GLOBAL OBSERVATIONS OF FORMALDEHYDE

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Introduction

Formaldehyde, the simplest but most abundant of the aldehydes

- is harmful to health, environment, ...
- HCHO is an **important indicator of hydrocarbon emissions and photochemical activity**

HCHO sources

- oxidation of Methane provides constant HCHO source
- tropospheric NMHC emissions
- biomass burning
- fossil fuel combustion

HCHO sinks

- reaction with OH
- photolysis (<400 nm)

→ HCHO is a good test for model oxidation mechanism and emission scenarios

→ it could be used as a proxy for biogenic emissions (isoprene) e.g. Palmer et al., 2003

Data retrieval

- Differential Optical Absorption Spectroscopy (DOAS) yields slant columns = averaged absorption along all contributing light paths
- Conversion to vertical columns using air mass factors (AMF) calculated by radiative transfer model SCIATRAN (Rozanov et al.)
- for satellites: constant background between 200 and 220°E assumed (normalisation) to account for instrumental drifts/inhomogenities - lookup table for AMF taking into account albedo, orography, aerosol and HCHO profile shape (in total 48.000 scenarios)
- from MAX-DOAS observations profile retrieval possible using Bremian Advanced MAX-DOAS Retrieval Algorithm (BREAM, see poster Oetjen et al.)

The Global View

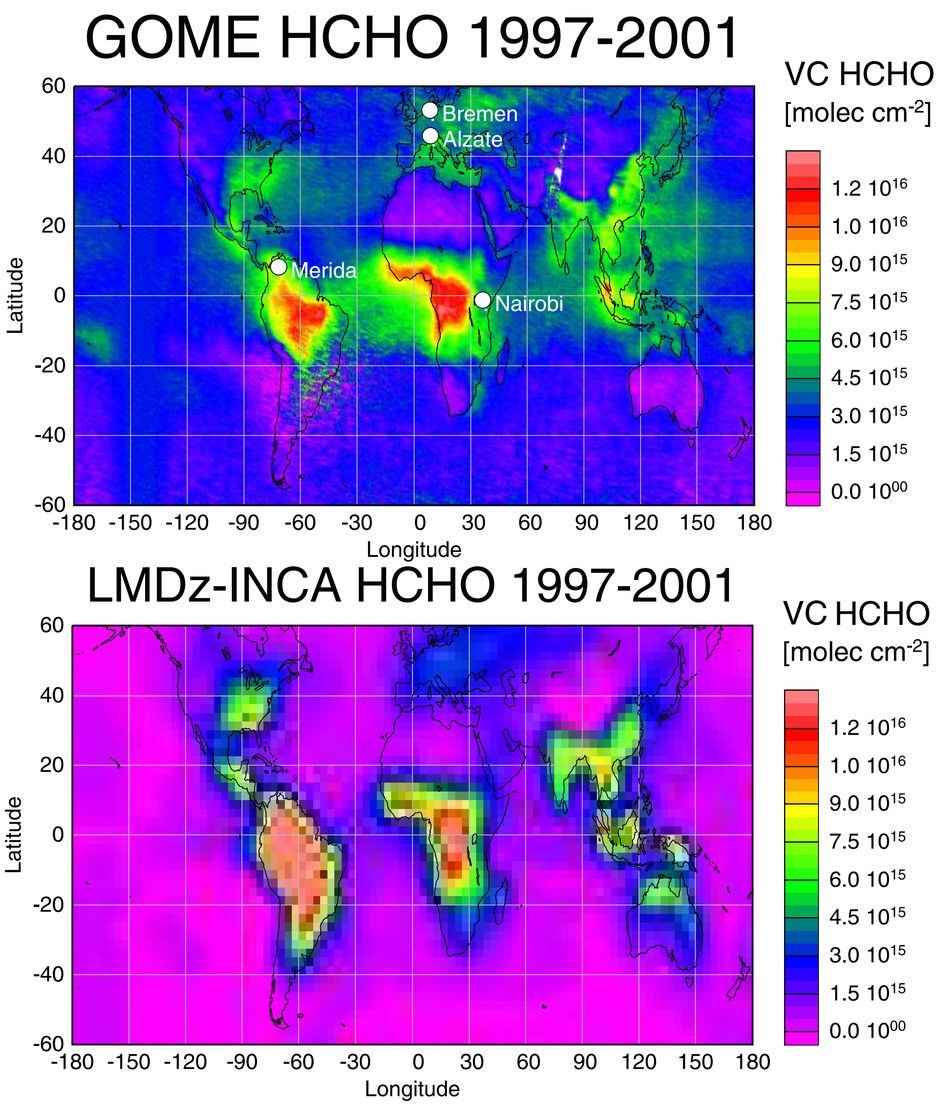


Fig 2: *The upper figure shows average values for HCHO calculated from all GOME measurements between 1997 and 2001. BREDOM stations for latitudes less than 60° and the location of the FORMAT campaigns in 2002 and 2003 (see Figure 4) are marked. The lower one illustrates the HCHO distribution as modelled by LMDz-INCA. The correlation between both data sets is 0.73. The maximum values of HCHO are well correlated to regions with a high vegetation index (tropical rainforests). The impact of industrial emissions on the total column is small.*

Experiments

GOME and SCIAMACHY satellite UV/vis instruments

- on sun-synchronous orbits
- global coverage within 3 (6) days
- spatial resolution 320x40 (60x30) km^2

Bremian DOAS Network for Atmospheric Measurements (BREDOM)

- High-sensitivity ground-based MAX-DOAS-instruments for stand-alone operation
- Zenith-sky and horizon (off-axis) viewing mode
- Two tropical stations (Nairobi and Merida)

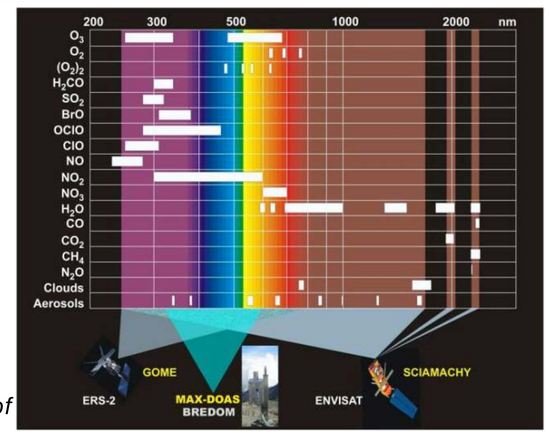


Fig 1: *Spectral coverage of instruments used in this study.*

Model LMDz-INCA

- LMDz (Laboratoire de Meteorologie Dynamique, zoom) is a grid point General Circulation Model (GCM)
- horizontal resolution of 3.75 degrees in longitude and 2.5 degrees in latitude, 19 vertical sigma-p levels extending from the surface to 3 hPa
- Interactive Chemistry and Aerosols (INCA) model integrated into LMDz
- INCA simulates tropospheric chemistry, emissions and deposition of primary tropospheric trace species including non-methane hydrocarbons
- INCA chemical scheme includes 85 chemical species and 303 chemical reactions, details in Hauglustaine et al., [2004] and Folberth et al., [2004].
- The simulation used in this study was performed using the nudged version for meteorology (i.e. meteorological fields are relaxed toward the ERA40 reanalysis). Regarding the emissions, anthropogenic emissions are from the EDGAR V2.0 inventory (Olivier et al. 1996), biomass burning emissions are those of Van der Werf et al. (2003 and 2004), biogenic emissions are from GEIA and aircraft emissions are provided by the NASA. The output is for the time of the GOME overpass.

Validation

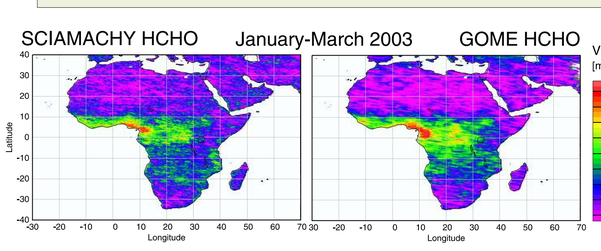


Fig 3: *Comparison between GOME and SCIAMACHY. Better spatial resolution for SCIAMACHY, but bias to higher latitudes.*

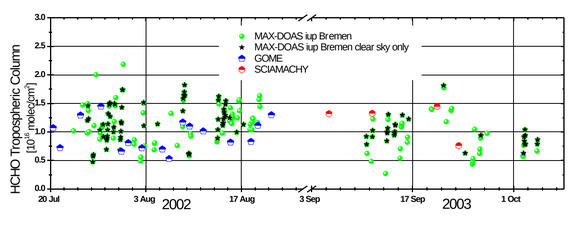
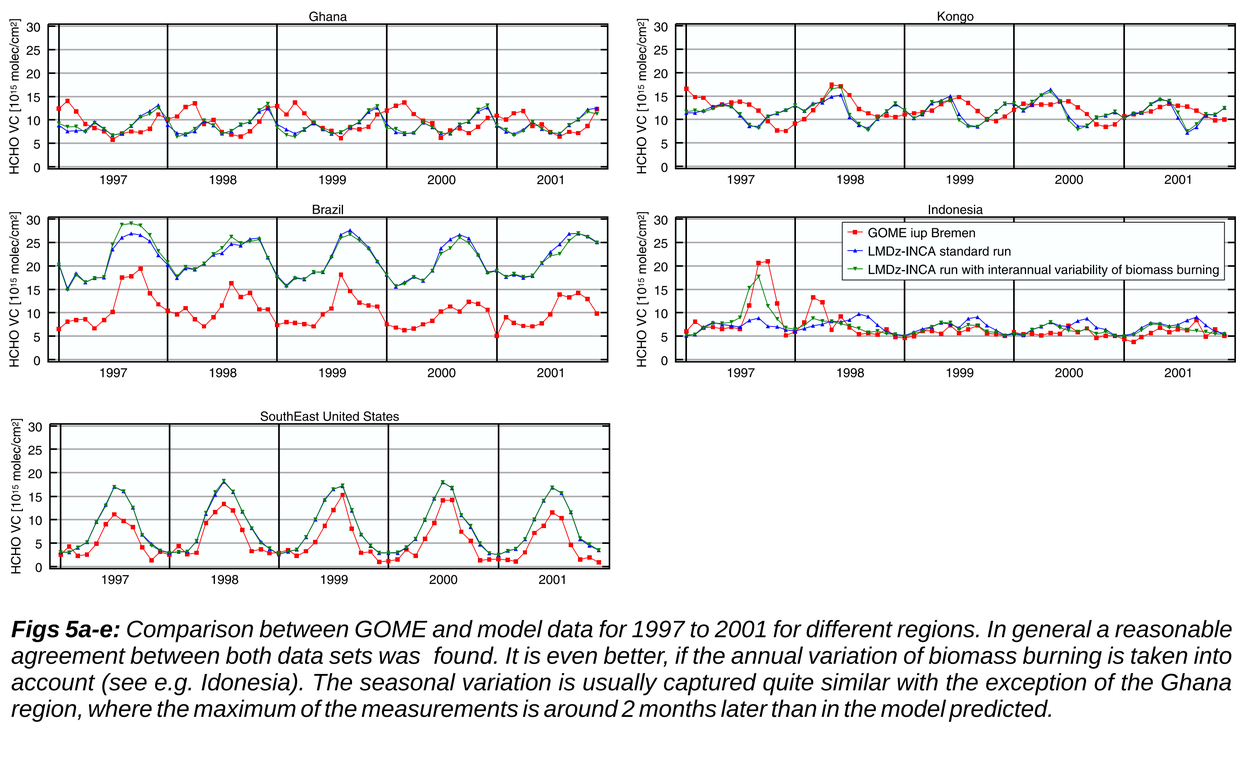


Fig 4: *Comparison between GOME/SCIAMACHY and MAX-DOAS data analysed with BREAM above Milano region (Alzate).*

- GOME data selected for SCIAMACHY nadir measurements
- ground-based values compared to satellite observations within 100 km radius

HCHO Time series from GOME and LMDz-INCA



Figs 5a-e: *Comparison between GOME and model data for 1997 to 2001 for different regions. In general a reasonable agreement between both data sets was found. It is even better, if the annual variation of biomass burning is taken into account (see e.g. Idonesia). The seasonal variation is usually captured quite similar with the exception of the Ghana region, where the maximum of the measurements is around 2 months later than in the model predicted.*

Conclusions

- continuous GOME nadir measurements of HCHO since July 1995
- SCIAMACHY HCHO available, but poorer quality at high latitudes
- agreement between different instruments quite o.k. at low latitudes
- MAX-DOAS instruments are able to validate the satellite measurements and provide a valuable link between in situ observations and satellite
- reasonable agreement between model and observations, but:
  - lower values in model above oceans, not an offset problem! at least in part outflow from continents ↔ long-lived NMVOCs from biogenic emissions?
  - significantly smaller values from satellite above the tropical rainforest in Brazil
  - in general a better agreement between model and observations is obtained for the run taking into account the annual variation of biomass burning

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Acknowledgements

This project has been funded in parts by:

- the German Federal Ministry of Education and Research (BMBF)
- the German Aerospace Agency (DLR)
- the German Research Council (DFG) and
- the State of Bremen and the University of Bremen
- the European Union (FORMAT, EVK2-2001-00085, RETRO, EVK2-CT-2002-00170)

We would like to thank the UNEP staff in Nairobi, the staff of the Koldewey station in Ny Ålesund and the Universidad de Los Andes, Merida for their assistance.

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