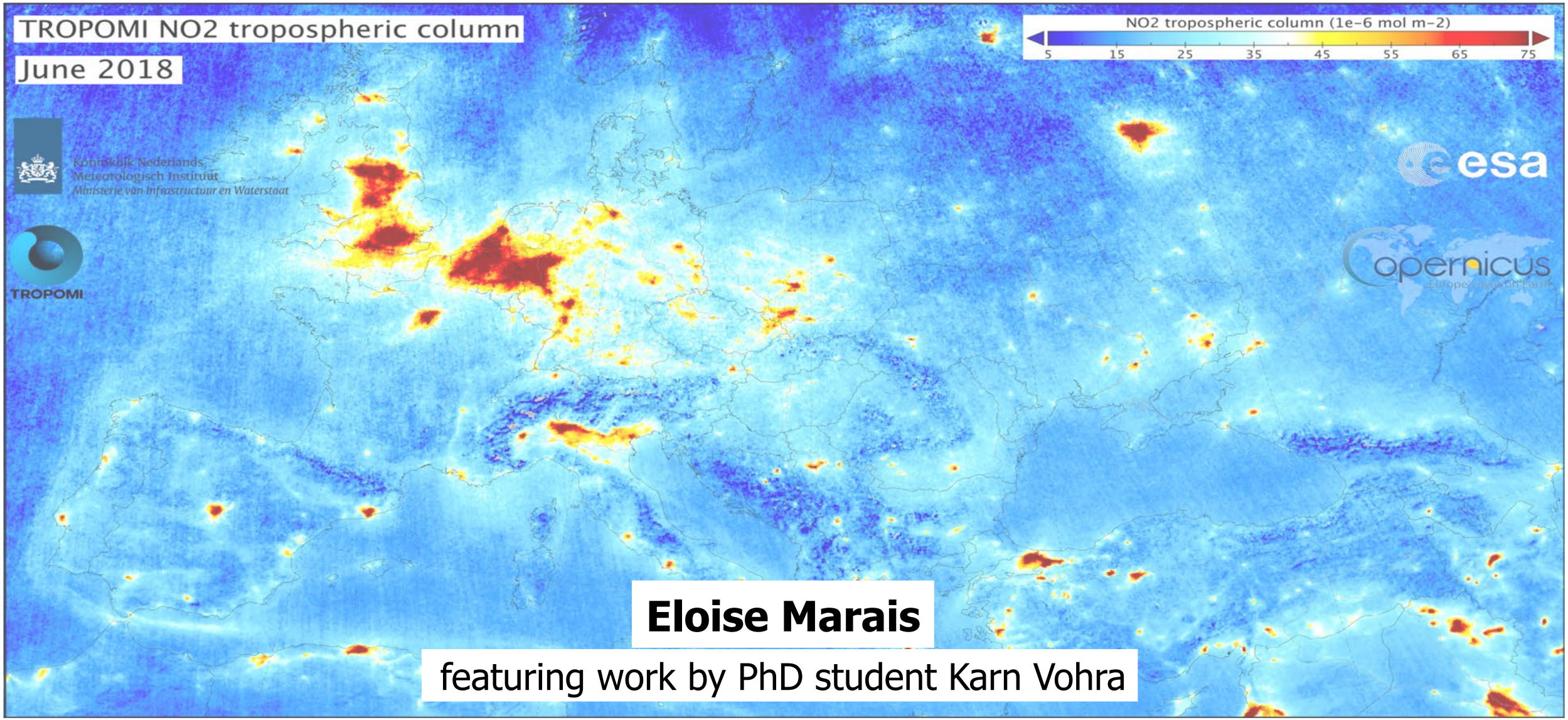
Air Pollution Monitoring Using Instruments in Space



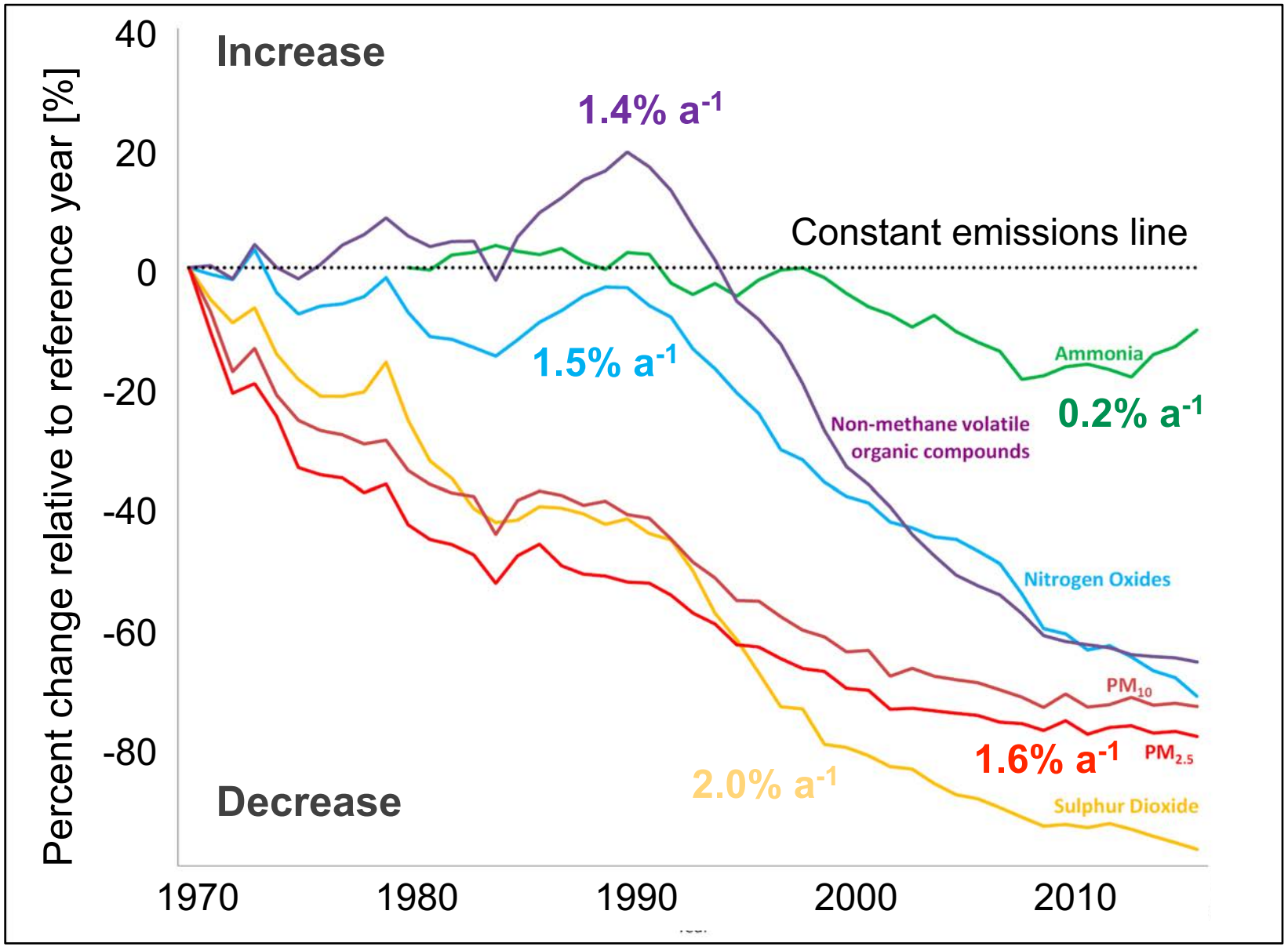
Eloise Marais

featuring work by PhD student Karn Vohra

UNIVERSITY OF LEICESTER

http://www.tropomi.eu/data-products/nitrogen-dioxide

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)

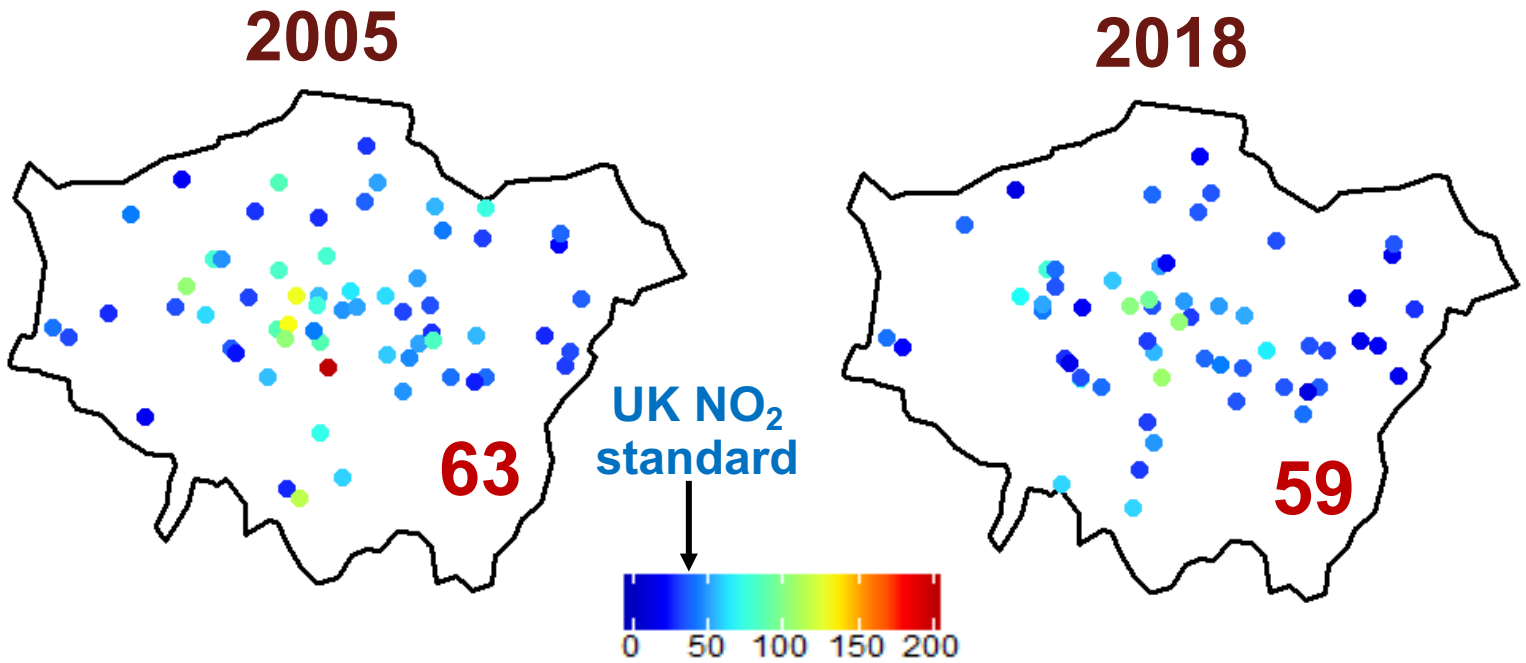
Are these accurate?

How are emissions changing in cities?

[Defra, 2018]

Satellites Provide Complete, Consistent Coverage of the UK

London Air Quality Network (LAQN) NO_2

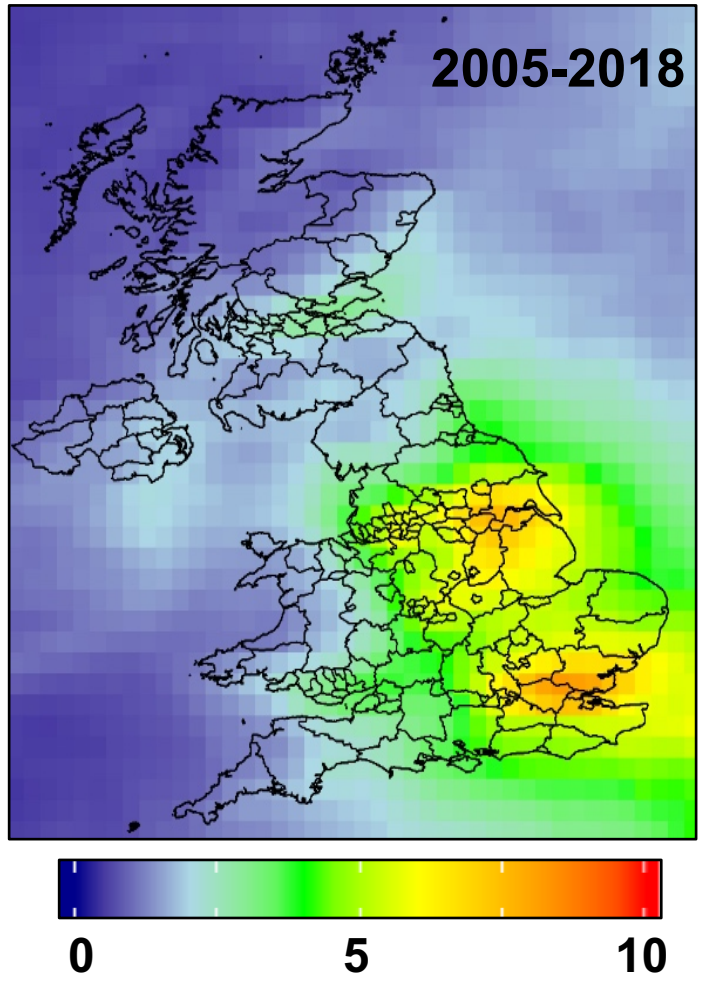


Network sites change with time and coverage is sparse
(London NO_2 data has the best coverage)

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

Ozone Monitoring Instrument (OMI) NO_2

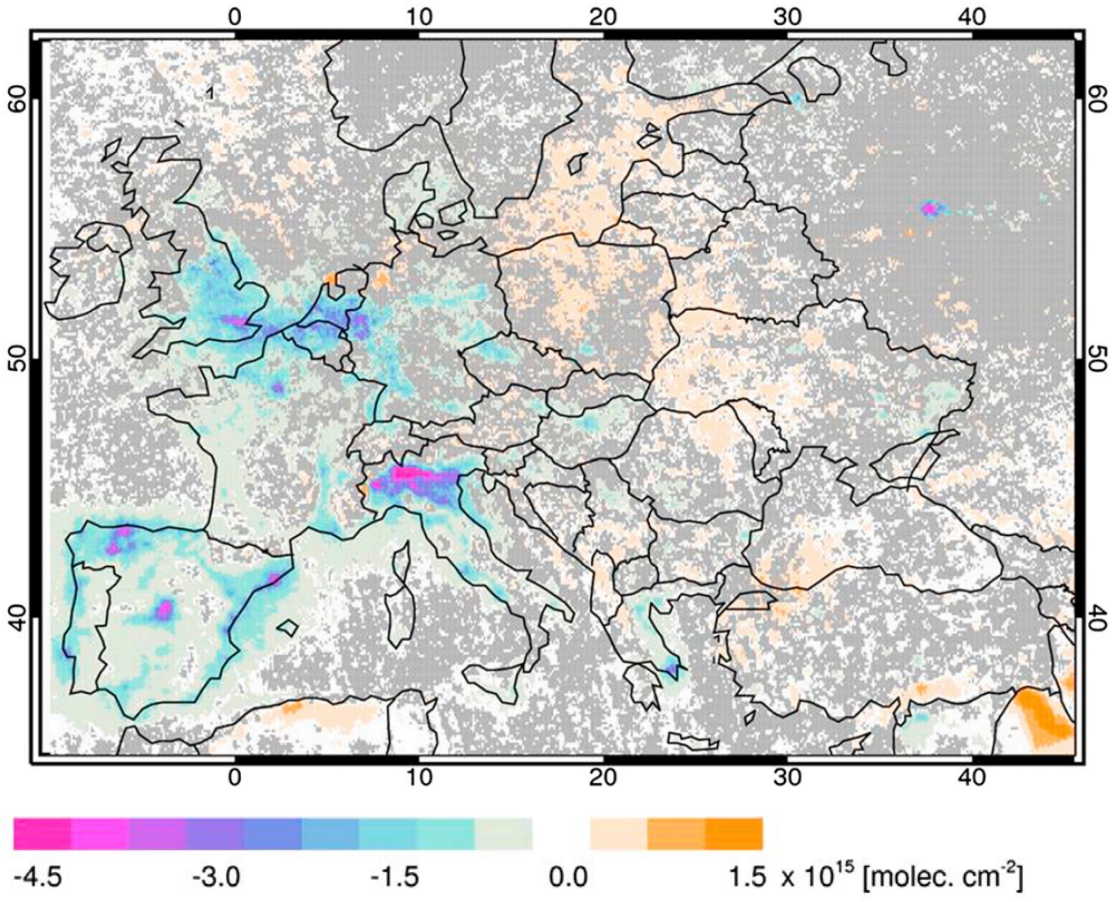
[10^{15} molecules cm^{-2}]



[DOI:10.5067/Aura/OMI/DATA2017]

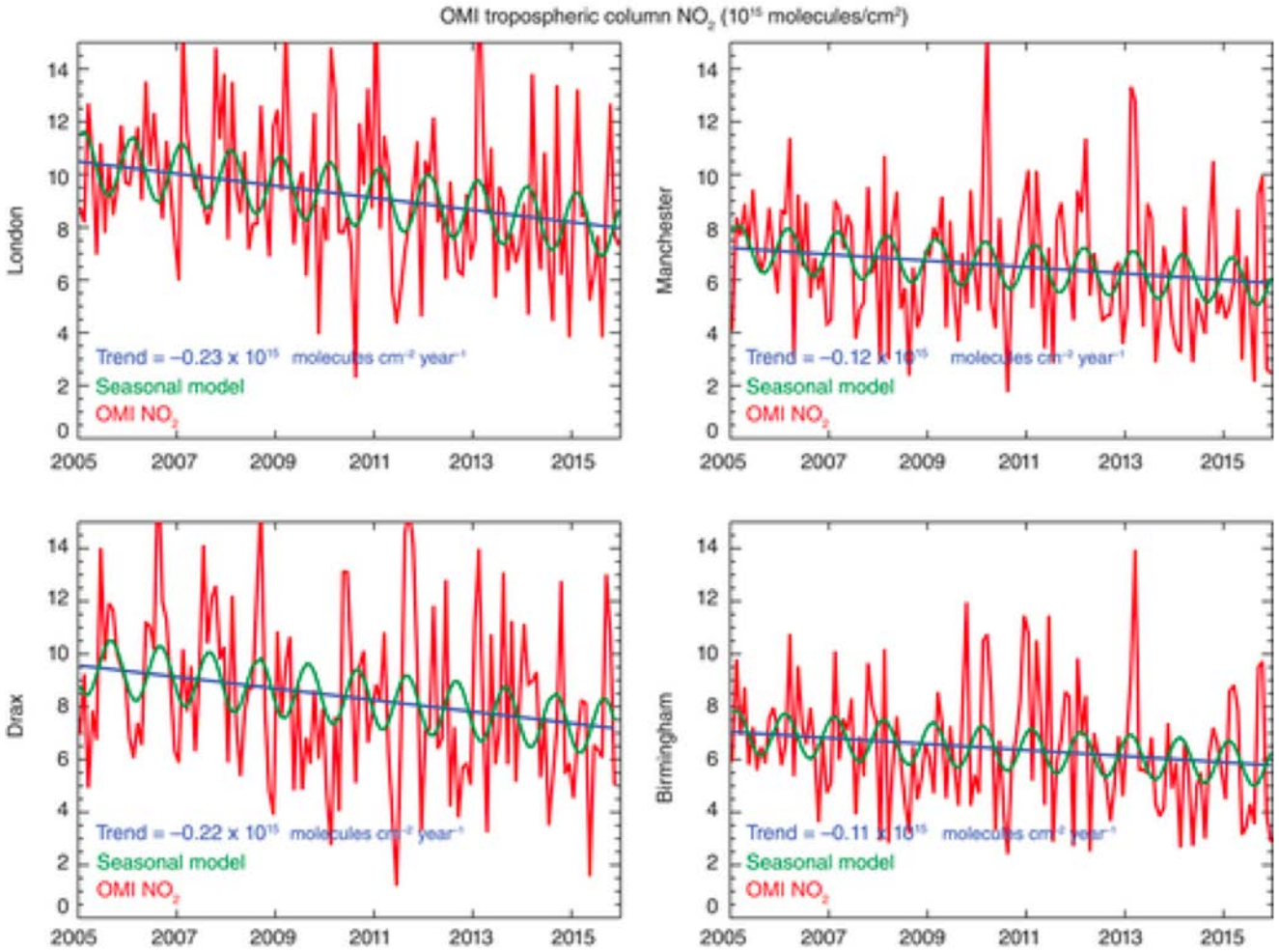
Satellite Already Used to Determine Air Pollution Trends

Change in NO_2 from 2005 to 2014 throughout Europe



[Duncan et al., 2016]

NO_2 trends in London, Birmingham, Manchester and at Drax Power Plant



[Pope et al., 2018]

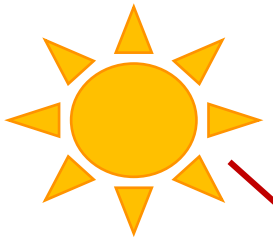
Satellites Monitor an Array of Air Pollutants and Precursors

NMVOCs

Intermediate product

OMI

HCHO



O_3

Food security

OMI

SO_X

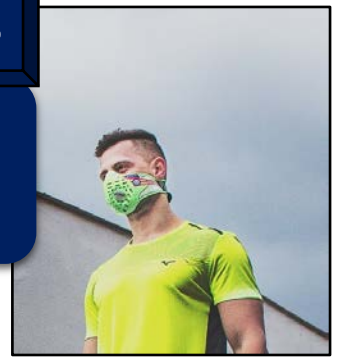
NO_X

OMI

MODIS

$PM_{2.5}$

Human health



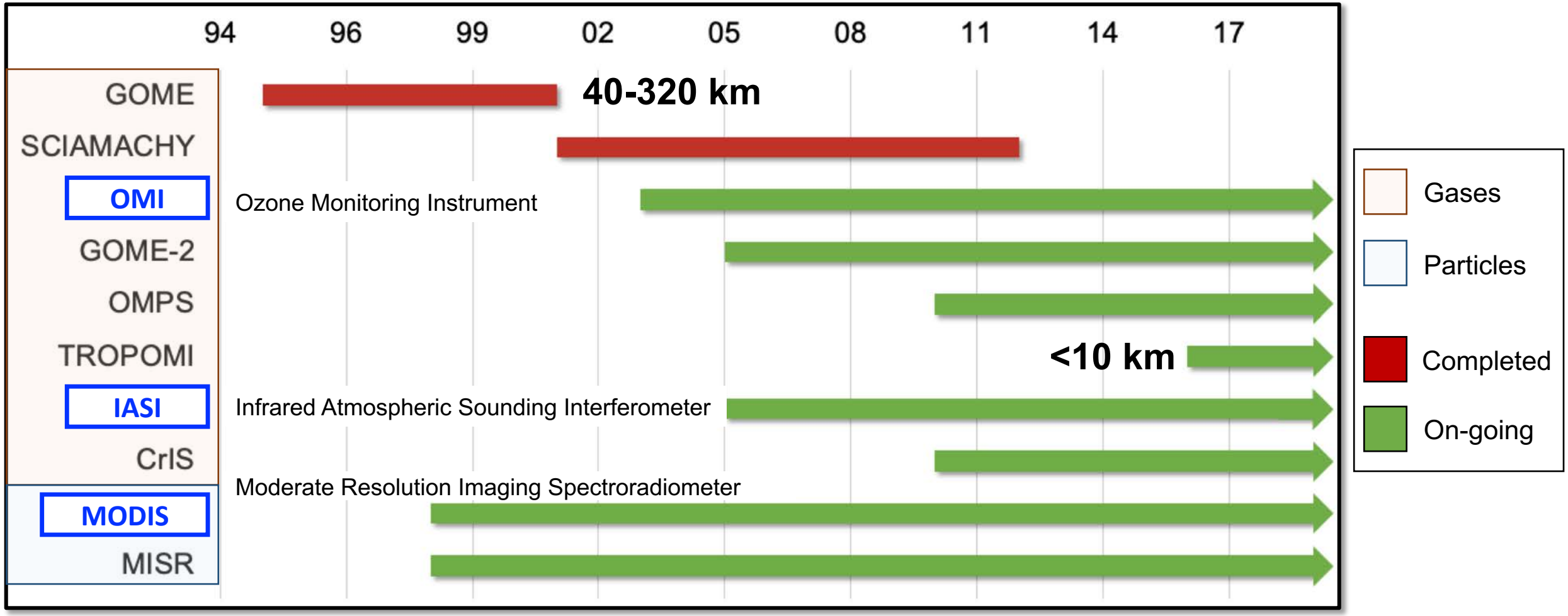
NH_3

IASI

Primary particles

The Satellite Record Extends to the Mid-1990s

Instruments we use in this work



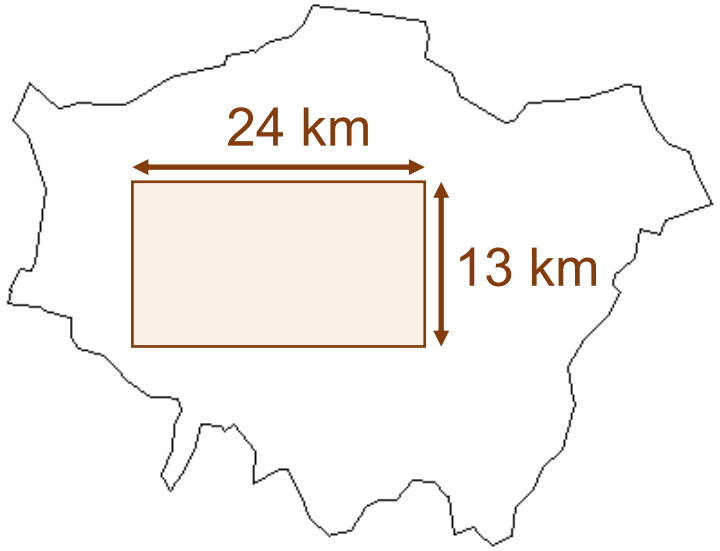
Spatial Resolution Can Be an Issue

Individual satellite pixels cover large swaths of a city

OMI

Ozone Monitoring Instrument

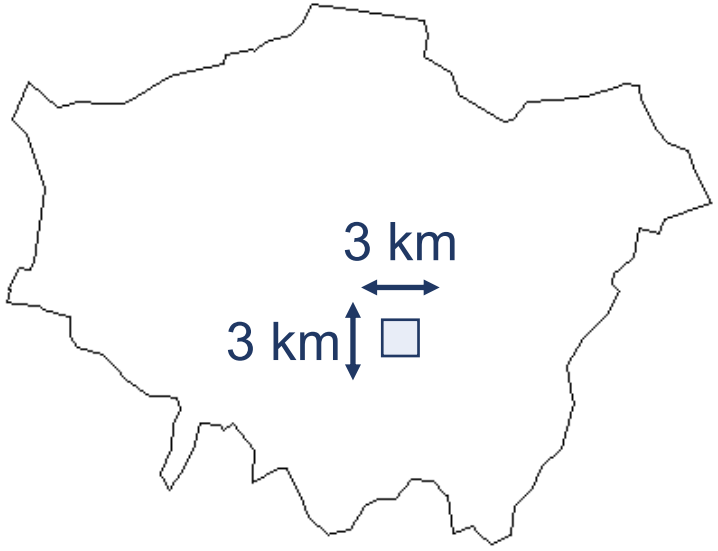
(**NO_2, HCHO**)



MODIS

Moderate Resolution Imaging Spectroradiometer

(**AOD**)



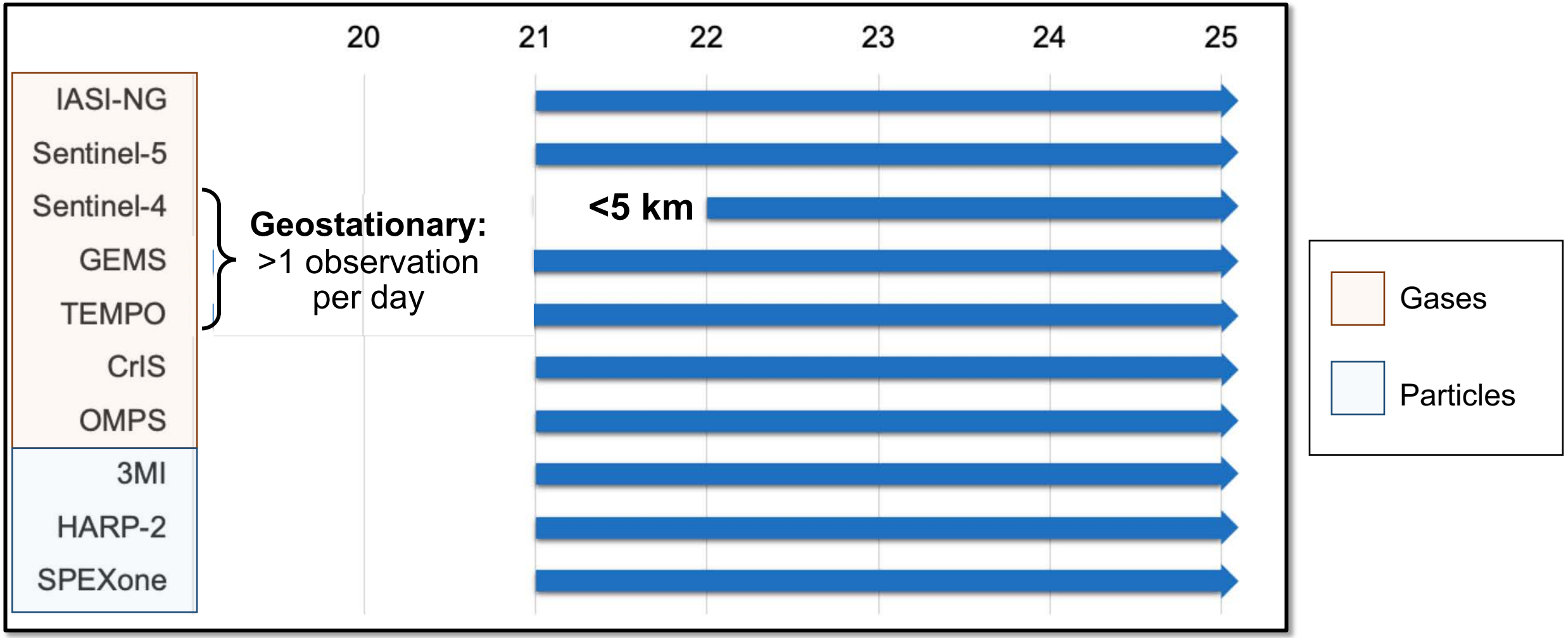
London

(1600 km^2)

IASI: 12 km (not shown)

Limited ability to determine sub-city variability

Spatial Resolution is Improving and the Record is Sustained Well into the Future

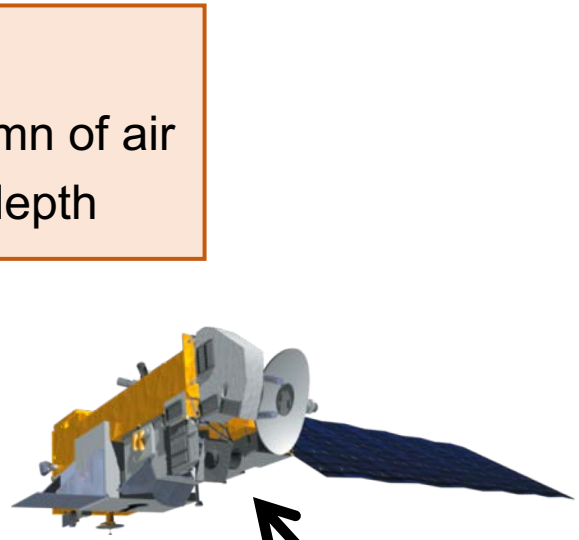


Satellites Measure Solar Backscattered Light Through the Whole Atmospheric Column

Measured quantities

Gases: Molecules in a column of air

Aerosols: Unitless optical depth



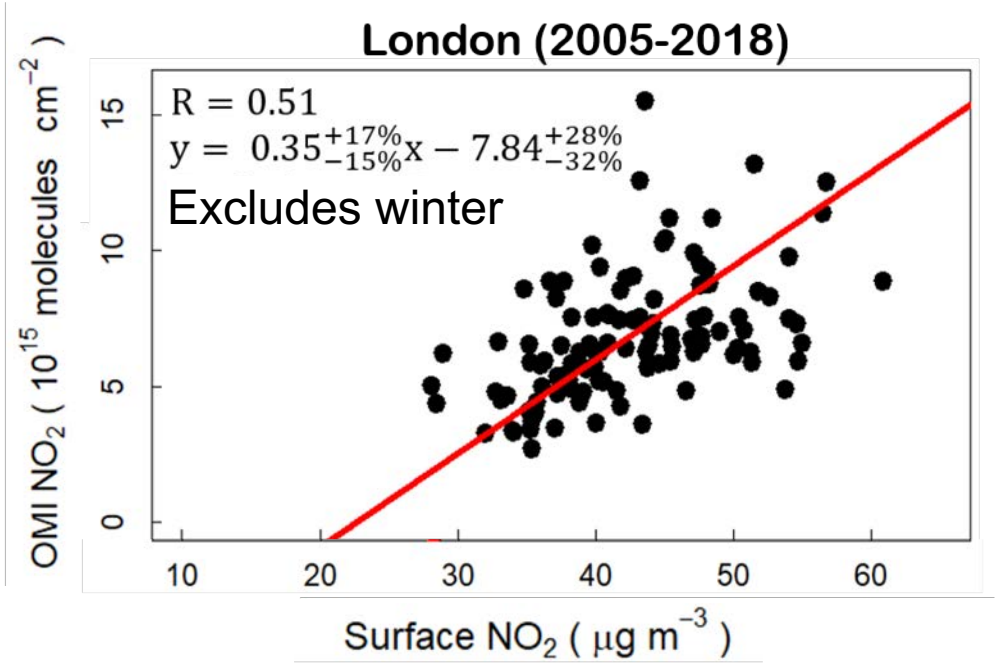
Pollution layer (1-2 km)

Troposphere layer
> 10 km

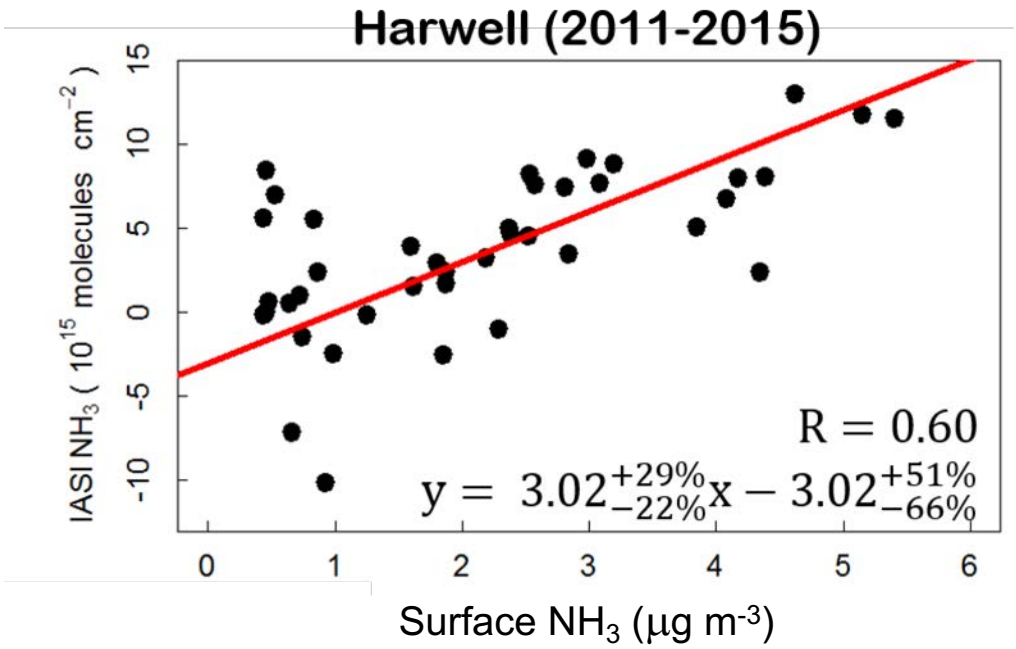
Test Sensitivity of Satellites to Surface Air Pollution

Quality checks with surface observations where these are available

Satellite versus surface NO_2 in London



Satellite versus surface NH_3 at the supersite in Harwell



Points are monthly averages. Correlation coefficient (R value) used to assess consistency

Evaluate satellite observations of all components of interest using surface observations

Summary of Quality Assurance Progress

Component	Completed	Passed
NO_2	✓	✓
NH_3	✓	✓
SO_2	✓	✗
AOD	✓	✓
HCHO		

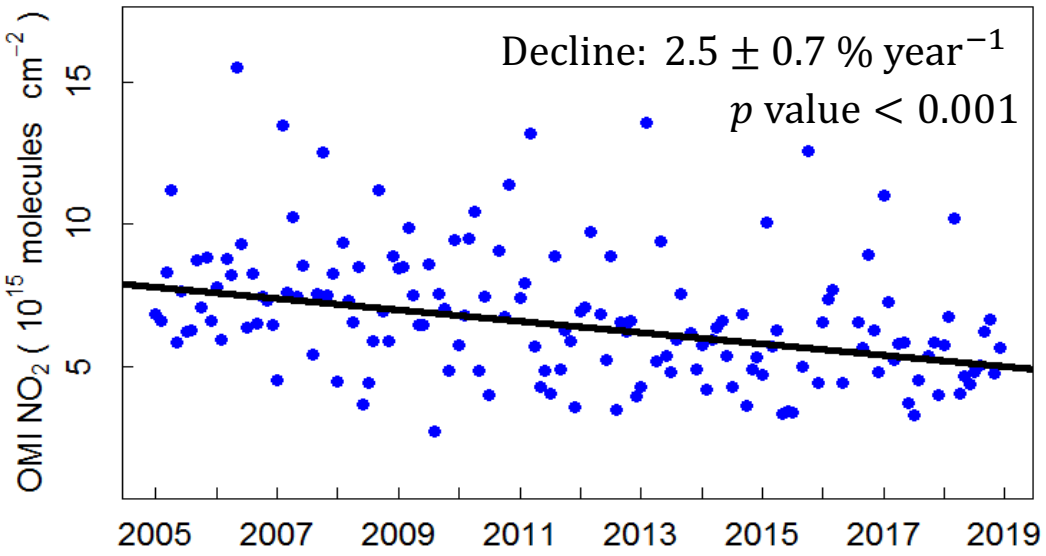
SO_2: poor detection, only suitable for very large sources (coal-fired power plants)

Formaldehyde (**HCHO**): validation still underway

Estimate Trends and Statistical Significance

Apply trend analysis to long-term record of satellite observations in London, Birmingham, and 2 cities (Delhi and Kanpur) in rapidly developing India

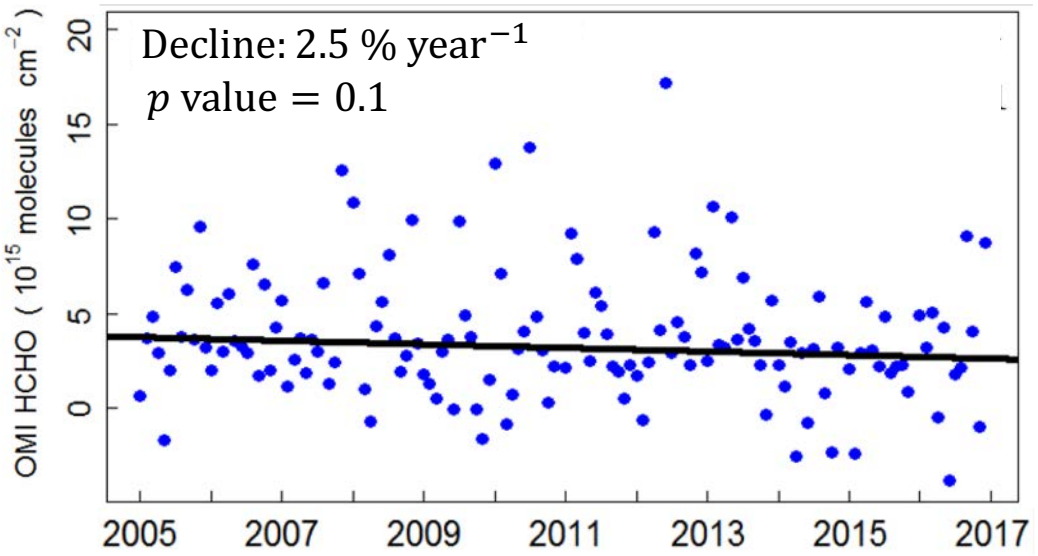
London NO_2



Decline based on monitoring network is much lower: **1.8% year^{-1}**

UK **NO_x** emission inventory trend: **1.5% year^{-1}**

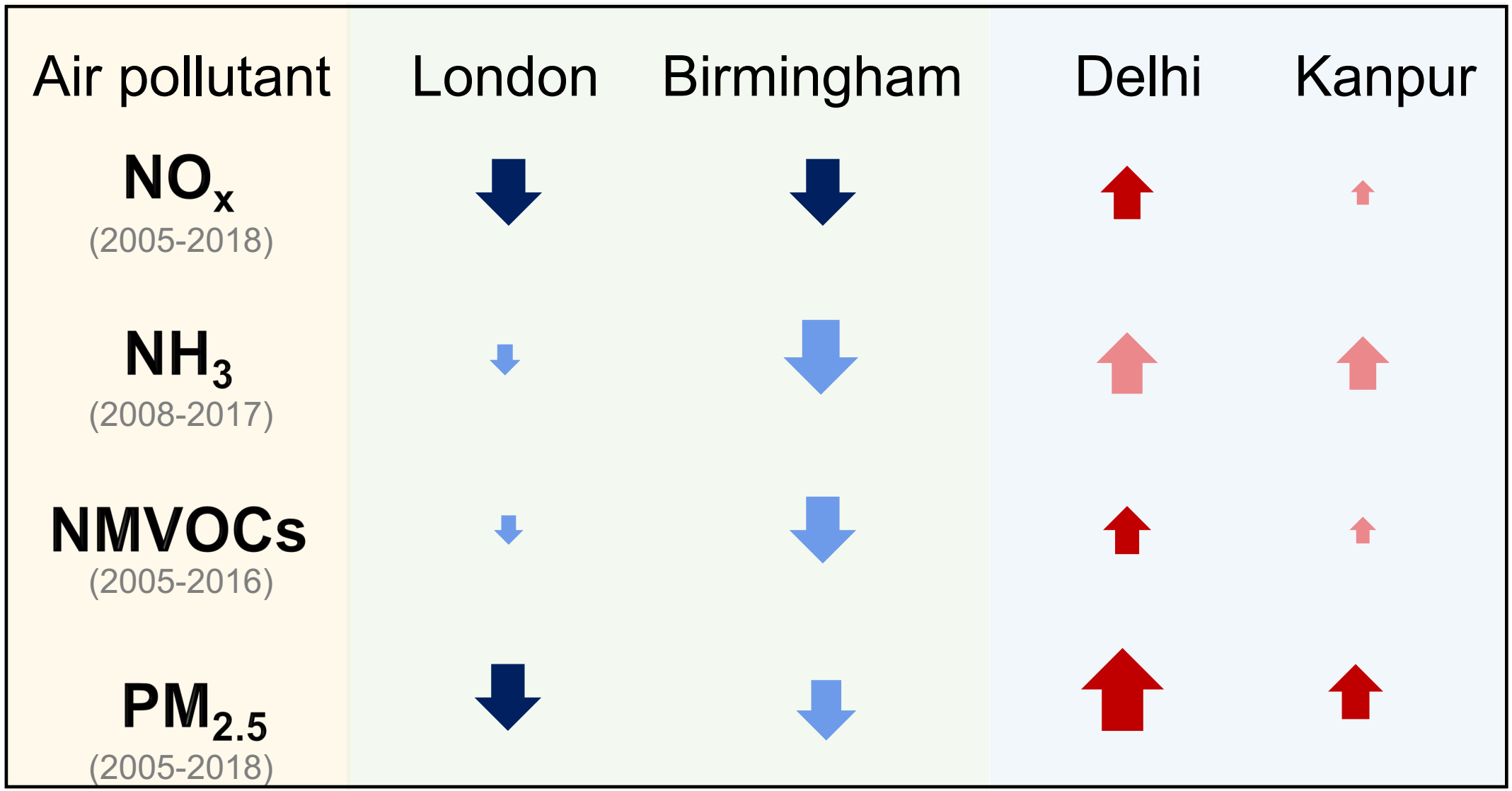
Birmingham NMVOCs

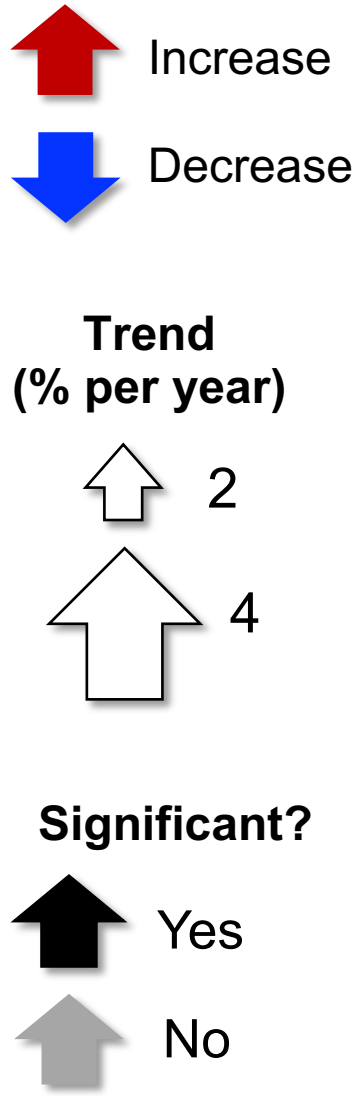


No measurements in cities.
Only a few long-term rural monitoring sites

UK **NMVOC** emission inventory trend: **1.4% year^{-1}**

Results of Trend and Significance Analysis

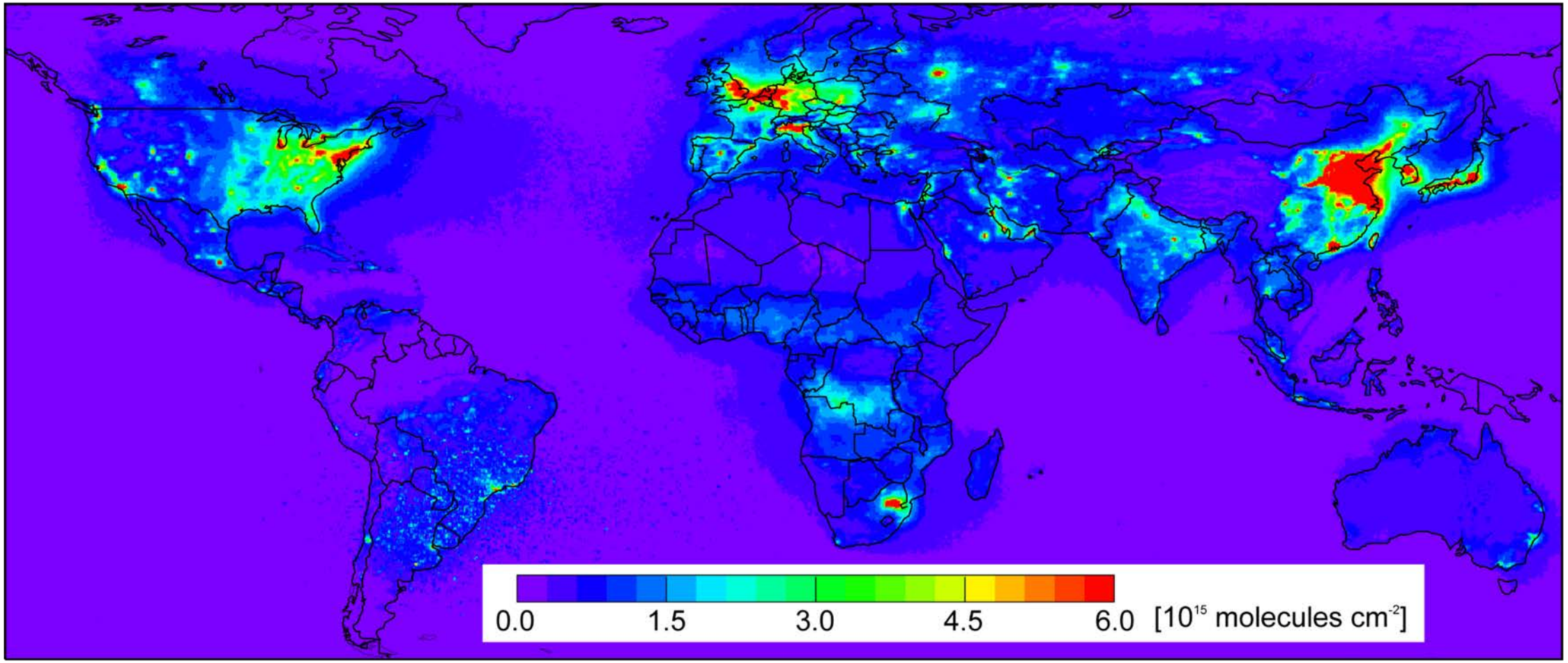




Trends in NO_x, NH_3, and NMVOCs concentrations relate directly to trends in emissions

Global Coverage of Satellites Allow us to Apply Trends to Estimate Approach to Any City in the World

Global annual average NO_2 concentrations observed with OMI for 2005-2006



Acknowledgements

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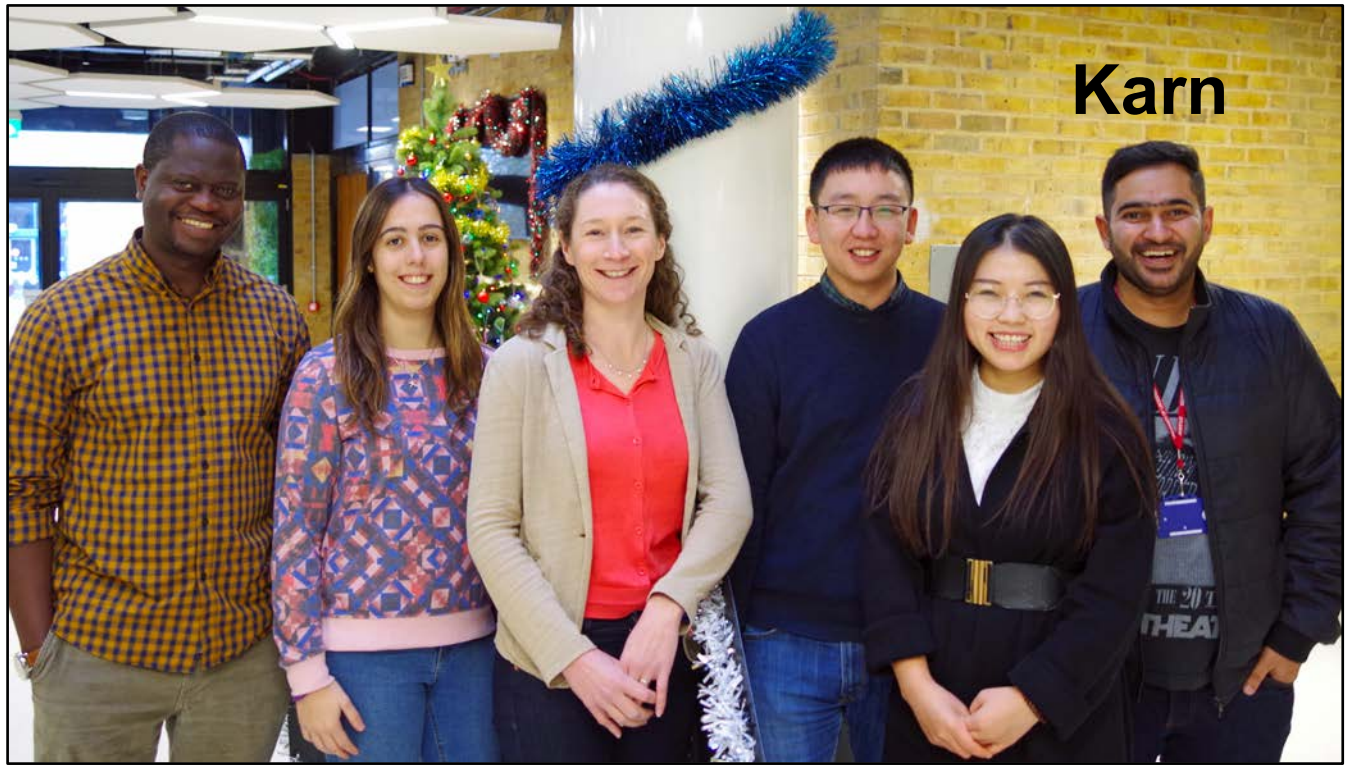

Alfred, Irma (visiting student), Eloise, Gongda, Nana, Karn

To find out about other activities in our group, visit us at:
http://maraisresearchgroup.co.uk/

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