Environment and Climate Change Canada | Environnement et Changement climatique Canada

Canada

Some Canadian TEMPO-related Activities

Chris McLinden, Chris Sioris, Vitali Fioletov, and Yves Rochon
Air Quality Research Division, Environment & Climate Change Canada (ECCC)

6th TEMPO Science Team Meeting
Boulder • 6-7 June 2018

Themes (or what do we want to do with TEMPO observations …)

- Help understand sources of air pollution and where it ends up
- Better quantify current levels of air pollution and improve forecasts

Activities:

- Validation
- Chemical Data Assimilation
- Algorithm development work
  - Strat-trop separation
  - Retrievals at high latitudes (e.g., over snow, larger viewing and SZA angles, more variable stratosphere)
  - RT modelling
- Emissions

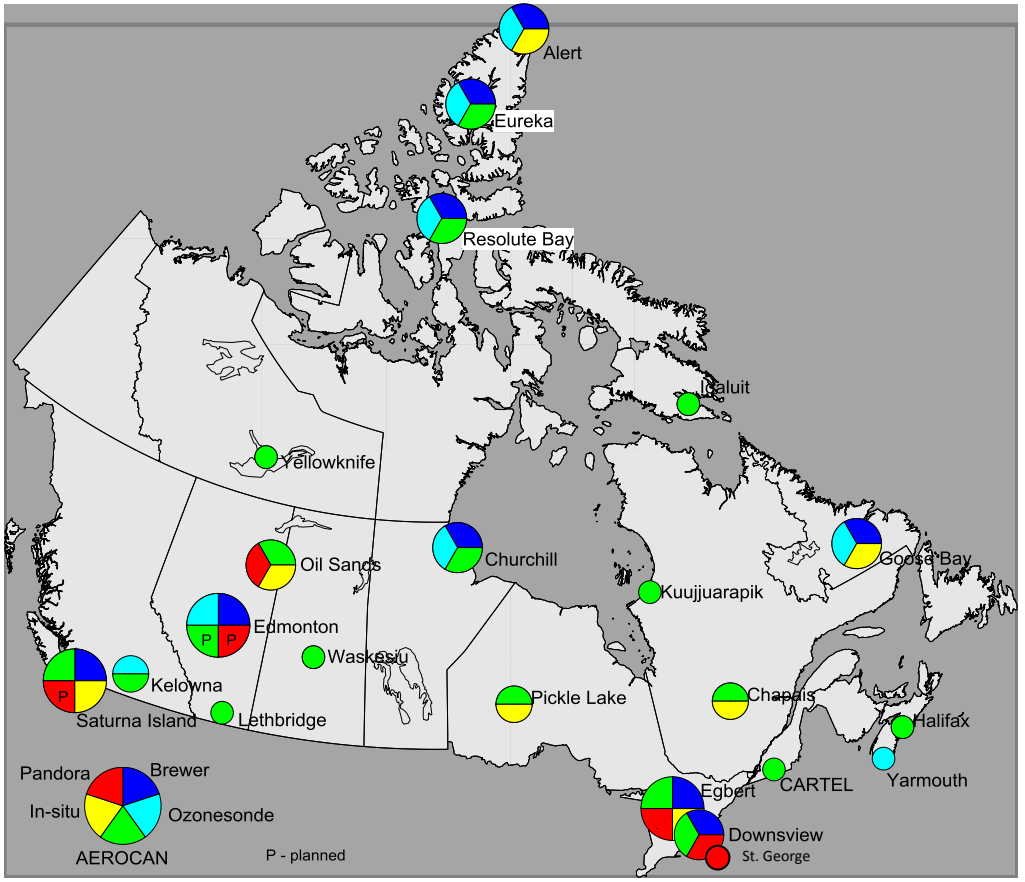
ECCC TROPOMI validation project

Environment and Climate Change Canada (ECCC) operates a network of ground-based instruments including

- Ozone and UV measurements by Brewers
- Ozone profile measurements by ozonesondes
- AOD measurements (AERONET)
- Pandora's NO_2 and SO_2
- In-situ monitoring instruments

ECCC also issues UV Index and Air Quality Health Index forecasts

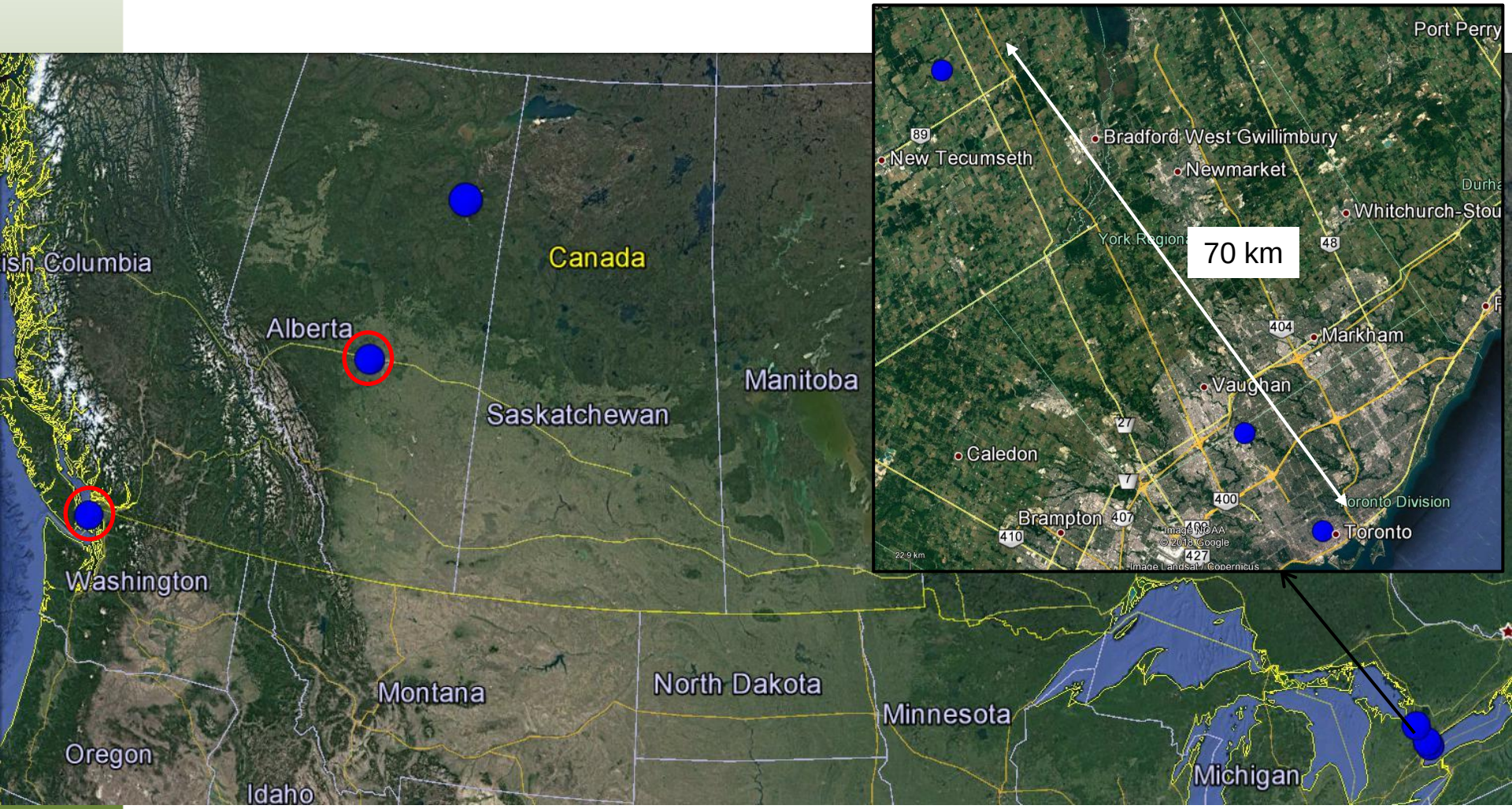
- **Brewers (8 sites with 2+ instruments, South Pole, Hawaii; 42 instruments including 12 Double Brewers)**
- **AEROCAN – Canadian part of AERONET (18 sites)**
- **Ozonesondes (8 sites)**
- **Pandoras (8 instruments)**

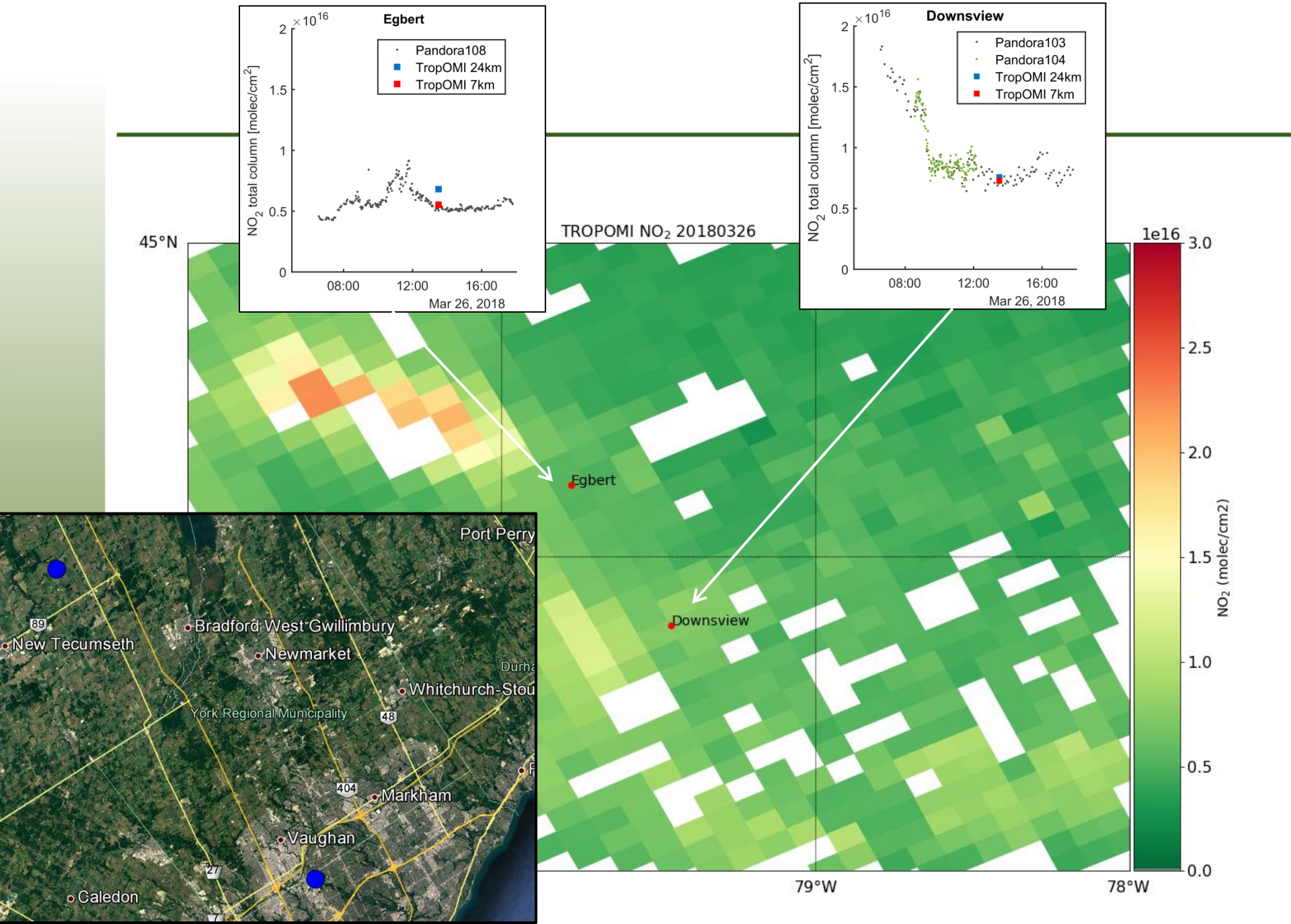


Pandora Network

As of June 2018: 8 total
4 Deployed
2 Planned
2 location TBD

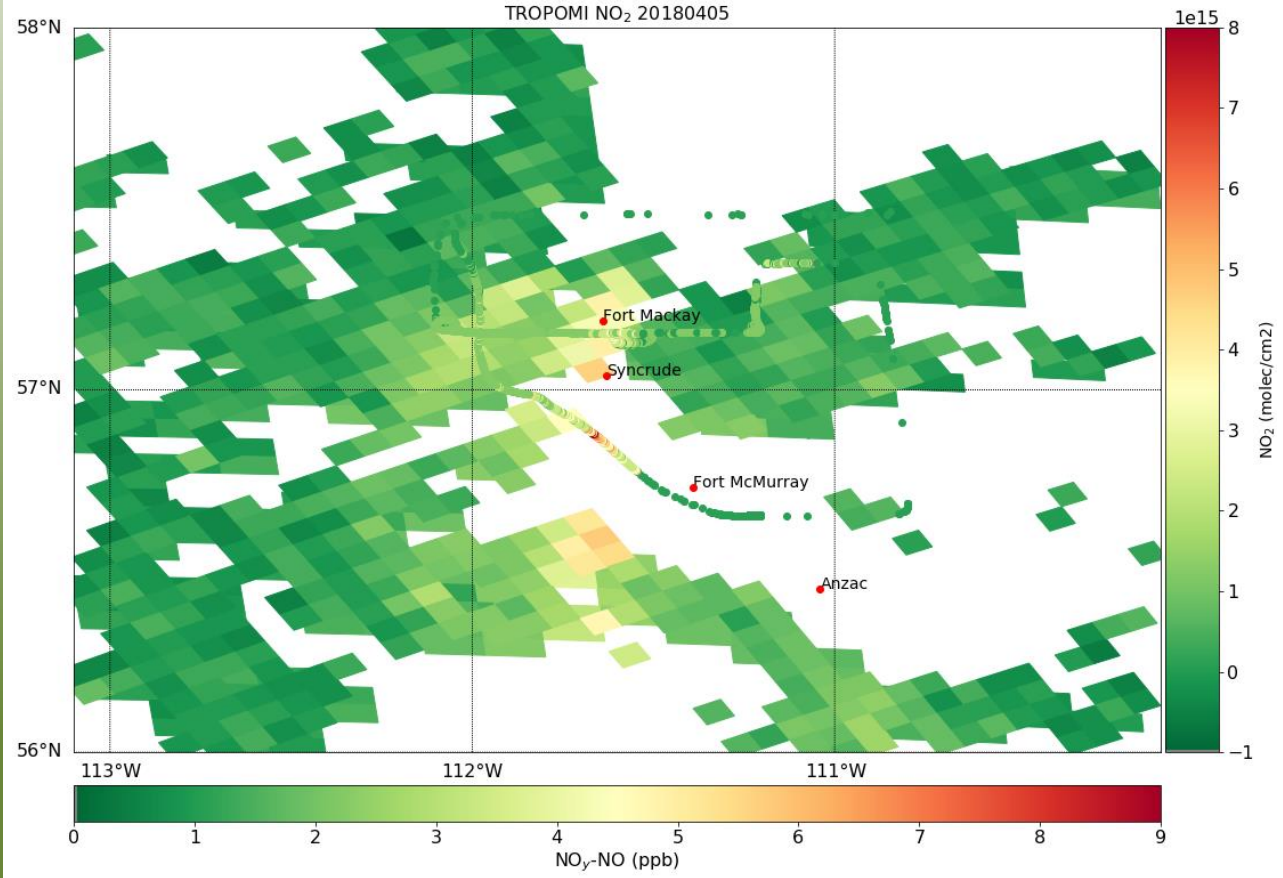
Canadian Pandora will join the US Pandonia Network

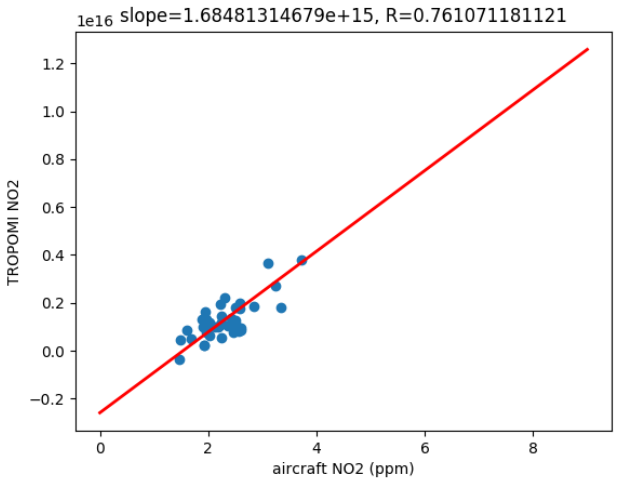



Egbert
Pandora108
TropOMI 24km
TropOMI 7km
$\times 10^{16}$
NO_2 total column [molec/cm^2]
08:00
12:00
16:00
Mar 26, 2018
Downsview
Pandora103
Pandora104
TropOMI 24km
TropOMI 7km
TROPOMI NO_2 20180326
45°N
79°W
78°W
Egbert
Downsview
1e16
NO_2 (molec/cm2)
Port Perry
Bradford West Gwillimbury
New Tecumseth
Newmarket
Whitchurch-Stou
York Regional Municipality
Markham
Vaughan
Caledon
89
48
404
27

2018 Aircraft Campaign in Alberta

- Phase 1: April; Phase 2: June/July
- Detailed comparisons with TropOMI underway using April data (with snow on ground)
  - Initial look finds good agreement for TropOMI NO_2
- Support at ECCC for TEMPO validation campaign





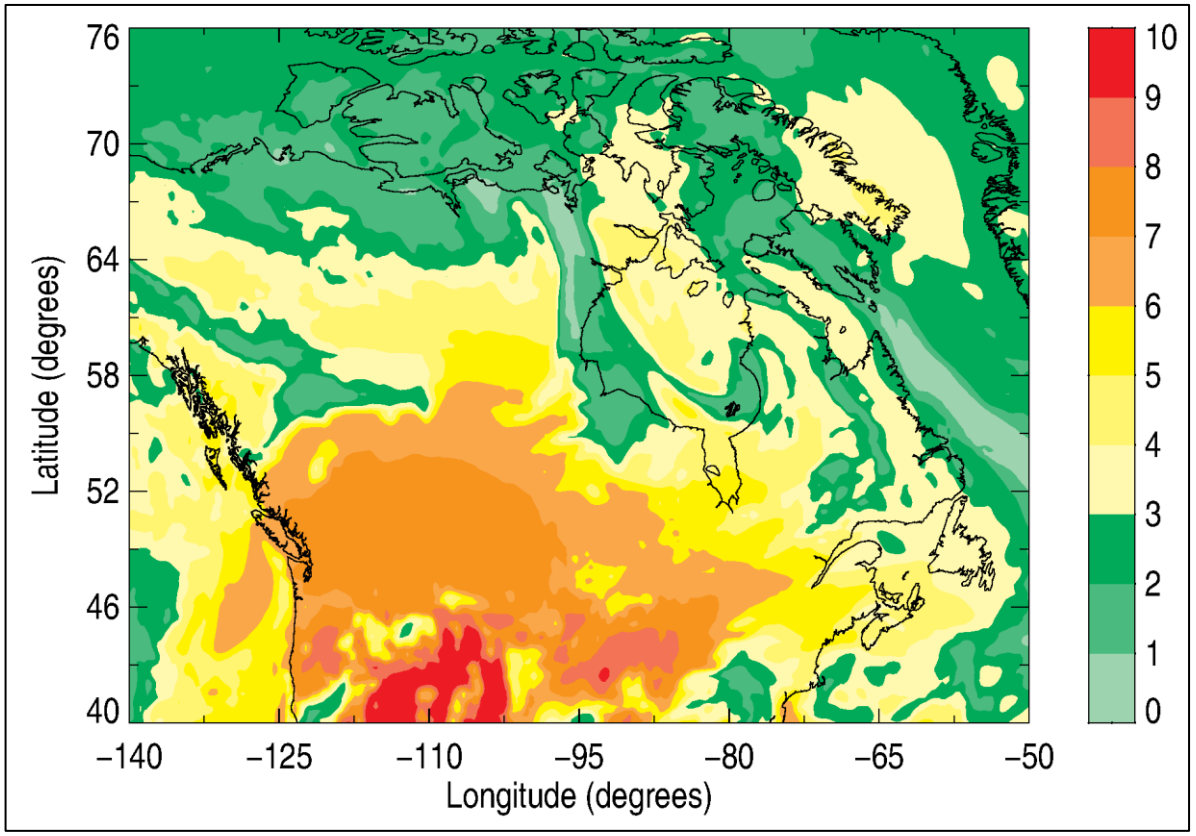
Canada

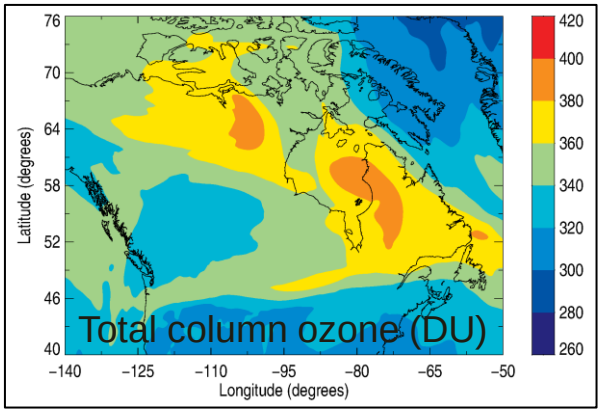
Chemical Data Assimilation: Develop an operational global/regional assimilation/forecasting system that will use:

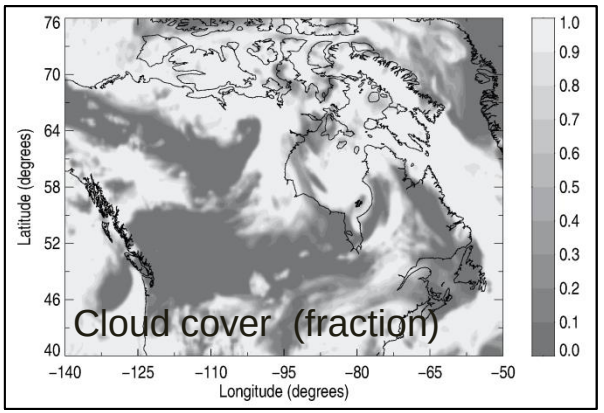
- ECCC GEM-MACH* operational AQ forecast model
- North American surface stations (O_3, NO_2, $PM_{2.5}$)
- TEMPO (+ TropOMI) total column measurements of O_3, NO_2, AOD
- Stratospheric profiles of O_3, NO_2 (pending availability)

* Global Environmental Multi-scale model - Modelling Air quality and CHemistry

Example: Image of UV index day four forecast -- July 11th 15:00 EDT

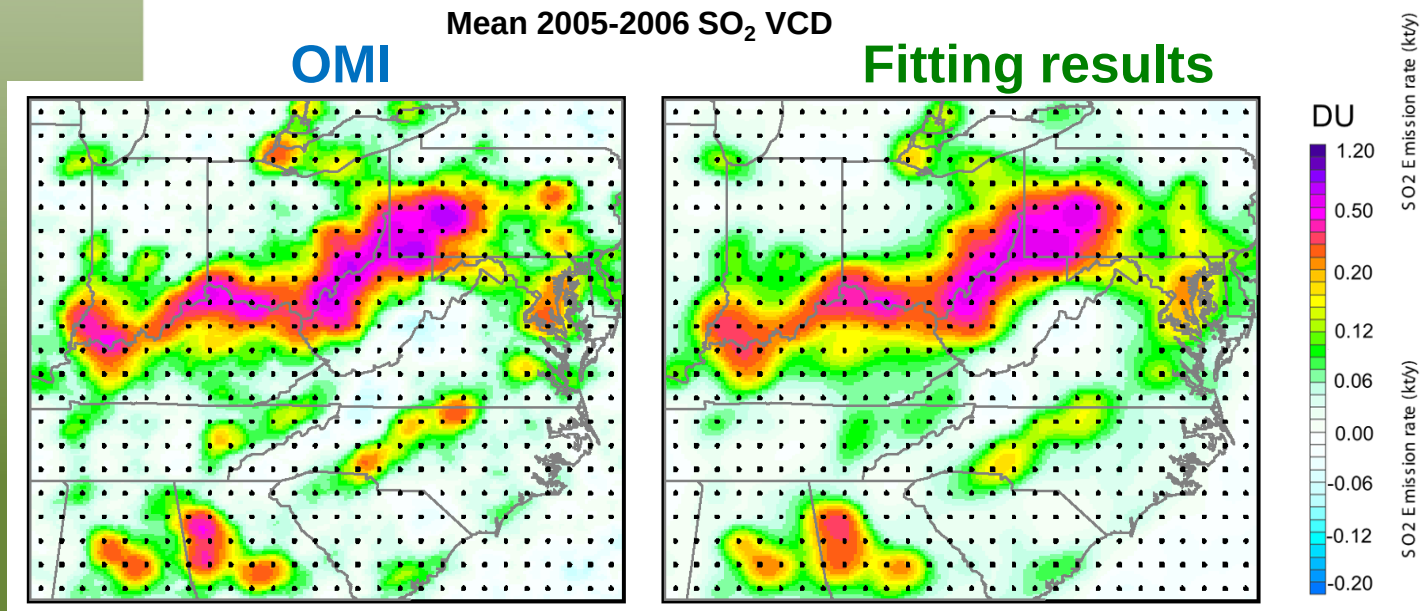


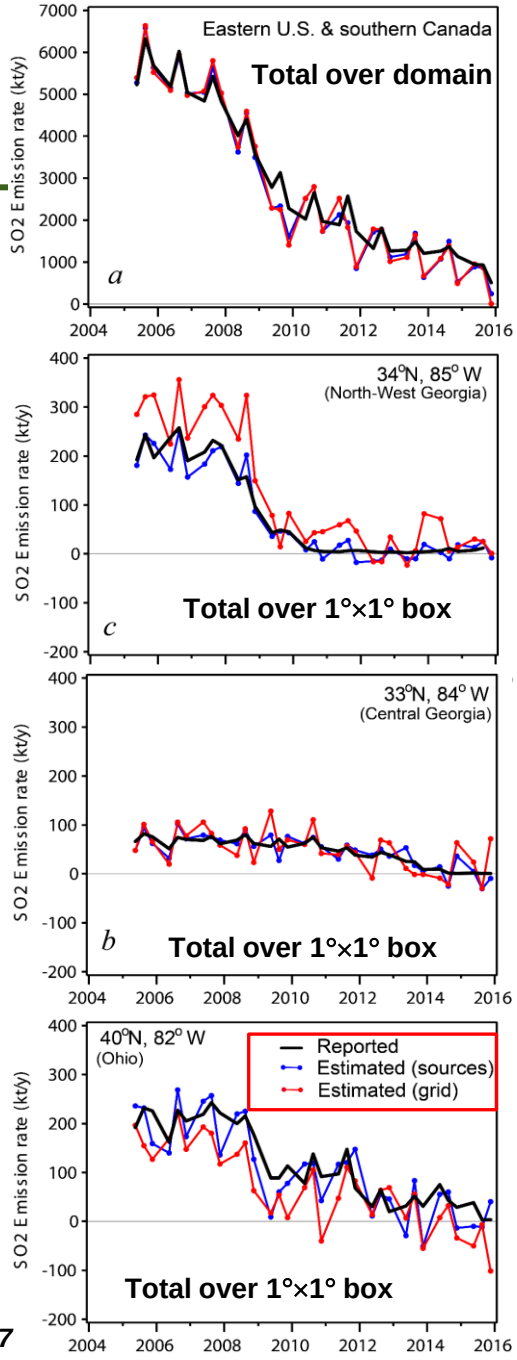




SO_2 emissions from OMI

- TEMPO should enable much better quantification of emissions (high spatial and temporal resolutions, lower detection limits)
- Here we show an example of deriving SO_2 from OMI using a multi-source inversion – each dot is a potential source
  - Performs slightly better if source locations known



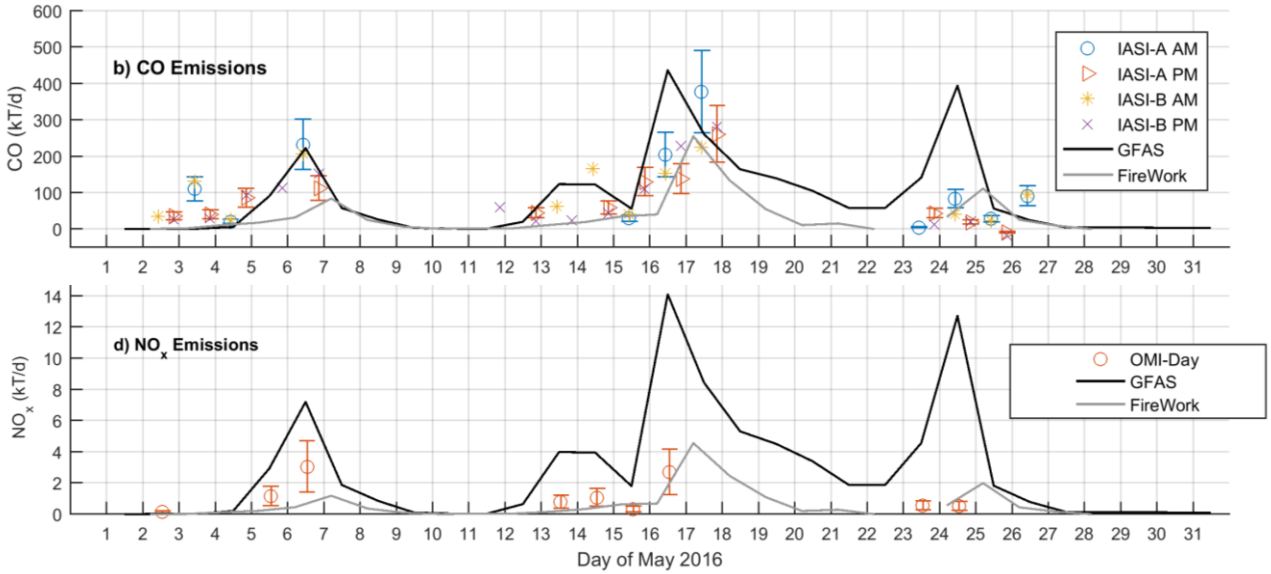


from Fioletov et al., ACP, 2017

Wildfire emissions

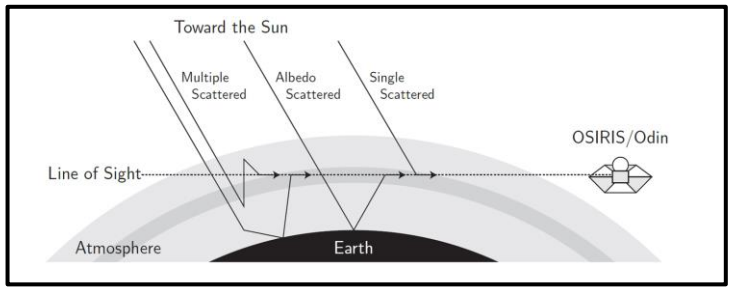
- Many wildfires in Canada occur below 58°N (e.g., Fort McMurray 2016; large British Columbia fires in 2017)
- Fire emissions are a key uncertainty for forecasting AQ
- TEMPO will allow for tracking NO_2, AOD, from many more (and much smaller)

Emissions from 2016 Fort McMurray Fire (Adams et al., in preparation)

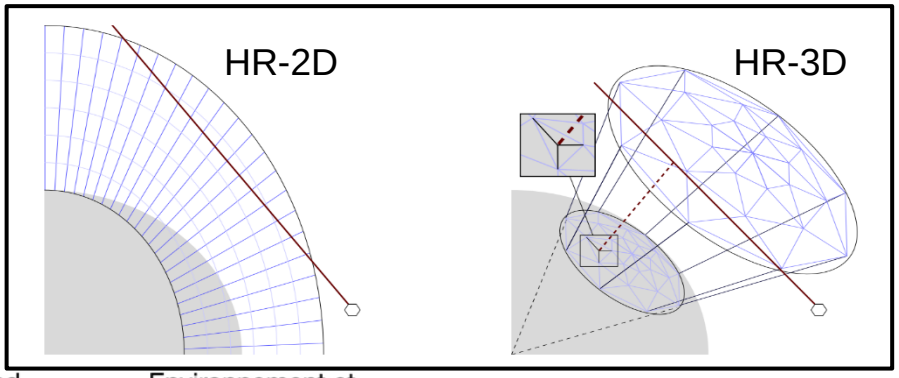


University of Saskatchewan Group Radiative Transfer

- Radiative Transfer capabilities: The **SASKTRAN** RT Model
  - Fully spherical, multiple scattering code developed for UV-vis-NIR limb scattering
  - Main stream retrieval code
    - 1D, scalar, successive orders with optimized resolution for speed

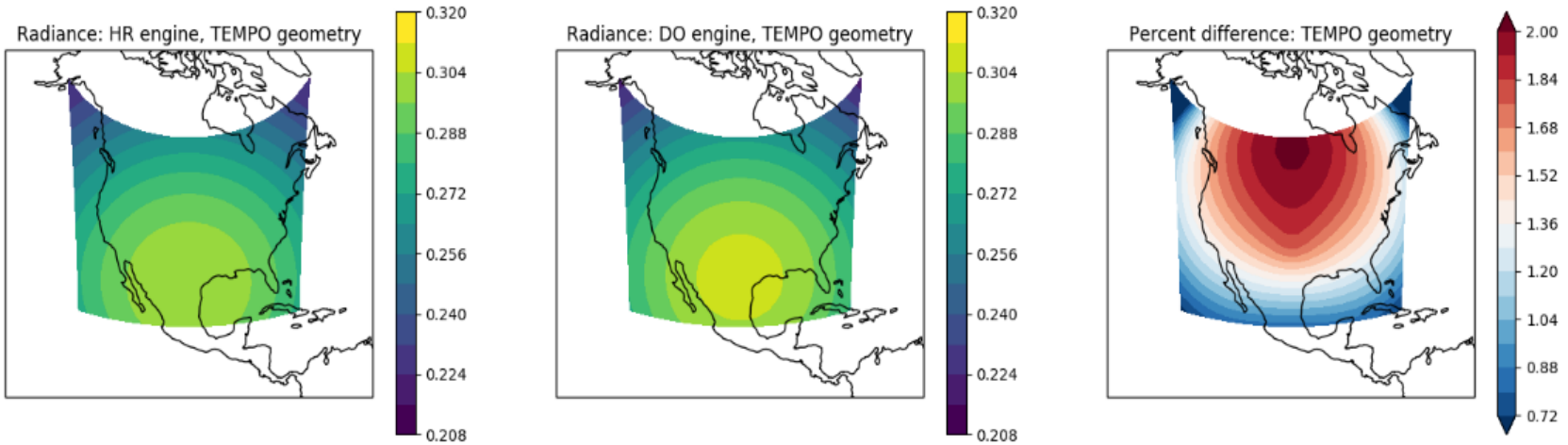


  - Research codes
    - Monte Carlo (MC), fully 3D, vector or scalar solution
      - Developed for benchmarking
    - High Resolution (HR), 2D (orbit plane) or 3D, successive orders
      - Developed for tomography, analytic Jacobians, polarized solution, BRDF



University of Saskatchewan Group Radiative Transfer

- New **SASKTRAN** RT Solver: Discrete Ordinates (DO) implementation
  - Faithful representation of distributed DISORT V2.0 (agreement to 5 decimal places)
  - Includes linearized weighting functions
  - Fully integrated into SASKTRAN framework: Atmospheric state, species concentrations, etc.
- Allows for robust comparison with spherical solution in “difficult” geometries, i.e. Canadian oil sands



Sample TEMPO simulation: TEMPO observations are simulated across the TEMPO field of regard using the discrete ordinates (DO) solution and the SASKTRAN high resolution spherical successive orders (HR) solution for a snow cover BRDF (Kokhanovsky, 2012).

- Early work on comparison of retrieved SCD and calculated air mass factors with the two models shows differences up to 5% at Canadian latitudes. Needs further investigation.