# Global observations of oxygenated volatile organic compounds .


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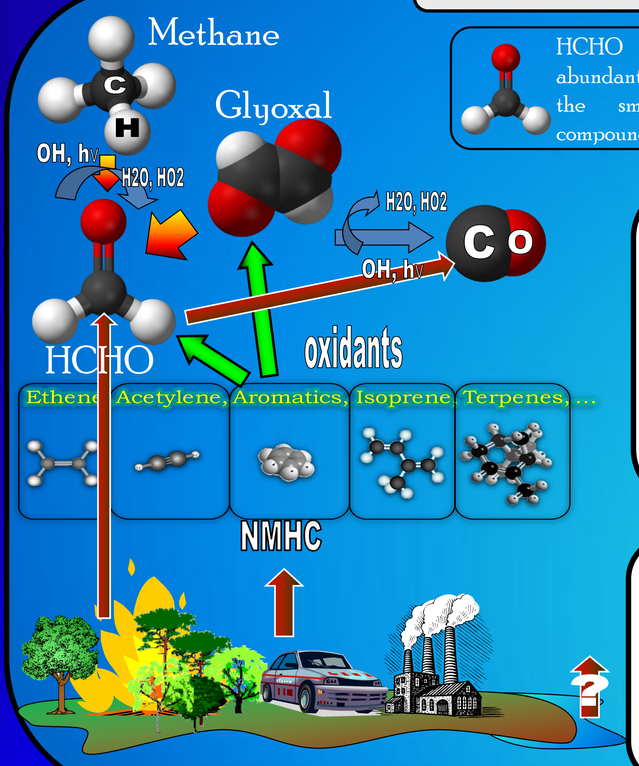
## ABSTRACT


**Formaldehyde (HCHO) and glyoxal (CHO.CHO) are key intermediate products 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 their short lifetime they are 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 both HOCH and 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: Slant column densities (SCDs) were retrieved in the UV and VIS spectral region respectively. 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 HCHO and 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




HCHO is the most abundant aldehyde, and the smallest carbonyl compound

Glyoxal is the smallest a-dicarbonyl compound

### Sources

**HCHO is mainly produced by the oxidation of methane ($CH_4$) and Non-Methane hydrocarbons (NMHC). It is also (to a lesser extend) primarily emitted by anthropogenic and biogenic sources.**

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

### Sinks

**The main known sinks of HCHO and CHOCHO are:**

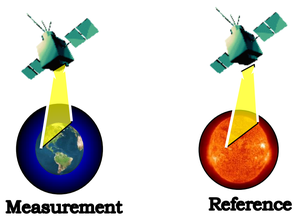
a) **reaction with OH radicals**
b) **photolysis leading to an estimated lifetime of 2h.**
c) **reversible, or irreversible uptake of CHO.CHO on/in aerosols and clouds (in the case of CHO.CHO).**
d) **wet and dry deposition.**

## 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

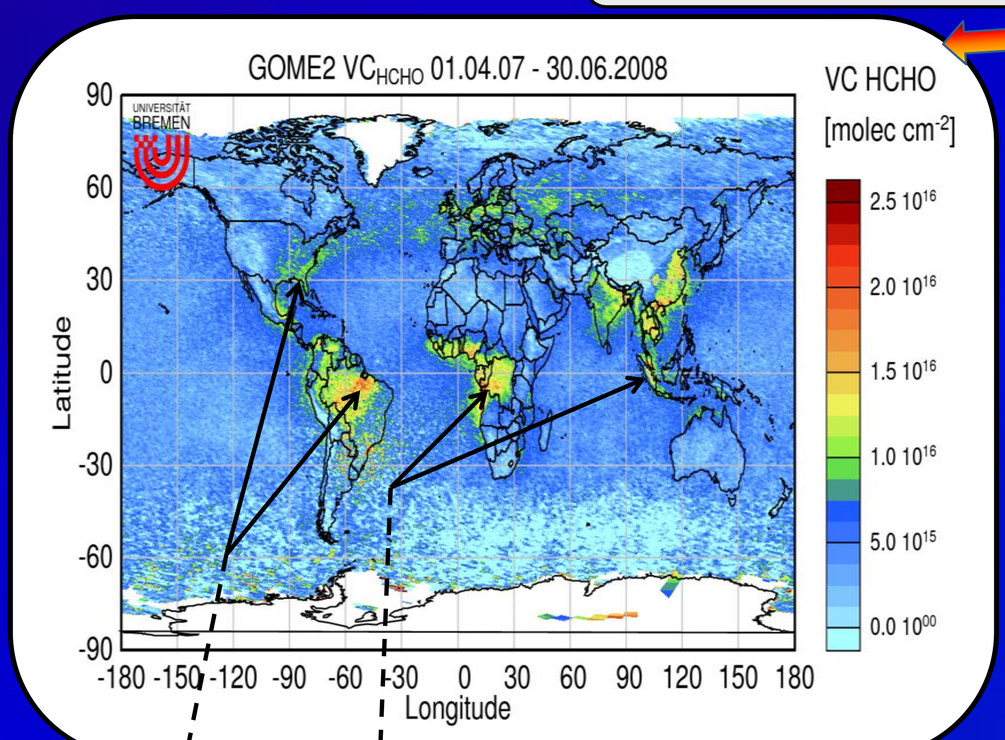


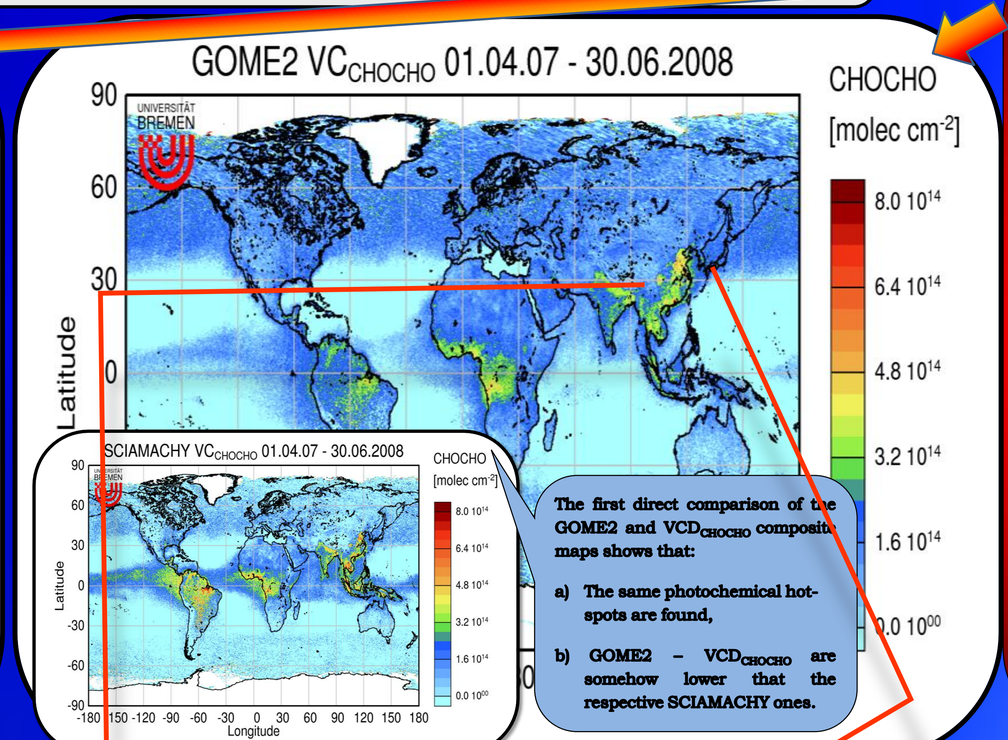

$\ln\left(\frac{\text{Measurement}}{\text{Reference}}\right)$ DOAS technique Lambert-Beer law

Radiative tranfer model (SCIATRAN) → Air Mass Factors (AMF) → **Vertical Column Densities $VCD_{CHOCHO}$**

**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. HCHO was retrieved at the UV region while CHOCHO at the blue spectral range. In specific, the spectral windows between 337 - 353nm and 435 - 457 are chosen for the analysis. The absorption cross sections of $O_3$, BrO, $NO_2$, $H_2O$, $O_4$, phytoplankton, a ring spectrum which accounts for the rotational Raman scattering, and a quadratic polynomial are included in the fitting procedures.**

## RESULTS ≈ 1 .5 years of measurements



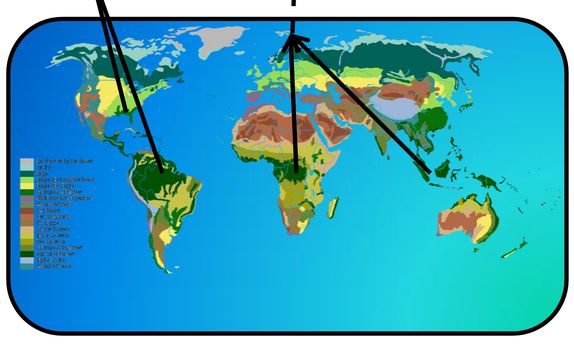




**The first direct comparison of the GOME2 and $VCD_{CHOCHO}$ composite maps shows that:**

a) **The same photochemical hot-spots are found,**
b) **GOME2 – $VCD_{CHOCHO}$ are somehow lower that the respective SCIAMACHY ones.**

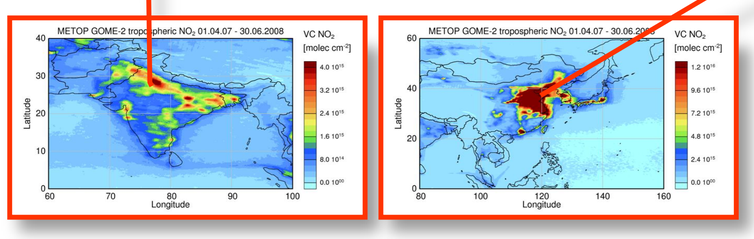
**Composite maps of the Vertical Column Densities of HCHO (left graph) and CHO.CHO (right graph) calculated for the period 1.4.2007 – 30.6.2008. As observed in both maps, certain regions appear to have enhanced VCD of HCHO and CHO.CHO indicative of the ongoing photochemistry. South America, Africa, India, Indonesia and Asia (mainly South-eastern China) are among the dominant regions where high values of HCHO (≥1.5.10¹⁶ molec·cm⁻²) and CHOCHO (≥5.0.10¹⁴ molec·cm⁻²) are retrieved. At higher latitudes, moderate values of $VCD_{HCHO}$ (≈0.8.10¹⁶ molec·cm⁻²) and $VCD_{CHO.CHO}$ (≈2.5.10¹⁴ 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 these oVOCs, the observed high VCD values are expected to originate from the region sources of the precursor VOCs.**

### Biogenic sources



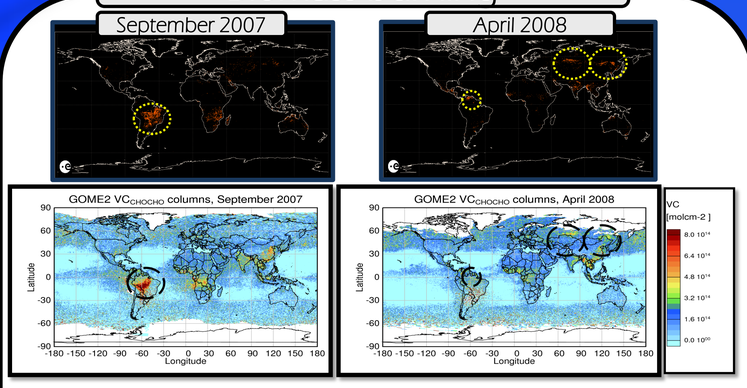
**When comparing the vegetation/biome maps (left picture) with the $VCD_{CHO.CHO}$ composite maps (top graphs) it can be seen that above the tropical and subtropical forests (mainly above South America, Africa and Indonesia) the mean $VCD_{HCHO}$ and $VCD_{CHO.CHO}$ obtain their highest values on a global scale.**

### Anthropogenic sources




**Except the regions where the biogenic processes control the ongoing photochemistry, formaldehyde and glyoxal also present 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.**

### Biomass burning




**Another important source of these oVOCs 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 $VCD_{CHOCHO}$ (black circles) show enhanced values.**


### Aknlowledgment

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