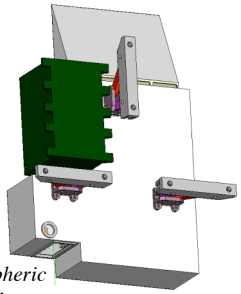
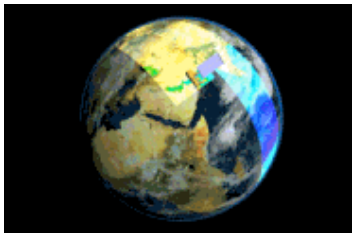
Quantifying smog ozone production and transport



Tropospheric Infrared Mapping Spectrometer concept, courtesy J. Kumer, Lockheed-Martin

IR mapping
[HCHO]
[O_3]
(total + profile)

UV mapping
[NO_2]
UV
[O_3]
(partial)



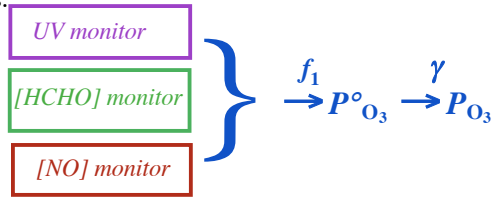
Formaldehyde (HCHO) and tropospheric O_3 may be sampled from space with high accuracy with a proposed mid-infrared sensing technology. Ozone, UV radiation and NO_2 (photochemically related closely to NO), may be sampled using UV technology e.g., the Ozone Monitoring Instrument, OMI.

NASA studies on board the Troposperic Chemistry Program's flying DC-8 laboratory have proved very promising in describing regional and continental smog ozone production. A method to quantify the chemical processes that create smog ozone unexpectedly appeared out of recent analysis of the Intercontinental Transport Experiment airborne campaigns in 2004 and 2006. Ozone production appears to be measurable by making a measurement of the reactive flow of volatile organic carbon (VOC) species in combination with nitric oxide that converts VOC-derived radicals to smog ozone. A simple formula,

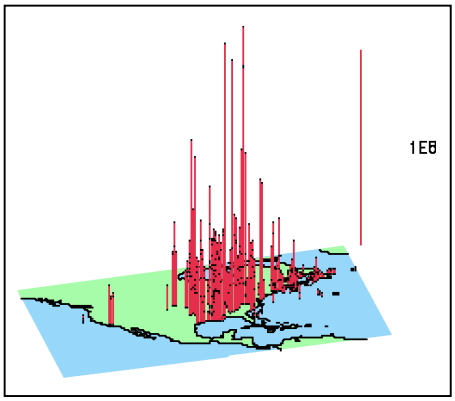
$P_{O_3} = \gamma f_1 (j_{HCHO} [HCHO] [NO])$

may be applied using medium-technology measurements of the chemical species formaldehyde and nitric oxide and UV radiation, suitable for surface and airborne monitoring, and where f_1 appears to be nearly a universal function, and the conversion parameter γ varies predictably over a small range. This work makes use of measurements by instruments developed at Penn State (Brune, Ren) and NCAR (Fried, Shetter). A second function closely related to f_1, F_2, should be useful in evaluating which ozone precursors are most effective in a regional controlled strategy.

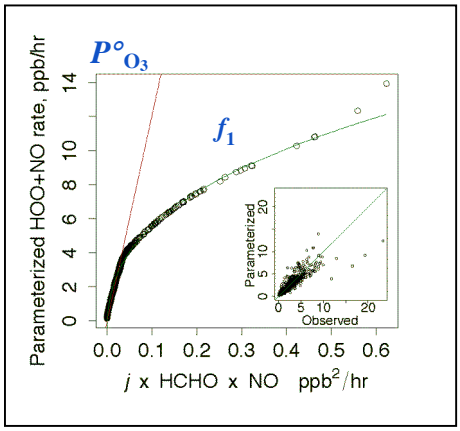
The generality of the function f_1 also suggests that remotely sensed measurements of lower-tropospheric formaldehyde, nitrogen oxides, and UV radiation can usefully inform and constrain our understanding of smog ozone production. HCHO measurements help quantify ozone production, while measures of smog-layer O_3 itself help define transport. Transport and production are often difficult to distinguish in pollution-control situations.



Simple surface measurement setup useful for augmented surface air pollution sites.



Wide variability of ozone production rates over the modestly smog-influenced lower atmosphere of the United States during the INTEX-NA campaign, July-August, 2004, units in molecules/cm^2/s



The function f_1 relating the α = simple product of a photolysis rate, the formaldehyde concentration, and the NO concentration of a near-surface air sample to the "principle" ozone production rate of the air, $P°_{O_3}$. Total production $P_{O_3} = \gamma P°_{O_3}$. The function bends downward in slope, reflecting the well-known fact that ozone is produced relatively less efficiently at high concentrations. Good correlation of the prediction and observations is shown in inset.

Point of Contact:
Robert B. Chatfield
Project Principal Investigator
650-604-5490, Robert.B.Chatfield@nasa.gov
http://geo.arc.nasa.gov/sgg/chatfield/index.html

Ames Research Center