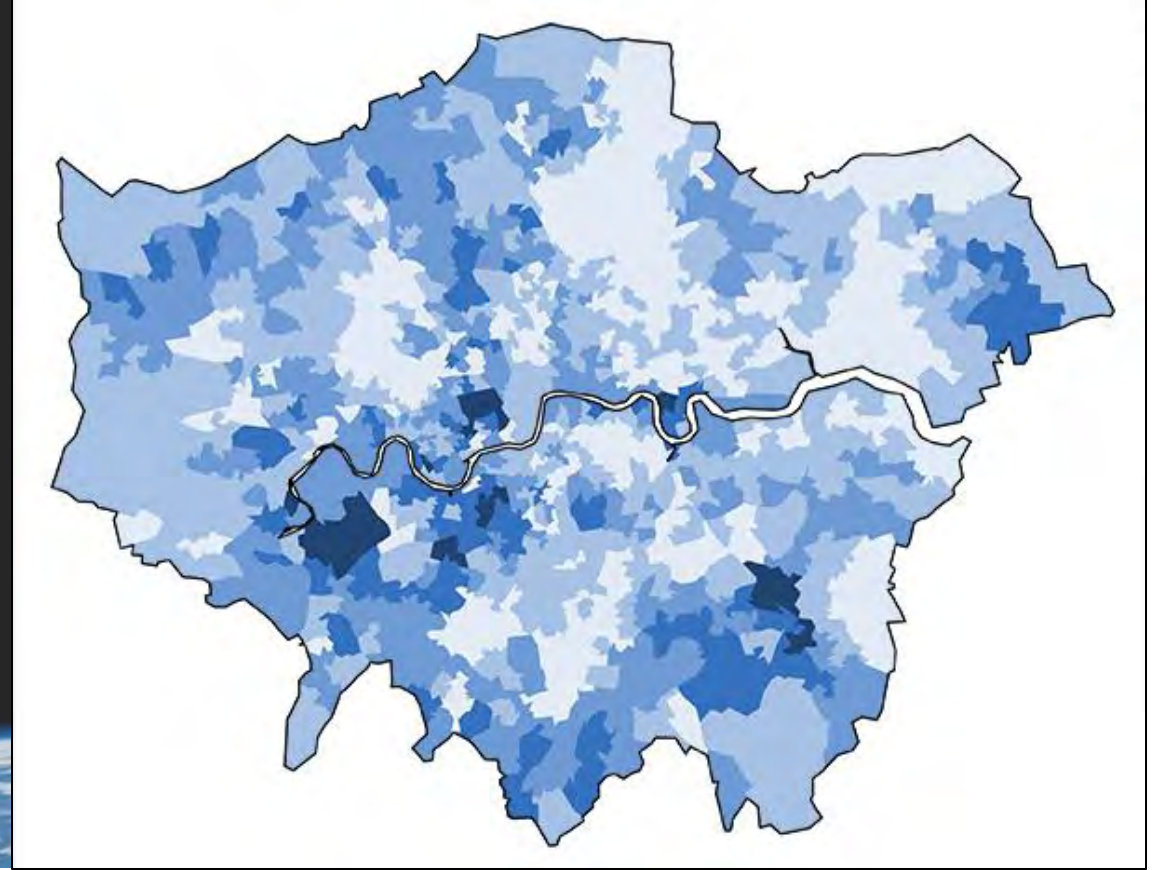# Using satellite-derived surface concentrations of NO$_2$ to assess inequities in exposure to traffic-related air pollution in UK cities

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With: Eleanor Gershenson-Smith (UCL), Karn Vohra (U. Birmingham)

Health burden of long-term exposure to NO_2 and traffic-related air pollution

Direct NO_2 exposure and NO_2 as marker for traffic-related air pollution:

NO_2: paediatric asthma

Traffic-related air pollution:
all-cause mortality

Unfair exposure

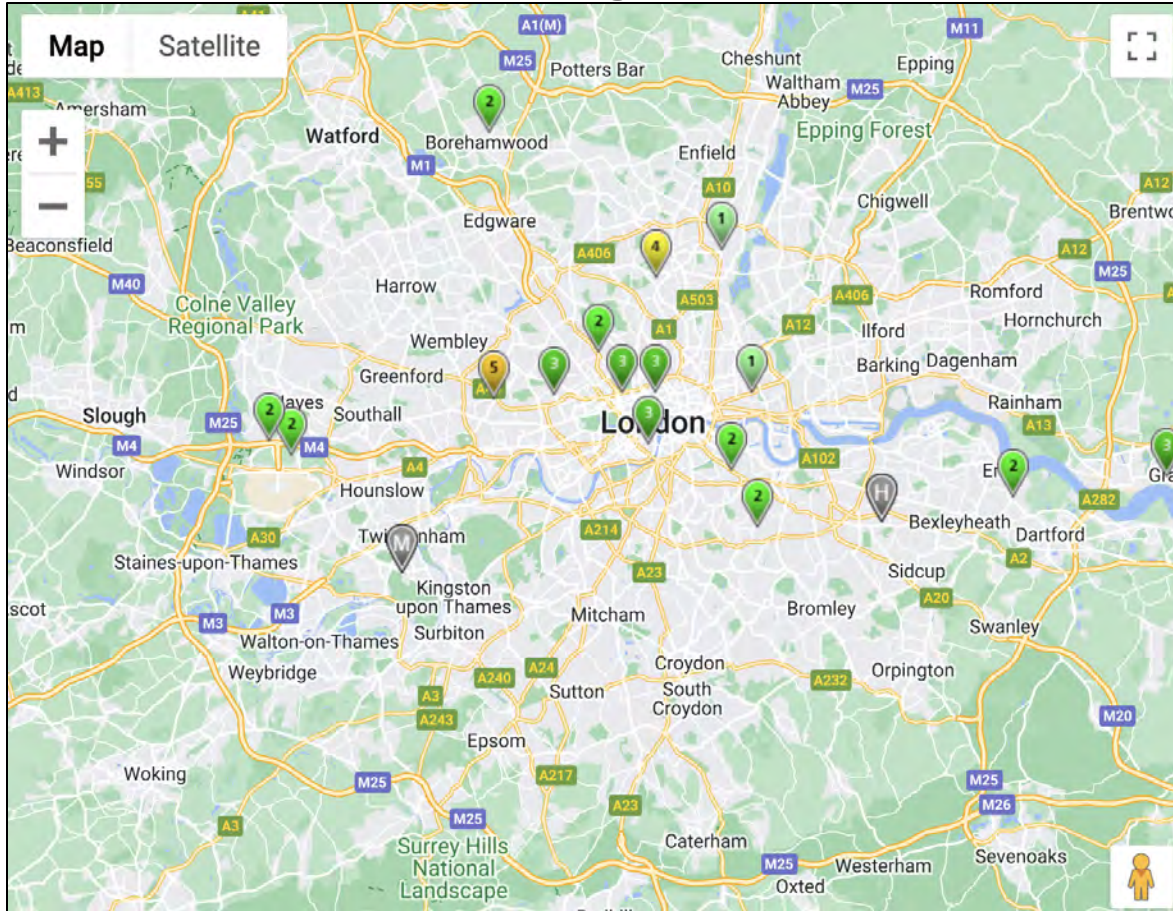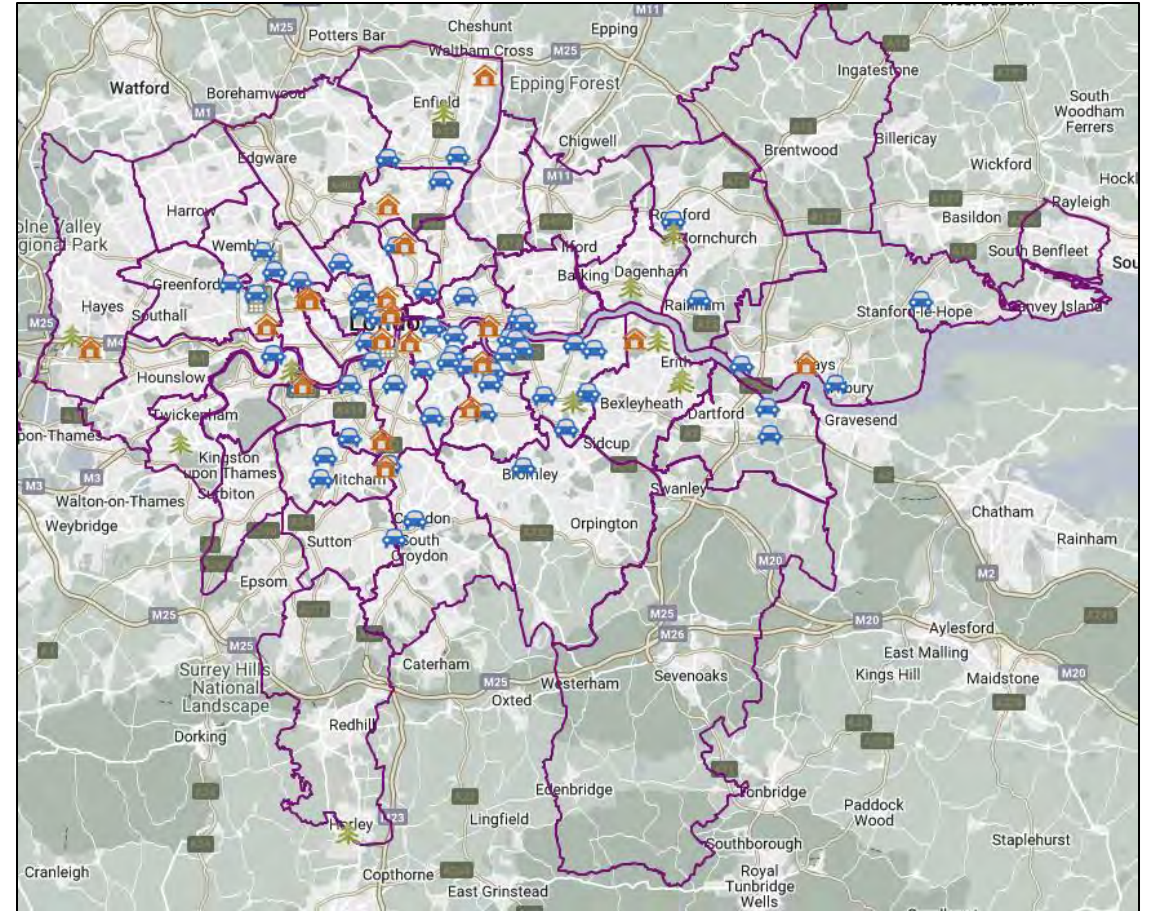Quantify exposure and health disparities, identify affected communities, direct policy and empower citizens

Existing datasets inadequate

Large time and space data gaps for national, local and academic measurement networks
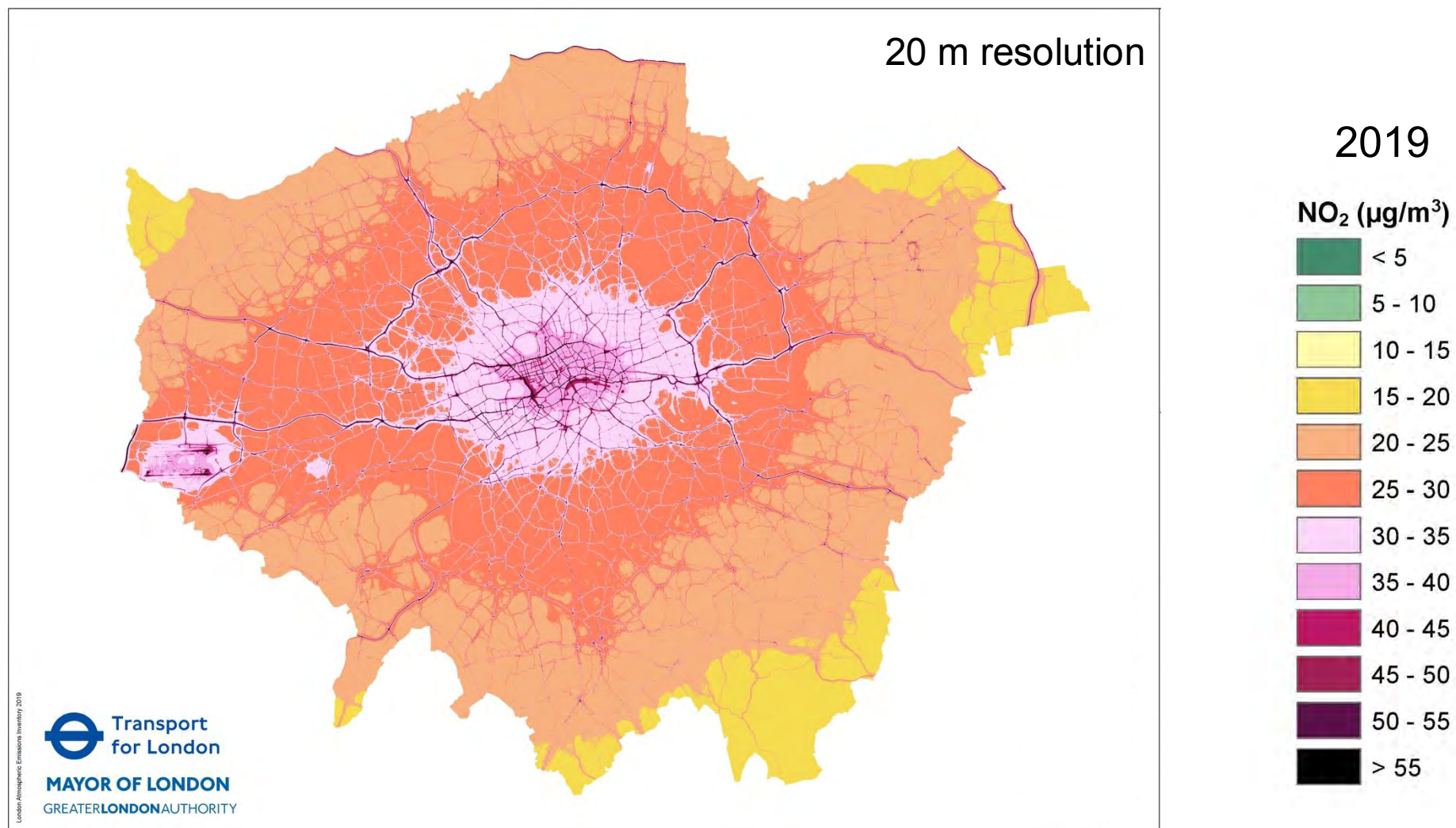
National monitoring network (AURN)

London Air Quality Network (LAQN)

Existing datasets inadequate

Hybrid model data achieves exceptionally high resolution (20 m), but resource intensive, hard to keep contemporary, only available for Greater London
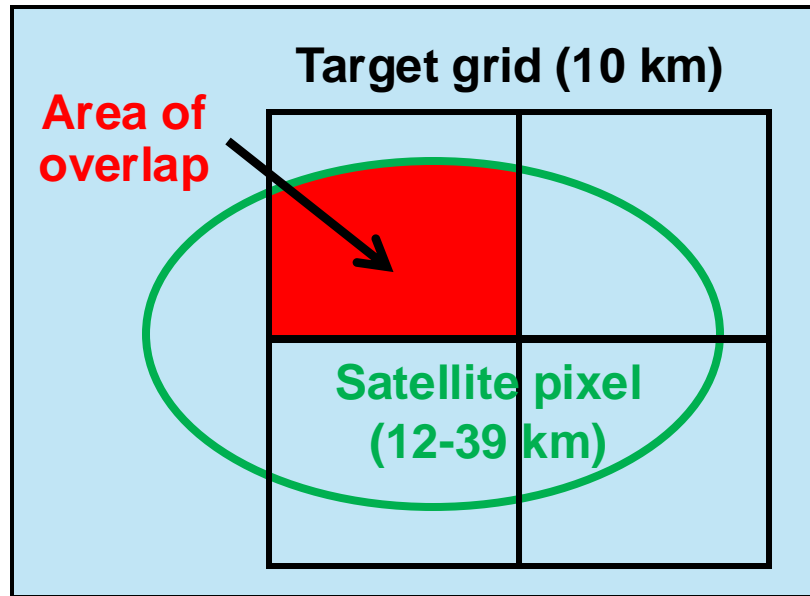

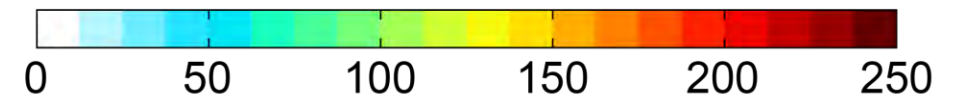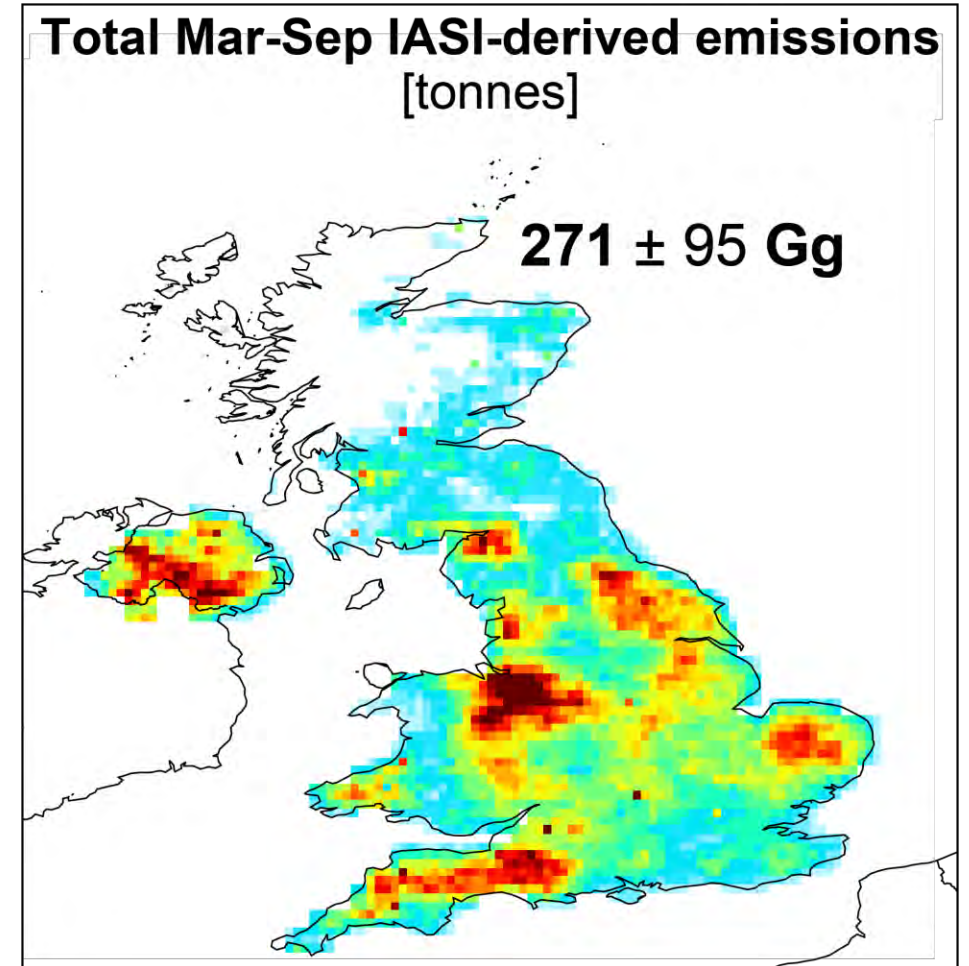Data from: https://data.london.gov.uk/dataset/london-atmospheric-emissions-inventory--laei--2019

Grid to Finer Resolution than Instrument

Used in past to derive ~10 km resolution UK NH_3 emissions from 12-39 km resolution instrument
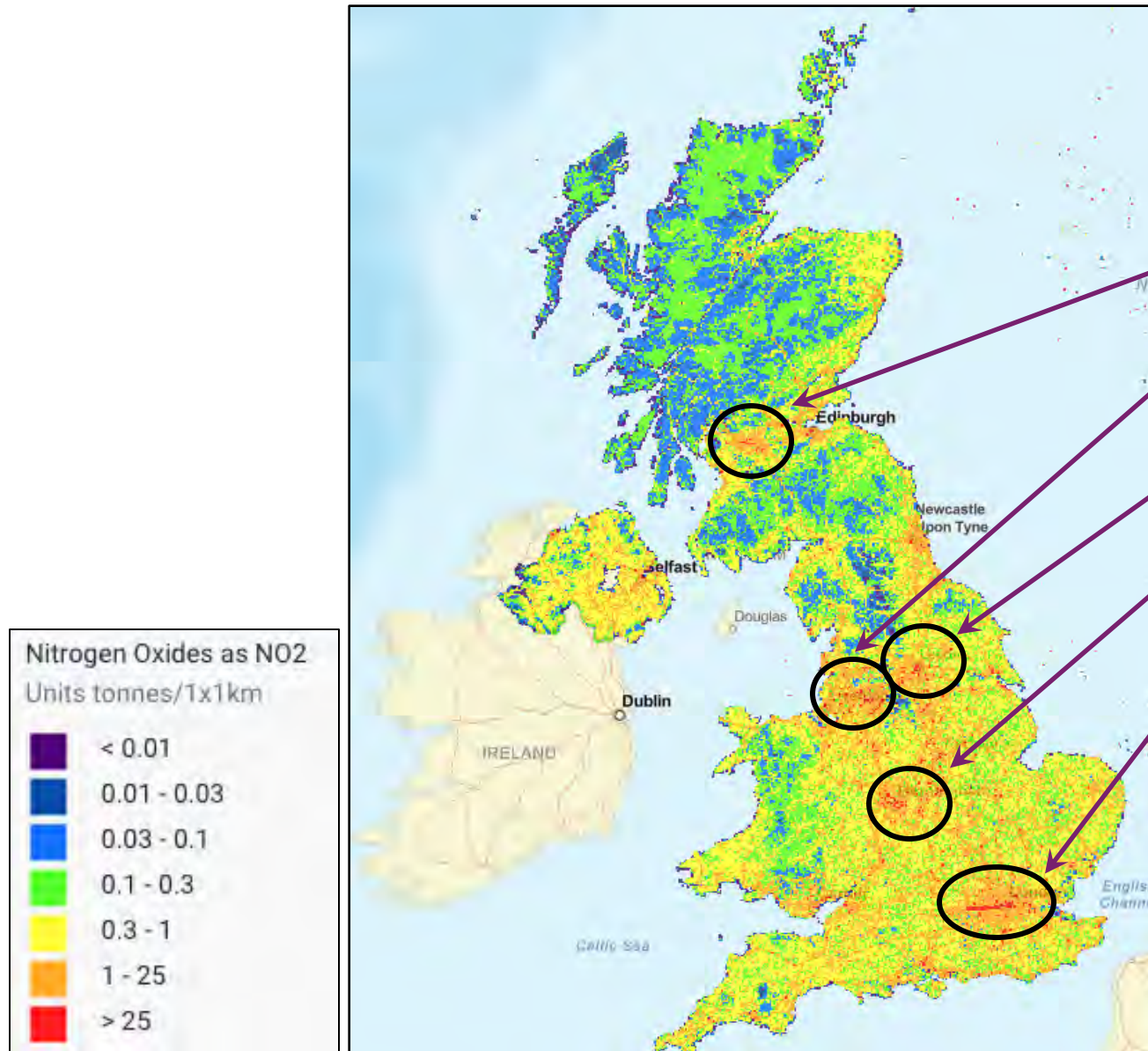
Oversampling Technique

Weights pixel by area of overlap

Total Mar-Sep IASI-derived emissions
[tonnes]

271 ± 95 Gg

Marais et al., JGR, 2021

Trade-off is lose temporal resolution to achieve greater spatial resolution

Select UK Cities Impacted by Traffic Emissions

Qualitative selection using UK National Atmospheric Emission Inventory (NAEI) NO_x emissions:

- Glasgow

- Manchester

- Leeds

- Birmingham
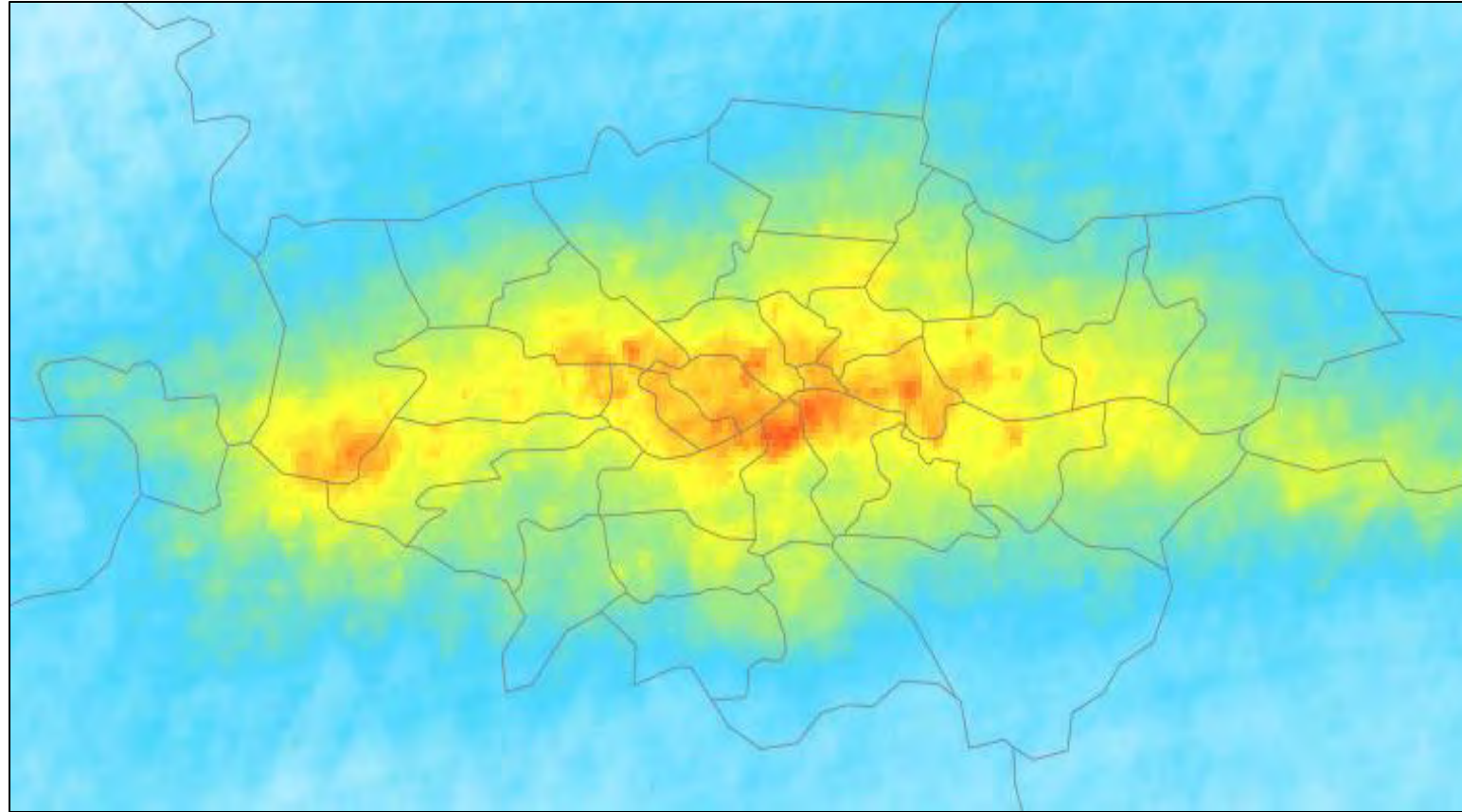
- London

Map source:
https://naei.energysecurity.gov.uk/emissionsapp/

Nitrogen Oxides as NO2
Units tonnes/1x1km

■	< 0.01
■	0.01 - 0.03
■	0.03 - 0.1
■	0.1 - 0.3
■	0.3 - 1
■	1 - 25
■	> 25

Achieve NO$_2$ spatial distribution at ~400 m resolution

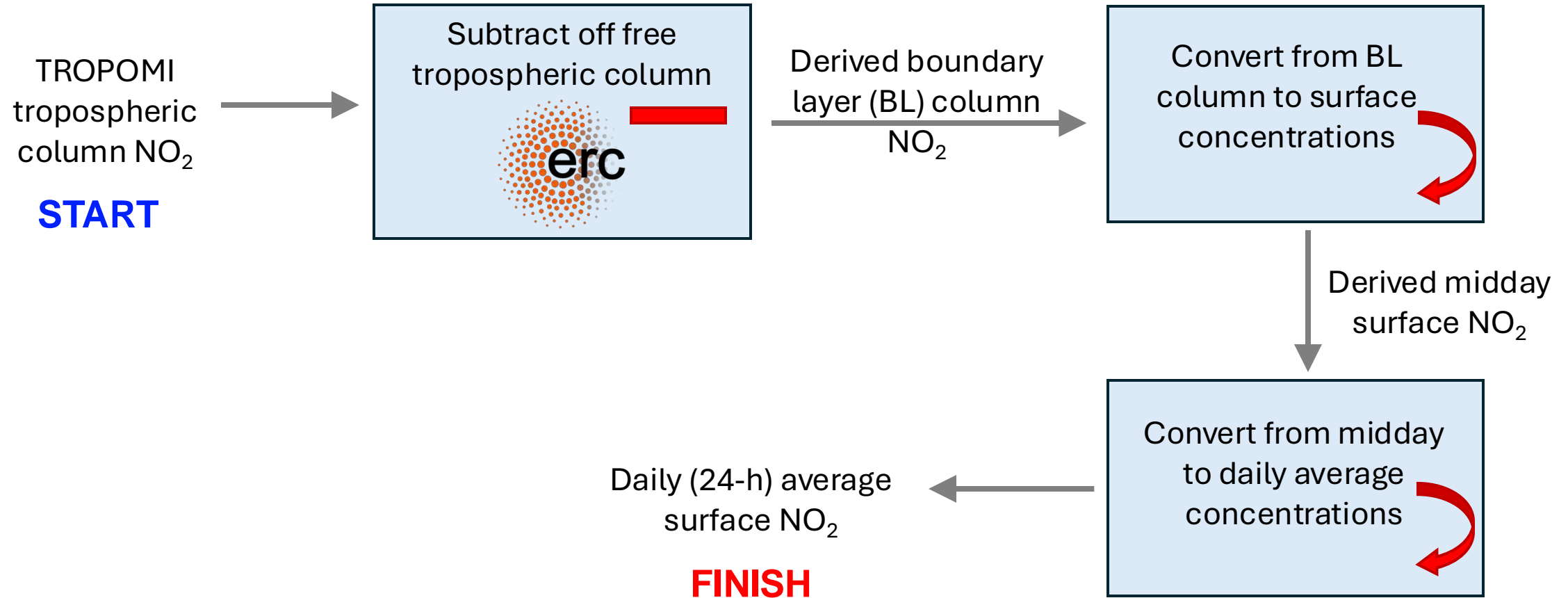Average tropospheric NO$_2$ column concentrations for 4 complete years

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

Enhancements linked to NO$_x$ producing activities evident: congested city centre, Heathrow

Convert from midday columns to 24h mean surface concentrations

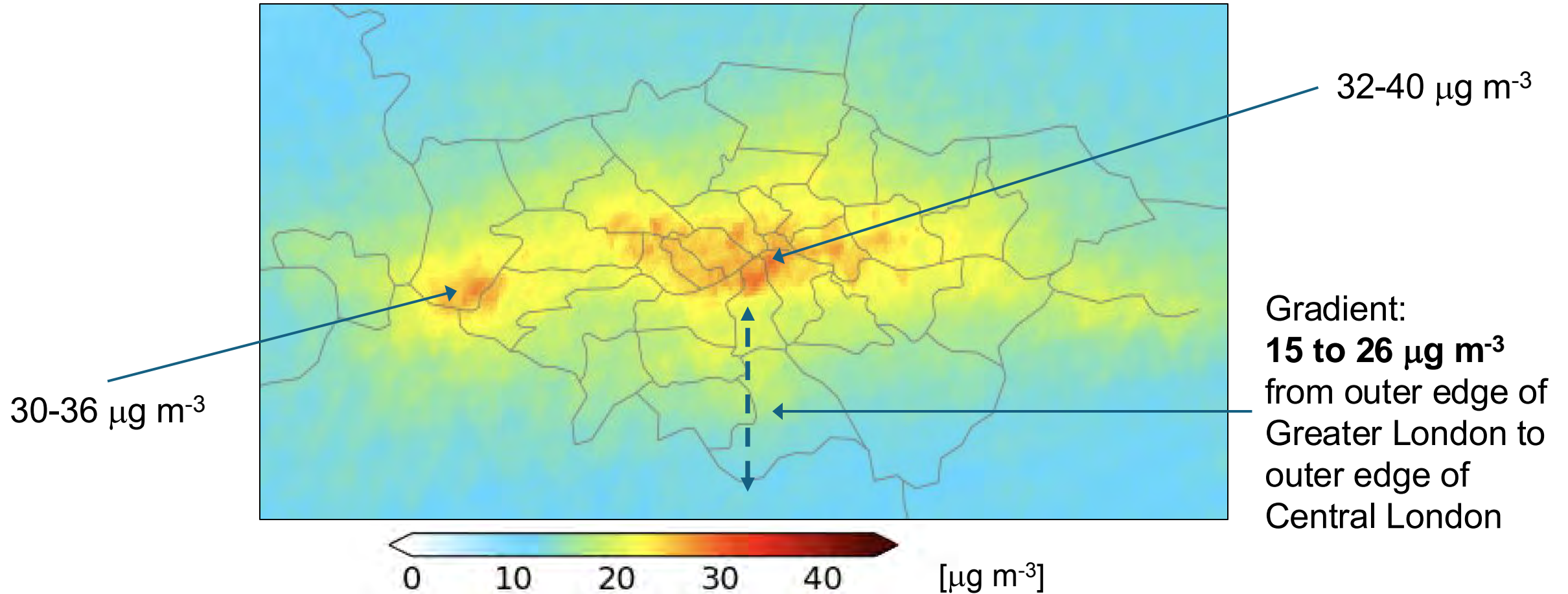Approach is a modification of more than a decade of method development initiated by Lamsal et al. [2008]

TROPOMI tropospheric column NO_2

START

→

Subtract off free tropospheric column

erc

Derived boundary layer (BL) column NO_2

→

Convert from BL column to surface concentrations

Derived midday surface NO_2

↓

Convert from midday to daily average concentrations

←

Daily (24-h) average surface NO_2

FINISH

Advantage: informed by observations rather than model, independent validation also possible

**Disadvantage**: requires a routine surface network of observations exists

Resultant surface concentrations of multiyear daily mean NO$_2$

Average daily (24-h) mean surface NO$_2$ concentrations for 4 complete years

32-40 μg m^{-3}

Gradient:
15 to 26 μg m^{-3}
from outer edge of
Greater London to
outer edge of
Central London

30-36 μg m^{-3}

0   10   20   30   40   [μg m^{-3}]

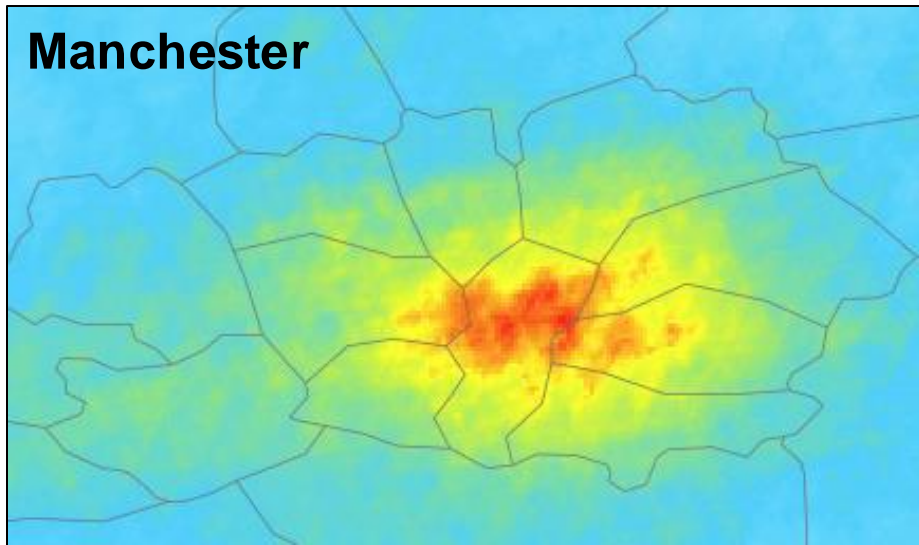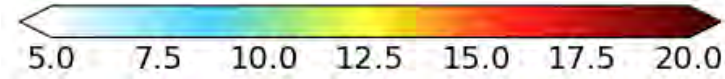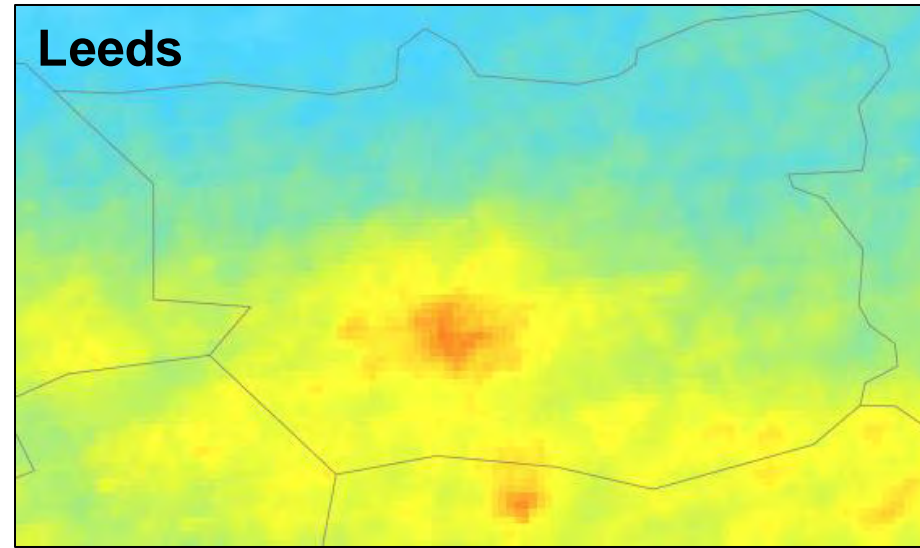Qualitatively similar to NO$_2$ concentrations developed with hybrid model
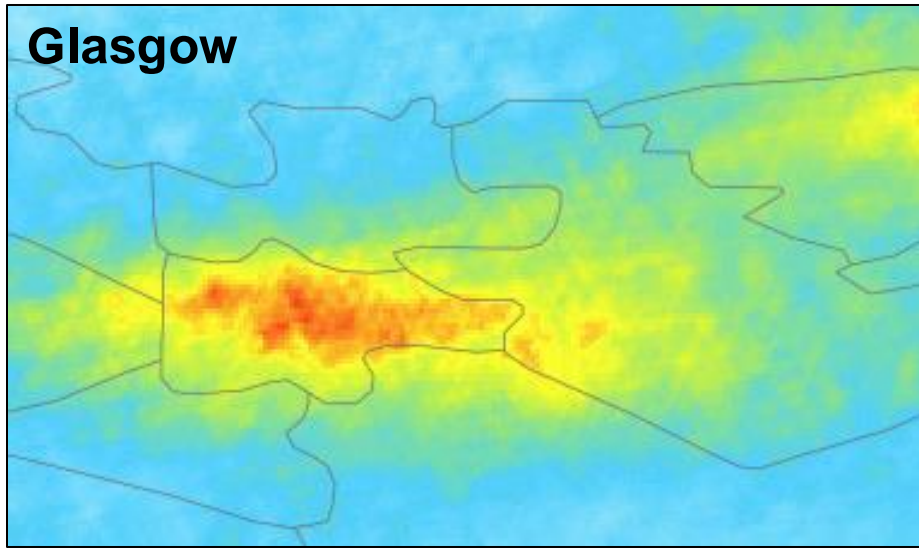
Independent Assessment Against Surface Sites
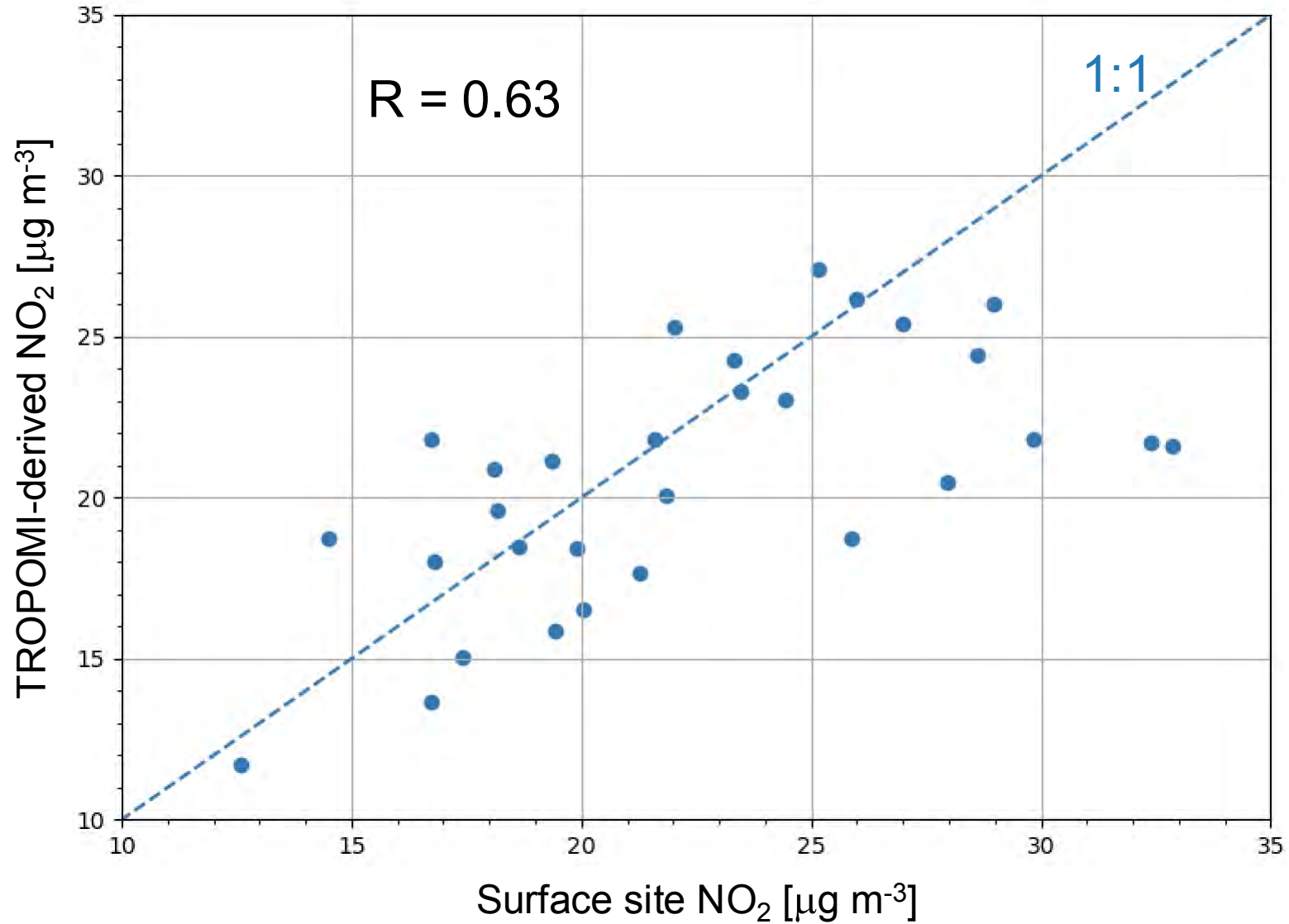
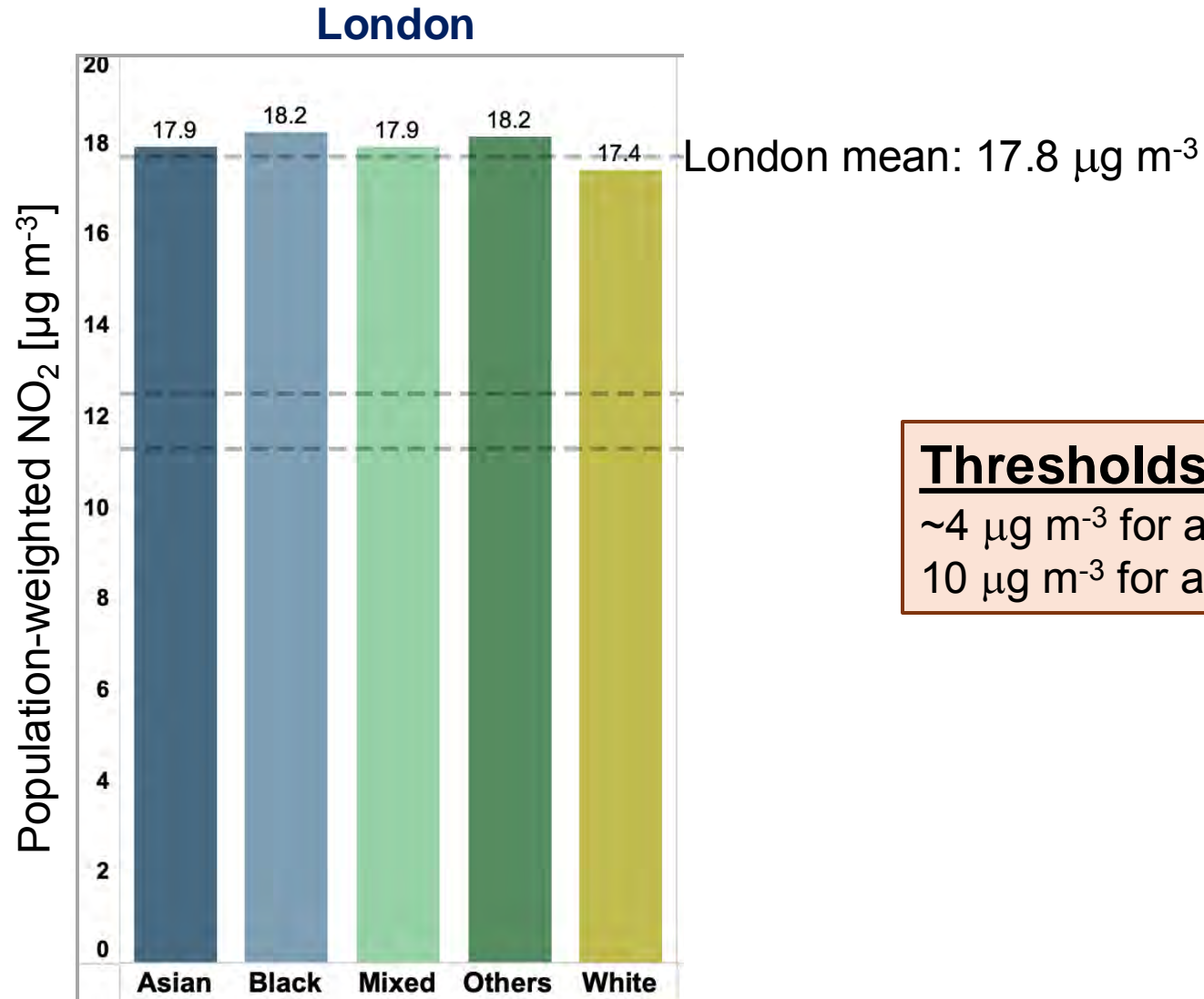TROPOMI-derived surface NO_2 ~8% less than surface sites, but surface sites prone to positive bias.

Surface NO$_2$ for the Other Target UK Cities
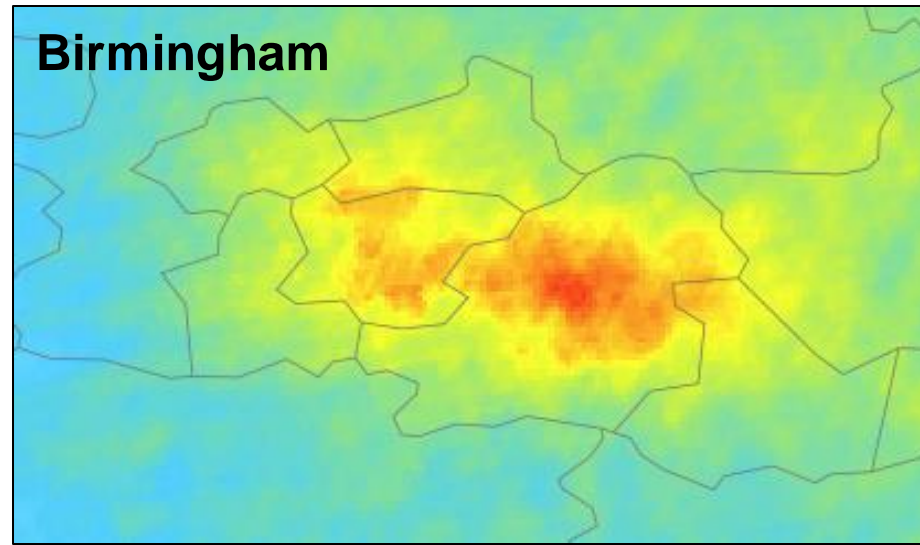
Scales differ

All are in $\mu g\ m^{-3}$

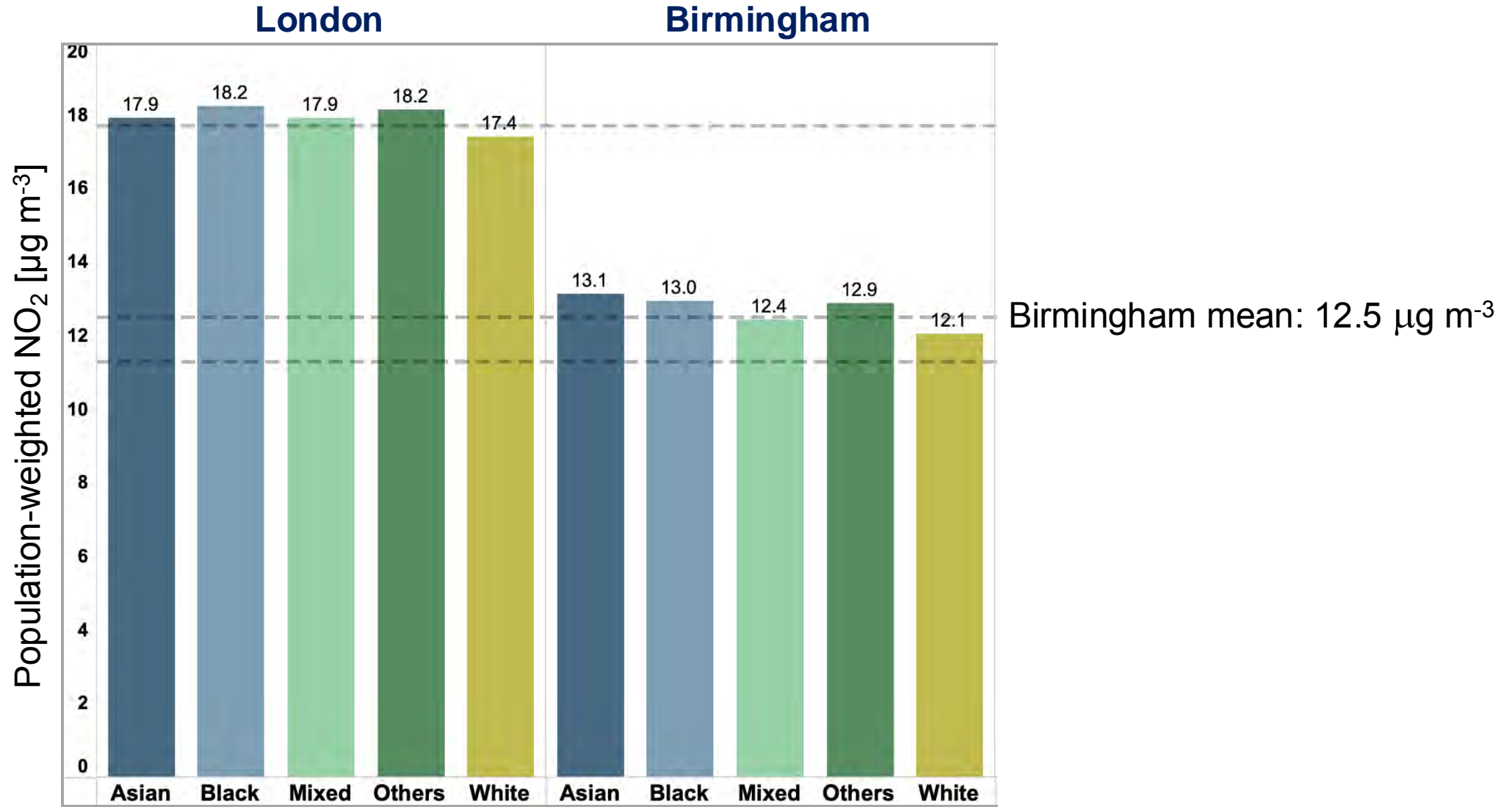# City-scale Ethnic Exposure Disparities Linked to NO₂ pollution

London

London mean: 17.8 μg m⁻³

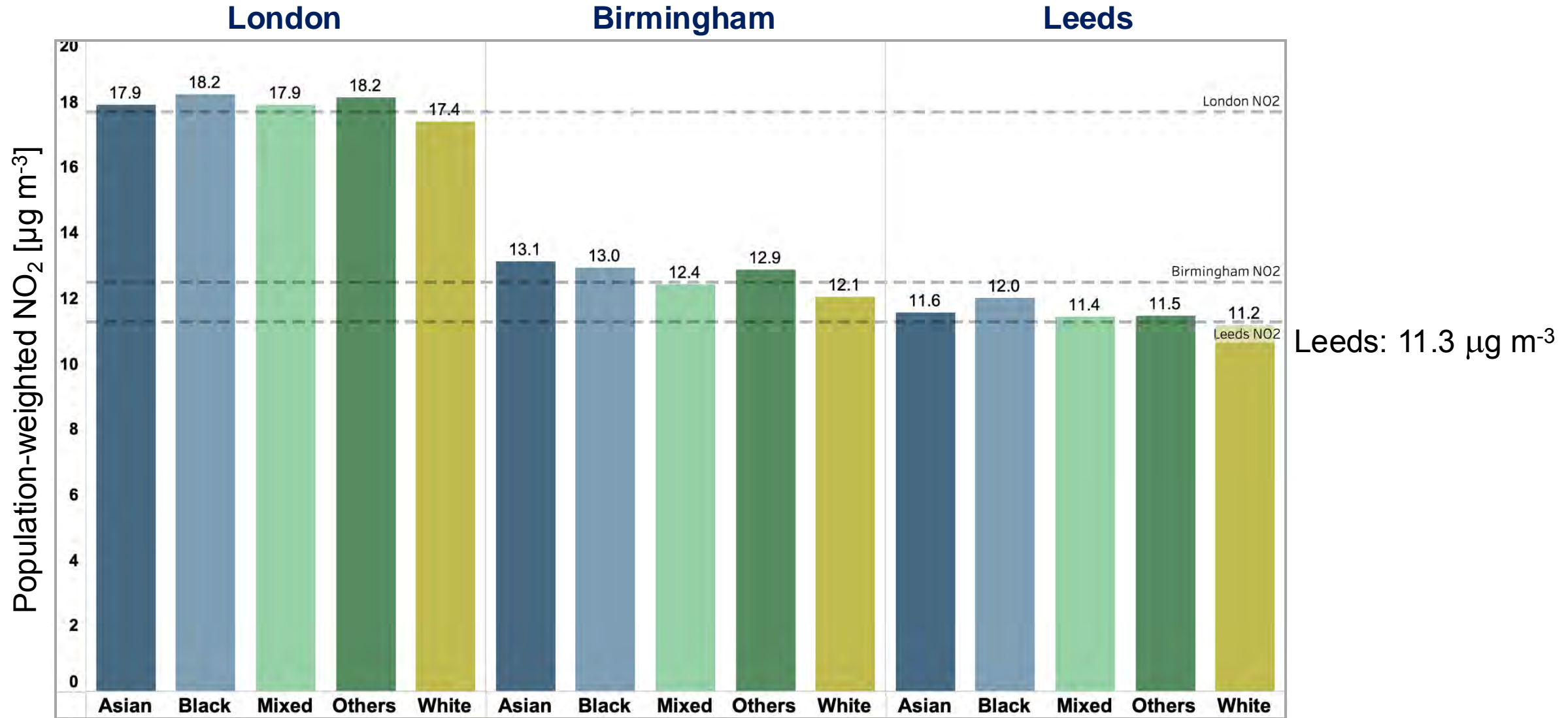**Thresholds for harm:**
~4 μg m⁻³ for asthma
10 μg m⁻³ for all-cause premature mortality

City-scale Ethnic Exposure Disparities Linked to NO$_2$ pollution

City-scale Ethnic Exposure Disparities Linked to NO$_2$ pollution

London   **Birmingham**   **Leeds**

Population-weighted NO$_2$ [μg m^{-3}]

London

Asian	Black	Mixed	Others	White
17.9	18.2	17.9	18.2	17.4

London NO2

Birmingham

Asian	Black	Mixed	Others	White
13.1	13.0	12.4	12.9	12.1

Birmingham NO2

Leeds

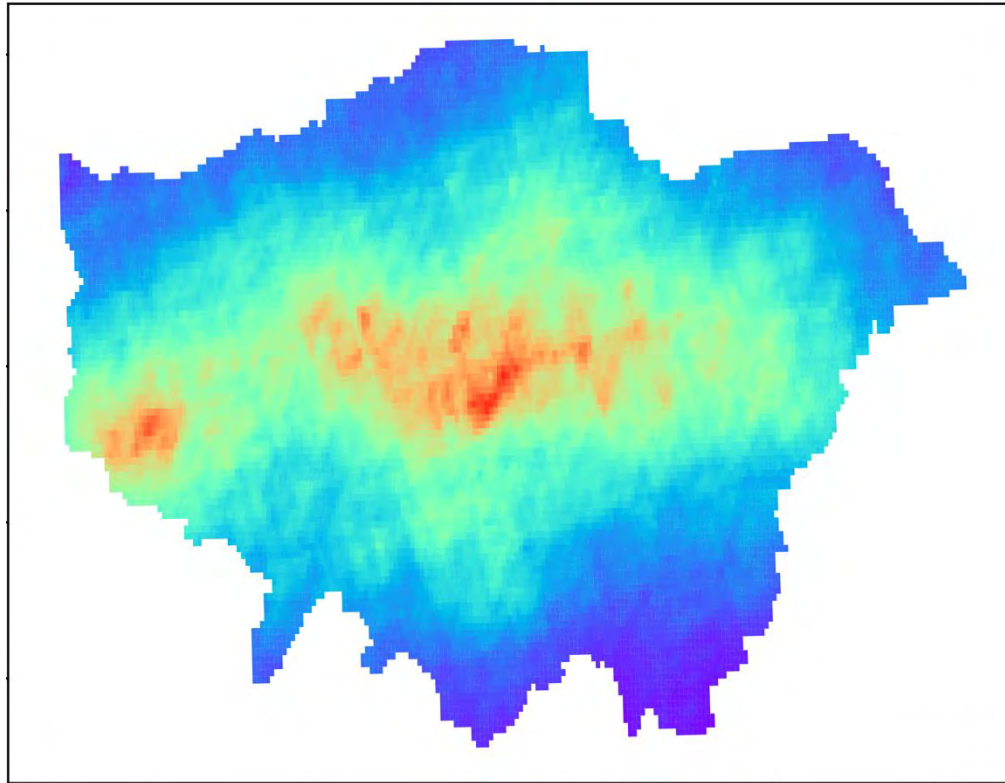| Asian	Black	Mixed	Others	White
11.6	12.0	11.4	11.5	11.2

Leeds NO2

Leeds: 11.3 μg m^{-3}

In all cities, all ethnic minority groups exposed to greater than city mean NO$_2$

That there is a disparity is not surprising, but our data enables quantification of the size of this disparity
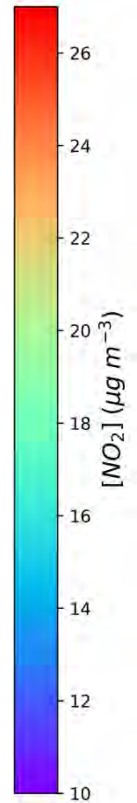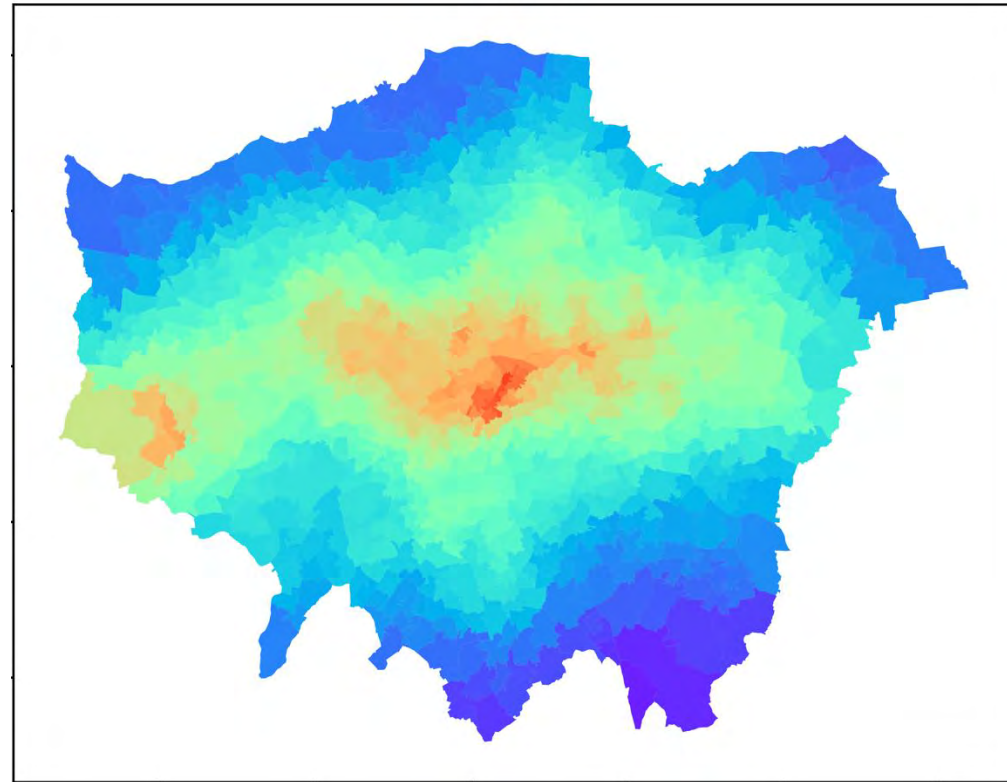
NO$_2$ Concentrations at Census-Tract Level

uniform ~400 m grid

Middle layer Super Output Areas (MSOAs)

Use census-tract NO$_2$ concentrations to quantify exposures and health outcomes

Maps generated by Eleanor Gershenson-Smith
(UCL PhD student)

Sets Us Up for Next Steps:

- Independent validation of satellite-derived NO_2 for all other cities.

- Ethnic exposure disparities for other 2 UK cities

- Exposure disparities at census-tract resolution

- Health burden disparities by ethnicity and for specific communities at the census-tract resolution

- Identify specific communities where resources/interventions are needed to address disparity

- Communicate results to decision makers, local leaders, and advocacy groups