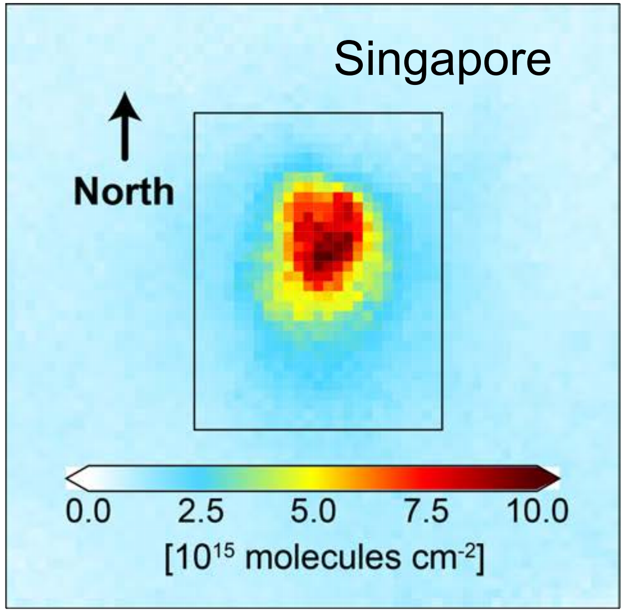
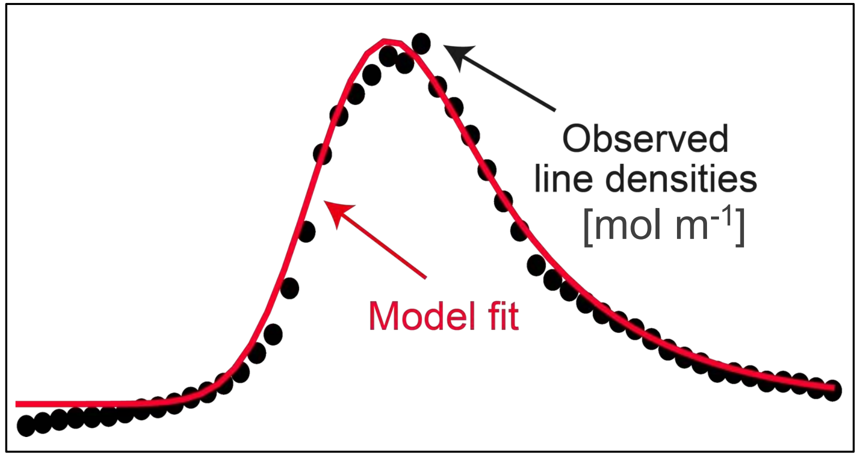
Near-Automated Estimate of City Nitrogen Oxides Emissions Applied to South and Southeast Asia

Wind rotated TROPOMI NO_2



Model fit to yield best-fit parameters

Across-wind sum of vertical columns



City NO_x Plume Emissions

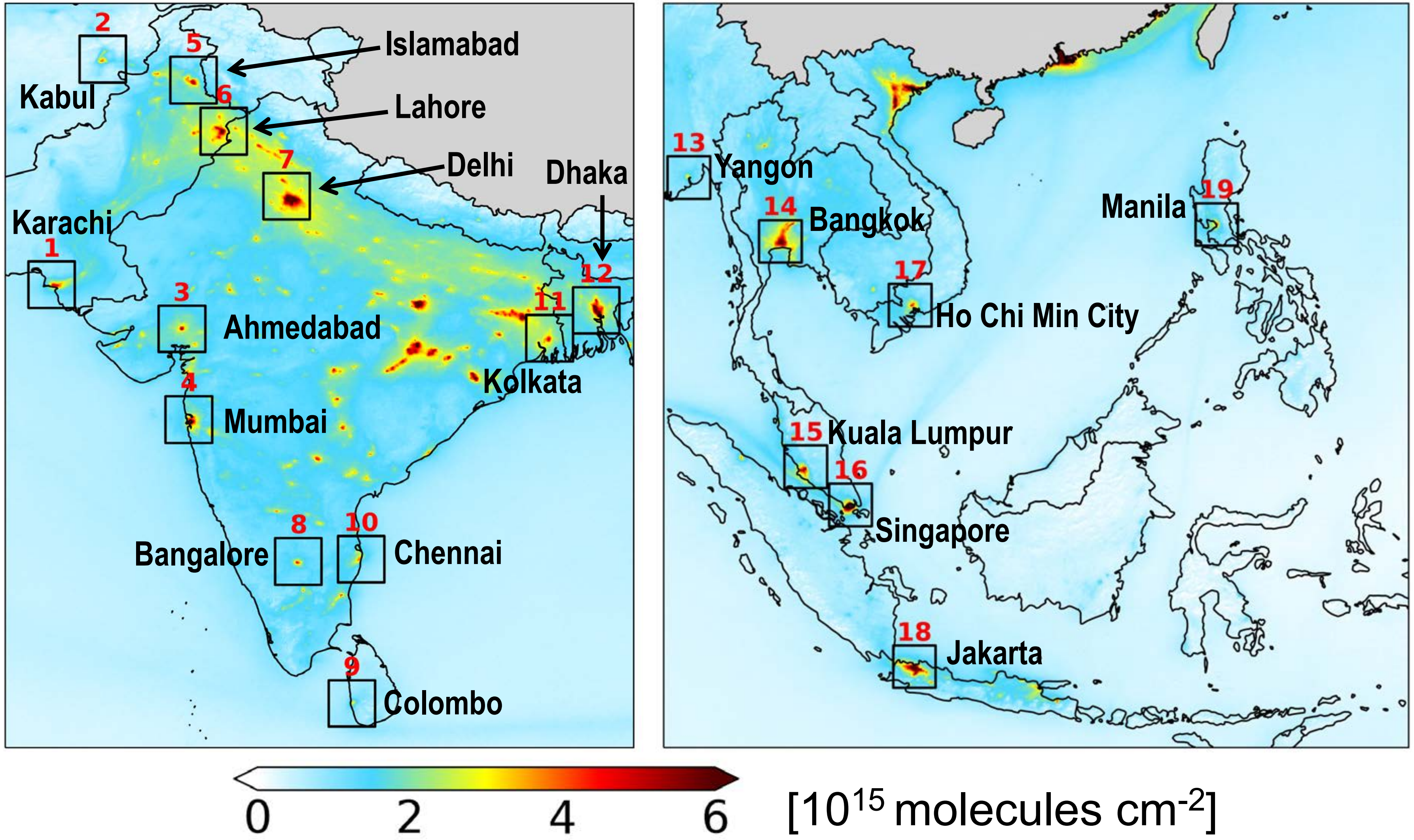
112 mol NO_x s^{-1}

Gongda Lu, **E. A. Marais**, K. Vohra, R. Horner, D. Zhang, R. V. Martin, S. Guttikunda

EGU General Assembly 2024

Target Cities in Understudied Regions with Large Hotspots

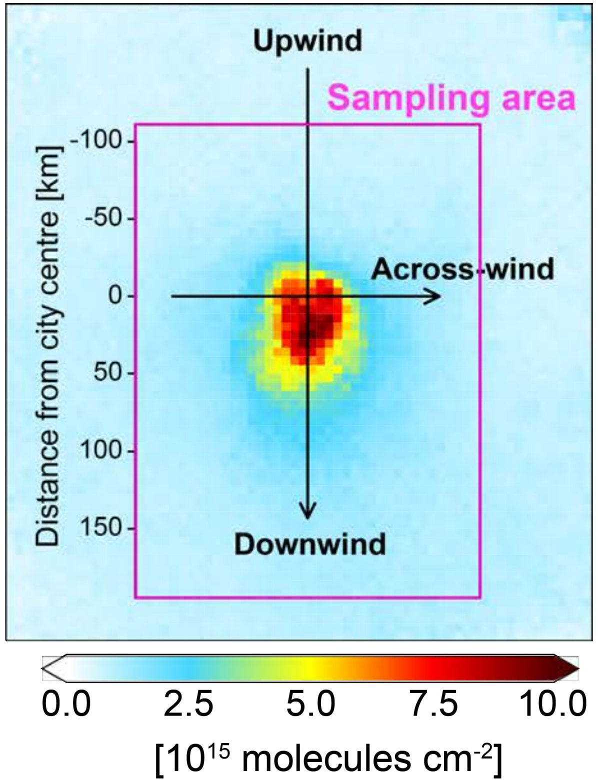
Annual (2019) mean TROPOMI NO_2 at ~5 km resolution



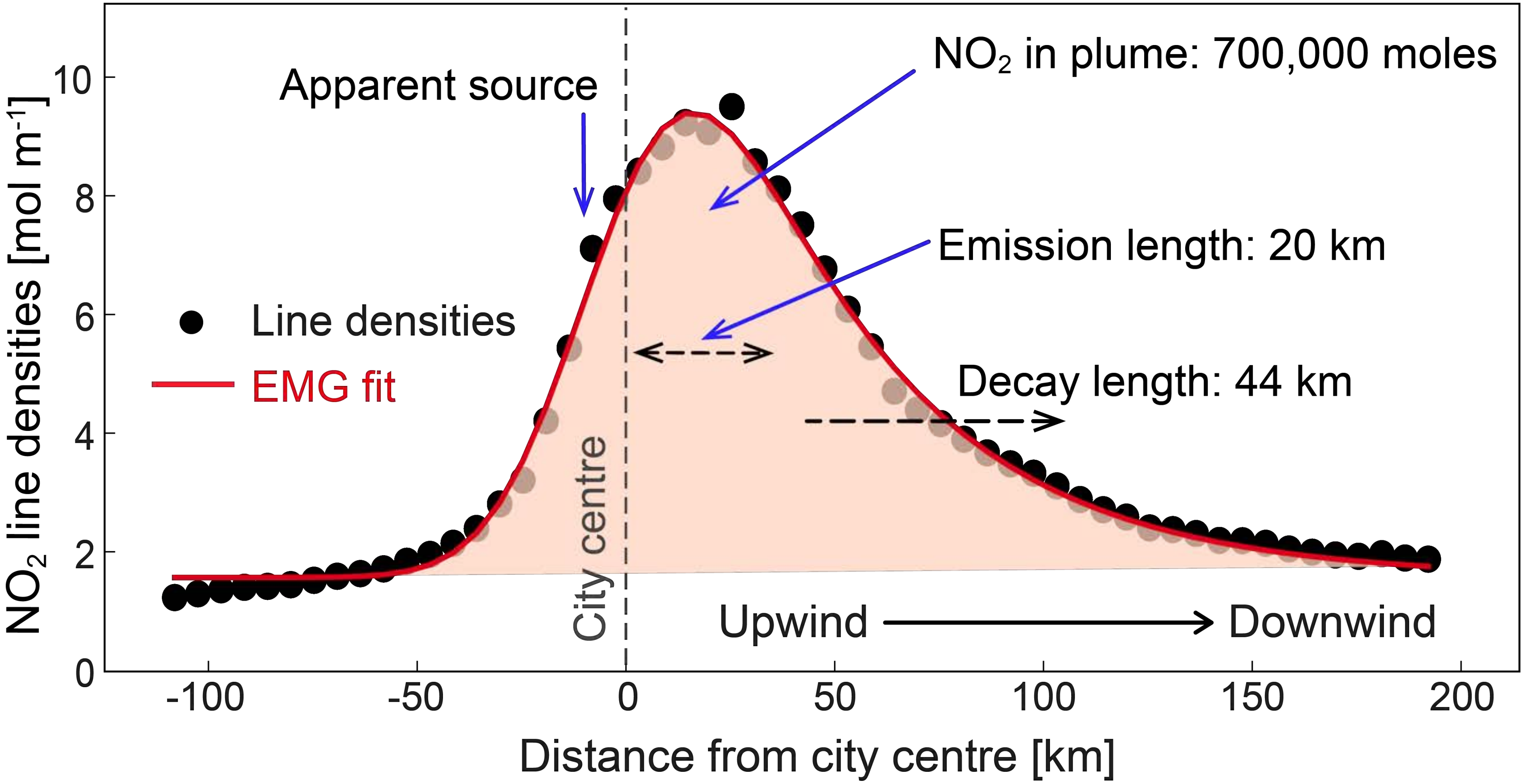
19 isolated hotspots selected (other hotspots: industries, power plants or not isolated)

Issue with Current Approach

Wind-rotated plume (speeds > 2 m/s)



Exponential Modified Gaussian (EMG) fit and best-fit parameters

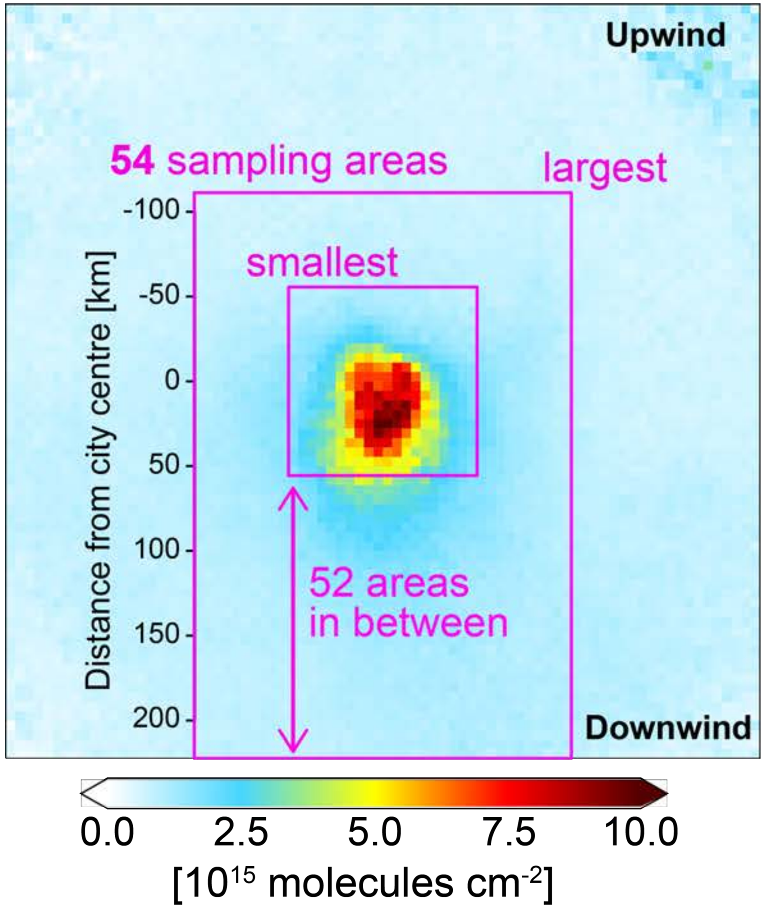


Many criteria must be satisfied for successful EMG fit, so often fails

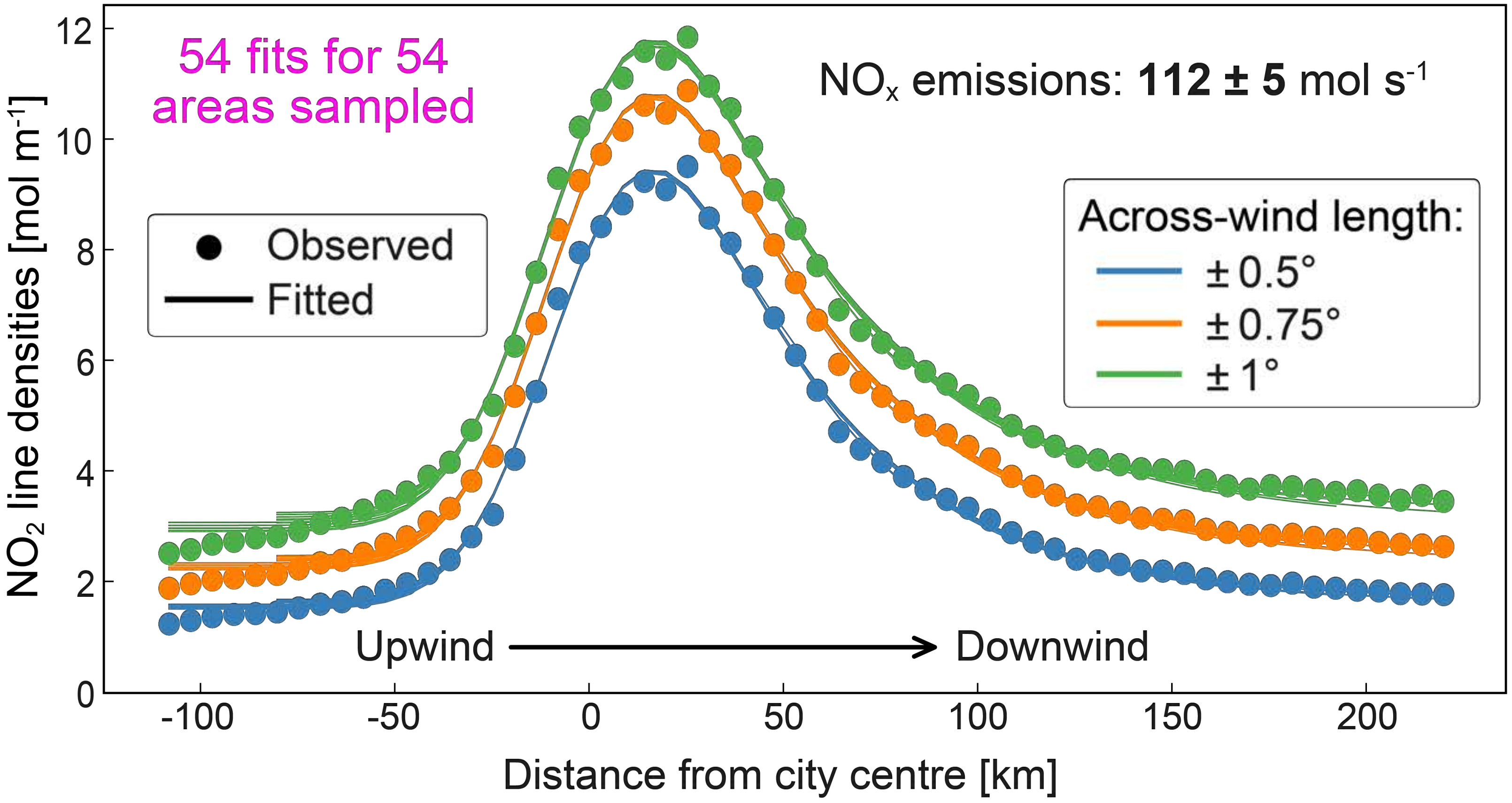
EMG fit fails for 40-60% of selected cities, depending on single sampling area chosen

Automate Selection of Multiple Sampling Areas

Wind-rotated plume



EMG fit to 54 sampling area line densities



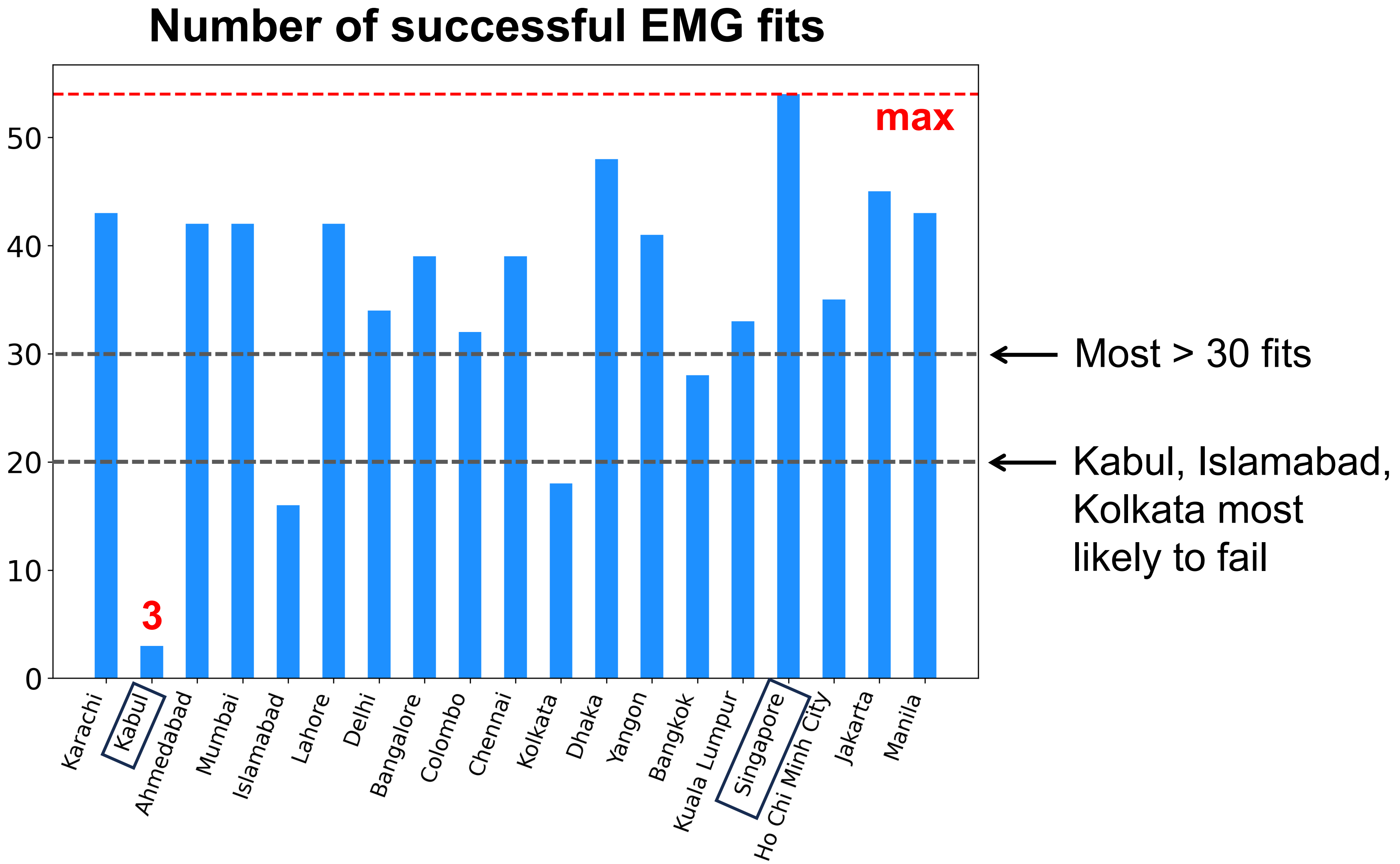
Mean of successful fits is the top-down emissions and standard deviation is the EMG fit error

Fit Success Enhanced with Many (54) Sampling Areas

Failed fits ranked:

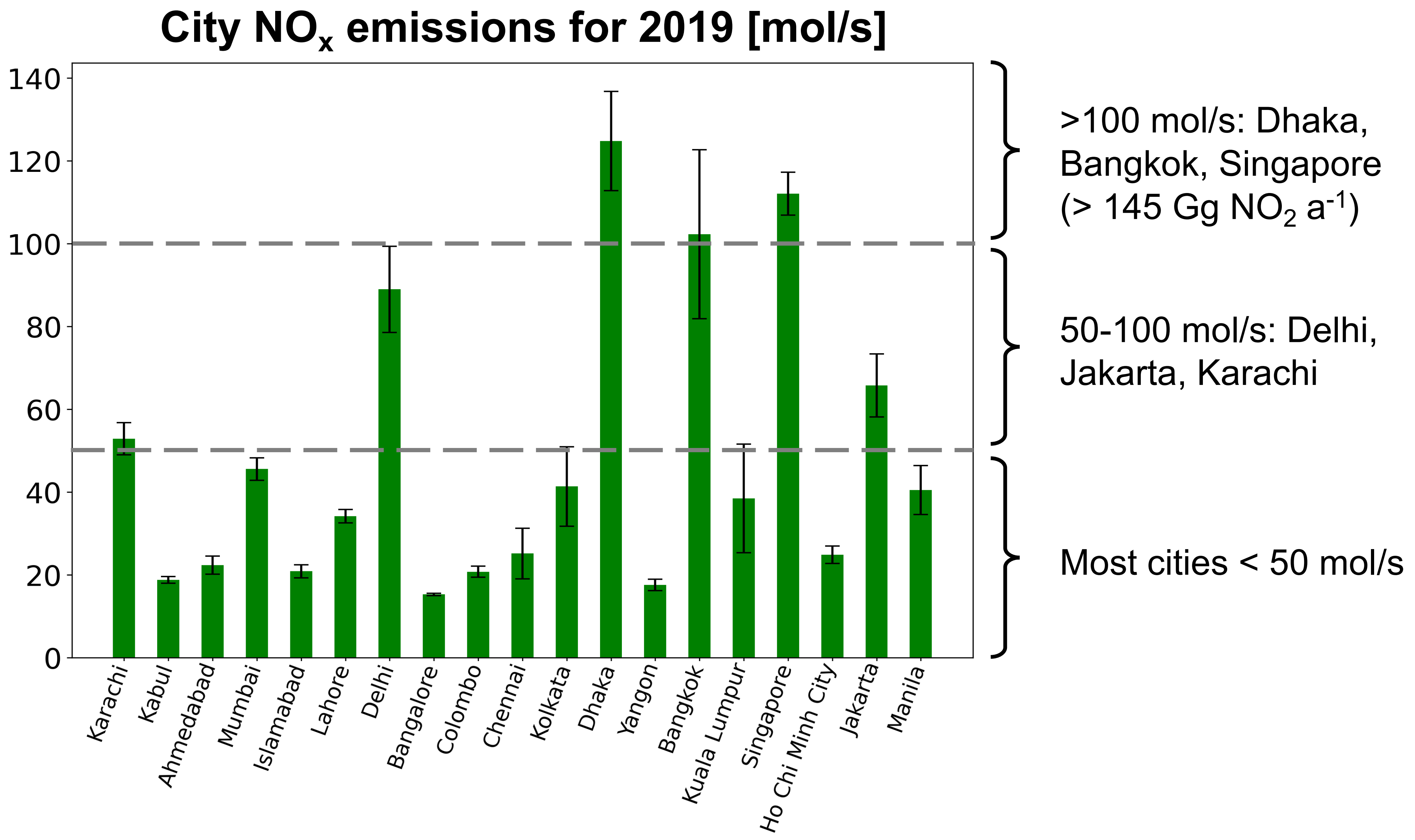
- Poor fit ($R^2 \leq 0.8$)
- Emission width > NO_2 decay length
- NO_2 in plume < 0
- NO_2 decay length outside sampling area

[Criteria adopted from Laughner & Cohen, 2019]



Improve from 5 to 11 city emissions reported for these regions in past studies to 19 in this work

Derive City-Specific NO_x Emissions and Fit Uncertainties

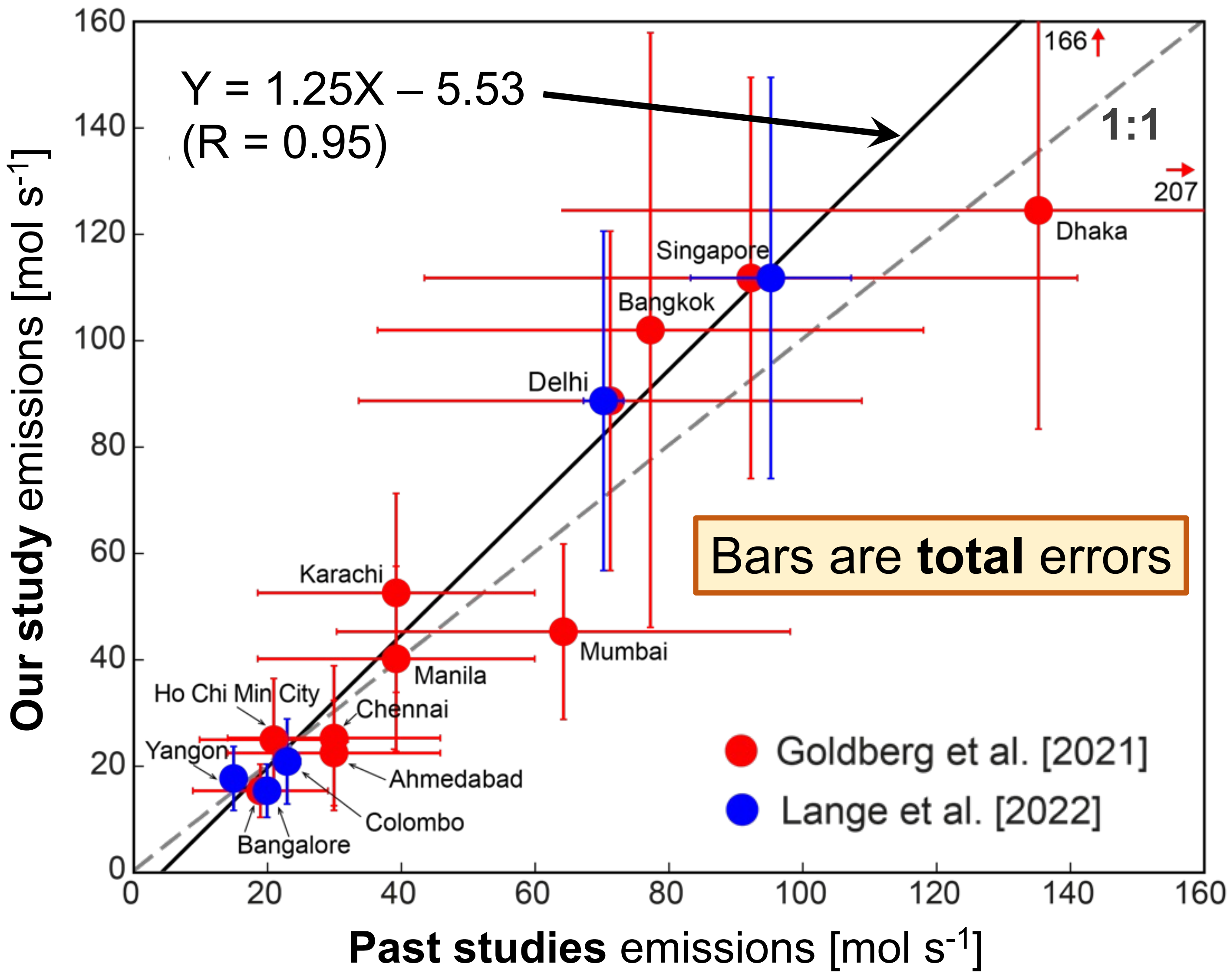


Relative error range:
4-34%

Range of past studies:
10-40%

NO_x emissions from mean of individual successful fits. Standard deviation provides fit error.

Assessment Against Past Top-down Studies



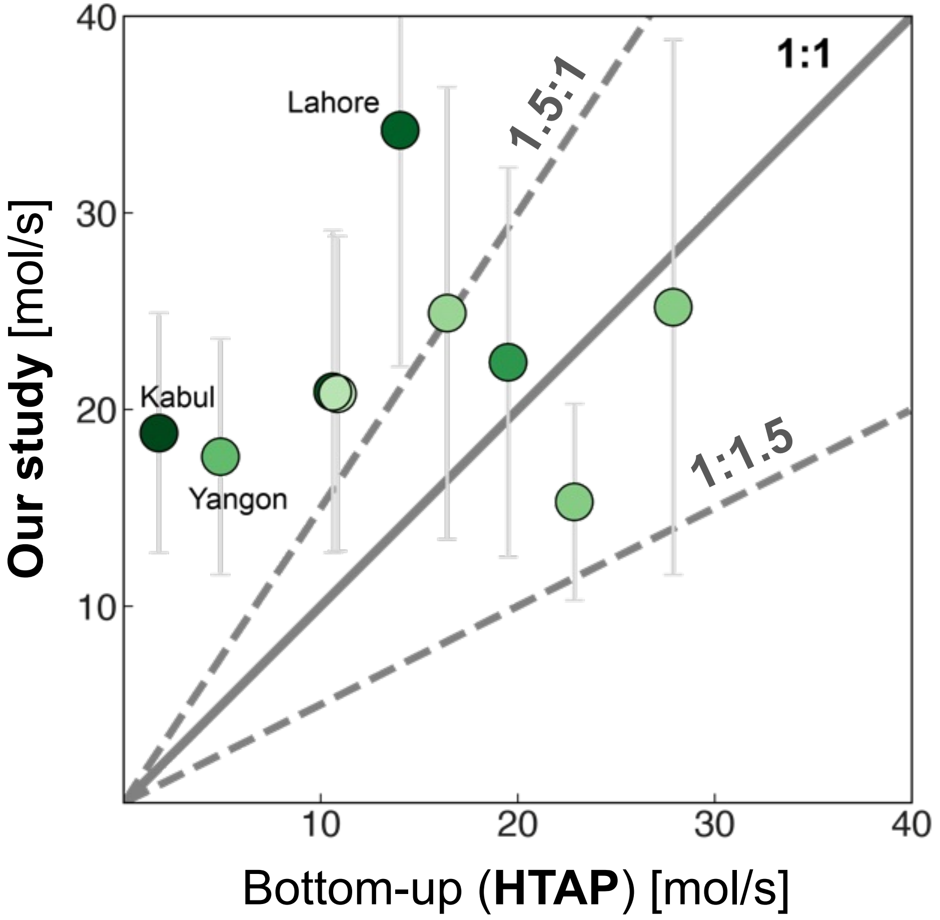
Goldberg et al:
OMI 3-year mean (2018-2020) of all months for all except Delhi and Karachi (May-Sept)

Lange et al:
TROPOMI until 03/2020 using earlier retrieval version

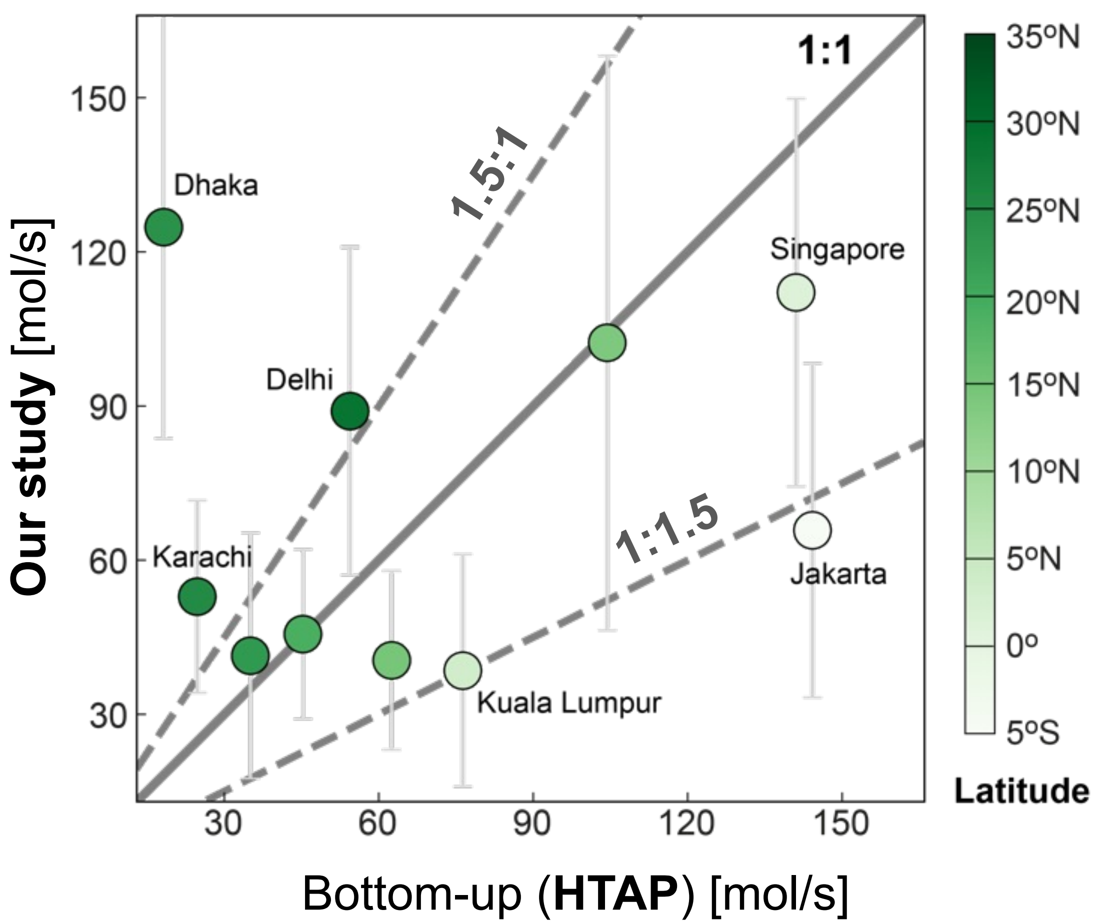
Our values ~25% more than others. Lange version differences. Goldberg causes not obvious.

Assessment Against Bottom-Up Estimates

Comparison for top-down < 35 mol/s



Comparison for top-down > 35 mol/s



Discrepancies greatest for Yangon (4 times), Dhaka (7 times), and Kabul (11 times).

Pattern emerges: Top-down > bottom-up to north and vice versa to south, as no accounting for latitudinal variability in photochemical lifetime of NO_x (NO_x loss dominated by advection)

Concluding Remarks

- Automate and eliminate need for subjective sampling area selection
- Success of deriving emissions improves from ~50% of cities to all (100%) cities
- Enables city-specific quantification of uncertainties in best-fit parameters
- Pattern emerges (latitude dependent discrepancies with bottom-up emissions) to identify opportunities to further improve the top-down method
- Enhanced success enables application to regions like Sub-Saharan Africa where **hotspots** are not so “**hot**”
- Questions or to use our code: e.marais@ucl.ac.uk
- Find out about other work in our group: https://maraisresearchgroup.co.uk/