First Results from Open-path FTIR boundary layer measurements in Halifax, Nova Scotia, Canada

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Joint Annual IRWG/TCCON Meeting

Outline

- **Halifax / Nova Scotia Air Quality (AQ) Context**
- Tropospheric Remote Sensing Laboratory (TRSL)
- **VERY** First Results from **/ Progress with** Open-Path Fourier Transform InfraRed (OP-FTIR) Measurements
- Near-future observation plans

Halifax Harbour (Population: 300,000)

One Month of Shipping Traffic

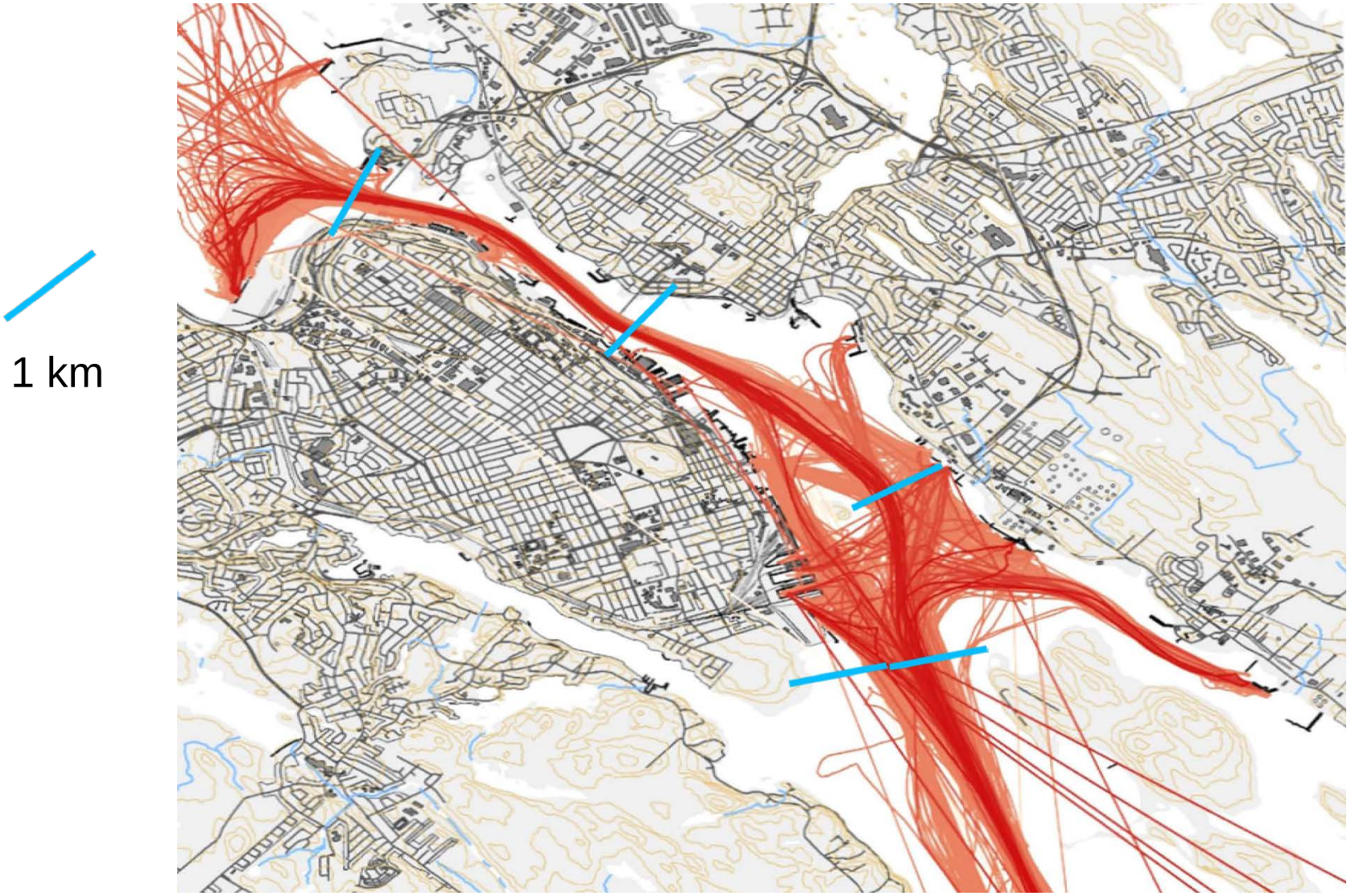
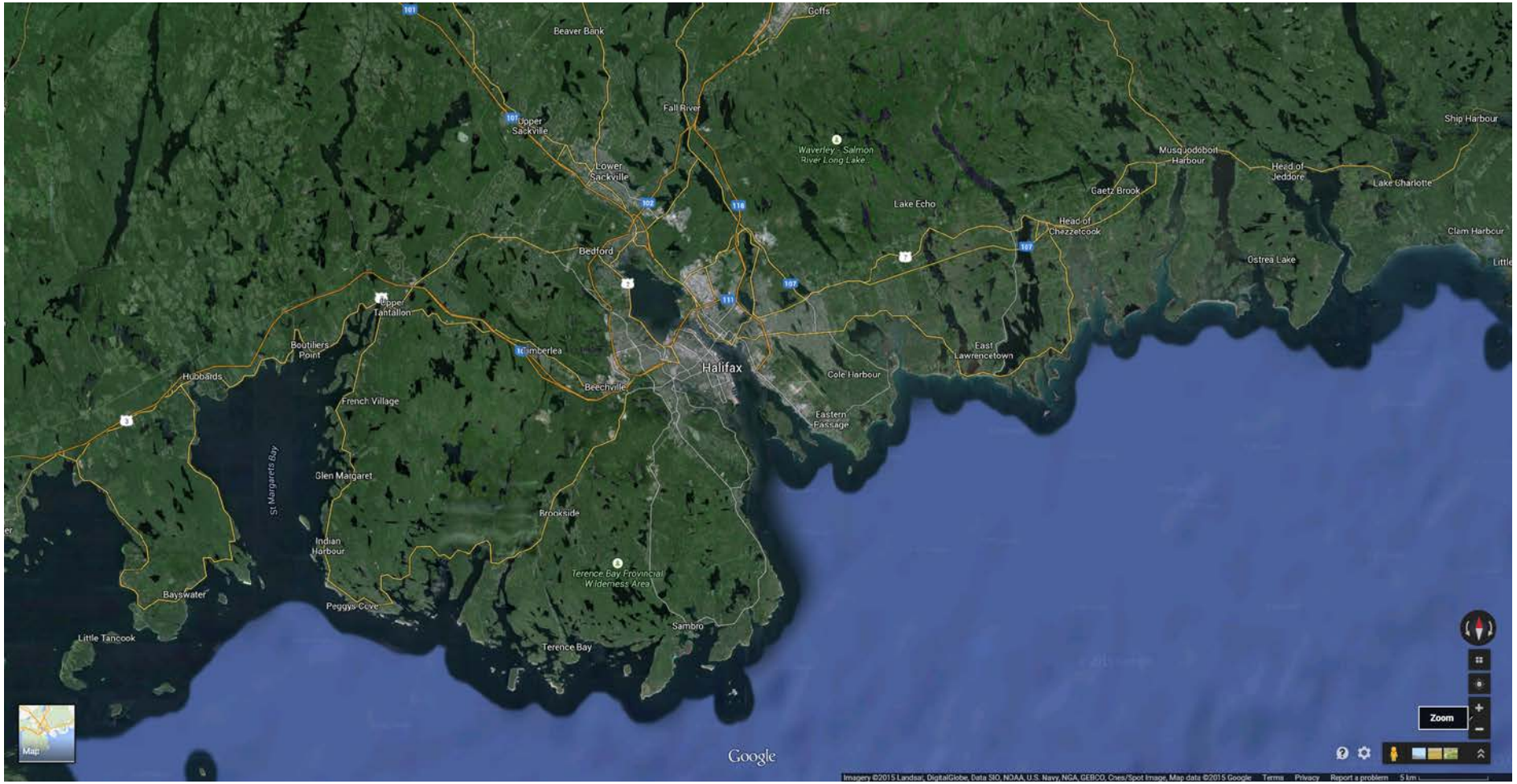


Image adapted from http://blog.halifaxshipingnews.ca/2012/10/one-month-of-traffic-visualized.html.

Zooming out: Acadian forest setting (mixed forest type)



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“Average” Nova Scotia Air Quality

Appears hydrocarbon limited in this data

Well below max. permissible [O_3] = 80 ppbv on average

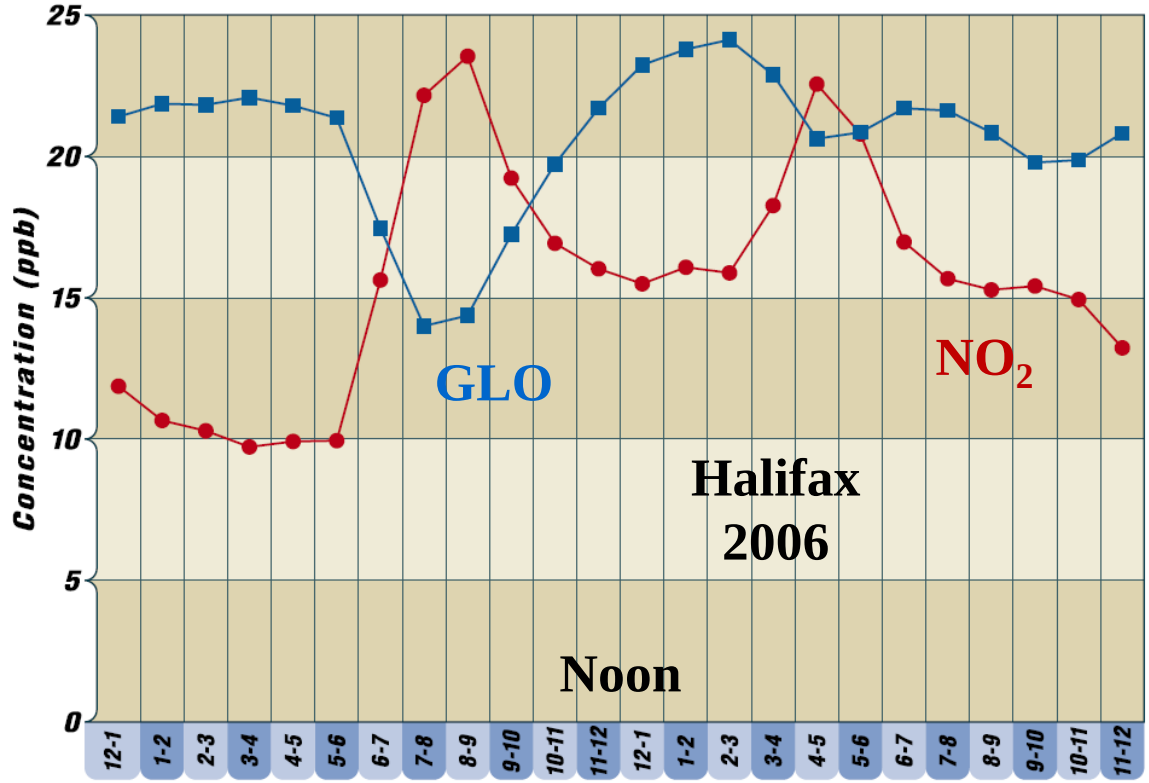


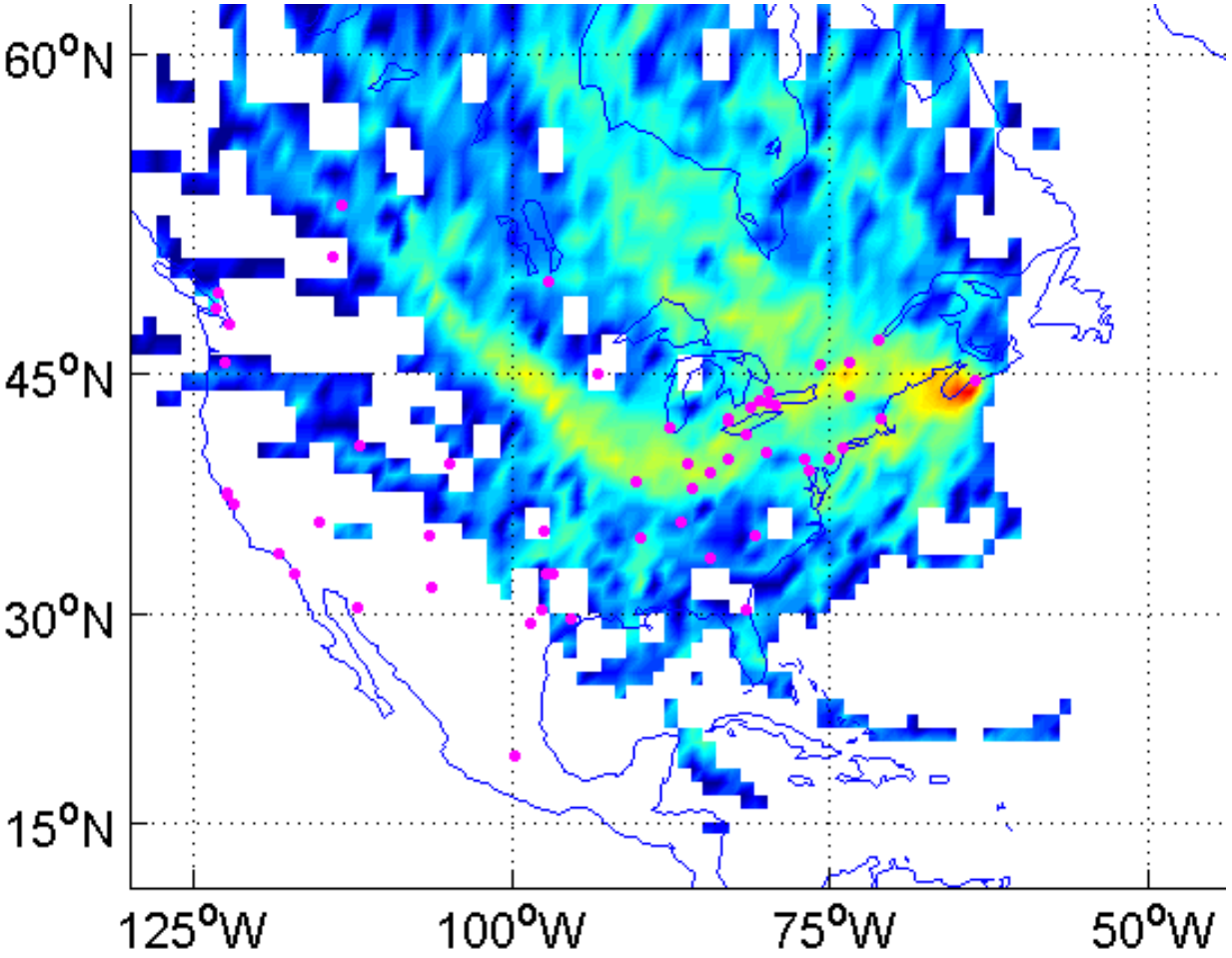
Figure from Nova Scotia Environment, 2007

Halifax City exceeds *desirable* [O_3] = 50 ppbv levels in summer

Biogenic-dominated “Valley” has true O_3 exceedances (summer)

Where does Halifax surface air come from?

(HYSPLIT 7-day backward trajectory compilation)



January
2014

Pink dots show large cities that are a source of pollution

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Where does Halifax surface air come from?

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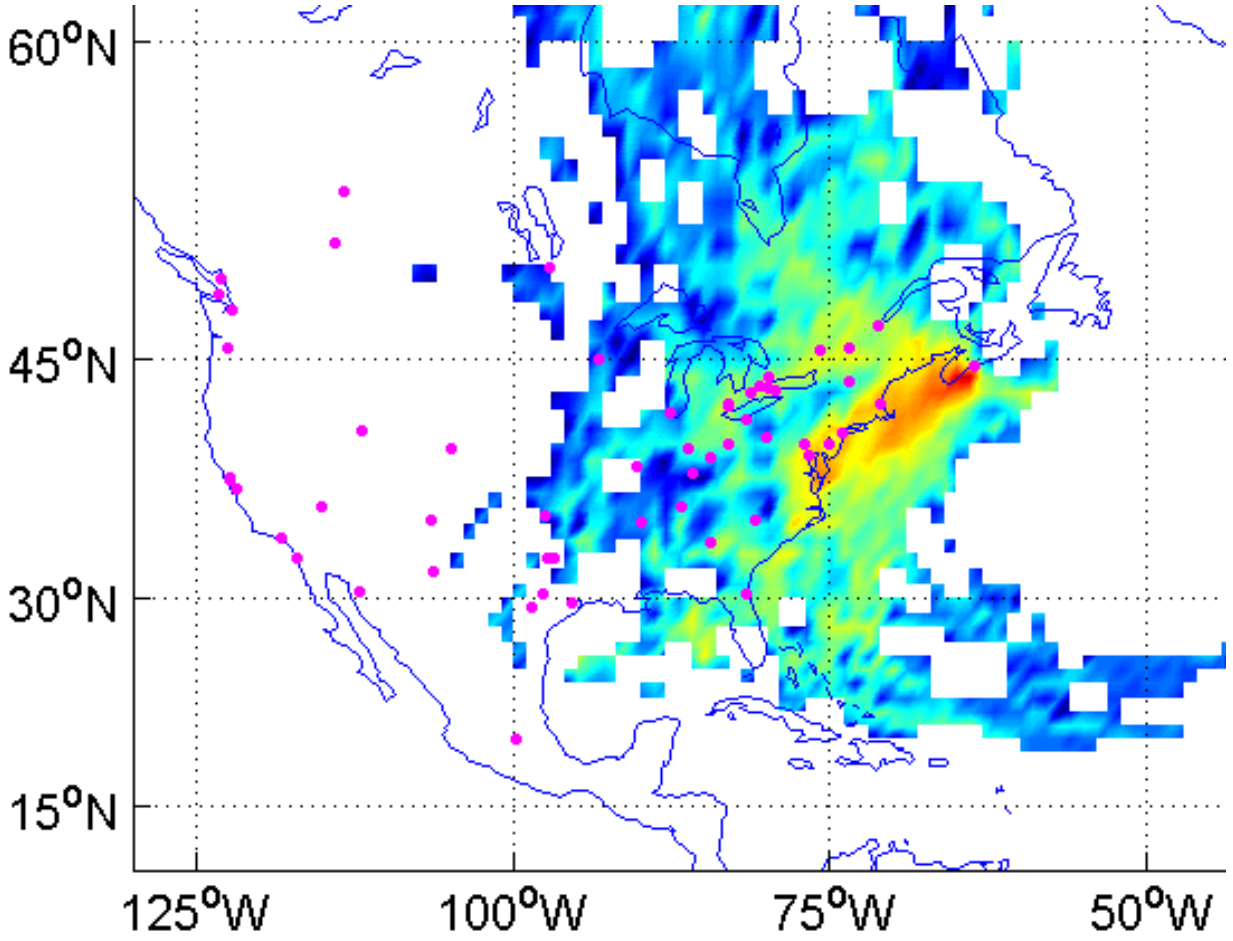

July
2014

Pink dots show large cities that are a source of pollution

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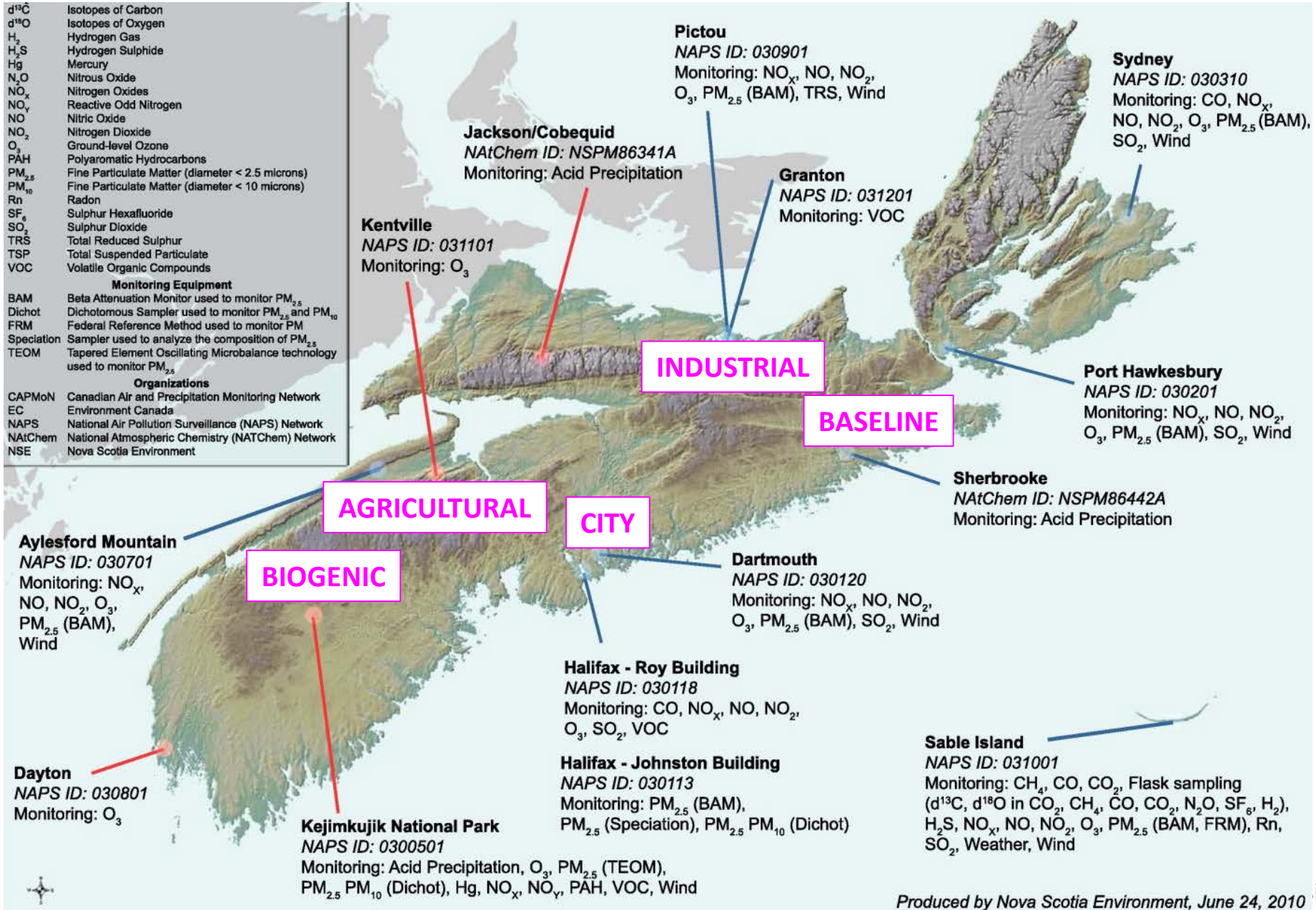
Nova Scotia Ambient AQ Monitoring, 2010



Current VOC monitoring in NS

Air samples in canisters

Once every 6 days for 24 hrs
(NAPS standards)

Sent to lab for analysis of

- ✔ Benzene
- ✔ Toluene
- ✔ Tetrachloroethylene
- ✔ Dichloromethane
- ✔ 1,1,1-trichloroethane
- ✔ 1,3-butadiene

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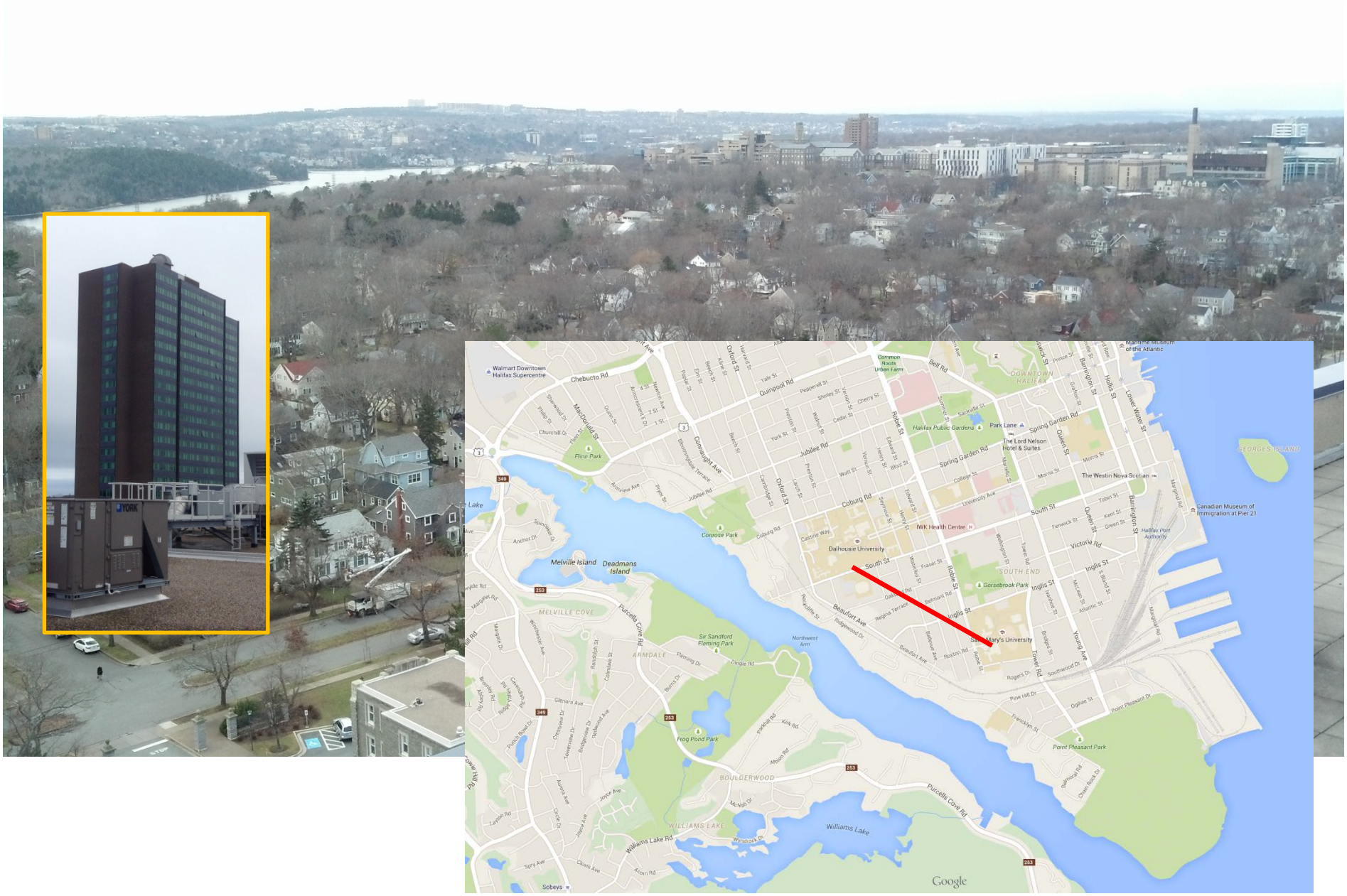
View from SMU towards Dalhousie



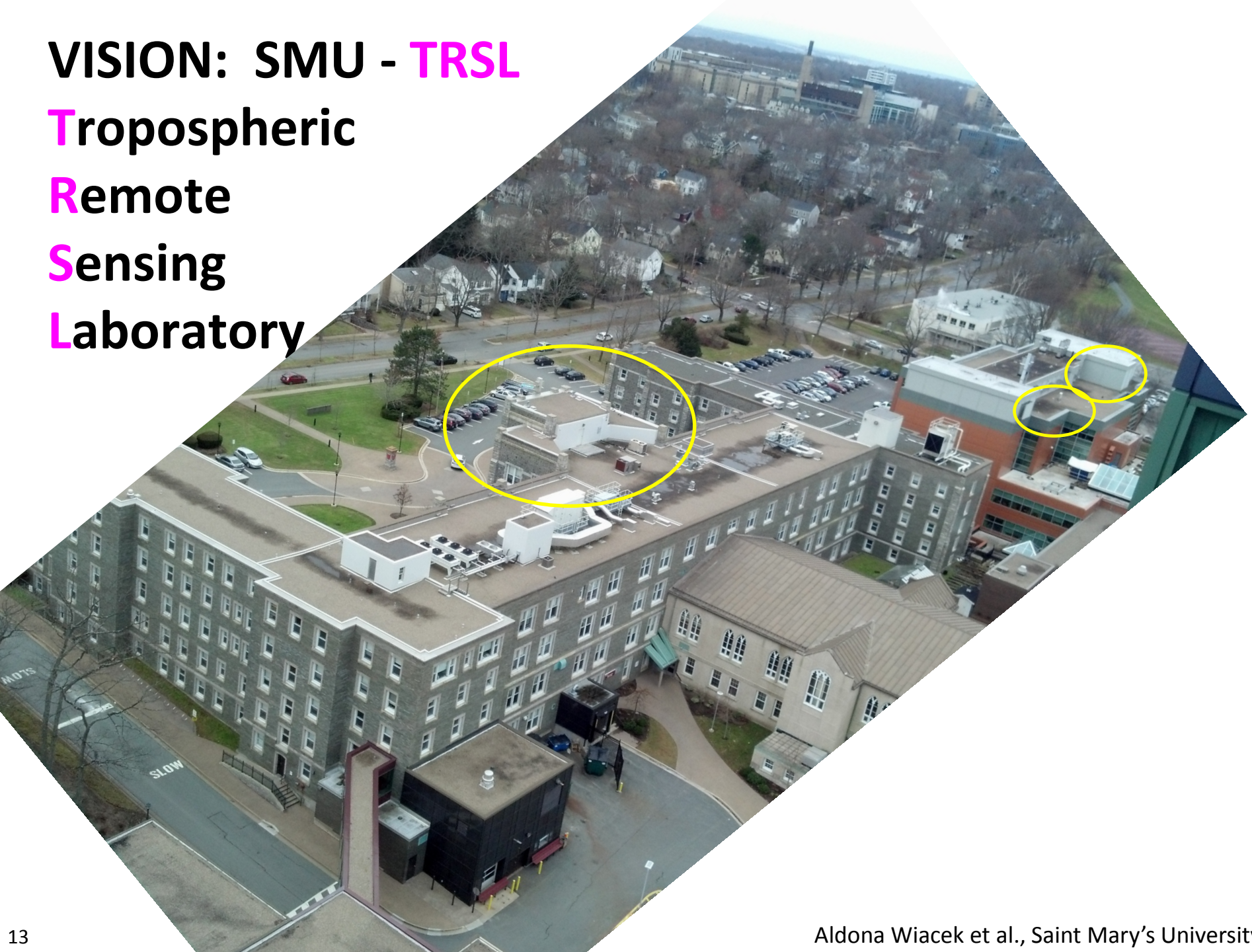
VISION: SMU - TRSL

Tropospheric

Remote

Sensing

Laboratory



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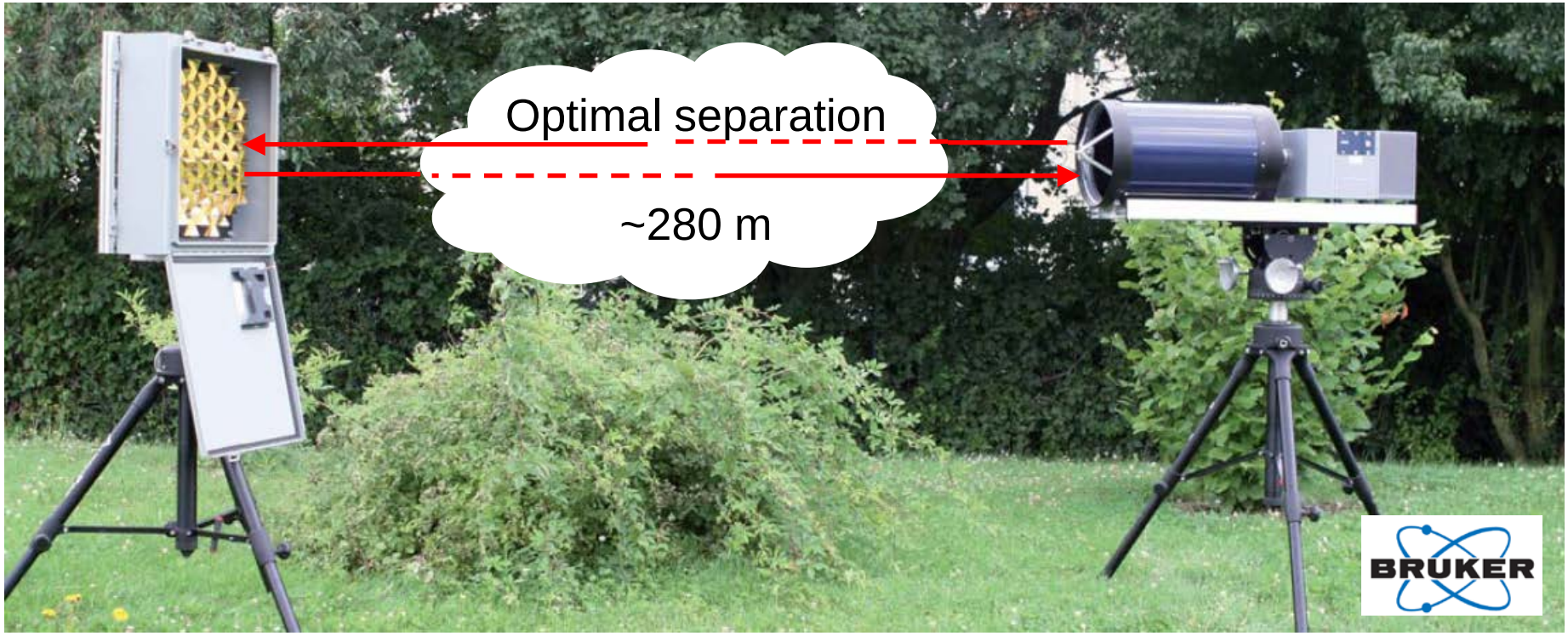
Minimum OP-FTIR System in monostatic arrangement:
source, FTS, telescope and detector collocated,
with retroreflector on opposite side of physical path

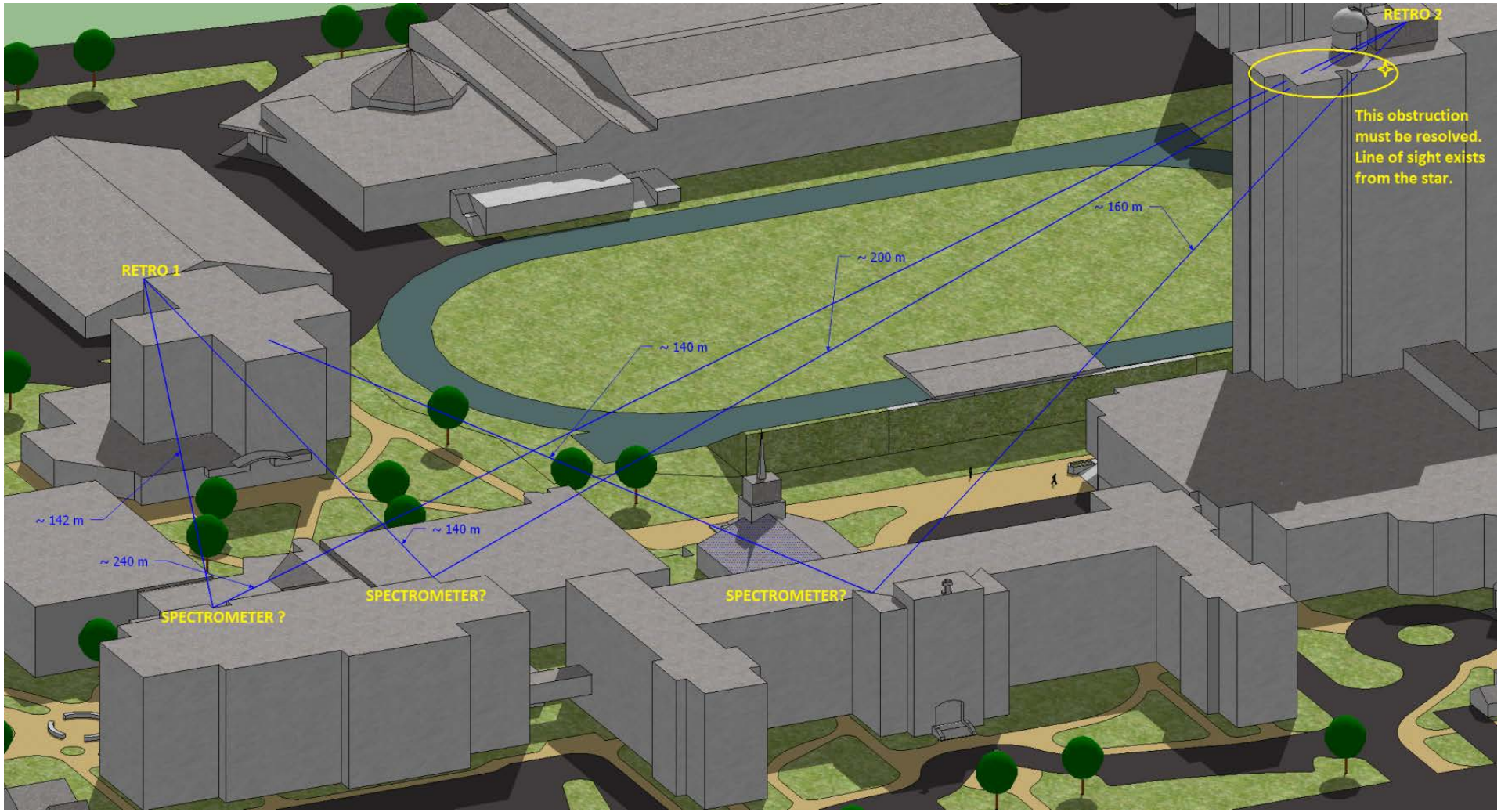


Interferometer: RockSolid design, 0.5 cm^{-1}, 5 spectra / s

Source: Globar Detector: Stirling-cooled MCT (700 cm^{-1} – 5200 cm^{-1} +)

Open-paths for remote sensing from TRSL @ SMU

[2 retroreflectors with automated pan-tilt have been acquired]



Permanent facility goal for the TRSL

1. House the **FTS + Telescope + Pan/Tilt** in a rooftop **hut**

   110V (✓) internet (✓), **NO** liquid nitrogen required (✓)

2. Construct a doorway/hatch/window which will open/close **automatically** in good observation conditions

   Postdoc starting July 1 (✓) with engineering & spectrosc. bgnd. (✓)

3. Permanently mount **RETRO 1** and **RETRO 2** on different roofs

   Similar or different open path lengths (for sensitivity options)?

   Is the 50 m altitude difference useful for flux work?

   How much degradation due to salty fog with fully passive enclosure?

4. **Automate** weather detection (based on SMU Astronomy Observatory data already being collected) and control of opening/closing of FTS access

5. Implement data "downlink" for continuous **Web Display** of AQ / GHG indicators

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Open-Path FTIR Setup

Modulated IR (low-intensity, non-laser) from internal globar is

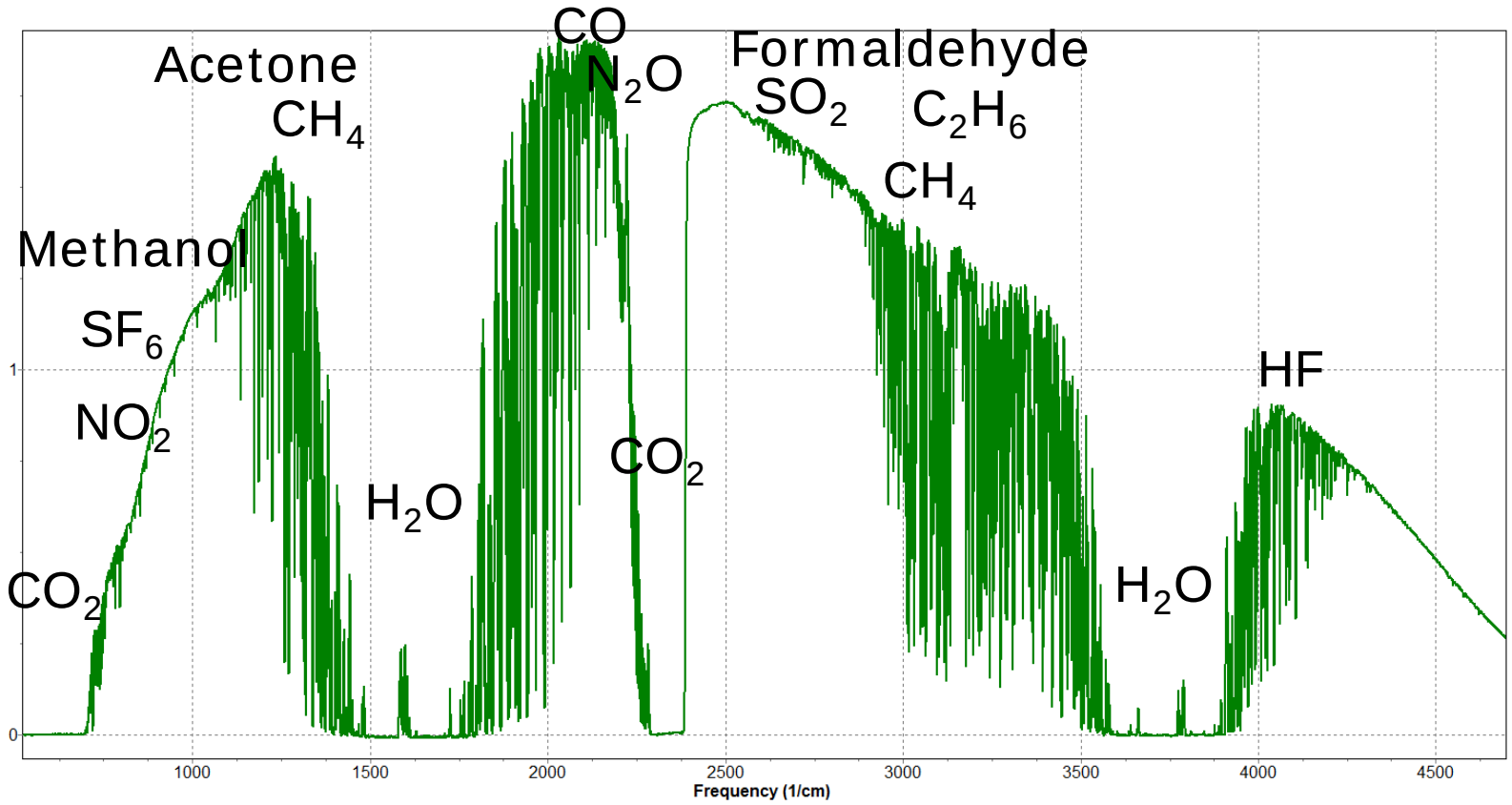
- sent out
- "retro-reflected"
- received
- processed into a **spectrum**
- analyzed for path-average trace gas **concentrations**

OP advantages

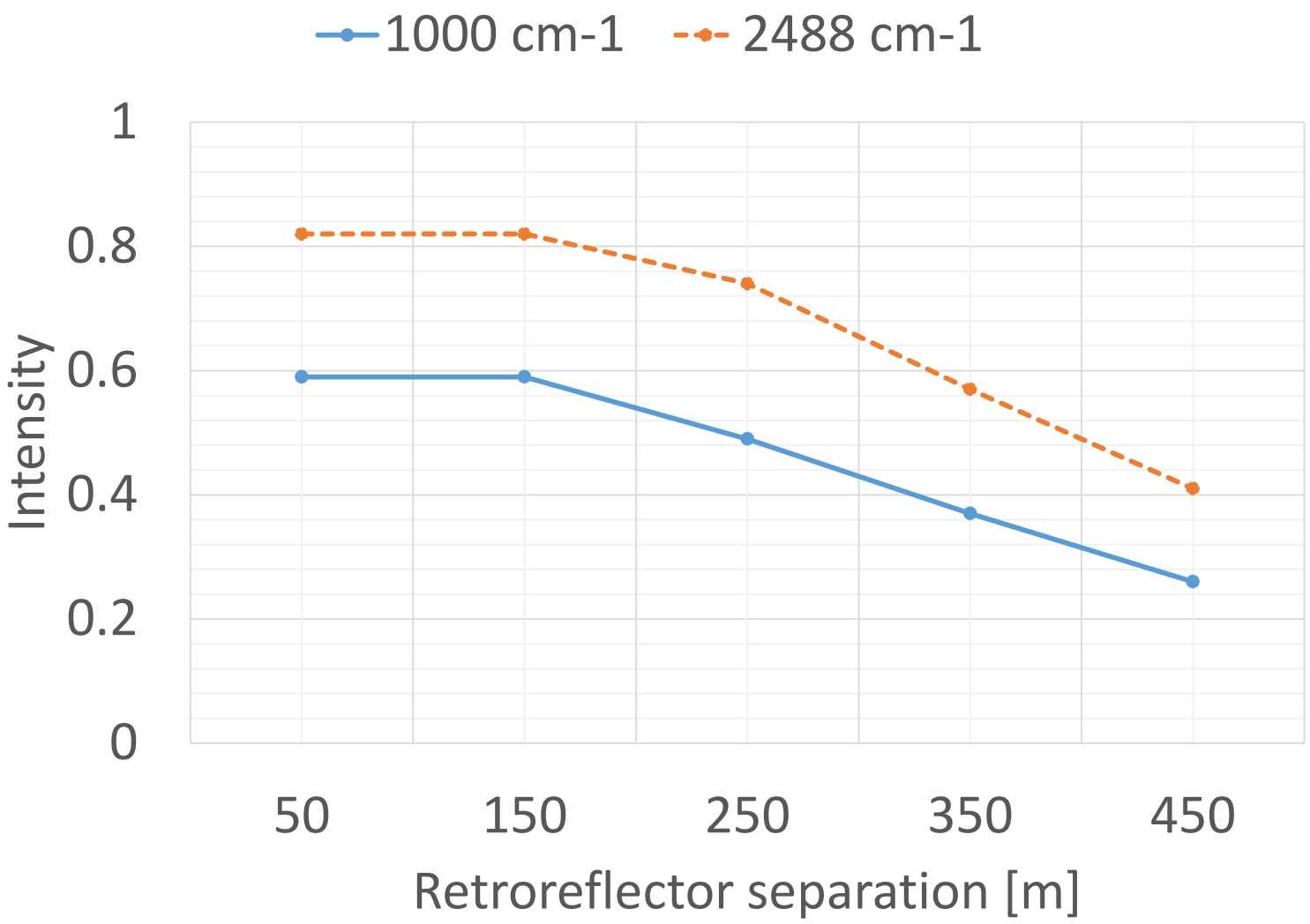
- cloudy / sunny / day / night
- path well-defined spatially
- multiple species at 5 Hz
- Dalhousie (1 km away) solar FTIR obs. complementary

Example Measured Spectrum

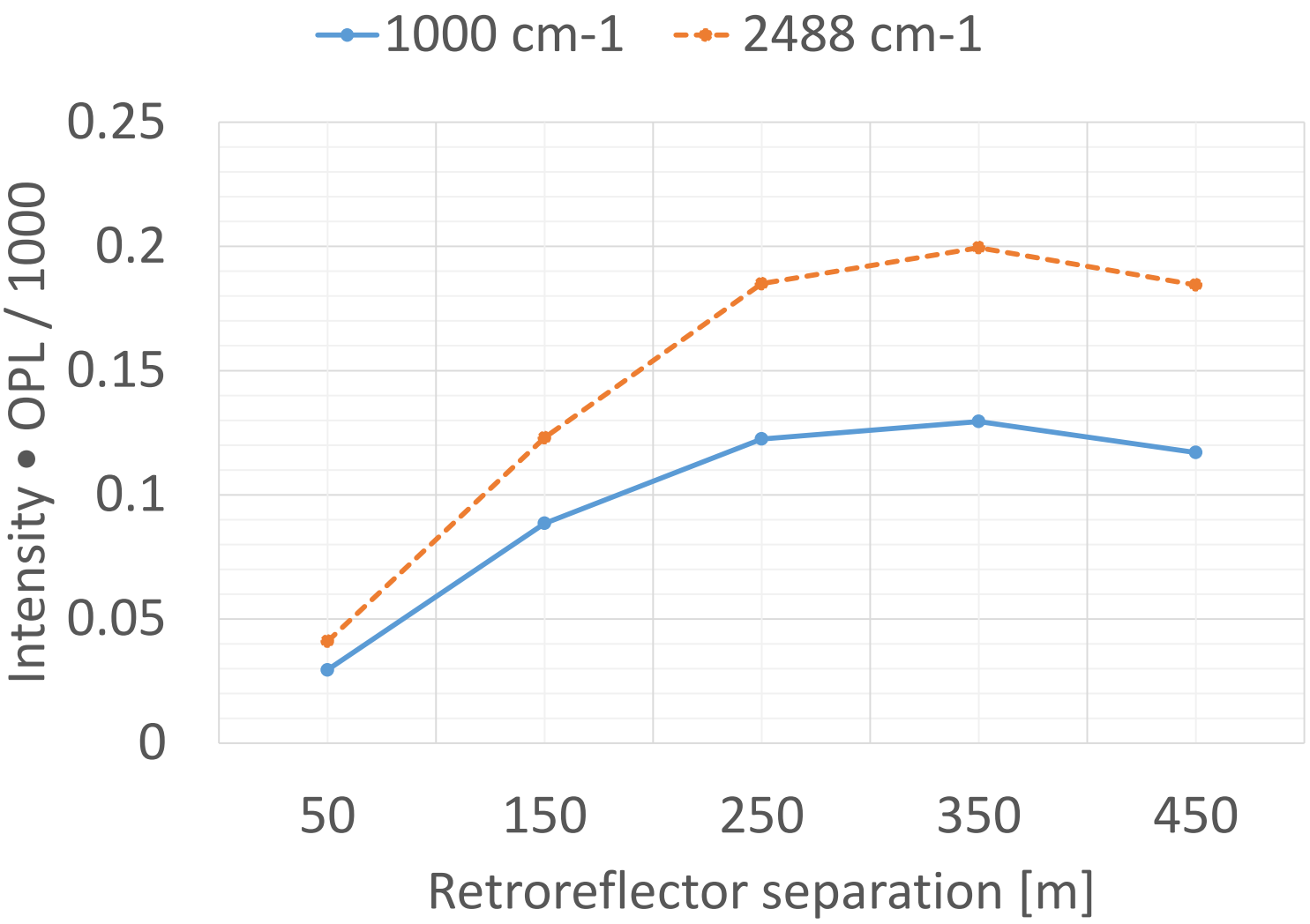
(0.5 cm-1 resolution)



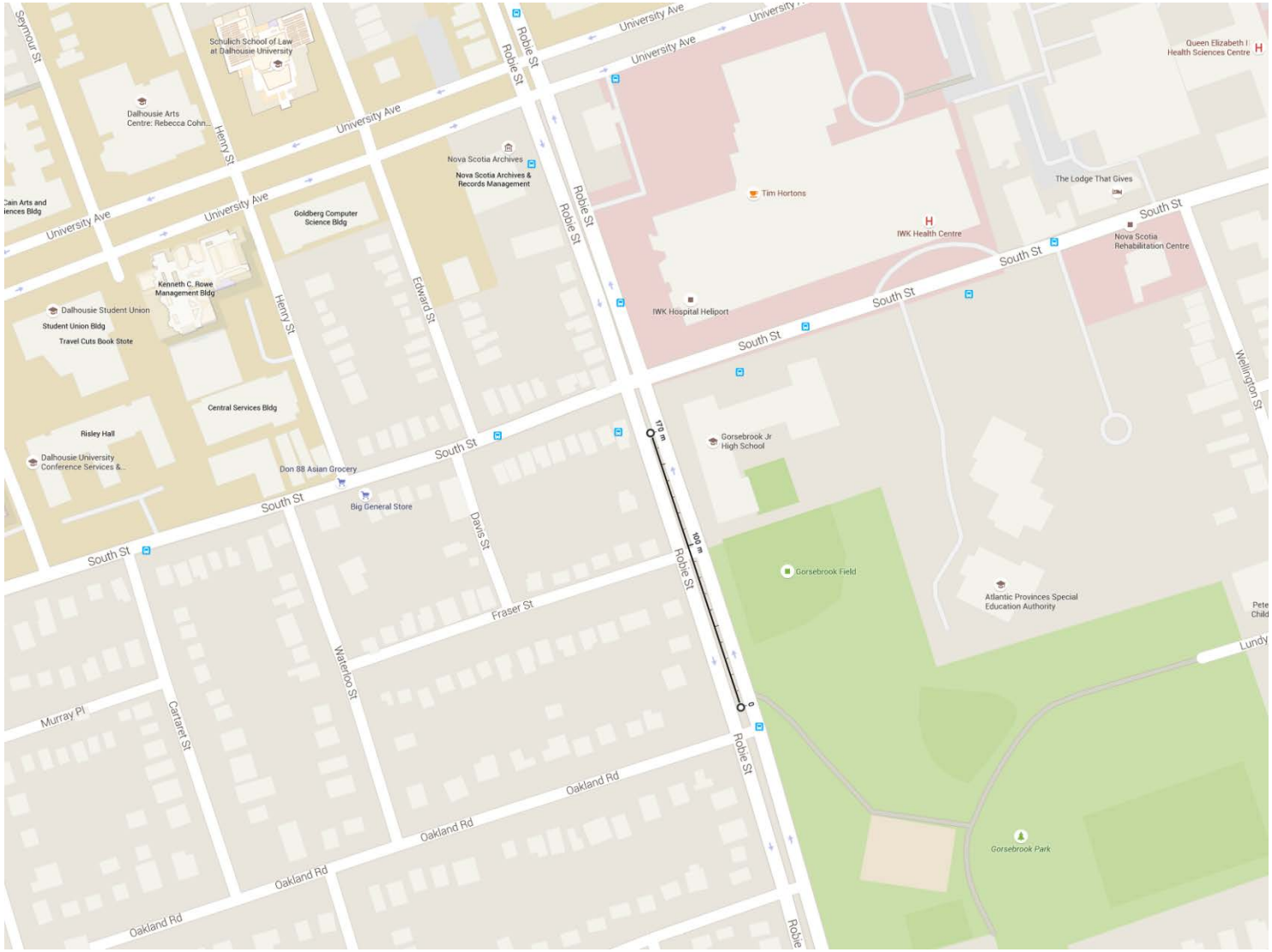
Intensity vs one-way separation



Optimal one-way separation

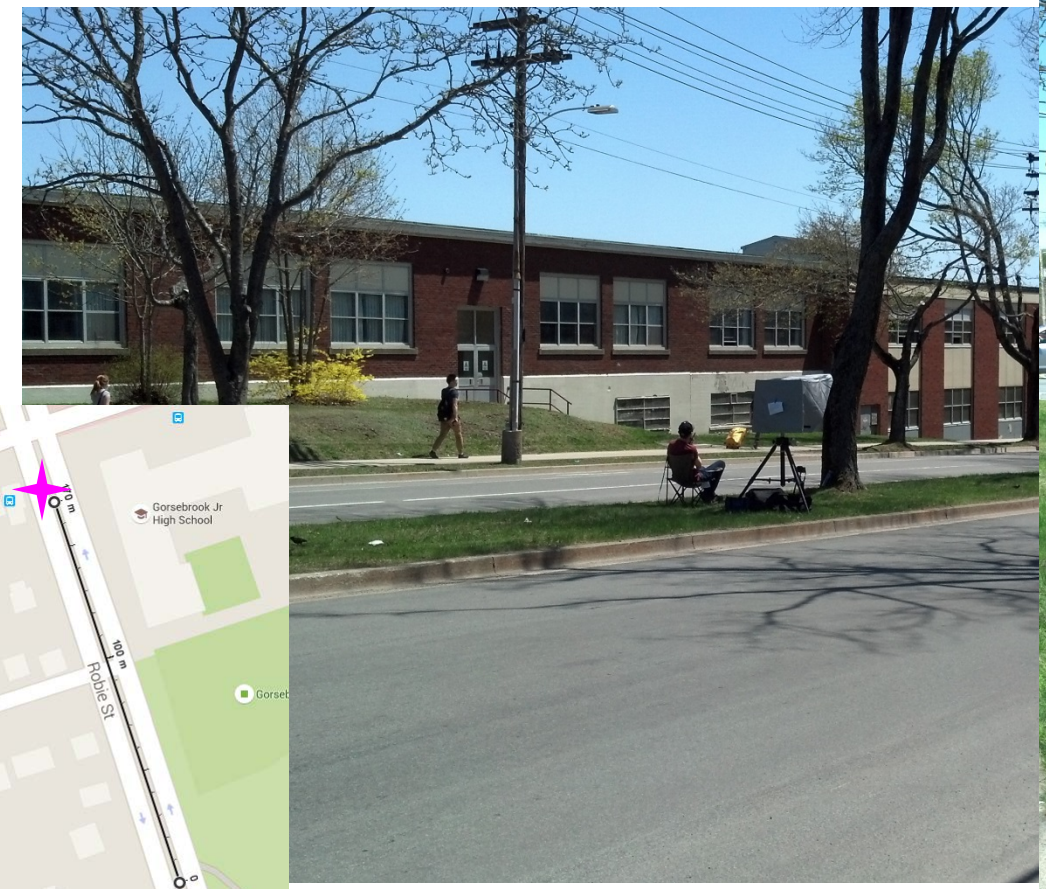


Our “First Light” on May 15, 2015
Vehicle Traffic Measurements



Robie & South (Gorsebrook Junior High)

(Keane Tobin)

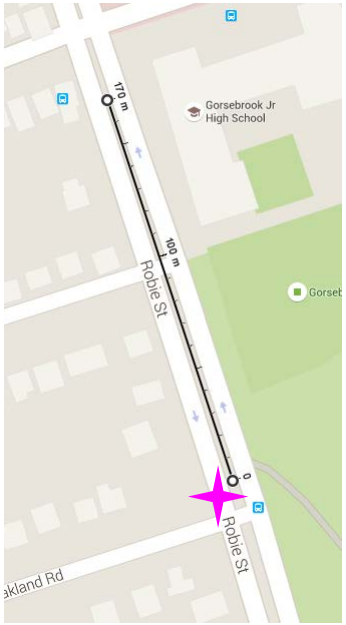


The open path between the FTS and Retro

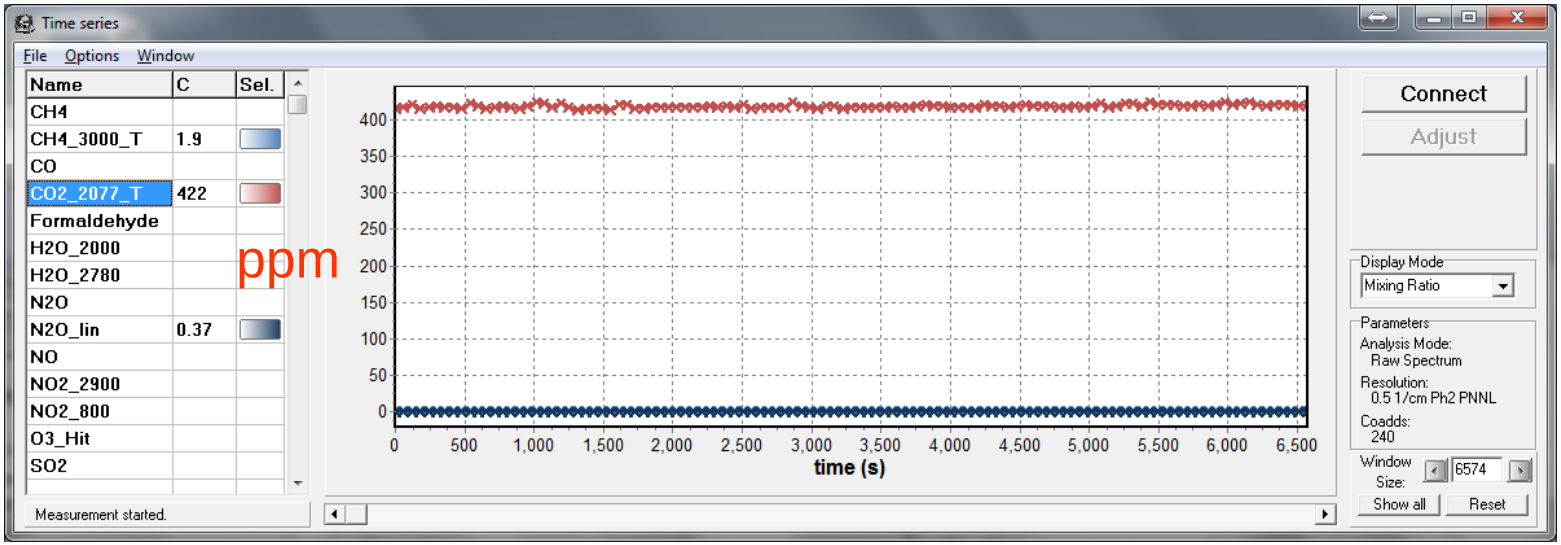
The open path between the FTS and Retro

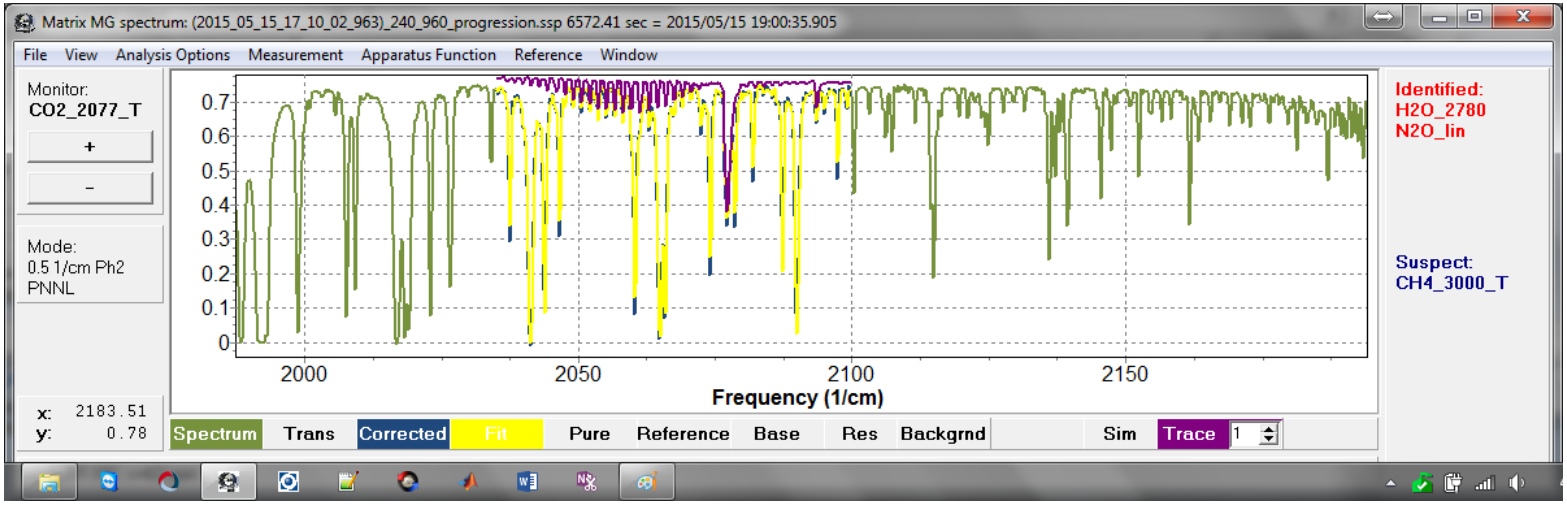
Robie & Oakland (Gorsebrook Park)

(Julia Purcell)



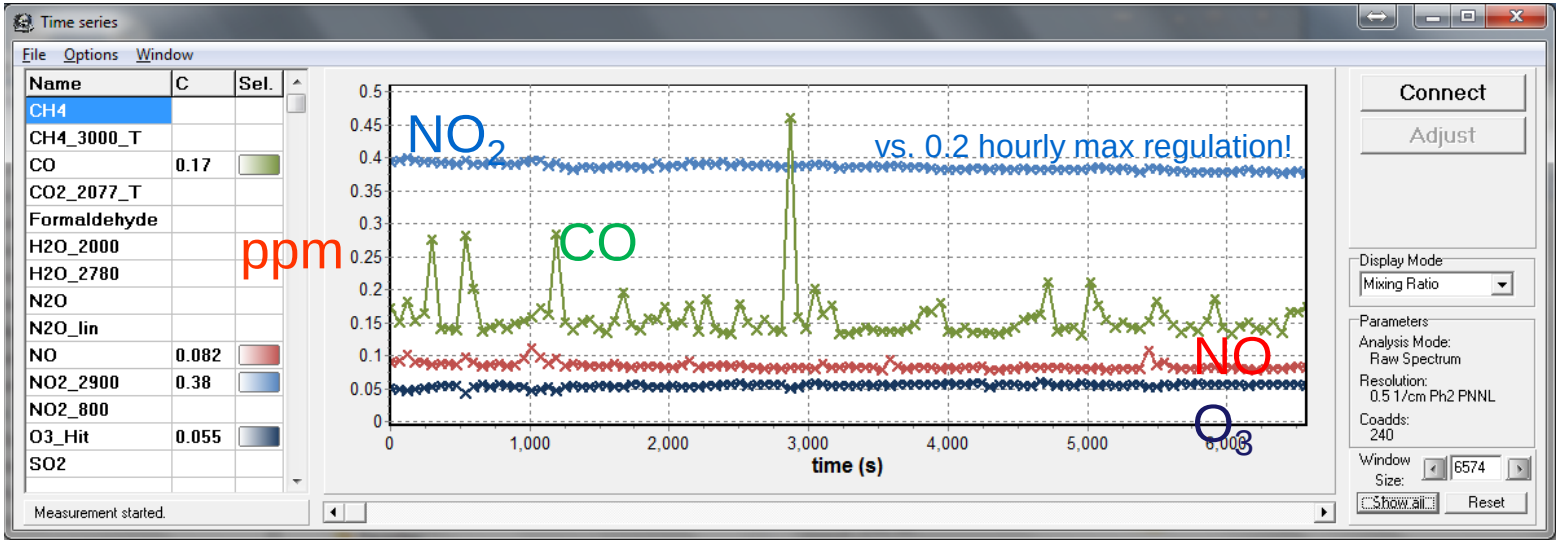
CO_2, CH_4, N_2O time series





Note: retrievals "out of the box" and not optimized in any way!
CO_2 window (water under fitted); all GHG's retrieved too high.

CO, NO_x, O_3



Note: retrievals "out of the box" and not optimized in any way!
(Interesting experiment in "naïve" FTIR operation)

All retrieved values high (except CO, which is low) but:
- Variability observed in CO and NO (emitted compounds)
- NO_2 creeping down as O_3 rises

All microwindows need work (learning about macro- vs. micro-windows)
NLLS retrieval needed, perhaps 2-stage, to handle water better

Summary

- Halifax / Nova Scotia Air Quality (AQ) Context
  - "relatively clean", coastal, forested, receptor site

- Tropospheric Remote Sensing Laboratory (TRSL)
  - for continuous & automated measurements at SMU if and when not out on field on campaigns

- **VERY** First Results from **/ Progress with** OP-FTIR
  - retrieval method / optimization work next

- Near-future observation plans
  - validate OP measurement with GHG LI-CORs (Dal)
  - conduct longer campaign at downtown NAPS station
  - possibly Oil&Gas emissions (AB & SK in Jul/Aug)
  - **Looking for 6-month intern and grad student to join myself, 2 students and post-doc!**

Funding Acknowledgments

- **6-month Environment Canada Science Horizons internship open**
- **MSc and/or PhD positions available**