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# MAX-DOAS measurements of $NO_2$ and $H_2CO$ in the city of Kinshasa from 2019-2020

R. Yombo Phaka[1,2] (rodriguez2yombo@gmail,com), A. Merlaud[3], G. Pinardi[3], R. Bopili Mbotia Lepiba[2], E. Phuku Phuati[2], E. Mahieu[2], J-P. Mbungu Tsumbu[2]

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## SUBJECTS of the PRESENTATION:

- Installation of a new MAX-DOAS instrument in Kinshasa since November 2019(replacing an old instrument one axis: R. Yombo et al. 2020 (JTECH processing )
- Presentation of the first MAX-DOAS measurements of $NO_2$
- and $H_2CO$ (DSCDs and VCDtropo)
- First comparisons with Tropomi

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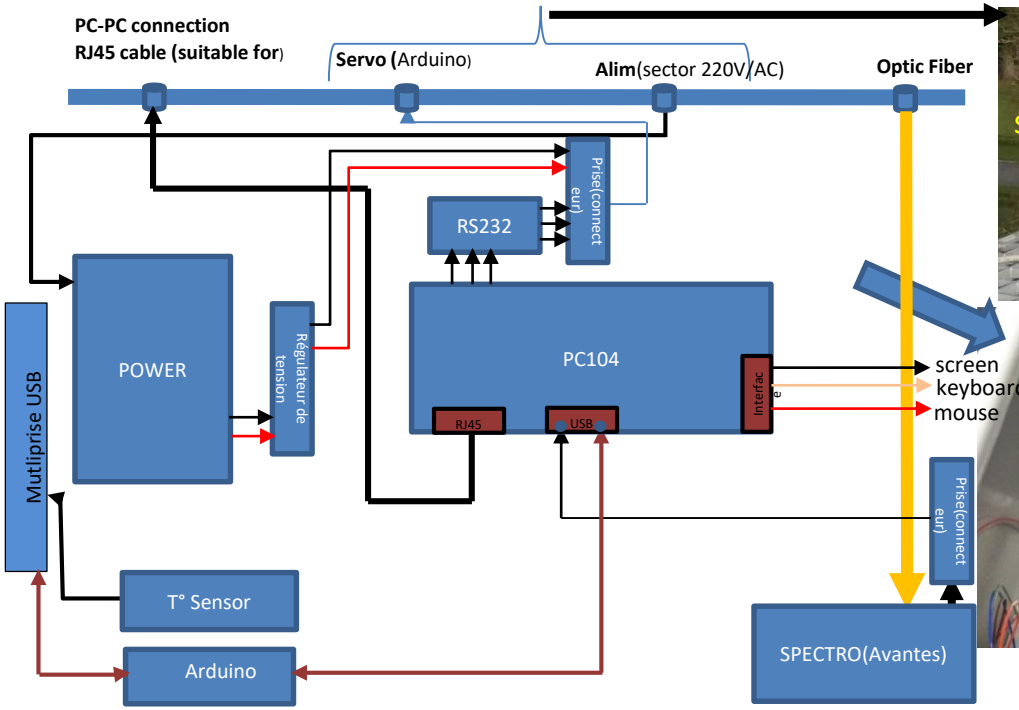
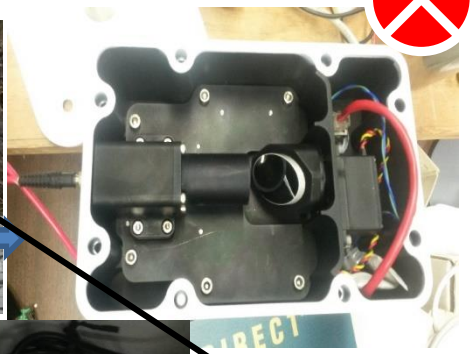
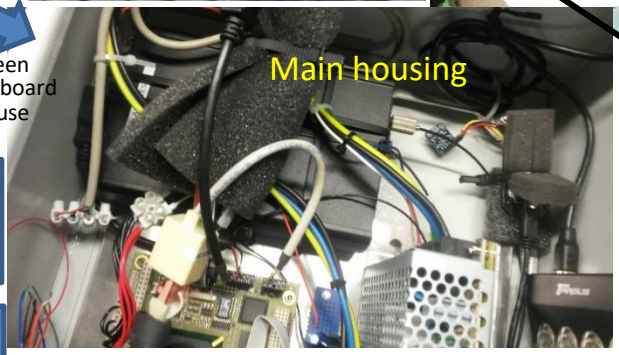
## Description Kinshasa MAX-DOAS instrument










Quartz window

Acquisition software developed at the IASB

spectro(280-550 nm, 0.7 nm FWHM), PC(104), Power supply with regulation, Acquisition Arduino card, connector (cables et plugs). 600 µm diameter fiber optic, 220V/AC, ethernet, RS-232 scanner control over RJ-45.

Elevation angle
0°,1°, 2°, 3°, 4°, 5°,6°, 7°,8°,15°,30°,45°,88°

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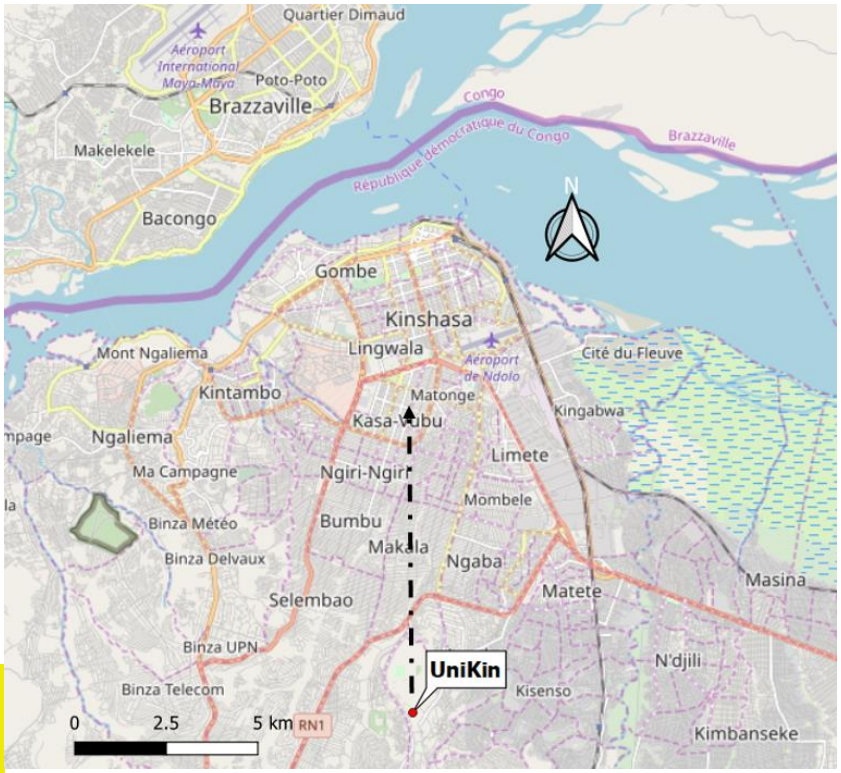


The city of Kinshasa, capital of the Democratic Republic of Congo (DRC) is the third largest city in Africa in terms of area. With an estimated population of 12 million in 2012 and it could reach 30 millions inhabitants by 63 2030 (UN 2016). Located between latitudes 4.30° and 4.50° South and longitudes 15.14° and 15.32° East, the city of Kinshasa is bounded on the West and North by the Congo River which forms the natural border with the Republic of Congo (see left Figure ). The MaxDOAS instrument as shown in the right Figure is installed at the University of Kinshasa, on the roof of the Faculty of Sciences (4.41 S, 15.31 E), 13 km from the river south of the city as indicated by the red dot in the left map. Kinshasa is in a hot and humid tropical climate, with a mean annual temperature of 25 C and a mean annual rainfall of 1,400 mm (Shomba Kinyamba et al. 2015). The city experiences two seasons: a rainy season and a dry season. The rainy season runs from mid-September to mid-May, with peaks of heavy rainfall in November and April. The dry season covers the period from mid-May to mid-September. The atmosphere of the city of Kinshasa is strongly influenced by clouds and aerosols, whose abundance varies with the seasons. In the vicinity of the city of Kinshasa, there are forest areas marked by forest fires, generally observed in the dry season.

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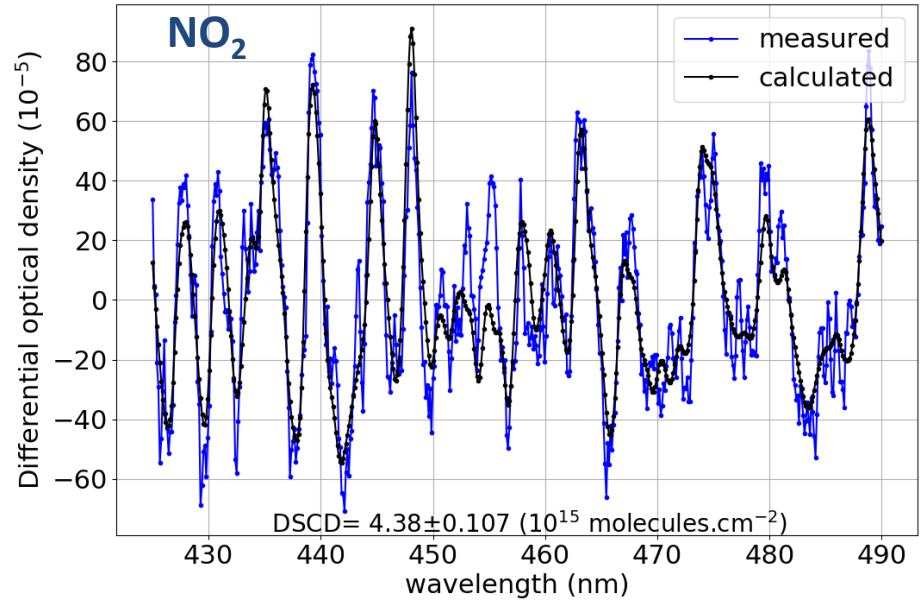
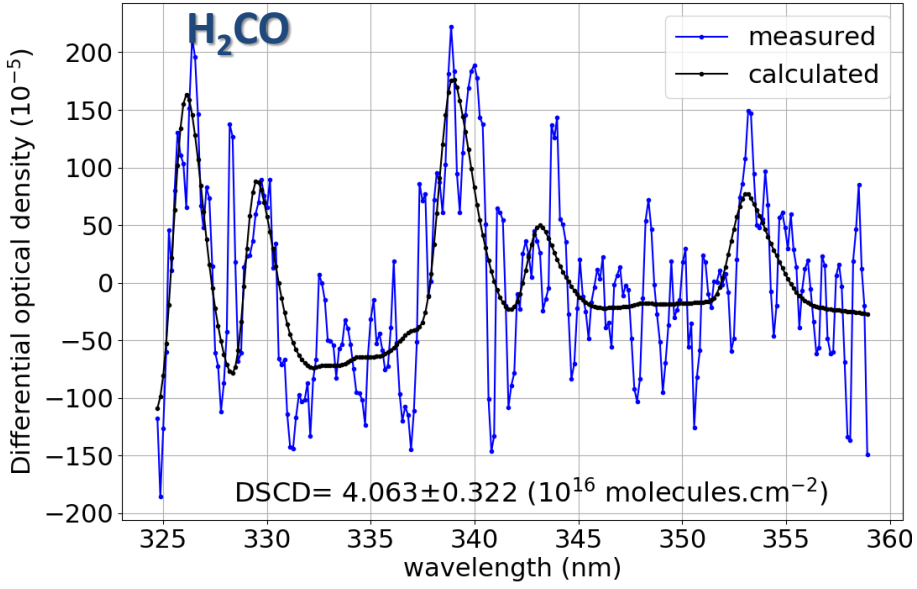
## QDOAS FIT EXAMPLE : 28 June 2020 (10:16 LT)

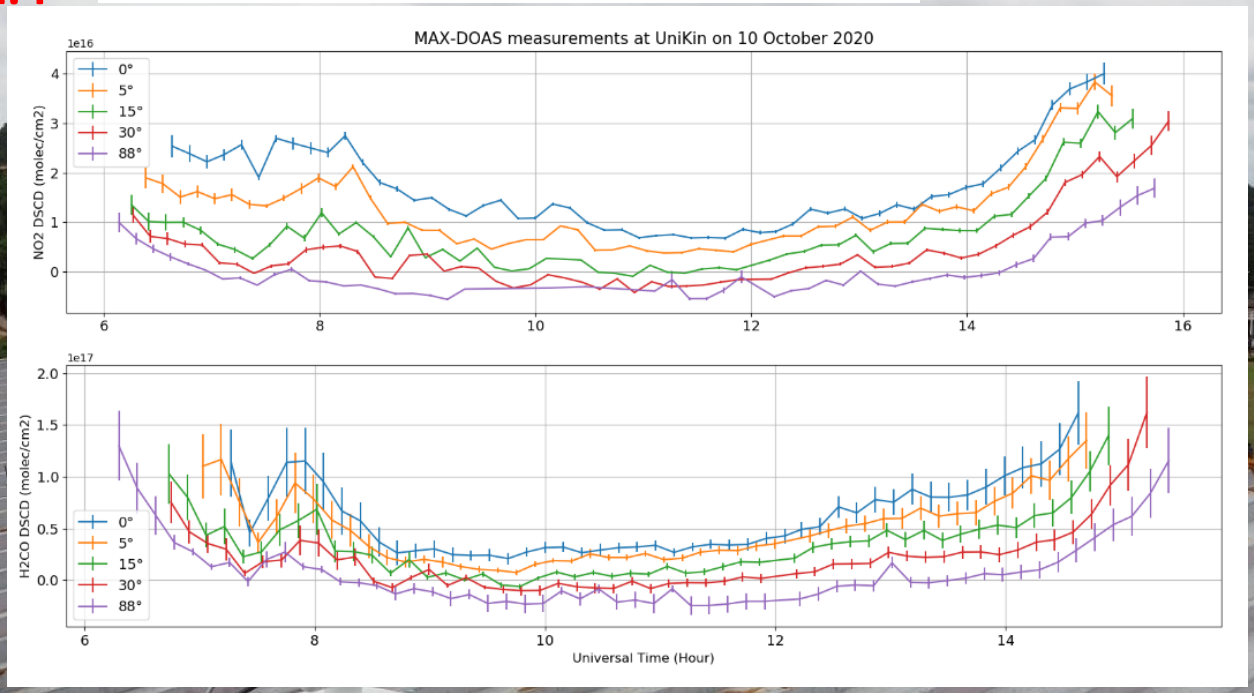


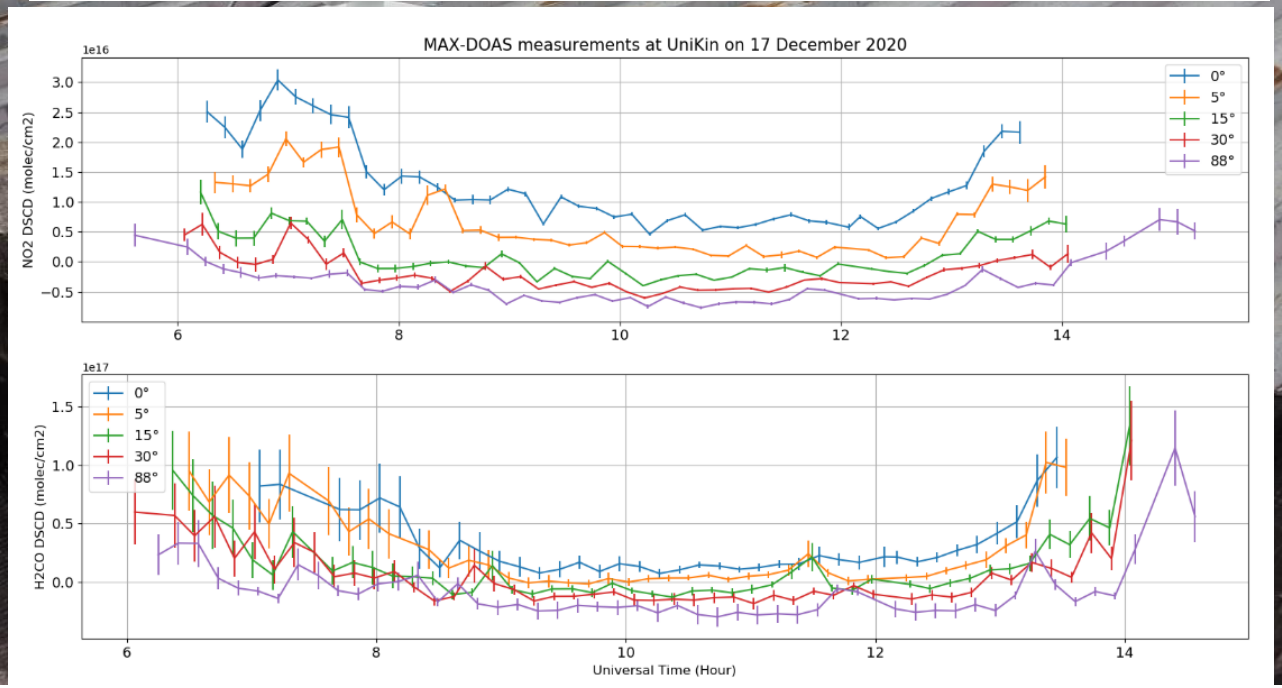




**A reference spectrum recorded at 12:17 local time (LT) on 1 June 2020 was used as the Fraunhofer reference spectrum (FRS) for all the retrievals to determine slant column densities (SCDs).**

| Parameters | QDOAS $NO_2$ SETTINGS | QDOAS $H_2CO$ SETTINGS: |
|---|---|---|
| Fitting interval | 425-490nm | 328,5 to 359 nm |
| Calibration | Chance and Kurucz (2010) | Chance and Kurucz (2010) |
| $NO_2$ | Vandaele et al.(1998), 298K | Vandaele et al.(1998), 298K |
| $O_3$ | Bogumil et al.(2003), 223K | Serdyuchenko et al., (2014), 223K and 243K |
| $H_2O$ | Harder and Brault 1997 | X |
| $O_4$ | Hermans et al. (2003) | Thalman and Volkamer (2013), 293K |
| $H_2CO$ | X | Meller and Moortgat (2000), 293K |
| BrO | X | Fleischmann and Hartmann (2004), 223K |
| Correction ring effet | Chance and Spurr (1997) | Chance and Spurr (1997) |
| polynomial Term | Polynomial of order 5 | Polynomial of order 5 |
| Offset intensity correction | Offset(constant), offset(order1) « Non-linear » | Offset(constant), offset(order1) « Non-linear » |

# DSCDs days EXAMPLE

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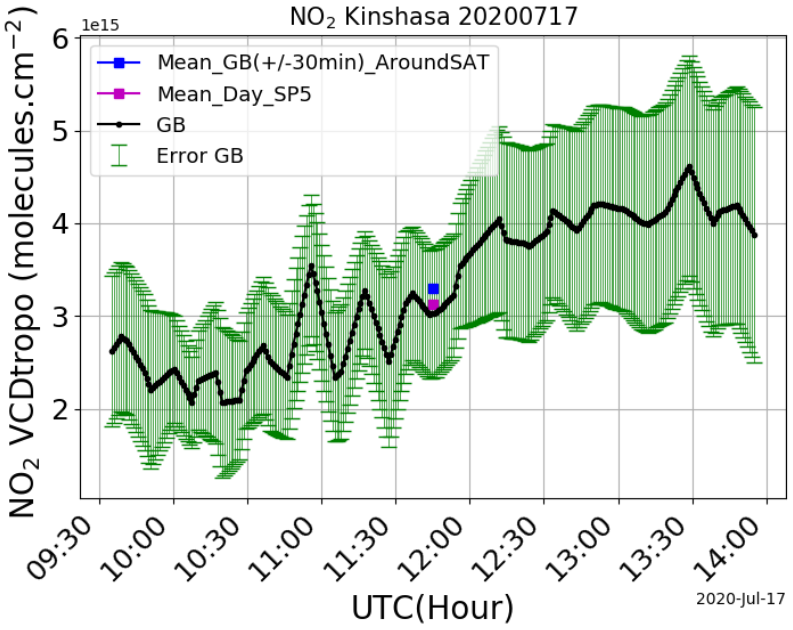
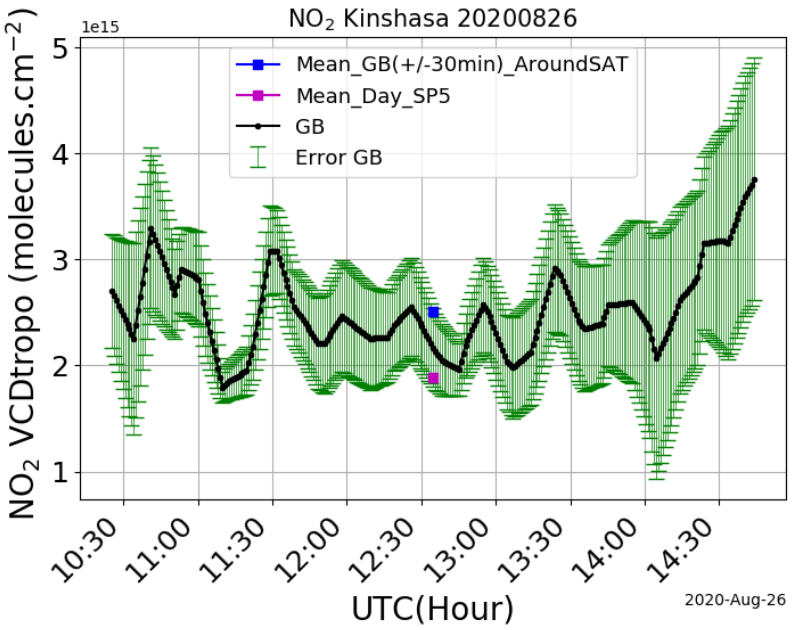
# VCDtropo retrieval examples



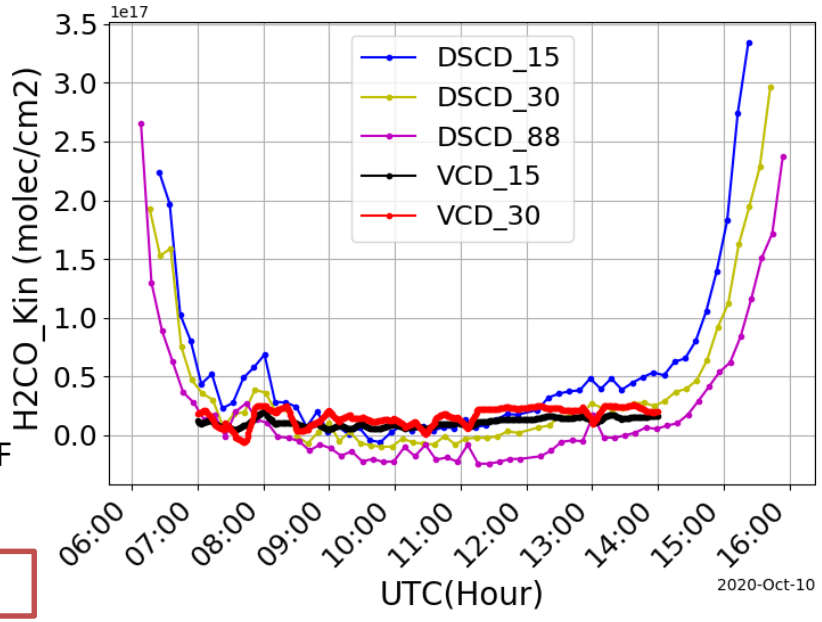

$$VCD = \frac{dSCD_{\alpha \neq 90^\circ} - dSCD_{\alpha = 90^\circ}}{AMF_{\alpha \neq 90^\circ} - AMF_{\alpha = 90^\circ}}$$

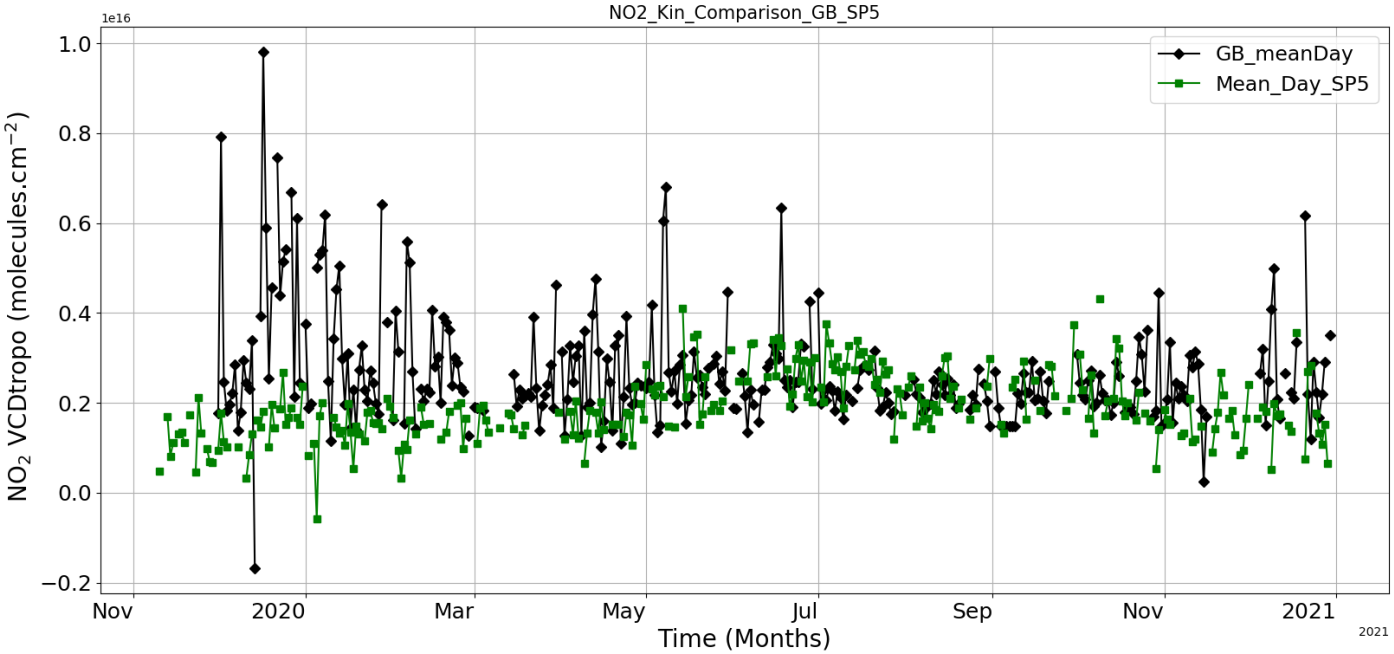
$$AMF\ (\alpha) = \frac{1}{\sin \alpha}$$

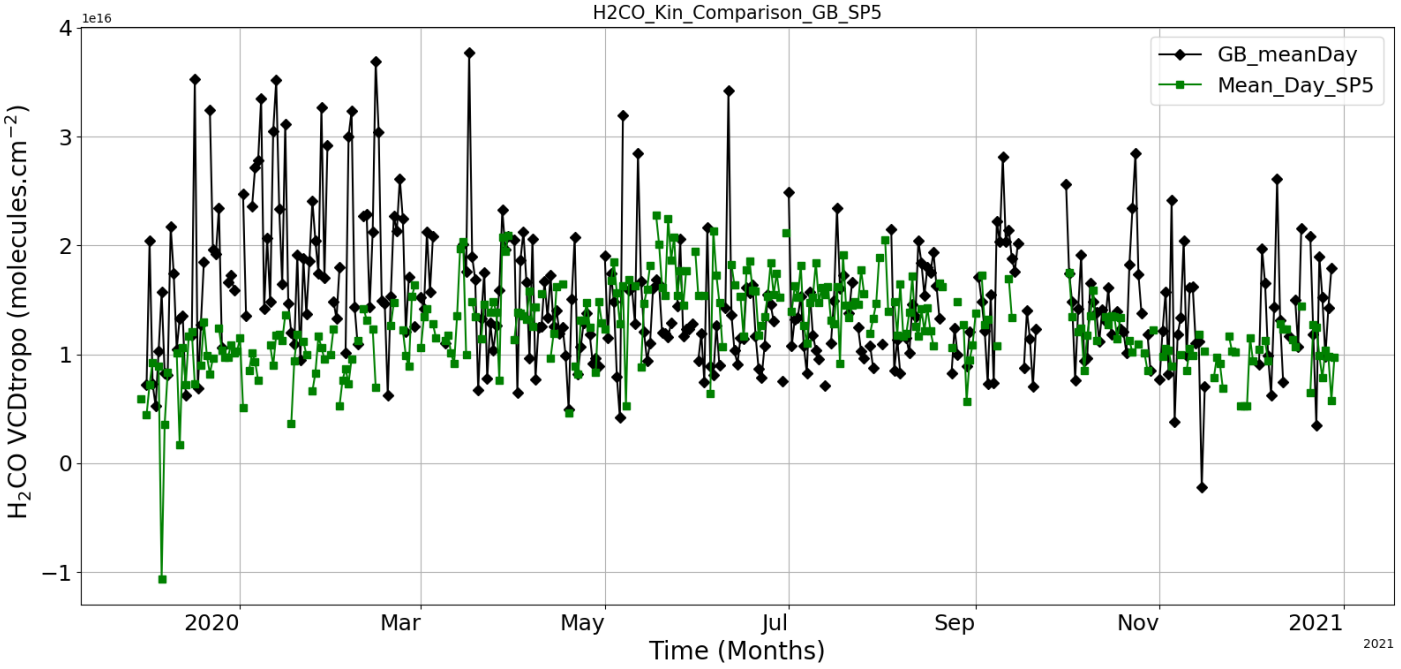
$$VCD = \frac{\Delta SCD}{\frac{1}{\sin \alpha} - 1}$$

The geometric approximation method to calculate the AMF proposed by Brinksma et al. (2008). $\alpha$ : elevation angle.

For the conversion equation, see: Hönninger et al. 2004).




NO2_Kin_Comparison_GB_SP5
1e16
1.0
0.8
0.6
0.4
0.2
0.0
−0.2
$NO_2$ VCDtropo (molecules.cm$^{-2}$)
GB_meanDay
Mean_Day_SP5
Nov
2020
Mar
May
Jul
Sep
Nov
2021
Time (Months)
2021


H2CO_Kin_Comparison_GB_SP5
1e16
4
3
2
1
0
−1
$H_2CO$ VCDtropo (molecules.cm$^{-2}$)
GB_meanDay
Mean_Day_SP5
2020
Mar
May
Jul
Sep
Nov
2021
Time (Months)
2021

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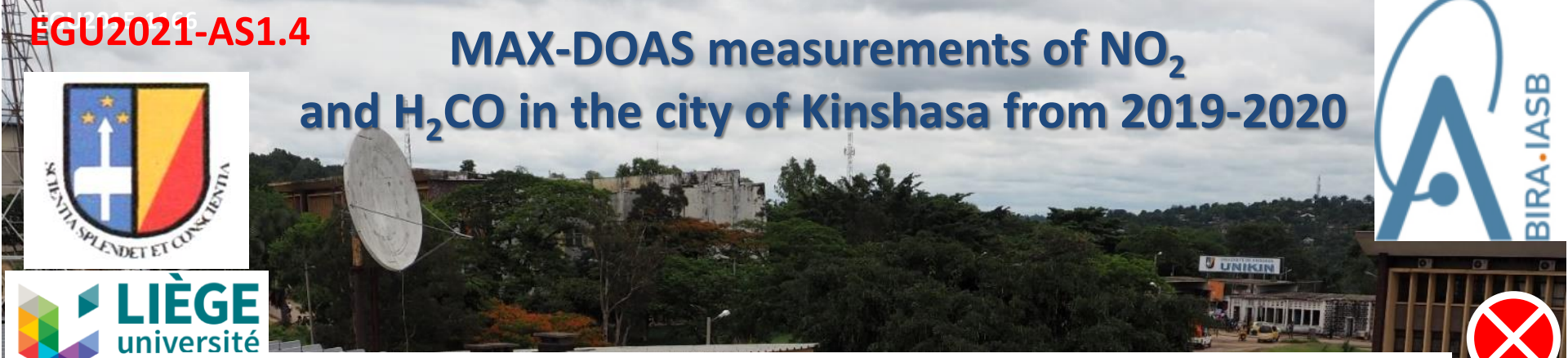


## PERSPECTIVES:

The results presented in this study are preliminary despite the illustration of first VCDtropo retrievals with geometrical approximation of $NO_2$ and $H_2CO$ and good prelilminary agreement between ground-based and S5p measuremnts.

We plan to add to these results, time series of VCDtropo extracted from ground measurements but using AMFs calculated with an appropriate radiative transfer model like VLIDORT.

We also plan to compare the results of this study with the results obtained from the same data but using the FRM4DOAS project. This work is already in progress.

We also plan to present some quantification exercises of emission sources using the chemistry transport model (GEOS-Chem implemented at ULG).

## Acknowledgments:

We would like to thank the Belgian Federal Science Policy Office (BELSPO) and the KinAERO Project for their financial support. Rodriguez Yombo Phaka benefits from a grant financed by ARES-CCD (Academy for Research and Higher Education - Commission for Development Cooperation), managed at ULiège by PACODEL (Center for Partnership and Development Cooperation). We also thank Lars Jacobs for his valuable contribution to the realization of some of the materials used in this work.

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