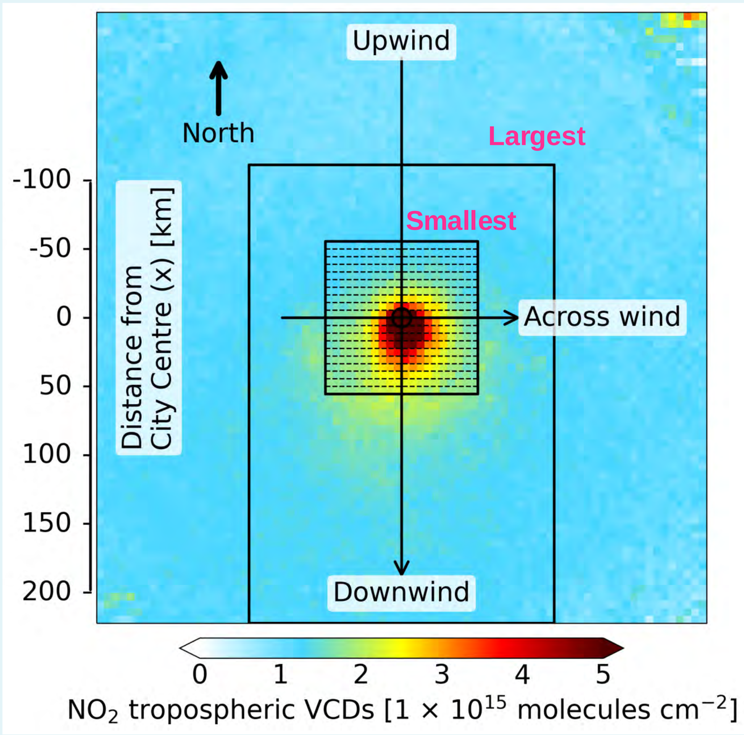
Application and Evaluation of a Widely Used Top-down NO_x Emissions Method to Hotspots in Sub-Saharan Africa

Nana Wei (nana.wei.21@ucl.ac.uk), Eloise A. Marais, G. Lu, S. Beirle

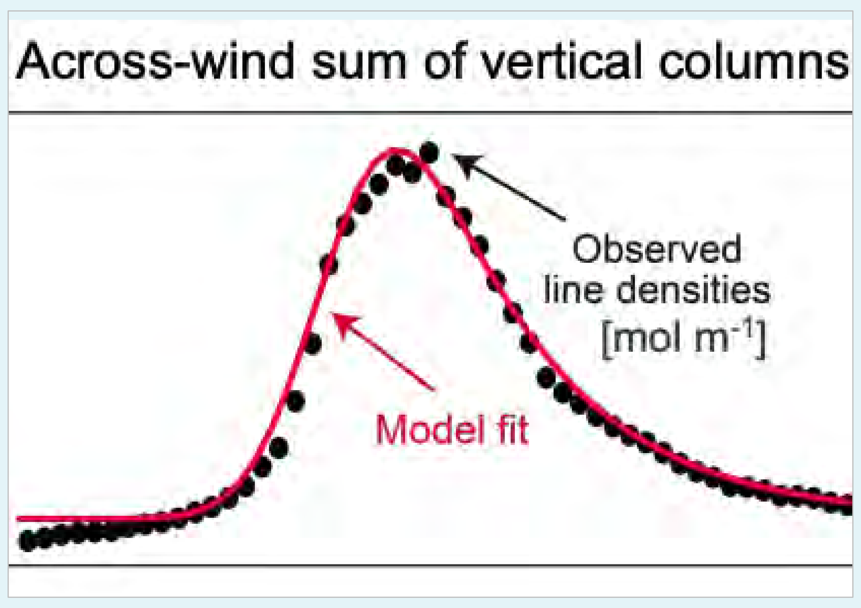
Major outputs: We updated anthropogenic NO_x emission inventory in GEOS-Chem and improved NO_2 column simulations.

Top-down NO_x Emissions method: Derive NO_x emissions of isolated hotspots viewed by UV-visible space-based sensors

1. Wind rotated TROPOMI NO_2 over hotspot



2. Model fit to line densities to yield best fit parameters



3. Hotspot NO_x emissions and lifetimes

1. Motivation

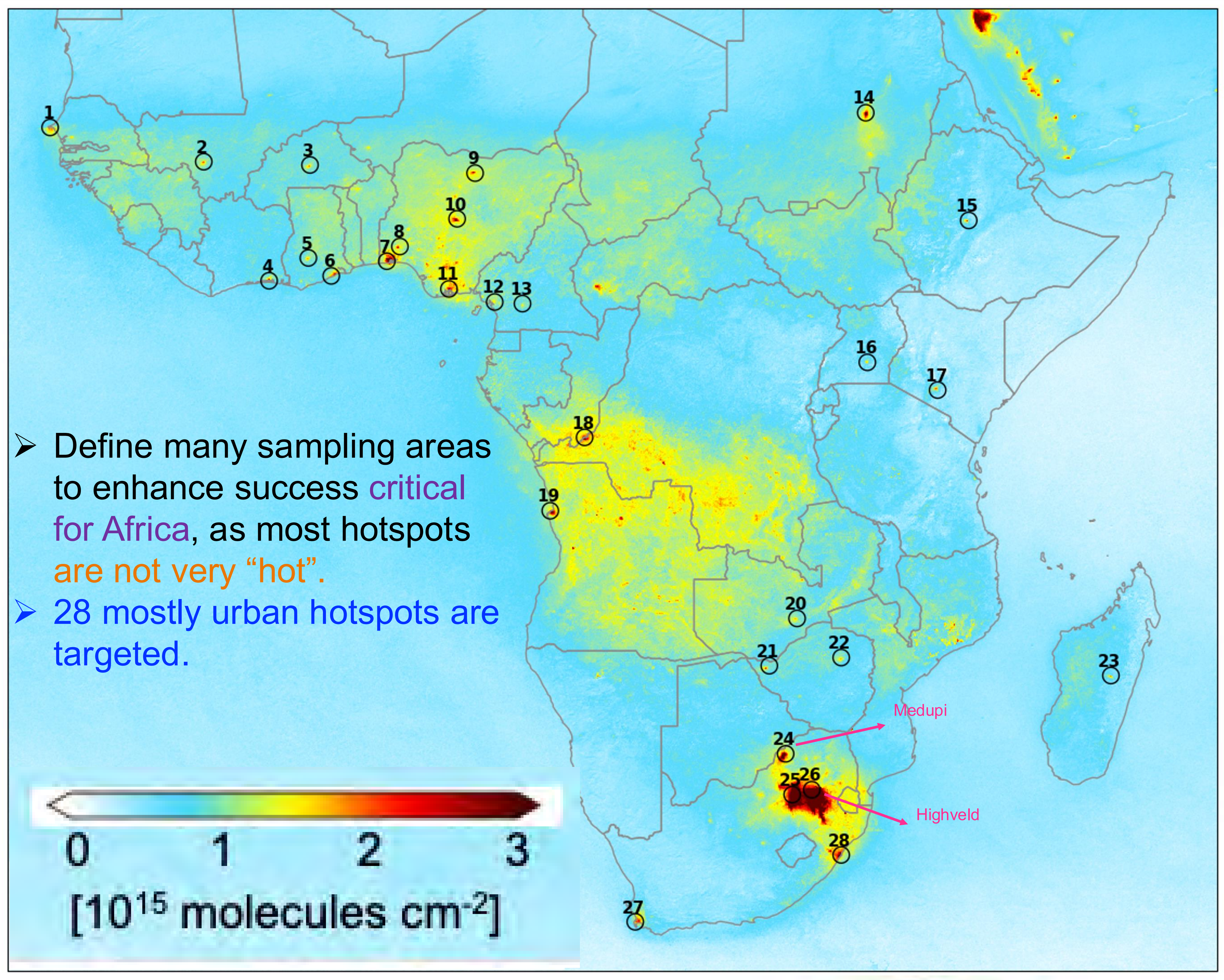
Target hotspots in understudied Sub-Saharan Africa

- Surface concentrations of NO_x are increasing at rates of up 10% per year in cities in Africa.
- Rapid population growth and urbanization in the absence of air quality policies
- Models needed to inform air quality policies use out-of-date inventories for cities in Africa.
- Most top-down emissions derivation methods require computationally costly models.

2. Research Methodology

Apply a recently improved method of deriving hotspot NO_x emissions from satellite (TROPOMI) observations of NO_2.

1. Rotation of hotspot NO_2 plume along a consistent wind direction.
2. Selecting multiple sampling areas (54) around emissions hotspots to fit a modified Gaussian to line densities to calculate emissions.



- Define many sampling areas to enhance success critical for Africa, as most hotspots are not very "hot".
- 28 mostly urban hotspots are targeted.

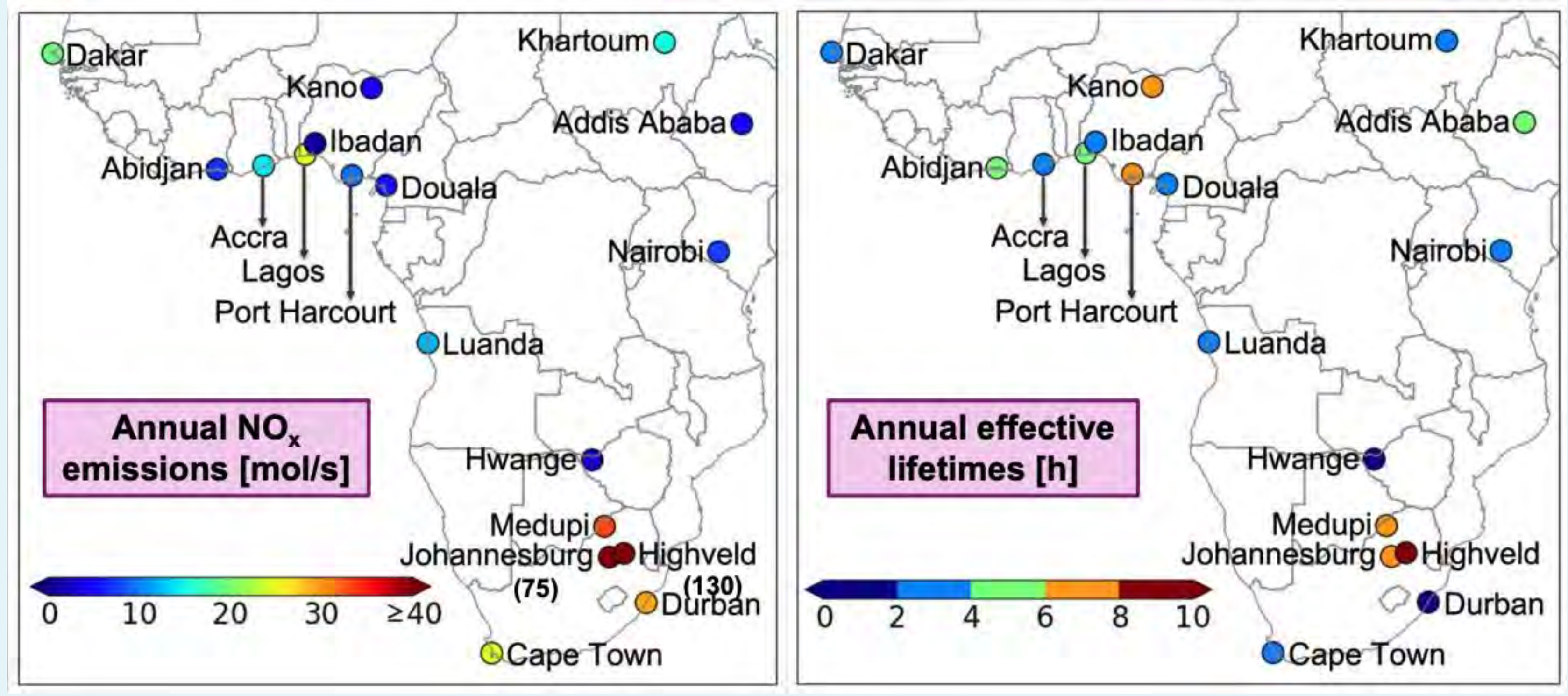
Update GEOS-Chem high resolution Global emission inventory CEDSv2 for anthropogenic NO_x

1. Update CEDSv2 with our top-down NO_x emissions.
2. Compare NO_2 columns from the original GEOS-Chem, GEOS-Chem informed by updated CEDSv2, and TROPOMI.

- Version 13.0.2
- 0.25x0.3125

- GEOS-FP at nested scale
- Model sampled during TROPOMI overpass

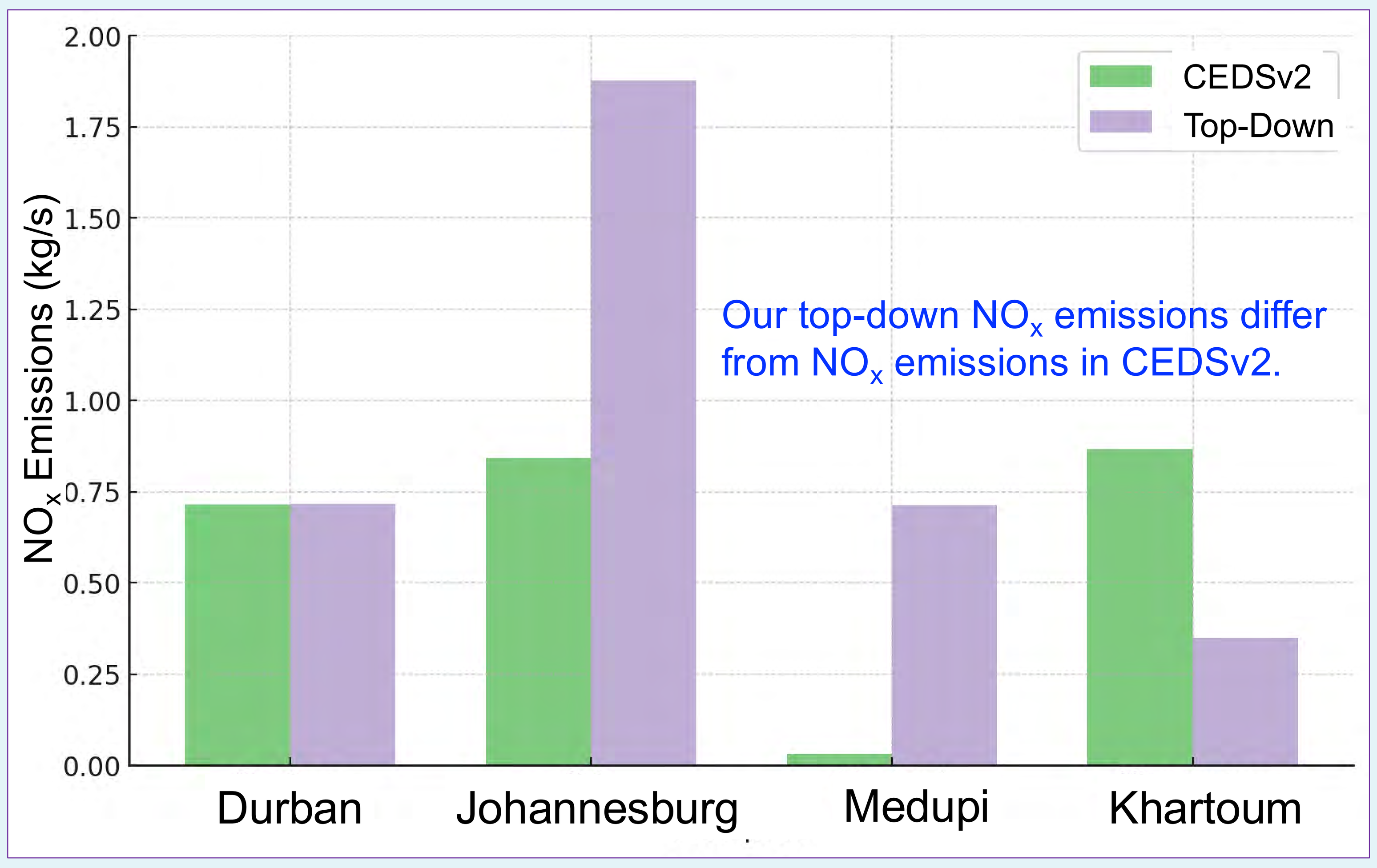
3. Derived NO_x emissions and lifetimes for 18 of 28 target hotspots



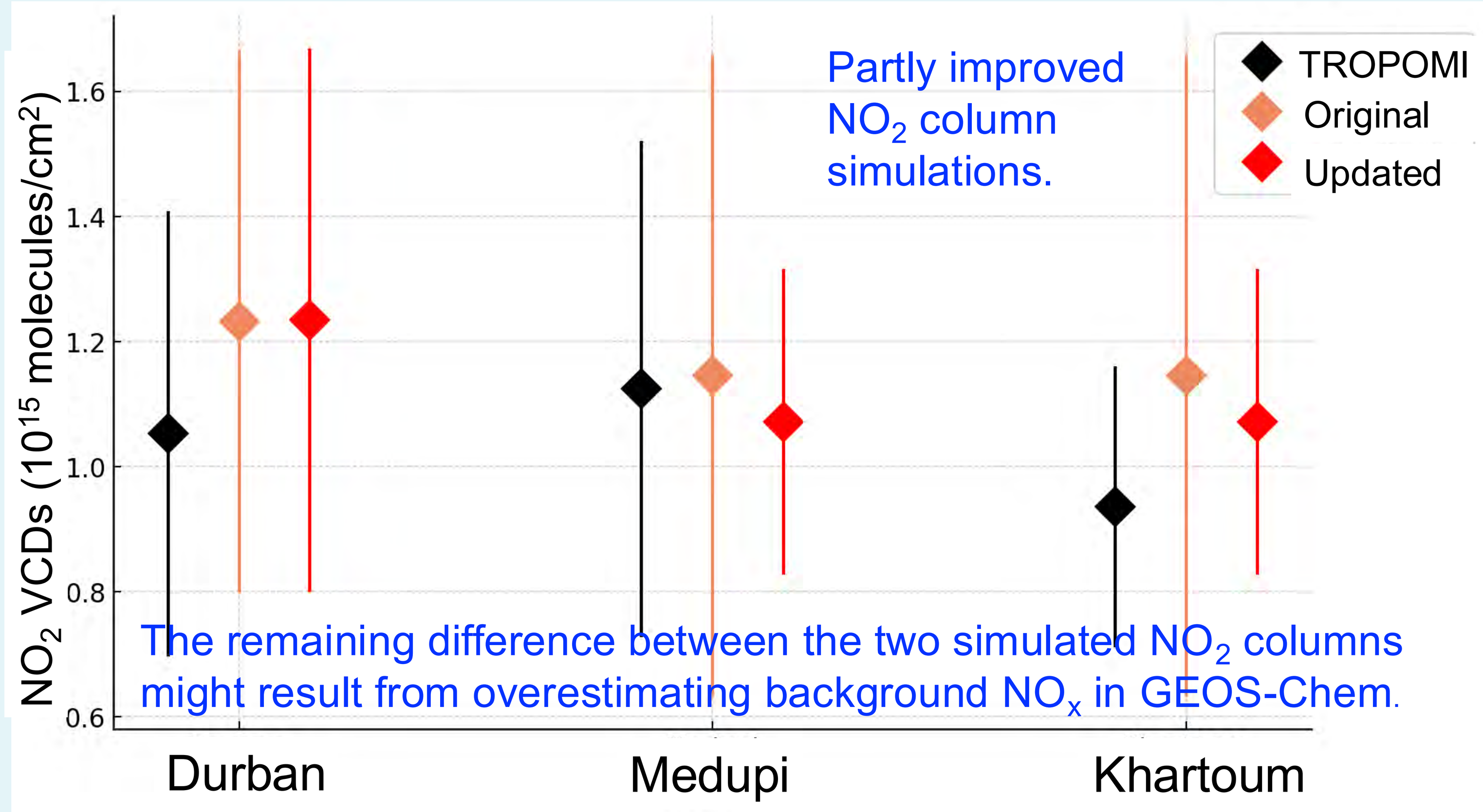
- Emissions range from 2 to 130 mol/s and lifetimes from 2 to 10 h.
- 8 fail, as background and plume are not distinct enough.
- South Africa hotspot emissions are far greater (28-130 mol/s) than rest of Sub-Saharan Africa (<28 mol/s)
- Our top-down NO_x emissions are on average ~28% less than Lange et al. and ~14% less than Goldberg et al.

4. NO_x emissions-informed GEOS-Chem improved NO_2 simulations

Comparison of CEDSv2 and Top-Down NO_x Emissions by Hotspots



Comparison of NO_2 columns from original and updated GC and TROPOMI



5. Concluding Remarks: NO_x emissions are derived successfully for 18 of 28 targeted hotspots in Sub-Saharan Africa. We improved NO_2 tropospheric column simulations in GEOS-Chem via updating anthropogenic NO_x emission inventory (CEDSv2) with our top-down NO_x emissions.

Acknowledgements: This work is funded by the European Commission.

Contact: Nana Wei, Department of Geography, UCL. Email: nana.wei.21@ucl.ac.uk