

Report on CANDAC Activities at Eureka, Nunavut during 2014
submitted to
The Nunavut Research Institute

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The Canadian Network for the Detection of Atmospheric Change
NRI Research License #02 005 13R-M

31 December 2014

Executive Summary

Throughout 2014 the Canadian Network for the Detection of Atmospheric Change (CANDAC) has operated under the grant funded by the Natural Sciences and Engineering Research Council (NSERC) Canadian Climate and Atmospheric Research (CCAR) entitled “Research related to the Polar Environment Atmospheric Research Laboratory (PEARL): Probing the Atmosphere of the High Arctic (PAHA)”. The PAHA grant permitted CANDAC to have a significant increase of person-days in Eureka, a total of 543 for the year. As yet, not all of our Memoranda of Understanding (MoUs) with Environment Canada (EC) are in place but this has not proven to be a significant problem.

While we have returned to more-regular operation, we continue to remotely operate as many instruments as possible. We also continued our efforts directed at putting as much of our data as possible into national and international data catalogues. The Polar Sunrise campaign was once again run in combination with the ACE satellite validation campaign in late winter – early spring.

In 2014, we had 21 visitors to the laboratory, 9 of them students (Appendix A). Additionally, we continue to publish research papers in peer-reviewed journals and to make numerous presentations at national and international conferences and workshops (Appendix B), and are members of multiple multi-nation Arctic research coordination efforts such as SAON, the Sustaining Arctic Observing Network, and IASOA, the International Arctic Systems of Observing the Atmosphere.

CANDAC continues to refine the resources for teachers available on our website (<http://www.candac.ca>) and continued our Student-Researchers Atmospheric Collaboration outreach project at Uxbridge Secondary School. Based on the continued positive feedback we have received, we hope to repeat this project, partnering schools in Nunavut with those in Southern Canada, but funding this level of outreach activity remains a significant challenge.

In April 2012, we discontinued the full-time on-site operator for fiscal reasons. The PAHA grant has allowed CANDAC to put more effort into our PEARL operations, raising the count of operator manned operation to 218 days. However, it is insufficient for re-establishing full-time on-site operations. We have been able to significantly increase our on-site operation presence from last year and were able to run extended summer and fall campaigns to operate instruments and carry our necessary repairs.

CANDAC instrumentation continues to operate as anticipated though we have experienced some significant failures. These failures are mostly do to the age of the instrument. We are working to return these instruments to operation and hope that we will once again have the full complement in operation by sunrise 2015.

Our challenges this year extended beyond the realm of the usual instrumental and scientific issues. With great sadness we report the passing of the CANDAC Network Manager, Lisa LeBlanc. Others of our team also faced adverse situations spanning serious injuries to themselves, to family members, as well as the death of close family members. These events caused slow-downs in various areas, but by the end of 2014 we have returned to a more even state. We anticipate that operations in 2015 will be smoother.

Introduction

As was noted in the 2013 report to the Nunavut Research Institute (NRI), Canadian Network for the Detection of Atmospheric Change (CANDAC) had to suspend full-time Polar Environment Atmospheric Research Laboratory (PEARL) operations as of April 30, 2012. In that report, we also noted that we had received further funding under the Natural Sciences and Engineering Research Council (NSERC) Canadian Climate and Atmospheric Research (CCAR) program and had commenced with our program of research entitled: Probing the Atmosphere of the High Arctic (PAHA). We are pleased to state that we have continued our PEARL operations and research, and expanded our on-site activities beyond the level of 2013. However, we also note that PAHA does not provide sufficient funding to return to the pre-2012 level of activity. We must also note with great sadness the passing of Lisa LeBlanc the CANDAC Network Manager. This together with several other similar significant events impacting key personnel has affected operations during 2014. Through out 2014 most of our instruments were in operation whether autonomous, remotely operated, or operated on site. We also made significant strides in the remote operability of those that had previously only been operable by on-site personnel. We are of course still experiencing the usual rate of instrument problems and failures. This is somewhat exacerbated by the increasing age of many of them. We have also added, or begun the process of adding, new instruments from outside of CANDAC that will complement our own, thereby expanding the scientific output of PEARL.

Our research program continues to be highly relevant and our collaborators in various global efforts such as the Total Column Carbon Observing Network (TCCON), the Network for the Detection of Atmospheric Composition Change (NDACC) and the Scientific Committee on Solar-Terrestrial Physics (SCOSTEP) are increasingly interested in our data and science products. TCCON in particular seeks to use PEARL data as part of the Orbiting Carbon Observatory (OCO)-2 satellite validation program. PEARL continues to be an important site for satellite validation, and the Canadian Space Agency continues to support our operations by contributing to the infrastructure costs. We continue to invest in our infrastructure through the addition of internet accessible devices to enhance remote monitoring and operation.

We continue to provide metadata of results from PEARL as well as data to the Polar Data Catalogue as well as various national and international databases.

Within the purview of our Outreach Program, we were delighted to be able to continue our Student-Researchers Atmospheric Collaboration with a school in Newmarket, Ontario, and to continue our project where students measure atmospheric aerosols. As will be discussed later, we were unable to continue the effort in Igloolik. In addition to these larger projects, we continue to visit schools in southern Canada to educate students about the research done at PEARL.

Instrument Installations, Removals, and Modifications

Ridge Laboratory

In October 2014 we installed a Fabry-Perot interferometer at the Ridge Laboratory. We also installed a

dome in preparation for a second all-sky imager .

In 2013, the two Brewer Spectrophotometers that were a part of our Guest Instrument program were removed. One was placed at the Eureka Weather Station and the other was returned to the Ridge Laboratory in June of this year.

The solar tracker used by the grating spectrometer was replaced and relocated to provide viewing angles to the horizon. The original unit was moved to a similar instrument expanding its measurement capabilities significantly.

The Zero-Altitude PEARL Auxiliary Laboratory (ØPAL)

There were no new instrument installations at ØPAL during this reporting period. One instrument, the meteor radar is in the process of being moved to the SAFIRE site to avoid on-going interference problems. In addition to the physical movement, the radar transmitter has been returned to its manufacturer for re-furbishment and upgrades.

The Surface and Atmospheric Flux, Irradiance and Radiation Extension (SAFIRE) Laboratory

As noted above, the meteor radar will be moving to the SAFIRE site. In order to avoid the potential for interference with the VHF wind turbulence radar already located there, the decision was made to construct an enclosure for the electronics near the current SAFIRE container. This necessitated cutting into the SAFIRE 600V power line and inserting a step-down transformer to provide 120V power. Currently, the antennas have been relocated and wired, and the power circuits have been wired. We are awaiting the return of the radar transmitter.

At the SAFIRE flux tower, a micro-barometer has been added to permit high precision measurement of pressure for the investigation of the role of gravity waves and other similar phenomena in the vertical energy transport of the lowest atmospheric layers. This also involved NOAA reprogramming flux tower temperature sensors to make more frequent measurements.

On-going Research

The Intensive Phase of the Canadian Arctic ACE Validation Campaign 2013 (aka the Polar Sunrise Campaign) took place from 26 February to 12 March at PEARL, with the Extended Phase immediately following between 13 March and 1 April. A team of researchers from the University of Toronto, Western University, York University and CANDAC collected atmospheric composition measurements using a suite of 11 instruments, some of which are permanently installed on-site and some of which were brought in for the campaign. These observations will be used to verify results obtained by two Canadian scientific satellite missions, the Atmospheric Chemistry Experiment (ACE) on SciSat and the Optical Spectrograph and InfraRed Imager System (OSIRIS) on ODIN. The measurements are made at polar sunrise when sunlight returns to Eureka and which is the period when ozone depletion processes are occurring. This is the tenth consecutive year that the ACE/OSIRIS team has conducted their campaign at PEARL.

For 2014 summer on-site operations began 2 June and continued to 6 September, providing operator coverage throughout much as would have been the case in years past. The work on the meteor radar antennas occurred during this time period. We also used the summer to educate and train a student, Peter McGovern, in the role of “Assistant Operator” through the CREATE program. The weather this year was much better than that of the 2013 summer permitting the “normal” slate of activities. We also assisted NavCan in their efforts to upgrade the Eureka airport weather and runway conditions reporting.

The fall sunset campaign was held from 10 October to 20 November. This campaign included taking solar measurements up to the last day the Sun was above the horizon (20 October) and also re-activating several of the night-time operating instruments. We again invested considerable effort into maintenance of existing instruments specifically the grating spectrometers and the aerosol mass spectrometer and invested substantial effort into returning the DIAL ozone lidar to operation. In addition we installed the Fabry-Perot interferometer and began preparations for another instrument. At the ØPAL complex, the starphotometer was returned to operation. Unfortunately, we also had to remove the E-AERI radiometer for transport south for repairs and refurbishment. We expect its return prior to the Sunrise campaign.

For the most part, all our instruments have been working as expected and the results are being reported in the scientific literature as well as being presented at various national and international conferences and workshops. In addition, we now hold monthly telecons with scientists and managers at Environment Canada to ensure they are kept current with our efforts and that we are responding to their requirements as dictated by the PAHA grant.

While we are open to continuing our collaborative activity with Dr. Eric Steinbring of the National Research Council of Canada to characterize the atmosphere above the PEARL Ridge Lab in terms of its turbulence, no measurements were undertaken this year. The measurements of the previous year indicate that the atmosphere there may be as good as or better than any on the Earth for high-precision astronomical measurements. We look forward to future collaborations in this area.

PEARL and the Eureka Weather Station continue to be excellent examples of how the existence of quality facilities provides synergies that lead to research projects not previously considered, and that may have a real impact on the lives of Canadians in remote communities.

Outreach Activities

As they do every year, our researchers participated in a number of outreach activities in southern Canada. Olga Summers and others at Dalhousie University gave presentations at Dalhousie University using their CASPED sphere (www.casped.ca); Emily McCullough (graduate student) gave an invited 1-hour public outreach talk to the RASC (Royal Astronomical Society of Canada) London Centre on 20 September 2014 entitled “Atmospheric Science at Eureka, Nunavut;” and the team at the University of Toronto, worked with four students from Uxbridge High School in a mentor supported independent research project. Working in pairs, the students designed and conducted their own observations relating to atmospheric aerosols. Their projects were entered in the Durham Regional Science Fair and they are writing an article on their results.

In past years, our outreach program has travelled to various locations in Nunavut to interact with interested schools. Unfortunately, in 2014 we were unable to do so. In recent years those outreach activities were supplemented with funding from the NSERC PromoScience program. CANDAC did not receive any such funding in 2014 which coupled with the reduced funding level under the PAHA grant meant that we were unable to support outreach in Nunavut. It is our earnest hope that we will once again return to Nunavut in 2015.

Our Aerosol Project, a mentor-supported independent research opportunity, was continued this year with two Uxbridge Secondary School students from Uxbridge, Ontario. They used sun photometers to acquire aerosol optical thickness measurements between January and June for individual research projects. The students were then invited to prepare posters at an informal poster session hosted at the University of Toronto in July. There has been interest expressed in continuing this project with new grade 10-11 students and schools and we will be exploring our ability to meet this interest.

We also took advantage of several opportunities to educate southern students about the work being done at Eureka. For example, a mock science fair was held in which four grade 9 Uxbridge Secondary School Students who have been conducting their own aerosol research since December 2013 presented their results .

In addition to organizing school visits, the CANDAC Outreach Facilitator continues to maintain, refine, and develop practical lesson plans and activities that Canadian teachers can easily incorporate into their regular science curriculum (grades 1-12). These lesson plans consider current science expectations by province and territory, and then incorporate Arctic atmospheric research in interesting and meaningful ways. They include topics such as ozone depletion, climate change, air pollution, and weather. Lesson plans and classroom activities have been made available on our website as part of the IPY legacy project The CANDAC Outreach Facilitator also distributed outreach toolkits for CANDAC members to use for outreach in their local areas.

On 9 May, we again hosted a CANDAC booth at the Canada-wide science outreach initiative, Science Rendezvous, at the University of Toronto. The booth featured CANDAC and PEARL posters, brochures, and stickers. CANDAC researchers demonstrated clouds in a jar, conducted spectroscopy and Cartesian diver building workshops, and displayed Arctic outdoor gear.

On a more provincial/national scale, we were invited to attend the Science Teachers' Association of Ontario Conference in Toronto on 14 November and the Toronto District School Board Gifted Student Conference in Toronto on 19 February where we facilitated hands-on workshops for elementary and secondary school teachers. We also gave a similar workshop at the Ontario Association of Physics Teachers' Conference in Oshawa, Ontario, in May. On 13 August, we participated in the University of Toronto's Science Unlimited week-long Summer Camp.

During November 2014 we brought on line our updated web-site at <http://www.candac.ca>. This is a more polished effort that we hope will contribute to knowledge of the Arctic and serve as a data portal for PEARL measurements. We are working hard on all aspects of the site, specifically that of making data available.

As expected, Mr. Ivan Semeniuk, the science reporter for the Globe and Mail newspaper published several articles in the Globe and Mail newspaper on PEARL and the Arctic.

Summary of Plans for 2015

As was the case at the end of 2013, at the time of the writing of this report, we are still in the process of negotiating our Memorandum of Understanding with Environment Canada. We are hopeful that the process will be completed in 2015 but do not expect that its completion will result in a materially different operating scenario. Aside from the standard operations, measurements, and maintenance, we will be continuing the effort to return to service our DIAL stratospheric ozone lidar system so that we can resume the nearly 20 year record of measurements from the PEARL location. We are anticipating the completion of the effort to relocate our meteor radar from ØPAL to SAFIRE. We also hope to install a sensor string adjacent to the flux tower to measure the near-surface and below-surface temperatures (from about 2m above to 2m below the surface). We will refine the automation of the operation of the Bruker IFS125HR infrared spectrometer so that it can continue its unique contribution to the TCCON dataset. Various other more minor instrument adaptation are also expected in support of CCAR/PAHA and general improvement to the measurement capabilities. We continue to find ourselves in discussion with multiple new groups beyond the CANDAC family that are considering installing instruments at PEARL.

While we still cannot support a year-round operator presence at PEARL, we are aiming to maintain an increased presence in throughout the year to facilitate acquiring more data with those instruments (mostly daytime instruments) that are least automated. At the same time, we will be working towards decreasing the amount of human intervention required by those instruments. We have arranged to increase our manned days on site during the polar night in support of our polar night theme. We hope to meet or exceed the 218 days manned days of 2014.

Assuming that the ACE/OSIRIS team receives funding – which at the present time seems very likely - to continue the Canadian Arctic Validation Campaign, it plans to return to PEARL for the twelfth such campaign in early 2015. (The proposal for funding was submitted to the Canadian Space Agency in late November.) The time period will be very similar as in previous years and we will be continuing to validate the ACE/OSIRIS results during polar sunrise.

CANDAC hopes to resume its outreach effort in the form of contact with Nunavut communities principally through school visits. We also hope to visit several schools in the south to educate those students about the Arctic and the importance of the work we do there. With our Outreach Facilitator now in her second year, we will investigate the areas in which we can possibly expand our outreach program.

Concluding Remarks

Despite the challenges faced in 2014 CANDAC has pushed forward with the PAHA project, demonstrating that it has a solid core complement of instrumentation, facilities and personnel. Operationally, 2014 is characterized by a useful increase in our on-site presence that has permitted us to

return to a significantly higher level of instrument operation and even to expand our measurement capabilities. We continue to have a significant amount of research dissemination while continuing with our development of highly qualified personnel. We have continued to improve instrument automation and we remain well-equipped to support both our own research and other research that might benefit from our facilities. PEARL based research results are continuously making their way into the scientific world and are contributing to a greatly-improved understanding of the Arctic atmosphere. We continue to extend the PEARL data record and as noted in the 2013 report, the data record for some instruments from the PEARL site is now approaching a length of time long enough to require the re-analyses of older data in light of what has been learned over those years and using new techniques. This is where the benefits of an enduring and well-instrumented site such as PEARL will become apparent as we continue with our efforts. Our outreach activities continue to educate future generations of Canadians. We are determined to continue our small part in asserting that the Arctic is an important part of Canada through our presence, our research, and through education. As always, the CANDAC team is working hard to ensure a continuation of these efforts in the future.