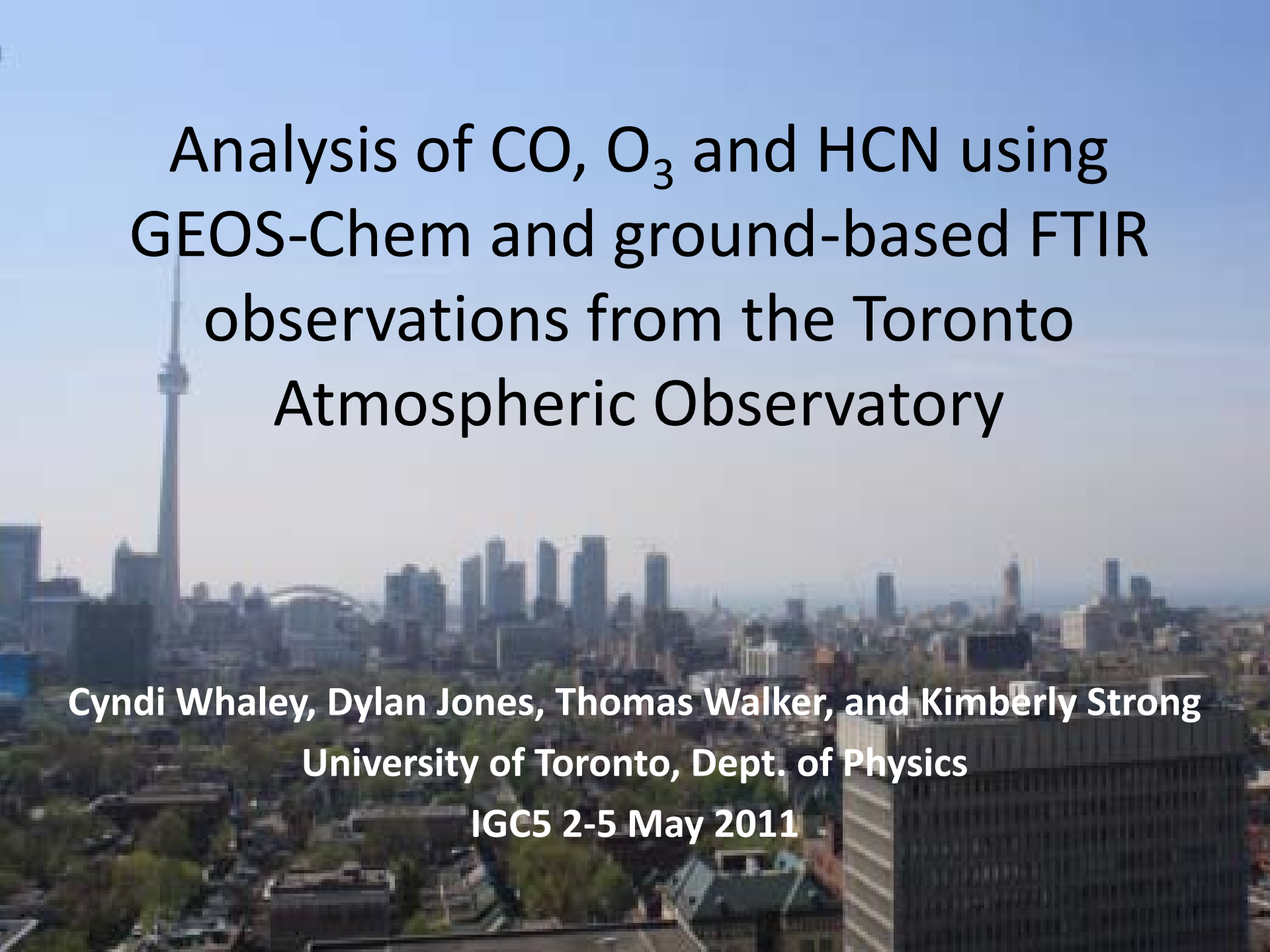
Analysis of CO, O_3 and HCN using GEOS-Chem and ground-based FTIR observations from the Toronto Atmospheric Observatory



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IGC5 2-5 May 2011

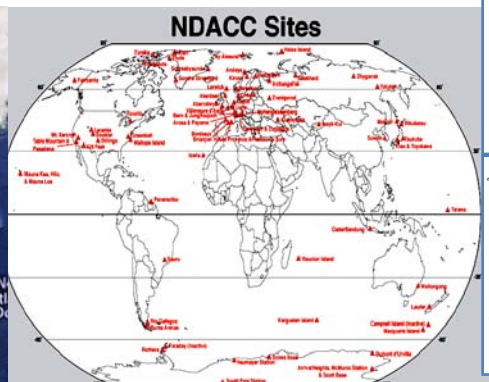
Toronto Atmospheric Observatory (TAO)

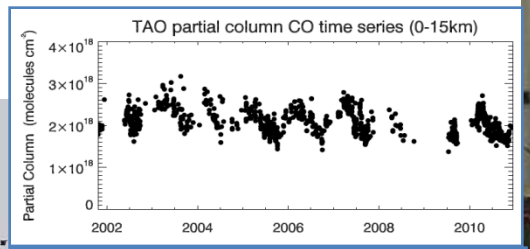
- **Location:** 43.66° N, 79.40° W, 174 m
- **Operational since 2002 → 9 years of data**

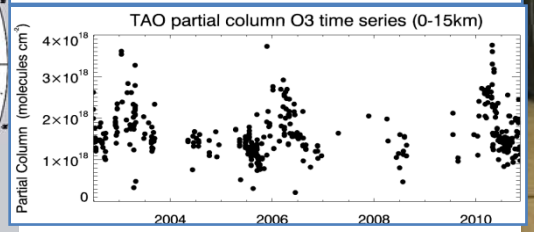
- **Primary instrument:** Bomem DA8 FTIR with solar tracker

- TAO is an NDACC (Network for Detection of Atmospheric Composition Change) site
- We use the Optimal Estimation Method for retrievals
  - Implemented with SFIT2 v3.94
  - Using HITRAN 2008 spectral line database
  - Employing harmonized retrieval parameters recommended by the NDACC Infrared Working Group

- GEOS-Chem profiles are smoothed with TAO averaging kernels before comparisons are made.

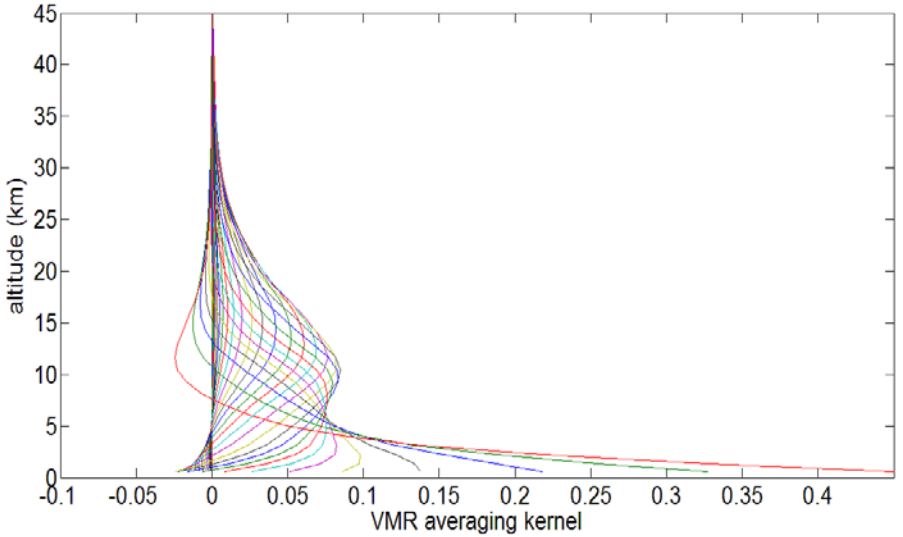




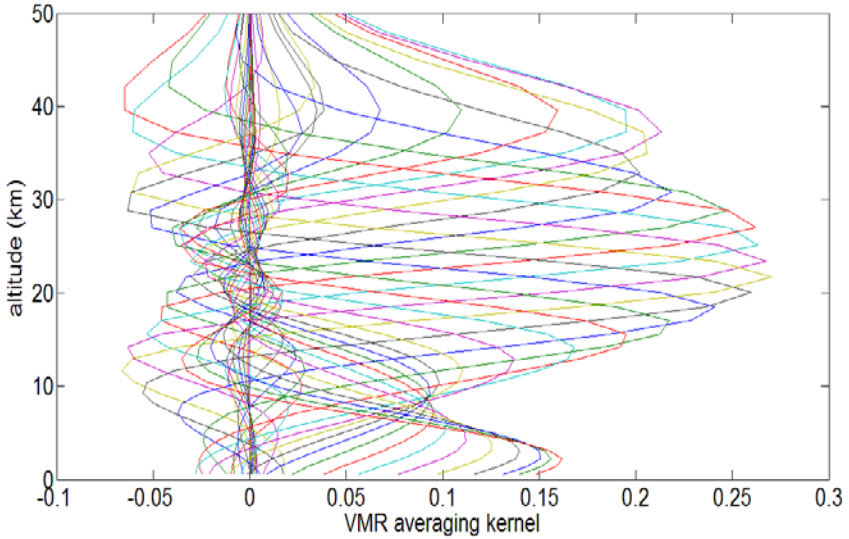


TAO Tropospheric Sensitivity: Typical Averaging Kernels

- Good sensitivity to the lower tropospheric signal

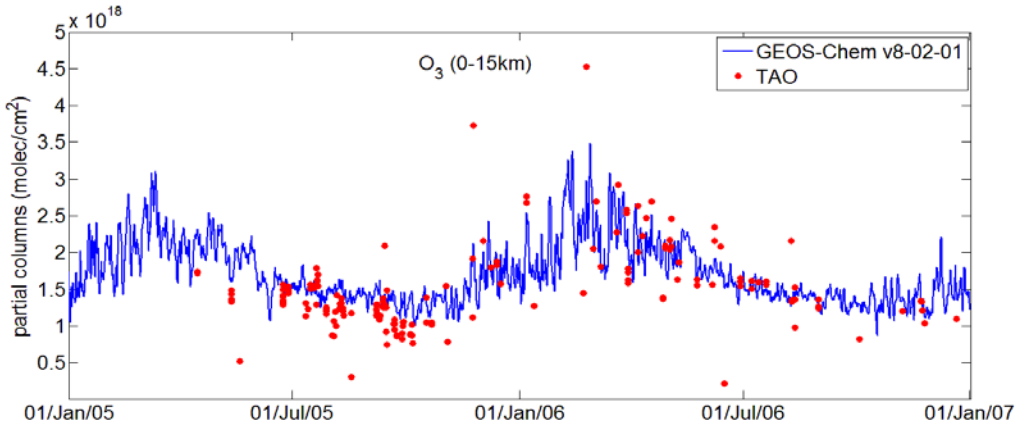


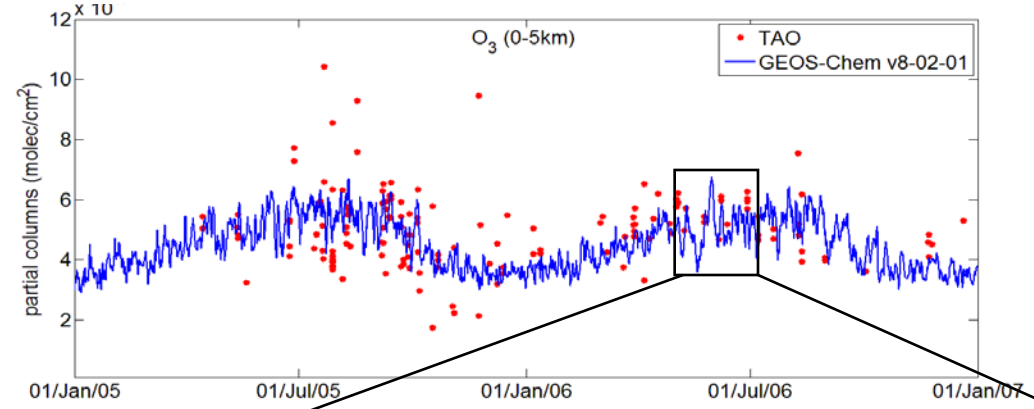
CO
DOFS=2.7 for
0-15km
DOFS=1 for
0-2.3km
(10-09-2009)

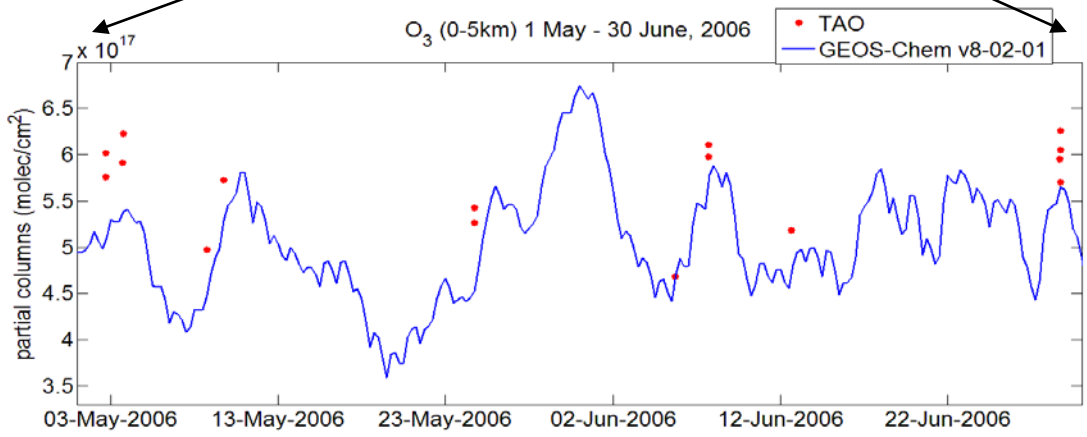


O_3
DOFS=2.8 for
0-15km
DOFS=1 for
0-7 km
(11-05-2007)

TAO and GEOS-Chem Ozone

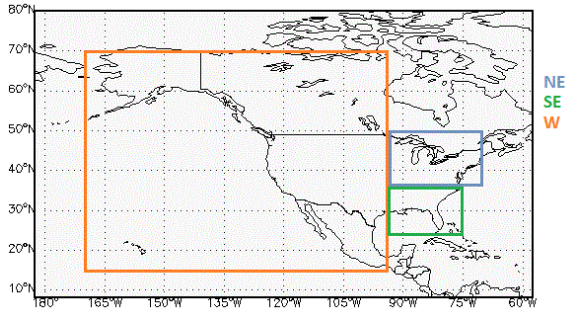


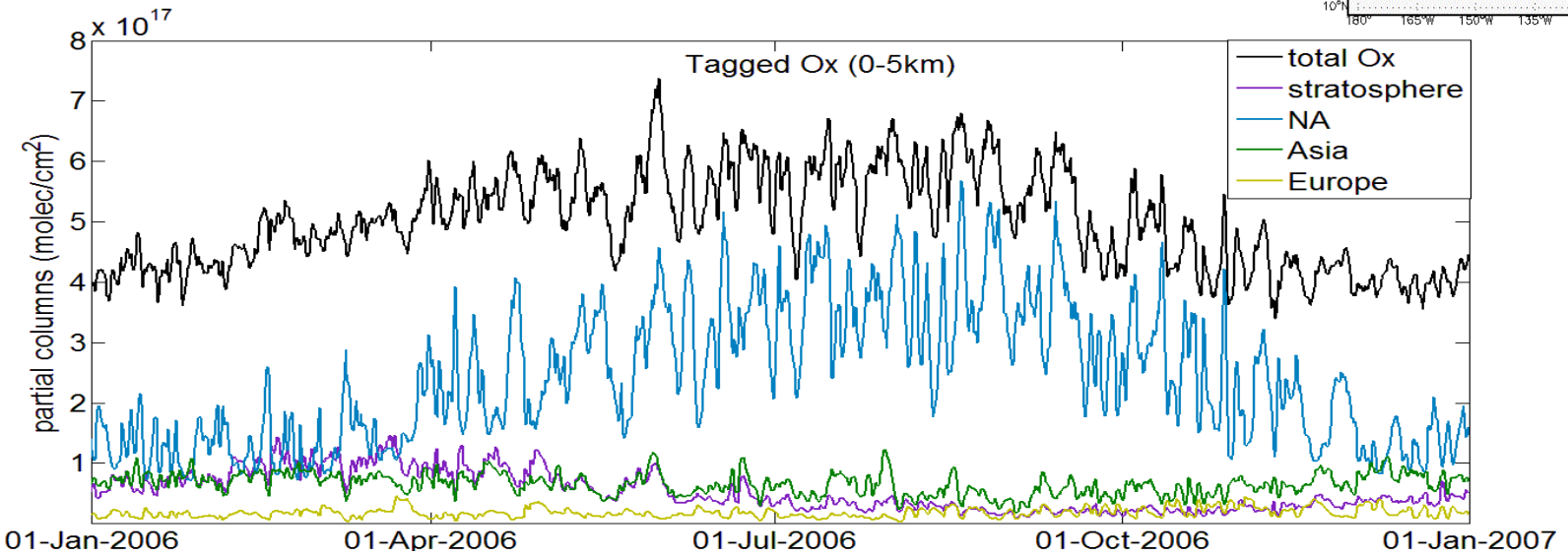


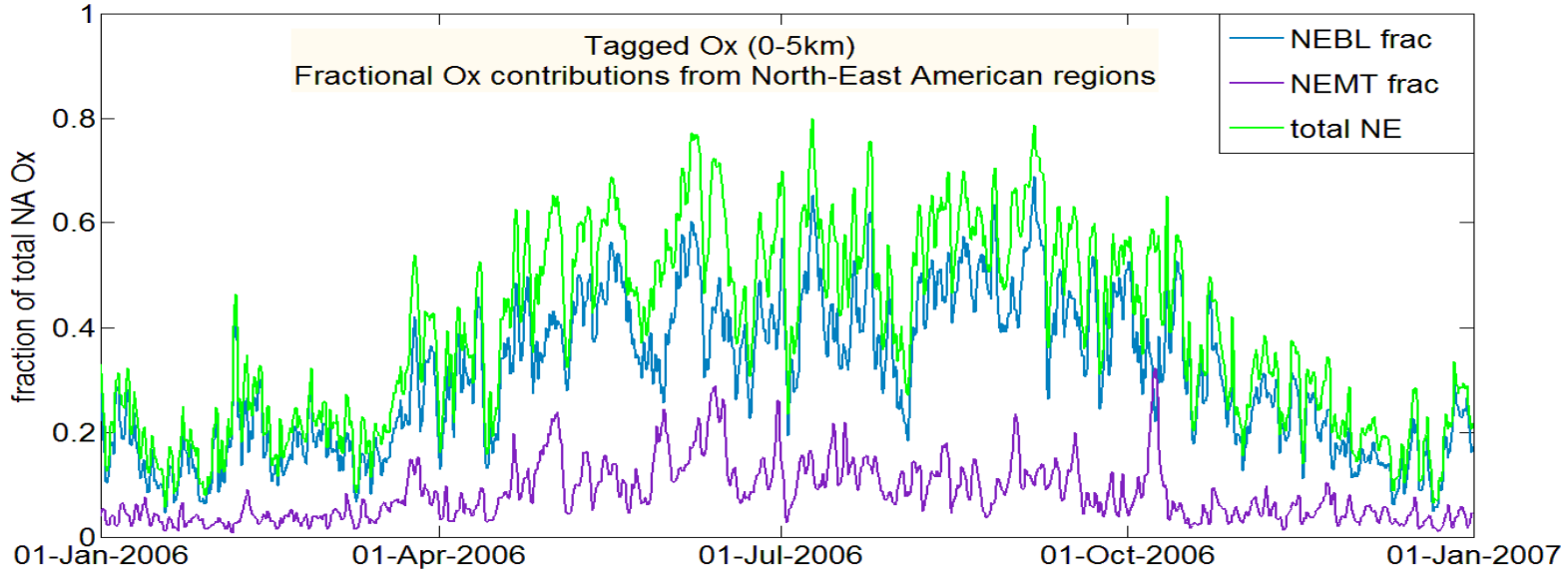


- The O_3 simulation agrees well with TAO
- Different partial columns show different seasonal cycle → lower tropospheric columns capture summertime O_3 production

GEOS-Chem Tagged Ox Sources

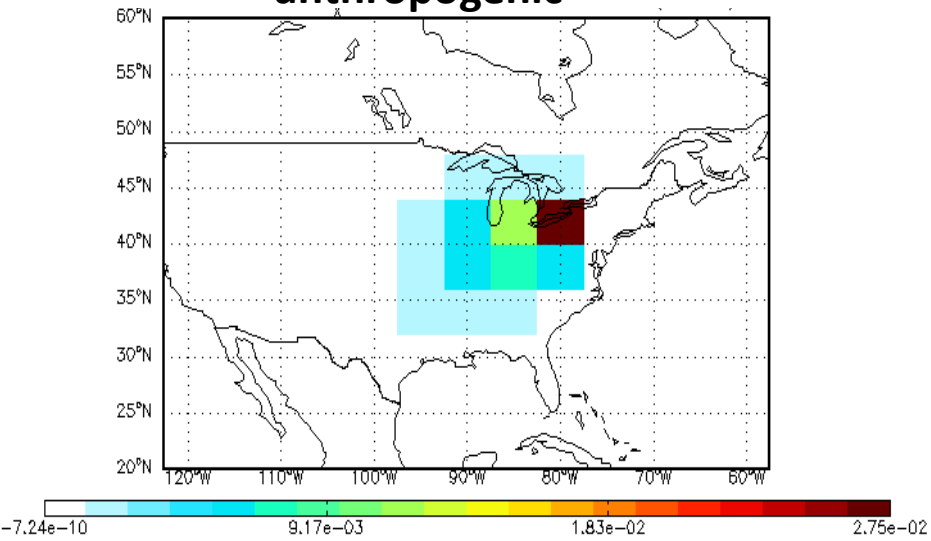






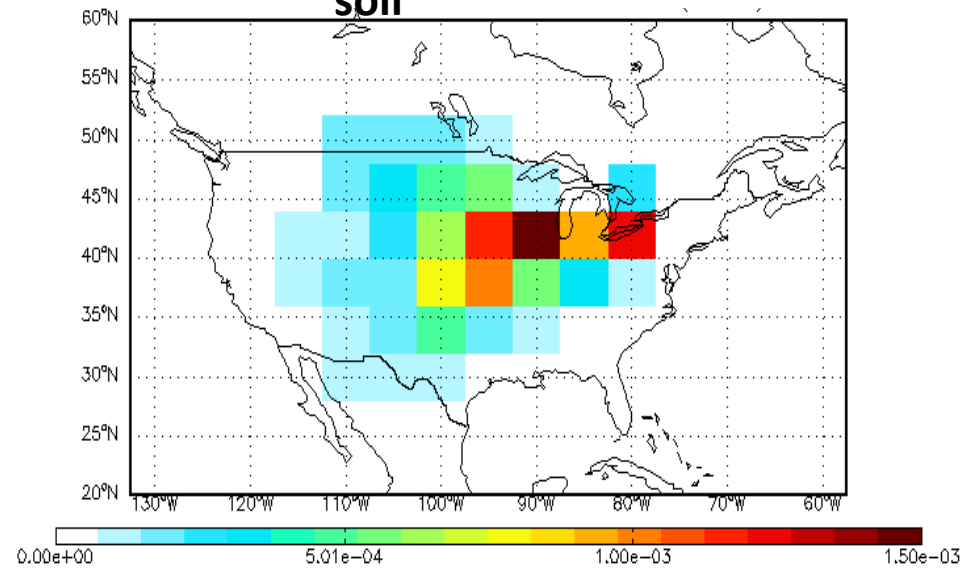
Adjoint Sensitivity Maps of O_3 Above Toronto to NOx Emissions in July 2006

anthropogenic

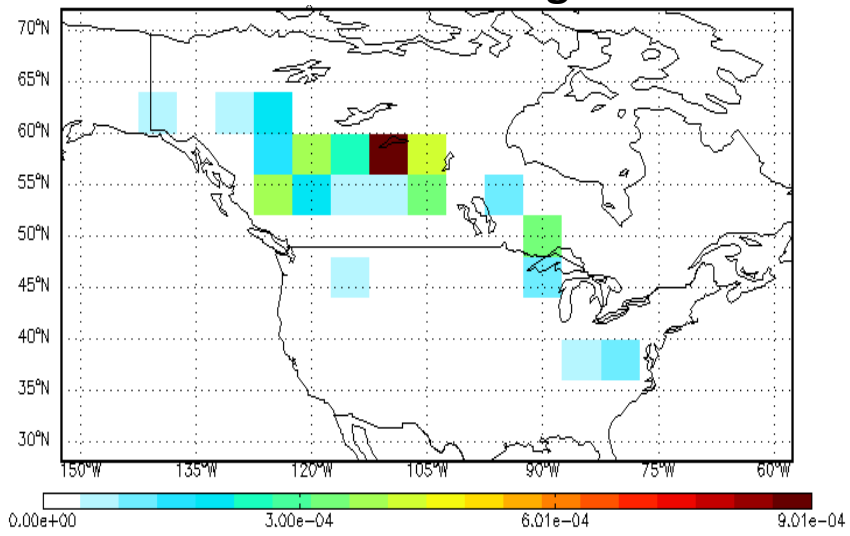


- Capturing mostly the local anthropogenic emissions
- Also sensitive to soil emissions from American agriculture, and biomass burning

soil

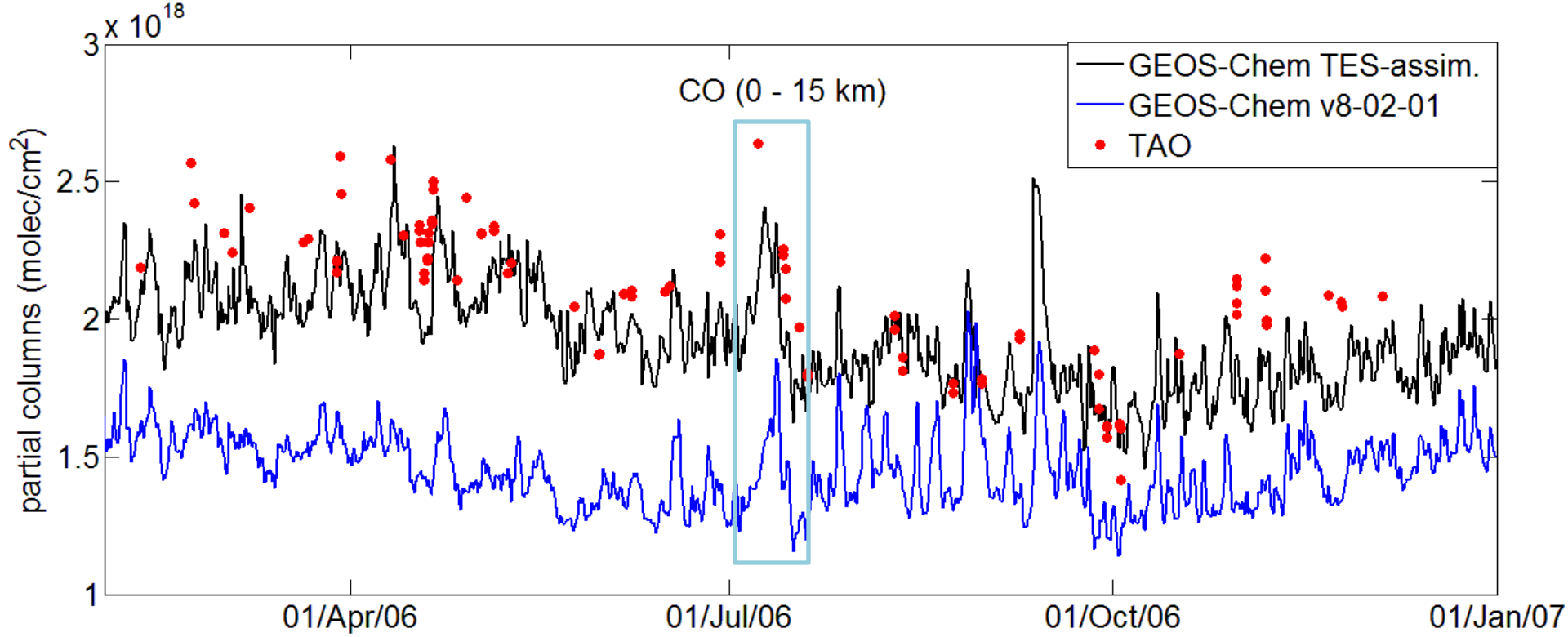


biomass burning



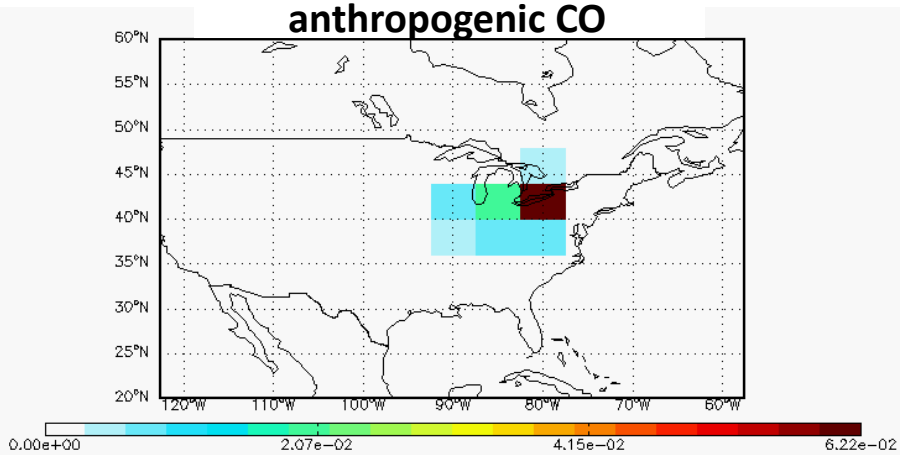
TAO and GEOS-Chem CO

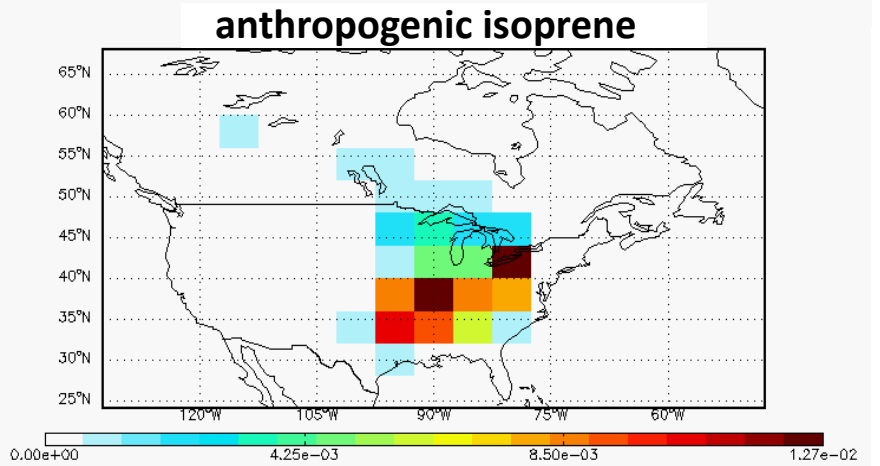
- Despite the good agreement in O_3, GEOS-Chem CO does not agree well with TAO
  - Kopacz et al. (2009) suggested that GEOS-Chem had a low CO bias due to an underestimate of fossil fuel emissions in Northern mid-latitudes
  - When TES observations are assimilated into the model, there is better agreement with TAO → clearly a problem with the emission inventories in the model

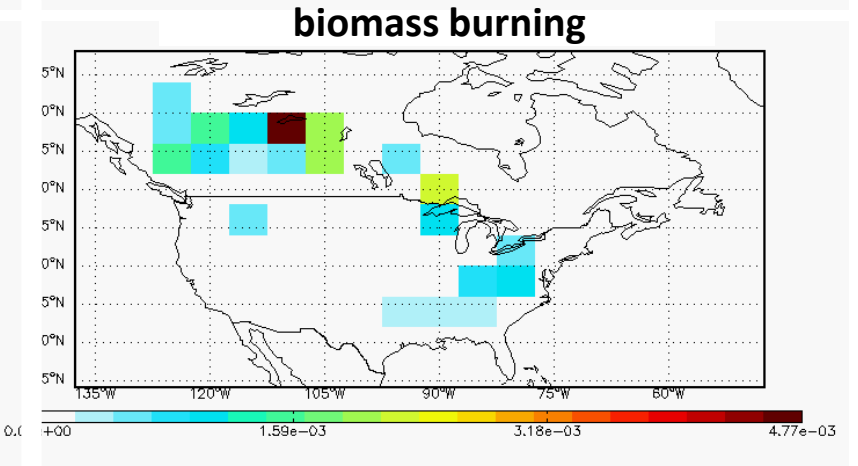


Adjoint Sensitivity Maps of CO Above Toronto to Emissions in July 2006

- Adjoint and tagged runs provide maps of CO from VOCs, fossil fuels and biomass burning
- Relative importance of various sources differs for CO and O_3







Summary and Conclusion

- TAO currently has 9 years of tropospheric trace gas measurements, revealing seasonal and short-term variabilities
- Short-term variations in CO and O_3 have been analysed with GEOS-Chem and sources of pollution affecting air quality in Toronto have been identified
  - Local anthropogenic emissions are a dominant source for O_3, and anthropogenic *and* biogenic sources are important for CO
- Future Work:
  - Expand GEOS-Chem analysis to include more species (C_2H_6, HCN, CH_2O), adjoint for CO, and higher resolution (nested grid) simulations
  - Quantify long-term trends as the TAO dataset increases in time
  - Preliminary investigation of HCN (not shown) reveals that the model is biased low. Work needed to assess the model situation.