ARRCU Strategic Plan Focus Paper: Academic-Government Partnerships in Atmosphere-Related Research

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Abstract

Introduction

This focus paper on academic-government partnership in atmosphere-related research (ARR) represents part of the strategic plan of the working group on Atmosphere-Related

Research in Canadian Universities (ARRCU).[1] The overarching purpose of this strategic plan is *to configure university-based ARR to most benefit Canada in a time of rapid environmental and socio-economic change*. The specific aims of the strategic plan are:

- To build university-based research capacity and excellence;
- To make university partnerships with government and industry more effective;
- To improve the sustainability of fundamental research support in ARR; and
- To enhance our community's efforts in education, training, and engagement with the broader Canadian public.

This focus paper will be the first of a series that will also cover academic-industry partnerships as well as education/training and related topics. This strategic planning effort will take place in 2017-2018, will produce a single document covering this series of topics, and is intended to be relevant to our activities over a *strategic planning horizon* of five to seven years.

The co-authors of this focus paper are University and federal government colleagues working in ARR who believe it is important to increase the effectiveness of our partnerships through long-range planning.[2] While universities are already engaged with government in many aspects of Canadian ARR, strategic planning of this nature will increase the effectiveness of our partnership and will remove barriers between our research efforts. This paper is intended to communicate with our research colleagues across all sectors, our university leadership, and decision makers.

Academic-government collaborations occur in many areas of ARR: development, validation, and use of observational and computing infrastructure; research involving field campaigns, modeling and data analysis; and education, training, internships, and professional development. In this paper, we will first address the general framework of Academic-government research partnerships (see next section), including research priorities identified by government agencies and mechanisms for the support of these priorities. The subsequent sections will discuss research infrastructure, international partnerships, and academic-government collaboration in education and training. Then, we will consider

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[1] ARRCU comprises Canadian university faculty working in weather, climate, and air quality under the general framework of atmosphere-related research (ARR). For an introduction to ARRCU, please see Kushner et al. (October 2016, *CMOS Bulletin*), and for a more in-depth discussion see our White Paper posted on the website www.ARRCU.ca.

[2] The co-authors of this document comprise the ARRCU Academic-Government Partnerships Committee, which was struck by the ARRCU Working Group Committee in September 2016. Our focus for this round of planning is exclusively in the domain of partnerships between universities and federal government agencies, where a history of collaboration exists and where university networks that cross provincial boundaries can be developed.

community organization to enhance partnership, including a proposal for a joint academic-government advisory body [tentatively named the *Panel for ARR in Canada* (PARRC)], and efforts to organize information about academic capacity in Canadian ARR. We will conclude with a summary of recommendations and next steps. Additional information relevant to our planning process are included in the Appendixes. Many of the details of planning, including mechanisms for partnerships, infrastructure, international programs, and education/training fall outside the scope of this focus paper. Our proposal to set up PARRC will provide a mechanism to continue our planning on an ongoing basis. We will conclude with a discussion of next steps and recommendations.

This paper summarizes input from consultation with the Canadian ARR community that has included workshops, video conferences, and extensive email communication (see the ARRCU.ca website for documents[3]). As was the case for the White Paper, general agreement by the academic community about the perspective set forth here will be demonstrated by consent of individual university faculty to be signatories to it. It is understood that coauthors from government agencies [currently Environment and Climate Change Canada (ECCC), the Natural Science and Engineering Research Council (NSERC), and Canadian Space Agency (CSA)] represent the institutional view of their agencies.[4] Viewpoints expressed here are advisory and not binding; they do not commit coauthors, institutions, or signatories to any specific action.

Academic-Government Research Partnerships

Priority areas for academic-government partnership

The mandates of several federal government agencies require input from ARR taking place in universities and industry in addition to the ARR taking place within the government itself. These agencies include, for example, ECCC, the Department of Fisheries and Oceans (DFO), Natural Resources Canada (NRCan), Agriculture Canada (AgCan), Department of Defense (DoD), and the National Research Council (NRC).[5] In this section we outline the range of ARR priorities of interest to the GoC. This outline (see Figure 1) is not intended to be comprehensive, but representative of some of the important priorities outlined by the parties to this document, and we welcome ideas to extend the list. The Canadian university

[3] Ideas specific to this focus paper were developed through a webinar in November 2016 where the document outline was laid out, a face-to-face workshop discussing a first draft of the document in January 2017, and follow on communications.

[4] Note for January 2017 draft: we will seek additional endorsements or expressions of interest from other federal agencies.

[5] Other agencies like NSERC and CSA serve to support research across government and academia, even if they do not define strategic research priorities themselves. The mandates of such agencies also extend to the areas of industry partnership and education/training, which will be the subject of subsequent focus papers.

community is already actively engaged in many of these areas, or has the immediate capacity to undertake research in them. These areas were identified in the ARRCU White Paper's *Priority Areas for Partnership*[6]. Opportunities will arise that require additional investment and coordination to be realized. These new priorities could include emerging areas of applied or policy concern or significant technological advance anticipated for the strategic planning horizon.

Key applied priorities in which ARR is required that will be undertaken by the Government of Canada (GoC) over the planning horizon are listed in the blue shaded row of Figure 1. They priorities cover areas of predictions and warnings, regulatory reporting, climate sensitive infrastructure, climate resilience, and disaster-risk reduction. The scientific ARR required to support these priorities is listed in the green shaded row in the figure. As in the ARRCU White Paper (see Figure 1 of that document), we emphasize the two-way connection between fundamental and applied research (*Discovery to Application* and *Application to Discovery*).

GoC activities take place within national and international regulatory frameworks, and in particular its science activities are coordinated with international programs where practicable. These aspects will be discussed further in the *International Connections* section.

Mechanisms: Research partnership programs

In order for academic-government research partnerships to be effective, strategic planning needs to take place in the areas of structuring, communication, and evaluation of research support programs and their impact. Details of such planning are beyond the scope of this paper, so we here confine ourselves to addressing some key points. Our proposed PARRC will provide a mechanism to shape partnership programs as opportunities arise.

In Canada, ARR partnerships between government and universities range from smaller projects led by individual or small teams of investigators, with typical budgets of less than $100K/year, to large networks with budgets in the range of $1M/year or more. These projects are supplemented by research infrastructure funded either directly by the project or available as in-kind support through a larger facility (e.g. aircraft or ship time, satellite data, computing or modelling resources). The smaller projects are funded through various mechanisms, such as the NSERC Strategic Projects, Collaborative Research and Development Grants, and the Grants and Contributions programs of individual federal

[6] The ARRCU White Paper's *Priority Areas for Partnership* with universities are: *Prediction*, *Arctic and Cold Regions*, *Regional Climate and Hydroclimate*, *Air Quality*, *Atmosphere-related biogeochemical cycles*, and *Applied Research*. The last category is a catch-all for product and service development activities carried out within universities, for partnership with government and industry.

agencies. The larger projects are typically, although not always, administered by NSERC but supported by contributions from one or more federal agencies. Space-based observational infrastructure projects are typically supported by the CSA. In Appendix A, we provide a review of currently available funding mechanisms in ARR.

Small-project and large-project funding provide distinctive advantages and challenges. Smaller projects (e.g. NSERC Strategic Projects) provide fast turnaround on specific research questions that can lay the groundwork for longer-term scientific advance. They are suitable for higher risk exploration for which the outcomes are more uncertain. Their cumulative impact is perhaps somewhat harder to measure than is the case for large network-type projects. Larger projects and networks [e.g. NSERC Climate Change and Atmospheric Research (CCAR) Networks] allow for comprehensive investigations on broader research or applied areas, or ongoing development of technological capacity. They can be challenging for university faculty to administer and tend to concentrate a large fraction of research resources over long periods of time.

One current example of large network-based partnership is the Climate Change and Atmospheric Research program (CCAR) of NSERC, which funded seven networks at the $1M/y level for 2013-2018. The CCAR program called for partnership between university researchers and federal government departments in areas of 1) understanding Earth system processes and their representation in weather, climate, and atmospheric chemistry models, 2) advancing weather, climate, and environmental prediction, and 3) understanding recent changes in the Arctic and cold region environments. The results of a midterm review of the CCAR program suggests that its partnership model has been successful in advancing GoC priorities.[7] As a result the program is thus under consideration for renewal with a proposed announcement of opportunity in 2017. Other networks … [8]

[7] If the conclusions of the CCAR review are available we can include them in appendix material.

[8] We could insert here a discussion of NCE programs (ArcticNet, MEOPAR, MITACS) or other partnership programs, or leave this for appendixes.

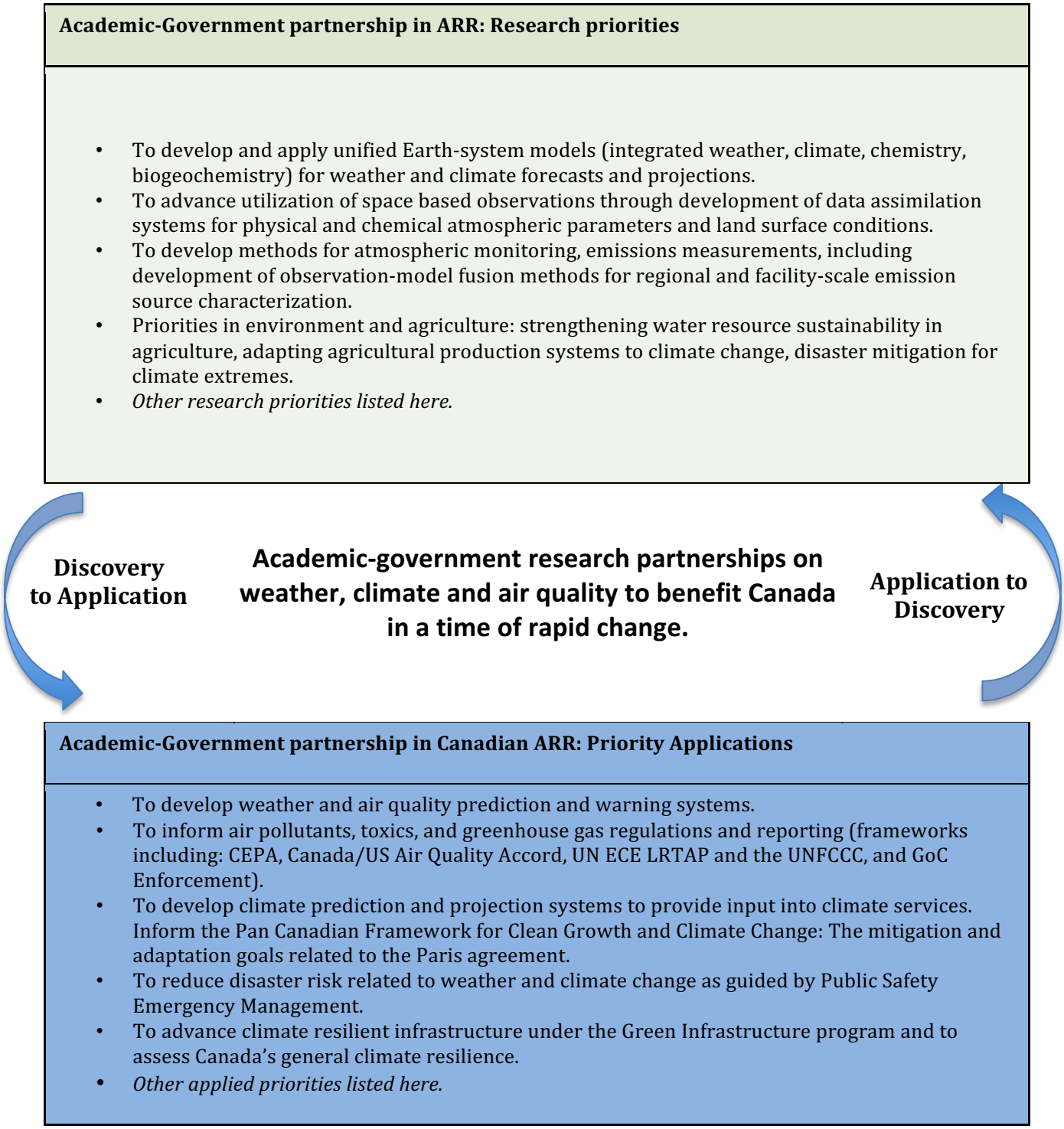

Figure 1: Research Priorities and Priority Applications for Government-Academic Partnerships over the Strategic Planning Horizon

We will undertake to quantify the current range of project partnership funding in our survey (see *Quantifying Capacity* section). Our consultations suggest that a suitable balance of partnership opportunities that encompass small projects and larger networks would best serve the overarching goal of configuring ARR to most benefit Canada. While there continues to be a range of research opportunities available, the ARRCU community has nevertheless noticed a decrease in the availability of small-project partnership support over the last 10-15 years. We thus encourage the support of programs that seed smaller project opportunities in areas that align with GoC priorities.

In addition, effectiveness of academic-government partnerships in ARR could be increased by ensuring that as much funding as possible is made available through open competitive proposal processes open to the entire academic community as potential partners.

To enhance international competitiveness of Canadian ARR, we recommend ensuring that partnership calls are well coordinated with international programs and available on similar timelines to these programs. A past example of a limited window opportunity, for example, is the range of activities leading up to the Year of Polar Prediction (2017-2019). This theme will be further explored in the *International Connections* section.

Finally, our consultations revealed support for reviewing how the current structure and regulations of Federal Tri-Council funding mechanisms impact the efficacy of academic-government partnerships. For example, it would be useful to review the impact of the two-year limitation on the length of postdoctoral fellowships, rules about the location of tenure of HQP being outside government labs given the context of academic-government partnership funding, and the rules for support of research costs related to management and administration of networks.

Overall, *we encourage increased engagement by both the academic and government research community in the design and delivery of partnership programs*, such as CCAR and the NSERC Strategic Projects. It is important that such planning involve those who are directly involved in the research as well as those who make use of its outcomes. Greater engagement by both sides of the partnerships at the design stage will improve everyone's understanding of and commitment to these programs. This, we believe, will enhance the effectiveness and impact of the programs, make them more predictable and consistent, and make them more transparent for purposes of accountability and evaluation.

Key recommendations in the area of partnership priorities and programs:

- Recommendation 1
- Recommendation 2

Partnership in Research Infrastructure

To carry out partnership research within government-academic ARR, strategic planning of partnerships in research infrastructure is required. Such partnerships can include joint

applications to obtain the resources needed to develop and operate the infrastructure, collaboration in using the infrastructure to carry out cutting edge ARR science, and partnerships for maintenance and ever-greening of these facilities and associated resources. The operational lifetime of ARR infrastructure often exceeds that of individual projects (3-5 years) and thus requires a longer planning horizon (5-10 years). The key issue is how to make most effective use of limited resources for infrastructure in ARR to address shared goals.

ARR is a highly interdisciplinary endeavour that rapidly responds to technological development. Thus, the infrastructure needs of ARR are wide ranging. A list of existing infrastructure categories in which partnership will help advanced our shared goals is presented in Table 1, with more details provided in Appendix B.

Table 1: Infrastructure Categories and Examples for Academic-Government Partnerships in Canadian ARR (more details in Appendix B).[9]

Infrastructure Type	**Examples**
Space-based infrastructure for global remote sensing of atmospheric composition and dynamics for process studies, assimilation in models and monitoring trends.	ACE-FTS spectrometer on SCISAT (2003), cloud radar on Cloudsat (2006), radiometer on SMAP (2015), wind lidar on ADM-Aeolus (2017), interferometric radar on SWOT (2021)
Ground-based infrastructure, including unique field stations and distributed observing networks (with consistent sensors).	CCAR CCRN, PEARL/PAHA, CHARS, …
Field campaign infrastructure (instruments, airborne platforms, ships, moorings) – includes deployment platforms and equipment to be deployed. Such equipment will include both equipment deployed for an extended period in the field (e.g. moorings) as well as equipment mounted just for the experiment.	NETCARE, … CSA-CNES stratospheric balloon program
Advanced research computing and other information technology resources, covering hardware, software, and datasets. Hardware includes CPU and mass stores. Software includes models (Earth system models, NWP models, chemical transport and air-quality models), retrieval workflows, analysis software for large complex data sets (e.g. climate, satellite, remote sensing).	Compute Canada resources (SciNet, SHARCNET, WestGrid, etc.), ECCC/DFO/DoD/university models, climate data records from ECCC and NRCan, etc.

[9] This table can be extended, as long as it doesn't exceed about a page. Remaining details can go into Appendix B.

For larger facilities, it is likely the government partners who will operate (or pay to operate) the given infrastructure. But an academic partnership can provide the impetus to support the facility development, and/or provide funds for operation, especially during the lifetime of key projects. In many cases, it may be that one partner provides in-kind contributions while the other provides actual cash, and/or personnel. Examples of successful partnerships of this nature include: *[… here we could insert a list including CANDAC/PAHA, other CCAR programs like NETCARE, GEOTRACES, VITALS, CNRCWP, CanSISE, Compute Canada facilities that are sometimes supplemented by local researchers, etc.]*. These examples show that coordinating with the academic community greatly increases the value of the original infrastructure investment.

Generally speaking, broad community use of infrastructure, ranging from satellite data streams to computing resources, models, etc., is the increasing norm today. This is especially the case in open-source modelling and open access data archives. This has the advantage of a large community working to access infrastructure, data, develop and improve codes. This trend opens the door to significant partnerships, where the academic community works on testing and exploring new approaches that can be used in operational settings. This also facilitates training and the ability for ARR HQP to transition between academia and government. Finally, it ensures that the broadest possible group within and outside Canada can exploit new resources. Supporting a large community provides a real challenge to government researchers but is an area where academic partners can assist in a liason and support role. Such a role aligns well with the universities' mandate in education and training (see below).

As research priorities for academic-government partnership are developed, we hope to identify major infrastructure priorities for the ARR community that can feed into programs and facility requests to agencies such as the Canadian Foundation for Innovation (CFI).

Key recommendations in the area of partnership in research infrastructure:

- Recommendation 1
- Recommendation 2

International Connections

Extending the value federal departments obtain through effective academic–government collaborations within Canada, there are opportunities for us to better coordinate our research at an international level. Canada brings scientific and technical strengths to several areas (modeling, prediction, Arctic and cold regions, cryosphere, aquatic environments, etc.) that have connections to global atmosphere-related processes. Weather, climate and air quality are global phenomena, so to effectively advance

atmospheric science requires access and contributions to global observing networks and satellite infrastructure. Canada also contributes significant global data to the international ARR community. For example, the Canadian space-based instruments ACE-FTS, OSIRIS and MOPITT generate important atmospheric composition data that is used by hundreds of scientists around the world, often in the context of WCRP/SPARC and WMO-UNEP activities. Canada is a participating member of the European Space Agency (ESA) and, through the CSA, makes significant investments in ESA's Earth Observation programs. This enables Canadian industry and researchers to participate in numerous competed activities related to the development, validation and use of data from ESA space-based instruments.

Canadian expertise, multi-decadal observational datasets, field campaign coordination and support capacity, and strong experience in model development and evaluation, are contributed to the international community. In return, Canada can leverage the resources of the international community through international engagement and collaboration.

Thus, the value of strong international engagement by Canadian atmospheric scientists is three fold. 1) Canada can leverage the large international capacity to advance key science of specific interest to Canada. 2) Canada can maintain scientific expertise and infrastructure at the leading edge, by remaining competitive with the highest excellence in ARR globally. This enables us to inform Canadian atmospheric policy, regulations and planning with the highest calibre and state of art knowledge. 3) As no one Canadian institution or community can address the diverse expertise in ARR needed to address federal priorities, we can reach outside of Canada to access globally available expertise to meet these needs.

There is a wide range of international ARR programs and sponsors (see Appendix C), many of which now are strongly linked and coordinated, and present opportunities for Canadian scientists:

- The multi-lateral UN based collaborative research programs coordinated by WMO, UNEP, and UNESCO which include WWRP, GAW…
- The ICSU Future Earth program, and the international Commission on Atmospheric Chemistry and Global Pollution (iCACGP). IGAC jointly sponsored by both.
- The WCRP sponsored by WMO, UNESCO, IOC and ICSU. Canadian space-based atmospheric composition data is of particular importance for Stratosphere-troposphere Processes And their Role in Climate (SPARC).
- Collaborative research programs inviting international participants, particularly in Earth observations (ESA Earth Explorer satellites, NASA AboVE)
- iLEAPS — Integrated Land Ecosystem-Atmosphere Processes Study and SOLAS — Surface Ocean–Lower Atmosphere Study which are Global Research Projects of Future Earth
- The national government sponsored collaborative research opportunities: EU Horizon 2020, NA CEC, NA IAI, etc.

- The science assessment programs of UNEP, WMO, Arctic Council and IPCC (e.g. Quadrennial Ozone assessment reports for the Montreal Protocol on Substances that Deplete the Ozone Layer).

Challenges in accessing these opportunities lie in simply being aware of them, in understanding the complexity of international relationships and structures in which the projects operate, obtaining base funding to enable participation or join as a partner, and in demonstrating the value back to GoC departments or granting councils who would be asked to support or facilitate Canadian engagement.

Attention to and coordination of Canadian engagement in the context of academic-government partnerships will contribute to federal government development of knowledge and tools to inform weather, climate and air quality policy, regulations and services. This includes enhanced opportunities:

- for field campaigns or intensive studies, located in Canada with increased Canadian participation in internationally coordinated programs. This would also further exploit and utilize existing Canadian observational networks and infrastructure.
- to advance atmospheric processes understanding and parameterization
- to integrate Canadian observational activities within international programs, giving Canada access to global surface and satellite data, and ensuring optimal use of observations made with Canadian infrastructure.
- to apply and evaluate Canadian models over Canadian and global domains, and
- to facilitate financial support for both government and academic participants, including uptake of new knowledge in federal programs.

Thus, we have identified the need for mechanisms to improve communication of opportunities, coordination and funding of ARR in Canada in the international context. Federal science based departments, the granting councils and National Research Council all have a role to play which would be facilitated by the proposed PARRC.

Key recommendations in the area of international connections:

- Recommendation 1
- Recommendation 2

Education and Training

Universities have the unique mandate of being responsible for academic education and thus contributing to the development of trained and skilled professionals needed by governmental departments. In one sense this can be viewed as a feeder system, with students getting their foundational learning in K-12 schools, and then going onto university and/or college that will provide the people to populate government operations, industry

and research. Given the importance of this system in providing the skilled people needed to satisfy governmental needs, strategic planning is needed to identify strengths, gaps and needed coordination. Because this aspect of planning also requires input from industry, and extends well beyond issues directly related to government partnerships, we will develop a separate focus paper on this topic. But we make several points related to academic-government partnership issues here.

We believe that it is important to increase exposure to atmosphere-related science (including the physics, chemistry, and biogeochemistry of the Earth system and its components) in the present-day school curriculum. This exposure will encourage students to consider further education and career in our fields, in a way that will allow them to productively develop their math, science, and computer programming abilities through creative hands-on research. Such exposure can happen if ARRCU raises awareness in school boards of the professional possibilities that a strong training in ARR can provide students in the work force in academia, government, and industry.

We see a need to bring better information to undergraduate education programs about the needs and opportunities in government-based research, on the same planning horizon as our research partnerships. Universities need to keep current on what is needed by working atmospheric and related science professionals within government so that students graduate with the skills qualifying them for work within government agencies. We also see an opportunity for academics and government researchers to communicate their views on the trends in training requirements.

Regarding training at the postgraduate and post-doctoral level, once we distil our priorities it will be more straightforward for university faculty members to share and teach towards these areas of need within government departments on the strategic planning horizon time frame. For students interested in applied areas, this will ensure that their research is relevant to current and medium-term needs. For students with an interest in more fundamental research, this awareness will allow them to efficiently plan their future professional work as necessary. We recommend enhancing the scope and opportunities for HQP training using various grants and contributions mechanisms in government laboratories. Additional ways to provide and facilitate internships and extended research stays in governmental labs would be beneficial. Such visits by university-based HQP would give them an understanding of the governmental work environment as well as facilitating direct interactions and building networks. We also see a need to make sure that organizations like MITACS, which focus on internships with industry, also ensure that internships with federal (and provincial) government departments qualify for internship funding. Finally, we recommend facilitating HQP training through providing government scientists enhanced opportunities to serve as visiting scientists at academic institutions, thus allowing significant exchange of ideas and expertise.

Along similar lines in the area of communication, many HQP could be made much more aware of available research and job opportunities within government departments, by the

development of a common job market posting resource and by regularly holding jobs fairs and career interview sessions at CMOS, CSC, and CAP meetings. Developing job market knowledge while they are still in training would help guide students in decisions about obtaining training relevant to available positions over the long-term. Seeing the range of opportunities will be helpful for those in degree programs in professional areas like meteorology or for potential recruits to our field; it would, for example, provide alternative paths for employment in ARR, beyond ECCC's regular recruitment of forecasters. ARRCU has started an opportunities email list to publicize programs of study and research opportunities, and with moderate support this could be broadened into a more systematic postgraduate career program in ARR that would serve the needs of academics and government.

The key area for progress, therefore, is in the area of communication and coordination between university and government departments for long-range planning in education and training in ARR. We are aware of international examples (for example, the US University Corporation for Atmospheric Research's educational programs) that shows what can be gained by investing in reviewing the feeder system and its effectiveness.

Key recommendations in the area of education and training:

- Recommendation 1
- Recommendation 2

Facilitating Academic-Government Consultation: The Canadian ARR Panel

Across the areas of research partnership, infrastructure partnership, and education/training, we have identified the urgent need for the Canadian ARR community to enhance communication and coordination for academic and government participants in ARR. We propose to establish the *Panel for ARR in Canada* (PARRC), whose purpose would be to ensure that we meet our overarching objective of configuring academic-government partnership in ARR to most benefit Canada. We see the PARRC as a mechanism whereby, in areas of common interest to the Canadian ARR community, Canada sustains and strengthens its international leadership in atmospheric-related science, and hence in the ARRCU priority areas for partnership. The PARRC interests include also research infrastructure, education and training.

The specific objectives of the PARRC would be:

1. A *strategic planning objective* for research partnerships and priorities, to propose new research priorities to address atmospheric-related national issues and to be involved in pushing forward and coordinating those new initiatives in collaboration with NSERC, CFI and other funding agencies. This would satisfy the need identified above of

increased engagement of both academic and government researchers in the design and delivery of strategic partnership programs.

2. An *operational objective* of enabling ongoing smooth collaboration between the academic and government ARR communities by working to coordinate research activities in collaboration with the NSERC, CFI and other funding agencies, and to ensure effective participation in relevant new national and international research programs.
3. An *international competitiveness objective* to ensure that the Canadian ARR community has access to internationally competitive tools and infrastructure for maintaining an appropriate national capability in observing, understanding, modelling and predicting the atmosphere.
4. An *education/training* objective to promote the more effective pull through of research to improve government services and training of relevant HQP.

The PARRC will allow the Canadian ARR community to speak with one voice on issues around major joint research programs and infrastructure investments and will permit a more unified approach to innovations arising from atmospheric-related research. The PARRC should be composed of government senior scientists (director, chiefs and scientists), university atmospheric department professors, possibly research or high level administrative officers from one or two universities, and one or two representatives from the NGO and industry sectors. The PARRC should aim at a balance between academia and government membership. Scientists will be invited for specific discussions, especially for program presentations or new initiative proposals within a recurring strategic planning horizon. The PARRC co-chairs should be one government and one academic representative. Members should have a mandate of three years (with possibility of one renewal). NSERC or other funding agencies representatives should be part of the membership. PARRC should meet at least twice a year (with one face-to-face). Further details of the mandate and a draft terms of reference regarding the PARRC are provided in Appendix E.

Key recommendations in facilitating government-academic consultation:

- Recommendation 1
- Recommendation 2

Quantifying University Capacity in ARR (1 page)

- *This topic will be discussed at the workshop on January 20.*
- More information needed about University capacity for research if we are to engage in effective strategic planning.
    - [EC used to compile info on faculty, research groups, etc.. CSA is doing some related compilations now. US UCAR does this regularly.]
- Canadian Universities need to find resources to compile this information and keep it updated.
- Appendix D including preliminary survey? This will require resources to carry out.

Key recommendations in quantifying university capacity:

- Recommendation 1
- Recommendation 2

Conclusion (1 page)

- Summarize key recommendations from above.
- Outline next steps and recommendations.

Appendix A

Table A1 (if the following is to be included it will be included as an appendix only)

Organization/Agency and/or Program	Research Priorities
Climate Change and Atmospheric Research Program (NSERC and various federal agencies), 2012	• Understanding Earth system processes and their representation in models; • Advancing weather, climate, and environmental prediction; • Understanding recent changes in the Arctic and cold region environments.
ARRCU Research Priority Areas for Partnership (2016)	• Prediction, Arctic and Cold Regions, Regional Climate and Hydroclimate, Air Quality, Atmosphere-related Biogeochemical Cycles
Government priorities related to ARR (2017)	• Develop Weather Prediction & Warnings. AQ Forecasts. • Inform Air Pollutants, Toxics, and Greenhouse Gases regulations and reporting as directed by CEPA, Canada/US Air Quality Accord, UN ECE LRTAP and the UNFCCC, and GoC Enforcement obligations. • Inform the Pan Canadian Framework for Clean Growth and Climate Change: The mitigation and adaptation goals related to the Paris agreement. Climate Services. • Reduce disaster risk related to weather and climate change as guided by the Public Safety Emergency Management • Advance climate resilient infrastructure under the Green Infrastructure program
ECCC ASTD Scientific Priorities	• Earth system based climate and weather models. Unified framework of fully coupled atmosphere – ocean – terrestrial models. Bio-geo-chemical cycles. • Advanced utilization of space based observations through development of data assimilation systems for physical and chemical atmospheric parameters, and land surface conditions. • Development of observed data (surface and satellite) – model fusion methods for regional and facility-scale emission source characterization. • Atmospheric monitoring methods research. • Emissions measurements research and testing

CSA Partnership Needs	▪ Deriving benefit from currently operating space infrastructure through analysis of data leading to the improvement of models, assimilation of data leading to improved environmental forecasts and greater societal resilience to environmental events. ▪ Activities throughout the space science mission cycle: science/instrument/mission concept studies, observing system simulation experiments, and science development in parallel with technology development. ▪ Development of new space missions to observe Earth's atmosphere, generation and Cal/Val of data products with ground-based and airborne observations. ▪ Hands-on training to students, and professional development, in all phases of the space mission cycle, including sub-orbital capability demonstration flights and analysis of data from currently operating satellites.
NSERC Strategic Partnership Target Areas relevant to ARR	**Targeted areas for Environment and Agriculture 1. Water: Health, Energy, Security - Strengthening water resource sustainability in agriculture** **2. Aquatic ecosystems - Adapting agricultural production systems to climate change** **3. Climate Change Research and Technology - Disaster mitigation for climate extremes**

Further material for Appendix A: Current partnership priorities, programs, funding calls (Sylvie/Dave to help here)

- Brief review/list of current partnership programs (NSERC Strategics, CCAR, Grants and Contributions). Expand in Appendix A.
- CSA Announcements of Opportunity for "Flights and Fieldwork for the Advancement of Science and Technology (FAST)", Student Participation in Conferences, Data Analyses Grants, and Stratospheric balloon flight opportunities. CSA Requests for Proposals for contracts to perform Concept Studies and Space Technology Development.
- ESA Invitations To Tender for contracts related to studies, simulations and data application.
- Refer to models provided by US and international government-academic programs (recurring calls by NOAA/NASA/ESA/ONR etc.)

Appendix B: ARR infrastructure in Canada

Space-based observing facilities and related data retrieval systems:

- Atmospheric Composition Experiment (ACE) – Fourier Transform Spectrometer (FTS), and Measurements of Aerosol Extinction in the Stratosphere and Troposphere Retrieved by Occultation (MAESTRO) on SCISAT

Stratospheric Balloon Program in cooperation with CNES.

Appendix C: International research and infrastructure programs with Canadian involvement

Space-based observing facilities:

- Optical Spectrograph and InfraRed Imaging System (OSIRIS) on Odin
- Measurements Of Pollution In The Troposphere (MOPITT) on Terra
- Cloudsat
- ESA missions in development for near-term launch (Sentinel 5 Precursor, ADM-Aeolus, Sentinel 3, EarthCARE)

WCRP Canadian national report of activities could be useful resource here.

Chapter 8 of Canada's Sixth National Report on Climate Change, on Research and Systematic Observation of Climate Change could be useful resource here.

Appendix D (perhaps): Preliminary survey on University research capacity

Appendix E (Panel on ARR in Canada (PARRC) Terms of Reference)