Scientific capacity building on the African continent for satellite validation, air quality and climate monitoring

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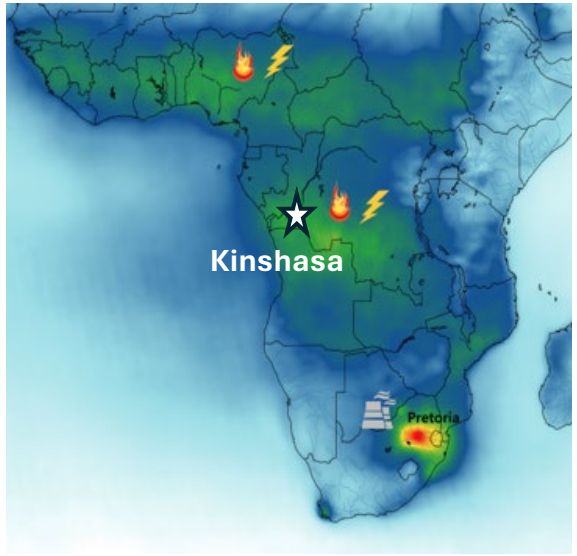
Outline

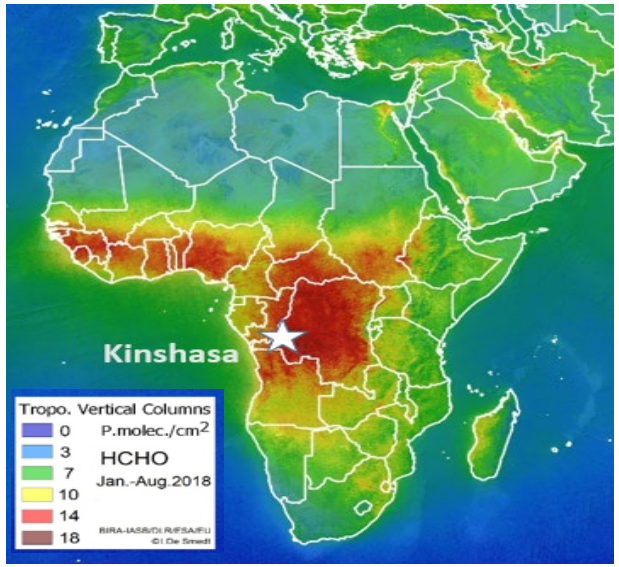
- 1) Ongoing air quality measurements (NO_2, H_2CO) in Kinshasa, DR Congo ongoing

- 2) Preparation of Greenhouse gas measurements (CO_2, CH_4) in Yangambi, DR Congo

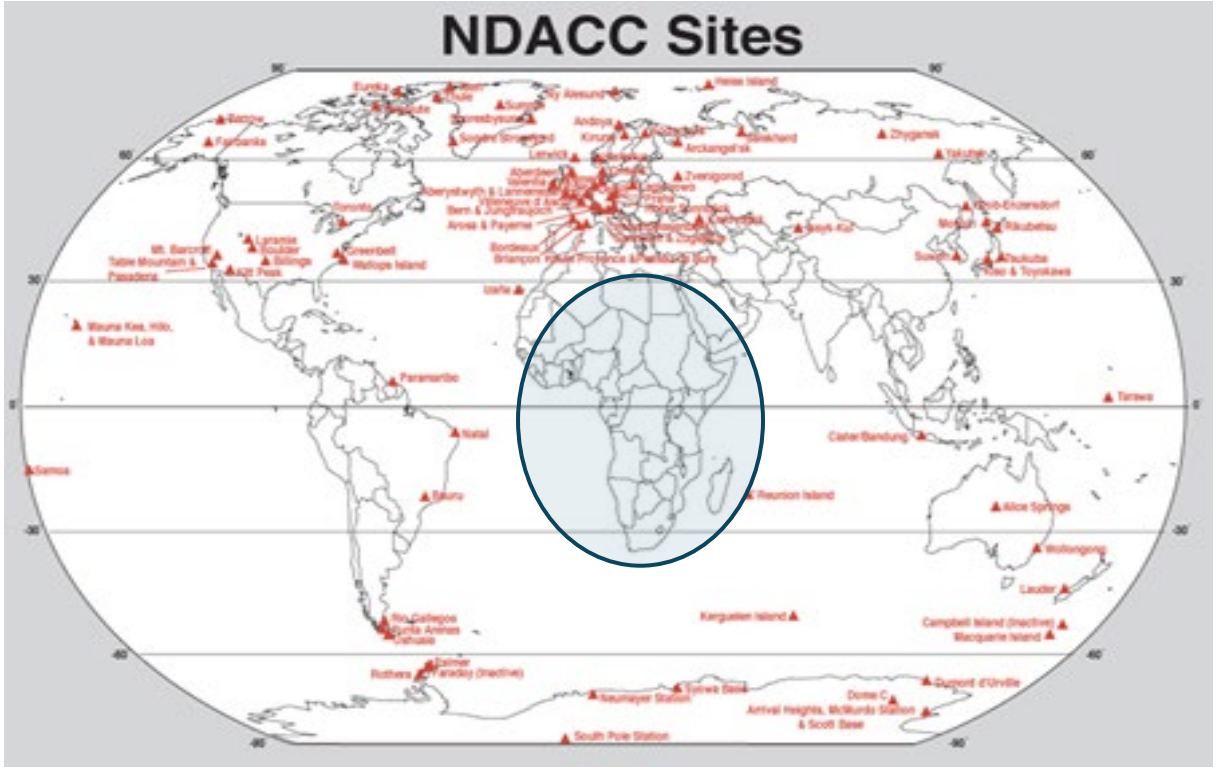
Air quality in Kinshasa: Context



OMI NO_2



TROPOMI HCHO

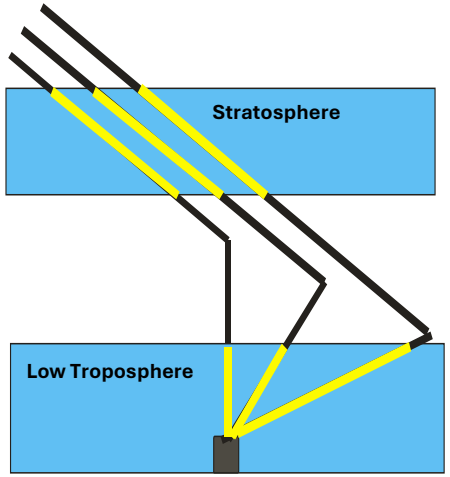


- Area with large biogenic, pyrogenic, and **increasing anthropogenic** emissions, **air quality worsening in megacities**
- Almost **no coverage by ground-based observations**
- Large **satellite uncertainties** on these emissions
- **Kinshasa** (DRC): 3rd largest city in Africa in terms of area, 17 million estimate pop. (2021), **projected to 60 millions in 2100**

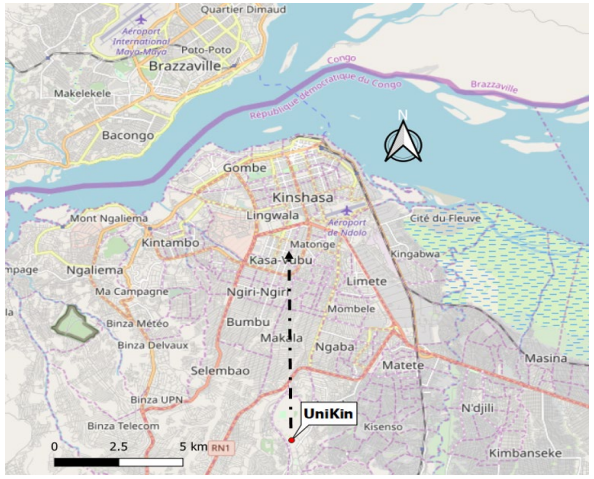
Liousse et al., Environ Res Lett (2014)
Vohra et al., Science (2022)

Air quality in Kinshasa: Methods

Max-DOAS (Dec. 2019 - now): Tropospheric NO_2, HCHO, Aerosol Optical Depth



Pointing in the city center direction



Centralized spectral analysis and profile retrievals

FRM4DOAS

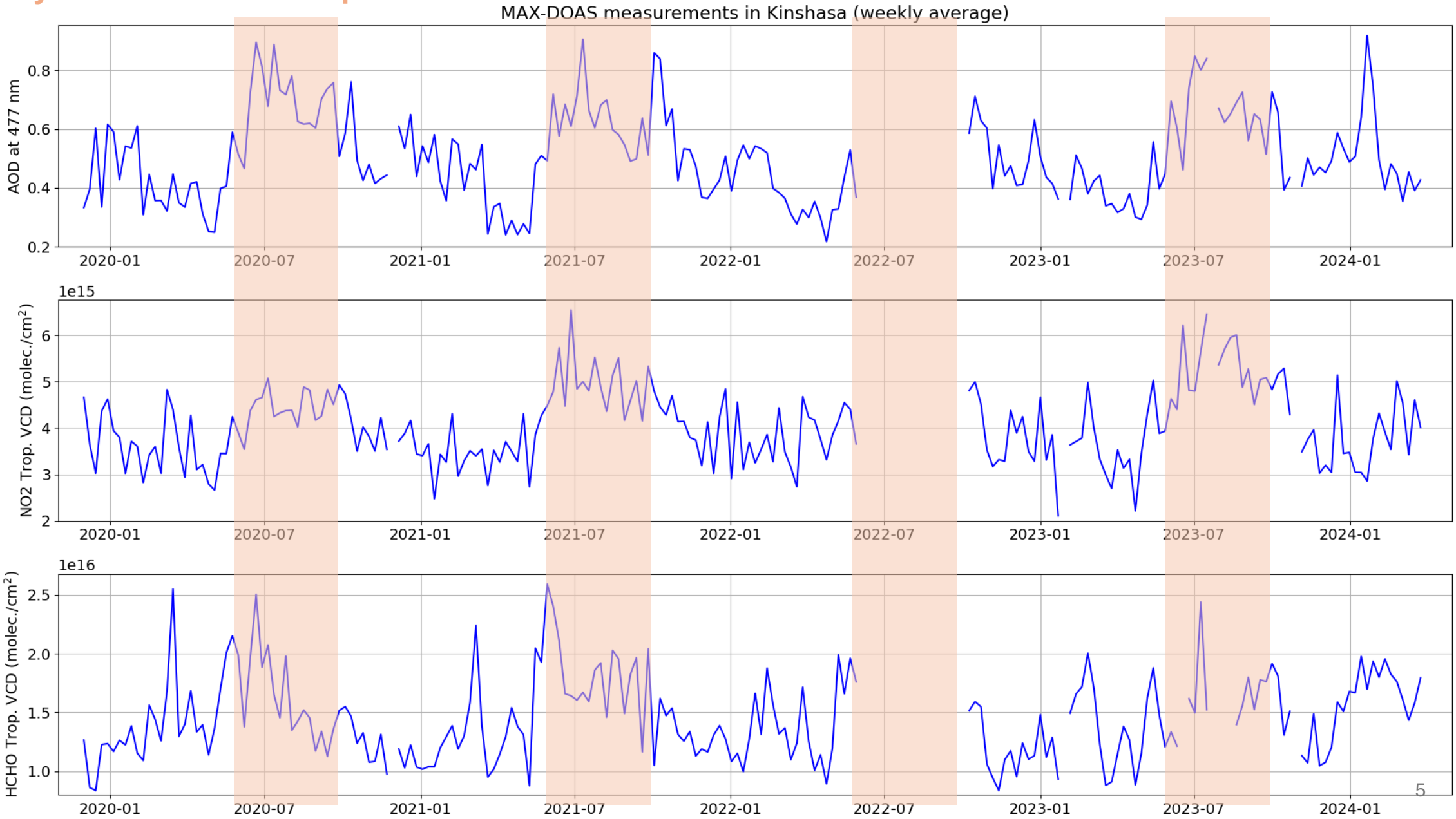
Yombo Phaka et al., J. Atmos. Ocean. Technol., 2021

Yombo Phaka et al., Atmos. Meas. Tech., 2023

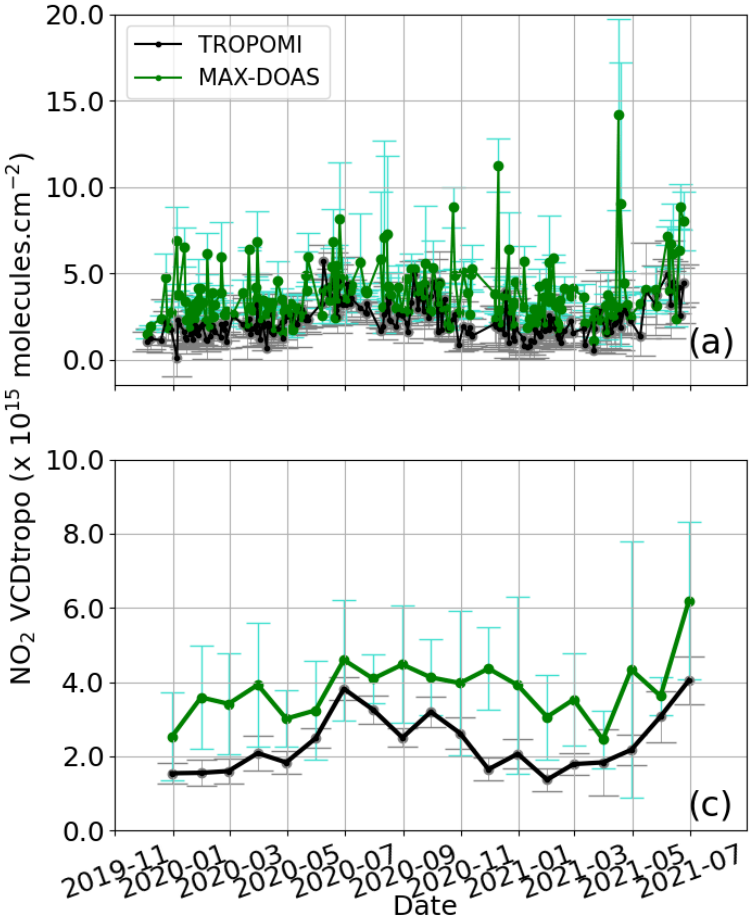
Yomba Phaka, PhD thesis, Uni. Liege, 2024

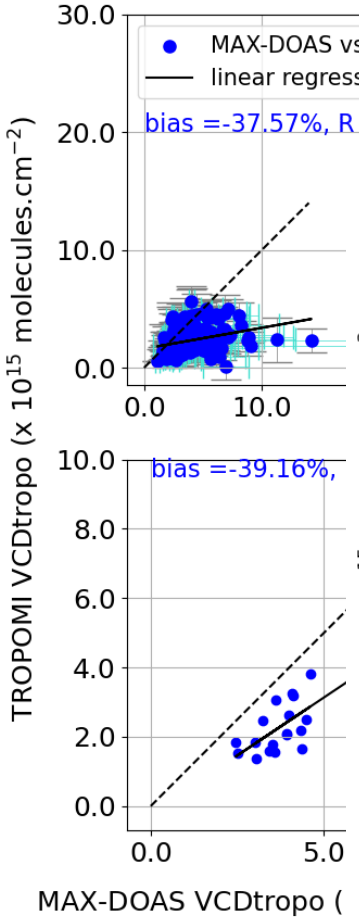
Air quality in Kinshasa: Results

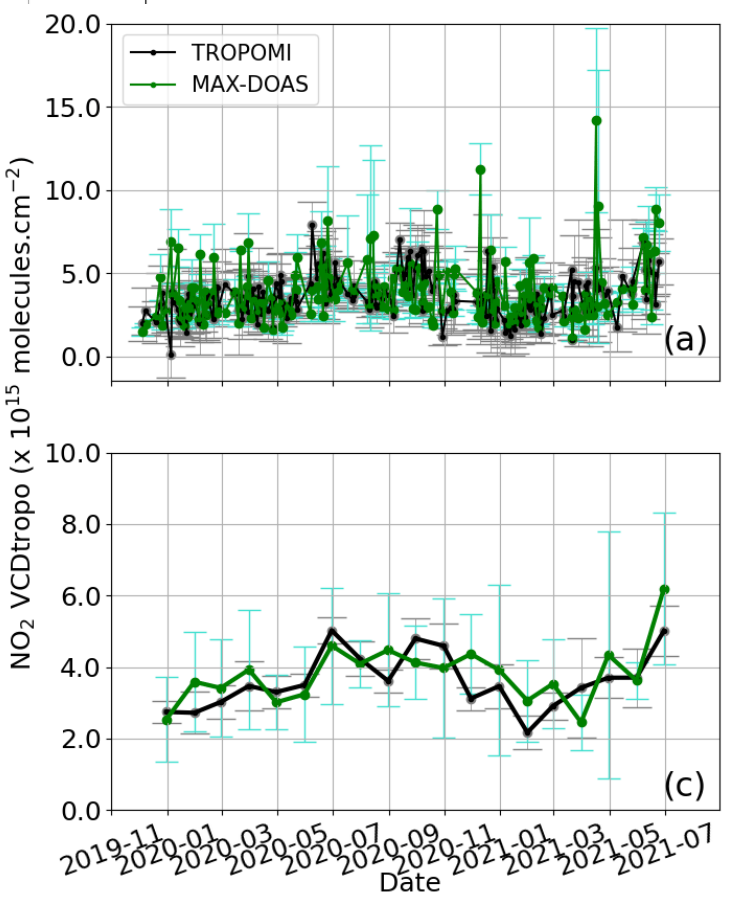
Dry season: June to September

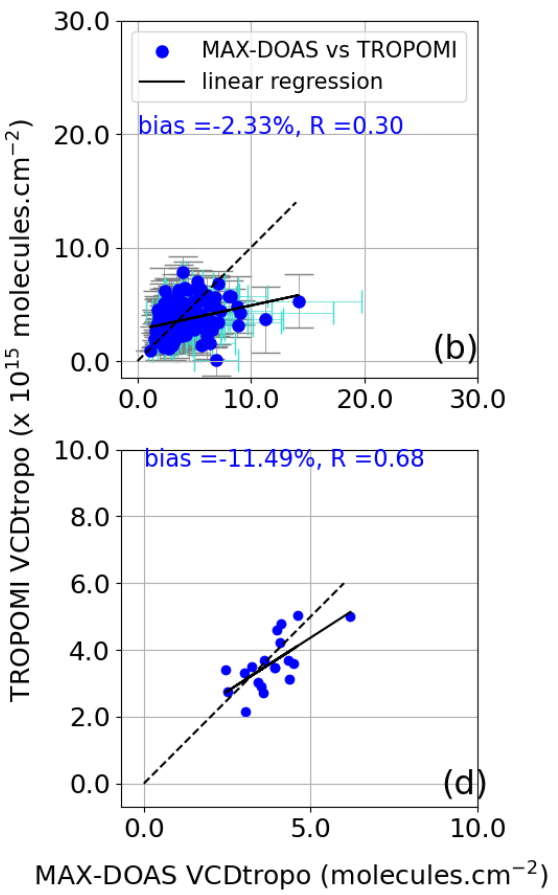


Air quality in Kinshasa: Results
Satellite vs MAX-DOAS: NO_2





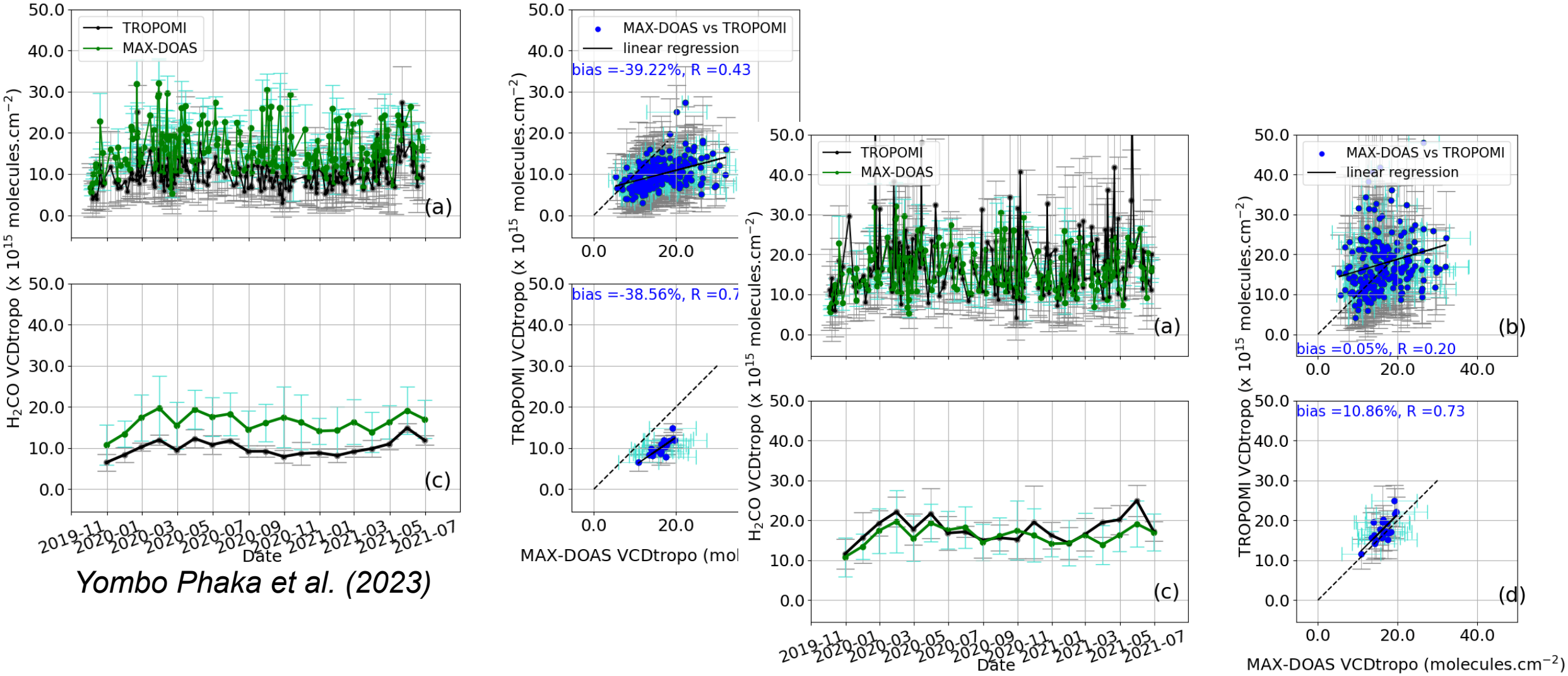




Yombo Phaka et al. (2023)

Standard TROPOMI product underestimates NO_2, but replacing a-priori satellite profile with MAX-DOAS derived profiles reduces the bias!

Air quality in Kinshasa: Results
Satellite vs MAX-DOAS: HCHO



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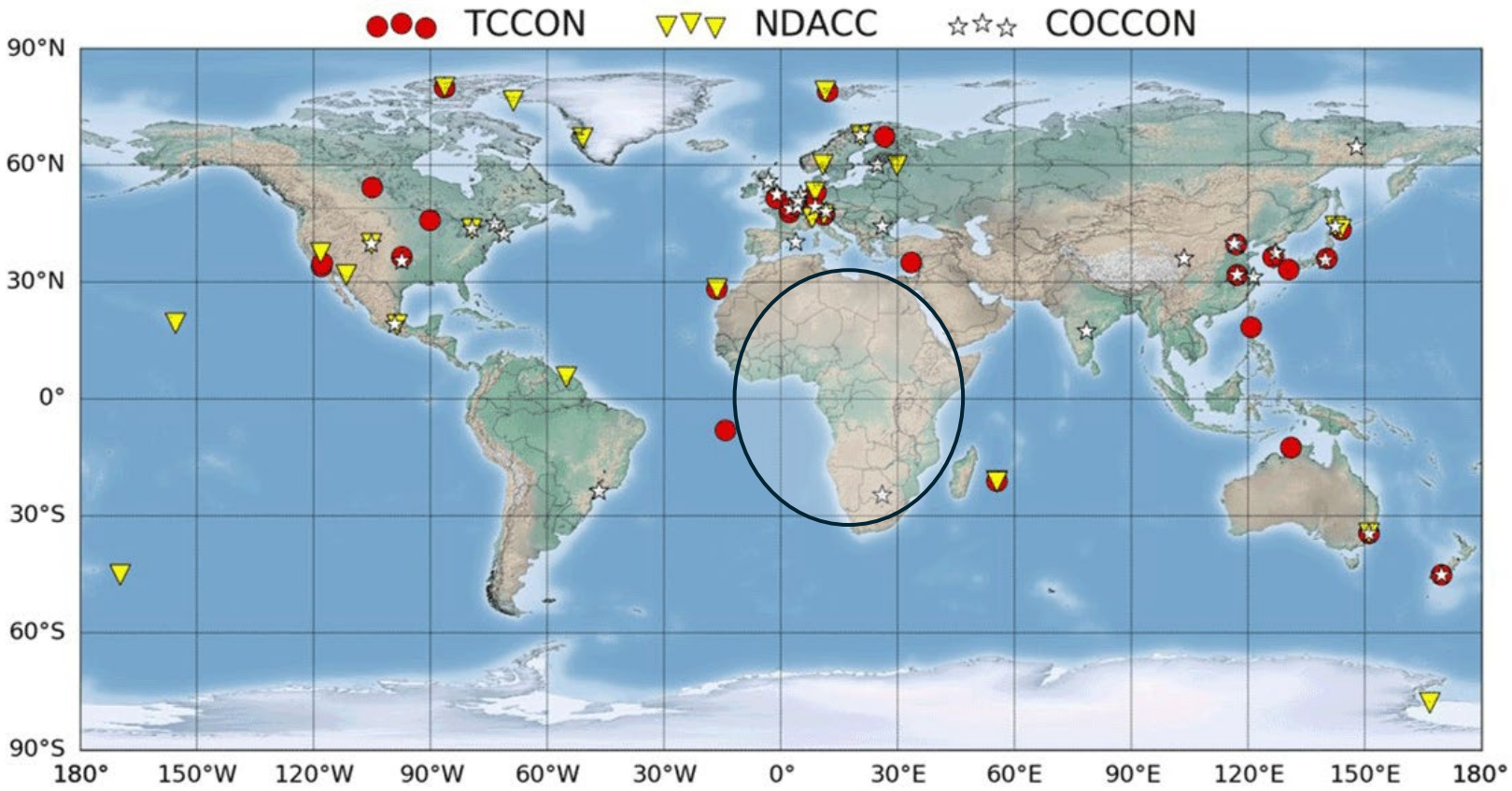
- 2) Preparation of Greenhouse gas measurements (CO_2, CH_4) in Yangambi, DR Congo

Greenhouse gases in Yangambi: Context

CO_2 : Uncertainties on the fate of the forest carbon sink in Africa
Hubau et al., Nature, 2020

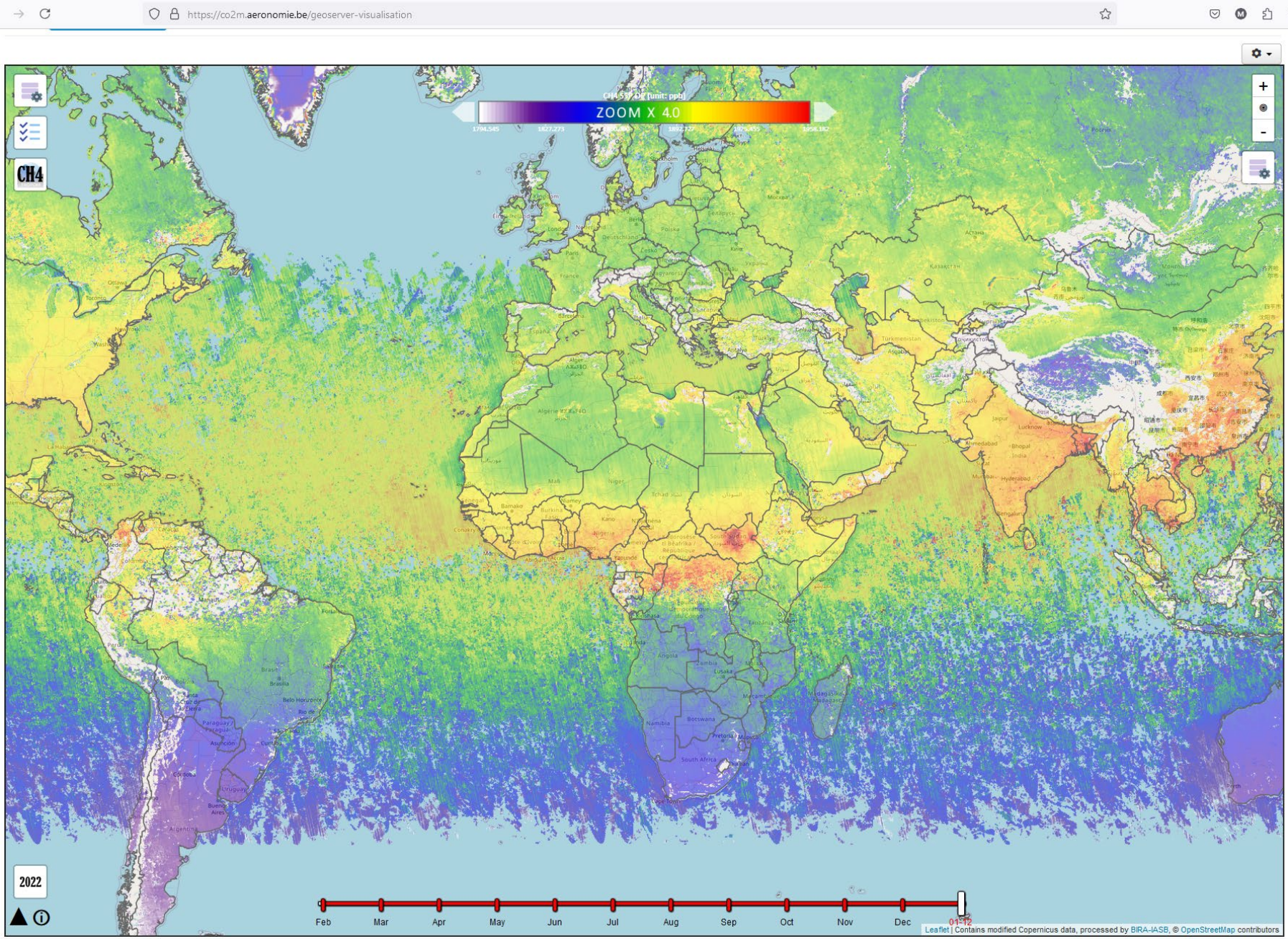
CH_4: Congo Basin greenhouse gas emissions differ from tropical forest models
Tsanni, Abdullahi, Nature Africa 2022
Emission from tropical wetlands on the rise and underestimated
Lunt et al., ACP, 2019



Sun et al., 2022, Global FTIR observation networks

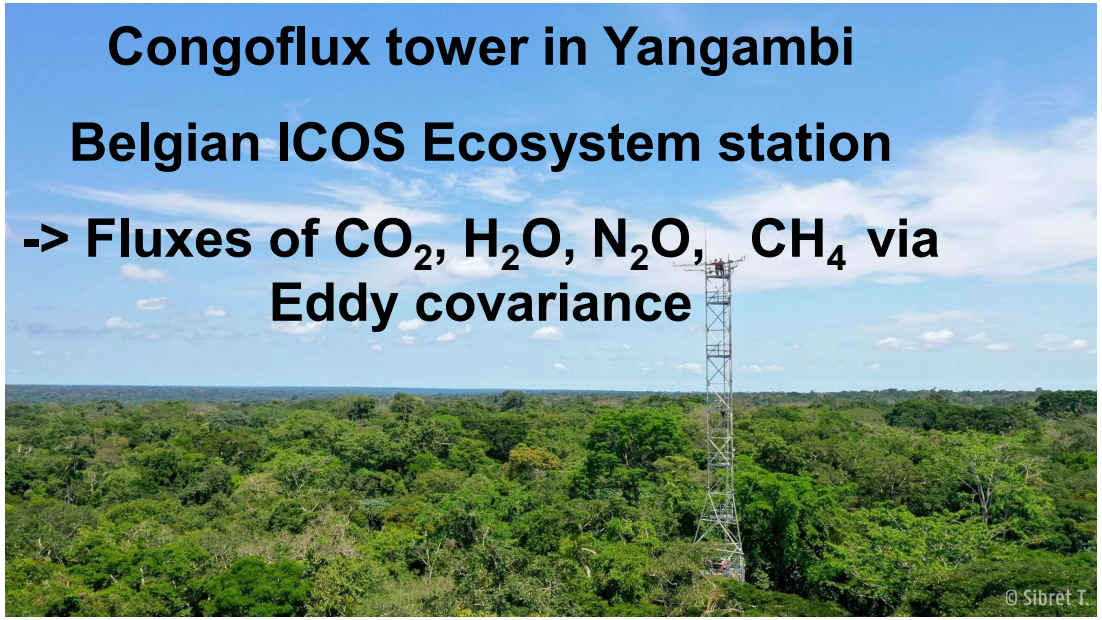
Almost **no coverage by ground-based observations**

Greenhouse gases in Yangambi: Context



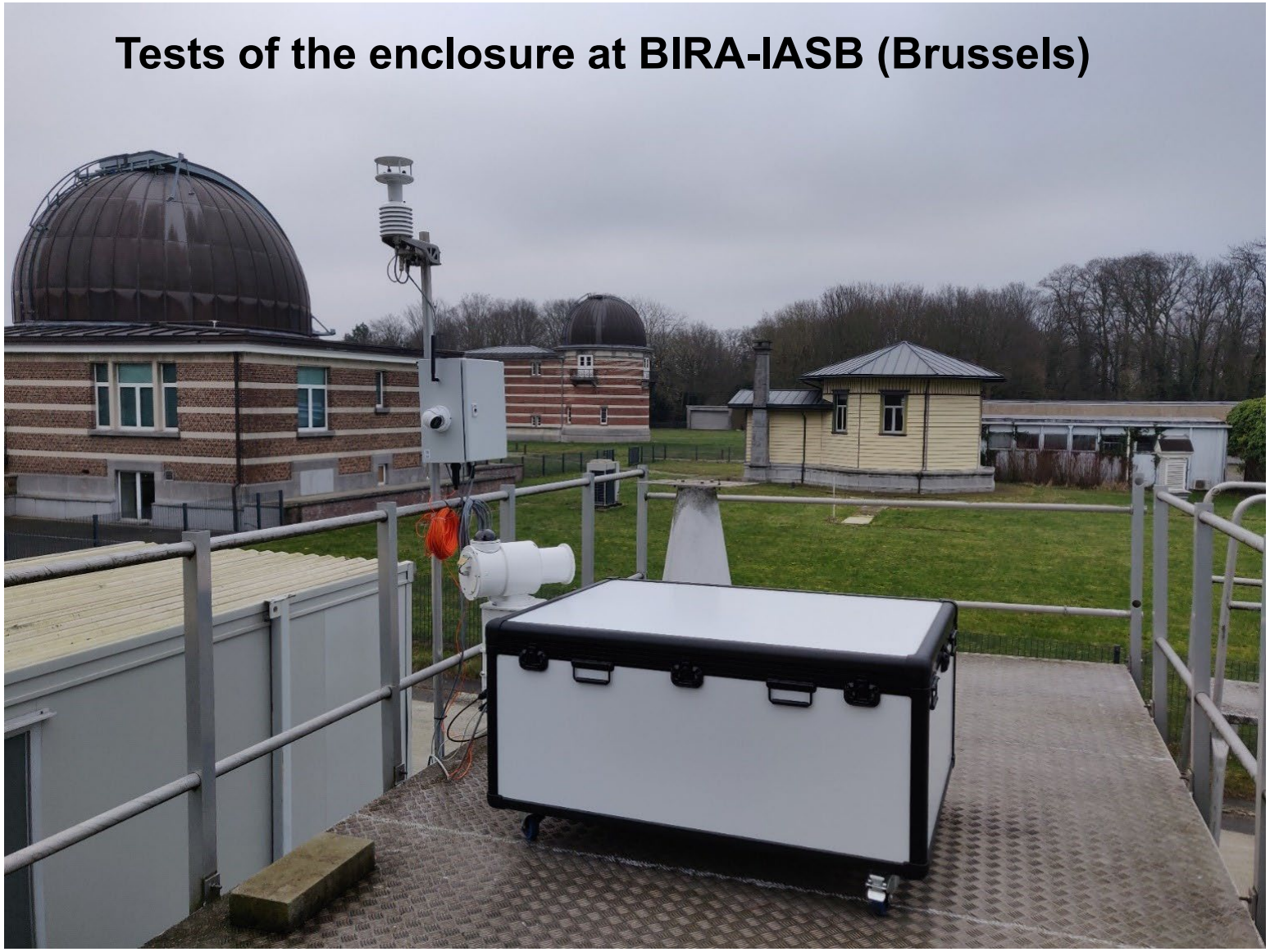
XCH_4 distribution from Sentinel-5 Precursor averaged for the year 2022. The elevated values in central Africa are clearly visible

Greenhouse gases in Yangambi: Methods



- BIRA-IASB-developed FTIR enclosure and solar tracker for a portable COCOON-type FTIR (Bruker INVENIO)
- Target species: total column concentrations of CO_2, CH_4, H_2O, CO
- Meteorological station providing: pressure, temperature, relative humidity, wind speed and wind direction at the surface
- Challenges include: protection against lightening, data transfer and monitoring, protection against ants

Greenhouse gases in Yangambi: Methods



- Planned installation in Yangambi: beginning of 2025
- Knowledge transfer to Congolese scientists also a goal
- Belgian national project ICOS-BE (https://icos-be.aeronomie.be/)

- With similar BIRA-IASB system planned in Mbandaka (DR Congo) & another FTIR in Republic of Congo (Uni Bremen) -> CH_4 emissions from Wetland in Congo Basin
- Airborne measurements to provide profiles
- Horizon Europe project – Investigating Methane for Climate Actions (IM4CA)

Summary and perspectives

- BIRA-IASB measurements in DR Congo contribute to satellite validation & training new generation of Congolese scientists

- Sentinel-5 Precursor underestimate NO_2 and H_2CO compared to MAX-DOAS measurements over Kinshasa, partly due to profiles used in the satellite products

- A new FTIR will monitor total column concentrations of CO_2, CH_4, CO and H_2O in Yangambi from beginning of 2025, two more FTIRs and airborne campaigns planned in the region – starting 2026 to study methane emissions from the wetlands

In preparation with ESA and Clean Air Task Force:

Workshop on *Validation and use of atmospheric satellite data for Africa,* April 2025, University Mohammed VI

Interested?

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