# GLOBAL OBSERVATIONS OF FORMALDEHYDE AND GLYOXAL WITH SPACEBORNE AND GROUND-BASED UV/VIS INSTRUMENTS

XY0129


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## Introduction

Formaldehyde (HCHO) and Glyoxal (CHOCHO) are **important indicators of hydrocarbon emissions and photochemical activity**

HCHO and CHOCHO sources

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

HCHO and CHOCHO sinks

- reaction with OH, photolysis

→ HCHO and CHOCHO are good tests for model oxidation mechanism and emission scenarios
→ they could be used as proxies for biogenic emissions (isoprene and monoterpene)

## 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 near to the equator assumed (normalisation) to account for instrumental drifts/inhomogeities - lookup table for AMF taking into account albedo, orography, aerosol and trace gas profile shape (in total 48.000 scenarios)
- from MAX-DOAS observations profile retrieval and tropospheric vertical columns using Bremian Advanced MAX-DOAS Retrieval Algorithm (**BREAM**, see also poster XY0181, Oetjen et al.)

## Experiments

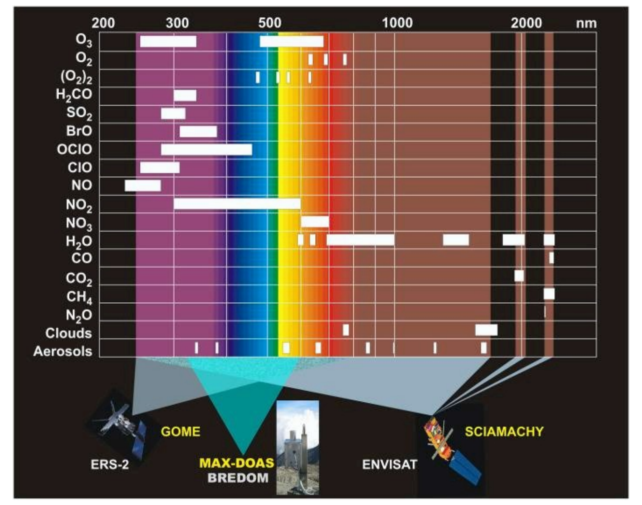


*Fig 1: Spectral coverage of instruments used in this study. Glyoxal (425 to 460 nm) is not marked in this illustration.*

**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
- four permanent stations (Ny-Alesund, Bremen, Nairobi and Merida)

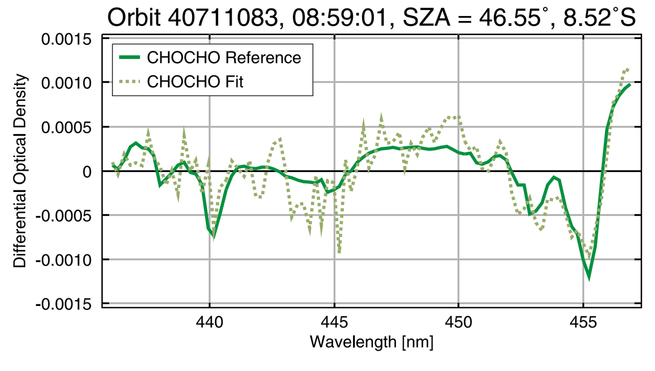


*Fig 2: Example of the laboratory (thick line) and observed (dotted line) DOAS fit spectrum for glyoxal (CHOCHO) using one SCIAMACHY measurement.*

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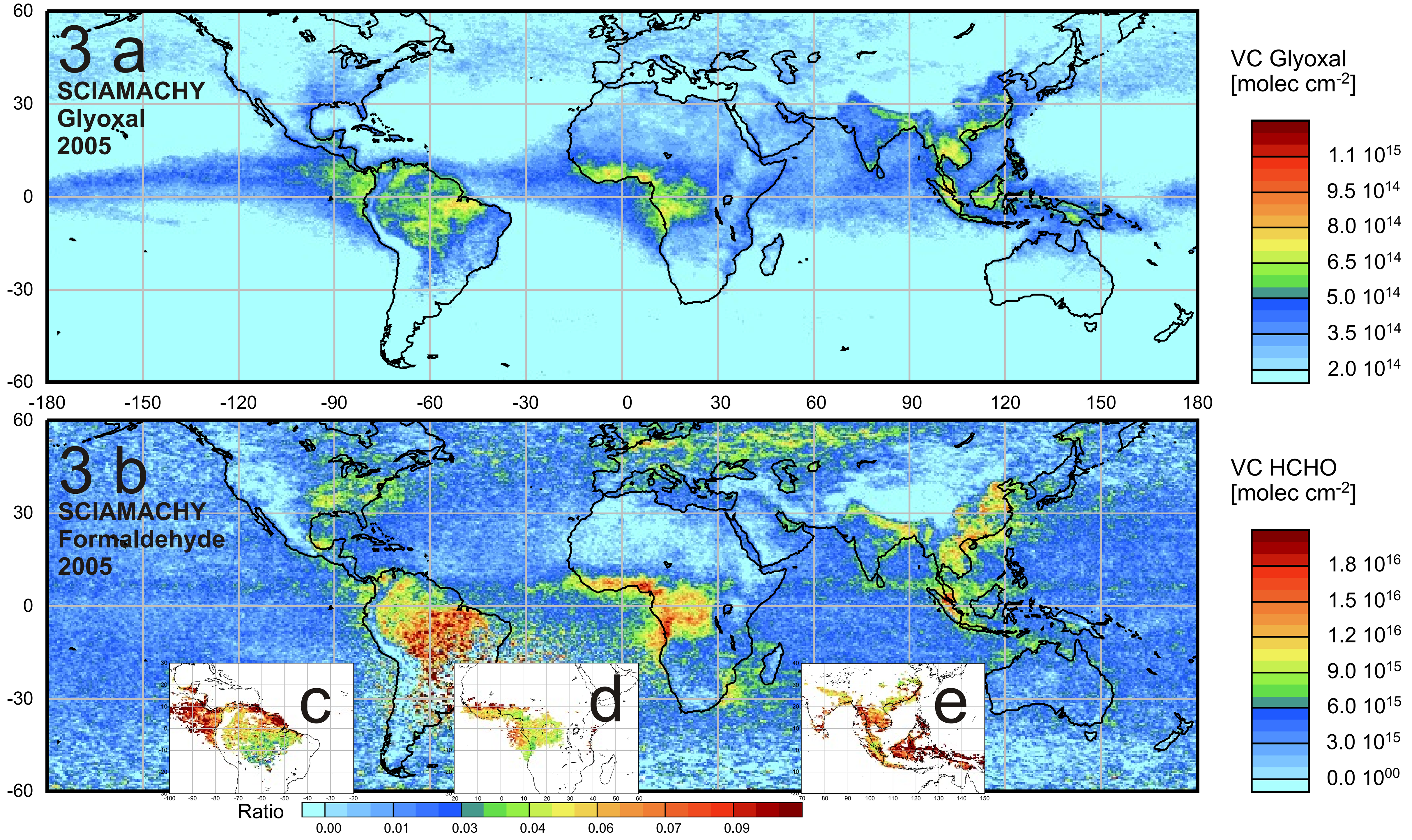
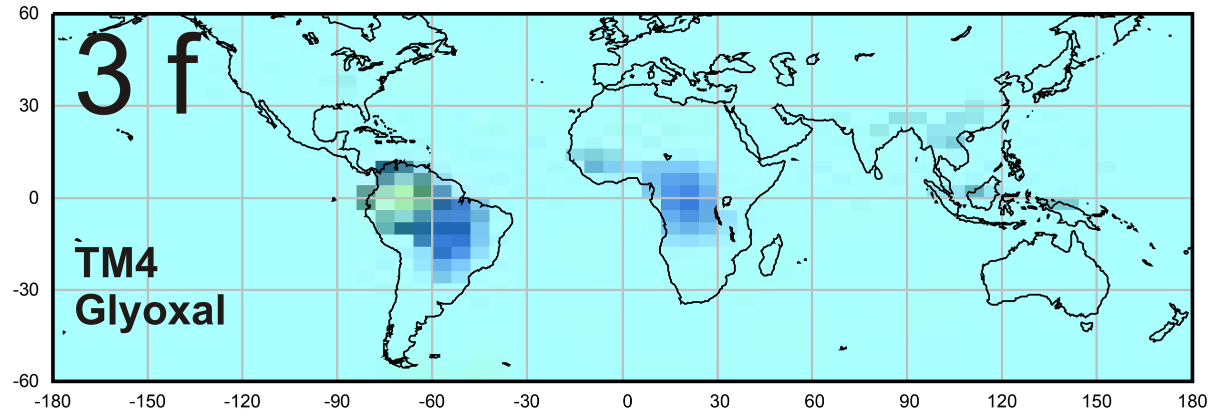
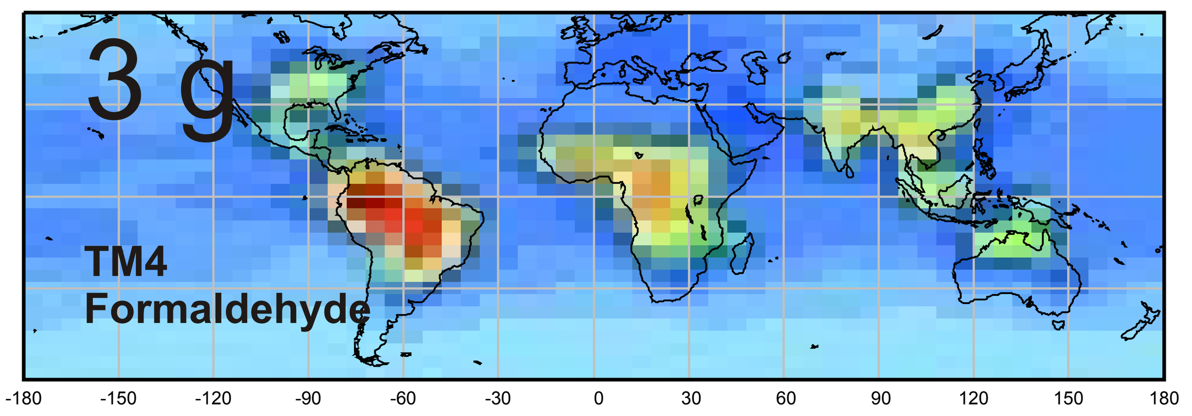
## Global View

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## Model TM 4 (ECPL)

- 3-D global model, forced by ECMWF meteorology
- horizontal resolution of 6 degrees in longitude and 4 degrees in latitude, 31 vertical levels extending from the surface to 3 hPa
- simulation of major aerosol components
- explicit $C_1$-$C_5$ hydrocarbon, terpene and aromatics chemistry
- no primary emissions of glyoxal
- emissions: 353 Tg/year isoprene, 112 Tg/year terpene, 243 Tg/year other VOC
- simulation of 2002 (2005 in preparation)

## Case Study Biomass Burning

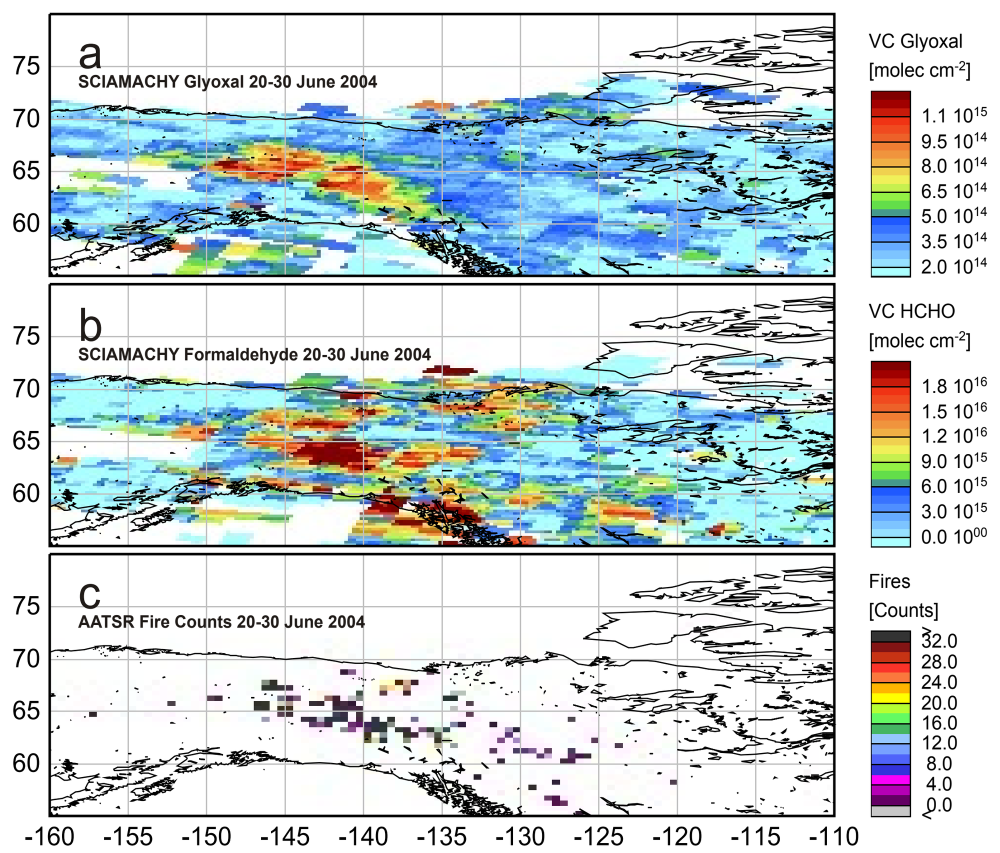


*Fig 4: Observations of glyoxal (a) and formaldehyde (b) during biomass burning in Alaska from 20 to 30 June 2004. Fire counts (c) are from the AATSR instrument.*

## First Validation

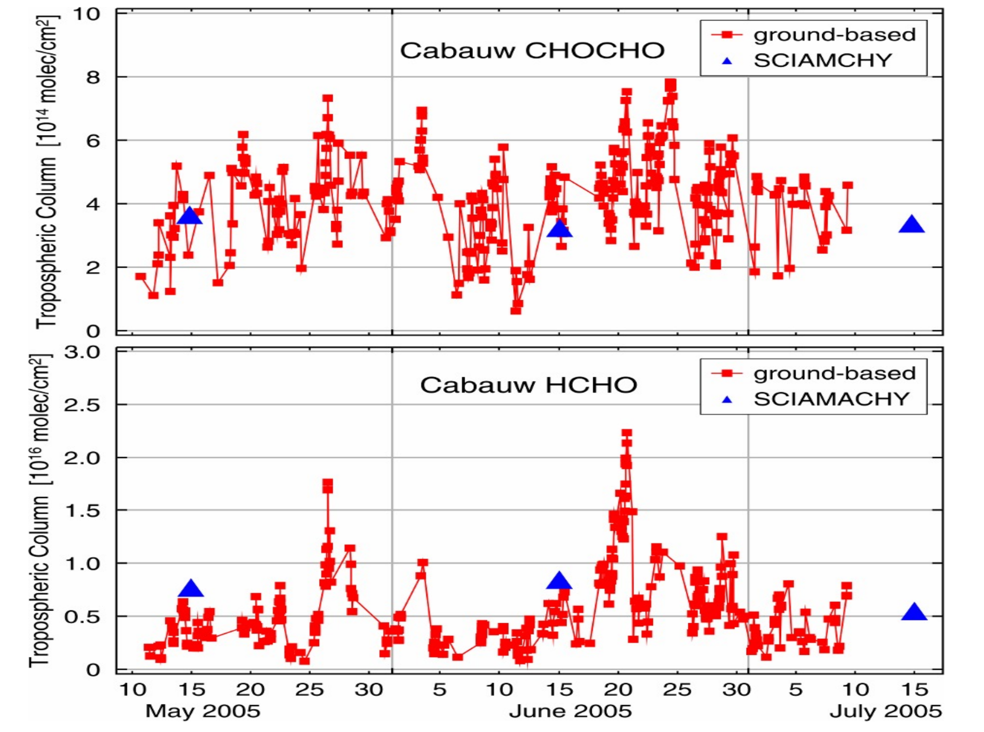


*Fig 5: Comparison between SCIAMACHY and MAX-DOAS observations of HCHO and CHOCHO above Cabauw (51°N, 5°E) during the DANDELIONS campaign. For the satellite, ground pixel within 100 km distance to the ground measurement site have been used to calculate monthly means.*

*Fig 3: **(a)** and **(b)** presents the first global annual composite of the CHOCHO and HCHO retrieved from SCIAMACHY. Enhanced CHOCHO column amounts are mainly observed in South America, Africa and Asia. In South America, high column values can be found in the Amazon Basin, the world's largest tropical rain forest, and low values are found over the Andes. In Africa, enhanced CHOCHO is found in regions having tropical rain forests and during biomass burning. In Asia, large values of CHOCHO are observed over Cambodia, Thailand, Sumatra, Borneo and particularly Nepal/ northern India. At first glance, the pattern observed for CHOCHO is similar to the global picture of HCHO, indicating common sources and life time. However, a closer look reveals some differences: the higher values of glyoxal are more closely clustered to the sources regions. This probably reflects the relatively short lifetime of CHOCHO. CHOCHO column amounts retrieved over water are influenced by an interference from liquid water absorption. This can lead to negative values above clear water regions. As can be seen in (a), several regions above the oceans exhibit significantly elevated CHOCHO amounts. This includes regions, which are known as biologically very active: e.g. near to the equator, at the Arabian Peninsula and close to the coast of China. As is the case for HCHO, the Pacific region between the Galapagos Islands and the coast of Colombia exhibit large amounts of CHOCHO. These observations are best explained by the outflow of terrestrial sources of the VOC precursors of HCHO and CHOCHO and the possible presence of biogenic VOC sources over the biogenically active oceanic regions. In **(c)-(e)**, the ratio derived from SCIAMACHY data is plotted for three different regions using only CHOCHO columns above a threshold of $5x10^{14}$ molec/$cm^2$ to avoid large scatter for ratios at low columns which are dominated by measurement noise. Overall, the range of ratios found is of the same order as the predicted value, supporting the current assumptions for CHOCHO formation. However, locally, significantly higher values are found, most likely resulting from additional formation mechanisms for CHOCHO.*
*The TM4-ECPL model computes column distributions of CHOCHO and HCHO (**(f)** and **(g)**) that are similar to those derived from SCIAMACHY. The model calculated annual mean values maximize in the tropics for both compounds over biogenic emission areas. However, the model does not capture the enhancement of CHOCHO columns over the tropical ocean seen in SCIAMACHY observations, which might indicate the existence of tropical sources (primary or secondary) of CHOCHO that are not taken into account in the model.*

## Conclusions

- global observations of HCHO and CHOCHO are possible using measurements of the SCIAMACHY instrument
- the global pattern of glyoxal columns was found to be similar to that of formaldehyde, indicating similar atmospheric sources
- the ratio between glyoxal and formaldehyde was found to be about one to twenty for source regions like tropical rain forests
- a first comparison of the columns retrieved from SCIAMACHY measurements with results from ground-based MAX-DOAS measurements shows reasonable aggreement
- a 3-d global CTM simulates the observed CHOCHO and HCHO annual mean columns reasonably well
- during strong biomass burning events CHOCHO and HCHO can also be observed as demonstrated for the 2004 fires in Alaska
- more detailed comparisons between measurements and model results should provide better constraints for VOC chemistry in current atmospheric models

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