Eureka 2019 Site Report

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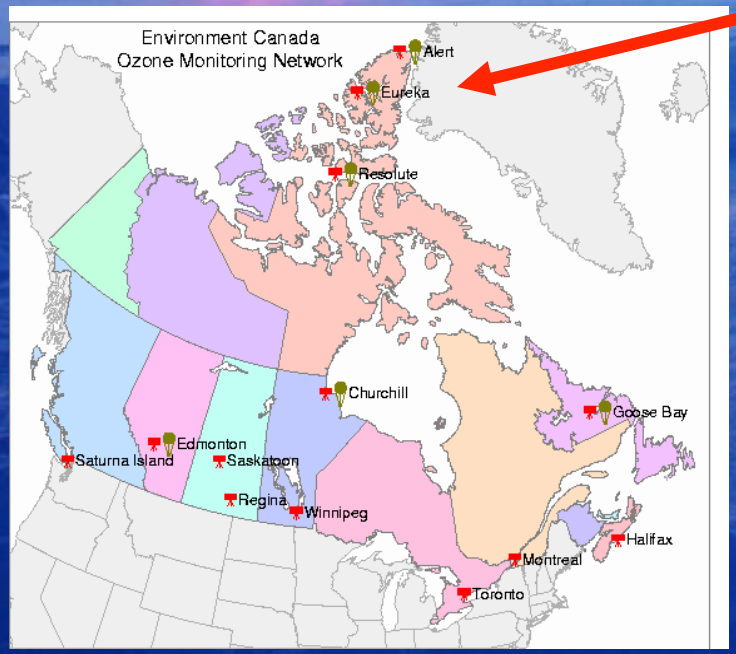
NDACC IRWG Meeting
Wanaka, New Zealand
May 2019

The PEARL at Eureka

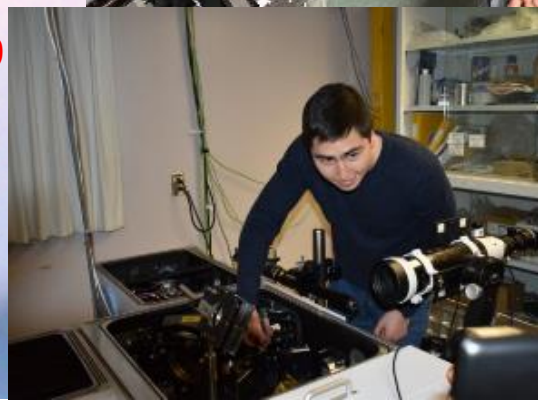
Polar Environment Atmospheric Research Laboratory

- Run by the Canadian Network for Detection of Atmospheric Change (CANDAC) since August 2005
- ~25 experiments at 3 facilities



- Located on Ellesmere Island, Nunavut (80°N, 86°W, 610m)
- 15 km from Env. Canada's Eureka Weather Station
- 1100 km from North Pole

PEARL 125HR History



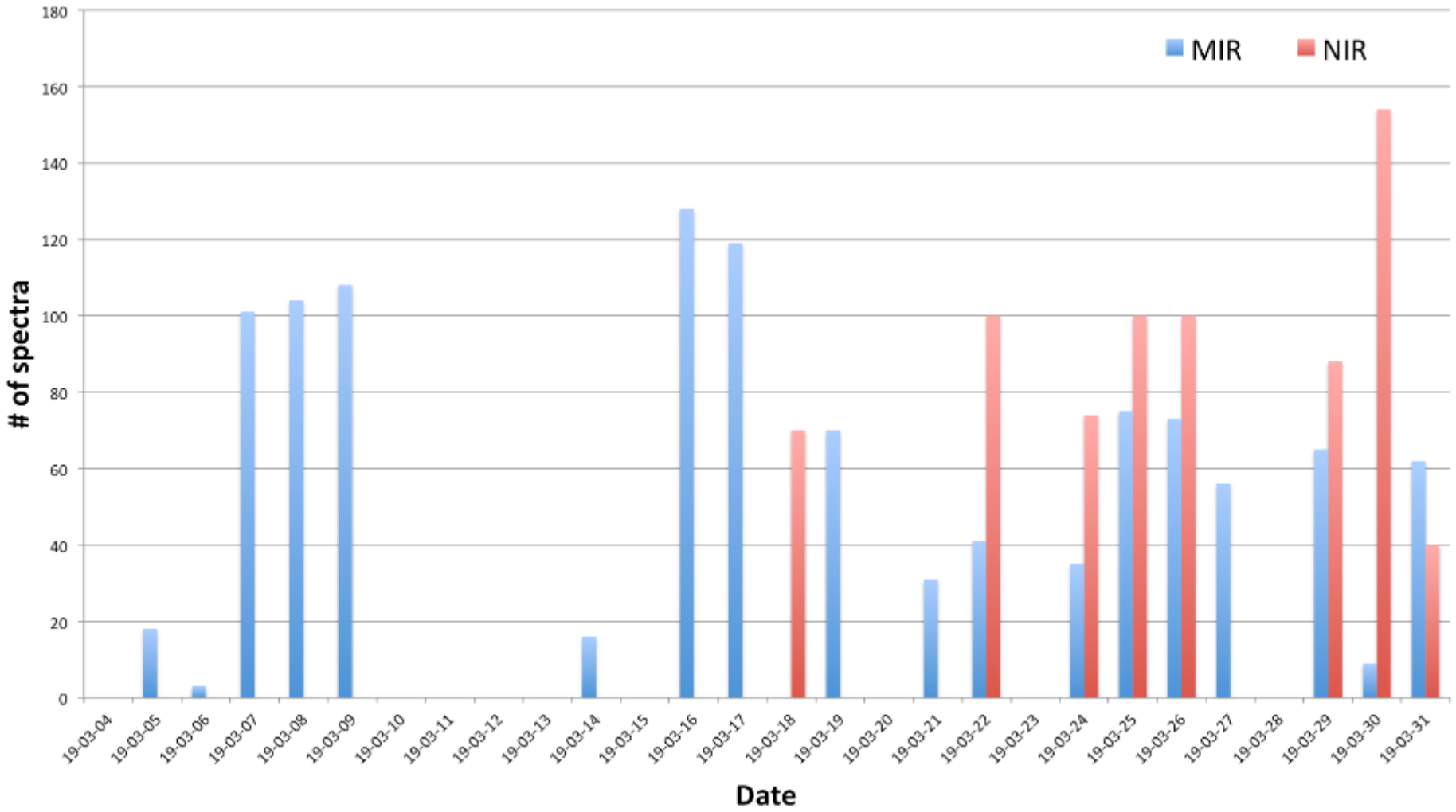
- Installed July 2006; mid-IR configuration
- NDACC certification February 2009
- Replaced Bomem DA8 – removed in 2009
- Joined TCCON June 2010; alternating mid-IR and near-IR
- Intensive campaigns
  - Canadian Arctic ACE/OSIRIS Validation Campaigns: 2007 → **2019**
  - July 2007 – Bomem DA8 inter-comparison
- Upgrades and maintenance
  - August-September 2009 – NIR upgrade
  - July 2010 – Relocation of 125HR
  - July 2013 – New Community Solar Tracker and Robodome
  - February 2015 – New computer installed
  - July 2015 – Laser replaced with SIOS
  - February 2016 – First N_2O cell tests
  - March 2017 – Alignment of 125HR
  - March 2018 – Exit flat mirror adjustment
  - March 2019 – New aperture wheels and entrance window + alignment
- Measurement days (MIR and/or NIR):

2006: 17	2012: 30	2018: 112
2007: 117	2013: 27	**2019: 51**
2008: 121	2014: 106	**(to date)**
2009: 111	2015: 144	
2010: 92	2016: 115	
2011: 85	2017: 102	

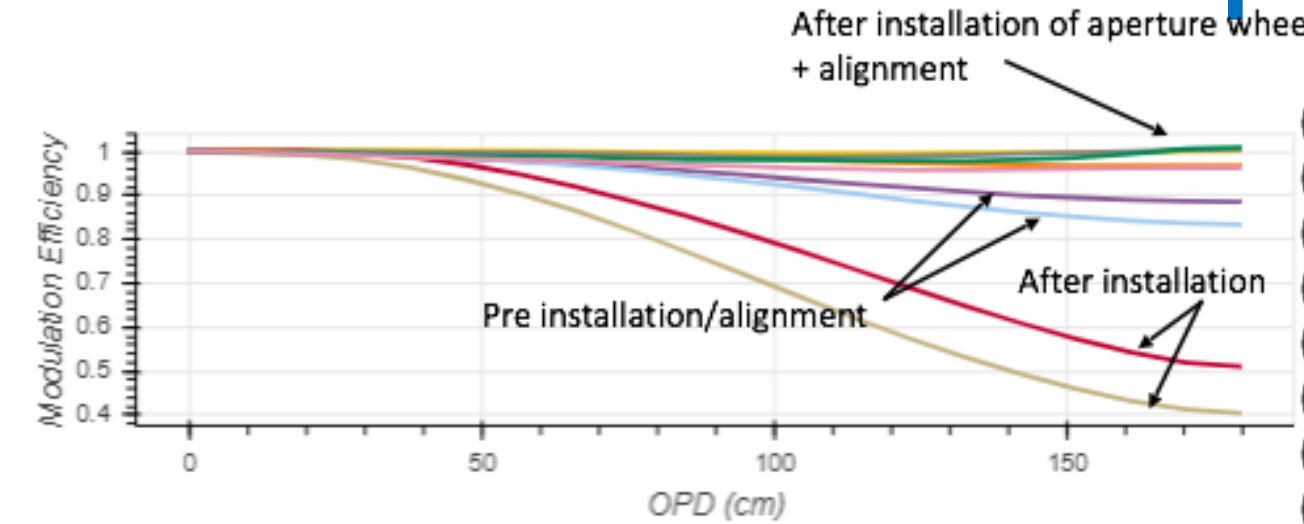
2019 Canadian Arctic ACE/OSIRIS Validation Campaign Measurements

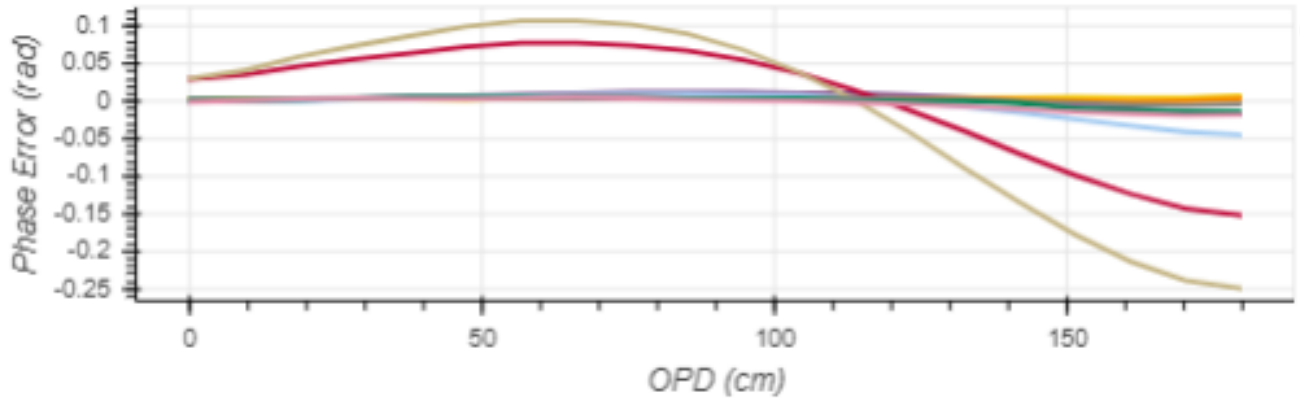
Collected **1840 solar measurements** during the 2019 campaign over 19 days between 5 March and 31 March.

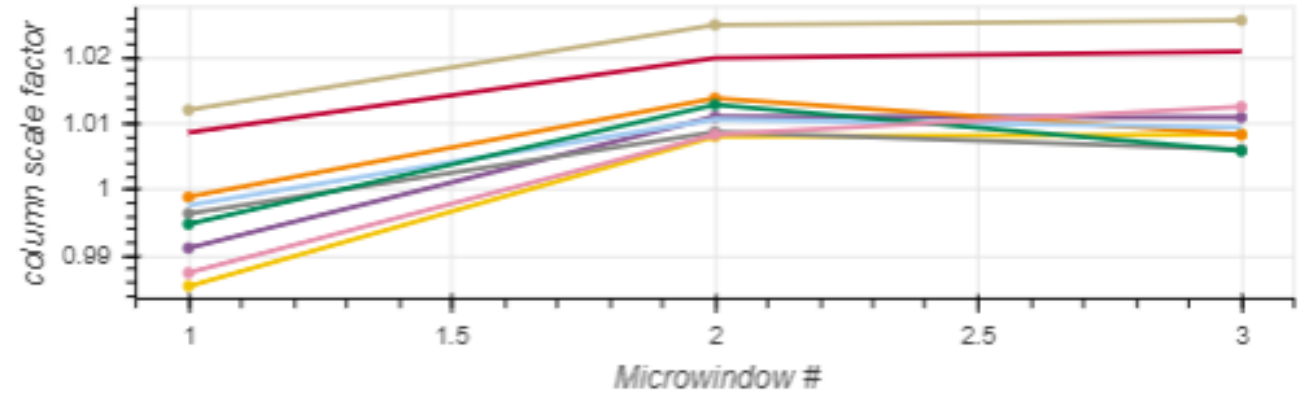
- » 1114 MIR (18 days)
- » 726 NIR (8 days)



Bruker 125HR Line Shape: MIR N_2O







(A) 180312_eu_N2O_180_e_0 reg=1.8
(B) 180313_eu_N2O_180_e_1 reg=1.8
(C) 190226_eu_N2O_180_e_0 reg=1.8
(D) 190226_eu_N2O_180_e_1 reg=1.8
(E) 190227_eu_N2O_180_e_0 reg=1.8
(F) 190227_eu_N2O_180_e_1 reg=1.8
(G) 190301_eu_N2O_180_e_0 reg=1.8
(H) 190302_eu_N2O_180_e_1 reg=1.8
(I) 190312_eu_N2O_180_e_0 reg=1.8

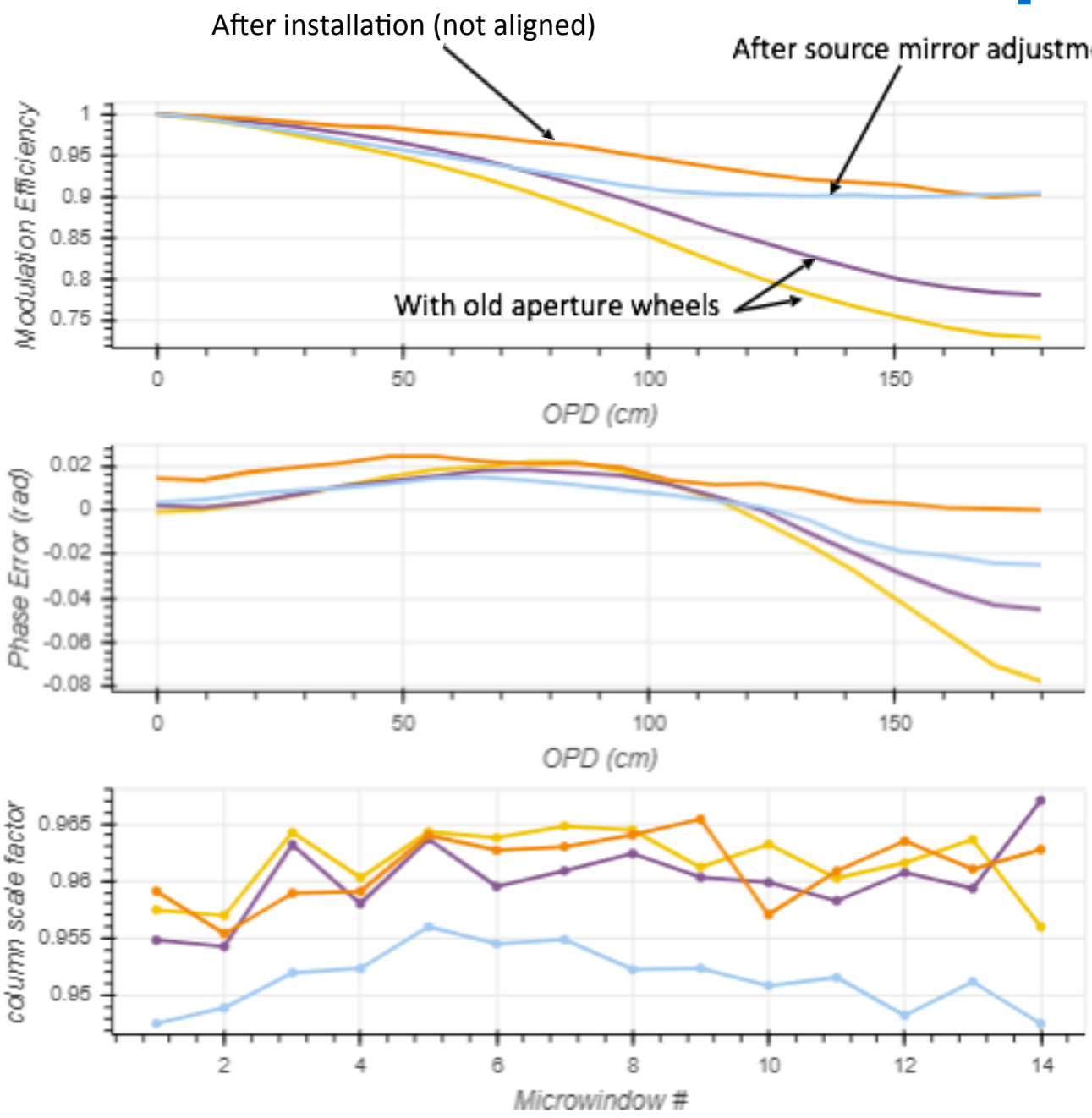
All tests with 180 cm MOPD

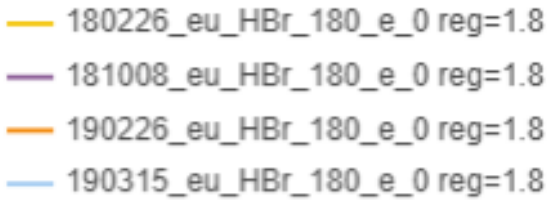
Date: ME at MOPD
180313: ~0.88
190226(D): ~0.83
190227(F): ~0.4 (after installations)
190301: ~ 1.0 (after alignment)
Done with 1.15mm aperture

All others done with 1 mm aperture

190312: after source mirror adjustment -> ~0.96, but better fits!

Bruker 125HR Line Shape: MIR HBr





All tests with 180 cm MOPD, 1.15mm aperture except 190226 w/ 1mm

Date: ME at MOPD
180226 : ~0.73
181008: ~0.78
190226: ~0.9 (post-installation)

190315: after the exit mirror adjustment -> ~0.9, but better fits

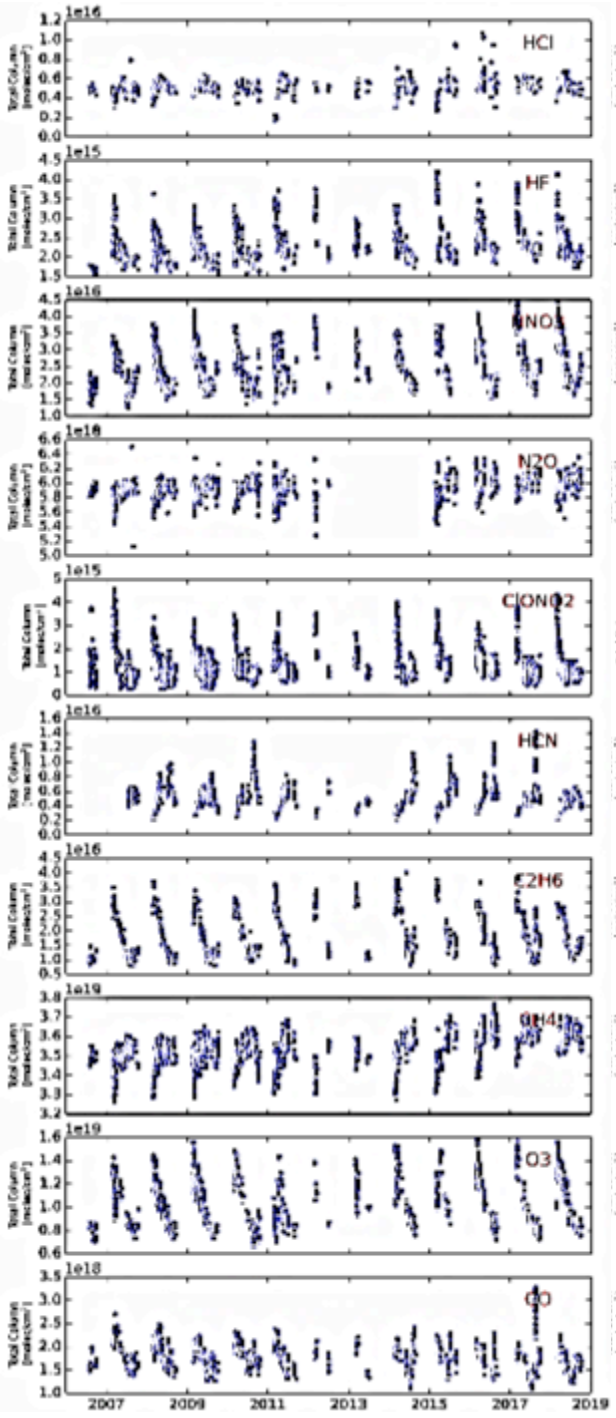
Sebastien Roche's talk covered the NIR alignment details

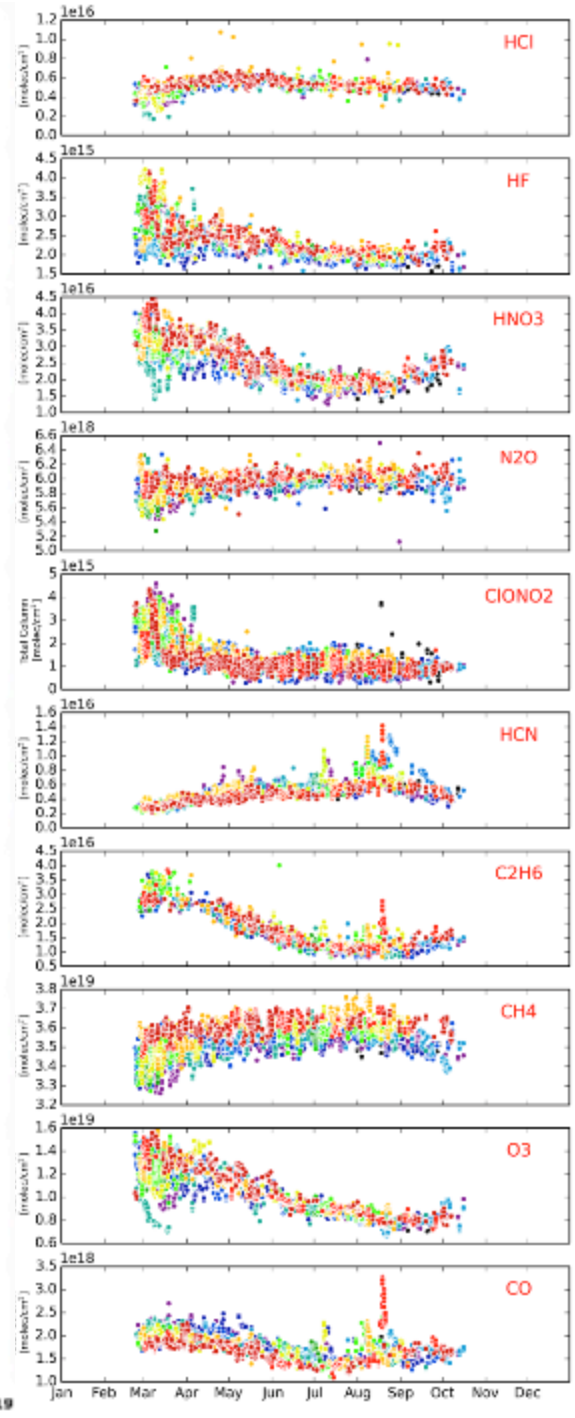
Status of NDACC Data

Most recent (eighth) archiving: May 2019

- Retrievals to December 2018 were uploaded in May 2019
- Analyzed using SFIT4 V0.9.4.4 with full error analysis, HITRAN 2008, WACCM v6 a priori profiles, SNR calculated from spectra, and formatted as HDF
- IRWG standard gases: CO, C_2H_6, CH_4, $ClONO_2$, HCl, HCN, HF, HNO_3, N_2O, *O_3
- Additional gases: C_2H_2, CH_3OH, HCHO, HCN, HCOOH, NH_3, NO_2
- Full time series (2006-2018) of O_3, CO and CH_4 were reprocessed using CAMS Rapid Delivery retrieval and error analysis as NDACC rejects consolidated files for RD molecules unless they meet CAMS QC criteria

  *Consolidated O_3 files were not archived as we review optimal retrieval strategy, particularly for high springtime solar zenith angles
- Began archiving Eureka CO, CH_4, and O_3 for CAMS Rapid Delivery in March 2018





PEARL FTIR Time Series: 2006-2018

Total columns for IRWG standard gases

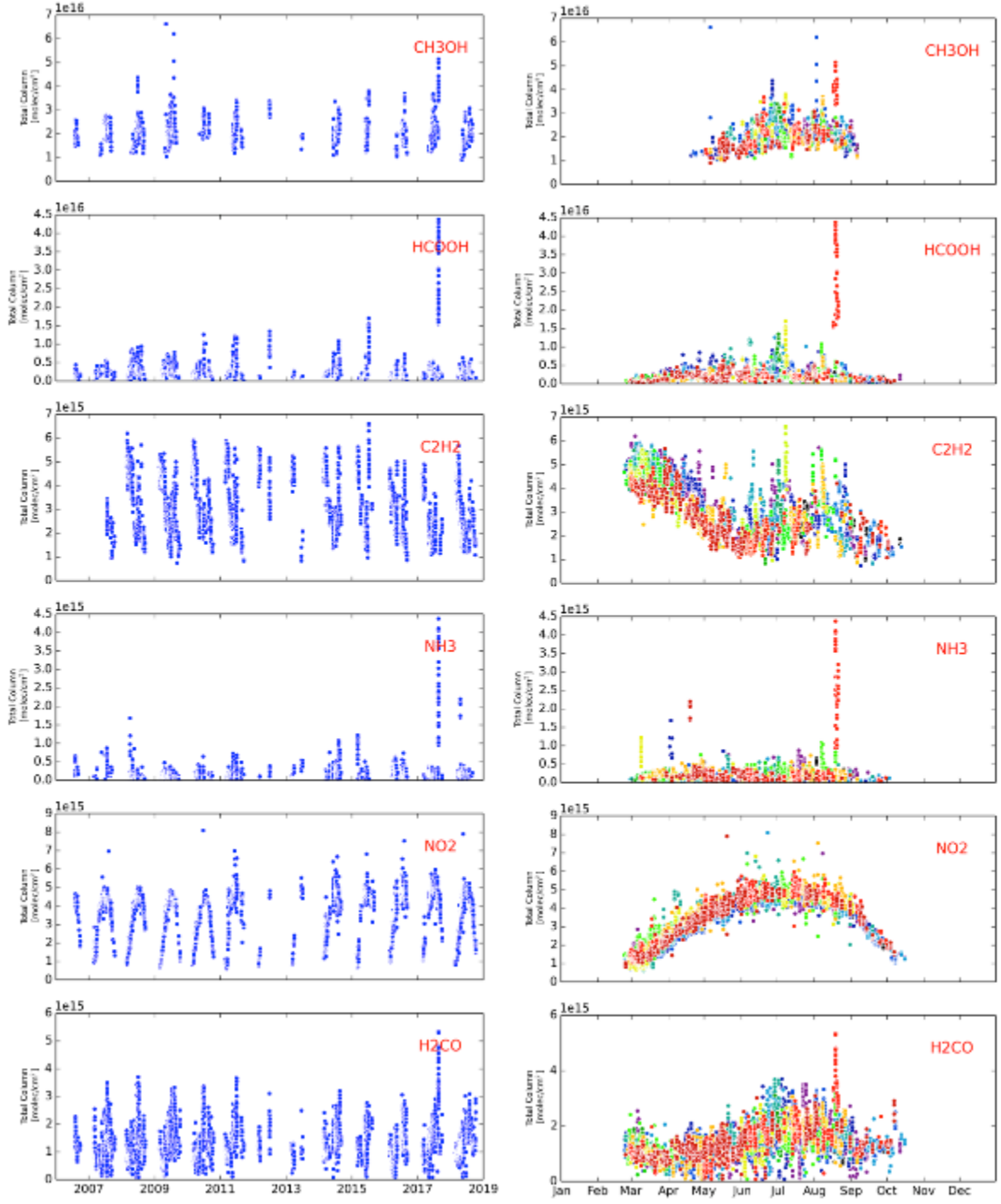
- 2006
- 2007
- 2008
- 2009
- 2010
- 2011
- 2012
- 2013
- 2014
- 2015
- 2016
- 2017
- 2018

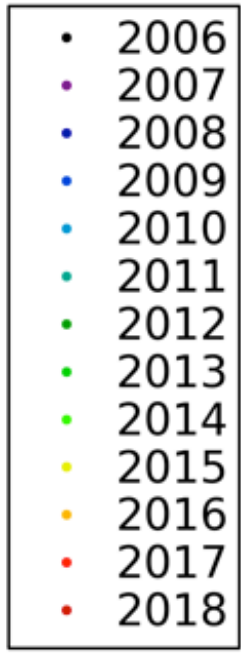
Analyzed using SFIT4 V0.9.4.4

Rodica Lindenmaier, Rebecca Batchelor, Dan Weaver, Joseph Mendonca, Stephanie Conway, Camille Viatte, Erik Lutsch, Sebastien Roche, Tyler Wizenberg

PEARL FTIR Time Series: 2006-2018

Total columns for additional gases





Additional gases were also retrieved using SFIT4 V0.9.4.4

Rodica Lindenmaier, Rebecca Batchelor, Dan Weaver, Joseph Mendonca, Stephanie Conway, Camille Viatte, Erik Lutsch, Sebastien Roche, Tyler Wizenberg

Activities Over the Past Year

- Running with a combination of remote operation and on-site operator, alternating MIR and NIR measurements
- **Erik Lutsch** – biomass burning studies **(see two talks)**; data analysis for CAMS RD and TROPOMI
- **Sebastien Roche** – TCCON analysis and CO_2 profiling **(see TCCON talks)**
- **Kristof Bognar** – ACE/OSIRIS O_3 & NO_2 validation
- **Dan Weaver** – H_2O profile intercomparisons using MUSICA, sondes, and satellite data
- **Tyler Wizenberg** – NDACC and CAMS retrievals, PAN retrievals, comparisons of PEARL-FTS to ACE-FTS & TROPOMI
- **Lei Liu** – trace gas retrievals and cloud studies using E-AERI emission spectra

O_3 and NO_2 Validation

K. Bognar et al., **Validation of ACE and OSIRIS ozone and NO_2 measurements in the Arctic using ground-based instruments at Eureka, Canada**. Submitted to *J. Quant. Spectrosc. Rad. Transfer*, 21 December 2018. **FTIR**

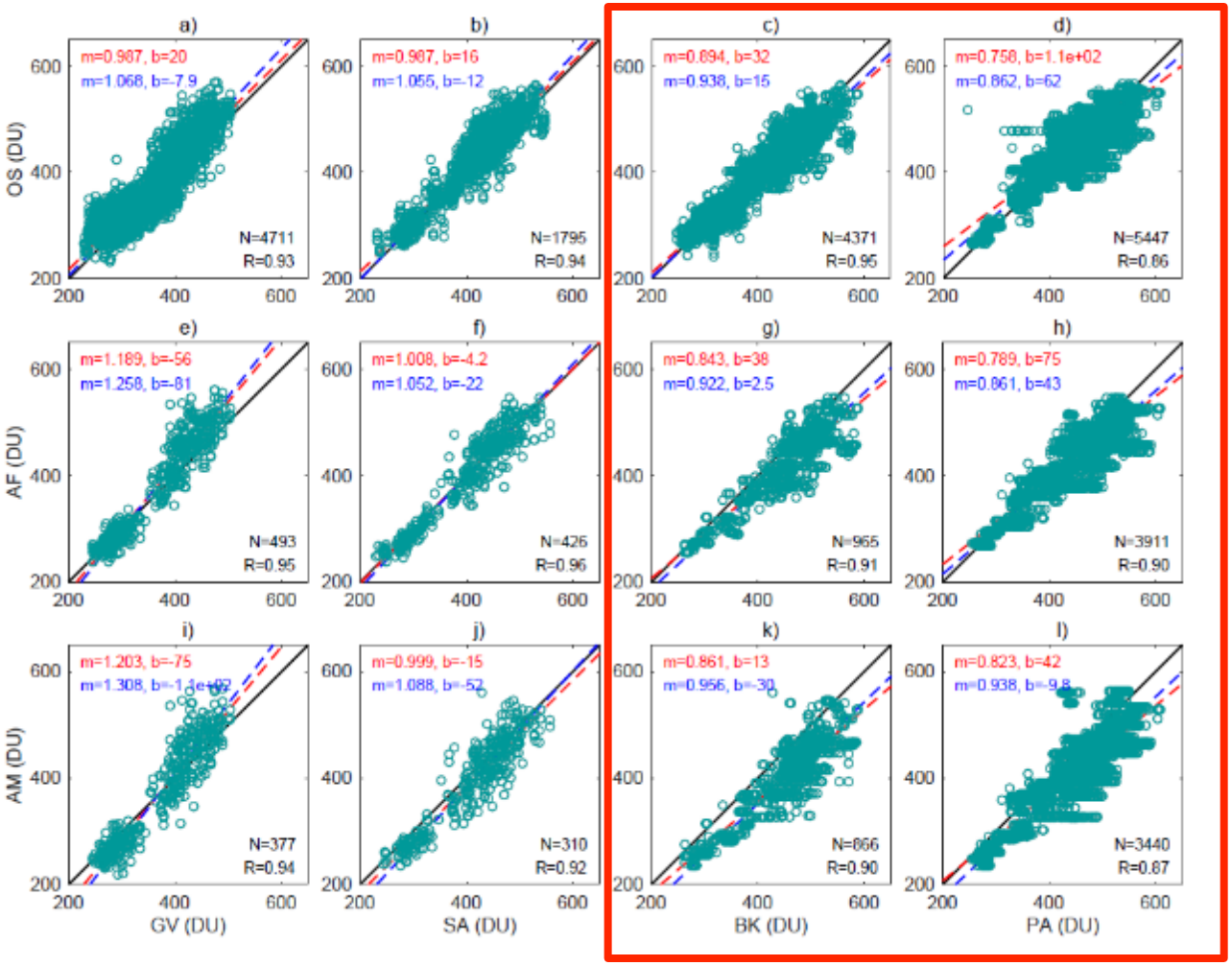


Figure 4: Correlation plots for satellite-plus-sonde 0-52 km ozone columns (y-axes) against the ground-based total columns (x-axes). The plots include best fit lines using the OLS (red dashed line) and RMA (blue dashed line) methods, as well as the one-to-one line (black). The slope, intercept, number of coincidences, and correlation coefficient are given as m, b, N, and R, respectively. Abbreviations and measurement periods are given in Table 1.

H_2O Validation

D. Weaver et al., **Comparison of ground-based and satellite measurements of water vapour vertical profiles over Ellesmere Island, Nunavut**. *Atmos. Meas. Tech. Discuss.*, in review, 2018. Submitted 9 August 2018.

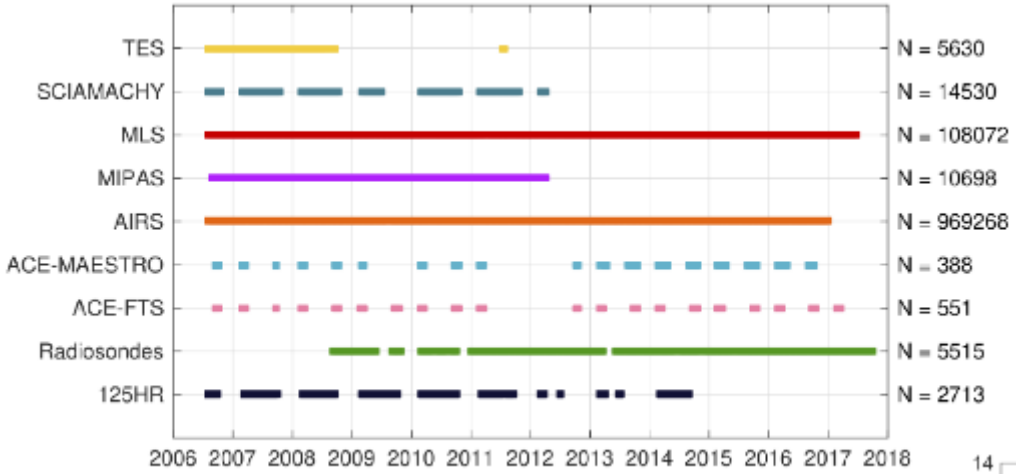


Figure 1: Temporal range of datasets used in this study. *N* is the number of measurements.

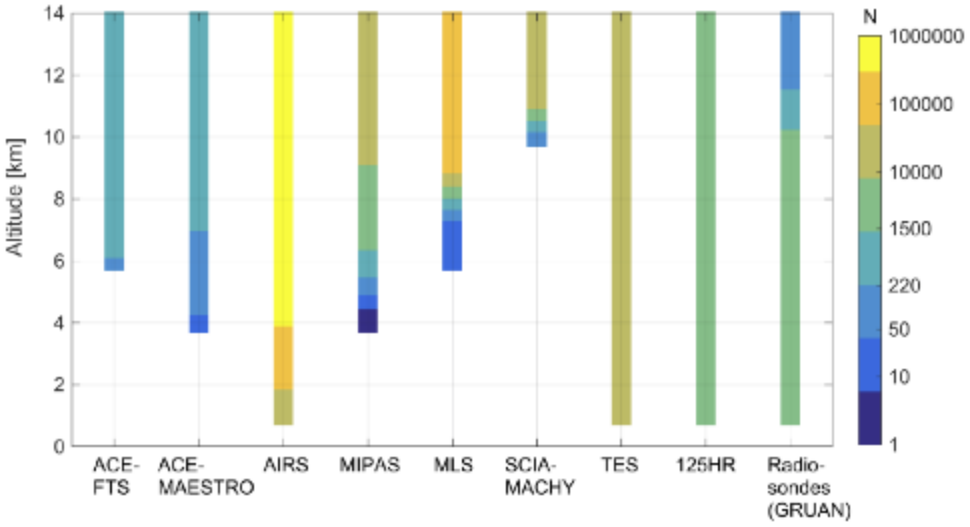


Figure 2: Vertical range of datasets used in this study. Colour range showing the number of profiles at each altitude level shows the log(N).

NDACC Publications

New Publications since May 2018

- **Vigouroux** et al., NDACC harmonized formaldehyde time-series from 21 FTIR stations covering a wide range of column abundances. *Atmos. Meas. Tech.*, 2018.
- **Daniel Weaver**, Water Vapour Measurements in the Canadian High Arctic, Ph.D. thesis, University of Toronto, December 2018.

Submitted Publications

- **Bognar** et al., Validation of ACE and OSIRIS ozone and NO_2 measurements in the Arctic using ground-based instruments at Eureka, Canada. *JQSRT*, in review, 2019.
- **Lutsch** et al., Unprecedented ammonia concentrations detected in the high Arctic from the 2017 Canadian wildfires. *J. Geophys. Res. Atmos.*, in review, 2019.
- **Strong, Simpson, Bognar, Lindenmaier, and Roche**. Chapter 3 Trace Gases in the Arctic Atmosphere, 81pp. In "Physics and Chemistry of Arctic Atmosphere", edited by A. A. Kokhanovsky and C. Tomasi, Springer Nature, in review, 2019.
- **Weaver** et al., Comparison of ground-based and satellite measurements of water vapour vertical profiles over Ellesmere Island, Nunavut. *AMTD*, in review, 2018.
- **Perro** et al., Pan-Arctic measurements of wintertime water vapour column using a satellite-borne microwave radiometer, *AMTD*, in review, 2019.
- **Ranjbar** et al., Extreme smoke event over the high Arctic. *Atmospheric Environment*, in review, 2019.

Publications in Preparation

- **Lutsch** et al., Detection of wildfire pollution in the Arctic using a network of FTIRs.
- **Lutsch** et al., NDACC FTIR trace gas measurements at PEARL from 2006 to 2017.

TCCON / GHG Publications

New GHG-related Publications since May 2018

- **Byrne** et al., Evaluating GPP and respiration estimates over northern mid-latitude ecosystems using solar induced fluorescence and atmospheric CO_2 measurements. *J. Geophys. Res. Biogeosciences*, 2018.
- **O'Dell** et al., Improved retrievals of carbon dioxide from Orbiting Carbon Observatory-2 with the version 8 ACOS algorithm. *Atmos. Meas. Tech.*, 2018.
- **Mendonca** et al., Using a speed-dependent Voigt line shape to retrieve O_2 from Total Carbon Column Observing Network solar spectra to improve measurements of XCO_2, *Atmos. Meas. Tech.*, 2019.

Submitted Publications

- **Byrne** et al., On what scales can GOSAT flux inversions constrain anomalies in terrestrial ecosystems? *Atmos. Chem. Phys. Discuss.*, in review, 2019.

Publications in Preparation

- **Hedelius** et al., Comparisons of MOPITT V7 XCO Retrievals with TCCON.
- **Kulawik** et al., Characterization of OCO-2 and ACOS-GOSAT biases and errors for CO_2 flux estimates.
- **Roche** et al., Retrieval of CO_2 profiles from TCCON near-infrared spectra.

Funding Outlook for PEARL

- NSERC's Climate Change and Atmospheric Research Program (2013-2018): Probing the Atmosphere of the High Arctic (PAHA): **extension to Sept 2019**
- CSA support for AVATARS – Arctic Validation And Training for Atmospheric Research in Space (2016-2019): **just ended**
- CSA support for the Canadian Arctic ACE/OSIRIS Validation Campaign project (2018-2022) led by Kaley Walker: **funding for two more spring campaigns**
- NSERC funding for "Operations and Maintenance Support for the Polar Environment Atmospheric Research Laboratory (PEARL)" (2017-2019): **extension to March 2020**

Current funding should enable operations through spring 2020. Looking for significant new funding to continue beyond then.

Acknowledgements

We gratefully acknowledge support from the following:

PEARL/CANDAC (**http://www.candac.ca**)

- ARIF, AIF/NSRIT, CFCAS, CFI, CSA, ECCC, GOC-IPY, INAC, MRI, MSC, NSERC, NSTP, OIT, ORF, PCSP, SEARCH
- PI Jim Drummond, Site Manager Pierre Fogal

ACE Arctic Validation Campaigns
(**https://eureka.physics.utoronto.ca**)

- CSA, ECCC, NSERC, NSTP
- Co-PI Kaley Walker

Logistical and operational support at Eureka

- The wonderful team at the ECCC Weather Station
- The CANDAC operators