Deriving NO_x Emissions of Hotspots in Sub-Saharan Africa with TROPOMI

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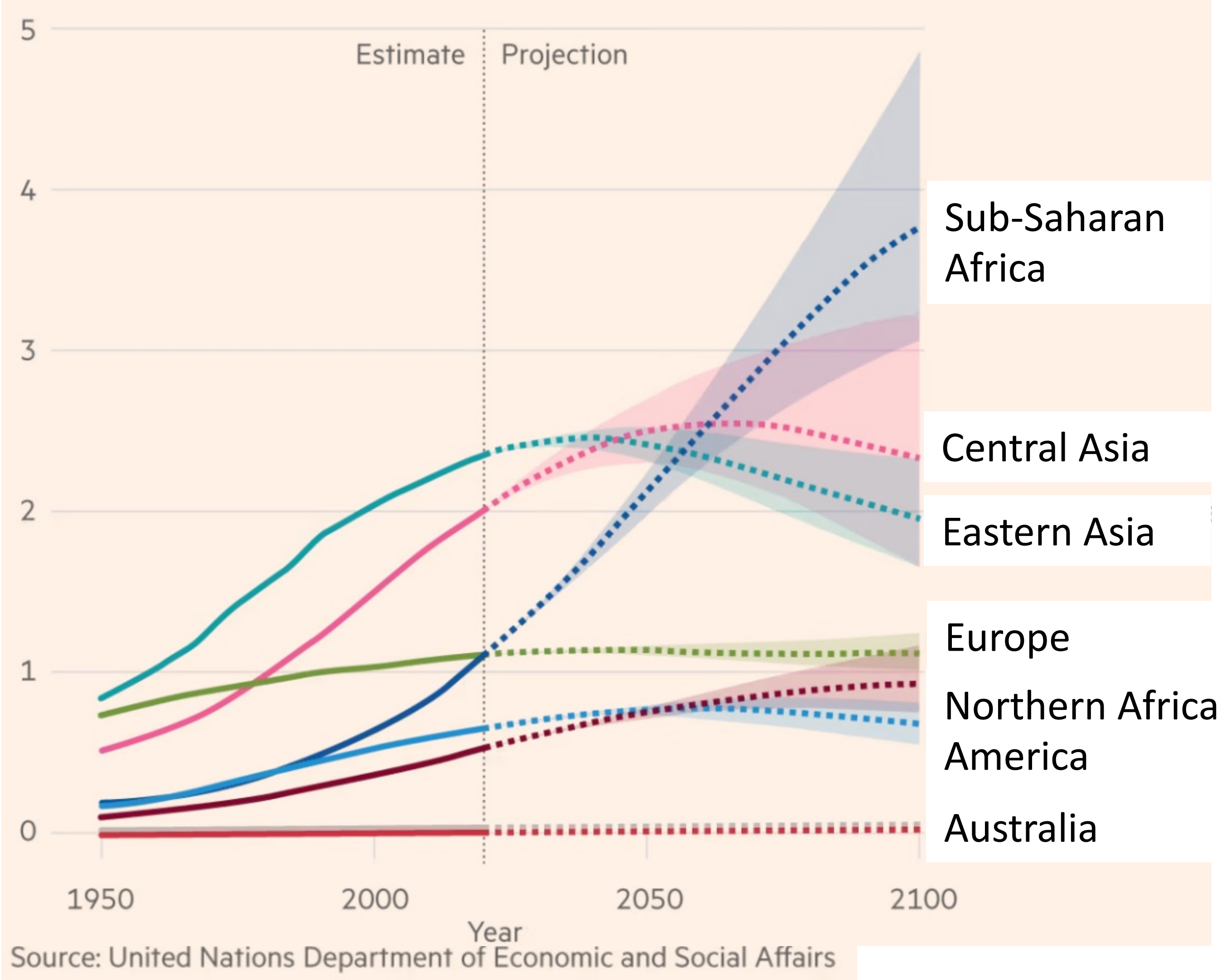
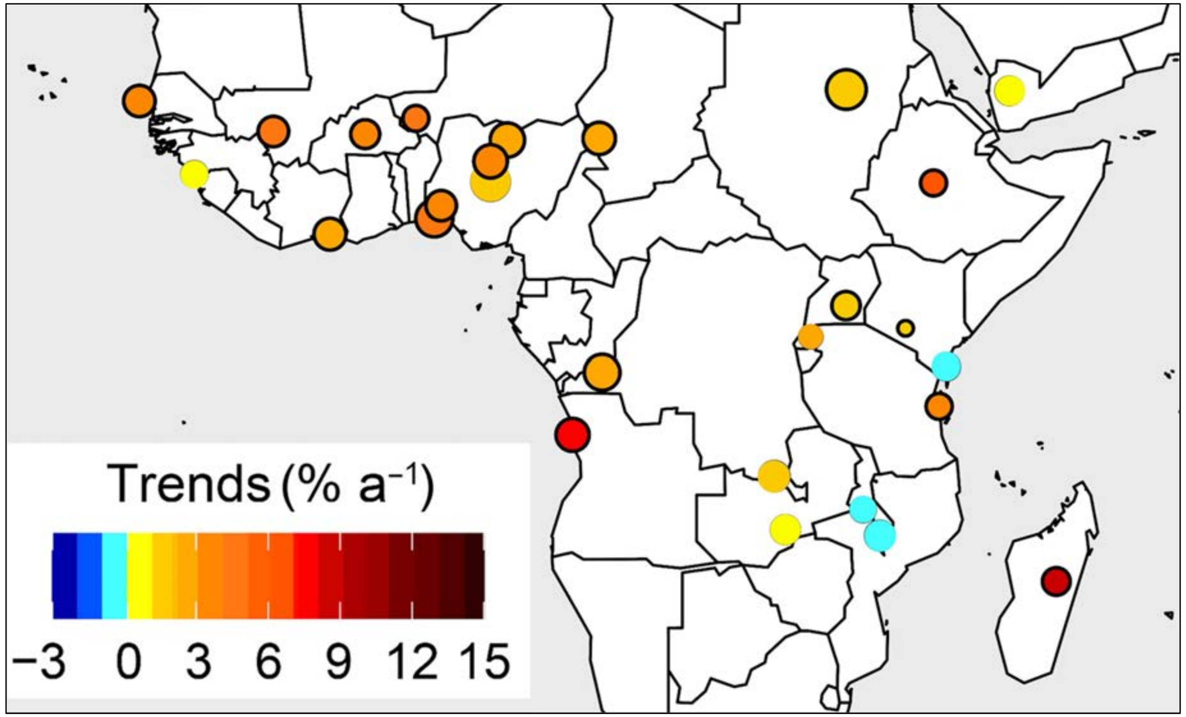
Figures: https://cer.org.za/news/eskom-flouts-air-pollution-laws-and-world-bank-loan-conditions

Significant annual increase of NO_2 in fast-growing cities in Sub-Sahara Africa

Total population (billion)



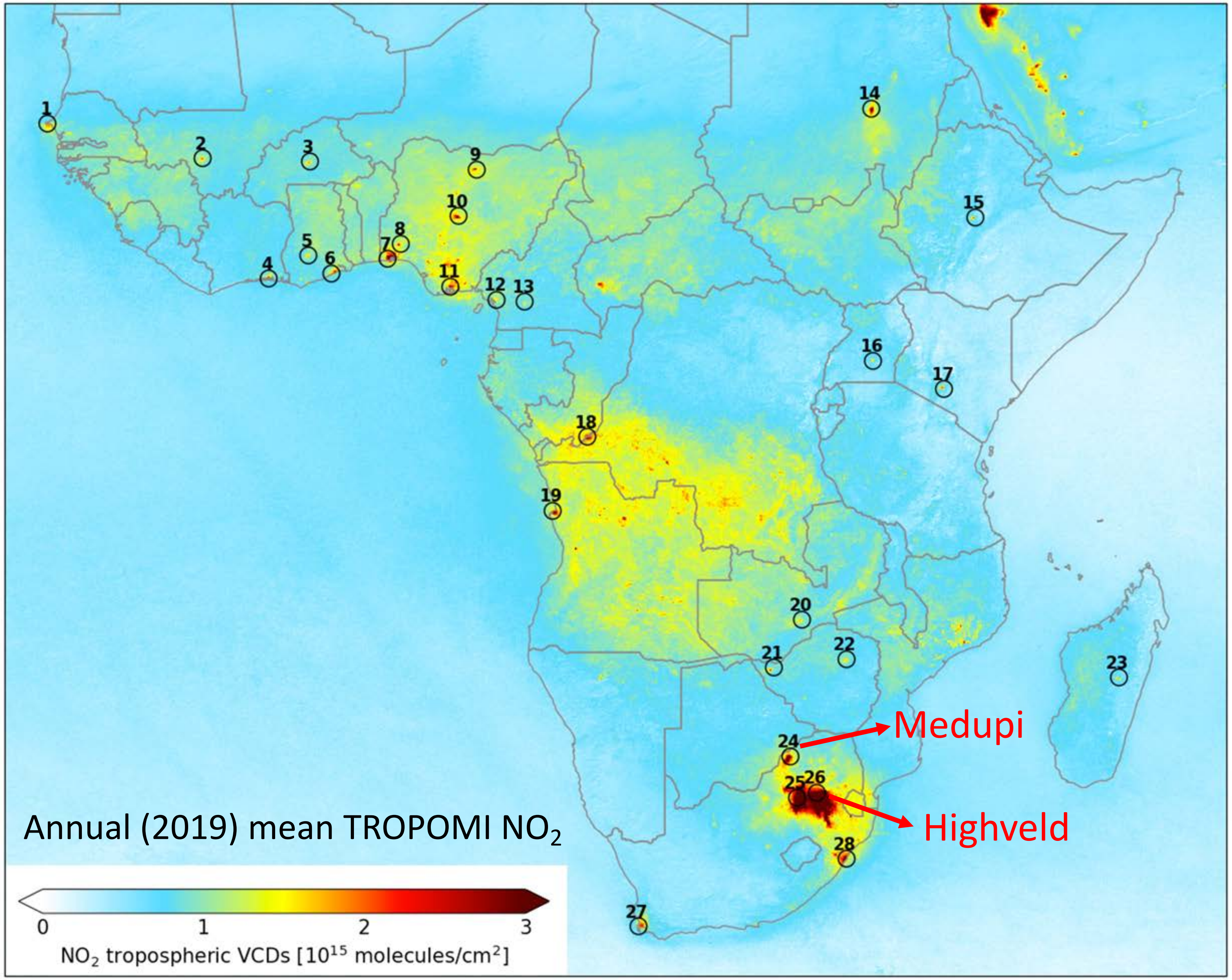
Trends in NO_2 for 2005-2018 from OMI

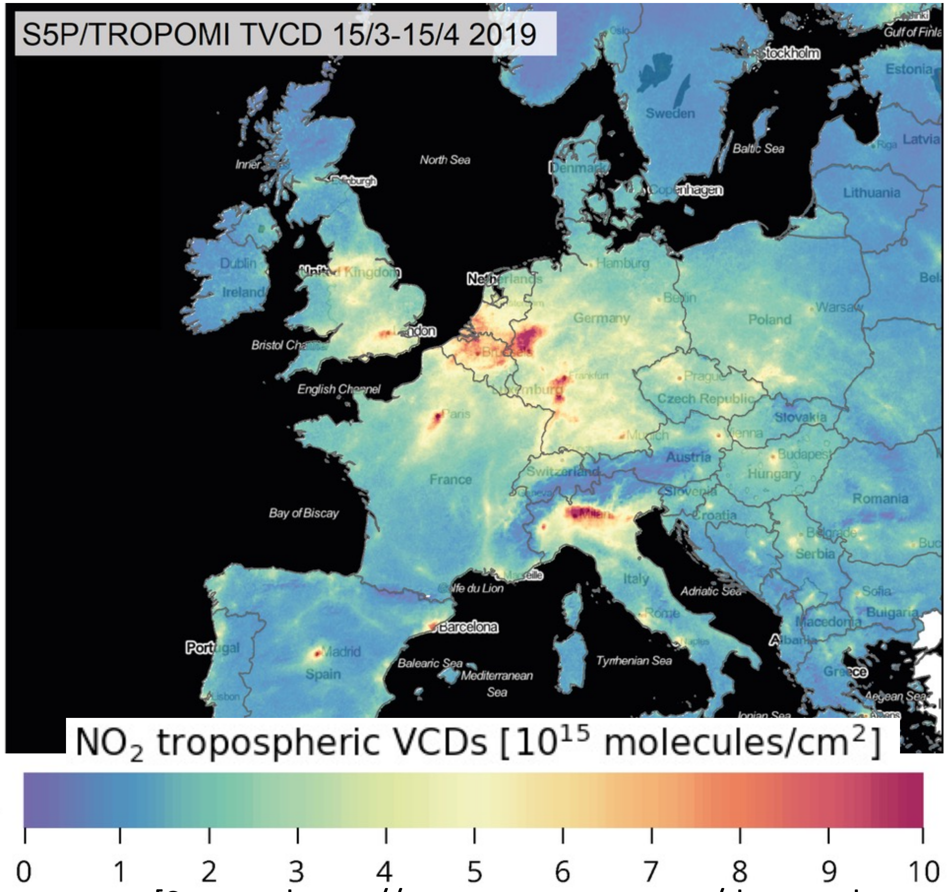


[Vohra et al., 2022]

Understanding underlying NO_x emissions in Sub-Sahara Africa is essential for policy making.

TROPOMI NO_2 in Sub-Saharan Africa and Europe



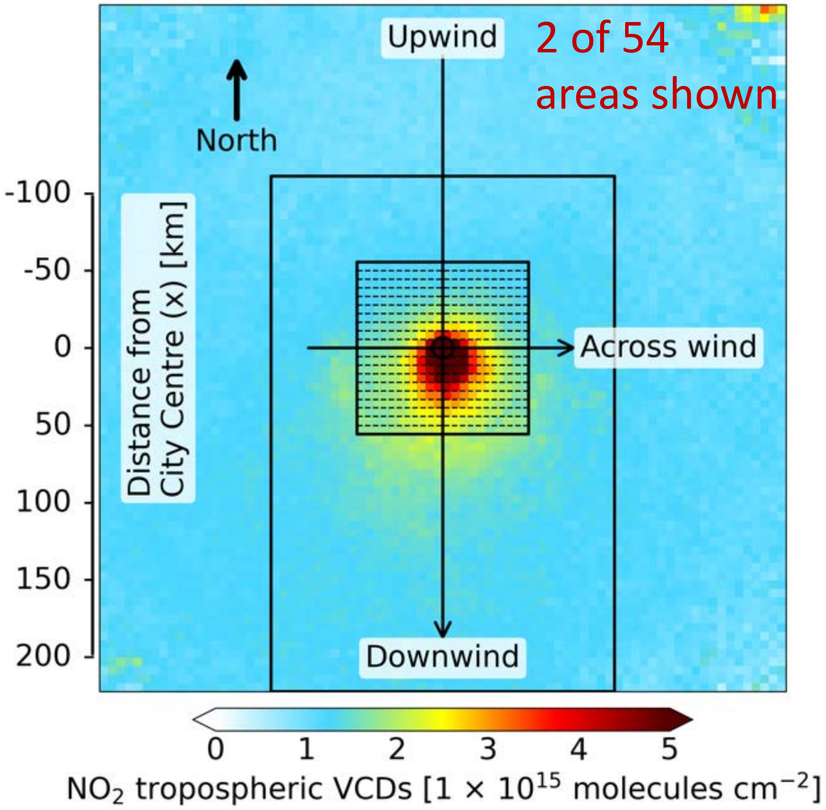


[Source: https://www.eea.europa.eu/data-and-maps]

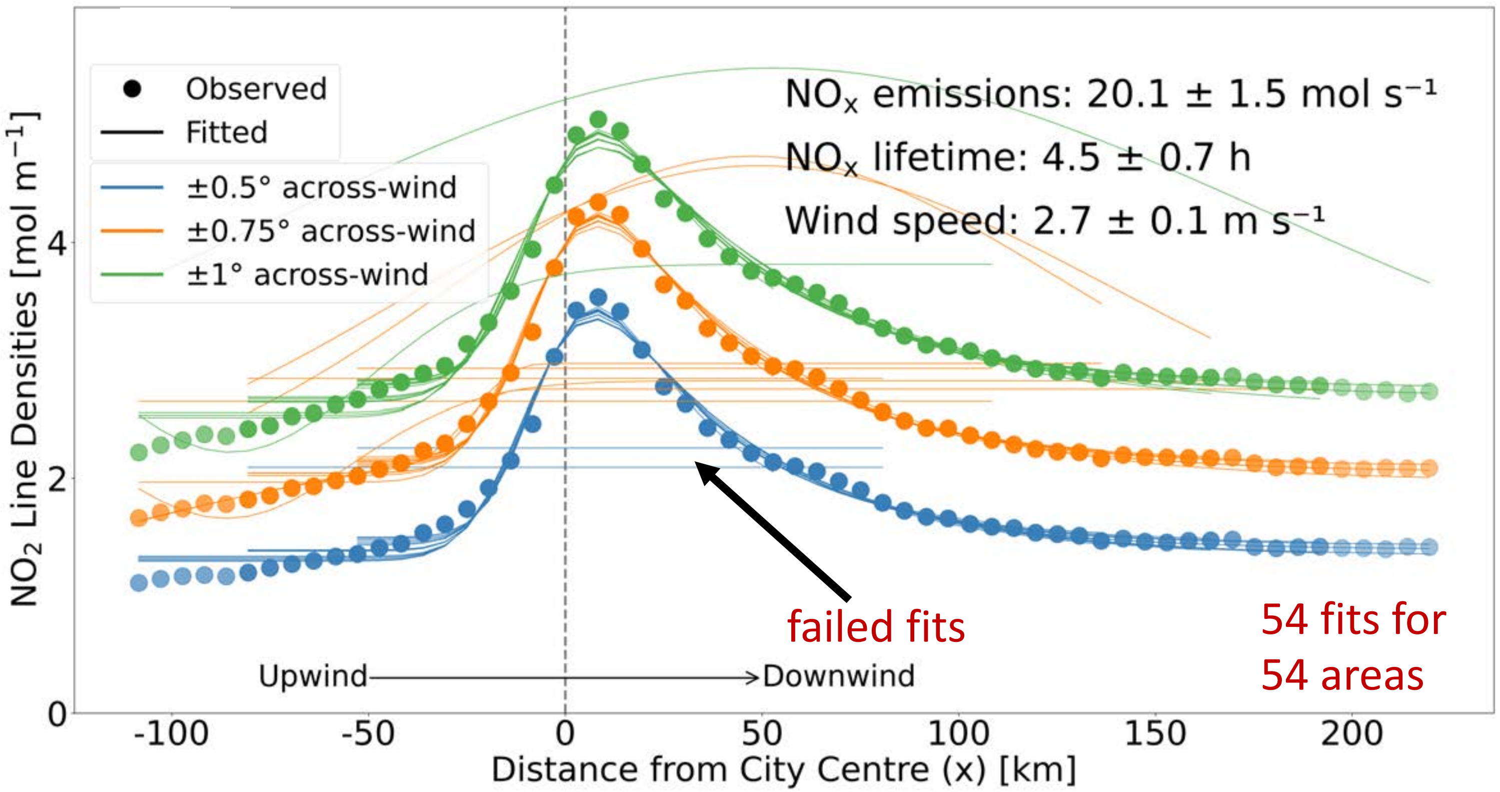
- 28 mostly urban hotspots.
- Much lower concentrations in Sub-Saharan Africa than Europe (above), China, North America, India.

Updated wind rotation and EMG fit approach to estimate NO_x emissions

Wind rotate and grid windy scene TROPOMI NO_2 for Lagos, Nigeria



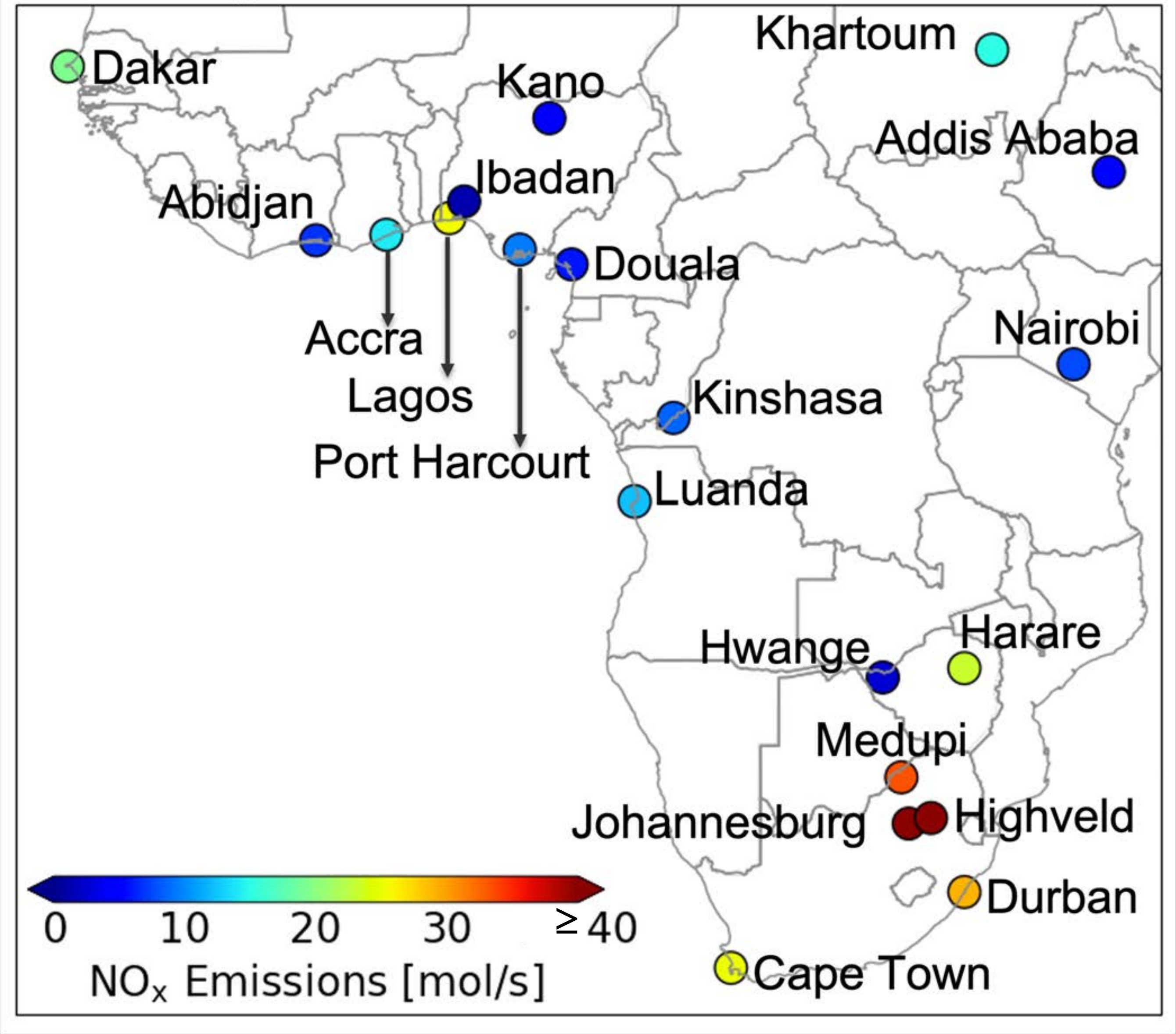
Fit the Exponential Modified Gaussian (EMG) function (solid lines) to observed line densities (filled circles)



We use an improved method (Lu et al., 2024) that selects many sampling areas to increase success of EMG fit.

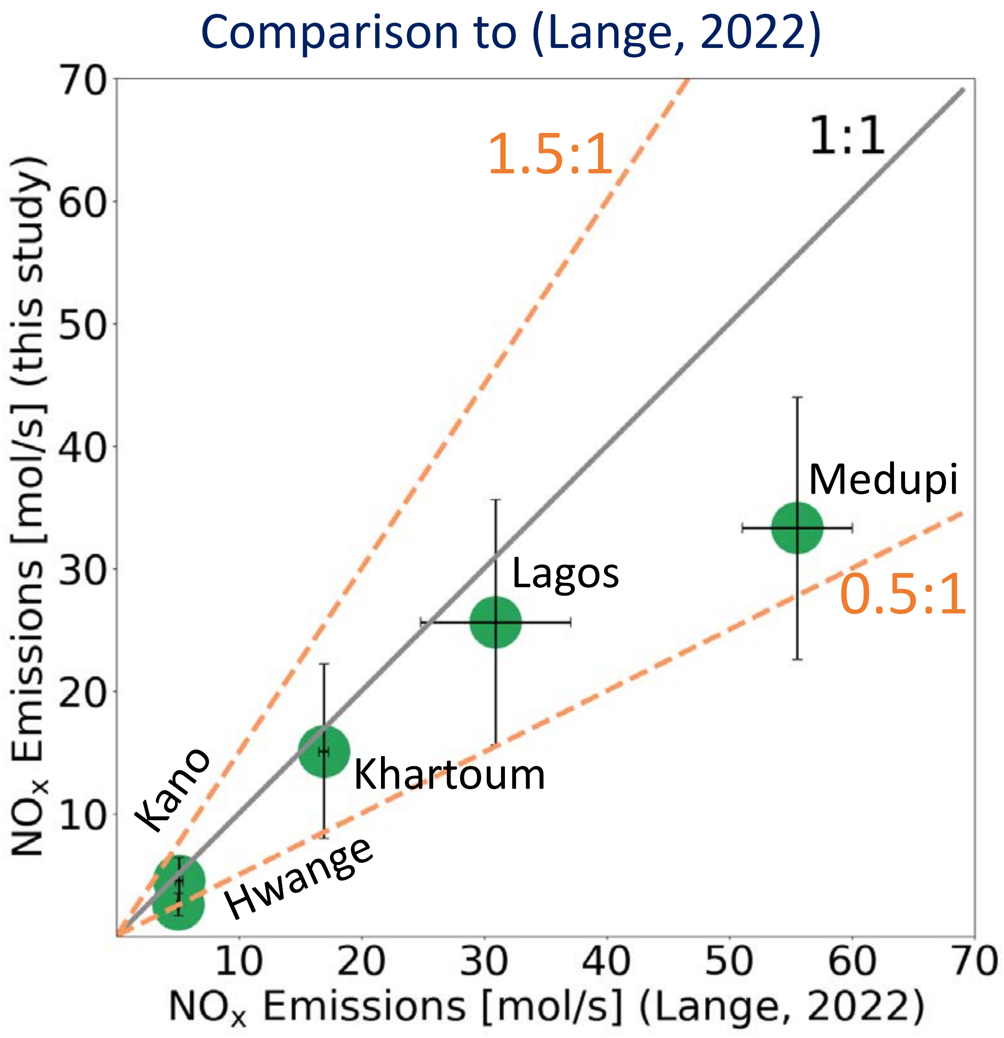
Derived annual mean NO_x emissions for the targeted hotspots

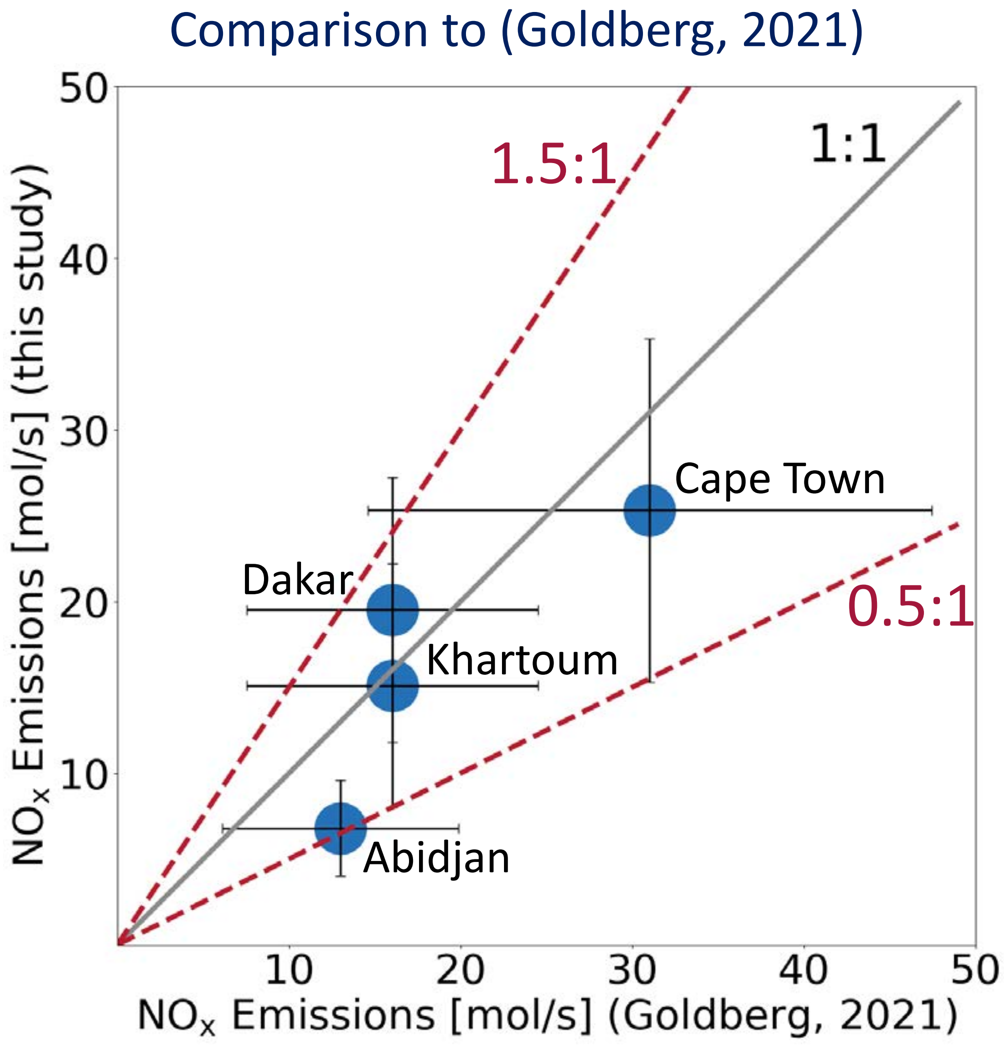
Annual (2019) mean NO_x emissions in Sub-Saharan Africa



- 20 out of 28 hotspots successful (18 cities, 1 power plant, 1 industrial area)
- 8 fail, as background and plume not distinct enough
- NO_x emission range:
  2 mol/s (Ibadan, Nigeria) to
  75 mol/s (Jhb, SA) to
  130 mol/s (Highveld, SA)
- South Africa hotspot emissions far greater (28-130 mol/s) than rest of Sub-Saharan Africa (<28 mol/s)

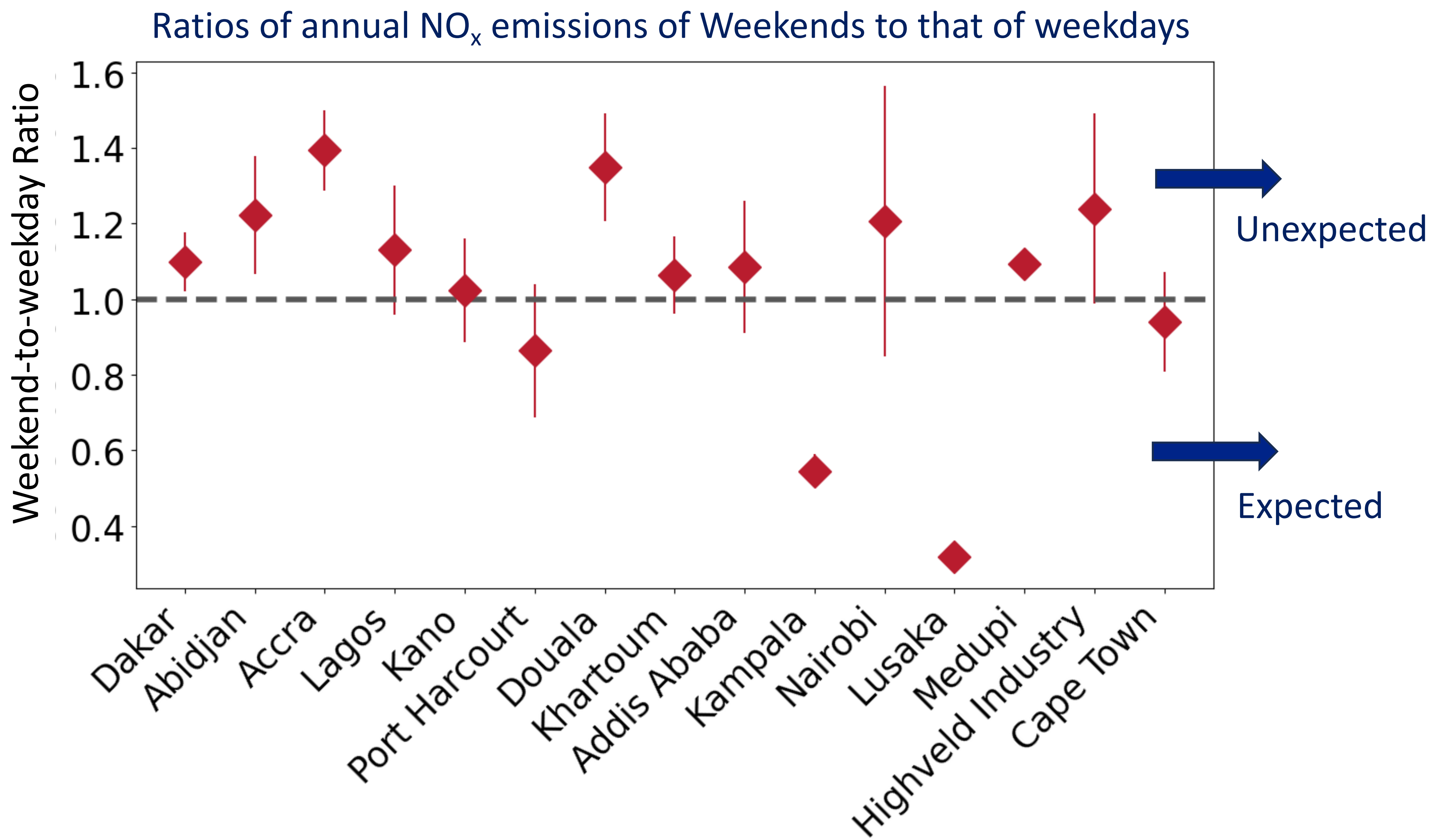
Comparison with NO_x emissions from previous EMG method





Our top-down NO_x emissions are on average ~28% less than Lange et al. and ~14% less than Goldberg et al.

Quantified weekend-to-weekday NO_x emissions ratios



Opposite effect (weekend > weekday) than is typical (weekend < weekday) in most cities.

Conclusions

1. NO_x emissions are derived successfully for 20 of 28 targeted hotspots in Sub-Saharan Africa.

2. Hotspots NO_x emissions range from 2 mol/s to 130 mol/s.

3. Our NO_x emissions are only 14-28% less than past studies.

4. Weekend effect finding (weekend NO_x > weekday NO_x) is different to what is expected.

Next Steps

1. Compare top-down NO_x emissions to global and regional anthropogenic emission inventories.

2. Assess accuracy of wind rotation and EMG fit using synthetic data with nested grid simulations of GEOS-Chem over African cities.