

Tool for Recording and Assessing the City Environment



Engineering and
Physical Sciences
Research Council



Natural
Environment
Research Council



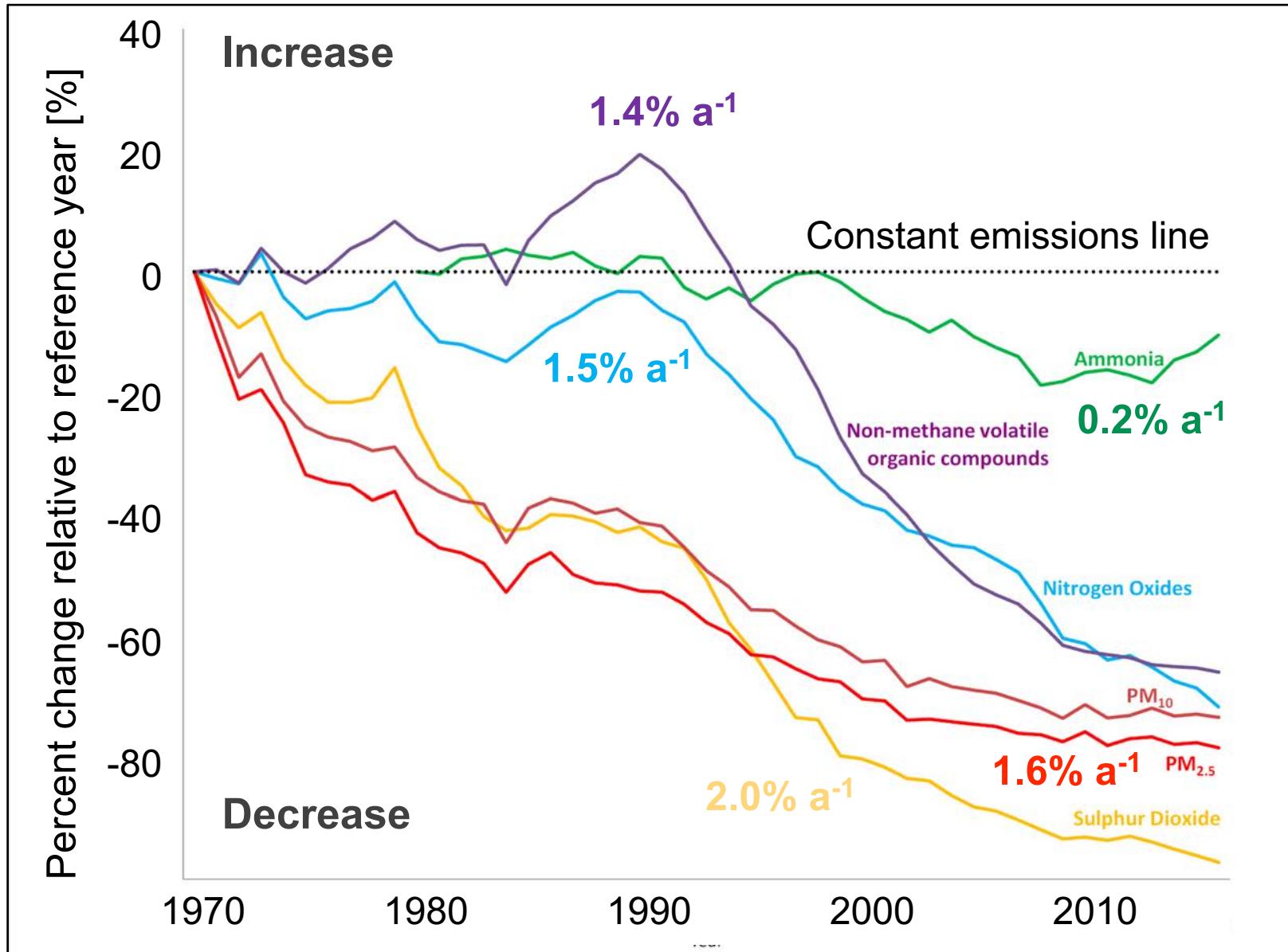
TRACE

RiR Event

Eloise A Marais

15 June 2020

Trends in UK Emissions of Pollutants and Precursors



Values are trends from the start of the record to 2016.

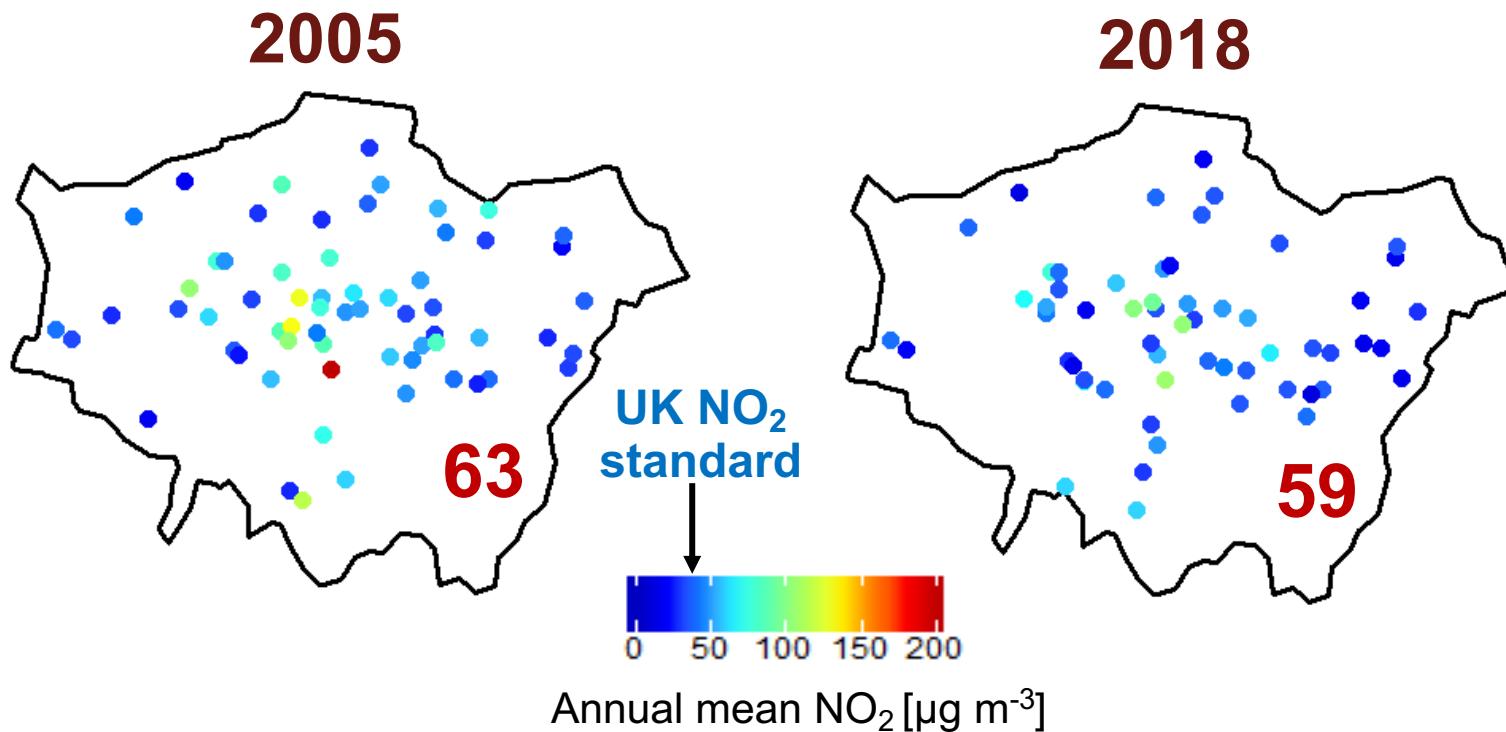
Emissions estimated in a bottom-up approach (relevant activities and emission factors)

Are these accurate?

How are emissions changing in cities?

Surface Monitors are Sparse and Inconsistent Satellites Offer Complete, Consistent Coverage

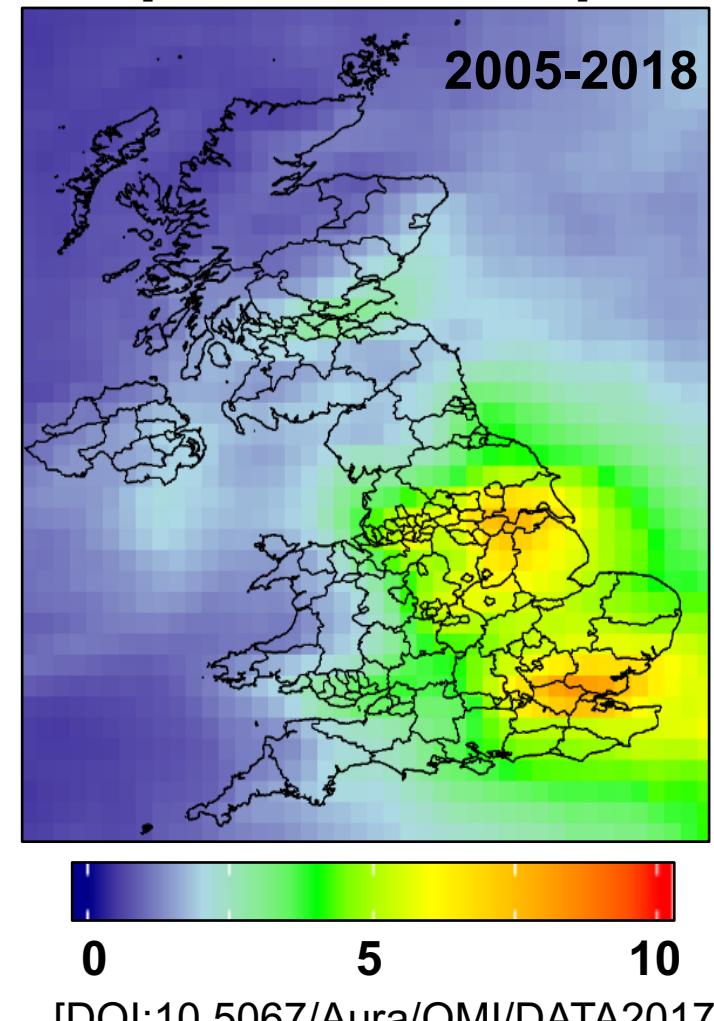
London Air Quality Network (LAQN) NO₂



London is likely the most widely monitored city in the world

[<https://www.londonair.org.uk/london/asp/datadownload.asp>]

Satellite NO₂
[10^{15} molecules cm⁻²]



Air Pollutants Impact Health and Vegetation

Food security



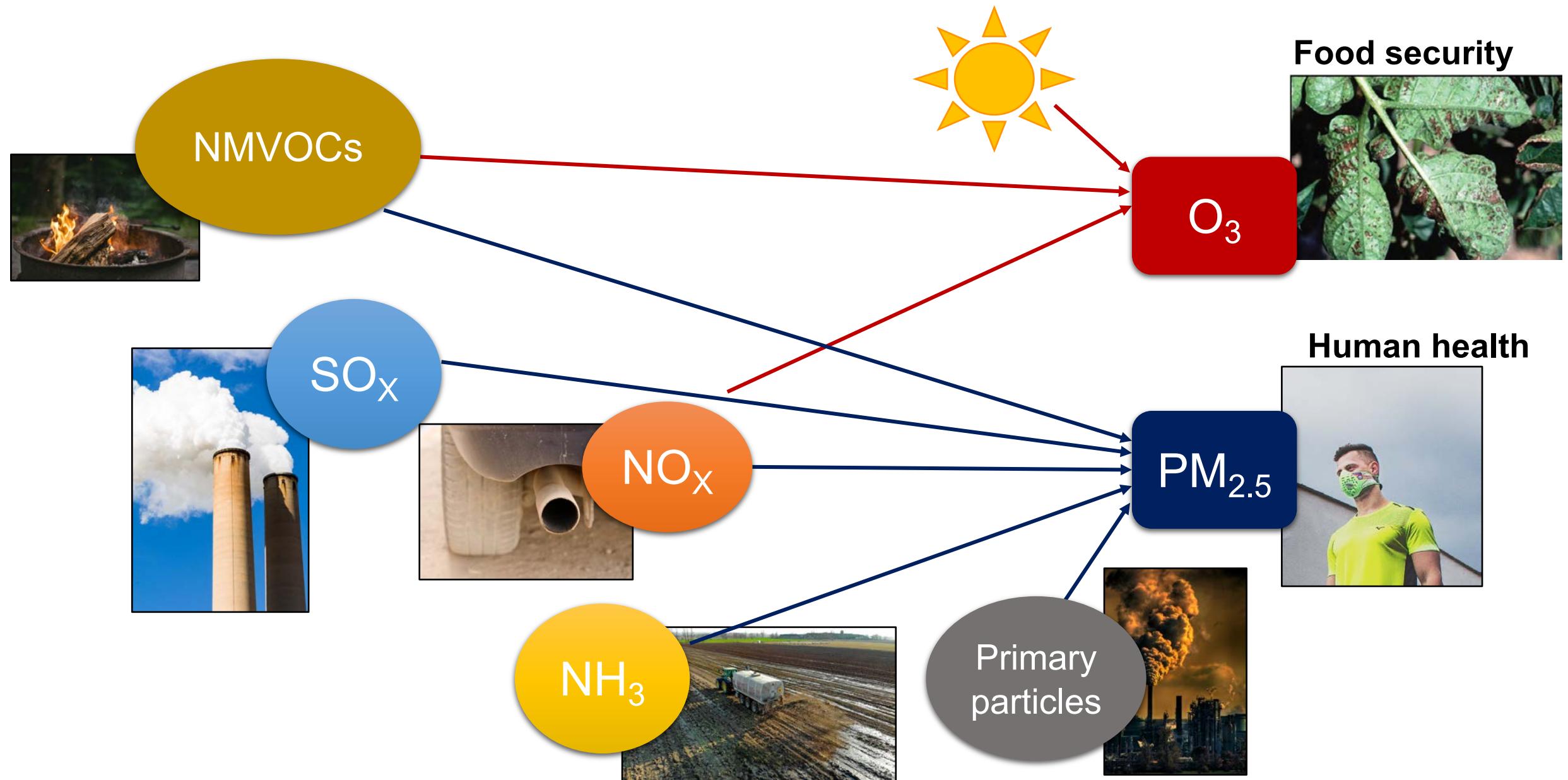
O_3

Human health

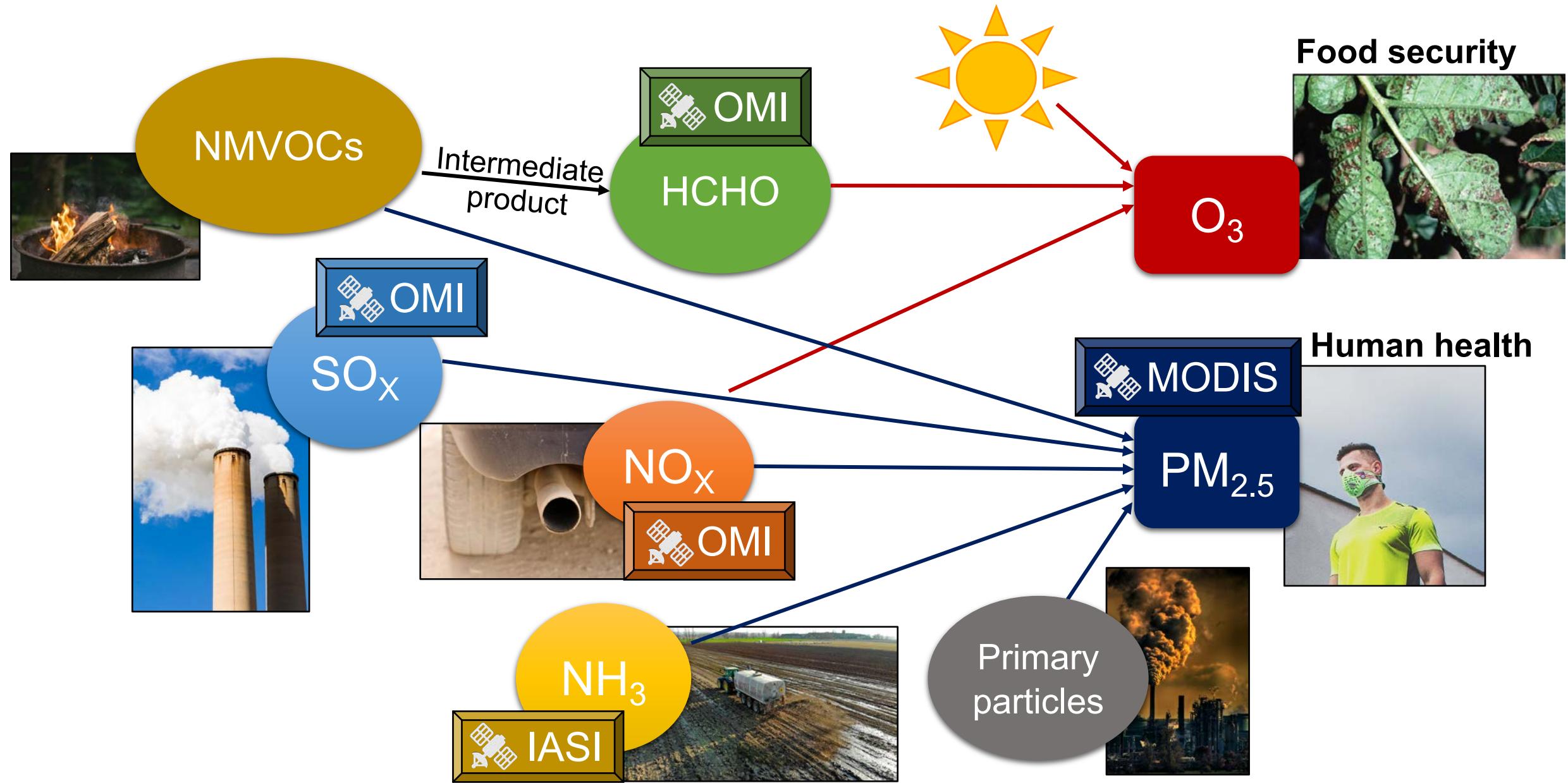
$PM_{2.5}$



These are Emitted or Formed Physically or Chemically



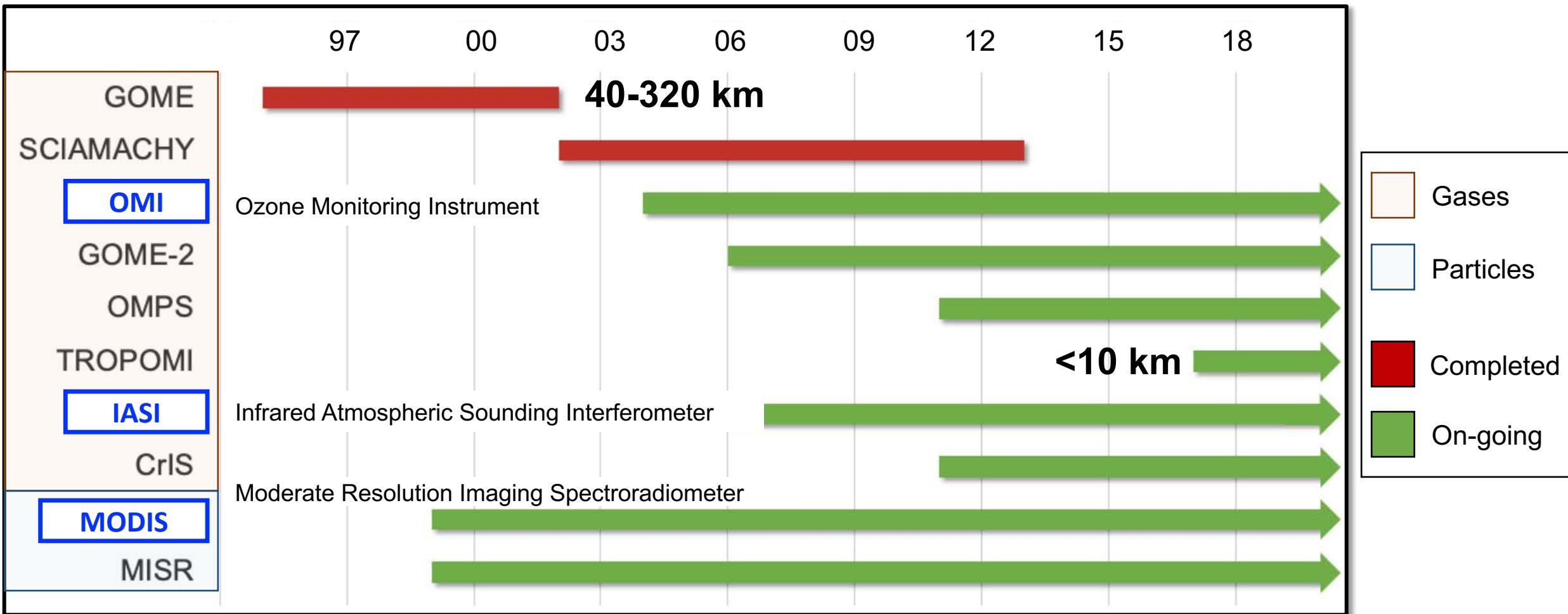
Satellites Monitor Many Air Pollutants and Precursors



The Satellite Record Extends to the Mid-1990s



Instruments we use

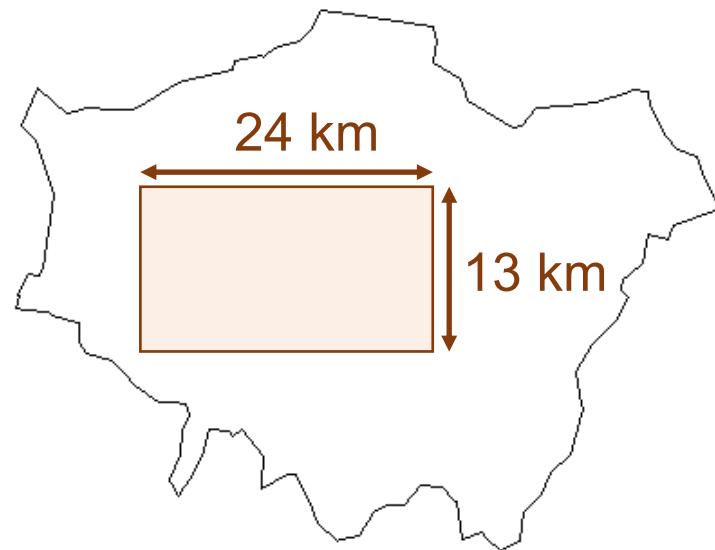


Measurements are at Coarse Spatial Resolution

Individual satellite pixels cover large swaths of a city

OMI

Ozone Monitoring Instrument
(NO₂, HCHO)



London
(1600 km²)

MODIS

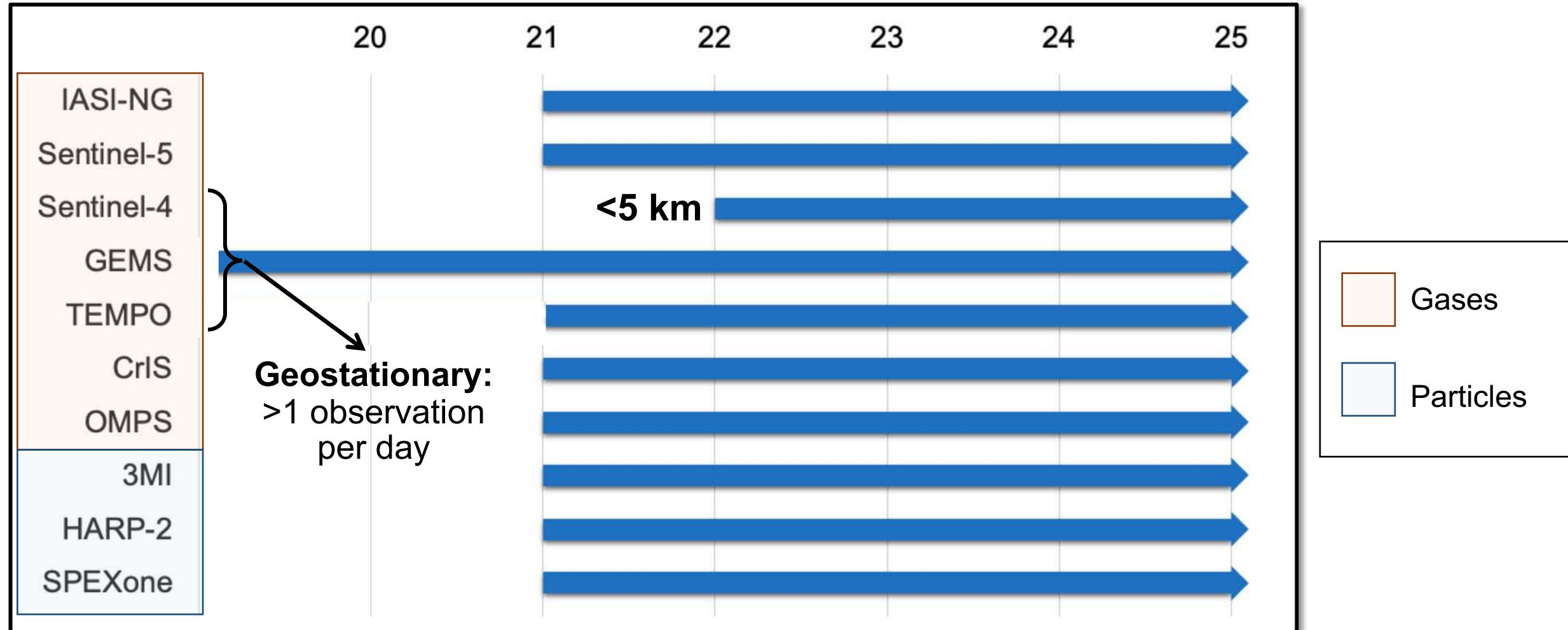
Moderate Resolution Imaging Spectroradiometer
(AOD)



IASI: 12 km (not shown)

Limited ability to determine sub-city variability

Spatial Resolution is Improving and the Record is Sustained



Satellites Measure Solar Backscattered Light Through the Whole Atmospheric Column

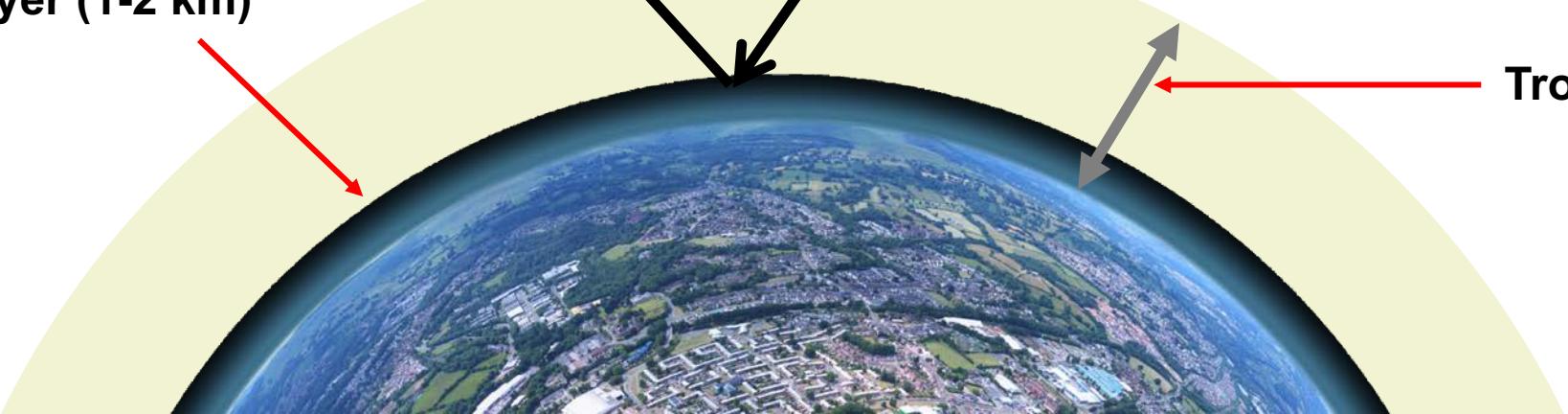
Measured quantities

Gases: Molecules in a column of air

Aerosols: Unitless optical depth

Pollution layer (1-2 km)

Troposphere layer
> 10 km



Quality Assure Against Reliable Surface Observations

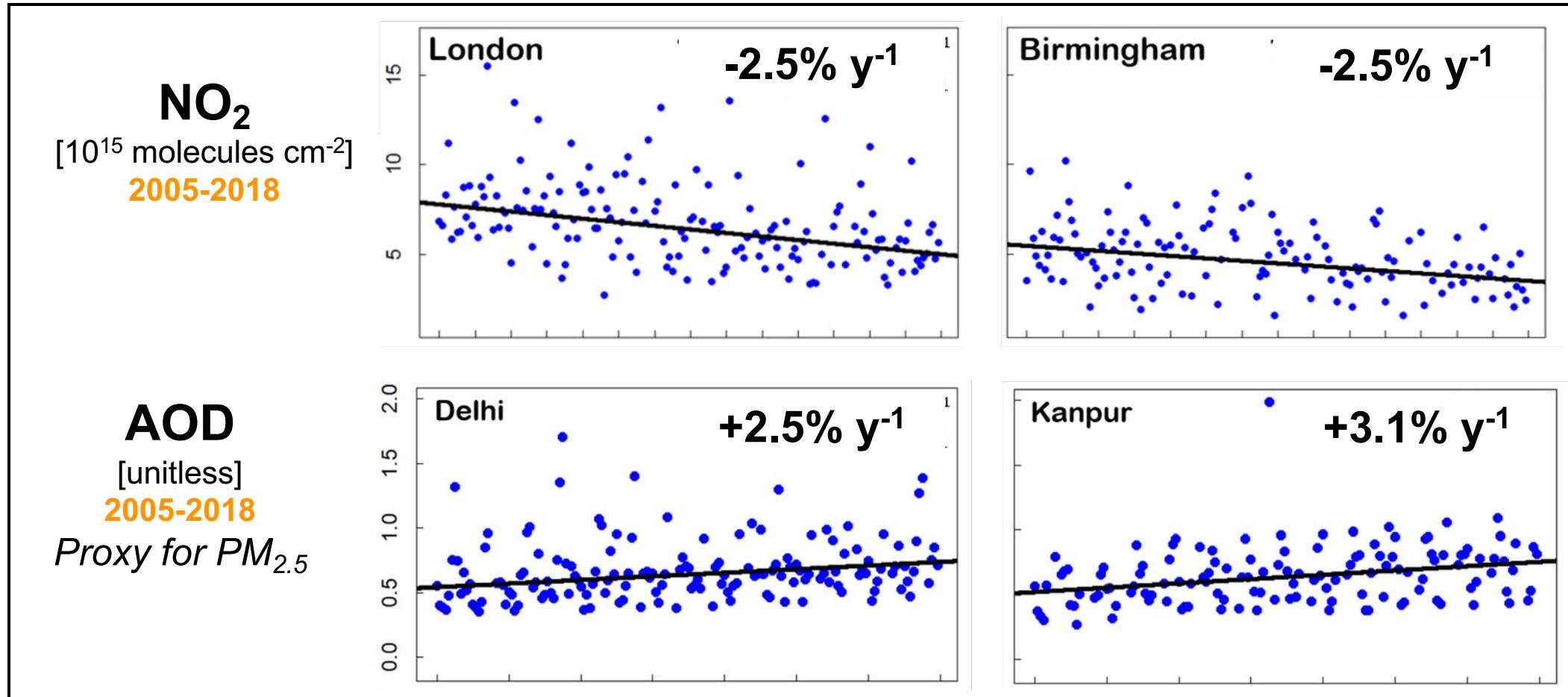
Component	Completed	Passed
NO_2	✓	✓
NH_3	✓	✓
SO_2	✓	✗
AOD ($\text{PM}_{2.5}$)	✓	✓
HCHO (NMVOCs)	—	—

SO_2 : poor detection, only sees large sources (unregulated coal-fired power plants)

Formaldehyde (HCHO): no suitable surface observations

Estimate Trends and Statistical Significance

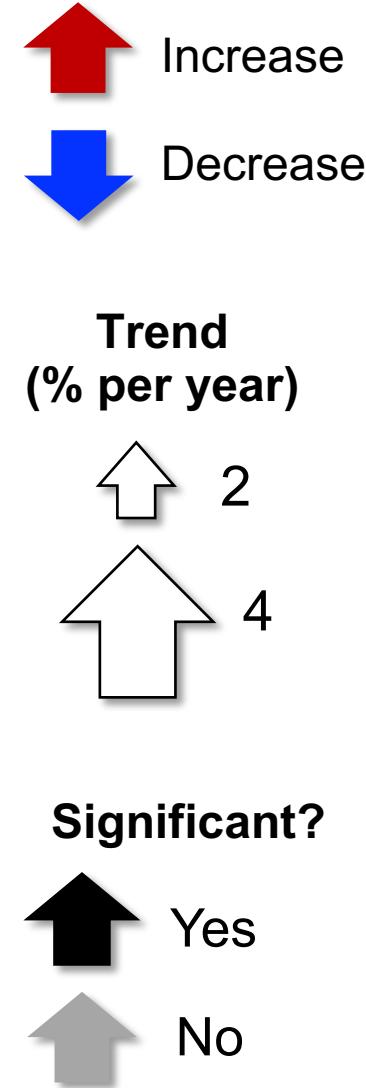
Apply trend analysis to long-term record of satellite observations in cities in the UK and India



These provide information about the effect of policies or development in their absence on air pollution across a city

Results of Trend and Statistical Significance Analysis

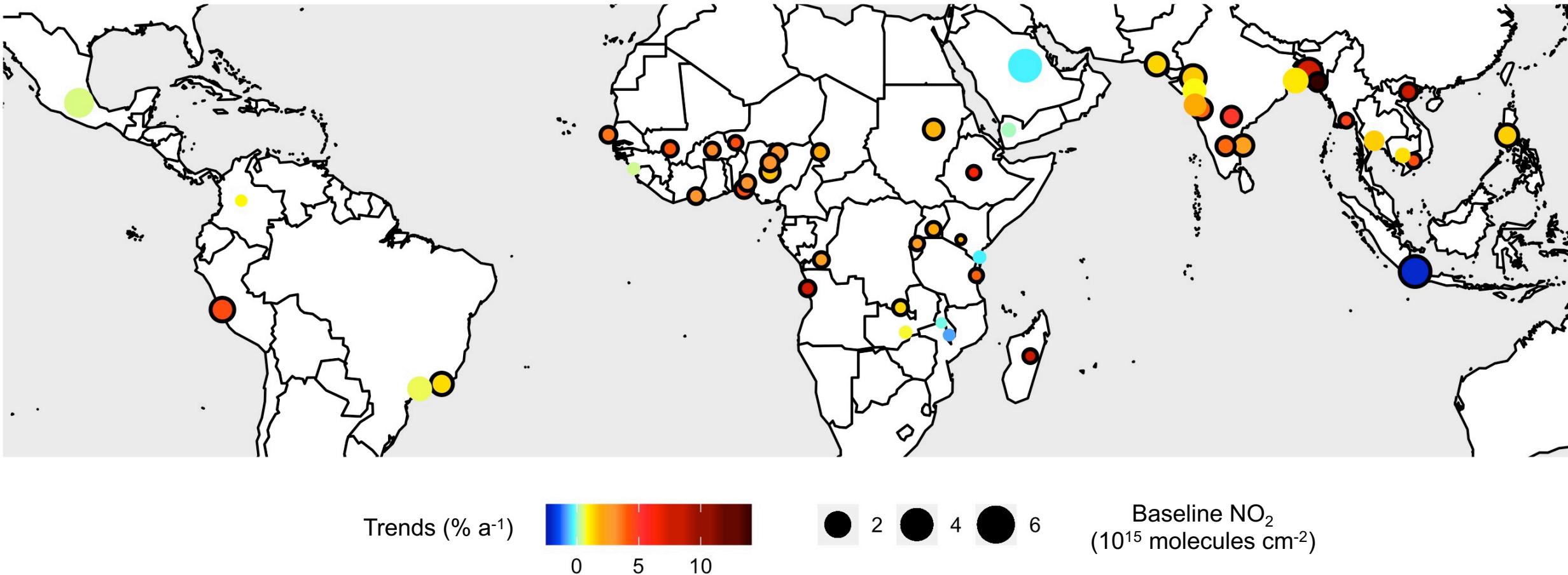
Air pollutant	London	Birmingham	Delhi	Kanpur
NO_x (2005-2018)	↓	↓	↑	↑
NH₃ (2008-2017)	↓	↓	↑	↑
NMVOCs (2005-2016)	↓	↓	↑	↑
PM_{2.5} (2005-2018)	↓	↓	↑	↑



Trends in NO_x, NH₃, and NMVOCs concentrations relate directly to trends in emissions

Application to Megacities of the Future

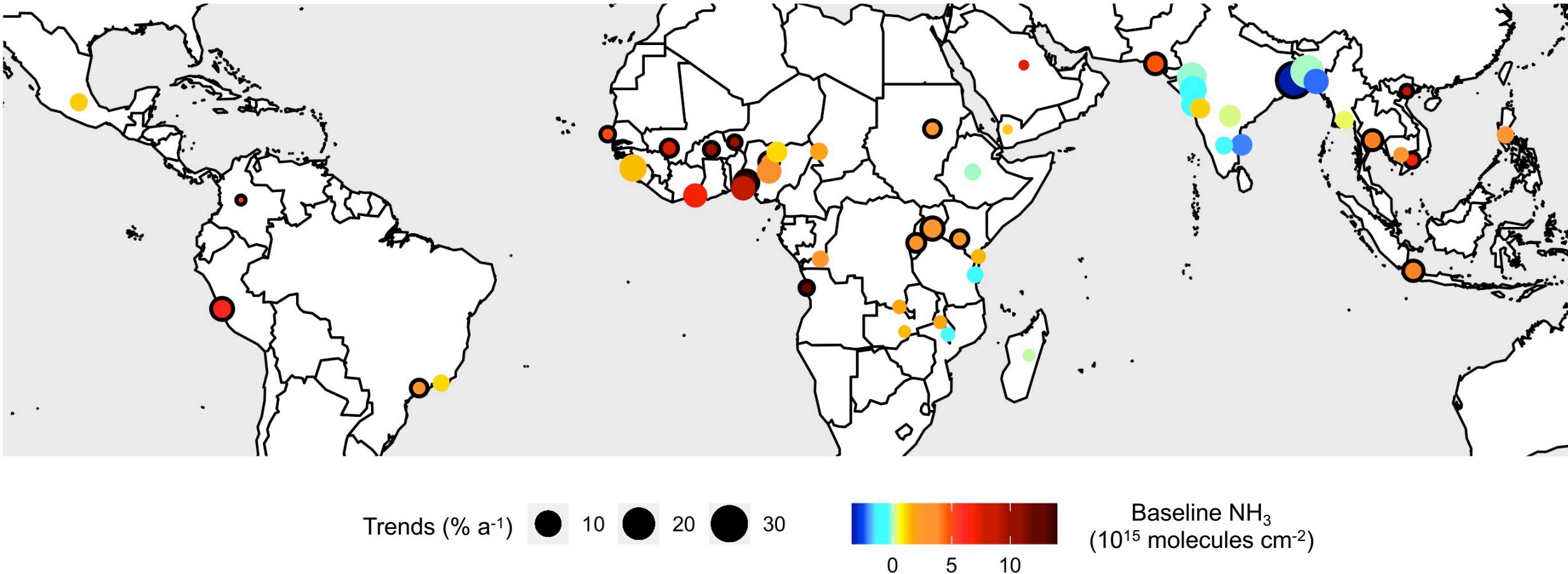
NO₂ trends from 2005 to 2018



NO₂ has increased in 46 out of 51 cities

Application to Megacities of the Future

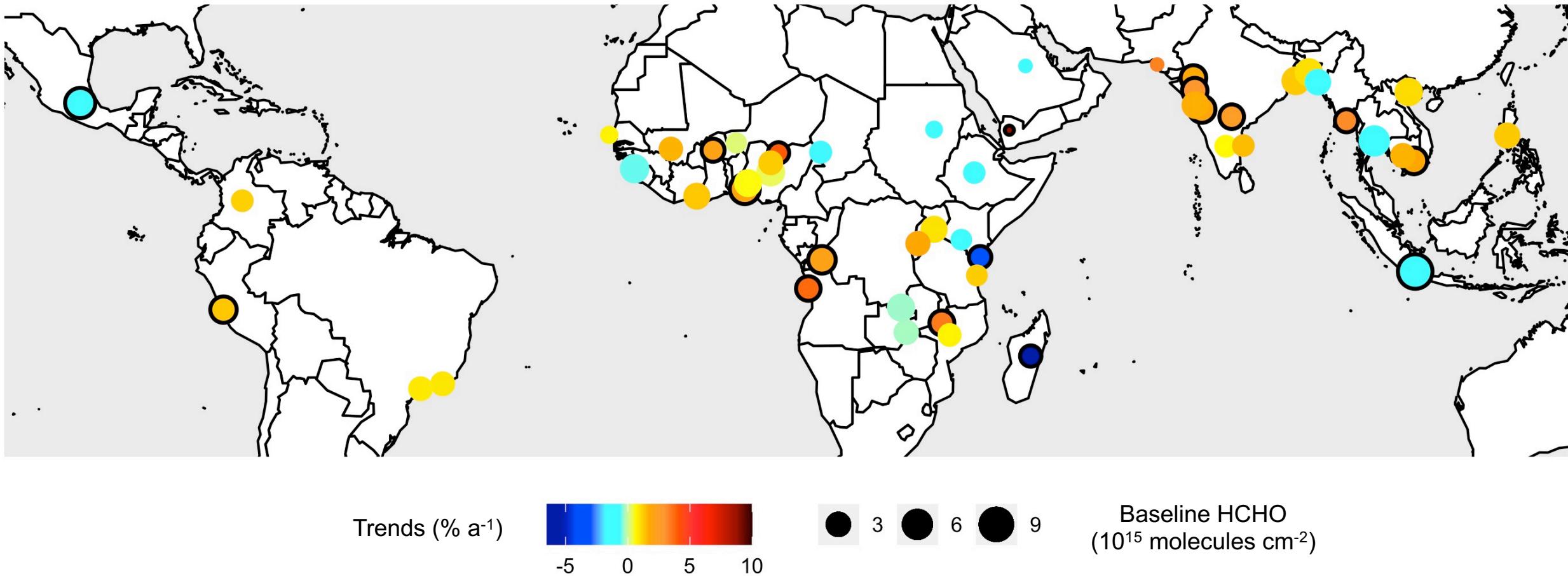
NH₃ trends from 2007 to 2018



NH₃ has increased in 40 out of 51 cities

Application to Megacities of the Future

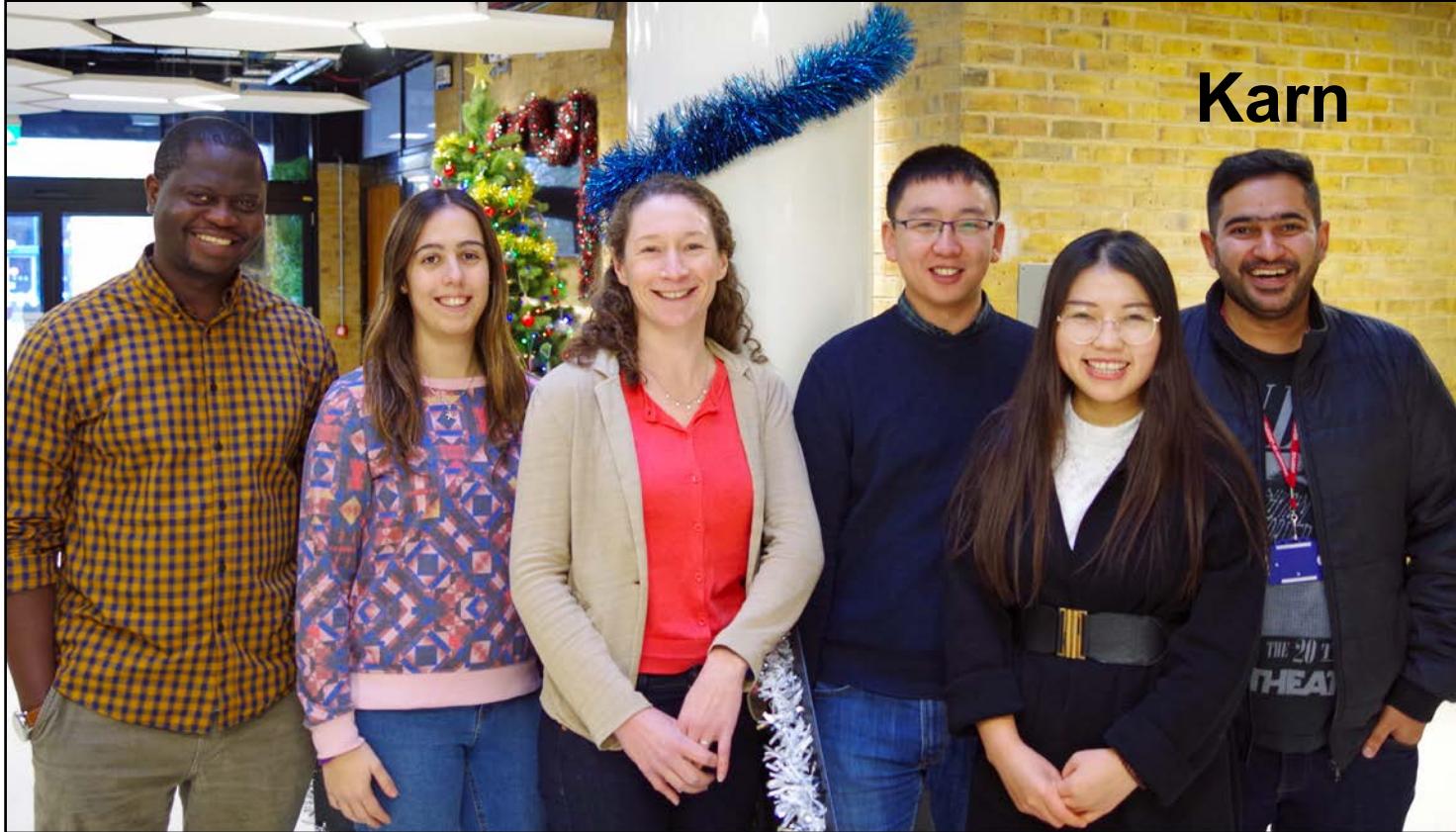
HCHO (reactive NMVOCs) trends from 2005 to 2018



HCHO (reactive NMVOCs) has increased in 37 out of 51 cities

Acknowledgements

Marais Research Group



Work presented is by my PhD student, **Karn Vohra**

Work presented has been submitted for peer-review (**Vohra et al., 2020**)

Alfred, Irma (visiting student), Eloise, Gongda, Nana, Karn

To find out about other exciting project activities in our group, visit <http://maraisresearchgroup.co.uk/>

Any Queries? Email eloise.marais@le.ac.uk

Thank you for your time!



TRACE