MAX-DOAS observation of CHOCHO, HCHO and NO_2 over Nairobi and Athens

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1. Introduction

- Glyoxal (CHOCHO) and formaldehyde (HCHO) are intermediate products in the oxidation of most volatile organic compounds (VOC) in the atmosphere. They therefore can be used as tracers of VOC concentrations in the atmosphere. VOC are emitted by a wide range of natural and anthropogenic sources as well as during fire events.
- Nitrogen dioxide (NO_2) plays an important role in tropospheric ozone formation in combination with VOC, and is mainly emitted by anthropogenic activities. While sources and chemistry of CHOCHO and HCHO are similar in many respects, the variation in production efficiency for different sources can be used to better constrain source attribution of VOC.

In this study, we report time series of CHOCHO, HCHO, and NO_2 vertical columns (VCs) from MAX-DOAS measurements taken in Nairobi from 2011 to 2014 and Athens from 2013 to 2014, which are part of the Bremian DOAS Network for Atmospheric Measurements (BREDOM).

2. Retrieval

- The DOAS method, based on absorption spectroscopy, allows for the determination of atmospheric trace gases with narrow absorption bands in the ultraviolet and visible.
- The retrievals include all interfering species for each gas as detailed in table 1. The main result obtained using the DOAS method are the differential slant columns (SCs), which by using a geometric approximation are convert to VCs.

***Table 1**: Settings for the DOAS glyoxal, formaldehyde, and dioxide nitrogen retrievals .*

Parameters	CHOCHO	HCHO	NO_2
Fitting window	433-458 nm	335-357 nm	425-497 nm
Polynomial	3	2	4
Cross-sections	CHOCHO, O_3, NO_2 (220 K and 294 K), O_4, H_2O_{vapour}, Ring	HCHO, O_3 (223 K and 293 K), NO_2, O_4, BrO, Ring	NO_2 , O_3, O_4, H_2O_{vapour}, Ring

3. Nairobi (1°S, 37°E)

- Nairobi is located in Kenia in Africa. This city has a population of about 3,375,000 habitants and a population density of 4,850 habitants/km^{2}.
- The instrument is performing measurements using the Multi-Axis-DOAS (MAX-DOAS) configuration, which is mainly sensitive for trace gases in the troposphere. Fig. 1 shows an example of glyoxal SCs for the different elevation angles that the instrument is measuring. The figure shows a clear separation between the different elevation angles, whit the maximum in SC around 11:00 local time.

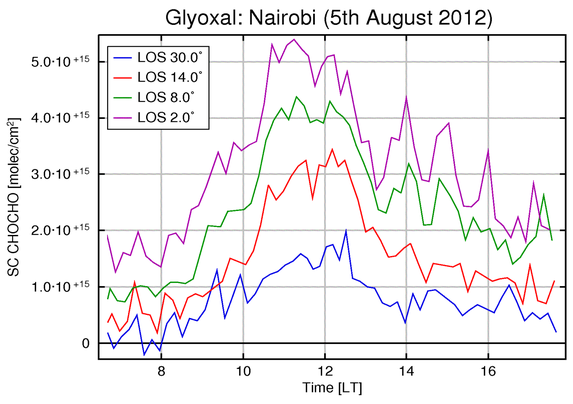
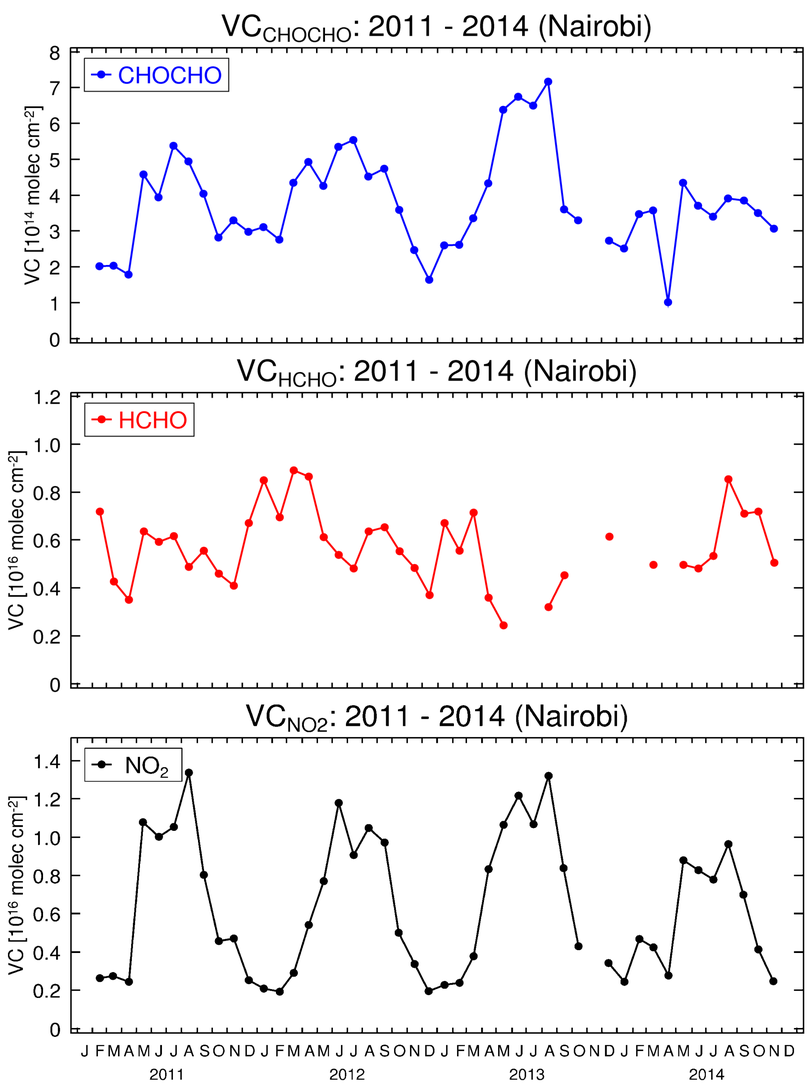


***Fig. 1:** Glyoxal SCs retrieved from measurements taken at elevation angles of 2°, 8°, 14°, and 30°. The miximum SC for all elevation angles are found around 11:00 local time.*

Time series of CHOCHO, HCHO and NO_2 vertical columns have been computed from 2011 to 2014 for Nairobi.

CHOCHO, HCHO and NO_2 shown a clear seasonal variability, which is more pronounced for glyoxal and NO_2 with their respective maxima corresponding to Jun-Jul-Aug, the major growing season (wet season) and with minima in Dec-Jan-Feb (dry season). For HCHO, the maxima are found in Dec-Jan-Feb, but also some higher amounts are also found in Jun-Jul-Aug. In addition, glyoxal shows a significant increase in 2013 in comparison to the years 2011 and 2012.



4. Athens (38°N, 23°E)

- Athens is located in Greece and has a population of about 3,158,400 habitants and a population density of 19,133 habitants/km^{2}.
- The instrument is performing measurements at different elevation angles over Athens in eight viewing directions (see Fig. 2): ocean, airport, city (R, S, T), olympic stadium, northern suburbs, and biogenic background. However, in this study only results from measurements in the direction T are presented.
- An example of HCHO SCs over Athens at the different viewing directions are presented in the Fig. 3.

***Fig. 2**: . Location and viewing direction over Athens.*

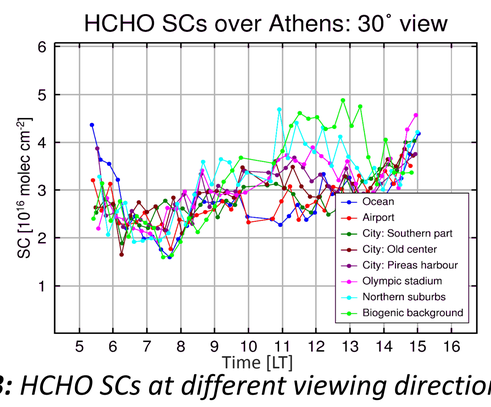
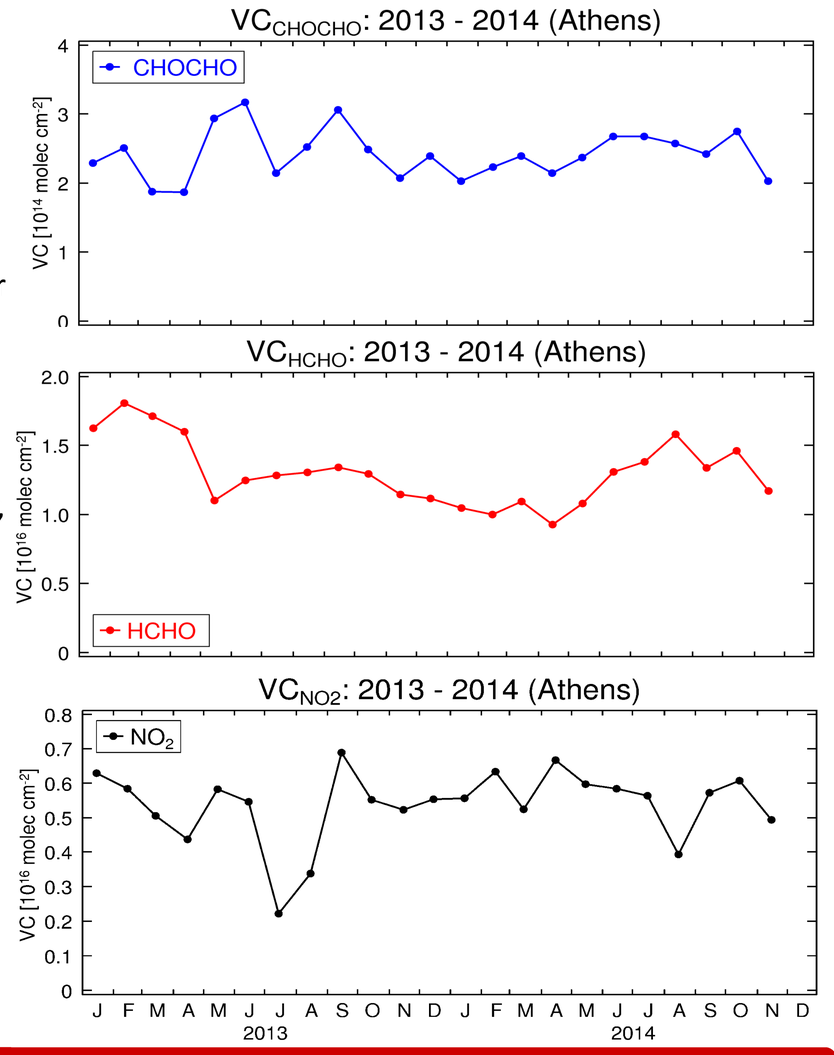


***Fig. 3:** HCHO SCs at different viewing directions. The SCs show similar behavior over ocean and airport direction, but these are in contrast with others direction.*

Similar to Nairobi, time series of CHOCHO, HCHO and NO_2 vertical columns have been computed between 2013 and 2014 for Athens.

In contrast to Nairobi, in Athens, no clear seasonal variability is observed for the three species. However, minima in NO_2 are found during August for both years. This could be related to a decrease of NO_x emissions during this period (summer vacations) or prevailing northerly winds. In addition, HCHO show high VC amounts for Jan-Feb-Mar 2013 and Jun-Jul-Aug 2014.



5. Summary and Outlook

- The MAX-DOAS technique provides valuable information on tropospheric CHOCHO, HCHO and NO_2. CHOCHO, HCHO and NO_2 time series have been obtained for Nairobi and Athens, showing a clear seasonality for Nairobi and no clear variability over Athens. The difference between the time series for the two stations could be related to the different emission sources (Nairobi mainly biogenic and Athens anthropogenic).
- Further work has to be done in order to get more information of CHOCHO, HCHO, and NO_2 levels over Athens and Nairobi: calculation of vertical profiles, contrast with climatological information (temperature, wind speed, etc.), computation of ratio of CHOCHO to HCHO and HCHO to NO_2.

6. Selected references

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7. Acknowledgements

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