

# Analysis of Toronto pollution using GEOS-Chem and ground-based Fourier transform infrared (FTIR) observations

Cyndi Whaley<sup>1</sup>, Kimberly Strong<sup>1</sup>, Dylan Jones<sup>1</sup>,  
Richard Mittermeier<sup>2</sup>, Hans Fast<sup>2</sup>, and Thomas Walker<sup>1</sup>

<sup>1</sup>University of Toronto, Dept. of Physics

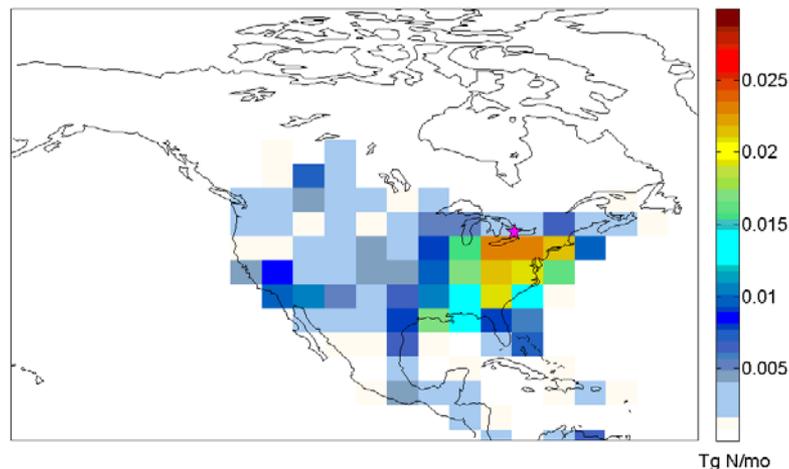
<sup>2</sup>Environment Canada, Air Quality Research Division

IGC6 May 9<sup>th</sup>, 2013



# Goal and motivation

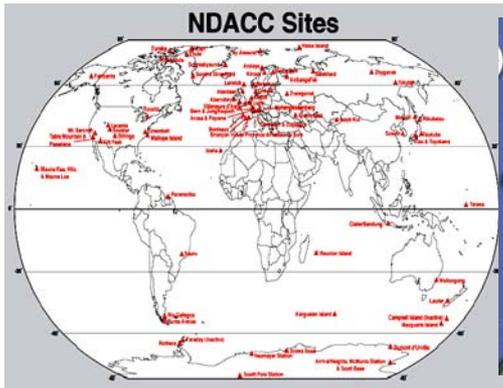
- **Goal:** To better understand the sources of tropospheric trace gases in the Toronto region (with a focus on CO & O<sub>3</sub>).
- “Most areas of Ontario are still above the Canada wide standard for ozone” (Air Quality in Ontario Report for 2010).
- Current O<sub>3</sub> standards for human health:
  - Provincial 1-hour air quality criterion is 80 ppb, and the Canada-wide standard is 65 ppb 8-hour running average.
- Toronto downwind of populated areas and industry, and is also centre of densest population in Canada.



Anthropogenic NO<sub>x</sub> emissions in North America (from GEOS-Chem)

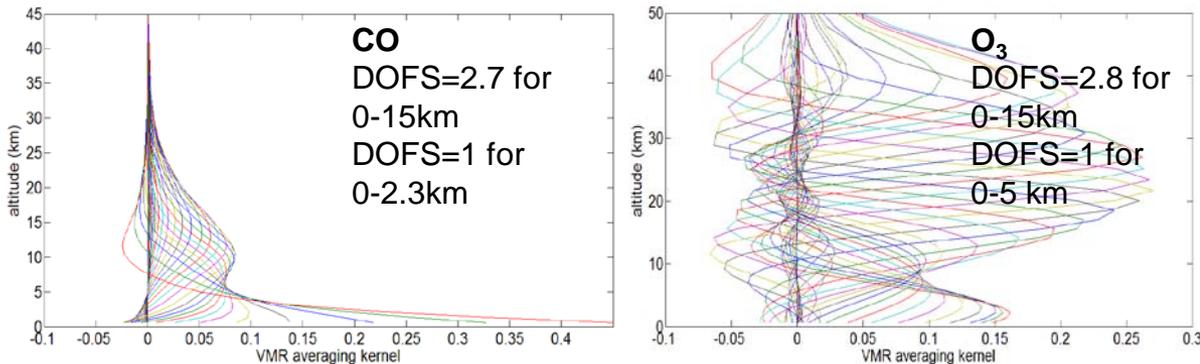
# Primary data: high resolution Fourier transform infrared (FTIR) spectroscopy

- University of Toronto Atmospheric Observatory (TAO, 43.66°N, 79.40°W)
- Environment Canada's Centre for Atmospheric Research Experiments (CARE, 44.23°N, 79.78°W)
- TAO is an NDACC (Network for Detection of Atmospheric Composition Change) site
- We use the Optimal Estimation Method for retrievals
  - SFIT2 v3.94
  - HITRAN 2008 spectral line database
  - Employing harmonized retrieval parameters recommended by the NDACC Infrared Working Group

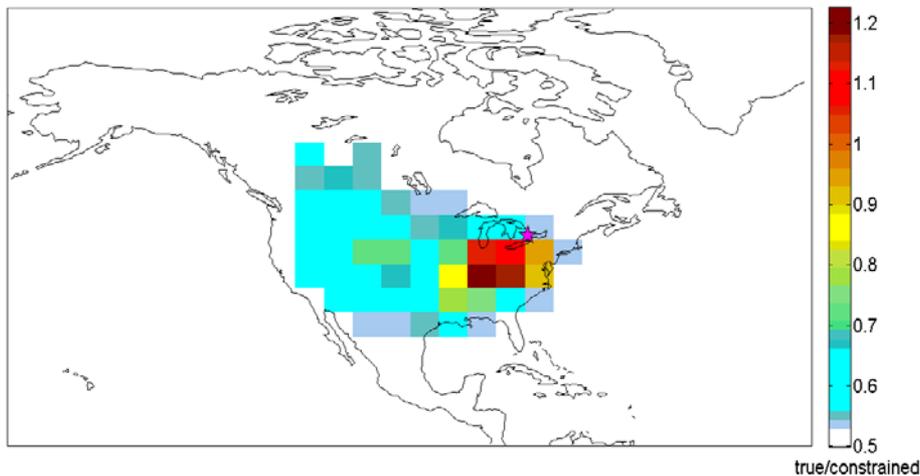


# FTIR measurements of the troposphere

- FTIR measurements of CO and O<sub>3</sub> have good sensitivity to the troposphere:



← Typical averaging kernels



← OSSE results: Ability of TAO measurements to constrain NO<sub>x</sub> emissions in the model

# 10 years of FTIR and GEOS-Chem CO & O<sub>3</sub>

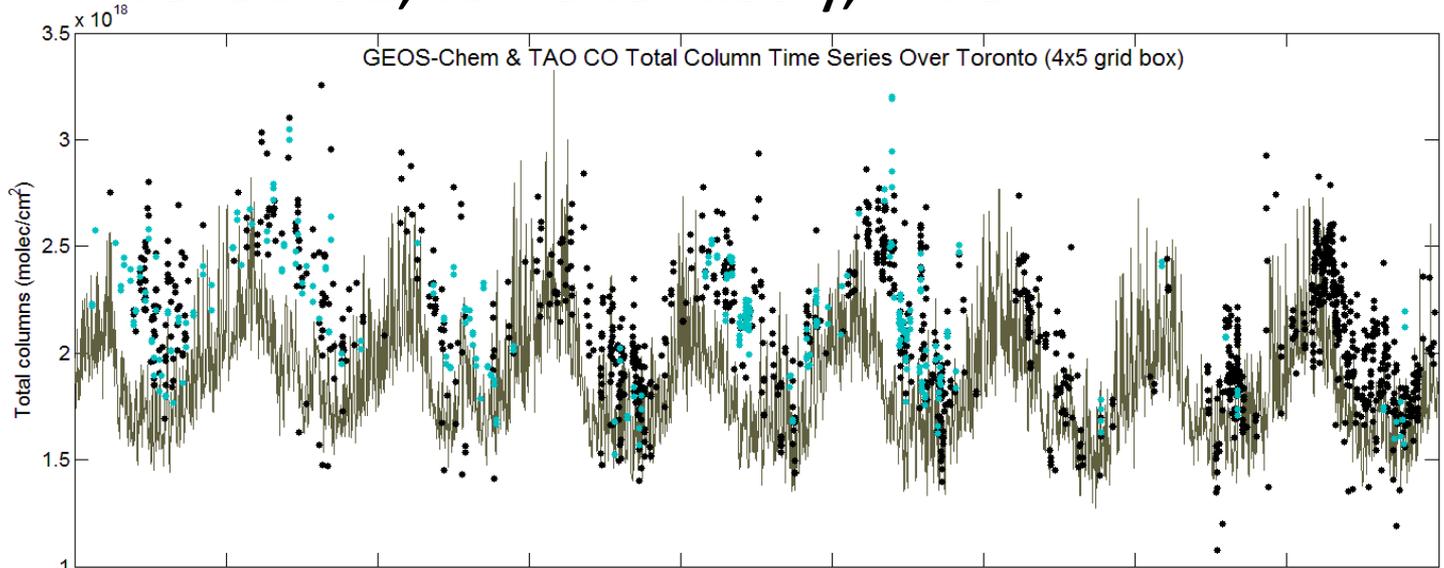
TAO

CARE

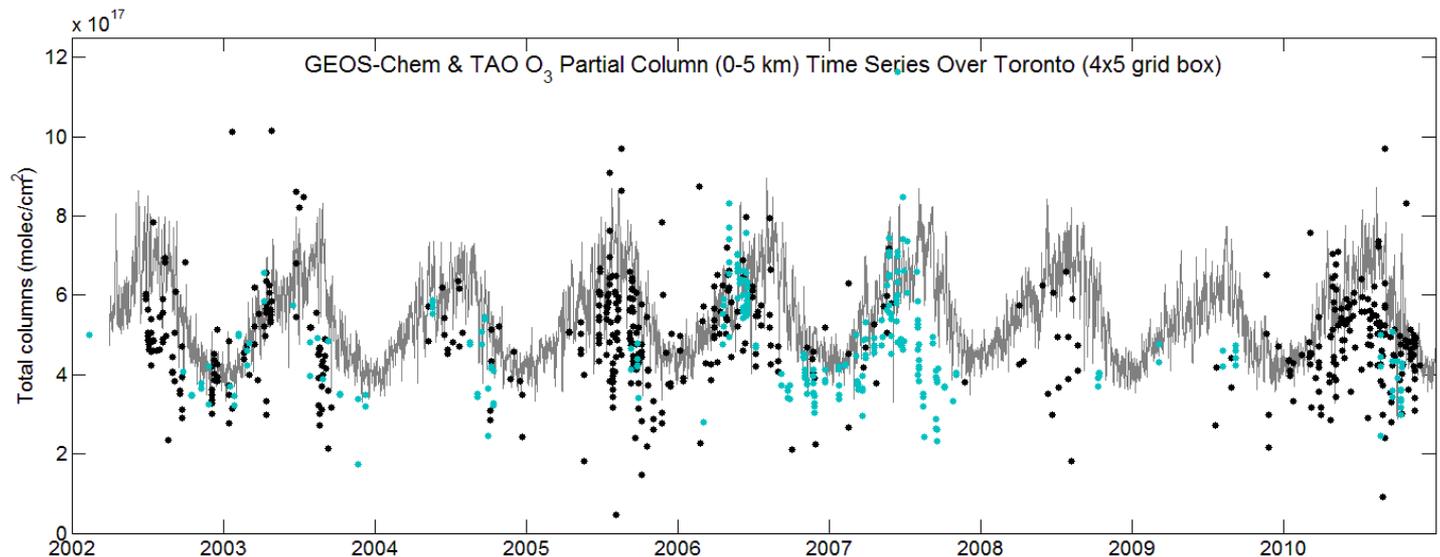
GEOS-Chem

V9-01-02, full chemistry, 4°x5°

total column  
CO →

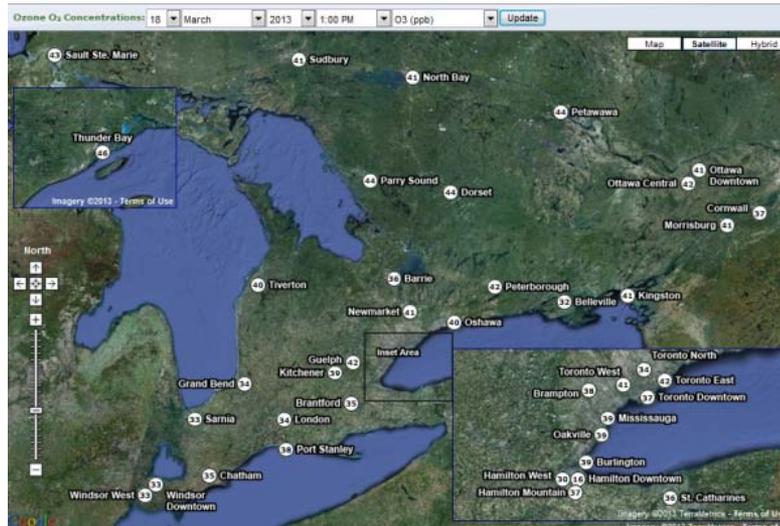


0-5 km partial  
column O<sub>3</sub> →



# Complementary data

- Ontario Ministry of Environment surface measurements of CO and O<sub>3</sub>



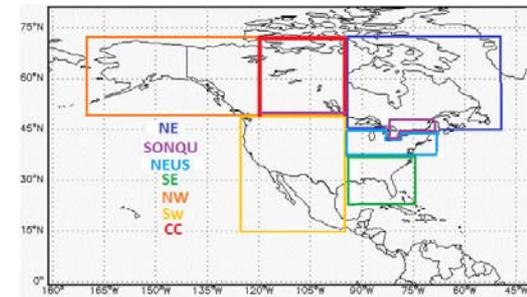
## Case studies

- Throughout the time series, there are enhancements in the CO and O<sub>3</sub> column → *pollution events*.
- These pollution events are confirmed with complementary data and explained with the GEOS-Chem model (full chem, tagged, & adjoint simulations).

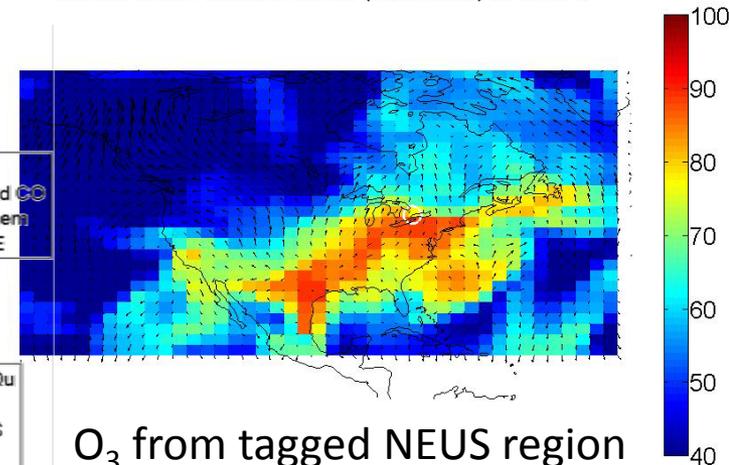
# August 2002, enhanced CO and O<sub>3</sub>

- CO and O<sub>3</sub> enhanced on Aug 12<sup>th</sup>, 2002, supported by surface O<sub>3</sub> and GEOS-Chem
- Winds from GEOS-4, and temperature data suggest that this enhancement was due to NE U.S. emissions and high temperatures.

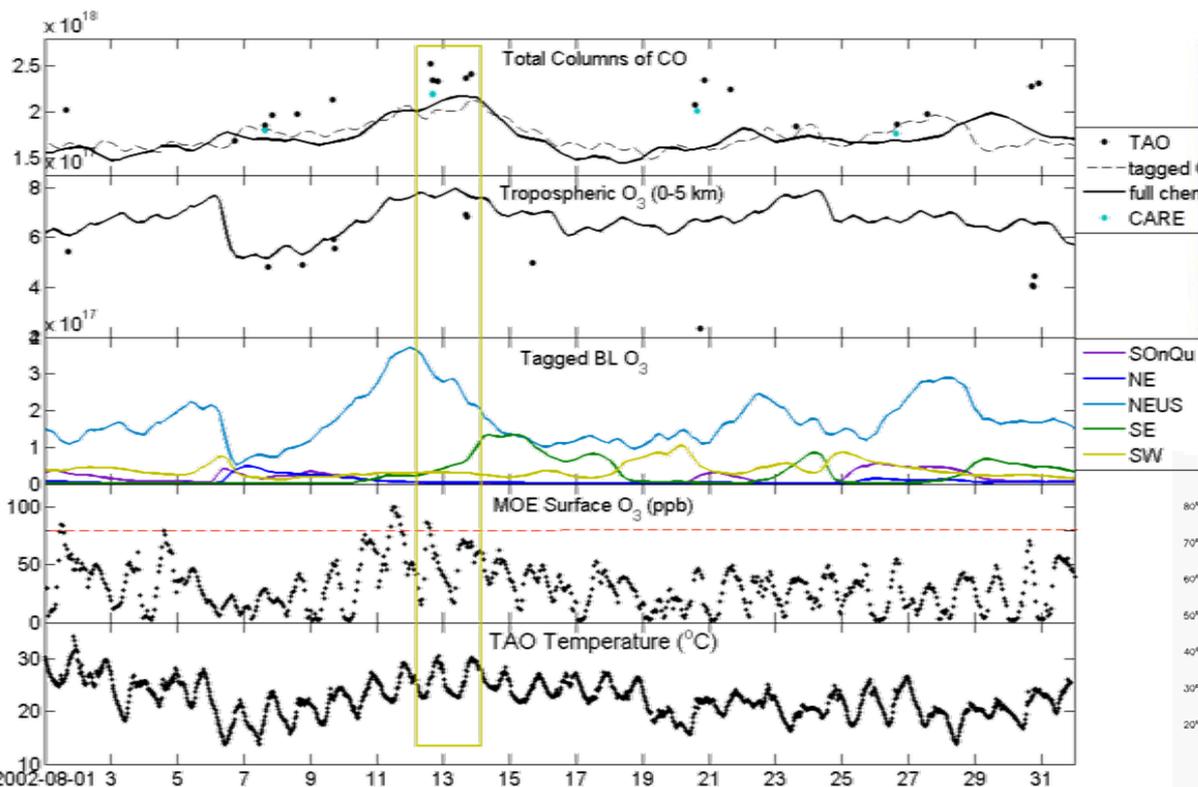
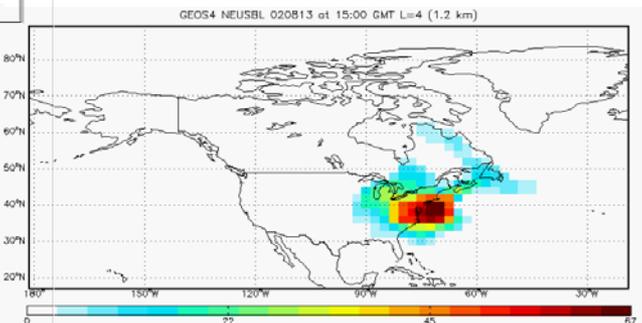
Tagged regions



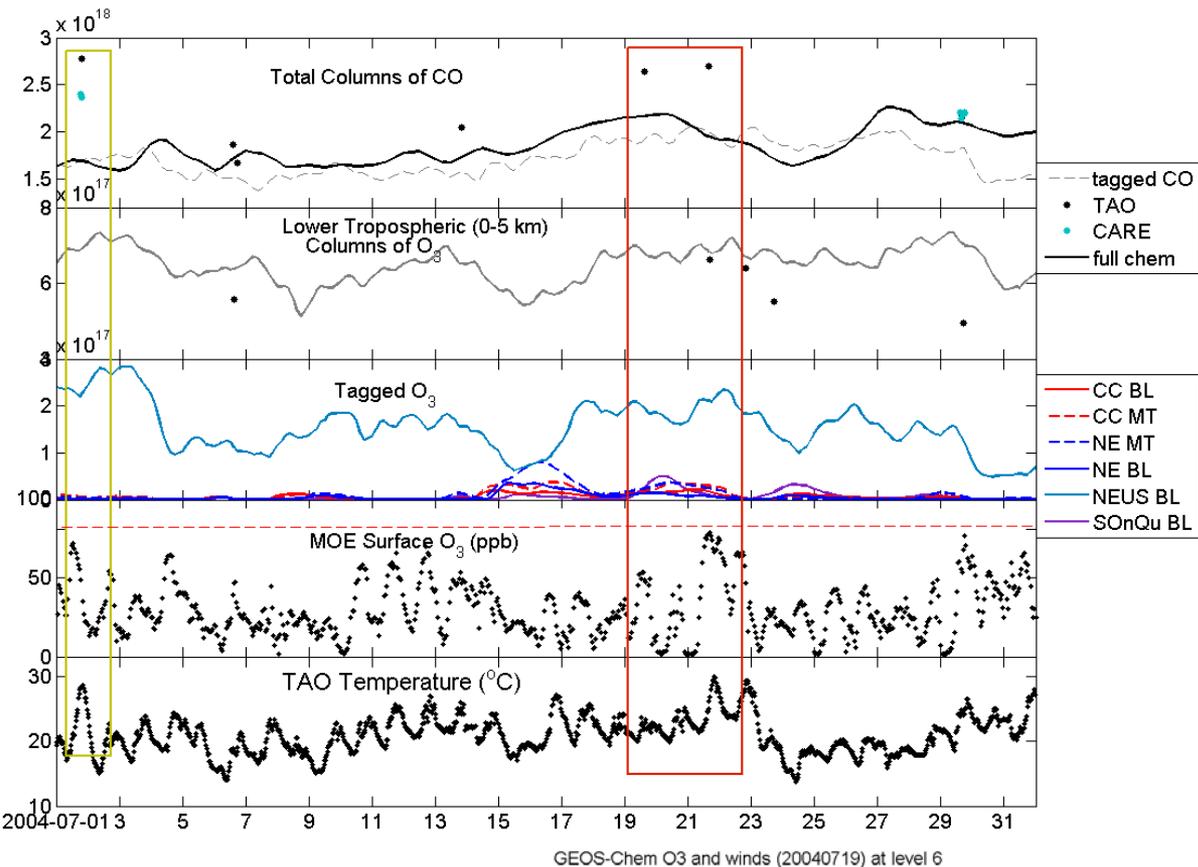
GEOS-Chem O<sub>3</sub> and winds (20020812) at level 6



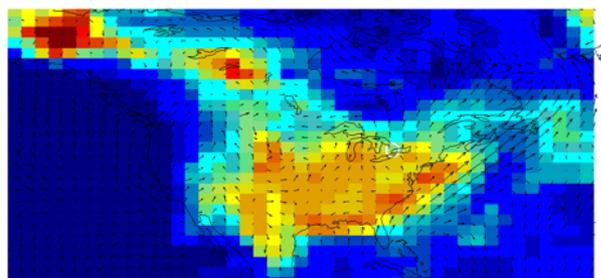
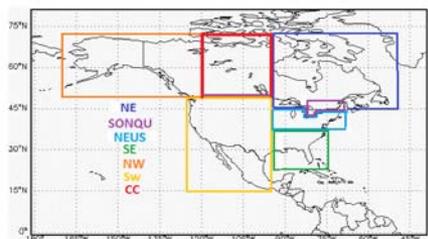
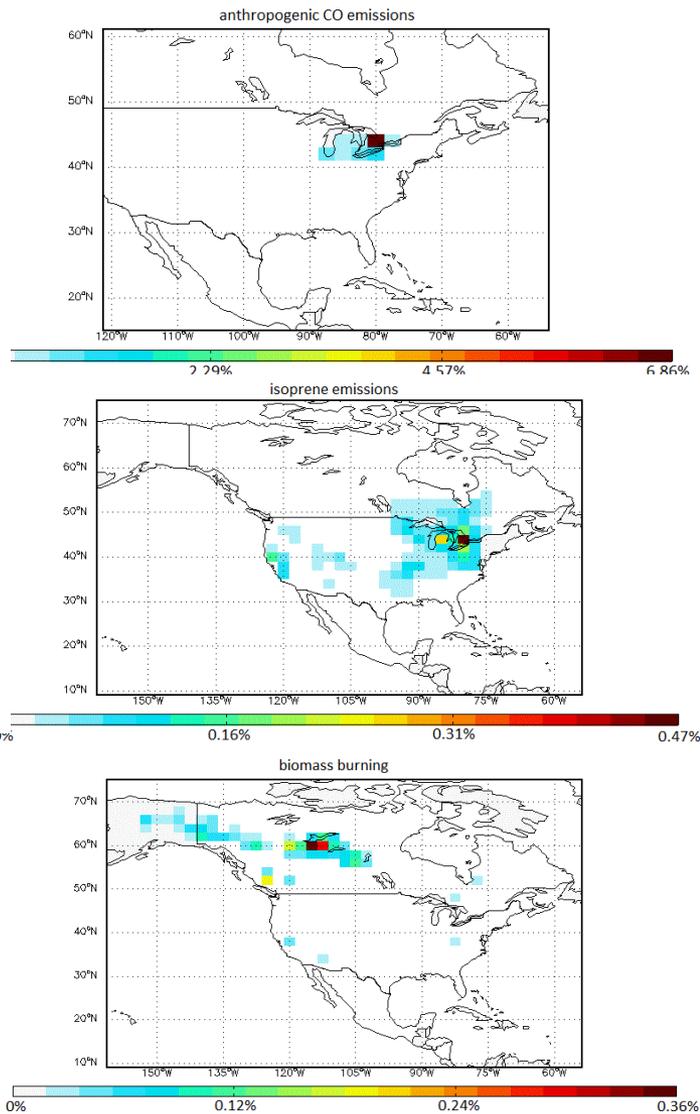
O<sub>3</sub> from tagged NEUS region



# July 2004, enhanced CO and O<sub>3</sub>



## CO sensitivity results:





# Acknowledgements

- NSERC
- Canadian Space Agency
- Environment Canada
- the many interns, students and postdocs who have made measurements at TAO
- Little Theo for keeping me on my toes

