FTIR Measurements of Biomass Burning Species from the 2014 Canadian Wildfires

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Annual NDACC-IRWG Meeting
Toronto, ON, Canada
June 12, 2015

Introduction

- Biomass burning presents significant contributions to pollution in the Arctic (*Shindell et al., ACP, 2008, Saha et al., ACP, 2010*).
- Emissions of radiatively and photochemically active species may affect climate (*Amiro et al., CJFR, 2001*).
- Quantifying biomass burning emissions is difficult due to the spatial and temporal variabilities of events.
- Emissions are also highly dependent on fuel type and burning stage.

Photo source: NWT Fire

2014 Northwest Territories Fires

July-August 2014: Over 365,000 hectares of boreal forest burned in the Northwest Territories, Canada.

Massive smoke clouds from Canadian wildfires are up to 15 km high and visible all the way to Portugal

NP MARGARET MUNRO, POSTMEDIA NEWS | August 4, 2014 | Last Updated: Jan 24 9:29 PM ET
More from Postmedia News

"It's a major event in the life of the earth system to have a huge set of fires like what you are seeing in Western Canada," says Douglas Morton, an earth scientist at NASA Handout/NWT Fire

Source: news.nationalpost.com

Hazy in Toronto? Blame the fires in Northwest Territories

By Nicole Mortillaro
Science and Weather Reporter Global News

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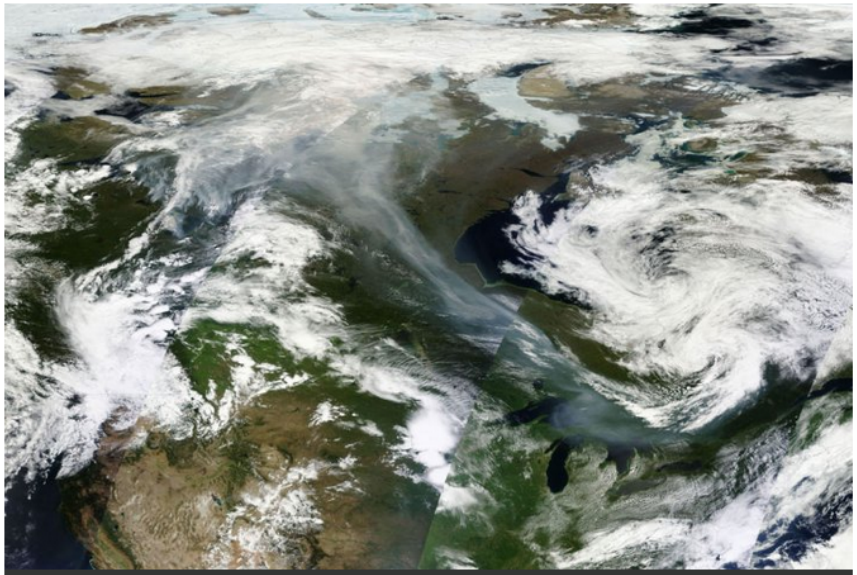


Smoke from wildfires in the Northwest Territories has reached all the way to southern Ontario.

NASA/EOSDIS

Source: globalnews.ca

FTIR Measurements

Pearl Environment Atmospheric Research Laboratory (PEARL)

- Eureka, Nunavut (80.02°N, 86.42°W)
- Bruker 125HR

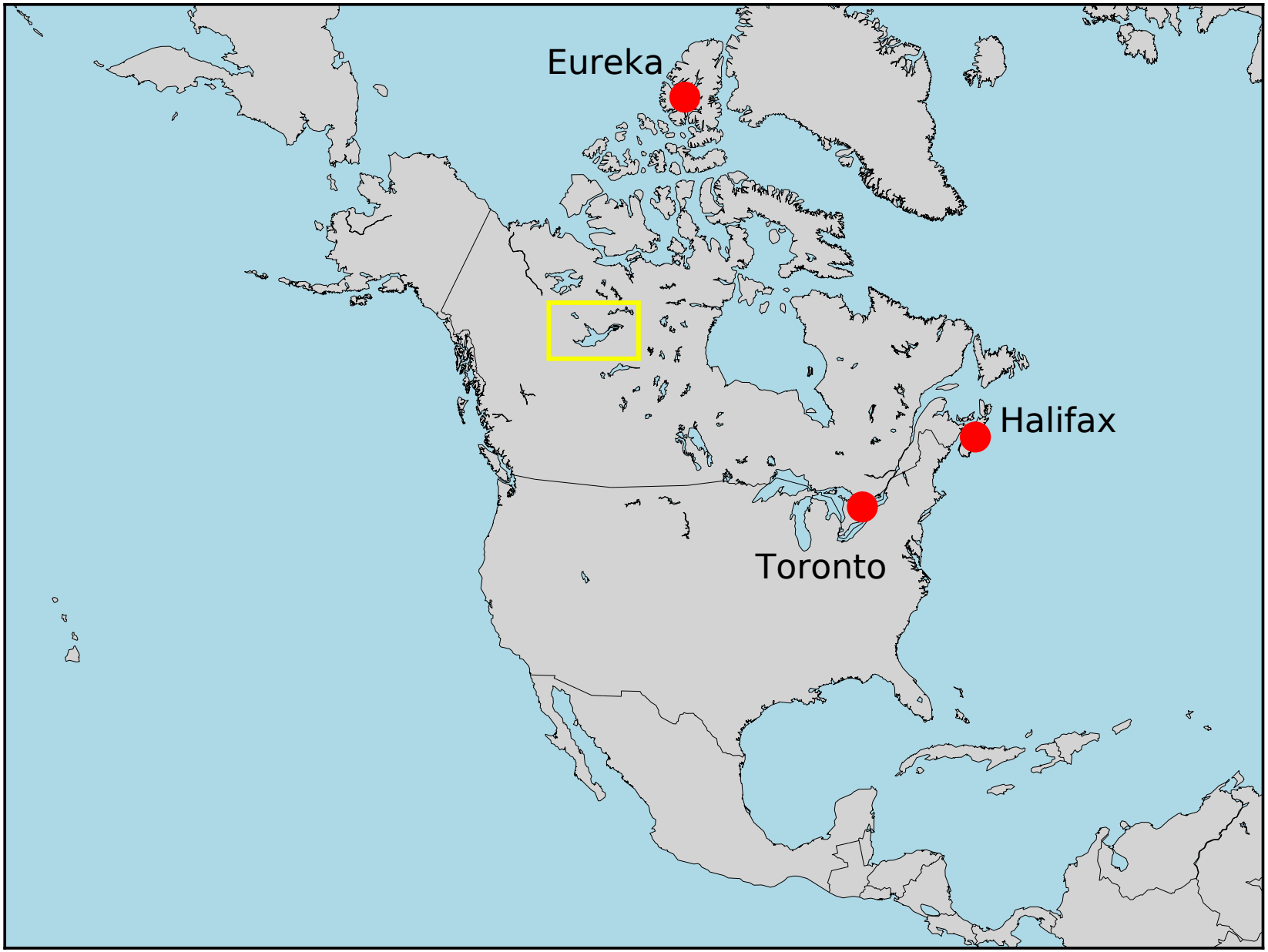
Toronto Atmospheric Observatory (TAO)

- Toronto, Ontario (43.70°N, 79.40°W)
- ABB Bomen DA8

Dalhousie Atmospheric Observatory (DAO)

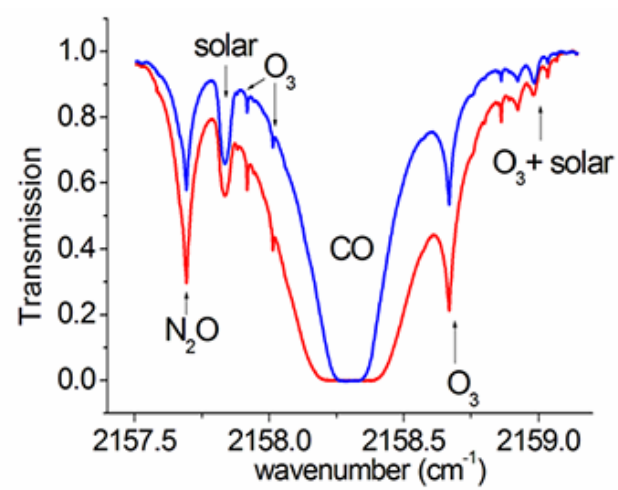
- Halifax, Nova Scotia (44.64°N, 63.59°W)
- ABB Bomen DA8

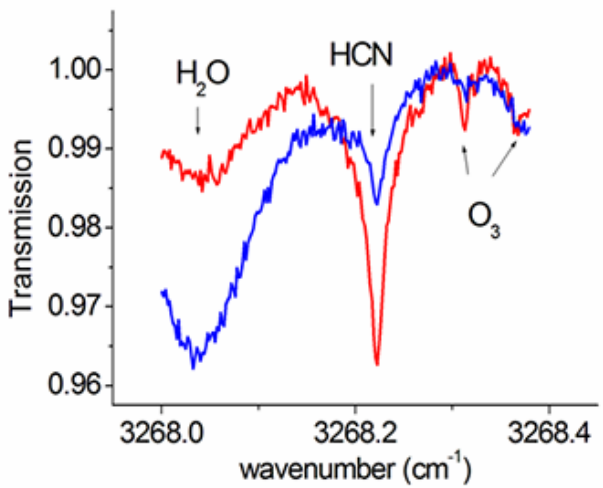
Measurement Sites

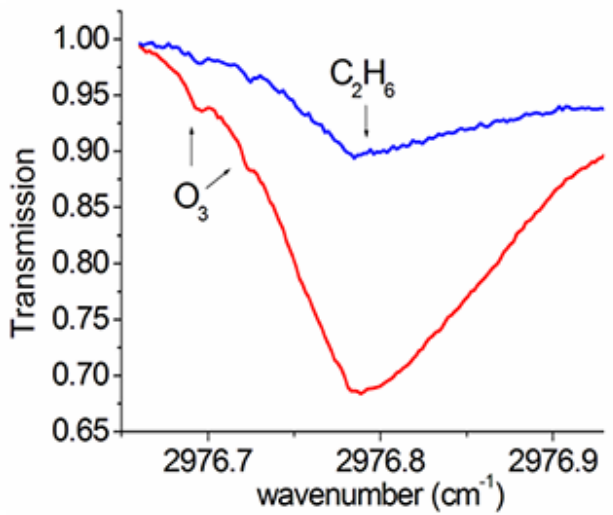


Retrieved Species

Species	Name	Sources	Sinks	Lifetimes
CO	Carbon Monoxide	BB, transport, steel industry, methane and VOC oxidation	Reaction with OH	2 months
HCN	Hydrogen Cyanide	BB, industry, fungi and plant emission	Reaction with OH and ocean uptake	2-6 months
C_2H_6	Ethane	BB, biofuel use, natural emission	Reaction with OH	1.5 months

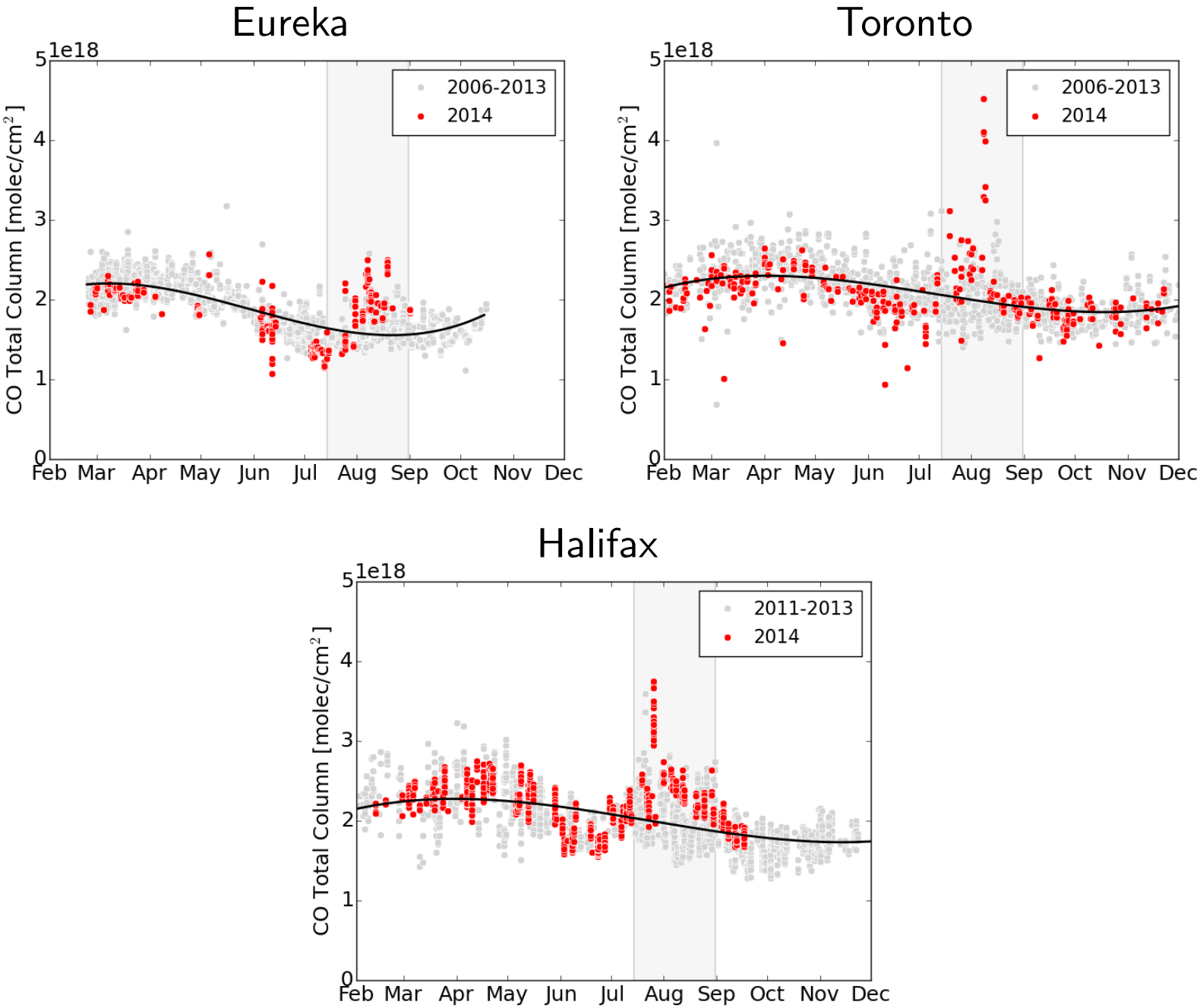




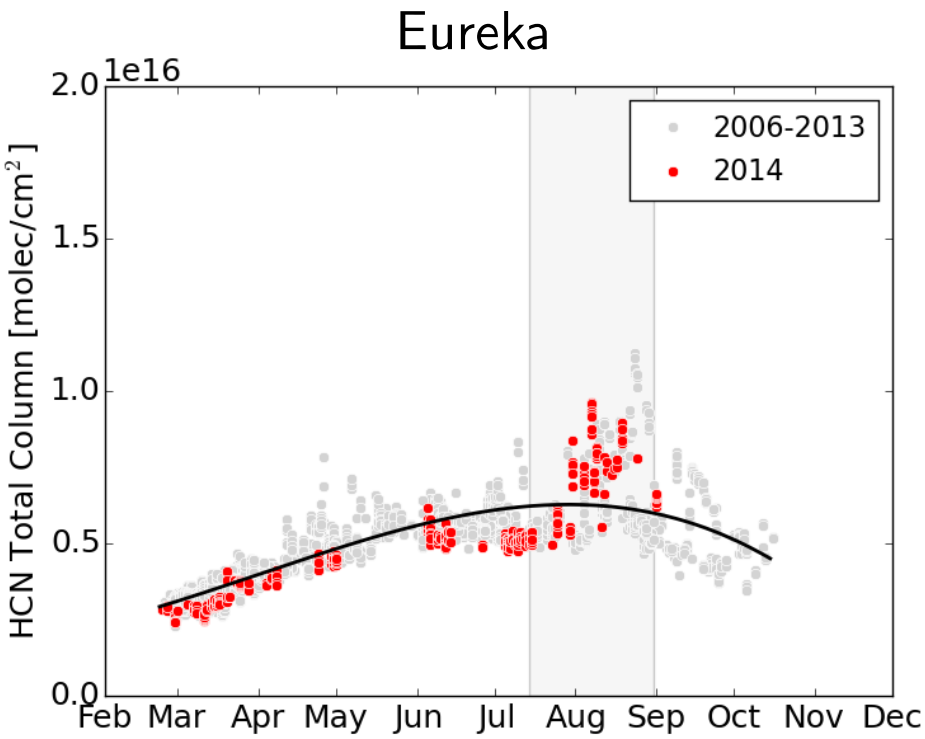


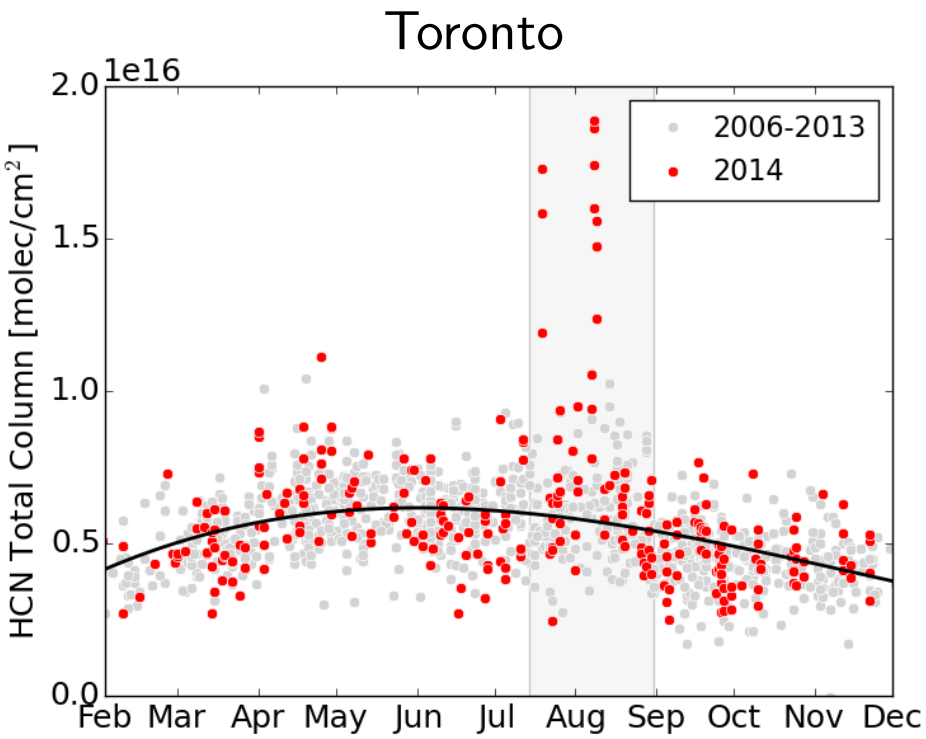
Viatte et al., AMT, 2014

Time series: CO

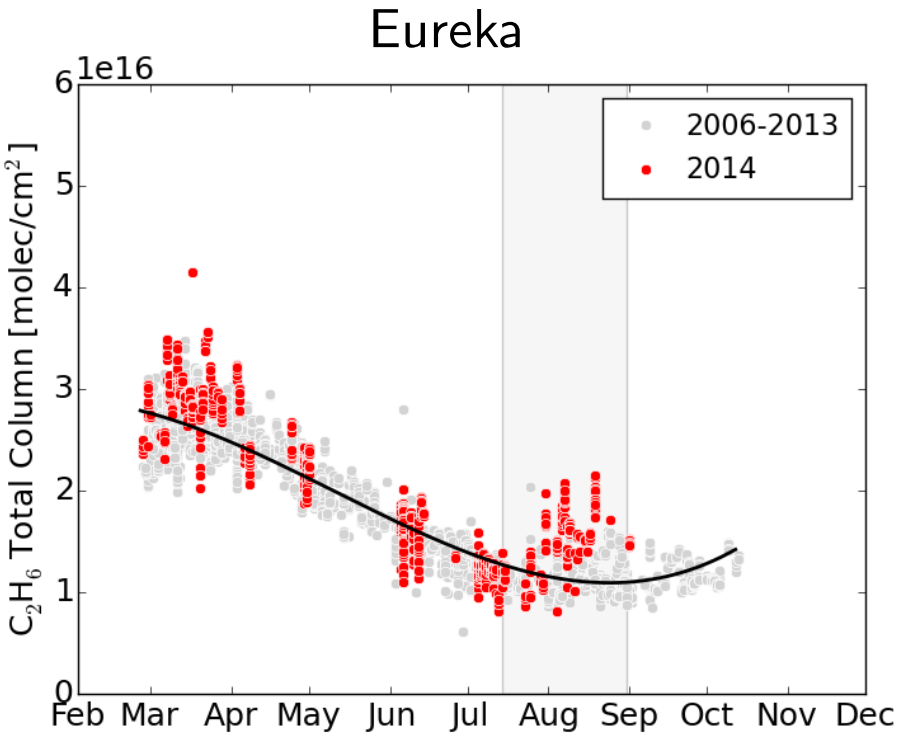


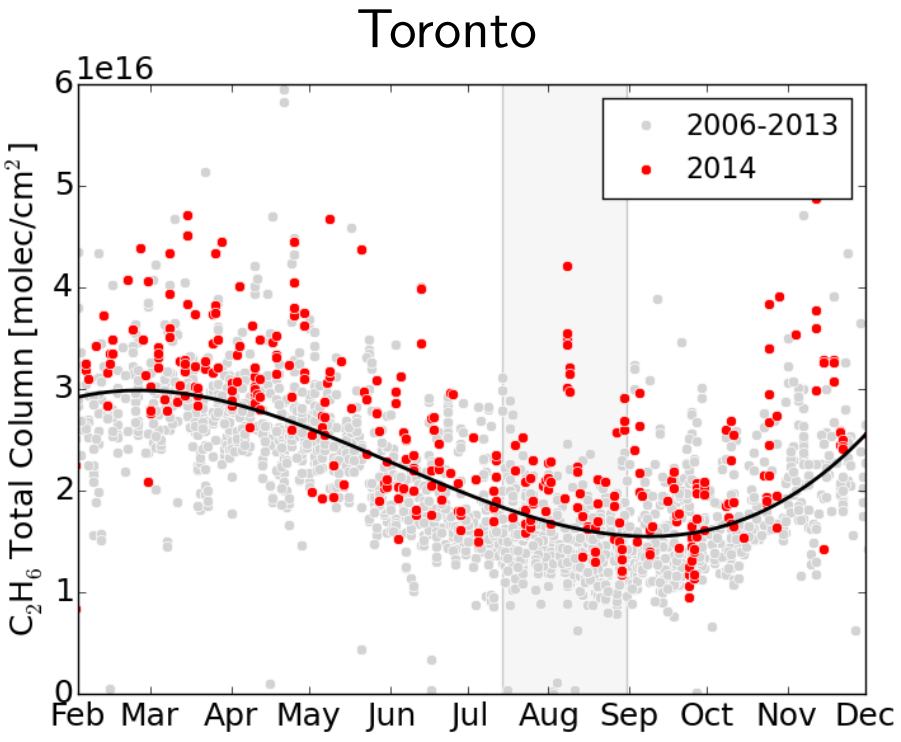
Time series: HCN



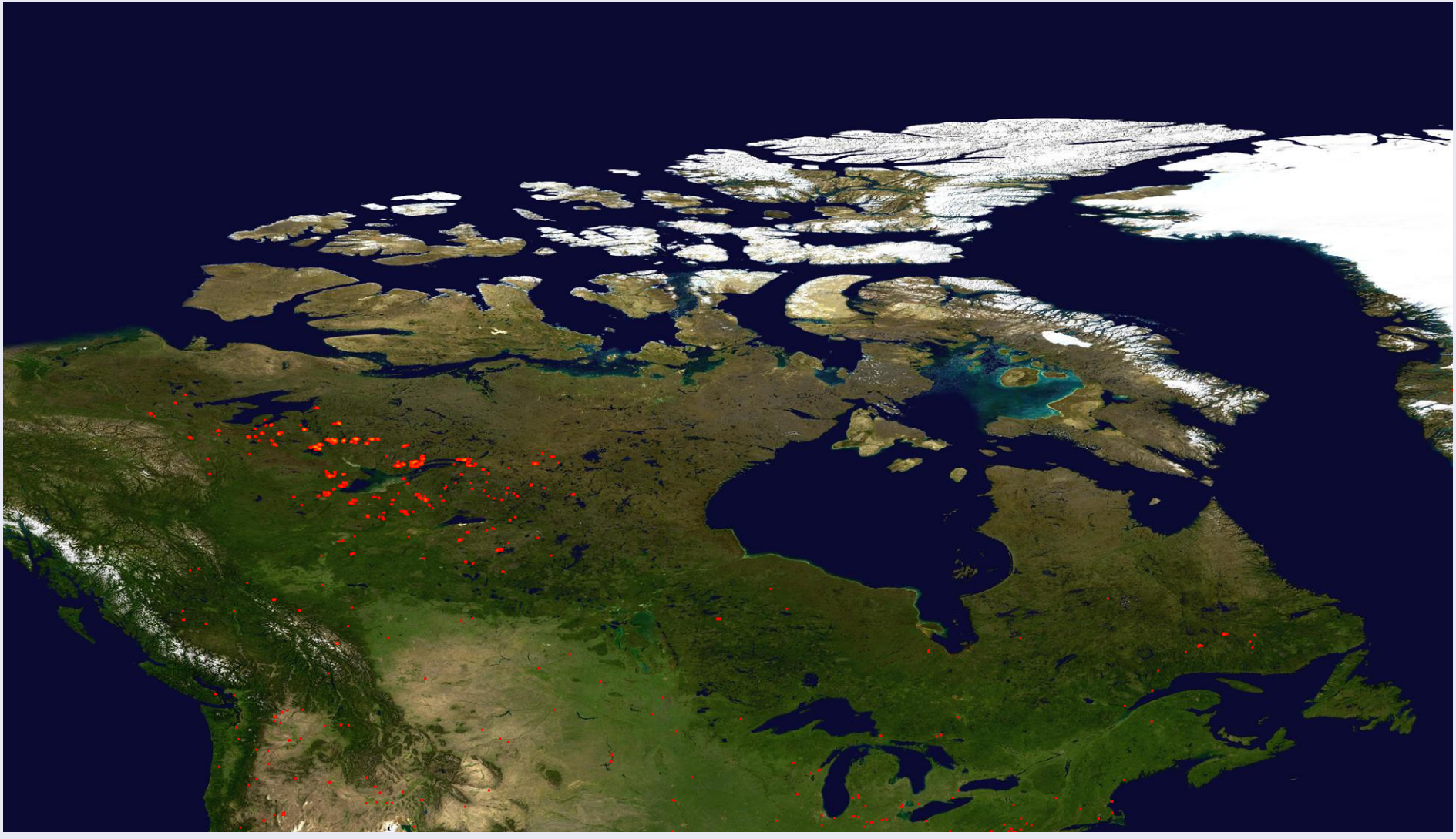


Time series: C_2H_6





MODIS: June 30 - July 09, 2014



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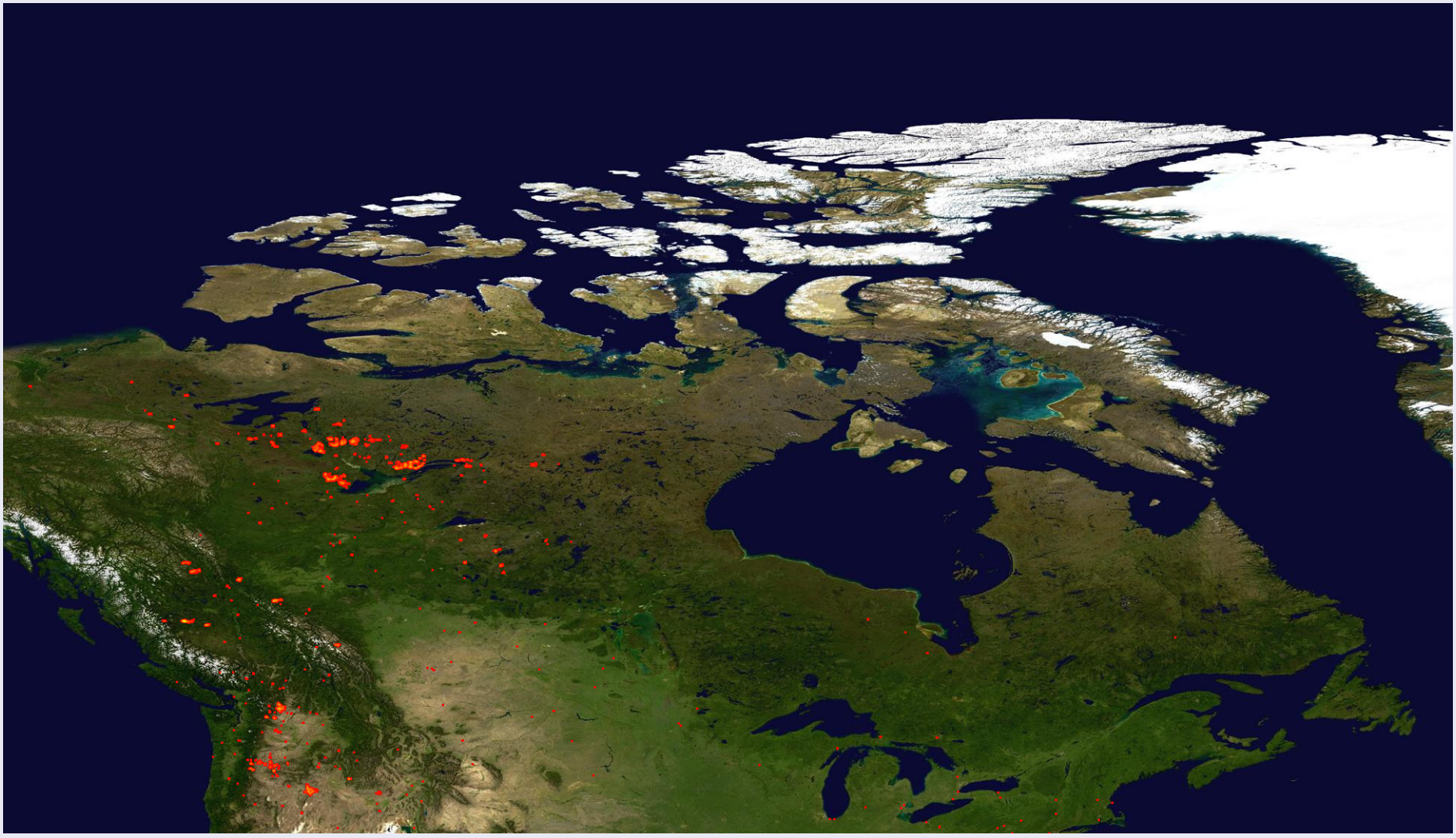
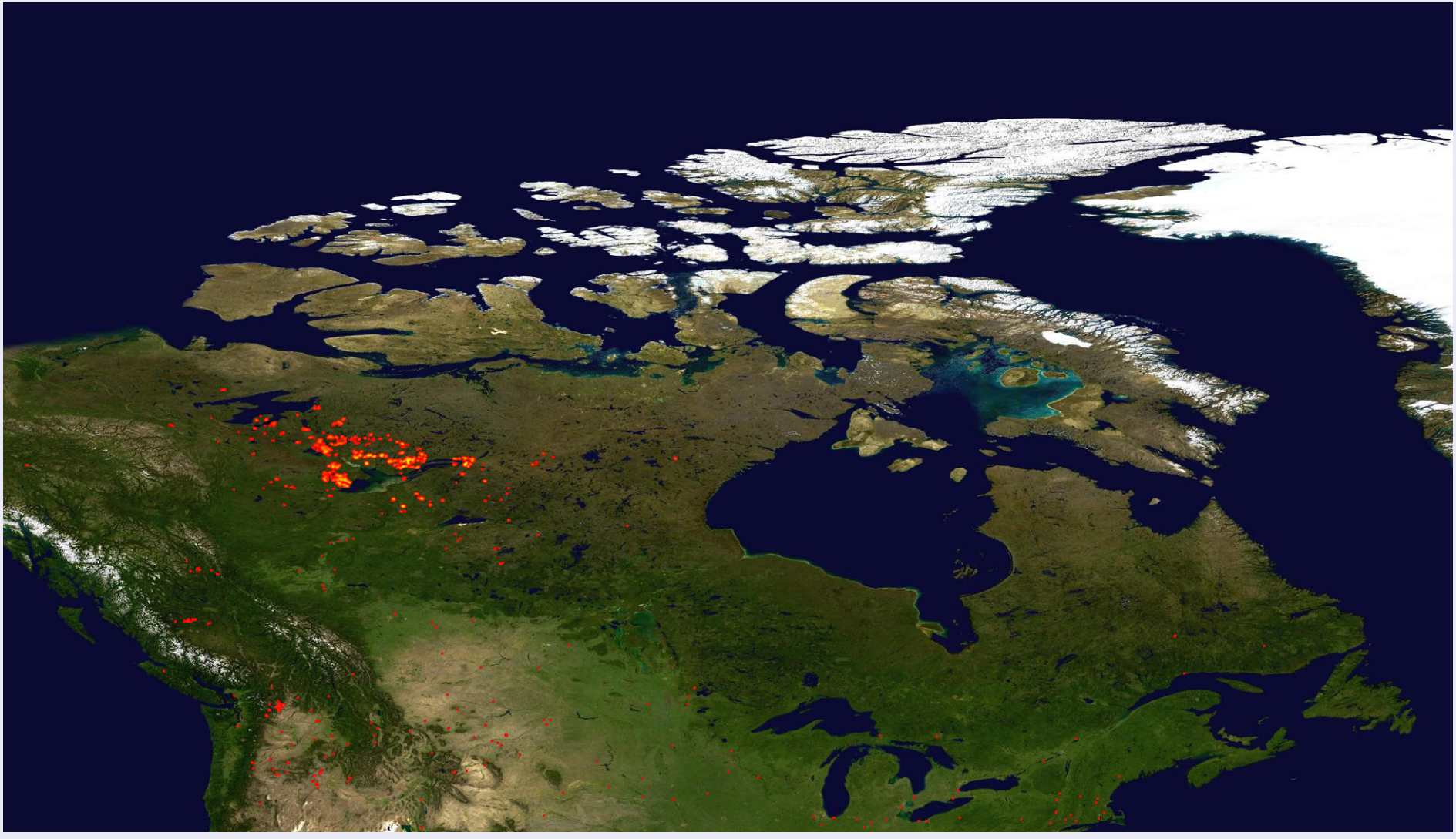
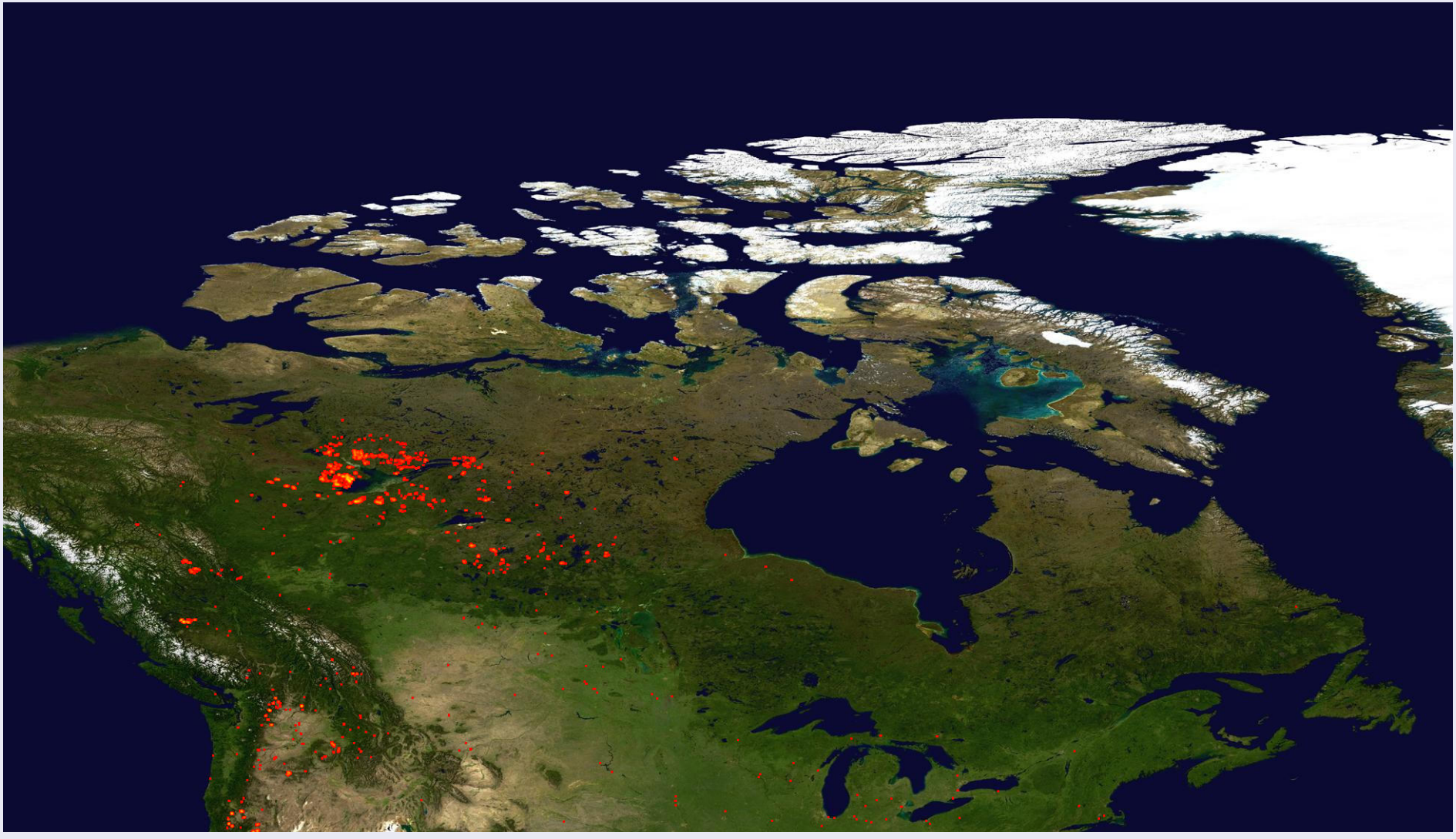


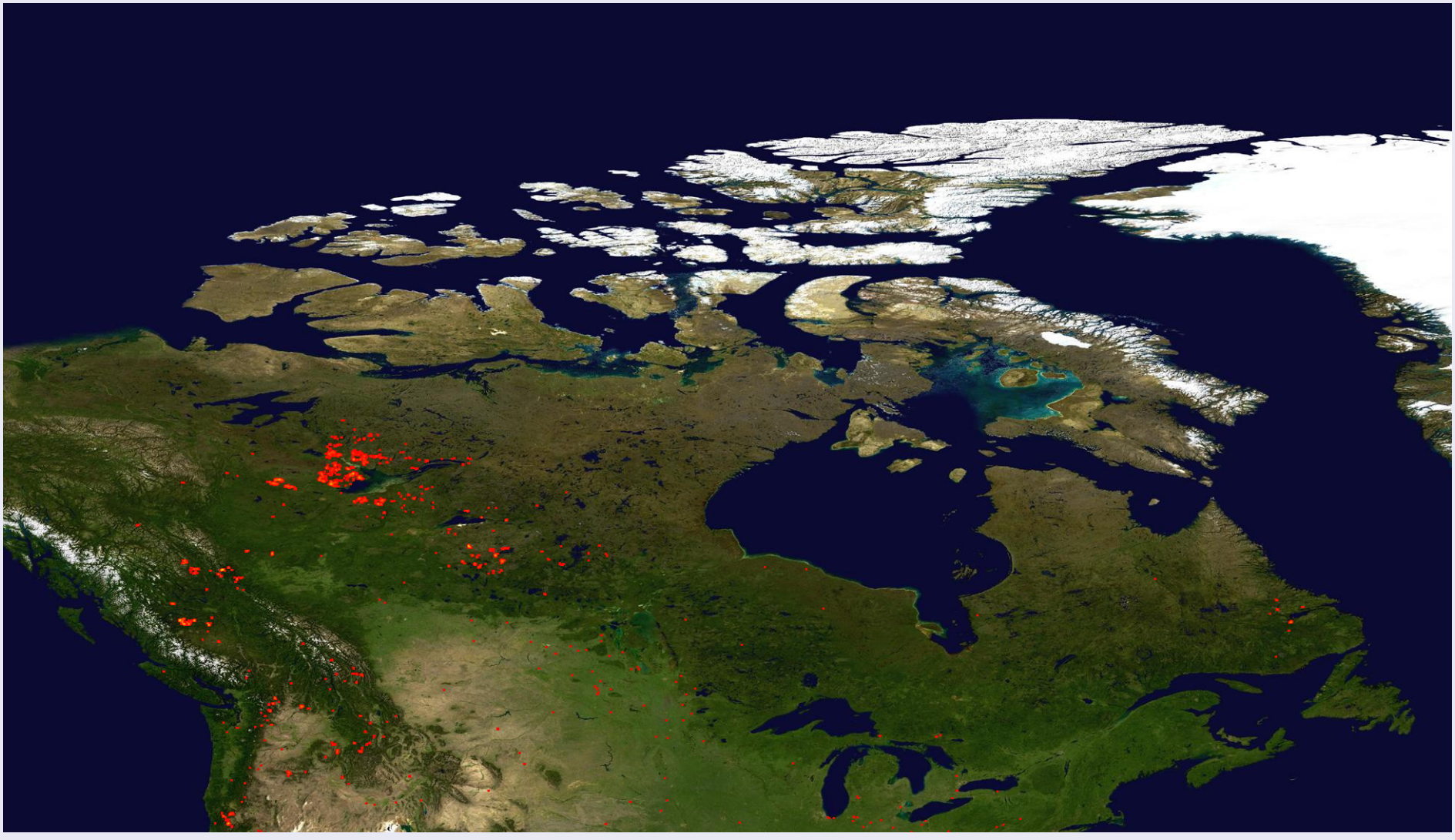
MODIS: July 20 - 29, 2014



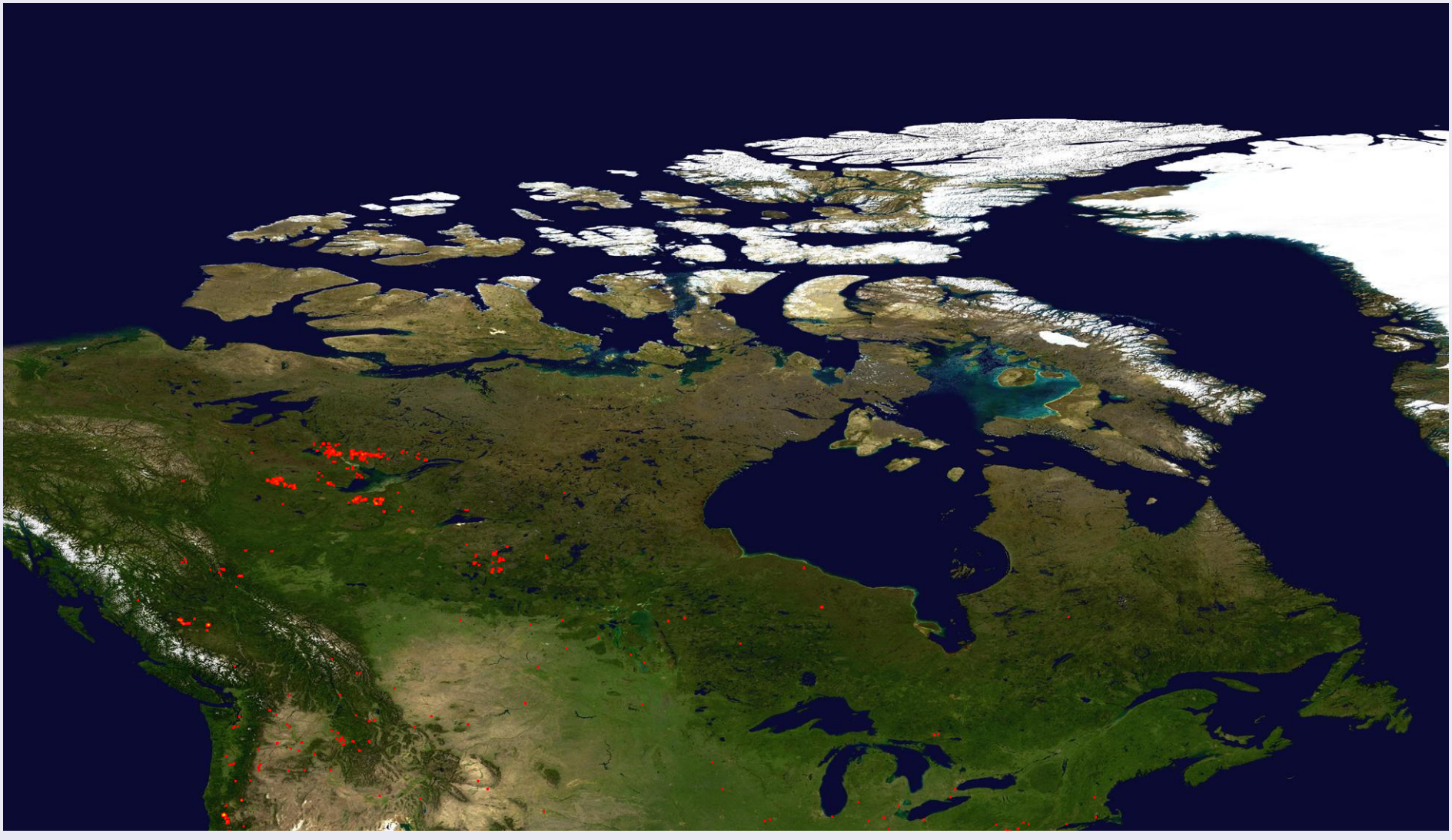
MODIS: July 30 - Aug. 8, 2014



MODIS: Aug 9 - Aug. 18, 2014

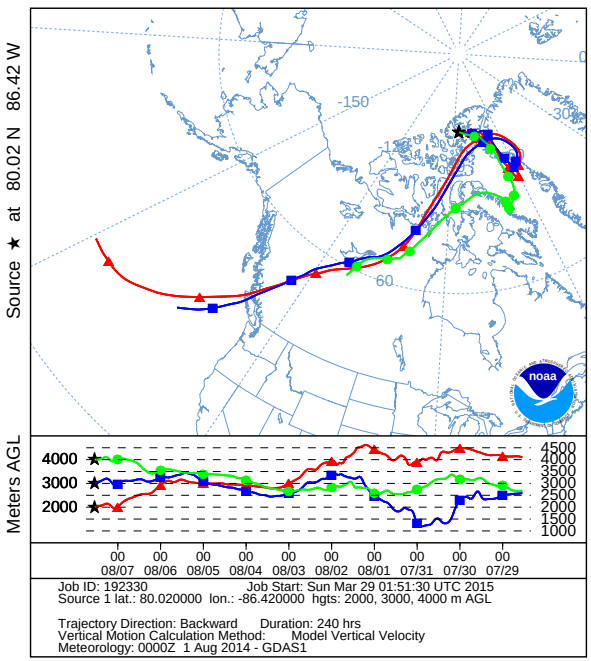


MODIS: Aug 19 - Aug. 28, 2014



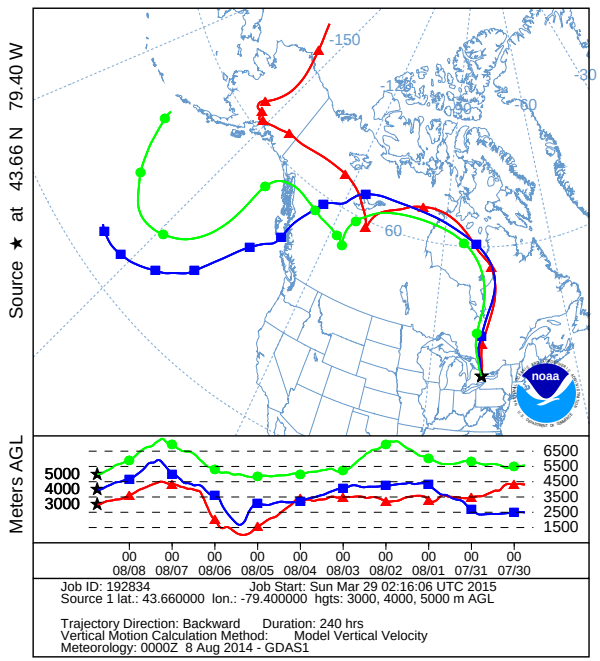
HYSPLIT Backwards Trajectory

Eureka



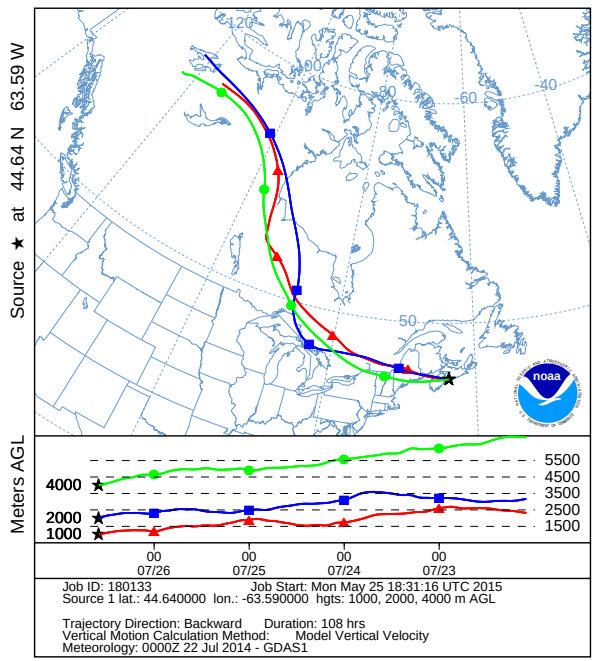
Aug. 7, ∼6 days

Toronto



Aug. 8, ∼3 days

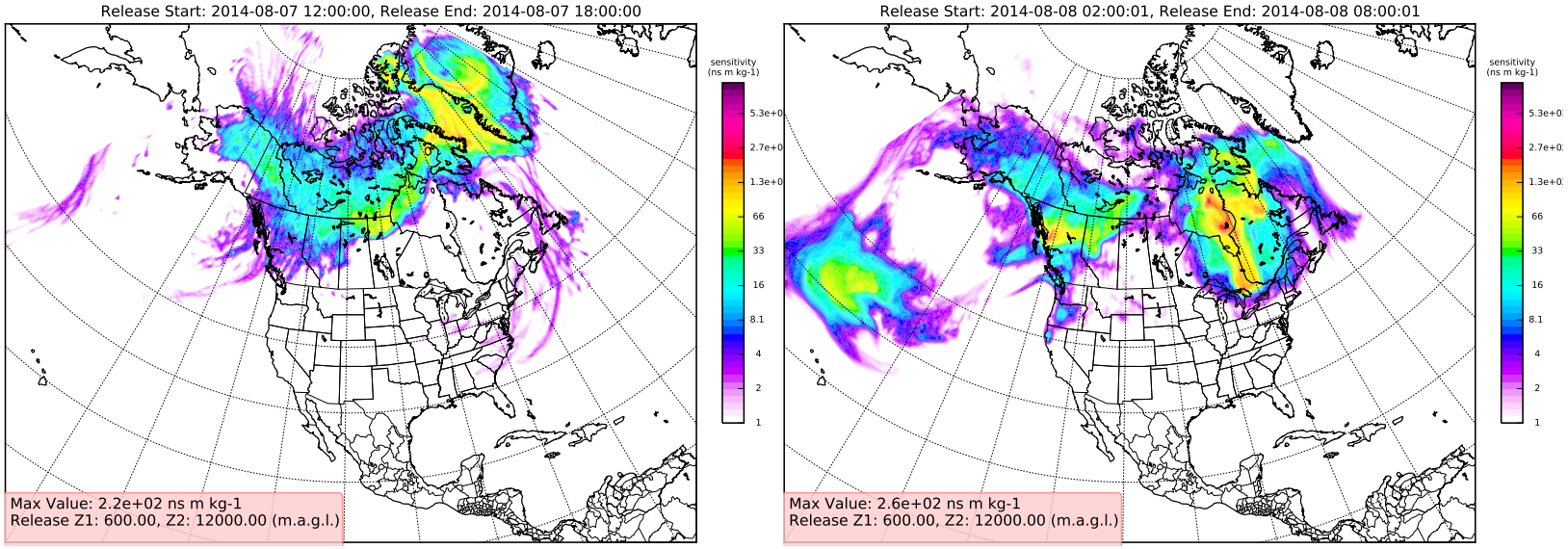
Halifax



July 26, ∼5 days

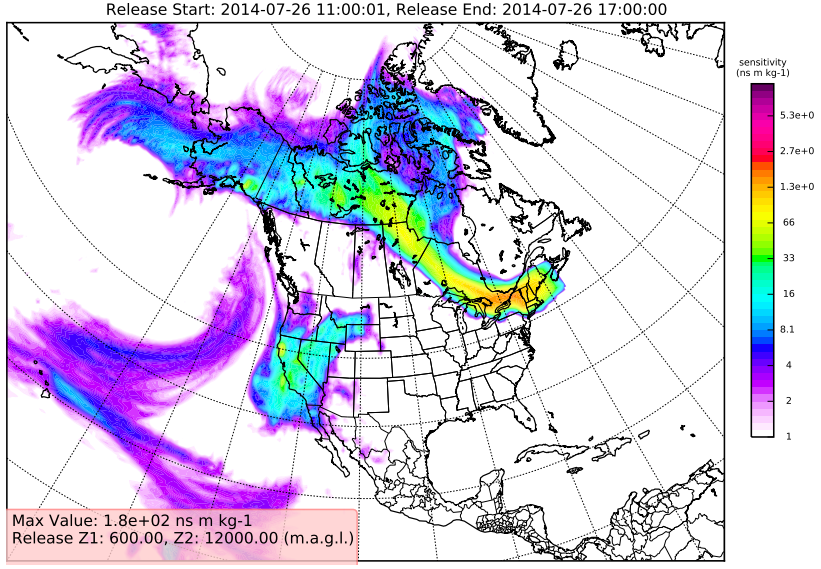
FLEXPART Backwards Runs

Eureka



Toronto

Halifax



Estimating Emissions

Total emission from a fire event:

$$E_X = \textit{Area Burned} \times \textit{Fraction Burned} \times EF_X \tag{1}$$

The emission factor for species X is defined by:

$$\mathrm{EF_X} = \mathrm{EF_{CO}} \cdot \mathrm{ER_{X/CO}} \cdot \left(\frac{\mathrm{MW_X}}{\mathrm{MW_{CO}}} \right) \tag{2}$$

- EF - emission factor
- ER - emission ratio
- MW - molecular weight

Emission Factor ($\mathrm{EF_X}$)

Mass of trace gas emitted per unit mass of fuel burned.

Calculation of Emission Factors

From FTIR measurements, we calculate:

$$\mathrm{Enhr_X} = \frac{[\mathrm{X}]}{[\mathrm{CO}]} \tag{3}$$

- Enhr - enhancement Ratio
- [X] - total column amount

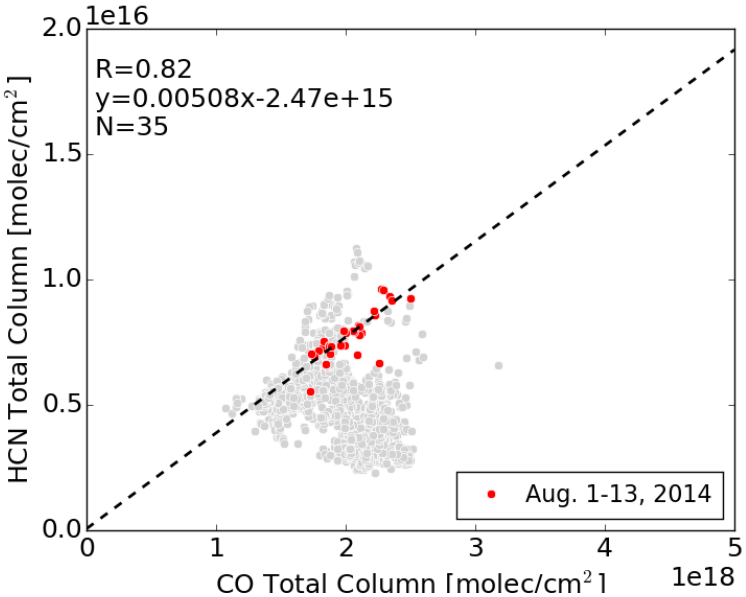
Decay during transport:

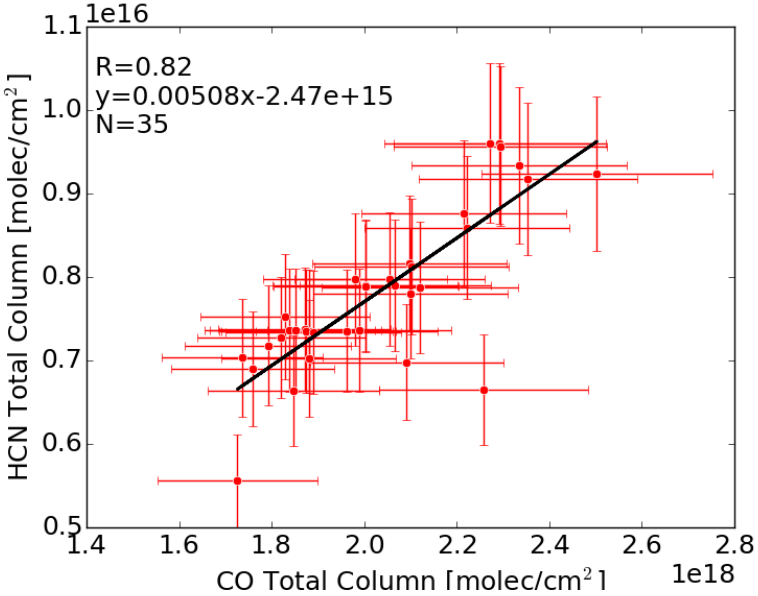
$$[\mathrm{X}(t)] = [\mathrm{X_0}] \exp\left(-\frac{t}{\tau}\right) \tag{4}$$

- t - travel time of plume from fire source to measurement site
- τ - atmospheric lifetime of gas

Enhancement Ratio: HCN

Eureka





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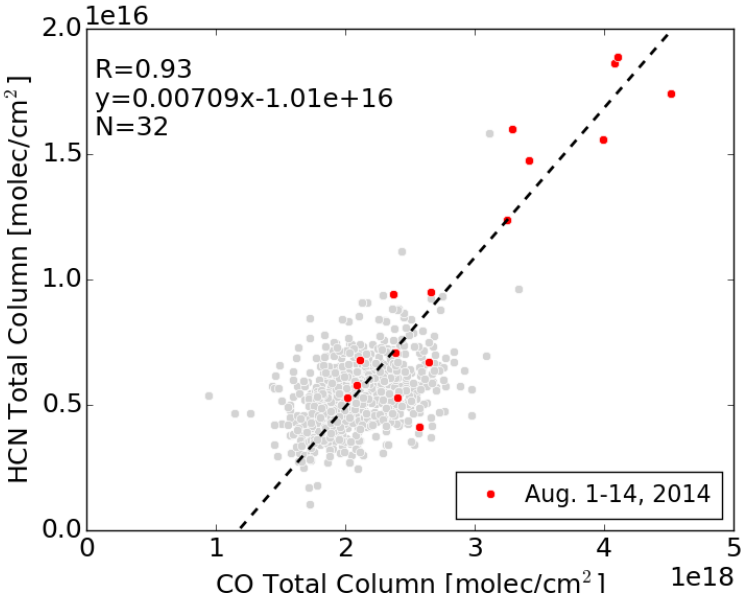
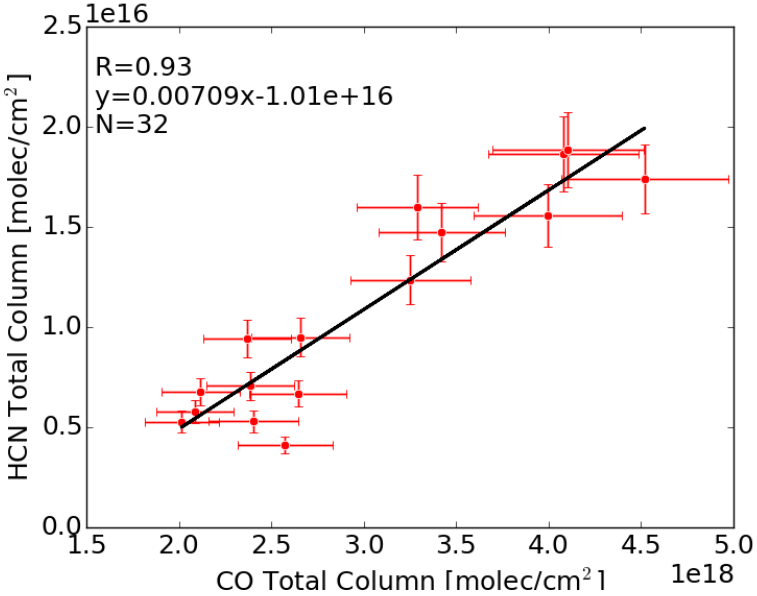
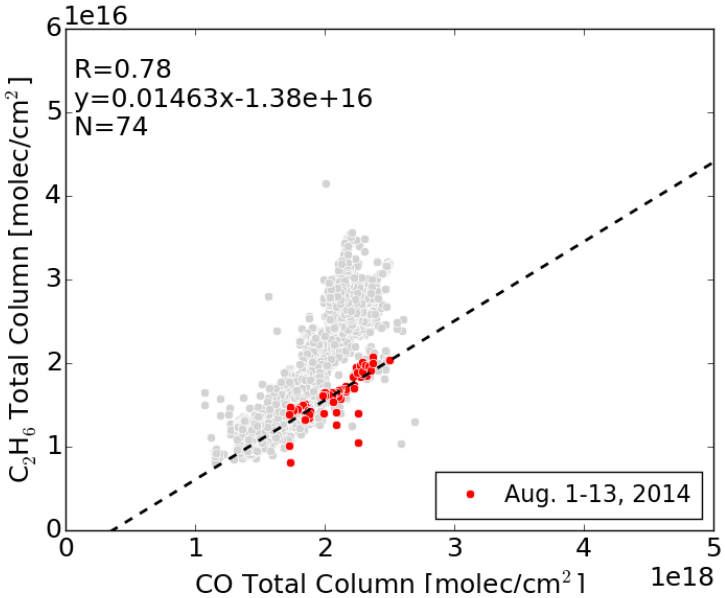
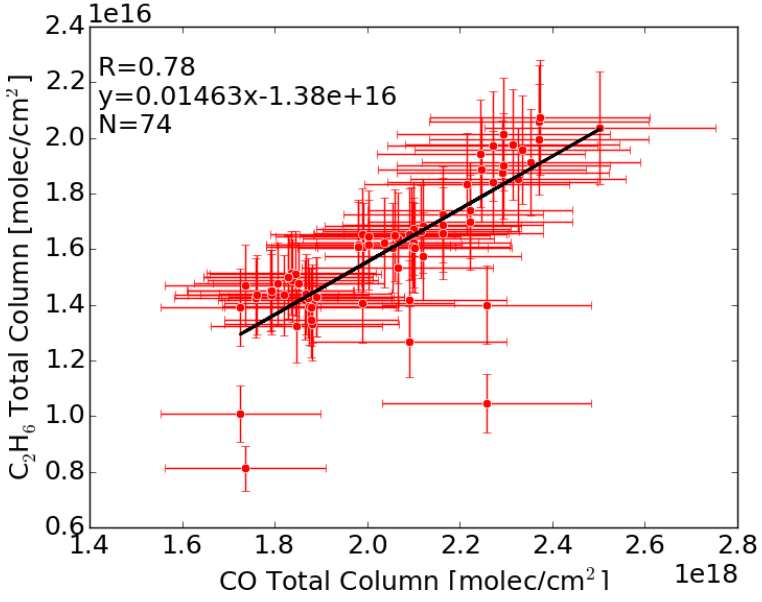




Enhancement Ratio: C_2H_6

Eureka





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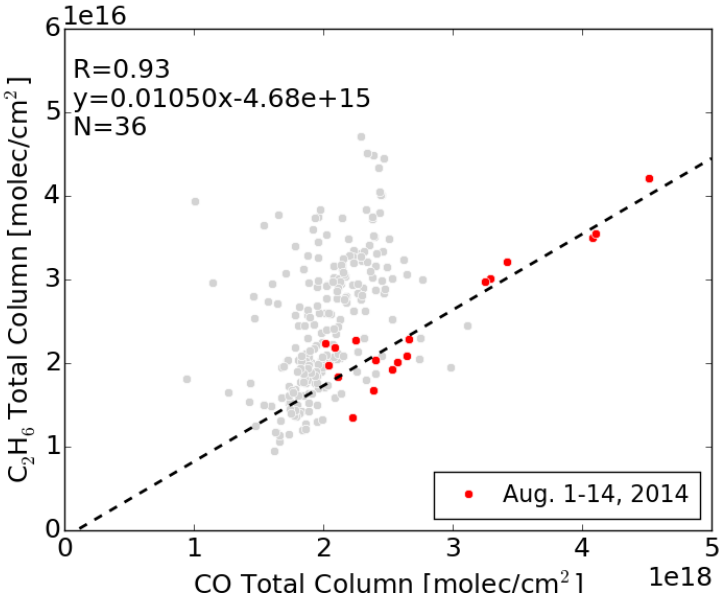
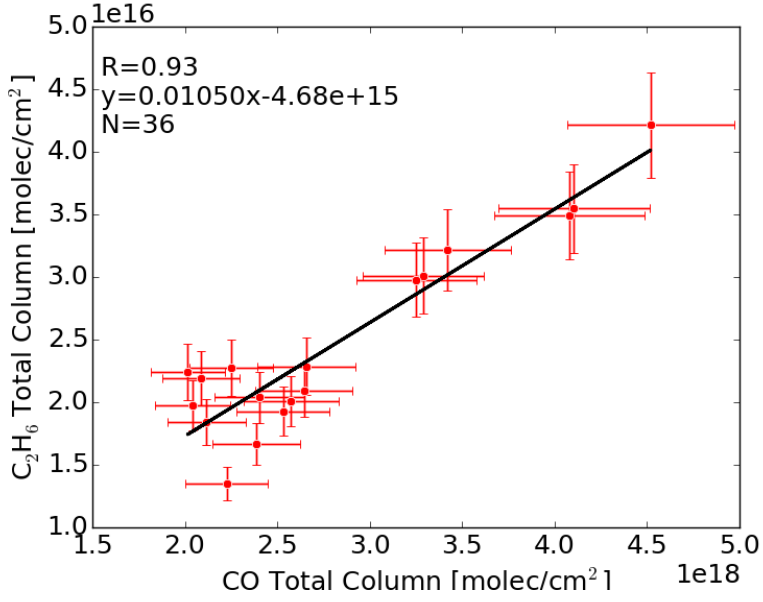
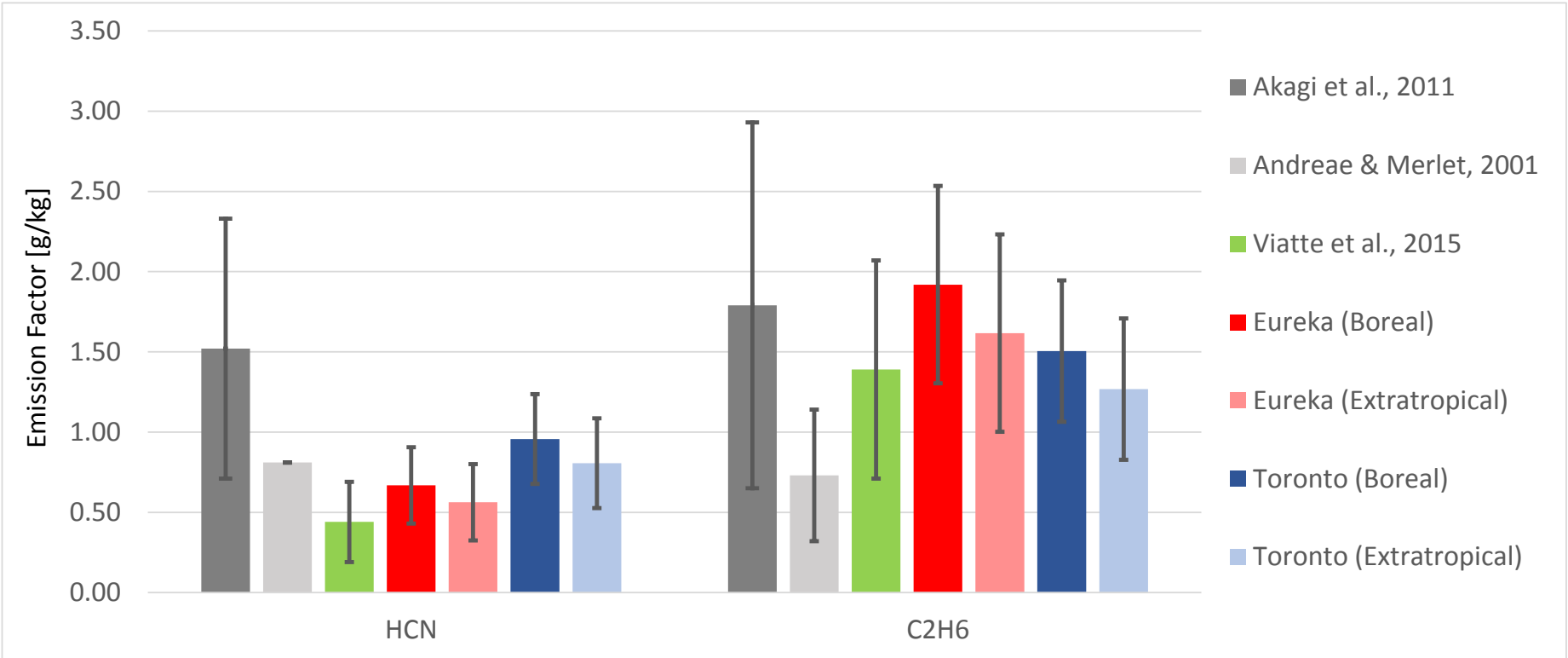




Emission Factors



Known literature values for emission factors of CO:

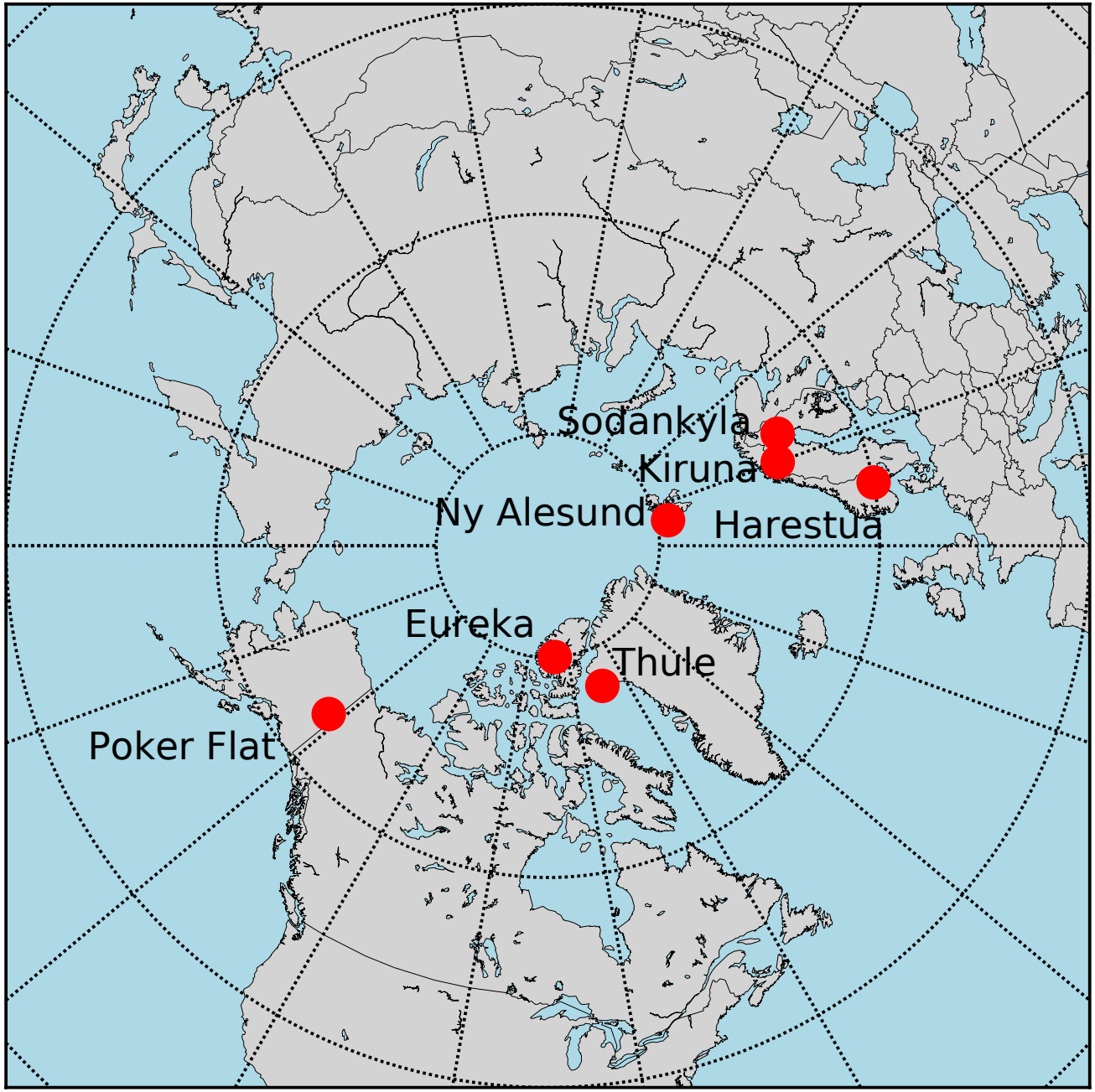
- *Andreae & Merlet, GBC, 2001* for extratropical forests.
- *Akagi et al., ACP, 2011* for boreal forests.

Emission factors from FTIR measurements by *Viatte et al., ACP, 2015*.

Conclusion

- Long-range transport of biomass burning emissions observed by FTIR measurements:
  - CO, HCN, C_2H_6 at Eureka and Toronto.
  - CO at Halifax , Nova Scotia.
- Enhancement in total columns attributed to boreal fires in Northwest Territories:
  - MODIS Fire Hotspots show fire source region.
  - HYSPLIT and FLEXPART illustrate plume trajectories.
- Emission factors determined for HCN and C_2H_6:
  - Consistent among Eureka and Toronto.
  - Good agreement with literature values.

Future Work


Sodankyla
Kiruna
Ny Alesund
Harestua
Eureka
Thule
Poker Flat

Future Work

High-Latitude FTIR Sites

Site	Lat., Lon.	Network	Years of Measurements (Last Year Archived)	Archived Species
Eureka	80°N, 86°W	Both	2006-present (2013)	CO, HCN, C_2H_6
Ny Alesund	79°N, 12°E	Both	1992-present (2011)	CO, HCN, C_2H_6
Thule	77°N, 69°W	NDACC	1999-present (2013)	CO, HCN, C_2H_6
Kiruna	68°N, 20°E	NDACC	1996-present (2012)	CO, HCN, C_2H_6
Sodankyla	67°N, 26°E	TCCON	2009-present (2012)	CO
Poker Flat	65°N, 142°W	Neither	1999-2011 (N.A.)	N.A.
Harestua	60°N, 11°E	NDACC	1994-2012 (N.A.)	N.A.

Current plans:

- Include retrievals of C_2H_2, CH_3OH, HCOOH and H_2CO.
- Investigate long-term trends and interannual variability.
- GEOS-Chem model comparisons to FTIR measurements.

Acknowledgements

This work was supported by the Canadian Space Agency through its funding of the Canadian FTIR Observing Network (CAFTON).

CANDAC and PEARL are supported by:
ARIF, AIF/NSRIT, CFCAS, CFI, CSA, EC, GOC-IPY, INAC, NSERC, NSTP, OIT, ORF, PCSP, , SEARCH

Logistical and operational support at Eureka:

- CANDAC/PEARL PI James R. Drummond
- PEARL site manager Pierre Fogal
- CANDAC data manager Yan Tsehtik
- CANDAC operators
- Team at the EC Weather Station

Canadian Arctic ACE Validation Campaigns supported by:

- CSA, EC, NSERC, and NSTP
- PI Kaley A. Walker