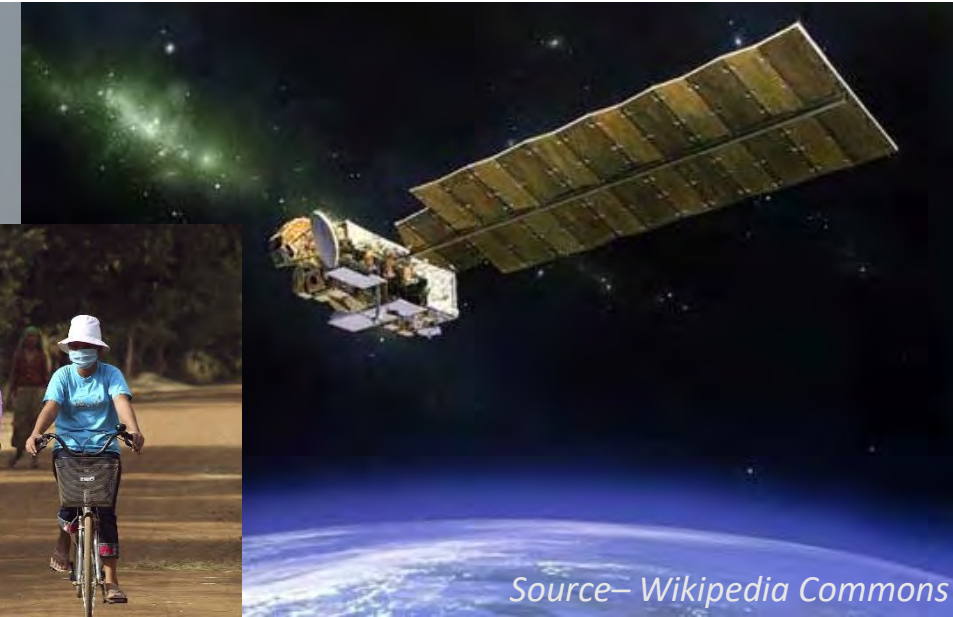


Satellites up above monitor the air down below!!!



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*West Midlands Speak Out For
Engineering Heats (17th Oct'19)*

The Problem

Exposure to fine particles caused 4.2 millions deaths worldwide in 2015 representing 7.6% of global deaths

Cohen et al., 2017

Air pollution may be damaging 'every organ in the body'

Schraufnagel et al, 2019

Estimated excess mortality attributed to air pollution in Europe

European Heart Journal, 2019

Air pollution takes decade off memory, study suggests

The Times, 2019

Pollution map reveals unsafe air quality at almost 2,000 UK sites

The Guardian, 2019

Study links air pollution exposure to miscarriages

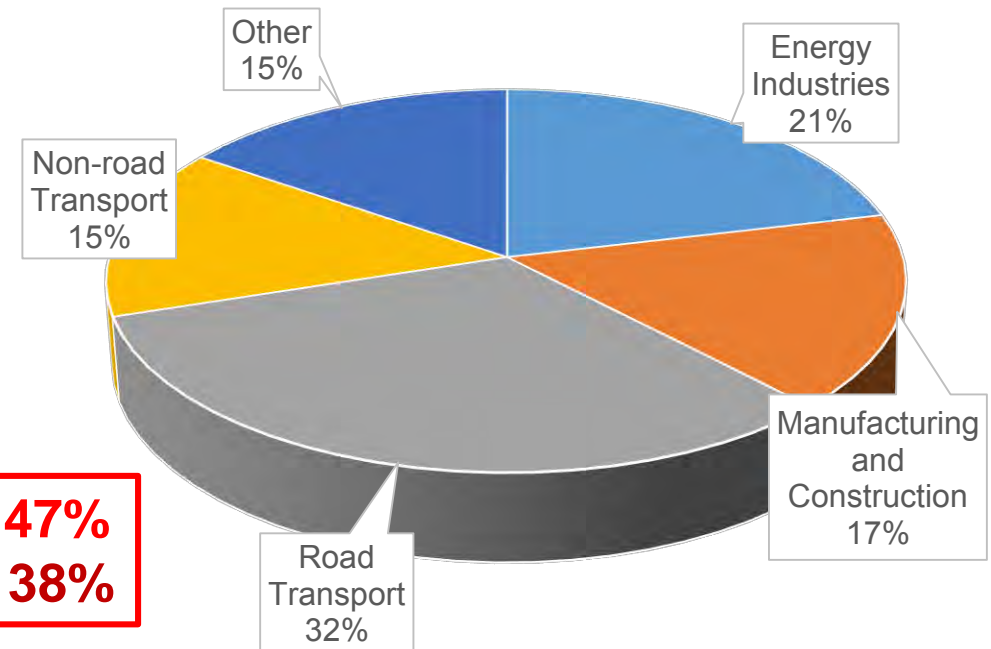
Zhang et al., 2019

What's common???

Nitrogen dioxide (NO₂)

But where is it coming from???

NOx Emissions (2017)

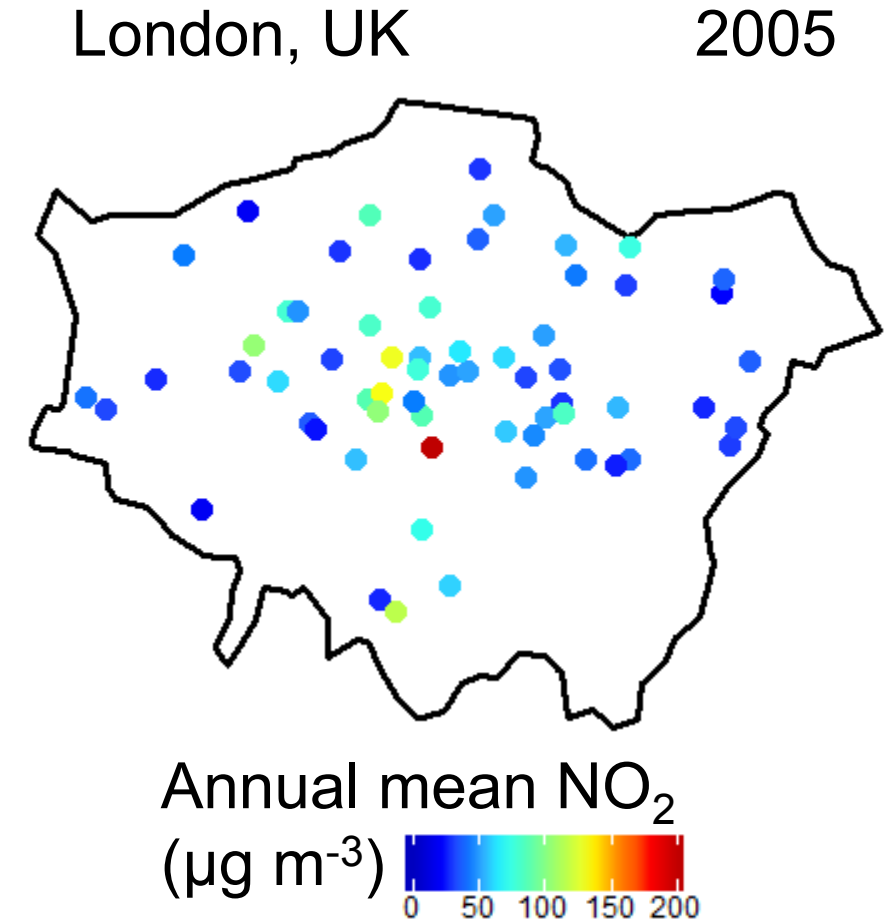


Transport: 47%
Industries: 38%

Data from National Atmospheric Emissions Inventory

The Current Approach

Surface monitoring networks
have their limitations

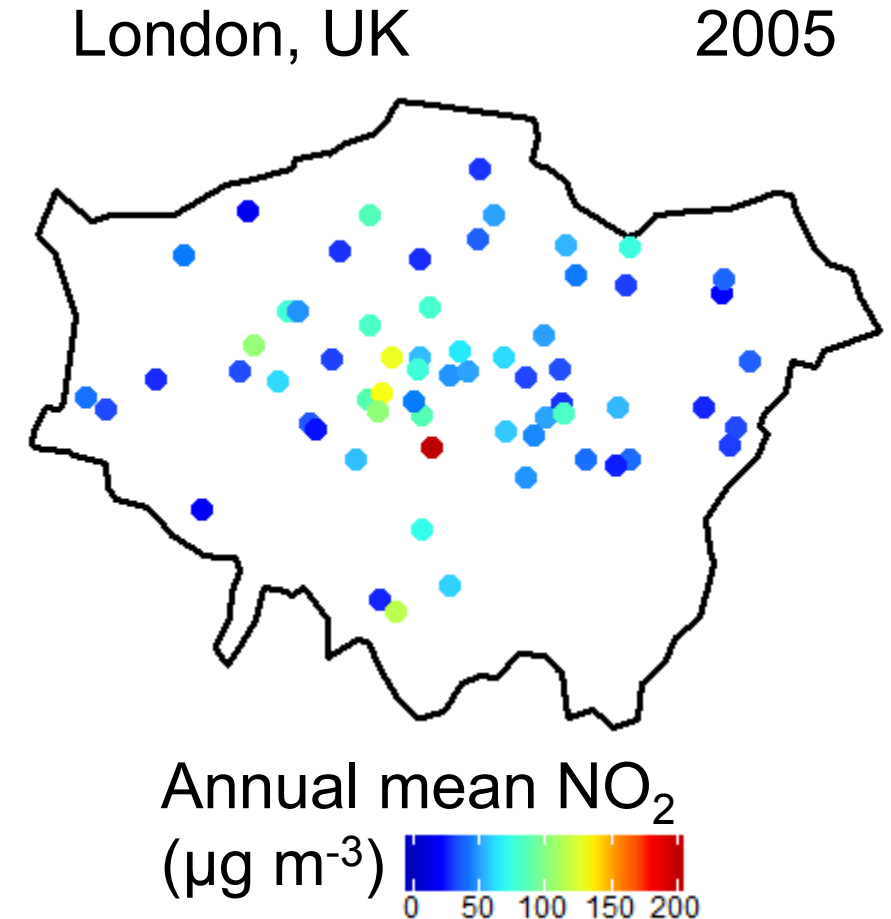


Data from *London Air Quality Network (LAQN)*

The Current Approach

Surface monitoring networks have their limitations

❑ Expensive to set up and maintain

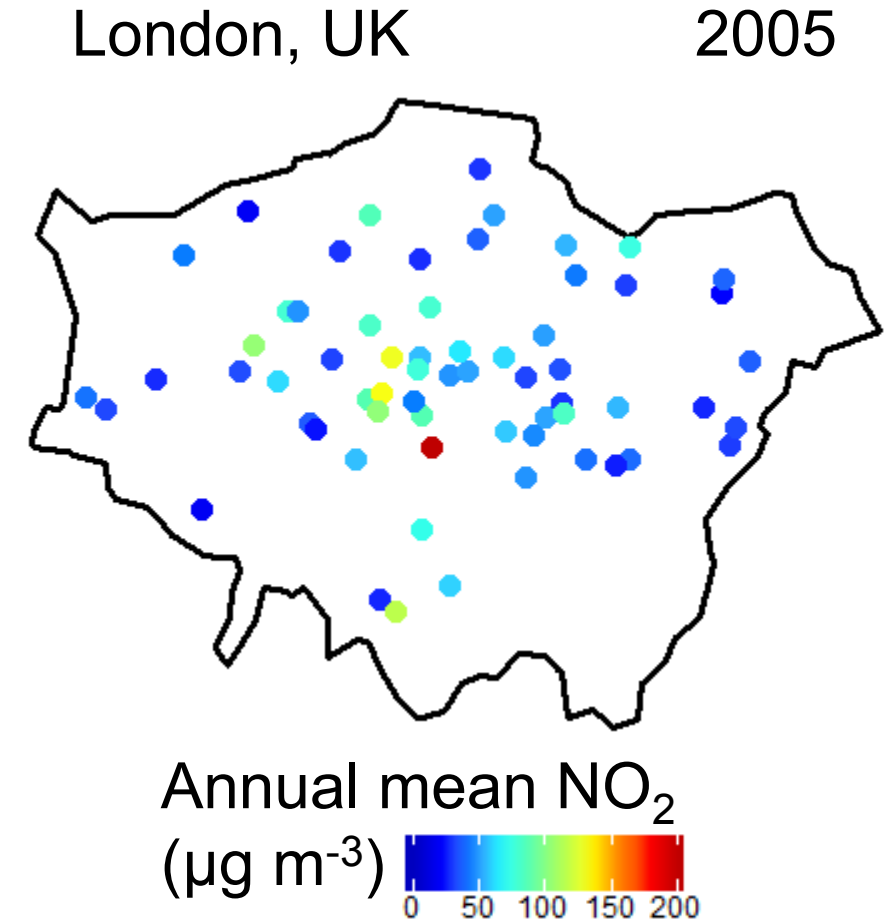


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Surface monitoring networks have their limitations

- ❑ Expensive to set up and maintain
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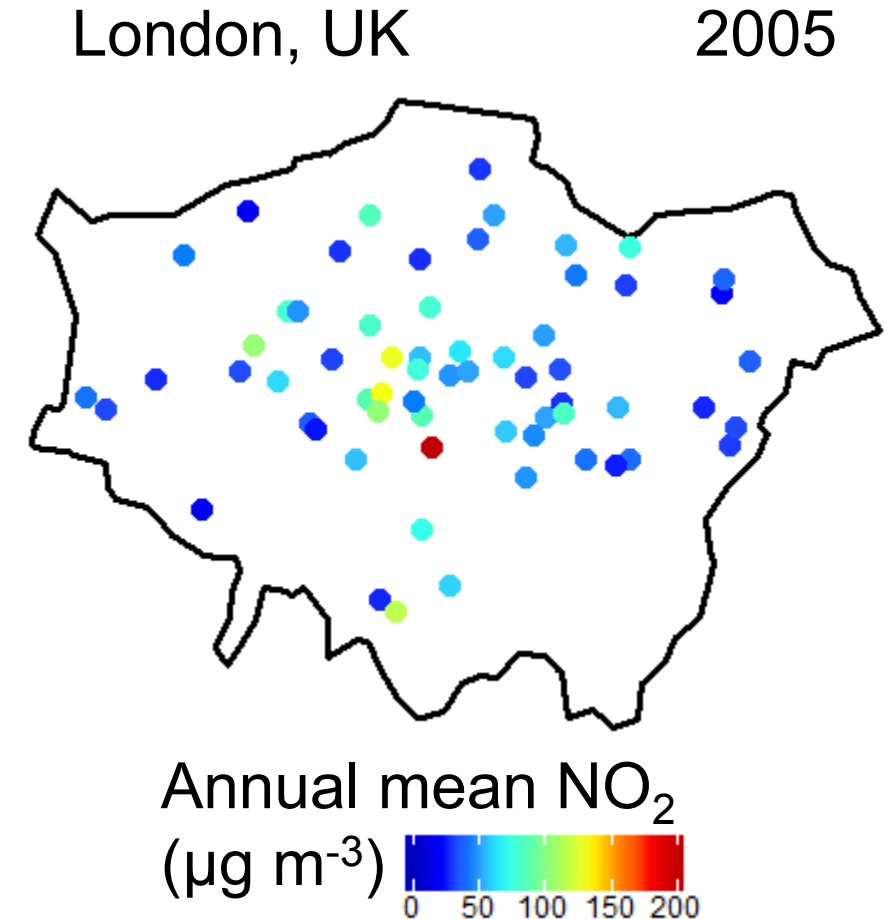


Data from *London Air Quality Network (LAQN)*

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Surface monitoring networks have their limitations

- ❑ Expensive to set up and maintain
- ❑ Limited spatial and temporal coverage
- ❑ Limited pollutants monitored

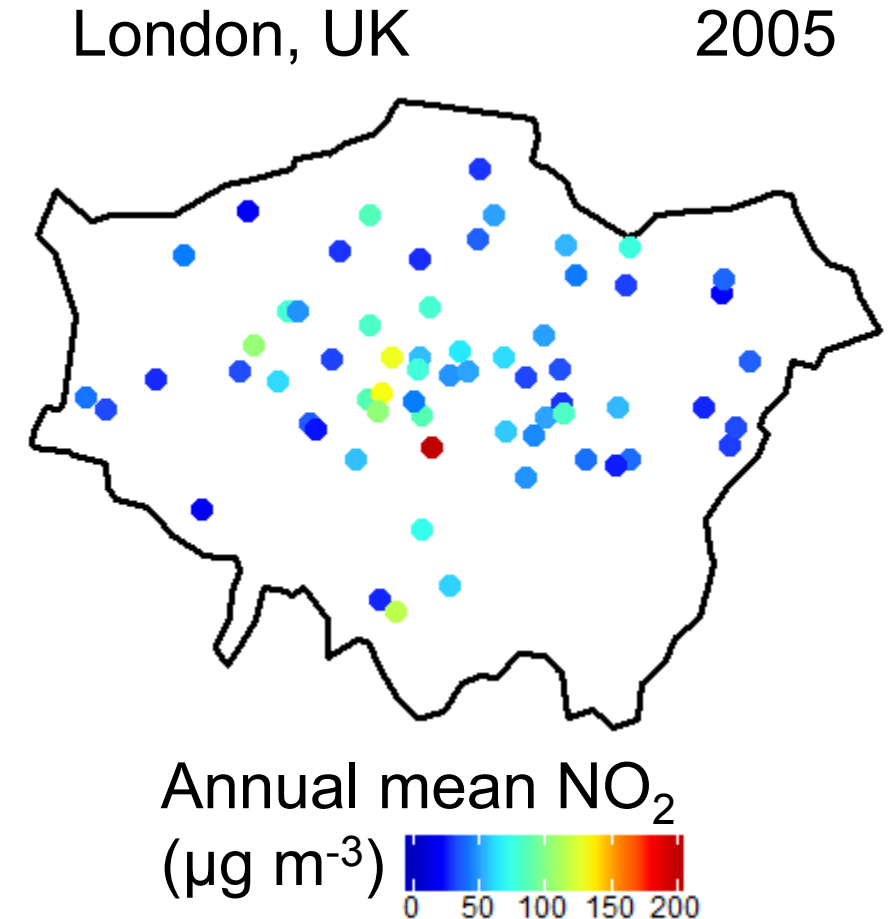


Data from *London Air Quality Network (LAQN)*

The Current Approach

Surface monitoring networks have their limitations

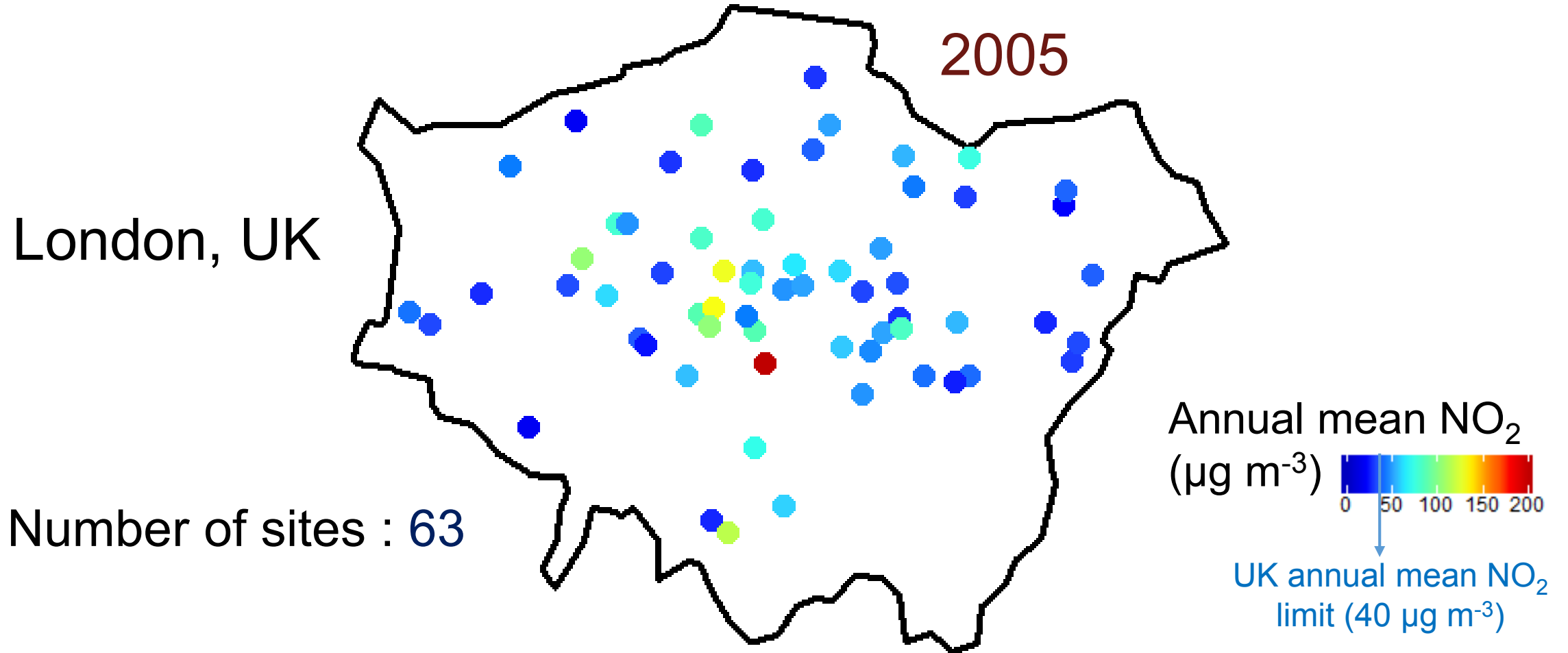
- ❑ Expensive to set up and maintain
- ❑ Limited spatial and temporal coverage
- ❑ Limited pollutants monitored
- ❑ Issues with data quality



Data from *London Air Quality Network (LAQN)*

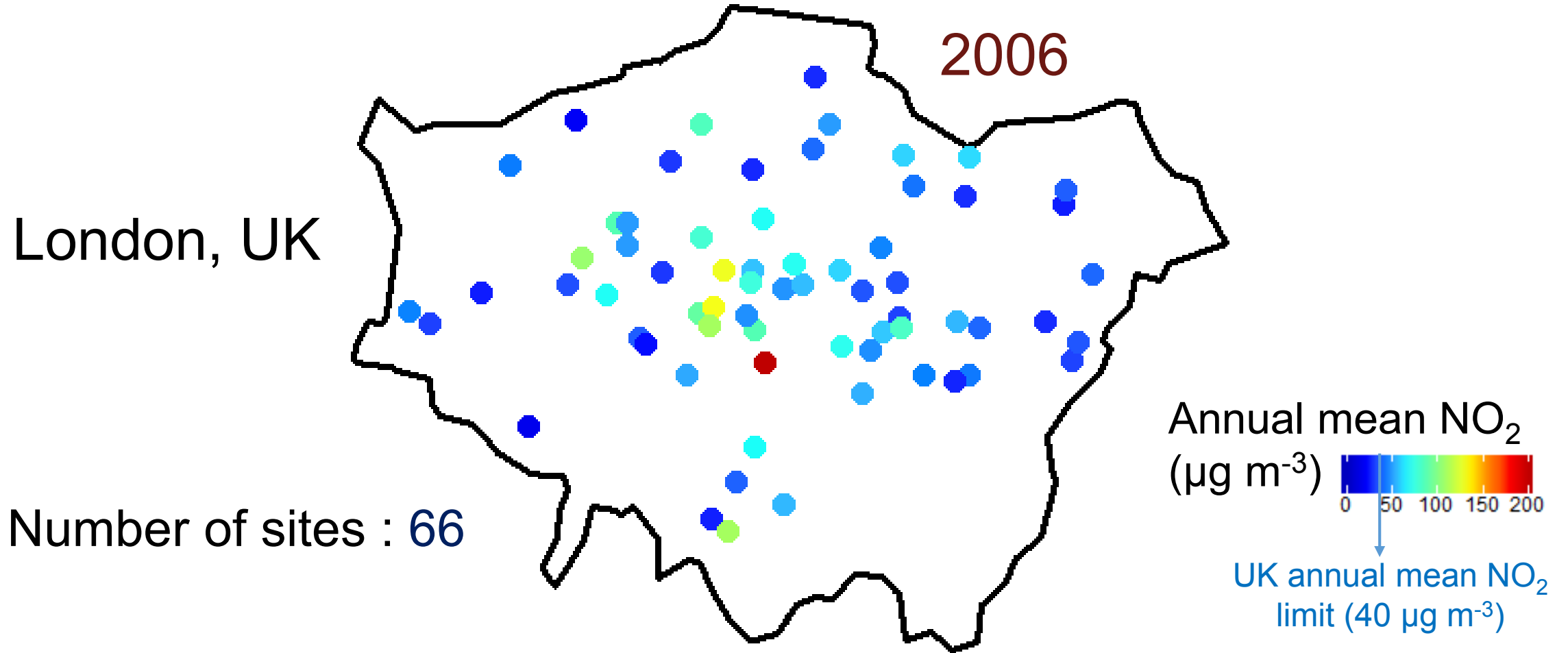
The Current Approach

❑ Inconsistent (sites come and go over time)



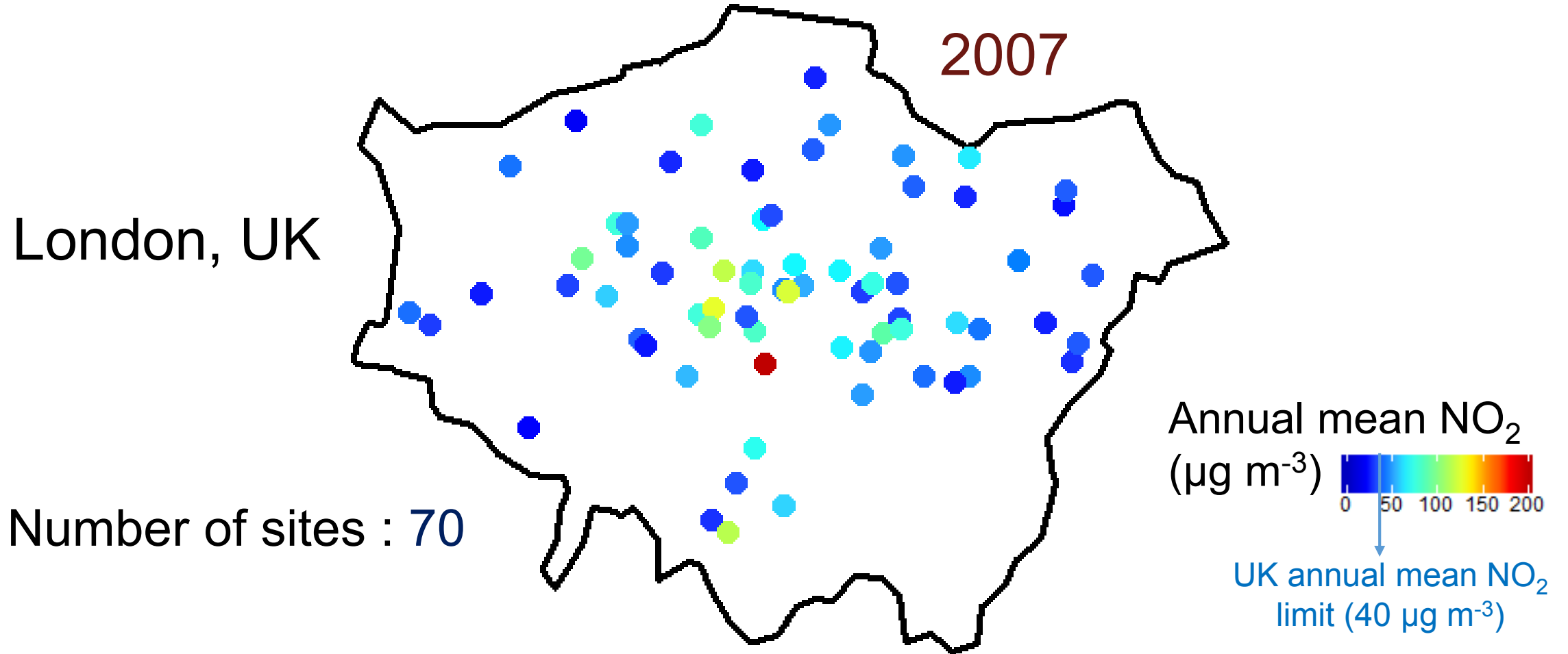
The Current Approach

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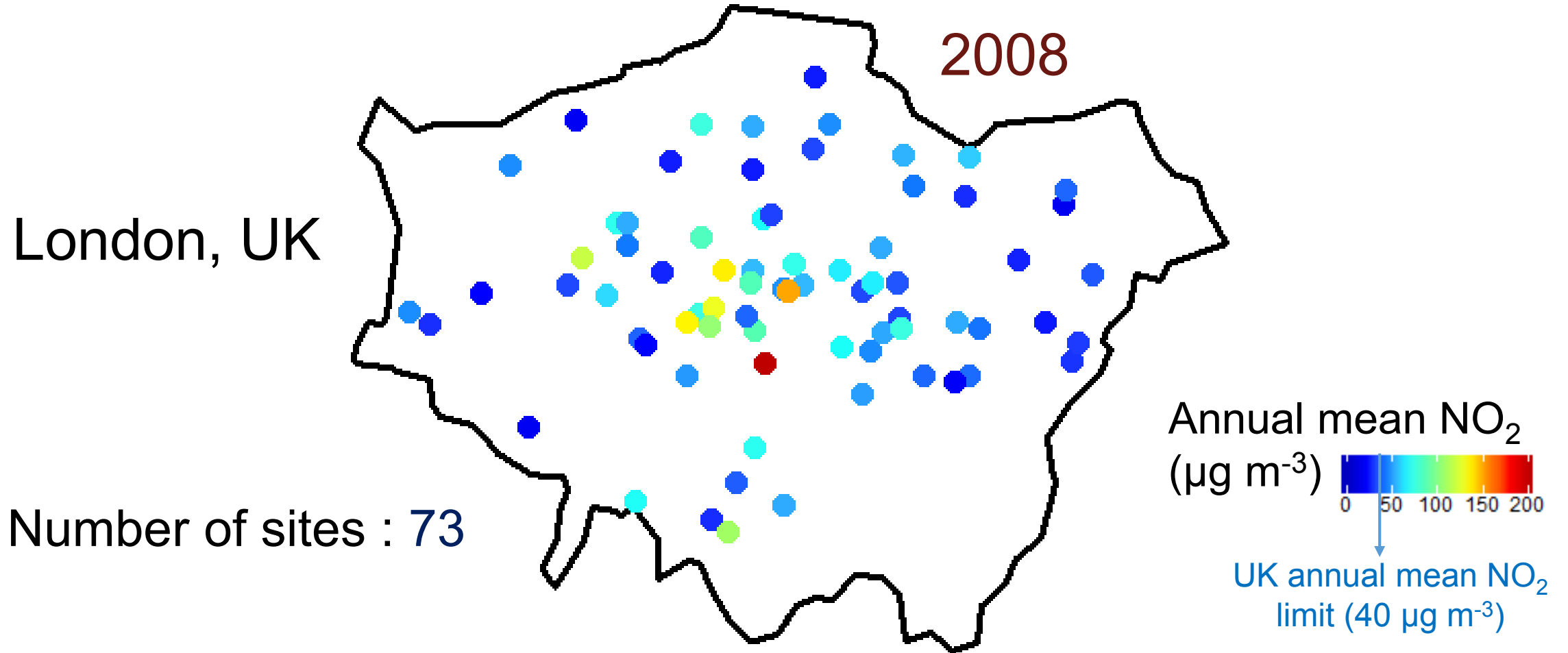
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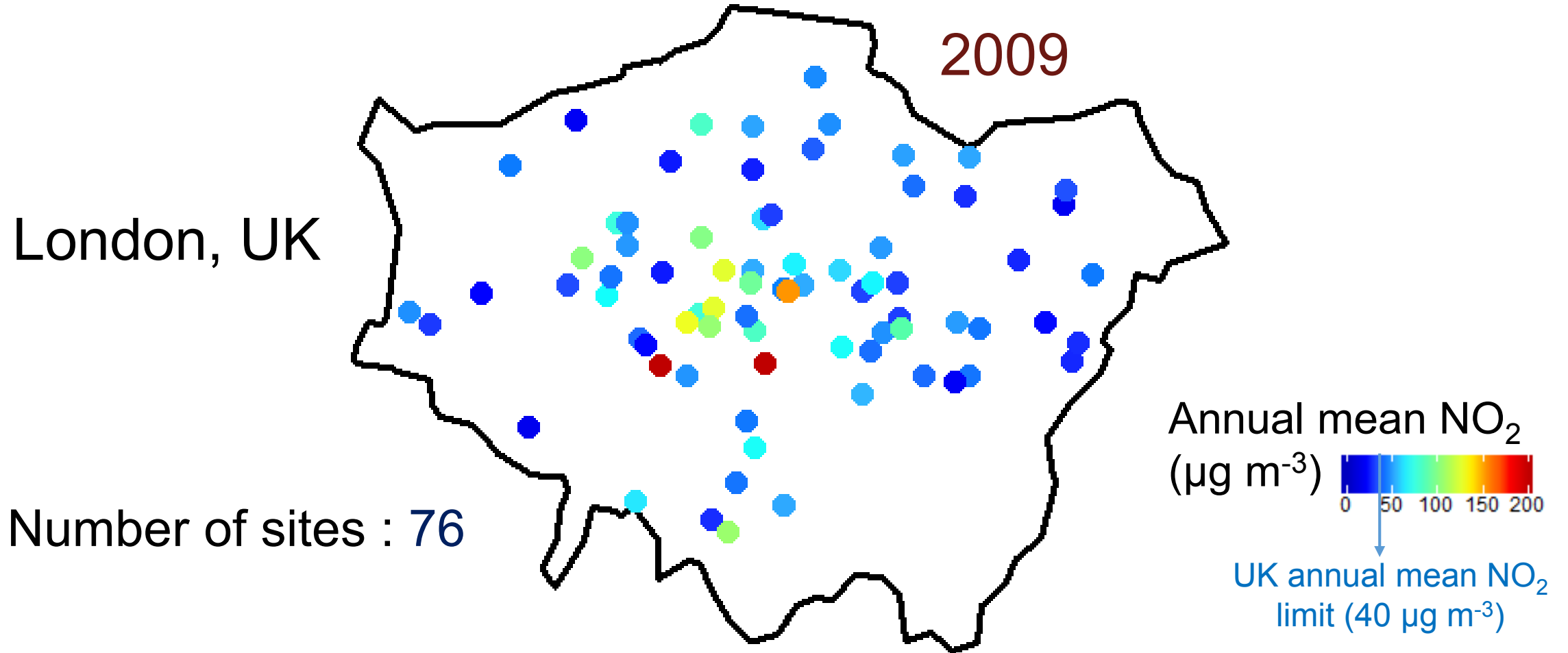
The Current Approach

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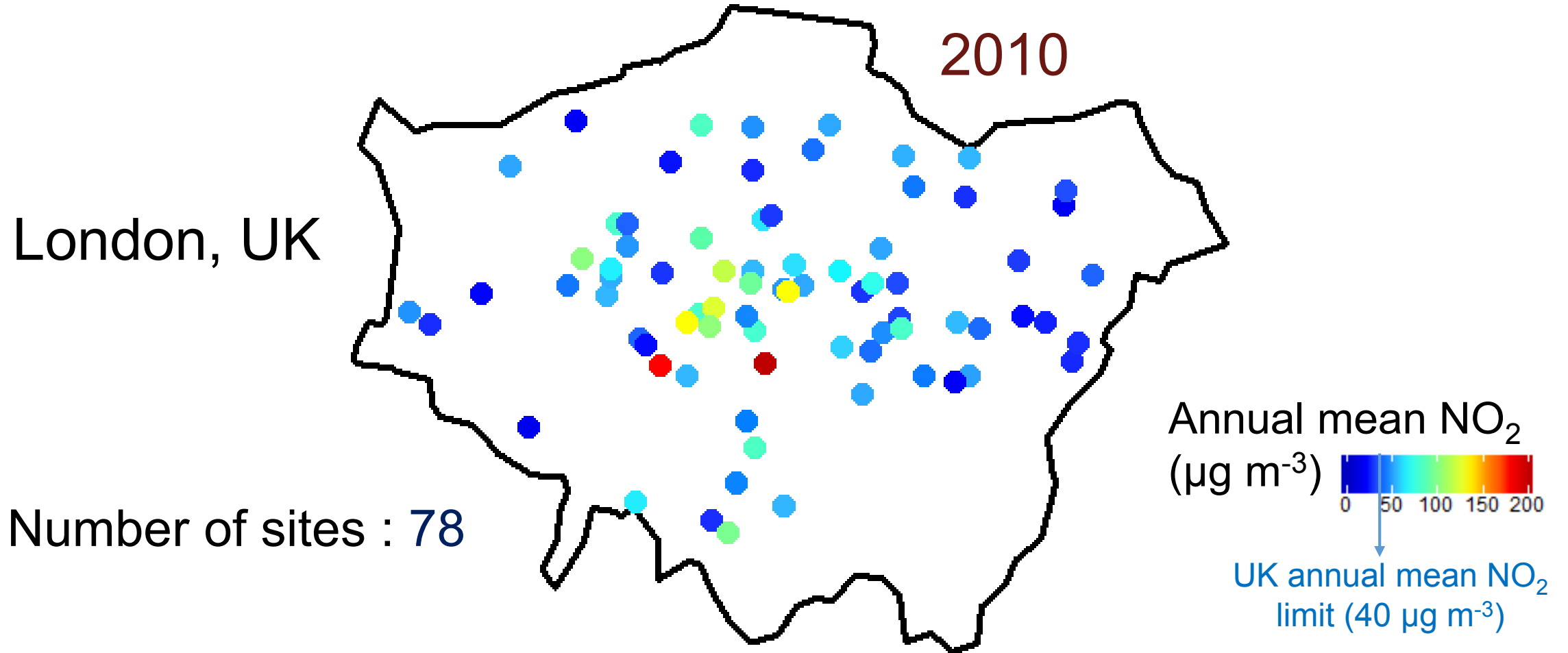
The Current Approach

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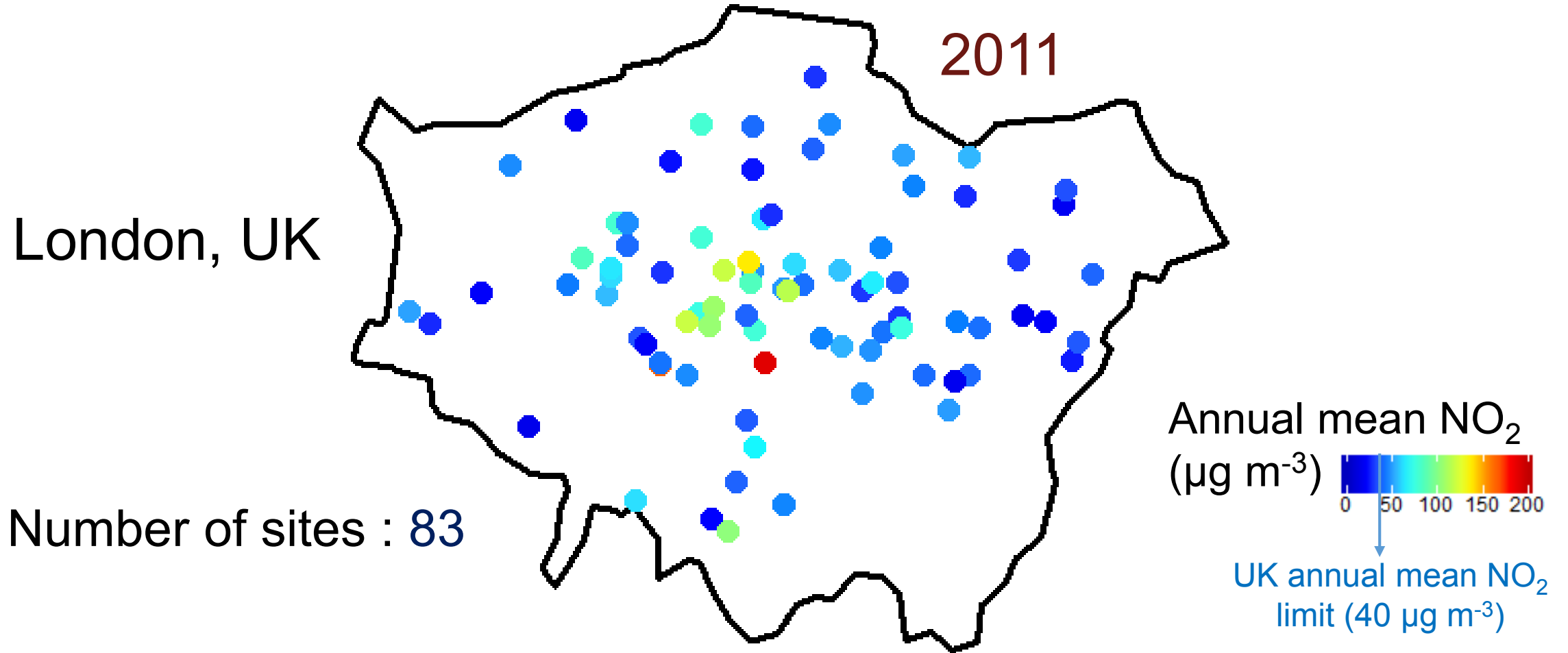
The Current Approach

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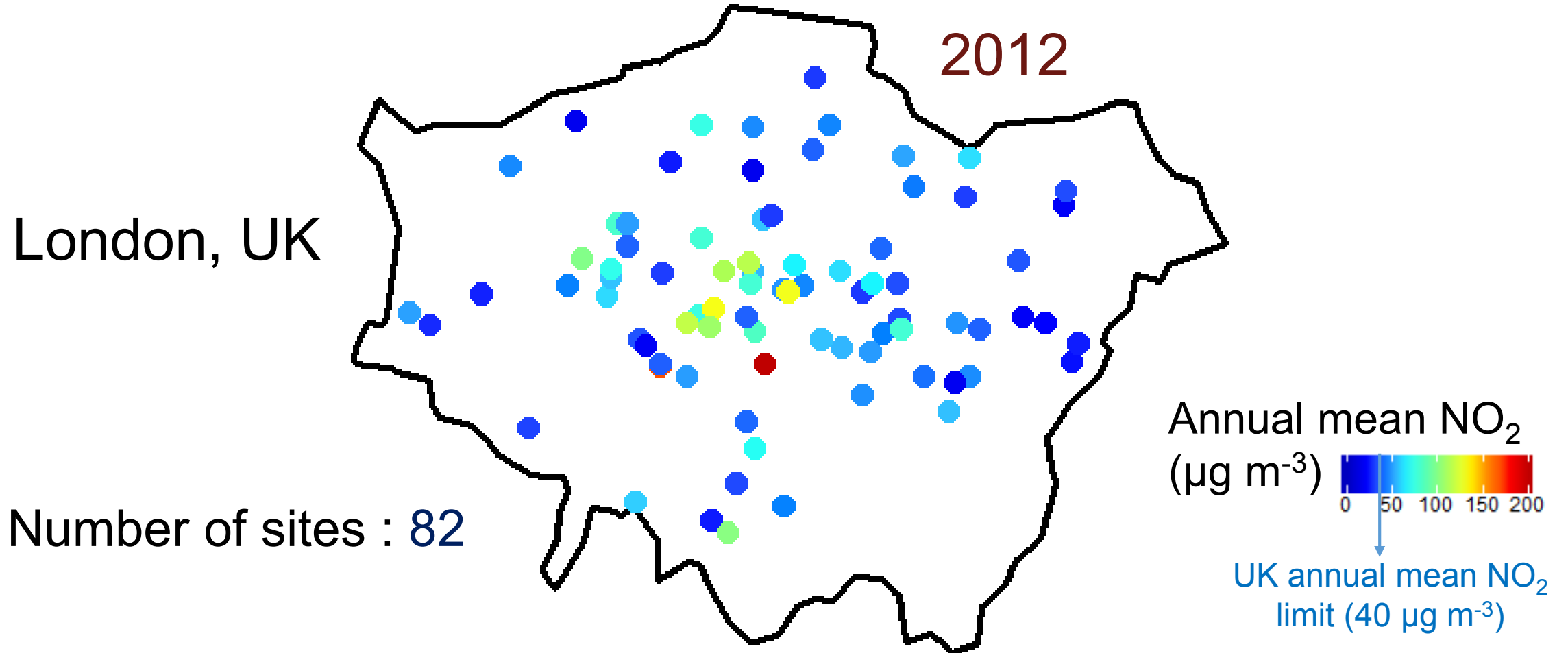
The Current Approach

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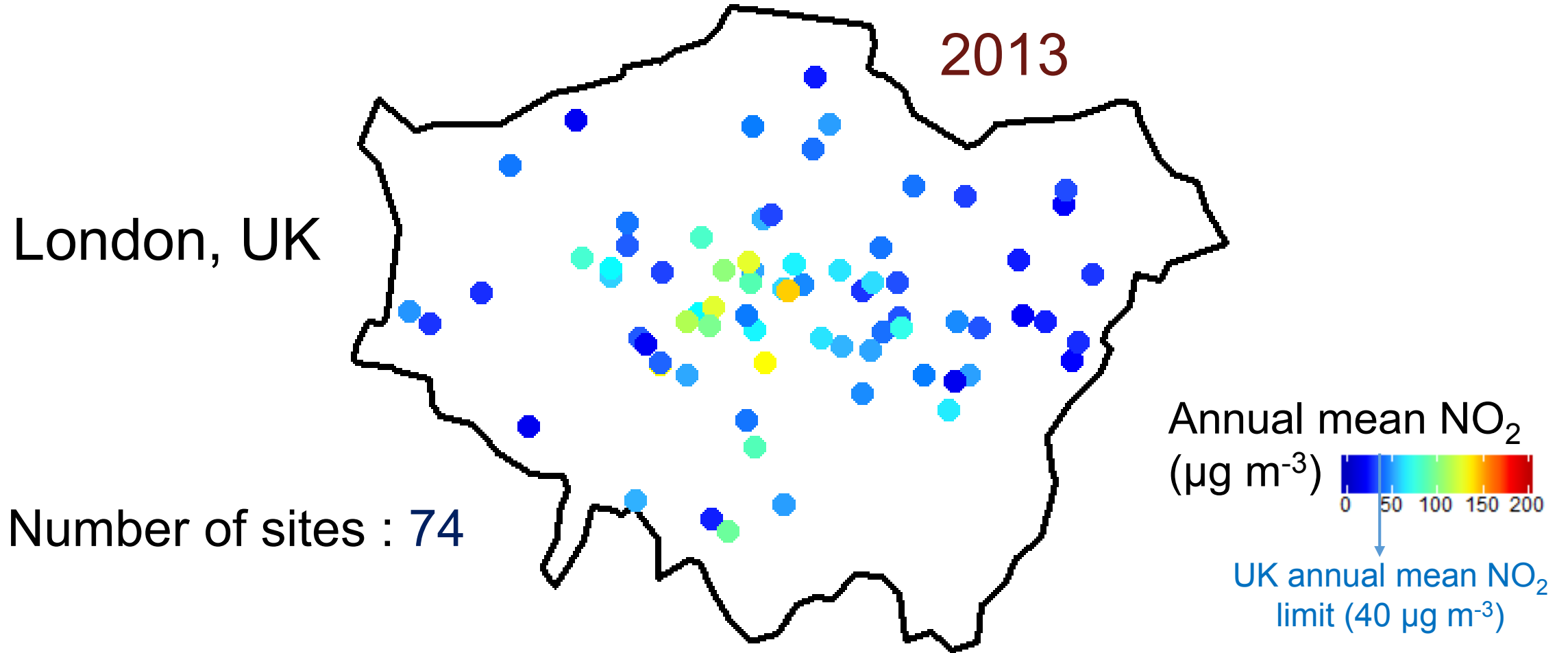
The Current Approach

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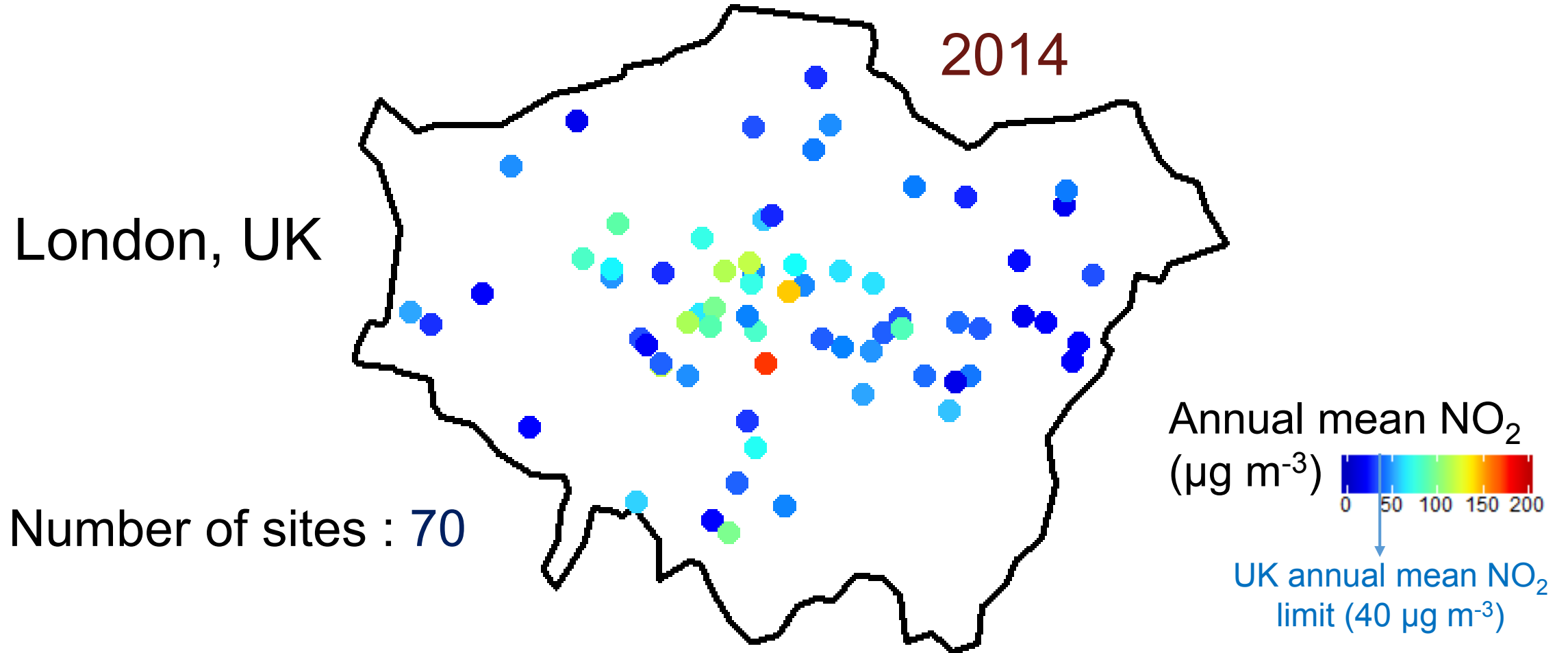
The Current Approach

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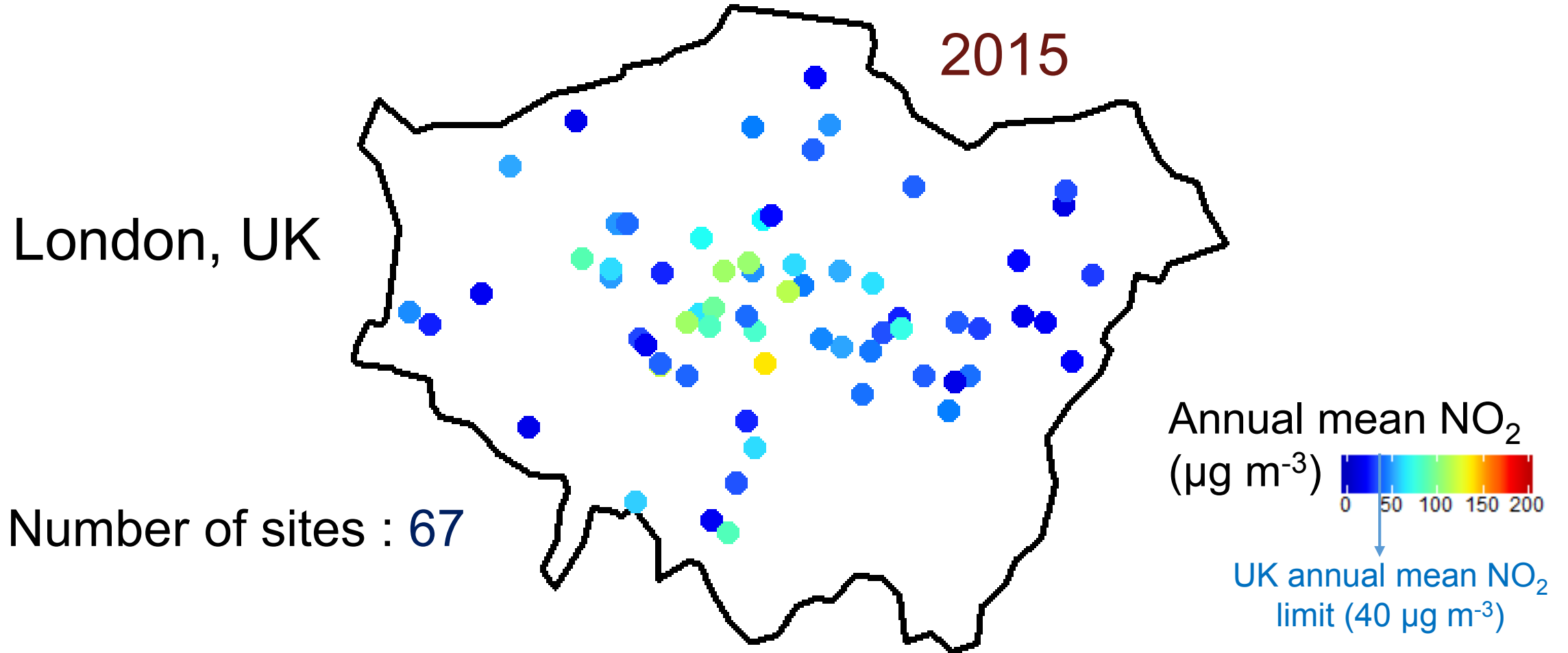
The Current Approach

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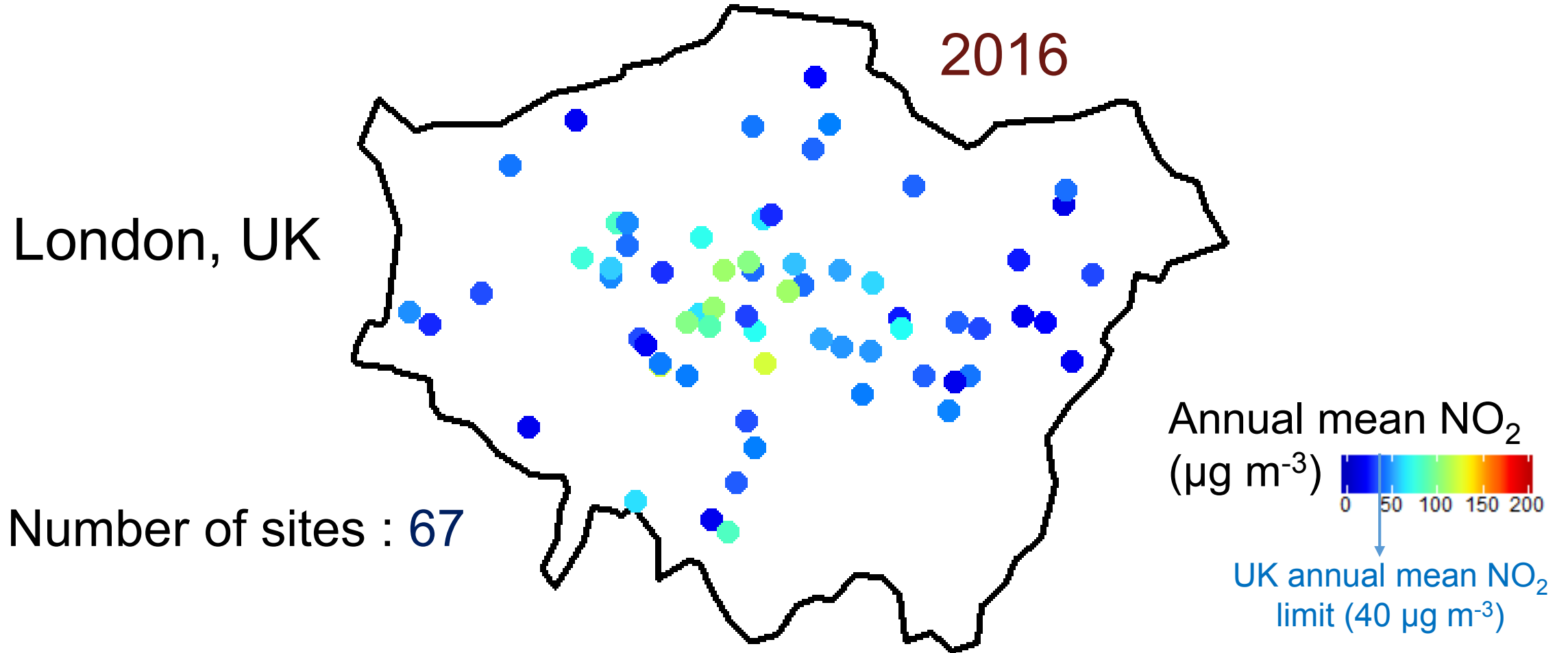
The Current Approach

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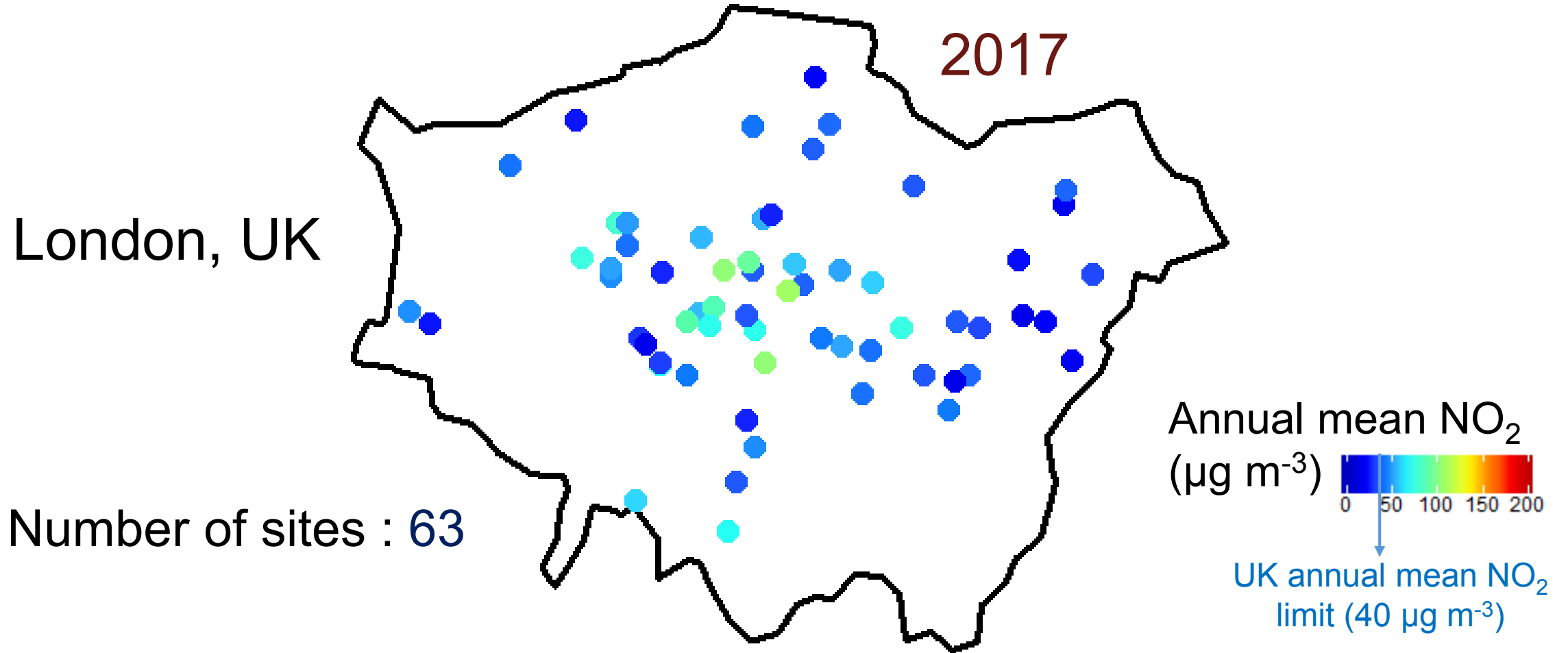
The Current Approach

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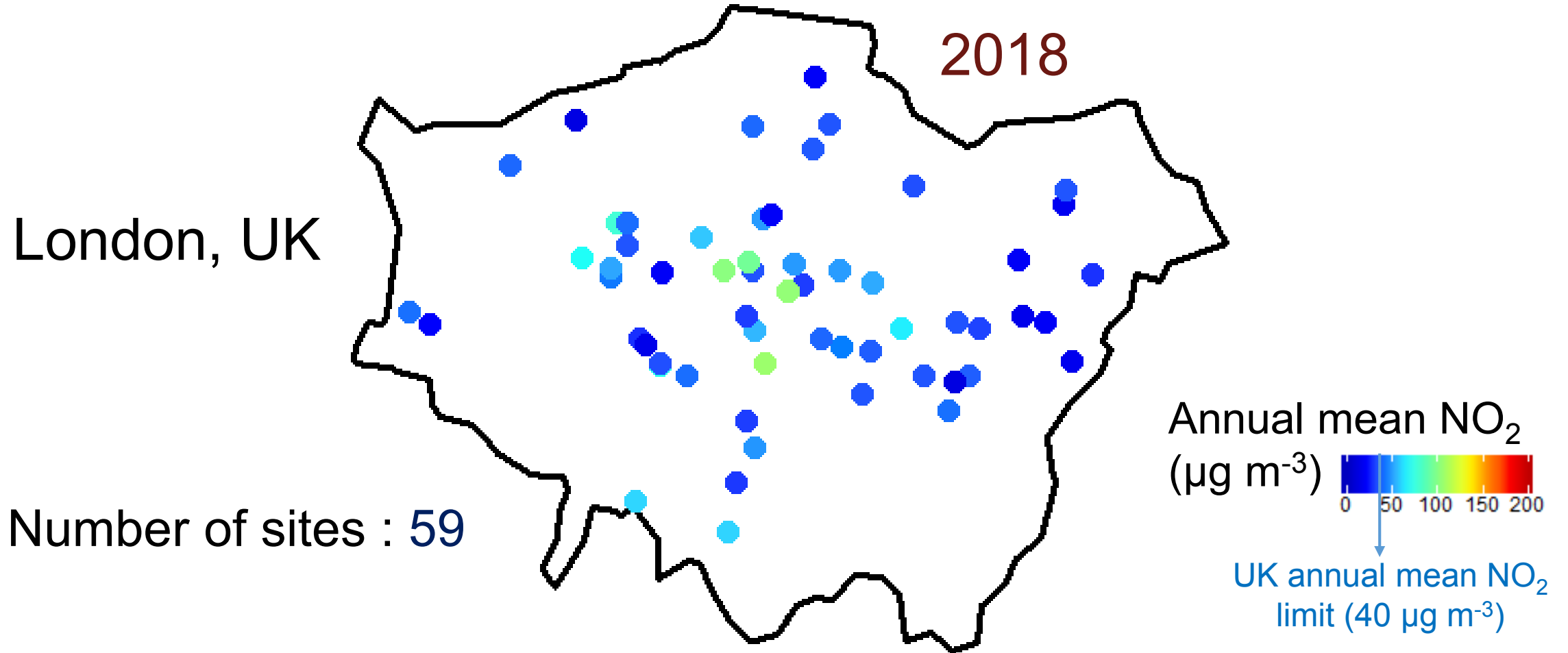
The Current Approach

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The Current Approach

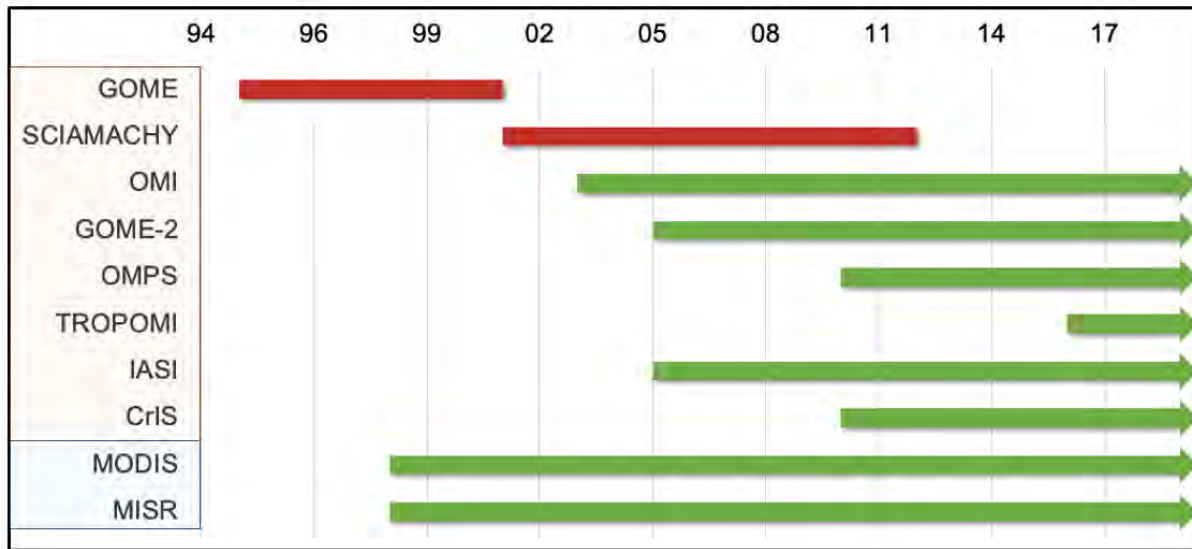
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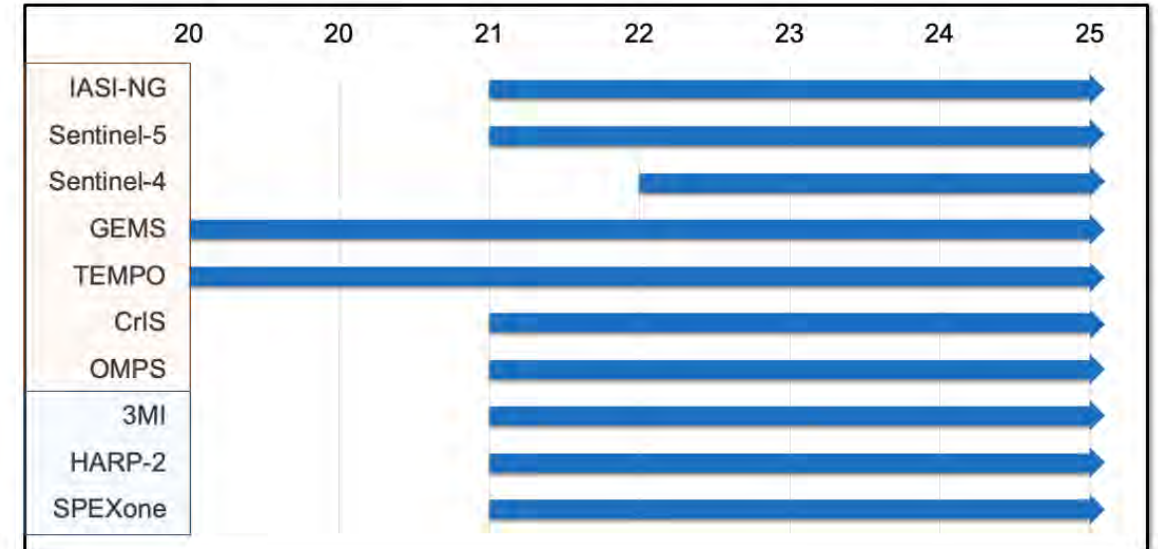
The Solution

Satellites are the only solution to address this global challenge

Sensors in space have been providing us with petabytes of data for more than 2 decades



Future missions will be cheaper and will have finer spatial resolution

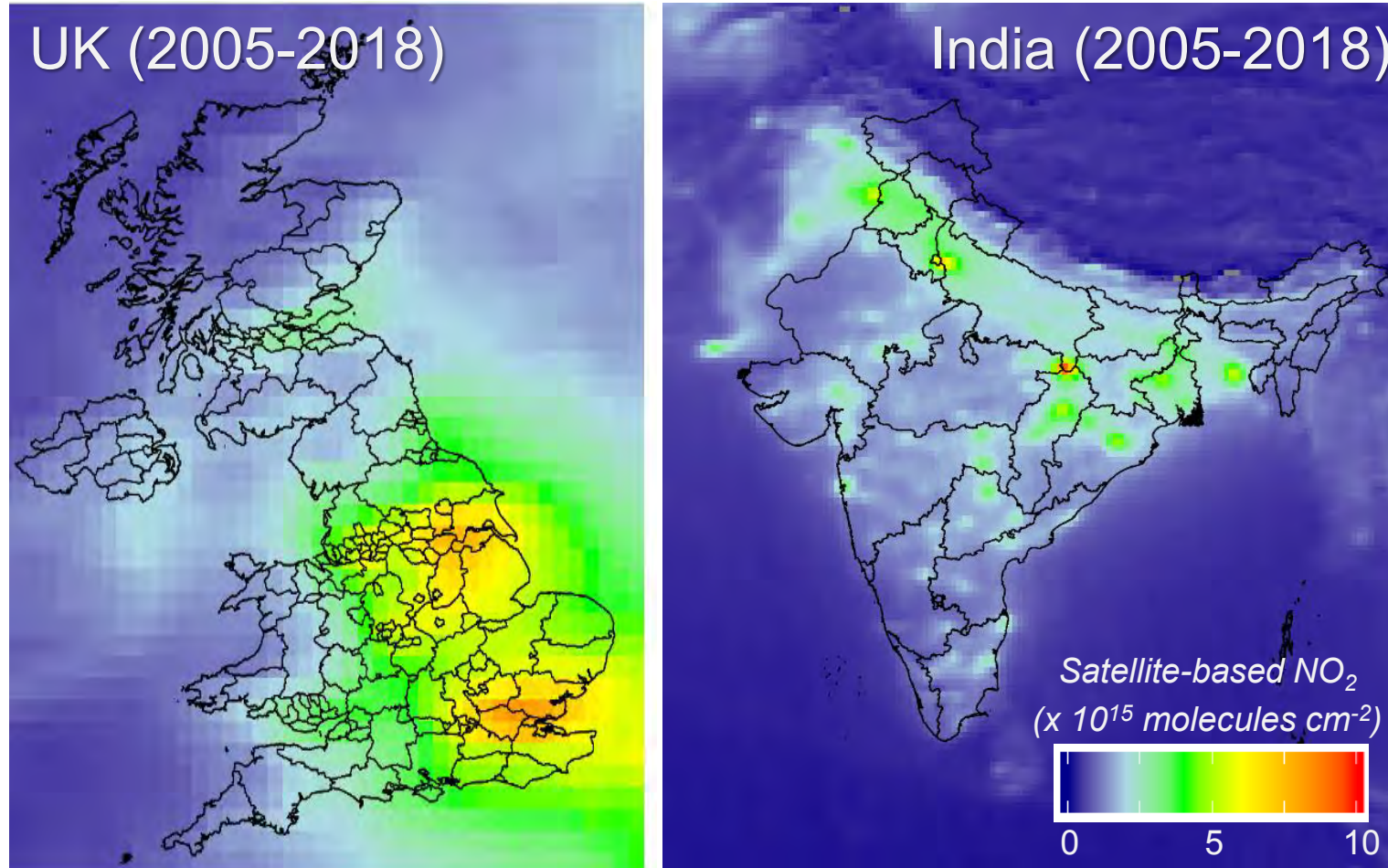


Gases
Particles

Completed
On-going

Future

Space-based instruments provide extensive data coverage



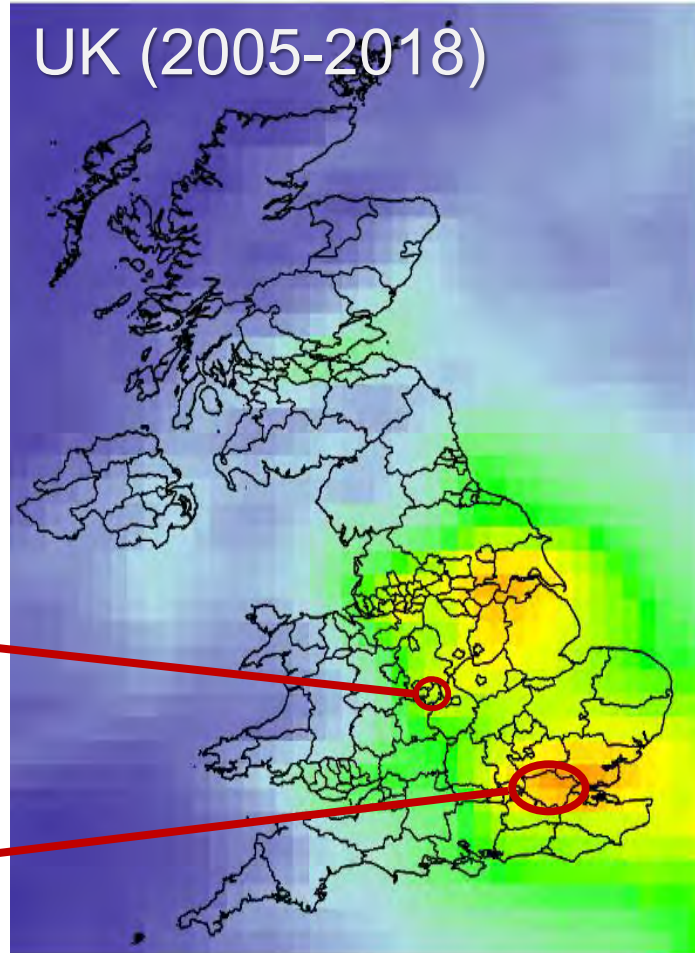
Space-based instruments provide extensive data coverage

We develop our tool focusing on 4 dynamic cities

UK (2005-2018)

Birmingham

London

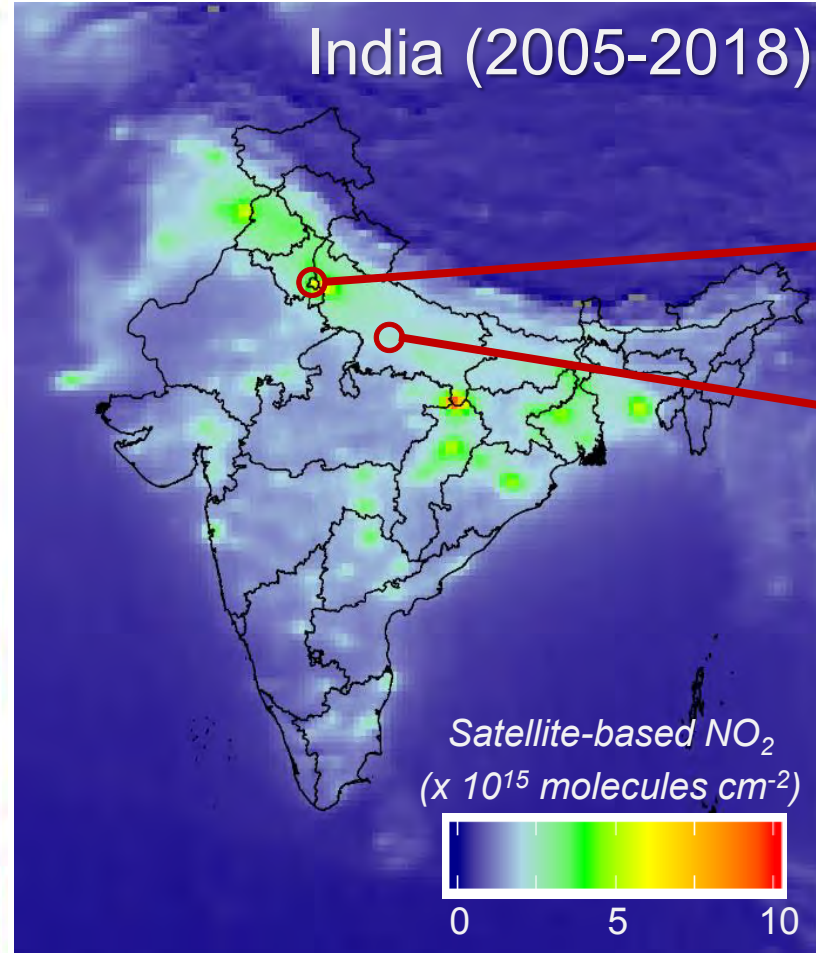
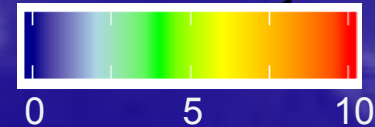


India (2005-2018)

Delhi

Kanpur

Satellite-based NO₂
($\times 10^{15}$ molecules cm⁻²)



The air around us is filled with pollutants
Air pollutants are emitted by multiple sources

Air pollutants undergo chemical reactions
And impact human health and food security

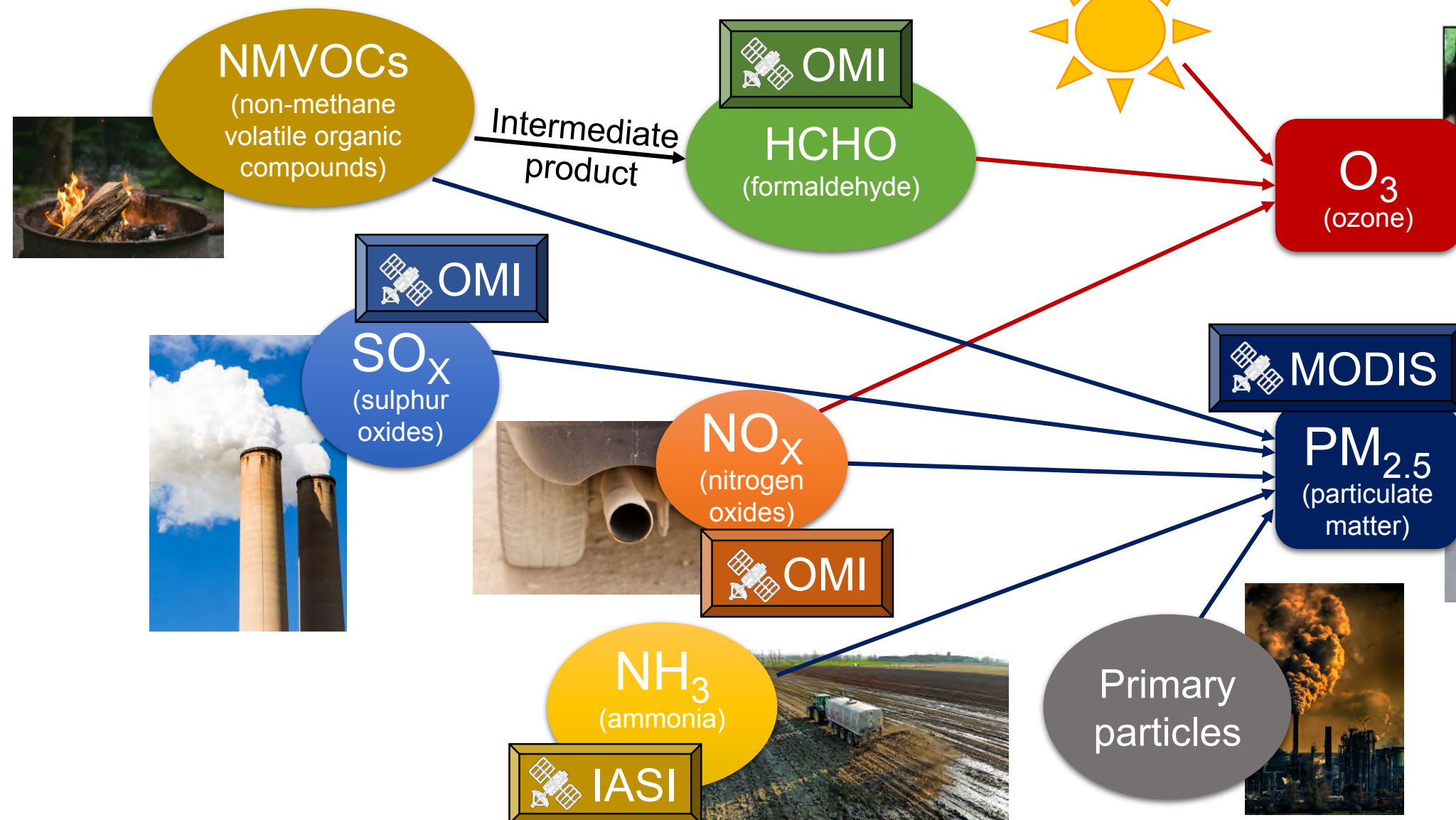
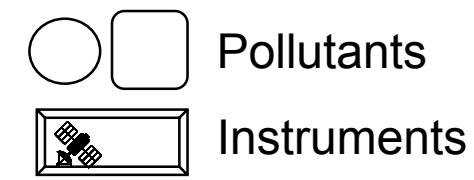
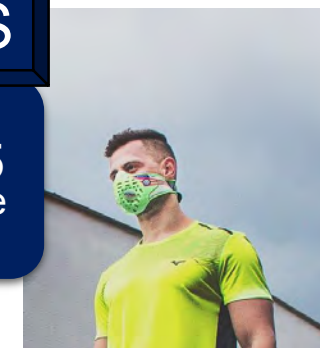
Satellites help monitor these air pollutants

Food security

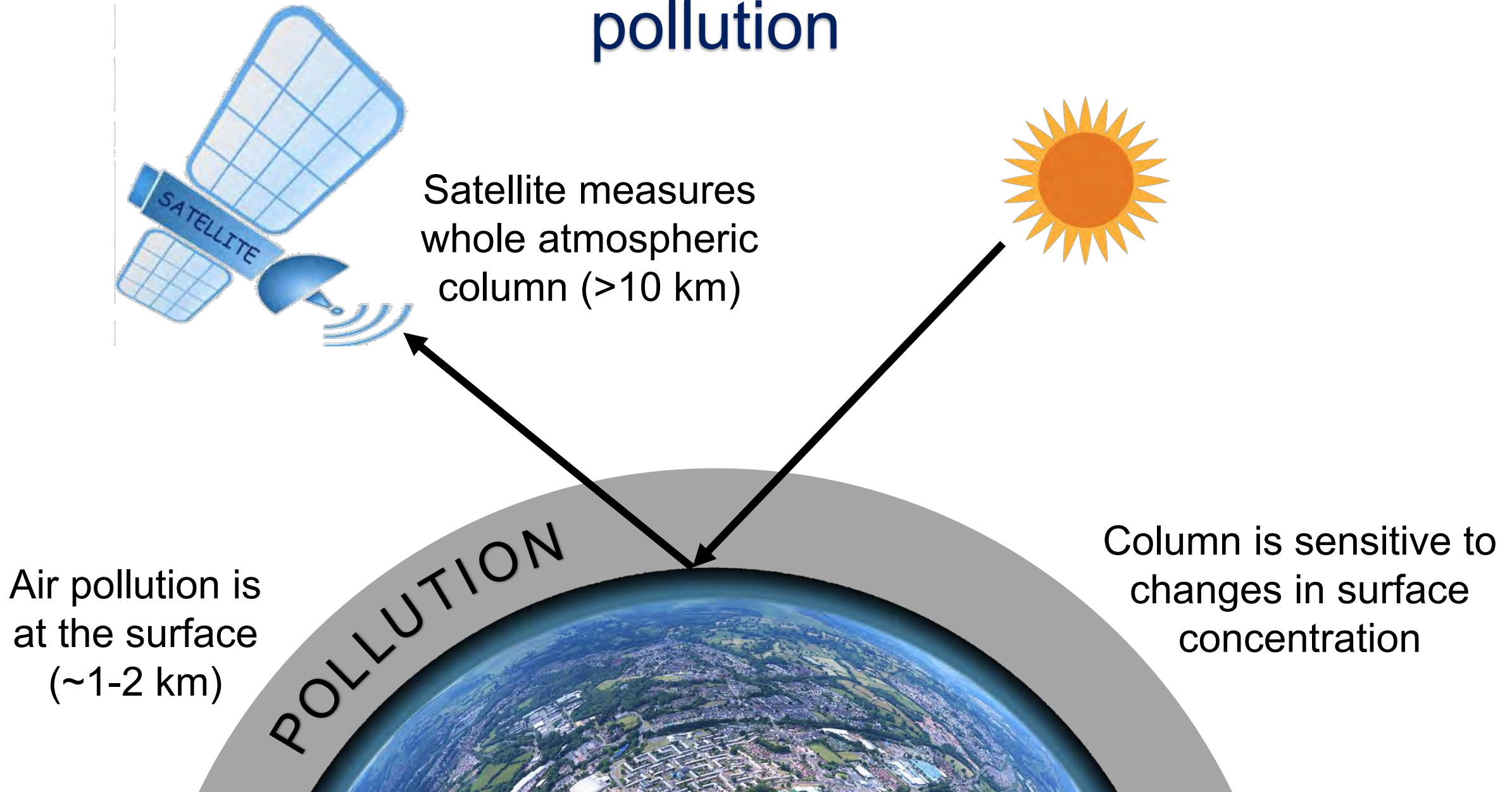


Photo credit: Dr Gerald Brust

Human health

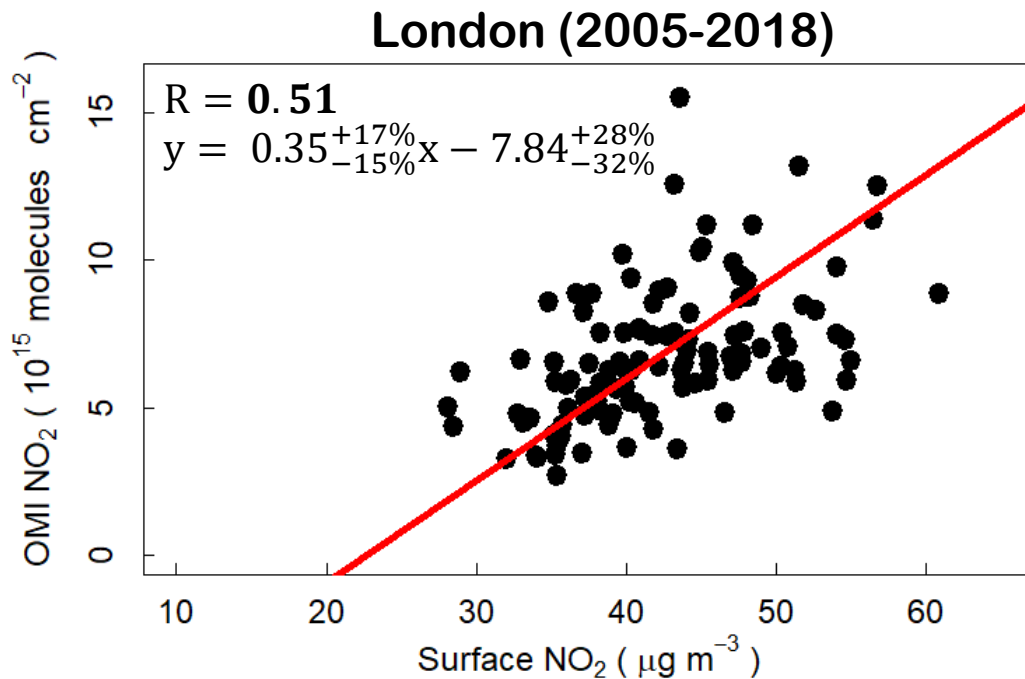


Satellite columns reflect changes in surface pollution

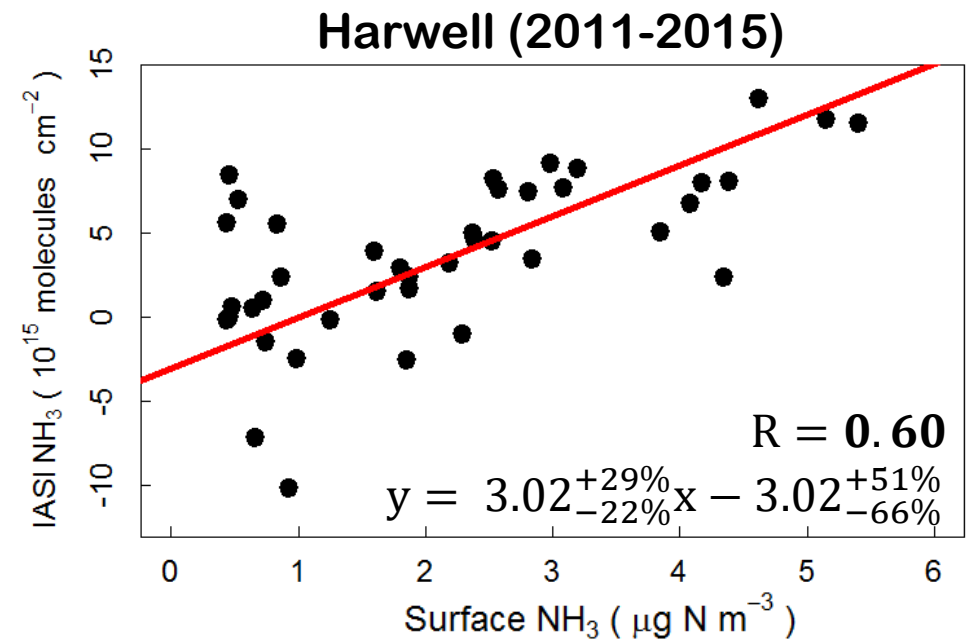


And conduct careful assessment with surface monitors (where available)

Satellite versus surface NO_2 in London



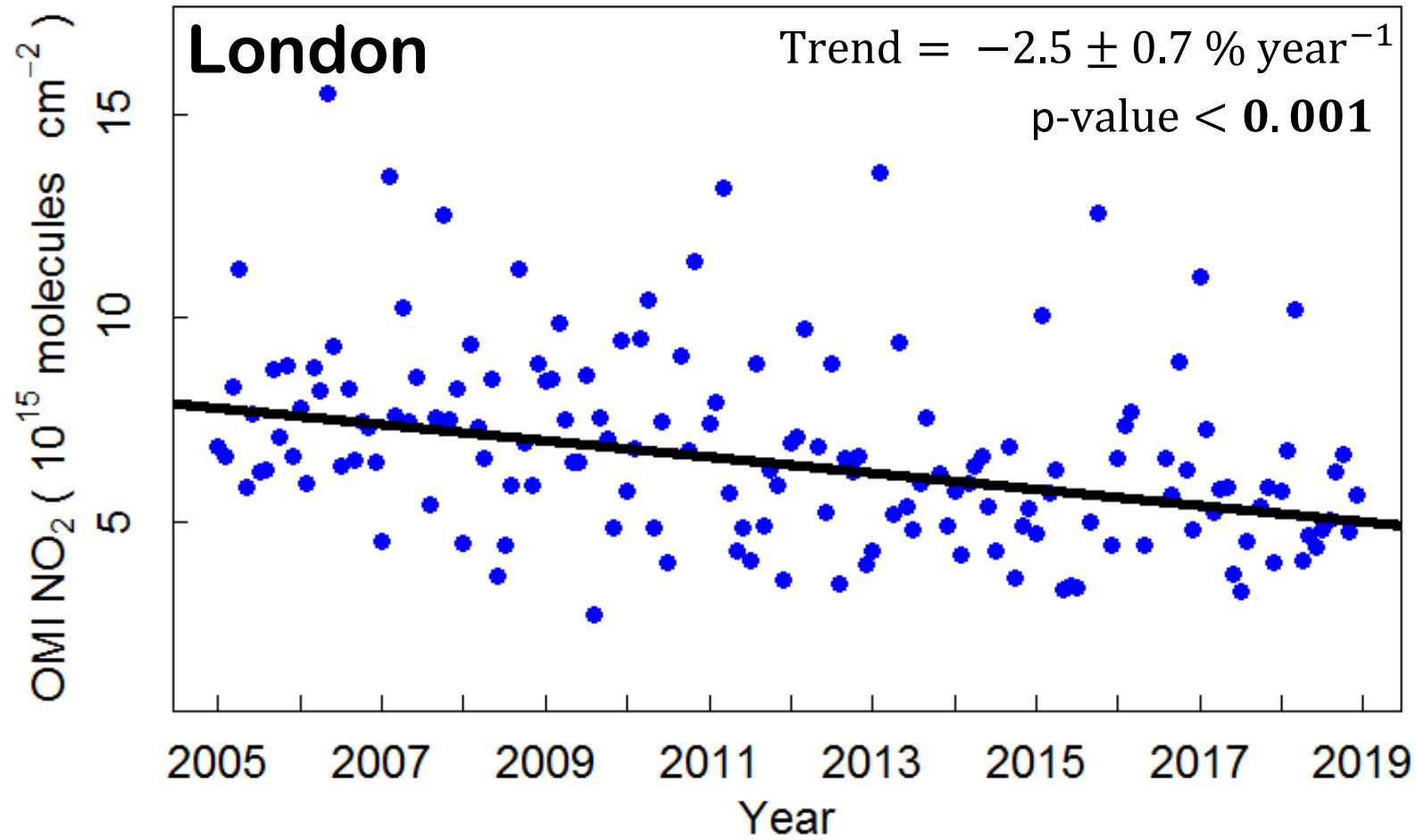
Satellite versus surface NH_3 in Harwell



Points are monthly averages

Pearson's correlation coefficient (R-value) indicates consistency

















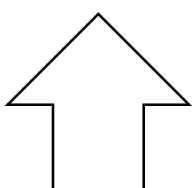





We use robust statistics to derive trends



NO₂ (NO_x) over London decreased by **35 %** from 2005 to 2018

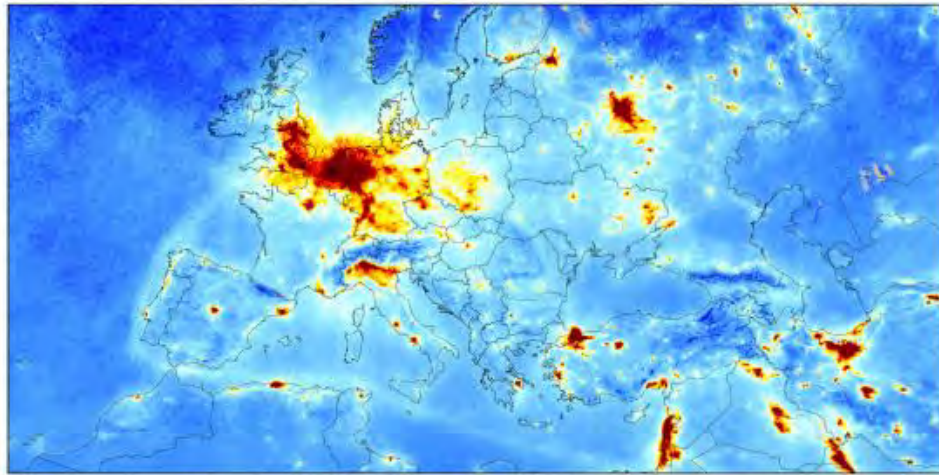
Air pollution control measures are working in the UK

While air quality has been deteriorating over time in India

Air pollutant	London	Birmingham	Delhi	Kanpur	 Increase  Decrease
NO_x (2005-2018)					Significant?  Yes  No
NH₃ (2008-2017)					
NMVOCs (2005-2016)					Trend (in % year⁻¹)  4  2
PM_{2.5} (2005-2018)					

Next steps

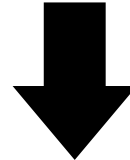
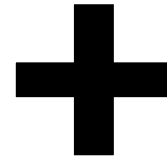
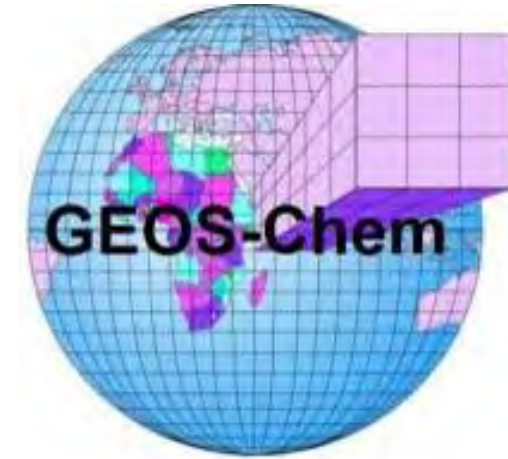
High spatial resolution satellite data



NO₂ tropospheric column gridded mean, TROPOMI sensor (10^{-6} mol m⁻²)

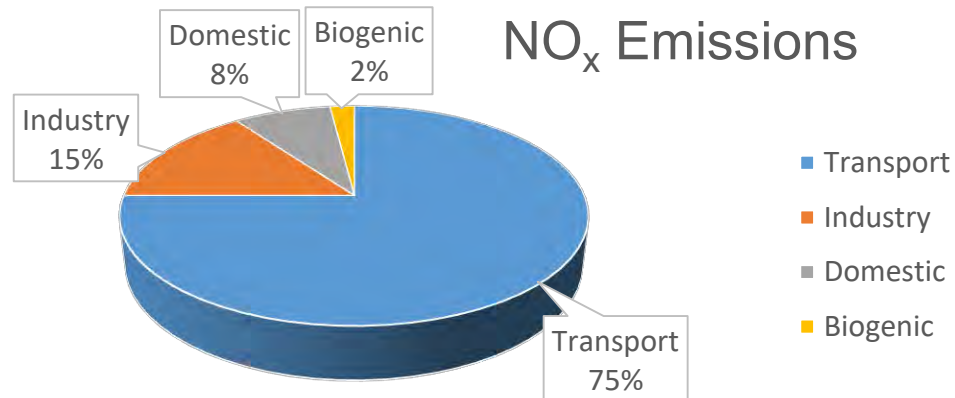
TROPOMI NO₂ for April 2018 [Geffen et al., 2019]

Global 3D Chemical Transport Model



Interpret data using model to understand drivers of trends and inter-annual variability in air pollutants

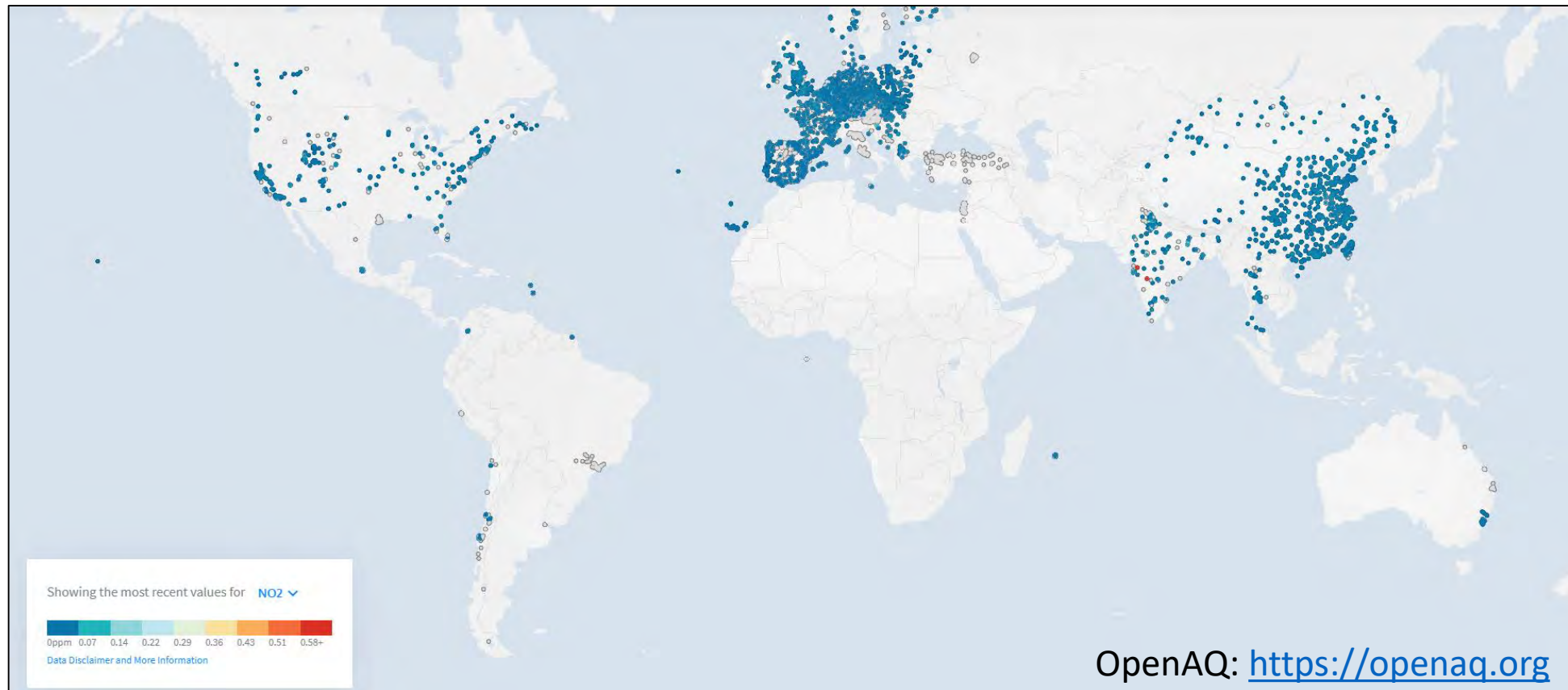
Compute
emission
inventory



A global problem

No routine monitoring of air pollutants in many parts of the world

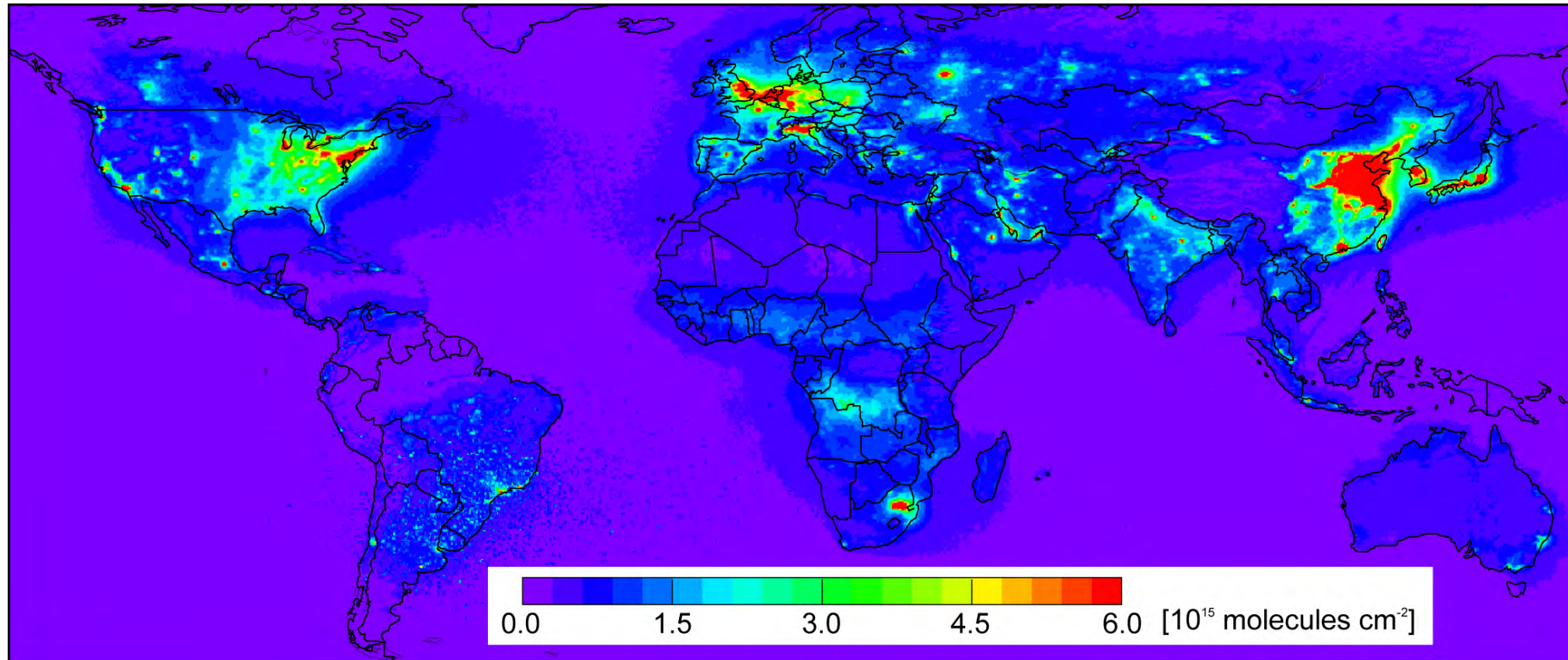
Publicly available NO₂ data for 14th October, 2019



A scalable solution

The algorithms that we have developed can
be applied to any city in the world

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



Acknowledgements



UNIVERSITY OF
BIRMINGHAM



UNIVERSITY OF
LEICESTER



defra
Department for Environment
Food and Rural Affairs



Leicester
City Council



Birmingham City Council



EPSRC

Copernicus



CATAPULT
Satellite Applications

CATAPULT
Connected Places

Thank you

Institution of
**MECHANICAL
ENGINEERS**

and everyone for your attention!!!