The Canadian Network for the Detection of Atmospheric Change (CANDAC)

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NOTE ON DOCUMENT STATUS: This is a draft document. There is currently no commitment from any of the named organizations to support this initiative

Executive Summary

Three great challenges confront the atmospheric community: *air quality, climate change* and *ozone depletion.* These are important issues for Canada because of its large land mass and varying climates. Their effect on the Arctic is particularly significant.

The Canadian Network for the Detection of Atmospheric Change (CANDAC) is a network of researchers and resources dedicated to addressing the issues outlined above. The network will possess two types of resources: *physical facilities* and *highly skilled people* who will conduct research in this area. A primary initial focus of CANDAC will be the revitalization of Arctic measurements at the Eureka Arctic Stratospheric Ozone (ASTRO) observatory.

The CANDAC network objectives will be

- Understanding atmospheric change over Canada
- Integration of measurements taken from space, aircraft, balloons and the ground
- Provision of quality-controlled research datasets to researchers
- Linkage with international networks for data exchange and supranational planning
- Maintenance of research-critical resources
- Training of skilled personnel
- Public Education

CANDAC recognizes that it cannot achieve these objectives in isolation. It will collaborate with Canadian government, university and industrial research organizations to further mutual goals. It will also interact with international organizations to ensure that the research is placed in a global context.

CANDAC will be supported by a number of government departments and funding agencies. It will have an appropriate management structure and will be accountable to the stakeholders.

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Introduction

Three great challenges confront the atmospheric community at the beginning of the 21st century: *air quality*, the health of the *ozone layer* and *climate change*. All of these are strongly influenced by anthropogenic activity, particularly in the industrialized nations of the world. No one organization and no one nation can possibly solve these atmospheric problems, but all nations have a responsibility to contribute according to their particular ability, infrastructure and geographical location. It is especially important for economically developed nations such as Canada to address these atmospheric problems. In striving to match our economic strength, the developing nations are beginning to have significant effects on the atmosphere. If their *per capita* influence were to approach ours, the situation would be unsustainable. Since any atmospheric change has a truly global reach, it is essential that we develop methods to identify the sources and quantify the effects. This is the only basis on which we can develop a strategy for the maintenance of a viable atmospheric envelope.

Canada has great strengths in atmospheric studies and has been active for a number of years in many aspects of the problem of atmospheric change. Canada also has unique responsibility for Arctic research, being a Northern country with a significant land area above the Arctic Circle, where the effects of climate change will be strongly in evidence. Canada is a large country with a correspondingly large variety of surfaces, from urban to forest, to tundra, to ice, to water, all of which impact the atmosphere in different ways. Canada is a country rich in resources and natural beauty, but deterioration in the atmospheric environment can have serious social and economic consequences ranging from health issues (e.g. smog), through short-term economic effects (e.g. tourism), to the social implications of large-scale changes in the atmospheric systems (e.g. droughts).

The Need for Measurements

Measurements are the life-blood of any attempt to understand atmospheric change. Measurements drive models. Measurements test predictions from models. Measurements are used directly to identify and understand atmospheric physical processes. In a research area where the results can have substantial social and economic impacts, it is essential that measurements be of the highest possible quality and be continuously improved. Some examples of the effect of measurements on atmospheric research can be seen in the time series of temperature which demonstrates global warming, a half century of tracking the increase in carbon dioxide due to fossil fuel use which has driven the issues of the effects of greenhouse gases, and the discovery of the Antarctic ozone hole which was almost totally unexpected by the community. The case for continued measurements and a continuous increase in quality is unarguable.

However, if we are to fully address these issues, then it will be necessary not only to deploy a measurement system but also to develop a complementary analysis capability that can be used to interpret these measurements in the context of atmospheric change, and a process to connect these results to public policy making. This overall program is not a small or trivial undertaking since it requires both the development and utilization of research-grade instrumentation over a wide geographical area, and penetrating analysis of the results. Further, these must be sustained over a long period of time.

The CANDAC Network

The Canadian Network for the Detection of Atmospheric Change (CANDAC) is a network of researchers and resources designed to address the issues raised above. Different specialists within the network will address the three major themes of air quality, ozone and climate change outlined above. Since all chemical and physical aspects of the atmosphere are to some extent interrelated, it will be necessary to manage and coordinate the efforts of the various specialists. The network structure will fulfill this requirement, providing both leadership and focus.

The domain of the network is the entire atmospheric system. The lower boundary is the surface, the upper extent cannot be precisely defined, as processes occur which link levels in the atmosphere in extremely subtle and complex ways. A nominal limit of 100km in height will be used for convenience. Geographically, the coverage is the area of Canada, but this can only be studied in relation to the rest of the globe and therefore spatial scales will range from the very small (meters to kilometers) to the very large (planetary scale). The range of time scales of the measurements is also very wide since significant processes happen on timescales as short as hours to as long as decades. It will be necessary to have accurate long-term measurements to ensure that a) the provisions of the Montreal Protocols and the Kyoto agreements are being adhered to and b) that the atmosphere is responding as expected.

The network will provide two types of resources: *physical facilities* that are required for the activity but are beyond the ability of any one group to supply, and *highly skilled*

people who are the driving force behind any progress that can be made in the field. Training of these personnel will be an important network activity. The network will establish linkages with other national and international groups to share information about atmospheric change on a global scale. It will also provide regular channels for communications both among scientists and to the general public.

Network Objectives

The overall focus for the network is understanding atmospheric change over Canada. In order to achieve this CANDAC will make high quality measurements, interpret the measurements critically, and then connect the measurements to social and policy issues. In order to achieve this objective a number of issues must be recognized:

- Because of the variety of atmospheric space and time scales, CANDAC must carry out measurements over a large range of spatial and temporal scales and integrate them together. For example, space measurements bring the largest spatial scale and fixed observing sites the smallest. However, space instrumentation is always of limited life, but fixed stations have a virtually unlimited lifetime. Both these techniques can be applied with success, and together and in combination with other measurements (e.g. aircraft, balloons) can be used to increase our understanding. *CANDAC will need to use a variety of observation methods and platforms to achieve the objective.*

- There are a number of atmospheric constituents that are central to our scientific understanding of the current atmospheric problems. These include: ozone, particulate matter, carbon dioxide, carbon monoxide, nitrogen dioxide and others. The local measurement of a few of these can be carried out by a single group, but their measurement throughout even a limited geographical region such as the Arctic requires the efforts of many groups. The synchronization of these measurements and the assembly of the resulting dataset can only be achieved by a coordinated network of scientists working with the common goal of addressing the current problems in atmospheric science. *CANDAC must work in a collaborative mode with other organizations to achieve the network objectives.*

- There are a number of dynamical phemonena, particularly of the Arctic atmosphere which need to be studied, both to develop a significant climatology and to understand changes in the physical state of the atmosphere. These structures (e.g. gravity waves) are observed by their signatures in variables such as temperature and winds. *CANDAC must measure many atmospheric parameters to achieve its objectives.*

- Clouds and aerosols play a very significant role in determining the atmospheric state and its changes Measurements of clouds and aerosols are of particular importance for climate research. The lack of knowledge in cloud properties and

their interactions with aerosols accounts for a large proportion of the uncertainties in model predictions of global warming. Observations of changes in cloud characteristics and properties may provide a first glimpse of climate change over any particular measurement site; this is particularly true for the Arctic, the region thought to be most sensitive to atmospheric change. *CANDAC must observe clouds and aerosols to fulfill its mandate.*

- A significant requirement to fulfill the above objectives is to carry out measurements over a considerable period of time (years to decades). Extraction of the important processes associated with climate change from the natural variability of the atmosphere requires very accurate measurements on a timescale that covers natural processes such as the solar cycle, orbital variations and so forth. *CANDAC must make measurements over a long period of time.*

- Measurements over such long periods present challenges in the calibration of instrumentation and the synthesis of measurements made using different techniques. In the past, such approaches have been used more in the operational arena, than in the research arena, but our current atmospheric problems demand that these quality control issues be brought into the research field as well. It should also be recognized that new measurement techniques may be developed (this should be encouraged) and these will have to be integrated into the overall picture. *CANDAC data must be subject to effective quality control.*

In order to make these measurements, infrastructure and people are required. Personnel must be trained in the required disciplines and supported while they gain the necessary experience to perform the research. *CANDAC must support the training and early career experience of Highly Qualified Personnel*

Finally the results of this research must be communicated to the relevant parties including the general public. *CANDAC must have an effective communications policy and practice.*

Network Products

The network will provide measurements at a "research grade" level. That is, they will be beyond the mandate of the standard observing networks. As noted under the objectives above, there will be some emphasis on evaluating new observation techniques which might form the basis for future routine observations. In this case, efforts will be made to relate new measurements to old measurements to ensure continuity of information.

Network products will include, but not be limited to: ozone (tropospheric and stratospheric), particulate matter, greenhouse gases, temperature, vertical and horizontal structure, winds, turbulence and clouds.

All network products will be quality-controlled in a traceable manner. This will include activities to ensure the reliability of individual measurements and also relevant intercomparisons and validation efforts. Emphasis will be placed on ensuring documented and assured datasets so that further efforts in the future will be able to use these data with confidence.

In addition to the network products listed above, the network will undertake extensive analyses to interpret these data in terms of atmospheric change. Through research publications and presentations these analyses will be communicated to the community to interpret and explain the network products.

Training

The continued health of this type of research in Canada requires a continuing supply of highly qualified personnel. This is not easy to achieve in a field where the requirements on researchers are very diverse and the time scale of the research is very long. It is also carried out under considerable scrutiny and time pressure. It is necessary for Canada to supply a career structure for those Canadians who choose to work in this area in this country, and to provide first-class training for our young scientists so that they can lead the program in the future.

This training will consist of formal and informal components. The formal components will be through workshops, courses and conferences, the informal component through placements and other training opportunities.

CANDAC will offer a number of positions to promising young Canadians to enable them to complete their training and build up their research experience.

Public Outreach

The network will be pro-active in the publicising of Network activities to undergraduate and high school students. To that end we will work with the public relations departments of our partners as well as initiating separate network activities.

There will be particular opportunities for the Network to reach out to young people in various areas. In the Arctic it will be desirable to find ways of involving youth in the network measurement activities. In all areas, young students can be educated in the relevant issues and the necessary techniques required to make these measurements.

A CANDAC web-site will be established with the objective of providing public information on network activities and of providing a forum for the exchange of scientific information. It is intended that network products should be freely available to other researchers after quality control is completed.

CANDAC - SUPPORTING INFORMATION

Network Facilities and Observation Sites

The network will establish, or actively support the establishment, of at least six atmospheric measurement/sampling sites to characterize the atmosphere. These must be situated at a variety of N-S and E-W locations across the country. Care will be taken to ensure that full account is taken of current measurement capabilities as well as the need for measurements in specific areas. It is expected that several sites will be in the Arctic region. One of these sites – at Eureka – has some unique issues and heritage and is therefore discussed specifically below. It will be the initial focus of the network, since the facility has been mothballed and the need to reactivate it is urgent. Other facilities will be added as the network capability increases.

As noted above, the network will ensure that measurements from these sites are integrated with space-based measurements through integrated observing programs, co-ordinated measurement campaigns and formal validation procedures.

Larger facilities for use by all members of the Network

1) The Arctic Stratospheric Ozone Observatory (ASTRO) Laboratory at Eureka. This high Arctic observatory is unique in Canada and in the world. It has been extant for over a decade and is a primary station for the Network for the Detection of Stratosperic Change (NDSC). It is recognized to be of specific international importance and a continuation of the measurements at this site is needed not only nationally, but also to ensure that Canada contributes fully to the combined global measurements of many countries. The ASTRO facility will be "loaned" to the Network by the Meteorological Service of Canada. It will be run as a research facility open to network users and to outside scientists. The maintenance of this unique resource is rated as one of the highest priorities of the network.

2) The (Space) Instrument Characterisation Facility at the University of Toronto. This facility exists to characterize the space instrumentation which will be used by Canadian researchers to determine atmospheric change. It is also used for testing instrumentation for other platforms (balloons, aircraft). This is also a unique resource for Canadian researchers.

3) A Calibration facility for remote sounding instrumentation. Since this instrumentation is required to operate over long periods of time and in hostile environments, a facility for ensuring the integrity of the instrumentation and the resultant data will be required.

4) A central analytical facility for chemical and physical analysis of samples collected at Network research stations. There is considerable opportunity here to

collaborate with other groups and networks since this is necessary for the success of the network, but is not a unique requirement.

5) A central data handling facility for the coordination, storage and distribution of all Network data products. Here also is an opportunity to collaborate with other networks and government departments to ensure the availability of a necessary, but not unique resource.

The infrastructure of these facilities will be maintained by the Network and expertise will be built up to ensure that the most effective use is made of the resources. It is expected that other groups will make use of these facilities for projects which are outside of the scope of the Network. As a matter of policy, the Network will permit other Canadian research activities not directly connected with the network to be situated at these facilities for the incremental cost of their accommodation.

The CANDAC network will make as much effort as possible to avoid duplication of facilities and resources. It will build on existing resources where possible, and create new resources where critical.

Supporting Canadian Groups

It is anticipated that many groups and organizations will interact with the network both formally and informally. Two Federal government Departments will be full partners in the network, in all of financial support, planning and utilization of the products

The Meteorological Service of Canada (MSC) Their interest stems from their government mandate to monitor the atmosphere and advise the government on atmospheric issues. Certain of the existing MSC stations will be linked closely with the Network to maximize the synergy in data acquisition while avoiding duplication of effort. The Network will provide measurements not currently provided by MSC (e.g. from Eureka) and the data from existing MSC sites will be made available for inclusion in the Network's data products and archives. The distinction between the MSC activities and the network activities can be stated, at its simplest as a distinction between a monitoring focus (MSC) and a research focus (CANDAC). However it is anticipated that there will be much overlap and interaction in this area.

The Canadian Space Agency (CSA) The Canadian scientific satellite program will benefit from Network measurements that have an overlap with satellite observations. These "validations" are an essential part of any satellite program. In addition, long term in situ measurements, combined with appropriate climate and GCM simulations can serve as useful planning studies for future satellite missions, since they may suggest trends that could be examined in future missions.

International Linkages

No atmospheric research can be conducted without reference to the global situation and therefore the network will necessarily establish links with relevant international organizations such as:

NDSC – Network for the Detection of Stratospheric Change. The Network for the Detection of Stratospheric Change is an international network devoted to similar objectives to this network for the stratosphere. It is anticipated that strong links will be forged with this organization and the network will also use some of the procedures and practices which have been developed in this organization to guide its own development. A specific objective of the network would be to have at least one of its observing sites, almost certainly the ASTRO laboratory at Eureka, equipped and designated as an NDSC primary observing site.

IANABIS - Inter-American Network For Atmospheric/Biospheric Studies The Inter-American Network will focus on measurements and research into the properties of airborne particulate matter as well as concomitant chemical and meteorological observations that facilitate interpretation of these data. The measurements will contribute to the characterization of aerosol emission sources and to the understanding of the diverse roles that aerosols play in various regional and global processes and their impacts. *IANABIS* will have nine research stations spaced at approximately equal intervals of latitude from Puenta Areñas in the southern tip of Chile to San Luis Potosí in Mexico. It will cooperate with a similar network in the United States, and the CANDAC Network. Cooperation will involve full data interchange and coordination of measurements in order to provide a continuous dataset covering the entire continent of the Americas from 80N (Eureka) to 55S (Puenta Areñas).

CAWSES – Climate and Weather of the Sun-Earth System CAWSES is the next major program being developed by SCOSTEP (**S**cientific **C**ommittee **O**n **S**olar-**TE**rrestrial **P**hysics a committee of the International Council for Science). This program will coordinate international scientific activity concerned with understanding the integrated solar-terrestrial environment and the impacts variations in this environment might have on the functioning of this system as a whole. The CANDAC network will provide observations of importance to this program, and take advantage of the international linkages and global data sets available through CAWSES to extend analyses beyond our national boundaries as is necessary for atmospheric research.

Management Structure

The management structure of the Network will consist of the following:

1) *The Network Co-ordinator* will be responsible to the sponsors for the management and financial integrity of the Network. The central administration and support facilities would be located at the Network Coordinator's institution. Network management will be carried out by two committees.

2) *The Scientific Advisory Committee* will be composed of scientists not involved elsewhere in the Network. Representation will be chosen widely and internationally to prevent the dominance of any one agency or group, to and obtain a variety of guidance and expertise. The committee would meet annually to review scientific progress, and if necessary, recommend new directions. Meeting costs would be borne by the Network. The Network Co-ordinator will chair this committee.

3) *The Management Committee* would be formed of the Network Coordinator, the Principal Investigators (see below) and a representative from each of the funding partners. This committee will be chaired by a senior atmospheric stakeholder at arms length from the network operations. The Management Committee would meet several times a year (perhaps electronically, but face-to-face at least annually) to review progress and deal with financial and planning issues. The Management Committee would have final authority on financial issues and research directions, but would not reject the advice of the Scientific Advisory Committee without providing written justification. The Management Committee will also oversee the replacement of the Network Coordinator, Principal Investigators and any other Network personnel should this become necessary.

4) *A Manager* will be hired to coordinate the business and financial aspects of the network. This person will be employed for the duration of the project to provide liaison between the two committees and work with the Network Co-ordinator on the operational aspects of the Network.

5) Initially the *Principal Investigators* will be the co-signors on the Network proposal. Each of these scientists will be responsible for one of the Network activities. They will head the scientific teams that will carry out the research and prepare funding proposals and reports for their areas on an annual basis. It is anticipated that there will be no more then ten Principal Investigators at any one time. It is also expected that Principal Investigators will "rotate" on an appropriate timescale and that young scientists will be actively recruited into these roles.

FAQ (Not part of the Document, but answers to "why is this document the way it is?")

1) *Why only two Canadian support groups mentioned?* Well we would like to put more in, but at the moment we actually have no-one signed up. We'd like to include more Canadian groups, but time presses. We need a way to get interested collaborators on-board. We would also note that CSA and MSC are supporters ($$), not just collaborators – although see the disclaimer at the top of the document.
2) *What about the XXXX International group?* We can include them when we know how we will interact with them. We could go on naming groups for ever, they must have a reason for being there
3) *What about the YYYY facility at ZZZZ university?* We can certainly collaborate with other facilities, etc. The ones listed are the initial list that we think CANDAC should financially support. It isn't a clean list – some of it is historical and may be able to get some services elsewhere.
4) *Why aren't you measuring ABC?* We might, we gave some examples or it is all too vague – we said "not limited to"
5) *Who are the members of the Network?* Probably anyone who wants to join. We will need a number of people to make this work. We would like as many people to support us as possible – that probably includes you!
6) *What about the work being done by QWERT?* Please tell us about it. This is going to be a highly matrixed collaborative effort. We think we fit into a niche (research measurements), not cover the waterfront.
7) *Who are we going to for money?* We have an application in development for CFI, we are also intending to go to CFCAS and NSERC. We hope also for some support from MSC and CSA.
8) *Isn't this a bit ambitious?* Yes
9) *When does all this start?* We aim to get the network going within a year. There is really a deadline because of Eureka support.
10) *How can I help?* Let us know anything useful that you can. Comment on documents. We will be having a workshop soon, come to that.