
Table of Contents

Executive Summary	ii
1 Introduction	1
1.1 The CCAR Initiative	1
1.2 Evaluation Questions.....	3
1.3 Methodology	4
1.4 Strengths and Limitations.....	4
2 Research on Climate Change and Atmospheric Processes in Canada.....	5
3 Enhancing Canadian Research on Climate Change and Atmospheric Processes	8
4 Collaborations.....	11
5 Knowledge Dissemination, Transfer and Use	15
6 The Next Generation of Researchers in Climate Change and Atmospheric Processes.....	21
7 CCAR’s Operational Efficiency	26
7.1 Areas for Improvement	27
8 Recommendations	28
Appendix A: Location of CCAR-Funded Networks Across Canada	30
Appendix B: Location of International Collaborations	31
Appendix C: CCAR Logic Model	32
Appendix D: CCAR Evaluation Matrix.....	33
Appendix E: Methodology.....	38
Appendix F: Other Federal Government Funding Programs/Initiatives to Address Climate Change	40
Appendix G: References	44

Executive Summary

Why is it important to fund climate change and atmospheric research?

The evaluation examined the rationale for CCAR, and found that there is a continued need for research to understand the underlying physical processes that are changing the Canadian climate. Climate change poses significant challenges to Canada and the world, with current and anticipated impacts that could have serious ecological, health, social and economic effects. Canada has an important role in climate change research as a northern nation where impacts are expected to be extreme.

Is CCAR an appropriate and necessary role for the federal government?

CCAR is one of the only sources of public funding for research on climate change and atmospheric processes, and is the largest in terms of the amount and duration of funding. Overall, it appears that providing funding for climate change research through CCAR is an appropriate and necessary role for the federal government given the increasing demand for information on climate change, a lack of available funding for fundamental research related to climate change and atmospheric processes and because all Canadians are vulnerable to the impacts of climate change. Additionally, CCAR supports several key priorities of the federal government, as well as its national and international commitments to prioritize, address and reduce the impacts of climate change.

Enhancing Canadian research on climate change and atmospheric processes

The evaluation was conducted before the five-year period of network funding was completed and before the networks consolidated the scientific progress they had made. Consequently, the evaluation centered on how effective CCAR-funded networks have been in terms of enhancing research on climate change and atmospheric processes to date. Overall, network members highlighted their network's contributions to the broader research community, such as: developing new or enhancing existing knowledge; improving various climate models and systems used to help predict changes in weather and climate patterns; linking observational and modeling data; building new, contributing to or applying existing observational datasets, etc. It was also acknowledged that the scale and scope of the research conducted would not have been possible without CCAR funds and the use of a network approach. This approach had a number of important benefits including: facilitating collaborations, enabling knowledge dissemination, transfer and use, as well as training a large number of highly qualified personnel (HQP). This latter benefit of the network approach is quite important to enhancing Canada's research capacity as it had direct implications for the extent of data collection, and analysis and/or reporting that could be undertaken by the networks.

CCAR collaborations

The CCAR initiative employed a network approach in part to encourage a high level of collaboration between network members, particularly university researchers and federal government scientists. Findings from the evaluation suggest that this objective was achieved as

collaborations between many different groups of national and international researchers, scientists and HQP existed within all seven networks. Network members perceive these collaborations as key contributors to enhancing the pace of discovery and the quality of the research produced by their network. The majority also consider the collaborations that existed within the CCAR-funded networks to be successful. All university researchers (100%) indicated that their involvement with the network increased their interest to continue collaborating with federal government scientists or other end-users on future research projects. While almost all federal government scientists or other end-users (96.9%) said the same about university researchers.

Knowledge dissemination, transfer & use

CCAR-funded networks were required to engage in knowledge dissemination and transfer activities to facilitate the use of the findings and/or products they generated by federal government departments and/or other appropriate end-users. The evaluation observed networks as they started to engage in such activities, the most common of which were conference presentations, research publications, media and social media activities, as well as network meetings, workshops and teleconferences. The network-specific activities were particularly important for knowledge transfer because they involved direct engagement and/or communication with end-users, including federal government scientists. The success of these dissemination and transfer activities has in turn supported the use of the knowledge and/or products already generated by the CCAR-funded networks by the federal government, particularly scientists working at Environment and Climate Change Canada (ECCC), as well as other potential end-users.

The next generation of researchers in climate change and atmospheric processes

A key element of NSERC's mandate is to help develop the next generation of scientists and to help generate scientific capacity by supporting graduate students and post-doctoral fellows in their academic and employment pursuits. The evaluation found that CCAR explicitly met this mandate by encouraging and enabling the networks to hire and train over 400 HQP. Through their involvement in CCAR-funded networks HQP received opportunities to: develop a variety of research and professional skills; contribute to research publications; and, present at national and international conferences.

CCAR's operational efficiency

Overall, it appears that the CCAR initiative is delivered in an efficient manner. The ratio of administrative expenditures for every \$1 of grants expenditures between fiscal years 2012-13 to 2015-16 was 4.45 cents. This is slightly lower than the ratio of administrative expenditures for NSERC's Research Grants and Scholarships (RGS) Directorate¹, which was 4.93 cents for every dollar spent during the same period. The lower ratio of administrative expenditures for CCAR may be attributed to the size of the grants (i.e. approximately \$5 million per grant), which is higher than the average grant distributed by the RGS Directorate

¹ CCAR is housed within the RGS Directorate.

Areas for improvement

Network members appear to be satisfied with their experience with the CCAR initiative including: the size and duration of the grants; the flexibility with which funds may be allocated across the network; and, the requirement of collaborations between university researchers and federal government scientists. There are, however, opportunities for improvement with regards to expanding the funding model to include small research projects in addition to networks. There are also opportunities to improve the monitoring and collection of performance information from the networks through their annual progress reports.

Recommendations

- 1. The federal government continues to fund fundamental research in climate change and atmospheric processes through NSERC's CCAR initiative, as long as these areas remain priorities for the federal government.** CCAR is currently the only source of large-scale research funding available to academic climate change and atmospheric researchers working in Canada. Continued CCAR funding would reinforce a Canada's capacity to conduct important research in these areas, and continued opportunities to train the next generation of highly qualified personnel in the fields of climate change and atmospheric processes. Sustained support for CCAR will build on the science base to inform decision-making, protect the health and well-being of Canadians, build resilience particularly in Northern and Indigenous communities, and enhance competitiveness in key economic sectors. It will also allow movement into new climate-related research areas, as well as maintenance and enhancement of long-term research initiatives.
- 2. Maintain the requirement that collaborations involve active research participation of scientists from at least one federal government department.** Collaboration among university researchers and federal government scientists is an essential component of the CCAR initiative and a key factor contributing to network success. By requiring such collaborations the CCAR initiative is perceived as reducing the research gap between academia and the federal government and supporting the sharing of expertise, as well as physical and human resources. Moreover, it is anticipated that these collaborations will facilitate the transfer of knowledge to and within federal government departments. In addition to the collaborations between university researchers and federal government scientists it is important to recognize the positive impact of other forms of collaborations within the CCAR-funded networks, particularly multidisciplinary collaborations and collaborations with international researchers. Such collaborations are important as research questions related to climate change and/or atmospheric processes are complex and rarely apply solely to one discipline or country. Consequently, the CCAR initiative should also continue to encourage these other forms of collaboration within funded networks.
- 3. Consider expanding the funding model of the CCAR initiative to include large networks and small research projects.** Large networks are valuable to address "big science" research questions with a focused objective as they increase the scale and scope of the outputs produced. There are, however, drawbacks to large networks including a lack of flexibility to respond to emerging research questions and difficulties adapting to changing needs within the research community. This is primarily because network financial and human resources are already committed to ongoing research projects. Funding small projects is

anticipated to mitigate some of these challenges by enabling researchers to quickly engage in short-term and targeted research to address new/emerging issues and/or events that may arise. It is anticipated that these research projects will also support national research priorities and generate knowledge that will be transferred to the federal government and other potential end-users for the benefit of Canada. The expansion of the CCAR initiative's funding model is supported by the majority of members of the current CCAR-funded networks.

- 4. CCAR management may want to consider developing a performance measurement strategy, as well as revising to their reporting templates.** As outlined in the new Policy on Results, federal government departments must demonstrate the achievement of results including outputs and outcomes. Defining and measuring the long-term scientific outcomes of the CCAR initiative and their indicators is a challenge, as funded networks are examining complex issues and these outcomes are not anticipated to transpire for many years. This process may be facilitated by using a working group approach and engaging federal government scientists involved with CCAR-funded networks to think strategically in terms of defining the key scientific outcomes of CCAR and how to measure the achievement of these outcomes. Moreover, adding closed-ended questions to the reporting templates will help increase the clarity and availability of performance information regarding the CCAR initiative, while still allowing the Principal Investigators (PIs) to highlight some of the unique attributes of and research generated by their network in response to the open-ended questions.

1 Introduction

This report presents the key findings, conclusions and recommendations from the evaluation of the Natural Sciences and Engineering Research Council's (NSERC) Climate Change and Atmospheric Research (CCAR) initiative. This is the first evaluation of the CCAR initiative and covers the period from fiscal year 2012-2013 until mid-way through 2016-2017. NSERC's and SSHRC's (Social Sciences and Humanities Research Council) Evaluation Division (hereafter referred to as the Evaluation Division) conducted the evaluation in collaboration with Alderson-Gill & Associates Inc.

The evaluation was designed to ensure that NSERC adheres to the requirements of the Treasury Board's *Policy on Results* (2016)² and section 42.1(1) of the *Financial Administration Act*, which requires that every grants and contributions program is evaluated every five years (1985)³. While the CCAR initiative has been implemented for less than five years, the initiative is currently set to end in 2017-2018, it was determined that an evaluation would be conducted to provide NSERC senior management with findings regarding CCAR's relevance, delivery, performance and efficiency.

1.1 The CCAR Initiative

Objectives and expected outcomes

Announced in the 2011 federal budget, the CCAR initiative is a five year program designed help Canadian researchers and scientists understand the economic, environmental, health and safety risks and opportunities of a changing climate and to make sound decisions on adaptation. Administered by NSERC, the initiative provides grants that support a limited number of large-scale research networks focused on addressing challenges that are high priorities for both the Canadian academic research community and federal government departments. The challenges addressed by funded networks connect to at least one of the following three theme areas: 1) earth system processes and their representation in models; 2) earth system prediction through improved forecasting methodologies; and 3) understanding recent changes in the Arctic and other Canadian cold region environments.

The main objective of the CCAR initiative is to produce valuable results and knowledge that can be transferred and disseminated to federal departments and other end-users to maximize their impact for the benefit of Canadians. Such benefits include, but are not limited to informed policies, regulations and/or services regarding climate change and atmospheric processes that reflect ongoing conditions, as well as an increased capacity to predict and adapt to changes in the climate and in atmospheric processes. Additionally, the CCAR initiative is expected to:

- facilitate collaborative research between Canadian university researchers and federal government scientists, as well as other potential partners including international researchers;

² Treasury Board. (2016). *Policy on Results*. Retrieved from: <https://www.tbs-sct.gc.ca/pol/doc-eng.aspx?id=31300>

³ Treasury Board, (1985). *Financial Administration Act*, Retrieved from: <http://laws-lois.justice.gc.ca/eng/acts/f-11/page-11.html>

-
- further strengthen Canada's leadership role and capacity in the three theme areas;
 - train the next generation of highly qualified personnel (HQP) in the fields of climate change and atmospheric processes;
 - build synergies with, but not duplicate, existing funding initiatives; and,
 - build on existing scientific knowledge and ensure that metadata results are available to, and compatible with, existing data-archiving platforms.

CCAR's expected outcomes are anticipated to occur at a variety of points in time. The achievement of these outcomes relies heavily on the activities of and decisions made by network principal investigators (PIs) and members. Expected outcomes are graphically depicted in the CCAR logic model, found in Appendix C, along with the initiative's activities and outputs.

Selecting and monitoring CCAR-funding recipients

NSERC employed a two-stage process for evaluating applications to the CCAR initiative. Initially, applicants were asked to submit a letter of intent (LOI) outlining the main research activities their proposed network would address and how they aligned with one or more of the theme areas, as well as anticipated collaborations, network outcomes, and biographies of the key network members including the PIs and federal government scientists. The call for LOIs was made in March, 2012 and of the 58 LOIs received, 24 applicants were invited to submit a full proposal.

Eligible proposals were peer-reviewed by the CCAR Initiative: Grant Selection Committee. Members of this committee were chosen from the international climate change and atmospheric processes research community, based on their stature and experience. Successful applications were screened by CCAR staff to ensure adherence to NSERC's policies and guidelines. When the list of successful applicants was finalized staff informed all applicants of the results in writing and the list of funded networks was posted on NSERC's website.

CCAR staff are responsible for administering the grants, as well as monitoring network outcomes and the use of funds through annual progress reports and statements of account submitted by the Principal Investigator (PI) on behalf of their network. The annual progress reports collect performance information through open-ended questions regarding: the network's accomplishments to date; anticipated research directions until the end of the grant; the growth and development of the research team; extent of HQP training; collaborations and interactions between network members including university researchers and federal government scientists; data management of research results; and, the communication/promotion of research results. The annual progress reports are reviewed by CCAR program staff. They are also peer-reviewed by researchers working in the fields of climate change and/or atmospheric processes who advise the program as to whether networks are making progress towards achieving expected outcomes. Once reviewed, CCAR program staff follow-up with each PI regarding the progress of their network, including whether there are any concerns/issues that need to be addressed. The progress reports and statements of account for each network also inform decisions regarding the release the next installment of funding and if there are any changes to be made to the amount of funding released for the next year. CCAR program staff also monitor the performance of funded

networks through participation in annual network meetings, teleconferences and/or ad hoc discussions with network PIs.

Funded networks

CCAR-funded networks are led by world-class Canadian university researchers and comprise Canadian university researchers and federal government scientists, along with HQP, international researchers and other partners, such as northern communities and/or the private sector. Funded networks receive grants of up to \$5 million over five years. Currently, there are seven networks receiving grants through the CCAR initiative⁴:

- Canadian Arctic GEOTRACES Program: Biogeochemical and Tracer Study of a Rapidly Changing Arctic Ocean;
- Canadian Network for Regional Climate and Weather Processes (CNRCWP);
- Canadian Sea Ice and Snow Evolution (CanSISE) Network;
- Changing Cold Regions Network (CCRN);
- Network on Climate and Aerosols (NETCARE): Addressing Key Uncertainties in Remote Canadian Environments;
- Research related to the Polar Environment Atmospheric Research Laboratory (PEARL): Probing the Atmosphere of the High Arctic (PAHA); and,
- Ventilation, Interactions and Transports Across the Labrador Sea (VITALS).

1.2 Evaluation Questions

The evaluation questions, located in Table 1 below, were developed in consultation with CCAR staff and management. The questions pertaining to performance are explicitly linked to the expected outcomes noted in the funding opportunity's logic model, found in Appendix C. The evaluation matrix located in Appendix D illustrates which lines of inquiry were used to inform each evaluation question.

Table 1: Evaluation Questions

Relevance: The extent to which CCAR addresses a demonstrable need, is aligned with federal government priorities and reflects an appropriate role for the government.

1. Is there a continued need for the CCAR initiative in light of the current context?
2. To what extent are the objectives of the CCAR initiative consistent with federal government priorities and NSERC strategic outcomes?
3. To what extent is providing the CCAR initiative funding an appropriate role for the federal government?

Design & Delivery: The extent to which CCAR is administered and delivered in its intended manner and reflects best practices.

4. To what extent are efficient and effective means being used to deliver the program?

⁴ Detailed information about each network is available on the following website: http://www.nserc-crsng.gc.ca/_doc/Professors-Professeurs/CCAR-RCCA_eng.pdf.

Performance: The extent to which CCAR is achieving or demonstrating progress towards expected outcomes.

5. To what extent is the CCAR initiative contributing to knowledge transfer and the use of research findings, methods, tools and/or data records by the federal government and other appropriate end-users?
6. To what extent is the CCAR initiative contributing to strengthened research capacity?
7. To what extent is the CCAR initiative contributing to developing a pool of highly qualified personnel in the fields of climate change and atmospheric processes?

Efficiency and Economy: CCAR's resource utilization in relation to the production of outputs and progress towards expected outcomes.

8. To what extent is the CCAR initiative delivered in a cost-efficient manner?

1.3 Methodology

Evaluating the extent to which CCAR is achieving its objectives and expected outcomes required multiple lines of inquiry including: a literature review, file review, case studies, key informant interviews, a survey of collaborators and co-investigators, a survey of HQP, as well as a cost-efficiency analysis. The seven lines of inquiry used to conduct the evaluation and the team members involved in each one are described further in Appendix E. To guide the data collection, a detailed evaluation matrix, including the evaluation questions, indicators and the sources of data was developed with CCAR staff and management.

1.4 Strengths and Limitations

While the evaluation benefitted from multiple lines of inquiry there are several limitations to the evaluation data. These limitations were identified prior to or throughout the evaluation and strategies were employed to address the limitations and facilitate the collection, analysis and/or use of data.

Recent implementation of CCAR

The CCAR initiative was implemented in 2012-13 and funded networks received their first funding installment in February, 2013. Therefore, during the time of the evaluation funded networks were only half to two-thirds of the way through their grant period. Consequently, it is too early to determine whether funded networks were able to complete all of their proposed project activities and the extent to which CCAR achieved its expected outcomes. Additionally, certain network activities, such as knowledge dissemination and transfer are likely to continue for some following the end of the grant period. For instance, journal articles may be submitted and/or approved for publication, and network members may continue to attend conferences and/or share their findings with other researchers. The evaluation addressed this limitation by focusing on the network activities and CCAR outcomes realized to date. It also attempted to assess the extent to which it is anticipated that expected network activities and CCAR outcomes will be achieved based on the progress of the networks.

High Levels of Participation and Self-Reported Data

Overall, there were high levels of participation from members of CCAR-funded networks for several lines of inquiry throughout the course of the evaluation. For instance, the majority of network members invited to participate in a case study interview agreed to participate and there was a high response rate for the survey of Co-Investigators and Collaborators (45%), as well as the survey of HQP (39%). These lines of inquiry, however, relied on self-reported data and there was concern that the network members may have a slight bias towards reporting positive results because they want the CCAR initiative to continue beyond its original five years. The evaluation addressed this limitation by employing the technique of “triangulation”, which facilitates the verification of data through cross verification of two or more sources⁵. In particular, by collecting data on the same evaluation questions from multiple sources using multiple lines of inquiry the Evaluation Division was able to increase the validity of the evaluation findings; thereby, minimizing the impact of any potential bias.

2 Research on Climate Change and Atmospheric Processes in Canada

The evaluation examined the rationale for CCAR, including evidence in the literature indicating that climate change poses significant challenges to Canada and the world, with current and anticipated impacts that could have serious ecological, health, social and economic effects. As such, there is a continued need for research to understand the underlying physical processes that are changing the Canadian climate. Canada has an important role in climate change research as a northern nation where impacts are expected to be extreme and because of the potential impacts of climate change for all Canadians. CCAR was found to be unique in Canada as a program targeting climate change research, as it is one of the only sources of public funding for climate change research, and is the largest in terms of the amount of funding and funding period. The evaluation found that CCAR is an excellent fit with the federal government’s current climate change priorities and NSERC’s strategic outcomes, and is in keeping with federal roles and responsibilities.

Why is it important to fund climate change and atmospheric research?

Climate systems are highly complex, consisting of inter-linkages between atmospheres, oceans, sea ice, land surface and the biosphere (American Meteorological Society (AMS), 2014). An understanding of the dynamic nature of these systems is imperative, in order to mitigate and adapt to changes that occur within them. Consequently, research into these systems is needed to reduce data and knowledge gaps and to help accurately predict climate changes, as well as their impacts (AMS, 2014).

The vulnerability of Canada’s environment, communities, and economy to a changing climate is well documented in the literature, as are many of the negative impacts of such changes including,

⁵ Better Evaluation. “Triangulation”, Retrieved from: <http://betterevaluation.org/en/evaluation-options/triangulation>

but not limited to: droughts; changes in the landscape; and, extreme temperatures. These negative impacts are particularly evident in Canada's North where thawing permafrost is affecting the stability of roads, buildings, pipelines, and other infrastructure as a result of temperature increases. The health of Canadians is also vulnerable to the changing climate as observed through increases in food prices and/or food shortages, as well as increases in infectious diseases, such as West Nile (Lemmen, 2008; Séguin, 2008).

Findings from the evaluation of the CCAR initiative concur with the literature and highlight some of the negative impacts of the changing climate on the Canadian environment. For instance, almost all network PIs, university researchers and/or government scientists that participated in the case studies spoke about the impacts they and/or their colleagues have observed over the years, such as increases in flooding, depletion of the ozone, forest fires and changes to important ecosystems. These individuals also echoed the assertion that impacts are particularly evident in Canada's North.

Is CCAR an appropriate and necessary role for the federal government?

CCAR is considered by key informants and case study participants as an essential source of federal funding because it is the only large-scale⁶ research funding available for Canadian researchers to perform fundamental and applied research solely within the realm of the natural sciences and engineering (NSE) that is aimed at better understanding climate change and atmospheric processes. Other funding sources and/or research networks in Canada focused on the impacts of climate change tend to include a health or social sciences component, e.g. ArcticNet⁷, and/or are focused solely on applied research, e.g. Pacific Climate Impacts Consortium (PCIC). Furthermore, other forms of federal funding for climate change research as available through Environment and Climate Change Canada (ECCC)⁸ and Natural Resources Canada (NRCan) are often allocated to focused objectives, are only for applied research, and/or are offered on a smaller scale⁹.

In addition to offering some funding for climate change research, ECCC and NRCan also have their own internal teams of scientists working together, with other departments, as well as with the national and international research community to engage in research related to climate change. The results of this research are used for climate policy development, adaptation and mitigation actions, as well as for climate-related services and products. These departmental research teams, however, cannot often meet the increasing demand for information from the federal government and/or Canadians in order to better understand, monitor and address changes in climate and atmospheric systems (Office of the Auditor General of Canada, 2010 and 2014).

Given this increasing demand for information, a lack of available funding for fundamental research related to climate change and atmospheric processes rooted in the NSE, and because all Canadians are vulnerable to the impacts of climate change, key informants (including

⁶ CCAR funds networks up to \$1 million a year for five years.

⁷ ArcticNet is an NSERC funded Network of Centres of Excellence of Canada <http://www.arcticnet.ulaval.ca/index.php>

⁸ At the national level climate change is primarily the responsibility of ECCC

⁹ A list of federal funding programs/initiatives related to climate change is found in Appendix F.

representatives from several federal government departments) and case study participants agree that CCAR is an appropriate and necessary role for the federal government. It was further agreed that by supporting research in Canada, CCAR is reinforcing the country's status as a key contributor to the fields of climate change and atmospheric research, as well as developing and retaining Canadian research expertise. Moreover, several key informants and case study participants perceived CCAR as an initiative that supports key priorities of the federal government as the three research themes were developed in collaboration with ECCC scientists and policy-makers to ensure their alignment with government objectives.

Other reasons why it is considered necessary for the federal government to continue to fund research on climate change and atmospheric processes include the government's national and international commitments to prioritize, address and reduce the impacts of climate change. These commitments include, but are not limited to the agreement made at the United Nations Climate Conference (COP21)¹⁰, which Canada ratified on October 5, 2016, as well as the government's Speech from the Throne and mandate letters to its Ministers outlining several priorities related to climate change. Moreover, changes in the Canadian climate affect a wide range of federal government responsibilities including, but not limited to: Indigenous Canadians, health, the environment, natural resources, oceans, transportation, etc. At times these changes have significant implications for the policies and programs of federal departments, particularly those related to the health of Canadians, as well as Canada's ecosystems, industries and infrastructures (OAG, 2010).

Despite ECCC's responsibility for addressing climate change in Canada and its involvement in developing the research themes for CCAR, the federal government determined that the initiative would be delivered by NSERC. Key informants perceive NSERC is well placed to deliver a program like CCAR because of its mandate to fund fundamental and applied research in the NSE in Canada, as well as its experience and resources for running a large peer-review process and administering large network grants, including monitoring the progress of funded networks. Additionally, CCAR is perceived as closely aligned to NSERC's mission by bridging the gap that often exists between academia and government and by fostering the next generation of researchers in the NSE¹¹. Key informants also spoke of how CCAR-funded networks support the Council's strategic objectives of building a diversified and competitive research base and bringing Canadian research into the international community¹² by engaging in multidisciplinary and international research.

¹⁰ <http://www.cop21.gouv.fr/en/>

¹¹ NSERC (2015). *Our Organization: What Drives Us*. Retrieved from: http://www.nserc-crsng.gc.ca/NSERC-CRSNG/NSERC2020-CRSNG2020/OurOrganization-NotreOrganisation_eng.asp

¹² NSERC (2015). *NSERC 2020 Strategic Plan*. Retrieved from: http://www.nserc-crsng.gc.ca/NSERC-CRSNG/NSERC2020-CRSNG2020/index_eng.asp

3 Enhancing Canadian Research on Climate Change and Atmospheric Processes

Overall there is a strong indication that CCAR-funded networks are enhancing Canadian research on climate change and atmospheric processes. In particular, networks are perceived as contributing to the development of new and/or the enhancement of existing knowledge, models, observational data sets, and/or tools, as well the linking of observational and modelling data. Additionally, there is agreement among case study participants and key informants that Canadian research on climate change and atmospheric processes would not have occurred on the same scale or with the same scope without CCAR funding. The flexibility with which NSERC allowed CCAR funds to be allocated across networks to support their activities and the use of the network approach are credited as contributing to the success of the networks and the achievement of their research contributions. The network approach, however, is not without challenges because despite the flexibility with which PIs are able to allocate CCAR funds, once the funds are allocated and the resulting activities commence the funds cannot be reallocated to address any emerging research issues that may arise during the five year funding period.

As the evaluation was conducted prior to the completion of the five-year funding term for CCAR networks it focused on the contribution of the CCAR funding model towards enhancing research on climate change and atmospheric processes, including perceptions of network members regarding the quality and value of what has been achieved to date. When asked about the contributions of their CCAR-funded networks the majority of respondents of the CCAR Co-Investigator Collaborator survey¹³ (hereafter referred to as the C&C survey) noted that networks have supported: the creation of new knowledge (92%); the extension/application of existing knowledge (84%); the creation of new models, observational data sets/records (82%); the extension/application of existing models and observational data sets/records (82%); and, the extension/application of existing tools, products and/or technologies (71%). Respondents were less likely to perceive networks as contributing to research capacity with the creation of new tools, products and/or technologies (58%), or the creation of new research methodologies (58%). Almost all respondents also found their network's contributions relevant to appropriate user groups to some or a great extent.

Case study participants and some key informants echoed the findings of the survey and spoke of network contributions such as: developing new or enhancing existing knowledge; improving various climate models and systems used to help predict changes in weather and climate patterns; linking observational and modeling data; building new, contributing to or applying existing observational datasets, etc. Specific examples of the contributions of CCAR-funded networks towards an improved understanding of climate change and atmospheric processes include, but are not limited to:

¹³ The Co-Investigators and Collaborators of CCAR-funded networks include: researchers working at a Canadian university or an international university; scientists working for the Government of Canada or an international government; research scientists working for an institute or non-profit organization; and, other potential end-users of the knowledge and/or products generated by at least one of the CCAR-funded networks.

-
- Improved understanding of how aerosols affect climate and air quality in remote Canadian environments;
 - Improved ability to evaluate ECCC's earth system climate model over Canadian regions;
 - Enhancements to ECCC's Canadian Land Surface Scheme (CLASS)/MEC-Surface & Hydrology (MESH) modelling capability for improved understanding and prediction of the water cycle (e.g. floods);
 - Improved modelling tools for Western and Northern Canada that combine existing and new experimental data with modelling and remote sensing products to better understand and predict changes to land, water and climate;
 - Improved understanding of the influence of ice formation on heat and water loss from the Upper Great Lakes;
 - Explanations of atmospheric conditions that caused the 2013 Calgary floods; and,
 - Supporting research agendas on wildfires in the northern boreal and taiga forest.

Several case study participants also spoke of the importance of CCAR funding in supporting field research campaigns and/or research sites in remote Canadian regions. In particular, it was noted that without these funds university researchers and/or HQP would not have been able to engage in extensive data collection and/or that certain research sites, such as the Polar Environment Atmospheric Research Laboratory, would no longer exist. Such field campaigns and research locations are considered critical to understanding and predicting changes in the climate and atmosphere as they provide opportunities to collect large amounts of data and/or continuous data that may be used for comparison with other countries and/or over time.

Augmenting the scale and scope of network research and results

While it is likely that research on climate change and/or atmospheric processes would have occurred in the absence of CCAR funding, key informants and case study participants were unanimous that research would not have occurred on the same scale or with the same scope without CCAR funding. In particular, it was perceived that generation and/or enhancement of knowledge, tools, models, datasets, etc., would have been far less and much slower without CCAR funding. Consequently, the completion, dissemination, transfer and/or use of research findings would also have been significantly less than what is observed and/or anticipated through the CCAR-funded networks.

The ability of these networks to generate a large volume of research and significant number of findings is partially attributed to a network approach that has, to date:

- Facilitated collaborations by bringing together large numbers of Canadian and international university researchers, government scientists, other potential end-users and HQP to work together on addressing complex research questions related to climate change and/or atmospheric processes, questions that could not have been answered without a significant amount of resources. At times these collaborations provide network members with access to knowledge and/or resources that were otherwise not available; thereby, enhancing and expediting the research process.

-
- Enabled knowledge dissemination and transfer through the generation of a large number of network outputs and activities such as annual meetings, workshops and/or learning events bringing together network members to discuss their research, results, new approaches, lessons learned and/or to offer solutions to problems that had arisen in each other's work. These activities facilitated the exchange of ideas and knowledge and at times contributed to the development of collaborations, publications, presentations and/or other research outputs.
 - Supported the hiring of a large number of HQP to work with university researchers and government scientists. Having access to a larger HQP research contingent allowed networks to collect and analyze larger amounts of data, to conduct much more expansive numerical modeling and simulations using historical data and data collected through the network, and to engage in more collaborative efforts with federal government scientists and/or international researchers.

Each aspect of the network approach that is credited with increasing the scale and scope of CCAR-funded networks will be examined further in the following sections of this report.

Key informants and some case study participants also credit the amount of funding and the flexibility with which NSERC allowed these funds to be allocated across networks as supporting the success of CCAR-funded networks in their contributions to the broader research community. This flexibility allowed the PI and other network members to target funds where they were needed most at different points of the network's lifecycle. For instance, some networks used funds to hire more HQP to fulfill requirements for data collection and/or analysis, while other networks allocated more funds to support attendance at a larger number of international conferences. Case study participants also indicated how important it was to be able to use CCAR funds for travel, which in turn supported collaborations within networks, especially among network members that did not live or work in the same location.

The process of having the annual reports submitted by CCAR-funded networks peer-reviewed was also perceived by some case study participants and key informants as supporting the research of the networks. The process provided networks with objective perspectives and ideas for altering and/or improving their activities, as well as addressing challenges that may have arisen. It was, however, noted that in some cases the reviewers did not appear to fully understand the research conducted by the network. As a result, they would sometimes make comments that the PI and/or other network members did not perceive as providing an accurate representation of the network's activities and/or ability to achieve expected results. In other cases it was noted that suggestions offered by the reviewers were difficult for the network to address because they did not reflect the reality of the network's situation.

While there were mixed perceptions regarding the value of the peer-review process for the annual progress reports, case study participants whose network included an advisory committee agreed that having such a committee offered important opportunities to enhance the quality of the network's research. In particular, they found that committee members provided ideas for improvement that were rooted in a clear understanding of the contextual factors that may impact

research activities including financial and/or human resources. Committee members were also often able to interact with other network members on a regular basis at network meetings, workshops and/or teleconferences. As such, they generally had a comprehensive and timely understanding of the network's activities, strengths and/or challenges and as a result would be called upon by the PI for their expertise and feedback.

4 Collaborations

The findings from this section of the report present evidence for the evaluation question regarding research capacity with a specific focus on building capacity through collaborations. Findings from the evaluation suggest that CCAR-funding enabled significant collaboration between many different groups of university researchers, end-users including federal government scientists and HQP working in the fields of climate change and atmospheric processes. While the nature of collaborations varied, survey respondents and case study participants overwhelmingly indicated that the collaborations that exist(ed) within CCAR-funded networks enhanced the quality of research and the pace of discovery. Consequently, they consider the collaborations to be successful, and many further indicated that they would want to continue collaborating with members of their CCAR-funded network once the funding period is ended.

Nature of CCAR collaborations

Almost all of the network co-investigators or collaborators that participated in the case studies or the survey (88%) indicated that they engaged in at least one collaboration as a result of their involvement with a CCAR-funded network. The nature of these collaborations often varied based on the expertise of the individuals involved, as well as their needs and available resources. According to C&C survey respondents the main types of activities characterizing collaborations within CCAR-funded networks include: leveraging each other's expertise and skills (86%); sharing technology or information resources (82%); and, participating in regular meetings and/or consultations (74%). Just over half of collaborations (56%) involved sharing of physical resources, such as facilities or equipment, while a little less than half (48%) involved jointly identifying targets, timelines and benchmarks of progress. In general, university researchers were more likely than non-university researchers (including government scientists) to participate in collaborations that involved participating in regular meetings or consultations (84 % vs. 63%) and sharing physical resources (74% vs. 37%).

When asked if the collaborations that existed within CCAR-funded networks were successful, the majority of C&C survey respondents (89%) indicated that they were. The main reasons why these collaborations were considered to be successful include, but are not limited to:

- they brought together national, international and multidisciplinary university researchers, federal government scientists and HQP;
- they facilitated good communication within the network and opportunities to meet with collaborators face-to-face;

-
- they brought together individuals with a shared scientific interest working towards a common objective; and,
 - the structure and governance of CCAR-funded networks including strong leadership from the PI who had the primary responsibility for the network, and from the co-PIs and/or co-investigators who were often responsible for individual projects within the network.

Most C&C survey respondents (87%) further identified that the CCAR-funded networks had and continue to contribute towards the development of new research collaborations within and across networks. The majority of case study participants also felt that the collaborations they participated in and/or observed throughout the network were successful and that the network was successful in developing new collaborations within the climate change and atmospheric sciences research community.

Collaborations between university researchers and federal government scientists

Case study participants and key informants were emphatic in their assertion that collaboration among university researchers and federal government scientists is an essential

“You never want two groups of people doing similar or complementary research without talking to each other. There are benefits to working together, whether it is new ideas, sharing of resources, etc.”
– ECCC Scientist

component of the CCAR model. There is a perception that researchers often work in silos; thereby limiting their access to available knowledge and/or resources. As such, university researchers may not be familiar with advancements made by the federal government, while government scientists and/or decision-makers are not always aware of research that may support government policies, regulations, tools and/or services. By facilitating research collaborations between university researchers and government scientists, case study participants and key informants perceive CCAR as reducing the research gap between academia and the federal government. Several key informants further perceive CCAR as the key mechanism by which the federal government can influence and leverage the work of university researchers through a collaborative model.

Of the C&C survey respondents who indicated participating in a collaboration through their CCAR-funded network, two-thirds (66%) of university researchers noted collaborating with at least one federal government scientist, while 74% of federal government scientists collaborated with at least one researcher working at a Canadian university. Most of these collaborations (60% for the university researchers and 73% for the federal government scientists) were new and developed as a result of the network. Just under one-half of university researchers (44%) and federal government scientists (42%) were also involved in collaborations with the other party that existed prior to their involvement with their CCAR-funded network¹⁴. Regardless of whether collaborations were new or existing, case study participants agreed that collaborations would not have occurred on the same scale and with the same scope without the CCAR-funded networks.

¹⁴ The categories of new or existing collaborations are not mutually exclusive.

By having university researchers and federal government scientists working together it was anticipated that each group would benefit from the other's expertise, as well as physical and human resources. Evidence from the case studies and key informant interviews suggests that this benefit was realized as each group provided resources that the other lacked and/or required in order to increase the pace of discovery, as well as enhance research capacity and quality. For instance, some climate models are proprietary to the federal government, but university researchers and their students were given access to these models through their collaborations. Moreover, government scientists were provided with additional human resources such as HQP. In the case of one network, university researchers working with Regional Climate Models (RCMs) were given access to the federal government's Global Climate Models (GCMs) in order to "add details" to the GCM simulations. RCMs operate at a higher resolution than GCMs and therefore offer improved representation of physical processes, feedbacks and interactions, which can in turn be integrated into the GCM simulations to improve their prediction capabilities. A great deal of the work accomplished within the network to support the improvement of ECCC's GCMs was completed by HQP, and several federal government scientists indicated that the contributions of the HQP significantly increased the pace of their own work and/or ECCC's research agenda.

When asked about the extent to which their involvement in a CCAR-funded network increased their interest in collaborating with federal government scientists in the future, all university researchers that participated in the C&C survey indicated that it increased their interest at least to some extent. Just over two-thirds of these individuals (70%) report an increase in interest to a great extent. Almost all federal government scientists reciprocate this sentiment with 96% indicating an increased interest in collaborating with university researchers in the future. A little over half of these individuals (61%) further noted that this increased interest was to a great extent. Case study participants also indicated that they would like to continue collaborations between university researchers and government scientists following the end of the CCAR funding period. The existence and nature of these collaborations, however, are dependent on the availability of funding.

Other forms of collaboration

In addition to collaborations between university researchers and federal government scientists, respondents of the C&C survey indicated that network members were also likely to collaborate with: HQP¹⁵ (73%); the network principal investigator (67%); and/or researchers working at a non-Canadian university (36%). With respect to the latter group of collaborators statistical analysis indicates that researchers working at a Canadian university were more likely to collaborate with researchers working at a non-Canadian university than were federal government scientists or non-university researchers¹⁶. Almost all researchers working at a Canadian university (95%) were also likely to collaborate with at least one other researcher working at a Canadian university and the majority of these collaborations (75%) developed through the

¹⁵ Collaborations between HQP and other network members will be examined further in section 6 of this report.

¹⁶ Statistical significance at $p \leq 0.05$.

network. These forms of collaborations were highlighted during the case studies, and noted as existing within all CCAR-funded networks. In particular, case study participants spoke of the value of collaborating with different groups of network members and how these collaborations greatly increased Canadian research capacity and quality, as well as Canada's presence in the international research community.

All seven CCAR-funded networks include members of the international research community on climate change and atmospheric sciences. Key informants and case study participants felt that it was important that networks include international representation as climate change is an international issue that cannot be addressed in isolation. Some of the countries represented in these networks include, but are not limited to: the United States, the United Kingdom; Germany; Denmark; France; Sweden; and China. The roles of international researchers and the extent to which they are involved in the networks varied with some researchers engaging directly in the data collection or analysis, while others assumed more of an advisory role for certain projects, HQP and/or the network as a whole.

Findings from the evaluation indicate that network members perceive significant benefits for Canada's research community resulting from the collaborations with members of the international research community. Not only are Canadian researchers and scientists able to draw on the knowledge and expertise of their international colleagues, but the research generated by the CCAR networks has influenced/supported contributions from Canadian universities and the federal government to the international climate and atmospheric sciences research community. Sharing data with and having access to data from international researchers and/or institutions may allow for comparison of data further validating Canadian data and/or climate models. For instance, findings from one network are being fed into international databases regarding atmospheric processes in the Arctic; while a deliverable from another network provides an overview of simulations of one of the federal government's climate models in the context of international modeling efforts. Many of the members of CCAR-funded networks also contribute to the international research community through their involvement with international research organizations, such as the National Center for Atmospheric Research (NCAR); the National Oceanic and Atmospheric Administration (NOAA); the Global Water and Energy Exchanges (GEWEX), which is a core project of the World Climate Research Programme (WCRP); and, the Network for the Detection of Atmospheric Composition Change (NDACC).

Another key form of collaboration contributing to the success of the CCAR-funded networks, as noted by case study participants and key informants, are multidisciplinary collaborations. While not explicitly required for CCAR funding, such collaborations were facilitated by the networks through the creation of teams of researchers and scientists from various disciplines working together on a common research objective. They were considered important for network success because research questions related to climate change and/or atmospheric processes are complex and rarely apply solely to one discipline. For instance, participants from one case study noted that members of one of the network's project working within a certain discipline approached a selection of physical processes with a focus on simplifying their representation in the models to make numeric modeling more feasible, whereas project members from another discipline

approached the same processes with a focus on understanding their complexities to make numeric modeling more comprehensive. Eventually by working together both groups were able to compare their methods and provide a more accurate and fulsome picture of the processes in question. Just over half (60%) of C&C survey respondents indicated that they participated in at least one multidisciplinary collaboration, and when asked the open-ended question about what factors contributed to their networks' success several respondents noted multidisciplinary collaborations as a contributing factor.

Collaborations between climate observers (i.e. researchers/scientists who conduct field research to observe and collect data on changes in the climate and atmosphere) and climate modelers (i.e. researchers/scientists who develop computer models of the climate system to simulate climate change) were also highlighted during the evaluation. It was noted that by working together observers and modelers were able to appreciate the complementarity of their work, which in turn allowed them to understand and address each other's' needs. The results of this understanding included enhanced research capacity through the generation of new knowledge and/or products, such as observational data records and journal articles, as well as the improvement of existing climate models. While many of the initial network collaborations focused on bringing climate observers and modelers from universities and the federal government, several case study participants and key informants also noted the unexpected outcome of networks bringing together climate observers and modelers working within the same federal government division, but in different locations across the country.

5 Knowledge Dissemination, Transfer and Use

During the time of the evaluation a number of members of each CCAR-funded network had started to engage in knowledge dissemination and/or transfer activities. The majority of these activities concentrated on sharing the knowledge and/or products generated by members of the network with each other and/or with the broader research community in order to receive feedback and draw on the expertise of other researchers and scientists. The most common dissemination outputs produced by the networks include conference presentations, peer-reviewed publications, as well as media and social media activities. With respect to knowledge transfer the most common activities were network meetings, network workshops, conferences and network teleconferences. In general, these dissemination and transfer activities were considered successful as they accelerated the exchange of research results among network members, as well as among members of the Canadian and international research communities. This success has in turn supported the use of the knowledge and/or products already generated by the CCAR-funded networks by the federal government, particularly scientists working at ECCC, as well as other potential end-users. The extent to which the knowledge and/or products will be used to inform federal government policies, regulations and/or services is uncertain at this time. However, case study participants, key informants and just under half of survey respondents (45%) do expecte that they will be used to support evidence-based decision making by the federal government in the future.

Knowledge Dissemination and Transfer

During the time of the evaluation, members of CCAR-funded networks were concentrating on data collection and analysis, as well as generating research outputs to disseminate their findings to the broader research community (e.g. publications, conference and/or poster presentations, etc). Table 2 below illustrates some of the types and estimated¹⁷ total number of dissemination outputs produced by the seven CCAR-funded networks from February, 2013 until January, 2016. Overall, there has been considerable production of outputs from the networks, particularly conference presentations and peer-reviewed publications which are the primary way that research is shared with the scientific community and contributes to overall advancement. These are also the most common outputs C&C survey respondents noted being involved in developing (75% in oral or poster conference presentations and 57% in articles published or accepted for publication in peer-reviewed journals), in addition to observational data records (55%). Statistical analysis of the survey results however, demonstrate that university researchers are more likely than government scientists and other non-university researchers to participate in the development of conference presentations (85% versus 64%) and observational data records (73% versus 38%)¹⁸. Such differences may be attributed to the fact that government scientists and other non-university researchers may be constrained in the amount of time they are able to dedicate to such tasks, particularly the development of observational data records as such data is generally collected during (sometimes lengthy) field campaigns.

Table 2: Examples of the type and number of outputs produced by CCAR-Funded networks from February, 2013 until January, 2016.

Type of Output	# of Outputs
Conference presentations (non-invited)	1037
Peer-reviewed publications	272
Media and social media activities	233
Joint peer-reviewed publications	206
Conference presentations (invited)	146
Observational data records	50
Other ¹⁹	28
Non peer-reviewed publications	8
White paper	1
Source: CCAR Network Data	

As part of the design of the CCAR initiative, funded networks were required to demonstrate how they would transfer the knowledge and/or products generated to federal government scientists and other potential end-users. It was expected that through this requirement network members, particularly the PI and other university researchers would make a concerted effort to engage, work with and/or communicate their results to federal government scientists and other potential

¹⁷ Networks were not required to systematically track this data. Consequently, some of the numbers provided by the networks are based on the data available to the PI at the time the data was requested.

¹⁸ Statistical significance at $p \leq 0.05$

¹⁹ Examples of some of the other types of outputs produced by CCAR-funded networks include: lectures and/or courses for government scientists; training sessions and/or summer courses for university students, patents, etc.

end-users, which would in turn facilitate the use of the knowledge and/or products generated. To comply with this requirement, CCAR-funded networks implemented several knowledge transfer activities throughout their lifecycle.

According to C&C survey respondents, the most common knowledge transfer activities they participated in were: network meetings (77%); network workshops (72%) conferences (66%) and network teleconferences (56%). The network-specific knowledge transfer activities are considered as “active” because they require direct engagement and/or communication with end-users, while conference presentations are considered as “passive” activities because it is up to the end-user to seek out the information. Statistical analysis of the survey results demonstrate that university researchers are more likely to participate in network meetings than government scientists and other non-university researchers (85% versus 68%), as well as conference presentations (81% versus 51%)²⁰. With respect to the latter activity, findings from the case studies suggest that government scientists had fewer opportunities to participate in conferences as they could not afford the time away from work or the cost of travelling to and/or attending the conferences.

Table 3: Types of knowledge transfer activities organized by CCAR-funded networks and the proportion of network members participating in these activities.

Type of Knowledge Transfer (KT) Activities	% of respondents participating in KT activities
Active Activities	
Network meetings	77%
Network workshops	72%
Network teleconferences	56%
Sharing results directly with federal government collaborators	27%
Community forums	11 %
Developing educational toolkits or modules	7%
Delivering training courses	6%
Developing knowledge exchange tools	4%
Passive Activities	
Conference presentations	66%
Panel discussions	21%
Social media	9%
Source: CCAR C&C Survey	

Collaborations between university researchers and federal government scientists were also expected to facilitate knowledge transfer to and across government departments. Because of their involvement in generating the research it was expected that government scientists would be more likely to bring network findings back to their department and share them with their colleagues, including policy analysts. In turn, it was expected that having access to such findings would enhance the department’s capacity for research and evidence-based decision-making. Case study participants indicated that these expectations were achieved as government scientists

²⁰ Statistical significance at $p \leq 0.05$

from all networks brought findings back from the projects they collaborated on to their departments to share with their colleagues. For example, one network conducted a project regarding the Calgary floods, which was a collaboration between university researchers and several ECCC scientists. The government scientists were heavily involved in this project including writing several joint publications with their network collaborators. Once the research was concluded and the publications written the scientists shared the findings of their research with their colleagues at ECCC in anticipation that it would be used to inform their ongoing work. Because of their familiarity with the research and its findings it was easy for the ECCC scientists to share this information and to support their colleagues in the use of the findings within the context of the work they were conducting at ECCC.

While primarily focused on ensuring that network findings were shared with the federal government and other potential end-users, the knowledge transfer activities of CCAR-funded networks were also designed to encourage network members to share their research progress and findings with one another. This sharing of information between network members was considered important by key informants and case study participants as each network was comprised of several small projects, some of which included members in different locations across Canada and/or the world. Consequently, network members were not always familiar with the work of their colleagues as their efforts were concentrated on their own project. Case study participants noted that the network meetings, workshops and teleconferences were particularly useful in terms of providing opportunities for network members to learn about the vast amount of research generated by their colleagues throughout the networks. Such knowledge transfer activities were also perceived as important vehicles for members to encourage the use of these findings to enhance ongoing research within the network and to support each other by sharing knowledge and/or resources.

During the time of the evaluation, other knowledge transfer activities that are less traditional in academic circles, such as sharing results directly to government collaborators, panel discussions, community information sessions, social media, developing educational toolkits or modules, delivering training courses and developing knowledge exchange tools are less evident among CCAR-funded networks. This is in part because those types of knowledge transfer activities are better suited to findings that have been synthesized and analyzed with end-users in mind, and networks were concentrating on producing outputs designed to report on findings with the purpose of advancing science and to invite constructive criticism from the research community. As CCAR-funded networks move closer towards the end of their grant period they are now at the stage where they are actively synthesizing and analyzing results with a greater focus on transferring results to the federal government and other end-users.

While not necessarily the main focus of CCAR-funded networks at the time of the evaluation, the knowledge transfer activities they had already undertaken are generally considered to have been successful. The majority of C&C survey respondents agree that the knowledge transfer activities of the networks have accelerated the exchange of research results among members of the network (80%), as well as members of the Canadian (72%) and international research communities (70%). Also, when asked if the knowledge transfer activities they participated in

raised their awareness of network results, 90% of C&C survey respondents who are government scientists or other end-users indicated that they had, with 62% indicating to a great extent.

Use

Findings from the evaluation suggest that the success of the knowledge transfer activities of funded networks has in turn supported the use of the knowledge and products generated by the networks. In particular, almost all C&C survey respondents representing the federal government and other potential end-users (90%) indicated that participating in the networks' knowledge transfer activities raised their awareness of their network's results at least to some extent, with 62% indicating to a great extent. Two-thirds (67%) of this same group of respondents further indicated that the network has contributed towards the use of research knowledge and/or products by federal government scientists, while only one third of this group of respondents (36%) noted that the same has happened with other potential end-users.

Findings from the case studies suggest that it is expected that federal government scientists would be the primary end-users of the results of CCAR-funded networks, particularly until the networks have completed all their activities. This is because federal government scientists represent the majority of potential end-users involved with the networks, have often been involved with networks since they began, and/or are heavily involved in the research and output production. Other expected end-users include nor-profit organizations that have also been active in one or more CCAR-funded network. In some cases networks are making efforts to raise awareness of their research and findings with several other end-user groups including local communities that are or may benefit from the findings of the research, as well as non-profit organizations whose work is closely aligned with the network's research and/or findings.

C&C survey respondents representing the federal government and other potential end-users overwhelmingly noted using the knowledge or products generated by the networks now and/or plan on using them in the future as demonstrated in Table 4 below. Only two-thirds of respondents, however, indicated that they would use new research methodologies generated by the networks. This smaller proportion of respondents may be attributed to the fact that networks were generally not focused on developing new methodologies.

Table 4: The proportion of federal government scientists and other potential end-users that are using and/or plan on using the knowledge and/or products generated by CCAR-funded networks.

	% of end-users
New knowledge	92%
New models, observational data sets and/or records	91%
Extension of existing knowledge	89%
Extension of existing models, observational data sets and/or records	89%
New tools, products and/or technologies	83%
Extension of existing tools, products and/or technologies	79%
New research methodologies	67%
Source: CCAR C&C Survey	

Case study interviewees from all CCAR-funded networks agreed that the knowledge and/or products generated by the networks are contributing to the work of several federal government departments, particularly ECCC and Fisheries and Oceans (DFO). For instance, the work conducted by several networks on regional climate and/or global climate models has generated knowledge that is being fed into ECCC's climate models to improve their quality and accuracy. Observational data collected by certain networks is also used for the same purposes, particularly with respect to improving the manner in which the Arctic is represented in and understood through these models. Network contributions to federal government departments may also have an international scope, such as the results of one CCAR network which were developed through collaborations between federal government scientists, university researchers and HQP and are currently being used as the foundation for Canada's next contribution to the Intergovernmental Panel on Climate Change (IPCC).²¹

While none of the key informants or case study participants could provide examples regarding if and/or how the knowledge and/or products generated by the CCAR-funded networks have influenced federal government policies, regulations and/or services, several of them expect that the findings from CCAR-funded networks will eventually influence and/or find their way into these government outcomes. A few case study participants were uncertain about whether their network's findings would influence government policies, regulations and/or services because they were unfamiliar with the processes for developing these outcomes. They were hopeful, however, that their work would eventually be used to support decisions by federal departments. Findings from the C&C survey echo those of the case studies with almost half of respondents (45%) indicating that they believe that their network's findings will eventually contribute towards informing government policies, regulations and/or services, with another third of respondents (30%) indicating that they do not know if this will occur. Respondents were, however, more aware and/or optimistic about their network's contributions towards an increased capacity to predict and adapt to changes in the climate and/or in atmospheric processes with 35% of respondents indicating that their network has already made such contributions and another 41% confident that their network will make such contributions in the future. In addition to supporting the work of the federal government divisions whose scientists are currently involved with CCAR-funded networks, some key informants noted that the findings generated by the networks may also be used to inform other government work and/or initiatives including the Federal Sustainable Development Strategy, as well as green infrastructure and infrastructure resilience, hazard mitigation and disaster risk reduction vis-à-vis the Emergency Management Plan, and the science and innovation agenda.

²¹ The IPCC is an international body that compiles climate change research and enables scientists to share findings, learn from advances in other countries and identify remaining knowledge gaps in the research.

6 The Next Generation of Researchers in Climate Change and Atmospheric Processes

A central pillar of NSERC's mandate is to develop the next generation of scientists and to help generate scientific capacity by supporting graduate students and post-doctoral fellows in their academic and employment pursuits (NSERC, 2016). CCAR promotes this mandate by encouraging funded networks to train HQP in the fields of climate change and atmospheric processes. Findings from the evaluation suggest that HQP were heavily involved in supporting data collection, analysis and/or reporting for all seven CCAR networks. There is also a strong indication that HQP received significant opportunities that supported their skills, knowledge and professional development and that these opportunities encouraged, supported and/or aligned with future academic and/or employment pursuits. As compared to other network members; however, HQP were less likely to engage in collaborations and/or knowledge dissemination or transfer activities.

Engaging HQP in CCAR-funded networks

All seven CCAR-funded networks engaged HQP to participate in data collection, analysis and/or reporting on one or more network projects. Over 400 HQP participated in CCAR-funded networks. The number of HQP that participated in each network varied based on the needs of the network and available funding. For instance, a smaller number of HQP may participate in networks with field research campaigns because of the costs associated with travel and/or conducting research in a remote location. Not all HQP that participated in a network; however, were funded using money received from CCAR. Some HQP were funded from other financial sources, such as their institution, their thesis supervisor, etc.

It is gratifying to see the number of HQP involved with the networks. They are being exposed to research activities, tools and the expertise of senior researchers. Many are also participating in field research and/or go to conferences. Furthermore, I appreciate how some networks have HQP specific activities, such as conferences or networking opportunities.

– Key Informant (paraphrase)

The majority of case study participants and key informants, as well as some C&C survey respondents, credited CCAR funding with the ability to engage such a large number of HQP to support network activities. They

also credited research objectives and activities of funded networks as contributing to the recruitment of HQP as the training and professional development opportunities afforded to these HQP may not have been possible without involvement in a large network. Network co-investigators and collaborators, as well as key informants were generally pleased with the number of HQP trained through the networks. They were also pleased with the exposure HQP received to research knowledge and products, as well as to other researchers in the fields of climate change and atmospheric processes through conferences and other networking opportunities.

In addition to investing in Canada's future scientists, NSERC is also committed to increasing the diversity of this the country's scientific base, particularly the number of women pursuing

education and careers in STEM²². Currently, women represent just over one-third of the HQP involved in CCAR-funded networks with 39% of HQP survey respondents (56 of 144 total respondents) identifying as female. Table 5 below demonstrates the distribution of disciplines among female HQP involved in a CCAR-funded network.

Table 5: Academic discipline of female HQP survey respondents

Discipline	Distribution of Disciplines among Female Respondents (n=56)	Distribution of Disciplines for Female Respondents as a % of Total Respondents (n=144)
Other (e.g. Geochemistry, Earth Sciences, Atmospheric Sciences, etc.)	58.9%	22.9%
Mathematics and Computer Science	12.5%	4.8%
Physical Sciences	10.7%	4.1%
Engineering	8.9%	3.4%
Oceanography	5.3%	2.0%
Life Sciences	3.5%	1.3%
Total	99.8%	38.5%

Source: CCAR HQP Survey

Developing research knowledge and skills

The HQP that participated in the case studies spoke highly of their experiences with their respective CCAR-funded network(s) and of the training they received with respect to conducting research in climate change and atmospheric processes. Overall, they appeared to appreciate opportunities to: engage in various stages of the research process; work with national and international university researchers and/or government scientists; build their network of potential future colleagues and collaborators; contribute to research publications; present their findings at national and international conferences; and, participate in network activities that allowed them to share their findings and learn about the research of their fellow network members.

“For the most part [the network] represents the best of how science should work. There is an openness, collegiality and commitment to getting the science right and collaborating and looking for those opportunities for efficiency and innovation. It has been a really valuable training experience for me.... I just hope it continues because I think it is necessary.” - HQP

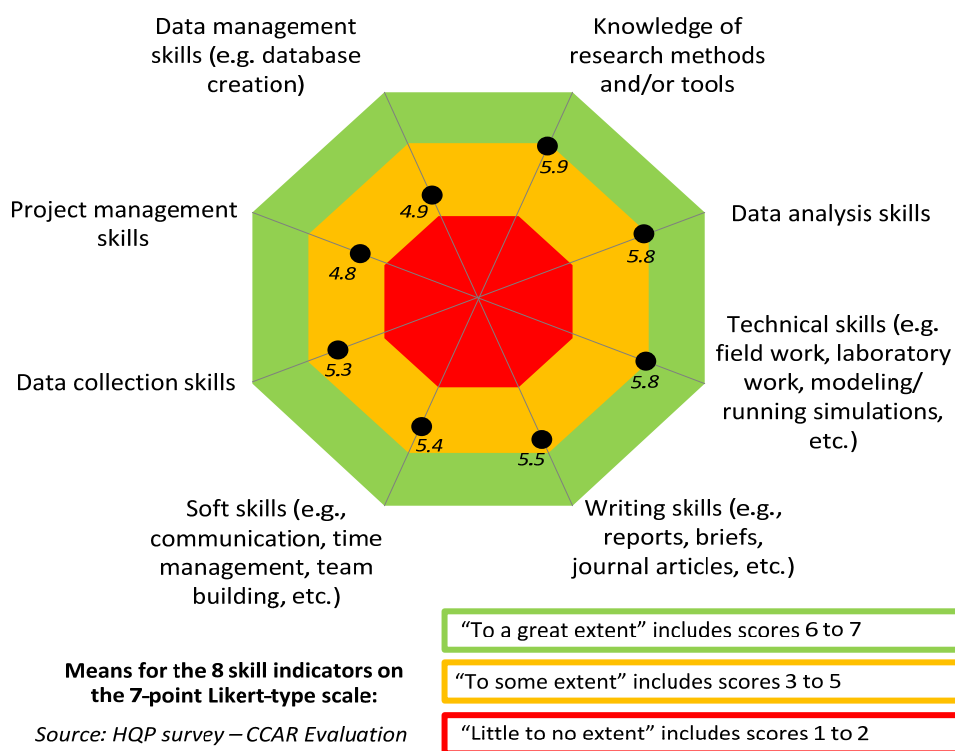
In five networks, many HQP also received opportunities to participate in field research, often in Canada’s North, which required and contributed to the development of unique knowledge and skills. For instance, some HQP had to learn how to work and cohabitate with university researchers and/or government scientists from various disciplines in confined and/or remote locations. Conducting research in remote locations also often meant that HQP would have to learn skills such as instrument automation, as well as fixing and/or rebuilding equipment onsite or at a distance with few resources. Some of the HQP that participated in field research referred

²² NSERC (2015). *NSERC 2020 Strategic Plan*. Retrieved from: http://www.nserc-crsng.gc.ca/NSERC-CRSNG/NSERC2020-CRSNG2020/index_eng.asp

to such opportunities as “once in a lifetime” and recognize that they may not have been possible without the existence of CCAR-funded networks.

According to case study participants, knowledge and skill development were two of the most important outcomes for HQP involved in CCAR-funded networks. In order to assess the impact of these networks on such development HQP survey respondents were asked to rate the extent to which the network allowed them to gain a variety of skills using a seven-point Likert scale. As demonstrated in Figure 1 HQP perceive their involvement in a CCAR-funded network as significantly contributing to their: knowledge of research methods and/or tools; data analysis skills; and, technical skills, (e.g. field work, modeling, etc.). HQP are slightly less likely to perceive the network as a significant contributing factor to the development of their: writing skills; soft skills, e.g. communication, time management, etc.; data collection skills; project management skills; and/or data management skills. Such perceptions may reflect the fact that the main network activities HQP survey respondents noted being involved with include: analyzing/interpreting research findings, which may include reporting of these findings (83%); data collection (51%); and, developing research ideas/questions (50%).

Figure 1: HQP rate the extent to which their involvement in a network allowed them to gain research and professional skills



Just under one-third of HQP survey respondents (30%) indicated developing other knowledge or skills as a result of their involvement in a CCAR-funded network. When asked to elaborate several respondents indicated that they developed knowledge and skills related to networking

and collaborations. HQP, however, were less likely to have engaged in collaborations as compared to other network members. While many HQP were able to establish new connections and develop their professional networks, only two thirds of the HQP surveyed (66%) indicated engaging in a collaboration. Statistical analysis of the HQP survey results suggest that postdoctoral fellows, Master's students and research staff were more likely to engage in collaborations through a CCAR-funded network than PhD students.²³ Of the 66% of respondents who reported participating in a collaboration through their CCAR-funded network the majority collaborated with other HQP (80%) and/or with researchers working at a Canadian university (67%). Just over half of these respondents collaborated with the network's principal investigator (56%) and/or government scientists working in Canada (51%),²⁴ while a smaller proportion had opportunities to participate in multidisciplinary collaborations (38%) and/or collaborations with international researchers (26%).

HQP involved in CCAR-funded networks were also provided opportunities to develop their skills in reporting and disseminating the findings of their network by producing and contributing to various research outputs, as well as transferring the findings to other network members and potential end-users of the research. In terms of disseminating network findings HQP were more likely to develop or contribute to oral or poster conference presentations. Survey respondents reported producing an average of 4 presentations, the majority of which occurred at international conferences. Another research output HQP often contributed to were articles that have been published or accepted in peer review journals. As for knowledge transfer activities, HQP survey respondents noted strong participation in network meetings (76%) and network workshops (74%), with just under half of respondents participated in network teleconferences (48%). A third of HQP are using social media (31%), while only 16% participated in a panel discussion and 15% contributed to transmitting the results of the network to government collaborators. It is anticipated that as the networks finish their analysis and get ready to report their findings in the next year (i.e. by 2018), HQP in conjunction with other network members will have more opportunities to engage in knowledge dissemination and transfer activities.

Academic and professional development

To gauge the longer-term impacts of CCAR-funded networks on participating HQP, survey respondents were asked to describe the extent to which their involvement in a network contributed to their current academic and/or employment status. Of the 135 HQP that responded to this question 91% indicated that being involved in a CCAR-funded network contributed to their academic/or employment status to some extent with 62% indicating that it contributed to a great extent. As illustrated in Table 6 the majority of survey respondents further indicated that the opportunities provided to them through their involvement in a CCAR-funded network contributed significantly to their academic and/or professional development.

²³ The correlations between these three groups of HQP and engagement in a collaboration were statistically significant ($p = 0.05$).

²⁴ These statistics include collaborations where the HQP interacted with the collaborator from a period of at least once a day to at least once a month.

Table 6: Extent to which HQP survey respondents perceive opportunities provided by CCAR-funded networks as contributing to their academic and/or professional development.

Opportunities	Contributed to HQP Development	
	To some extent	To a great extent
To collaborate with other HQP	32%	68%
To participate in a quality research experience	26%	72%
To attend/present at conferences	28%	70%
To receive quality training	37%	58%
To author/co-author research publications	14%	81%
To work with researchers at a Canadian university	18%	77%
To work with Canadian government scientists	28%	64%
To work with international researchers	35%	52%

Source: CCAR HQP Survey

Findings from the case studies support those from the HQP survey, as many of the HQP interviewed spoke about how the opportunities provided to them through the networks support their academic and/or professional development. In particular, they mentioned that the training they received from and opportunities to work with university researchers and/or government scientists helped them to develop their research knowledge and skills and provided opportunities to contribute to research publications and/or present at national and/or international conferences. Several HQP also spoke about the opportunities they received to work with international researchers, in some cases abroad at the researcher's university, which allowed them to learn about and/or contribute to new and ongoing research in other countries. Overall, the HQP that participated in the case studies were positive and thankful for the opportunities afforded to them through the networks.

"I talk to my friends from university, and they can't believe how lucky I am to have these opportunities." – HQP

The academic or employment status of most HQP involved with CCAR-funded networks remained static throughout the evaluation period. A small proportion of HQP, however, advanced to the next stage of their academic career (e.g. from a Master's to a PhD student), including part-time or full-time employment within or outside of the network. In some cases employment was found with the federal government or with international institutions, such as the National Aeronautics and Space Administration (NASA) and the Royal Netherlands Meteorological Institute. Case study participants credit the quality of the training they received and the connections they made through the networks with such opportunities for advancement. Of the 39 HQP survey respondents currently employed within or outside the network,²⁵ the majority indicated that there is a good match between their field of study and current position (81%), and/or that they use the skills they acquired through the network in this position (80%). A slightly smaller proportion of respondents felt that they work in a field or sector targeted by the network (69%) in that the knowledge and/or products generated by the network directly

²⁵ Some of these HQP may have been employed when they became members of a CCAR-funded network, while others transitioned to employment during and/or as a result of their involvement with a network.

apply to their current employment. Consequently, there appears to be a strong alignment between the opportunities provided to HQP through CCAR networks and potential employment opportunities in the fields of climate change and atmospheric sciences.

7 CCAR's Operational Efficiency

Overall, it appears that the CCAR initiative is delivered in an efficient manner. A common measure of the operational efficiency of NSERC's grant programs is to assess the ratio of administrative expenditures²⁶ in relation to the total amount of grant expenditures (i.e. funds awarded). This ratio represents the cost to NSERC of administering \$1 of grant funds. A funding opportunity's operational efficiency may also be presented as the percentage of administrative expenditures within the total expenditures for the funding opportunity.

Between the 2012-2013 and 2015-2016 fiscal years the total annual grant expenditures for the CCAR initiative almost doubled from \$4,373,568 to \$7,934,992. The increase in grant expenditures is partially a result of the fact that the first installment of CCAR funds was not awarded to the networks until February, 2013 and was split between the 2012-2013 and 2013-2014 fiscal years. This was done to facilitate cash flow management as the networks required fewer funds until they were established and ready to begin their projects. Once established the networks required more funds to: hire HQP; collect data including possible field campaigns; host network meetings including the cost of travel for some network members; and travel to and/or attendance at conferences to present findings generated by the networks. In certain cases, however, it took longer than anticipated for networks to establish themselves due to unforeseen factors, such as hiring delays and/or challenges mounting field campaigns. Consequently, some of the grant funds were deferred to another fiscal year to ensure their availability when the network was ready and able to use them. In other words, the grants expenditures were not consistent each fiscal year, but coincided with the needs of the networks. As such, it is anticipated that the amount of grant expenditures will decrease for 2016-2017 and 2017-2018 as the networks wind down their activities during the last two years of the grant period.

Over the same period the administrative expenditures of the CCAR initiative also increased on an annual basis. These increases are a reflection of the costs required to manage the CCAR grants, particularly travel to and participation in annual network meetings to support the funded networks as they worked towards achieving their objectives. Despite this increase in administrative expenditures, the ratio of administrative expenditures steadily declined between 2012-13 and 2015-16. Consequently, there is evidence that CCAR is delivered in an efficient manner and that economy is achieved as the program delivers more grant funds for a lower administrative cost.

²⁶ Administrative expenditures include the direct and indirect costs of administering the program. Direct costs include salary and non-salary expenditures, which relate to the adjudication of the award, post-award management, corporate representation and general administration of the Research Grants and Scholarships Directorate. Indirect costs include common administrative services for NSERC, such as Human Resources, Finance and Awards, IT, etc. Both direct and indirect costs are included in the total calculation of costs and estimated using the ratio of total CCAR awards to total NSERC grant funds.

As per Table 7, the average ratio of administrative expenditures for every \$1 of grants expenditures between fiscal years 2012-13 to 2015-16 was 4.45 cents. This is slightly lower than the ratio of administrative expenditures for NSERC's Research Grants and Scholarships (RGS) Directorate²⁷, which was 4.93 cents for every dollar spent during the same period. The lower ratio of administrative expenditures for CCAR may be attributed to the size of the grants (i.e. approximately \$5 million per grant), which is higher than the average grant distributed by the RGS Directorate

Table 7. Operating expenditures for CCAR grants between 2012-13 to 2015-16

Fiscal Year	Grant Expenditures	Administrative Expenditures	Total Administrative and Grant Expenditures	Administrative Expenditures per \$1 of Grant Expenditures	Administrative Expenditures (% of Total Cost)
2012-13	\$4,373,568	\$235,307	\$4,599,446	¢5.38	5.1%
2013-14	\$5,251,544	\$247,107	\$5,485,499	¢4.71	4.5%
2014-15	\$6,636,934	\$269,579	\$6,894,714	¢4.06	3.9%
2015-16	\$7,934,992	\$291,228	\$8,219,172	¢3.67	3.5%
Total	\$24,197,038	\$1,043,220	\$25,240,258	¢4.45	4.3%

Source: Finance and Awards Administration Division, NSERC

7.1 Areas for Improvement

Network Approach

Overall, network PIs and members appear to be satisfied with CCAR including: the size and duration of the grants; the flexibility with which funds may be allocated across the network; and, the requirement of collaborations between university researchers and federal government scientists. The majority of case study participants and C&C survey respondents also support the CCAR model of funding large-scale research networks as they facilitate large volumes of research and significant contributions to the broader research community. There is, however, concern among network members that by only funding large-scale networks the CCAR initiative will miss opportunities to support fundamental research regarding new or emerging issues that arise after the networks are in place. In particular, it was noted that despite the flexibility with which CCAR funds may be allocated across networks to support the achievement of expected results, once the funds are allocated and the resulting activities commence the funds cannot be reallocated to address any emerging research issues and/or events that may arise during the five year funding period. This poses a challenge for researchers working in the dynamic fields of climate change and atmospheric processes as situations may arise that require immediate

²⁷ CCAR is housed within the RGS Directorate.

attention because they may have significant and even possibly negative impacts on the environment and/or society.

To address this challenge it was suggested by case study participants that NSERC consider funding small research projects in addition to large-scale networks²⁸ by applying a staggered call for proposals. They anticipate that expanding the funding model to include small projects will enable researchers to quickly engage in short-term and targeted research to address new/emerging issues and/or events that may arise in the fields of climate change and atmospheric processes. Additionally, having a staggered call for proposals was perceived important for the climate change and atmospheric research community as it would provide researchers with opportunities to improve their proposals and re-apply and/or for new researchers in the field to apply. It was further suggested that these projects could involve collaborations with federal government scientists and/or other appropriate end-users to facilitate the use of the knowledge and/or products generated by these projects. The majority of C&C survey respondents (87%) support the notion of funding smaller, collaborative research projects in addition to networks.

Performance Data

There were some issues with the consistency of performance information provided by CCAR-funded networks through their annual progress reports. While all networks provided the required performance information, the amount of information and manner in which it was presented varied from one network to another. Additionally, it was challenging to draw out specific, quantitative information from these reports, such as the number of outputs produced or HQP trained by the network. This difficulty is primarily a result of the format of the reports, which are solely comprised of open-ended questions.

8 Recommendations

- 1. The federal government continues to fund fundamental research in climate change and atmospheric processes through NSERC's CCAR initiative, as long as these areas remain priorities for the federal government.** CCAR is currently the only source of large-scale research funding available to academic climate change and atmospheric researchers working in Canada. Continued CCAR funding would reinforce a Canada's capacity to conduct important research in these areas, and continued opportunities to train the next generation of highly qualified personnel in the fields of climate change and atmospheric processes. Sustained support for CCAR will build on the science base to inform decision-making, protect the health and well-being of Canadians, build resilience particularly in Northern and Indigenous communities, and enhance competitiveness in key economic

²⁸ Many case study participants specifically mentioned that they would like NSERC to consider adopting the funding model used by the Canadian Foundation for Climate and Atmospheric Sciences (CFCAS), which was the main funding body for university-based research on climate change from 2000 until 2010. The CFCAS funded both networks and projects and was considered by some members of CCAR-funded networks as a successful funding model.

sectors. It will also allow movement into new climate-related research areas, as well as maintenance and enhancement of long-term research initiatives.

- 2. Maintain the requirement that collaborations involve active research participation of scientists from at least one federal government department.** Collaboration among university researchers and federal government scientists is an essential component of the CCAR initiative and a key factor contributing to network success. By requiring such collaborations the CCAR initiative is perceived as reducing the research gap between academia and the federal government and supporting the sharing of expertise, as well as physical and human resources. Moreover, it is anticipated that these collaborations will facilitate the transfer of knowledge to and within federal government departments. In addition to the collaborations between university researchers and federal government scientists it is important to recognize the positive impact of other forms of collaborations within the CCAR-funded networks, particularly multidisciplinary collaborations and collaborations with international researchers. Such collaborations are important as research questions related to climate change and/or atmospheric processes are complex and rarely apply solely to one discipline or country. Consequently, the CCAR initiative should also continue to encourage these other forms of collaboration within funded networks.

- 3. Consider expanding the funding model of the CCAR initiative to include large networks and small research projects.** Large networks are valuable to address “big science” research questions with a focused objective as they increase the scale and scope of the outputs produced. There are, however, drawbacks to large networks including a lack of flexibility to respond to emerging research questions and difficulties adapting to changing needs within the research community. This is primarily because network financial and human resources are already committed to ongoing research projects. Funding small projects is anticipated to mitigate some of these challenges by enabling researchers to quickly engage in short-term and targeted research to address new/emerging issues and/or events that may arise. It is anticipated that these research projects will also support national research priorities and generate knowledge that will be transferred to the federal government and other potential end-users for the benefit of Canada. The expansion of the CCAR initiative’s funding model is supported by the majority of members of the current CCAR-funded networks.

CCAR management may want to consider developing a performance measurement strategy, as well as revising to their reporting templates. As outlined in the new Policy on Results, federal government departments must demonstrate the achievement of results including outputs and outcomes. Defining and measuring the long-term scientific outcomes of the CCAR initiative and their indicators is a challenge; however, as funded networks are examining complex issues and these outcomes are not anticipated to transpire for many years. This process may be facilitated by using a working group approach and engaging federal government scientists involved with CCAR-funded networks to think strategically in terms of defining the key scientific outcomes of CCAR and how to measure the achievement of these outcomes. Moreover, adding closed-ended questions to the reporting templates will help increase the clarity and availability of performance information regarding the CCAR initiative, while still allowing the Principal Investigators (PIs) to highlight some of the unique attributes of and research generated by their network in response to the open-ended questions.

Appendix A: Location of CCAR-Funded Networks Across Canada

CCAR Networks distribution in Canada

NETCARE - Network on Climate and Aerosols: Addressing Key Uncertainties in Remote Canadian Environments To implement comprehensive measurements and supporting modelling activities focusing on carbonaceous aerosols, role of the ocean, and formation of ice clouds; as well as assessing the climate impact of these aerosols on remote Canadian environments.

GEOTRACES- Biogeochemical and tracer study of a rapidly changing Arctic Ocean To understand the large-scale oceanic distribution, biogeochemical cycles and climate-sensitivity of selected Trace Elements and isotopes that regulate or serve as tracers for critical biogeochemical and physical processes. It is the Canadian contribution to the GEOTRACES International program.

CNRCWP - Canadian Network for Regional Climate and Weather Processes. To reduce uncertainty in numerical weather prediction and climate projection systems for Canada's Northern and Arctic regions by improving our understanding of climate processes and interactions in these regions using a Regional Earth System Model approach

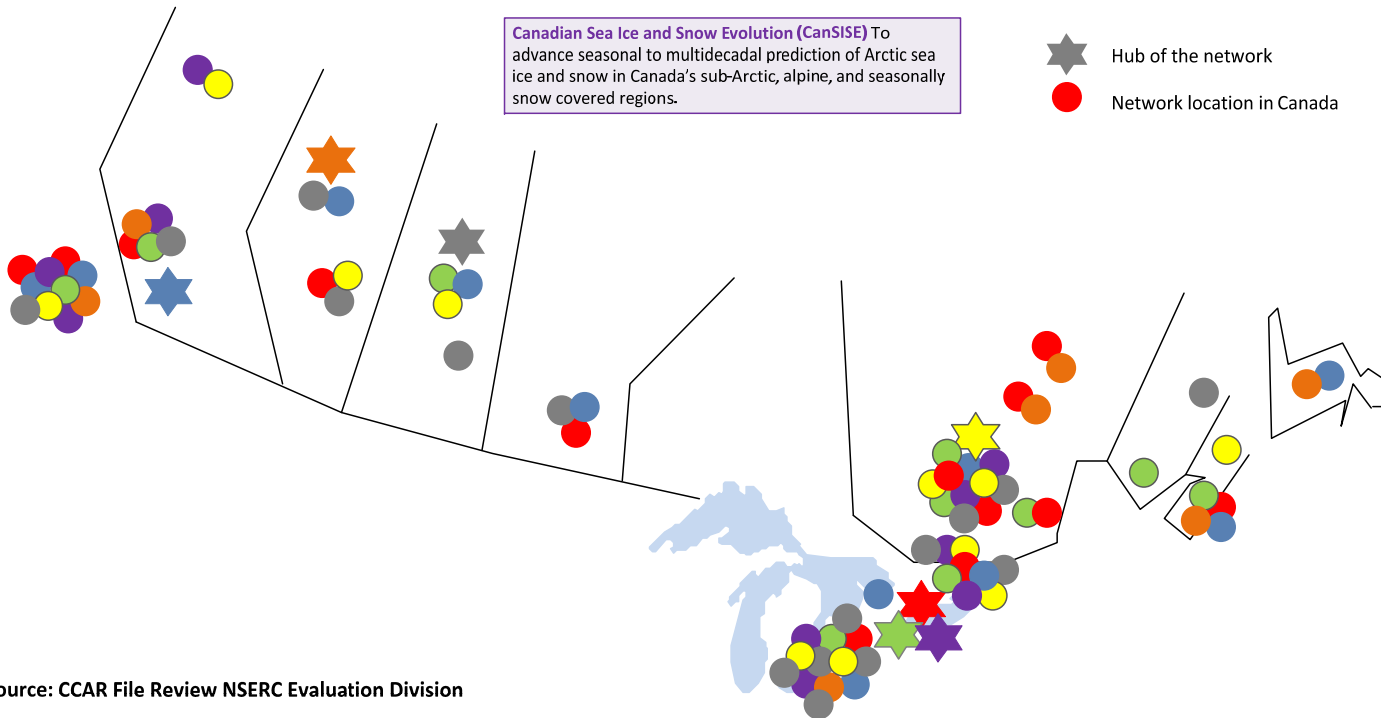
Ventilation, Interactions and Transports Across the Labrador Sea (VITALS) The goal of this network is to understand and model the functioning and vulnerability of the Labrador Sea as a key component of the earth's climate system, including its uptake of oxygen, anthropogenic carbon, and exchange of heat with the atmosphere.

Changing Cold Regions Network (CCRN) To understand and address the changing climate of Western Canada's cold interior. This cold interior is found East of the Continental Divide and has one of the world's most extreme and variable climates and is experiencing rapid environmental change.

PEARL - Polar Environment Atmospheric Research Laboratory To provide a unique Canadian data source to study changes in the Arctic atmosphere and to assess their impact on the Arctic, Canada and the entire planet.

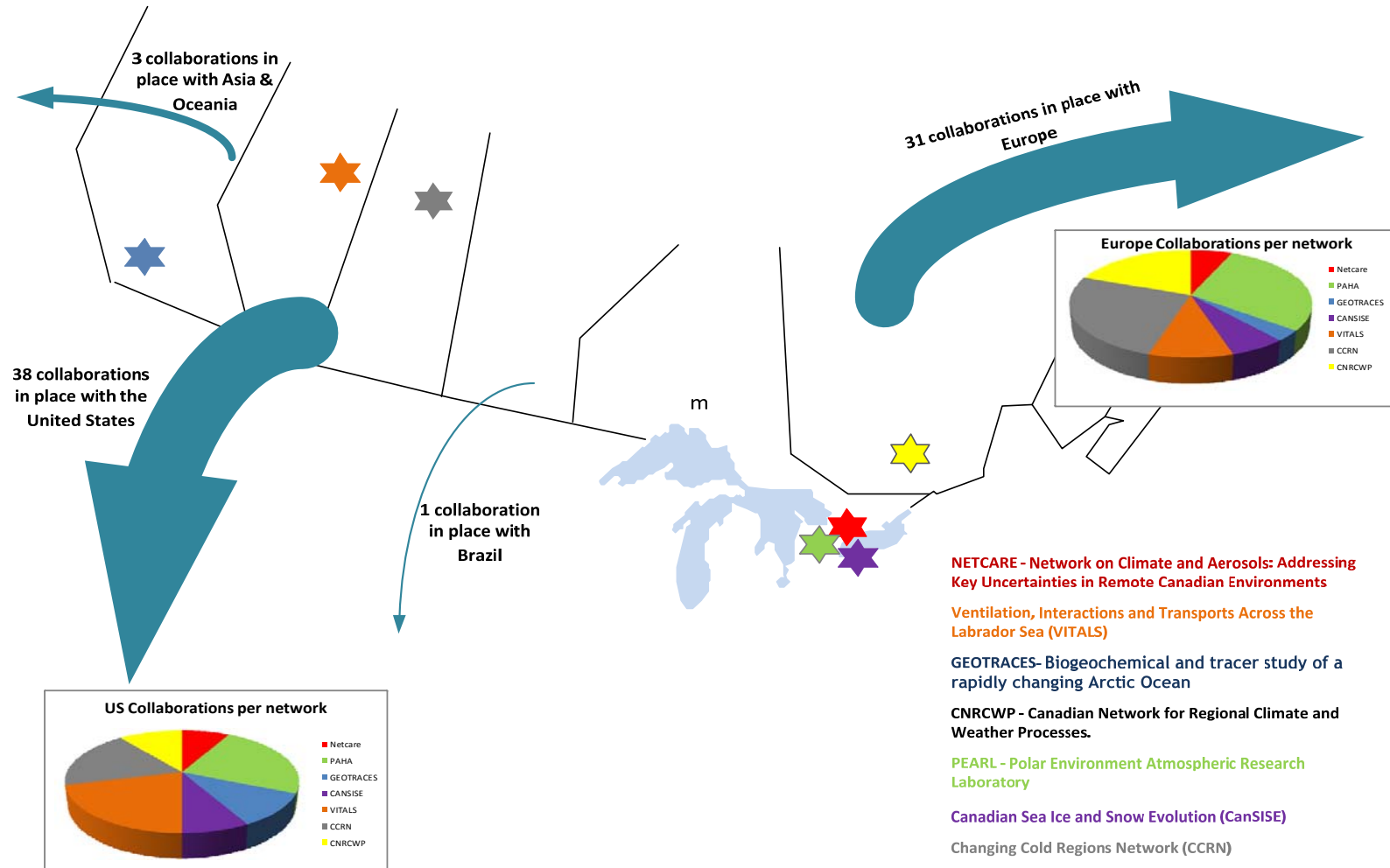
Canadian Sea Ice and Snow Evolution (CansISE) To advance seasonal to multidecadal prediction of Arctic sea ice and snow in Canada's sub-Arctic, alpine, and seasonally snow covered regions.

★ Hub of the network
● Network location in Canada



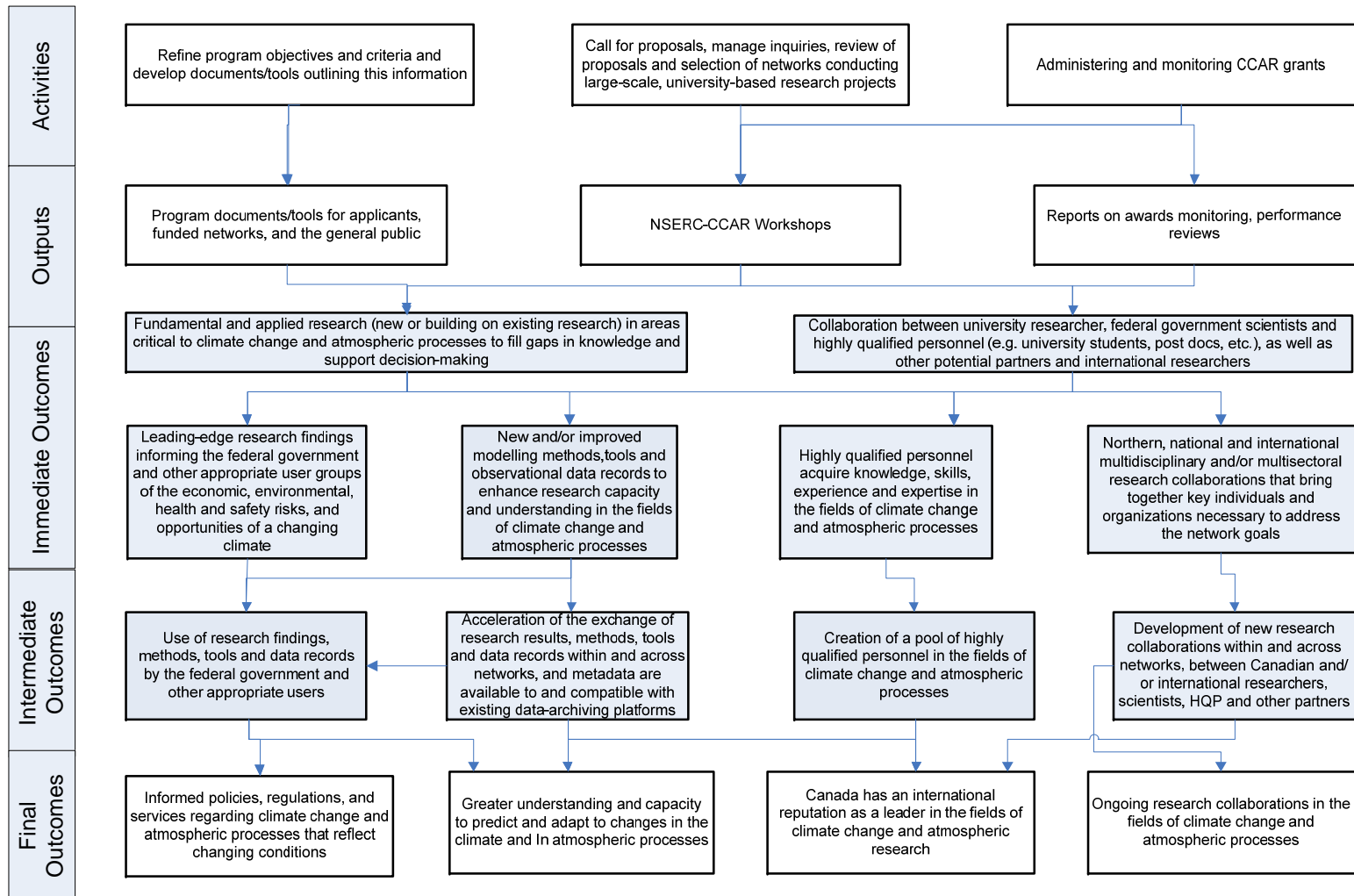
Source: CCAR File Review NSERC Evaluation Division

Appendix B: Location of International Collaborations



Source: CCAR File Review

Appendix C: CCAR Logic Model



Appendix D: CCAR Evaluation Matrix

Question	Indicator	Team	Admin data	Lit/Doc review	File review	Case studies	Survey	KI interviews
<i>Relevance</i>								
1. Is there a continued need for the CCAR initiative in light of the current context?	Evidence that there is a need for research in the fields of climate change and atmospheric processes			✓	✓			✓
	Extent of alignment between the objectives of the CCAR initiative and perceived knowledge production/research needs of the federal government and/or other appropriate end-users				✓	✓		✓
	Extent to which the network would exist in the absence of CCAR funding (i.e. which elements of the network would not be possible without CCAR funding).			✓	✓	✓		
	Description of similar funding sources available for research in the fields of climate change and atmospheric processes			✓	✓	✓		✓
2. To what extent are the objectives of the CCAR initiative consistent with federal government priorities and NSERC strategic outcomes?	Extent of alignment between the objectives of the CCAR initiative and federal government priorities			✓				✓
	Extent of alignment between the objectives of the CCAR initiative and NSERC's strategic outcomes			✓				✓

Question	Indicator	Team	Admin data	Lit/Doc review	File review	Case studies	Survey	KI interviews
3. To what extent is providing the CCAR initiative funding an appropriate role for the federal government?	Description of the federal government's responsibility for providing funding (including division between federal and provincial/territorial responsibilities) for research in the fields of climate change and atmospheric processes			✓				✓
	Description of federal government's historical involvement in funding research in the fields of climate change and atmospheric processes			✓				
Performance: Progress towards outcomes								
4. To what extent is the CCAR initiative contributing to knowledge transfer and the use of research findings, methods, tools and/or data records by the federal government and other appropriate end-users?	# and description of research outputs produced by the networks (by type of output and each network)				✓	✓		
	Perceptions on the quality of the research outputs generated by the networks (i.e. what is the value-added).				✓	✓	✓	✓
	# and description of knowledge transfer strategies used by the networks currently and planned for the future (i.e. are there steps in place for KT and/or to support future KT).				✓	✓	✓	
	Perceptions regarding the quality of the knowledge transfer strategies used by networks, including which are working well and which require improvement.				✓	✓	✓	
	Description of the ways in which the knowledge and/or products produced by the networks are being used and/or are expected to be used by the federal government and other end-users.				✓	✓	✓	

Question	Indicator	Team	Admin data	Lit/Doc review	File review	Case studies	Survey	KI interviews
	Description of knowledge transfer success/hindrance factors (lessons learned)				✓	✓	✓	
5. To what extent is the CCAR initiative contributing to strengthened research capacity?	# and description of new and/or improved knowledge and/or products (i.e. methods, tools and/or observational records, etc.) produced by the networks				✓	✓	✓	
	Perceptions on the quality of the knowledge and/or products, i.e. methods, tools and/or observational records, etc., produced by the networks (i.e. what is the value-added).				✓	✓	✓	✓
	# of northern, national, international, multidisciplinary and/or multi-sectoral collaborations (by network).				✓	✓	✓	
	Description of the nature of collaborations, including whether they existed prior to the CCAR network				✓	✓	✓	
	Perceptions regarding the extent to which capacity development is not/ would not be possible without the CCAR initiative				✓	✓		
	Description of research capacity development success/hindrance factors				✓	✓	✓	
6. To what extent is the CCAR initiative contributing to developing a pool of highly qualified personnel in the fields	# of HQP involved in the CCAR initiative (by HQP type and network)				✓			
	% of funds spent on HQP (by type) by each network and the CCAR initiative as a whole.		✓		✓			
	Description of training/experience provided to the HQP				✓	✓	✓	

Question	Indicator	Team	Admin data	Lit/Doc review	File review	Case studies	Survey	KI interviews
of climate change and atmospheric processes	# and type of HQP research outputs (e.g., publications, conference presentations, etc.)				✓	✓	✓	
	Perceptions of the extent of knowledge and skill development				✓	✓	✓	
	Perceptions of quality of training experience					✓	✓	
	#/% of HQP pursuing further education during/following their involvement with a network				✓	✓	✓	
	#/% of HQP pursuing employed during/following their involvement with a network (by sector)				✓	✓	✓	
	Perceptions of the extent to which working for a network contributed to further opportunities (i.e. education and/or employment).					✓	✓	
	Description of student employment success/hindrance factors					✓	✓	
<i>Design & Delivery</i>								
7. To what extent are efficient and effective means being used to deliver the program?	Aspects of the CCAR initiative that support the achievement of expected outcomes				✓	✓		✓
	Aspects of the CCAR initiative that are barriers to the achievement of expected outcomes				✓	✓		✓
	Extent to which the network approach supports the achievement of the CCAR objectives			✓	✓	✓	✓	✓

Question	Indicator	Team	Admin data	Lit/Doc review	File review	Case studies	Survey	KI interviews
	Extent to which networks are implementing/implemented effective practices to achieve expected outcomes				✓	✓		✓
<i>Performance – Efficiency and Economy: Resource utilization in relation to the production of outputs and progress toward expected outcomes</i>								
8. To what extent is the CCAR initiative delivered in a cost-efficient manner?	Ratio of administrative costs to grant funding for the CCAR initiative and comparable programs		✓					
	Ratio of non-monetary costs (e.g., volunteer and applicant time) to grant funding for the CCAR initiative and comparable programs		✓					
	Opportunities to minimize cost to stakeholders (money and time) while maintaining quality		✓					✓

Appendix E: Methodology

The seven lines of inquiry used to conduct the evaluation of the CCAR initiative, and the team members involved in each one are described in the table below.

Line of Inquiry²⁹	Team Members
<i>Literature & Document Review (32 documents)</i>	
<p>The literature review provided context for the evaluation and contributed to answering evaluation questions pertaining to relevance, as well as design and delivery. The review included 18 internal government documents and 14 external documents, regarding the impact of changes in the climate and atmosphere, the importance of conducting research regarding climate change and atmospheric processes and other sources of federal government funding for research and/or activities related to climate change.</p>	Evaluation Division
<i>File Review</i>	
<p>The file review provided evidence regarding the design and delivery of the CCAR initiative and the progress of funded networks. The review focused on the applications for funding and annual progress reports, as well as the feedback received from the peer-review of the progress reports.</p>	Evaluation Division
<i>Case Studies with all CCAR-funded networks</i>	
<p>The case studies gathered in-depth evidence regarding the relevance, as well as the design and delivery of the CCAR initiative. The case studies also provided evidence and examples of the performance of the seven CCAR-funded networks.</p> <p>Each case study included a document review, as well as interviews with a minimum of seven network members including the PI, university researchers, federal government scientist, HQP and when possible other end-users of the knowledge and/or products generated by the network. The evaluation team also conducted site visits for all seven case studies, several of which included attendance at a network meeting or event.</p>	Evaluation Division/ Alderson-Gill & Associates
<i>Survey of Co-Investigators and Collaborators (n = 83; 45% response rate)</i>	
<p>The survey of co-investigators and collaborators involved with CCAR-funded networks provided a broader range of network members, including university researchers, federal government scientists and other end-users with the opportunity to provide information about their experience with CCAR and their network, including design, delivery and perceived impact. It was determined that the survey sample would include all of the co-investigators and collaborators for each network, with the exception of those individuals</p>	Evaluation Division

²⁹ For more information on the methodology for each line of inquiry please consult the respective technical reports.

<p>that participated in the case studies.</p> <p>Ultimately, 184 co-investigators and collaborators were invited to participate in the survey and 83 responded.</p>	
<i>Surveys with Highly Qualified Personnel (n = 139; 38% response rate)</i>	
<p>Results from the surveys with HQP provided information regarding their experience with the networks and helped answer the evaluation questions regarding the design and delivery, as well as the performance of the CCAR initiative. It was determined that the survey sample would include all of the HQP for each network, with the exception of those individuals that participated in the case studies.</p> <p>Ultimately, 370 HQP were invited to participate in the survey and 139 responded.</p>	Evaluation Division
<i>Key Informant Interviews (n = 10; 83% response rate)</i>	
<p>The purpose of the key informant interviews was to acquire a strategic perspective regarding the relevance of CCAR funding in Canada including the importance of funding fundamental research in the fields of climate change and atmospheric processes and of collaborations between academia and the public sector. These interviews also provided information regarding the design and delivery of CCAR and of the networks funded.</p> <p>Ten interviews were conducted with three stakeholder groups including: NSERC management and staff; selection committee members and representatives from other federal government departments.</p>	Evaluation Division
<i>Cost-Efficiency Analysis</i>	
<p>This line of inquiry determined if CCAR was delivered efficiently and whether economy was achieved. Given the timing of the evaluation, the most recent complete set of financial data covered the fiscal years 2012-2013 until 2015-2016. The data for this analysis were provided by the NSERC-SSHRC Finance and Awards Administration Division.</p> <p>The analysis examined total administrative expenditures relative to grant expenditures for the PromoScience funding opportunity and results were compared to the cost-efficiency analyses for the NSERC's Research Partnerships, and Research Grants and Scholarships Directorates.</p>	Evaluation Division

Appendix F: Other Federal Government Funding Programs/Initiatives to Address Climate Change

ECCC and NRCan are the main federal government departments tasked with addressing climate change in Canada. The table below identifies existing funding programs and initiatives delivered by these departments to support research and other efforts towards this end. ECCC's Clean Air Agenda however, is not included in this list as the initiative ended in March, 2016.³⁰³¹

Funding Program/Initiative	Description
<i>Environment and Climate Change Canada (ECCC)</i>	
2016–2019 Federal Sustainable Development Strategy	<ul style="list-style-type: none"> The 2016–2019 Federal Sustainable Development Strategy outlines federal government action to create a sustainable economy, protect the environment and enhance Canadians' well-being for the next three years. Its main intent is to support engaging Canadians on their views on what a sustainable Canada looks like, what environmental sustainability targets we should aim for, and how we can best measure and report on them. The Strategy aims to make environmental decision-making more transparent and accountable to Parliament. <p>http://fsds-sfdd.ca/index.html#/en/intro/</p>
Clean Air Agenda	<ul style="list-style-type: none"> A \$1.9 billion federal government initiative from 2007–2016 to fund over 40 federal programs to reduce greenhouse gas emissions and air pollutants. Out of this total funding amount, \$85.9 million was allocated to six programs to help Canadians increase their capacity to adapt to a changing climate. The federal partners are: Environment and Climate Change Canada, Fisheries and Oceans Canada, Global Affairs Canada, Health Canada, Indigenous and Northern Affairs Canada, National Research Council Canada, Natural Resources Canada, Parks Canada, Public Health Agency of Canada, Standards Council of Canada, and Transport Canada. <p>https://www.ec.gc.ca/ae-ve/default.asp?lang=En&n=DD5BE1B8-1#sec5</p>
Research Activities on climate system and climate change	<ul style="list-style-type: none"> Environment Canada is a national focal point for Canadian research on the climate system and the science of climate change. Our scientists investigate Canada's past, present and future climate to determine how our climate is changing, as well as the causes and effects of this change. In addition, we develop the science needed to understand the impacts of climate change on Canada, and how we can adapt to these changes.

³⁰ The Clean Air Agenda: Lead department: Environment Canada, Lead department program activity: PA3.2 and PA2.1 Start date: Announced in Budget 2011, End date: March 31st, 2016. Total federal funding allocation (start to end date): \$ 1,519.62 million, <https://www.tbs-sct.gc.ca/hidb-bdih/initiative-eng.aspx?Hi=12>

³¹ Environment and Climate Change Canada (2016). Evaluation of Canada's Clean Air Regulatory Agenda (CARA), <https://www.ec.gc.ca/ae-ve/default.asp?lang=En&n=DD5BE1B8-1#sec5>

	<ul style="list-style-type: none"> - Canadian Greenhouse Gas Measurement Program - Adjusted and Homogenized Canadian Climate Data (AHCCD) - Canadian Centre for Climate Modeling and Analysis (CCCma) - Climate Trends and Variations Bulletin (CTVB) - Intergovernmental Panel on Climate Change (IPCC) - Literature Reviews for Climate Change Science - Cold Climate Processes and Cryosphere <p>https://www.ec.gc.ca/sc-cs/default.asp?lang=En&n=DE007646-1</p>
Various Funding Programs	<ul style="list-style-type: none"> • Community Action Programs for the Environment <ul style="list-style-type: none"> - Aboriginal Fund for Species at Risk - Community Interaction Program - St. Lawrence Action Plan - EcoAction Community Funding Program - Environmental Damages Fund - Great Lakes Sustainability Fund - Habitat Stewardship Program for Species at Risk - Lake Simcoe/South-eastern Georgian Bay Clean-Up Fund - Lake Winnipeg Basin Stewardship Fund - National Wetland Conservation Fund - Gulf of Maine Initiative - Atlantic Ecosystems Initiatives - Employment Programs - Science Horizons Youth Internship Program <p>https://www.ec.gc.ca/financement-funding/default.asp?lang=En&n=923047A0-1</p>
Natural Resources Canada (NRCan)	
Climate Change Geoscience Program	<ul style="list-style-type: none"> • There is considerable potential for development of natural resources (minerals and oil & gas) in northern Canada. A changing climate has the potential to affect terrain and coastline stability, thus affecting critical infrastructure and communities. Sound geoscience information will help reduce the uncertainties associated with development of critical infrastructure for the resource industries. This will positively affect investment in northern resource development. The Earth Science Sector's Climate Change Geoscience Program (CCGP) is focused on developing geoscience information to help land-use planners, industry and regulators mitigate the risks in northern resource development arising from climate change. • The program has three projects. The Land-based Infrastructure project is focused on regions with existing road and airport infrastructure and is undertaking terrestrial terrain characterization, mapping and assessment of climate change susceptibility. The Coastal Infrastructure project is carrying out northern coastline characterization, mapping and assessment with focus on regions with existing and potential coastal infrastructure. The Essential Climate Variables project is monitoring and assessing key components of the climate system, including glacier mass balance,

	<p>permafrost, and snow cover.</p> <ul style="list-style-type: none"> • Researchers in the program collaborate nationally and internationally with other federal government departments, provincial and territorial agencies, academia and industry to improve geoscience knowledge and ensure that it is used to mitigate the risks to responsible northern resource development that arise from climate change. Through its monitoring of selected components of the climate system, the program also contributes to international initiatives to understand the Earth's changing climate. <p>http://www.nrcan.gc.ca/earth-sciences/resources/federal-programs/climate-change-geoscience-program/10900</p>
Environmental Geoscience Program	<ul style="list-style-type: none"> • The ESS Environmental Geoscience Program (2009-2014) generates innovative geoscience knowledge and remote sensing applications to address the environmental risks, impacts and constraints associated with the development of Canada's conventional and emerging energy and mineral resources. Research activities focus on issues of strategic importance to Canadians, including the oil sands, shale gas, metal mines, northern pipelines, offshore renewable energy, and carbon capture and storage. • These studies support responsible resource development by providing geoenvironmental baseline data and new geoscience information to strengthen environmental assessments and stewardship. Improved understanding of baseline conditions and processes allows decision-makers to assess the incremental or cumulative risks from proposed resource development projects, and to specify fair and appropriate standards for final site restoration. Research under the Environmental Geoscience Program also leads to the development of new tools to distinguish between natural and industry-related sources of metals and organic contaminants, and provides novel methods to monitor and manage the environmental effects of natural resource development. These tools will result in more robust characterization of the true risks associated with mineral and energy development, and lead to more efficient and cost-effective environmental management. • Environmental geoscience research at ESS is conducted in close collaboration with partners from NRCan, academia, industry, and other federal, provincial, and territorial government departments. These interdisciplinary and multi-stakeholder partnerships lead to a more comprehensive understanding of complex environmental systems, and help to ensure that project results are shared directly with risk assessors, environmental managers, and government regulators. Studies carried out through the Environmental Geoscience Program are helping to improve the quality of Canada's environmental regulations and performance, and are providing publically accessible geoscience information in support of decision-making. • An evaluation of the program was conducted in 2011 http://www.nrcan.gc.ca/evaluation/reports/2011/820

	<p>http://www.nrcan.gc.ca/earth-sciences/resources/federal-programs/environmental-geoscience/10902</p>
<p>Helping Canadians Adapt to Climate Change</p>	<ul style="list-style-type: none"> • The Government of Canada is helping Canadians adapt to the challenges posed by climate change. Adaptation involves making adjustments in our decisions, activities, and thinking because of observed or expected changes in climate, in order to reduce harm or take advantage of new opportunities. • Adaptation actions can be in anticipation of, or in response to the impacts of a changing climate. Examples of adaptation measures include the development of more stringent building standards for areas where heavier snowfall is expected, or limiting development in coastal areas where sea level is projected to rise. By making informed decisions, we will be able to avoid certain costs associated with climate change. • Canada has invested significantly in federal adaptation programs. This funding will allow the Government of Canada to provide credible, scientifically-sound information to support adaptation planning and decision-making. • In addition, the Federal Adaptation Policy Framework will help the Government take account of climate risks as decisions are made on a wide range of programs and activities that support the well-being of Canadians. It will help bring climate change issues into the mainstream of federal decision-making and help guide federal priorities to address climate risks in the future. • Evaluation released in 2015: Evaluation Report: Climate Change Adaptation Sub-Program confirm the need for knowledge production http://www.nrcan.gc.ca/evaluation/reports/2015/18140#a31 <p>http://www.climatechange.gc.ca/default.asp?lang=En&n=2B2A953E-1</p>
<p>Remote Sensing Science Program</p>	<ul style="list-style-type: none"> • The Remote Sensing Science program provides a foundation of scientific expertise that is key to rendering satellite data useful to the Government of Canada. • The program encompasses experts in remote sensing technology, satellite signals, data methodologies, and the development of value-added image products, information, applications and services. Canada Centre for Remote Sensing scientists within RSS work in partnership with many other departments, as well as with academia, private sector and international collaborators. • In addition to transforming data from existing satellite sensors, the RSS program also focuses on the development of next-generation satellite sensors, and the scientific preparations for effectively and immediate use of data from sensors that will be launched shortly. <p>http://www.nrcan.gc.ca/earth-sciences/geomatics/satellite-imagery-air-photos/federal-programs/10986</p>

Appendix G: References

- American Meteorological Society (2014). *Earth's Climate as a Dynamic System in Our Changing Climate: An Introduction to Climate Science*. Retrieved from: <https://www.ametsoc.org/ams/index.cfm/education-careers/education-program/undergraduate-faculty/climate-studies/course-components/textbook/climate-chap1/>
- Lemmen, D.S., Warren, F.J., and Lacroix, J., & Bush, E. (Eds) (2008). *From Impacts to Adaptation: Canada in a Changing Climate 2007*. Ottawa: Government of Canada. Retrieved from: <http://www.nrcan.gc.ca/environment/resources/publications/impacts-adaptation/reports/assessments/2008/10253>
- NSERC, (2016). Report on Plans and Priorities – 2016-17. Retrieved from: http://www.nserc-crsng.gc.ca/NSERC-CRSNG/Reports-Rapports/RPP-PPR/2016-2017/index_eng.asp
- Office of the Auditor General, Canada. (2010). *Adapting to Climate Impacts in 2010 Fall Report of the Commissioner of the Environment and Sustainable Development*. Retrieved from: http://www.oag-bvg.gc.ca/internet/English/parl_cesd_201012_03_e_34426.html.
- Office of the Auditor General of Canada, (2014). *Opening Statement to the Senate Standing Committee on Energy, Environment, and Natural Resources*. Retrieved from: http://www.oag-bvg.gc.ca/internet/English/oss_20141202_e_40004.html
- Séguin J., (ed.). (2008). *Human Health in a Changing Climate: A Canadian Assessment of Vulnerabilities and Adaptive Capacity*. Ottawa: Health Canada. Retrieved from: <http://www.2degreesc.com/Files/CCandHealth.pdf>