DOAS measurements of NO₂ at Kinshasa and Comparisons with Satellites Observations

Rodrigue Yombo Phaka, Gaia Pinardi, Alexis Merlaud, Emmanuel Mahieu, Martina Friedrich, Caroline Fayt, François Hendrick, Michel Van Roozendael, Lars Jacob, Richard Bopilli Mbotia Lepiba
1. Université de Kinshasa, Faculté des Sciences, Dept de Physique, 2. ULiège, GIAPAS, Institute of Astrophysics and Geophysics, 3.Institut Royal d’Aéronomie Spatiale de Belgique (BIRA-IASB)

*rodrigueyombo@gmail.com

1. Introduction

Kinshasa, the capital of the Democratic Republic of Congo is affected by air pollution as shown by several scientific researches and the latest WHO reports [WHO, 2006]. The Royal Belgian Institute of Space Aeronomy (BIRA-IASB) in collaboration with the University of Kinshasa (UniKin), have installed in May 2017 an optical remote sensing instrument on the UniKin site (4°42’S, 15°31’E). Since then, the instrument has been in operation and provides data to measure the column amounts of several polluting species above Kinshasa.

2. The KinAero instrument

The KinAero instrument was installed above the roof of the Faculty of Sciences of the UniKin. The instrument is based on a compact AVANTES spectrometer covering the spectral range 290 - 450 nm with 0.7 nm resolution. The spectrometer is a Czerny-Turner type with an entry slit of 50 µm wide, and a grating of 1200 l/mm. A 10 m long and 600 µm diameter optical fiber is connected to the spectrometer to receive the light from the sky. In addition to the measurements in zenith geometry, we also used an amateur telescope (Nexstar) to perform measurements in Multi-axis mode (Honninger et al., 2004). Measurements were mainly made by looking in a fixed direction (90°, 35°).

3. Observation site

The city of Kinshasa is situated between latitudes 4.17° and 4.22° East and between longitudes 15.34° and 15.32° South, the city of Kinshasa is bounded to the West and North by the Congo River forming the natural border with the Republic of Congo Brazzaville (Fig a).

The sources of pollutants in and around Kinshasa are different from those found in Europe. For example, they include forest fires, open dumps, charcoal for domestic cooking, heavy road traffic, involving a majority of old vehicles (Fig b).

4. QDOAS settings

The recorded spectra were analyzed using the QDOAS software. The density of the NO₂ column was recovered in the 425-490 nm spectral region. Absorber cross sections such as NO₂, O₂, O₃, Ring were taken into account. In addition, a fifth degree polynomial was used to account for the contribution of broadband absorption. QDooas Settings: see Constantin et al. 2013

5. DSCD to tropospheric VCD conversion

\[ \text{VCD}_{\text{Tropo}} = \text{DSCD} - \text{SCD}_{\text{strat}} + \text{SCD}_{\text{res}} \]

\[ \text{DSCD} : \text{differential slant column density (obtained from the QDOAS analysis)} \]

\[ \text{SCD}_{\text{strat}} : \text{stratospheric component of slant column density} \]

\[ \text{SCD}_{\text{res}} : \text{residual column} \]

\[ \text{VCD}_{\text{Tropo}} : \text{Tropospheric NO}_2\text{ column densities} \]

6. A priori Information

The NO₂ profile (Fig. a) and climatology of Kinshasa, extracted from the simulation of the GEOS-Chem model (v 12.0.2). Data were extracted on a grid of 52 layers of 200 m thick between 1 and 12 km, 9 layers of 200 m thick between 12 and 30 km, and 6 layers of 500 m thick between 30 and 6 km. Our simulation covers the period from 2017 to 2019. The temperature and pressure profiles (Fig. b) used in this work come from global meteorological reanalysis of the European Centre for Medium-Range Weather Forecasts (ECMWF), taken over the 20-year period.

7. Components obtained with RTM

\[ \text{stratpheric SCD}_{\text{model}}(2017) \]

\[ \text{AMF}(90°) : \text{sensitivity test at different AODs} \]

UV/vis/Disort radiative transfer model RTM) [Mayer et al., 2005] coupled with a photochemical box-model PSCBox (Hendrick et al., 2014) was used to calculate the stratospheric column and the VUDORT (Fayt et al., 2014) was used to calculate tropospheric AMF. The NO₂ profile and the climatology as shown in the figures above were used to calculate tropospheric AMF.

8. Result and comparison

Examples of Tropospheric NO₂ column densities around OMI QA4ECV NO₂(+/-30 min)

9. Conclusion & future plans

We have presented in this paper some preliminaries comparisons of tropospheric vertical columns extracted from the one axis measurements (90° and 35°) made in Kinshasa. The comparisons made over a few days corresponding to the OMI observations give a slope of 0.43. The result of the comparison can be linked to the unknown NO₂ profile in Kinshasa and also to the coarse OMI horizontal resolution. The study will be further extended by exploiting data from the new MaxDOAS instrument installed in Kinshasa since November 2019 (see Fig. a) and the use of the GEOS-Chem model and TROPOMI comparison.