# INVESTIGATION OF TRACE GAS TO AEROSOL RELATIONSHIPS OVER BIOMASS BURNING AREAS USING DAILY SATELLITE OBSERVATIONS

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## ABSTRACT

We investigate the spatial and temporal relationships between satellite observations of selected trace gases (CO, $NO_2$, HCHO, CHOCHO), the UV aerosol index (UVAI) and the aerosol optical depth (AOD) measured either by satellite or from ground. In contrast to previous studies we use daily observations, since only from daily observations information on individual biomass burning events can be obtained. Unlike the AOD, satellite observations of trace gases and UVAI are possible in the presence of clouds. This might be important for the study of aerosol-cloud-interactions.

## 1. INTRODUCTION

The quantification and characterization of aerosol properties from space is a great challenge. Especially in the presence of clouds and over land surfaces, it is often difficult to distinguish the signals of aerosol scattering from scattering by cloud particles or surface reflection. Instead of deriving aerosol properties directly, information on aerosol properties might be also derived from satellite observations of tropospheric trace gases and the so called UV aerosol (absorbing) index (UVAI), which is an indicator of the aerosol absorption [1, 2, 3, 4]. Such observations have two potential advantages: First, from the composition of trace gases, additional information on the aerosol type can be derived. Second, such observations are possible in the presence of clouds (although usually with reduced sensitivity if the trace gas is located below the cloud).

In this feasibility study we investigate the relationship between satellite observations of tropospheric trace gases (CO, NO2, HCHO, CHOCHO), the UVAI and AOD (measured from satellite or ground). In contrast to previous studies (e.g. [5]) we investigate daily observations (instead of monthly averages). The focus of our study is on aerosol emissions from biomass burning, which have a strong impact on atmospheric chemistry and the atmospheric energy budget through direct and indirect effects.

## 2. DATASETS

In this study we mainly use satellite observations. Fire counts derived from AATSR are obtained from ESA (http://shark1.esrin.esa.it/ionia/FIRE/). Cloud fraction and AOD retrieved from MODIS are obtained from NASA (http://neo.sci.gsfc.nasa.gov). Note that fire counts and AOD can only be obtained for cloud-free conditions. CO vertical column densities (VCD) retrieved from MOPITT are obtained from NASA Langley Research Center, (http://eosweb.larc.nasa.gov/PRODOCS/mopitt/table_mopitt.html.). Here it should be noted that MOPITT CO data are only retrieved for clear sky conditions. UVAI data are retrieved from SCIAMACHY (http://www.temis.nl). The remaining trace gas data ($NO_2$, CO, HCHO, CHOCHO) are analysed from SCIAMACHY measurements using algorithms developed in our group (see e.g. [6, 7]). Note that for CO the VCD, and for HCHO and CHOCHO the slant column density (SCD), and for NO2 either the VCD or SCD are retrieved. The trace gas data are analysed for all SCIAMACHY observations including clear and cloudy conditions. In addition to the satellite data, also AERONET observations (http://aeronet.gsfc.nasa.gov/ new_web/index.html, see also [8]) from the following stations are used: Abracos Hill in South America (-10.75°, 62.35°W), Mongu in Africa (15.25°S, 23.15°E), Bac Giang in South Asia (21.28°N, 106.22°E).

## 3. SPATIAL PATTERNS OF BIOMASS BURNING EMISSIONS

In Fig. 1 maps of several quantities derived from satellite observations over South America and Africa for two selected months (September and December 2004) are shown. During these months, many biomass burning fires were observed in both continents (Fig. 1 a). Similar patterns of enhanced values are also found for the other measurements (AOD, UVAI and trace gases). Although monthly averages are shown, for some quantities (e.g. the AOD) still gaps occur in some regions, which are caused by persistent cloud cover. Fig. 2 shows a similar study, but now observations for one selected day are presented. On this day enhanced values of the AOD, UVAI and trace gases are found over a biomass burning area in South America. The MODIS cloud cover data shown in Fig. 2a indicate that most of the continent was covered by clouds. Thus AOD and CO VCDs could only be retrieved for the remaining cloud free regions. In contrast, enhanced values of the other trace gases and the UVAI are found also for cloudy areas. This finding demonstrates the great potential of trace gas and UVAI observations to provide information on aerosols also in the presence of clouds.

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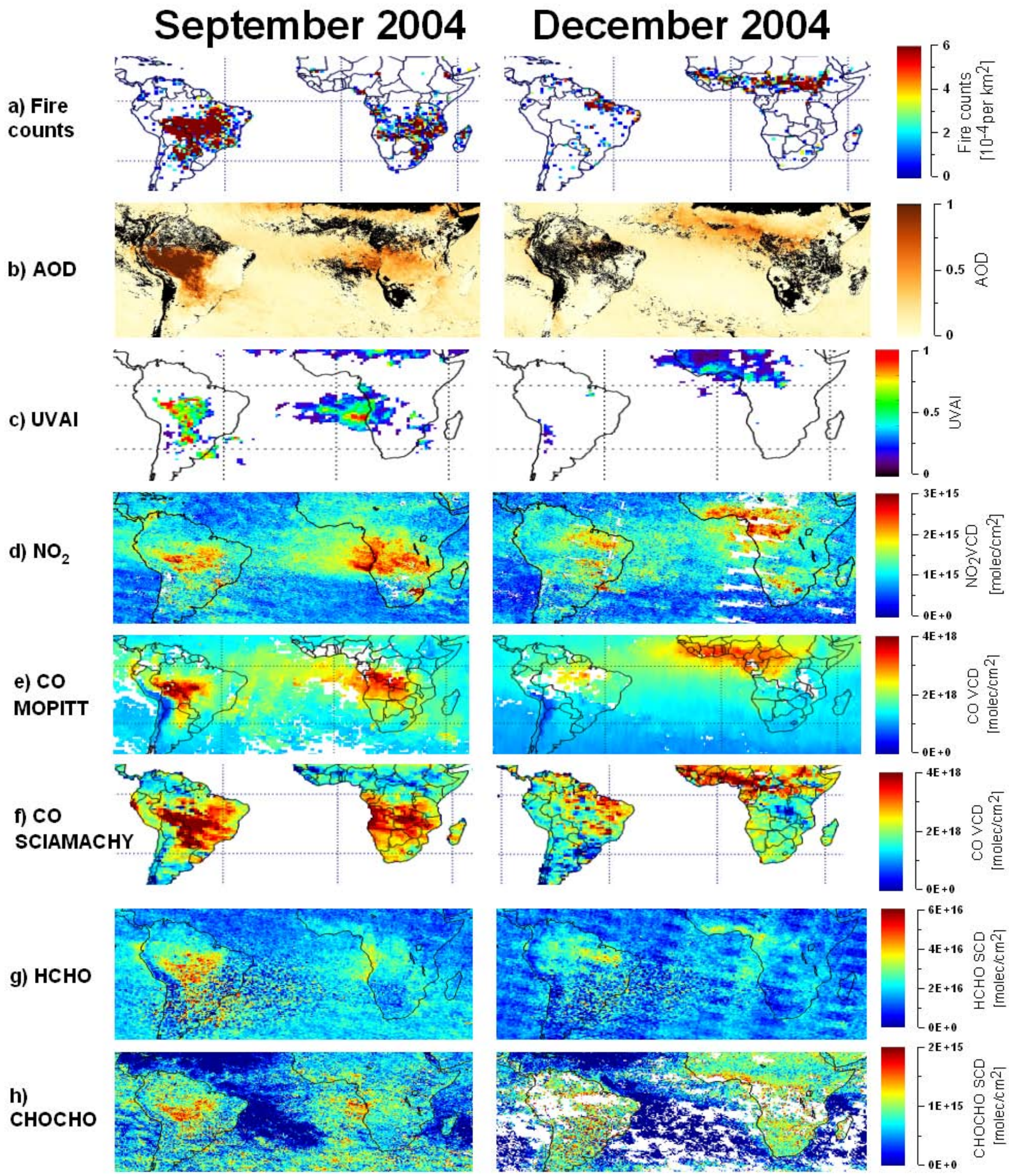


Figure 1. Monthly averages (left: September 2004, right: December 2004) for different quantities retrieved from satellite observations over biomass burning regions. a) Fire counts derived from AATSR (obtained from ESA, http://shark1.esrin.esa.it/ionia/FIRE/), b) AOD retrieved from MODIS (http://neo.sci.gsfc.nasa.gov), c) UVAI retrieved from SCIAMACHY (http://www.temis.nl), d) NO2 VCD retrieved from SCIAMACHY, e) CO VCD retrieved from MOPITT for clear sky conditions (from NASA Langley Research Center, http://eosweb.larc.nasa.gov/PRODOCS/mopitt/table_mopitt.html.), f) CO VCD retrieved from SCIAMACHY g) HCHO SCD retrieved from SCIAMACHY, h) CHOCHO SCD retrieved from SCIAMACHY. Observations from SCIAMACHY (UVAI, NO2, CO, HCHO, and CHOCHO) are averaged for all (clear and cloudy sky) observations. NO2, CO (SCIAMACHY) HCHO, and CHOCHO are from retrievals of the MPI for Chemistry, Mainz.

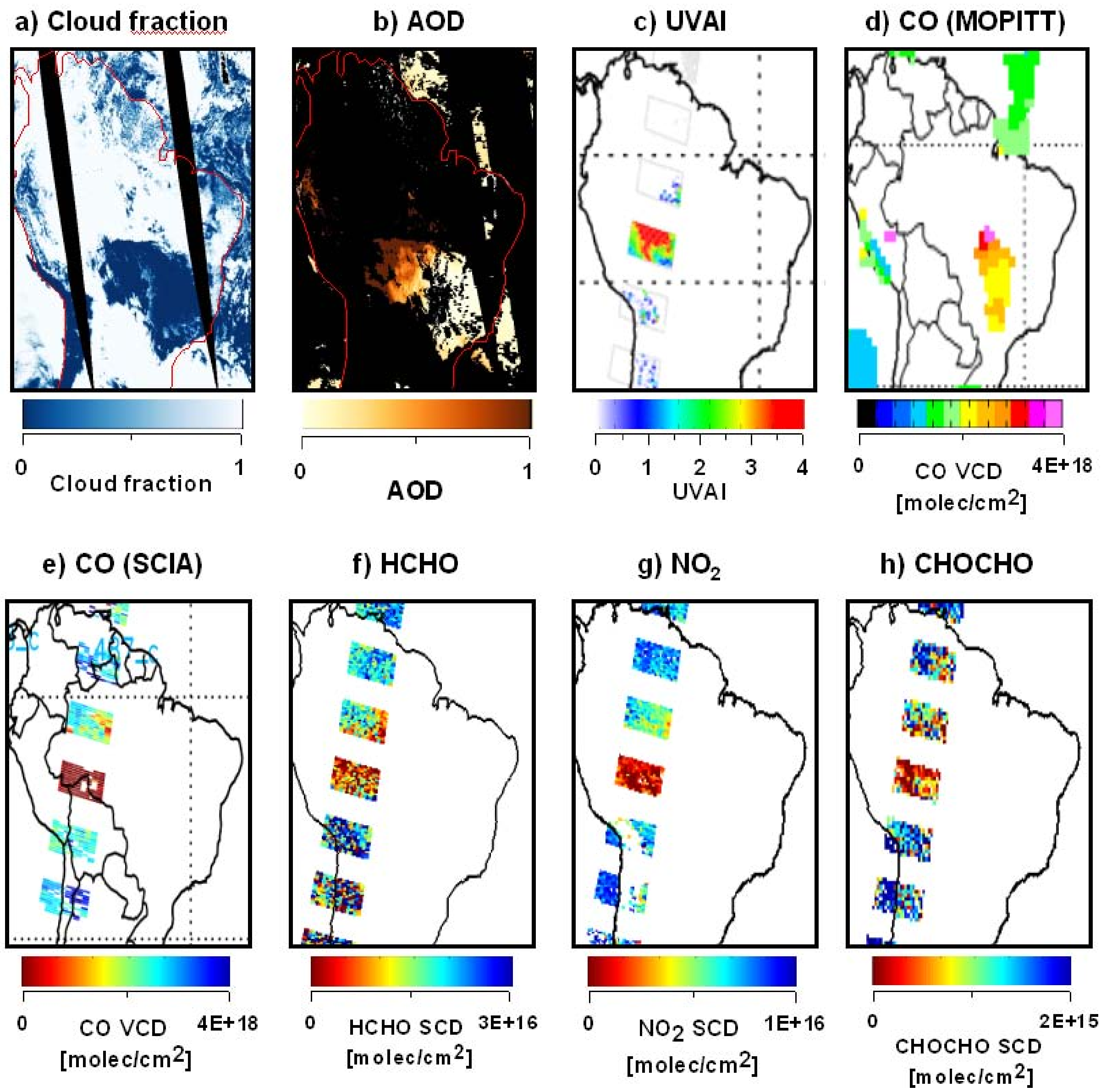


Figure 2. Daily observations (12 September 2004) for different quantities retrieved from satellite observations. a) cloud fraction derived from MODIS (http://neo.sci.gsfc.nasa.gov), b) AOD retrieved from MODIS (http://neo.sci.gsfc.nasa.gov), c) UVAI retrieved from SCIAMACHY (http://www.temis.nl), d) CO VCD retrieved from MOPITT for clear sky conditions (from NASA Langley Research Center, http://eosweb.larc.nasa.gov/PRODOCS/mopitt/table_mopitt.html), e) CO VCD retrieved from SCIAMACHY, f) HCHO SCD retrieved from SCIAMACHY, g) NO2 SCD retrieved from SCIAMACHY, h) CHOCHO SCD retrieved from SCIAMACHY. Observations from SCIAMACHY (UVAI, CO, NO2, HCHO, and CHOCHO) show results for clear and cloudy observations.

## 4. TIME SERIES AND CORRELATION STUDIES

In Fig. 3 time series of selected quantities are shown for the location of the AERONET the station Abracos Hill (-10.75°, 62.35°W). The satellite data were extracted within ±0.6° latitude and ±0.3° longitude around the AERONET stations. Enhanced values of fire counts AOD, UVAI and trace gases are found regularly at the end of summer. The clearest enhancements during these periods are seen in the AOD, CO and UVAI. In Fig. 4 correlation analyses of the time series at Abracos Hill are presented: Daily values of the UVAI and trace gas data are plotted versus the respective AERONET AOD. Clear correlations are found for the CO and UVAI data. But also for $NO_2$ and HCHO still correlation coefficients of 0.36 and 0.28 are found, respectively.

Similar correlation studies are performed for the other AERONET stations, and the respective slopes and correlation coefficients are presented in Fig. 5. Also for the other stations enhanced correlation coefficients were found for most trace gases (albeit smaller than for Abracos Hill). Interestingly, the slopes of the regression lines are similar for the different stations (except for cases with low r²).

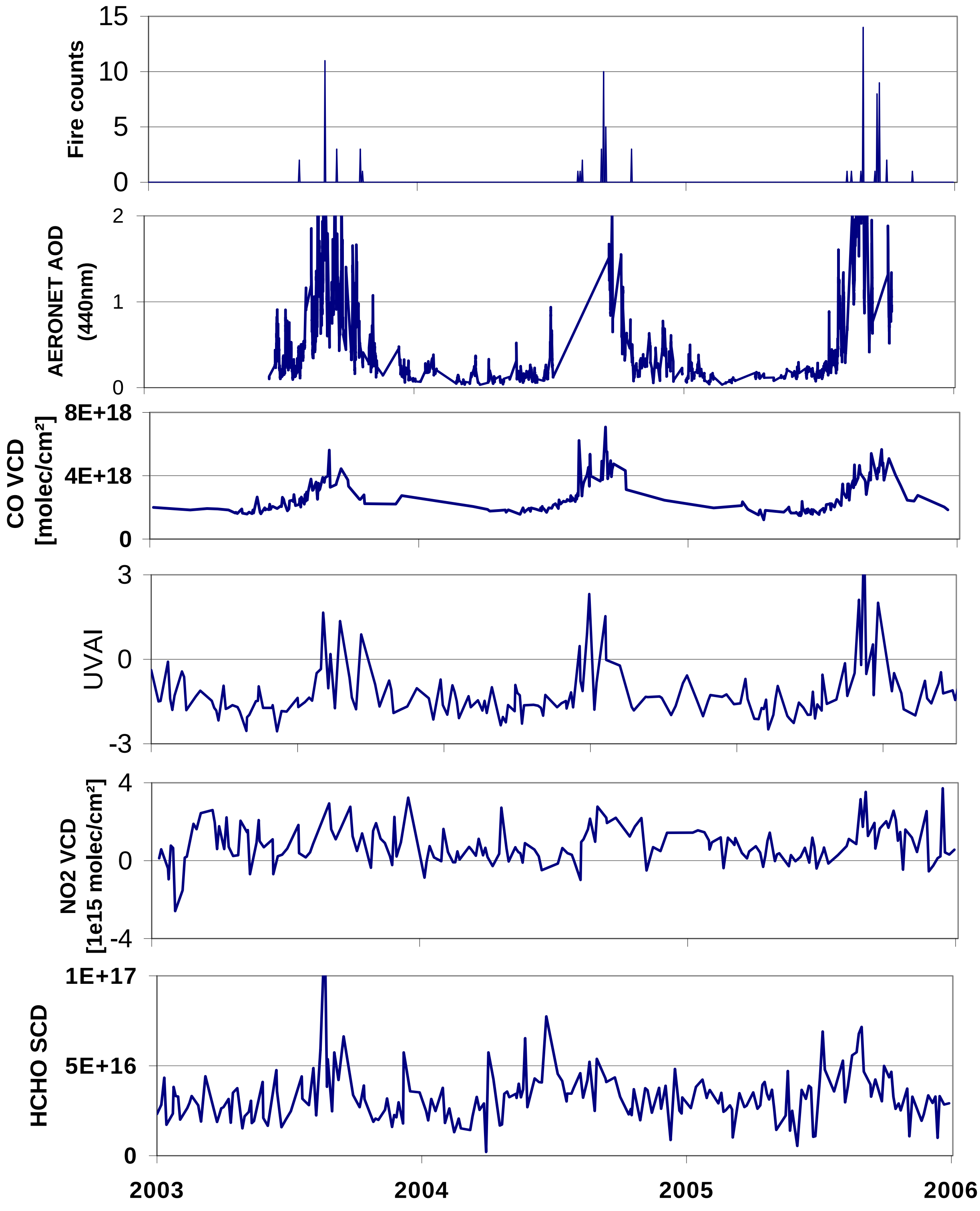


Figure 3. Time series of satellite observations of fire counts, UVAI and several trace gases around the AERONET station Abracos Hill in South America (-10.75°, 62.35°W). Also shown is the AOD measured by the AERONET station. Enhanced values of all quantities are regularly observed during the biomass burning region at the end of summer.

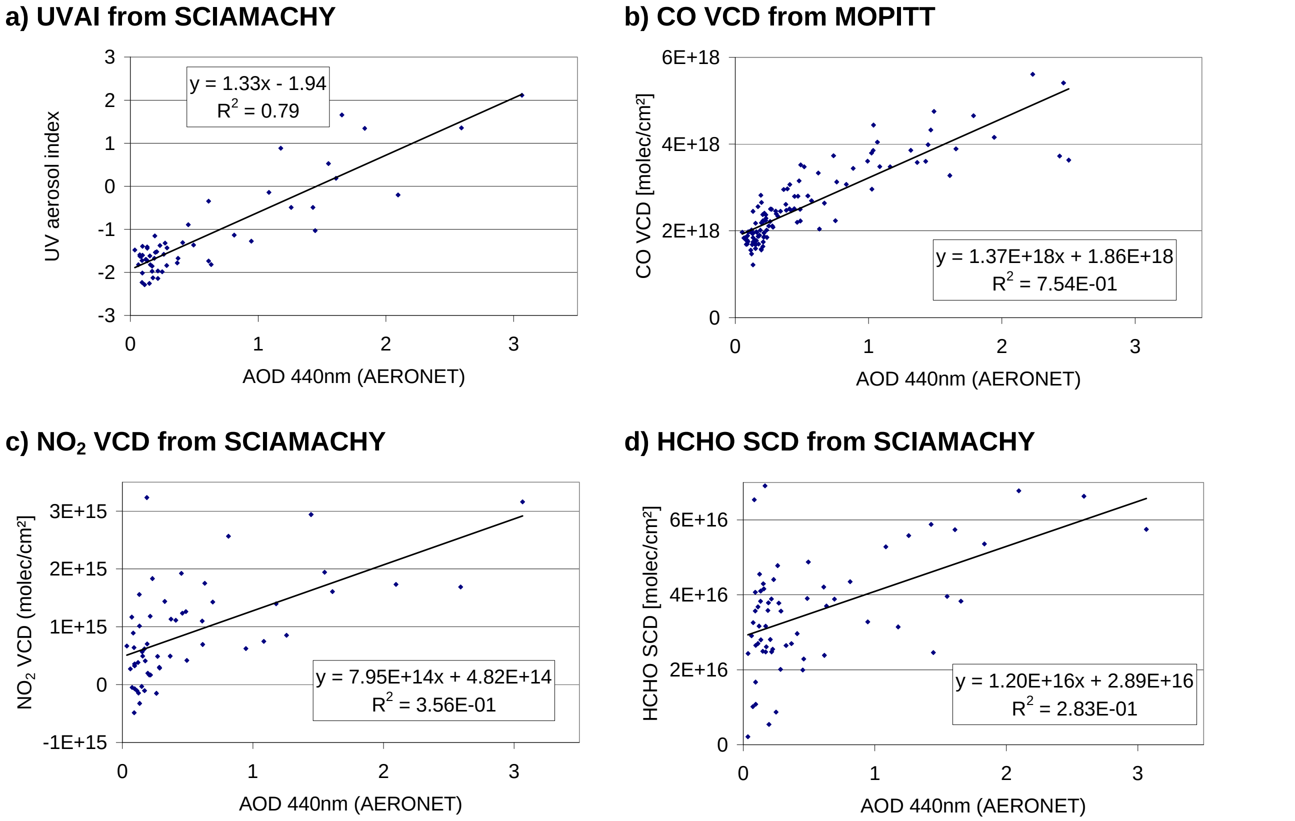


Figure 4. Correlation analyses between daily satellite observations of a) the UVAI, b) the CO VCD, c) the $NO_2$ VCD and d) the HCHO SCD versus coincident AOD observations (daily averages) from the AERONET sun photometer at Abracos Hill in South America (-10.75°, 62.35°W).

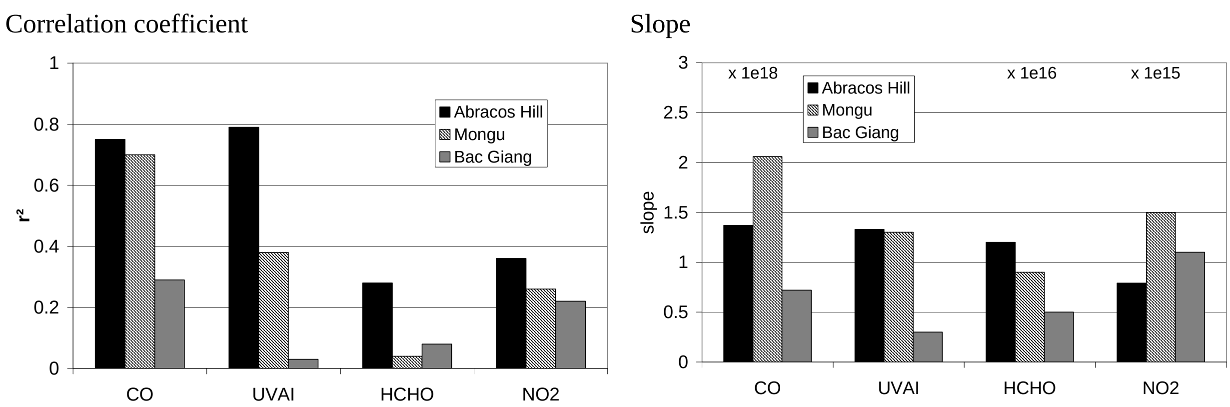


Figure 5. Results of correlation analyses for selected AERONET stations: Abracos Hill in South America (-10.75°, 62.35°W), Mongu in Africa (15.25°S, 23.15°E), Bac Giang in South Asia (21.28°N, 106.22°E).

## 5. CONCLUSIONS

We investigated the suitability of satellite measurements of trace gases (CO, $NO_2$, HCHO, CHOCHO) and the UVAI to identify and characterise aerosols over biomass burning regions. Similar spatial patterns of these quantities and AOD and fire counts are found in monthly averages but also in daily maps. We also investigated the temporal variation of the selected quantities based on daily observations around selected AERONET stations. In most cases similar temporal patterns were found indicating the general suitability of the selected quantities to serve as aerosol proxies. Since the trace gases and the UVAI can be analysed in the presence of clouds, these aerosol proxies might be useful for the investigation of aerosol-cloud interactions.

## 6. ACKNOWLEDGEMENTS

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