of biofuels, for example. Many services can be valued economically to aid in such decisions. However, the overview of our sample of research units doing impact and adaptation research indicates that virtually nothing is being done in this research area in these units, although it was mentioned as a possible future direction in one unit.

In the following we sketch how a group of Norwegian research programs is addressing the impacts and adaptation to current and projected climate change. These have been reviewed and evaluated in a number of contexts. Most recently, there has been an overview of all Norwegian research in biology, medicine and health (RCN, 2011b,) which looked at the broad sweep of their capacity and accomplishments in these research areas. The present review covers many of the same units, but with a specific focus on climate change. The units covered in this section's analysis represent a broad range of foci: some are very small units and others are extensive in all dimensions. They range from government institutes to university departments, from an applied to a basic science focus, from marine to terrestrial research, and derive from a range of disciplinary foci –in the physical, natural and social sciences. We ask what their main focus is as a unit and how this relates to the study of the impacts of climate change and research on approaches to mitigating and adapting to climate change. What capacity do they have to accomplish their goals, how productive have they been and how is their work viewed by others, both nationally and internationally? We look at outreach and relevance of their work and their future plans.

As will be noted, the research entities that we investigate in relation to climate-change research are predominately working on impacts and to a very much lesser degree on mitigation and adaptation. No doubt this is due to the historical foci of ecological and production research groups that have centred their work in their study of organism/environment interactions on the prime controlling determinant – climate. Thus, climate change impact work is an extension in focus rather than a shift to a new goal. By contrast, mitigation and to a certain extent adaptation research in natural systems, is to a large degree a new direction. This imbalance is hidden to a certain degree by lumping units that are doing research in any one of these areas into a basket called impact (climate effects) and adaptations as described in Section 1.2. of this report. However, when looking at the actual content of the research proposals awarded to NORKLIMA, for example (data not shown), there is very little research on adaptation and mitigation of natural and managed ecosystems, but extensive support for impacts. The current overall RCN research support agenda is augmenting attention to this area across a broad spectrum including agriculture, aquaculture and nature management and also including basic biological adaptive processes such as genetic adaptation (e.g. Bioforsk, UiO, NIVA). Furthermore, there are programmes in agricultural mitigation strategies to reduce greenhouse gas emissions. However, these biotic adaptation and mitigation research efforts only constitute a rather small fraction of the total research support of RCN. No doubt there will be a shift in research emphasis in the future as data accumulate showing the increasing impacts on the distribution and performance of organisms from climate change. The questions about how to mitigate and adapt will become central. The research on the societal adaptive responses to change is discussed in Section 2.1.3 in this report.

2.1.2.2 Strategic foci of the groups dealing with climate impacts and adaptation

The sample groups from Theme 2 include those units dealing only with impacts (or adaptation and mitigation) as well as some having an overlap with the climate system as well as with social responses (Figure 2.2.4). This is a very heterogeneous group. It includes government research laboratories or institutes, national research facilities and university research departments. The institutes cover a broad range of sectors, including production (crops and forests), terrestrial and marine natural systems and monitoring. They include the Norwegian Water Resources and Energy Directorate, the Norwegian Institute for Nature Research (NINA), the Norwegian Institute for Agricultural and Environmental Research, the Institute for Marine Research, the Norwegian Forest and Landscape Institute, and the Norwegian Polar Institute, as well as national (and international) facilities such as the Centre for Plant Research in Controlled Climate, University Centre in Svalbard, the Norwegian Polar Institute and a range of university departments spread throughout the country from Subpolar to Polar regions. Collectively, they cover most of the ecosystems in the country, with some doing only monitoring, but most are research-based and some are entirely so, particularly the institutes, as well as those with teaching and research missions such as the university departments. They differ considerably in the amount of effort they devote to climate change research.

2.1.2.3 Capacity: strengths and weaknesses

Do the research units have the capacity to fulfil their potential for climate-change impact and adaptation research? Climate change research in the area of impacts and adaptation calls upon science that is in part well-developed, such as impact research, but it is also directed toward areas that do not have established protocols, such as adaptation (or mitigation), where new approaches are needed. This has implications for the capacity of the research units to meet the challenges of the future. Some of the units have very small staffs and have neither the means, nor the attractions to recruit new staff. Some of the institutes are mandated to provide basic accounting of natural resource delivery in the country and have limited potential for growth. Strategically then, the issue is how build capacity in the neglected areas of climate change research. In order to build further capacity in the weak areas, there must either be some redirection within the current talent pool or the means for additional recruitment to fulfil these needs. The basic complaint of many of the units is that it is hard to recruit on the basis of new money that is tied to short-term goals, but it is clear that adaptation (and mitigation) will be a research area of increasing importance in the years ahead, particularly in northern regions. Although, as noted, there is existing activity in the social dimensions of adaptation research, there is little activity in the natural and managed systems concerning the use of vegetative feedback to the climate system as well as investigation of the capacity of different species and populations to adapt in place to climate change or their capacity for dispersal to new, more favourable habitats. Some of the forestry researchers think that there is enough variability in the tree crop species under long-term study so that adding new species to the mix will not be necessary in order to adapt the industry to a changing climate. In summary, the breadth and capacity of the research units that exist at present to document the impacts of the climate change that is already occurring are quite strong. What needs more attention is increasing the capacity to meet the climate change challenges of the near future, i.e. adaptation. This is also the conclusion of the Climate Impact Research for a Larger Europe report (CIRCLE, 2008). The new controlled growth facility (Centre for Plant Research in Controlled Climate) should be a big plus in obtaining data for model development of climate change impacts.

For mitigation (see Section 2.1.3 for social responses), the main work being done by natural scientists within Theme 2 is on biofuels, which is a growing element in forestry research.

There appears to be little climate modification scheme research, either by working with technology, or by natural land surface modification.

2.1.2.4 Status

As noted in the self-evaluations of the research output, most of the research units in the climate impact research area produce work of very high quality and of importance to the international climate change research community. Naturally, this is due to the high calibre of the scientists involved, but also the unique facilities that are located in crucial locations for climate change research, where climatic change effects are most notable and where the impacts on habitat types related to permafrost and sea ice are noteworthy. Furthermore, many of the groups have a deep tradition in population studies on major plant types and animal species. This capacity and tradition have meant that they had the foundation for quantifying the impacts of climate change on the distribution of organisms. One of many examples that can be noted is the work carried out in the past by the University of Oslo, where fundamental work on genetic and population responses (terrestrial and marine) to climate has resulted in many high profile publications. One of the most highly cited papers in climate change research by Norwegian scientists resulted from work led by the leader of this group.

Furthermore, Norwegian scientists have had a history of doing experiments in the field that provided information for predicting future impacts. The universities, more than institutes, have predominated by far in the quantity of impact research as noted in Figure 2.2.4. The abundant research in the climate effects area has had a high impact factor (Figure 2.2.7).

2.1.2.5 Future directions

Collectively the Theme 2 research units have ambitious and important strategic plans for future research. For the universities in particular, realizing these plans will depend on the nature of the calls for proposals and the success of these units in getting awards. A flavour of some of the areas that the various research groups would like to pursue can be characterised by the following elements: more research on adaptation and mitigation, exploration of the feasibility of new crops, more work on bio-energy and carbon sequestration (and their ecosystem impacts), improving the dialogue with decision-makers, upgrading field facilities, establishing proposed monitoring systems, improving the capacity for model development of ecosystem responses to climate change, and developing ecosystem-service research projects. All of these are important goals.

2.1.2.6 Summary of key findings

Norway has diverse, extensive, and successful research on the impacts of climate change on its natural resource base. High quality research is being pursued in some of the most critical "hot spots" of climate change. However, the Norwegian climate change research effort could certainly profit from improvement. As noted above, the greatest gap in research is substantial work on adaptation, and any work on ecosystem services. Opportunities to expand monitoring capacity are planned, but need to be realised and can be tied in part to monitoring the changes in the capacity of biotic systems to continue to deliver crucial ecosystem services.

The challenge for the future is to continue to support those areas where there is already considerable strength, but also to find a way to identify the critical gaps and to provide the means to fill them. One possibility is to host an annual or biannual meeting to stimulate the climate change research units to work together to identify research needs and strategies for meeting these needs. This would also serve to develop a more integrated national research programme for climate change in Norway, and to some extent would call upon the research community itself to provide input with regard to setting priorities in the calls for proposals.

Furthermore, as noted previously, there needs to be a mechanism to align climate change research more closely with research on other global changes that are occurring and that may either mitigate or exacerbate the impacts of climate change alone.

2.1.3 Theme 3 Institutions and instruments for response to climate change

2.1.3.1 Background

While the natural scientists working on system Earth have been dealing with issues related to climate change for decades, if not in limited number for more than a century (see Section 2.1.2), social scientists have only much more recently turned their attention to climate change research and to the institutions and instruments needed to deal with the problem of climate change. There are two reasons for this: climate science is not intrinsically a part of the social science agenda, and funding for climate-change-related social science has only emerged in recent years. As a result, social scientists and social science research face a dual challenge: if funding stops they return to their core research areas, and since funding is limited, they often do not have the critical mass to make a difference, so when countries decide to focus resources in their key research areas, social science is the area that gets marginalized. This general experience is also something we witnessed during our analysis of the social science climate change landscape in Norway.

The components of social science research in relation to climate change and in particular, Theme 3, include a range of issues dealing with understanding the anthropogenic drivers of climate change and how these can be addressed as well as the impacts of climate change and how societies can cope with these impacts. These drivers include not only an understanding of the sectors that emit greenhouse gases, but how sectoral emissions are embedded into our production and consumption patterns, and in our definition of how societies develop (e.g. the development paradigm), our ideologies (e.g. neo-liberalism), and our units for defining development (e.g. GDP; HDI). In assessing response strategies, we need to understand technological options, the socio-cultural and psychological issues that influence behaviour, and the options for dealing with this from the local up to the global level. This not only requires social science research, but also closer collaboration between social scientists and natural scientists in understanding how the Earth system actually functions. Research on climate change in the social science field in Norway is of high quality but very marginal in quantity. Eleven groups are active in the field[3]: broadly speaking this includes Statistics Norway (SSB) on statistics applied to energy and climate economics and the Frisch Centre on climate economics, the Centre for International Climate and Environmental Research (CICERO) on economics and politics with some sociology, geography and anthropology, the Fridtjof Nansen Institute (FNI) on politics, the University of Oslo (UiO)/Dept. of Sociology and Human Geography (SHG) on vulnerability, adaptation and transformation, UiO/Natural Resources Law Group (NRL) on national and international legal issues, the Norwegian University of Life Sciences (UMB)/Dept. of Ecology and Natural Resource Management (INA) on forestry and agriculture, UMB/Dept. of International Environment and Development Studies (NORAGRIC) on climate and development, the Institute of Transport Economics (TØI) on transport economics and policy, Sámi University College (SUC) together with the International Centre for Reindeer Husbandry (ICR) on indigenous peoples, and the Western Norway Research Institute (WNRI) on tourism and consumption patterns.

[3] The NIBR and groups at NTNU in Trondheim are also active but not covered as they did not participate in the process. Possibly there are other groups as well, but they have not been covered by the evaluation process. Nevertheless, the groups mentioned here have been the most active in Theme 3.

Theme 3 constitutes about 10 per cent of the research personnel in Norwegian climate research, and a few per cent more in interdisciplinary research when Themes 2 and 3 are taken together. As further described in Section 2.3 (Figure 2.3.10), the amount of RCN research funding to Theme 3 was about 38 MNOK in 2009 (12 per cent of the total RCN climate research funding) and 51 MNOK in 2010 (14 per cent). In terms of publications, only about 700 of the total of 6,450 climate-related publications with Norwegian co-authors in ISI journals came from the social sciences (Appendix 2.2.4). This does not include social science journals that are traditionally not part of the ISI system – e.g. law journals. Furthermore, there were very low numbers of social science research publications till around 2006, when the numbers started to increase (Appendix 2.2.4). The institutions and instruments theme provides about 7.6 per cent of the total number of papers (Figure 2.2.2). It does not do as well as the other areas in terms of citation rates, but has improved to a higher level in recent years (see Figure 2.2.6) (see Chapter 2.2).

2.1.3.2 Strategic focus and trends

The relatively low funding for social science research in climate research in general has entailed that few groups have a strategic research plan that they can execute. In addition, the relatively low funding for free research money entails that researchers cannot develop an independent strategy and then seek resources. At the same time, our experience within research panels shows that free interdisciplinary research money is relatively more difficult to acquire for social scientists because the evaluation system often promotes technological and natural science aspects of climate research in cases where social scientists are in a minority in the review panels. Still, it should be emphasised that several social science groups have benefited from available funding in the former FRIMUF (Free (interdisciplinary) research on environment and development, which merged with FRISAM in 2011).

The dependence on funding entails that their research tends to move to where the money is if there is a fit with disciplinary expertise (TØI, UiO/NRL, FNI). In recent years, NORKLIMA has allocated 30% of its budget to social science research (see Table 3.3.1), but it was seen as being largely geared towards adaptation and inadequately covering mitigation. Research on social science issues within IPY was also very limited (see Section 2.3.1).

The dependence on funding also entails that research institutes find it difficult to prioritise work in international epistemic communities such as IPCC – since there are no dedicated resources for this, and there is no narrow academic value in terms of Impact Factor evaluations (FNI, UiO/SHG). However, there are five convening and lead authors in WG III of IPCC AR5, and that is impressive for a small country (Table 4.5.1). Some of the researchers felt that they did not wish to participate in IPCC despite invitations because of the way such work is evaluated by the academic community.

In terms of coverage, there is a greater focus on local to national issues such as climate change, consumption and tourism issues (WNRI); energy and climate economics (SSB), transport economics and policy in Norway (TØI), and relevant climate policy (FNI).

There is some focus on European issues such as climate change multi-level governance and the effectiveness of instruments and transport economics within the European Union.
At the global level, there is work on climate negotiations and links with other negotiations (CICERO), policy instruments, institutional design and effectiveness of climate governance (CICERO), comparative implementation. multi-level governance (FNI), REDD related forest research (UMB/NORAGRIC and UMB/INA), evaluation of economic instruments and

technological issues (Frisch and CICERO), and the relationship between climate and security (UiO/SHG).

2.1.3.3 Capacity: students, personnel, infrastructure, etc.

Some of these groups are quite substantial and have *critical mass* on their own. Others are small, but in collaboration with related groups acquire critical mass. Still others are very small and vulnerable. Groups with critical mass are SSB (with ca. 20 people), which has core funding for basic research and close links with policymakers, UMB/NORAGRIC, which has successfully raised resources in recent years (with 10 senior staff and 5 PhD students). CICERO and FNI are stable research groups. Statistics Norway (SSB) has critical mass because of the mutual support of the two departments working there on climate change, namely climate economics and energy economics, funded primarily from project money. However, their core funding is focused on social issues. One third of Frisch's budget is spent on climate change and energy, but their work in this field is funding-driven. If the funds dry up, they have no independent source of resources to allow them to continue the work. A smaller group at WNRI claims to have a critical mass. The university groups – on social geography, law (2-3 senior staff) and the Sámi University College have low critical mass because of very limited core funding and limited success in raising resources, even though they have acquired scientific reputations.

One can distinguish between *university groups* that publish well and have good academic reputations but are very small and *research institutes* that are larger, more stable and better able to function in the research market. For the university groups, a key challenge is raising the resources for PhDs and post-docs and offering a tenure track to qualified young people. The RCN might also consider communicating with universities to request them to direct some of their core funding to new priorities, e.g. those related to climate change (UiO/SHG). The interviewees also claimed that this has to do with the way the research calls are designed, where they (a) see social science needs from the perspective of the natural sciences (UiO/geography), (b) keep a strong Norwegian focus (FNI), and (c) have little space and resources for new and creative research lines.

In terms of students, some of the groups have no students and some have recently established a Master's programme that is relevant (UiO/NRL has a new Master's programme). There are increasingly more young people being educated in climate change social science, so the potential for hiring qualified people will increase in the future.

Although social scientists do not often need much infrastructure, those analysing quantitative data may need considerable computing facilities, and those working with qualitative methods often need resources for field work and data collection. In addition, resources for reviews and communication activities are important because social scientists are frequently called upon by government commissions and asked to comment in the debate, and this work is often underfunded (see also Section 5.2).

2.1.3.4 Disciplinary strengths and weaknesses in the Norwegian research landscape

The background documents and the literature reveal some general conclusions: (a) some disciplines are dominant – e.g. economics/statistics; (b) some disciplines are strong – e.g. political science; (c) some disciplines are very marginally involved – e.g. human geography, law, development studies; and (d) some disciplines are inadequately covered – e.g. anthropology, humanities, history, sociology. Many of the groups focus much more on the local and national levels; very few focus on the European and global levels.

2.1.3.5 Disciplinary approaches

This section focuses on disciplinary approaches used by the social scientists in the climate change field.

Several of the groups are primarily mono-disciplinary in nature. Frisch and SSB are focused primarily on economics and collaboration between different economic theories and models. FNI works primarily in the political science field, UiO/NRL focuses on environmental and energy law and UiO/SHG focuses on human geography.

Some adopt a *multidisciplinary* approach. Either they depend on several disciplines within their own staff, or they try to complement their knowledge with researchers from other disciplines elsewhere. SSB seeks complementary work from other institutes (e.g. CICERO, engineers) whereas UiO/NRL collaborates with other Faculties on MILEN. The University of Oslo, FNI and CICERO have a CICEP Centre for Environment Friendly Energy with substantial funding from RCN. UMB/INA focuses on forestry through the forest technology, economics, civil culture, resource economics, biology and nature conservation traditions in developing countries; though they have a broad foundation, they do not have a truly interdisciplinary approach. Despite its name, the Institute of Transport Economics (TØI) is highly multidisciplinary with some 60 per cent of its staff being non-economists who provide insights from sociology, political science, geography and engineering when exploring the efficiency of various greenhouse gas mitigation measures.

A minority embrace *interdisciplinary* work within the social sciences as well as across to natural sciences (CICERO) or with other engineers and technology experts (Western Norway Research Institute; TIO). SSB, Frisch, the Institute for Energy Technology, SINTEF Energy and groups at University of Oslo have together established CREE, a RCN funded Centre for Environment-friendly Energy, for renewable energy issues. Despite being very small player in the climate research field, Sámi University College (SUC) together with International Centre for Reindeer Husbandry (ICR) have made efforts to bridge the gap between the humanities and the climate sciences. UMB/NORAGRIC also apply interdisciplinary approaches between the natural and social sciences, linking across scales.

For CICERO, the interdisciplinarity within the institute encourages them to do interdisciplinary work within the institute, and to engage in cooperation with other research institutions. However, interdisciplinary work within the institute is sometimes hampered by the fact that many funding instruments favour collaboration among different research institutes.

Both WNRI and CICERO attempt transdisciplinary work, going sometimes as far as action research, i.e. a reflective process of solving collective problems using participatory research methods.

2.1.3.6 Future directions

This section analyses the gaps perceived by the research groups and those that we perceived ourselves.

First some of the research institutions highlighted the lack of an integrated approach to climate change. For example, there is no promotion of national integrated transport research and policy (TØI), no real research on climate change in terms of the broader framework of sustainable development from the local up to the global level, no debate on the concept of (negative) economic growth (WNRI), and very little research on the role of marginalized

communities such as the Sámi people (Sámi University College). There is too much focus on framing climate change in terms of a nationalistic, parochial definition of climate change research (FNI). There is also poor integration among the science, the impacts and the mitigation issues.

Second, the framing of social science research on climate change is seen as largely supportive of the natural sciences (UiO/SHG), or as a relatively less important issue, and there is little emphasis on the need for continued data collection.

Third, the complete dependence on the 30% funding from NORKLIMA for social science climate-related research makes the research more vulnerable. There is hardly any core funding available for devotion to climate change research in any of the institutes spoken to. This also implies that if the social sciences cannot capture a niche market in the global research arena this may lead to a situation where less research resources go to the social sciences in the future, leading to a vicious cycle.

Fourth, the need for creative, risky, critical thinking is not being encouraged (WNRI). Finally, to the extent that Norwegian social science researchers are nominated and selected to participate in international epistemic communities, there needs to be funding for these scholars, and there should be recognition for the scientific value of such work. This is further discussed in Section 5.1.

Fifth, the global challenge of climate change refers not just to the problem, but also to our inability as a global community to sit down and set legally binding targets and timetables to address the problem at a speed that will enable us to minimize its worst effects. This means that we need more research on issues related to the architecture of global governance as well as a greater understanding of how we can modify our definitions of development, our criteria for modifying growth, and our incentives in society to achieve a green economy. These issues are central to the forthcoming discussions in Rio de Janeiro during the UN Summit on Sustainable Development in 2012 and are bound to set a research agenda in this direction. Furthermore, given that the climate change problem is serious and the impacts are increasingly being felt, there needs to be much more adaptation research to support global efforts to help the poorest and most vulnerable to adapt.

From our perspective, we believe that in addition to the above points, there is an imbalance in the investment in social and natural science research work on climate change. We miss the development of climate research in the humanities. There is very limited research being done on the issues of global politics and equity/development and on the role of indigenous peoples in general. There is also limited research on public opinion on climate change, on how this problem should be resolved and on the factors shaping consumer and producer behaviour, and there is a relative lack of systems perspectives and analyses of coupled social and ecological systems and innovation analysis. There is limited funding for research bridging natural and social systems and for promoting inter- and transdisciplinarity. There is a need to broaden the narrow focus on Norway to be able to make most research globally relevant science.

2.1.3.7 Summary of key findings

We draw three conclusions. First, although the Norwegian social science Theme 3 research is relatively small, it is very influential. This is evidenced by the success of Norwegian scientists in securing funding from European sources, and by the fact that Norwegian scholars are invited to participate in IPCC. Peer reviewed publications are increasing.

Second, there is an important issue of capacity and critical mass. Scholars in this field use core funding for other research. This makes their climate research dependent on climate related research funds. The recent funding to this sector has improved their capacity to produce; but should the funding dry up it will have implications for the survival of these research groups. This also affects their ability to participate in IPCC-type activities. Even if this work is internally peer reviewed within IPCC, it is not accounted for in individual research assessment procedures, nor is it funded, and many potential IPCC writers have said that they cannot afford to participate in this process. The dependence on external funding also leads to short-term projects rather than long-term thinking about devising a research strategy. This is further exacerbated by the number of specific as opposed to open calls. It is very important that the Theme 3 research not be reduced to an instrumental vision of how to address the various drivers of climate change, but that space be allowed for critical and innovative thinking as well.

Third, the research arena is fragmented into small projects and a diversity of funders. There is no attempt to collate this material into a meta-analysis that adds up to more than the sum of the individual projects. This also means that there are limited opportunities to reflect on the big picture issues – the architecture of climate governance from local to global levels, and how best to create a green, sustainable and equitable society, also from local to global levels.

2.1.4 Integration across all themes

2.1.4.1 Background

As discussed in Sections 2.1.1, 2.1.2 and 2.1.3, the climate system is complex and requires an integrated, comprehensive approach in order to understand it, see where it is going and understand its interactions with and impacts on all of the components of the global Earth system, including people, and the ways in which actions or lack of actions by people will make a difference. There are strengths in all the components of climate science in Norway, and these have been evaluated. In this section, the focus is on how these many research initiatives and projects are integrated or, in a sense, how the sum as a whole compares with the pieces. The 78 institutes or research groups that delivered fact sheets identified the theme areas that they considered to be the principal focus of their climate science. In the hearings, eight research units participated in Theme 1, seven in Theme 2, and seven in Theme 3. Seven units were across Themes 1 and 2 and six across Themes 2 and 3. Six units that were interviewed identified themselves as being across all 3 themes. These were: the Centre for International Climate and Environmental Research – Oslo (CICERO), the Norwegian Institute for Air Research (NILU), and the Norwegian University of Life Sciences (UMB), Dept. of Mathematical Sciences and Technology (IMT), including the section for geomatics, two groups in the section for construction and environmental technology, and the section for natural sciences. Two other research units, the University of Bergen, Dept. of Geography, and the Norwegian University of Science and Technology (NTNU), Faculty of Social Sciences and Technology Management, Dept. of Geography were also in the category, but they were not part of the interview process.

These groups are assessed in terms of their theme-specific research in Sections 2.1.1, 2.1.2 and 2.1.3. As noted there, Norwegian climate research on the climate system has created a broad knowledge base and competence in climate research so that many Norwegian research groups are world leaders and important players in international climate research arenas, as demonstrated by their strong role in the IPCC and other assessments (see 4.5).

2.1.4.2 Strategic focus and trends

The climate system, its variations and changes, and the local, national and international responses are very complex. Much of scientific research has traditionally been done in a disciplinary approach – based, for example, on physics, chemistry, biology, geography, sociology, economics, political science, various fields of engineering and law. Understanding and responding to environmental issues, such as climate change, requires an integration of knowledge and the cross-disciplinary analyses of issues and responses. This is still a challenge. This section looks at the integration across themes as defined in this review.

As noted above, only 6 of the 39 groups interviewed were, by their self-assessment, undertaking research across all themes. However, based on the information provided, some other groups could also been included, and the full scope of coverage of the 6 groups may not always be across all themes. One group, CICERO, was established in 1990 in recognition of the broad areas of research related to climate and environmental issues, as laid out in the Report: WCED: Our common future (1987). The CICERO report notes that their "research spans many disciplines and research traditions (atmospheric chemistry and physics, political science, economy, social anthropology, human geography and sociology) across natural and social sciences. Most of our natural scientists work in the core of their disciplines, while our social science researchers mainly conduct applied research according to CICERO's mandate, i.e. on impacts of, and adaptation to, climate change (CC), and curbing of climate emissions." Their research is highly rated in external reviews and they have several researchers who have been or are currently acting as Coordinating Lead Author or Lead Author for the IPCC Working Group I and II reports.

The political science programme at CICERO follows and analyses international climate negotiations and work with the Department of Political Science at UiO. The CICERO strategic plan for 2009-2014 identified priorities for: climate system and international agreements, the reduction of emissions and costs (including political feasibility and opportunities for political action), and the impacts of climate change on society. These seem fully appropriate for an institute mostly focused on the policies related to climate change.

NILU has been traditionally strong in research on atmospheric composition change, air quality and toxic substances. Its strategic goal is to be recognized as highly competent in all scientific disciplines relevant to meeting the mandate outlined in the institute statutes. With changing global agendas, climate-related integrated assessment and impact assessment, which are less traditional research topics for NILU, are also being developed. NILU has a strong research reputation and has garnered much praise for publications in its traditional research area, and this carries over into what is mainly Theme 1 climate research. For example, NILU acts as the Chemical Coordinating Centre for EMEP and coordinates the atmospheric monitoring work under the Convention on Long-Range Transboundary Air Pollution. This is a scientifically based and policy-driven programme with high relevance to the institute's involvement in, and relation to, international research infrastructure projects. This expertise and their international experience would serve well in terms of international climate change monitoring (both the state of the climate and emissions of GHGs). Aerosols, black carbon and related issues are now seen as most important for the climate system, and the NILU expertise on atmospheric chemistry in the broad sense of the field is relevant.

The UMB Dept. of Mathematical Sciences and Technology (IMT) has as its research foci: geodesy, glaciology and landscape mapping; impacts of climate change on flood damages;

climate exposure and adaptation of buildings; meteorological monitoring and agricultural meteorology. As such, these seem mainly focussed on Themes 1 and 2.

As mentioned, the above description is based on the self-assessment by the groups that were interviewed. In addition, several of the research groups emphasised that they are striving to work cross-disciplinary and that there are opportunities available to do so through the various funding schemes. For instance, the centres of excellence that have been created cover several disciplines: the Bjerknes centre and the newly established Centre for Environment-friendly Energy Research (CEER) are examples thereof. Some also mentioned that they collaborate in specific research projects. Hence, there is a growing awareness of the need to search for research partnerships across disciplines and research units in the pursuit of climate research.

2.1.4.3 Capacity: students, personnel, infrastructure etc.

CICERO`s expansion of staff has been quite marked in the period 2007-2010. In 2010 they had about 42 full-time equivalent researchers among 80 employees. NILU has leading expertise in chemical analytical instrumentation, which serves as the basis for the institute's extensive work on pollution components in the environment. NILU's infrastructure is available for climate research studies, and NILU has more than 15 researchers and about 20 technicians doing the work. The UMB-IMT has about 110 employees and a broad programme in mathematics and technological sciences, including computer science and structural engineering and architecture. They have a large number of students.

2.1.4.4 Disciplinary strengths and weaknesses in the landscape

With the exception of CICERO, the integration across all themes at a single institution seems to be not very strong. However, it is not clear whether this need be the case. Research studies of the climate system, its impacts and response strategies need to be based on very high quality science, and the approach needs to bring these elements together in an integrated interdisciplinary approach so as to provide the best understanding, knowledge and focus for responses. CICERO did note that, in their opinion, the funding councils seemed to focus interdisciplinary research on linking units rather than recognizing, as in their case, the interdisciplinary competence within one unit.

The strengths and weaknesses across the landscape for each theme have been identified in Sections 2.1.1–2.1.3.

One of the challenges for interdisciplinary research is finding the "high-quality" journals in which to publish. The usual assessments of journals give high ratings to disciplinary journals, and publications in other journals, which are generally newer and less well-recognised, are valued less highly. The usual reward and promotion systems of universities and national academies are also discipline-based so that those who work across disciplines often encounter barriers to promotion and recognition.

Another challenge involves to the time factor. It takes considerable time and effort to create a well-functioning interdisciplinary research group. Most research grants, however, are short-term, and by the time the researchers have got to know each other and developed an atmosphere of trust and creativity, the research time is often finished. Therefore, extended funding for 4-10 years is often a prerequisite for establishing truly interdisciplinary research groups. The time factor is of course closely connected to the availability of sufficient funds over a longer period of time, because multi-, inter- and transdisciplinary research requires considerably larger budgets than traditional monodisciplinary research since it requires more

time to find common ground for collaboration across different epistemologies and research methods.

2.1.4.5 Attitudes: disciplinary, interdisciplinary, transdisciplinary, national-international

Norwegian climate research has developed a strong disciplinary tradition and competence. RCN has recognized the need for interdisciplinary efforts in climate science. The methods of development of broad interdisciplinary programmes need to be examined with regard to their effectiveness. Comparisons could be made between these approaches in a variety of countries in order to examine the mixture of approaches since it is unlikely that a monolithic approach will be best. Centres of Excellence have proven to be a successful tool for building strong disciplinary competence while simultaneously enhancing the interdisciplinary research collaboration among research groups.

The bibliometric study showed that Norwegian climate research encompasses a high number of scientific disciplines and sub-fields (see Figure 2.2.6). Thus, there is great potential for cross-breeding among disciplines. In the NORKLIMA programme, interdisciplinary research has been high on the agenda. The RCN distinguishes in its reporting between (a) cooperation inside the social sciences, natural sciences or humanities, and (b) "radical" cooperation between different disciplines, i.e. between the social sciences and natural sciences and/or humanities, where the share of this kind of research cooperation in the NORLIMA programme from 2004 to 2011 is depicted in Figure 2.1.4.1. There was an upward trend from 2006 until 2008 when the share of interdisciplinary projects within the natural or social sciences increased considerably, but more recently that share has decreased and been partially replaced by an increase in "radical" interdisciplinary projects. The share of monodisciplinary projects has generally decreased even though a small increase can be discerned between 2010 and 2011.

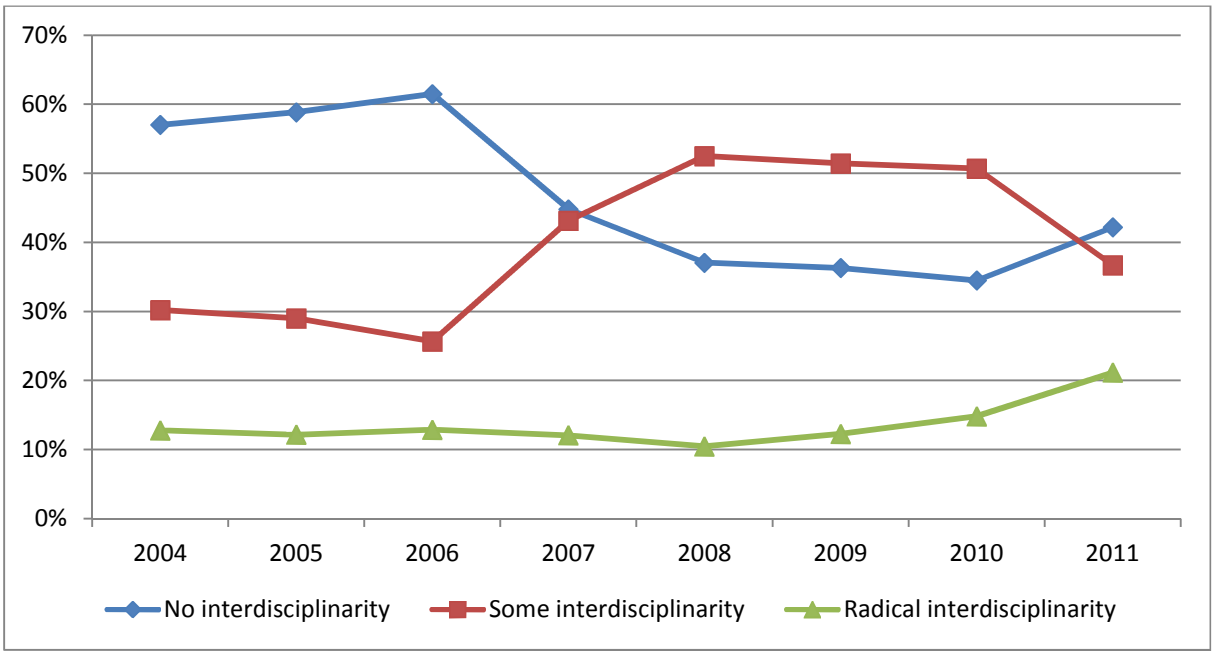

Figure 2.1.4.1: Interdisciplinary of NORKLIMA projects. 2004–2011. Share of project budgets.
Source: RCN.
Note: *Some* interdisciplinary covers all research projects that include cooperation between disciplines within the social sciences, the natural sciences or the humanities. *Radical* interdisciplinary covers all research projects that include cooperation between different disciplines, i.e. the social sciences and the natural sciences and/or the humanities.

2.1.4.6 Future directions

In several institutions there has been a move towards more integrated research. This has also been happening in the NORKLIMA programme. The CICERO approach has been excellent, and it has worked well with partner groups at, for example, the University of Oslo. The shift of NILU from its traditional very strong focus on air quality-pollution issues to the issues of the climate system is also promising. The Research Council has encouraged this process through their funding approaches, but there are still difficulties. In particular, the budgetary constraints and the short time horizons create obstacles to the establishment of integrated research to meet future challenges. This will be elaborated further in Section 6.

2.1.4.7 Summary of key findings

There are some excellent examples of integrated research across all themes. However, the overall balance of research in the Norwegian landscape still has gaps or areas of relatively less strength. Examples include the social sciences in general and research on adaptation. The engineering aspects of mitigation and disaster risk reduction also seem less evident. The overall issues of connectivity between climate change adaptation and disaster risk reduction, as described in the 2012 IPCC Special Report on Climate Extremes (for which the Government of Norway was a major supporter) seem not yet fully identified in the research programmes. Integration across all themes will have to go beyond the traditional 3 themes of climate system science and response. It should be emphasised that interdisciplinary research is resource-intensive and requires longer time horizons than monodisciplinary research, due to the need to develop crossdisciplinary understanding, and this argues for targeted support of interdisciplinary Centres of Excellence.

2.2 Quality of Norwegian Climate Research

This sub-section will give an assessment of Norwegian climate research based on the analysis of relevant publications. Firstly, the results of two bibliometric analyses of scientific articles published in peer-reviewed international journals are summarised: (a) a study of a national sample of relevant publications which has been selected on the basis of a combination of relevant keywords and core journals and (b) a study of the publications selected by the research units participating in the hearings. The results of both studies are compared to assess the reliability of both analyses.

Bibliometric data is especially useful for analysing the scientific output and collaboration patterns in the natural sciences and medicine, whereas researchers in the humanities publish many more book sand book chapters than journal articles. The publication behaviour of social scientists has changed in recent decades. Many social scientists have a reasonably high output of international journal articles.

2.2.1 Analysis of the national sample

The *national sample* of climate research articles was retrieved from the Thomson ISI database, Web of Science (ISI WoS). The study of the national sample is based on a merging of two samples: a core journal sample and a keyword-based sample. Articles, proceeding papers, and review articles with Norwegian author address(es) and that were published in the period 2001–2010 were included. The results of both search strategies have been merged into one sample, which has been analysed further. For further analysis the Thomson's National Citation Report for Norway 2010 was used.

Firstly, a sample of core journals relevant to climate research was established. Climate research is multidisciplinary with publications not only in specialized climate research journals, but also in important multidisciplinary journals such as Nature or Science. Indeed one could say that climate research is embedded in several disciplines, and this is particularly true of the social sciences, where climate issues are seldom a major focus of the research but one of several aspects of societal engagement with the environment and sustainable development (Schwechheimer and Winterhager, 1999). Therefore, it was decided to define a short basic list of specialized climate research journals and a much more comprehensive list of relevant keywords for identifying publications outside the sample of these journals. A first draft of the basic list of journals was created from a combination of a very rough search in the ISI data base on climate research over the last ten years, a list of journals covering the physical aspects of the climate system (Prall, 2010) and a list of journals on climate change published by Springer[4]. Initially, this list included over 500 journals, which was far too many, so the list had to be shortened. A sample of relevant journals was proposed by experts from the Research Council of Norway (RCN) in collaboration with Norwegian researchers. This sample was shortened to seventy journals in dialogue with RCN (Appendix 2.2.1). Relevant articles from other journals were identified with keywords. Three major subject fields have been covered in this evaluation: (a) 'Climate system and climate change', (b) 'Climate effects and adaptations', and (c) 'Institutions and instruments for response to climate change'. Some of the journals cover more than one subject field. The core journal sample consisted of 2,928 papers.

Secondly, relevant papers were identified via keyword-based search strings which have been developed on the basis of keyword lists in the 2007 IPCC reports, the bibliometric mapping exercise of Danish climate research (Schneider and Larsen, 2009) and feedbacks from the Evaluation Committee. The index of the 2007 IPCC reports was used (IPCC, 2007a-d). The list of keywords is presented in Appendix 2.2.2. The keyword sample consisted of 4,596 papers.

The merged national sample consisted of 6,448 papers. This number is high compared with the results of the Danish bibliometric study. The Danish study identified 1,408 Norwegian papers on climate research (Schneider and Larsen, 2009) and highlighted the fact that Norway has the most climate research papers per capita in the world (0.3 papers per 1,000 inhabitants). By comparison Sweden and Denmark achieved 0.18 climate research papers per 1,000 inhabitants in the study.

The papers in our analysis were published in over 900 different journals. 89 per cent of the papers were articles, the rest were either review articles (5 per cent) or proceeding papers (7 per cent). The overlap between the two samples was rather small (1,076 papers). This confirmed the value of our strategy of defining the national sample by a combination of keywords and a sample of core journals.

Over the past decade, the number of papers has risen steadily by 12 per cent per year on the average (Figure 2.2.1) or 177 per cent for the whole period. This increase over the last decade is much higher than the increase in the overall Norwegian publication output and in the global publication output. By comparison, the number of geoscience articles increased by 118 per cent in the last decade (Aksnes & Klitkou, 2011). The results are consistent with the results of a recently published bibliometric study of Norwegian polar research, which can more or less

[4] SPRINGER: List of journals on Global Change - Climate Change: http://www.springer.com/environment/global+change+-+climate+change?SGWID=0-158402-12-449699-0

be regarded as a sub-field of Norwegian climate research (Aksnes et al., 2012). The number of Norwegian polar research articles increased by 46 per cent from 2005 to 2010, while the number of Norwegian climate research articles increased by 55 per cent in the same period. The list of the hundred journals that most frequently carry Norwegian climate research papers is presented in Appendix 2.2.3. Thirty journals accounted for over 40 per cent of all published papers and 100 journals accounted for over 66 per cent.

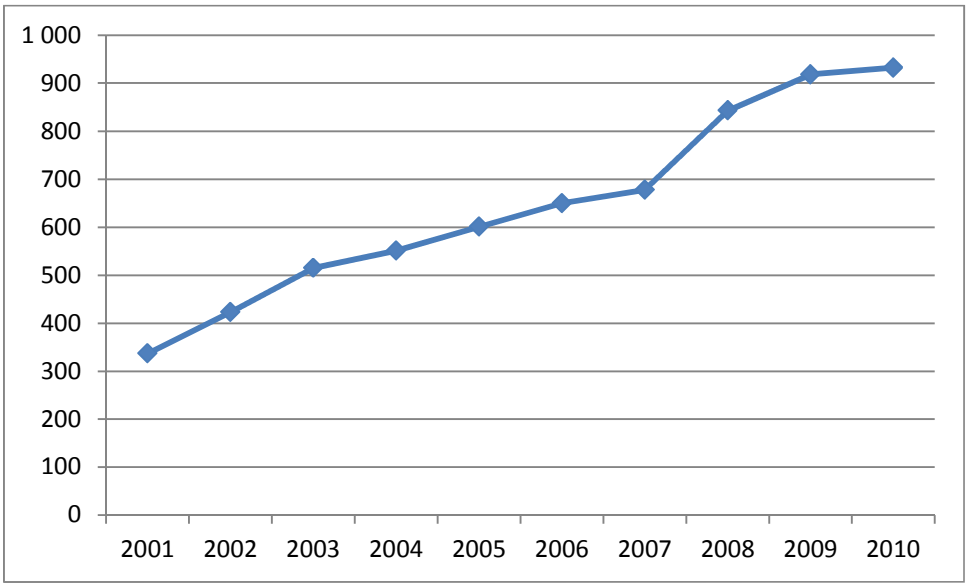

Figure 2.2.1. Number of Norwegian climate research papers. 2001–2010. N=6,448. Source: ISI WoS / NCR Norway 2010 / NIFU.

In Figure 2.2.2, the papers were categorised into three themes: (a) 'Climate system and climate change', (b) 'Climate effects and adaptations', and (c) 'Institutions and instruments for response to climate change' based on both the categories for the core journals and the different sets of keywords (see Appendices 2.2.1 and 2.2.2). There is considerable overlap between the first two themes because some of the journals cover both themes, and many papers were found by different sets of keywords belonging to more than one theme. Therefore weighted counts for all papers have been calculated (see Appendix 2.2.4). In the calculation of the weighted counts we have applied the principle that each of the thematic assignments of a paper is weighted as 1/N of a publication, where N is the total number of thematic assignments. If a paper was assigned to two themes each theme received just ½ point.

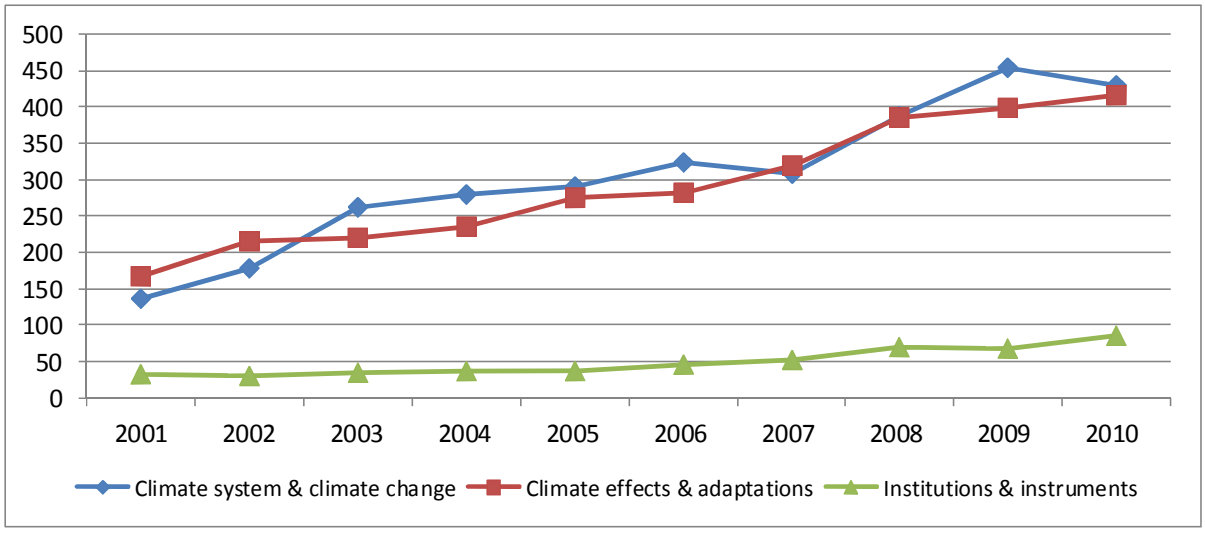

Figure 2.2.2. Norwegian climate research papers by theme, based on fractionalised counts. 2001–2010. N=6,448. Source: ISI WoS / NCR Norway 2010 / NIFU.

For the first two themes, 'Climate system and climate change' and 'Climate effects and adaptations', the publication output and its development are quite similar: for 'Climate system and climate change' almost 3,045 papers or 47 per cent of all papers and for 'climate effects and adaptations' almost 2,912 papers or 45 per cent of all papers – and there were only minor differences between them over the last ten years. The third theme, 'Institutions and instruments for response to climate change', was less prominent in the sample with 490 papers or 8 per cent of all papers. However, it has more than doubled from 2001 to 2010. 'Climate system and climate change' achieved the highest growth rate of the three themes followed by 'Institutions and instruments for response to climate change' and 'Climate effects and adaptations'.

Over 11,922 Norwegian addresses for the 6,448 papers were identified and standardised in accordance with the registry of Norwegian R&D organisations. Table 2.2.1 gives an indication of the distribution of climate research publications among the main R&D sectors. Based on total counts, almost 70 per cent of all papers had an address in one of the universities or university colleges, and almost half of the papers had an address in at least one research institute. The private business sector was listed for seven per cent of all papers. Because of co-authorship, it is more accurate to use a weighted share of addresses rather than total numbers.[5] Of addresses in Norway, the universities had 60 per cent, the institute sector 36 per cent and the private sector 4 per cent. In total, 55 per cent of the weighted co-authorships were Norwegian and the remaining 45 per cent were foreign author addresses. An analysis of the international co-authorship of Norwegian climate researchers is presented in Section 4.4.

[5] When calculating the weighted share of addresses, i.e. each article has n numbers of addresses and the share is calculated as the n-share of the number of addresses.

Table 2.2.1. Distribution of Norwegian climate research papers among R&D sectors, based on total counts and weighted counts. N=6,448. 2001–2010. Source: ISI WoS / NCR Norway 2010 / NIFU.

	Number of papers by R&D sector, total counts	Weighted share of addresses
Institute sector	3,100	1,247
Universities and university colleges	4,478	2,097
Private business sector	444	149
NGOs	11	3
Unidentified address	33	18

Note: Many of the papers are co-authored with foreign authors. Therefore the sum of the weighted shares is lower than the total number of papers.

The distribution of research papers among the different themes shows the specific strengths of research units in the three different themes. Here weighted counts have been used.

For the theme 'Climate system and climate change' (Figure 2.2.3) the university researchers contributed more than half of all publications and over one third of the publications were published by researchers affiliated to one of the independent research institutes.

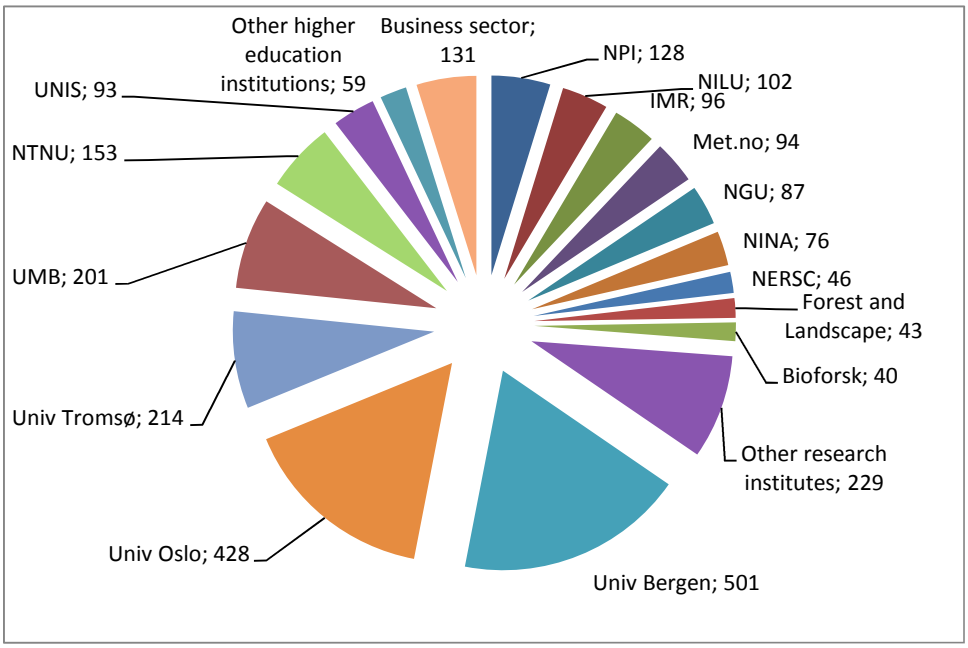

Figure 2.2.3. Number of scientific papers on climate system and climate change, based on weighted address counts. (N=4,091, weighted address counts 2,837). 2001–2010. Source: ISI WoS / NCR Norway 2010 / NIFU.

Note: Following abbreviations have been used: NPI: Norwegian Polar Institute; IMR: Institute of Marine Research; Met.no: Norwegian Meteorological Institute; NGU: Geological Survey Norway; NILU: Norwegian Institute for Air Research; NIVA: Norwegian Institute for Water Research; NERSC: Nansen Environmental and Remote Sensing Centre; UMB: Norwegian University of Life Sciences; NTNU: Norwegian University of Science and Technology; UNIS: University Centre in Svalbard.

The most prominent institutions in terms of publishing in this area are: the Norwegian Polar Institute (128), the Norwegian Institute for Air Research (102), the Institute of Marine Research (96), the Norwegian Meteorological Institute (94), the Centre of Excellence Bjerknes Centre at the University of Bergen (102), the Department of Earth Science (77) at the University of Bergen, and the Department of Biology (82) and the Department of

Geosciences (97) at the University of Oslo (see the table in the Appendix 2.2.5. for more details). There are more than sixty other research institutes that have co-authored almost 230 papers. This entails that climate issues are integrated into the research activities of many research institutes that are not specialized in research on climate system and climate change.

The publication pattern was quite similar for the theme 'Climate effects and adaptations' (Figure 2.2.4). The university researchers were responsible for more than half of all publications and about one third were published by researchers affiliated with one of the independent research institutes. The most prominent institutions in terms of publishing in this area were: IMR (228), the Department of Biology at the University of Oslo (167) and the Department of Biology at the University of Bergen (99), NINA (116), NPI (75), Met.no (70) and CICERO (64) (see the table in Appendix 2.2.5. for more details). More than seventy other research institutes co-authored almost 300 additional papers. This shows that research on climate effects and adaptations is integrated into the research activities of many research institutes that are not specialized in this field.

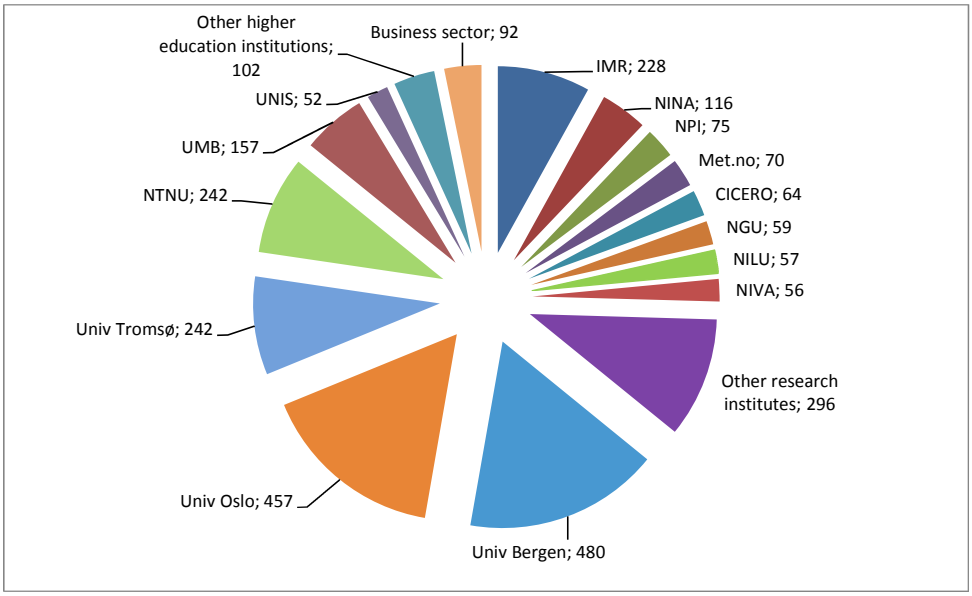

Figure 2.2.4. Number of scientific papers on climate effects and adaptations, based on weighted address counts. (N=4,025, weighted address counts 2,856). 2001–2010. Source: ISI WoS / NCR Norway 2010 / NIFU. IMR: Institute of Marine Research; NINA: Norwegian institute for nature research; NPI: Norwegian Polar Institute; Met.no: Norwegian Meteorological Institute; CICERO: Centre for International Climate and Environmental Research; NGU: Geological Survey of Norway; NILU: Norwegian Institute for Air Research; NIVA: Norwegian Institute for Water Research; NTNU: Norwegian University of Science and Technology; UMB: Norwegian University of Life Sciences; UNIS: University Centre in Svalbard.

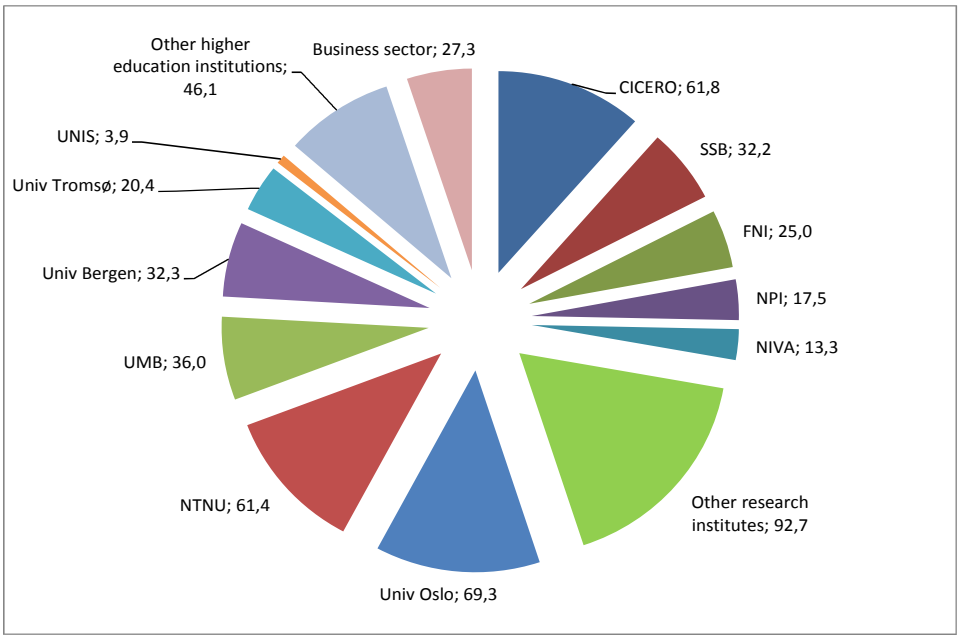

Figure 2.2.5. Number of scientific papers on institutions and instruments for response to climate change, based on weighted address counts. (N=691, weighted address counts: 550). 2001–2010. Source: ISI WoS / NCR Norway 2010 / NIFU. CICERO: Centre for International Climate and Environmental Research; SSB: Statistics Norway; FNI: Fridtjof Nansen Institute; NPI: Norwegian Polar Institute; Met.no: Norwegian Meteorological Institute; NIVA: Norwegian Institute for Water Research; NTNU: Norwegian University of Science and Technology; UMB: Norwegian University of Life Sciences; UNIS: University Centre in Svalbard.

For the theme '*Institutions and instruments for response to climate change*' the research institutes were the most important actors (194 out of 298): CICERO (62), Statistics Norway (SSB, 32) and the Fridtjof Nansen Institute (25) were especially active (see Figure 2.2.5.). Almost 50 other institutes co-authored almost 100 additional papers. The institute sector in total co-authored 45 per cent of all publications, and the universities and other higher education institutions co-authored half of the papers. At the universities, the publications in this area were distributed over many different research units (281 out of 550) (see the table in Appendix 2.2.5. for more details).

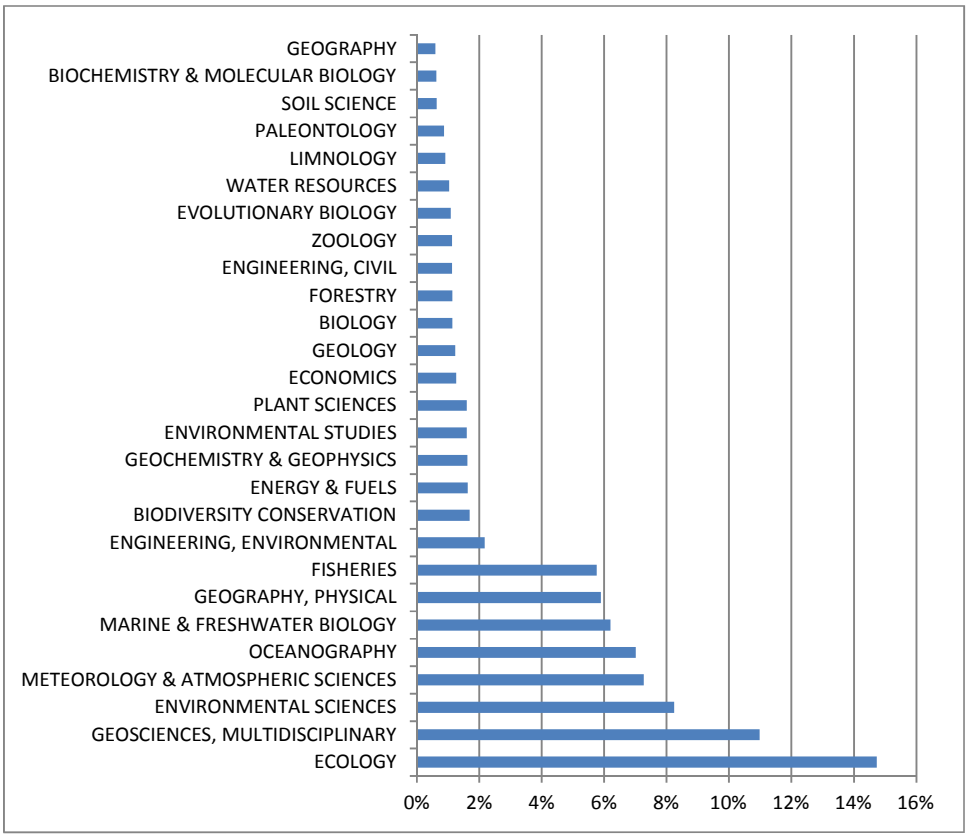

Figure 2.2.6. Main scientific sub-fields in Norwegian climate research articles. 2001–2010. N=6,448. Source: ISI WoS / NCR Norway 2010 / NIFU.

The sample of Norwegian articles covers a multitude of scientific disciplines as an analysis of the distribution of the articles at the sub-field level shows (Figure 2.2.6).

For assessing the quality of the papers, a citation analysis was based on publications published not later than 2009 (5,516 papers) applying an open citation window – to include all citations obtained until the end of 2010. Table 2.2.2 and Appendix 2.2.6 summarise the results. The results of the citation analysis can be summarised as follows:

1. The papers had received 77,622 citations by the end of 2010.
2. The average number of citations per paper (CPP) was 14.1, but 7.3 per cent received no citations. This is much better than the average for Norwegian papers, which is 12.3 per cent according to Thomson Reuter's National Science Indicators, Deluxe Edition for 2001 to 2008.
3. The maximum number of citations for one article was 522.[6] 42 per cent of the papers were cited at least 10 times. The 10 most cited papers are listed in Appendix 2.2.5. On

[6] This paper has been co-authored by a group of 56 international researchers coming from 19 different research groups from 11 countries, one of the research organisations was the Norwegian Polar Institute: Augustin, L., Barbante, C., Barnes, P. R. F., Barnola, J. M., Bigler, M., Castellano, E., Cattani, O., Chappellaz, J., DahlJensen, D., Delmonte, B., Dreyfus, G., Durand, G., Falourd, S., Fischer, H., Fluckiger, J., Hansson, M. E., Huybrechts, P., Jugie, R., Johnsen, S. J., Jouzel, J., Kaufmann, P., Kipfstuhl, J., Lambert, F., Lipenkov, V. Y., Littot, G. V. C., Longinelli, A., Lorrain, R., Maggi, V., Masson-Delmotte, V., Miller, H., Mulvaney, R., Oerlemans, J., Oerter, H., Orombelli, G., Parrenin, F., Peel, D. A., Petit, J. R., Raynaud, D., Ritz, C., Ruth, U., Schwander, J., Siegenthaler, U., Souchez, R., Stauffer, B., Steffensen, J. P., Stenni, B., Stocker, T. F., Tabacco, I. E., Udisti, R., van de Wal, R. S. W., van den Broeke, M., Weiss, J., Wilhelms, F., Winther, J. G., Wolff, E. W., Zucchelli, M., & Members, E. C. (2004). Eight glacial cycles from an Antarctic ice core. Nature, 429(6992), 623-628.

average, the expected citation rate (XCR) was 12.6, based on the average citation rate of all papers world-wide in the same journal set and in the same year.

4. The impact of Norwegian climate papers compared to the expected citation rate (CPP/XCR) was 1.15 and demonstrated a high visibility of Norwegian climate research in the international research community.

Table 2.2.2. Summary of citation indicators. Source: ISI Web of Science / NCR for Norway. N=5,516.

	Number of papers (total counts)	Number of received citations	Average number of citations per paper	Average expected citation rate (XCR)	Impact compared to XCR
2001	337	8,555	25.4	24.7	1.08
2002	423	11,030	26.1	21.7	1.23
2003	515	10,532	20.5	19.5	1.10
2004	551	10,787	19.6	18.2	1.08
2005	601	10,830	18.0	15.6	1.17
2006	650	10,094	15.5	12.9	1.18
2007	678	7,220	10.6	9.8	1.11
2008	843	5,201	6.2	5.7	1.16
2009	918	3,373	3.7	3.0	1.22
Total	5516	77,622	14.1	12.6	1.15

The analysis by theme (Appendix 2.2.8) showed that ’Climate system and climate changes’ had the highest impact, averaging 1.2, ‘Climate effects and adaptations’ also had a high impact and achieved a higher impact with the most recent papers published in 2008 and 2009. The theme ‘Institutions and instruments for response to climate change’ had an impact equivalent to the world average, but lower impact compared to the other two themes. Over the last two years, however, this theme showed remarkable achievements: the impact compared to the expected citation rate increased to 1.4 in both years, which was the best result for any year in all three subject fields (Figure 2.2.7).

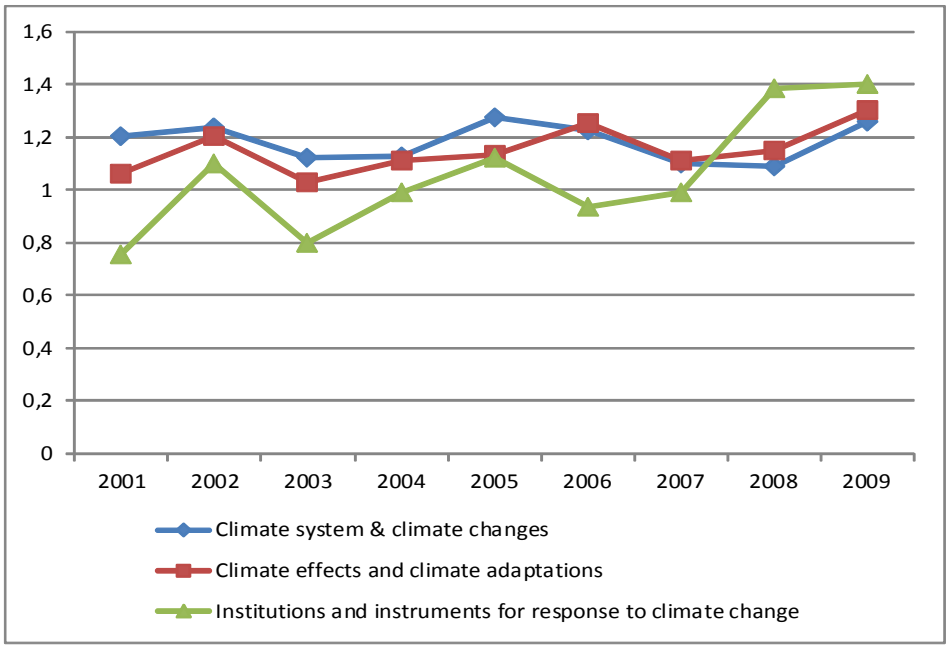

Figure 2.2.7. Impact of Norwegian climate research compared to expected citation rates for the three themes, where 1 stands for the average impact of all published articles in this field.
Source: ISI WoS / NCR Norway 2010 / NIFU

2.2.2 Analysis of the sample of papers selected by the research units

The second part of the bibliometric analysis was based on the sample of papers selected by the research units that participated in the hearings. In this sample, we were able to go into more depth in our analysis of publication patterns, and also include those that were not included by the national sample. Every research unit was asked to submit its 5 to 10 most important climate-related research articles published in the period 2001–2010. This selection was quality checked because not all of the submitted papers were articles: some were books, book chapters, editorial material or other types of publications, and not all were published in the period 2001–2010 (38 articles). In addition not all of the scientific articles were indexed by Thomson ISI/NCR Norway (31 articles), the databases used for calculating the bibliometric indicators. Altogether 311 papers had been submitted by the research units, 207 of which were published in the period 2001–2010 and indexed in the database NCR Norway 2010.[7]

The Evaluation Committee examined the thematic specialization of these papers. The Committee determined that 14 of these papers are not climate research papers and another 7 papers were only indirectly related to climate research. That means that the final sample of papers selected by the research units consists of altogether 186 papers in total.

About two-thirds of the papers were published in the last four years. Eight articles in this sample had not been captured by the search of selected keywords or core journals in the national sample. The most prominent journals in the selected sample were Science (13 articles), Nature (7 articles) and Tellus Series A: Dynamic Meteorology and Oceanography (7 articles).

[7] Each year Thomson ISI gathers publication and citation data in national citation reports (NCR). The NCR for Norway (2010 edition) has been used to receive comparable citation data for all articles.

The thematic classification was based on the assessment of the Evaluation Committee. This meant that part of the sample was distributed over more than one theme (see Figure 2.2.8). 44 per cent of the articles came under *climate system and climate change* (theme 1), 26 per cent of the papers came under *climate impact and climate adaptations* (theme 2) and 19 per cent are on *institutions and instruments for response to climate change* (theme 3). Seven per cent of the papers covered theme 1 and 2, and 4 per cent cover theme 2 and 3.

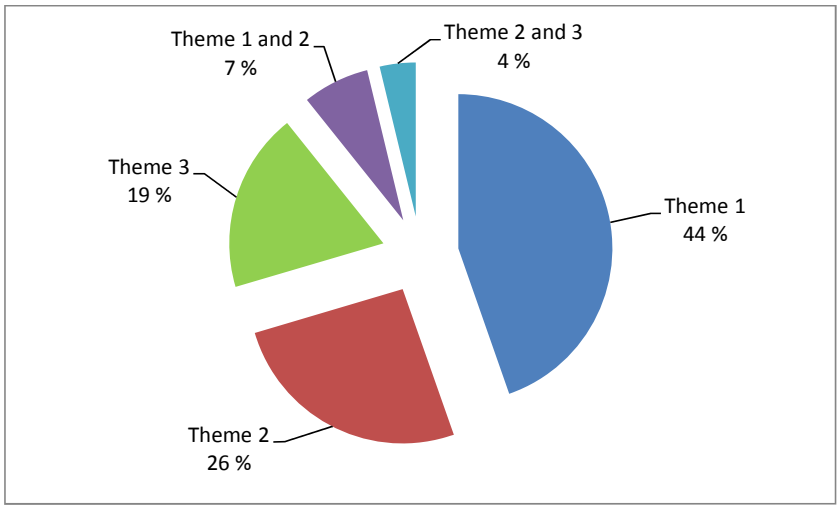

Figure 2.2.8. Thematic distribution of the selected Norwegian climate research papers submitted by research units. 2001–2010. N=186.
Source: ISI WoS / NCR Norway 2010 / NIFU / Evaluation Committee.

For a citation analysis, only articles published up until 2009 have been included – a total of 151 articles. The sample of papers selected by the research units achieved an average citation rate of 33.6 citations per paper. The different themes also had different citation rates: the leading theme here was theme 2 with on average 50.3 citations per article, whereas theme 1 received an average of 33.5 citations and theme 3 received 10.1 citations (Figure 2.2.9). The number of non-cited papers was 7, which was better than the total sample, but it is remarkable that papers have been selected that have not yet received any citations. The article that received the most citations – 493 citations in total – came under theme 2, and there were 6 articles in that theme that received over 100 citations, whereas such highly cited papers were more rare in the other themes: 3 in theme 1, 1 in theme 1 and 2, but none in theme 3 or in theme 2 and 3.

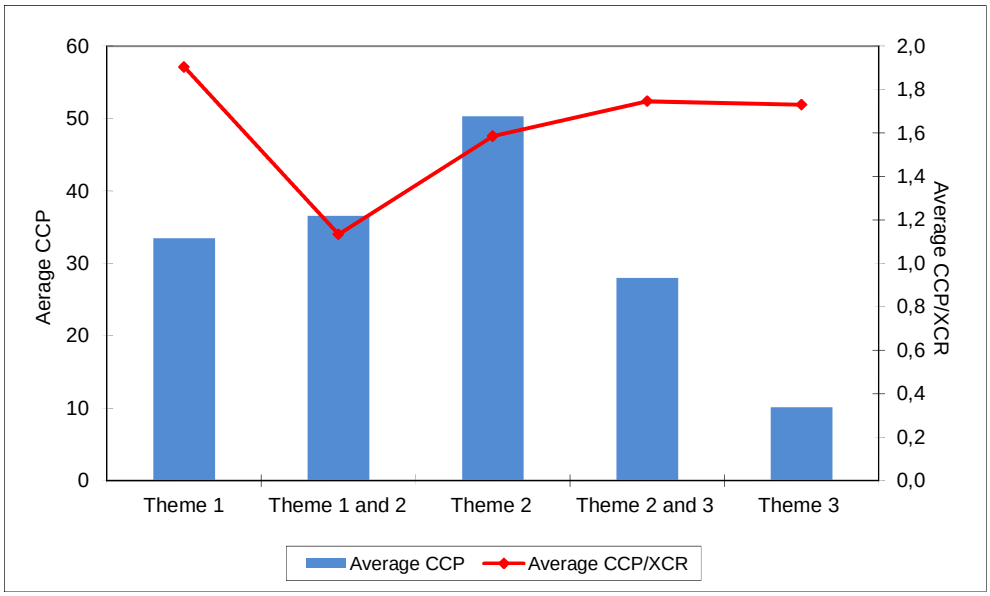

Figure 2.2.9. Average citation rates and average impact achieved by the selected Norwegian climate research papers submitted by research units. 2001–2009. N=151. Source: ISI WoS / NCR Norway 2010 / NIFU.

A better method than just calculating the average citation rate is to benchmark this citation rate with the expected citation rate (CCP/XCR). This makes it possible to assess the international standing of the articles in the sample. The expected citation rate for all articles was 25.8, whereas the actual citation rate was 33.9. The average impact of these papers – 1.73 – was much higher than for the larger sample (1.15), which was expected since these articles are supposed to be the most important articles.

When calculating the impact compared to the expected citation rate for the different themes (see the red line in Figure 2.2.9) theme 1 achieve the highest impact with 1.90, theme 3 came second with 1.73. Theme 2 and 3 combined also had a very high impact, 1.75.
The results of the citation analysis of the selected sample from the research units participating in the hearings can be summarised as follows:

1. The number of papers published between 2001 and 2009 was 151.
2. Those papers received 5,079 citations up to the end of 2010.
3. The average number of citations per paper (CPP) was 33.6.
4. 4.6 per cent or 7 papers out of 151 received no citations.
5. The maximum number of citations for one article was 493. This highly cited paper was published in Science. 61.2 per cent of the climate papers, published before 2010, were cited at least 10 times.
6. The expected citation rate (XCR) was on average 25.8.
7. The impact of Norwegian climate papers compared to the expected citation rate is 1.73 and showed the high visibility in the international research community of the small sample of best articles from Norwegian climate research.

2.2.3 Summary of key findings

The number of Norwegian climate research papers – 6,448 papers – was high when compared with the results of earlier studies. Earlier studies revealed that Norway has the most climate research papers per capita in the world (0.3 papers per 1,000 inhabitants). By comparison, Sweden and Denmark achieved 0.18 climate research papers per 1,000 inhabitants. Over the last decade, an increased interest in climate research has contributed to a much greater

increase in research articles on climate research than in other scientific topics. Many scientific disciplines and sub-fields have contributed to this development. The most important scientific fields are ecology, multidisciplinary geosciences, the environmental sciences, meteorology and the atmospheric sciences, oceanography, marine and freshwater biology, and physical geography. These fields account for over 60 per cent of all articles.

The impact of Norwegian climate papers relative to the expected citation rate demonstrated a high visibility of Norwegian climate research in the international research community. The theme 'Climate system and climate changes' had the highest impact, averaging 1.2, 'Climate effects and adaptations' also had a high impact and achieved a higher impact with the most recent papers published in 2008 and 2009. The theme 'Institutions and instruments for response to climate change' had an impact equivalent to the world average, but than the other two themes. However, over the last two years this theme showed remarkable improvements: the impact relative to the expected citation rate increased to 1.4 in both years, which is the best result in any year for all three themes.

There are some very strong university departments and research institutes specialized in climate research and related issues, but there are also many research institutes that have co-authored only a few climate research articles, and this may imply a strong fragmentation of the research system. However, this may also be interpreted as a high degree of awareness: climate issues are integrated into the research activities of many research institutes, even when they do not specialize in climate research.

2.3 Funding of Norwegian Climate Research

2.3.1 National funding, including analysis of different instruments

There are two main public funding modes for public research organisations in Norway: basic funding and external funding.

Since 2004 the national *basic funding* of universities and university colleges has been based on a funding model consisting of three components: (1) a *basic component* of ca. 60 per cent of the funding, which gives a stable subsidy based on historical experience, local differences and special tasks, (2) an *education component; ca.* 25 per cent of the funding, which is an open budget frame based on education performance indicators, and (3) a *research component* of 15 per cent of the funding, which is a closed budget frame consisting of two elements: (a) strategic resources for PhDs and research equipment, and (b) a redistribution of allocations based on performance indicators in the area of scientific publishing, PhD candidates, and competitive funding received from RCN and the EU Framework Programmes. Basic funding of universities and university colleges is allocated from the annual state budget. The funding model for research institutes subject to government guidelines for funding has been adapted accordingly in 2009. The basic funding of these research institutes is allocated in the annual budget of RCN, and RCN receives earmarked funding from the different ministries for this purpose. Usually the basic funding is rather low (less than 10 per cent of total funding).

The other main source of national public funding is *external funding*. External funding is provided as (a) competitive funding of specific research projects provided by RCN through RCN's programmes calls and by other public R&D funding institutions, and as (b) funding of research projects provided by ministries, public agencies or private organisations. The latter

includes both competitive and non-competitive funding. We have no indication of the share of non-competitive funding.

The following analysis is based on two main sources: the information provided in the fact sheets by the 78 research units included in the evaluation and the labelling of climate research project funding provided by RCN.

36 out of 78 research units reported *basic funding for their climate research.* The other research units did not use basic research funding for climate research. The total amount of basic funding used for climate research over the five years was about NOK 1.7 billion (Figure 2.3.1). That means that the research units covered 42 per cent of the R&D expenditure (NOK 4.1 billion) on climate research from basic grants. The amount of basic funding for climate research increased by about 100 MNOK between 2006 and 2010. However, there were large differences among the research units. The research unit with the highest basic funding was the Norwegian Polar Institute. NPI covered an average of 77 per cent of its substantial expenditures by basic funding.

At the same time as the basic funding has increased, the share of *external funding* of climate research has also risen. 65 research units reported data on this matter. On average there was a 68 per cent share of external funding, but there were large deviations among the research units: the standard deviation is 35 per cent. External funding came from the following main funding sources: RCN, other national grants, Nordic sources, EU FP 6 and FP 7, other European grants and other international grants. 89 per cent of all external funding came from Norwegian sources: 74 per cent from RCN and the rest from other national grants (public and private) (Figure 2.3.4).

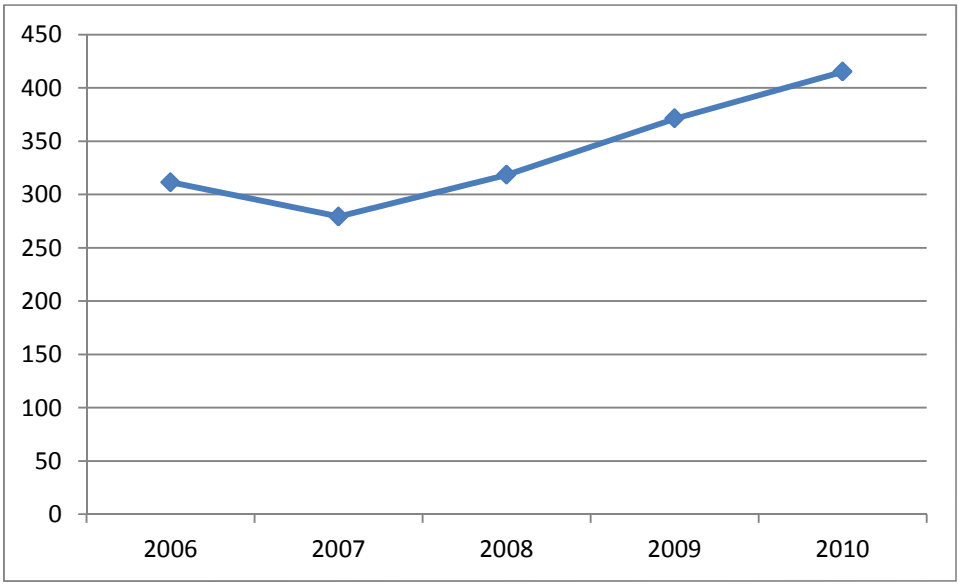

Figure 2.3.1. Basic funding for Norwegian climate research. 2006–2010. MNOK.
Source: Fact sheets provided by the research units. 36 out of 78 units reported basic funding spent on climate research.

The reported external funding has some flaws however. Many research units did not report all funding for the first three years because their accounting system did not provide these statistics. Furthermore, many research units reported projects funded by RCN outside the NORKLIMA programme as 100 per cent climate research, whereas RCN has weighted the share of climate research for projects outside the NORKLIMA programme. Some of them

may still be 100 per cent climate research, but many are accounted for at a lower level. This leads to inconsistencies between the total volumes of funding reported in the fact sheets and the total numbers provided by RCN.

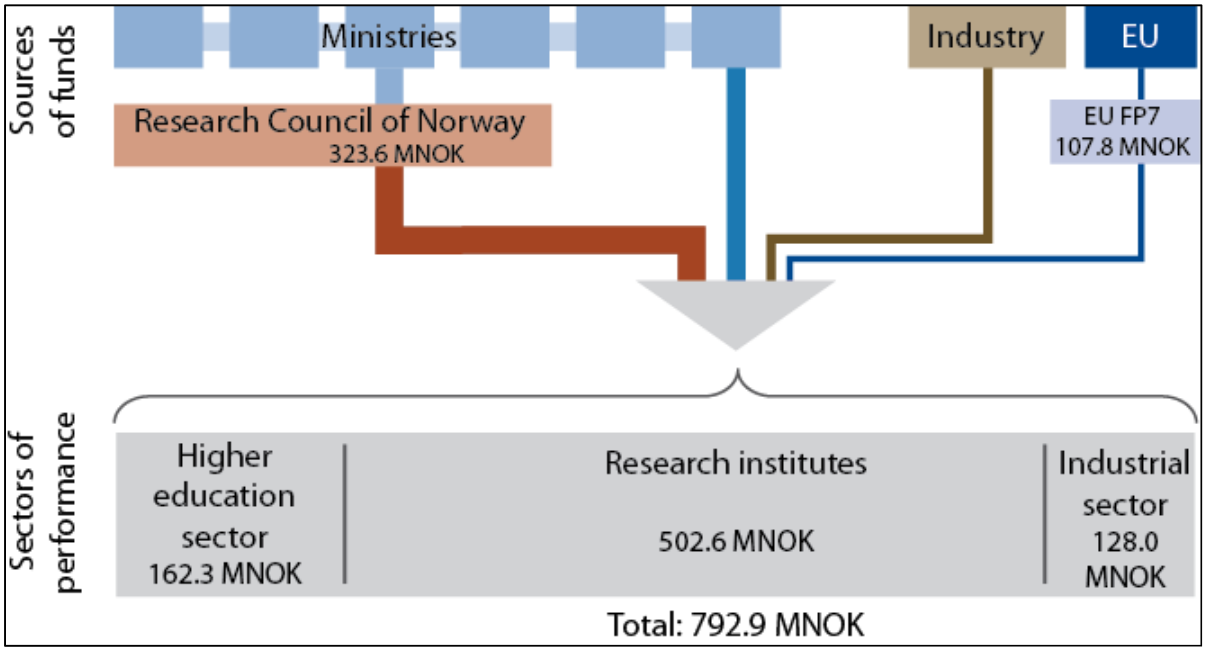

Figure 2.3.2. Main funding streams for Norwegian climate research, 2009. Source: RCN, NIFU/SSB
Notes: The volume of RCN and EU FP7 funding is based on data provided by RCN. The figures in the sectors of performance part of the diagram explain the R&D expenditures. They are based on data provided by NIFU/SSB's R&D Statistics (2011).

Figure 2.3.2 shows the most important funding streams for Norwegian climate research. The main sources of funding are the ministries, which fund the Norwegian climate researchers either directly or through RCN, mainly at independent research institutes and universities. The private business sector and the European Union are less important sources of research funding.

Table 2.3.1 gives an overview of the allocation of climate research resources from the different Ministries to RCN, distinguishing between NORKLIMA, IPY and other RCN climate-relevant funding. This information was provided by RCN. The most prominent sources of funding were the Ministry of Environment, the Research Fund (the Research Fund was established in 1999 and finances long-term, basic research with emphasis on quality-measures) and the Ministry of Education and Research.

Table 2.3.1. Sources of earmarked funding for climate research received by RCN, MNOK. 2004–2010.

Programme / Funding source	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
NORKLIMA:							
Ministry of the Environment [1]	38.1	38.1	39.6	39.6	41.4	46.4	60.4
Ministry of Education and Research [2]	5.8	5.5	5.5	5.5	5.5	15.53	9.5
The Research Fund	48.3	41.0	36.0	20.0	20.0	20.0	20.0
Ministry of Agriculture and Food	3.0	2.5	3.0	3.0	4.0	4.0	7.0
Ministry of Fisheries and Coastal Affairs	1.0	1.0	1.0	1.0	2.0	2.0	2.0
Ministry of Transport and Communications			1.0	0.8	0.8	1.3	3.3
Other sources	4.5						
Total NORKLIMA [3]	***100.7***	***88.1***	***86.1***	***69.9***	***73.7***	***89.2***	***102.2***
IPY [4]				64.0	64.0	64.0	64.0
Other earmarked climate-relevant funding:							
Ministry of Foreign Affairs: Cooperation with China					9.0	9.0	9.0
Ministry of Education and Research: CoE Bjerknes Centre for Climate Research [5]	17.0	17.0	17.0	17.0	17.0	17.0	17.0
Total other climate-relevant funding:	***17.0***	***17.0***	***17.0***	***17.0***	***26.0***	***260***	***26.0***
Total:	***117.7***	***105.1***	***103.1***	***150.9***	***163.7***	***179.2***	***192.2***

Source: RCN.

Notes:

1. Ministry of the Environment: for 2009 and 2010 6 MNOK taken over from RENERGI are included.
2. Ministry of Education and Research: for 2009 10 MNOK from the government's economic rescue programme are included.
3. The Climate Agreement has increased funding for NORKLIMA for 2010 (14 MNOK from the Ministry of the Environment, 4 MNOK from the Ministry of Education and Research, 3 MNOK from the Ministry of Agriculture and Food and 2 MNOK from the Ministry of Transport and Communications.
4. IPY: 80 MNOK/year 2007-2010 (80% of the funding is labelled as funding of climate research).
5. Centre of Excellence Bjerknes Centre for Climate Research: only CoE funding provided by RCN listed.

Figure 2.3.3 shows the trend in RCN allocations compared with RCN's annual budget proposals, Klima21's proposed growth of RCN's climate research budget and RCN's own proposed budget trend after the Climate Agreement (*Klimaforliket*) (compare with Section 3.2 as well). Thus, neither Klima21's ambitions nor RCN's proposals were followed up by government allocations, and this is one reason why it was difficult to fund all of the excellent research proposals submitted by Norwegian researchers. For NORKLIMA, thematic calls for proposals (as opposed to open calls) were written in accordance with available funds so as to ensure a realistic number of applications relative to the scope of the call and the funds available. Experiences in NORKLIMA indicate that for calls with a success rate of 15–20 per cent all projects with exceptional and excellent quality were funded, compared with calls with a lower success rate of 8–10 per cent where several projects of excellent quality could not be funded.

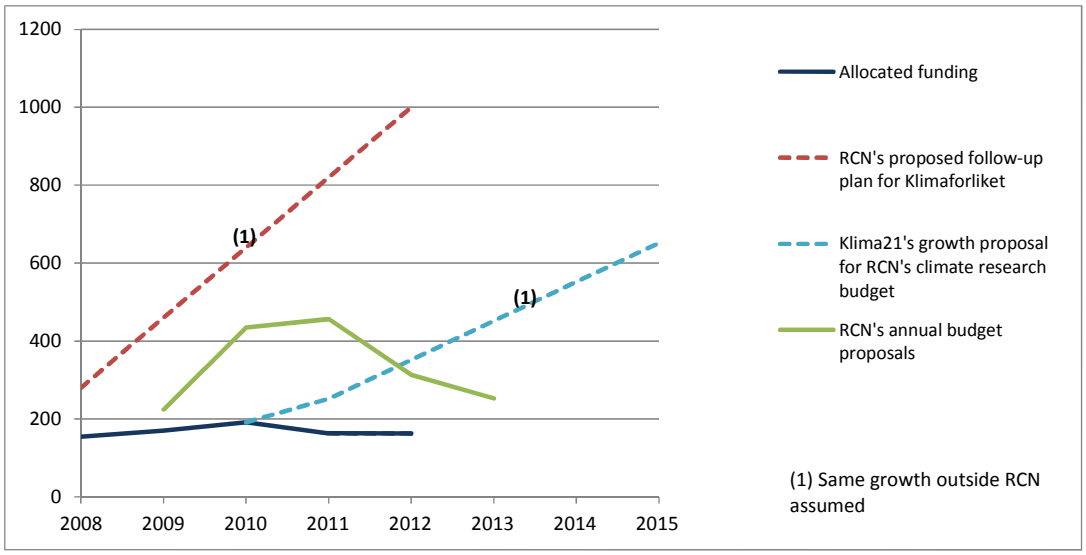

Figure 2.3.3. Trend in RCN allocations compared with RCN's annual budget proposals, Klima21's growth proposal and RCN's follow-up of the Climate Agreement. MNOK. 2008–2015. Source: RCN

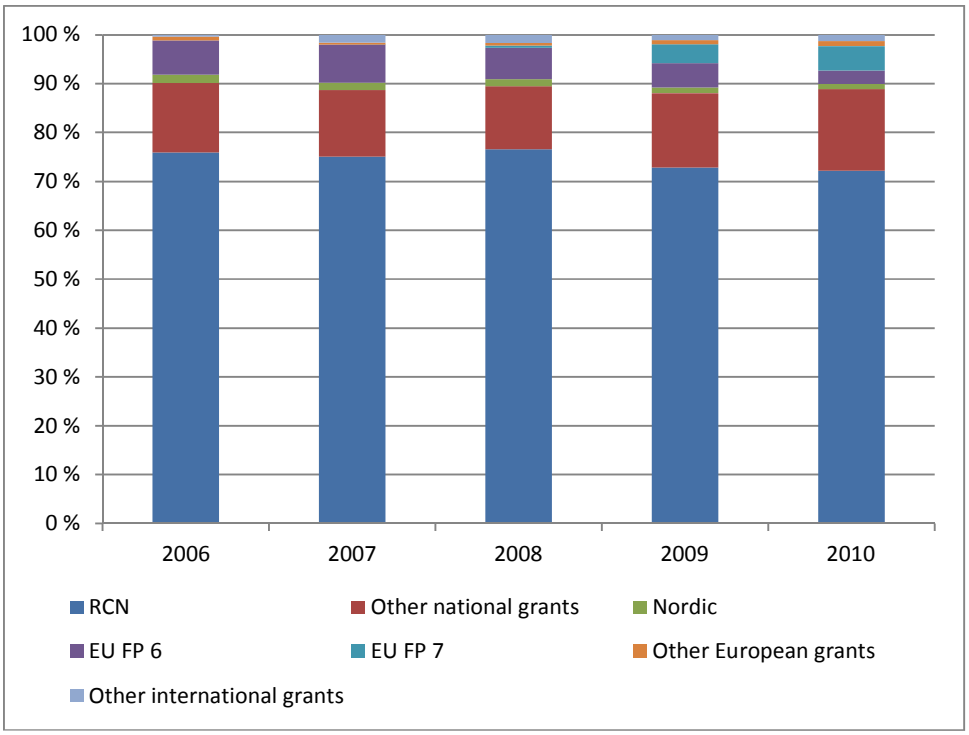

Figure 2.3.4. Distribution of all external funding sources in per cent. 2006–2010.
Source: Fact sheets provided by 72 research units.
Notes: 72 out of 78 research units reported external funding sources: 67 research units reported RCN funding; 45 units reported other national grants; 17 units reported Nordic sources; 20 units reported EU FP6 funding; 21 units reported EU FP7 funding; 14 units reported other European grants; and 12 units reported other international grants.

All in all, about 39 per cent of RCN funding of climate research was channelled through NORKLIMA and 16 per cent through the polar research programmes for the period 2005–2010 (see also Figure 3.3.1). The support for Centres of Excellence was important, not just for climate research, but also for funding for scientific excellence in general. This funding was given to several centres, not just the Bjerknes centre. In addition to these research programmes dedicated to supporting climate research, about 80 different RCN instruments provided funding of climate research to some extent. In the period 2005–2010 RCN funded

climate research for over 1,652 MNOK according to RCN's classification of climate-related funding. Main funding types were project funding (71%) and institutional grants (25%). Personal scholarships and other types of funding were less important (Figure 2.3.5). The following table lists the main RCN funding instruments, together with their duration and their main objectives.

Table 2.3.2. Main RCN programme funding instruments for climate research.[8]

Name	Start	End	Objective
NORKLIMA - Climate changes and impacts in Norway	2004	2013	The primary objective of NORKLIMA is to generate vital new knowledge as a basis for adaptive responses by human society. The main focus is on the climate system; climate trends in the past, present and future, and direct and indirect impacts of climate change on the natural environment and society.
IPY – The International Polar Year 2007–2008	2007	2010	IPY is a research programme under the auspices of *the International Council for Science (ICSU)* and the *World Meteorological Organization (WMO).* Norwegian participation in the IPY is administered by RCN, which has appointed an IPY committee under the permanent National Committee on Polar Research and established an IPY secretariat. The IPY was launched on 1 March 2007 and the Norwegian part of IPY has been a 4-year research programme which lasted until 2010. During that time, research resources and funding from over 60 countries were coordinated in an extraordinary initiative to increase our knowledge about both the Arctic and the Antarctic.
POLRES – Polar Research	2010		The Polar Research programme will help safeguard Norway`s special responsibility for the research-based knowledge that is necessary to conduct policy, management and business activity in the polar regions. Research affiliated with Svalbard will receive priority, including developing Svalbard as an international research platform and strengthening research cooperation with Russia. Since the Polar Research programme is still under launching, most of the funding for the period 2011-2012 has been announced via NORKLIMA.
Norwegian Centres of Excellence	2003		RCN has initiated this scheme with the intention of bringing more Norwegian researchers and research groups up to a high international standard. The centres are affiliated with Norway's top universities and independent research institutes. Today there are 21 centres of excellence. As research organisations continue to apply for this status, this number will increase.
FORINFRA – National Financing Initiative for Research Infrastructure	2008	2017	Research will provide the key to developing solutions to many challenges facing society today in areas such as health, climate and energy. The objective of the national financing initiative for research infrastructure is to provide researchers with the equipment they need in order to perform high quality science and to efficiently meet the needs of the business sector for high-calibre research. In addition, the initiative aims to enhance the Norwegian

[8] This list of programmes is not complete and there are other RCN programmes which contributed with substantial funding, for example FRIMUF and NORGLOBAL.

			research community's international reputation as a provider of outstanding research infrastructure.
HAVKYST – The oceans and coastal areas	2006	2015	The objective of this programme is to encourage creative marine environmental research of high international quality. A broad understanding of our marine environment forms a basis for long-term management of the marine ecosystems and their resources. The programme will bring about basic competence building in order to strengthen the integrated understanding of the structure, function and species diversity of the ecosystem.
NATURNAER – The research programme on nature-based industry	2008	2013	The main focus of this programme is to generate knowledge that supports industrial development based on the sustainable use of forests, coastal zones, and other land and coastal resources associated with the natural environment and areas of cultural significance.
MATPROG – The food programme	2006	2011	This programme aims to strengthen industrial development through research and innovation in Norway's food industries.
BIA – User-driven research based innovation	2006		This programme funds industry-oriented research and has no thematic restrictions. This broad-based programme supports high-quality R&D projects with good business and socio-economic potential. BIA is targeted at industry in collaboration with research organisations.
Centres for environmental-friendly energy research	2009	2013	The CEER scheme is a direct follow-up of the political agreement on climate policy achieved in the Storting (the Norwegian Parliament) in 2008 and of the national R&D strategy *Energi21*. The objective of the scheme is to establish time-limited research centres that conduct focused, long-term research of high international standing in order to solve specific challenges in the field. The first eight centres were established in 2009. In 2011, three new centres were established with a focus on social sciences, one of which focusses on international climate and energy policy.
RENERGI – Clean energy for the future	2004	2013	The objective of RENERGI is to develop knowledge and solutions as a basis for ensuring environment-friendly, economically efficient and effective management of the country's energy resources, a highly reliable energy supply and internationally competitive industrial development. RENERGI has a large number of projects that involve social research on energy and other social research projects that are climate-relevant. The allocations to these projects are accounted for in the next section.

The number of climate research projects labelled as 100 per cent climate research and including research project funding, institutional grants and scholarships increased by 38 per cent from 132 in 2007 to 182 in 2010, and the total volume of funding also including other types of funding (conferences, seminars etc.) increased by 34 per cent from 296 MNOK in 2007 to over 396 MNOK in 2010 (Figure 2.3.5).

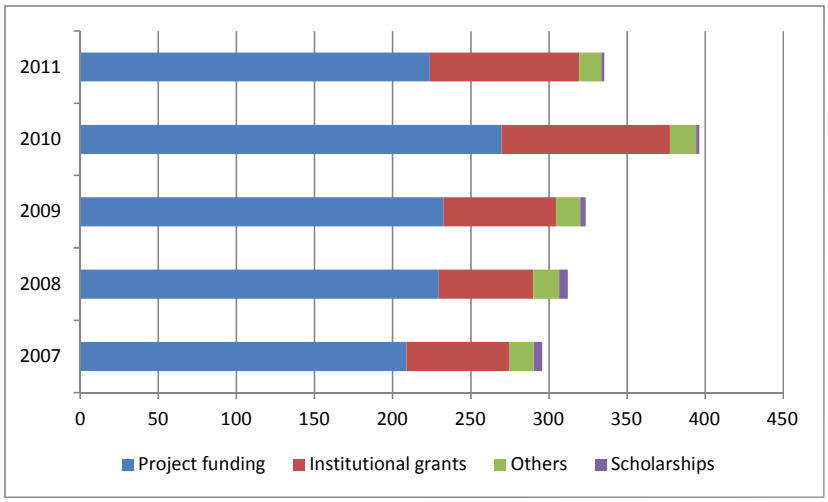

Figure 2.3.5. RCN funding for climate research by types of funding. 2007–2010. MNOK.
Source: RCN

The number of institutional grants declined from 44 to 40 in the same period, while the amount increased in the same period from 68.4 MNOK to 114.7 MNOK in 2010, which means that there is a stronger concentration of the institutional grants. Institutional grants include mainly institutional funding of research institutes active in climate research, strategic institute programmes, strategic university college programmes, Centres of Excellence, Centres for research-driven innovation, Centres for Environment-friendly Energy Research and institutional support for expensive research infrastructure.

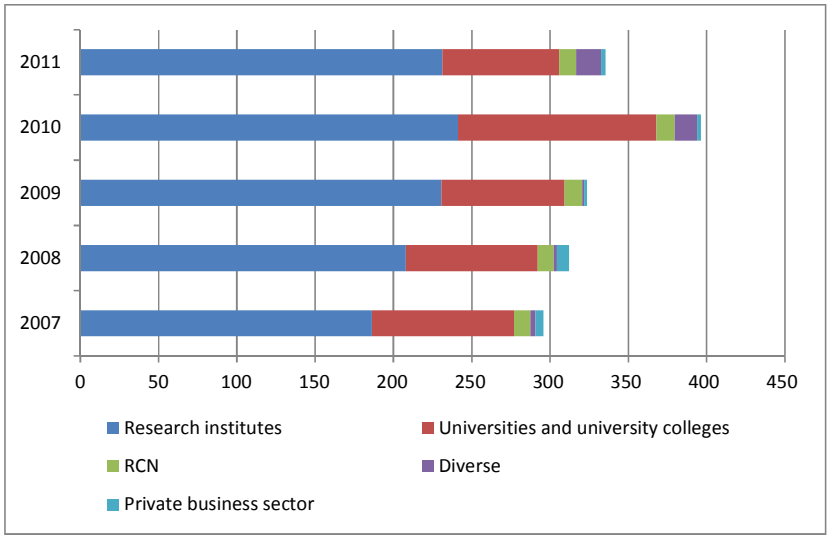

Figure 2.3.6. RCN funding of climate research by sectors of beneficiary, based on principal investigator. 2007–2010. MNOK.
Source: RCN

Universities and especially research institutes received most of the funding for climate research (Figure 2.3.6). Among the universities the University of Oslo and the University of Bergen received most of the RCN funding, which may be explained by their relative size. Among the research institutes, the Bjerknes Centre for Climate Research, CICERO and NILU received the most funding. There was also some minor funding of climate research in the business enterprise sector.

In addition to RCN, there were also some other important national funding sources for climate research. In total, 45 research units reported in the fact sheets that they had received funding from other national sources, a total of 467 MNOK for the whole period. This funding increased from 58 MNOK in 2006 to 135 MNOK in 2010. The Norwegian Polar Institute (NPI) received substantial funding from the Ministry of Environment annually. Since 2010, NPI also received funding from the ICE centre and the Fram Centre. The Department of Arctic Geology at UNIS got funding from the Norwegian Space Agency. In 2010, the Bjerknes Centre in Bergen received a new 12-year institutional grant from the Ministry of Education and Research to ensure the key competence of the Bjerknes Centre after the Centre of Excellence period is over in 2012. The new 12-year grant will be used to fund the Centre for Climate Dynamics at the Bjerknes Centre.

2.3.2 Nordic instruments

Only 16 research units out of 78 reported Nordic funding sources, and the total amount was 40 MNOK for the entire period. Except for the Nordic Energy Research (NER) and the Top-level Research Initiative (TRI), the different Nordic research funding instruments have not been specified. In the following we give an account of Nordic climate research funding based on information provided by NER and NordForsk.

NER provides funding in four-year cycles. The year 2010 marked the end of such a cycle, in which the thematic focus was on "climate and energy, energy efficiency, renewable energy, hydrogen technology, and energy markets" (Nordic Energy Research, 2011). One of the projects with a focus on climate and energy was "Climate and energy systems – risks, potential and adaptation" with a total budget of 18.2 MNOK. This project was funded with 10.0 MNOK by NER, with the participation of several Norwegian actors: NVE, Sintef and Statkraft.

During 2003–2007, the most visible and important joint initiatives were the Nordic Centres of Excellence (NCoE) funded by NordForsk, under the NCoE Programme on Global Change. Four NCoEs were established and funded (Figure 2.3.7), one of which, "EcoClim: The dynamics of ecological systems under the influence of climatic variation", was led by a Norwegian research organisation, the University of Oslo. The NCoEs received basic funding from their national sources and were supported by NordForsk with 58.3 MNOK (see Section 4.2 as well).

The programme was evaluated in 2009, and the evaluation report stated that funding from this programme was "low compared with other sources of funding at the national and European levels" (NordForsk 2009a, p. 12). However, the status of the Nordic Centres of Excellence was prestigious and helped obtain funding from other sources.

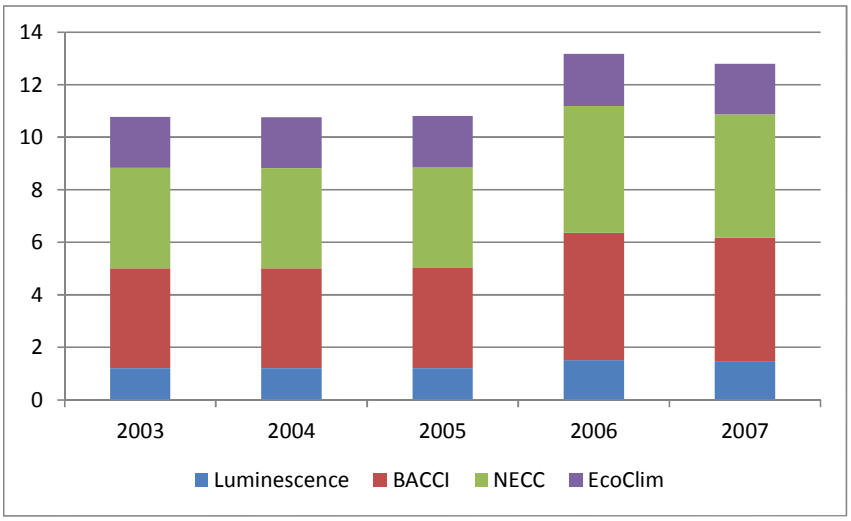

Figure 2.3.7. Nordic Centres of Excellence funding by research organisations that received it. 2003–2007. In MNOK (NordForsk, 2009a).

In 2009 the Top-level Research Initiative (TRI) was launched. The TRI has a budget of 410 MNOK over five years. Two sub-programmes in TRI are of particular interest for climate research, "Interaction between climate change and the cryosphere" and "Effect studies and adaptation to climate change". Both sub-programmes had calls for Nordic Centres of Excellence in 2010, and in both programmes one of the three established centres has a Norwegian project leader. The two NCoEs have funding of about 70 MNOK over five years. Most of this money is for networking activities and PhD/post-doc training.

The NCoE "NorMER (The Nordic Centre for Research on Marine Ecosystems and Resources under Climate Change)" is led by the University of Oslo and has 17 partners from all of the Nordic countries, 10 PhDs and 7 post docs. The sub-programme also funds ten Nordic networks and each network receives up to 0.3 MNOK per year for three years (see Section 4.2 as well). There are four Nordic networks with Norwegian project leaders. The NCoE "SVALI – Stability and Variations of Arctic Land Ice" is led by the University of Oslo and has 15 partners from all Nordic countries, 11 PhDs and 6 post-docs. In the other four NCoEs Norwegian research groups are partners.

It is difficult to estimate the amount of TRI funding of the climate research in Norway, but based on the number of PhDs and post-docs, an estimate of 8 MNOK per year seems reasonable.

2.3.3 European instruments

The EU Framework Programmes are reported by the research units as the third most important funding source overall: FP 6 accounts for 5.4 per cent of all external funding and FP 7 accounts for 2.3 per cent. The reason for the lower share of FP 7 funding is that the programme period is still going on, whereas FP 6 is already finalised. Other European, international or Nordic funding sources are less prominent.

The total funding reported by the 20 research units that reported grants from the 6th EU Framework programme (FP6) was about 150 MNOK. The most important EU research programme listed was 'Sustainable development, global change and ecosystems', which received about half of the funding volume (Figure 2.3.8). There is also a large amount of

funding in the category ‘unspecified’, 41 MNOK, where the research units did not specify the thematic focus of the funded projects.

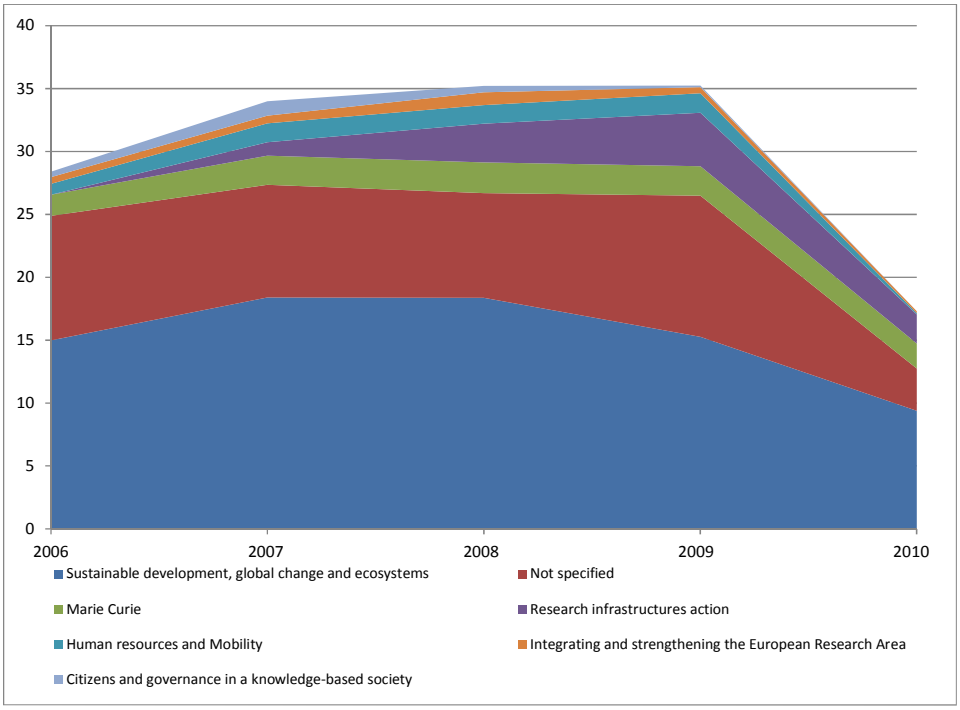

Figure 2.3.8. Funding of Norwegian climate research by EU FP6, in MNOK (N=20). 2006–2010. Source: Fact sheets from the research units. 20 out of 78 units reported FP6 funding.

From 2008 to 2012, Norwegian researchers participated in 93 projects categorised as climate research under the 7th EU Framework programme (FP7) (based on RCN data). In the period 2008–2011 the total funding provided to Norwegian participants in 77 projects was about 420 MNOK. The most important programme under FP7 in terms of the volume of funding was the programme “Environment, (including climate change)” (Figure 2.3.9). Two-thirds of the FP7 funding came from this programme. The thematic topics “Space”, “Research infrastructure” and “Transport” provided the next highest levels. Research projects on political framework conditions and instruments for reducing emissions received higher priority in 2011.

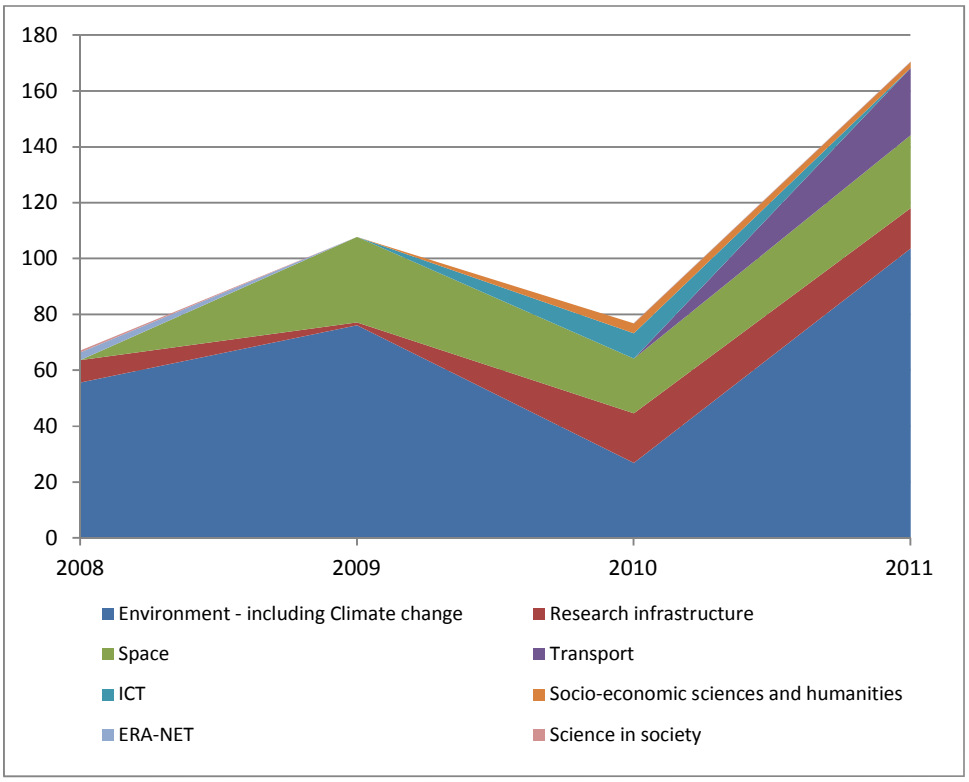

Figure 2.3.9. Funding of Norwegian climate research by EU FP7 by funding programme, MNOK (N=77 projects). 2008–2011.
Source: RCN, based on labelling of EU FP7 projects by RCN; the year is the year when the project started.

We have no account of the number of climate research proposals, but we take proposals to the FP7 programme "Environment, (including climate change)" as a good proxy since 51 of the 93 projects were labelled as climate research. Norwegian researchers have submitted 349 research proposals so far, and 93 projects received funding which means a success rate of 26.6 per cent, which is rather high. Altogether Norwegian researchers coordinated 11 projects labelled as climate research in the Environment programme. This means a share of 22 per cent, which was higher than the share of coordinators for all Norwegian projects under the programme "Environment, (including climate change)" in total, where Norway had the highest share of coordinators (16 per cent) among the Nordic countries.

In addition to the European Framework Programmes, 14 research units reported other European funding sources, without specifying which funding instruments they received funding from. The total funding from these sources was about 24 MNOK.

2.3.4 Other international instruments

Finally, 11 research units reported in the fact sheets that they had received a total of 40 MNOK from other international funding instruments. This funding increased from a rather low level in 2006 to over 10 MNOK in 2008.

2.3.5 Thematic focus of climate research funding

Basic funding of climate research was especially high for research units specialized in the themes 'Impacts of, and adaptation to, climate change and variability' and 'Climate system

and climate change', whereas the theme 'Institutions and instruments for response to climate change' received less than one per cent of the basic funding.

For the period 2009–2011, the climate research projects have been labelled by RCN according to the three different themes, which are identical with the themes in this evaluation (Figure 2.3.10). 'Climate effects and adaptations' (Theme 2) received the highest share of funding and also an increase for 2010. 'Institutions and instruments for response to climate change' (Theme 3) were less prioritised. However, funding for Theme 3 has increased in 2010 and 2011 relative to 2009, in both the amount and percentage of total funding.

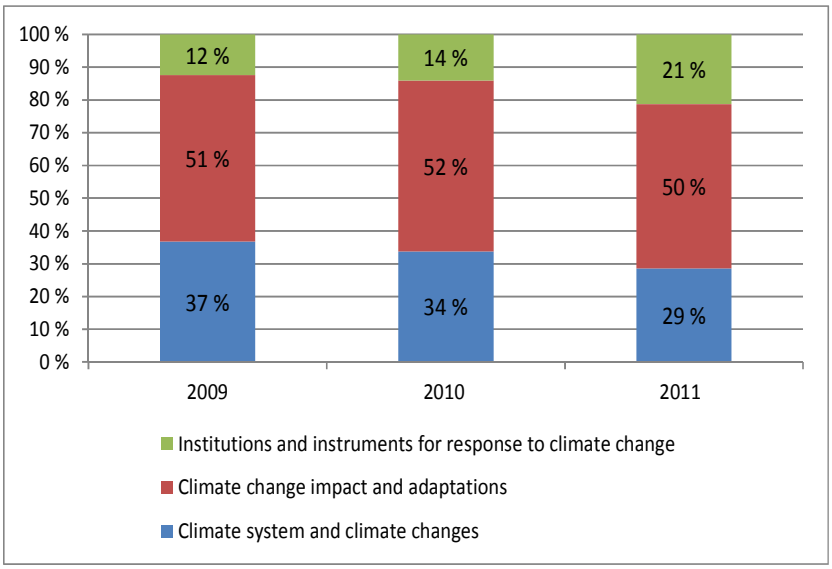

Figure 2.3.10. Thematic distribution of RCN climate research funding. Percentage. 2009–2011.
Source: RCN.

RCN also labelled the thematic orientation of all 77 FP7 projects according to these three research themes (Figure 2.3.11). Almost 80 per cent of all projects were labelled with more than one research theme: 57 per cent were labelled with two themes, 21 per cent were labelled with three themes, whereas only 21 per cent were labelled with only one theme. 'Impacts of, and adaptation to, climate change and variability' and 'Climate system and climate change' predominate. The third theme, 'Institutions and instruments for response to climate change', has gained much more funding in 2011, which may indicate a new trend.

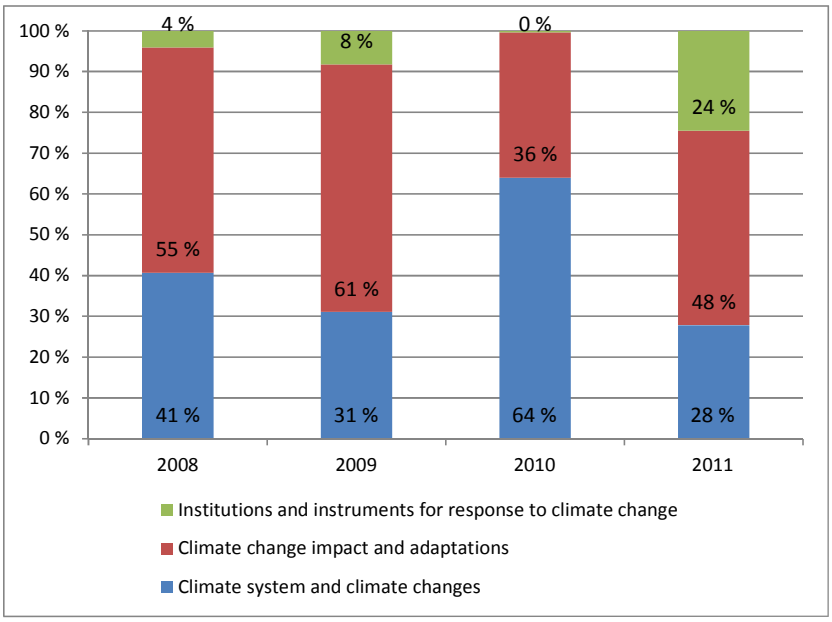

Figure 2.3.11. Funding of Norwegian climate research by EU FP7. Percentage. 2008–2011.
Source: RCN, Note: Based on project start year.

2.3.6 Summary of key findings

There are two main public funding modes for public research organisations in Norway: basic funding and external funding. External funding came from the following main funding sources: RCN, other national grants, Nordic sources, EU FP 6 and FP 7, other European grants and other international grants. 89 per cent of all external funding came from Norwegian sources: 74 per cent from RCN and the rest from other national grants (public and private).

RCN received funding of climate research from various ministries. The most prominent sources of funding were the Ministry of Environment, the Research Fund (the Research Fund was established in 1999 and finances long-term basic research with emphasis on quality-measures) and the Ministry of Education and Research. The most important RCN activities in terms of funding climate research were NORKLIMA, IPY, and the basic funding of research institutes.

Nordic funding of Norwegian climate research was less prominent, but some programmes gave important contributions: the Nordic Centres of Excellence funded by NordForsk under the Programme on Global Change, Nordic Energy Research, and the Top-level Research Initiative with the two sub-programmes, “Interaction between climate change and the cryosphere” and “Effect studies and adaptation to climate change”.

The most important EU FP6 programme was ‘Sustainable development, global change and ecosystems’ which accounted for about half of the funding volume. The most important programme under FP7 in terms of the volume of funding was the programme “Environment, (including climate change)”. Altogether Norwegian researchers coordinated 19 out of 77 projects labelled as climate research.

Basic funding of climate research was especially high for research units specialized in the themes ‘Impacts of, and adaptation to, climate change and variability’ and ‘Climate system and climate change’, whereas the theme ‘Institutions and instruments for response to climate

change' received less than one per cent of the basic funding. 'Impacts of, and adaptation to, climate change and variability' (Theme 2) received the highest share of RCN funding, including an increase for 2010. 'Institutions and instruments for response to climate change' (Theme 3) were less prioritised. However, funding for Theme 3 has increased in 2010 and 2011 relative to 2009, in both the amount and percentage of total funding. Among FP7 projects 'Impacts of, and adaptation to, climate change and variability' and 'Climate system and climate change' predominate.

3 Strategic Focus of Norwegian Climate Research

3.1 Climate Research Policy Priorities

This subsection describes Norwegian climate research policy priorities based on relevant policy documents. Climate research policies have been addressed in a series of Norwegian policy documents over the last decade. Here we give a short overview of the most relevant policies and comment briefly on how they relate to the research agenda. As the analysis shows, the ambitions are high, but their realization remains only partial, with important gaps still to be filled in order to address the political targets.

3.1.1 White Paper "Norwegian climate policy"

Three ambitious political goals were proposed by the Norwegian government in the Report No. 34 (2006–2007) to the Storting (a White Paper), namely that:

- Norway will become carbon neutral by 2050;
- Norway should assume an obligation to reduce global emissions of greenhouse gases by 2020 equivalent to 30 per cent of Norway's emissions in 1990;
- Norway will intensify its Kyoto commitments by ten percentage points to nine per cent below the 1990 level (Miljøverndepartementet, 2007).

According to the White Paper, key instruments of high priority for achieving these goals are research and technology development, including environment-friendly energy technology, research on the climate system, and monitiring of climate processes and the consequences of climate change in the Arctic. Interdisciplinary research is also stressed, as well as cooperation among different ministries, especially between the Ministry of Science and Education and the Ministry of Environment. Furthermore, the White Paper emphasises the geographical location of Norway, with its access to the Arctic region and its research activities in the Antarctic, providing great possibilities for contributing to international climate research with continuous surveillance and measurement of relevant indicators. Long-term involvement is deemed necessary for being able to realize such a continuous long-term surveillance.

The White Paper on Climate policy was based on the recommendations of the Climate Research Panel established by RCN in 2005 (for more details, see Section 3.2).

3.1.2 Political agreement on the White Paper on climate policy (the Climate Agreement *[Klimaforliket]*)

In January 2008, most of the political parties in the Storting (the Norwegian parliament) reached a political agreement on the White Paper on climate policy (Arbeiderpartiet et al., 2008). This led to a stronger focus on climate-related research, resulting in increased funding of research centres for environment-friendly energy. Norway's contribution to the further development of the knowledge base for climate policy is again emphasised. It foresees the

establishment of a strategic body for climate and environmental research following the model of Energi21. The agreement sets the following target areas for Norwegian climate research:

- regional and global climate changes – research on and surveillance of climate processes and consequences of climate changes in the Arctic region;
- consequences of and adaptation to climate change, among others for public and private sector activities;
- social science research as an input to policy making and to framework conditions of climate policy;
- development of climate-friendly technology and renewable energy;
- development of business activities based on climate technology development.

3.1.3 Klima21

The development of a research and development strategy for the energy sector – Energi21 – contributed to an increase in public expenditure on environment-friendly energy. This process was followed up in part of the climate research in the research strategy, Knowledge for climate (Klima21) (Styringsgruppen for Klima21, 2010). This strategy was developed by a committee appointed by the government in December 2008. The strategy was published in February 2010. Klima21 made the following recommendations to the government:

- a considerable increase in funding for climate research – in 2015 the public funding should be at least 1 billion NOK above the level in 2010;
- long-term research priorities and incentives based on intellectual property rights should be established so as to give the research groups and the business sector predictability;
- coordination of climate research by continuing the work of Klima21 through interaction between the ministries' efforts and the funding of climate research, and by further ensuring the responsibility of the Research Council for the coordination and evaluation of those efforts;
- establishment of a climate science council where researchers, the government and central politicians may meet for dialogue and exchanging knowledge.

These recommendations still remain to be implemented.

According to Klima21 three fields of research need to be prioritised: the climate system, consequences of and adaptations to climate change and mitigation, in particular to reduce greenhouse gas emissions. Recommended measures in those three themes included:

(1) The climate system:
  - establish a long-term research programme to reduce uncertainty in the climate-change scenarios;
  - secure long-term financing for high-performance infrastructure;
  - continue to develop and establish critical infrastructure for research and monitoring;
  - budget growth of 250 MNOK by 2015 and prioritisation of infrastructure.

(2) Consequences and adaptation:
  - establish long-term and economic research centres on the basis of national competition;
  - establish a long-term research programme with user (stakeholder) focus;
  - continue to develop and establish critical infrastructure for research and monitoring;

- budget growth of 250 MNOK by 2015 with rapid and, relatively speaking, the greatest growth in social science research.

(3) Reduced greenhouse gas emissions:

- establish long-term financed social science research centres;
- include emission-reducing research in various research programmes;
- budget growth of 500 MNOK by 2015, coordinated with and in addition to funding from industry.

The Klima21 proposals for research measures are awaiting consensus among the political parties and ministerial bodies before they can be implemented (RCN, 2011f). As our evaluation analysis shows, several of them are mentioned as highly relevant and necessary to be addressed by the research units, and we return to this in our conclusions about the future directions of the research.

3.1.4 High North Strategy

In 2006, the government, through the Ministry of Foreign Affairs, developed its first High North strategy. The High North Strategy underlined the importance of intensifying monitoring of climate change and knowledge generation with regard to the impacts of climate change (Norwegian Government, 2006; p. 46).

In the spring of 2009, the government published a follow-up to this strategy: "New Building Blocks in the North – The Next Step in the Government's High North Strategy". Its first chapter is devoted to developing knowledge about climate and the environment in the High North. It states that the Norwegian research communities in the "northern areas have a considerable advantage as regards research on climate change in general, and more specifically on the role the Arctic plays in the global climate system" (Norwegian Government, 2009; p. 9). The following table highlights important strategic aims and the ways they have been implemented so far.

Table 3.1. Strategic aims of the High North Strategy (2009) and their implementation

Aims of the Government's High North Strategy (2009)	Implementation processes
Developing a centre for climate and environmental research in Tromsø that would include:	
Establishment of the Centre for Ice, Climate & Ecosystems (ICE)	The Fram centre is expanded with 21 participating research organisations in a joint High North Research Centre for Climate and the Environment. The Fram centre has 5 flagship projects. The ICE centre was opened in March 2009 at the Norwegian Polar Institute. It is to become a national competence centre for ice and climate research in the Arctic. The ICE centre is an important contribution to the Fram centre flagship research programme 'Sea ice in the Arctic Ocean, technology and agreements'.
Generating knowledge of the environment and living resources in the northern marine environment	This research area is covered by the work of HAV21, a strategy group established by the Norwegian government in 2011. It is also planned to be covered by the JPI Oceans. Both HAV21 and JPI Ocean will include a Nordic dimension. Relevant research is funded by RCN's

	programmes NORKLIMA and The Oceans and the Coastal Areas (HAVKYST). Relevant knowledge building is going on under the flagship projects of the Fram centre and in connection with the work on the Management plan for the Barents Sea.
A new research programme on climate change and ocean acidification	Relevant research will be conducted under the Fram centre flagship research programme Ocean acidification and ecosystems effects in Northern waters. Relevant research is funded by RCN's programmes NORKLIMA and HAVKYST.
Knowledge building on the impacts of and adaptation to climate change for business and industry, based on cross-sectoral cooperation	Important problems and challenges were identified in the report of the RCN and the National Polar Research Committee report titled 'Business and polar research' (2011). The research government initiative NORDS-ATSING has a focus on tourism and arctic technology. The latter include relevant research projects. RCN funds a centre for research-driven innovation: 'Sustainable Arctic Coastal and Marine Technology', coordinated by NTNU.
Knowledge building on the impacts of the growing volume of maritime transport in the Arctic	Barents2020 and RCN's programme MAROFF are relevant here. NORKLIMA funds a relevant project on climate impact of arctic ship traffic.
Further development of expertise on coastal and fjord ecology	HAVKYST has activities in the sub-programme Marine eco systems. There are also relevant projects under the sub-programme Impact on eco-systems..
Establishment of an environmental specimen bank of ecological toxins	In 2009, the Climate and Pollution Agency (Klif) started a programme for monitoring of environmental toxins, petroleum and radioactive substances in the Norwegian coast and sea regions.
Establishing new technical research infrastructure including:	
Establishing an Arctic Earth observation system in Svalbard	SIOS is in the preparatory phase with funding from EU and RCN. This is a prioritised research infrastructure and Norway has offered to host SIOS.
Building a next-generation radar system in the High North (EISCAT 3-D)	EISCAT-3D is in the preparatory phase with funding from EU and RCN. The final funding has not been decided, but RCN assumes that this will be an important part of the High North Strategy of the Norwegian government and Norway's established membership in Eiscat. The Nordic research councils have been oriented and are communicating with Eiscat about it.
A new ice-class research vessel	The Design of new ice-class vessel is accomplished under leadership of the Institute of Marine Research, but the government has not yet determined the final funding of the vessel.
Mapping the diversity of the seabed	The programme MAREANO will survey the seabed and the seabed environment, biodiversity and the pollution of sediments in the Norwegian coast and sea regions. The programme is funded by three ministries, and it contributes to the work on the Management plan for the Barents Sea.

3.1.5 Adapting to a changing climate

In December 2008, a committee was appointed to explore Norway's vulnerability and adaptation needs as a result of climate change. The committee published its report to the Ministry of Environment in November 2010: Adapting to a changing climate (NOU, 2010). The report supported the Klima21 recommendations in terms of both research needs and the need to fund climate research. The committee had the task of surveying relevant research programmes and specifying research needs regrding consequences of climate change. The report gives a short overview of Klima21 and RCN's NORKLIMA programme (p. 210). The report states that the need for a regularly updated knowledge base is not adequately met through ordinary research programmes and projects of a relatively short-term nature. The committee supports the Klima21 recommendation to establish large-scale, long-term research programmes that specifically address the climate system and the impacts of, and adaptation to, climate change. It recommends that the Research Council should establish a strategic research programme for the construction industry, with a primary focus on the impacts of climate change on that industry.

Existing monitoring programmes must be shored up, and new programmes must be developed, particularly relating to the natural environment and natural hazards. The committee also advises improving the monitoring of wind and short-term precipitation.

3.1.6 Summary of key findings

The overall priority areas for Norwegian climate research are as follows:

- an improved knowledge of the climate system, including the development of climate scenarios with reduced uncertainty and a greater degree of detail, and an increased understanding of the Arctic climate;
- research on consequences of and adaptation to climate change for nature and society, including public policy and technology;
- research on the development and implementation of policies and instruments to reduce greenhouse gas emissions, including research into behavioural changes for the reduction of emissions.

3.2 Policy Development within the Research Council of Norway

The above-depicted Norwegian climate research policy gives an overall framework, but in order to translate this into specific funding allocations, RCN has to specify these research needs to the relevant ministries and persuade them to make budgetary provisions. The Ministry for Education and Research does not have sole responsibility for research funding in Norway, as is the case in many other countries, but it is expected that the allocation of funding will be shared by several ministries. For climate research, the Ministry of the Environment, the Ministry of Agriculture and Food, the Ministry of Fisheries and Coastal Affairs, the Ministry of Transportation and Communication and the Ministry of Foreign Affair are the main sponsors in addition to the Ministry for Education and Research. There are also possibilities to apply for funding from private industry, and such funding is used for some projects in which there is more immediate potential to make use of the research results. This means that there is a constant bargaining process under way with numerous actors which result in multiple implementation constraints. The iterative process between the Norwegian

Government's policy and the subsequent allocation of funding to RCN appears complex and rather time-consuming as compared with the situation in other countries.

Figure 3.2.1 gives an overview of the timeline from 2006 to 2010 for the political strategies and report to the Storting issued by the Norwegian Government, other important policy documents based on cross-party collaboration, and RCN's policy actions. Taken together, they form an intricate web of interactions between policy-making, budgetary demands and allocations. The respective RCN documents are commented upon in the following.

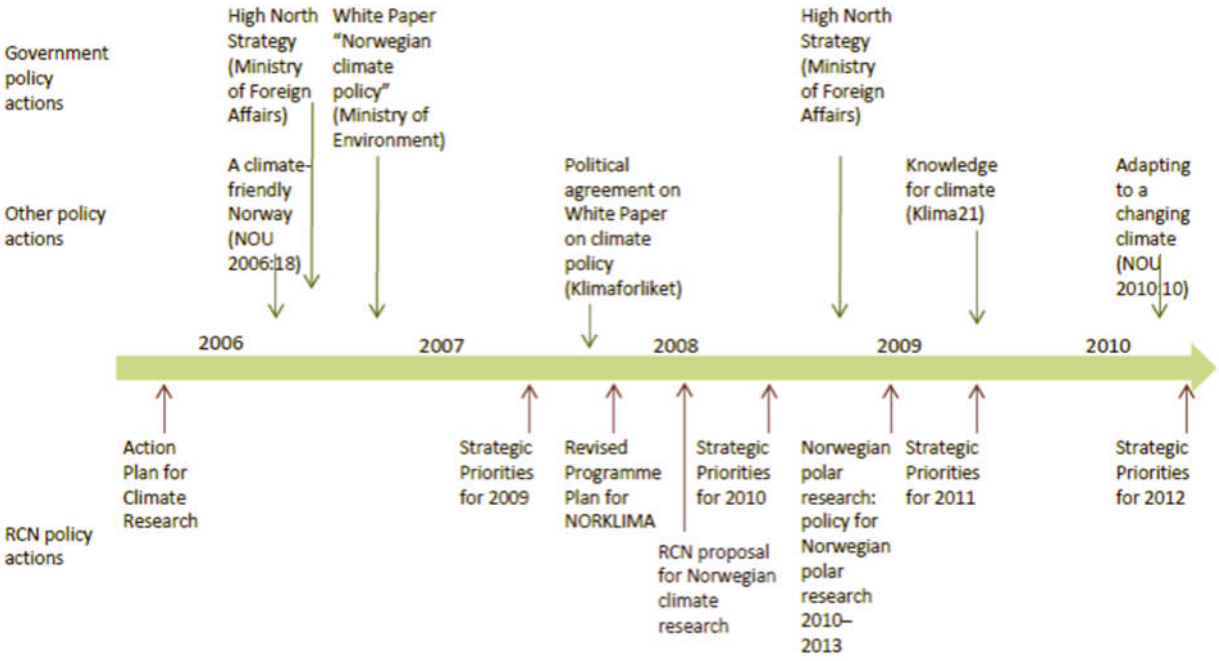

Figure 3.2.1. Climate research policy time line: 2006–2010

3.2.1 Action Plan for Climate Research

The global climate crisis has received increased political attention in Norway. The development of an Action Plan for Climate Research in 2006 (RCN, 2006) was an important contribution to the improvement of Norwegian climate research. The Action Plan is based, among other things, on a survey of Norwegian climate research which showed that in 2005 a total of 1,012 MNOK had been expended on climate research (Røsdal & Aksnes, 2006). Norwegian climate research is distributed among the following science groups: natural sciences (52 per cent), technology (42 per cent) and social sciences (6 per cent). Norwegian climate research has been improved as a result of a report by the coordinating committee for climate research in 2000. The growth in funding was by far the greatest in natural sciences, but also substantial in technology and engineering sciences. Social science research remained at almost the same level in 2005 as in 1998 (RCN, 2006). The coordinating committee for climate research at RCN stressed that climate research requires strong disciplinary research and multidisciplinary cooperation. Climate-related research has to meet transdisciplinary needs, which can only be addressed by combining understanding in several scientific fields (p. 31).

The Action Plan for Climate Research lists specific national interests related to climate, such as the North Atlantic Drift and its extension, the Norwegian Atlantic Current, the vulnerability

of the Arctic, fishing and other nature-based businesses, and boundary zones between ecosystems.

3.2.2 Revised Programme Plan for NORKLIMA

In August 2008, the Programme Plan for NORKLIMA was revised (RCN, 2008b). The revised Programme Plan specified the research priorities for the remaining period of NORKLIMA, 2008–2013. The programme stated that the original main priorities remain unchanged: "to generate vital new knowledge about the climate system, about climate trends in the past, present and future, and about the direct and indirect impacts of climate change on the natural environment and society, as a basis for adaptive responses by society" (p. 6). The scientific objectives cover the broad thematic range of this evaluation to improve understanding and knowledge of:

1. the climate system and its variability, and to quantify uncertainty.
2. climate change and its impacts on buildings, infrastructure and other installations, both on land and offshore.
3. climate change and its impacts on natural and cultivated ecosystems and natural-resource-based industries.
4. the impacts of climate change on society and the ways in which adaptive capacity can be improved.
5. the links between emission trends and the development of society, and of international cooperation to mitigate climate change (p. 10).

3.2.3 RCN proposal for improving Norwegian climate research

In October 2008, as a follow-up of the Political agreement on the White Paper on climate policy (The Climate Agreement), RCN issued a proposal for how to enhance the volume and improve the strategic orientation of climate research (RCN, 2008a). It was proposed that the funding of climate research be increased via different funding instruments from the 2008-level of 260 MNOK to NOK 1 billion in 2012. It was proposed that this increase be achieved through a stepwise process: 300 MNOK in 2010, and 220 MNOK annually in 2011 and 2012. The document also supported the work of Klima21. The document proposed that the increased budget be divided as follows among four different thematic areas:

- climate development and climate change – increase with 120 MNOK;
- consequences of and adaptation to climate changes – increase with 200 MNOK;
- climate policy – increase with 100 MNOK;
- actions and emission reductions – increase with 320 MNOK.

3.2.4 Norwegian polar research: policy for Norwegian polar research 2010–2013

In September 2009, RCN's Executive Board adopted this policy document on Norwegian polar research 2010–2013 (RCN, 2009a). The document covers polar research in both the Arctic and in the Antarctic. The document states the following four overall objectives for Norwegian polar research:

1. "Scientific: Norway will be the leading nation in certain fields of polar research. Norwegian polar research will provide important input to research of global interest.

2. Management and environmental: Norwegian polar research will provide a basis for sustainable development and management of the Polar Regions.
3. Political: Norwegian polar research will provide an important knowledge base for Norwegian policy in the Polar Regions and contribute to sustainable development of the global community.
4. Industrial: Norwegian polar research will contribute to sustainable industrial development of the Polar Regions" (p. 9).

The document recommends giving priority to the following thematic areas:

- developing an *Earth system science approach* using models that link regional studies in the polar regions with global studies;
- research on *economic activities in the Polar Regions and their impact* on marine ecosystems, ice conditions, ice loads and ice mechanics, and pollution;
- *social science research* on change and adaptation, and on geopolitical issues relating to change in the polar regions; research on natural resource management, and on indigenous peoples in the Arctic, historical and cultural heritage research on earlier human activities in the polar regions, and research on the management and conservation of the polar cultural heritage.

3.2.5 Annual national budget proposals

Each year, RCN submits an input – Strategic priorities (Store satsninger) – to the annual budget discussions in the relevant ministries (RCN, 2007a, 2008c, 2009b, 2010, 2011g). These proposals for an increased budget for climate research have been one of RCN's main priorities in the annual budget discussions. Here is a summary of the proposed increase and the government allocations from 2009 to 2013:

- 2009: RCN proposed a growth of 300 MNOK for research on renewable energy, environmental technology and climate change, of which 70 MNOK would be on climate, but no growth in RCN's allocations to climate research was achieved;
- 2010: RCN proposed a growth of 585 MNOK for research on energy, the environment and climate, of which 265 MNOK would be on climate, and the result was that RCN's allocations to climate research increased by 30 MNOK;
- 2011: RCN proposed a growth of 480 MNOK for research on climate and energy, of which 265 MNOK would be on climate, but RCN's allocations to climate research were reduced due to the finalising of IPY;
- 2012: RCN proposed a growth of 150 MNOK for research on climate and climate policy, but it is not likely that any growth in RCN's allocations to climate research will be achieved;
- 2013: RCN proposed an increased allocation of 90 MNOK for research on climate changes and sectoral challenges, 115 MNOK for the bio-economy, 140 MNOK for health and welfare, 135 MNOK for environmental technology and 100 MNOK for research equipment and infrastructure (Figure 3.2.2).

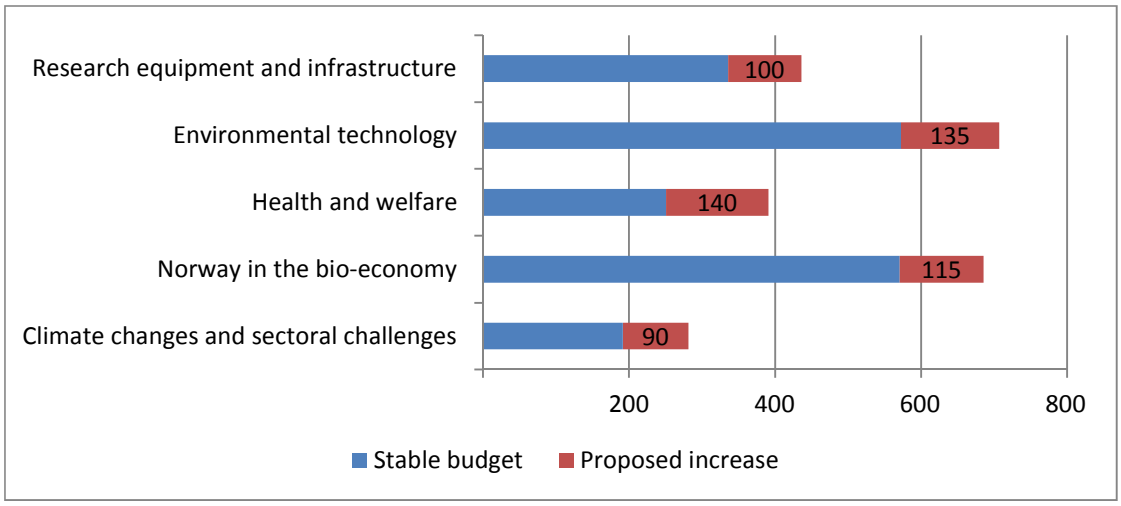

Figure 3.2.1. Proposed budgets for selected strategic priorities in 2013.
Source: English translation of RCN (2011g).
Note: Blue colour signals the size of the last budget, red colour signals increase for 2013.

3.2.6 Summary of key findings

In the years 2006–2009 the Norwegian government issued several important policy documents that gave high priority to climate change research in view of addressing Norway's climate goals. However, the more specific recommendations vary over the years, and quite a few remain to be implemented in practice. In particular, the Klima21 recommendations are still highly valid but poorly addressed in climate change research priorities.

Parallel to the Government's climate policy development, RCN responded by developing an Action Plan for Climate Research in 2006 and accompanying follow-up in the annual NORKLIMA Action Plans, the revised Programme Plan for NORKLIMA and yearly budget requests to the Government. The overall picture is one of high expectations, and well-developed plans for meeting the identified research needs, but the actual budget allocations have not met those expectations. The complex annual negotiation procedure between the RCN and a large number of ministries and other societal actors entails that decisions are piece-meal and implementation deficits commonplace. To date, few of the stated research priorities and needs have been adequately met and much remains to be done.

3.3 NORKLIMA and IPY

3.3.1 Background

Though the full breadth of available funding sources for climate research – national, Nordic, European and 'other' – has already been described (Section 2.3), it is plain that the NORKLIMA and IPY programmes have played such an important role in the funding of climate research in Norway over the past decade (lower two blocks in the histograms of Figure 3.3.1) as to justify a special focus in this evaluation.

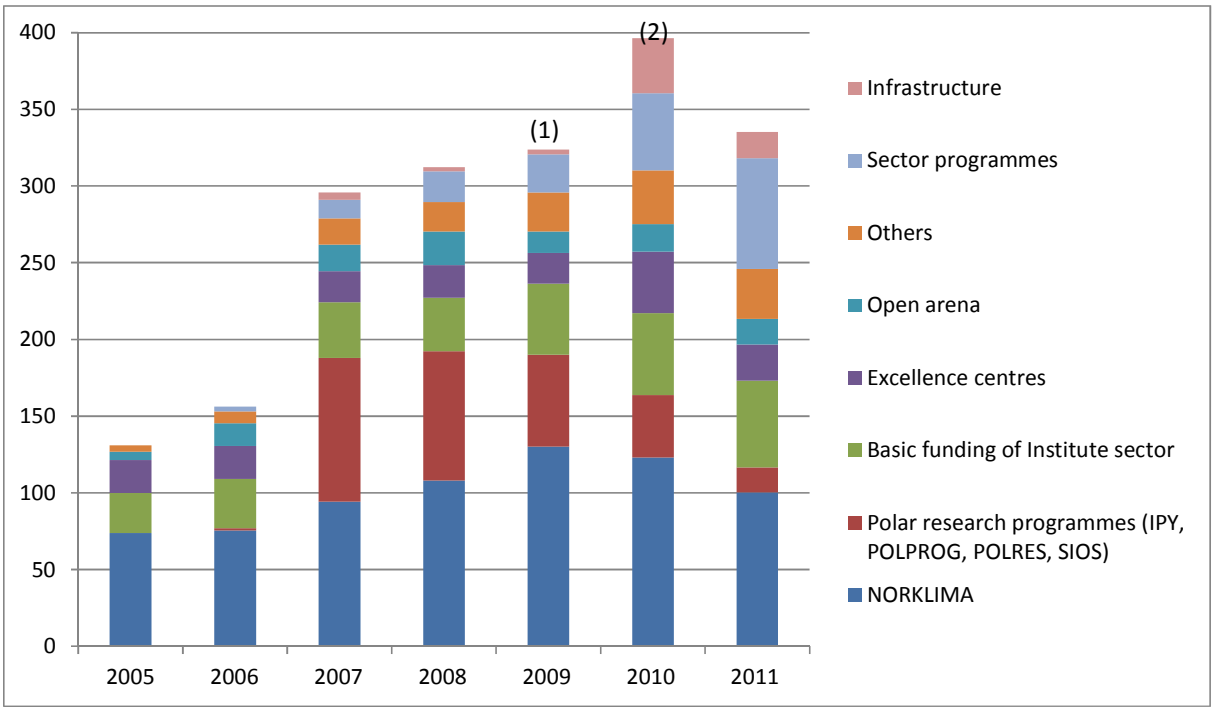

Figure 3.3.1. Climate research funded by RCN. 2005–2011. MNOK.
Source: Underlagsdokument – Kunnskapsgrunnlaget, Draft, 2011, and updated data March 2012 (RCN, 2011f). (The breakdown for 2004 is not yet complete).

Notes: (1) Since 2009 technology research addressing greenhouse gas emissions is not labelled as climate research. (2) The 20 MNOK funding of the Centre for climate dynamics at the Bjerknes Centre is included. After 2010 the centre is separately funded from the state budget. (3) IPY is the major part of 'polar research'.

3.3.2 NORKLIMA and IPY

3.3.2.1 NORKLIMA

The large scale Programme on Climate Change and Impacts in Norway (NORKLIMA; 2004-2013) has been a primary driver of climate research for almost a decade, with a total funding of 721.6 MNOK. In practise NORKLIMA 'inherited' the tail-end of pre-existing projects on related topics between 2000 and 2004. NORKLIMA will also continue to manage the main part of the Polar budget from the present 'until a new effort on polar research has been decided' (RCN, 2011b, Figure 3 and footnote to p15). Thus the allocated budget for all NORKLIMA applications including 'inherited projects' in the extended period 2000–14 amounts to the somewhat larger figure of 948.3 MNOK. The span of its primary objective was and is remarkably complete: 'to generate vital new knowledge on the climate system, its past, present and future trends, and the direct and indirect impacts of climate change on environment and society in order to generate a new knowledge base to guide our adaptive response to these changes'. To meet this aim, the programme has been organised around six sub-goals, although the final two (on emissions and society) were added relatively recently in 2008 and 2010:

1. To improve understanding of **the climate system and its variability**, and to quantify uncertainty.
2. To improve knowledge of **climate change and its impacts on buildings**, infrastructure and other installations, both on land and offshore.
3. To improve knowledge of climate change and its impacts on natural and cultivated ecosystems and natural resource-based industries.

4. To improve knowledge of the **impacts of climate change on society** and how adaptive capacity can be strengthened.
5. To improve knowledge of the **links between emission trends and the development of society**, and of international cooperation to mitigate climate change (this subgoal was included in 2008).
6. To improve knowledge of the **measures and policies for emission reductions** (this subgoal was included in 2010).

The expenditure on each of these subgoals as a function of time is shown in Figure 3.3.3.

3.3.2.2 IPY

The International Polar Year (IPY), which ended in March 2009, was the fourth in a series of global research initiatives (including the International Geophysical Year, 1957-58) dating back to 1882-1883. As such, it represented about a 50% increase in the global funding of polar science, a major expansion of the observation effort across polar and subpolar seas, the deployment of a wide range of new and complex observation techniques and a gratifying new degree of international collaboration in their use. As a result, the IPY has revolutionized our polar data sets to provide our first real glimpse of the ocean- atmosphere- cryosphere operating as a complete system. Resources for the 4-year Norwegian IPY effort, 2007-10, were awarded in a single round following one main funding call in January 2006. As finally realised in October 2006, the Norwegian IPY Programme consisted of 27 research projects with a budgetary framework of 290 MNOK, supplemented by the funding of more than 10 NORKLIMA projects that were closely related to the IPY (Orheim 2011, p39). Education, Outreach and Communication (EOC) projects were covered by a later call in 2006; all in all, a total of 14 MNOK was allocated to EOC activities by Norway with a further 10 MNOK on websites, communications etc. (Orheim op cit). The Norwegian programme was special in terms of its 4-year span, its bi-polar scope, its built-in emphasis on outreach, and the resources devoted to it. Norway had the third largest budget of the IPY-participating nations and the fourth manpower commitment.

Taken together, the annual funding of climate research through NORKLIMA and IPY by RCN peaked at about 190 MNOK around 2008 and has declined since then to under 120 MNOK (Figure 3.3.1).

3.3.3 The Submissions

Since both the IPY and NORKLIMA programmes have concluded or are scheduled to end shortly, the views of greatest interest to the evaluation were those that might aid the design and optimise the execution of any follow-up programme(s) that might be thought justified. Although views on these issues might be discussed at any level of detail, it was fairly clear that with 27 projects to consider in IPY and over 100 in NORKLIMA, the evaluation would most likely be couched in broad-brush terms, though not exclusively so. From the written submissions and interviews, the comments made to the Committee clustered around two issues in particular. The first concerned the perceived change in emphasis of NORKLIMA while the programme was underway. The second concerns the question of whether and how these programmes and their funding might be protracted into a legacy phase. We describe these in order below:

3.3.3.1 Content and steering of the programmes

In general terms, the administration of the IPY and NORKLIMA programmes was not faulted and in one case (Norwegian Meteorological Institute; met.no), the RCN was given special mention for the transparent and professional manner in which this was done. However, as the interviews continued, a small but insistent unease began to emerge regarding the design and steering of NORKLIMA (the shorter-term nature of IPY meant that this was not an issue). Two issues in particular were:

a) whether an appropriate balance had been struck and maintained between basic and applied science or between the natural and the social sciences. To quote examples, the Institute of Marine Research (IMR) as a body with the key responsibilities for the management of the marine ecosystem and environment submitted that, in its view, there has been a tendency for NORKLIMA to look at the two ends of its climate research spectrum, i.e. the climate itself and its effects on humans, but less on the ecosystems in between (note also the responses described under Sections 2.1.2.1 and 2.1.2.4 above, which support this view). The same point was articulated in a different way by the Norwegian University of Life Sciences (UMB) Nitrogen Group: 'NORKLIMA has been very important, but it was considered that the programme had become too social-science oriented'.

b) whether there had been a tendency for funding calls to become too specific and directed. In apparent support was the concern expressed by both the University of Bergen Geophysical Institute and the Bjerknes Centre for Climate Research (BCCR) that a recent perceived reduction in the number of climate models ('reduction of modelling toolbox') might have been one result of the over-direction of programmes, with the specific recommendation that RCN takes steps to set aside some investment funding for revitalising model development and for the maintenance of existing climate models. The BCCR submission confirmed that climate system research funding in Norway is undergoing a strong downward trend with erosion of the science base and a drive towards short-term and more opportunistic projects.

3.3.3.2 The case for continuation

The majority of written submissions and interviews stressed the past importance of NORKLIMA and IPY in advancing Norwegian Climate Research on a broad front. Probably the most important of these was its funding of a sequence of collaborative model advances (stemming from the RegClim, NorClim and currently EarthClim projects), which along with several EU projects, have brought the necessary new methods, analyses and products to bear. With its shorter duration, the IPY programme offered short-term PhD opportunities and was welcome for that, 'but not long-term employment'. With a few conspicuous exceptions the request that NORKLIMA and IPY should be continued in some form or another, was probably the clearest message received by the Evaluation Committee during a week of interviews.

The written submissions and interviews made a wide range of suggestions relevant to the management of climate research in general in Norway and to the planning of any extension of NORKLIMA and IPY in particular; i.e. that the RCN, not the Ministries directly, is the more appropriate vehicle for distributing climate research funding; that climate research in Norway has become too much policy-driven and applied; that funding has seemed too much influenced by high-level regional lobbying with too many programmes, too much competition and a fragmentation [one submission termed it a 'pulverisation'] of science; that RCN should incorporate what the University Centre in Svalbard (UNIS) called 'a dependable continuity' to certain themes in climate research that may take the place of or supplement long-term

monitoring; and that Norway should contribute to global research areas for their own sake instead of the current overemphasis on Norway *per se.*

3.3.4 The Evaluation

3.3.4.1 Content and steering of the programmes

As mentioned above (Section 3.3.1), two issues that featured in the submissions to the Committee were whether an appropriate balance had been struck and maintained between basic and applied science or between the natural and the social sciences. In fact it was relatively easy to examine both of these statements. The first can be assessed in Figure 3.3.2 below, which shows the relative proportions of 'basic' vs. 'applied' research throughout NORKLIMA (2004–11) from data supplied by RCN.

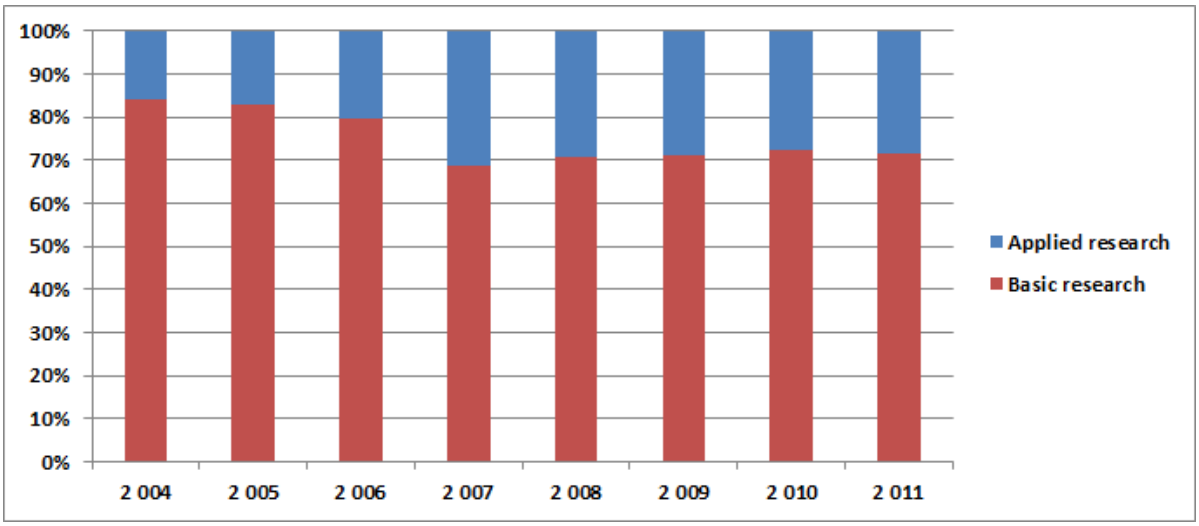

Figure 3.3.2. Proportion of basic vs. applied research in NORKLIMA.
Source: from data supplied by RCN, March 2012. Basic research is defined as experimental or theoretical work undertaken primarily to acquire new knowledge about underlying phenomena and observable facts without aiming at any particular application or use.

Although the relative proportions of 'applied' and 'basic' will depend to some extent on how these terms are defined (see caption), this is unlikely to overturn the principal conclusion that we draw from Figure 3.3.2, which is that the proportion of 'applied' has been a relatively steady 20–30% throughout the lifetime of NORKLIMA.

On the second point raised, the balance between natural and the social sciences, it was relatively easy to find evidence that the scientific focus of NORKLIMA *had* been adjusted and steered throughout the lifetime of the programme so that, whether it was 'too much' or not (see above), the programme did become much more social-science-oriented at the finish than at the start. This steering was accomplished by issuing multiple calls for further work, so that compared to the single main call in respect of the 4-year IPY campaign (i.e. excluding the Education, Outreach and Communication call), no fewer than 27 funding calls for NORKLIMA were issued in the 8-year period 2004–11 (Appendix 3.3.1).

The net result of this development was that the social science content of NORKLIMA rose from around 1–3% of total expenditure in 2004–06 to around 30% in 2010–11 (Table 3.3.1). The Evaluation Committee found nothing particularly untoward in this. In fact as Gørill Kristiansen (Special Adviser to the RCN on NORKLIMA) pointed out to us, the profile of the

Programme was kept in continuous review with regard to basic vs. applied research, social science vs. natural sciences, number of PhDs, post-docs, percentage of female vs. male, etc. This analysis formed the basis for the action plan for the year in question, and that gave direction to the calls. As she pointed out, a few years ago the goal was to reach 30% social science in NORKLIMA, and a few years later that was attained (Table 3.3.1).

Table 3.3.1. The total amounts of funding for NORKLIMA 2004–2011 and amounts and percentages to social science research. In 1,000 NOK.

	2004	2005	2006	2007	2008	2009	2010	2011
Social sciences	2 453	2 824	1 133	15 359	17 302	28 364	30 584	31 833
Total	84 672	87 193	83 350	94 356	108 452	129 928	123 084	99 183
Share of social sciences	3 %	3 %	1 %	16 %	16 %	22 %	25 %	32 %

Source: RCN. Note that in Figure 3.3.2 above, social science research may fall into either the 'basic' or the 'applied' categories.

Though this shifting scientific focus of the NORKLIMA programme was deliberate, we are still entitled to ask who decided upon these changes in the thrust of the programme and whether these decisions had a downside.

We can make little headway with the first of these questions. Though the basis for the action plans and calls is, naturally, the NORKLIMA programme plan (revised in 2008; RCN 2008b), the Programme Steering Committee also had to meet successive demands for programme adjustments from both the scientific community and the government. The latter can express their research imperatives in various ways, either by making their strategies known to scientists in the normal way, or more directly, by simply earmarking funds for their preferences in the budget. The degree and influence of government 'earmarking' on the science of NORKLIMA was not a subject that the evaluation felt able to approach. If the science of NORKLIMA changed with time, as it did, this may have reflected the net response of the Steering Committee to a changing balance of demands that were largely unknown to us.

The question of a 'downside' to changing the scientific focus of NORKLIMA is more easily argued. With smaller funding than expected, an unchanging breadth of scientific interest and yet a time-dependent research focus, it is difficult to see from Figures 3.3.3 and 3.3.4 how any significant continuity of research could have been developed over the full NORKLIMA period. On the positive side, if these changes in policy goals had not been undertaken, there would have been no focus on instruments for emission reduction and adaptation, which is absolutely essential to addressing the problem of climate change.

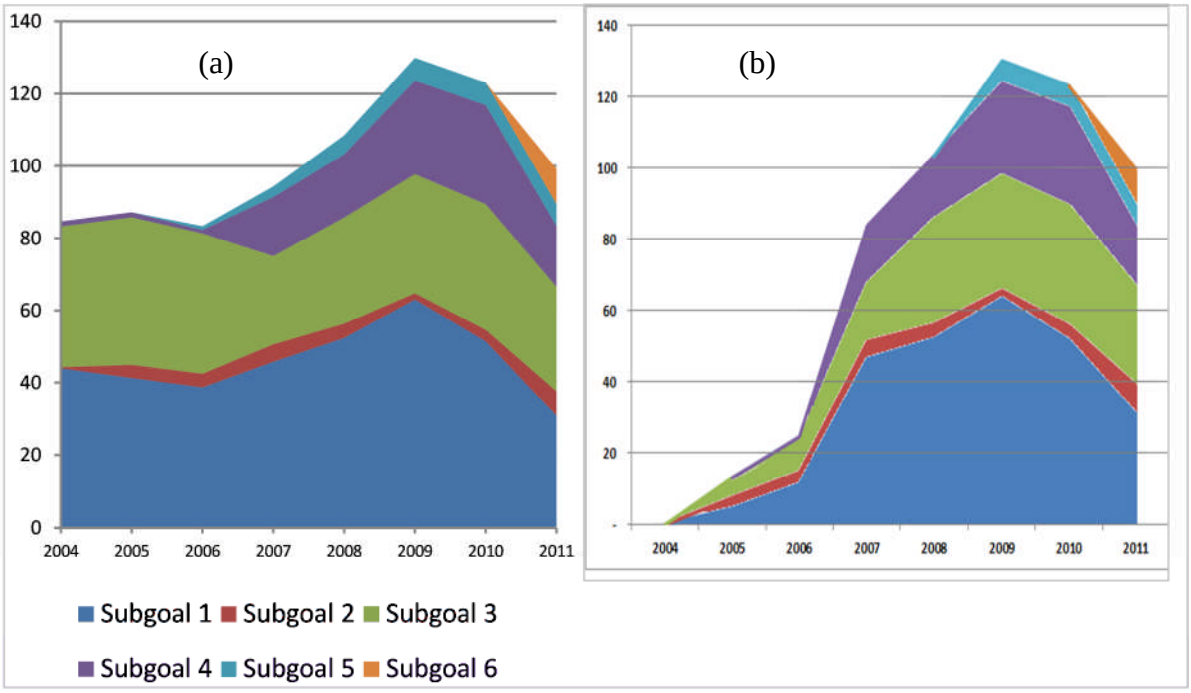

Figure 3.3.3. NORKLIMA expenditure on each of its six sub-goals as a function of time (MNOK). Source: RCN
Note: The left hand panel includes the funding of pre-existing projects 'inherited' by NORKLIMA while the right hand panel describes NORKLIMA funding alone. [Subproject goals are 1) To improve understanding of the climate system and its variability, and to quantify uncertainty; 2) To improve knowledge of climate change and its impacts on buildings, infrastructure and other installations, both on land and offshore; 3) To improve knowledge of climate change and its impacts on natural and cultivated ecosystems and natural resource-based industries; 4) To improve knowledge of the impacts of climate change on society and how adaptive capacity can be strengthened; 5) To improve knowledge of the links between emission trends and the development of society, and of international cooperation to mitigate climate change (this subgoal was included in 2008; and 6) To improve knowledge of the measures and policies for emission reductions (this subgoal was included in 2010)]

The panels in Figure3.3.3 are of some relevance in deciding whether and to what extent NORKLIMA achieved success as a long-term research programme. Though 3.3.3a (the left-hand panel) suggests that subgoal 1 (for example) was rather strongly and stably funded at 30-50% of the annual total throughout the life of the programme to date, this impression is partly due to the inclusion of the 'inherited projects' in the early years which may bear little or no relation to the projects funded under the NORKLIMA programme itself. For those projects, we have to rely on the right hand panel which clearly shows that with 'tapering in', 'tapering out' and adjustments due to 'steering', none of the programme elements of NORKLIMA can be said to have been constant with time (Figure 3.3.3b).

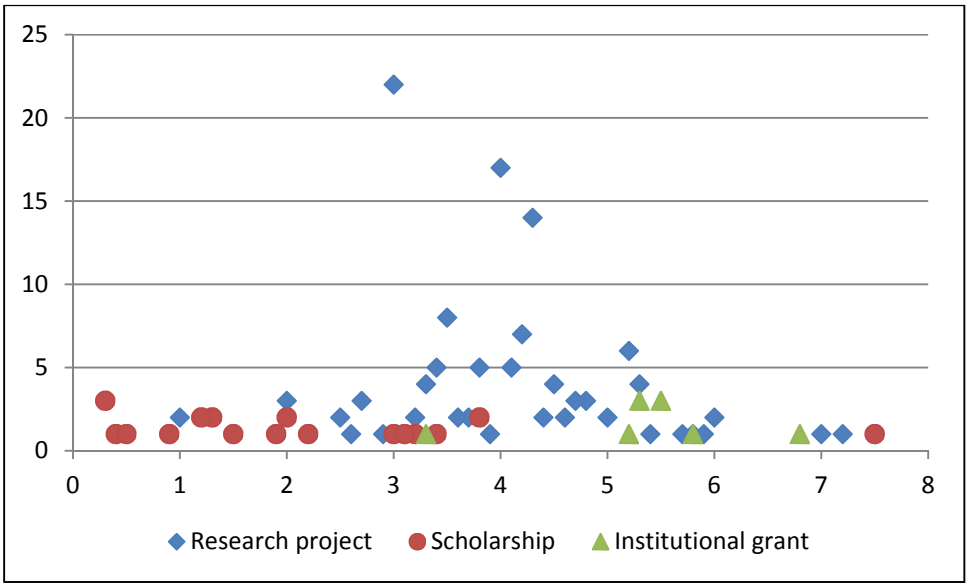

Figure 3.3.4. Number versus duration in years for all 174 NORKLIMA and NORKLIMA-inherited projects, started in the period 2000–2012.
Note: Included are research projects (142), scholarships (22), and institutional grants (10) but not the 'others' category in Table 3.3.2 which largely refers to project workshops, etc. For these 174 projects, the mean duration is 3.8 years, the standard deviation is 1.3, and the median is 4.0. Data from RCN, plot from NIFU-NORKLIMA

Table 3.3.2. NORKLIMA – types of funding. 2000–2012, by start-up year (N=195)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
Research project			13	23		16	2	28	22	13	12	8	5	142
Scholarship		2	2	2		5		2	2	3	4			22
Institutional grant	2	2	6											10
Others					2	6	1	3	5	3	1			21
Total	2	4	21	25	2	27	3	33	29	19	17	8	5	195

In fact, if we examine the average duration of all 174 NORKLIMA-funded projects including inherited projects (Figure 3.3.4), we find that although the duration of a few projects exceeded 7 years, the average was 3.8 years (SD = 1.3 years; median = 4.0). Project funding accounts for the vast majority (131 out of 174 projects; Table 3.3.2), with institutional grants apparently disappearing, after the start of the NORKLIMA programme.

For a complex of reasons, including those just described, what was intended and regarded by the funding agency as a 10-year research programme will have appeared to NORKLIMA principal investigators to be a funding programme rather than a research programme, delivering disconnected short-term efforts with little continuity on, say, climate variability, ecosystem impact and societal impact in place of the coherent ten-year study that was intended. As explained by Eli Aamot, Head of the NORKLIMA Programme Board, this problem is not simply attributable to the short span of individual projects; a project span of 3-4 years should not be disadvantageous as long as there are funding calls available for their follow-up. Neither is it attributable to funding the subgoals unevenly during the programme; such a phased approach, starting with an emphasis on subgoal 1, was always the execution strategy of NORKLIMA. But coupled with a third factor, namely a mismatch between the anticipated (by the RCN administration and the NORKLIMA Board) and the allocated

funding, the net result of all three factors was the perception of a programme with little continuity or coherence.

The debate on a follow-up programme will no doubt consider ways of minimising these adverse effects, perhaps using smaller balanced grants over longer periods of time.

3.3.4.2 The case for continuation

The Committee accepts the view widely expressed in these sessions that NORKLIMA has been a major stimulus of climate research in its broadest sense, that the programme has been unique in combining natural science and social science in its portfolio, and that a decade of strong climate science under NORKLIMA and IPY should be continued in some form. How could it be otherwise? Basic science funding of this order (~1 billion NOK) is rare anywhere, and as almost always happens, the questions raised by the scientific advances of NORKLIMA are at least as compelling as the ones that have been solved. As examples, the sequence of collaborative model advances under NORKLIMA (via the RegClim, NorClim and EarthClim projects) seem poised to continue with further developments in the Norwegian Earth System Model and the establishment of a distributed National Climate Service Centre (Section 5.2 below); and without making too deep a synthesis of advances in the other fields of NORKLIMA, such global issues as 'what drives the signal of ocean-climate change into and through the Arctic deep basins?', 'how will an increasingly-open Polar Sea drive change in the atmospheric circulation?', 'how will global change affect the Barents Sea cod stock?' and 'how will society mitigate for and adapt to the impacts of climate change', all glimpsed but as yet unresolved, are of such fundamental importance to Norway as to justify making the attempt to design a follow-up phase in which our understanding of these and other issues may be developed and tested. Information gathering for a future programme is, in fact, already well advanced in RCN and conforms to the view, strongly expressed in our interviews, that the process should be an open one. In January 2012, meetings organised by RCN and attended by the Chair of this Evaluation Committee were held in Oslo, Bergen, Trondheim and Tromsø with the stated aim of gathering 'the thoughts of national and international stakeholders regarding future needs for knowledge about climate issues'[9].

3.3.5 The future: how to develop continuation, building on NORKLIMA and IPY

The strengths and weaknesses of the two programmes are briefly recalled here, before an international context for developing their 'legacy phase' is described.

3.3.5.1 NORKLIMA

By and large, the strengths and weaknesses of the NORKLIMA programme that were revealed in submissions to the evaluation Committee were encountered again in the course of the four follow-up sessions in Oslo, Bergen, Trondheim and Tromsø. As just described, there is no doubting that NORKLIMA has been a major stimulus of climate research in its broadest sense. The case for continuation, however, needs both a thorough synthesis of past strong results and a back-up strategy for the eradication of past weaknesses. Having described them in some detail above, the weaknesses we need to avoid would appear to be the following: 1. Due to the shifting focus and the lack of a scientific synthesis, NORKLIMA was more of a funding programme than a research programme. 2. The intentional breadth of the programme coupled with smaller than expected funding due to Government cuts (see Section 3.2.2 above) meant that each component of NORKLIMA received relatively little support, preventing the

9 http://www.forskningsradet.no/no/Nyheter/inviterer_til_dialog/1253970027006.

substantial building of new capacity. 3. Though intended as a 10-year programme, NORKLIMA was not a long programme from the viewpoint of scientists. Though the programme is not yet ended, it is hard to read much more than a single 3-4 year period of strong and stable funding into the time-dependencies of Figure3.3.3, in any discipline. 4. Smaller grants over longer periods of time might have countered the shifting focus of the programme and permitted a more dynamic development of projects. 5. The programme calls were too prescriptive and there is a realisation that the most exciting and innovative approaches do not often fit the calls so that an element of basic science ('FRIKLIM') may profitably be developed in parallel with a new climate effort. 6. But ultimately, what is standing in the way of a continuation programme is the fact that unlike the Norwegian IPY programme, NORKLIMA to date has included very little if any synthesis. A thorough synthesis is a prerequisite both for underscoring what was achieved and for designing and justifying any follow-up phase. It should be carried out as a matter of high priority as the programme nears its close.

This requirement for a thorough synthesis is implicit in the first main recommendation of this Evaluation Committee (Section 7): 'The Government should establish an overall strategy for climate research funding building on the recommendations of Klima21 and...taking into account the accomplishments of NORKLIMA and IPY'. The four follow-up planning sessions organised by RCN in January 2012 can only be part of that process. According to timetable information supplied by RCN, with the RCN Board due to decide the issue of 'one or several programmes' by the end of 2012, a Programme Planning Committee to be established early in 2013, a new climate programme Board to be established late in 2012, a programme plan in mid-2013, calls to be issued in mid-2013 and a start to be made on 1 January 2014, it is difficult to see where such a thorough synthesis may be fitted in. Nevertheless, at the time of writing (mid-March 2012), it remains the stated intention of RCN to organise such a synthesis during the "exit-phase" of NORKLIMA including a science conference (2-3 days, for researchers and users), and a synthesis book (for researchers and other academics). [The first bullet point in the second recommendation of this Committee (Section 7 below) is designed to prevent this problem from recurring in any follow-up programme].

3.3.5.2 IPY

As regards the possible involvement of Norway in the evolving 'legacy phase' of IPY, the information available to the Evaluation Committee has been and still is patchy and incompletely resolved. At one extreme, a modern multidisciplinary synthesis of the achievements of Norwegian science during the IPY has already been compiled (Orheim and Ulstein, 2011) providing the essential basis for justifying and planning a national continuation effort. To provide the international framework for such a continuation, our new ideas, stemming from the IPY, on the role of (bi)polar seas in climate have been carefully shaped into integrated international plans for study by the Marine WG of the International Arctic Science Committee (IASC; Dickson, 2011b) and by the Scientific Committee on Antarctic Research (SCAR; Rintoul et al., 2012). However, apart from the briefest of statements in the supporting paperwork from RCN [.....*'until a new effort on polar research has been decided'*...; RCN 2011b, footnote to p. 15], we learned little of a specific nature about Norwegian plans for the 'Legacy Phase' of the IPY in the course of this evaluation, nor despite its obvious relevance here, did we learn anything definite about whether the building of a dedicated ice-breaker or ice-strengthened vessel was under serious consideration in Norway, though the Norwegian Polar Institute and Institute of Marine Research interviews were encouragingly positive and suggested that such plans are underway.

That situation now appears to be changing rapidly, and from the perspective of this evaluation, appropriately so. With a northward-tending government policy, with the stated aim of met.no and others of achieving further expansion of their R&D effort in the Arctic, with new Norwegian technical analyses providing support (e.g., RCN 2011c), and with the international community poised with actual and prospective new equipment (seagliders/deepgliders, ocean-ice-atmosphere sounding autonomous buoys and an enhanced capability in remote sensing; see Dickson, 2011b; Morison et al., 2012) to directly observe the newly open polar sea and its effects on the regional atmospheric circulation (Overland et al., 2011), the stage seems set to advance Norwegian polar science 'from Knowledge to Action' (the working title of the IPY Conference in Montreal, April 2012). Though most of the 'continuation funding' has thus far been announced via the NORKLIMA Programme *[2010 – Understanding the climate system; 2011 – Impacts of climate change on the environment and communities in the polar regions]*, it is the understanding of the Evaluation Committee that a new Polar Research Programme is now in the process of being launched. The task is clear enough: for Norway to decide how best to attain the research-based knowledge necessary to exercise its policy, management and business activity in the Polar Regions. Several appropriate lead-ins to that decision now exist. Though the future programme remains undefined as far as this Committee was concerned, the following elements – *incomplete and of unknown priority* – were noted in the course of the evaluation as possible/likely/commended candidates for the new programme:

- A funding framework has been set up by the International Arctic Science Committee (IASC) to promote interdisciplinary research coordination among its five working groups (marine, atmosphere, cryosphere, terrestrial and social & human). The first fruit of this funding has been the initiation of an Arctic Climate System Network (ACSNet), which will complete its planning at the IPY Conference in Montreal, in April 2012. Although in its early stages ACSNet will mostly be concerned with the ocean-atmosphere-cryosphere, the intent is to extend its coordination across all five WGs, each of which has two Norwegian members.

- Developing Svalbard as an international research platform is another element that is bound to be given priority in any new Norwegian Polar Programme. The Svalbard Integrated Arctic Earth Observing System (SIOS) was one of the proposals from Norway accepted for the 2008 Roadmap of the European Strategy Forum on Research Infrastructures (ESFRI) and from now, until September 2013, the formal and financial framework of SIOS is being worked out in an EC-funded SIOS preparatory phase project coordinated by RCN. This development path is unlikely to end there. It has since been proposed (Holmén & Ellis-Evans, 2011, pers. Comm..) that SIOS could be developed as a regional element of the 'Future Earth – Research for Global Sustainability' initiative of ICSU (http://www.icsu.org/future-earth/home), designed to facilitate the study of the Earth's environment as an integrated system in order to understand how and why it is changing, and to explore the implications of these changes for global and regional sustainability. Their suggestion that *'An important capacity building activity should be developing new observational techniques for environmental monitoring in frigid and sensitive areas'* not only makes appropriate use of the unique high-latitude location of Svalbard but is likely to be of growing international importance as climate science expands in scope and complexity poleward, for example in the ACSNet initiative just described.

- A third possible element concerns the course recommended by the Sámi University College (SUC) in their submission to this evaluation. For the Sámi and other pan-Arctic reindeer herders, the Norwegian IPY Programme (though not NORKLIMA) has been of fundamental importance in applying a mix of formal climate science and traditional knowledge to their critical discussions on climate change, land use change, adaptation and resilience, and a continuation of IPY funding by RCN is seen as vital to continuing the spread of their community-based workshops and 'downscaled' climate advice across the circumpolar Arctic to span all of the major reindeer herding regions of the world (see Section 5.2 below).

- Another topic raised during the evaluation was the need for Norwegian research to develop an improved understanding of terrestrial ecosystem feedbacks to the climate system in response to initial impacts. Within a new Polar Research Programme, RCN might support knowledge- and competence-building in terms both of terrestrial ecosystem responses & feedbacks to the climate system and of the overall functioning of biogeochemical cycles in the high-latitude regions. The rapidly changing northern permafrost forms an important study area for this work, one in which Norwegian researchers have the triple advantage of ideal geographical location, good national research facilities and a northward-tending science policy. In such a research environment and as part of the new Research Programme, Norwegian researchers would be important contributors to international permafrost research and to Polar ecosystem impact, adaptation and mitigation studies.

- Climate modelling itself may provide a further significant avenue for post-IPY development: an IPY follow-up might be just the place to encourage the science of decadal predictability and variability, in the submission of BCCR.

- Bolstered by recent statements by the Prime Minister on Antarctica, Norwegian research there seems set to expand. For example, with the British Antarctic Survey supporting the costs of the field operation and Norway (BIAC-UiB/BCCR) proposing to cover the equipment costs of maintaining observatories beneath the Filchner-Ronne ice shelf, the long term and climatically valuable observations that have been made there by Norway since 1977 seem set to continue beyond the BIAC 'Legacy Phase', and a new Norwegian Antarctic Research Expedition (NARE project WEDDELL) is planned.

- Finally, in rounding off this selection of possible-to-probable initiatives for a new Norwegian Polar Programme, one issue in particular is likely to prove problematic. Resolving the Arctic Ocean circulation in the Nansen Basin (a key issue in determining the role of the Northern Seas in climate; see Dickson, 2011b) must absolutely involve the strengthening of research cooperation with Russia that Norway has been pursuing as a matter of its Northern Policy, despite the past difficulties that Orheim alludes to obliquely in his précis of the IPY (Orheim and Ulstein, 2011, p 43).

However fruitful they may appear, these glimpses of a possible new Polar Research Programme remain to be confirmed at the time of writing, see http://www.forskningsradet.no/prognett-polarforskning/Home_page/1231229969357.

3.3.6 Summary of key findings

The large scale Programme on Climate Change and Impacts in Norway (NORKLIMA) with its six sub-goals was a primary driver of climate research in Norway for the past decade (2004-14), with a total funding of about 721 MNOK. If we include a range of pre-existing projects inherited by NORKLIMA, the total funding devoted to climate research in Norway in this programme increases to about 948 MNOK between 2000 and 2014. In addition, between 2007 and 2010, i.e. during the middle years of NORKLIMA, a Norwegian IPY Programme was developed by RCN as a contribution to the globally-coordinated International Polar Year, April 2007-April 2009. With 27 research projects and a budgetary framework of 290 MNOK, the Norwegian IPY programme was special in terms of its 4-year span, its bi-polar scope, its built-in emphasis on outreach, and the resources devoted (Norway ranked third of all the IPY-participating nations in terms of budget and fourth in terms of manpower devoted to IPY). The total spending on climate research under NORKLIMA–IPY in the decade 2004-14 amounted to 1,011 MNOK.

Though there is no doubting the fact that NORKLIMA has been a major stimulus to climate research in its broadest sense, the submissions to the Evaluation Committee revealed the weaknesses of the NORKLIMA programme as well as its strengths. As many of the institutes suggested, the scientific focus of NORKLIMA had been adjusted and steered throughout the lifetime of the programme so that the programme became much more social-science-oriented at the finish than at the start. This steering was intentional, reflecting the changing demands on the Steering Committee, and it was accomplished by the issuing of multiple funding calls (27 in the 8–year period 2004–11 compared with the single main research call for IPY). Partly in consequence of and partly through a shortfall in the anticipated funding, none of the programme elements of NORKLIMA were evenly funded over the course of the programme (although the relative proportions of 'applied' and 'basic' research were maintained), and there was less continuity and coherence among the main themes of the programme (climate variability, ecosystem impact and societal impact) than might have been envisaged. Though intended as a 10-year programme, NORKLIMA was not a long programme from the viewpoint of scientists. Taking all 174 NORKLIMA-funded research projects, including inherited projects, we find that although the duration of a few projects exceeded 7 years, the average duration was 3.8 years. Smaller grants over longer periods of time might have permitted a more coherent and more dynamic development of projects.

A major conclusion is that NORKLIMA should be followed by a major new research programme with a consistent focus for its entire 10-year span. The primary bases for this new investment in climate change research should be the recommendations of Klima21, which were developed in a strong dialogue with the Norwegian science community, and the accomplishments of NORKLIMA itself, once these have been properly assessed in a thoroughgoing synthesis phase. The latter has yet to be carried out but since the recommendations of Klima21 were developed in 2008-10, both are required. In any future programme, the requirement for synthesis activities should be incorporated from the outset to ensure that the whole becomes more than the sum of its funded projects. Calls within any new programme should be fewer and considerably less specific than in NORKLIMA. As an important component of any new funding initiative, RCN should establish an unrestricted 'FRIKLIM' programme to enable funding of the best natural and social sciences disciplinary research solely on the basis of disciplinary quality.

The synthesis phase of Norway–IPY is already completed, and (whether part of a new climate programme or separate from it), a new Polar Research Programme is now in the process of being launched. Though the task is clear enough – to decide how best to attain the research-based knowledge necessary in order to exercise Norway's growing policy, management and business activity in the Polar Regions – its specific elements had not yet been decided or made clear to this Committee at the time of writing. Several appropriate lead-ins to that decision now exist, however, and we will note some that appear to be front-runners.

4 Research Partnership

4.1 National Research Partnerships

Climate research in Norway is distributed among a number of research institutes and university departments. A total of 78 research entities have submitted fact sheets and out of them 36 have submitted self-assessment reports. This number represents a few rather large institutions as well as a number of smaller ones.

Although spread over a large number of topics and locations there seems to be considerable interaction between the individual groups. Some of those are in a large strategic alliance through a formalised collaborative agreement, such as in the Norwegian Climate Centre between the major Norwegian research groups concerned with research in the climate system or the Centre for Interdisciplinary Environmental and Social Research (CIENS), which is strategic research collaboration between independent research institutes and the University of Oslo. Other collaborative models are the Norwegian Centres of Excellence, for example the Bjerknes Centre for Climate Research (BCCR) and the Centre for Climate Dynamics. Such collaborations can boost individual groups with excellent niche competences to provide first class science results, such as for example the development of the Norwegian Earth System Model (NorESM).

These important collaborations are typically supported by large research funds. In a small country too fierce national competition for funding may actually limit national research collaboration. Therefore, RCN has followed a successful strategy of inviting potential competitors to take part in research networks and applications. This reduces the number of competitors and strengthens the national networks. Being part of a larger network is in some cases the only way for small research groups to get a share of the research funding, in particular if funding is announced in relatively large blocks.

RCN has undoubtedly been very successful in engaging a broad spectrum of research groups in climate research. In some cases this has been achieved by preferring cooperation between independent research institutes in order to foster interdisciplinarity, rather than appreciating interdisciplinary activities within the research institute. This may improve the scientific quality of the programme in total, but maybe at the price of not taking full advantage of the quality of individual interdisciplinary projects that happen to be located in a single institution.

The available infrastructure for climate research in Norway, in part supported by Norwegian polar politics, is an important determining factor in the formation of research partnerships. Facilities in Svalbard as well as the research station in Antarctica are obviously valuable assets for climate research and for the establishments of research networks. Since the climate in the Arctic and in Antarctica often develops quite differently it is certainly an advantage to compare the two polar areas; that may contribute quite significantly to the understanding of the complex climate processes.

The project collaboration in NORKLIMA projects can be used to analyse national collaboration on climate research. The network diagram (Figure 4.1.1) is based on social network analysis of all projects funded by NORKLIMA with more than one project

participant, including also projects inherited from other RCN programmes. The analysis of 145 projects identified 75 Norwegian organisations. The earliest projects were started in 2000, and the latest projects started in 2012. 27 projects are not included because they have not more than one participant. The diagram is based on degree centrality measures.

The most central organisations in the national collaboration network are the University of Oslo, which includes several departments engaged in climate research, CICERO, the Bjerknes Centre for Climate Research, the University of Bergen and the Norwegian Meteorological Institute. The diagram shows also a multitude of independent research institutes with only limited activities. Some public agencies contribute to the collaboration network actively, most importantly the Norwegian Water Resources and Energy Directorate (NVE). The business enterprise sector has practically no participation in the network.

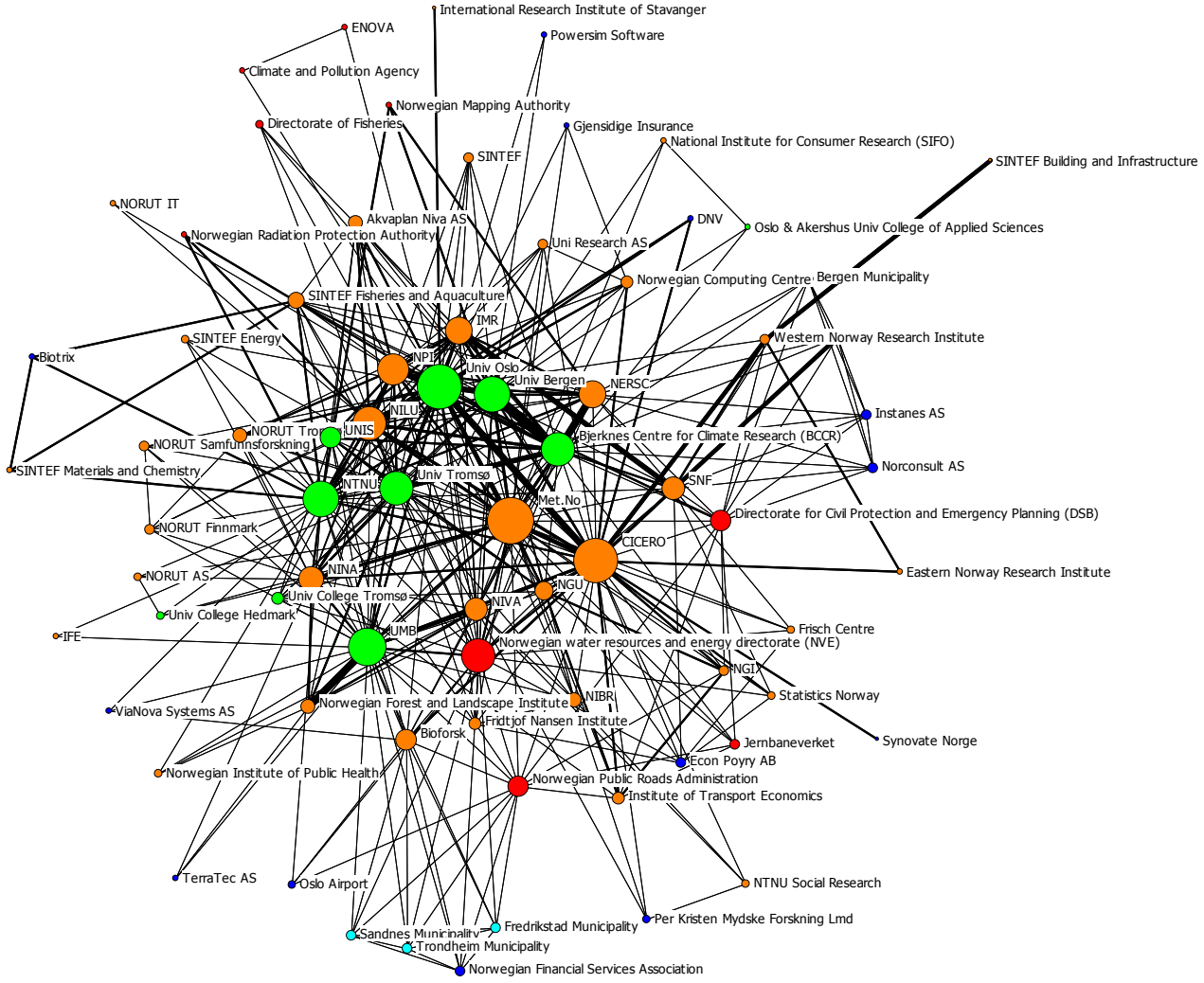

Figure 4.1.1. National collaboration on climate research. Based on project data for NORKLIMA (N=145) and degree centrality (2000–2012). Source: RCN
Notes: Colours depict different types of organisations: green: universities and university colleges, orange: independent research institutes, red: government agencies, light blue: municipalities, dark blue: companies. The size of the circles indicates the number of projects, the thickness of the lines indicates the strength of collaboration and the length of the lines indicates the relative importance of the collaboration for the network. Created with Borgatti, S.P., Everett, M.G. and Freeman, L.C. 2002. Ucinet for Windows: Software for Social Network Analysis. Harvard, MA: Analytic Technologies, and Borgatti, S.P. 2002. NetDraw: Graph Visualization Software. Harvard: Analytic Technologies.

4.2 Nordic Research Partnerships

The Nordic Countries – Denmark (incl. the Faroe Islands and Greenland), Finland, Iceland, Norway and Sweden – have a long tradition of regional climate research cooperation. This is because these countries have similar geographical orientation and thematically common interests resulting in rather similar research priorities (e.g. emphases on polar research, boreal and marine ecosystems). Also Nordic countries host several internationally leading research groups in climate research and it is easy to operate with strong research groups that have almost identical institutional frameworks and the collaboration is further enhanced by the possibilities to use joint Nordic funding instruments. It has been also observed that Nordic collaboration in science policy and research in general provides a stronger voice at the EU level.

NordForsk, the Nordic research board under the Nordic Council of Ministers, is the main funding body to support Nordic research collaboration in addition to national research funding bodies. NordForsk focuses on research areas in which the Nordic countries are internationally recognized and promotes research and researcher training of high international quality. Paleoclimatology, climate modelling, atmospheric research and oceanography stand out as particularly strong areas in the Nordic countries and in all these fields the Norwegian contribution is significant. At the international level, Nordic climate research particularly contributes to areas such as the Arctic region, the Baltic Sea, agriculture, forests, wetlands and marine ecosystems.

A recent bibliometric study (Schneider and Larsen, 2009; NordForsk, 2009b) showed that Sweden, Norway, Denmark and Finland are among the top 20 countries in terms of production of publications related to climate change research (incl. energy research). When the number of publications is compared to the number of inhabitants, Norway had the highest number of scientific publications in climate change research in the world.

In terms of co-authorship of scientific articles the other Nordic countries are important partners for Norwegian climate researchers (Table 4.2.1). Among Nordic countries collaboration in climate research is strongest with Sweden (999 co-authorships in 2001–2010) but also Denmark and Finland are prominent in terms of research collaboration with 619 and 476 co-authorships in 2001–2010, respectively. The Nordic collaboration is further demonstrated when studying Norwegian international research collaboration at the organisational level. The international co-authorship analysis at organisational level reveals a dominating position of Nordic research organisations – eight of the ten foreign organisations in the world who have published with Norwegian institutions are Nordic. The most prominent publication collaboration is with Swedish universities (see Section 4.3). However, for co-authorship of Norwegian climate research articles, the Nordic countries only account for 10% (Table 4.3.1)

Table 4.2.1. Co-authorship of Norwegian climate researchers with Nordic countries. 2001–2010.

	Fractionalised counts	Total counts
Sweden	190	999
Denmark	116	619
Finland	83	476
Iceland	31	163
Greenland	4	21

Source: NCR 2010
Notes: Fractionalised counts are given for to avoid double counts because of co-authorship with more than one country and organisation.

A long tradition of Nordic collaboration has also resulted in many joint initiatives within research funding and research policy. Climate change research has always been one of the research areas relevant for joint Nordic initiatives. The most visible and important joint initiatives are the Nordic Centres of Excellences (NCoE) funded by NordForsk. In 2003–2007, under the NCoE programme on Climate Change, four NCoEs were established and funded: BACCI – biosphere-aerosol-cloud-climate interactions", coordinated by University of Helsinki, EcoClim – the dynamics of ecological systems under the influence of climatic variation, coordinated by University of Oslo, NECC – ecosystem carbon exchange and its interactions with the climate system, coordinated by University of Lund and NcoE for luminescence research, coordinated in Risø, Denmark. The Centres received basic funding from their national sources and were further supported by joint Nordic funding at around 11.9 MNOK annually. The Nordic funding was to cover grants and salaries for visiting researchers and PhD students. The NCoEs final evaluation (NordForsk, 2009a) revealed that NCoEs were very successful in binding national Centres of Excellence together and considering the low budget, the results were remarkable and had a good input/output ratio. The Evaluation report also acknowledges the NCoE programme's focus on scientific leadership, which created a clear Nordic added value.

The EcoClim NCoE was important for the start of the Norwegian Centre of Excellence 'Centre for Ecological and Evolutionary Synthesis (CEES)' at the Department of Biology, University of Oslo, in 2007. The Social Network Analysis of the collaboration patterns of the four Centres (Figure 4.2.1a) reveals a central position of the University of Oslo together with Risø National Laboratory (today merged into the Technical University of Denmark), the University of Helsinki and Lund University.

During the first NCoE period, the network supported by the NCoE programme was still rather small. It consisted of only 15 nodes. At that time, the University of Aarhus was more an outsider, only connected with Risø National Laboratory. And there were only two Norwegian research organisations included, the University of Oslo and the Norwegian Institute of Air Research. The Bjerknes Centre, CICERO, the Norwegian Meteorological Institute, the universities in Bergen and Tromsø, UNIS and many other important organisations were not a part of this network. But the NCoEs helped to build up new connections, and in their sub-projects they included also other research organisations, some outside the Nordic countries.

In the autumn of 2008, the Nordic countries initiated the largest joint Nordic research and innovation initiative to date. The Top-level Research Initiative (TRI) involves a number of

Nordic organisations and national institutions, and it has a budget of 410 MNOK over five years. There are two sub-programmes under the TRI with relevance for climate research:

1. Effect Studies and Adaptation to Climate Change;
2. Interaction Between Climate Change and the Cryosphere.

The sub-programme «Effect Studies and Adaptation to Climate Change» has the aim "to improve knowledge about the effects of climate change, about the adaptation capacities of society, and about the risks and opportunities that the effects of climate change may bring to the Nordic region". The sub-programme gives funding to ten Nordic networks and each network receives up to 300,000 NOK per year for three years. Norwegian research organisations are represented in all but one of them.

The following Nordic networks have Norwegian project leaders:

- Nordic Network for Climate Change, Adaptation, and Multilevel Governance (NORCAM), Project leader: CICERO Centre for International Climate and Environmental Research, Norway
- Interdisciplinary research: theories and applications in urban climate change adaptation, Project leader: Oslo University College, Norway
- Statistical Approaches to Regional Climate Models for Adaptation, Project leader: Norwegian Computing Centre, Norway.

The sub-programme gives also funding to three Nordic Centres of Excellence (NCoE), with a total budget of 90 MNOK. Norwegian researchers participate in all three Nordic Centres of Excellence and there is one with a Norwegian project leader:

- NCoE NorMER (The Nordic Centre for Research on Marine Ecosystems and Resources under Climate Change), Project leader: CEES, Department of Biology, University of Oslo, Norway, with a co-primary investigator at the Stockholm Resilience Centre/Stockholm University, Sweden.

Figure A

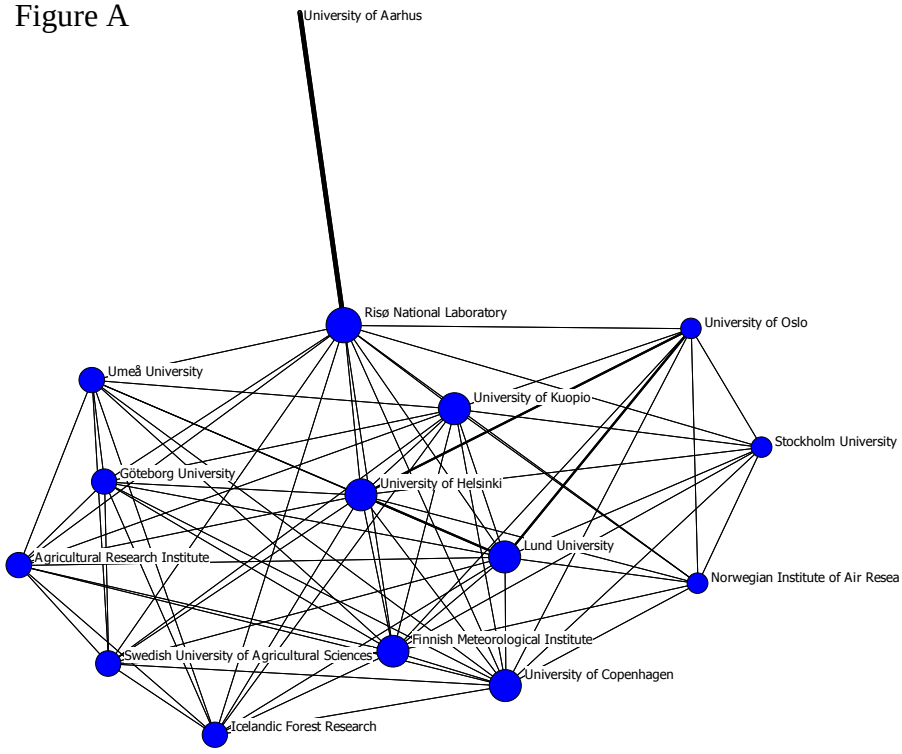

Figure B

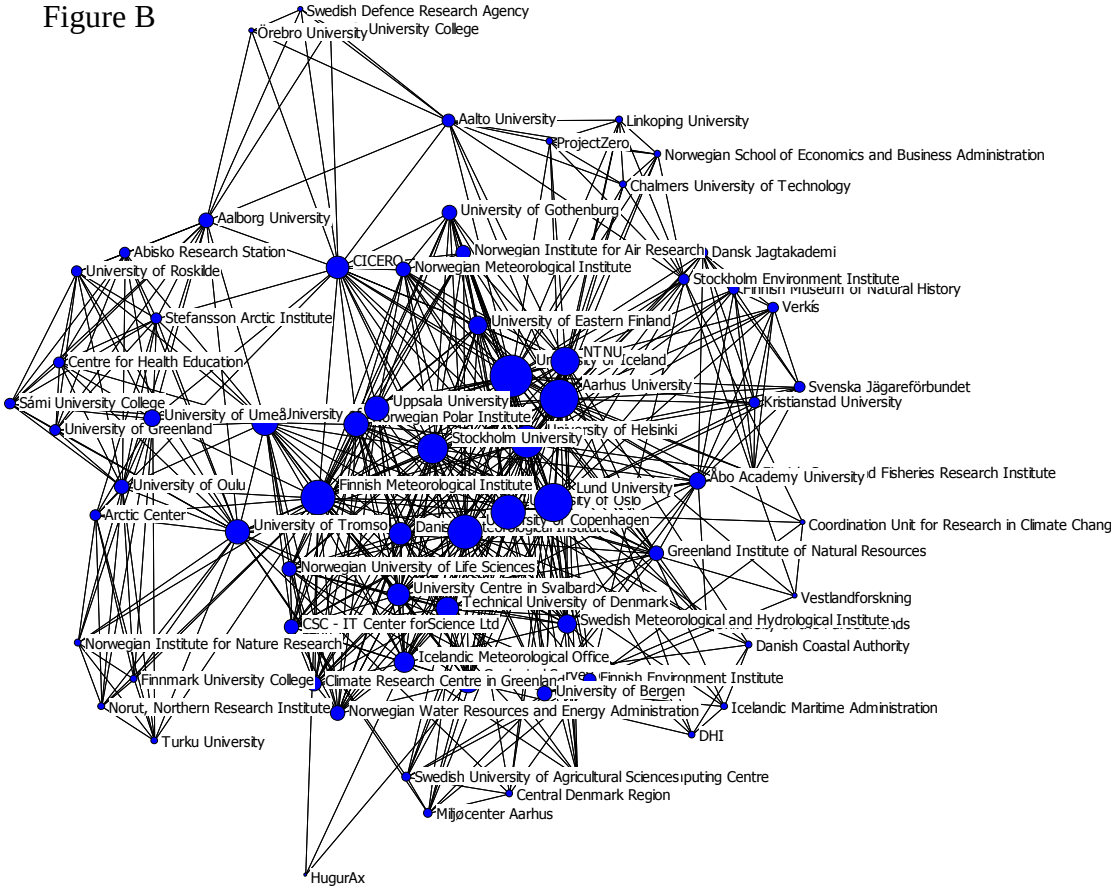

Figure 4.2.1. A) Nordic climate research collaboration in the Nordic Centre of Excellence Programme on Climate change 2003-2007 (Note: Including the main nodes of the four centres, but not sub-projects).
B) Nordic climate research collaboration in the Top-level Research Initiative.
Both figures are based on degree centrality measures of project partnership. Data source: Top-level Research Initiative. Created with Borgatti, S.P., Everett, M.G. and Freeman, L.C. 2002. Ucinet for Windows: Software for Social Network Analysis. Harvard, MA: Analytic Technologies, and Borgatti, S.P. 2002. NetDraw: Graph Visualization Software. Harvard: Analytic Technologies

The most active Norwegian research institutions under this sub-programme are: NTNU, the University of Tromsø, CICERO, University of Oslo, University of Bergen and the Norwegian School of Economics and Business Administration. Their most important collaboration partners in these projects are Aarhus University (Denmark), University of Helsinki and the Finnish Meteorological Institute (both Finland), University of Iceland, Lund University and University of Umeå (both Sweden).

The sub-programme «Interaction between climate change and the cryosphere» has the objective "to reinforce Arctic research cooperation in the Nordic region and internationally, to improve modelling of the climate change interactions with the cryosphere, and provide results for infrastructure risk assessments and possibilities"). The sub-programme has a budget of about 100 MNOK.

The sub-programme also gives funding to three Nordic Centres of Excellence and Norwegian researchers participate in all three. There is one Nordic Centre of Excellence with a Norwegian project leader:

- NCoE SVALI (Stability and Variations of Arctic Land Ice), Project leader: University of Oslo.

The most active Norwegian organisations are the Norwegian Polar Institute, the University of Oslo and the University Centre in Svalbard. Their most important collaboration partners in these projects are Aarhus University, the Danish Meteorological Institute and University of Copenhagen (all Denmark), University of Helsinki and University of Eastern Finland (both Finland), University of Iceland, Stockholm University, Lund University and Uppsala University (all Sweden).

Figure 4.2.1b illustrates the project collaboration in both TRI sub-programmes based on Social Network Analysis (SNA). Figure 4.2.1b shows the central position of Aarhus University in Denmark, the University of Iceland and NTNU. Remarkable are the differences compared with the original NCoE programme on climate change (Figure 4.2.1a). Now many more research organisations are included: the network consists of 72 nodes and many other Norwegian research organisations are now participating.

Figure 4.2.1b shows that other research organisations have an important role to keep different parts of the network together, such as the Finnish Meteorological Institute and the University of Tromsø.

In addition to TRI climate related sub-programmes, under NordForsk's Nordic Programme on Impacts of Climate Change in Nordic Primary Industries, several new projects have been started, extending over 3 to 4 years. Three out of six projects have a Norwegian coordinator, but Norwegian research organisations are involved in all projects:

- Forest Soil C Sink Nordic Network, coordinated by the University of Copenhagen, includes the Norwegian Forest and Landscape Institute;
- Sustainable Primary Production in a Changing Climate, coordinated by the Risø National Laboratory (today merged into the Technical University of Denmark), includes the Norwegian company, Graminor AS;
- Nordic network: Climate impacts on fish, fishery industry and management in the Nordic Seas, coordinated by the Institute of Marine Research, includes the Fridtjof Nansen Institute, the Bjerknes Centre for Climate Research, the Institute of Research in Economics and Business Administration, the University of Tromsø and CICERO;
- Nordic Research Network on Animal Genetic Resources in the Adaptation to Climate Change (AnGR-NordicNET), coordinated by the Norwegian University of Life Sciences;
- Arctic char; A species under threat and with great potentials in the age of climate change (NORDCHAR), coordinated by the Institute of Freshwater Fisheries, Iceland, includes the Norwegian Institute for Nature Research (NINA);
- Nordic Forage Crops Genetic Resource Adaptation Network (NOFOCGRAN), coordinated by the Norwegian University of Life Sciences, includes the Norwegian Institute for Agricultural and Environmental Research (Bioforsk) and the Norwegian company Graminor AS.

The research programme on Impacts of Climate Change in Nordic Primary Industries has a total budget of 18 MNOK and a self-financing of minimum 60 per cent of the total project budget is required for each network which means that national co-funding is needed.

4.2.1 Summary of key findings

It is foreseen that the connections and joint activities among NCoE partners will further strengthen the Nordic climate change research and increase the international visibility of the Nordic research in global arenas. Therefore, it is also beneficial to Norwegian climate change researchers to participate in these Nordic activities. Because Nordic funding is often limited and mainly directed to networking and research exchange schemes, it is important that the research groups participating in TRI or other joint Nordic research activities are supported with sufficient national co-funding to fulfil the requirements of the research collaboration. Solid national funding also gives more freedom to seek and benefit from the new research opportunities provided at the Nordic level. We recommend that RCN should develop a clear vision and national strategy for coordinating Norwegian and Nordic funding. Special attention should be given to the need for national co-financing of Nordic initiatives.

Although the research collaboration at the Nordic level is extensive, it is noteworthy that the Nordic collaboration on research infrastructure developments, i.e. sharing the Nordic Research Infrastructure (RI) facilities and data, and the distribution of RI work, is relatively poorly developed and could be promoted further at the Nordic level. This also applies to computational intensive grid and cloud based research (e-Science), which is coming relevant to the Earth and climate research. It is time to examine what possibilities and benefits Nordic collaboration in Information and Communication Technology (ICT) based infrastructures could offer for the Norwegian climate research community and how it could be enhanced at the Nordic level. In the hearings it was mentioned that the climate modelling collaboration should be further strengthened among Nordic countries. Norway holds a strong position in climate modelling and could take the leading role in promoting and developing Nordic collaboration in climate modelling. Leading Nordic modellers have proposed that a single and substantial Nordic activity on Advanced Climate Modelling (ACM) should be established in order to mobilize the entire intellectual capacity and operational capabilities in the Nordic region. The Top Research Initiative or similar instruments could provide an excellent opportunity to further advance these activities leading to improved Nordic collaboration on the delivery of climate information and climate model development. Therefore, RCN should promote Nordic collaboration on research infrastructures, especially on ICT-based infrastructures.

Although the Nordic collaboration is generally strong, it was also mentioned in CICERO's self-assessment report that the Nordic collaboration between natural science and social science is rather weak. This can be an indication that the Nordic climate change research collaboration between social and natural sciences has probably not yet significantly developed and needs further enhancement.

4.3 European and International Research Partnerships

4.3.1 European research funding and network activities

Both this evaluation and previous Earth Science and Biological Science evaluations (RCN 2011a, d) indicate that there is a high level of European and international collaboration within the Norwegian climate research community. This is reflected by a high contribution rate in the European climate research projects, e.g., EC funded Framework Programmes are the third most important source of external climate research funding reported by Norwegian research organisations (FP 6 with 5 % and FP 7 with 2.6 % of all external funding; Figure 2.3.3). The activity in European projects is also indicated by a good national success rate in EC funding competition - in FP7 Environment (until March 19 2012) the national success rate was 26.6%, being the second highest within EU countries. The University of Bergen (41.6 MNOK), NILU (30.4 MNOK) and the Institute of Marine Research (29.6 MNOK) are the most successful Norwegian research organisations in receiving EC funding from FP7 Environment. EC funded projects have resulted in strong research networks and partnerships, particularly in polar research, both within natural science and social science, atmospheric and marine research. The most important EU FP 7 programme for Norwegian climate research is the programme 'Environment - including climate change', but also the programmes 'Research infrastructure', 'Space' and 'Transport' provide funding for large projects with Norwegian participation or even leadership (see also Section 2.3). 19 FP 7 climate research projects (out of 93 projects where Norwegian researchers are involved) have a Norwegian coordinator. Here the Nansen Environmental and Remote Sensing Centre is especially successful, but also other research organisations are taking the lead, such as the Norwegian Meteorological Institute, the Institute of Marine Research, the University of Tromsø, the Norwegian Geotechnical Institute or Bioforsk. Examples of EU FP 7 projects with Norwegian participation are the preparation of the Svalbard Integrated Arctic Earth Observing System, studies on atmospheric pollution and on Arctic stratospheric ozone loss, a study of the impact of sub-seabed CO_2 storage on marine ecosystems, and the European Carbon Dioxide Capture and Storage Laboratory Infrastructure.

Almost all the research groups and organisations are (or have been in recent years) partners in the European level projects or networks. However, national co-funding is crucial for research groups when participating in European and Nordic research projects and programmes. Many of the EC research projects require at least 25% support from the host institution. In addition, in many cases also national research funding is needed to successfully carry out the European level research collaboration. In general, research programmes such as NORKLIMA provide good national support for research groups but the lack of national support can create major difficulties for participation in European efforts. This has been observed, for example, for terrestrial system and greenhouse gas research with lower support from NORKLIMA. Thus, for Norwegian researchers it has been difficult to participate in major European projects such as CarboEurope (EU FP5), GHGEurope (EUFP7) and NordFlux (Nordic Council of Ministers).

In addition to the EC Framework Programme, the European Research Council (ERC), launched in 2007, supports individual world-class researchers of any nationality and age who wish to pursue their frontier, curiosity driven research. None of the Norwegian climate researchers hold a European Research Council's advanced researcher's grant and only three currently funded ERC advanced grants can be considered to partly include a climate change aspect (Department of Biology-UiB/Tron Frede Thingstad, NIVA/Merete Johannessen

Ulstein, NTNU/Bernt-Erik Sæther). The grant is an indication of world leading science quality and the importance of the research group/leading scientist at the international level. In general, Norwegian success in ERC grants has been moderate and knowing the high quality of Norwegian climate researchers, they should be encouraged and trained to apply more often for these highly competitive grants.

Those climate research groups that have been successful in gaining national long-term funding for their climate research are also strong in European and international collaboration. This is particularly shown by their capabilities to take part in other European activities than typical EC funded research projects. Examples of this type of activities are e.g. involvement in developing the European Research Area (ERA) via several initiatives such as the European Strategy Forum on Research Infrastructures (ESFRI). Research organisations stated in their self-assessments that they were active e.g. in SIOS – Svalbard Integrated Observation System, EMBRC – European Marine Biological Resource Centre, ICOS – Integrated Carbon Observation System, and Joint Programming Initiatives – JPI Oceans, JPI Climate and JPI FACCE (on food security and climate change). In addition to research groups, RCN is also a very active and important player in developing climate change research relevant ESFRI and JPI initiatives. Currently, RCN holds the vice-chair position in the JPI Climate Governing Board, has representatives on the JPI FACCE Governing Board and the JPI Oceans Management Board, and leads the JPI Oceans Secretariat. ESFRI SIOS is led by Norwegians and SIOS coordination is in RCN. Some research groups also mentioned that they would take part in the newly established European Climate Research Alliance (ECRA) collaboration. ECRA aims to deepen the collaboration among European research institutions in the field of climate research. For all above mentioned activities, Norwegian research organisations such as Norwegian Meteorological Institute, Norwegian Institute for Air Research (NILU), Bjerknes Centre for Climate Research, University of Bergen/Biology, Fridtjof Nansen Institute (FNI), BioForsk and CICERO have been active.

Norwegian research organisations have also a prominent role in collecting data and maintaining several climate related databases, such as the European Monitoring and Evaluation Programme (EMEP) database under the Convention on Long-range Transboundary Air Pollution and many EC funded project databases, mainly hosted by NILU. In addition, the Norwegian Meteorological Institute is a member of several operational European observation and modelling networks and initiatives such as EUMETSAT, EUMETNET, ECMWF Convention and GMES (through MACC and MyOcean).

NORKLIMA supported actively the networking of Norwegian research organisations with their international partners. 50 per cent of all projects had at least one international partner. Besides the USA the main collaborating countries were the United Kingdom, Germany, Sweden, Finland and the Netherlands. Also other countries outside Europe have gained importance, such as China, Canada, Russia and Australia. Collaboration with developing countries is only sporadic. At the organisational level appear many of the organisations which are also visible in the bibliometric co-authorship analysis (see Section 4.3.2), such as the Nordic research organisations: the University of Gothenburg, the Stockholm University, the Uppsala University and the University of Helsinki. Among the organisations outside the Nordic region there are several European research organisations but also organisations outside Europe are prominent: the University of Cambridge in the United Kingdom, the Chinese Academy of Science, the Alfred Wegener Institute for Polar and Marine Research in Germany which is high up in the bibliometric study, the ETH Zürich in Switzerland, the NASA Goddard Space Flight Centre in the USA and the University of Reading.

4.3.2 International publishing collaboration

The analysis of international co-authorships of Norwegian researchers further supports the observation that Norwegian climate research is highly networked with the international research community. About 63 per cent of all articles were internationally co-authored. The analysis was based on weighted shares of co-authorship research identified by keywords and core journals (see Section 2.2).

The most important region of international co-authorship is the European Union. About two thirds (2,880 of 4,028 articles) of all internationally co-authored articles are co-authored with researchers from at least one EU27 country. When analysing single countries, the U.S. is the most important partner with 10.5 per cent (Table 4.3.1). The UK and Germany followed with 8.4 per cent and 5.2 per cent, respectively. The Nordic countries when combined were an important research partner for the Norwegian researchers. About 10.5 per cent of all international articles are co-authored with Nordic partners.

Table 4.3.1. International co-authorship of Norwegian climate research articles, in fractionalized counts of co-authors from different countries in 2001–2010 (N=4,028). Only countries > 1% of share are shown.

Country	Number of co-authored articles (fractionalized shares)	Share of total
USA	424.5	10.5 %
Nordic countries total		10.5 %
UK	339.0	8.4 %
Germany	210.4	5.2 %
Sweden	190.2	4.7 %
France	161.1	4.0 %
Canada	124.1	3.1 %
Denmark	115.7	2.9 %
Netherlands	87.1	2.2 %
Finland	82.6	2.0 %
Peoples R China	75.8	1.9 %
Russia	71.3	1.8 %
Spain	58.4	1.4 %
Switzerland	56.1	1.4 %
Italy	49.4	1.2 %
Australia	47.1	1.2 %

Source: ISI WoS / NCR Norway 2010 / NIFU.

When studying Norwegian publishing collaboration at the organisational level, the co-authorship analysis revealed that there is a dominating position of Nordic research organisations in European and international collaboration, only two of the top 10 organisations coming from other countries, namely from Germany and Russia (Table 4.3.2). The most prominent publication collaboration is with Swedish universities.

Table 4.3.2. Most important international partner organisations measured by the number of co-authorships (fractionalized counts were used to avoid double counts).

Organisation	Country	Number of co-authored articles, fractionalized counts
Uppsala University	Sweden	33.0
Alfred Wegener Inst Polar & Marine Res	Germany	29.1
Stockholm University	Sweden	27.7
University of Copenhagen	Denmark	26.9
University of Gothenburg	Sweden	26.9
Russian Academy of Sciences	Russia	26.4
Lund University	Sweden	22.7
University of Helsinki	Finland	22.0
Aarhus University	Denmark	21.3
Swedish University of Agricultural Sciences	Sweden	20.9

The Social Network Analysis of international co-authorship patterns shows that the European co-authorship is central for Norwegian researchers. The United Kingdom, Germany, Sweden, France, Denmark, the Netherlands and Finland are the most prominent countries in this analysis (Figure 4.3.1). Among the new EU member countries Estonia is most central.

When analysing the betweenness centrality measures of the European co-authorship network (see also Section 4.2) other countries are more central than the United Kingdom, such as Sweden, the Netherlands, Germany, Denmark, France and Finland. They have an important function to keep the network together. While the UK is the strongest collaboration partner of the Norwegian researchers, they are less connected with the other parts of the network.

However, this analysis has to be interpreted with caution. This is a network centred on Norwegian authors co-authoring with researchers from EU countries. It does not reflect the co-authorship between the other parts independently from the Norwegian researchers. This is the main difference from the Nordic collaboration networks in Section 4.2., where all Nordic project collaborations on climate research have been covered, not only those with Norwegian participation.

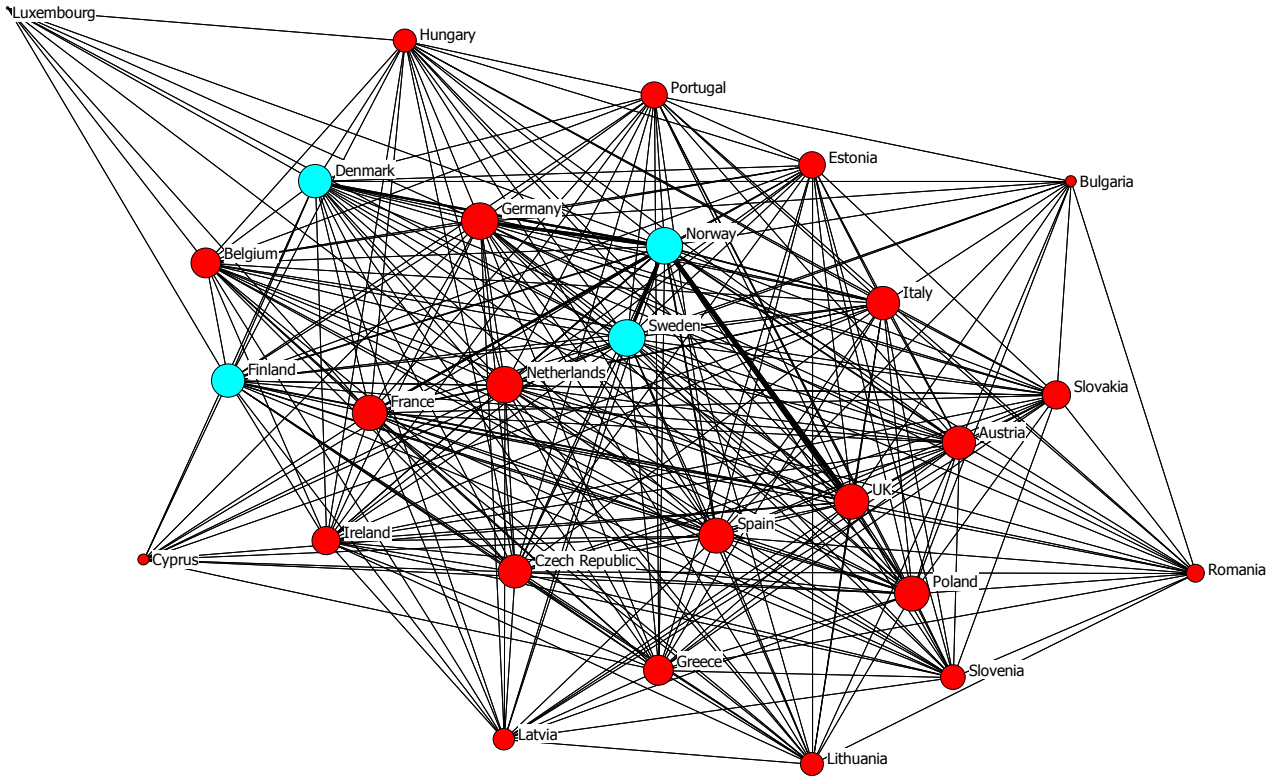

Figure 4.3.1. Co-authorship of Norwegian researchers with EU27 countries on climate research, based on degree centrality measures of co-authorship (N=2,880, total counts). 2001–2010.
Data source: NCR 2010, NIFU
Created with Borgatti, S.P., Everett, M.G. and Freeman, L.C. 2002. Ucinet for Windows: Software for Social Network Analysis. Harvard, MA: Analytic Technologies, and Borgatti, S.P. 2002. NetDraw: Graph Visualization Software. Harvard: Analytic Technologies¨

4.3.3 International research programmes, committees and councils

Norwegian researchers contribute to a wide range of international research under the International Council for Science (ICSU) global climate related programmes, such as the World Climate Research Programme (WCRP), the International Geosphere-Biosphere Programme (IGBP), the International Human Dimensions Programme on Global Change (IHDP), and the Earth System Science Partnership (ESSP) and their Core Projects[10] by holding committee memberships, chairmanships and coordinating specific task groups and/or projects. In addition, the Polar Environmental Centre in Tromsø (supported by the Norwegian Polar Institute and the Norwegian Research Council) hosts the international office of the *Climate and Cryosphere* (CliC) Core Project of WCRP and the Department of Sociology and

[10] IGBP: IGAC – International global Atmospheric Chemistry, iLEAPS – Integrated Land Ecosystem–Atmosphere Processes Study, PAGES – Past Global Changes, SOLAS – Surface Ocean – Lower Atmosphere Study, AIMES – Analysis, Integration and Modelling of the Earth System, GLP – Global Land Project (with IHDP), LOICZ – Land-Ocean Interaction in the Coastal Zone (with IHDP), IMBER – Integrated Marine Biogeochemistry and Ecosystem Research. WCRP: CLIVAR – Climate Variability and Predictability, CliC – Climate and Cryosphere, GEWEX – Global Energy and Water Cycle Experiment, SPARC – Stratospheric Processes and their Role in Climate. IHDP: GECHS – Global Environmental Change and Human Security, ESG – Earth System Governance, ITG – Integrated Risk Governance, IT – Industrial Transformation, UGEC – Urbanization and Global Environmental Change. ESSP: GCP- Global Carbon Project, GECHH – Global Environmental Change and Human Health, GWSP – Global Water System Project, START – Global Change System for Analysis, Research and Training, MAIRS – Monsoon Asia Integrated Regional Study, CCAFS – Climate Change Agriculture and Food Security (with CGIAR).

Human Geography, University of Oslo (supported by RCN and the Norwegian Agency for Development Cooperation) hosted the International Project Office of Global Environmental Change and Human Security (GECHS) of IHDP for ten years until 2010. The International Project Office for the Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) Core Project of IGBP is located at the University of Bergen.

Currently the global change research programmes are undergoing a major change; a new ten-year initiative "Future Earth – research for global sustainability" on Earth system research for global sustainability is being established through the partnership of ICSU, the International Social Science Council (ISSC), UNESCO, UNEP and UNU, with WMO as an observer and supported by funding agencies, including RCN. Norwegians have been active in planning and establishing this new global initiative (ICSU, 2010). For example, Professor Karen O'Brien (UiO) is a member of the international transition team (17 members) that will guide this major change in the focus of international global change research.

Norwegians are also active contributors in many international Arctic, Ocean, Meteorological and United Nations committees and councils, e.g. in IASC (International Arctic Science Committee), ICES (International Council for the Exploration of the Sea), OSPAR Commission for protecting and conserving the North-East Atlantic and its resources, and WMO – Global Atmosphere Watch, iCACGP (International Commission on Atmospheric Chemistry and Global Pollution), UNECE/CLRTAP (United Nations Economic Commission for Europe/Convention on Long-range Transboundary Air Pollution), UNESCO Intergovernmental Oceanographic Commission (IOC).

Norwegian scientists have played a leading role, under the leadership of Peter Schei, in the establishment and functioning of the Convention on Biological Diversity (CBD) through their Trondheim Conferences (the first was held in 1993) that have been hosted by the Norwegian Ministry of the Environment in collaboration with the United Nations Environment Programme (UNEP) and the Secretariat of the CBD and including the Norwegian ministries of Foreign Affairs, Agriculture and Food, and Fisheries and Coastal Affairs.
These meetings were organised by the Norwegian Directorate for Nature Management (DN) in collaboration with the Norwegian Institute for Nature Research (NINA) and the Norwegian University for Science and Technology (NTNU). The results of these international meetings have been very influential in initiating international work programmes and policies on the many dimensions of global change on biological systems. NINA was important in the success of these events through the local leadership of Odd Sandlund and others.

The scientists from NINA were also important in the establishment of the work programme of the IGBP programme on Global Change and Terrestrial Ecosystems.

All the above mentioned activities give great visibility to Norwegian researchers. However, some of the interviewees claimed that the incentives to interact in the international research partnerships and networks (such as giving input to IPCC or international research programme) come primarily from the researchers themselves and not from the institutional level, as this engagement is not really counted in the university or research institution system. We recommend university departments and research institutions to take into account the important and visible international activities of the researchers when reviewing the quality and the efforts of the individual researchers and research groups.

Several research institutions listed also direct bilateral collaboration with countries such as Russia, China, India, US, Canada, Germany, South Africa in their self-assessments. Particularly, The Nansen Centre with its international Nansen Group research organisations (e.g. in Russia, China, India and South Africa) provides a good platform for bi-lateral collaboration in the form of scientific exchange visits, affiliated positions, Nansen fellowships for students and young scientists as well as sharing of creative ideas, research tools, experiments and data. Generally Norwegian researchers seem to have strong ethical motivation and willingness to contribute to global climate research and operate globally, especially in developing and emerging countries.

The Norwegian government launched Norway's International Climate and Forest Initiative in 2007 to reduce greenhouse gas emissions from deforestation in developing countries. The aim of the initiative was to contribute to the development of the REDD (Reducing Emissions from Deforestation and Forest Degradation in Developing Countries) agenda through research and the demonstration of possible solutions for REDD+ by allocating up to 3 billion NOK annually to its activities. In this way, Norway´s International Climate and Forest Initiative supports the development of the international REDD+ agenda and international architecture for REDD+. Much of the funding support has been channelled through Norad **(**Norwegian Agency for Development Cooperation) and via its Civil Society Support funding scheme.

The funding scheme supports REDD+ pilot activities and development of methodologies by civil society organisations, in order to generate input to the climate change negotiations and experiences from REDD+ activities in the field. For example, in 2009 36 different civil society actors received a total of 172.9 MNOK in support for REDD-related initiatives, analysis, policy work and demonstrational projects via Norad. Allocations for 2010 have a similar profile, although with additional emphasis on governance and rights aspects of REDD+. Most of the funded organisations have been international research organisations and only a few Norwegian research organisations have been supported by the Civil Society Support funding scheme. Some of the research groups mentioned REDD-related activities in their self-assessment reports, such as The Norwegian University of Life Sciences (UMB), the Department of International Environment and Development Studies (NORAGRIC), UiB Biology, but knowing the governmental level interest in on supporting REDD+ research activities, it was surprisingly rarely mentioned by the research groups. Therefore, we recommend stronger collaboration between RCN and Norad to support climate change related studies in developing countries. RCN and Norad supported research should consider the nexus between the environmental, economic and social pillars of sustainable development and special attention should be given to research that is necessary to underpin the development of REDD+.

4.3.4 Summary of key findings

Most of the research groups and institutions consider themselves as active European and international partners and they listed many international projects, programmes, initiatives, committees and commissions in which they participate. All these activities strengthen the international research collaboration and research partnerships further.

Although, Norway is not an EU Member State, Norwegians are active in participating in European level collaboration, particularly though EC projects and other ERA initiatives. Solid, national long-term base funding and sensible national co-funding, e.g. for EC projects,

are the essential tools for successful international research collaboration. To enhance the role and the visibility of Norwegian climate research internationally, RCN should take into account the needs of co-funding when planning future support for climate research.

Norwegian researchers have strong international publishing collaboration with many counties, Nordic collaboration together with US, UK, Germany, the Netherland and France being the strongest.

Participation in global research programmes, councils and committees is active and compared to other counties of similar size and resources, e.g. to other Nordic countries, Norwegian researchers have a high participation rate in IPCC.

There seems to be a strong sense of global responsibility among Norwegian climate researchers and they show a strong desire and motivation to collaborate internationally, including with developing countries and emerging countries. However, projects of the NORKLIMA programme had only sporadic collaboration between developing countries. The collaboration with developing and emerging countries was mainly supported by bilateral projects. RCN and Norad should explore mechanisms for increased funding for climate research collaboration with developing countries. We are not convinced that bilateral programmes are the best mechanism. Collaboration with developing countries can have several different aims. It can, for example, be part of efforts through development aid to strengthen research capacity in developing countries to conduct climate research together with Norwegian partners. It can aim at efforts to understand important aspects of the climate system by addressing some essential components that are best researched in developing countries with scientists from those countries, and it can help address issues such as the effect of climate change on smallholder farmers or the risk of vulnerable populations to extreme weather events. It is not evident for what reason bilateral programmes with a few of the major developing countries necessarily help with any of these issues. If bilateral programme support is retained, it is important to clearly outline the scientific or political reason for doing so.

4.4 Assessments

In the mid-1980 there were scientific committees and individual scientists identifying climate change as a serious issue. This led to governments, in 1988, creating the Intergovernmental Panel on Climate Change (IPCC), jointly by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) (Bruce, 2001). The IPCC was created to provide authoritative internationally written and reviewed assessments of the state of knowledge of climate change science, its impacts and mitigation methods. These assessment reports have contributed significantly to the development of international agreements. The IPCC reports bring together, as authors and reviewers, a wide range of experts chosen from around the world. Selection as an IPCC author is confirmation of international recognition as a scientific expert in the topic area. The reports undergo an extensive open and accessible peer and governmental review process. The Summaries for Policy Makers, which are approved by governments, are extremely useful for moving forward with the declarations of the need to take action. Based on the need for inputs to the Second World Climate Conference (SWCC), the IPCC First Assessment Reports were prepared quickly, in less than two years, and formed the basis for the SWCC, held in 1990. The international negotiations that followed, after a UN resolution, led to the UN Framework

Convention on Climate Change which was signed at the Earth Summit in 1992 and ratified in 1994. The Second Assessment Reports in 1995, fed into the Kyoto Protocol negotiations and the Third and Fourth Assessments (2001, 2007), have continued to be the basis for international and national climate change policy development. The IPCC has also prepared special reports of interest to policy makers. One was the very recently completed IPCC Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (IPCC, 2012). The preparation of this report was requested by the United Nations International Strategy for Disaster Reduction (UN ISDR) and the Government of Norway.

Authors for the IPCC reports are chosen on the basis of their scientific excellence but also based on geographical and disciplinary distribution. Since nominations are generally from countries, selection also depends on being nominated by a country. It is interesting to note the involvement of Norwegian scientists in the IPCC reports since 1990. Since the number of authors involved has generally grown since the first reports and noting that there is a likelihood that if a lead author is from one country, then other authors from that country are more likely to be chosen, a comparison is given with Sweden. There are four categories of formal contributors: Convening Lead Author (usually 2-3 per chapter); Lead Authors (5-10 per chapter); Contributing Authors (many) and Review Editors (2-3 per chapter). The terminology has changed through the sequence of reports so for simplicity here a total is given (Table 4.5.1) except for the now underway 5th Assessment Report, for which the contributing authors are not yet identified.

Over the five full IPCC assessments for WGI (science of climate system), the ratio of Norwegian to Swedish scientists, which was initially less than parity, has been about two-to-one for the last three assessments, indicating the growing recognition of the strength of relevant Norwegian science (Table 4.5.1).

Overall, in the IPCC reports there has been an increasing relative participation of scientists from Norway, compared to Sweden, over the years. The relative participation by Norway has been mainly in the sciences of climate change (WGI) and Mitigation (WGIII). This may reflect the relative support for scientists in the impact and adaptation sciences.

In 2000, the Ministerial Meeting of the Arctic Council endorsed the establishment of the Arctic Climate Impact Assessment (ACIA) to evaluate and synthesize knowledge of climate variability and change and the impacts in the Arctic Region. The report was completed and accepted by the Arctic Council in 2004. Norway, as one of the eight member countries of the Arctic Council, played a major role in the preparation of the ACIA. The Vice-Chair of the ACIA Assessment and Integration Team was from Norway as were two additional members. The Lead Authors for three of the 17 scientific chapters were from Norway. In addition of the scientists listed as contributors to the chapters 20 came from Norway (some were authors contributing to more than one chapter). The numbers of authors from Sweden were about half of the numbers from Norway.

Table 4.5.1. Number of Norwegian and Swedish Convening Lead Authors (CLA), Lead Authors (LA) and Review Editors (RE) in the reports of the three IPCC Working Groups for Assessment Report 4 (2007) and 5 (to be published in 2014). Data for the recent SREX report (IPCC, 2012) are also included.

Report	WGI		WGII		WGIII		Total	
	Norway	Sweden	Norway	Sweden	Norway	Sweden	Norway	Sweden
FAR-1990	2	5	2	0			4	5
SAR-1995	3	4	6	8	2	2	11	14
TAR-2001	16	8	3	1	6	1	25	10
AR4-2007	15	7	3	6	5	0	23	13
AR5-2014	6	2	8	6	5	2	19	10
Totals	42	26	22	21	18	5	82	52
SREX							4	4
ACIA							23	12

Note: SREX and ACIA were single reports and did not include separate working groups.

A scoping workshop was held in 2011 to prepare an Arctic Resilience Report (Arctic Council, 2011). And at the subsequent Arctic Council meeting, the Senior Arctic Officials approved the Arctic Resilience Report as an Arctic Council project. The participants in the scoping workshop were from many countries including at least four from Norway.

4.4.1 Summary of key findings

The participation of Norwegian scientists in the international climate science assessments of IPCC and the Arctic Climate Impact Assessments has been very strong, both in an absolute sense and compared to Sweden, in a relative sense. This participation rate has also been generally increasing particularly related to the sciences of the climate system and emissions reductions, but less so in the sciences related to impact, vulnerability and adaptation to climate change and variability.

5 Relevance of Norwegian Climate Research

5.1 Stakeholder Relevance and Interaction

5.1.1 Observations and analysis

Climate change is likely to have far-reaching impacts on natural, societal, and economic systems in Norway and elsewhere. Applying research effort toward understanding these impacts and responding to climate change – by both mitigating and adapting to the risks – will, ostensibly, be advantageous to society. Research funding bodies are increasingly interested in assessing the societal relevance or benefit of research, whether this is in the form of improvements in quality of life, management of risks, increases in sustainability, identification of potential commercial opportunities or, in the case of curiosity-driven research, enhancements to the scope and depth of knowledge in itself. Societal relevance and benefit are assessed in order to justify funding from the public purse, and to identify strengths and gaps and make recommendations for future directions in research. This section aims to give a brief, overall assessment of the societal relevance of climate research in Norway.

The Research Council of Norway strives to fund research of the highest scientific quality and relevance. RCN's guidelines on scoring relevance and benefit to society refer to the extent to which a project or programme is able *"to contribute to knowledge/competence that would in the short or long term be of significance to meeting major challenges in the public sector, industry and the civil society, viewed in a regional, national or global context."*[11]

In addition, the Research Council's evaluation focuses on environmental perspectives, ethical aspects, and gender issues when relevant.

There are several challenges in assessing the societal impact of the Norwegian Research Council's climate research programme, or indeed any research programme. These are outlined below (adapted from Sutherland et al., 2011).

- The problem of attribution, due to the complexity of the effect of research: It can be very difficult to determine whether a particular programme or piece of research has resulted in an increase in sustainability, for example, or a reduction of risks. Often these benefits are the compound or indirect effect of accrued research results. Despite the difficulty of attributing direct results, some of the research groups we interviewed were able to point to changes in management that occurred as a direct result of their research. The Department of Biology at the Norwegian University of Science and Technology, for example, has provided research results to government ministries and other authorities that have resulted in changes in the management of protected natural areas.
- The influence of factors beyond research: Management decisions are made for many different reasons (e.g. cost, political acceptability, etc.), making it difficult to ascribe

[11] http://www.forskningsradet.no/en/Research_infrastructure_INFRA/1195592883822, accessed 26.03.2012

them solely to research. In some cases, a decision may appear to be in line with research results, even though it was taken for entirely separate reasons. These confounding factors challenge our ability to attach societal relevance to research, although in some cases there is a clear cause and effect. The management of Norway's water and renewable energy resources is directly informed by applied research undertaken by Norwegian Water Resources and Energy Directorate (NVE, within the Ministry of Petroleum and Energy). This is a strong statement that the research is important to stakeholders and that research outcomes are directly usable in understanding and responding to a changing climate. Given the critical importance of the hydropower sector to Norway's economy, as well as the direct exposure of this sector to changing climatic variables, NVE's research must be considered highly relevant.

- Time lag: The often considerable interval between research outcomes and societal impact can be problematic for attributing benefit or relevance to particular pieces of research. In the case of the Department of Sociology and Human Geography (University of Oslo), however, cutting-edge research has been commissioned directly by Norwegian government ministries to feed into current policy work on the climate change dimensions of disaster risk reduction, human security, alleviation of poverty, and globalization and national interests.

To ensure that research projects fulfil the criteria of societal relevance, it is critical that impact pathways are addressed at the proposal stage. Many examples of impact and relevance pathway frameworks exist. One of the most widely used is the Participatory Impact Pathways Analysis (PIPA) (Douthwaite et al., 2008), which improves evaluation by allowing proponents to formalize a project's impact pathways and to monitor progress, encouraging reflection, learning and adjustment along the way.

Communication with stakeholders is an important ingredient in bridging the gap between researchers and societal actors, and in making research results known and useful to others. According to the vision of RCN: *"Research generates greater insight, enhanced opportunity and innovative solutions. Research is a driving force behind the advancement of Norwegian society and is vital to promoting scientific and knowledge-related development. Research is in and of itself enriching and comprises an important part of Norwegian culture. At the same time it provides direct practical benefits and is a tool for satisfying society's need for concrete results."*[12]

The NORKLIMA plan 2008-2013 (revised Nov 2008; RCN 2008b) stated in its secondary objectives that it "seeks to maintain close contact between researchers and society and achieve effective dissemination of research results" (p. 18). This is further exemplified: *"Active, two-way dialogue between researchers and users will be crucial when identifying relevant research questions, especially those related to society's adaptation to climate change. Certain projects should also maintain an ongoing dialogue with users to ensure that the research activity remains relevant" (p.18).*

This means that relevant stakeholders should be involved in the formulation of research questions, endorsement of research results and putting research into practice when appropriate. In practice, however, some types of research findings are more easily communicated, and other research results may need to be reformulated into conclusions for

[12] http://www.forskningsradet.no/no/Visjon_og_mandat/1138785796497, accessed 21.02.2012

practice. This responsibility lies with three actors: (1) the RCN to facilitate such communication; (2) the research institutions to provide sufficient support and guidance; and (3) research groups and individuals to prioritise communication as part of the research process. Though our evaluation did not explore research communication in depth, we asked questions in the survey and the interviews that indicate to what extent and how such communication has taken place within Norwegian climate research, with particular emphasis on the role of the research institutions.

Conferences, seminars and workshops are part of communication activities, which may be more or less directed towards audiences outside the research community itself. The same can be said for professional education of non-specialists, and teaching within universities. Such activities are a natural part of the research process for all institutions and projects that we investigated. Former students who are employed by government or industry may also – directly or indirectly – act as a bridge between their academic department and their employer. Explicit outreach and information activities as part the research process are also mentioned by almost all the climate research environments, but to varying degrees.[13]Some have special web portals, dedicated user meetings, popular newsletters and question-and-answer services, while others limit their user interaction to occasional one-way information events such as keynote speeches, popular articles and public media.

Interaction with international, national, regional and local environmental authorities takes place in many, albeit seemingly not all, research institutions. Some is initiated through commissioned work for government bodies, and therefore of direct practical relevance. About one-third of the research units mentioned that they carry out studies and reviews for ministries, agencies and Norwegian municipalities. To give a flavour of what this entails, NILU works primarily for the Ministry of the Environment, the Climate and Pollution Agency and Norwegian municipalities; the Fridtjof Nansen Institute (FNI) and the Norwegian Polar Institute (NPI) work with the Ministries of Environment or Foreign Affairs; the Frisch Centre and the Statistics Norway (SSB) have frequent contact with, and undertake commissioned research for, the Ministry of Finance; and Bioforsk serves the Ministry of Food and Agriculture and farmers' unions. The regionally-based institutes tend to have more interaction with societal actors in their surrounding region than with those based in Oslo and Bergen.

There is less evidence of substantial collaboration with the private sector, though notable exceptions include commodity institutes with links to the private sector in the food and fibre industries, and connections between researchers within the Ministry of Petroleum and Energy and private sector customers. The Norwegian government has placed special emphasis on the possibilities offered by Northern and Arctic regions for Norwegian trade and industry and national welfare (Norwegian Government, 2011). RCN (2011c) has developed a plan for collaboration between science and industry in relation to the new possibilities and the geopolitical dimensions of polar areas. The report emphasises that economic development in the area must be based on appropriate scientific knowledge with special emphasis on oil and gas exploration, maritime transport and fisheries. The report states that a targeted polar research initiative is essential and has an important strategic dimension to underpin and strengthen Norway's geopolitical importance in the region. In particular, research should be central for the development of Svalbard and the surrounding ocean waters as a basis for industrial development. The report documents industrial research in the region, current

[13] Out of the 36 investigated research groups, 11 had a thorough description of a variety of communication activities, 20 had some mentioning of such activities (notably on dissemination), while 6 said nothing about communication or outreach in their self-assessment despite our explicit question.

collaboration between research institutions and industry, and industrial needs for R&D in a 20-year perspective.

In research projects that involve interdisciplinary approaches and/or assessments, developing a common understanding of the project goals and finding coherent solutions requires increased communication efforts among researchers as well as other stakeholders. Experiences gained from EU framework programme projects in particular point towards increased communication demands which require professionalism and well-developed communication strategies. On the one hand, our review noted a tendency for the institute sector to be more involved with outreach and interaction with a range of societal actors as compared with the universities. This difference can be explained by the different funding situations, where some of the institutes claim that they are more dependent on attracting external research projects, or are directly funded by particular ministries and agencies to serve their knowledge needs. On the other hand, universities have teaching as a core activity which is closely related to their research, and teaching also implies interaction with students that come from different backgrounds. Some students are professionals in further training, which exposes the university researchers to practice.

We may take CICERO as a prime example of an institute where communication is highly prioritised: 10-15 per cent of its staff is dedicated fulltime to these activities, which include regular events like "Klimaforum", production of the popular bimonthly magazine Klima and the newsletter "Climate News", comprehensive web-pages, a "Climate Forum" seminar series, and numerous presentations and live public interactions in a very wide variety of settings. It should be said, though, that this implies costs: the budget for communication activities in CICERO has risen from 1 MNOK in 2005 to 5 MNOK in 2010 (p. 12-13 in CICERO's self-assessment). In addition, CICERO uses communication channels in the social media: Facebook, Twitter and Origo for the general public. Their communication staffs works with researchers on large research projects from an early stage. CICERO asserts that involving communications experts in research projects from the proposal writing phase onwards gives the best results, both in terms of generating useful research outputs and communicating them effectively. They have also produced books, films and a wide variety of communication products in conjunction with the ACIA, the IPCC's Fourth Assessment Report and the International Polar Year (IPY). The Bjerknes Centre for Climate Research also employs dedicated communications professionals.

Another example of research where stakeholders form an integrated part is from IPY EALÁT implemented by Sámi University College and the International Centre for Reindeer Husbandry. They report from the IPY EALÁT-Network Study, which ran 21 community-based workshops in local reindeer herding communities across the circumpolar Arctic with the purpose of being "engaged in a process of knowledge development, deliberation and outreach, leading to better knowledge foundations for developing local adaptation strategies to climate change", i.e. acknowledging the need for two-way interaction. Similarly, the Department of Sociology at UiO emphasised the importance of co-production of innovative, reflexive responses to climate change, where communication with stakeholders forms part of research and outreach on climate change, while engaging with a wide range of stakeholders, including policymakers, NGOs, the arts community, the general public (and youth in particular). The PLAN project[14] (Potentials of and Limits to Adaptation in Norway), Tipping Point Norway[15] (with the participation of artists) and the Climate Festival are mentioned as

[14] See http://www.sv.uio.no/iss/english/research/projects/plan/
[15] See http://www.sv.uio.no/iss/english/research/projects/plan/events/2008/tipping-point-norway/index.html

innovative examples. In all those instances, communication activities have thus been prioritised in the budgets, as part of research.

There are many other examples of university departments that also devote much effort to communication activities, even though some of them place more emphasis on dissemination than interaction, and they seem to be quite dependent on individual researchers' priorities. In Bergen, for instance, climate researchers at the Earth Science Department who are affiliated with Bjerknes Centre for Climate Research deliver fact sheets and data to local authorities and others to inform climate adaptation actions. Similarly, the Western Norway Research Institute has produced greenhouse gas (GHG) emission calculators as well as an online climate change adaptation teaching tool. The Biology Department at UiO gives many examples of contributing to government commissions and often interacts with politicians and decision makers in meetings. Some of the natural science climate change research units also mention links with the private sector, such as the Norwegian University of Life Sciences (UMB) Forest and Landscape group with forestry and bioenergy companies and the UMB Nitrogen group's collaboration with the fertilizer industry, a mechatronics company for GHG emissions measures, and a sewage company to reduce water emissions.

As many of the research groups note, interdisciplinary research requires better communication among the different disciplinary researchers, and the focus on collaborative problem-solving can also help support internal as well as external communication. We hear from several sources that the creation of the Oslo Centre for Interdisciplinary Environmental and Social Research (CIENS) has spurred affiliated university departments to increase their communication activities. Therefore, it seems as if university researchers can be motivated to raise expectations on outreach and stakeholder interaction through the establishment of interdisciplinary units of research for climate (and other) knowledge needs. At least such units may help both in providing an arena for interaction and an incentive for those kinds of activities. In the best case, they may also provide professional expertise in communication.

Another pattern that we see from our analysis is that communicative efforts often rely heavily upon individual researchers, of whom many make substantive and well-acknowledged efforts, rather than being systematically pursued by their research units. With few exceptions, the universities and institutes lack professional communication expertise, and communication activities are still often seen as voluntary even if they are part of the mandate. Climate researchers often have little communication experience or training, however, because of their expertise and knowledge of a politically important issue that features heavily in the media, they are called upon to act as spokespeople. The main responsibility here should lie with research institutions to support and give more credit to those researchers who engage in stakeholder dialogues. But the RCN could also help improve their communication skills and capacities through arranging training and giving support to dedicated seminars. Model programmes have been developed elsewhere (e.g. Stanford's Leopold Leadership Program) that give researchers the tools to effectively communicate with the media and policy community.

Overall, we gather that there is a growing need for communication of scientific results, adapted to the audience in question. However, since such work is scarcely funded in project budgets, it is generally not given the deserved attention. Good communication requires an appropriate level of resources and forethought. Dedicated funding of communication activities by the RCN should be seen as part of achieving research outcomes, rather than as a separate activity. Good communication will serve to disseminate scientific results to a wide range of

stakeholders in the public and private sectors. In addition, we see an important role for the RCN itself to instigate stakeholder dialogues, like the series of meetings in January 2012 that took place in Tromsø, Trondheim, Bergen and Oslo, and to arrange and /or provide further funding for conferences and seminars on climate change issues that bridge science and policy.

As outlined in the Norwegian government's wide-ranging report on the country's vulnerability and capacity to adapt, climate change is likely to affect every aspect of society (NOU, 2010). It presents risks for local communities, the built environment, cultural assets, as well as natural systems. Given that climate change is a challenge to which society must respond, it is clear that research related to climate change has high validity.

Our evaluation covered a broad range of research units which are addressing research topics that are highly relevant for practitioners, programme planners, and policy-makers. Monitoring and assessment of climate change impacts in natural systems are particularly well covered, as is economic analysis of mitigation policy. Other issues, which would seem to be highly relevant in terms of importance to Norwegian society in the context of climate change, are not as well covered. These include:

- Assessment of climate change impacts on spatial planning, built infrastructure and fixed assets, particularly transport, communications and other vital infrastructure;
- Vulnerability and adaptive capacity of economically important industrial sectors (excluding hydroelectric power generation, transmission and distribution, which appears to be well addressed);
- Conflicts and synergies between adaptation and mitigation responses;
- Assessing the weight of evidence for adaptation options in practice situations (e.g. *how* to adjust management practices?);
- Integration of climate change adaptation into regular planning and decision-making (e.g. taking climate changes into account during Environmental Impact Assessments, decommissioning of assets);
- How climate change affects priority-setting and handling of conflicts in the management of natural resources and ecosystems;
- Handling propagation of uncertainty – from uncertainties related to climate science through to uncertainties in socio-economic impacts and the efficacy of adaptation and/or mitigation responses -in decision-making (in contrast to efforts to *reduce* uncertainty, which are addressed in Section 5.2, Climate Services);
- Global climate change impacts and knock-on consequences for Norway (e.g. industry sectors or markets with long supply chains); and
- Organisation of economies in a changing climate – exploring institutional change that can drive technological change.

Even if research topic areas are of interest to decision-makers, research results themselves cannot have societal relevance without effective communication. This could entail adjustment of modelling results (both climate modelling and impact modelling) to enable them to be on scales that are relevant to society's problems. The approach to climate change research and interaction with policy often assumes a linear relationship, namely that research results are produced and then, if applicable, readily used for decision-making. In practice, however, for research results to be utilised in this respect, scientists must be proactive and seize opportunities at critical junctures when the streams of problems, policies and politics are joined (Owens & Rayner, 1999). Through such important feedback processes, society's needs may reshape the priority setting in both basic and applied research. We have discussed communication with stakeholders in more detail in Section 5.2, where we highlight

CICERO's approach to involving stakeholders from the start of a research programme, in order to optimise the utility of research outputs. If there is effective engagement between researchers and practitioners or policy makers at key stages in the research process, it should increase the likelihood of research results achieving potential impact and relevance to society.

5.1.1 Summary of key findings

Establishing the relevance of research is crucial to deriving a societal benefit, particularly with respect to climate change, which is likely to have far-reaching impacts on a broad range of systems both in Norway and globally. Although relevance is very difficult to measure in isolation, several guidelines and tools exist to aid in the evaluation of societal relevance or impact. Our evaluation has established that, on the whole, research units are addressing research topics that are highly relevant for practitioners, programme planners, and policy-makers.

The RCN places a high emphasis on communication and two-way dialogue between researchers and users. This responsibility lies with the RCN to facilitate such communication, the research institutions to provide sufficient support and guidance, and research groups and individuals to prioritise communication as part of the research process.

Explicit outreach and information activities form part the research process within almost all of the research units, but to varying degrees. Interaction with international, national, regional and local environmental authorities takes place in many research institutions, though with few exceptions the universities and institutes lack professional communication expertise, and communication activities are still often seen as voluntary even if they are part of the mandate.

Interdisciplinary research requires better communication among the different disciplinary researchers, and the focus on collaborative problem-solving can also help support internal as well as external communication. There is a growing need for communication of scientific results, adapted to the audience in question. Good communication requires an appropriate level of resources and forethought. Dedicated funding of communication activities by the RCN should be seen as part of achieving research outcomes, rather than as a separate activity. Good communication will serve to disseminate scientific results to a wide range of stakeholders in the public and private sectors.

5.2 Climate Services

5.2.1 Background

'Climate services' is a term that has evolved and was a principal focus of World Climate Conference 3 held in 2009. Since then, the World Meteorological Organization (WMO) and its members, the national weather services of all countries, have been moving towards implementation of the Global Framework for Climate Services (GFCS) which has as its main goal to 'enable better management of the risks of climate variability and change and adaptation to climate change, through the development and incorporation of science-based climate information and prediction into planning, policy and practice on the global, regional and national scale' (Figure 5.2.1).

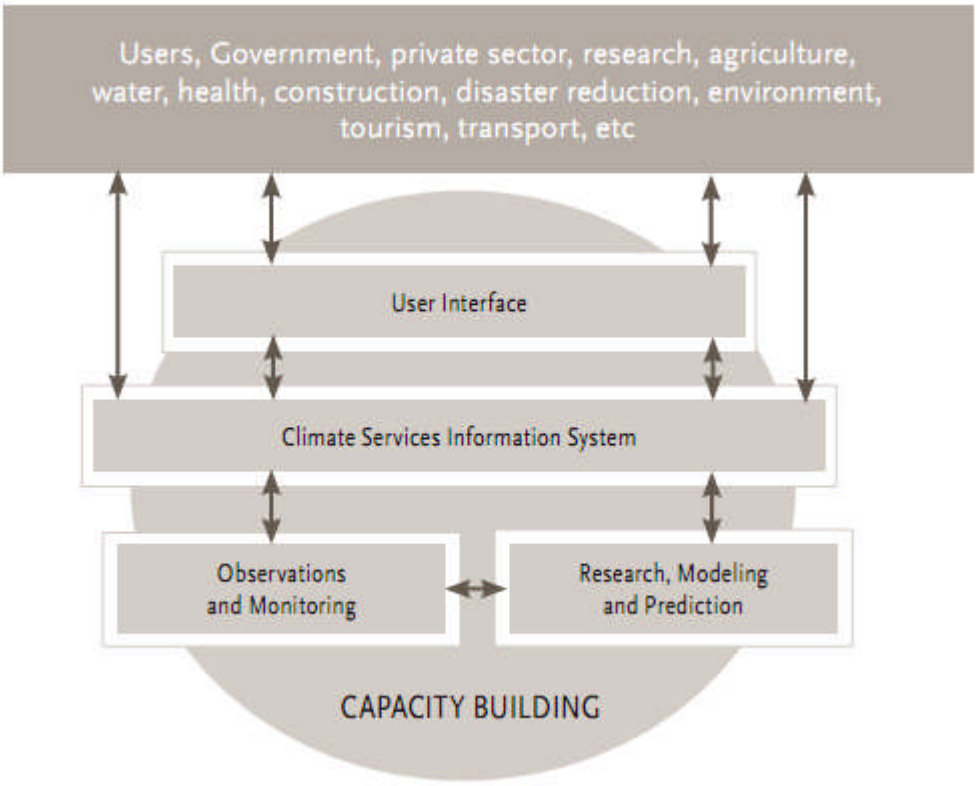

Figure 5.2.1. A schematic of the components of the Global Framework for Climate Services with capacity building occurring within and between all other components. (WMO, 2011, p. 9).

A Climate Services Partnership (CSP) has now been formed (October 2011) to advance climate services around the world, and after GFCS and CSP have thought-through a range of case studies that document experiences in the provision, development and application of climate services, the GFCS Implementation Plan, including these case studies, will be presented before an Extraordinary Congress of WMO in October 2012. The global provision of climate services seems well underway. Climate services pertain to very broad provision of information to a nation's citizens with respect to all aspects of climate variability and change, their possible impacts, adaptation strategies and opportunities and other aspects. The full implementation of climate services will require the integration of socio-economic, engineering and natural sciences and these present challenges and opportunities for Norwegian and global integrated climate sciences.

The provision of climate services will depend, in part, on the ability to provide reliable predictions of information on finer time and space scales than is typically done at present. The moves to shift down-scale in climate science and in the provision of climate services are both logical extensions of recent advances in observing and modelling the climate system. Through both, we have come to realise that although we cannot understand global change in the ocean-atmosphere-cryosphere-terrestrial system except on the largest space and time scales accessible to us (pan-Arctic; years to decades) we cannot do much that is useful with that understanding unless and until we find some way of downscaling the science to the local and regional scales that make sense to people. There is therefore great need for integrated development of the climate services approach across the natural climate science community, the biospheric communities of impacts and responses and the socio-economic communities. The consensus is that although progress has been slow (e.g. Kerr, 2011), the task of downscaling is achievable (Shukla et al., 2009). The questions for the present evaluation

were: are such plans on track in Norway? And are they appropriate and optimal from a national and international perspective?

5.2.2 The submissions

Though the Evaluation Committee has not yet received official confirmation of its acceptance let alone its funding, the setting-up of a Norwegian Climate Service Centre is a recurrent theme throughout these self-evaluations and interviews. The idea in its present form is attributed in the submission of the Norwegian Meteorological Institute (met.no) to Working Group 1 'Natural variability and man-made forcing' of the Klima21 Committee, which recommended as a priority for research the topic of 'Regionalisation using both dynamical and empirical-statistical downscaling based on models as well as observations....adding sufficient detail to cover specific user needs in a given region or locality' and proposed the establishment of a Norwegian Climate Service Centre for its implementation. This recommendation and proposal of Klima1 are strongly endorsed in the met.no submission, which described in some detail the progress already made over 15 years to build up a strong research group in both dynamical downscaling using nested Regional Climate Models (RCMs), and in empirical-statistical downscaling. The downscaling /RCM group is now one of the four main divisions of met.no, and comparing and combining results from both approaches, met.no report making a large ensemble of climate projections of temperature and precipitation for the different regions of Norway to 2100, together with estimates of their uncertainties. But there too, the first problems seem to have been identified. Both for model validation and improvement and in their ability to maintain the complex of curiosity-driven science that underpins their understanding of the physical processes being modelled, met.no and others complain of too little funding for curiosity-driven science and too much competition in modelling. As they point out, the business of improving the utility and relevance of their predictions through downscaling is not simply a case of dividing down scales mathematically but is critically dependent on observing, assimilating and understanding the key processes at finer resolution in space and time.

One reason for the strong met.no endorsement of a Norwegian Climate Service Centre must stem in part from the fact that it would replace the current system with a truly long term nationally-funded climate modelling system, coupled of course with the fact that, following the direction set by WMO, such centres have also been established in other EU countries. Discussions with met.no, the Bjerknes Centre for Climate Research (BCCR) and others appeared to confirm our impressions that such a centre has been proposed and is apparently under consideration for a Government White Paper on climate adaptation due in 2012 so that funding may be present in the Budget for 2014; the met.no group confirmed that collaborations between met.no and its main collaborators on the issue, the Bergen Group, seem to involve little that was contentious and subsequent discussions with the component institutes of the Bergen Group appeared to agree. According to the perspective of the BCCR, the Climate Service Centre is likely to be a distributed one with 'ownership' going to met.no, and with BCCR and others such as the Water Directorate acting as contractors for lesser amounts of the budget. Others, such as the Institute of Marine Research (IMR), would act as users and also, importantly, as originators of data. This issue of data provision is a key point so far as the Evaluation Committee was concerned and it is even one that may help to redress any perceived 'imbalance' on this issue in the present landscape of Norwegian climate research.

5.2.3 The evaluation

Though the Evaluation Committee does not have expertise in downscaling or regional climate modelling, certain issues of the 'shift downscale' are within its compass. The first concerns the important questions of whether downscaling in climate prediction implies that the scales of observation must move to higher resolution as well, and if so, by whom and at what cost. Since it is now argued (and even demonstrable) that internal variability contributes increasingly to uncertainty as the space-scales of climate prediction decrease (e.g. Hawkins & Sutton, 2009 in the case of temperature; or Hawkins and Sutton, 2010 in the case of precipitation), the potential to narrow uncertainty in regional climate predictions would seem to depend critically on observing the system and assimilating its changes on a finer scale at least for critical regions for test and evaluation of model simulations. The met.no self-evaluation notes that 'dynamical downscaling by atmospheric Regional Climate Models forced with low-resolution data should produce fine-scale climate details with skill'. It is expected that IPCC AR5 [Chapter 9 "Evaluation of Climate Models" in WG1], will provide further guidance. In the interim, it is noted that Rummukainen (2010) has been clear on the issue of observations:

'Typical RCM resolution over the past years has increased from around 100 km to around 25–50 km. Regional climate modelling is now starting to explore using higher resolutions of around 10 km and even higher, approaching true local scales. Initial results indicate further improvements in the representation of spatial detail and extremes [though] increased resolution carries a penalty in computational cost. Another complication is the limited spatial availability of suitable observational data on such high resolution. Increasing resolution also warrants changes in the representation of the dynamical and physical processes in the models. Nevertheless, the prospects are promising, in terms of both research on local climate processes (and their impact on larger scales) and provision of impact and adaptation applications'.

The same dependence of predictive skill on fine-resolution data is most recently implicit in Matei et al. (2012), where multiyear prediction of the climatically important Atlantic Meridional Overturning Circulation is stated to be restricted to 26.5N, the only location where a high enough data density exists. Quite simply, without observations for verification you have no prediction.

Since the capacity to deliver appropriate climate services will depend on the high-quality and verifiable small scale predictions on climate time scales, the concerns of met.no, the likely 'owner' of the proposed Norwegian Climate Service Centre, about having 'a limited capability in research driven by *in situ* experimental observations or by new *in situ* observational techniques which are in a development phase' are important. Thus in their stated aims of achieving further expansion of their R&D effort in 'the better coverage of the Arctic, the further regionalisation based on both dynamical and empirical downscaling based on models, and an improved push to quantify uncertainties of climate projections', three of the four areas where met.no proposes expansion, the met.no group suggested that they would look to IMR, NPI and others with core funding and skills in observing the high North to provide these sorts of data; they would not plan to tackle it themselves. This makes sense; with its research vessels performing 1600 sea days a year, IMR is already responsible for most of the marine climate monitoring in Norway and the Norwegian Polar Institute (NPI) is already the strongest Norwegian performer in ice-covered seas. Devising an effective framework for using the ocean-atmosphere-cryosphere-terrestrial research teams of the

Norwegian Polar Institute's Centre for Ice, Climate and Ecosystems (ICE) to provide the high resolution data sets that the Climate Service Centre will need seems one way of strengthening the North-South bond in the Norwegian climate 'landscape'.

5.2.4 Discussion

5.2.4.1 Substantiating the need for improved National Climate Services

Apart from the potential future need for longer-term changes to the observing system in support of Climate Services, the submissions to the Evaluation Committee raised a number of grounds for improvement in the present system. Often, these reflect cases where a research institution collects and maintains its own long-term high-resolution data-series (e.g. habitat data in the case of the Norwegian Institute for Nature Research (NINA), or urban water infrastructure data in the case of the Department of Mathematical Science and Technology of the Norwegian University of Life Sciences (IMT/UMB), but they lack climate data (observed and projected) on a comparable scale with which to do the impacts research they wish to or are asked to carry out. The following are examples only, not intended as a comprehensive list. These examples also demonstrate some areas where climate services could be implemented. This will require not only the provision of downscaled climate information but also the knowledge and techniques upon which to base services for the communities of interest.

- IMT/UMB questioned the adequacy of the met.no observing network for its urban storm drainage focus, suggesting that Norway has far too few precipitation stations to capture intensive rain events, causing large uncertainties in their analyses. If true, this lack of gauging is likely to be a growing issue for met.no as it downscales its precipitation projections.
- NINA would like better climate predictions at an ecologically-relevant scale, because management and policy-oriented research questions demand more spatially- and temporally-precise modelling.
- The Norwegian Water Resources and Energy Directorate recommended more regionalisation (i.e. downscaling) of climate data, as well as a focus on climatic extremes – intense precipitation events, winds, floods, droughts, and the effect of sediment transport in rivers – all of which require analysis at higher temporal resolution.

5.2.4.2 The pan-Arctic provision of Climate Services; combining science with local knowledge

In their submission to this Evaluation, the experience and recommendations of the Sámi University College (SUC) and the International Centre for Reindeer Husbandry (ICR) appear to reflect a rather different requirement for 'climate services'. From their largest project in the field of climate research [the EALÁT Project ('something to live on')], they suggest that for them, 'Adaptation to climate change is about building competence locally. One of the challenges for Norwegian climate research is to make a bridge over the gap between researchers at the universities and people outside of the universities'. Between 2007-2011 the EALÁT project has made major strides towards this goal through the organising of 21 community-based workshops in local reindeer herding communities across the circumpolar Arctic, including Norway, Sweden, Finland, NW Russia, Western Siberia, Eastern Siberia, Southern Siberia, the Russian far-east, as well as the far-north of Canada, spanning the major reindeer herding regions of the world and eight different Arctic reindeer herding peoples. While climate data were collected by partners in Russia and Scandinavia, statistical downscaling was done in IPY EALÁT by the Norwegian Meteorological Institute. Land-use

change scenarios were done in IPY EALÁT by ICR, UNEP/Grid-Arendal, NASA Goddard Space Flight Centre and St. Petersburg State University. And the twin keys to the eventual success of this approach will lie in the facts that scientists as well as local reindeer herding peoples have taken part, formal climate science and traditional knowledge will both have been used in the critical discussions on climate change, land use change, adaptation and resilience, and the 'downscaled' climate advice achieved will have been the parameters that are actually of interest to the indigenous people themselves, based on, but differing in significant ways from, the standard output of RCMs [for examples see the Sámi submission: 'Selected key findings of the EALÁT Project']. While the Sámi University College is convinced that the adaptation strategies evolved at these workshops can reduce vulnerability to climate change in reindeer husbandry in Finnmark and elsewhere, the real challenge is achieving long-term funding of Sámi/indigenous research teams or units on climate change. 'The research council of Norway can help in this situation'. The Sámi experience appears to have much in common with attempts currently underway to downscale science to inform policy at the local level in the Canadian North. There also, Carmack and Holling (2009) suggest that 'practical downscaling' might be achieved by coupling the large-scale and long-term methods of Western science with a community-based watch at regional scale carried out by community residents and drawing on indigenous knowledge.

In either case, the issue under test is whether the science of change can, in any practical sense, be downscaled to the point where it begins to make real and practical connections with a whole web of *local* needs (Dickson, 2011a). If it can, as Carmack and Holling (2009) point out, we stand a real chance of linking communities across the full subarctic/panarctic domain and of bridging the needs for climate services. Three ground rules are offered in support: (1) that the suites of measurements must be fully comparable (e.g. simple measurements made with robust, off-the-shelf instruments); (2) the data must flow two ways (e.g. from the communities to a central data processing centre and then back again to the communities); and (3) the project must live on the world wide web.

5.2.5 Summary of key findings

Following the World Climate Conference-3 in 2009, a Global Framework for Climate Services (GFCS) and a Climate Services Partnership (CSP) have been formed to advance climate services around the world. A GFCS Implementation Plan including case studies relevant to the provision, development and application of climate services will be submitted to WMO in October 2012. The Klima21 Committee recommended dynamical and empirical-statistical downscaling based on models as well as observations as a priority for research in Norway and proposed the establishment of a National Climate Service Centre (NCSC) for its implementation.

Though the Evaluation Committee had no knowledge of whether this Klima21 recommendation has been accepted by Government, discussions with met.no, BCCR and others in the course of this evaluation conveyed the strong impression that such a centre is currently under active consideration for a Government White Paper on climate adaptation. From these discussions, the National Climate Service Centre seems likely to be a distributed one with 'ownership' going to met.no, and with BCCR and others such as the Norwegian Water Resources and Energy Directorate acting as contractors for lesser amounts of the budget. Others such as IMR would act as users and also, importantly, as originators of data. While an NCSC would be in line with other national initiatives elsewhere, the finer-scale

resolution in the representation of dynamical and physical processes would carry a penalty in terms of computational cost as well as in the cost of providing observational data at sufficiently high resolution (model input and verification).

With the broad range, unusual nature and high societal importance of climate issues in Norway, the Norwegian experience in the provision, development and application of climate services is likely to be sufficiently out of the ordinary to recommend that specific Norwegian case studies be developed and submitted in support of the GFCS Implementation Plan to WMO in October 2012.

The Sámi University College and the International Centre for Reindeer Husbandry suggest that a different path to the provision of climate services would be more appropriate in the case of the indigenous peoples of the circum-Arctic. In their experience, formal climate science and traditional knowledge are both required in their critical discussions on climate change, land use change, adaptation and resilience if the 'downscaled' climate advice achieved is to concern the parameters of interest to the indigenous people themselves, not simply the standard output of RCMs. Given continuity of funding, they would rely on the continued spread of community-based workshops across the circumpolar Arctic to put this into effect. This example stresses the need for integrated interdisciplinary science that relates climate variables to ecosystems and to human concerns and needs and develops the climate services in this modality. The funding approach of RCN will need to reflect these issues and the needs of all communities.

6 Future Developments and Major Challenges

Norway is an important oil producing country (No. 15 in the world with major new areas recently opened up for exploration). The country is highly dependent on the petroleum sector, which accounts for nearly half of exports and over 30% of state revenue. The Ministry of Petroleum and Energy is the fourth largest financial contributor to RCN in 2011 with 722 MNOK (RCN, 2011h). Furthermore, Norway will voluntarily strengthen its Kyoto commitment by 10%. One could thus argue that Norway and RCN have a moral obligation to strongly support climate research and that it is important that the recommendations of Klima21 for increased funding of climate research be implemented, so that in 2015 it might rise to 1bn NOK above the amount in 2010.

There has been much scientific progress in understanding the climate system, the impacts of climate change and strategies for adapting to such changes. IPCC has played, and will continue to play, an important role not only in describing the scientific basis for climate change but also in identifying areas in which our scientific knowledge is still so incomplete that assessments can only give indications of changes to come, possible interventions to reduce human impact on the climate system and how societies can adapt to such changes.

We believe that Norway must continue to have a strong climate research agenda building on past achievements and especially the results from NORKLIMA and IPY. Such research must be based on the best science in relevant disciplines. Norway is a relatively small country, but even though it ranks No. 16 in the global ranking of research and development spending per GDP (1.7%), it has specific areas of scientific research where it is in the forefront internationally. Norway should focus on areas where it has competitive advantages and build on the strengths outlined in Sections 2.1–2.3. For Theme 1, there is a strong track record in relation to modelling the climate system based on oceanic and atmospheric observations. A major challenge will be the development of the Norwegian Earth System Model (NorESM). Such modelling must be done in an international context, with model intercomparisons essential to test robustness and quantify model uncertainties. Model development must be based on excellent basic research and dedicated long-term monitoring systems.

It will be important to continue funding research on the effects of climate variability and change on plant and animal populations, where there are several strong research groups working in both terrestrial and marine environments. Norway offers an excellent opportunity to further explore the influence of factors such as permafrost and ice cover extent and their effects on populations. However, it is also important to strengthen areas where scientific understanding is essential for society and the development of Norway. In relation to Theme 1, an increased effort in understanding the basic natural climate processes could be advantageous for Norwegian climate research. Furthermore, there seems to be a lack of research on the importance of land surface characteristics, such as albedo and the influence of land-cover change on the hydrological cycle. Parameterization of such characteristics will be important for the continued development of Earth System Models and realistic downscaling of climate models.

For Theme 2, we have identified a lack of research on adaptation of biological systems at all organisational levels to a changing climate. There is also relatively little research on mitigation. The role of ecosystem services merits additional research emphasis. There is also a need for research on strategies for how Norway should further develop the utilization of biological resources in agriculture, forestry and fisheries in relation to climate variability and change. Such research could address the resilience of ecological and social systems and the economic valuation of various ecosystem services and the trade-offs between different societal goals.

In general, natural science disciplines are stronger than social sciences when it comes to climate research despite the fact of the importance of social systems and individuals in causing climate change and the need to understand options for both mitigation and adaptation. The social science research is rather fragmented and there are only a few areas, where there is sufficient critical mass to build a strong disciplinary environment. Issues that are in need of further research support include the architecture of global governance; basic questions of how we organise economies and societies in a changing climate; a greater understanding of how definitions of development and growth need to be modified; risk management in relation to natural resources, infrastructure and societal planning; relationships between global politics and equity and development; the role of indigenous peoples and traditional knowledge; what shapes consumer and producer behaviour; the role of public opinion; and finally, an identified lack of systems perspectives and analyses of coupled social and ecological systems. Such research should include fundamental research that enriches the social science understanding of global to local governance on an issue such as climate change. There is a general disconnect in the mind of many that basic social science is not related to climate change because it is not so labelled. However, there is considerable scope to engage many social science disciplines in basic research of relevance to environmental issues in general and climate research questions in particular.

However, it is necessary to advance climate research also in new directions and into uncharted territories. Climate variability and change are not the only global change factors that put pressure on ecosystems and social systems. Biodiversity loss will affect ecosystem function and in turn determine how systems affect the climate system and are affected by it. Changes in biogeochemical cycles will in turn affect the climate system and there are many socioeconomic changes that directly or indirectly affect the climate system. A challenge for the future is to expand studies of climate to other important global change factors. This can be guided by the fact that global change research currently is being reformulated at the international level through “Future Earth – Research for global sustainability” by the International Council for Science (ICSU) and its partners (ICSU, 2010). This initiative seeks to meet this challenge of the threats of climate change and other global change processes through new alliances of researchers, scientific organisations and research users, who will join to co-design an integrated research agenda, foster new research programmes, coordinate research funding, and deliver knowledge for solutions to the global community.
To address major climate policy issues, the need for interdisciplinary research engaging both natural and social scientists has become increasingly recognized. In addressing the climate change challenges, humans are the drivers and we need a proper understanding of the behaviour of companies and individuals, production and consumption patterns, economic and political structural conditions, and the role of institutions and policy instruments for the implementation of international agreements.

Climate and climate change issues all need an understanding of the links between the climate system and social system. Thus, a future RCN initiative should properly reflect this changing landscape and provide opportunities for both disciplinary science of the highest quality as well as interdisciplinary science bridging the gap between understanding the physical climate system, biogeochemical cycles and the role that humans have in forcing the climate system well enough to foreshadow its changes, as well as research addressing both climate change mitigation and adaptation in response (Figure 6.1.2).

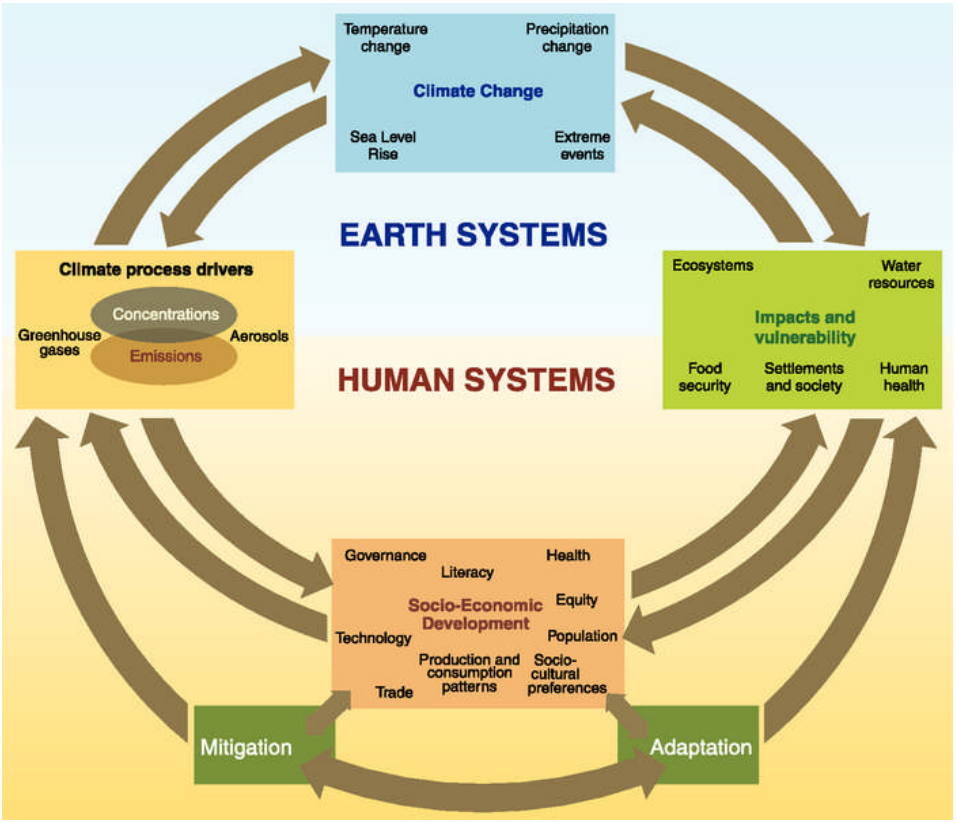

Figure 6.1.2. Schematic framework of anthropogenic drivers, impacts of and responses to climate change, and their linkages (IPCC, 2007a)

It is clear that the units interviewed for this evaluation had very different perceptions of interdisciplinarity. Some considered collaboration between meteorology and hydrology to be interdisciplinary, whereas others clearly underlined the importance of bridging the gap between social and natural sciences in any future Norwegian climate research programme. However, universities consist of faculties and departments for specific disciplines within the natural and social sciences and this often hinders the development of research on the integrated Earth system as it relates to climate and its change. However, there are important new initiatives, such as MILEN, the University of Oslo's inter-faculty research area on environmental change and sustainable energy or the new Nordic Centre of Excellence NorMER (Nordic Centre for Research on Marine Ecosystems and Resources under Climate Change) to be administered by the Department of Biology at the University of Oslo but funded from 2011 as a cross-Nordic collaborative project combining the expertise of internationally recognized research teams from all of the Nordic countries to implement a broad international and multidisciplinary research strategy to explore the biological, economic, and societal consequences of global climate change on fisheries resources in the Nordic region. The Oslo Centre for Interdisciplinary Environmental and Social Research (CIENS) is another example, where the University of Oslo has itself invested in linking some

of the most relevant research institutes together in a research network with high relevance to climate change research. This has resulted in further strengthening of interdisciplinary cooperation, for example in the newly funded Strategic Challenges in International Climate and Energy Policy (CICEP), with CICERO and the Fridtjof Nansen Institute (FNI) as research partners.

To foster such new collaboration is a major challenge for RCN. Within any new programme structure, it is important to develop platforms for the exchange of ideas and the development of research proposals involving relevant disciplines. Thus, new mechanisms should be put in place to build on the excellent disciplinary research to address new scientific challenges of linked Earth and human systems.

In advancing climate science, it is also necessary to have strong monitoring programmes and long time-series of observations of key variables. Research and monitoring provide the two essential backbones for assessments, such as the IPCC and Arctic Climate Impact Assessment. Many of the units we interviewed were engaged in various monitoring activities but expressed concerns about the ability to collect long time-series. Overall responsibility for monitoring of the environment rests with the Climate and Pollution Agency (Klif), which publishes State of the Environment Norway, though most of the marine climate monitoring has historically been undertaken by the Institute of Marine Research, governed by a Ministry-appointed Board until 2011 but since then by a professional council with international participation.

Monitoring should have dedicated financing that is sustainable over the long term. Too much of the necessary monitoring is financed through research grants with limited life-time, by individual scientists without much hope for continuation after their retirement, and without adequate data centre support that make the collected data openly and freely available. International initiatives, such as the Global Climate Observing System (GCOS) or the Global Ocean Observing System (GOOS), have been fairly successful and well linked to both research (through WCRP) and assessment (through IPCC). There is no such stability when it comes to monitoring of terrestrial systems, although the GEO BON (Biodiversity Observation Network of the Group on Earth Observations) provides one element of the international strategy. To become sustainable, this must be supported by national monitoring programmes with stable funding.

Since climate change will affect all aspects of society, it is important to ensure that climate information is available in forms that can be used by various stakeholders (see Section 5.2 – Climate Services). In order to truly engage both the public and private sectors, participatory approaches could be used to engage relevant stakeholders in defining the problem, becoming partners in the research and co-owners of the results. In order to advance the sciences, involving also relevant decision makers and stakeholders at various levels, transdisciplinary research approaches might be useful. One characteristic of transdisciplinary research is the inclusion of stakeholders in defining research objectives and strategies in order to better incorporate lay knowledge and provide for mutual learning between scientists and practitioners in the research process, as well as helping towards the diffusion of knowledge produced by the research. Collaboration between stakeholders is deemed essential – not merely at an academic or disciplinary collaboration level, but through active collaboration with people affected by the research and community-based stakeholders (Wickson et al., 2006). Transdisciplinary research is taking hold in academic institutions and some believe that this will offer a new paradigm that will be a key factor in the advancement of science in the

coming years. Norway could take the lead in also developing the possibilities for such approaches within its climate research portfolio. However, it is also essential that such approaches build on high quality disciplinary research.

Ever since the publication of the Brundtland Report (WCED, 1987), Norway has been among the world leaders in promoting sustainable development, also through research. For the future, the nexus between climate change and development is paramount. This should include research relevant for a sustainable development in the context of climate change in Norway as well as Norwegian support for addressing the role of climate change and its threat to sustainable development in the least developed countries. RCN could further develop joint programming with Norad to provide financing for Norwegian research in and for the least developed countries. The strengthening of Norwegian development research is consistent with recommendations from the RCN review of Norwegian development research (RCN, 2007b) and the Norad evaluation of Norwegian development assistance work (Norad, 2011). Climate variability and change will affect the poorest countries most severely and research on climate as it affects the poorest nations should be an important component of the Norwegian research portfolio. As pointed out by the Norad evaluation, "greater output of independent research is required to ensure that policy-makers have access to impartial, evidence-based analysis of the impact of different aid modalities in different countries and contexts". The climate dimension should certainly be part of the evidence base that policy makers need.

One example, where Norway could take the lead is research on REDD+ (United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries). Prime Minister Jens Stoltenberg promised substantial Norwegian funding for REDD during the climate change negotiations in Bali in December 2007. The initiative seeks to achieve cost-effective and verifiable reductions in greenhouse gas emissions from deforestation and forest degradation in developing countries, and applies to all types of tropical forests. However, there are no allocated research funds linked specifically to the Norwegian investment in REDD+. Despite this, there is important Norwegian research and a Norwegian REDD Research Network was established on the initiative of the University of Oslo Centre for Development and the Environment (SUM) and the Fridtjof Nansen Institute (FNI) in collaboration with CICERO and the Norwegian Institute for Nature Research (NINA), with financial support from Norad's Climate and Forest Initiative. Additional research on REDD would guide its implementation and could become a future key area for Norwegian climate research.

Another example, where Norway could focus is on the expected directions that may be taken at the UN Summit on Sustainable Development in June 2012 that have direct or indirect relevance for the climate issue. At global level, there will be increasing demand for research on the green economy and institution building to promote the green economy. These are the two key themes for discussion during the UN Summit which will try to integrate climate change and other environmental concerns within the context of the development paradigm to be discussed and promoted all over the world. Within these two broad themes, there are a wide variety of specific issues that need to be dealt with. Policy ideas to implement a green economy include reinventing economies; getting the prices right (e.g. internalization of environmental externalities, green taxes, linking social goals with economic goals); promoting science-based sustainable product chains; the dematerialization and decarbonisation of society; multiple land use and sustainable agriculture, better water use and the protection of ecosystem services. Although these elements are all critical and useful ideas, actually implementing these ideas through instruments that can take the systemic character of

these ideas into account is very difficult. For example, decarbonisation as part of the green economy is easier said than executed. A second challenge is developing a green governance programme from local to global levels. This takes into consideration the organisation of social structures from local (local self-governance, community based management) through to global levels (the organisation of governance at global level). A good quality social science programme can be developed to cover these issues which systematically integrate climate change issues into the system of production, consumption, development and governance patterns.

Norway should make use of its unique geographic location, with Svalbard as a national and international research platform. As outlined in the RCN strategy for the Arctic and Northern Areas 2011-2016 (RCN, 2011b), Norway has much to offer in terms of expertise and advanced infrastructure, as well as the unique research opportunities available on Svalbard. This provides a unique research platform for studying a variety of phenomena, not only by virtue of its location far north, but also because of the extensive research infrastructures available for investigating the marine environment, vegetation and permafrost, glaciers, and the atmosphere. The European Strategy Forum on Research Infrastructures (ESFRI) project "Svalbard Integrated Arctic Earth Observation System"), which is currently in its preparatory phase, is crucial for establishing an effective framework for international cooperation and sustainable utilisation of the research potential on Svalbard (RCN, 2011b). International collaboration in the Arctic was strengthened during IPY and it is a major opportunity to continue building on the IPY legacy.

Norwegian scientists have played major roles in IPCC assessments and are thus well positioned to also help fill the gaps in scientific knowledge. The fact that the Bergen Climate Model (BCM) was one of four European models used in IPCC AR4 indicates the high quality of Norwegian research in this area. The development of The Norwegian Earth System Model - NorESM, building on BCM with additional components from Oslo on aerosols, clouds, and atmospheric chemistry will provide important input to IPCC AR5. This provides a major opportunity for Norwegian science to play an internationally leading role, if sufficient and stable long-term funding is provided in support of the Earth system modelling efforts.

The future offers exciting opportunities to build on current strengths of Norwegian climate research, expand its scope and augment its funding. In the following section we make six recommendations and outline steps necessary to plan and implement a bold and visionary new Norwegian climate research programme based on a strong governmental strategy to address the opportunities and challenges over the coming decade.

7 Conclusions and Recommendations

Climate research in Norway is impressive and provides a solid basis on which to build a major expanded effort. The dynamic development of global change research internationally offers exciting new possibilities for the Norwegian research community. Based on our review, we have formulated six key recommendations and identified a number of steps that would be necessary for their implementation.

Recommendation 1: Establish a clear and coherent national strategy for climate research and its funding

Norway has a strong history of excellence in climate change research and many individuals and groups are highly recognized internationally. In particular NORKLIMA and IPY have provided excellent opportunities for national collaboration and international partnerships. The Research Council of Norway (RCN) has played a leading role in providing funding for this research, but other funding mechanisms have also been important and the overall picture is rather fragmented.

The government has published a number of policy documents of relevance for climate research, but the various conclusions and recommendations have in many cases not been implemented. For that reason, it is essential to develop a long-term national strategy building on the many existing policy documents.

- The Government should establish an overall strategy for climate research funding building on the recommendations of Klima21 taking into account the importance of both natural climate variations and human-induced change and their full impacts on, and response to, natural and human systems, in a fully interdisciplinary, coordinated approach.
- The research strategy should address the importance of understanding the integrated climate system including the natural and human forcing of the climate system as well as the response of ecosystems and social systems.
- Options for mitigation and adaptation approaches and their socio-economic costs and benefits should be considered a crucial part of the strategy in order to provide the evidence and understanding for the development of responses by public and private sectors to climate variability and change.
- Funding for climate research should be a high priority. An increase in total funding level in 2015 as recommended in Klima21 seems highly justified.
- The currently complex national funding landscape should be simplified to provide stronger coherence of the research effort with the Research Council of Norway (RCN) given primary responsibility for funding climate research so that it is based on open and competitive application processes, while addressing national needs and strategic goals.

Recommendation 2: The Research Council of Norway should develop a new integrated long-term climate research programme

RCN has played a major role in stimulating Norwegian climate research and climate issues have been funded by many RCN programmes. NORKLIMA and IPY have been especially important in funding dedicated climate research covering a wide range of scientific disciplines. However, NORKLIMA has been a funding programme rather than a research programme due to the relative lack of overall strategy and synthesis products. IPY, being an important component of a major international effort on polar research, has, on the other hand, been a research programme with both national and international synthesis efforts. Energy and climate issues are very closely connected and it is important that RCN provides mechanisms to enable energy and climate research to be mutually supportive, if financed through different RCN programmes.

- NORKLIMA and IPY should be followed by one overarching integrated and strategic long-term research programme building on scientific unknowns identified by NORKLIMA, IPY and other processes as well as on relevance for society.
- An overall scientific framework should be established and synthesis activities built into the programme to ensure that the whole becomes more than the sum of its funded projects.
- As an important component of the new programme, an unrestricted 'FRIKLIM' component should enable funding of the best natural and social science research projects based on disciplinary and innovative quality and open, non-restricted calls.
- Calls within the new programme should be fewer and considerably less specific as compared to NORKLIMA.
- RCN should ensure better coordination between programmes for funding climate and energy research to stimulate synergies and avoid duplication.
- Funding should be based on criteria for quality and innovation as well as relevance. It is important that RCN clearly communicates which relevance criteria will be applied for the evaluation of proposals.
- Further development of Norwegian Earth System modelling (NorESM) should continue to play an important role. Global modelling should include contributions to the future IPCC modelling activities and be complemented by the development of methodologies to provide and validate higher space and time resolution (down-scaling) in order to address the needs of studies of ecosystems and social systems and contribute to making relevant 'climate services' available to the private and public sectors.
- Social science research, including economic analyses, should be an important component of a new programme and attempts should be made to also include humanities research as relevant.
- RCN should strengthen its dialogue with the social sciences community in order to frame issues that are of disciplinary social science interest and can attract interest in climate research from a wide variety of disciplines within the social sciences and humanities. Qualitative social sciences (critical and non-instrumental research) should also receive attention.

Recommendation 3: Build on strengths and develop capacities where Norway currently lacks sufficient scientific expertise

Norway has a strong tradition in many areas of climate research, but we have also noted areas where relatively little research is done and there is a weak and fragmented research community. Thus, the national climate research strategy should consider the needs of various stakeholders for climate research information. For the science community, it is important to build strategic partnerships with researchers and institutions in other countries having complementary and necessary skills, since a relatively small nation cannot have world class research in all disciplines.

- It is important to strengthen research on both adaptation to climate variability and change and mitigation of change. For adaptation, a much improved understanding of regional climate variability is needed with seasonal to decadal predictions. For mitigation, the involvement of the engineering research community is relevant.
- Adaptation research could address the resilience of natural and social systems in the context of climate change.
- The role of terrestrial systems in regulating the climate system through albedo and influence on the biogeochemical and hydrological cycles also merit special emphasis.
- RCN should, through dialogue with Norad, ensure that research on climate change as affecting the least developed countries receives special attention. Such research should consider the nexus between the environmental, economic and social pillars of sustainable development.
- In the new programme, it is important to stimulate research on climate related issues with perspectives from various disciplines in areas where there is strong disciplinary expertise but less expertise in climate related work (e.g. anthropology, systems ecology, sociology, history).
- Consideration should be given to smaller grants over longer periods of time to allow for the build-up of capacity in new areas of research.
- International collaboration should be emphasised in calls for the new programme, especially as it relates to strengthening Norwegian competencies in areas where the science community is relatively weak.

Recommendation 4: Ensure societal relevance as well as inter- and transdisciplinarity in research

Research must be built on the best disciplinary knowledge and research. However, to solve many of the crucial scientific issues necessitates a multidisciplinary approach. Also, to address issues of societal relevance, it is often necessary to develop projects involving natural, socioeconomic, engineering and health sciences. Norwegian climate research has already demonstrated the ability to build such bridges and develop research of high relevance for both the public and private sectors. However, much remains to be done. The new programme should address issues of importance for Norway and provide insights and knowledge to assist in both public and private decision making. It should thus stimulate research bridging natural and social sciences.

- The development of interdisciplinary project proposals, bringing together different disciplines, needs a consolidated planning phase for which RCN should consider giving planning grants based on pre-proposals. Requirements for interdisciplinarity

should not penalise proposals from individual research institutions that are themselves already highly interdisciplinary in nature.
- Composition of review committees should reflect inter- and transdisciplinary research experience, as appropriate.

Recommendation 5: Emphasise collaboration and cooperation as a basis for successful climate research

Collaboration is a natural part of the scientific enterprise and past initiatives at both Nordic, European and global levels have provided much stimulus. Norwegian climate research has many international partners and foreign scientists conduct research in Norway, partly due to the special biogeographic conditions offered by, for example, Svalbard. The planning and implementation of Norwegian climate research should be informed by developments at the Nordic, European and global levels. RCN should, as appropriate, influence and strive to engage in international planning and coordination of climate research and also take advantage of the opportunities offered by international programmes.

- RCN should develop a national strategy for coordinating Norwegian and Nordic funding. Special attention should be given to the need for national co-financing of Nordic initiatives. Areas for Nordic collaboration should also include research infrastructure.
- Norway should continue to engage in the planning for European research funding with the next Framework Programme of special importance. Norwegian scientists should be encouraged to seek the role of coordinator of major programmes and if successful offered the necessary administrative support.
- The planning for a new programme should take note of the developments as a follow-up to IPY internationally and be informed by, and engage in, the new international 'Future Earth – Research for Global Sustainability' initiative.

Recommendation 6: Prioritise outreach and stakeholder interaction

In order to ensure societal relevance and resulting use of climate research, it is necessary to develop and enhance dialogue with relevant stakeholders, both from the public and private sectors. We are not fully convinced that the importance of establishing platforms for such dialogues is fully recognized by the science community. Although some institutions that we interviewed had ambitious outreach with dedicated and substantial funding, other groups had not yet realized the importance of the societal dimensions of their climate research.

- The new programme should have outreach as an important component of each funded project, which should clearly demonstrate how the research outputs are leading to outcomes and impacts.
- RCN should consider an annual or biannual meeting, including a public event to deliver information on the status of climate change research in Norway and a second part for the scientific community to discuss priorities and stimulate new collaborative partnerships.
- The involvement of stakeholders should be considered, e.g., through transdisciplinary action research on relevant climate topics. RCN should continue to arrange dialogue meetings, both with the science community and stakeholders.

- RCN should have a clear data policy to make sure that results are easily available to the scientific and other user communities. There should be full and open access to data.
- A national strategy for monitoring of essential climate variables should be developed, which should include the support of coordinated data bases. Svalbard is a key site for the Integrated Arctic Earth Observing System, which will become a fundamental basis for a global Arctic observing system.
- Norway should establish a strategy for making 'climate services' available to the public and private sectors, for example through the establishment of a Norwegian Climate Service Centre, but should also consider complementary distributed activities. A national initiative to address the needs for climate services should focus on function, deliverables and user needs and these should factor in the development of a national research strategy that would enable effective delivery and use of climate information services.
- Norway should continue to support the involvement of Norwegian scientists in IPCC, IPBES and similar international assessments and provide appropriate incentives for such engagement.

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9 Appendices

Appendix 1.1 Mandate and framework for the evaluation

Mandate and framework for the evaluation of Norwegian climate research

The Research Council of Norway, revised 13 October 2011

Background

The Research Council of Norway has initiated an evaluation of climate research in Norway. The aim of the evaluation is to provide a critical review of Norwegian climate research in an international perspective, and to give recommendations on measures to enhance the quality, efficiency and relevance of the future climate research. The Research Council's strategy and recommendations regarding the future focus of climate research must be based on sound knowledge of the existing research framework. The evaluation outcome will provide a good basis for determining how to allocate research funding, and for offering guidance on research-related issues within the Research Council itself, to the research institutions, and to the authorities.

Climate research extends across a wide range of subject areas – from meteorology and biology to political science and psychology – and requires substantial multi- and interdisciplinary focus. The evaluation of Norwegian climate research is to examine the knowledge flow between disciplines and the synergies arising from this, and will thus comprise more than the sum of evaluations of the individual disciplines. It is nonetheless crucial that the evaluation builds on the knowledge developed in other evaluations and review activities, and avoids unnecessary overlap and duplicated efforts.

Timetable

The evaluation will be launched after the appointment of the evaluation committee in spring 2011, and is expected to be concluded in May 2012. The progress plan for implementation will be prepared by the evaluation committee and the secretariat in cooperation with the Research Council of Norway.

Definitions and delimitations

The evaluation is to assess Norwegian climate research in relation to research quality and capacity, strategic focus, communication and interaction, and relevance to society, and it is to make recommendations regarding particular areas where Norway has special interests and needs but lacks sufficient capacity or expertise.

Climate research may be defined as *research that is relevant in the long and short term, and at the global, regional and local levels, for predicting climate change and the impacts of these*

changes on the natural environment and society, and for identifying measures for adapting to climate change and reducing greenhouse gas emissions.

For the purpose of this evaluation, climate research is defined with three thematic areas, as follows:

- *The climate system and climate change*: Research into climate variability and change in order to improve capability in understanding climate and in projecting climate change for different time scales with reduced uncertainty and increased spatial detail. Advances will provide climate information for decision making in a national and international context. Focus is on physical, chemical and biological processes in the atmospheric, oceanic, terrestrial and cryospheric systems that are relevant for the climate system.
- *Impacts of, and adaptation to, climate change and variability*: Insights into the impacts of climate change and variability on the natural environment and society, i.e. research into how species and ecosystems will be affected and how society will be affected through changes in food production, water availability, health, etc.
- *Institutions and instruments for response to climate change*: Research on national and international climate policy, institutions (norms, principles, organisations, strategies, measures and instruments) for reducing greenhouse gases and adapting to climate change. Analysis of how societal relations at multiple levels of governance need to change in order to deal with climate change. This includes issues related to economic growth and poverty reduction, migration, changes in attitudes and behaviour of the population etc.

Further delineation:

- In all three of these areas, the evaluation should focus on those geographical and thematic areas that are especially relevant for Norway, i.e. areas in which Norway has particular expertise, a long-standing tradition, favourable conditions, needs, the potential for value creation or responsibility.
- Research groups and researchers at institutions (universities, university colleges, independent research institutes, centres, etc.) who have applied for funding from the Research Council are of particular interest.
- The evaluation should focus on climate research conducted in the past 10 years, with special emphasis on the last part of this period.
- The evaluation is not to encompass the area of technological energy research.

Mandate

The evaluation is to compile an updated overview of the role that Norway plays in the international climate research landscape, and make recommendations on how climate research should be organised and which priorities should be set to move the field in a direction that will meet the needs of tomorrow's society.

The thematic areas to be addressed are described in points 1-4 below.

The evaluation is to assess research quality, effectiveness, interaction, relevance and needs related to these points, and make recommendations on future Norwegian climate research. For all the relevant points, the evaluation must direct particular attention towards the role

played by the Research Council, especially the contribution of the Large-scale Programme for Climate Change and Impacts in Norway (NORKLIMA) and The International Polar Year (IPY), and towards how the Research Council should organise and coordinate its activities in this area to optimise its use of resources.

1. Research quality and capacity

- Norway's contribution to advancing the research front;
- The quality of Norwegian research groups in an international context;
- Publication activity and scores on research quality indicators;
- Basic and applied research, multi- and interdisciplinary research[1];
- Capacity related to recruitment, infrastructure, investment, etc.

2. Strategic focus and interaction

- Distribution of tasks, interaction and coordination between national instruments for climate research, both within and outside of the Research Council (large-scale programmes, action-oriented programmes, support for independent projects, infrastructure, independent research institutes, centres under the Centres of Excellence (SFF), Centres for Environment-friendly Energy Research (FME) and other schemes, other centres, etc.);
- Interaction between Norwegian and international instruments for climate research, e.g. in the Arctic Council countries, the Nordic countries and the EU.

3. The players involved in climate research – participation, communication and cooperation

- National researcher cooperation and Norwegian participation in researcher cooperation in bilateral, Nordic, European and global arenas;
- Interaction between national players, such as the Research Council, government ministries, agencies, directorates and research groups. Relevant players that are not mobilised;
- Dissemination of knowledge to the public administration, industry players and participants in society at large.

4. Relevance to the challenges to society

- Relevance of research for Norwegian and international climate policy priorities in light of what the evaluation committee views as key challenges in climate research and knowledge needs of industry players and others in society.

Data material

The data used in the evaluation may include:

- Background data on the overall participation of players involved in climate research and the research groups under evaluation;
- Bibliometric analysis of scientific production;
- Analysis of citation data;
- Self-assessments by the research groups;
- Selected scientific publications;
- Interview data compiled from meetings between the research groups and members of the evaluation committee.

[1] For the purpose of this evaluation we understand the term interdisciplinary as collaboration and interactions between natural and social sciences.

Composition of the evaluation committee

It is suggested that the committee be comprised in the following manner:

- A chairperson with broad-based experience and expertise in the area of climate research and research strategy, as well as good knowledge of the international research system;
- Three or four members with expertise in natural science research on the climate system and climate change, preferably with interdisciplinary experience. Of these, one should have experience from a different field, i.e. solar research, and thus have a different perspective on climate system research.
- Two members with expertise in various fields of social science research.
- Two or three members with expertise in research on the impacts of climate change. One member should have expertise on the impacts for ecosystems and natural resources, and the other should have expertise related to other impacts of climate change, such as in relation to physical planning and infrastructure.
- One member with knowledge of management and user interests related to climate research.

The evaluation committee must have an international membership. At least three members should be affiliated with key international organisations for climate research, such as the World Meteorological Organization (WMO), the International Geosphere-Biosphere Programme (IGBP) or the International Council for Science (ICSU), and all of the members should have international experience and an international orientation.

Secretariat and external support

The Research Council will establish a secretariat with expertise related to the work involved with subject-specific evaluations, Norwegian and international research policy, the Norwegian research system, the players involved in Norwegian climate research and climate research in general. The committee's working language will be English, although a number of relevant documents will be in Norwegian. The staff of the secretariat will therefore have good written and oral language skills in both Norwegian and English. The secretariat will assist the evaluation committee with the following tasks:

1. Research secretary

The secretary will provide assistance to the evaluation committee and facilitate its activities as agreed on with the chairperson of the committee and the Research Council. In cooperation with the committee, the secretary will e.g. draw up a progress plan for the committee's activities; plan, prepare and summarise the meetings of the committee; prepare the data collection, provide the data needed, and adapt the data for use by the committee; draw up an outline for the evaluation report, write the first draft, incorporate the contributions of the committee members, and finalise the report.

2. Background data on and overview of the structural framework for climate research

In order to limit the scope of the evaluation, the evaluation committee needs an overview of the subject areas included in Norwegian climate research. This overview should take its point of departure in the mandate's definition of climate research and data on the various players involved in Norwegian climate research, the researchers' educational qualifications and the publication channels used. The overview must describe climate research on the basis of this data and discuss various alternatives for limiting the scope of the evaluation.

The secretariat will gather and adapt information on the framework conditions for climate research in Norway, i.e. describe the players involved in Norwegian climate research, the national instruments for climate research both within and outside of the Research Council, and the research groups' economic and personnel-related parameters and funding sources.

3. Bibliometric analysis

The secretariat will perform a bibliometric analysis and a citation analysis of the research groups included in the evaluation. This analysis will constitute part of the basic data used by the evaluation committee. The purpose of this analysis is to provide an overview of the scope and quality of Norwegian publications on climate research. The analysis will be performed in line with the analysis that has been carried out previously in connection with subject-specific evaluations at the Research Council and will be based on publication lists submitted by the researchers and on data from the International Statistical Institute (ISI).

Cooperation with the Research Council

The Research Council is responsible for the content of the mandate and the framework conditions for the activities in connection with the evaluation, and may be consulted on an ongoing basis by the committee and secretariat regarding the fundamental and practical aspects of the mandate, activities, limitations and other matters requiring clarification during the process.

The Research Council will assist by providing relevant background material and helping to organise meetings.

Travel must be planned in cooperation with the Research Council, and expenses will be reimbursed according to established government rates.

Appendix 1.2 Invitation letter from the Research Council of Norway

Invitation letter to participate in the Evaluation of Norwegian Climate Research and to deliver fact sheet information.

Invitasjon til evaluering av norsk klimaforskning

Forskningsrådet er i gang med en evaluering av norsk klimaforskning. Målet er å få en systematisk gjennomgang og vurdering av norsk klimaforskning med anbefalinger om videre innretting. Vi inviterer dere til å være med å danne grunnlaget for evalueringen og å sette agendaen for videre satsing på klimaforskning i Norge.

Bakgrunn

Forskningsprogrammet NORKLIMA er i avslutningsfasen og Det internasjonale polaråret (IPY) er avviklet. Forskningsrådet har derfor begynt å forberede strategien for videreføring av norsk klimaforskning. Det er 15 år siden klimaforskningen i Norge sist ble evaluert, og for at en ny innretting av klimaforskningen skal ha gode prioriteringer, er det viktig med et solid kunnskapsgrunnlag. I denne sammenheng ser Forskningsrådet behov for en ny evaluering.

Evalueringen skal gi et helhetlig bilde av norsk klimaforskning. Det vil si at fokuset vil være mer på helheten og samspillet enn på hvert enkelt forskningsmiljø. Likevel er det de enkelte miljøene som til sammen utgjør helheten. Derfor blir det nødvendig også å gå inn i de ulike forskningsmiljøenes bidrag.

Evalueringen skal munne ut i anbefalinger for videre satsing som vil møte det evalueringskomiteen ser som nøkkelutfordringene i norsk klimaforskning og samfunnets framtidige behov for klimakunnskap.

Komite og mandat

Evalueringskomiteen består av ni medlemmer som til sammen dekker stor bredde av fagområder og internasjonale miljøer innen klimaforskning. Mandat og komiteesammensetning er vedtatt av Divisjonsstyret for energi, ressurser og miljø, og komiteen hadde sitt første møte i Oslo i august.

Thomas Rosswall leder komiteen. Rosswall er professor emeritus i vann og miljø med spesiell kompetanse innen økosystemer og landbruk, mikroøkologi og biokjemiske sykler. Han er tidligere professor ved Universitetet i Stockholm og Linköping og har vært rektor ved Sveriges lantbruksuniversitet. Han har hatt flere lederposisjoner i nasjonale og internasjonale organisasjoner, bl.a. ICSU og IGBP, og er nå leder for Steering Committee for the CGIAR Challenge Programme on Climate Change, Agriculture and Food Security.

I mandatet heter det blant annet at evalueringen skal se på faglig kvalitet og kapasitet, strategisk innretting, kommunikasjon og samspill og samfunnsrelevans knyttet til norsk klimaforskning. På alle områder skal evalueringen rette spesiell oppmerksomhet mot Forskningsrådets rolle, inkludert NORKLIMAs og IPYs bidrag, og hvordan klimaforskningen i Forskningsrådet bør organiseres og koordineres for bedre utnyttelse av ressursene.

Les mer om evalueringen på
www.forskningsradet.no/no/Artikkel/Evaluering_av_norsk_klimaforskning/1253966989776
og
http://www.forskningsradet.no/servlet/Satellite?c=Nyhet&cid=1253968843561&p=1226993599893&pagename=norklima%2FHovedsidemal

Faktaark og videre prosess

Vedlagt i denne e-posten er et faktaark og retningslinjer for utfyllelse av faktaarket. Faktaarket vil gi oss en oversikt over blant annet størrelse, finansiering og tematisk orientering hos de ulike miljøene, og danne grunnlag for å si noe om den totale størrelsen av klimaforskning i Norge. Faktaarkene vil også være utgangspunkt for utvelgelse av miljøer som blir med videre til en dybdeevaluering.

Vi ber dere vennligst om å fylle ut faktaarket og returnere det til Forskningsrådet ved Malin Lemberget Lund (mlu@rcn.no) senest **19. september 2011**.

Miljøer som velges ut til dybdeevaluering vil ha frist i begynnelsen av november for utfylling av en selvevaluering. Videre avholdes høringsmøter med komiteen i desember. Selve hovedrapporten ventes ferdigstilt i april/mai 2012.

Vi håper dere ser dette som en anledning til å vise fram deres virksomhet, få fram hva som fungerer og hva som ikke fungerer i norsk klimaforskning, og ikke minst til å være med på å stake ut kursen videre. Vi vet at flere har vært gjennom andre evalueringer i det siste, og vi jobber for å få minst mulig overlapp.

Appendix 1.3 Fact sheet for Evaluation of Norwegian Climate Research

Deadline September 19, 2011
e-mail: mlu@rcn.no

Fact sheet for Evaluation of Norwegian Climate Research

(See attachment with guidelines for completing the fact sheet.)

Name of institution or administrative unit: .....

1. Description of organisation

Please give a brief and concise description of the institute structure/where the department fits into the university structure, and how the climate research is organised. If applicable, make a simple organisation chart.

2. Number of personnel in full-time equivalents

Positions	*Univ/RI basic budget**	*External grants***
Researcher (with PhD)		
Professor		
Associate professor		
Adjunct professor		
Adjunct associate professor		
Post-doctoral research fellow		
Doctoral students		
Administrative personnel		
Technical personnel		
Research assistants (without PhD)		
Total		

* "Univ"/"RI": financed by the university basic budget/research institute basic budget
** "External": financed by external grants

Comments regarding external personnel: ……..

3. Researchers, professors, associate professors, adjunct professors, adjunct associate professors, post-doctoral research fellows, doctoral students

Name and title	*Type of position**	*Year of birth*	*Full time equivalent (in %)*	*Thematic area***		
				The climate system and climate change	*Impacts and adaptation*	*Instruments for response to climate change*

* Use the position categories in question 2 above.

** You may tick more than one box. See description of the thematic areas in the guidelines.

4. Number of graduated doctorial students per year, title of thesis and thematic area

Name and title of graduate	*Title of thesis*	*Thematic area**			*Year of graduation*				
		The climate system and climate change	*Impacts and adaptation*	*Instruments for response to climate change*	*2006*	*2007*	*2008*	*2009*	*2010*

* You may tick more than one box. See description of the thematic areas in the guidelines.

5. Master courses offered at the institution, thematic area and number of students per year

Name of master course	*Thematic area**			*Number of students*				
	The climate system and climate change	*Impacts and adaptation*	*Instruments for response to climate change*	*2006*	*2007*	*2008*	*2009*	*2010*

* You may tick more than one box. See description of the thematic areas in the guidelines.

6. R&D expenditure and main sources of funding (in 1,000 NOK)

Type of expenditure – Source of funding	*2006*	*2007*	*2008*	*2009*	*2010*
Labour costs					
Instruments and equipment costs					
Land and building costs					
Other costs					
Total expenditures					
Basic grants					
The Research Council of Norway (RCN) grants					
NORKLIMA					
IPY					

Type of expenditure – Source of funding	*2006*	*2007*	*2008*	*2009*	*2010*
INFRASTRUKTUR					
Centres of Excellence (SFF)					
Centre for Environmental-friendly Energy (FME)					
Other RCN schemes or instruments					
Other national grants (public or private)					
International grants					
Nordic programmes					
Top-level Research Initiative					
Nordic Energy Research					
Other Nordic schemes					
European research programmes					
EU FP6					
(Specify which programme(s), add new rows if necessary)					
EU FP7					
(Specify which programme(s), add new rows if necessary)					
Other European programmes or instruments					
Other international grants					
External funding, total					
External funding as % of total expenditures					

7. Expenditure on research infrastructure related to climate research (in 1,000 NOK)

Type of expenditure	*2006*	*2007*	*2008*	*2009*	*2010*
Investment costs					
Operating costs					
Costs related to the participation in international research infrastructure projects					

Contact person: .....

Phone number of contact person: .....

E-mail address of contact person: .....

Date of form completion: .....

Appendix 1.4 Fact sheet guidelines

For the purpose of this evaluation, *climate research* is defined with three *thematic areas* as follows:

The climate system and climate change: Research into climate variability and change to develop capability in climate understanding and projections on time scales of seasons to a century that have less uncertainty and a greater spatial and temporal detail. Advances will provide climate information for decision making in a national and international context. Focus is on physical, chemical and biological processes in the oceanic, atmospheric, terrestrial and cryospheric systems that are relevant for understanding the climate system.

Impacts of, and adaptation to, climate change and variability: Insights into the impacts of climate change and variability on the natural environment and society. Research on how species and ecosystems will be affected and what are the impacts on society through food production, water availability, health, etc.

Institutions and instruments for response to climate change: Research on national and international climate policy institutions and instruments for reducing greenhouse gases and adapting to climate change. Analysis of how societal relations at multiple levels of governance need to change in order to deal with climate change. This includes issues related to economic growth and poverty reduction, migration, changes in attitudes and behaviour of the population etc.

1. Description of organisation

Universities, university colleges: Present a brief, concise description of where the department fits into the university structure and how the climate research is organised. If applicable, make a simple organisation chart in Word or Power Point, for example.

Research institutes: Present a brief, concise description of the institute's structure. If applicable, make a simple organisation chart in Word or Power Point, for example.

Only one fact sheet per university department/university college/research institute should be filled in (there should not be separate fact sheets for the different research groups).

2. Number of personnel in full-time equivalents

Report the number of the different types of positions in the department (s)/institute (s). Please report only personnel engaged in or supporting climate research. Include also personnel who are affiliated to other departments or institutes, but at the same time take part in the department's/institute's climate research and/or the education of climate researchers. Please give a comment regarding the number of such external personnel and to where (which departments) their main positions belong.

The abbreviation "Univ" refers to positions funded by a university's basic budget, the abbreviation "RI" refers to positions funded over a research institute's basic budget, while "External" refers to personnel who are affiliated to other departments or institutes, but at the same time take part in the department's/institute's climate research and/or the education of climate researchers.

The terms "Administrative personnel" and "Technical personnel" refer solely to non-scientific positions that provide technical or administrative support services for the climate research.

“Research assistants” are defined as persons providing climate research support without having a PhD.

All numbers are to be given in full-time equivalents in the form of percent.

3. Researchers, professors, associate professors, adjunct professors, adjunct associate professors, post-doctoral research fellows, doctoral students

This table should list the name, title and year of birth of all the researchers, professors, associate professors (førsteamanuensis), adjunct professors (professor II), adjunct associate professors, post-doctoral research fellows and doctoral students who participate in climate research at the department/institute.

All numbers are to be given in full-time equivalents in the form of percent. Thematic research areas: See the description of the three thematic areas under the definition of climate research above.

Please indicate for each research personnel their main thematic area. It is possible to tick (with an "X") more than one box. Please add new rows if necessary.

4. Number of graduated doctorial students per year, title of thesis and thematic area

Please list the name of the doctoral candidates who completed their degree over the past five years (2006 to 2010), the title of the thesis and the year of graduation, and indicate the thematic areas to which they belong. You may tick (with an “X”) more than one column.

Please add new rows if necessary.

5. Master courses offered at the institution, thematic area and number of students per year

Please list the name of the climate courses (Masters) that the institution offers and the number of participating students per year, and indicate the thematic areas to which they belong. You may tick (with an “X”) more than one column. Please add new rows if necessary.

6. R&D expenditures and main sources of funding (NOK 1,000)

This table intends to give an overview of the department’s or research institute’s R&D expenditures and the main sources of funding: basic grants and external funding over the past five years (2006 to 2010). Overhead expenses financed by the university/research institute should be listed under other costs.

The table requires more detailed information for specific funding schemes/instruments of the Research Council of Norway, Nordic funding programmes, European funding programmes and other international grants. Please add new rows where necessary.

7. Expenditure on research infrastructure related to climate research (NOK 1,000)

This table intends to get a more detailed overview over costs related to large research infrastructure for climate research. Please distinguish between investment costs and operating costs.

The table requests information on costs related to the participation in international research infrastructure projects. Examples of such infrastructures can be found at the homepage of the European Strategy Forum on Research Infrastructures. Also other international research infrastructure projects can be included here.

Contact person

Please indicate the name, telephone number and e-mail address of the contact person responsible (faglig ansvarlig kontaktperson) for completing the sheet, and the date of form completion.

Appendix 1.5 List of research units which delivered fact sheets and participated in the hearings

List of research units which delivered fact sheets for the evaluation and their thematic specialization (N=78), and the research units which participated in the hearings (N=39).

Name	Participated in hearings	Assigned main thematic group	Other specialization
Bergen University College, Faculty of Engineering		2 and 3	
BI Norwegian Business School		3	
Bioforsk	X	2	All 3
Bjerknes Centre for Climate Research (BCCR)	X	1	1 and 2
Centre for International Climate and Environmental Research – Oslo (CICERO)	X	All 3	
Fridtjof Nansen Institute	X	3	2 and 3
Frisch Centre	X	3	
GenØk – Centre for Biosafety		2	
Geological Survey Norway (NGU)	X	1	
Institute of Marine Research (IMR)	X	1 and 2	
Institute of Transport Economics	X	3	
IRIS		2	
Møreforsking		3	
Nansen Environmental and Remote Sensing Centre (NERSC)	X	1	1 and 2
Northern Research Institute (Norut)		2	
Norwegian Computing Centre	X	1	2 and 3
Norwegian Forest and Landscape Institute	X	2	2 and 3
Norwegian Geotechnical Institute (NGI)		2 and 3	All 3
Norwegian Institute for Air Research (NILU)	X	All 3	
Norwegian Institute for Nature Research (NINA)	X	2	All 3
Norwegian Institute for Urban and Regional Research (NIBR)		2 and 3	
Norwegian Institute for Water Research (NIVA)		2	All 3
Norwegian Institute of Wood Technology		2 and 3	
Norwegian Meteorological Institute	X	1	1 and 2
Norwegian Polar Institute	X	1 and 2	
Norwegian School of Veterinary Science (NVH), Dept. of Food Safety and Infection Biology		2	
Norwegian University of Life Sciences (UMB), Centre for plant research in controlled climate	X	2	
Norwegian University of Life Sciences (UMB), Dept. of Animal- and Aqua-cultural Sciences		All 3	
Norwegian University of Life Sciences (UMB), Dept. of Ecology and Natural Resource Management (INA)	X	2 and 3	

Norwegian University of Life Sciences (UMB), Dept. of Economics and Resource Management		2 and 3	
Norwegian University of Life Sciences (UMB), Dept. of International Environment and Development Studies (NORAGRIC)	X	2 and 3	All 3
Norwegian University of Life Sciences (UMB), Dept. of landscape architecture and spatial planning (ILP)		2 and 3	
Norwegian University of Life Sciences (UMB), Dept. of Mathematical Sciences and Technology (IMT), Section for geomatics	X	All 3	
Norwegian University of Life Sciences (UMB), Dept. of Mathematical Sciences and Technology (IMT), Section for construction and environmental technology, Flood and drain	X	All 3	
Norwegian University of Life Sciences (UMB), Dept. of Mathematical Sciences and Technology (IMT), Section for construction and environmental technology, Climate adaptation of buildings	X	All 3	
Norwegian University of Life Sciences (UMB), Dept. of Mathematical Sciences and Technology (IMT), Section for natural sciences, Flood in cities	X	All 3	
Norwegian University of Life Sciences (UMB), Dept. of Plant and environmental sciences (IPM), Geology section		1 and 2	All 3
Norwegian University of Life Sciences (UMB), Dept. of Plant and Environmental Sciences (IPM), Nitrogen Group	X	2	
Norwegian University of Life Sciences (UMB), Dept. of Plant and environmental sciences (IPM), RENKLIMA		2	
Norwegian University of Life Sciences (UMB), Dept. of Plant and environmental sciences (IPM), Plant genetics and biology		2	
Norwegian University of Life Sciences (UMB), Dept. of Plant and environmental sciences (IPM), Soil science		2 and 3	
Norwegian Water Resources and Energy Directorate (NVE)	X	1 and 2	
NTNU Social Research AS		3	
NTNU, Dept. of Biology	X	2	2 and 3
NTNU, Dept. of Civil and transport engineering, Div. of geomatics		1	
NTNU, Dept. of Geography		All 3	
NTNU, Dept. of hydraulic and environmental engineering		All 3	
NTNU, Dept. of Industrial Economics and		3	

Technology Management			
NTNU, Dept. of Interdisciplinary studies of culture		2 and 3	
NTNU, Museum of Natural History and Archaeology		1	
PRIO		3	
Sámi University College	X	2 and 3	
SINTEF Building and Infrastructure		2 and 3	
SINTEF Energy		2 and 3	1 and 2
Statistics Norway (SSB)	X	3	
Uni Research AS, Uni Bjerknes Centre	X	1	1 and 2
University Centre in Svalbard (UNIS), Dept. of Arctic Biology	X	2	1 and 2
University Centre in Svalbard (UNIS), Dept. of Arctic Geology	X	1 and 2	2 and 3
University of Bergen, Dept. of Archaeology, History, Cultural Studies and Religion		3	
University of Bergen, Dept. of Biology	X	1 and 2	All 3
University of Bergen, Dept. of Earth Science	X	1 and 2	
University of Bergen, Dept. of Economics		2 and 3	
University of Bergen, Dept. of Foreign Languages		3	
University of Bergen, Dept. of Geography		All 3	
University of Bergen, Dept. of Mathematics		3	
University of Bergen, Dept. of Psychosocial Science		2 and 3	
University of Bergen, Faculty of Law		3	
University of Bergen, Geophysical Institute	X	1	
University of Oslo, Dep. of Sociology and Human Geography	X	2 and 3	
University of Oslo, Dept. of Biology	X	2	1 and 2
University of Oslo, Dept. of Chemistry, Environmental analysis		2	
University of Oslo, Dept. of Geosciences	X	1 and 2	
University of Oslo, Physics of Geological Processes (PGP)		All 3	
University of Oslo, Scandinavian Institute of Maritime Law, Natural Resources Law Group	X	3	
University of Tromsø, Department of Mathematics and statistics		1	
University of Tromsø, Dept. of Arctic and Marine Biology	X	2	All 3
University of Tromsø, Tromsø Museum		2	2 and 3
Western Norway Research Institute	X	3	2

Appendix 1.6 Outline of the self-assessments

Self-assessment

The self-assessments from the academic departments and research institutes will provide essential information for the Evaluation Committee. In order to ensure quality, it is important that a list of publications by the scientific staff is included. The self-assessments are intended to give relevant information about the participating university departments and research institutes focusing both on past strengths and future challenges.

The deadline for submitting the self-assessment is November 14th 2011.

Procedure

Each academic department/research institute should fill in a self-assessment at department/institute level. Please submit the self-assessment electronically in one PDF-file. Attachments should be submitted separately as Word-, Excel- or PDF-files. The content should be organised according to the outline shown on the following pages and all text must be searchable.

We recommend that you read the mandate for the Evaluation Committee before you fill in the self-assessment. For the purpose of this evaluation, climate research is defined with three thematic areas, as follows:[16]

- The climate system and climate change: Research into climate variability and change in order to improve capability in understanding climate and in projecting climate change for different time scales with reduced uncertainty and increased spatial detail. Advances will provide climate information for decision making in a national and international context. Focus is on physical, chemical and biological processes in the atmospheric, oceanic, terrestrial and cryospheric systems that are relevant for the climate system.
- Impacts of, and adaptation to, climate change and variability: Insights into the impacts of climate change and variability on the natural environment and society, i.e. research into how species and ecosystems will be affected and how society will be affected through changes in food production, water availability, health, etc.
- Institutions and instruments for response to climate change: Research on national and international climate policy, institutions (norms, principles, organisations, strategies, measures and instruments) for reducing greenhouse gases and adapting to climate change. Analysis of how societal relations at multiple levels of governance need to change in order to deal with climate change. This includes issues related to economic growth and poverty reduction, migration, changes in attitudes and behaviour of the population etc.

All self-assessments will be reviewed by the Research Council before the material is forwarded to the Evaluation Committee. Meetings between the Evaluation Committee and the research units are scheduled to take place in the period December 12–16, 2011. Once the Evaluation Committee has completed the draft report, the relevant sections will be sent

[16] The wording of the three thematic areas is slightly different compared to the guidelines for the fact sheets.

to each department for fact-checking before the final report is submitted to the Research Council of Norway. The evaluation is limited to assessments and recommendations at the department/research institute level, and individual researchers will not be mentioned. Please note that this is not an evaluation of individual researchers but of the national research landscape and its international context.

English is the working language for the evaluation. This means that **the self-assessment and attachments must all be written in English.** Please make sure that the information given in the self-assessment and in the fact sheet is consistent.

The self-assessment should be no more than 30 pages long. Supporting materials can be submitted as attachments and are not included in this page limit. Please use 12 pt. Times New Roman font.

Outline of the self-assessment

On the first page of the self-assessment, please name the unit being assessed.
You may also highlight specific research groups or parts of your unit, and their specific thematic areas within climate research.
Please use the proposed structure below and give comments in relation to each topic (1–8). There are keywords/suggestions for issues you may comment on under each topic.
You should discuss strengths, weaknesses and possible opportunities and threats (topics 7 and 8 in particular).

1. Quality of research

This section should explain the scientific quality of your climate research results. For this purpose, the climate-related scientific publishing of your institute/department should be discussed.
Please attach your unit's list of publications within climate research, for the period 2001–2010 (see specification attachment 1 below).
Please describe and comment on your choice of publication channels, your national and international co-authorship and the impact of your publications.
Please comment on your selection of the 5–10 most important climate research articles in international peer reviewed scientific journals (2001–2010) (see specification attachment 2 below).

2. Capacity

This section is intended to discuss issues related to the research capacity of your institute/department for climate research.
Please describe and comment on past experiences and present efforts regarding: the number of climate researchers at your unit; funding of climate research; climate research infrastructure; and, recruitment and mobility of your climate researchers. What are the strengths of your research unit? Are there any bottlenecks that impact progress?
We suggest that you include the following issues (you can add others that you feel are relevant here):

- recruitment and development of a new generation of researchers;
- masters programmes (if relevant);
- involvement of PhDs and post-doctoral research fellows;
- core funding vs. external programme/project funding;
- short-term funding vs. long-term funding;
- main funding schemes/instruments, both national and international; and,
- participation in national and international research infrastructure (e.g. in climate research related ESFRI research infrastructures).

3. Strategic focus

This section should explain/describe the strategic focus of your climate research in the past, present and future, and how this is related to the three thematic climate research areas specified in the mandate of this evaluation. Please explain how climate research fits into the overall activities of your department/research institute. You may wish to address the following issues:

- the thematic focus of your climate research;
- the disciplinary and methodological approaches used in your climate research;
- your experiences with, and need for, interdisciplinary climate research;
- your main contribution to addressing climate research policy priorities with regard to the gaps defined by the IPCC; and,
- your contribution to strengthening the knowledge base that informs climate policy.

In this context the evaluation committee wants to explore also how the Research Council of Norway and its different research programmes have contributed to the development of a strategic focus in Norwegian climate research. You may wish to comment on the following issues:

- the importance of NORKLIMA for your research;
- the importance of IPY for your research; and,
- the administration of climate research by the Research Council of Norway in general and by NORKLIMA specifically.

4. Research partnerships – national & international

This section should explain/describe your national and international research collaboration networks. Please discuss your role (leadership vs. participation) in national and international research collaboration networks, your priorities for such collaboration and what these collaborations have meant to the development of your climate research. You may wish to comment on the following issues:

- your main national research partnerships;
- the impact of national competition for funding on national collaboration;
- your main international research partnerships in European, Nordic and international climate change research initiatives, such as EU FP7, ERA-Nets, Nordic networks, Top level research initiative, Joint Programming Initiatives, ESFRI Research Infrastructures;

- your participation in the international global change research programmes (i.e., WCRP, IGBP, IHDP, DIVERSITAS, IPY) and your view of the importance of such initiatives;
- the engagement of researchers at your department/research institute in IPCC assessments and other relevant international assessments; and,
- shaping future research priorities: involvement on planning of national, Nordic, European and international science policies, research priorities, funding instruments, etc. (e.g., participation in EC's Horizon 2020 development).

5. Communication with stakeholders

This section should explain/describe your communication with stakeholders. Communication with stakeholders can have different purposes, such as the discussion of a research agenda, the formulation of research questions, the development of new knowledge, instruments or techniques and the dissemination of research results. Communication can be interactive or one-way. Please describe how these communications have evolved, what their purpose is and assess their impact. You may wish to comment on the communication with:

- public agencies or policy makers at national, regional or local level;
- specific groups which might be highly exposed to climate change, or which might be instrumental in implementing adaptation actions (e.g., land owners, farmer's associations, the Sámi people);
- the private sector;
- non-governmental organisations, and,
- how such communication processes have been integrated within an interdisciplinary research framework.

6. Relevance to society

This section should discuss the relevance of your climate research to society. You may distinguish between specific target groups and the society as a whole. Issues you may wish to address here include the following:

- relevance of your research for the international scientific community;
- interactions with target user groups;
- the application of your research results by your target user groups;
- the extent to which your research has contributed to (or resulted in) any changes to policy, standards, plans, or regulations;
- your participation in national and international climate related policy processes; and,
- possible conflicts or synergies between relevance and scientific quality.

7. What next?

This section should discuss your future plans for addressing identified strengths and weaknesses and possible opportunities and threats. Please describe your strategy or plan on climate research. You may wish to discuss plans for changes regarding:

- strategic focus,
- capacity development,
- cooperation patterns, and,
- interaction with target user groups the coming 5–10 years.

8. Recommendations

This final section gives you the opportunity to make recommendations for the further development of Norwegian climate research. Please discuss the main challenges for Norwegian climate research, the future needs for climate-related knowledge, and how Norwegian climate research policy should address these challenges and knowledge needs.

You may wish to comment on the scope and focus of climate research funding instruments, the support for climate research infrastructure, cooperation with stakeholders and the international research community and relevance to society, among other issues.

Please give some recommendations on how the Research Council of Norway should administer climate research in the future. In particular, describe any actions by the Research Council of Norway that you think necessary to minimise threats to your plans or develop opportunities for their success.

Attachment 1

Publication list for your university department/research institute (total reference list within climate research for the last ten years: 2001–2010) as an Excel-file

Please distinguish between following categories: (1) articles in international peer reviewed academic journals, (2) academic books and (3) chapters in academic books.

Attachment 2

List of the 5–10 most important articles in international peer reviewed scientific journals for the last ten years (2001–2010) including the abstracts and be prepared to make a PDF version available if any of the panel wants to read further. Please also comment briefly on your selection (see topic 1).

Appendix 1.7 The Structure of the hearings

1. Future developments – SWOT analysis
- Major challenges
- Major opportunities
- Future strategies

2. Strategic focus of Norwegian climate research (this is covered by the self-assessment reports, but will ask more about NORKLIMA, IPY and RCN)
- Importance of NORKLIMA and IPY in Norwegian climate research
- Administration of Norwegian climate research by the Research Council of Norway

3. Relevance and use of Norwegian climate research and communication with stakeholders
- Relevance of climate research in the national context
- The concept of climate services in a Norwegian context

4. Open issues which are of specific interest for the research units

Appendix 2.2.1 List of core journals by subject field

Number of articles, 2001–2010

Journal title	Climate system and climate change	Climate effects and adaptations	Institutions and instruments for response to climate change
AMBIO			60
AMERICAN NATURALIST		37	
ANNALS OF THE ASSOCIATION OF AMERICAN GEOGRAPHERS			4
ARCTIC			10
ARCTIC ANTARCTIC AND ALPINE RESEARCH	31		
ATMOSPHERIC CHEMISTRY AND PHYSICS	129		
BIOLOGICAL CONSERVATION		49	
CANADIAN JOURNAL OF FISHERIES AND AQUATIC SCIENCES		99	
CLIMATE DYNAMICS	20		
CLIMATE POLICY			17
CLIMATE RESEARCH		12	
CLIMATIC CHANGE		35	35
COLD REGIONS SCIENCE AND TECHNOLOGY	45		
CORAL REEFS		1	
CRYOSPHERE	8		
DEEP-SEA RESEARCH PART II-TOPICAL STUDIES IN OCEANOGRAPHY		86	
DEEP-SEA RESEARCH PART I-OCEANOGRAPHIC RESEARCH PAPERS		37	
EARTH SURFACE PROCESSES AND LANDFORMS	10		
ECOLOGICAL APPLICATIONS		19	19
ECOLOGICAL ECONOMICS			41
ECOLOGY		72	
ECOLOGY LETTERS		26	
ECOSYSTEMS		12	
ECOTOXICOLOGY		10	
ENERGY POLICY			75
ENVIRONMENT AND PLANNING A			13
ENVIRONMENT AND PLANNING B-PLANNING & DESIGN			4
ENVIRONMENT AND PLANNING C-GOVERNMENT AND POLICY			10
ENVIRONMENTAL POLITICS			5
EVOLUTION		31	
FISHERIES OCEANOGRAPHY		20	
FISHERIES RESEARCH		105	

GEOFORUM			11
GEOGRAPHICAL JOURNAL			4
GEOMORPHOLOGY	17		
GEOPHYSICAL RESEARCH LETTERS	213		
GLOBAL BIOGEOCHEMICAL CYCLES	15		
GLOBAL CHANGE BIOLOGY		31	
GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS			20
GLOBAL ENVIRONMENTAL POLITICS			6
ICES JOURNAL OF MARINE SCIENCE		173	
INTERNATIONAL ENVIRONMENTAL AGREEMENTS-POLITICS LAW AND ECONOMICS			8
INTERNATIONAL JOURNAL OF CLIMATOLOGY	13		
JOURNAL OF ANIMAL ECOLOGY		85	
JOURNAL OF APPLIED ECOLOGY		30	
JOURNAL OF CLIMATE	26		
JOURNAL OF ECOLOGY		26	
JOURNAL OF EVOLUTIONARY BIOLOGY		44	
JOURNAL OF EXPERIMENTAL MARINE BIOLOGY AND ECOLOGY		40	
JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES	183		
JOURNAL OF GEOPHYSICAL RESEARCH-EARTH SURFACE	22		
JOURNAL OF GEOPHYSICAL RESEARCH-OCEANS	95		
JOURNAL OF GLACIOLOGY	46		
JOURNAL OF MARINE SYSTEMS		63	
JOURNAL OF PHYSICAL OCEANOGRAPHY	34		
JOURNAL OF SEA RESEARCH		20	
JOURNAL OF SUSTAINABLE TOURISM			4
LIMNOLOGY AND OCEANOGRAPHY		59	
MARINE AND FRESHWATER RESEARCH		3	
MARINE BIOLOGY		69	
MARINE ECOLOGY-PROGRESS SERIES		194	
MARINE ENVIRONMENTAL RESEARCH		15	
NATURE GEOSCIENCE	11		
OECOLOGIA		77	
OIKOS		86	
PERMAFROST AND PERIGLACIAL PROCESSES	25		
POLAR RECORD			21
POLAR RESEARCH			84
PROCEEDINGS OF THE ROYAL SOCIETY OF LONDON SERIES B-BIOLOGICAL SCIENCES		72	
SUSTAINABLE DEVELOPMENT			8

Source: ISI WoS / NCR Norway 2010 / NIFU

Appendix 2.2.2 List of keywords used for the national sample

Climate system
Biosphere
biosphere climat*
biome* climat*
forests climat*
forest climat*
boreal forest*
biodiversity climat*
coral reef* climat*
ecosystem* climat*
biological species* climat*
phenology OR phenologic*
biological system* climat*
climat* AND (plankton* OR phytoplankton OR zooplankton)
vegetation climat*

Hydrosphere
hydrosphere climat*
river* climat*
ponds climat*
swamps climat*
lake climat*
basin climat*
ocean* climat*
seas* climat*
(subterranean water OR underground water) AND climat*
sea level climat*
sea level AND (change* OR rise)
(sea OR ocean) AND thermal expansion
Ocean acidification

Hydrology
"tide gauge*" AND climat*
(streamflow OR river discharge) AND climat*
"saltwater intrusion" AND "sea-level ris*"
Meridional Overturning Circulation
"gulf stream"
"Hydrological cycle" OR "hydrological system*"

Hydrography
aquifer AND climat*
arid region* AND climat*
wetland* AND climat*
desert* AND climat*
drought AND climat*
flooding AND climat*
erosion AND climat*
freshwarer lens AND climat*
groundwater AND climat*
hydrographic events AND climat*
isohyet AND climat*
landslide* AND climat*
mires AND climat*
ombrotrophic bog AND climat*
paludification AND climat*
polynya AND climat*
"saltwater intrusion" AND climat*
runoff AND climat*
semi-arid region* AND climat*
streamflow
tsunami AND climat*
upwelling region AND climat*

Cryosphere
cryosphere climat*
(glacier OR snow OR ice OR frozen ground OR permafrost) AND climat*
“glacier” AND “flow”
“glacier dynamics”
Glaciology
“ice-discharge”
“ice-stream”
"Ice sheet" AND climat*
“Ice-sheet flow”
"Ice cap" AND climat*
"sea ice" AND climat*
(ice shelf*) AND climat*

Atmosphere
atmospher* AND climat*
cloud* climat*
meteorological drought*
(Extreme weather event*) AND climat*
monsoon* AND climat*
"radiative forcing" AND climat*
weather AND climat*
storm* OR cyclon*) AND climat*
troposphere AND climat*
stratosphere AND climat*
tropopause AND climat*
meteorolog* AND climat*

Land surface temperature
land surface* AND climat*
borehole temperature* climat*
surface temperature* climat*
"soil temperature" climat*
global surface temperature

Biota
benthic communit* AND climat*
alpine* AND climat*
biota AND climat*

calcareous AND climat*
coccolithophores AND climat*
Coral* AND climat* NOT Reef*
diadromous AND climat*
ecological communit* AND climat*
ecological corridor* AND climat*
ecophysiological process*
ecotone AND climat*
food chain* AND climat*
(forest limit OR forest line) AND climat*
extinction AND climat*
habitat AND climat*
"keystone species"
legume AND climat*
limnolog* AND climat*
(peat OR peatland) AND climat*
pelagic communit* AND climat*
(phytoplankton OR plankton) AND climat*
“Ultraoligotrophic Eastern Mediterranean”
("population system" OR "ecological system*"
pteropods AND climat*
succulent* AND climat*
sub-alpine* AND climat*
taiga AND climat*
tree line AND climat*
trophic AND climat*
tundra AND climat*
vernalisation AND climat*

Carbon sequestration
region AND climate
topograph* AND climate
land-use AND climate
carbon sequestration

Climate system patterns
"climate system"
"climate feedback*"
Climate-carbon cycle coupling
"Climate sensitivity"
"Climate shift" OR "climate regime*" OR (Patterns of climate variability)
"El Nino-Southern Oscillation"
Climat* variability
erosion climat*
Evapotranspiration OR "water evaporation" OR transpiration
"North Atlantic Oscillation" OR "Pacific-North American pattern" OR "Northern Annular Mode" OR "Arctic Oscillation" OR "Southern Annular Mode" OR "Antarctic Oscillation"

Albedo
albedo NOT Subject Areas=(ASTRONOMY & ASTROPHYSICS)
albedo feedback*
Solar activity
"solar activity" AND climate
Energy balance
"energy balance" AND climate

Climate history
climate history
glaciolo*
palaeoclimat*
paleoclimate
interglacial*
last glacial maximum
dendroclimatolog*
climat* AND (precambrian* OR phanerozoic* OR quaternary* OR proterozoic* OR holocene* OR "hockey stick*" OR "temperature record*" OR "lithologic indicators" OR "Dansgaard-Oeschger*" OR "pollen analys*" OR pleistocene OR "warm period*" OR eemian OR "tree ring)
"ice core*" OR "ice-core*" OR "icecore*"
ice AND (NGRIP OR NorthGRIP OR WAIS OR NEEM OR GRIP OR GISP2)

Climate change
Climate change
Climate change*
Abrupt climate change*
Rapid climate change*
thermohaline circulation
deglaciation
melting of permafrost
soil respiration
carbon cycle
aerosol* climate
aerosol* AND cloud*
algal bloom
desertification
coral bleaching

Forest
deforestation climate
land-use change climate
forestry climate
human-induced degradation of forest*

Impact
impact* AND ("climate change*" OR "climate shift*")
aggregate impacts AND "climate change*"
impact assessment AND ("climate change*" OR "climate shift*")
integrated assessment AND ("climate change*" OR "climate shift*")

non-market impact* AND climate change*

Market impact
market impact* AND climate change
market potential* AND climate change
net market benefit* AND climate change

Adaptation
resilience AND climat*
Vulnerability AND "climate change"
Vulnerability AND sustainability
acclimatisation AND "climate change*"
climate change* adaptation*
climate change* adaptive capacit*
adaptability AND climate change*

Coasts
coastal squeeze
Coastal ecosystem*
salt march* AND climate change*
mangrove* AND climate change*
mud AND sand flats AND climate change*

Diseases
disease* AND climate change*
"dengue fever" AND climate change*
cholera AND climate change*
virus AND climate change*
hantavirus AND climate change*
malaria AND climate change*
meningitis AND climate change*
morbidity AND climate change*
zoonoses AND climate change*

Global warming
("carbone dioxide" OR CO_2) AND fertilisation
("food security" OR "food insecurity") AND climat*
"global warming"
"greenhouse effect*"

Carbon cycle
Carbon cycle
carbon cycle
“North Atlantic Sink”

Emissions
Anthropogenic emission*
greenhouse gas*
Carbon dioxide emission*
Carbon dioxide equivalent*
CO_2 equivalent*
CO_2 emission*
methane emission*
nitrous oxide emission*
hydrofluorocarbon* emission*
perfluorocarbon* emission*
sulphur hexafluoride* emission*
CH_4 emission*
N_2O emission*
PFCs emission*
SF_6 emisson*

Climate threshold
"carbon leakage"
"carbon intensity"
climate threshold

Climate models
Climate model*
Coupled Atmosphere-Ocean General Circulation Model*
AOGCM*
climate prediction*
climate forecast*
climate projection*
climate scenario*
emission* scenario*
SRES scenario*
"dynamic global vegetation model"

Mitigation
Mitigation climate change
United Nations Framework Convention on Climate Change
UNFCC
Activities Implemented Jointly climat*
AIJ climat*
Joint Implementation climat*
Kyoto Mechanism*
Kyoto Protocol*
Clean Development Mechanism*
CDM climat*
Certified Emission Reduction Unit* climat*
mitigation climate change
mitigation climate change potential*
mitigation climate change capacit*
mitigative climate change capacit*

Economic policy measures
emission* trading
tradable permit*

Taxes
carbon tax*
energy tax*
eco tax*

Policy
climate policy
climate politic*

energy policy

Actions
(technology transfer OR "technological change") AND climate
voluntary AND (action* OR agreement*) AND climate
Forest
afforestation
reforestation

Renewable energy
"renewable energy"
(fuel cell*) OR hydrogen
methane recovery
retrofitting AND climat*
biofuel* AND climate

Appendix 2.2.3 100 most frequent journals for Norwegian climate research papers (2001–2010)

Journal title	Number of papers
1. GEOPHYSICAL RESEARCH LETTERS	212
2. MARINE ECOLOGY-PROGRESS SERIES	194
3. JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES	183
4. ICES JOURNAL OF MARINE SCIENCE	172
5. ATMOSPHERIC CHEMISTRY AND PHYSICS	129
6. FISHERIES RESEARCH	104
7. QUATERNARY SCIENCE REVIEWS	101
8. CANADIAN JOURNAL OF FISHERIES AND AQUATIC SCIENCES	99
9. JOURNAL OF GEOPHYSICAL RESEARCH-OCEANS	95
10. OIKOS	87
11. JOURNAL OF ANIMAL ECOLOGY	85
12. DEEP-SEA RESEARCH PART II-TOPICAL STUDIES IN OCEANOGRAPHY	84
13. POLAR RESEARCH	81
14. OECOLOGIA	77
15. ENERGY POLICY	74
16. ECOLOGY	72
17. HOLOCENE	69
18. MARINE BIOLOGY	69
19. JOURNAL OF MARINE SYSTEMS	62
20. PROCEEDINGS OF THE ROYAL SOCIETY OF LONDON SERIES B-BIOLOGICAL SCIENCES	62
21. AMBIO	59
22. LIMNOLOGY AND OCEANOGRAPHY	59
23. BOREAS	51
24. BIOLOGICAL CONSERVATION	49
25. JOURNAL OF GLACIOLOGY	46
26. AQUACULTURE	46
27. ENVIRONMENTAL SCIENCE & TECHNOLOGY	46
28. ATMOSPHERIC ENVIRONMENT	46
29. COLD REGIONS SCIENCE AND TECHNOLOGY	45
30. JOURNAL OF EVOLUTIONARY BIOLOGY	44
31. JOURNAL OF EXPERIMENTAL MARINE BIOLOGY AND ECOLOGY	41
32. ECOLOGICAL ECONOMICS	41
33. SCIENCE OF THE TOTAL ENVIRONMENT	40
34. MARINE GEOLOGY	37
35. DEEP-SEA RESEARCH PART I-OCEANOGRAPHIC RESEARCH PAPERS	37
36. AMERICAN NATURALIST	36
37. NORWEGIAN JOURNAL OF GEOLOGY	34
38. CLIMATIC CHANGE	34

39. JOURNAL OF PHYSICAL OCEANOGRAPHY	34
40. POLAR BIOLOGY	33
41. GEOLOGY	32
42. FOREST ECOLOGY AND MANAGEMENT	32
43. PALEOCEANOGRAPHY	32
44. HYDROBIOLOGIA	31
45. JOURNAL OF PALEOLIMNOLOGY	31
46. EVOLUTION	31
47. PALAEOGEOGRAPHY PALAEOCLIMATOLOGY PALAEOECOLOGY	31
48. ARCTIC ANTARCTIC AND ALPINE RESEARCH	31
49. TELLUS SERIES A-DYNAMIC METEOROLOGY AND OCEANOGRAPHY	30
50. JOURNAL OF APPLIED ECOLOGY	30
51. GLOBAL CHANGE BIOLOGY	30
52. EARTH AND PLANETARY SCIENCE LETTERS	30
53. SCIENCE	29
54. PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA	29
55. GLOBAL AND PLANETARY CHANGE	28
56. JOURNAL OF ECOLOGY	26
57. PERMAFROST AND PERIGLACIAL PROCESSES	26
58. JOURNAL OF QUATERNARY SCIENCE	26
59. JOURNAL OF CLIMATE	26
60. JOURNAL OF BIOGEOGRAPHY	26
61. PROGRESS IN OCEANOGRAPHY	26
62. ECOLOGY LETTERS	25
63. JOURNAL OF HYDROLOGY	24
64. MARINE AND PETROLEUM GEOLOGY	23
65. HYDROLOGY AND EARTH SYSTEM SCIENCES	23
66. REMOTE SENSING OF ENVIRONMENT	23
67. JOURNAL OF GEOPHYSICAL RESEARCH-EARTH SURFACE	22
68. POLAR RECORD	21
69. BIOGEOSCIENCES	21
70. JOURNAL OF SEA RESEARCH	20
71. FISHERIES OCEANOGRAPHY	20
72. CLIMATE DYNAMICS	20
73. NATURE	19
74. JOURNAL OF VEGETATION SCIENCE	19
75. ANNALES GEOPHYSICAE	19
76. ECOLOGICAL APPLICATIONS	19
77. TELLUS SERIES B-CHEMICAL AND PHYSICAL METEOROLOGY	19
78. THEORETICAL AND APPLIED CLIMATOLOGY	19
79. GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS	19
80. MOLECULAR ECOLOGY	18
81. ECOGRAPHY	17
82. ENVIRONMENTAL & RESOURCE ECONOMICS	17

83. BASIN RESEARCH	17
84. GEOMORPHOLOGY	17
85. CLIMATE POLICY	16
86. QUATERNARY RESEARCH	16
87. JOURNAL OF FISH BIOLOGY	16
88. CLIMATE RESEARCH	16
89. SCANDINAVIAN JOURNAL OF FOREST RESEARCH	16
90. SEDIMENTARY GEOLOGY	15
91. GEOGRAFISKA ANNALER SERIES A-PHYSICAL GEOGRAPHY	15
92. GLOBAL BIOGEOCHEMICAL CYCLES	15
93. GEOCHEMISTRY GEOPHYSICS GEOSYSTEMS	15
94. MARINE ENVIRONMENTAL RESEARCH	15
95. WATER AIR AND SOIL POLLUTION	15
96. NEW PHYTOLOGIST	14
97. BIOGEOCHEMISTRY	14
98. CHEMOSPHERE	14
99. HYDROLOGICAL PROCESSES	14
100.RESOURCE AND ENERGY ECONOMICS	14

Appendix 2.2.4 Norwegian climate research papers by theme, 2001–2010

Norwegian climate research papers by theme, total and weighted counts, 2001–2010.

	Total counts			**Weighted counts**			
	Climate system & climate change	**Climate effects & adaptations**	**Institutions & instruments**	**Climate system & climate change**	**Climate effects & adaptations**	**Institutions & instruments**	***Total***
2001	177	211	42	137	167	33	*337*
2002	228	270	36	178	216	29	*423*
2003	325	290	47	261	219	35	*515*
2004	366	327	51	279	236	36	*551*
2005	379	366	49	291	274	37	*601*
2006	420	386	60	323	282	45	*650*
2007	422	438	73	307	318	53	*678*
2008	543	549	107	388	385	71	*843*
2009	623	577	100	453	398	67	*918*
2010	608	611	126	430	417	85	*932*
Total	*4091*	*4,025*	*691*	*3,045*	*2912*	*490*	*6,448*

Source: ISI WoS / NCR Norway 2010 / NIFU. N=6,448.

Appendix 2.2.5 List of the ten most cited papers

Authors with Norwegian address are highlighted.

Year	Bibliographic description	Number of citations
2004	Augustin, L., Barbante, C., Barnes, P. R. F., Barnola, J. M., Bigler, M., Castellano, E., Cattani, O., Chappellaz, J., DahlJensen, D., Delmonte, B., Dreyfus, G., Durand, G., Falourd, S., Fischer, H., Fluckiger, J., Hansson, M. E., Huybrechts, P., Jugie, R., Johnsen, S. J., Jouzel, J., Kaufmann, P., Kipfstuhl, J., Lambert, F., Lipenkov, V. Y., Littot, G. V. C., Longinelli, A., Lorrain, R., Maggi, V., Masson-Delmotte, V., Miller, H., Mulvaney, R., Oerlemans, J., Oerter, H., Orombelli, G., Parrenin, F., Peel, D. A., Petit, J. R., Raynaud, D., Ritz, C., Ruth, U., Schwander, J., Siegenthaler, U., Souchez, R., Stauffer, B., Steffensen, J. P., Stenni, B., Stocker, T. F., Tabacco, I. E., Udisti, R., van de Wal, R. S. W., van den Broeke, M., Weiss, J., Wilhelms, F., Winther, J. G., Wolff, E. W., Zucchelli, M., & Members, E. C. (2004). Eight glacial cycles from an Antarctic ice core. *Nature, 429*(6992), 623-628.	522
2005	Kanakidou, M., Seinfeld, J. H., Pandis, S. N., Barnes, I., Dentener, F. J., Facchini, M. C., Van Dingenen, R., Ervens, B., Nenes, A., Nielsen, C. J., Swietlicki, E., Putaud, J. P., Balkanski, Y., Fuzzi, S., Horth, J., Moortgat, G. K., Winterhalter, R., Myhre, C. E. L., Tsigaridis, K., Vignati, E., Stephanou, E. G., & Wilson, J. (2005). Organic aerosol and global climate modelling: a review. *Atmospheric Chemistry and Physics, 5*, 1053-1123.	510
2002	Stenseth, N. C., Mysterud, A., Ottersen, G., Hurrell, J. W., Chan, K. S., & Lima, M. (2002). Ecological effects of climate fluctuations. *Science, 297*(5585), 1292-1296.	493
2006	Leininger, S., Urich, T., Schloter, M., Schwark, L., Qi, J., Nicol, G. W., Prosser, J. I., Schuster, S. C., & Schleper, C. (2006). Archaea predominate among ammonia-oxidizing prokaryotes in soils. *Nature, 442*(7104), 806-809.	307
2002	Lambin, E. F., Turner, B. L., Geist, H. J., Agbola, S. B., Angelsen, A., Bruce, J. W., Coomes, O. T., Dirzo, R., Fischer, G., Folke, C., George, P. S., Homewood, K., Imbernon, J., Leemans, R., Li, X. B., Moran, E. F., Mortimore, M., Ramakrishnan, P. S., Richards, J. F., Skanes, H., Steffen, W., Stone, G. D., Svedin, U., Veldkamp, T. A., Vogel, C., & Xu, J. C. (2001). The causes of land-use and land-cover change: moving beyond the myths. *Global Environmental Change-Human and Policy Dimensions, 11*(4), 261-269.	287
2004	Svendsen, J. I., Alexanderson, H., Astakhov, V. I., Demidov, I., Dowdeswell, J. A., Funder, S., Gataullin, V., Henriksen, M., Hjort, C., Houmark-Nielsen, M., Hubberten, H. W., Ingolfsson, O., Jakobsson, M., Kjaer, K. H., Larsen, E., Lokrantz, H., Lunkka, J. P., Lysa, A., Mangerud, J., Matiouchkov, A., Murray, A., Moller, P., Niessen, F., Nikolskaya, O., Polyak, L., Saarnisto, M., Siegert, C., Siegert, M. J., Spielhagen, R. F., & Stein, R. (2004). Late quaternary ice sheet history of northern Eurasia. *Quaternary Science Reviews, 23*(11-13), 1229-1271.	273
2001	Ottersen, G., Planque, B., Belgrano, A., Post, E., Reid, P. C., & Stenseth, N. C. (2001). Ecological effects of the North Atlantic Oscillation.	273

	Oecologia, *128*(1), 1-14.	
2006	Barbante, C., Barnola, J. M., Becagli, S., Beer, J., Bigler, M., Boutron, C., Blunier, T., Castellano, E., Cattani, O., Chappellaz, J., Dahl-Jensen, D., Debret, M., Delmonte, B., Dick, D., Falourd, S., Faria, S., Federer, U., Fischer, H., Freitag, J., Frenzel, A., Fritzsche, D., Fundel, F., Gabrielli, P., Gaspari, V., Gersonde, R., Graf, W., Grigoriev, D., Hamann, I., Hansson, M., Hoffmann, G., Hutterli, M. A., Huybrechts, P., Isaksson, E., Johnsen, S., Jouzel, J., Kaczmarska, M., Karlin, T., Kaufmann, P., Kipfstuhl, S., Kohno, M., Lambert, F., Lambrecht, A., Landais, A., Lawer, G., Leuenberger, M., Littot, G., Loulergue, L., Luthi, D., Maggi, V., Marino, F., Masson-Delmotte, V., Meyer, H., Miller, H., Mulvaney, R., Narcisi, B., Oerlemans, J., Oerter, H., Parrenin, F., Petit, J. R., Raisbeck, G., Raynaud, D., Rothlisberger, R., Ruth, U., Rybak, O., Severi, M., Schmitt, J., Schwander, J., Siegenthaler, U., Siggaard-Andersen, M. L., Spahni, R., Steffensen, J. P., Stenni, B., Stocker, T. F., Tison, J. L., Traversi, R., Udisti, R., Valero-Delgado, F., van den Broeke, M. R., van de Wal, R. S. W., Wagenbach, D., Wegner, A., Weiler, K., Wilhelms, F., Winther, J. G., Wolff, E., & Members, E. C. (2006). One-to-one coupling of glacial climate variability in Greenland and Antarctica. *Nature*, *444*(7116), 195-198.	207
2002	Tank, A., Wijngaard, J. B., Konnen, G. P., Bohm, R., Demaree, G., Gocheva, A., Mileta, M., Pashiardis, S., Hejkrlik, L., Kern-Hansen, C., Heino, R., Bessemoulin, P., Muller-Westermeier, G., Tzanakou, M., Szalai, S., Palsdottir, T., Fitzgerald, D., Rubin, S., Capaldo, M., Maugeri, M., Leitass, A., Bukantis, A., Aberfeld, R., Van Engelen, A. F. V., Forland, E., Mietus, M., Coelho, F., Mares, C., Razuvaev, V., Nieplova, E., Cegnar, T., Lopez, J. A., Dahlstrom, B., Moberg, A., Kirchhofer, W., Ceylan, A., Pachaliuk, O., Alexander, L. V., & Petrovic, P. (2002). Daily dataset of 20th-century surface air temperature and precipitation series for the European Climate Assessment. *International Journal of Climatology*, *22*(12), 1441-1453.	206
2006	Menzel, A., Sparks, T. H., Estrella, N., Koch, E., Aasa, A., Ahas, R., Alm-Kubler, K., Bissolli, P., Braslavska, O., Briede, A., Chmielewski, F. M., Crepinsek, Z., Curnel, Y., Dahl, A., Defila, C., Donnelly, A., Filella, Y., Jatcza, K., Måge, F., Mestre, A., Nordli, Ø., Penuelas, J., Pirinen, P., Remisova, V., Scheifinger, H., Striz, M., Susnik, A., Van Vliet, A. J. H., Wielgolaski, F. E., Zach, S., & Zust, A. (2006). European phenological response to climate change matches the warming pattern. *Global Change Biology*, *12*(10), 1969-1976.	205

Appendix 2.2.6 Summary of citation indicators by theme

	Climate system & climate changes				
	Number of papers in total counts (P)	Number of received citations (C)	Average number of citations per paper (CPP)	Average expected citation rate (XCR)	Impact compared to XCR (CPP/XCR)
2001	177	5,057	28.6	23.7	1.2
2002	228	5,982	26.2	21.2	1.2
2003	325	6,612	20.3	18.2	1.1
2004	366	7,485	20.5	18.2	1.1
2005	379	7,617	20.1	15.8	1.3
2006	420	7,012	16.7	13.6	1.2
2007	422	4,965	11.8	10.7	1.1
2008	543	3,519	6.5	5.9	1.1
2009	623	2,527	4.1	3.2	1.3
Total	*3,483*	*50,776*	*14.6*	*12.4*	*1.2*
	Climate effects and adaptations				
	P	C	CPP	XCR	CPP/XCR
2001	211	6,197	29.4	27.6	1.1
2002	270	7,684	28.5	23.7	1.2
2003	290	6,736	23.2	22.6	1.0
2004	327	7,774	23.8	21.3	1.1
2005	366	7,285	19.9	17.6	1.1
2006	386	7,021	18.2	14.5	1.3
2007	438	5,223	11.9	10.8	1.1
2008	549	3,892	7.1	6.2	1.1
2009	577	2,526	4.4	3.4	1.3
Total	*3,414*	*54,338*	*15.9*	*14.0*	*1.1*
	Institutions and instruments for response to climate change				
	P	C	CPP	XCR	CPP/XCR
2001	42	579	13.8	18.3	0.8
2002	36	732	20.3	18.5	1.1
2003	47	703	15.0	18.7	0.8
2004	51	568	11.1	11.2	1.0
2005	49	726	14.8	13.2	1.1
2006	60	472	7.9	8.4	0.9
2007	73	489	6.7	6.8	1.0
2008	107	595	5.6	4.0	1.4
2009	100	279	2.8	2.0	1.4
Total	*565*	*5,143*	*9.1*	*9.1*	*1.0*

Source: ISI Web of Science / NCR for Norway. N=5,516

Appendix 2.2.7 Articles which have been selected by the research units participating in the hearings

The articles with the highest impact compared to the expected citation rate, sorted by theme (2001–2009).

Year	1st Author	Title	Journal	Citations	XCR	Impact CCP/XCR	Theme
2005	Sausen, R	Aviation radiative forcing in 2000: An update on IPCC (1999)	METEOROLOGISCHE ZEITSCHRIFT	89	7.5	11.9	1
2004	Johannessen, OM	Arctic climate change: observed and modelled temperature and sea-ice variability	TELLUS SERIES A-DYNAMIC METEOROLOGY AND OCEANOGRAPHY	169	19.6	8.6	1
2008	Nesje, A	Norwegian mountain glaciers in the past, present and future	GLOBAL AND PLANETARY CHANGE	41	7	5.9	1
2005	Ottesen, D	Submarine landforms and the reconstruction of fast-flowing ice streams within a large Quaternary ice sheet: The 2500-km-long Norwegian-Svalbard margin (57 degrees-80 degrees N)	GEOLOGICAL SOCIETY OF AMERICA BULLETIN	87	16	5.4	1
2004	Svendsen, JI	Late quaternary ice sheet history of northern Eurasia	QUATERNARY SCIENCE REVIEWS	273	57.1	4.8	1
2006	Xu, CY	Analysis of spatial distribution and temporal trend of reference evapotranspiration and pan evaporation in Changjiang (Yangtze River) catchment	JOURNAL OF HYDROLOGY	45	10.4	4.3	1
2007	Stohl, A	Arctic smoke - record high air pollution levels in the European Arctic due to agricultural fires in Eastern Europe in spring 2006	ATMOSPHERIC CHEMISTRY AND PHYSICS	63	14.9	4.2	1
2006	Larsen, E	Late Pleistocene glacial and lake history of northwestern Russia	BOREAS	33	8.9	3.7	1
2004	Foldvik, A	Ice shelf water overflow and bottom water formation in the southern Weddell Sea	JOURNAL OF GEOPHYSICAL RESEARCH-OCEANS	40	11.7	3.4	1
2003	Hagen, JO	On the net mass balance of the glaciers and ice caps in Svalbard, Norwegian Arctic	ARCTIC ANTARCTIC AND ALPINE RESEARCH	47	14.2	3.3	1
2001	Orvik, KA	Atlantic inflow to the Nordic Seas: current structure and volume fluxes from moored current meters, VM-ADCP and SeaSoar-CTD observations, 1995-1999	DEEP-SEA RESEARCH PART I-OCEANOGRAPHIC RESEARCH PAPERS	72	25.2	2.9	1
2004	Myhre, G	Intercomparison of satellite retrieved aerosol optical depth over the ocean	JOURNAL OF THE ATMOSPHERIC SCIENCES	50	18.1	2.8	1
2006	Haddeland, I	Effects of irrigation on the water and energy balances of the Colorado and Mekong river basins	JOURNAL OF HYDROLOGY	28	10.4	2.7	1

2004	Berglen, TF	A global model of the coupled sulfur/oxidant chemistry in the troposphere: The sulfur cycle	JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES	52	20.1	2.6	1
2009	Sejrup, HP	Middle and Late Weichselian (Devensian) glaciation history of south-western Norway, North Sea and eastern UK	QUATERNARY SCIENCE REVIEWS	15	5.8	2.6	1
2001	Hisdal, H	Have streamflow droughts in Europe become more severe or frequent?	INTERNATIONAL JOURNAL OF CLIMATOLOGY	52	22.3	2.3	1
2008	Solberg, S	European surface ozone in the extreme summer 2003	JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES	17	7.3	2.3	1
2001	Vinje, T	Fram strait ice fluxes and atmospheric circulation: 1950-2000	JOURNAL OF CLIMATE	87	38.7	2.2	1
2006	Morkved, PT	N2O emissions and product ratios of nitrification and denitrification as affected by freezing and thawing	SOIL BIOLOGY & BIOCHEMISTRY	28	12.8	2.2	1
2008	Beldring, S	Climate change impacts on hydrological processes in Norway based on two methods for transferring regional climate model results to meteorological station sites	TELLUS SERIES A-DYNAMIC METEOROLOGY AND OCEANOGRAPHY	8	4.1	2	1
2008	Seland, O	Aerosol-climate interactions in the CAM-Oslo atmospheric GCM and investigation of associated basic shortcomings	TELLUS SERIES A-DYNAMIC METEOROLOGY AND OCEANOGRAPHY	8	4.1	2	1
2009	Stohl, A	An analytical inversion method for determining regional and global emissions of greenhouse gases: Sensitivity studies and application to halocarbons	ATMOSPHERIC CHEMISTRY AND PHYSICS	11	5.4	2	1
2008	Yttri, KE	Elemental and organic carbon in PM10: a one year measurement campaign within the European Monitoring and Evaluation Programme EMEP	ATMOSPHERIC CHEMISTRY AND PHYSICS	17	9.8	1.7	1
2008	Fuglestvedt, J	Climate forcing from the transport sectors	PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA	33	20.7	1.6	1
2007	Nygard, A	Extreme sediment and ice discharge from marine-based ice streams: New evidence from the North Sea	GEOLOGY	21	13.6	1.5	1
2007	Morkved, PT	The N2O product ratio of nitrification and its dependence on long-term changes in soil pH	SOIL BIOLOGY & BIOCHEMISTRY	12	8.7	1.4	1
2007	Fagerli, H	Modeling historical long-term trends of sulfate, ammonium, and elemental carbon over Europe: A comparison with ice core records in the Alps	JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES	14	11.1	1.3	1
2006	Moran, K	The Cenozoic palaeoenvironment of the Arctic Ocean	NATURE	134	111	1.2	1
2007	Kaab, A	On the response of rockglacier creep to surface temperature increase	GLOBAL AND PLANETARY CHANGE	13	10.6	1.2	1

2003	Furevik, T	Description and evaluation of the bergen climate model: ARPEGE coupled with MICOM	CLIMATE DYNAMICS	66	59.8	1.1	1
2004	Haugan, PM	Metrics to assess the mitigation of global warming by carbon capture and storage in the ocean and in geological reservoirs	GEOPHYSICAL RESEARCH LETTERS	6	14.7	0.4	1
2002	Gascard, JC	Long-lived vortices as a mode of deep ventilation in the Greenland Sea	NATURE	43	175.9	0.2	1
2003	Holtan-Hartwig, L	Low temperature control of soil denitrifying communities: kinetics of N2O production and reduction	SOIL BIOLOGY & BIOCHEMISTRY	48	25.3	1.9	1 and 2
2004	Heinze, C	Simulating oceanic CaCO3 export production in the greenhouse	GEOPHYSICAL RESEARCH LETTERS	27	14.7	1.8	1 and 2
2003	Stenseth, NC	Studying climate effects on ecology through the use of climate indices: the North Atlantic Oscillation, El Nino Southern Oscillation and beyond	PROCEEDINGS OF THE ROYAL SOCIETY OF LONDON SERIES B-BIOLOGICAL SCIENCES	192	111.7	1.7	1 and 2
2007	Olli, K	The fate of production in the central Arctic Ocean - Top-down regulation by zooplankton expatriates?	PROGRESS IN OCEANOGRAPHY	13	11.5	1.1	1 and 2
2009	Solberg, S	Analyses of the impact of changes in atmospheric deposition and climate on forest growth in European monitoring plots: A stand growth approach	FOREST ECOLOGY AND MANAGEMENT	12	1.8	6.9	2
2007	Wassmann, P	Food webs and carbon flux in the Barents Sea	PROGRESS IN OCEANOGRAPHY	53	11.5	4.6	2
2006	Berge, J	Ocean temperature oscillations enable reappearance of blue mussels Mytilus edulis in Svalbard after a 1000 year absence	MARINE ECOLOGY-PROGRESS SERIES	43	11.6	3.7	2
2002	Loison, A	Disentangling the sources of variation in the survival of the European dipper	JOURNAL OF APPLIED STATISTICS	28	8.6	3.3	2
2006	Walker, MD	Plant community responses to experimental warming across the tundra biome	PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA	138	42	3.3	2
2009	Nilsen, EB	Climate, season, and social status modulate the functional response of an efficient stalking predator: the Eurasian lynx	JOURNAL OF ANIMAL ECOLOGY	10	3.6	2.7	2
2001	Ottersen, G	Ecological effects of the North Atlantic Oscillation	OECOLOGIA	273	114	2.4	2
2005	Stenseth, NC	Weather packages: finding the right scale and composition of climate in ecology	JOURNAL OF ANIMAL ECOLOGY	51	22.6	2.3	2
2007	Tveraa, T	What regulate and limit reindeer populations in Norway?	OIKOS	23	10.5	2.2	2
2005	Pettorelli, N	Using the satellite-derived NDVI to assess ecological responses to environmental change	TRENDS IN ECOLOGY & EVOLUTION	173	87.1	2	2

2008	La Porta, N	Forest pathogens with higher damage potential due to climate change in Europe	CANADIAN JOURNAL OF PLANT PATHOLOGY-REVUE CANADIENNE DE PHYTOPATHOLOGIE	3	1.5	2	2
2006	Yom-Tov, Y	Recent changes in body weight and wing length among some British passerine birds	OIKOS	24	12.7	1.9	2
2001	Solberg, EJ	Effects of density-dependence and climate on the dynamics of a Svalbard reindeer population	ECOGRAPHY	42	25	1.7	2
2002	Stenseth, NC	Ecological effects of climate fluctuations	SCIENCE	493	315.4	1.6	2
2006	Saether, BE	Climate and spatio-temporal variation in the population dynamics of a long distance migrant, the white stork	JOURNAL OF ANIMAL ECOLOGY	30	18.5	1.6	2
2007	Jenssen, BM	Endocrine-disrupting chemicals and climate change: A worst-case combination for arctic marine mammals and seabirds?	ENVIRONMENTAL HEALTH PERSPECTIVES	31	19.4	1.6	2
2008	Bergjord, AK	Modelling the course of frost tolerance in winter wheat I. Model development	EUROPEAN JOURNAL OF AGRONOMY	8	5.1	1.6	2
2005	Ims, RA	Trophic interaction cycles in tundra ecosystems and the impact of climate change	BIOSCIENCE	33	28.2	1.2	2
2005	Klanderud, K	Simulated climate change altered dominance hierarchies and diversity of an alpine biodiversity hotspot	ECOLOGY	33	29.3	1.1	2
2002	Aanes, R	The Arctic Oscillation predicts effects of climate change in two trophic levels in a high-arctic ecosystem	ECOLOGY LETTERS	43	43.9	1	2
2003	Saether, BE	Climate variation and regional gradients in population dynamics of two hole-nesting passerines	PROCEEDINGS OF THE ROYAL SOCIETY OF LONDON SERIES B-BIOLOGICAL SCIENCES	33	36.4	0.9	2
2005	Grotan, V	Climate causes large-scale spatial synchrony in population fluctuations of a temperate herbivore	ECOLOGY	27	29.3	0.9	2
2001	Mysterud, A	Nonlinear effects of large-scale climatic variability on wild and domestic herbivores	NATURE	103	187.9	0.5	2
2005	OBrien, K	Mapping vulnerability to multiple stressors: climate change and globalization in India	GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS	72	28.3	2.5	2 and 3
2009	Eriksen, S	The vulnerability context of a savanna area in Mozambique: household drought coping strategies and responses to economic change	ENVIRONMENTAL SCIENCE & POLICY	7	2.8	2.5	2 and 3
2008	Eriksen, SH	Vulnerability, poverty and the need for sustainable adaptation measures	CLIMATE POLICY	8	3.4	2.3	2 and 3
2003	Turner, BL	Illustrating the coupled human-environment system for vulnerability analysis: Three case studies	PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES OF THE UNITED STATES OF AMERICA	76	77	1	2 and 3

2007	OBrien, K	Why different interpretations of vulnerability matter in climate change discourses	CLIMATE POLICY	19	3.4	5.5	3
2009	Hertwich, EG	Carbon Footprint of Nations: A Global, Trade-Linked Analysis	ENVIRONMENTAL SCIENCE & TECHNOLOGY	23	4.2	5.5	3
2003	Brekke, KA	An economic model of moral motivation	JOURNAL OF PUBLIC ECONOMICS	46	10.8	4.3	3
2005	Petersen, AK	Environmental and economic impacts of substitution between wood products and alternative materials: a review of micro-level analyses from Norway and Sweden	FOREST POLICY AND ECONOMICS	23	6	3.8	3
2009	Skjaerseth, JB	The Origin, Evolution and Consequences of the EU Emissions Trading System	GLOBAL ENVIRONMENTAL POLITICS	5	1.4	3.6	3
2008	Gossling, S	Consequences of climate policy for international tourist arrivals in developing countries	THIRD WORLD QUARTERLY	4	1.3	3	3
2009	Gerlagh, R	Optimal Timing of Climate Change Policy: Interaction Between Carbon Taxes and Innovation Externalities	ENVIRONMENTAL & RESOURCE ECONOMICS	3	1.1	2.8	3
2009	Gossling, S	Carbon neutral destinations: a conceptual analysis	JOURNAL OF SUSTAINABLE TOURISM	2	0.8	2.7	3
2004	Denstadli, JM	Impacts of videoconferencing on business travel: the Norwegian experience	JOURNAL OF AIR TRANSPORT MANAGEMENT	10	4.2	2.4	3
2009	Skodvin, T	An agenda for change in US climate policies? Presidential ambitions and congressional powers	INTERNATIONAL ENVIRONMENTAL AGREEMENTS-POLITICS LAW AND ECONOMICS	4	1.7	2.4	3
2001	Hoel, M	Taxes and quotas for a stock pollutant with multiplicative uncertainty	JOURNAL OF PUBLIC ECONOMICS	35	14.9	2.3	3
2003	Bruvoll, A	Greenhouse gas emissions in Norway: do carbon taxes work?	ENERGY POLICY	16	10.3	1.6	3
2003	Bruvoll, A	Quantifying central hypotheses on Environmental Kuznets Curves for a rich economy: A computable general equilibrium study	SCOTTISH JOURNAL OF POLITICAL ECONOMY	7	4.6	1.5	3
2005	Holden, E	The ecological footprints of fuels	TRANSPORTATION RESEARCH PART D-TRANSPORT AND ENVIRONMENT	14	10.4	1.3	3
2006	Asheim, GB	Regional versus global cooperation for climate control	JOURNAL OF ENVIRONMENTAL ECONOMICS AND MANAGEMENT	10	7.7	1.3	3
2003	Greaker, M	Strategic environmental policy; eco-dumping or a green strategy?	JOURNAL OF ENVIRONMENTAL ECONOMICS AND MANAGEMENT	15	17.2	0.9	3
2002	Andresen, S	Leaders, pushers and laggards in the making of the climate regime	GLOBAL ENVIRONMENTAL CHANGE-HUMAN AND POLICY DIMENSIONS	12	29.3	0.4	3

2002	Berg, E	Oil exploration under climate treaties	JOURNAL OF ENVIRONMENTAL ECONOMICS AND MANAGEMENT	4	16.1	0.2	3
2002	Bye, B	Taxation, unemployment, and growth: Dynamic welfare effects of "green" policies	JOURNAL OF ENVIRONMENTAL ECONOMICS AND MANAGEMENT	3	16.1	0.2	3

Appendix 3.3.1 Complete list of calls for proposals from NORKLIMA, 2004-2011

Provided in translation for the Evaluation by RCN. The 6 'areas of research' referred to in column 4 are listed in the caption to Figure 3.3.2.

Closing date for applications	Available funding	Subject	Area of research
Running (until 2006.10.12)	Maximum NOK 100 000 per project	Call for proposals for funding of project establishment – joint call between NORKLIMA and RENERGI	All
2004.06.15	Total of 40 MNOK distributed over 3-4 years	Call for proposals for funding from the Fund for Research and Innovation for 2005	All
2004.06.15	6-7 MNOK per year for 3-4 years	Call for proposals for remaining research funds for 2005	3
2006.03.17	2 MNOK per year for 3 years	Climate effects on the transport infrastructure	2,4
2006.06.08	25 MNOK per year for 3-4 years	1. Polar climate research	All
2006.06.08	15 MNOK per year for 4 years	2. Research to improve the understanding of the climate system and improve climate scenarios	1
2006.06.08	12 MNOK per year for 3-4 years	3. Social consequences of and adaptions to climate changes	4
2006.06.08	2 MNOK per year for 3 years	4. Free projects for younger scientists	1
2006.10.12	3 MNOK per year for 4 years	Consequences of climate changes for the energy sector (RENKLIM)	1
2007.06.06	22 MNOK per year for 3-4 years	I. Research on consequences of climate changes on ecosystems and nourishments based on biological resources	3
2007.06.06	25 MNOK per year for 3-4 years	II. Nationally coordinated projects integrating research on and adaption to climate changes	4
2007.06.06	13 MNOK per year for 3-4 years	III. Research on climate feedback mechanisms in the climate system	1
2008.06.04	0,5 MNOK	Personal Overseas Research Grants, Personal Visiting Researcher Grants and Support for Events	All
2008.11.26	30 MNOK + 10 MNOK extra from KD = 40 MNOK	Climate change and society: Research that provides a basis for adaptation	4,5
2008.11.26	20 MNOK	Climate change - research cooperation with China	All
2009.06.04	0,5 MNOK	Personal Overseas Research Grants, Personal Visiting Researcher Grants and Support for Events	All
2009.10.14	10 MNOK distributed over 3 years	Impacts of extreme weather events on infrastructure	2
2009.10.14	11 MNOK distributed over 3 years	Sector-oriented climate scenarios	1
2009.10.14	27 MNOK distributed over 3 years (18	Marine ecosystems: Climate change, CO2 concentration and fisheries	3

	MNOK from NORKLIMA)	technology	
2010.06.01	0,5 MNOK	Personal Overseas Research Grants, Personal Visiting Researcher Grants and Support for Events	All
2010.09.01	25 MNOK from NORKLIMA + 30 MNOK from Polarprogrammet	Understanding the climate system	1
2010.09.01	34 MNOK distributed over 3 years	Instruments and policy to promote emission reductions	4+5 + new subgoal (6) NORKLIMA
2010.12.01	22 MNOK distributed over 3 years (NORKLIMA) + 25 MNOK (Miljø 2015)	Research cooperation with China on Climate Change and Environmental Pollution (NORKLIMAs part: Ecosystem functioning, adaptation and climate-ecosystem interaction)	3
2011.08.06	0,5 MNOK	Personal Overseas Research Grants, Personal Visiting Researcher Grants and Support for Events	All
2011.31.08	30 MNOK distributed over 3 years (Polarprogrammet)	Impacts of climate change on the environment and communities in the polar regions	3, 4
2011.31.08	18 MNOK (Indiaprogrammet)	Research cooperation with India on Climate Change, hydrological impacts and adaptation	1,2,4

10 List of abbreviations and acronyms

ACIA	Arctic Climate Impact Assessment
ACM	Advanced Climate Modelling
ACSNet	Arctic Climate System Network
AIMES	Analysis, Integration and Modelling of the Earth System
AnGR-NordicNET	Nordic Research Network on Animal Genetic Resources in the Adaptation to Climate Change
AOSB	Arctic Ocean Sciences Board
BAS-UK	British Antarctic Survey
BCCR	Bjerknes Centre for Climate Research
BCM	Bergen Climate Model
BIAC	Bipolar Atlantic thermohaline circulation
C3O	Canada Three Oceans project
CAVIAR	Community Adaptation and Vulnerability in the Arctic Regions
CBD	Convention on Biological Diversity
CCAFS	Climate Change Agriculture and Food Security
CEER	Centre for Environmental friendly Energy Research
CEES	Centre for Ecological and Evolutionary Synthesis
CGIAR	Consultative Group on International Agricultural Research
CICEP	Strategic Challenges in International Climate and Energy Policy
CICERO	Centre for International Climate and Environmental Research – Oslo
CIENS	Centre for Interdisciplinary Environmental and Social Research
CliC	Climate and Cryosphere
CLIVAR	Climate Variability and Predictability
CoE	Centre of Excellence
COST	European Cooperation in Science and Technology
CPP	Citations per paper
CSP	Climate Services Partnership
Dept.	Department
EarthClim	Integrated Earth System Approach to Explore Natural Variability and Climate Sensitivity
ECMWF	European Centre for Medium-Range Weather Forecasts
EcoClim	The dynamics of ecological systems under the influence of climatic variation
ECRA	European Climate Research Alliance

EMBRC	European Marine Biological Resource Centre
EMEP	European Monitoring and Evaluation Programme
ERA	European research area
ESF	European Science Foundation
ESFRI	European Strategy Forum on Research Infrastructures
ESG	Earth System Governance
ESSP	Earth System Science Partnership
EU	European Union
EUMETNET	European National Meteorological Services network
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
FAR-1990	IPCC First Assessment Report 1990
FME	Centre for Environment-friendly Energy Research
FNI	Fridtjof Nansen Institute
FP	Framework Programme
FRISAM	RCN Independent basic research projects – Social sciences
FRIMUF	RCN Free research on environment and development
FRISCH	Ragnar Frisch Centre for Economic Research
GCOS	Global Climate Observing System
GCP	Global Carbon Project
GDP	Gross Domestic Product
GEC	Global environmental change
GECHH	Global Environmental Change and Human Health
GECHS	Global Environmental Change and Human Security
GEO BON	Biodiversity Observation Network of the Group on Earth Observations
GEWEX	Global Energy and Water Cycle Experiment
GFCS	Global Framework for Climate Services
GHG	Greenhouse gas
GLP	Global Land Project
GMES	Global Monitoring for Environment and Security
GOOS	Global Ocean Observing System
GWSP	Global Water System Project
HAVKYST	The Oceans and the Coastal Areas
HDI	Human Development Index
HELCOM	Helsinki Commission for Baltic Marine Environment Protection
IASC	International Arctic Science Committee
iCACGP	International Commission on Atmospheric Chemistry and Global Pollution

ICCS	International Conference on Climate Services
ICE	Norwegian Polar Institute's Centre for Ice, Climate and Ecosystems
ICOS	Integrated Carbon Observation System
ICSU	International Council for Science
ICR	International Centre for Reindeer Husbandry
IGAC	International global Atmospheric Chemistry
IGBP	International Geosphere-Biosphere Programme
IHDP	International Human Dimensions Programme on Global Change
iLEAPS	Integrated Land Ecosystem – Atmosphere Processes Study
IMBER	Integrated Marine Biogeochemistry and Ecosystem Research
IMR	Institute of Marine Research
IOC	Intergovernmental Oceanographic Commission
IOC-UNESCO	Intergovernmental Oceanographic Commission
IPCC AR4	IPCC Assessment Report 4
IPCC AR5	IPCC Assessment Report 5
IPCC	Intergovernmental Panel on Climate Change
IPY	International Polar Year
ISI	Thomson Reuters, Institute for Scientific Information
ISSC	International Social Science Council
IT	Industrial Transformation
ITG	Integrated Risk Governance
JPI	Joint Programming Initiative
Klif	Climate and Pollution Agency
LCA	Life-cycle assessment
LOICZ	Land-Ocean Interaction in the Coastal Zone
MA	Millennium Ecosystem Assessment
MACC	Monitoring Atmospheric Composition and Climate
MAIRS	Monsoon Asia Integrated Regional Study
Met.no	Norwegian Meteorological Institute
MEURO	Million Euros
MILEN	Environmental change and sustainable energy
MNOK	Million Norwegian kroner
MyOcean	Ocean Monitoring and Forecasting
NCoE	Nordic Centre of Excellence
NCR	National Citation Report
NCSC	National Climate Service Centre
NER	Nordic Energy Research

NERSC	Nansen Environmental and Remote Sensing Centre
NGO	Non-governmental organisation
NGU	Geological Survey of Norway
NIFU	Nordic Institute for Studies in Innovation, Research and Education
NILU	Norwegian Institute for Air Research
NINA	Norwegian institute for nature research
NIVA	Norwegian Institute for Water Research
NOFOCGRAN	Nordic Forage Crops Genetic Resource Adaptation Network
Norad	Norwegian Agency for Development Cooperation
NORCAM	Nordic Network for Climate Change, Adaptation, and Multilevel Governance
NorESM	Norwegian Earth System Model
NORKLIMA	Climate change and impacts in Norway
NorMER	Nordic Centre for Research on Marine Ecosystems and Resources under Climate Change
NOU	Norges offentlige utredninger (Official Norwegian Reports)
NPI	Norwegian Polar Institute
NTNU	Norwegian University of Science and Technology
NVE	Norwegian Water Resources and Energy Directorate
OSPAR	Protecting and conserving the North-East Atlantic and its resources
PAGES	Past Global Changes
PDO	Pacific Decadal Oscillation
PI	Principle investigator
R&D	Research and development
RCM	Regional Climate Model
RCN	Research Council of Norway
REDD	Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
RegClim	Regional Climate Development under Global Warming
RESCUE	Responses to Environmental and Societal Challenges for our Unstable Earth
SAON	Sustained Arctic Observing Network
SAR-1995	IPCC Second Assessment Report 1995
SCAR	Scientific Committee on Antarctic Research
SIOS	Svalbard Integrated Observing System
SNA	Social Network Analysis
SOLAS	Surface Ocean – Lower Atmosphere Study
SPARC	Stratospheric Processes and their Role in Climate

SREX	Special Report Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation
SSB	Statistics Norway
START	Global Change System for Analysis, Research and Training
SUC	Sámi University College
SVALI	Stability and Variations of Arctic Land Ice
SWCC	Second World Climate Conference
TAR-2001	IPCC Third Assessment Report 2001
TØI	Institute of Transport Economics
TRI	Top-level Research Initiative
UGEC	Urbanization and Global Environmental Change
UiB	University of Bergen
UiB-GI	University of Bergen, Geophysical Institute
UiO – NRL	University of Oslo, Natural Resources Law Group
UiO – SHG	University of Oslo, Department of Sociology and Human Geography
UiO	University of Oslo
UMB – IMT	Norwegian University of Life Sciences, Department of Mathematical Sciences and Technology
UMB – INA	Norwegian University of Life Sciences, Department of Ecology and Natural Resource Management
UMB – NORAGRIC	Norwegian University of Life Sciences, Department of International Environment and Development Studies
UMB	Norwegian University of Life Sciences
UN ISDR	United Nations International Strategy for Disaster Reduction
UNECE	United Nations Economic Commission for Europe
UNECE/CLRTAP	Convention on Long-range Transboundary Air Pollution
UNEP	United Nations Environmental Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIS	University Centre in Svalbard
UNU	United Nations University
WCED	World Commission on Environment and Development
WCRP	World Climate Research Programme
WG	Working Group
WMO	World Meteorological Organization
WNRI	Western Norway Research Institute
WoS	Web of Science
XCR	Expected citation rate

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The Research Council of Norway
P.O. Box 2700 St. Hanshaugen
NO-0131 Oslo

Telephone: +47 22 03 70 00
Telefax: +47 22 03 70 01
post@rcn.no
www.rcn.no

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