One year of GOME-2 global observations of glyoxal (CHO.CHO) from space.

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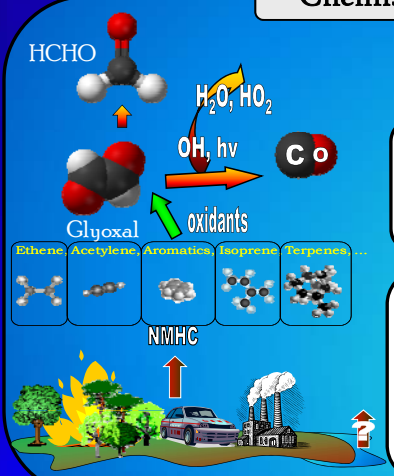
ABSTRACT

CHO.CHO is a key intermediate product of the oxidation of volatile organic compounds (VOCs) mainly by the hydroxyl radical (OH), ozone molecule (O_3) and the nitrate radicals (NO_3). Due to the short lifetime of CHO.CHO (~2 – 3 hours) it is expected to provide valuable information on the identification of the photochemical hot spots globally which are attributed to the various sources of anthropogenic, biogenic and biomass burning origin.

This study presents the global picture of CHO.CHO vertical column densities as obtained, for the first time, from the GOME-2 instrument. More than a year of data (April 07 – June 08) where analyzed with the following procedure: Glyoxal slant column densities (SCDs) were retrieved in the VIS spectral region. The technique used was the differential optical absorption spectroscopy technique (DOAS). The vertical column densities (VCDs) were calculated by applying air mass factors to the respective SCDs.

It was found that the highest values of the vertical column densities of CHO.CHO are observed above regions of anthropogenic activities, biogenic processes and biomass burning. This identification of the photochemical hot spots is in agreement with earlier studies performed with the SCIAMACHY instrument on board of the ENVISAT satellite.

Chemistry



Glyoxal is the smallest a-dicarbonyl compound

Sources

CHOCHO is formed by the oxidation of NMHC. Contrary to HCHO no direct sources are expected. This makes CHOCHO a good indicator of the VOC oxidation.

Sinks

The main known sinks of CHOCHO are:

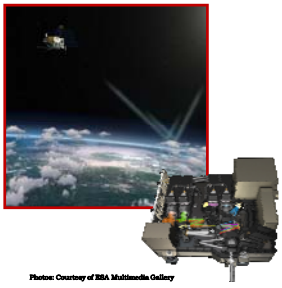
a) reaction with OH radicals

b) photolysis leading to an estimated lifetime of 2h.

c) reversible, or irreversible uptake of CHO.CHO on/in aerosols and clouds.

d) wet and dry deposition.

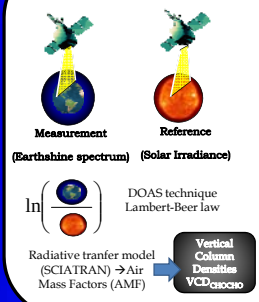
INSTRUMENTATION



Photos: Courtesy of ESA Multimedia Gallery

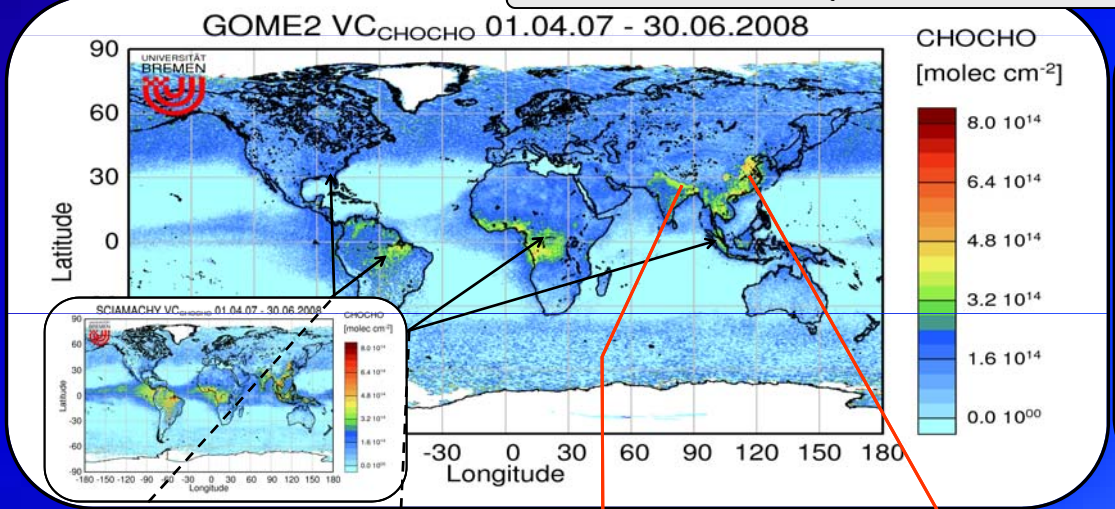
The GOME-2 (Global Ozone Monitoring Experiment) instrument is mounted to the MetOp satellite. GOME-2 was launched into a sun-synchronous orbit in October 2006 and has been providing operational data since March 2007. It consists of a series of UV/visible spectrometers capturing the light reflected by the Earth's surface and atmosphere. GOME-2 is very similar to GOME instrument but has improved spatial resolution (40 x 80 km²), a wide scanning width (1920 km) which provides a better global coverage (within 1.5 days).

EXPERIMENT



The vertical columns (VC) of glyoxal are calculated with the Differential Optical Absorption Spectroscopy (DOAS) by subsequently applying the air mass factor correction (AMF, calculated by the radiative transfer model SCIATRAN) to the slant columns (SC). The latter is the integrated amount of absorber averaged over all light paths. CHOCHO was retrieved at the blue spectral range. In specific, the spectral window between 435 and 457 which includes a sharp peak at 455nm, is chosen for the analysis. The absorption cross sections of O_3, NO_2, H_2O, O_4, phytoplankton, a ring spectrum which accounts for the rotational Raman scattering, and a quadratic polynomial are included in the fitting procedure.

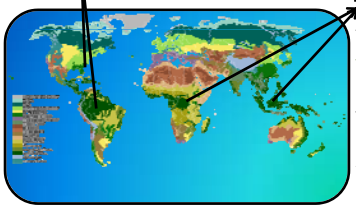
RESULTS ≈ 1 year of measurements



The graph to the left depicts the composite map of the Vertical Column Densities of CHO.CHO calculated for the period 1.4.2007 – 30.6.2008. Certain areas appear to have enhanced vertical column values of CHO.CHO indicative of the ongoing photochemistry. South America, Africa, India, Indonesia and Asia (mainly South-eastern China) are among the dominant regions where high values of CHOCHO (≥4.5.1014 molec·cm^{-2}) are retrieved. At higher latitudes, moderate values of $VCD_{CHO.CHO}$ of about 2.5·10^{14} molec·cm^{-2} are discernible, for example above North America, Europe and Australia. Notably, high column amounts of CHO.CHO are also observed above water suggesting enhanced biogenic activity. Due to the short lifetime of CHOCHO of about 2-3 hours, these high values are expected to originate from the region sources of the precursor VOCs.

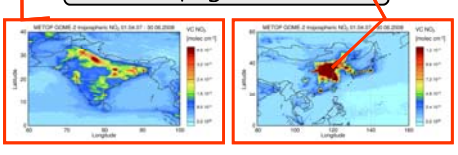
The first direct comparison of the GOME2 and SCIAMACHY (bottom left picture) VCD_{CHOCHO} composite maps shows that a) The same photochemical hotspots are found, b) GOME2 – VCD_{CHOCHO} are somehow lower that the respective SCIAMACHY ones.

Biogenic sources



When comparing the vegetation/biome maps (left picture) with the $VCD_{CHO.CHO}$ composite maps (top graphs) it can be seen that above the tropical and subtropical forests (mainly above South America, Africa and Indonesia) the mean $VCD_{CHO.CHO}$ obtain their highest values on a global scale (≈4.5-5.0·10^{14}molec·cm^{-2}).

Anthropogenic sources



Except the regions where the biogenic processes control the ongoing photochemistry, glyoxal also presents enhanced VCD values above areas overwhelmed by anthropogenic activities (eg India and China). Contrary to the biogenic regions, the identity of these areas is characterized by both high tropospheric VCD_{NO2} values (red framed graphs) and high VCD_{CHOCHO} values.

Aknowledgment

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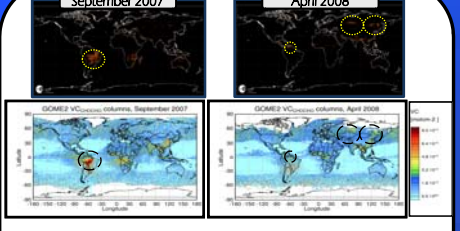
Biomass burning



Another important source of glyoxal is the biomass burning. This can be confirmed by contrasting the AATSR fire count maps (black colored graphs) with the respective $VCD_{CHO.CHO}$ maps. Wherever intensive fires occur (yellow circles) the VCD_{CHOCHO} values (black circles) show enhanced values.