Assessing Top-down NO_x Emission Estimates with Synthetic Columns from GEOS-Chem: Application to Hotspots in Africa

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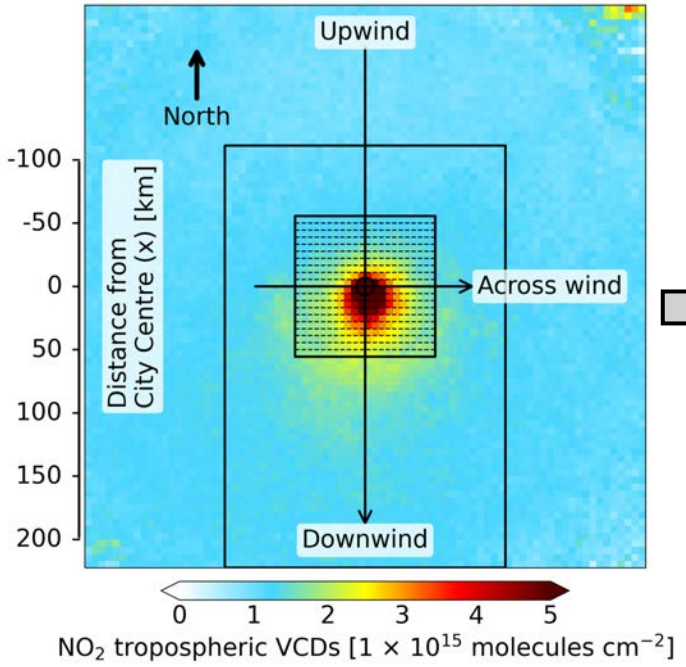
Top-down Estimate of NO_x Emissions

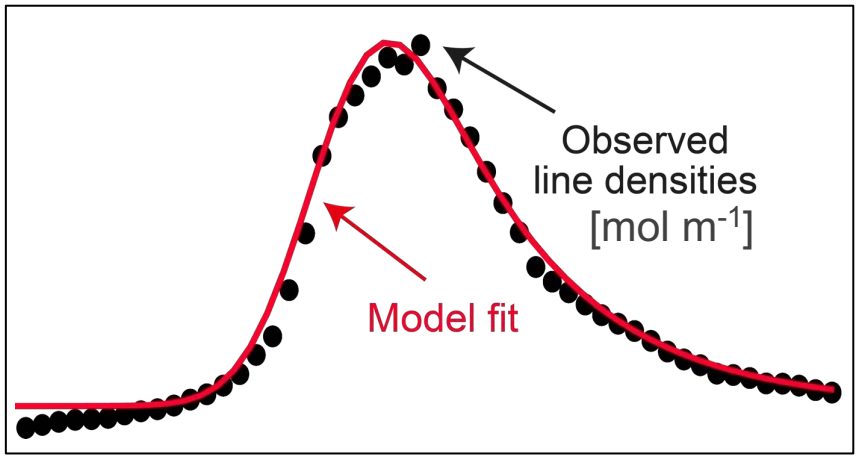
Derive NO_x emissions of isolated hotspots viewed by UV-visible space-based sensors

Wind rotated TROPOMI NO_2 over Lagos



Model fit to line densities to yield best-fit parameters

Across-wind sum of vertical columns



Lagos NO_x emissions and lifetimes

25 mol NO_x s^{-1}

~5 h

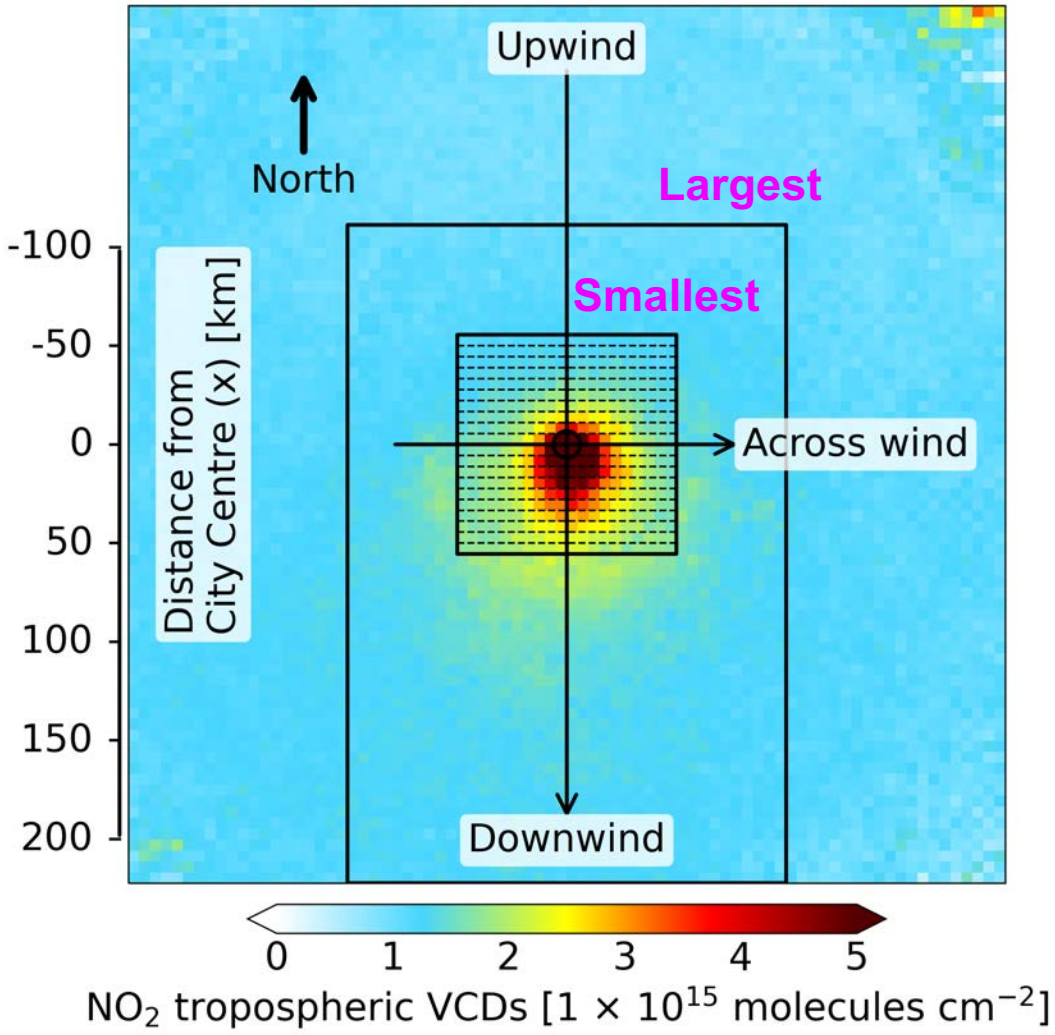
Target hotspots in understudied regions of the world:

Cities in South and Southeast Asia completed [Lu et al., *in review*]

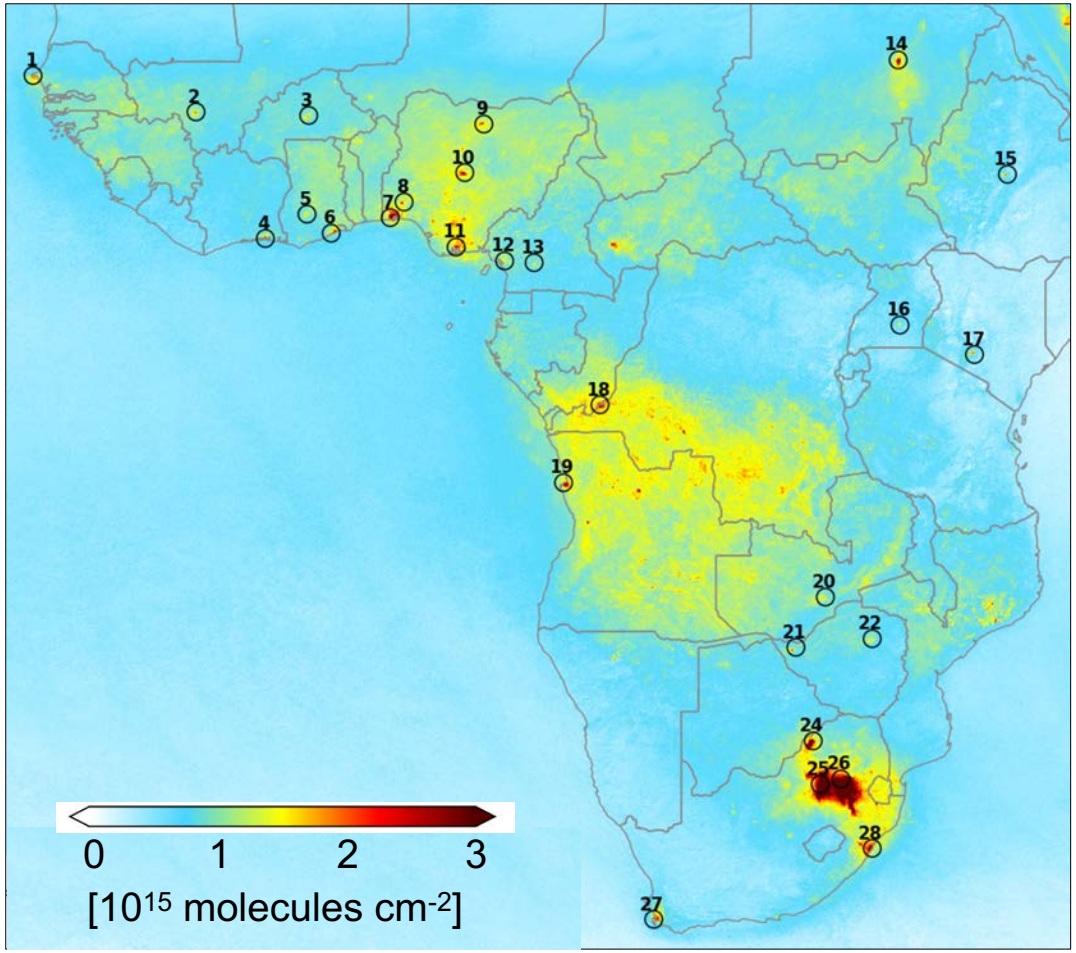
Hotspots in Sub-Saharan Africa in progress [Wei et al., *in prep*]

Simple Method Update to Improve Success

Define many (54) sampling areas



Enhanced success critical for Africa, as most hotspots not very "hot"

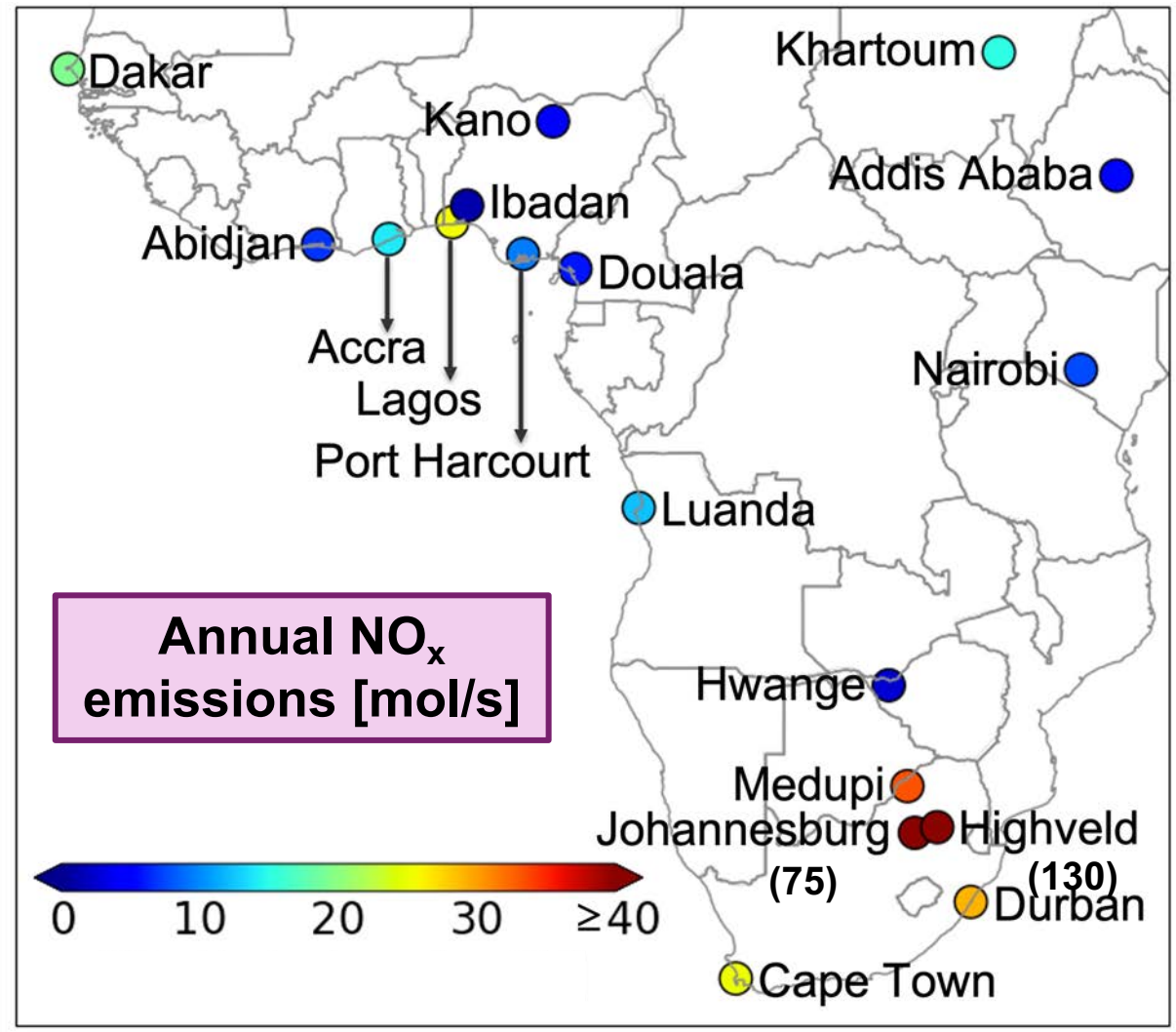


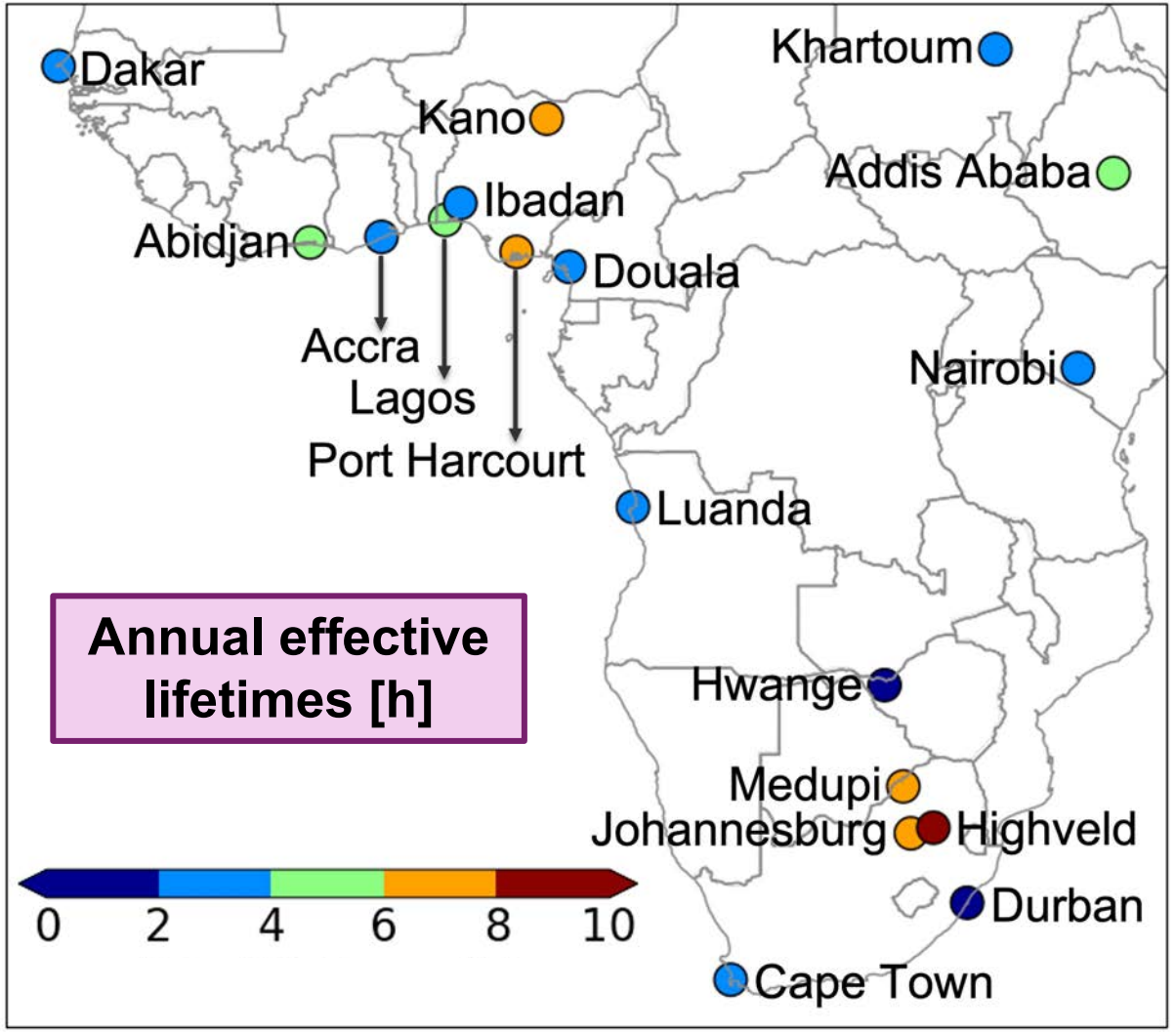
For South and Southeast Asia derive emissions for all target cities rather than 40-60%

Removes manual, subjective sampling area selection and allows for city-specific fit error estimate

Improved Approach Applied to Hotspots in Sub-Saharan Africa

Derive emissions and lifetimes for 18 of 28 target hotspots, compared to 4-5 in past studies

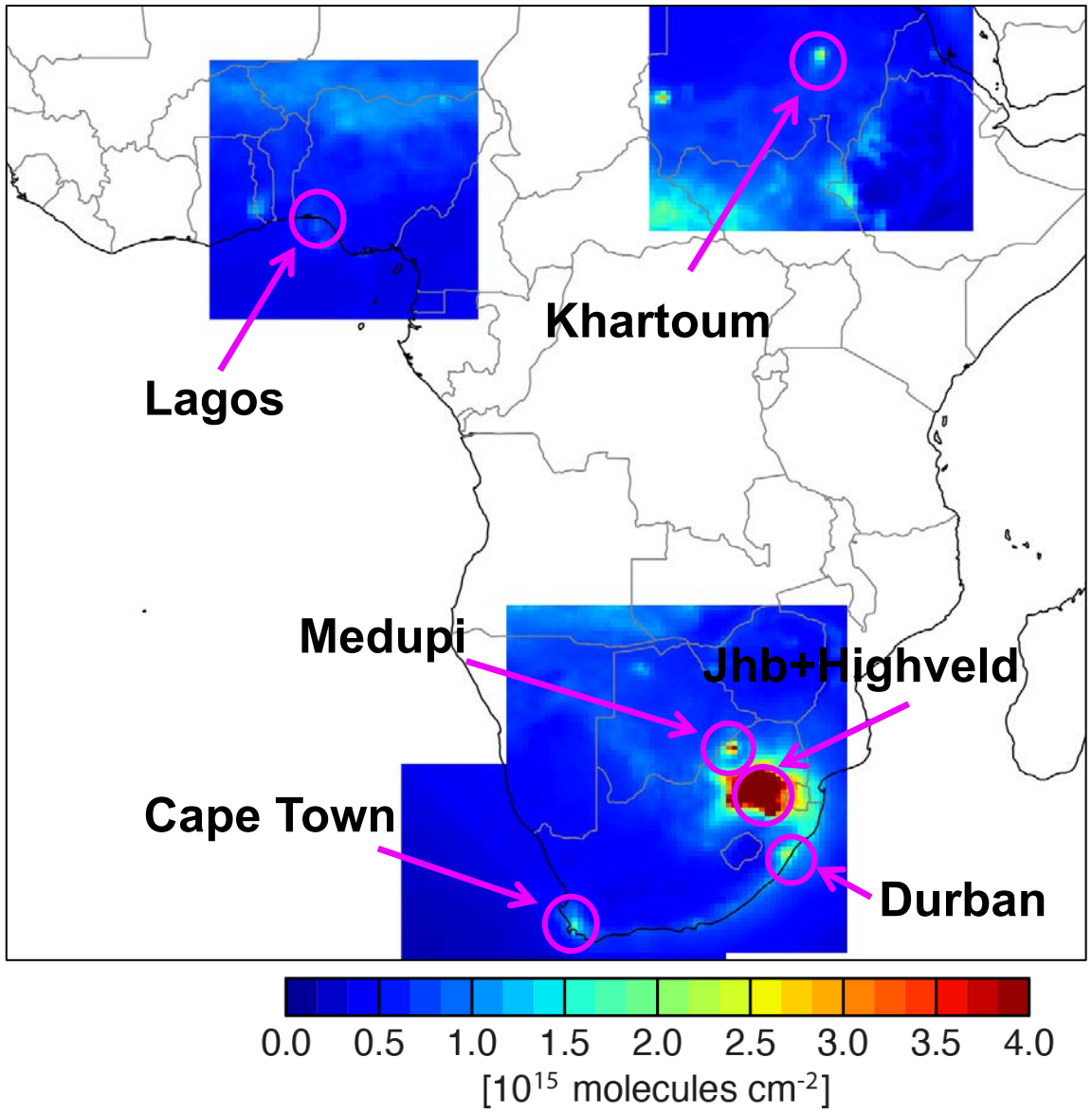




Emissions range from 2 to 130 mol/s and lifetimes from 2 to 10 h. But what do these represent?

Apply Top-down Method to Synthetic GEOS-Chem Columns

GCClassic FlexGrid tropospheric NO_2 columns for 2019



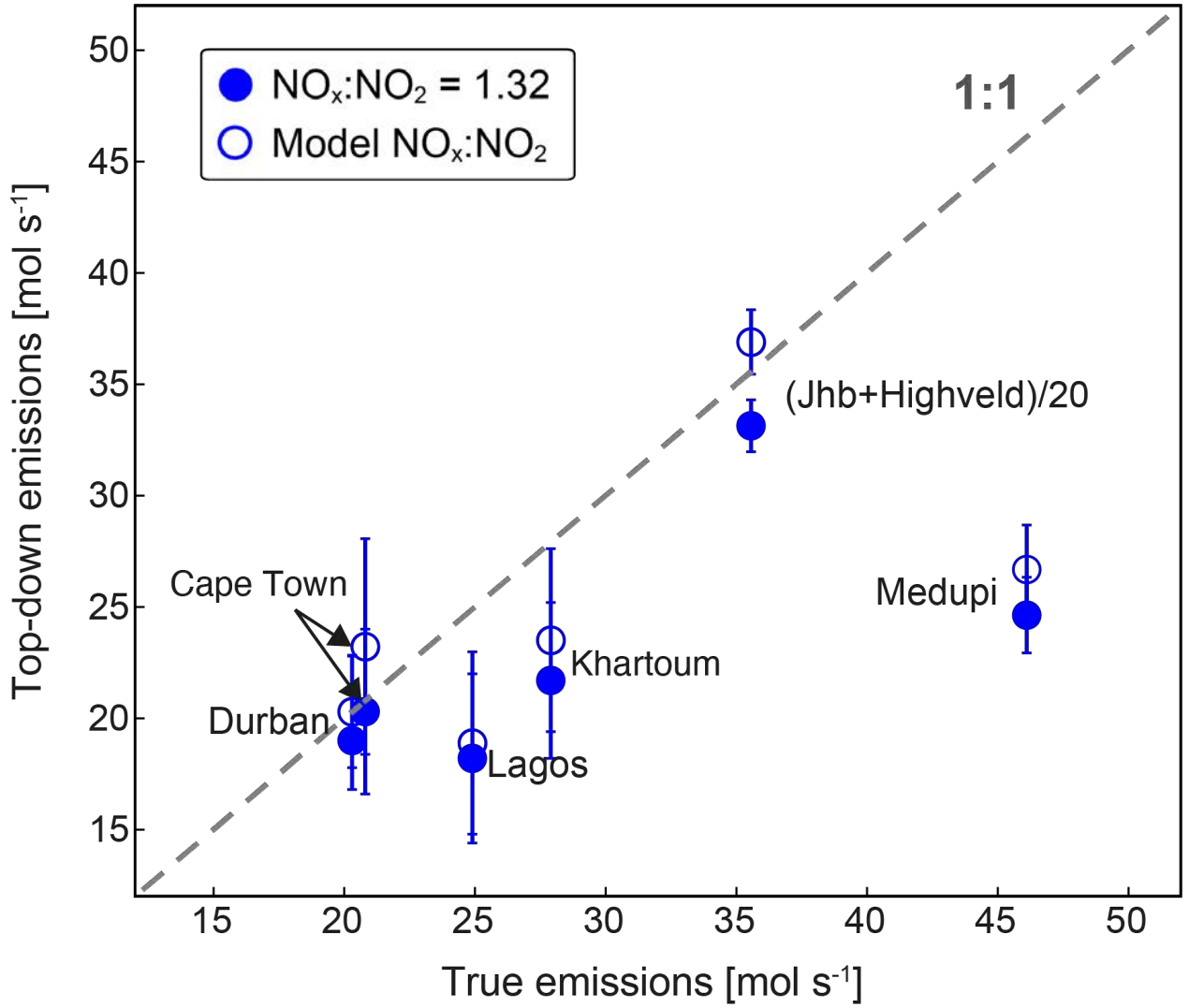
GEOS-Chem set up:

- Version 13.0.2
- GEOS-FP at nested scale
- **Medupi emissions added**
- Model sampled during TROPOMI overpass

Caveat:
Model coarser resolution and lower sampling frequency than TROPOMI

"True" Versus Top-Down Annual and Seasonal Emissions

Does wind rotation and EMG fit routine yield "true" emissions?



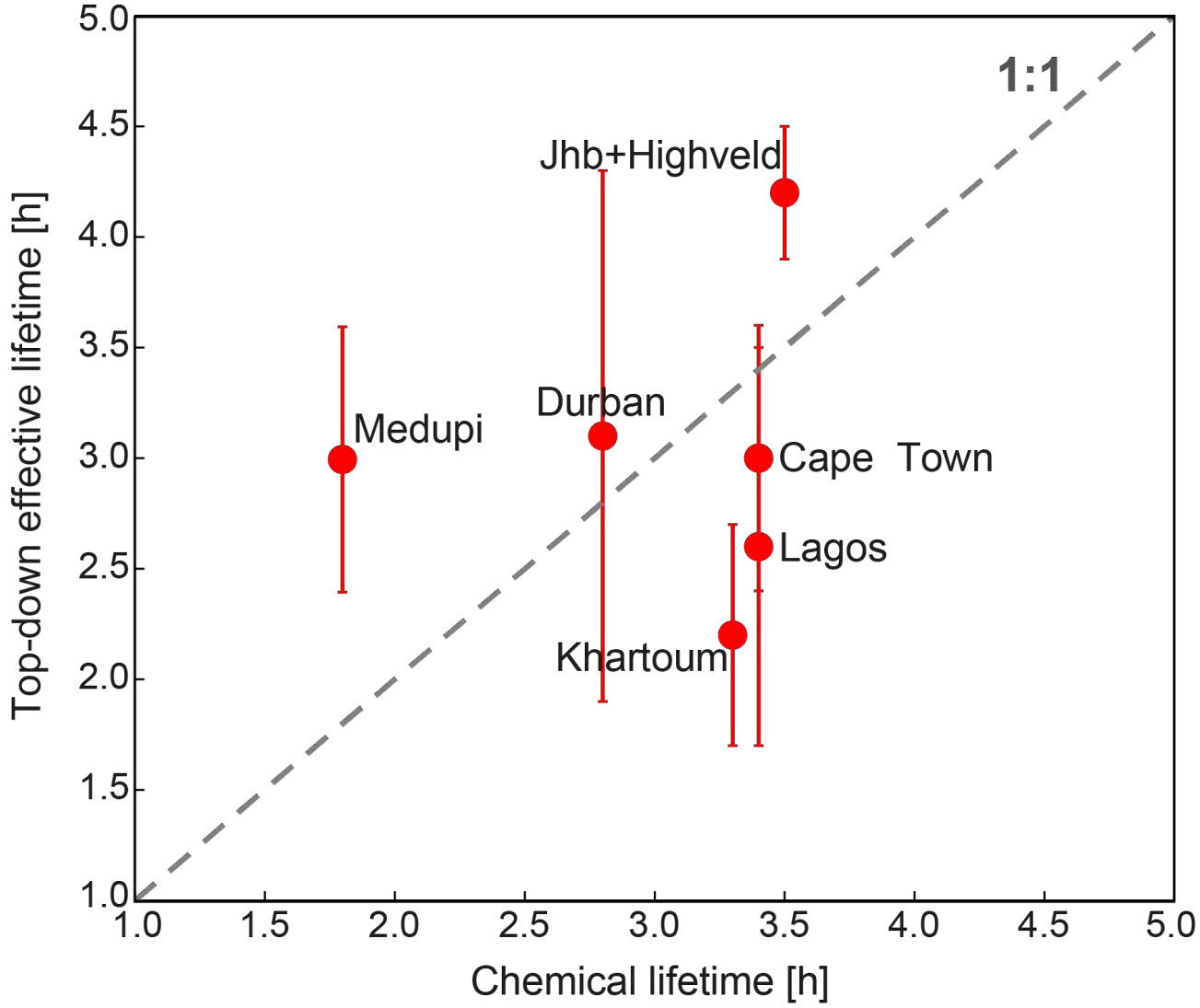
NO_x:NO_2 converts moles NO_2 in plume to moles NO_x

Caveat:
Medupi is Jan-Jul only

Top-down reproduces "truth" for all except Medupi annual estimates with city-specific NO_x:NO_2

Comparison of Top-Down and Chemical Lifetimes

How does the effective lifetime compare to the “true” chemical lifetime?



Chemical lifetime:
HNO_3 production via
$NO_2 + OH \rightarrow HNO_3$

Caveat:
Medupi is Jan-Jul only

Top-down annual effective lifetimes dissimilar to chemical lifetimes without any clear pattern

Take-Home Messages

- TROPOMI-derived emissions range from 2 to 130 mol s^{-1} for hotspots in Sub-Saharan Africa
- TROPOMI-derived effective lifetimes range from 2 to 10 h for the same hotspots
- Top-down annual emissions consistent with “true” emissions for synthetic experiment using GEOS-Chem if city-specific NO_x:NO_2 used
- Top-down effective lifetimes shorter than chemical lifetimes for plumes that are not huge
- Assessment of top-down seasonal emissions and lifetimes underway