2013 Summer School in Arctic Atmospheric Science

July 15-19, 2013 • Nottawasaga Inn • Alliston, Ontario, Canada

2013 Program

Welcome to the Third Annual Summer School in Arctic Atmospheric Science!
NSERC CREATE Training Program in Arctic Atmospheric Science

Program Director: Prof. Kimberly Strong
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University of Toronto
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Email: akilgour@atmosp.physics.utoronto.ca

Program Website: http://www.candac.ca/create/

Program Description:

The NSERC CREATE Training Program in Arctic Atmospheric Science is a six-year project, begun in 2010 and supported by NSERC's Collaborative Research and Training Experience Program. Our Program aims to provide students and postdoctoral fellows with training in Arctic atmospheric science, including the use of state-of-the-art instrumentation and analysis of large data sets.

This Program takes advantage of the unique capabilities of the Polar Environment Atmospheric Research Laboratory (PEARL) located at Eureka, Nunavut in the High Arctic (80N, 86W). PEARL has been established by the Canadian Network for the Detection of Atmospheric Change (CANDAC), which is dedicated to addressing issues related to air quality, ozone and climate change. The PEARL facility is home to more than 25 instruments that are being used to make comprehensive measurements of the atmosphere from the ground to 100 km. It is also one of the observatories of the International Arctic Systems for Observing the Atmosphere (IASOA). The students supported under this CREATE Program benefit from the significant investment that Canada has made in PEARL; they have access to a world-class facility, unique data sets, and a large team of researchers with a breadth of expertise.

The Training Program includes formal and informal supervision, an Exchange Program, an Annual Summer School, an Annual Research Symposium, an Undergraduate Summer Internship Program, and an Industrial Partnership Program.

The ultimate goal of the Training Program is to significantly enhance the educational opportunities available to young researchers interested in polar, atmospheric, and climate sciences, enabling them to build collaborations and networks, and to develop scientific, technical, communications, and organizational skills. Such skills will make them excellent candidates for employment in academic, industrial, and government positions in environmental science and policy.
Summer School Speakers

**Thomas Davis** holds a BSc in Geology and a PhD in Environmental Geochemistry and Chemical Engineering from McGill University. Following McGill, he held NATEQ and NSERC postdoctoral fellowships in The Netherlands and Switzerland. He began working with Environment Canada in 2007 where he coordinated Nanotechnology, Biotechnology and Chemicals research to support the Regulatory and Policy oversight of toxic substances in Canada. In 2010 he joined the Canadian Space Agency's Government Liaison Office as Senior Advisor for Science & Technology.

**Ed Eloranta** is a Senior Scientist at the University of Wisconsin. He received a BSc in Physics and a PhD in Meteorology from the University of Wisconsin. His research involves the design, construction of innovative lidars for use in atmospheric research. Most recently he has led the development of High Spectral Resolution Lidars for untended operation in remote locations. These systems are currently operating in Barrow AK, Singapore, Huntsville AL, Boulder CO and on a container ship sailing back and forth from California to Hawaii.

**Udo Friess** works as a Research Assistant at the Institute of Environmental Physics at the University of Heidelberg, Germany. His main research interests are chemistry and composition of the atmosphere in remote areas, with focus on halogen radicals in the marine boundary layer and in polar regions, as well as the development and application of spectroscopic techniques for measurements of atmospheric trace gases.

**Craig Haley** is a member of the Systems Engineering group at COM DEV. He completed his PhD on the OSIRIS satellite instrument and at COM DEV is currently supporting the development of the Fine Guidance Sensor, Canada's contribution to the James Webb Space Telescope, and M3MSat, a ship tracking microsatellite for CSA and Department of National Defence, which is scheduled to launch this fall.

**Glen Lesins** is Assistant Professor in the Department of Physics and Atmospheric Science at Dalhousie University in Halifax. His research interests include Arctic climate and remote sensing. He has developed courses that integrate the multidisciplinary nature of climate change.

**Noel McDermott** lived and taught in Nunavut for 35 years. He was principal of Nunavut Arctic College where he also taught courses in Inuit literature, mythology and language. He currently teaches Inuit language (Inuktitut) and history at Queen's University, Kingston where he is a Teaching Fellow.
Tom McElroy holds the CSA/ABB/NSERC/York U Industrial Research Chair in Atmospheric Remote Sounding at York University and is very active nationally and internationally in science issues related to ozone. He has led satellite instrument projects (MAESTRO on ACE) and is active in ozone measurements and trend studies.

Jennifer Murphy is an Associate Professor and Canada Research Chair in the Department of Chemistry at the University of Toronto. Her research program is focused on the atmospheric chemistry and biogeochemistry of reactive nitrogen, which influences air quality, climate change and ecosystem health. Her research group carries out long-term observations at a monitoring site in Haliburton Forest, and participates in collaborative international field measurement campaigns around the world.

Ivan Semeniuk is a science journalist, broadcaster, and the Globe and Mail's national science reporter, based in Toronto. He is the host of OASIS channel's Cosmic Vistas and has previously been the US news editor for Nature, a bureau chief for New Scientist magazine in Boston and a producer and columnist with Discovery Channel's Daily Planet. He was an MIT Knight Science Journalism Fellow in 2007/2008 and an associate Canadian Journalism fellow at the University of Toronto in 2009/2010. Prior to becoming a journalist he was on staff at the Ontario Science Centre where he developed public programs and exhibits.

Ray Nassar is a Research Scientist at Environment Canada working in the area of greenhouse gas measurements and models. He is actively involved in CO₂ model development and has over a decade of experience working with satellite observations of the atmosphere from Canadian and international missions.

Sarah King is the Coordinator of The Writing Centre at the University of Toronto Scarborough. She has sat on both academic and non-academic hiring committees, has taught workshops for graduate students and faculty, and has worked individually with hundreds of students on their resumes and CVs.

Ruth Louden is the Assistant Director of the Academic Advising & Career Centre at the University of Toronto Scarborough (UTSC), has facilitated workshops for students and mid-career professionals on all aspects of job search. Prior to joining UTSC, Ruth worked for 15 years in human resources consulting with an emphasis on recruitment.

Sheryl Stevenson coordinates programs that support graduate students’ professional development at the University of Toronto Scarborough. Before coming to U of T, she was a university professor and department chair in the US, mentoring graduate students and serving on many hiring committees for new faculty at the assistant professor level.
CREATE Speakers

Kimberly Strong is a professor in the Department of Physics at the University of Toronto and Director of the University’s new School of the Environment. Her research involves atmospheric remote sounding using ground-based, balloon-borne, and satellite instruments for studies of stratospheric ozone chemistry, climate, and air quality. She runs four instruments at PEARL and is the CREATE Training Program Director.

Ashley Kilgour is the CREATE Training Program Coordinator and the Education and Outreach Facilitator for CANDAC. She informs and interacts with students, teachers and community members in both Northern and Southern Canada. She also develops educational materials for teachers and students aimed at enhancing environmental science education.

James Drummond is a professor at Dalhousie University. He is a Fellow of the Royal Society of Canada, and holds a Canada Research Chair in remote sounding of atmospheres. He is PI of the MOPITT satellite experiment, Co-I on the ACE mission, and PI for CANDAC and PEARL.

Felicia Kolonjari is a PhD student at the University of Toronto, studying polar ozone depletion through analysis of ACE-FTS CFC and HCFC measurements. She is Chair of the CREATE Trainees’ Advisory Committee and the Trainees’ Representative on the Training Program Committee.

Dan Weaver is a PhD student at the University of Toronto, analyzing atmospheric water vapour measurements and ozone depletion at Eureka. He is a member of the CREATE Trainees’ Advisory Committee and its Social Media Coordinator.
## Summer School Students

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution (home/summer)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Christian Akpanya (MSc)</td>
<td>University of New Brunswick</td>
</tr>
<tr>
<td>Peter Argall (CREATE intern)</td>
<td>University of Western Ontario</td>
</tr>
<tr>
<td>Jennifer Beale (PhD)</td>
<td>York University</td>
</tr>
<tr>
<td>Eric Boone (PhD)</td>
<td>University of Michigan (USA)</td>
</tr>
<tr>
<td>Orfeo Colebatch (Research Officer)</td>
<td>University of Toronto</td>
</tr>
<tr>
<td>Jonathan Franklin (PhD)</td>
<td>Dalhousie University</td>
</tr>
<tr>
<td>Paul Godin (PhD)</td>
<td>University of Toronto</td>
</tr>
<tr>
<td>Kostya Golovan (CREATE intern)</td>
<td>University of Toronto</td>
</tr>
<tr>
<td>Debora Griffin (PhD)</td>
<td>University of Toronto</td>
</tr>
<tr>
<td>Sean Hartery (CREATE intern)</td>
<td>Dalhousie U/University of Western Ontario</td>
</tr>
<tr>
<td>Shannon Hicks (MSc begins Sept. 2013)</td>
<td>University of Western Ontario</td>
</tr>
<tr>
<td>Angela Hong (PhD)</td>
<td>University of Toronto</td>
</tr>
<tr>
<td>Liviu Ivanescu (PhD)</td>
<td>Université de Sherbrooke</td>
</tr>
<tr>
<td>Ali Jalali (MSc)</td>
<td>University of Western Ontario</td>
</tr>
<tr>
<td>Magnus Joelsson (PhD)</td>
<td>University of Copenhagen (Denmark)</td>
</tr>
<tr>
<td>Mathilde Jutras (CREATE intern)</td>
<td>Université de Montréal/Dalhousie University</td>
</tr>
<tr>
<td>Tony Kang (summer intern)</td>
<td>University of Toronto</td>
</tr>
<tr>
<td>Bradley Kloosra (CREATE intern)</td>
<td>University of Toronto</td>
</tr>
<tr>
<td>Felicia Kolonjari (PhD)</td>
<td>University of Toronto</td>
</tr>
<tr>
<td>Stefan Kowalewski (PhD)</td>
<td>University of Bremen (Germany)</td>
</tr>
<tr>
<td>Sam Kristoffersen (PhD)</td>
<td>University of New Brunswick</td>
</tr>
<tr>
<td>Jeffery Langille (PhD)</td>
<td>University of New Brunswick</td>
</tr>
<tr>
<td>Valérie Losier (CREATE intern)</td>
<td>McGill U/University of New Brunswick</td>
</tr>
<tr>
<td>Erik Lutsch (BSc)</td>
<td>University of Waterloo</td>
</tr>
<tr>
<td>Marlene Machemy (summer intern)</td>
<td>University of Victoria/University of Toronto</td>
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<tr>
<td>Zen Mariani (PhD)</td>
<td>University of Toronto</td>
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<tr>
<td>Emily McCullough (PhD)</td>
<td>University of Western Ontario</td>
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<tr>
<td>Joseph Mendonca (PhD)</td>
<td>University of Toronto</td>
</tr>
<tr>
<td>Omid Moeini (PhD)</td>
<td>York University</td>
</tr>
<tr>
<td>Jan-Marcus Nasse (MSc)</td>
<td>University of Heidelberg (Germany)</td>
</tr>
<tr>
<td>Melissa Olsfoorn (MSc begins Sept. 2013)</td>
<td>York University</td>
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<tr>
<td>Kevin Olsen (PhD)</td>
<td>University of Toronto</td>
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<tr>
<td>Onaizah Onaizah (summer intern)</td>
<td>University of Toronto</td>
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<tr>
<td>Christopher Perro (PhD)</td>
<td>Dalhousie University</td>
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<tr>
<td>Anthony Pugliese (summer intern, MSc begins Sept. 2013)</td>
<td>University of Toronto</td>
</tr>
<tr>
<td>Meike Rotermund (CREATE intern)</td>
<td>Dalhousie University</td>
</tr>
<tr>
<td>Niall Ryan (PhD)</td>
<td>University of Toronto</td>
</tr>
<tr>
<td>Ilya Stanевич (PhD)</td>
<td>University of Toronto</td>
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<tr>
<td>Christopher Vail (MSc)</td>
<td>University of New Brunswick</td>
</tr>
<tr>
<td>Jeffrey VanKerkhove (MSc begins Sept. 2013)</td>
<td>University of Western Ontario</td>
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<tr>
<td>Zahra Vaziri (PhD)</td>
<td>York University</td>
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<tr>
<td>Camille Viatte (PDF)</td>
<td>University of Toronto</td>
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<tr>
<td>Chen Wang (PhD)</td>
<td>University of Toronto</td>
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<tr>
<td>Dan Weaver (PhD)</td>
<td>University of Toronto</td>
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<tr>
<td>Xiaoyi Zhao (PhD)</td>
<td>University of Toronto</td>
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</table>
The Canadian Network for the Detection of Atmospheric Change (CANDAC) is a network of university and government researchers dedicated to studying the changing atmosphere over Canada. CANDAC recognizes that two resources are critical for this effort: *physical facilities* which are used to perform research, and *highly skilled people* who conduct the research.

The CANDAC objectives are:

- 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

Since Canada has a significant portion of its territory in the Arctic, CANDAC has a particular emphasis on the Arctic. Recognizing that there is a lack of measurements recorded in the Arctic, and that the difficulties of making measurements there are very real, the first task of CANDAC has been to rejuvenate and operate the Polar Environment Atmospheric Research Laboratory (PEARL) at Eureka, Nunavut. This activity was accelerated by a desire to be ready for International Polar Year in 2007-2008 in order to participate in the world-wide effort to intensively study the Arctic region.

CANDAC/PEARL research has been conducted within four major themes:

- Arctic Tropospheric Transport and Air Quality
  - How is air quality in the Arctic influenced by southern activities and vice-versa?
- Radiative Forcing
  - How do changes in the surface and atmosphere lead to heating and cooling?
- Middle Atmosphere Chemistry
  - How is the ozone layer changing?
- Waves and Coupling Processes
  - How do the various regions of the atmosphere interact?

In addition, CANDAC undertakes measurements at PEARL simultaneously with several satellite instruments. These “validation” measurements are extremely effective because of the location of PEARL, and they further enhance the science return of the research effort.
The Polar Environment Atmospheric Research Laboratory (PEARL) is found on the northern part of Ellesmere Island, in the vicinity of the Environment Canada Weather Station at Eureka, Nunavut. PEARL is composed of a number of interlinked observation sites. The major site is the PEARL Ridge Lab, which was formerly Environment Canada’s Arctic Stratospheric Ozone Observatory (AStrO), located at 80°N, 86°W, 610 m altitude. The building was constructed by Environment Canada in 1992, specifically to study stratospheric ozone. It is some 15 km by road from Eureka and about 1,100 km from the North Pole.

The Zero Altitude PEARL Auxiliary Laboratory (ØPAL) is located at sea level at the outer perimeter of the Weather Station proper, and was added to expand the range of scientific research into the very lowest layers of the atmosphere. A third facility, the Surface and Atmospheric Flux, Irradiance and Radiation Extension (SAFIRE) is located remote from all structures, for measurements of the undisturbed terrain about 5 km from the Weather Station.

Operating research grade instrumentation in this remote environment thousands of kilometers from typical support structures is much like operating from a satellite, albeit on the ground. The challenge is to develop and implement instrument systems that will provide state of the art measurement capabilities with little hands-on intervention.

While at PEARL, CANDAC personnel and visiting scientists are housed at the Eureka Weather Station. The station is also an important link in the support chain for PEARL. CANDAC relies upon the skills, abilities, and hard work of the station staff for housing, meals, power and transportation. The Weather Station also handles tasks such as aircraft handling and plowing of the roads to the sites. The station contributes scientific value as well through their measurement program, especially the radiosonde and ozonesonde flights.

In April 2012, PEARL formally ended full-time year-round operations due to funding constraints. Since then, automated instruments continue to run with remote access, while those requiring manual intervention are being run on a campaign basis as funding allows, as CANDAC no longer has an operator on site. We have recently been successful in obtaining new funding for activities at PEARL from NSERC’s Climate Change and Atmospheric Research Program. This new project, called Probing the Atmosphere of the High Arctic (PAHA), has three scientific themes: Composition Measurements, Polar Night, and Satellite Validation.
The Canadian Network for the Detection of Atmospheric Change (CANDAC) is pleased to announce that it has received a grant from the Natural Sciences and Engineering Research Council (NSERC) of $5M over five years to conduct research in “Probing the Atmosphere of the High Arctic” (PAHA). PAHA relies heavily on the Polar Environment Atmospheric Research Laboratory (PEARL) instrumentation and capacity for its program. The PAHA team consists of researchers from Canadian universities, the Canadian government, the United States and Europe.

Probing the Atmosphere of the High Arctic:
CANDAC Introduces PAHA

PAHA research will consist both in taking data at PEARL in the time frame 2013-2018 and in analyzing these data, as well as data from other sources and previous data taken at PEARL to provide answers to the following questions (and others):

- How are clouds and particles in the atmosphere changing and why is this happening?
- What is the influence of the wintertime polar vortex on both the Arctic and on the rest of the globe?

These questions concerning the High Arctic have been identified as having a high priority by the Canadian government. Canada is the steward of a large portion of the Arctic and knowing how the Arctic works and how it is changing is an important part of that stewardship.

PAHA will address the above questions through a program of measurements at PEARL using much of the equipment already in place, and an analysis program involving university faculty members, government scientists, graduate students and post-doctoral fellows. The results will be communicated to the Canadian government, but also presented in national and international conferences as well as specialised workshops and, of course, in articles submitted to scientific journals.
Many of the questions raised above have an issue concerning the difference between the Polar day (summer) and the Polar night (winter). Since PEARL is located well above the Arctic Circle, it experiences prolonged periods of total darkness in the winter and similar long periods of continuous daylight in the summer.

For a number of reasons there has been a tendency to make many more measurements during the summer than the winter and this has led to a lack of knowledge about what happens in the months of darkness. It also contributes to a bias in our understanding of many phenomena because most measurements are taken in daylight. By making measurements throughout the year and by paying special attention to measurements in the winter months, PAHA will overcome this bias and be able to produce a clearer picture of the situation throughout the year. This is more than a purely scientific issue since, if resource extraction in the High Arctic becomes a reality, it will proceed throughout the year.

So PEARL measurements will continue through as much of the year as possible. We are planning to run several “campaign” periods, where there will be personnel on-site, but there will not be a year-round operator at PEARL. Between visits the instruments will be monitored and maintained remotely. The PEARL team is investing in more tools to improve the automation and remote monitoring, but, because communication costs are very high and the funds available to pay for communications very restricted, there is a limit to how much remote monitoring can be done. Physical instrument failures will have to wait for the next on-site visit for repair.

Measurements often have multiple uses and so it is important to make any measurements made at such a unique location as PEARL available to as many people as possible. To do this, PAHA will utilise its own web-site at http://www.candac.ca and will also put the information into international databases that have the resources to maintain the data and make it available both now and in the future. Other data uses include validation of satellite measurements and input to local, regional and global models.

PAHA and CANDAC will also continue their outreach activities through a linked grant from the NSERC PromoScience program. Previous outreach activities have included visits to Northern schools, arranging joint projects between Northern and Southern Schools, participations in formal outreach events and training of teachers in activities related to the atmosphere and to the Arctic. Our plan is to continue many of these activities while also taking advantage of new opportunities.

CANDAC, PEARL and PAHA are grateful for the support of many agencies for these research programs. This most recent effort is supported by NSERC through the Canadian Climate and Atmospheric Research (CCAR) and PromoScience programs. Environment Canada who support our activities at PEARL, Eureka, the Canadian Space Agency and Dalhousie University.

Article contributed by James Drummond, Principal Investigator
Our thanks to the following for their support of CANDAC and PEARL:
Aboriginal Affairs and Northern Development Canada, the Arctic Research Infrastructure Fund, Atlantic Innovation Fund/Nova Scotia Research and Innovation Trust, Canadian Foundation for Climate and Atmospheric Science, Canada Foundation for Innovation, Canadian Space Agency, Dalhousie University, Environment Canada, Government of Canada International Polar Year, NSERC, the Northern Scientific Training Program, Ontario Innovation Trust, Ontario Research Fund, Polar Continental Shelf Program, the US Study of Environmental Arctic Change (SEARCH) and the University of Toronto.
Summer School Agenda

Monday July 15, 2013

Lectures will be held in room 10 and posters will be on display in room 10A on the ground floor. Poster boards will be set up on Monday morning and posters can hung in room 10A any time after arrival. Please refer to page 28 for poster room layout, including individual poster locations. Each day, two new science outreach demonstrations will be on display at the back of room 10. The Welcoming Icebreaker begins at 8:30 PM in room 10.

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker/Organizer</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>10:00 – ~11:30</td>
<td>Chartered bus departs Holiday Inn (280 Bloor Street West, Toronto, ON) for the Nottawasaga Inn. Please be there and ready to leave promptly at 9:45 AM.</td>
<td></td>
</tr>
<tr>
<td>11:30 – 12:00</td>
<td>Arrival and check-in at Nottawasaga Inn (6015 Ontario 89, Alliston, ON)</td>
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<tr>
<td>12:00 – 1:30</td>
<td>Lunch (Riverview Dining Room)</td>
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<tr>
<td>1:30 – 1:45</td>
<td>Welcoming remarks</td>
<td>Kim Strong Introduction to the CREATE Training Program in Arctic Atmospheric Science and CANDAC/PEARL</td>
</tr>
<tr>
<td>1:45-1:50</td>
<td>Felicia Kolonjari</td>
<td>Overview of the CREATE Trainees’ Advisory Committee (TAC)</td>
</tr>
<tr>
<td>1:55-2:00</td>
<td>Dan Weaver</td>
<td>Overview of the Career Panel</td>
</tr>
<tr>
<td>2:00 – 3:45</td>
<td>Jamboree</td>
<td>All attendees Student and speaker research jamboree (two minutes and one slide per attendee)</td>
</tr>
<tr>
<td>3:45 – 4:15</td>
<td>Coffee break (room 10A)</td>
<td></td>
</tr>
<tr>
<td>4:15 – 5:00</td>
<td>Lecture A</td>
<td>Ray Nassar The carbon cycle</td>
</tr>
<tr>
<td>5:00 – 5:45</td>
<td>Lecture B</td>
<td>Tom McElroy History of ozone column measurement and Canada’s global role in ozone monitoring</td>
</tr>
<tr>
<td>5:45 – 6:30</td>
<td>Lecture C</td>
<td>Glen Lesins Clouds and aerosols</td>
</tr>
<tr>
<td>6:30 – 6:35</td>
<td>Icebreaker introduction</td>
<td>Emily McCullough and Dan Weaver Description of video icebreaker activity</td>
</tr>
<tr>
<td>6:35 – 7:00</td>
<td>Free time (except for poster judges – they will meet in room 10)</td>
<td></td>
</tr>
<tr>
<td>7:00</td>
<td>Dinner (Riverview Dining Room)</td>
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<tr>
<td>8:30</td>
<td>Welcoming Icebreaker</td>
<td>CREATE Trainees’ Advisory Committee (TAC) Sponsored by COM DEV Includes filming of videos and cocktail social</td>
</tr>
</tbody>
</table>
Tuesday July 16, 2013

Lectures will be held in room 10 and posters will be on display in room 10A on the ground floor. Please stay near your poster for your assigned presentation times. Note that awards will be given to the best posters on Thursday evening after the Career Panel. Judges will be evaluating your poster during your assigned presentation times. Bonfire will take place at the fire pit (see page 25 for map) beginning at 8:30 PM.

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker/Organizer</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:00 – 9:00</td>
<td>Breakfast (Riverview Dining Room)</td>
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</tr>
<tr>
<td>9:00 – 9:45</td>
<td>Lecture A</td>
<td>Udo Friess</td>
</tr>
<tr>
<td>9:45 – 10:30</td>
<td>Lecture B</td>
<td>Ed Eloranta</td>
</tr>
<tr>
<td>10:30 – 11:00</td>
<td>Coffee break (room 10A)</td>
<td></td>
</tr>
<tr>
<td>11:00 – 12:30</td>
<td>Posters</td>
<td>All attendees</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>12:30 – 1:30</td>
<td>Lunch (Riverview Dining Room)</td>
<td>Summer interns</td>
</tr>
<tr>
<td>1:30 – 3:00</td>
<td>Free time</td>
<td></td>
</tr>
<tr>
<td>3:00 – 3:45</td>
<td>Lecture C</td>
<td>Noel McDermott</td>
</tr>
<tr>
<td>3:45 – 4:30</td>
<td>Lecture D</td>
<td>Glen Lesins</td>
</tr>
<tr>
<td>4:30 – 5:00</td>
<td>Coffee break (room 10A)</td>
<td></td>
</tr>
<tr>
<td>5:00 – 5:45</td>
<td>Lecture E</td>
<td>Tom McElroy</td>
</tr>
<tr>
<td>5:45 – 6:30</td>
<td>Lecture F</td>
<td>Ray Nassar</td>
</tr>
<tr>
<td>6:30 – 7:00</td>
<td>Free time</td>
<td></td>
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<tr>
<td>7:00</td>
<td>Dinner (Riverview Dining Room)</td>
<td></td>
</tr>
<tr>
<td>8:30</td>
<td>Free time &amp; optional bonfire</td>
<td>All attendees</td>
</tr>
</tbody>
</table>
**Wednesday July 17, 2013**

Lectures will be held in room 10 and posters will be on display in room 10A on the ground floor.

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker/Organizer</th>
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<td>Breakfast (Riverview Dining Room)</td>
<td></td>
</tr>
<tr>
<td>9:00 – 9:45</td>
<td>Lecture A</td>
<td>Ed Eloranta High Spectral Resolution Lidar - hardware implementation</td>
</tr>
<tr>
<td>9:45 – 10:30</td>
<td>Lecture B</td>
<td>Udo Friess Remote sensing of atmospheric trace gases</td>
</tr>
<tr>
<td>10:30 – 11:00</td>
<td>Coffee break (room 10A)</td>
<td></td>
</tr>
<tr>
<td>11:00 – 11:45</td>
<td>Lecture C</td>
<td>Glen Lesins Climate change</td>
</tr>
<tr>
<td>11:45 – 12:30</td>
<td>Lecture D</td>
<td>Tom McElroy A day in the life – a retrospective on a physicist’s career</td>
</tr>
<tr>
<td>12:30 – 1:30</td>
<td>Lunch</td>
<td>Trainees’ Advisory Committee members CREATE Trainees’ Advisory Committee meeting</td>
</tr>
<tr>
<td>1:30 – 3:00</td>
<td>Free time</td>
<td></td>
</tr>
<tr>
<td>3:00 – 4:15</td>
<td>Workshop</td>
<td>Sarah King, Ruth Louden, and Sheryl Stevenson From ad to interview: Strategies for scientists on the job market. <em>How do scientists who complete advanced degrees land the jobs they want, whether in academic or non-academic settings? The materials and exercises in this interactive session will help participants develop strategies for decoding job ads, tailoring a CV or resume, and preparing for interview questions. The workshop will show how scientists entering the job market can gain an edge by seeing the hiring process from the employer’s angle and thus learning to anticipate different employers’ expectations.</em></td>
</tr>
<tr>
<td>4:15 – 4:45</td>
<td>Coffee break (room 10A)</td>
<td></td>
</tr>
<tr>
<td>4:45 – 6:30</td>
<td>Workshop</td>
<td>Interview workshop continued</td>
</tr>
<tr>
<td>6:30 – 7:00</td>
<td>Free time</td>
<td></td>
</tr>
<tr>
<td>7:00</td>
<td>Dinner (Riverview Dining Room)</td>
<td></td>
</tr>
<tr>
<td>8:30 - 9:30</td>
<td>Lecture E</td>
<td>Noel McDermott Beginnings of trade – from Vikings to the Hudson’s Bay Company (may include a brief introduction to Inuktitut)</td>
</tr>
</tbody>
</table>

*CREATE Trainees’ Advisory Committee Members:* Christian Akpanya, Debora Griffin, Liviu Ivanescu, Felicia Kolonjari (Chair), Zen Mariani (Secretary), Emily McCullough, Chris Perro, and Dan Weaver (Social Media Coordinator). The TAC is currently looking for a few new recruits, so please join them for lunch at 12:30 PM if you are interested.

- 14 -
Thursday July 18, 2013

Lectures will be held in room 10 and posters will be on display in room 10A on the ground floor. Outdoor recreational activities will take place on field 9 (see page 25 for map) beginning at 8:30 PM.

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker/Organizer</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:00 – 9:00</td>
<td>Breakfast (Riverview Dining Room)</td>
<td></td>
</tr>
<tr>
<td>9:00 – 9:45</td>
<td>Lecture A</td>
<td>Jennifer Murphy. Nitrogen oxide chemistry in the Arctic troposphere</td>
</tr>
<tr>
<td>9:45 – 10:30</td>
<td>Lecture B</td>
<td>Ed Eloranta. High Spectral Resolution Lidar – data analysis</td>
</tr>
<tr>
<td>10:30 – 11:00</td>
<td>Coffee break (room 10A)</td>
<td></td>
</tr>
<tr>
<td>11:00 – 11:30</td>
<td>Lecture C</td>
<td>Jim Drummond. CANDAC/PAHA update</td>
</tr>
<tr>
<td>11:30 – 12:30</td>
<td>Lecture D</td>
<td>Ivan Semeniuk. It's complicated: A quest for meaning in science media. How do science reporters do their work when the technical details of a story are hard to understand, experts have divergent views, public opinion is influenced by self-interest and ideology and policy outcomes are murky? That's climate change in a nutshell. This talk will look at the evolving landscape in science journalism around climate change and more generally about the challenge of reporting responsibly on complicated and consequential subject matter.</td>
</tr>
<tr>
<td>12:30 – 1:30</td>
<td>Lunch (Riverview Dining Room)</td>
<td></td>
</tr>
<tr>
<td>1:30 – 3:00</td>
<td>Free time (except for poster judges – they will meet in room 10 at 1:30 to decide on poster awards)</td>
<td></td>
</tr>
<tr>
<td>3:00 – 3:45</td>
<td>Lecture E</td>
<td>Noel McDermott. Wards of the state – Ahiarmiut relocations in the 1950s</td>
</tr>
<tr>
<td>3:45 – 4:30</td>
<td>Lecture F</td>
<td>Thomas Davis. Science policy</td>
</tr>
<tr>
<td>4:30 – 5:00</td>
<td>Coffee break (room 10A)</td>
<td></td>
</tr>
<tr>
<td>5:00 – 6:30</td>
<td>Career panel</td>
<td>Dan Weaver and all attendees. Panelists: Thomas Davis (government), Craig Haley (industry), Noel McDermott (Northern education), Jennifer Murphy (academia), Ray Nassar (government), and Ivan Semeniuk (media)</td>
</tr>
<tr>
<td>6:30 – 7:00</td>
<td>Poster awards</td>
<td>Poster judges. The posters awards will be announced</td>
</tr>
<tr>
<td>7:00</td>
<td>Dinner (Riverview Dining Room)</td>
<td></td>
</tr>
<tr>
<td>8:30</td>
<td>Free time &amp; optional outdoor recreational activity</td>
<td>All attendees. Outdoor sports (soccer, volleyball, ultimate frisbee, horseshoes)</td>
</tr>
</tbody>
</table>
Friday July 19, 2013

Lectures will be held in room 10 and posters will be on display in room 10A on the ground floor. Your poster must be removed before lunch on Friday. Please check out by 11 AM; you may want to check out in the morning before lectures begin at 9 AM. The front desk can store your luggage until departure.

<table>
<thead>
<tr>
<th>Time</th>
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<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>7:00 – 9:00</td>
<td>Breakfast (Riverview Dining Room)</td>
<td></td>
</tr>
<tr>
<td>9:00 – 9:45</td>
<td>Lecture A  Ray Nassar</td>
<td>CO₂ source/sink estimation methods: past, present and future</td>
</tr>
<tr>
<td>9:45 – 10:30</td>
<td>Lecture B  Craig Haley</td>
<td>Doing science in space: challenging and exciting</td>
</tr>
<tr>
<td>10:30 – 11:00</td>
<td>Coffee break (room 10A)</td>
<td></td>
</tr>
<tr>
<td>11:00 – 12:00</td>
<td>Summer School Survey  CREATE Trainees’ Advisory Committee</td>
<td>Trainees’ Advisory Committee presentation Presentation of student video awards Summer school survey</td>
</tr>
<tr>
<td>12:00 – 1:00</td>
<td>Lunch (Riverview Dining Room)</td>
<td></td>
</tr>
<tr>
<td>1:30 – 3:00</td>
<td>Depart Nottawasaga Inn for Toronto. Please be ready to leave at 1:30 PM – meet in the front lobby.</td>
<td></td>
</tr>
<tr>
<td>~3:00</td>
<td>Arrive at the Holiday Inn (280 Bloor Street West)</td>
<td></td>
</tr>
</tbody>
</table>
Jamboree

Requests

The slides are in alphabetical order by last name beginning with speakers followed by students. Please refer below to find your presentation slot and be prepared to begin when the person before you finishes. You will be given two minutes to introduce yourself and your research. Please be courteous to the next speaker and wrap-up promptly when the bell rings. Please excuse any formatting errors that may have occurred in compiling the slides into one presentation.

Organizers

1. Kimberly Strong (CREATE Training Program Director)
2. Ashley Kilgour (CREATE Training Program Coordinator)

Speakers and Panelists

3. Ed Eloranta (University of Wisconsin-Madison)
4. Udo Friess (University of Heidelberg)
5. Glen Lesins (Dalhousie University)
6. Noel McDermott (Queen’s University)
7. Tom McElroy (York University)
8. Ray Nassar (Environment Canada)
   *Kim Strong will introduce absent speakers:*
9. Thomas Davis (Canadian Space Agency)
10. James R. Drummond (Dalhousie University)
11. Craig Haley (COM DEV)
12. Sarah King, Ruth Louden, and Sheryl Stevenson (University of Toronto Scarborough)
13. Jennifer Murphy (University of Toronto)
14. Ivan Semeniuk (Globe and Mail)

Students

1. Christian Akpanya (MSc) (University of New Brunswick)
2. Peter Argall (CREATE intern) (University of Western Ontario)
3. Jennifer Beale (PhD) (York University)
4. Eric Boone (PhD) (University of Michigan)
5. Orfeo Colebatch (Research Officer) (University of Toronto)
6. Jonathan Franklin (PhD) (Dalhousie University)
7. Paul Godin (PhD) (University of Toronto)
8. Kostya Golovan (CREATE intern) (University of Toronto)
9. Debora Griffin (PhD) (University of Toronto)
10. Sean Hartery (CREATE intern) (Dalhousie University/University of Western Ontario)
11. Shannon Hicks (MSc begins Sept. 2013) (University of Western Ontario)
12. Angela Hong (PhD) (University of Toronto)
13. Liviu Ivanescu (PhD) (Université de Sherbrooke)
14. Ali Jalali (MSc) (University of Western Ontario)
15. Magnus Joelsson (PhD) (University of Copenhagen)
16. Mathilde Jutras (CREATE intern) (Université de Montréal/Dalhousie University)
17. Tony Kang (summer intern) (University of Toronto)
18. Bradley Kloosra (CREATE intern) (University of Toronto)
19. Felicia Kolunjari (PhD) (University of Toronto)
20. Stefan Kowalewski (PhD) (University of Bremen)
21. Sam Kristoffersen (PhD) (University of New Brunswick)
22. Jeffery Langille (PhD) (University of New Brunswick)
23. Valérie Losier (CREATE intern) (McGill University/University of New Brunswick)
24. Erik Lutsch (BSc) (University of Waterloo)
25. Marlene Machemy (summer intern) (University of Victoria/University of Toronto)
26. Zen Mariani (PhD) (University of Toronto)
27. Emily McCullough (PhD) (University of Western Ontario)
28. Joseph Mendonca (PhD) (University of Toronto)
29. Omid Moemi (PhD) (York University)
30. Jan-Marcus Nasse (MSc) (University of Heidelberg)
31. Melissa Olsthoorn (MSc begins Sept. 2013) (York University)
32. Kevin Olsen (PhD) (University of Toronto)
33. Onaizah Onaizah (summer intern) (University of Toronto)
34. Christopher Pero (PhD) (Dalhousie University)
35. Anthony Pugliese (summer intern, MSc begins Sept. 2013) (University of Toronto)
36. Meike Rotermund (CREATE intern) (Dalhousie University)
37. Niall Ryan (PhD) (University of Toronto)
38. Ilya Stanevich (PhD) (University of Toronto)
39. Christopher Vail (MSc) (University of New Brunswick)
40. Jeffrey VanKerkhove (MSc begins Sept. 2013) (University of Western Ontario)
41. Zahra Vaziri (PhD) (York University)
42. Camille Viatte (PDF) (University of Toronto)
43. Chen Wang (PhD) (University of Toronto)
44. Dan Weaver (PhD) (University of Toronto)
45. Xiaoyi Zhao (PhD) (University of Toronto)
Welcoming Icebreaker

2013 NSERC CREATE Summer School in Arctic Atmospheric Science

Welcoming “Icebreaker”

Thank-you to our sponsor for this event

COM DEV

Lower patio at 8:30 PM (meet in room 10)
Nottawasaga Inn, Alliston, Ontario
July 15, 2013
www.comdev.ca
Recording and Editing Video Footage (advice from the TAC)

The following pages review useful tips for recording footage for outreach videos in addition to advice on a few of the software programs available for video editing.

Tips for recording good videos .... or...
"How to take video for outreach so that you don't hate yourself when you edit it later"

1. Don't move the camera - use a tripod.
2. Do not zoom while recording.
3. Practice/know your lines.
4. If you mess up your lines, keep the camera running. Just be quiet for a minute, and then try your lines again. When editing later, you can cleanly cut the video.
5. Quiet on set! (Crunching snow underfoot is loud...)
6. If you want multiple perspectives and are tempted to move the camera in the middle of the take... don’t! Instead, record footage twice. Move the camera between shots and glue the pieces together later.

Windows Live Movie Maker

For anyone looking to edit and create their video using a Windows computer, Windows Live Movie Maker is a quick and easy option. Import videos recorded from your camera, edit the clips, preview your video and then save it in any format and resolution.

Tutorial video: [http://www.youtube.com/watch?v=JZXK68NS7gU](http://www.youtube.com/watch?v=JZXK68NS7gU)

Advantages:
- Comes free with every Windows computer
- Easy to add videos, photos, or graphics
- Drag and drop software allows for easy editing
- Save the final video in any format and quality

Disadvantages:
- Perhaps too simple
- Sometimes splits your imported video from your camera into small little videos
- Editing audio can be tricky (however you can fade audio in/out)
- Very limited options and available graphics, animations, etc.

How to use (briefly):
- Click ‘Add videos and Photos’ and select your camera’s videos
- Drag and drop video/image segments in the order in which you want them played
- Right-click on a video segment for more options (insert, zoom, etc.)
- In the ‘Edit’ tab, you can select ‘Split’ to split long segments (or trim)
- Animations and Visual Effects tabs allow transitions between scenes
- Save project = save working project. Save movie = save as a movie file.
Camtasia

Camtasia Studio is a useful tool for recording on-screen activity. The software is compatible with both Macs and Windows machines. Video editing with this software is easy to learn and implement. It can be downloaded from the site: http://www.techsmith.com/download/camtasia/

Advantages:
- Free 30-day trial
- Free to University of Toronto students (http://www.oise.utoronto.ca/online/Instructors/Camtasia/index.html)
- Overlay a small view of the speaker over the video of the presentation
- Easily record webinars or record in PowerPoint

Disadvantages:
- Not free for everyone
- Can be complex/intimidating at first glance

Usage Advice:
- Learn “as you go”: TechSmith offers video clips explaining the appropriate procedures: http://www.techsmith.com/tutorial-camtasia-8.html
- In case the video format from the camera is not accepted by Camtasia, one can convert it with this “Format Factory” free software tool from: http://www.pcfreetime.com/

iMovie

For anyone looking to edit and create their video using an Apple computer, iMovie is a great option. Import videos recorded from your camera, edit the clips, add items from other programs, preview your video and then save it in any format and resolution.

Tutorial Videos: http://support.apple.com/videos/#imovie

Advantages:
- Free with all Apple computers
- Create and edit your own footage
- Stabilize shaky video
- Import files from iPhoto, iTunes, GarageBand, and iLife

Disadvantages:
- iMovie is movement sensitive on the iPhone/iPad; pay attention when editing a movie!
- Learning iMovie can be challenging. The layout is not "beginning user-friendly."

Usage Advice:
- View the tutorial page to learn how to go from importing a video to creating a Hollywood-style movie trailer!
- Enhance your project by adding movie titles, themes, and background music.

A note on copyrights

It is important to recognize that it is not acceptable to use video or audio recordings that have a copyright. For advice on free music that can be used visit www.creativecommons.org and/or http://freeplaymusic.com.
Career Panel

The Career Panel will take place on Thursday, July 18 from 5:00 – 6:30 PM and will be moderated by Dan Weaver, CREATE Trainees’ Advisory Committee member and Social Media Coordinator.

This event provides an opportunity for CREATE Summer School attendees to gain valuable insight into future career paths. This diverse panel of successful science professionals represent the breadth of job opportunities available to science graduates. The session will begin with a short introduction by each panelist, and proceed into an hour-long question and answer session.

Students are encouraged to think about their professional goals and anticipated career paths, and what questions they might ask during the Career Panel session to help inform or inspire their future job seeking efforts. The Trainees’ Advisory Committee will provide a question-submission box (in room 10A) to enable students to anonymously submit their questions in writing ahead of time. The panel (or specific panelist) will be asked these questions during the session by the moderator.

Panelists

Thomas Davis
(government)
Canadian Space Agency’s
Government Liaison Office as
Senior Advisor for Science &
Technology

Craig Haley
(industry)
Systems Engineer at
COM DEV

Noel McDermott
(Northern education)
Teaching Fellow at
Queen’s University

Jennifer Murphy
(academia)
Associate Professor and Canada
Research Chair in the Department
of Chemistry at the University of
Toronto

Ray Nassar
(government)
Research Scientist at
Environment Canada

Ivan Semeniuk
(media)
Science journalist, broadcaster and
the Globe and Mail's national
science reporter
Suggested Readings and Websites

Thomas Davis:  http://www.asc-csa.gc.ca


Ed Eloranta:  http://lidar.ssec.wisc.edu/staff/eloranta.htm

Udo Friess:  http://www.iup.uni-heidelberg.de/institut/forschung/groups/atmosphere/troposphere/Mitarbeiter/en/

Suggested readings:

Craig Haley:  http://www.comdev.ca/

Ashley Kilgour:
http://candac.ca/candac/Outreach/CANDACcollaboration/
http://apecs.is/outreach/

Suggested reading:

Sarah King, Ruth Louden, and Sheryl Stevenson:  http://ctl.utsc.utoronto.ca/home/

Glen Lesins:  http://www.dal.ca/faculty/science/physics/about/atmospheric-science.html

Noel McDermott:  http://www.queensu.ca/indigenous/index.html

Tom McElroy:  http://larss.science.yorku.ca/

Jennifer Murphy:  http://www.chem.utoronto.ca/wp/murphygroup/

Ray Nassar:  http://www.ec.gc.ca/

Ivan Semeniuk:  http://www.theglobeandmail.com/authors/ivan-semeniuk

Kimberly Strong:  http://www.atmosp.physics.utoronto.ca/people/strong/strong.html

CREATE/CANDAC:
http://www.candac.ca/create/
http://www.candac.ca/candac/

@CREATEArcticSci (https://twitter.com/CREATEArcticSci)
/CANDAC (http://www.facebook.com/groups/CANDAC/)
CREATE Arctic Science Blog (http://createarcticscience.wordpress.com/)
Nottawasaga Inn Facilities

Complimentary with Accommodations
25 metre indoor swimming pool
100ft waterslide
Squash & racquetball courts
Fully-equipped fitness centre
Sauna & Whirlpool
(Available during scheduled times. Age and ability restrictions may apply)

Seasonal
Outdoor swimming pool
Bocce
Volleyball
Horseshoes
Nature/jogging trail

Pay-As-You-Play Activities
45 holes of golf on 2 courses
Private golf lessons (CPGA certified instructors)
(Call main pro shop for rates & tee-off times - (705) 435-5504)

Centre Ice Arena
2 NHL-size ice surfaces

Jungle Quest
Indoor 18 hole miniature golf
($5. per person)

Games Room
Video arcade and billiards tables

Tennis
3 indoor courts
(Call the Sports & LeisureDome for rates & availability - (705) 435-5502)

Aerobics, Aquafit, Fitness Classes, Swim Lessons
(Call the Sports & LeisureDome for rates & availability - (705) 435-5502)

Massage Therapy
(rates starting at $45. Call the Sports & LeisureDome - (705) 435-5502)

Esthetician - (705) 435-8829
Hair Salon - (705) 435-4570

Starlite Lounge
Located on the 3rd floor, east wing
Monday to Saturday: 3pm - 12am
Sunday: 4pm - 11pm

Sports & LeisureDome
Hours of Operation
Monday to Thursday
Facility: 6:30am - 10:00pm
Fitness Club: 6:30am - 9:30pm
Pool & Sauna: 7:00am - 9:30pm
Waterslide: 8:00pm - 9:00pm

Friday
Facility: 6:30am - 11:00pm
Fitness Club: 6:30am - 10:30pm
Pool & Sauna: 7:00am - 10:00pm
Waterslide: 5:00pm - 9:30pm

Saturday
Facility: 8:00am - 11:00pm
Fitness Club, Pool, Sauna: 8:00am - 10:00pm
Waterslide: 10:00am - 12:00pm, 1:00pm - 5:00pm, 8:00pm - 9:00pm

Sunday
Facility: 9:00am - 9:00pm
Fitness Club, Pool, Sauna: 9:00am - 8:00pm
Waterslide: 10:00am - 12:00pm, 6:30pm - 8:00pm
(Hours of operation may change seasonally)

Riverview Dining Room
Breakfast Buffet: 7:00am - 10:00am
Lunch Buffet: 11:30am - 1:30pm
Sunday Brunch: 10:30am - 1:30pm

Dinner (Table d’hôte)
Monday - Thursday: 6:00pm - 9:00pm
Friday & Saturday: 5:30 - 9:30pm
Sunday: 5:30pm - 9:00pm
(A buffet dinner may be substituted for menu options during certain holiday periods)

Mahogany Room
Monday - Thursday: 6:00pm - 9:00pm
Friday & Saturday: 5:30 - 9:30pm
Closed Sundays & Holidays
(Smart-casual dress code in effect for Mahogany Room)

Inn Café
Monday - Thursday: 10:00pm - 10:00pm
Friday & Saturday: 10:00am - 11:00pm
Sunday: 9:00pm - 10:00pm

www.nottawasagaresort.com
Nottawasaga Maps

Field 9: Location of Thursday’s outdoor recreational activities.

Bonfire Pit 7: Location of Tuesday’s bonfire and s’mores social.

Sports & Leisure Dome 2: Rain alternative location for Thursday’s outdoor activities.
Lecture Room 10:
Talks daily at 9:00 AM

Lower Patio:
Icebreaker social
Monday at 8:30 PM

Poster Room 10A:
Poster session Tuesday
at 11:00 AM

Riverview Dining Room:
Breakfast 7-9:00 AM;
lunch 12:30-1:30 PM;
dinner 7-8:30 PM;
TAC meeting Wednesday
at 12:30 PM

Starlite Lounge:
Rain alternative
location for Monday’s
icebreaker
**Poster Session**

Posters will be displayed in room 10A from Monday through Friday. Poster boards will be set up on Monday morning. Please mount your posters in the locations indicated below sometime on Monday. Please stay near your poster for your assigned session on Tuesday, as judges will be visiting during your assigned session. Note that awards will be given to the best posters during the awards ceremony on Thursday afternoon, immediately after the Career Panel. Please take down your poster before lunch on Friday.

**Judges for MSc, PhD and PDF posters**

<table>
<thead>
<tr>
<th>Master's, PhD, PDFs</th>
<th>Undergraduates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ed Eloranta</td>
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<tr>
<td>Udo Friess</td>
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<tr>
<td>Glen Lesins</td>
<td></td>
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<tr>
<td>Ray Nassar</td>
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</tbody>
</table>

**Session A (11:00 – 11:45 AM):**

<table>
<thead>
<tr>
<th>MSc/PhD/PDFs</th>
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</tr>
</thead>
<tbody>
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<td>Eric Boone (PhD)</td>
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<td>Erik Lutsch</td>
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<td>Stefan Kowalewski (PhD)</td>
<td>Marlene Machemy</td>
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<td>Sam Kristofer (PhD)</td>
<td>Jeffrey VanKerkhove</td>
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<tr>
<td>Chen Wang (PhD)</td>
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<tr>
<td>Xiaoyi Zhao (PhD)</td>
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</tbody>
</table>

**Judges for undergraduate posters**

| Session A: Jennifer Beale and Camille Viatte |
| Session B: Stefan Kowalewski and Kevin Olsen |

**Session B (11:45 – 12:30 PM):**

<table>
<thead>
<tr>
<th>MSc/PhD/PDFs</th>
<th>Undergraduates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jennifer Beale (PhD)</td>
<td>Shannon Hicks</td>
</tr>
<tr>
<td>Jonathan Franklin (PhD)</td>
<td>Mathilde Jutras</td>
</tr>
<tr>
<td>Debora Griffin (PhD)</td>
<td>Bradley Kloostra</td>
</tr>
<tr>
<td>Liviu Ivanescu (PhD)</td>
<td>Valérie Losier</td>
</tr>
<tr>
<td>Ali Jalali (MSc)</td>
<td>Onaizah Onaizah</td>
</tr>
<tr>
<td>Felicia Kolonjari (PhD)</td>
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<td>Jeffery Langille (PhD)</td>
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<td>Emily McCullough (PhD)</td>
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<td>Omid Moeini (PhD)</td>
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<tr>
<td>Niall Ryan (PhD)</td>
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<tr>
<td>Christopher Vail (MSc)</td>
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<tr>
<td>Zahra Vaziri (PhD)</td>
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POSTER ABSTRACTS
Comparative analysis of gravity waves detected by PEARL All Sky Imager (PASI) and E-Region Wind Interferometer (ERWIN)

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Pronounced and extensive gravity wave signatures have been identified in the intensity images from the OH airglow all sky imager of January 26 2009 between the hours of 07:30 to 13:00 UTC. Similar signals are seen in the ERWIN OH intensity observations for the same time period. In this paper, the characteristics of these waves are discussed and whether associated wind signatures are present in the ERWIN wind observations. These observations provide the means of identifying the nature of these waves and determining their intrinsic properties. This is of interest for investigating the nature of the dynamical influences forcing the large-scale flow in the mesopause region (~90 km height). It was observed that the OH in PASI and ERWIN did not match exactly to establish the correlation. This work presents methods that identify the precise viewing locations that match both PASI and ERWIN based on the evaluation of zenith coordinates on CCD and their relation to angle of inclination from the vertical in the sky using a star map. Nonlinear least square approach was used to evaluate the best possible approximation of the zenith coordinates on CCD in pixels. This is important in validating further analysis of this work in order to ascertain that the features we observe in the image correspond to the real atmosphere for a particular time and location. Digital filtering techniques are being applied to the time series observations. Correlations between the irradiance and wind signatures for specific time periods where gravity waves are present are being explored to identify their characteristics. We have found zenith coordinates on CCD and the correction of the rotational offset associated with PASI. The data used for this calculation fits our model equation confirming the linear relationship between apparent inclination and radial distance from the zenith on CCD.
Development of a New Lidar Data Analysis Program

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Over the past year it became evident that the Purple Crow Lidar's data analysis system, Picon, no longer meets the needs of the group. Picon was written in 2009 using Object Oriented Matlab as part of Paul Doucet’s MSc thesis. Since then, Picon has had 14 major revisions which implemented new functionality and the ability to analyze measurements from 2 additional Lidar Systems, the Eureka DIAL and CRL lidars.

Over time, Picon’s code base has become undocumented spaghetti. This decay is in part due a poor use of objects. The spaghetti code has led to a number of issues including users being unable to analyze measurements from new lidar data inputs as well as slow performance.

The new System, Pecon, is also written in Object Oriented Matlab because the group has previous experience with Matlab. The design process mapped out the relationships between objects, leading to a simplified design. One of main advantages of Pecon is that it allows for the easy implementation of new Lidar systems. Writing Pecon also has the added benefit of verifying the analyses algorithms. This poster will show examples of how these changes increase performance and simplify data analyses.
Investigating the “Escalator Effect” in the Kilmore East fire of February, 2009 using GEM-AC

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In early February, 2009, the Kilmore East district (Southeast Australia) was swept by intense bush fires which burned an area of about 3000 km². Observations show biomass burning products directly injected into the stratosphere as early as the next day (Fromm et al. 2012 AGU Fall meeting) and lifting to ~25 km during the 7-14 days after fire ignition (Pumphrey et al. 2011 ACP). This study continues the study by Glatthor et al. (2013 ACP) which compared MIPAS observations to a high-resolution model run of the Kilmore East Fire plume transport with the Global Environmental Multiscale model with Air Quality (GEM-AQ). There is generally good agreement between the GEM-AQ simulation and the observations, but the lack of distributed aerosols and radiatively active aerosols within GEM-AQ likely accounts for the model’s discrepancy in plume evolution.

In this study we re-run a high resolution simulation of the Kilmore East fire plume transport employing GEM-AC, an extended climate version of GEM-AQ. GEM-AC has, in addition to the extensive on-line chemistry inherited from GEM-AQ, a 60 km lid, M7 and CAMx aerosol microphysics, revised HCN and CH₃CN, extensive halogen, DMS, OCS and NH₃ chemistry. This GEM-AC simulation adds black carbon and organic carbon estimates as part of the burning process to assess their role in the lifting of the biomass burning material within the stratosphere after direct stratospheric injection of the biomass burning products. Aerosol heating is implemented for the 3 hydrophobic and 4 hydrophobic aerosol modes via 3-dimensional (196x40x36) look-up tables of the aerosol single-scattering albedo, asymmetry parameter, and extinction efficiency. GEM-AC will be run with a global variable (GV) grid where the core has uniform grid spacing and the exterior grid expands. Our simulations use ~300 m vertical resolution and 50x50 km² resolution in the inner core with an ~4000x4000 km² horizontal extent, and input the gas and aerosol species at several different heights suggested by higher resolution (2x2 km²) simulations. Tracking the biomass burning gas and aerosol products, we will assess the impact of OC and BC heating on the evolution of the plume.

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Aerosol particles play an important role in the chemistry of the atmosphere by providing surfaces for heterogeneous reactions, contributing to radiative forcing, and forming clouds. However, knowledge of their specific chemical and physical characteristics, particularly in the Arctic, is not well understood. In the springtime, haze layers, formed from transport of anthropogenic pollution and photochemistry, are visible in the Arctic. Therefore, aircraft-based measurements of particle size and concentration were conducted in March 2012 near Barrow, Alaska. The particle diameter mode was generally 200-300nm, suggesting major contributions from Arctic haze aerosol, rather than sea spray. Background concentrations were typically ~100 particles/cm³ with enhanced layers present in the free troposphere. Modeled backward air mass trajectories were used to determine transport and possible particle sources. Air masses associated with background-level concentrations of aerosols were transported low over the Arctic sea ice. The air masses associated with the enhanced aerosol layers originated from around Russia and spent several (2-5) days in transit high over the Arctic Ocean. These results give further insights into the characteristics of the Arctic aerosols and will be used, in combination with chemistry data, to improve future models and predictive studies of atmospheric chemistry in this changing environment.
Solar tracker development in support of ground-based solar absorption spectroscopy

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Remote sensing of atmospheric trace gases via high-resolution Fourier transform spectrometers is a proven technique whereby the atmosphere is probed via its effects on the solar spectrum. The accuracy of the determined trace gas columns is very sensitive to the stability of the solar beam during measurements.

This work focuses on the development of an automated large-aperture solar tracker that has been successfully deployed at the Dalhousie Atmospheric Observatory located in Halifax, Nova Scotia (44.6°N, 63.6°W). The simply designed altitude-azimuth tracker is tuned using rotation stages controlled by a Newport ESP301 driver and the entire system operates from within a RoboDome from Technical Innovations.

A portion of the solar beam is directed to a camera (NetcamXL, StarDot Technologies, 2048x1536 pixels) which allows us to accurately monitor the position of the sun and make active feedback corrections, and a passive system of ephemeris calculations enables us to continue tracking in the event of a temporary loss of signal. This arrangement permits high tracking precision with an rms error of ~50 micro-radians. The entire system is controlled via code and a graphical user interface written in Python.

An identical system is currently being installed in support of ground-based solar absorption measurements at the Polar Environment Atmospheric Research Laboratory (PEARL) located on Ellesmere Island (80.0°N, 86.4°W).
Overview of Laboratory Spectroscopy at the University of Toronto

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An overview of the laboratory spectroscopy facilities at the University of Toronto is presented. Two gas cells are used; the first is known as the short cell (optical pathlength of 6 cm) and is used to make cross-section measurements of strongly absorbing species such as perfluorotributylamine (PFBAm), hydrofluoroethers (HFE), and Hydrofluorocarbons (HFC). These cross-sections can then be used to calculate the global warming potential (GWP) of a given species.

Currently in development is a multipass White cell, which is expected to have a pathlength of 100 m. The White cell will be used to make measurements of weak lines in methane, carbon dioxide, and water vapour that have been known to interfere with the retrievals of several trace gases. Furthermore, carbon dioxide broadening coefficients will be determined for trace gases retrievals of other planets, such as Mars and Venus.

The lab makes use of a Bomem DA8.003 spectrometer. The DA8 has a spectral range of 500-8500 cm\(^{-1}\) and an unapodized spectral resolution of 0.0004 cm\(^{-1}\).
Evaluating and Improving the Performance of the FTIR Spectrometer at the Toronto Atmospheric Observatory

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The Fourier Transform Infrared (FTIR) spectrometer installed at the Toronto Atmospheric Observatory (TAO) is an ABB Bomem DA8 model. The DA8 is a modified Michelson interferometer with HgCdTe (MCT) and InSb detectors that are used for coverage from 750 to 4500 cm$^{-1}$. Six filters are installed to optimize the signal in specific spectral regions. The DA8 has an optical path difference of 250cm resulting in a maximum spectral resolution of 0.004cm$^{-1}$. Using solar absorption measurements from the TAO DA8, retrievals of HF, CO, O$_3$, HCl, N$_2$O, CH$_4$, C$_2$H$_6$ and HCN columns, among others can be performed. Daily measurements, weather permitting, have been taken at TAO since May 2002.

In June 2007, MCT filter 6, which is mainly used for retrievals of O$_3$ but also for ClONO$_2$, HNO$_3$, N$_2$O, CH$_4$ and C$_2$H$_2$ was moved into the sample compartment of the spectrometer from the external filter wheel location in order to increase the accuracy of aperture centering by having an empty slot on the filter wheel. However, this was found to have introduced channeling into the signal. This discovery led to an assessment of the signal-to-noise ratio (SNR) of eleven years of data taken with all six filters, to evaluate the quality of the data over the years. A variety of mirror scan speed and scan co-add tests were also performed in order to decrease noise levels in future measurements. This poster will present results from the completed tests.
Investigation of ozone depletion in the Arctic polar vortex - using ground-based FTIR measurements at Eureka between 2005 and 2013

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Large stratospheric ozone (O⁢₃) loss over Antarctica was observed for the first time in the 1980s. Polar O³ depletion is primarily caused by chlorine chemistry on the surface of polar stratospheric clouds (PSCs). PSCs can form under very cold conditions in the lower stratosphere which can be reached inside the polar vortex. Arctic O³ depletion is usually not as strong as that in the Antarctic because Arctic stratospheric temperatures are typically much higher and more variable than those in the Antarctic.

Ground-based measurements have been carried out during the polar sunrise period (from mid-February to mid-April) at Eureka, Nunavut (80.05°N, 86.42°W) since 2004 during the Canadian Arctic ACE (Atmospheric Chemistry Experiment) Validation Campaigns. As part of this campaign project, the Portable Atmospheric Research Interferometric Spectrometer for the Infrared (PARIS-IR), which is a ground-based Fourier Transform Spectrometer (FTS), was used to measure total as well as partial columns of trace gases important to O³ depletion simultaneously.

The time series of O₃, HCl, HNO₃, ClONO₂ and HF during the polar sunrise periods between 2005 and 2013 is presented here. Measured O₃ columns are significantly lower in 2011 compared to the other years. Both chemical and dynamical processes can produce changes in the O₃ column in the Arctic during the springtime. To investigate whether the loss of O₃ was caused primarily by chemical or dynamical processes, the HNO₃, HCl and O₃ columns are normalized with the HF columns. The PARIS-IR measurements demonstrate that the apparent O₃ decrease in 2011 arose from chemical loss due to chlorine activation was largely responsible for the observed decrease in O₃. The chemical O₃ loss in 2011 was significantly greater than in other years, where O₃ depletion was between 0 and 20%. In 2011, the O₃ loss is estimated to be approximately 37%, using the HF normalization method. The correlation between the O₃ and HF total columns indicates that this loss was over 100 DU. These results compare well to other studies of the Arctic O₃ depletion in 2011, e.g. Manney et al. (2011), and Lindenmaier et al. (2012).

Lindenmaier et al. (2012): Unusually low ozone, HCl, and HNO₃ column measurements at Eureka, Canada during winter/spring 2011 Atmos. Chem. Phys., 12, 3821–3835
Methods of Calibration for the Purple Crow Lidar

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The Purple Crow Lidar (PCL) is a laser radar capable of measuring composition and temperature in the lower, middle and upper atmosphere. The accuracy of its measurements depends on the calibration and efficiency of the detector system. The PCL was recently moved to a new location and much of the counting electronics has changed. As a CREATE summer student my project is to test and calibrate the new detectors. These tests include red light calibration tests, such that the absolute system calibration coefficient can be monitored; beam path measurement, such that we may confirm that our detectors are measuring from ground level; determination of signal induced noise effects, since our PMT’s photocounts are proportional to density, and thus temperature, over counting errors due to ringing, ghosting or saturation can lead to large changes in our temperature profiles; and detector delay calibration, such that we may confirm that our analog and digital channels from our Licel counting systems detect events at the same time. These tests are crucial to the integrity of our climatologies, since our profiles are reliant on how well we can resolve our measured altitudes; for instance, our system has up to 7.5m of vertical resolution in some areas, and so altitude shifts beyond this range must be compensated for. Taking these considerations into account, we are confident that the data collection at the PCL is now closer than ever to working in tandem with theory.
Comparing Clumps in Saturn's F Ring

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Saturn’s F ring is unusual in that it is subject to dynamic structural changes over short periods of time – anywhere from days to months. Images from the Voyager and Cassini spacecraft have revealed structural phenomena such as kinks, fans, channels, streamers, and clumps, all of which change over these short time intervals. Most of these features are caused by interactions between the moon Prometheus and the F ring. However, clumps do not appear to be related to these movements, thus making them unique. This work focuses on the nature and behavior of clumps, diffuse bright objects that extend 3-40 degrees in longitude. Previous work by Showalter (2004, Icarus, 171, 356) showed that it was possible to analyze and track clumps with respect to the F ring’s mean motion over time using Voyager data. Now using 6 years' worth of Cassini images, we have developed a new method of detecting clumps using wavelet theory. We compare the physical attributes of current clumps to those discovered in the Showalter study and find significant differences. In general, modern clumps are wider, less bright, and occur less frequently. This is particularly interesting due to the fact that the reason for why these changes are occurring is currently unknown. Nevertheless, it is becoming increasingly evident that the F ring we see today is not the same ring it was 30 years ago.
Halide-mediated behaviour of nitrate at the air-aqueous interface and implications for the liquid brine layer at the surface of snow and ice

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A rich chemical composition including hydrocarbons, photoactive metals, and halides exists in snow and ice through deposition, condensation, and exclusion to the brine layer by repeated freeze-thaw cycles. To date, there is only a rudimentary understanding of multi-component frozen systems: the effect of individual chemical species differentially excluded to the liquid brine surface, how they interact and influence the overall relative abundance of other co-existing species via photo-oxidation, and the resulting composition of the planetary boundary layer are largely unknown.

Nitrate (NO$_3^-$) is an important ion at frozen water interfaces where it can undergo heterogeneous photolysis to form nitrogen oxides (NO$_X$ = NO + NO$_2$) that can subsequently react with halogen oxides, hydroxyl radicals (HO$_X$ = HO + HO$_2$), and volatile organics in the atmosphere. The air-aqueous interface of ternary sodium-nitrate-halide solutions was interrogated by glancing-angle Raman spectroscopy to compare the behaviour of NO$_3^-$ at the interfacial region to the bulk phase. In the presence of Cl$^-$ and Br$^-$ ions, NO$_3^-$ exhibits divergent behaviour at the surface compared to the bulk. In the bulk solution, the NO$_3^-$ signal is independent of halide addition. At the surface of Br$^-$ containing solutions, we observe a NO$_3^-$ surface excess that becomes more pronounced at higher halide concentrations. In contrast, this trend is only weakly observed for Cl$^-$ containing solutions. The effect of halide salts on NO$_3^-$ surface affinity was further demonstrated by constructing surface adsorption isotherms of pure NO$_3^-$ solutions versus NO$_3^-$ in Cl$^-$ or Br$^-$ containing solutions. Our results suggest that Br$^-$ enhances the surface affinity of NO$_3^-$ whereas Cl$^-$ reduces its tendency to exist at the interface.

Halide-mediated changes in nitrate’s propensity for the air-aqueous interface may also be occurring in the liquid brine layer of ice or snow. Laboratory experiments from our group have demonstrated that NO$_3^-$ is excluded to the brine layer at the air-ice interface upon freezing of the liquid solution$^1$. We are interested in understanding how the distribution of NO$_3^-$ at the surface of snow and ice is affected by other ions. As a first step, urban snow samples were collected during a snowfall event in Toronto and the bulk snow water was melted to analyze for a suite of inorganic ions.

Supervised feature classification of atmospheric particles from lidar charts

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We propose a supervised feature classification of atmospheric particles, using a PCI Geomatics tool, based on the lidar charts of vertical profiles as a function of time. The “spectral” bands used for this purpose are the 355 nm and 532 nm backscattering and depolarization profiles of the CANDAC Raman Lidar from Eureka, NU. We present details of the procedure and assess the class discrimination performance. The method looks very promising, automatically classifying all known types of particles, including the transitional ones between aerosols and clouds. It’s nevertheless less good for discriminating different types of optically thin ice clouds. The procedure also emphasises a comprehensive way of viewing the atmospheric components in a synthetic RGB chart.

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Extension of the Purple Crow Lidar Rayleigh temperature climatologies using an Inversion Approach

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Temperatures retrievals from Rayleigh-scattering lidar measurements have been performed since the 1980’s using the algorithm given by Chanin and Hauchecorne (1980; henceforth CH). Recently Khanna et al. have presented an inversion method to retrieval atmospheric temperature profiles. Argall and Sica (2007) used the CH method to produce a climatology which was compared with the CIRA-86 model. The CH method requires the assumption of a pressure at the highest from a model. The uncertainty due to this assumption causes the top two scale heights of temperatures from profile to be discarded until the retrieval is no longer sensitive to the seed (assumed) pressure. The inversion approach uses a nonlinear inversion method with improved Monte Carlo technique for the statistical uncertainties. This method is used to perform temperature climatology without limitation of traditional method for evaluation. This comparison can detect some information about this method and also global change temperature in middle atmosphere based on temperature measurements obtained by the Purple Crow lidar research facility located near the University of Western Ontario during the period that it has been operated from 1994 to the present.
Clumped kinetic isotope effect in CH4 + Cl

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Methane, as the greenhouse gas with second strongest radiative forcing, hold a big potential for altering the Earth’s climate. Atmospheric methane abundance has undergone a critical growth from pre-industrial levels of 400–700 ppb to above 1750 ppb around year 2000 where the growth seemed to level out [1]. The most recent trend, however, shows a renewed growth rate of atmospheric abundance. The reason for these changes are not well known. Methane has an array of both natural and anthropogenic sources with a wide range of temperatures. The study of clumped (multiple-substituted) isotopes is a promising tool for determining sources of methane, since the formation temperature give each source a isotopical fingerprint [2]. Isotopic composition are in general stored, but removal processes such as oxidation reactions might prefer one isotopologue over another and thus shift the isotopical composition. A metric of this process is the kinetic isotope effect, e.g. αkin(13C3H7/13C3H8), defined as:

\[ \alpha_{\text{kin}}(12\text{C}^1\text{H}_4/13\text{C}^1\text{H}_3^2\text{H}) \equiv k(12\text{C}^1\text{H}_4)/k(13\text{C}^1\text{H}_3^2\text{H}) \]  

where \( k(X) \) is the reaction rate coefficient for the reaction \( X + \text{Cl} \rightarrow X^* + \text{HCl} \). The kinetic isotope effect will render in a clumping effect, \( \Delta(13\text{C}^2\text{H}) \), if:

\[ \Delta(13\text{C}^2\text{H}) \equiv \delta(13\text{C}^2\text{H}) - \delta(13\text{C}) - \delta(2\text{H}) \neq 0 \]

where \( \delta(E) \) is the enrichment of isotope \( ^i\text{E} \) relative to an accepted standard. \( \delta \) relates to \( \alpha_{\text{kin}} \):

\[ \delta \approx \delta_0 + (\alpha_{\text{kin}} - 1) \times \ln(f) \]

where \( f \) is the fraction of isotopically light sample remaining [3].

\( \alpha_{\text{kin}}(12\text{C}^1\text{H}_4/13\text{C}^1\text{H}_3^2\text{H}) \) for the reaction \( \text{CH}_4 + \text{Cl} \rightarrow \text{CH}_3 + \text{HCl} \) was studied experimentally in the photochemical reactor at Copenhagen Center for Atmospheric Research [4]. The relative rate method, which utilizes the relationship:

\[ \ln([13\text{C}^1\text{H}_3^2\text{H}]_{\text{int}}/[13\text{C}^1\text{H}_4]) = (k(12\text{C}^1\text{H}_4)/k(13\text{C}^1\text{H}_3^2\text{H})) \times \ln([12\text{C}^1\text{H}_4]_{\text{int}}/[12\text{C}^1\text{H}_4]) \]  

was used. Equation (iv) describes a straight line where the slope corresponds to \( \alpha_{\text{kin}}(12\text{C}^1\text{H}_4/13\text{C}^1\text{H}_3^2\text{H}) \) as defined by equation (i). A synthesised sample of pure \( ^{13}\text{C}\text{H}_3^2\text{H} \), natural abundance \( \text{CH}_4 \) and \( \text{Cl}_2 \) was introduced in the photoreactor cell together with \( \text{N}_2 \) to a total pressure of 200 mb. \( \text{Cl}_2 \) was photolysed into \( \text{Cl}^* \) radicals to initiate the reaction \( \text{CH}_4 + \text{Cl} \rightarrow \text{CH}_3 + \text{HCl} \). Under the course of reaction several infrared spectra were recorded with a Bruker IFS 66v/s Fourier Transform Infrared spectrometer. The experiments were conducted at room temperature (298 K). The spectra were analysed using the non-linear least squares algorithm MALT [5]. \( \alpha_{\text{kin}}(12\text{C}^1\text{H}_4/13\text{C}^1\text{H}_3^2\text{H}) \) was obtain from the data points of two experiments by linear regression and was found to be \( 1.636 \pm 0.044 \). This value, together with previous results of \( \alpha_{\text{kin}}(1^2\text{H}/2^2\text{H}) \) and \( \alpha_{\text{kin}}(12^1\text{C}/13^1\text{C}) \) [6-8], proves a clumping effect, i.e. \( \Delta(13\text{C}, 2\text{H}) \neq 0 \) for \( f < 1 \).

A PID Controller for the Ozone DIAL System at Eureka

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The Arctic Ozone DIAL system, installed at Eureka (80°N, 86°25’W), is used to measure the ozone profile of the atmosphere of the Arctic. The original laser failed in 2009 and was replaced by a new one which operates at a slower pulse rate. This requires a change in most of the electronics of the lidar, and mainly of the chopper which is used to select the altitude of the scattered signal and to prevent the high intensity signal from the lower part of the atmosphere from saturating the detectors.

To regulate the speed of the chopper, we use a loop PID (Proportional-Integral-Derivative) controller. An optical sensor detects the current rotation speed of the chopper and a microcontroller produces a pulse width modulation (PWM) signal which is sent to the driver of the motor to constantly adjust its speed by changing the applied voltage.

On a lighter level, the newly installed WXT-520 Vaisala Weather Transmitters at Eureka will provide interesting information about the weather and particularly about the difference in the weather between different locations in Eureka.
Refurbishment of the DU DA2 for PARABLE Project

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The Bomem BB-DA2 (balloon-borne dynamical alignment system with a 2-inch aperture) is a Michelson type Fourier Transform Spectrometer (FTS) with two inch input optics. The BB-DA2 was designed for balloon-based measurements and began to operate in 1977. The DA (dynamical alignment) design was highly regarded as it fixes the angular instability in the moving mirror by adjusting the stationary mirror so parallel alignment is maintained between the two mirrors. When making atmospheric measurements, the DA2 uses sunlight as a source of light. This collimated beam is then split into two identical beams with equal amplitude. One beam will be reflected by a stationary mirror while the other will be reflected by a moving mirror. The two beams will then recombine to create an interference pattern which is also known as the interferogram (raw data). This single beam is then split into two by a half silvered mirror where one beam goes to the InSb (Indium antimonide) detector that measures from 2650 cm$^{-1}$ to 3250 cm$^{-1}$ (can measure HCl and O$_3$) and the other beam goes to the HgCdTe (mercury cadmium telluride) detector that measures from 700 cm$^{-1}$ to 1300 cm$^{-1}$ (can measure HNO$_3$, CH$_4$, N$_2$O, ClONO$_2$, CClF$_3$ and CCl$_2$F$_2$). Then one performs a Fourier Transform in order to convert the interferogram (amplitude vs. time) into a spectrum (amplitude vs. frequency). With the Sun acting as a hot blackbody, it provides high signal to noise ratio (SNR) with high sensitivity. DA2 has a 50 cm maximum optical path difference which results in a FWHM (full width at half maximum) resolution of 0.01 cm$^{-1}$.

This research is conducted as part of The PAyload for Remote Sounding of the Atmosphere Using Balloon Limb Experiments (PARABLE) project. There are three main objectives in this project. Firstly, it will develop and fly a balloon-borne payload that will make atmospheric composition measurements using three instruments; PARIS-IR (Portable Atmospheric Research Interferometric Spectrometer for the Infrared) an FTS, DA2, and Sun Photo Spectrometer (SPS-B) a UV-visible grating spectrometer. Secondly, it is expected to create multi-year data sets and build on the ballooning heritage in Canada following the ‘Stratoprobe’ and Middle Atmosphere Nitrogen TRend Assessment (MANTRA) projects. This will ultimately allow one to develop comparison between new and proven instruments. Lastly, the project will provide training and experience to help develop highly qualified personnel who will contribute to future Canadian space missions. As part of PARABLE, DA2 will be repaired and upgraded in both hardware and software areas. The hardware upgrades and maintenance are being undertaken. To improve the software, a Linux kernel will be implemented using Xenomai in order to provide a real-time development framework. Comedi (control and measurement device interface) will also be used to provide a real-time support for hardware and more efficient method of data acquisition.
New eye on the sky: SPÉIR, a millimetre-wave radiometer for High Arctic research

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SPÉIR is a millimetre-wave radiometer currently being developed for use at the Polar Environment Atmospheric Research Laboratory (PEARL) located in Eureka, Nunavut (80.05°N, 86.42°W). The radiometer will make measurements of emitted radiation from rotational transitions of ozone (O₃), nitric acid (HNO₃), nitrous oxide (N₂O), and chlorine monoxide (ClO) in the 265–280 GHz range in order to determine altitude profiles of atmospheric composition. The instrument will perform measurements in two regimes: total power measurement for rotational transitions of more abundant species (O₃ and N₂O), and balanced measurement for species of lower abundance (HNO₃ and ClO). SPÉIR’s detector consists of a superconductor-insulator-superconductor mixer (SIS) and Fast Fourier Transform Spectrometer (FFTS) with 1 GHz bandwidth and 1 MHz spectral resolution. Emission measurements will be calibrated with thermal radiation from two blackbody targets (one at 77 K, one at ambient temperature) to obtain brightness temperature as a function of frequency.

This presentation will focus on the design methodology for the instrument control and data processing systems as well as the graphical user interface (GUI). The system will be flexible to enable autonomous operation in the Arctic. The operator will need only specify a measurement schedule; all other operations will be performed automatically. Furthermore, the system is designed to be robust (function dependably in the wide array of weather conditions in the high Arctic) and efficient (maximise amount of data by minimising setup time between measurements).

SPÉIR’s measurement technique necessitates switching the signal beam between the atmosphere and calibration targets. To accomplish this, instrument operation will involve the control of three motors: one to align the periscope mirror for collecting the atmospheric signal, one to facilitate two-body brightness calibration measurements, and one to quickly transition between calibration and atmosphere measurement modes. In addition, temperature and voltage sensors will be used to communicate important operation information to the user via the GUI and to monitor the instrument to ensure safe autonomous operation.

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Do we understand the global distribution of HCFC-22?

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The annual springtime minimum in stratospheric ozone over the Antarctic is primarily caused by catalytic reactions of ozone and chlorine. Anthropogenic chlorofluorocarbons (CFCs) are major sources of this chlorine. After the implementation of the Montreal Protocol on Substances that Deplete the Ozone Layer in 1987, hydrochlorofluorocarbons (HCFCs) have been the primary replacement for CFCs. In particular, HCFC-22 has been used since its shorter lifetime leads to a much lower ozone depletion potential. Rising atmospheric concentrations of HCFC-22 are however causing concern due to its strong global warming potential.

The Atmospheric Chemistry Experiment (ACE) is a mission on-board the Canadian satellite SCISAT. The primary instrument on SCISAT is a high-resolution mid-infrared Fourier Transform Spectrometer (ACE-FTS). With its wide spectral range, the ACE-FTS is capable of measuring an extensive range of gases including key CFC and HCFC species. The altitude distribution from the ACE-FTS profiles provides information that is complementary to ground-based measurements that are used to monitor these species but are confined to the lower troposphere. An increase in the global concentration of HCFC-22 has been observed since the start of the ACE mission in 2004. Comparisons to ground-based in-situ and air-borne measurements show good agreement with the ACE-FTS measurements. The global distribution of HCFC-22 has been computed from the profiles, revealing seasonal variations and an inter-hemispheric gradient.

The Canadian Middle Atmosphere Model (CMAM) has been used extensively as a free-running chemistry-climate model. To assess chemical processes in the CMAM, a twenty-year run has been produced where the dynamics of the model have been nudged to the ERA Interim reanalysis (the CMAM20 run). Halocarbons in the CMAM are grouped for ease of calculation; therefore, a direct comparison to measurements is complicated by varied mixing and chemical timescales. For example, the HCFC-22 group combines HCFC-22 with four other HCFCs. To facilitate comparisons with the ACE-FTS measurements, an HCFC-22 tracer was added in parallel to the grouped species with no delivery of reactive chlorine into the model when it breaks down. The parallel HCFC-22 has a hemispherically-defined average mixing ratio lower boundary condition based on surface in-situ observations, advection as a tracer, and appropriate chemistry. To compare the representation of HCFC-22 in the CMAM20 run, the model output on both 6-hourly and monthly timescales have been sampled at each occultation location. Our understanding of the behaviour of HCFC-22 in the upper troposphere and lower stratosphere is investigated by comparing the zonal mean distributions and joint probability density functions computed from the model and the measurements.

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The mesospheric hydroxyl airglow layer – A study based on ground-based spectroscopic observations at Spitsbergen and mesospheric models

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The hydroxyl airglow layer is a prominent feature of the mesospheric region at about 87 km altitude. Its radiative emission contains information on surrounding ambient air temperatures and can be observed via spaceborne as well as ground-based instruments during night times.

Because in-situ measurements in this atmospheric region are very sparse, the continuous observation of the hydroxyl airglow layer plays an important key role in studying the mesospheric region. In particular the polar mesospheric region is subject to strong dynamical variability, which can even affect the lower atmospheric layers.

In this poster we present near-infrared spectroscopic observations of the hydroxyl airglow layer made with a Bruker 120 HR Fourier-Transform Spectrometer, which is located at the AWIPEV research station in Ny-Ålesund, Spitsbergen at 78°55' N, 11°55'E.

We discuss some of the dynamical features, which are reflected by changes in temperatures due to adiabatic cooling/heating from vertical up/downlifting of mesospheric air.

In addition we introduce a mesospheric quenching model, which we use to study the responsiveness of the vertical structure of the hydroxyl emission layer to chemical as well as dynamical changes within the mesospheric region.
Wind and Gravity Wave Observations with ERWIN-II

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The E-Region Wind Interferometer (ERWIN-II) is a Michelson interferometer which measures winds in the mesosphere by detecting Doppler shifts in the airglow layers; specifically greenline (557.7 nm), OH (843 nm) and O$_2$ (860 nm). ERWIN-II has been taking wind measurements at the PEARL observatory in Eureka, Nu since 2008. Wind measurements for all four cardinal directions (north, east, south, and west) and the zenith are measured simultaneously, allowing for a high instrument cadence (~3 minutes) with a precision of ~2 m/s. The high temporal resolution allows for the detection of both low frequency waves (such as tides and planetary waves) and higher frequency waves (such as gravity waves). A summary of these wind observations and studies of gravity waves using the linear polarization equations.
Imaging winds in the upper atmosphere: the Michelson Interferometer for Airglow Dynamics Imaging (MIADI) and the Birefringent Imaging Doppler Wind Interferometer (BIDWIN)

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The Michelson Interferometer for Airglow Dynamics Imaging (MIADI) and the Birefringent Imaging Doppler Wind Interferometer (BIDWIN) are two instrument techniques being developed at the University of New Brunswick. MIADI is a scanning field widened Michelson interferometer capable of providing two dimensional images of the perturbations in the line of sight Doppler wind (~ 2 m/s precision) and irradiance field (~1 % variations) of the mesospheric airglow. This is done for an 80km x 80 region of the night sky binned into 5 km x 5 km bins. The instrument concept has been tested in the lab and the design of the field implementation is ongoing. The BIDWIN is a static (no moving parts) instrument constructed using high quality imaging optics, a Lithium Niobate field widened birefringent delay plate, Wollaston prisms, wave plates and a CCD detector. This instrument technique is being investigated at UNB in collaboration with COM DEV ltd for the purpose of imaging LOS Doppler winds in the airglow or aurora either from the space or the ground. The approach is based on a similar design used to image two dimensional Doppler winds in plasmas at the Australian National University (ANU). In that application the sensitivity of the wind measurements was not explored in detail since the LOS wind gradients were on the order of ~1000 m/s and a high signal to noise ratio and short exposure time was used. The advantage of the BIDWIN is that it is lightweight, has no moving parts and is relatively cheap to build. A prototype version of the BIDWIN has been constructed in the lab at UNB using parts provided by COM DEV ltd. To aid in the installation, alignment and characterization process a Jones matrix model of the instrument has been developed. In this paper, the MIADI and BIDWIN instrument technique is explored in detail and the results from the characterization and testing of the instruments is presented. The intended field application of MIADI and BIDWIN is also discussed.
The Waves Michelson Interferometer: Design Principles and Validation

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The Waves Michelson Interferometer (WaMI) is a field widened Michelson interferometer intended to simultaneously measure dynamical signatures, such as wind and temperature, and constituent signatures. This spectral imaging by the satellite instrument is used to help understand the large-scale dynamics and identify the large-scale waves of the upper stratosphere, mesosphere and lower thermosphere (from 45 to ~180 km).

WaMI, a combination of the Wind Imaging Interferometer (WINDII) and a near-IR Michelson, is set up to take simultaneous measurements from both its visible and near infrared channel in six distinct directions. Atmospheric motion results in a Doppler shift in the wavelength of the observed emission line. The associated shift in fringe phase allows the line-of-sight wind to be determined. The remaining fringe parameters allow constituent information and temperature to be determined.

It is possible to obtain valuable information on the upper stratosphere/lower mesosphere region (altitudes between 45-75 km) using the infrared channel. Since the internal rotational states of molecular oxygen, O₂, are populated in accordance with the Boltzmann distribution at the local temperature, the relative distribution of energy in the emission lines in the band is related to the local temperature. The emission lines can be separated and imaged. The observed relative intensities of carefully selected lines from the O₂ molecular band can be used obtain the rotational temperature.

In this paper, the design principals of the WaMI will be described. Laboratory testing to validate these principles is underway. The laboratory setup for these tests will be outlined and initial results presented.
Properties of polar stratospheric clouds obtained by ACE-FTS extinction measurements

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We present a method for the determination of the composition and aerosol particle size distributions of polar stratospheric clouds (PSCs). The results are obtained by extinction measurements made by the Atmospheric Chemistry Experiment (ACE) Fourier Transform Spectrometer (FTS) aboard the SCISAT-1 satellite. The spectral range of the ACE-FTS instrument (750-4400 cm⁻¹) allows for the retrieval of aerosol particles of size between 0.5 to 12 μm.

From the measured extinction spectra of ACE-FTS, gas phase contributions to solar extinction are removed to form a residual spectra. Reference spectra of ice, nitric acid trihydrate (HNO₃·3H₂O), and a supercooled ternary solution (H₂SO₄/HNO₃/H₂O) are calculated by Mie theory from the complex refractive indices of each component respectively. A least-squares problem is formulated and inverted to determine the particle size distributions of the PSC aerosol particles. The composition of the PSC is also determined.
Understanding the Decline of the Arctic Sea Ice Rate of Retreat using CMIP5 Observations

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We examine the characteristics of the Arctic sea ice extent (SIE) and thickness (SIT) loss rates as simulated by 24 Earth system and general circulation models from the Coupled Model Intercomparison Project, phase 5 (CMIP5). Our analysis shows that for a high climate forcing scenario, the models are consistent in the sea ice change projections despite internal variability.

Both SIT and SIE show a decline in loss rate towards ice-free conditions under increasing radiative forcing. The growth-thickness feedback is one explanation for that decline. The changes of multiyear and seasonal ice that lead the Arctic sea ice towards a regime of decreased memory and decreased sensitivity to climate forcing would also cause the sea ice loss rate to slow down. The area effect as the Arctic field is reduced to a parcel of ice in the Arctic Ocean could explain the behaviour of the SIE rate, but is not valid for the SIT.

Our results suggest a distinctive behaviour between the SIT and SIE loss rates in winter and spring. They also show that the SIT systematically reaches its maximum decline rate decades before the SIE does. This timing discrepancy can be explained by the fact that the SIT has longer memory time scales, and enhanced sensitivity to long-term forcing. These results also suggest that the acceleration of the SIT trends could be a predictor of the SIE trends.

A closer look at the distribution of the SIT over time suggests a non-uniform decrease in SIT, with a larger decrease of thicker ice and a gradual shift towards a thinner ice cover, which is consistent with the growth-thickness feedback. Our analysis of the mean seasonal SIT growth does not show any substantial change until later in the century. The models agree on the timing of decline in mean seasonal SIT growth.
Year-round Radiance and Trace Gas Variability in the Arctic using the E-AERI - Poster Abstract

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The Extended-range Atmospheric Emitted Radiance Interferometer (E-AERI) is a moderate resolution (1 cm\(^{-1}\)) Fourier transform infrared (FTIR) spectrometer for measuring the absolute downwelling infrared spectral radiance from the atmosphere between 400 and 3000 cm\(^{-1}\). The instrument was installed at the Polar Environment Atmospheric Research Laboratory (PEARL) Ridge Lab at Eureka, Nunavut, in October 2008. Spectra from the E-AERI provide information about the radiative balance and budgets of trace gases in the Canadian high Arctic. The impact of clouds and ice crystals on the radiative budget has been measured at two altitudes. Total columns of O\(_3\), CO, CH\(_4\) and N\(_2\)O have been retrieved year-round using a new modified version of the SFIT2 retrieval algorithm and show good agreement with measurements from other ground-based spectrometers. The seasonal and diurnal variability of these gases have been determined using E-AERI measurements, which are taken every seven minutes year-round, including polar night when the solar-viewing FTIR spectrometers at PEARL are not operated. This allows E-AERI trace gas measurements to fill in a gap in the PEARL dataset during polar night.
Thin liquid layers in Arctic tropospheric clouds during the 2012 Canadian Arctic ACE Validation Campaign

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Depolarization ratio measurements allow liquid droplets to be discerned from frozen particles in clouds. Liquid droplets can exist well below 0 °C, so this is an interesting quantity to examine in cold Arctic clouds. The radiative behaviour of clouds is dependent on particle phase, so this work contributes to our understanding of the radiative balance of the atmosphere. This poster presents examples of very thin liquid layers within thick icy clouds.

Depolarization measurements by the CANDAC Rayleigh-Mie-Raman Lidar (CRL) at Eureka, Nunavut, Canada (80°N, 86°W) are improving our understanding of Arctic clouds. The transmitted 532 nm lidar laser pulse is linearly polarized. The depolarization ratio measures the depolarizing effect of the cloud particles on the backscattered 532 nm photons.

A typical linear depolarization lidar uses signals in two polarization-specific detection channels to determine the depolarization ratio: A “Parallel” channel and a “Perpendicular” channel, both of which are sensitive to light linearly polarized in only one plane. The CRL lidar has been experimenting with an alternate approach: Using the polarization-sensitive Parallel channel in conjunction with a “Polarization-Insensitive” channel. The latter is the familiar Rayleigh Elastic channel. This avoids the need to use the Perpendicular channel which, in the CRL, receives signals an order of magnitude smaller than those in the other two channels (and thus has lower signal-to-noise ratios than the other channels).

The 2012 Canadian Arctic ACE Validation Campaign provided an opportunity to run the CRL depolarization measurements nearly continuously (both day and night) throughout the polar sunrise season, measuring cloud particle phase with 7.5 m resolution in altitude and 1-minute time resolution in the troposphere. The 2012 measurements were made using the Parallel and Polarization-Insensitive channels, and are compared with local meteorological measurements.

The high resolution of the 2012 “alternate method” CRL measurements is shown to be of importance for cloud types which include liquid layers as their morphology is variable on timescales of several minutes. Several examples in early March show layers < 15 m in vertical extent. Results from this campaign were encouraging, and an expanded investigation of the technique was carried out during the 2013 Canadian Arctic ACE Validation Campaign. Calibrations and analyses which are currently underway will explicitly demonstrate the validity of the alternate depolarization ratio technique, and will quantify its advantages.

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The Spectral Line Shape Problem and Airmass Dependence in TCCON Spectra

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The Total Carbon Column Observing Network (TCCON) is a network of ground-based Fourier transform spectrometers (FTS) that record solar absorption spectra. From these spectra one can retrieve precise amounts of column-averaged dry air mole fraction (Xgas) of CO2, CH4, N2O, CO, H2O and HDO. The Bruker IFS 125HR FTIR (which will be called PEARL FTS) at the Polar Environment Atmospheric Research Laboratory (PEARL), near Environment Canada’s Eureka weather station, has been making TCCON near-infrared measurements since September 2009. The Eureka instrument joined TCCON in July 2010 and is the most Northern site in the network.

The goal of TCCON is to provide a useful data set in order to validate space based measurements of greenhouse gases and help understand how greenhouses gases exchange between the atmosphere, biosphere and ocean. A 1-ppm accuracy is needed by satellite measurements of XCO2, when trying to resolve regional fluxes (Miller et al., 2007). This requires that ground-based measurements have an accuracy greater than 1 ppm in order to be useful for satellite validation. Studies by Hartman et al. (2008) and Thompson et al. (2012) show that the Voigt profile is inadequate to model the spectral line shape of CO2 and is one of the causes of an airmass dependence seen in XCO2 at TCCON sites. This airmass dependent artefact causes retrievals of XCO2 to be ~1% larger at a 20° solar zenith angle (SZA) compared to 80° (Wunch et al., 2011). Since the SZA varies seasonally and with latitude between sites, if not taken in to account, this artefact will lead to false differences in the seasonal cycle of XCO2 between sites. This in turn would lead to incorrect estimates of regional fluxes of XCO2 (Wunch et al., 2011). The Voigt profile assumes that spectral lines are collisionally isolated and when they are not, collisions will transfer intensity from one line to another (line mixing).

In this study I used a line shape profile that takes into account both line mixing and speed dependence (takes into account variable speed at time of collision) effects in order to decrease the dependence of CO2 measurements on the amount of air mass measured through. The new line shape provides a better agreement between calculated and measured spectrums (spectral fits) and the dependence on airmass has decreased. However systematic residuals still remain in the spectral fits and an airmass dependence still remains.
A mathematical model of Brewer instrument for estimating stray light amount

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Like other kind of grating spectrometers, scattering by the grating is the major source of stray light in Brewer Spectrophotometers. Presence of the stray light due to imperfection of Brewer as well as the large intensity gradient due to ozone absorption at large ozone paths result in a finite out-of-band rejection, which means that light of longer wavelengths contributes in measurement at short wavelengths. This results in underestimated ozone column especially when the ozone slant path becomes more than 1000 Dobson Unit (D.U.). The ozone column of 600 D.U. with an airmass factor of 3 (1800 D.U.) can be measured 8\% lower than actual amount. In this work, a mathematical model of instrument response was developed for two versions of Brewer (Single-monochromator and Double-monochromator) to estimate the amount of stray light from the slit functions measured using a He-Cd laser. This model can be used to validate the methods of correcting the stray light effect.

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Measuring mesoscale horizontal and vertical distributions of reactive halogen oxides in Antarctica

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Halogen compounds have an important influence on the atmosphere of the Earth. In the polar troposphere chlorine, bromine and iodine released from sea salt particles or produced by photolysis of halocarbons. I₂ can be emitted by the ocean. These compounds destroy ozone which strongly influences the equilibrium of tropospheric chemistry.

Especially sudden increases in reactive bromine in polar springtime can cause nearly complete ozone destruction in the boundary layer over areas of several million square kilometers. The origin of these elevated concentrations are heterogeneous, autocatalytic reactions on sea ice surfaces and sea salt aerosols exponentially increasing the reactive bromine (bromine explosion).

Model results also indicate that even small concentrations of iodine species in the range of a few parts per trillion (ppt) could have important consequences for tropospheric chemistry: increased ozone destruction, possible particle formation with impact on the (local) climate and change of the oxidation properties of the troposphere resulting for example in elevated mercury deposition with according consequences for the local biosphere.

Despite major scientific efforts many details of polar halogen chemistry such as distribution, vertical profiles, sources and sinks and key processes are still not completely understood.

The poster presents a short introduction into the subject including the most important reaction cycles of polar halogen chemistry, the basic principles of Multi Axis Differential Absorption Spectroscopy (MAX-DOAS) and profile retrieval. The measurement campaigns ANT XXIX-6 and ANT XXIX-7 of RV Polarstern conducted from June to October 2013 are described.

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Temperature and Pressure Retrievals for Mars: Evaluation Over the Earth's Arctic

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The Canadian Space Agency is interested in using the instrument design of the highly successful Atmospheric Chemistry Experiment (ACE) to explore the atmospheres of other planets. Having an ACE-like instrument at Mars would lead to an unprecedented understanding of the composition of the Martian atmosphere, and the processes that govern it. The objective of our current research is to develop a method to retrieve vertical profiles of temperature and pressure from the spectra, which are vital to obtaining the volume mixing ratio (VMR) of target gases. Our approach attempts to do this using minimal assumptions, \textit{a priori} knowledge, or model information about the state of the atmosphere since these will be either unavailable for Mars, or less reliable than for Earth. We present the mathematical basis for retrieving temperature and pressure, and show current results. To evaluate this method, we are analyzing data recorded by ACE and comparing our results to those of ACE and The Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC) and The Greenhouse Gases Observing Satellite (GOSAT).
Validation of ACE-FTS satellite data using ozonesonde measurements

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Satellite data is an important tool for monitoring gases in the atmosphere. The Atmospheric Chemistry Experiment (ACE) is a mission on board the Canadian satellite SCISAT. ACE-FTS, a high resolution (0.02 cm\(^{-1}\)) infrared Fourier transform spectrometer, is the main instrument on SCISAT. The spectra measured by this instrument can be used to retrieve a wide range of gases including ozone. Ozone is an important gas because it helps to block harmful radiation from reaching the surface of the Earth. It is important to monitor ozone because catalytic loss cycles with chlorine from CFCs have caused depletion of ozone.

Monitoring the quality of data retrieved from ACE-FTS is a critical process. As the instrument ages, the quality of the data must be assessed to ensure that it is still reliable. By comparing the ACE-FTS measurements to another instrument, an assessment can be made. In this study, ozone profiles measured by ozonesondes are used. Ozonesondes are balloon-borne instruments that are launched at Eureka daily during the Canadian Arctic ACE Validation campaigns in February and March. Since the satellite frequently makes measurements over Eureka during this time, the data can be compared. Validation comparisons have been performed between ACE-FTS and ozonesonde measurements. To validate the ACE-FTS measurements, a coincidence criteria was defined based on previous work and used to calculate means and differences. Measurements made between 2004 and 2009 were used in this validation. Initially, measurements recorded in 2011 were also briefly analyzed due to unprecedented arctic ozone loss during the year.
Arctic Precipitable Water Measurements and Comparisons using the Microwave Humidity Sounder

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The Microwave Humidity Sounder (MHS) is an instrument onboard the polar orbiting NOAA-18 and MetOp-A satellites. MHS measures the brightness temperatures at five channels near 183 GHz for the purpose of measuring water vapour column without significant interference from ice or water clouds. The water vapour retrieval technique is independent of surface emissivity and favours low column amounts of water vapour (< 7 mm), ideal for Arctic winter measurements. A calibration is produced using winter precipitable water measurements from the G-Band radiometer (GVR), located in Barrow, Alaska (71N, 156W).

The MHS dataset is used to generate Pan-Arctic plots, which can be produced twice-daily with 15 km resolution at nadir. This technique can also be applied to other satellite instruments that measure brightness temperatures near 183 GHz, which include the Advanced Technology Microwave Sounder (ATMS), Microwave Humidity Sounder (MWHS), and Advanced Microwave Sounding Unit (AMSU-B). The addition of these instruments allows for an increase in the temporal resolution of the precipitable water fields.

An assessment of the Arctic radiosonde network will be shown to test the results of the new MHS calibration and to show the quality of water vapour measurements at each station. A case study of a thick precipitating ice cloud extending from the surface to the tropopause will be shown as measured by the CANDAC Rayleigh-Mie-Raman lidar (CRL), located in Eureka, Nunavut (80N, 86W). Pan-Arctic maps of water vapour using the MHS in combination with FLEXPART back trajectories indicate two possible water vapour masses contributing to the formation of the thick ice cloud. Thick precipitating ice clouds occur frequently at Eureka with several cases being measured each winter by the CRL. Time evolution of the precipitable water fields can provide insight into the dehydration of the atmosphere in the Arctic. A water budget for the Arctic can also be constructed using the high spatial and temporal resolution analysis.
Installation of a New Suntracker for the Bruker IFS 125HR Fourier Transform Infrared Spectrometer in Eureka

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The Bruker IFS 125HR Fourier Transform Infrared Spectrometer (FTIR) was installed in 2006 at the Polar Environment Atmospheric Research Laboratory (PEARL) Ridge lab, located in Eureka, Nunavut, Canada (\(80.05^\circ\text{N}, 86.42^\circ\text{W}\)). The Bruker FTIR is used for measuring atmospheric trace gases by solar absorption spectroscopy, using the sun as its source. The setup uses a suntracker to follow the sun’s movement during the course of the day, directing the beam of sunlight into the spectrometer through a series of three mirrors: a mirror on the roof to follow the sun azimuthally, a mirror on the roof to follow the sun’s elevation, and a mirror in front of the spectrometer to reflect the incoming beam into the spectrometer. To optimize the quality of measurements, and eventually allow for control of the equipment from a remote location, in June 2013 a new suntracker was installed in the PEARL Ridge Lab for the Bruker FTIR. An automated dome was installed to protect the equipment, and a camera was installed near the spectrometer’s mirror to monitor alignment of the beam. In addition, larger azimuthal and elevation mirrors were installed on the roof, increasing the size of the beam, creating the potential for more instruments to take portions of the signal. The suntracker also has the capability to operate in two different modes of tracking: active and passive. Active tracking is using the camera to monitor and follow the sun’s movement, whereas passive tracking is using a calculated method to determine and follow the sun’s position.

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CANDAC Rayleigh-Mie-Raman Lidar Analysis at Eureka, Nunavut and Surface Temperature Comparisons in the Northern Hemisphere

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The CANDAC Rayleigh-Mie-Raman Lidar (CRL) stationed in the High Arctic at Eureka, Nunavut (80N, 86W) measures aerosols, clouds, and molecules from near the ground up to the upper stratosphere. Nanosecond pulses of laser light are directed upwards, scattering with particles in the atmosphere from which back-scattered light is collected by a 1 m telescope and recorded by photon/analogue counting. As a result the atmosphere’s aerosol and cloud structure is known at a certain period in time. Analysis of the Arctic’s atmosphere (particularly over seasonal changes) demonstrates the sensitivity of the climate in higher latitude regions.

To further understand the Arctic’s climate and its affect on the rest of the world a comparison to other stations in the Northern Hemisphere is done by analyzing each location’s surface temperature. Since 1950 the global average temperature has been increasing steadily, with an exception to the last few years where there has been a plateau in the global mean temperature. To try to understand this interesting feature, many locations in the Northern Hemisphere were studied including Eureka. NASA Goddard Institute for Space Studies (GISS) has surface temperature data sets available from stations around the world, which were categorized by 10° latitude regions between 35°N and 85°N. The yearly average temperature anomaly was calculated to average data sets at similar latitudes. It was verified that at higher latitudes a greater increase in temperature is evident compared to lower latitude regions between 1950 and 2012. Although the Arctic’s yearly average temperature is steadily increasing and not slowing down, the plateau of the global average temperature is still apparent.
A Tale of two Instruments

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KIMRA (Kiruna Microwave Radiometer) and MIRA 2 (Millimetre-wave Radiometer) are two ground-based radiometers that are currently operating in the Arctic at Kiruna, Sweden (68N, 20E). Since the installation of MIRA 2 at Kiruna in November 2012, both instruments have been making regular measurements of radiation emitted from ozone, O\textsubscript{3}, in the atmosphere. These measurements of rotational transitions are used to retrieve atmospheric concentration profiles of O\textsubscript{3} over altitudes of approximately 16 – 70 km. Since they operate under the same principle, and use similar hardware, this provides an excellent opportunity to compare the results from each instrument and identify the cause of any disagreement.

In this contribution I will show the results obtained from the measurements of each radiometer using the same technique and, in particular, show how the differences in each instrument can give rise to differences in retrieved concentrations of O\textsubscript{3} in the atmosphere.

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FTIR measurements of acetylene, formic acid, and formaldehyde at the University of Toronto Atmospheric Observatory

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Tropospheric trace gas measurements have been made in downtown Toronto at the University of Toronto Atmospheric Observatory using ground-based solar absorption Fourier transform infrared (FTIR) spectroscopy. Measured gases include acetylene (C$_2$H$_2$), formic acid (HCOOH) and formaldehyde (H$_2$CO). The University of Toronto Atmospheric Observatory (TAO, 43.66° N, 79.40° W, 174 masl) employs an ABB Bomem DA8-model FTIR spectrometer coupled to a suntracker. The retrievals of C$_2$H$_2$ were performed on the TAO FTIR spectra for the period from January 2002 to September 2011, HCOOH – from January 2002 to May 2007, and H$_2$CO – from October 2001 to April 2007. Atmospheric profiles and columns of trace gas abundances were retrieved from TAO spectra using the optimal estimation method implemented with SFIT2 v3.94 and spectral line parameters from the HITRAN2008 database. The a priori gas profiles were obtained from WACCM version 6 model. The constraint matrix was taken to be based on Tikhonov regularization method. Error budgets for the retrieved gases are also presented. The degrees of freedom for the retrievals are close to unity which results in scaling of the a priori profiles. The results showed notable seasonal variability for acetylene, formic acid and formaldehyde with the highest column amounts in February, July and August, respectively. The retrievals also indicated 6 and 1.5 times increased mean ground volume mixing ratio values for formic acid and formaldehyde, respectively, compared to the a priori values. The obtained total error budget for formaldehyde appeared to be high due to noise in spectrum and uncertainty of spectroscopic parameters.
Observations of Gravity Waves over Eureka using the All Sky Imager

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Located at PEARL is the PEARL All Sky Imager (PASI) which is a CCD imaging system with six different spectral band narrow band filters. These filters are targeted at emissions: Sodium (at 589.3 nm), Background (at 572.5nm), Molecular Nitrogen ion (at 427.8nm), Molecular oxygen green line (at 557.7nm) and Molecular oxygen red line (at 630.0nm) and Hydroxyl (at 720-910nm notched at 865nm due to the molecular oxygen). The OH emission observations are taken every other image and the other emissions are cycled through sequentially. On average an image is taken every minute.

The analysis of airglow observations in terms of gravity wave signatures is reported in this poster. Gravity wave parameters of interest are the background wind corrected phase speed and period and the correlation between propagation direction and these quantities. Occurrences of these waves in individual images are defined in terms of horizontal spatial wavenumber, and phase. Temporal phase information is deduced from consecutive images which contain wave signatures with similar wavenumbers. Monthly variations of these quantities during the 2008-2009 season will be presented.
A study of disk composition in NGC1333

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We have gathered data for 79 young stellar objects in the NGC1333 reflection nebula, one of the youngest star-forming regions observed. Using spectra and photometry collected over the course of the Spitzer Space Telescope mission, we correct for mispointing and dust extinction. A method called the 'Two Temperature Model' is then used to compute dust compositions for stellar accretion disks. Such mineralogical studies are essential in understanding the early evolution of circumstellar disks, which in some instances lead to the formation of planetary systems.
A New Calibration Procedure which Accounts for Non-linearity in Single-Monochromator Brewer Ozone Spectrophotometers

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It is now known that Single-Monochromator Brewer Spectrophotometer ozone and sulphur dioxide measurements suffer from a non-linearity due to the presence of instrumental stray light. Because of the large gradient of the ozone absorption spectrum in the ultraviolet, the atmospheric spectra measured by the instrument possess a very large gradient in intensity in the 300 to 325 nm wavelength region. This results in a significant sensitivity to stray light when there is more than 1000 Dobson Units (D.U.) of ozone in the light path. The measurements can be on the order of 8% low for an ozone column of 600 D.U and an airmass factor of 3 (1800D.U.).

Primary calibrations for the Brewer instrument are carried out at Mauna Loa Observatory in Hawaii. They are done using the Langley plot method to extrapolate a set of measurements made under a constant ozone value to an extraterrestrial measurement. Since a small non-linearity at lower ozone paths may still be affected, a better calibration procedure should account for the non-linearity of the instrument response. This poster presents a mathematical model of the instrument response and a non-linear retrieval approach that calculates the best values for the model parameters. The model can then be used in reverse to provide correct ozone values even at large ozone slant paths.

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Observation of biomass burning species at Eureka

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We present five years of observations of seven tropospheric species, which are released by fires: carbon monoxide (CO), hydrogen cyanide (HCN), ethane (C\textsubscript{2}H\textsubscript{6}), acetylene (C\textsubscript{2}H\textsubscript{2}), methanol (CH\textsubscript{3}OH), formic acid (HCOOH), and formaldehyde (H\textsubscript{2}CO). Total columns of these gases were measured using a ground-based FTIR (Bruker IFS 125HR) at the Polar Environment Atmospheric Research Laboratory (PEARL), located at Eureka, Nunavut, Canada (80°N, 86°W) from 2007 to 2011.

The different lifetimes of these molecules play a role in the observed seasonal variabilities in the Arctic: CO, HCN, C\textsubscript{2}H\textsubscript{6}, and C\textsubscript{2}H\textsubscript{2} are driven by the OH reaction and long-range transport whereas CH\textsubscript{3}OH, HCOOH and H\textsubscript{2}CO are driven by biogenic emission and short-range transport. We focused on these species because our ability to predict trace gas concentrations and variability in models, such as degradation mechanisms of Non Methane Hydrocarbon’s, are poorly understood and have yet to be satisfactorily quantified, especially in the Arctic region.

Eleven biomass burning events transported from Russia and Asia have been identified, by detecting simultaneous enhancements of all biomass burning tracers concentrations in the time series. One significant case study is shown for August 2010, when simultaneous enhancements of aerosol optical depth (AOD) and total columns of CO, HCN, and C\textsubscript{2}H\textsubscript{6} were observed at PEARL. Moderate Resolution Imaging Spectroradiometer (MODIS) hot spots, Ozone Monitoring Instrument (OMI) aerosol index maps, and HYSPLIT back-trajectories were used to attribute these enhancements to an intense boreal fire event occurring in Russia.

Furthermore, to improve the simulation of fire emissions in chemical transport models, the composition of smoke plumes needs to be quantified accurately. Therefore, we derived equivalent emission factors for all these species. Given the large range of values found in the literature, this study adds new observations to the sparse dataset of emission factors that have been reported and compiled in the literature.
Determination of Setschenow Constants of Organic Compounds in Ammonium Sulfate Solutions and the Salt Effect on Air-Water Partitioning

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The presence of salts significantly influences the partitioning behavior of organic compounds between the gas phase and environmentally relevant aqueous phases such as sea water and aqueous aerosol. The change in the activity of organic chemicals in aqueous solutions caused by inorganic salts is quantified with empirical Setschenow constants. Atmospheric water (cloud, fog and aqueous aerosol) contains a mixture of various inorganic salts, of which ammonium sulfate is often the most abundant. As a result, Setschenow constants for ammonium sulfate are required for accurate atmospheric phase distribution assessments of organic compounds, including those implicated in secondary organic aerosol (SOA) formation. However, Setschenow constants for ammonium sulfate are available only for a very limited number of chemicals. One reason for this lack of data might be that their determination traditionally requires highly precise measurements of aqueous solubility at different ionic strength. In the present study, the suitability of three methods for determining Setschenow constants in a relatively simple, reliable and inexpensive way is explored. They are a shared headspace passive dosing method, a negligible-depletion solid phase micro-extraction (SPME) technique, and a headspace gas chromatography method. The objective of this project is to make measurements of the Setschenow coefficients for diverse organic compounds (especially SOA relevant substances) in ammonium sulfate solutions and then develop a predictive model for estimating Setschenow coefficients from chemical structure.
Intercomparison of atmospheric water vapour measurements at Eureka

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Water vapour plays a critical role in atmospheric dynamics and the Earth’s radiative balance. However, its concentration, evolution and transport processes are still poorly understood. One of the instruments at the Polar Environmental Atmospheric Research Laboratory (PEARL) in Eureka, a Bruker IFS 125HR Fourier transform infrared (FTIR) spectrometer, is able to measure many trace gases, including water vapour. The PEARL FTIR spectrometer recently joined the new MUSICA network (Multi-platform remote Sensing of Isotopologues for investigating the Cycle of Atmospheric water). MUSICA aims to answer outstanding questions regarding the atmospheric water cycle. This poster evaluates PEARL FTIR water vapour measurements in the Canadian high Arctic using comparisons to other ground-based PEARL instruments, as well as satellite measurements.
Cloud identification using the UV-visible colour index at the Polar Environment Atmospheric Research Laboratory

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In UV-visible spectroscopy, Rayleigh and Mie scattering contribute to the broadband extinction seen in spectra of scattered sunlight. The relative intensity of these two components of scattering is highly dependent on the cloud condition of the sky. The colour index, defined as the ratio of light intensities at different wavelengths, typically 350 nm and 550 nm, provides a means of determining the cloud conditions.

A UV-visible triple-grating spectrometer, the UT-GBS (University of Toronto Ground-Based Spectrometer), was installed at the Polar Environment Atmospheric Research Laboratory (PEARL, 86.4°W, 80.1°N) in 1999. Since then, the instrument has made daily measurements during spring from 1999-2009, and year-round, with the exception of polar night, from 2010-2013. The UT-GBS measures vertical column densities of ozone, NO₂, as well as slant column densities of enhanced BrO and OClO, by using the Differential Optical Absorption Spectroscopy (DOAS) technique.

Several stratospheric ozone loss events were observed during spring by the UT-GBS; these will be discussed in the context of the location of the polar vortex relative to Eureka, stratospheric temperatures, and cloud index as the evidence of polar stratospheric clouds (PSCs).

In addition to detecting PSCs, the cloud index may also be used for the detection of tropospheric clouds. Our preliminary research shows that the UT-GBS cloud index results match well with data from the Millimetre Could Radar (MMCR) at PEARL. Thus the cloud index may be useful as index for the quality of DOAS retrievals, which can be greatly affected by the tropospheric clouds.

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