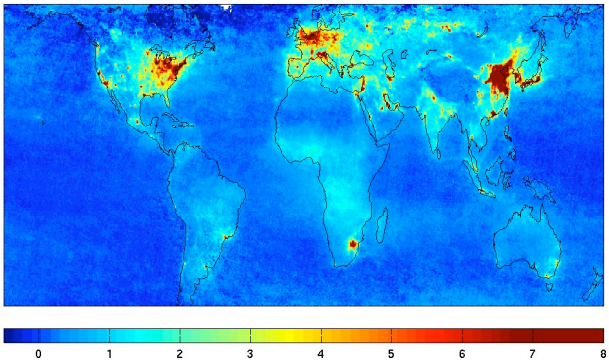
Constraints on Emission Inventories Using Satellite and Aircraft Measurements

Space-borne and airborne measurements of atmospheric gases provide top-down constraints on emissions

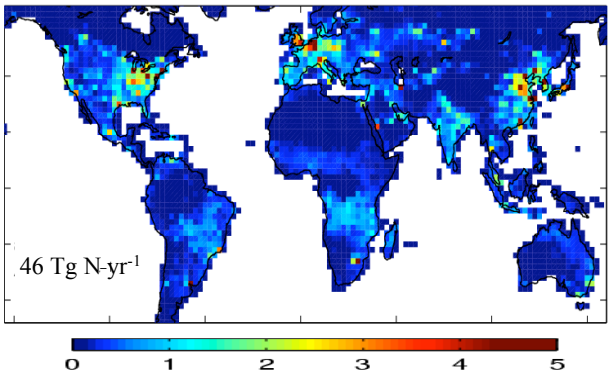
Current understanding of emissions are based largely on "***bottom-up***" estimates determined by aggregating information from diverse sources such as fuel and land use statistics, in-tunnel measurements of emission ratios, and estimates of burned areas. "***Top-down***" information from observations of trace gases provides an additional constraint on emissions through inverse modeling.

What did we do during ICARTT?

- Retrieved concentrations of nitrogen dioxide (NO_2), carbon monoxide (CO), and formaldehyde (HCHO) from the ENVISAT/SCIAMACHY and Terra/MOPITT satellite instruments.
- Conducted inverse modeling and sensitivity studies with the GEOS-Chem and MOZART chemical transport models.
- Measured reactive nitrogen species, CO, and HCHO from the NASA DC-8 and NOAA WP-3D aircraft.
- Applied the airborne measurements to improve the satellite retrieval algorithm and to validate the satellite measurements.
- Evaluated the top-down emission inventory with the airborne measurements.



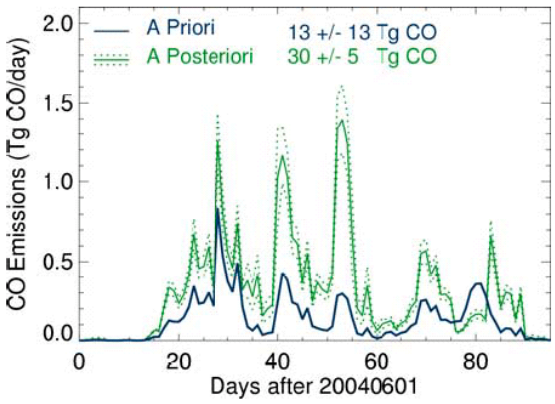
Tropospheric NO_2 (10^{15} molec cm^{-2})

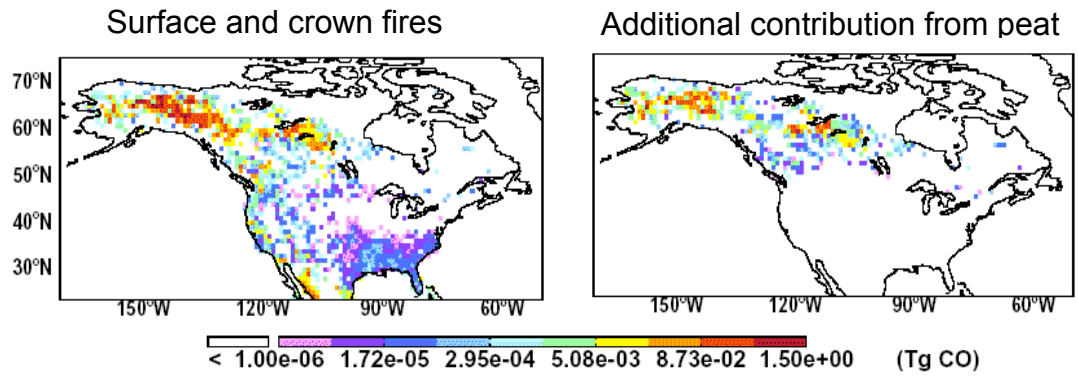


NO_x emissions (10^{11} atoms N cm^{-2} s^{-1})

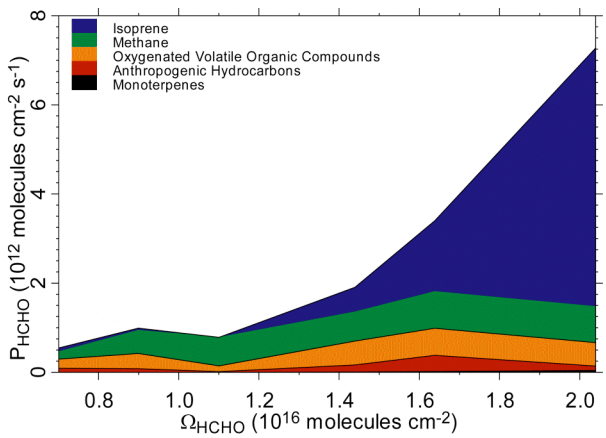
(Left) Tropospheric NO_2 columns determined from the SCIAMACHY satellite instrument.
(Right) NO_x emissions determined through inverse modeling of the SCIAMACHY observations.

The right panel shows CO emissions from Alaskan and Canadian forest fires for summer 2004. The blue "a priori" line is based on bottom-up information. The green "a posteriori" (top-down) emissions are determined through inverse modeling of the MOPITT observations of CO with the MOZART model.





Spatial distribution of CO emissions for summer 2004. Emissions of CO from peat burning are necessary to explain elevated CO in the MOPITT satellite and airborne observations.



Atmospheric production of HCHO (P_{HCHO}) occurs via oxidation of organic compounds. INTEX-A aircraft measurements show that the dominant source of variability in column HCHO (Ω_{HCHO}) is isoprene. Satellite observations of HCHO can thus be used to infer isoprene emissions from North America.

What did we learn?

- Space-borne and airborne measurements of tropospheric gases are generally consistent
- Top-down emission inventories from satellites improve model simulations of trace gases
- NO_x emissions from East Asia now exceed those from either North America or Europe
- Peat burning plays an important role in boreal forest fire emissions.
- The emissions of CO from the wildfires in Alaska and Canada during summer 2004 were comparable to the anthropogenic emissions of CO in the US during the same period.
- Space-borne measurements of formaldehyde (HCHO) columns can reliably be used as a proxy for isoprene emissions from North America.

What does it mean?

- The top-down approach is becoming an increasingly useful tool for improving estimates of emissions that are used for air quality and climatic assessments
- Air quality regulations may need to devote additional attention to long-range transport from distant sources

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The multi-agency ICARTT <http://www.al.noaa.gov/ICARTT/> was formed to study the sources, sinks, chemical transformations and transport of ozone, aerosols and their precursors to and over the North Atlantic Ocean. ICARTT Fact Sheets are designed to present important new science results and findings of high societal relevance to technical non-experts in the community and have been reviewed by an internal committee of peers.