The University of Toronto Atmospheric Observatory: 2019 Site Report

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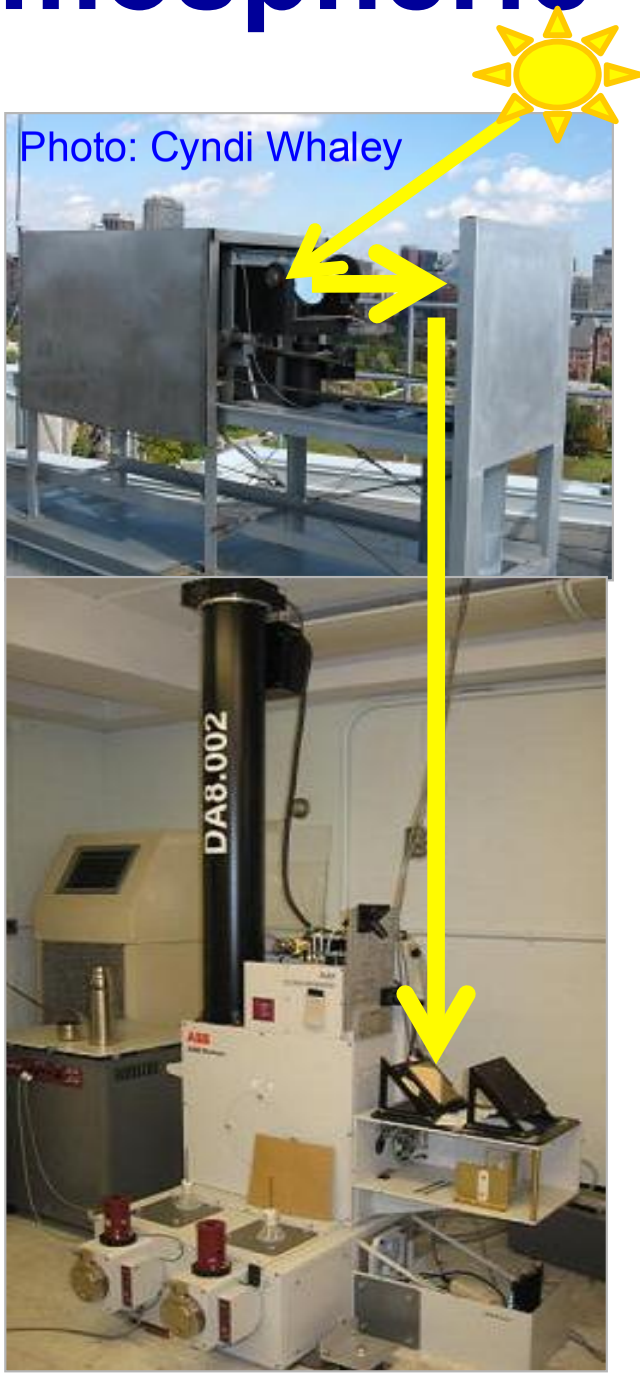
NDACC IRWG Meeting

Wanaka, New Zealand

22 May 2019

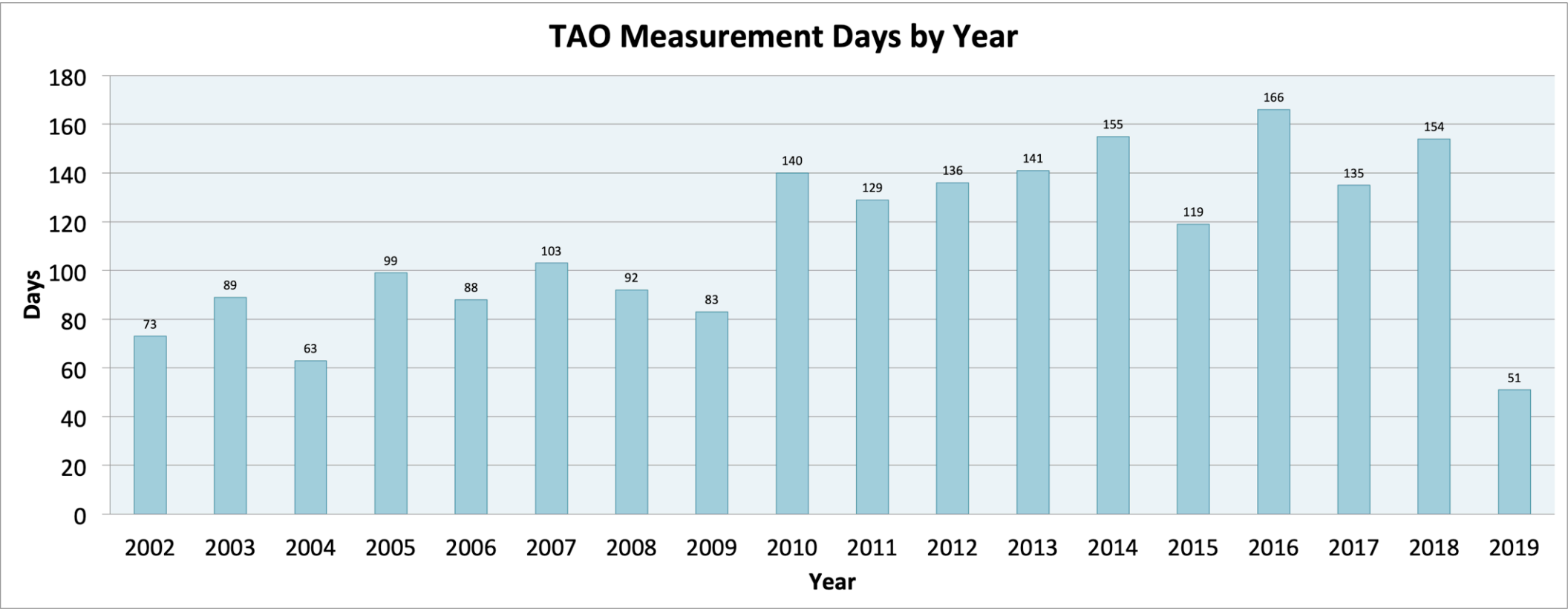
University of Toronto Atmospheric Observatory: TAO

- 43.66°N, 79.40 °W, 174 m asl
- Primary instrument: Bomem DA8 FTIR
  - → Coupled to Community Solar Tracker (pointing accuracy of 10-20 arc seconds, 0.0028°)
  - → Semi-automated MIR measurements
  - → Can be remotely accessed/operated
  - → Columns and vertical profiles retrieved using the SFIT4 algorithm
- Additional instruments:
  - → ECCC Brewer (on loan 2005-2016)
  - → ECCC Pandora UV-visible spectrometer for O_3, NO_2, O_4, HCHO, HONO, etc. (#109 Nov 2016 – May 2018, #145 since 15/5/2018)
  - → Weather station (Davis Vantage Pro 2 Plus, and Vaisala PTU300)



TAO FTIR Measurements

- October 2001 – Bomem DA8 operational
- May 2002 to present – regular solar measurements
- March 2004 – NDACC certification



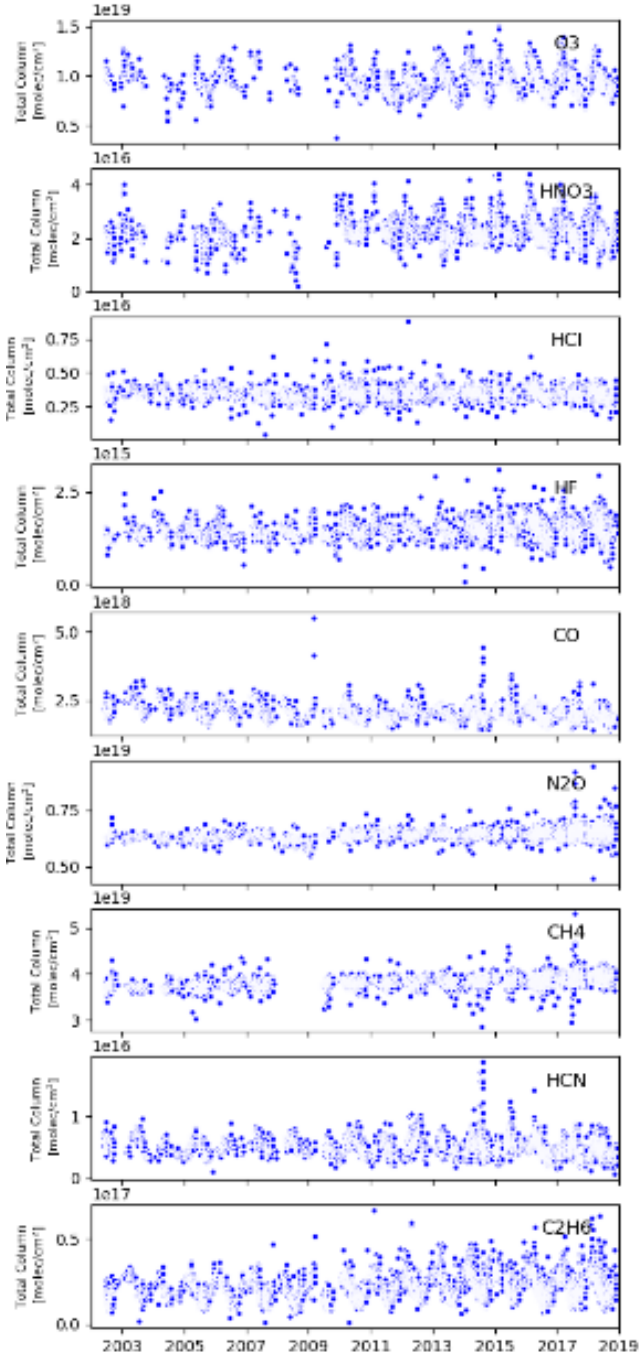
Status of NDACC Data

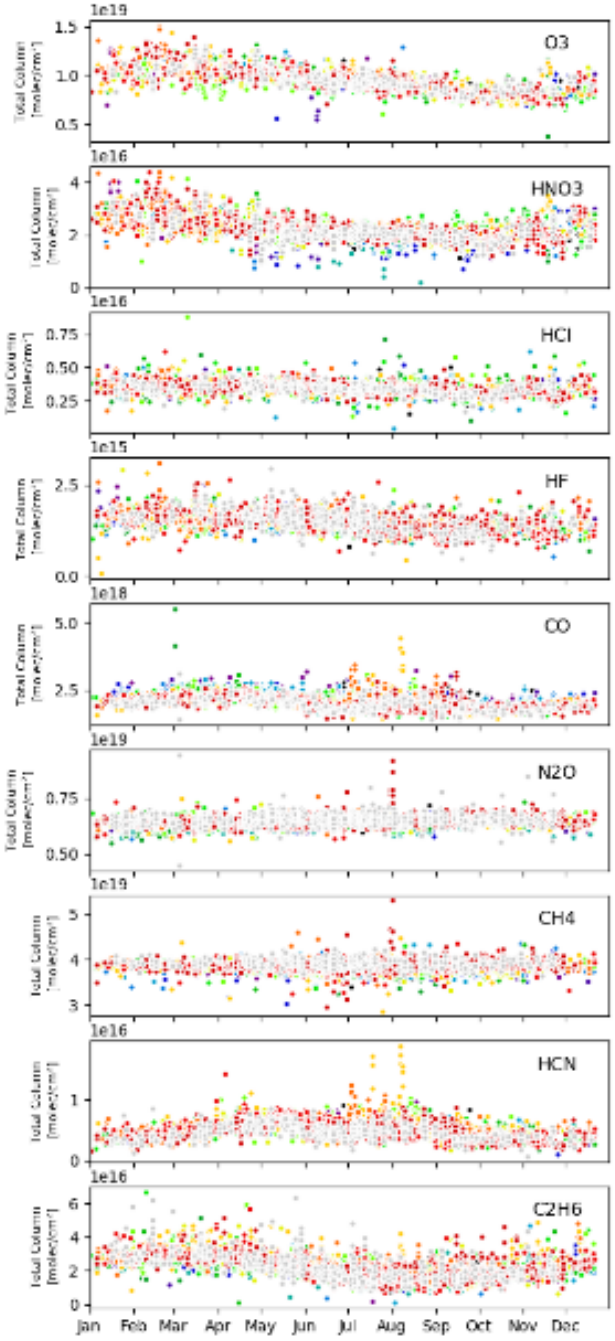
Most recent (ninth) archiving: May 2019

- 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, HCl, HCN, HF, HNO_3, N_2O, O_3, (not $ClONO_2$)
- Additional gases: C_2H_2, CH_3OH, HCHO, HCOOH, NH_3
- Full time series (2002-2018) of O_3, CO and CH_4 were reprocessed using CAMS Rapid Delivery retrieval and error analysis because NDACC rejects consolidated files for RD gases unless they meet CAMS QC criteria

  *Consolidated CH_4 files were not archived as we investigate scatter in the data
- Began archiving Toronto CO, CH_4, and O_3 for CAMS Rapid Delivery in March 2018

TAO FTIR Time Series: 2002-2018





Total columns for IRWG standard gases

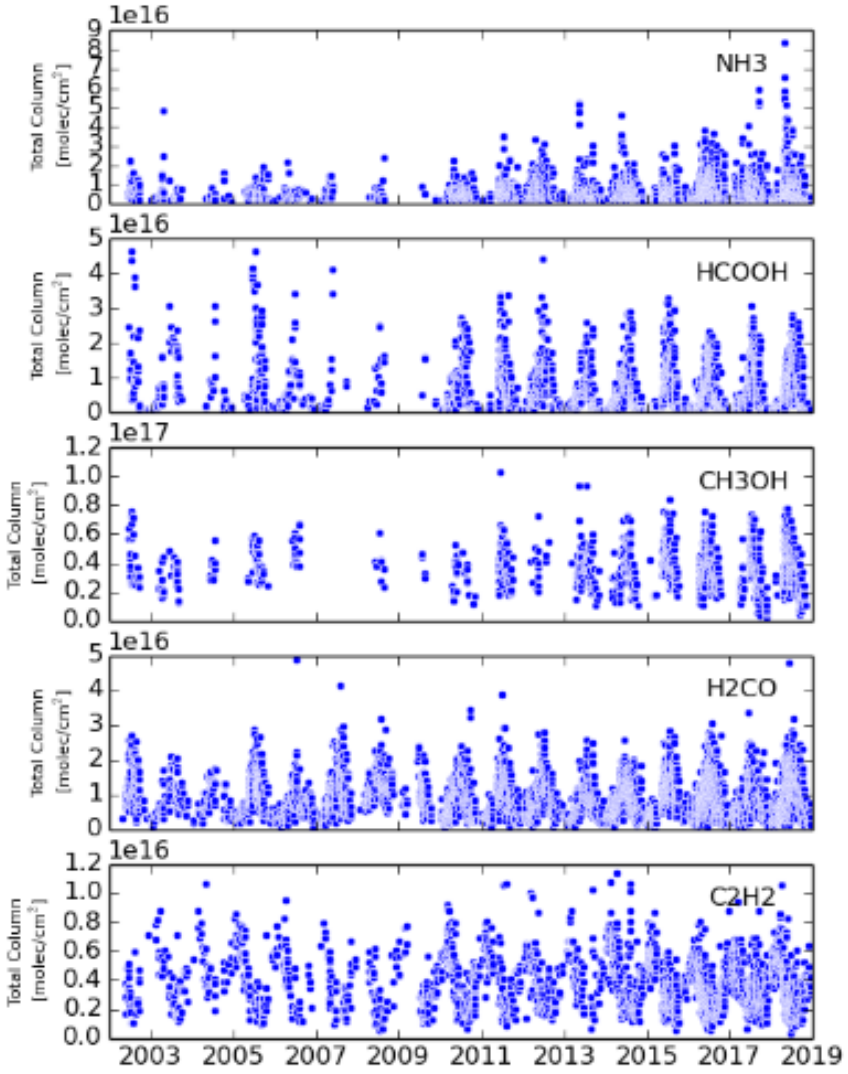
Analyzed using SFIT4 V0.9.4.4

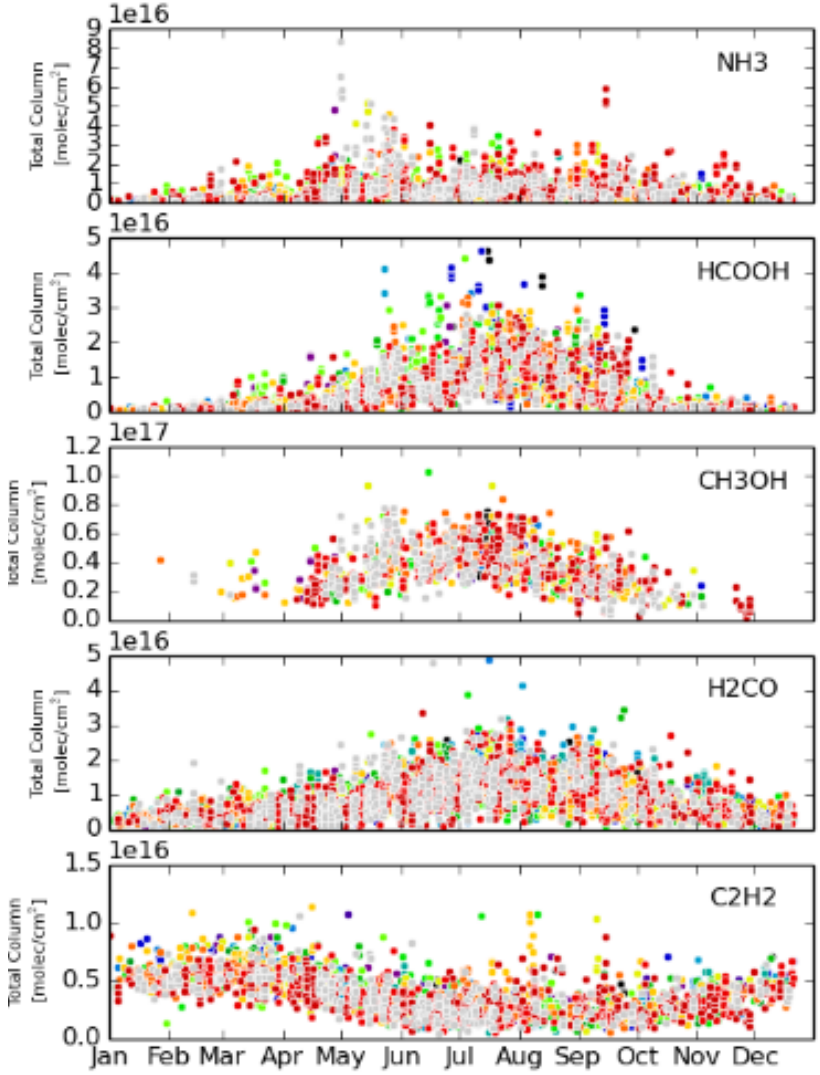
Aldona Wiacek,
Jeff Taylor,
Cyndi Whaley,
Ilya Stanevich,
Stephanie Conway,
Orfeo Colebatch
and many others
Plot: Shoma Yamanouchi

TAO FTIR Time Series: 2002-2018

Total columns for additional gases

Additional gases were also retrieved using SFIT4 V0.9.4.4





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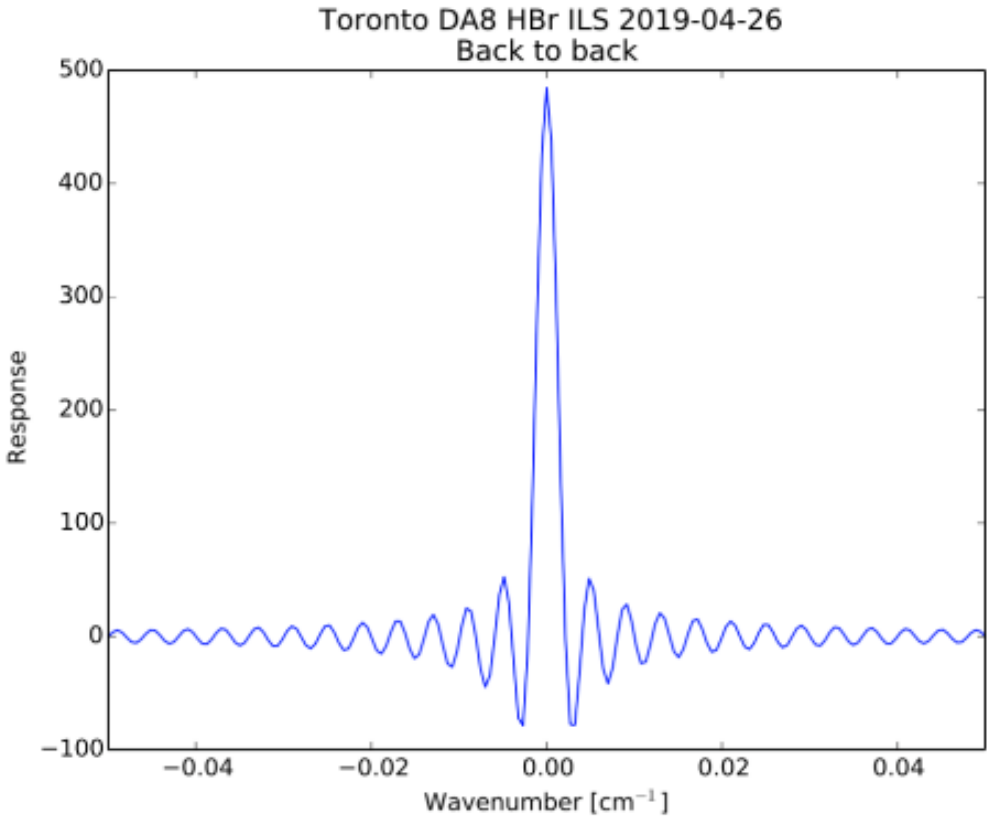
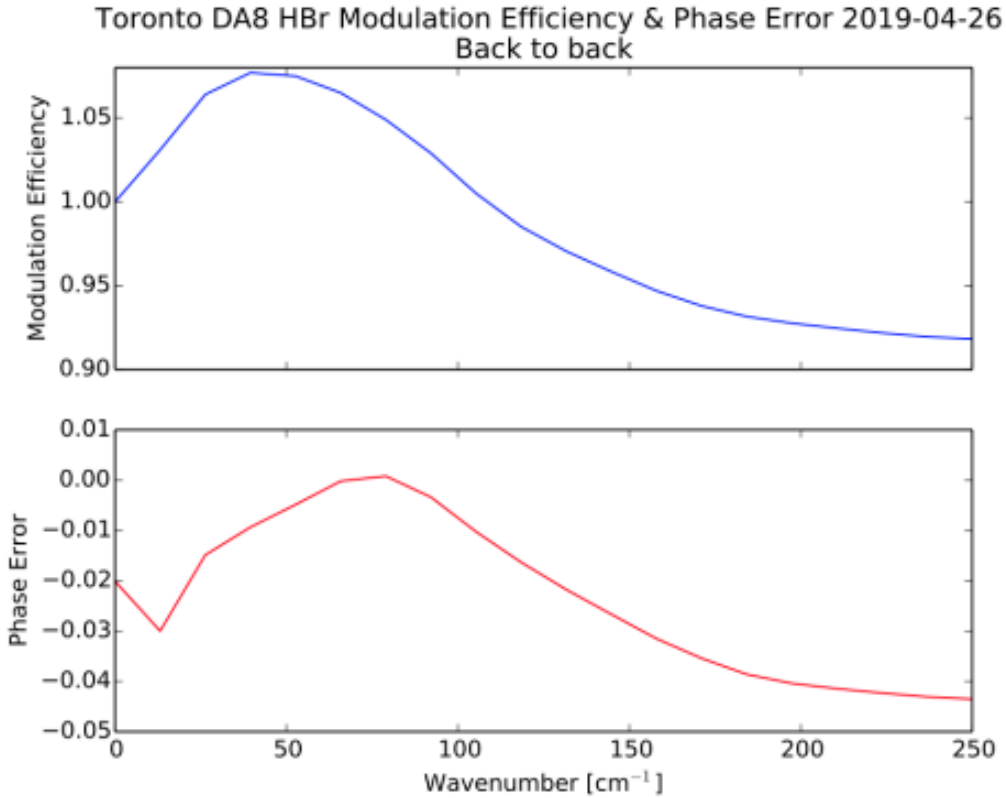
HBr Instrument Line Shapes

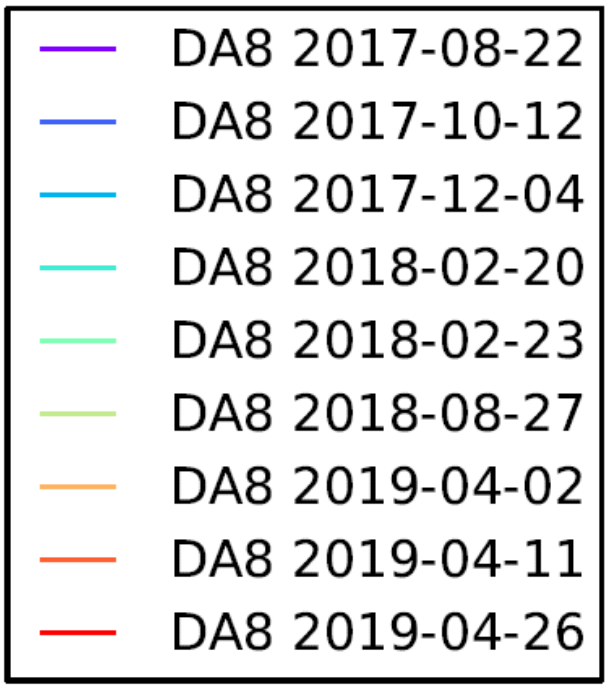
- HBr cell #48, measured on 26 April 2019
  - → 100 scan HBr, 0.004 cm^{-1}, filter 3
  - → Background: Norton-Beer strong apodization, 0.01 cm^{-1}, filter 3
  - → Analyzed with LINEFIT v14.5
  - → ILS measurements were updated to 100 scan + low-resolution background in February-March 2017

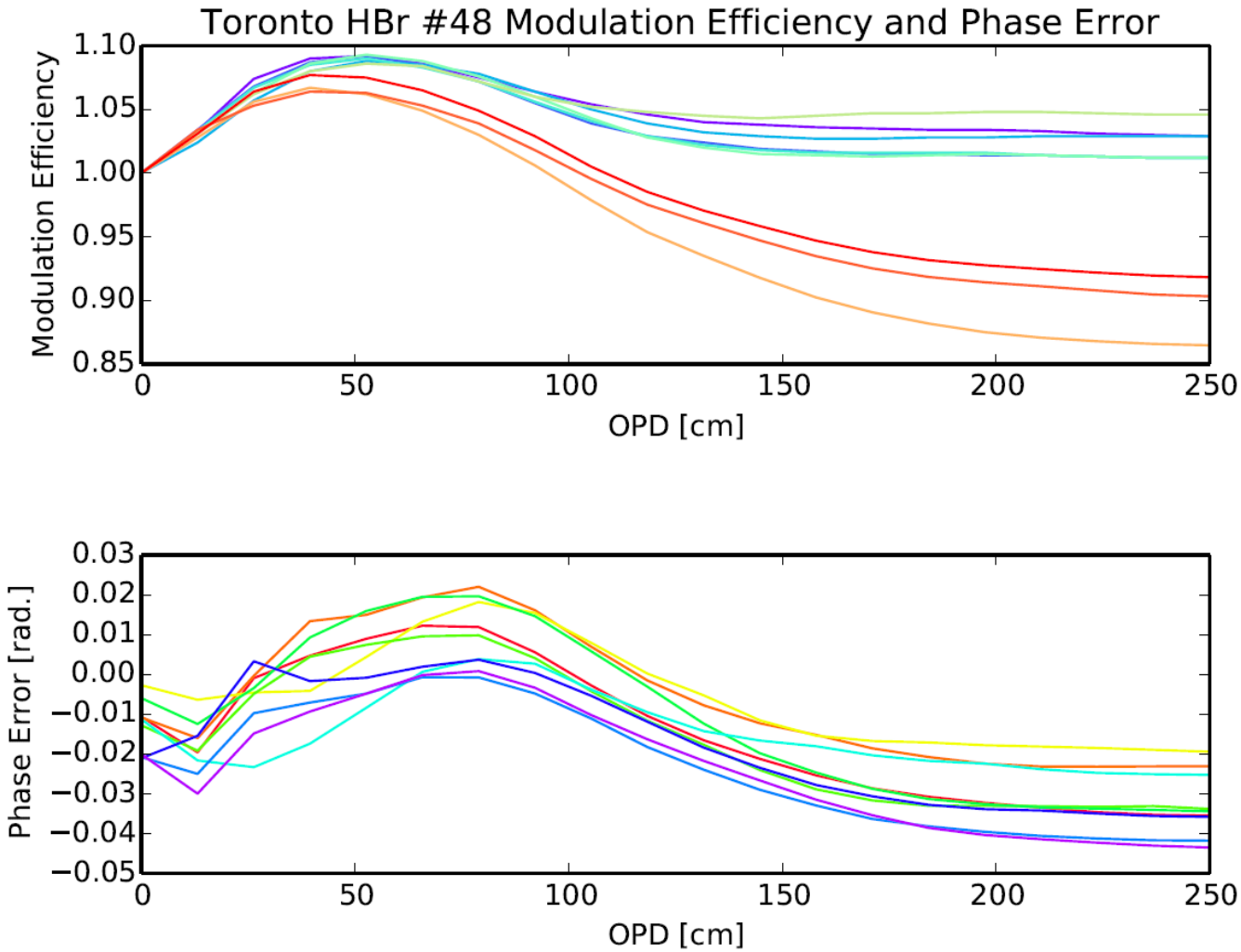




HBr Instrument Line Shapes

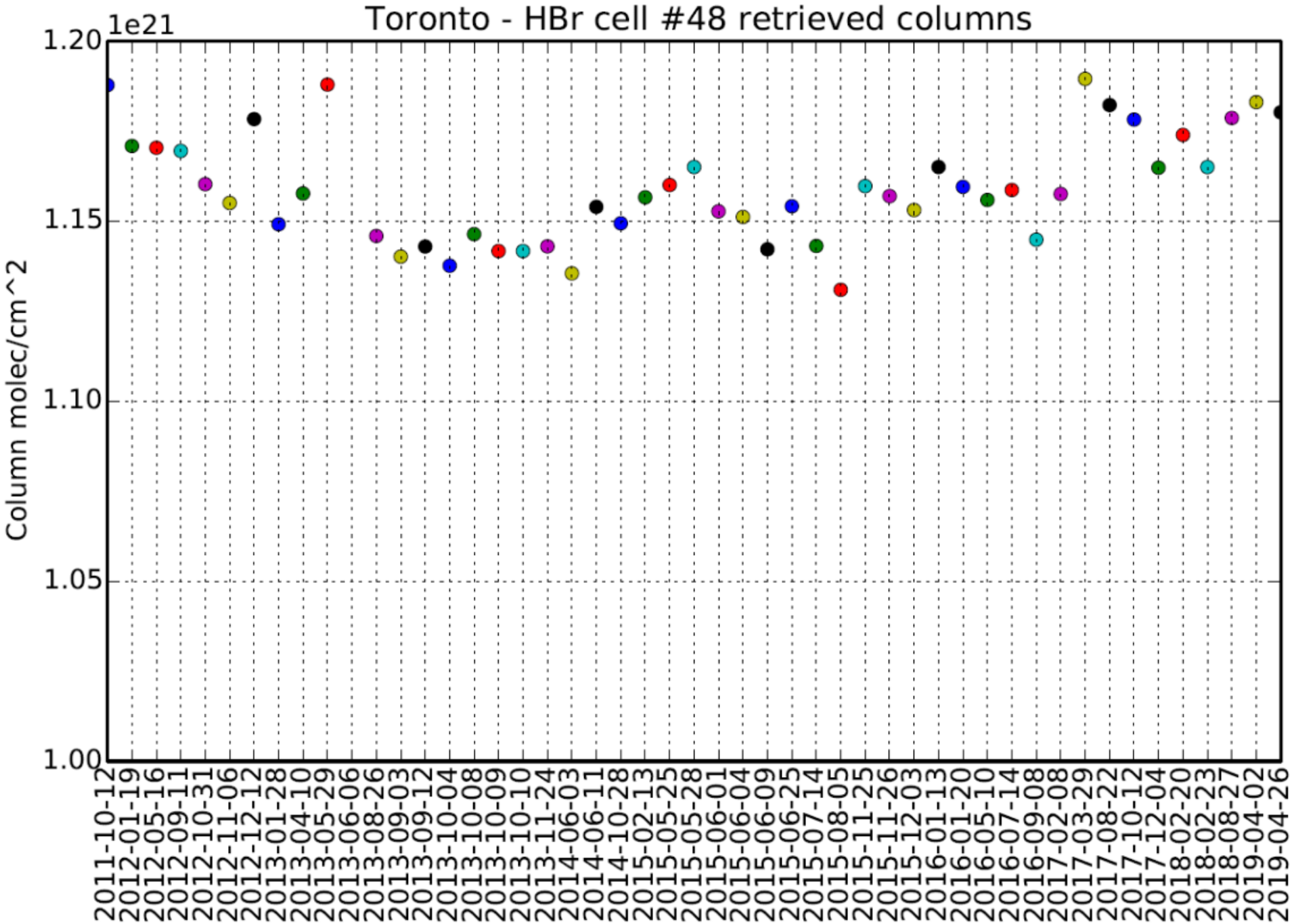
Recent results





The ME decreased in April 2019 after repair of internal source mirror motor and beam-selecting mirror solenoid. We suspect the beam-selecting mirror is not pointing correctly – will fix this.

Retrieved HBr Columns: Cell #48



TAO Activities over the Past Year

- Measurements
  - → Semi-automated daily measurements with remote desktop functionality
  - → Generating daily summary reports showing FTIR spectra, sun-tracking, solar radiation and weather conditions
  - → Running TAO 125M OP-FTIR and recommissioning Egbert DA8
- Research
  - → **Shoma Yamanouchi** **(see talk)** – biomass burning (paper in prep.), trend analysis, retrievals and analysis for CAMS RD (TAO)
  - → **Erik Lutsch** **(see talks given by Tyler)** – wildfire pollution (paper in prep.), data analysis for CAMS RD and TROPOMI
  - → **Brendan Byrne** – OP-FTIR GHG measurements (*Atmosphere-Ocean*, submitted)
  - → **Erik, Shoma, Stephanie Conway** – TAO retrievals (ESSD in prep.)
- Contributions to other studies
  - → **Corinne Vigouroux** – NDACC HCHO time series (AMT 2018)
  - → **Zitely Tzompa-Sosa** – C_2H_6 emissions (JGR 2019)

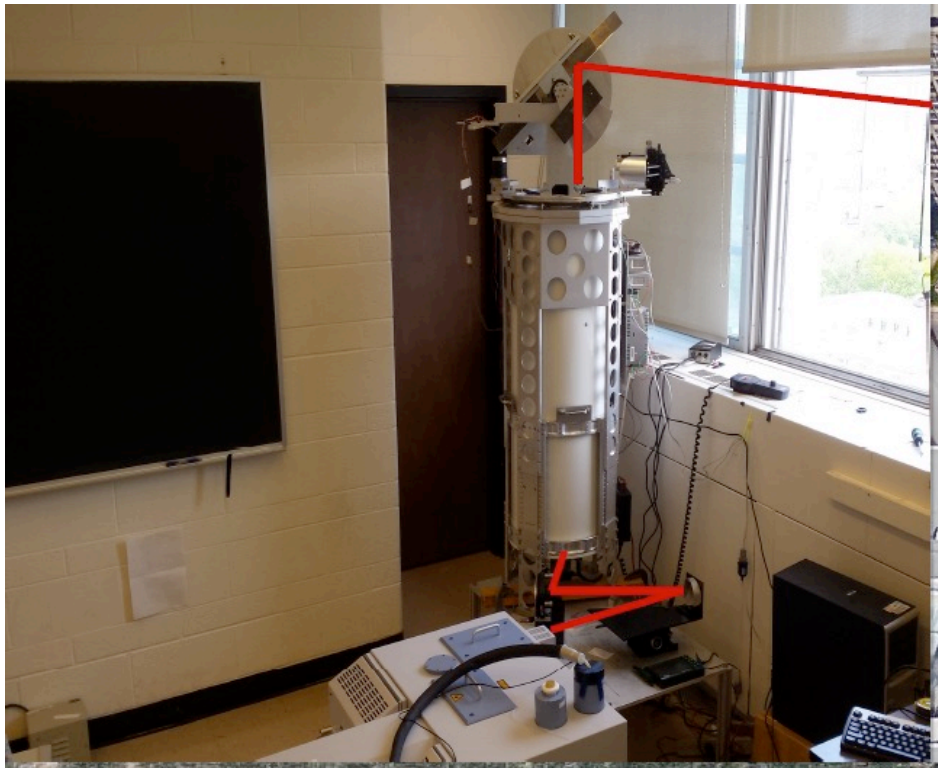
Recommissioning Egbert DA8 FTIR

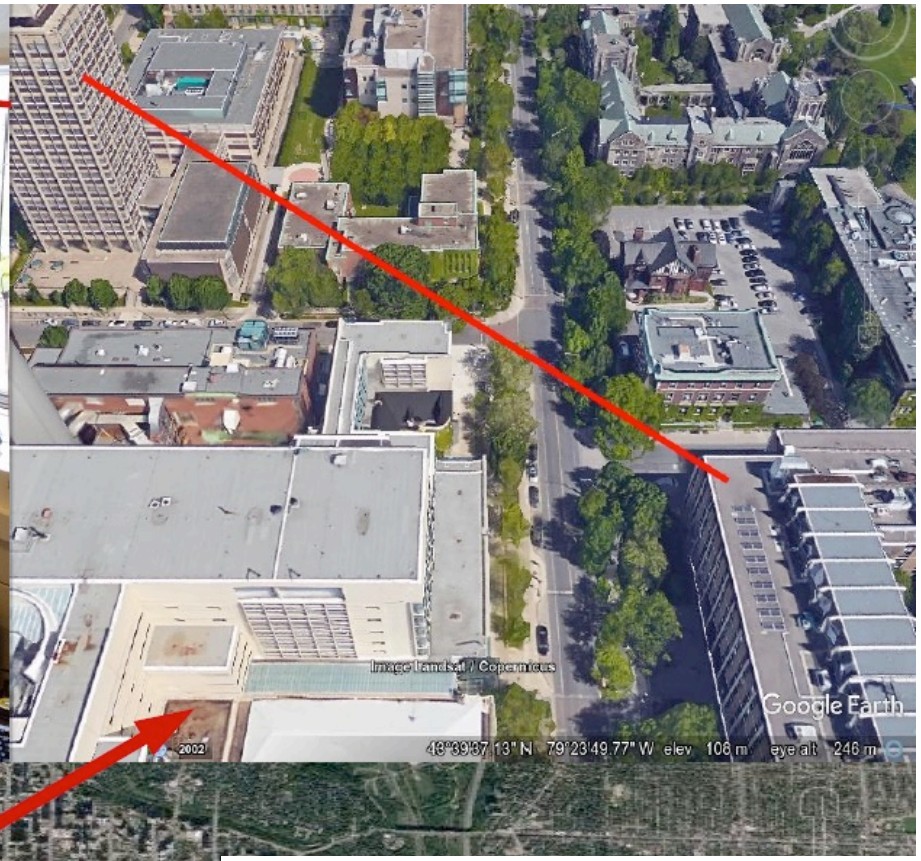
- Have been given ECCC's Egbert DA8 on long-term loan
  - → Located at ECCC's Centre for Atmospheric Research Experiments (44°14'N, 79°47'W), a rural site approx. 75 km NNW of Toronto
- Replaced old Denver sun-tracker with Bruker sun-tracker and new housing
- Currently working on realigning the DA8 (last operated by ECCC in 2011) and completing the recommissioning

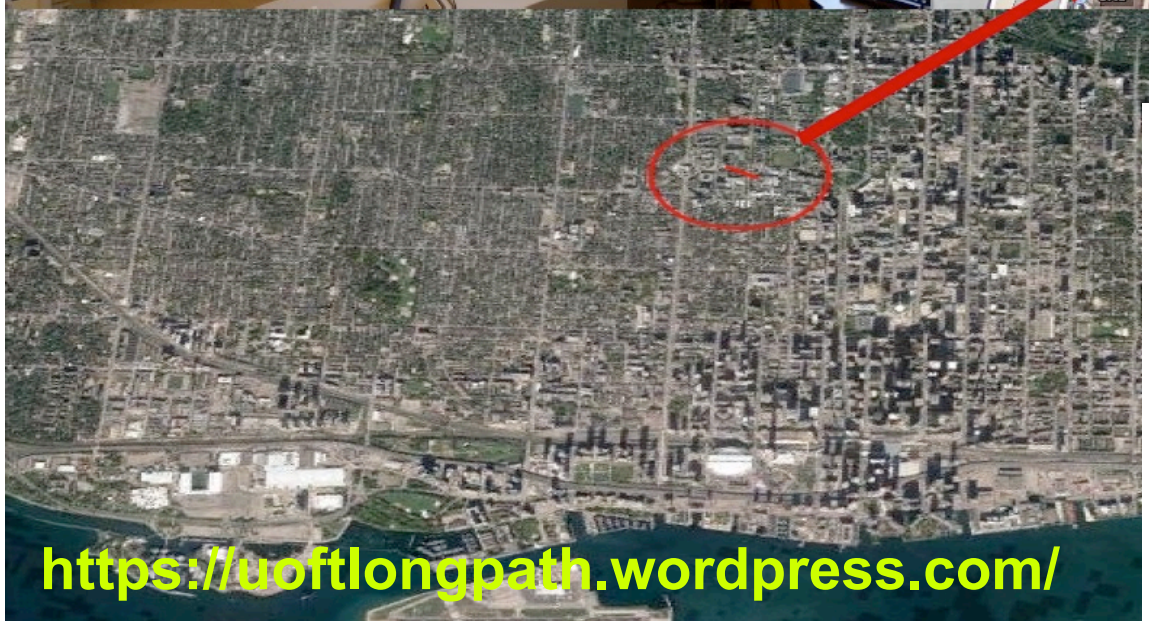
Old Denver suntracker

New suntracker + housing

Open-Path FTIR in Toronto







- Bruker 125M with telescope and retroreflector from ECCC
- Open-path operation with initial focus on CO_2, CO, CH_4 and N_2O in downtown Toronto

Brendan Byrne, Orfeo Colebatch

UofT OP-FTIR Time Series

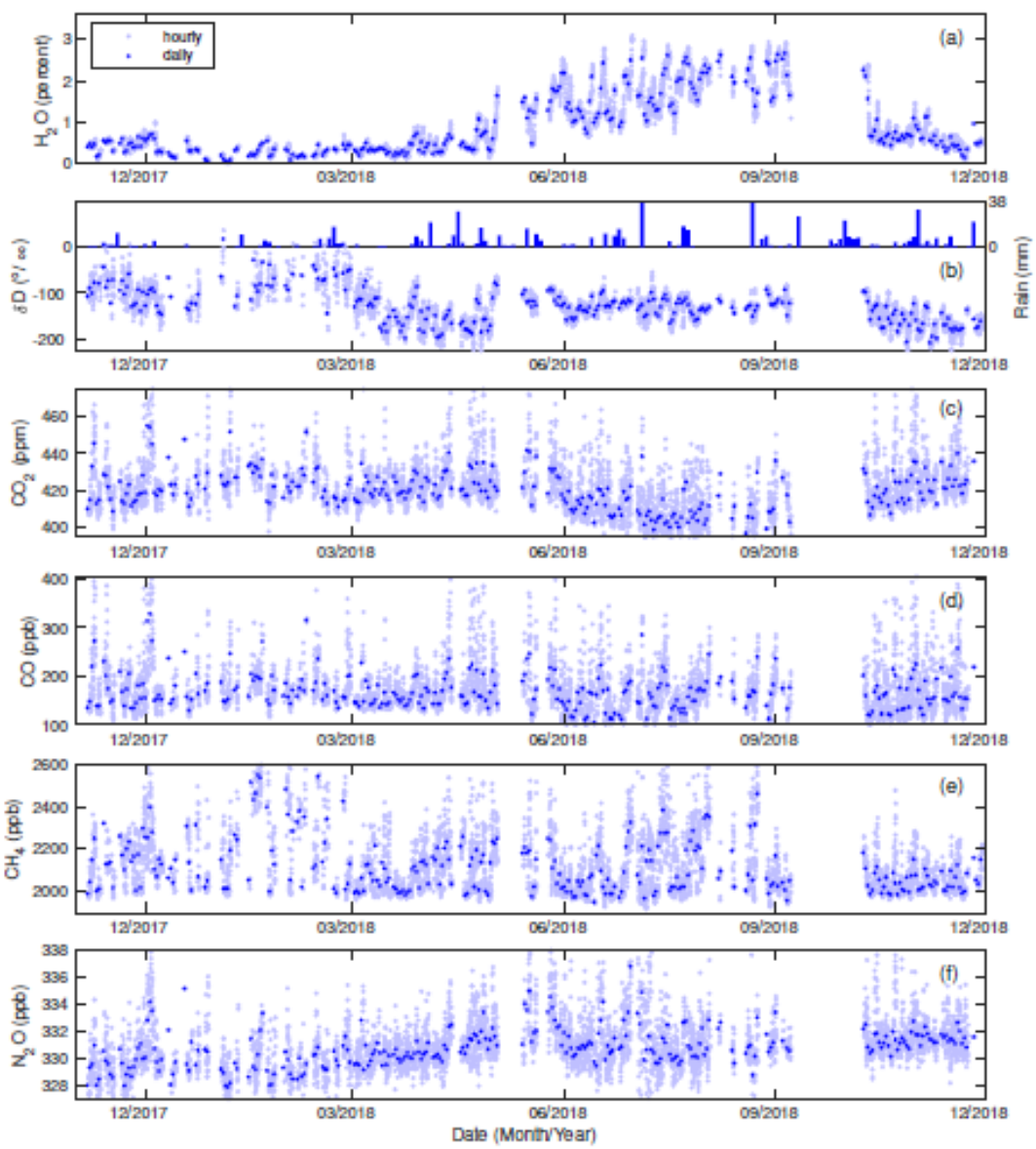


Fig. 8 Time series of (a) H_2O, (b) δD and rainfall, (c) calibrated CO_2, (d) calibrated CO, (e) calibrated CH_4, and (f) N_2O dry-air mole fractions retrieved from OP-FTIR measurements. Pastel colors indicate hourly means and darker colors indicate daily means. The rainfall histogram shows 2-day bins of rainfall measured by the McLennan met-station.

- Daily measurements since November 2017
- Co-located met station
- Retrievals with MALT software
- Investigating sensitivity to meteorology
- Two Picarro GHG CRDS instruments were deployed from 12-16 Nov 2018 for calibration of CO_2, CO, and CH_4

Brendan Byrne, Orfeo Colebatch ("Monitoring urban greenhouse gas emissions using open-path Fourier transform spectroscopy", submitted to *Atmosphere-Ocean*)

Outlook & Future Work

- Ongoing DA8 measurements, analysis, interpretation
- Integration of measurements and modelling (GEOS-Chem) in collaboration with Dylan Jones (UofT)
- Urban (TAO) and rural (Egbert) FTIR measurements
- New project with Camille Viatte and Cathy Clerbaux (LATMOS/CNRS): “The Impact of Ammonia Emissions on Urban Air Quality (AmmonAQ)”
- New project with Vitali Fioletov (ECCC): “Validation and interpretation of vertical column density measurements of air pollutants from satellite instruments” with Pandoras and FTIR
- Funding
  - → Natural Sciences and Engineering Research Council of Canada
  - → Canadian Space Agency (CSA)
  - → Environment and Climate Change Canada (ECCC)
  - → University of Toronto