# Emissions and Modelling
# Remapping London's Air pollution

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# Main Objectives

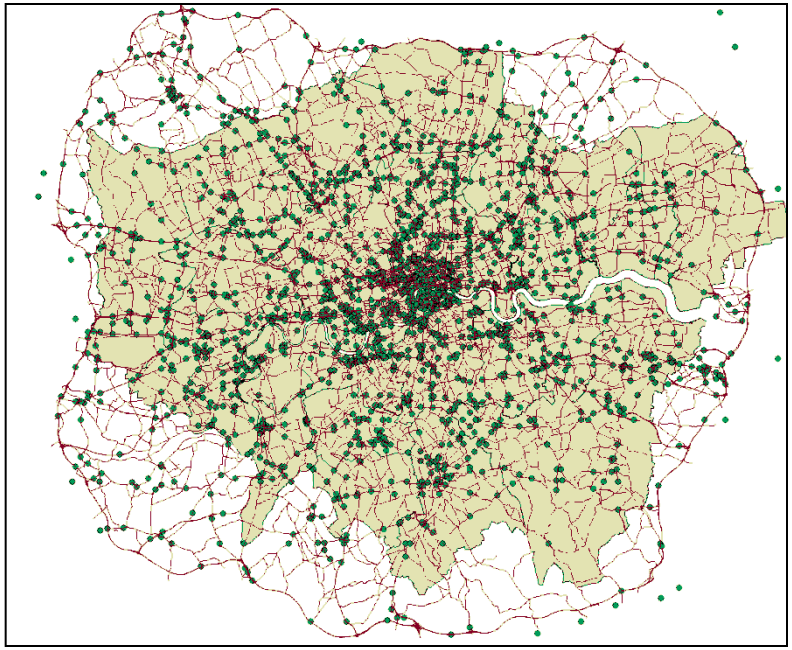
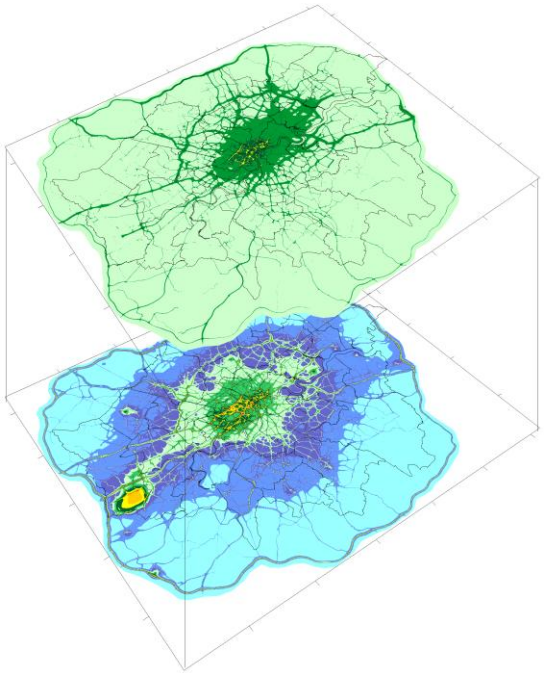
1. What is King's recipe for mapping London's Air pollution?
2. Are Others responsible for London Air quality problems?
3. LAEI2010 Emissions Inventory (What is new?)
4. Which London's emissions source are the worst offenders in terms of air quality?
5. LAEI2010 mapping (What is new?)
6. Can we predict future air quality? (And How will London look like?)

# What is King's recipe for mapping London's Air pollution?

- Emission sources in London (we use LAEI2010)



- Dispersion Model  (we use King's LAQT)

# King's London Air Quality Toolkit (LAQT) description

- Modelling-measurement Approach

- A kernel modelling technique, based on ADMS, describe the initial dispersion

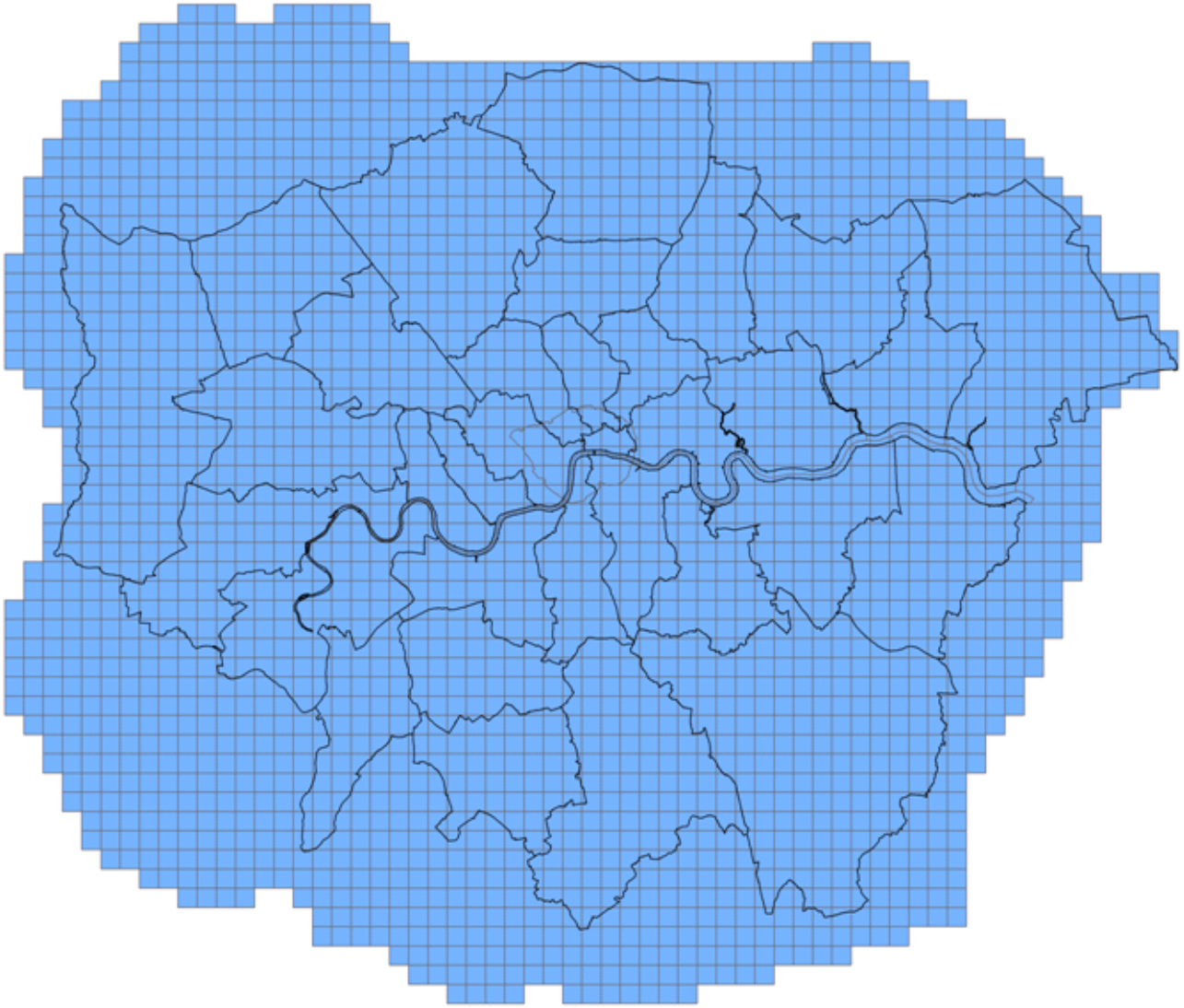
- Kernels are created using hourly meteorological measurements.

- The contribution from each emission source is calculated by applying each kernel summed onto a fixed grid

- The LAQT provides annual mean $NO_X$, $NO_2$ , $O_3$, $PM_{10}$ and $PM_{2.5}$

# Treatment of sources

A single receptor point is located in the centre of each (1km X 1 km) squares, covered by LAEI.



# Treatment of sources

**The model sums together three source categories:**

- **First**, sources outside the model domain (background concentration)
  For $NO_X$, we use rural measurements
  For PM, we use rural and regional sources (secondary PM and natural)

- **Second**, within the model domain, but greater than 500m from a receptor location (London background)
  All London sources represented as volumes sources

- **Third**, for those sources within 500m of a receptor location
  Detailed treatment of local road/gas/rail/aircraft sources

# Treatment of sources

**Predictions in London are based upon the LAEI sources and include:**

- Road transport
- Passenger and freight rail
- Aviation sources
- Passenger and commercial shipping
- Gas heating (domestic and industrial-commercial)
- Large regulated industrial processes (Part A)
- Small regulated industrial processes (Part B)
- Construction source (NRMM)
- Others (Oil combustion sources (domestic and large boiler plant), Coal combustion sources (domestic and commercial), agricultural, landfill, waster transfer, accidental fires, construction/demolition and household sources)

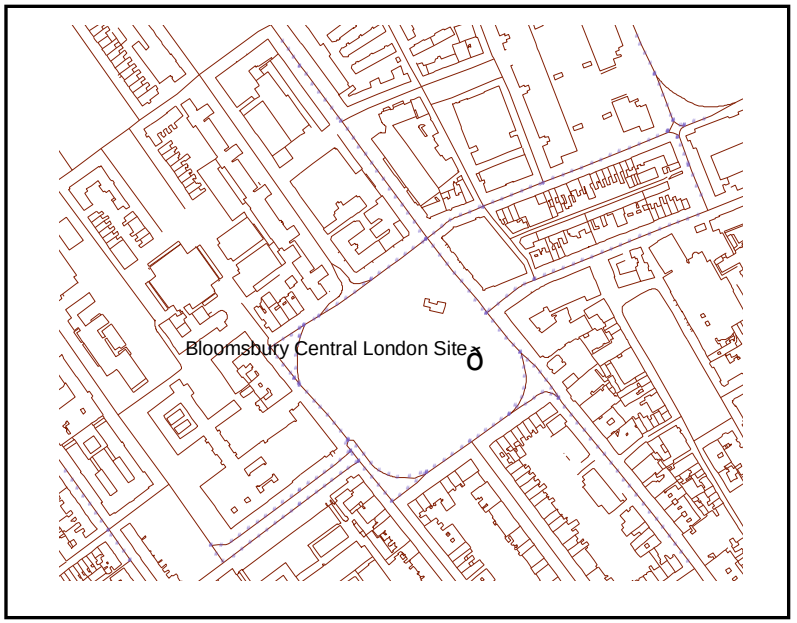
# Representing road sources

- King's London Emission Toolkit (LET) provides detailed and flexible traffic emissions required to run LAQT
- Road emissions are modelled as a series of road links 10 m long
- Based on geographically accurate Ordnance Survey road map data

**Six road categories** (and associated kernels):

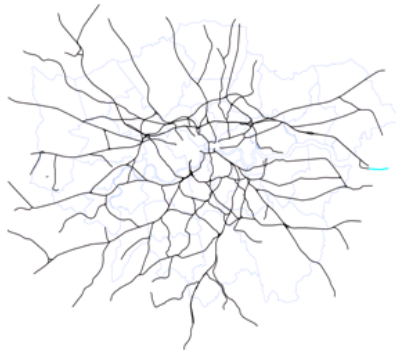
- Open roads (motorway)
- Typical roads
- Street canyon (by orientation)

- LAQT covers over 2 million 10m road sources



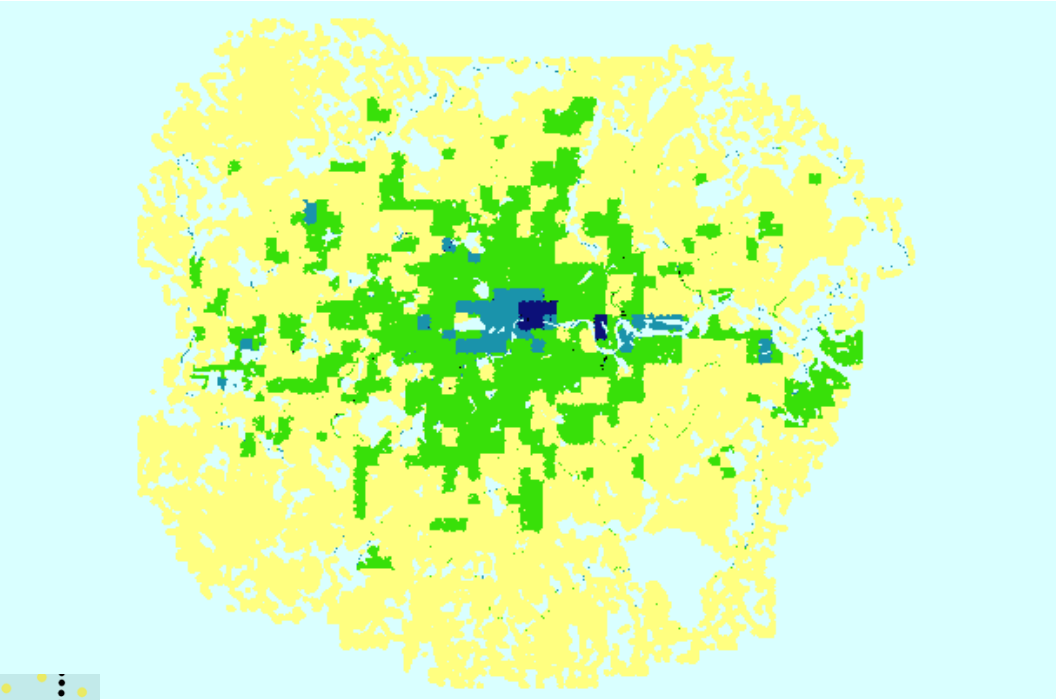

# Representing railway sources

- Treated in the same way as for roads but using rail network

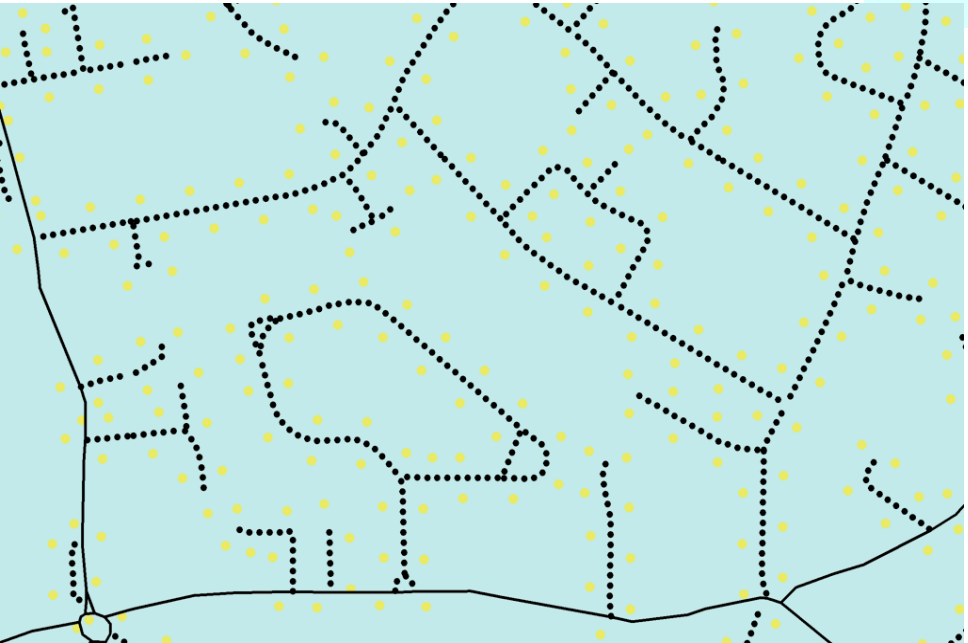


# Representing gas sources

- Height of release



- Spatial distribution



**Assumed building heights – Commercial gas combustion (low-yellow, med – green, high – grey and very high -navy)**

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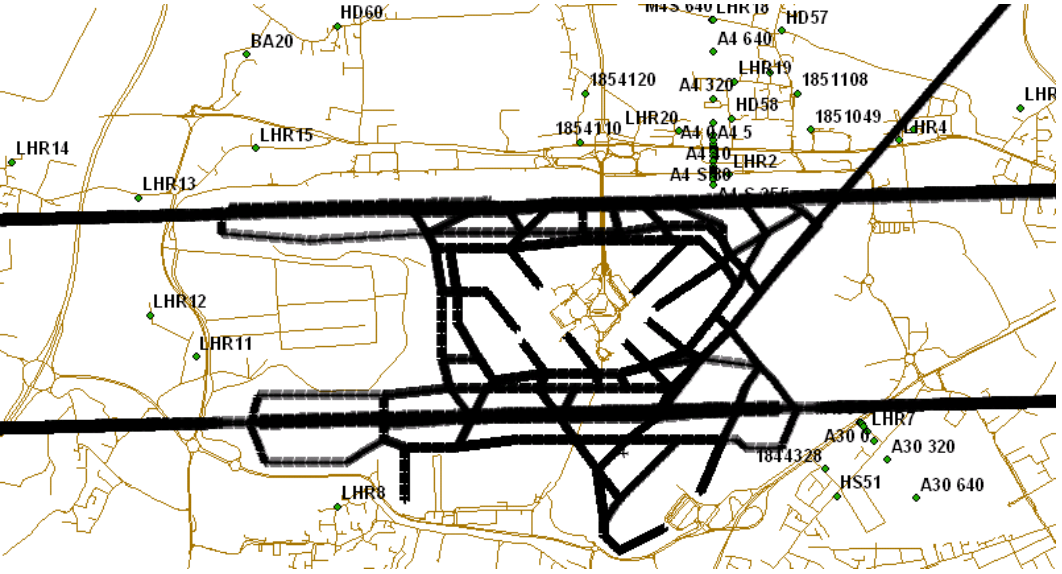
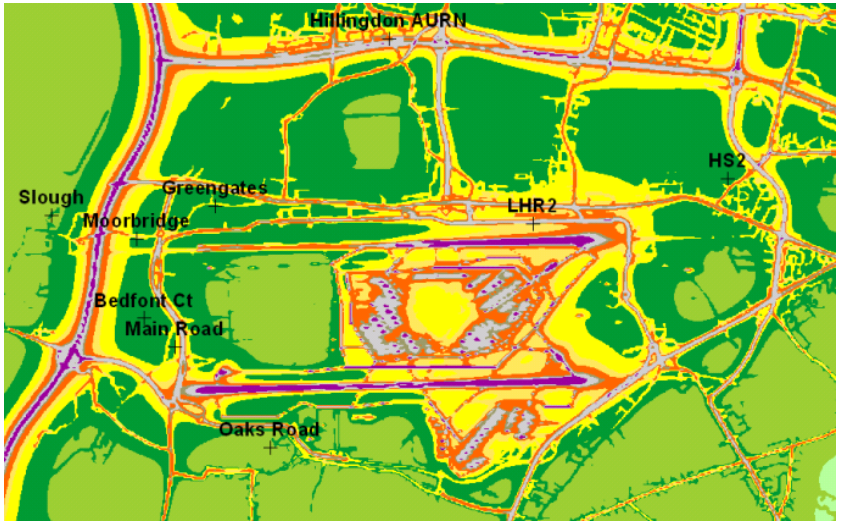
# Representing Heathrow Airport

- Aircraft sources were represented using the same method as roads
- Account was taken of the rapidly reducing effect of aircraft emissions to ground level concentrations at different aircraft heights



# Model Evaluation

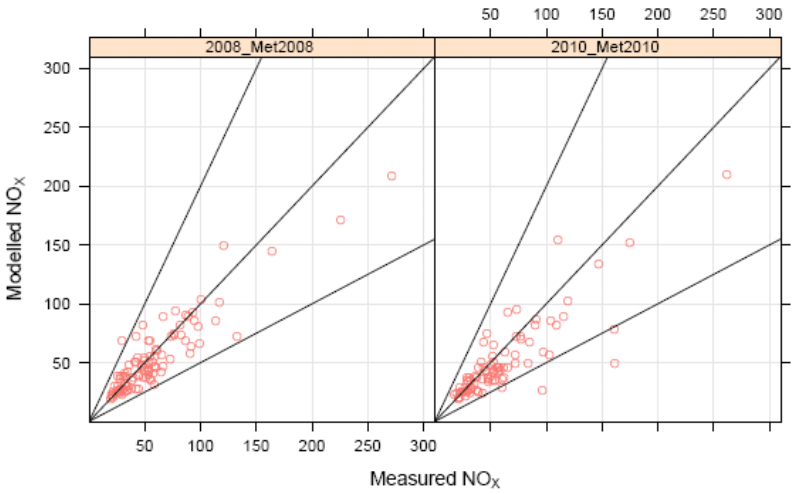
Of course many factors cannot be adequately described and modelling deficiencies exist.

BUT

The LAQT provides a compromise between detailed input data availability and model flexibility.

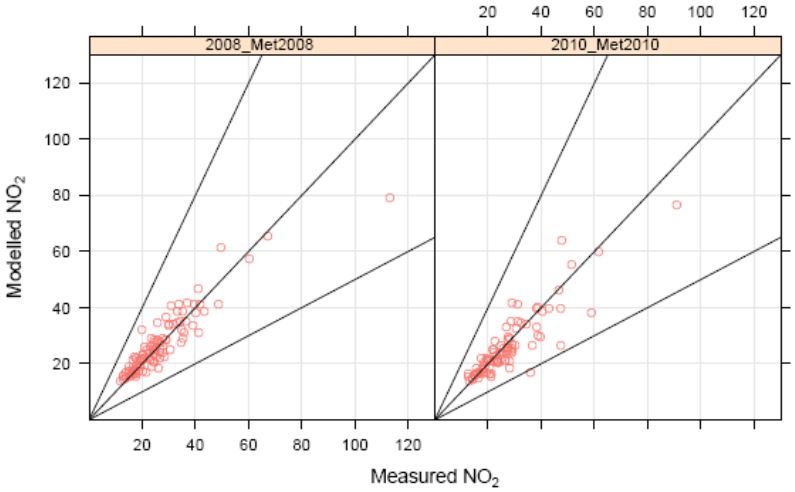
# Model Evaluation $NO_X$ and $NO_2$

LAQM – $NO_x$, Annual Average, all sites




| Type | n | FAC2 | MB | MGE | NMB | NMGE | RMSE | r |
|---|---|---|---|---|---|---|---|---|
| 2008_Met2008 | 100 | 0.99 | −4.5 | 11 | −0.078 | 0.20 | 17 | 0.91 |
| 2010_Met2010 | 87 | 0.95 | −9.8 | 15 | −0.164 | 0.25 | 23 | 0.85 |

LAQM – $NO_2$, Annual Average, all sites




| Type | n | FAC2 | MB | MGE | NMB | NMGE | RMSE | r |
|---|---|---|---|---|---|---|---|---|
| 2008_Met2008 | 100 | 1.00 | 0.28 | 3.4 | 0.010 | 0.13 | 5.3 | 0.92 |
| 2010_Met2010 | 87 | 0.99 | −1.31 | 3.9 | −0.048 | 0.14 | 6.0 | 0.88 |

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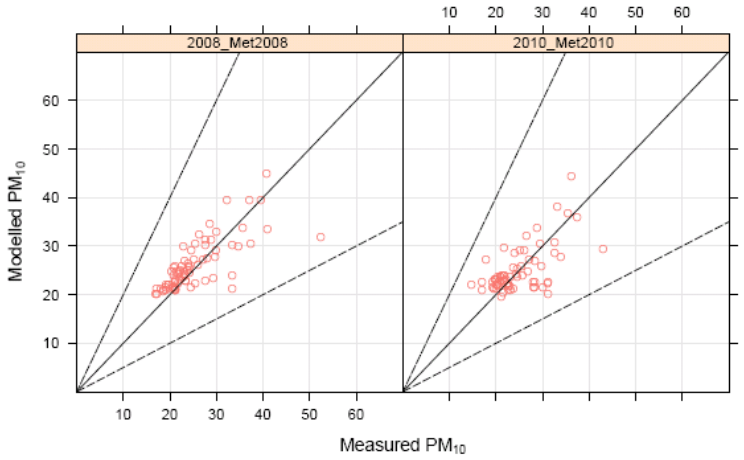
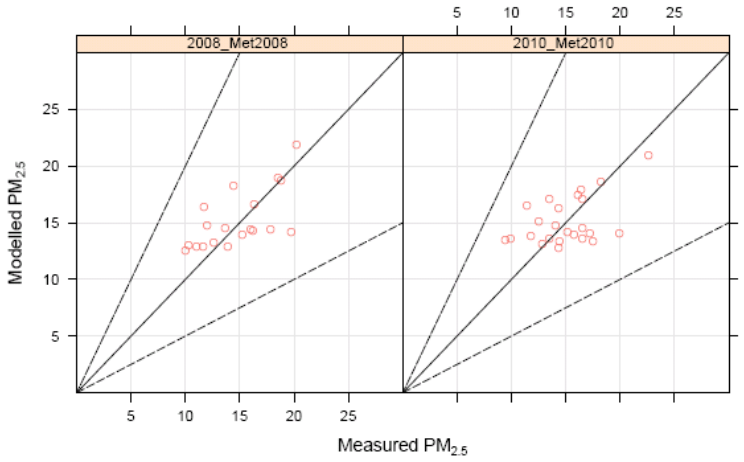
# Model Evaluation $PM_{10}$ and $PM_{25}$

LAQM – $PM_{10}$, Annual Average, all sites




| Type | n | FAC2 | MB | MGE | NMB | NMGE | RMSE | r |
|---|---|---|---|---|---|---|---|---|
| 2008_Met2008 | 76 | 1 | 0.69 | 3.0 | 0.0275 | 0.12 | 4.3 | 0.76 |
| 2010_Met2010 | 68 | 1 | 0.16 | 3.4 | 0.0064 | 0.14 | 4.4 | 0.62 |

LAQM – $PM_{2.5}$, Annual Average, all sites




| Type | n | FAC2 | MB | MGE | NMB | NMGE | RMSE | r |
|---|---|---|---|---|---|---|---|---|
| 2008_Met2008 | 19 | 1 | 0.45 | 2.0 | 0.0304 | 0.14 | 2.5 | 0.65 |
| 2010_Met2010 | 24 | 1 | 0.12 | 2.2 | 0.0077 | 0.15 | 2.7 | 0.48 |

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# Are Others responsible for London Air Quality problems?

# Or is it a Myth?

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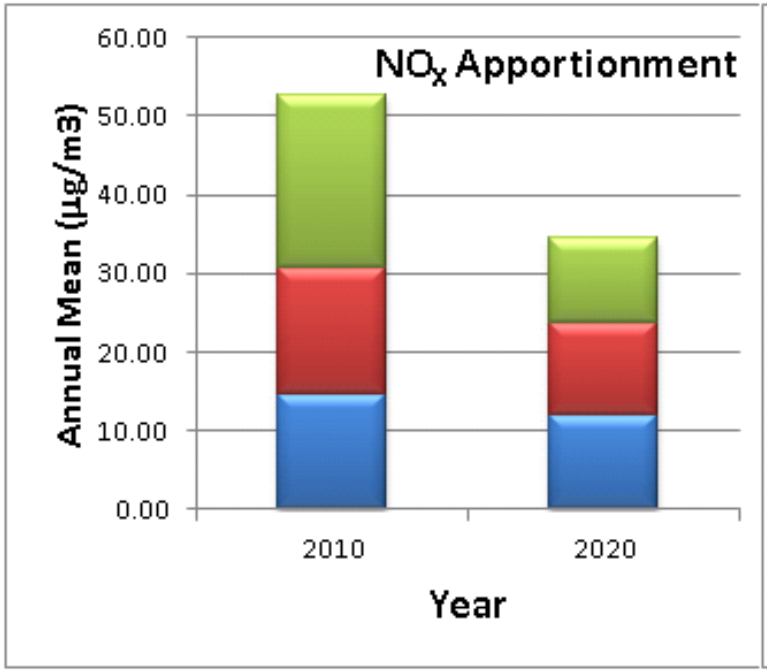
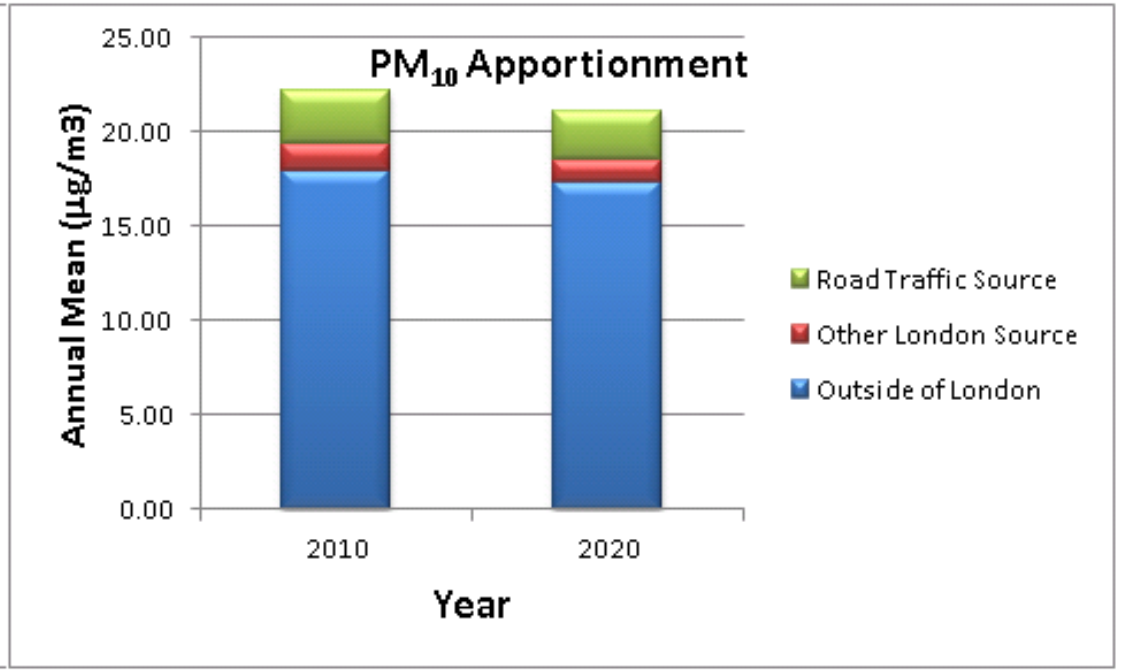
# Air Quality Apportionment

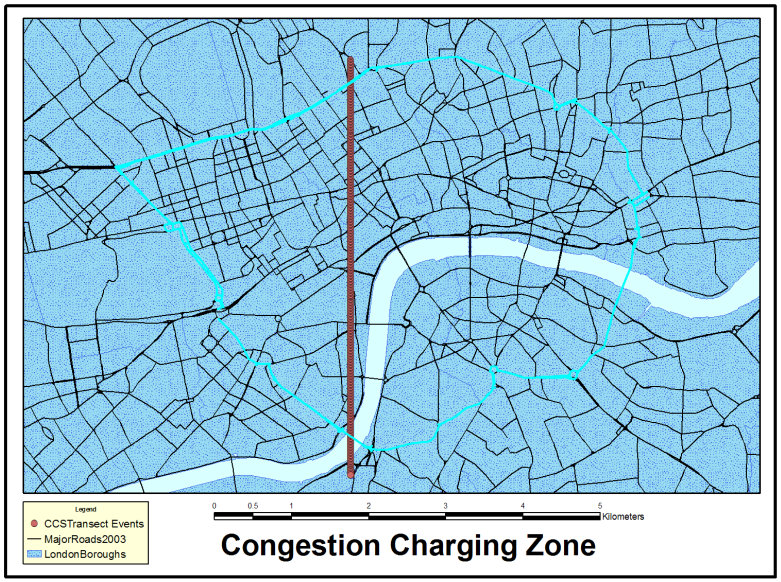


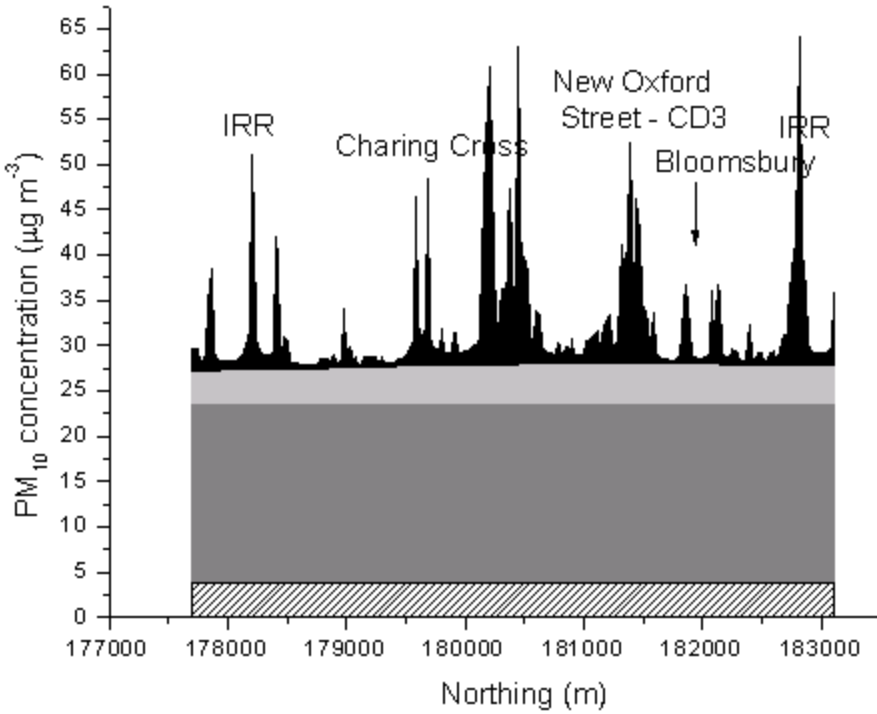

At first it seems that high concentration blowing from outside of London or continent could be largely responsible for London's problem

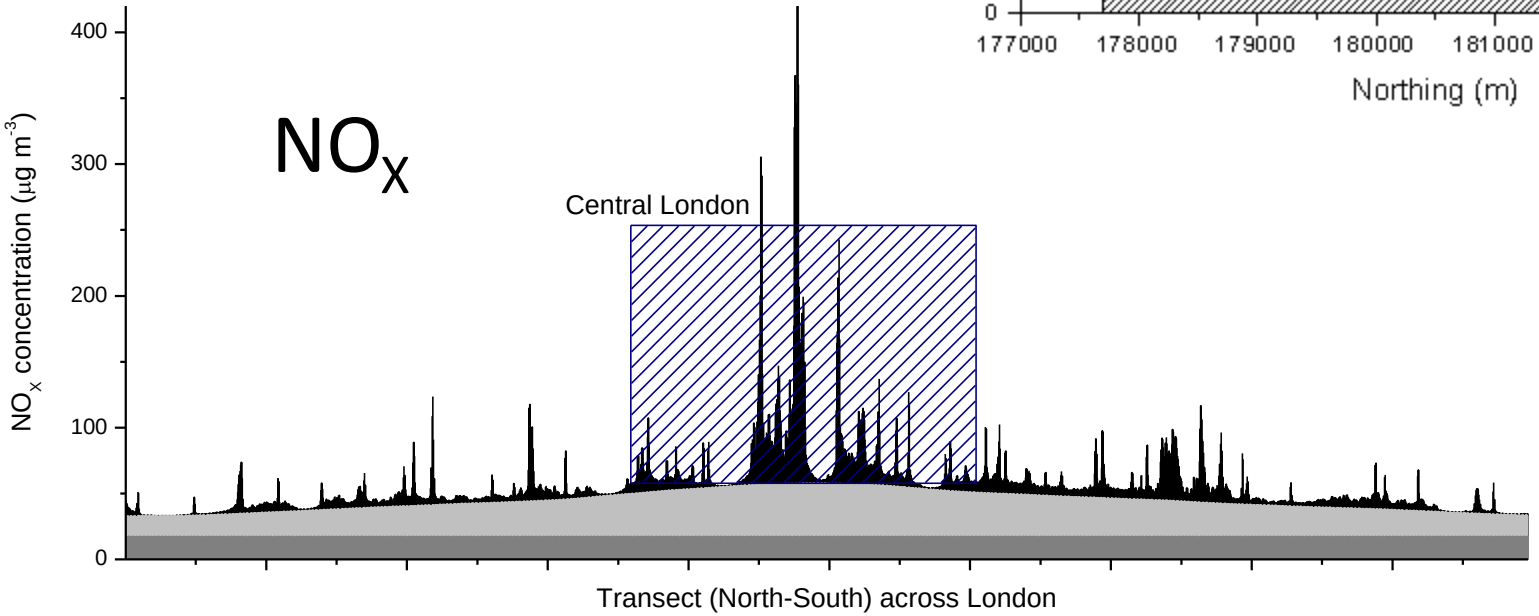
**BUT**

# Cross sectional concentrations




$PM_{10}$

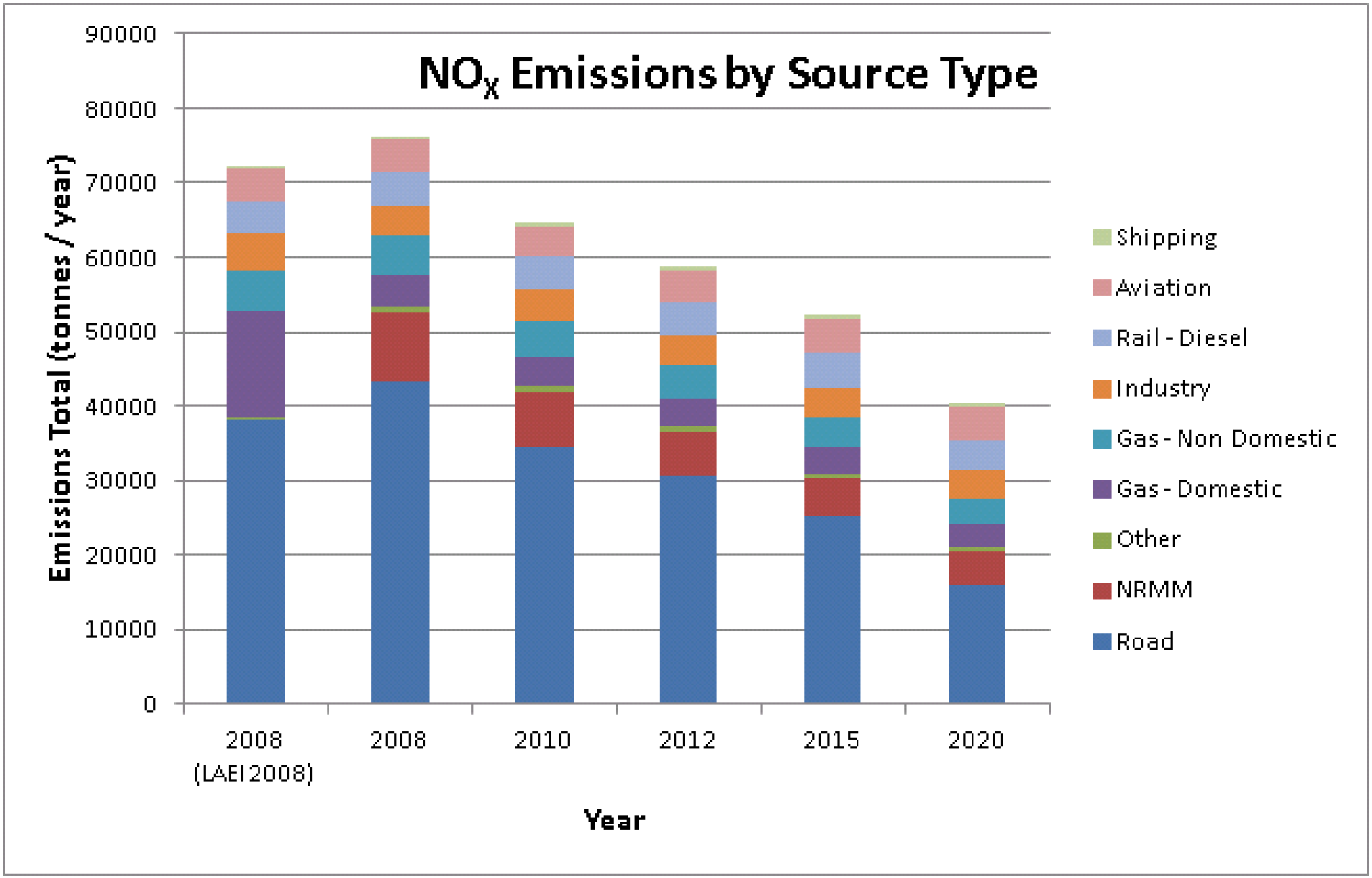


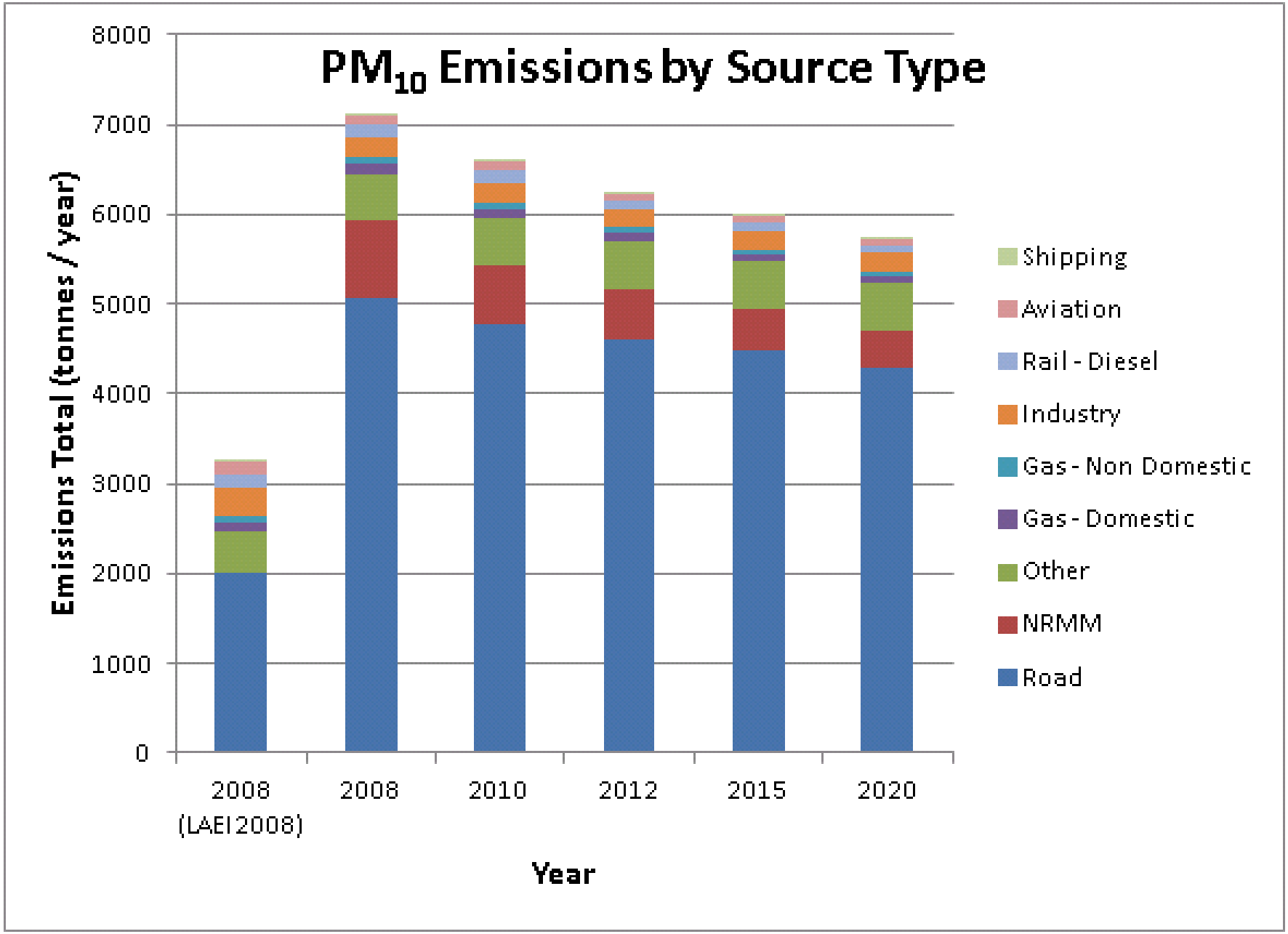

**In Fact** air quality problems are mostly caused by local emission sources

# Overview of LAEI2010 (What is New?)

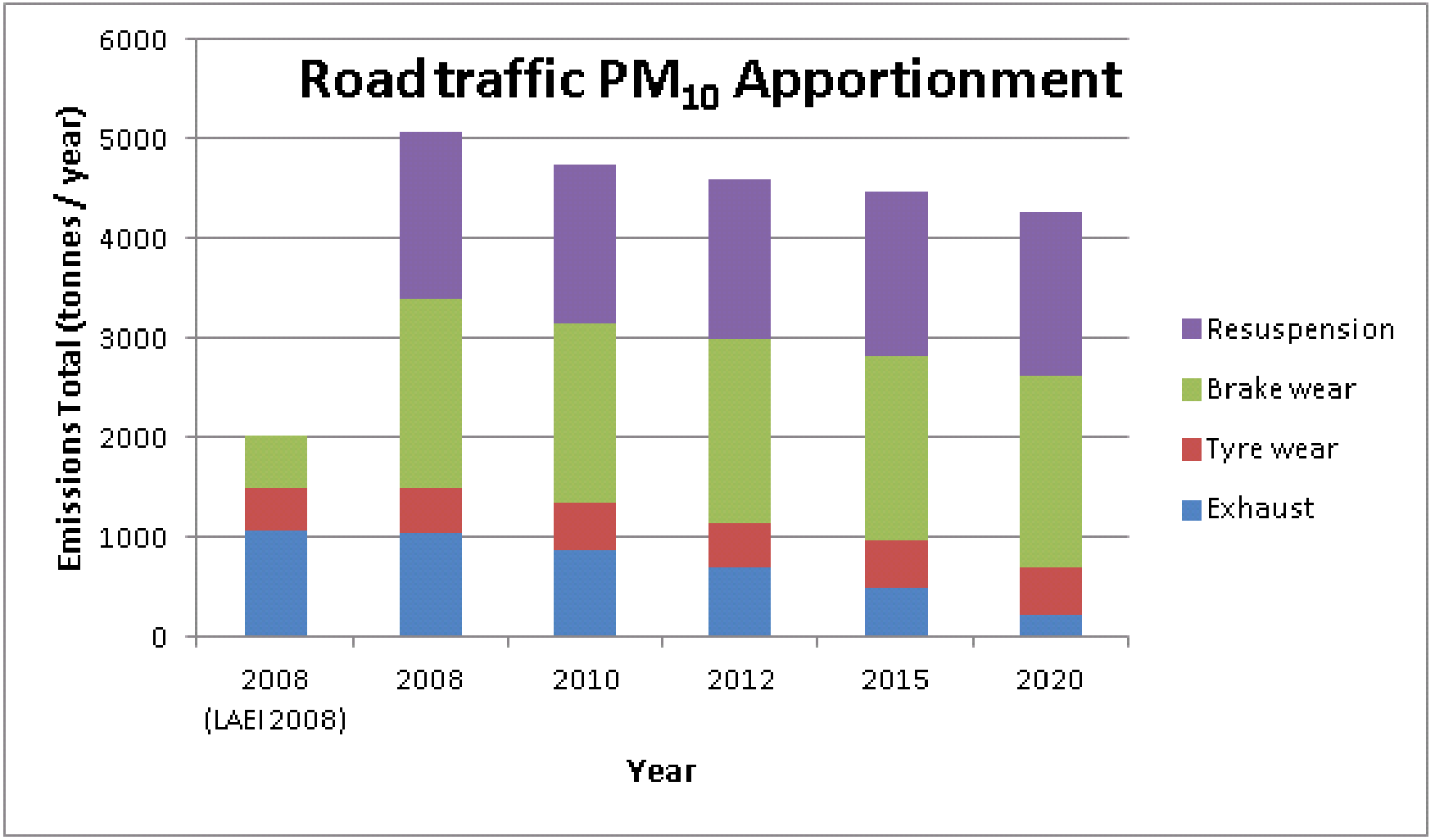
# $NO_X$ Yearly Emissions in GLA area by Source Type



# $PM_{10}$ Yearly Emissions in GLA area by Source Type

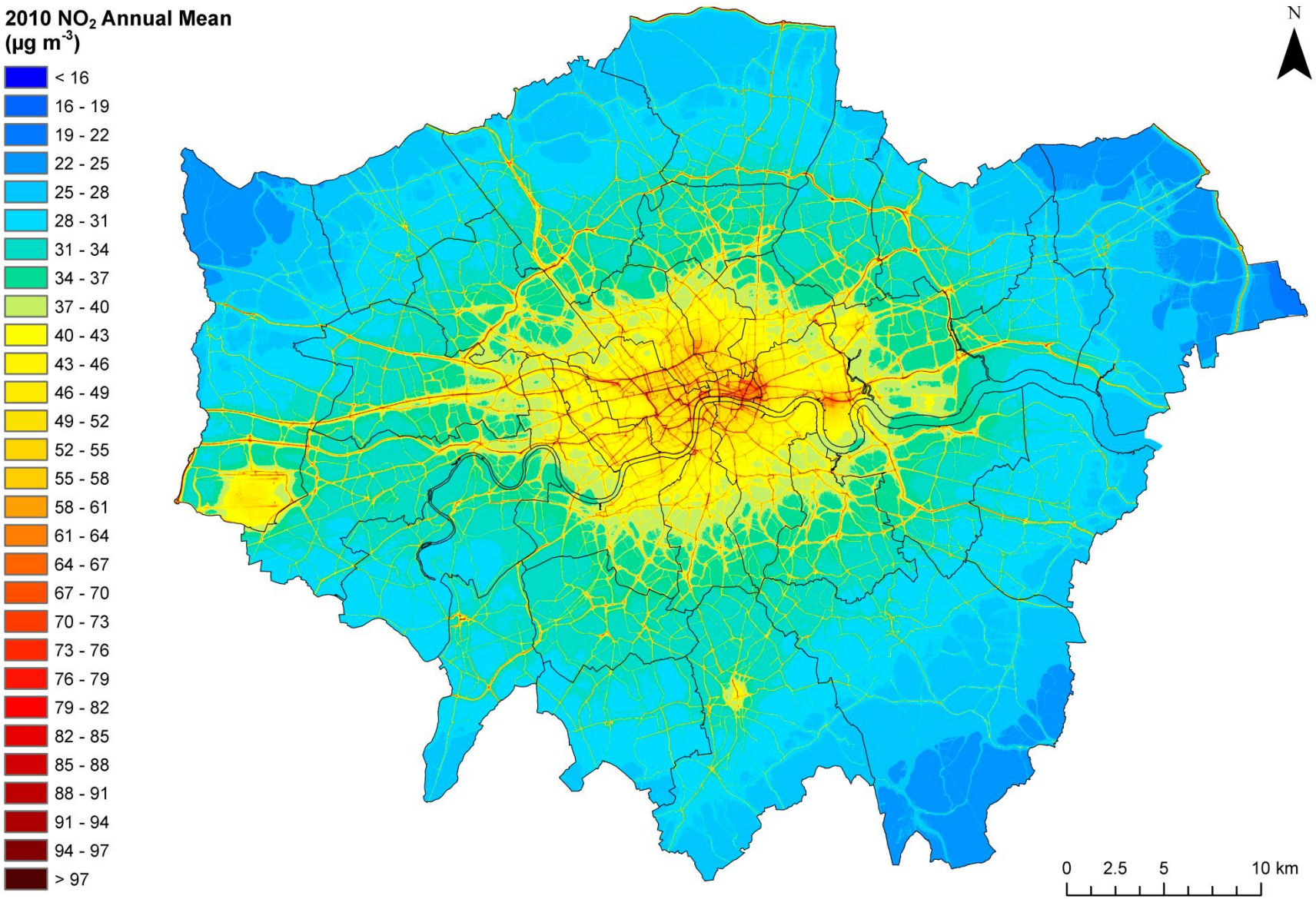


# Exhaust/NonExhaust $PM_{10}$ emissions trend from road traffic

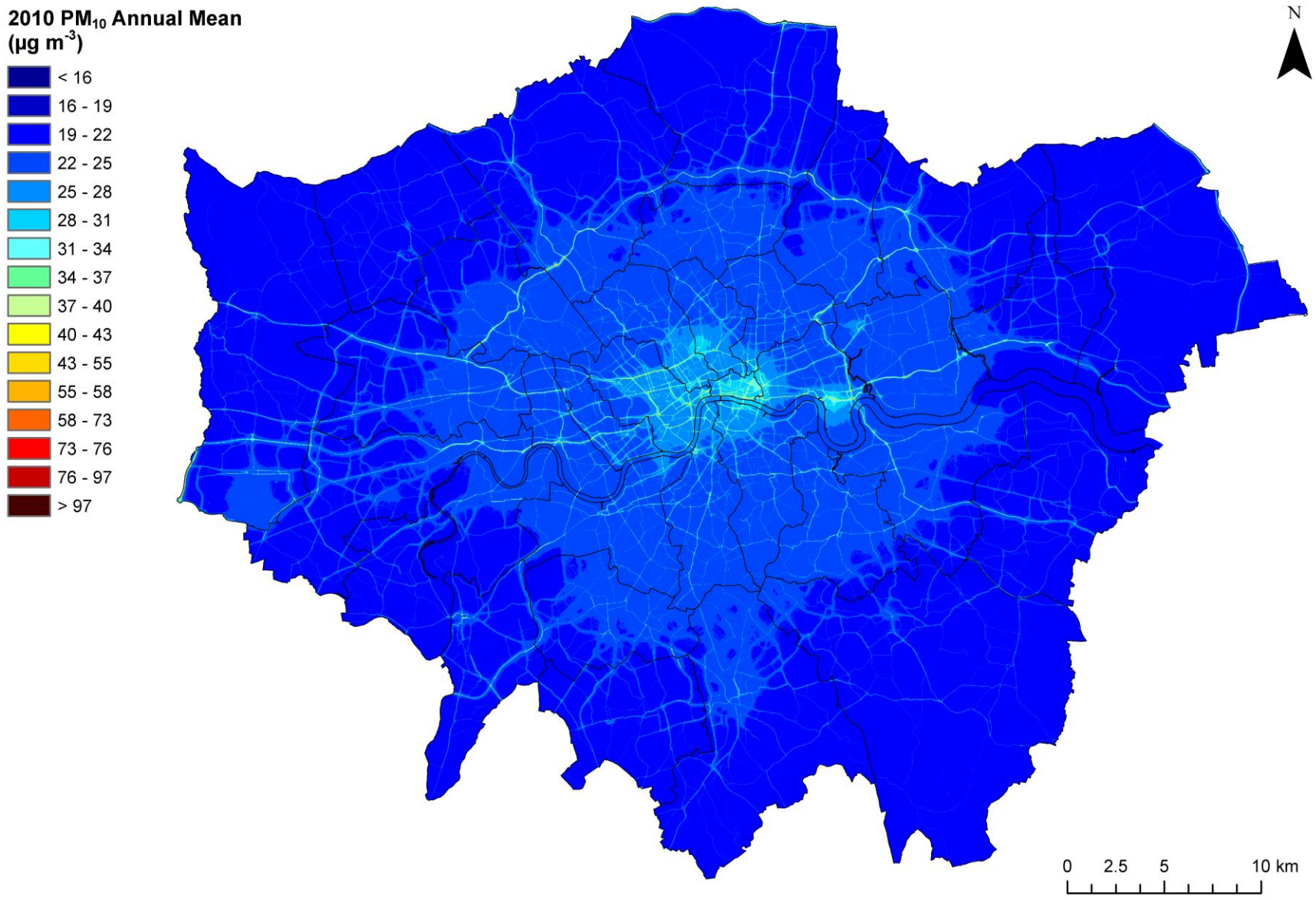


# Which emissions sources are the worst offender in terms of Air quality?

# 2010 $NO_2$ Annual Mean (LAEI2010)

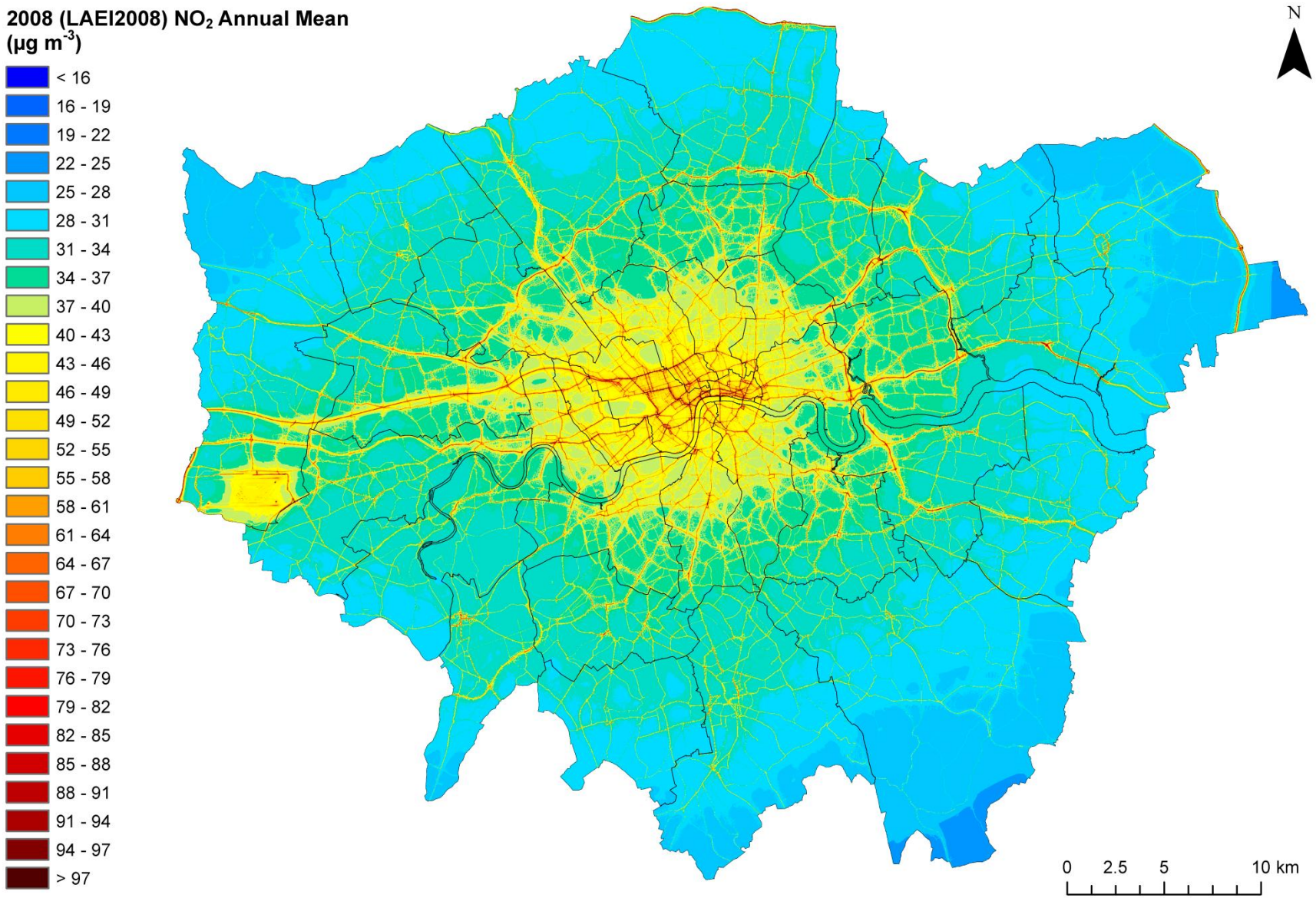


# 2010 $PM_{10}$ Annual Mean (LAEI2010)

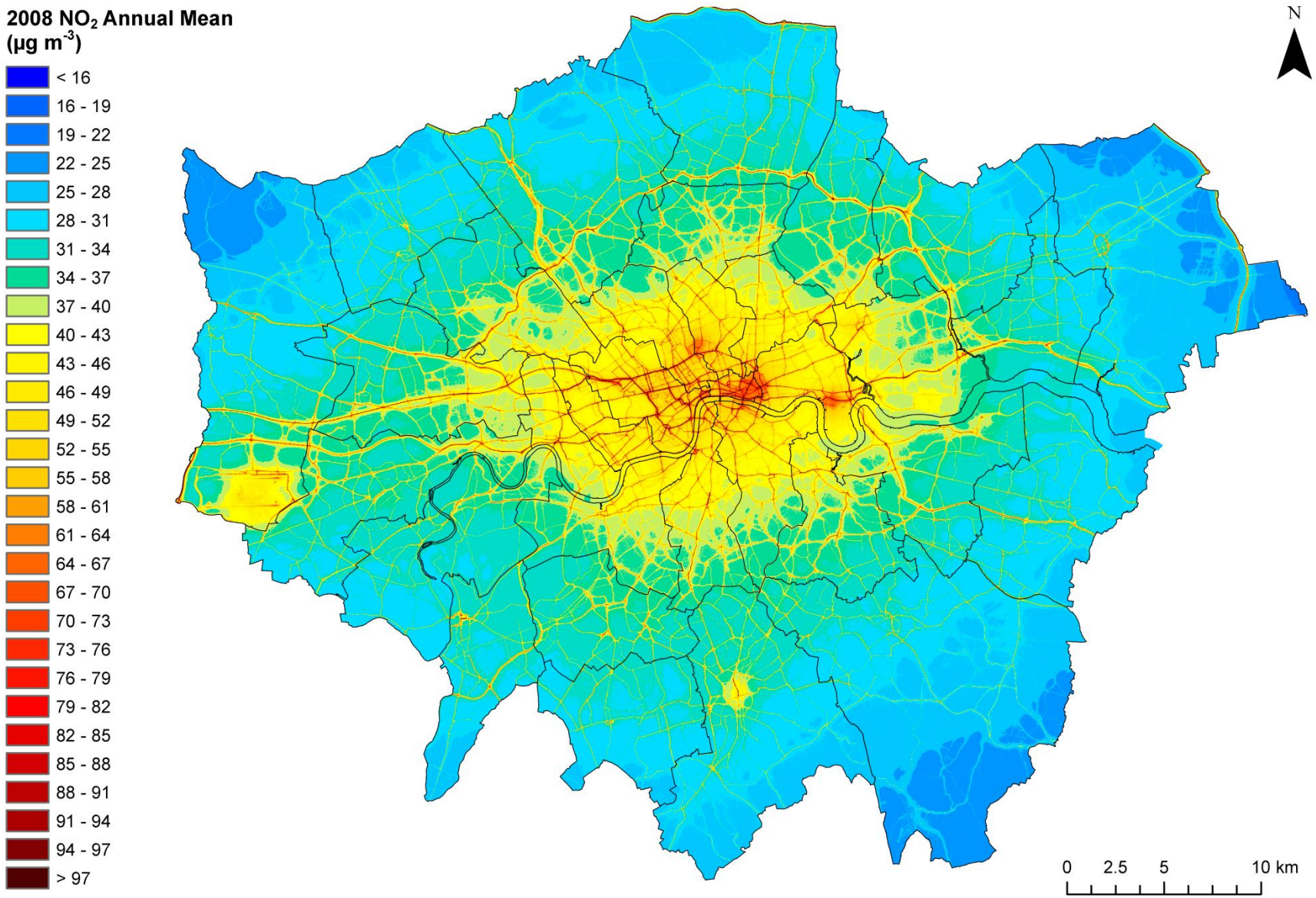


# LAEI2010 mapping (What is New?)

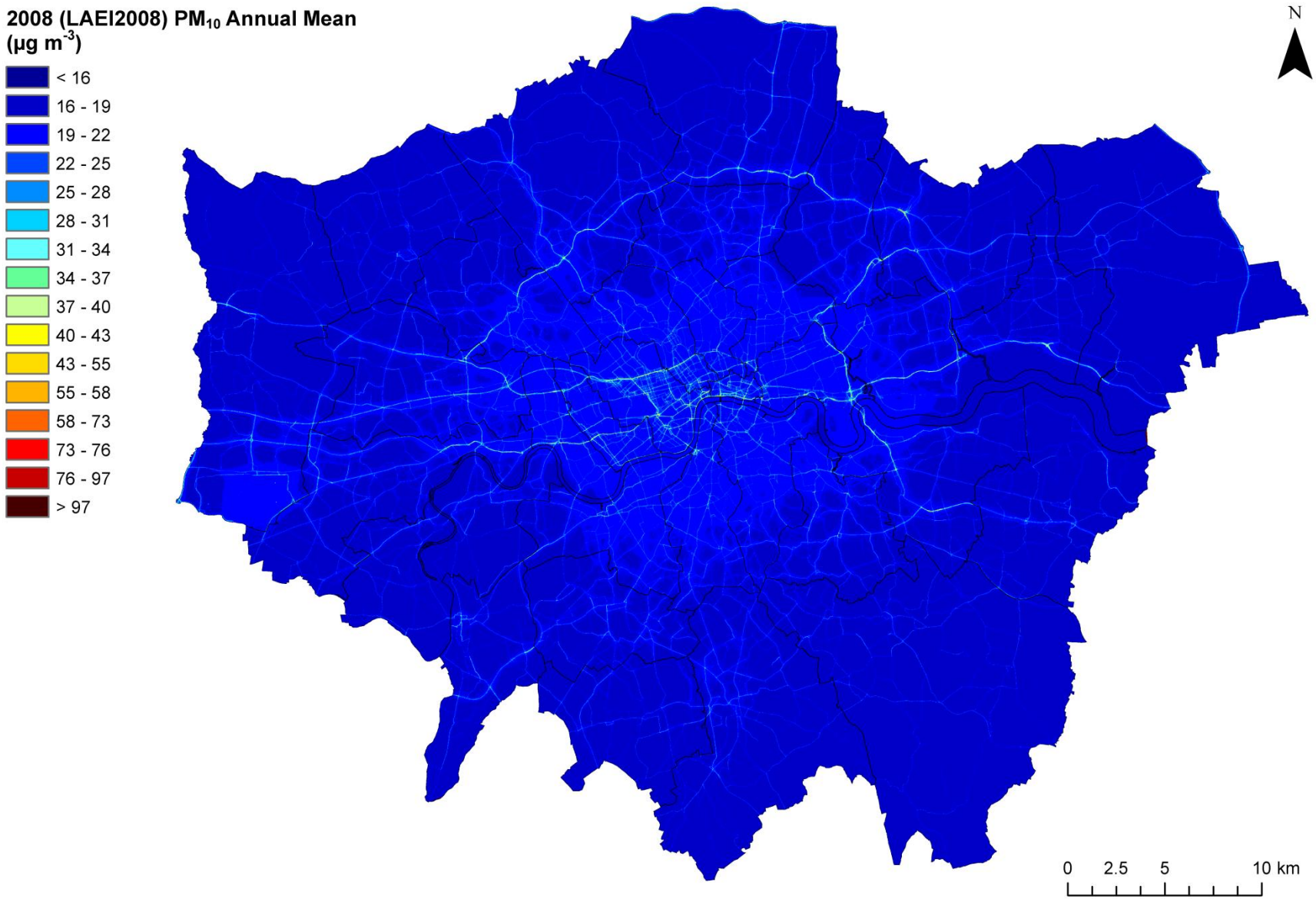
# 2008 $NO_2$ Annual Mean (LAEI2008)



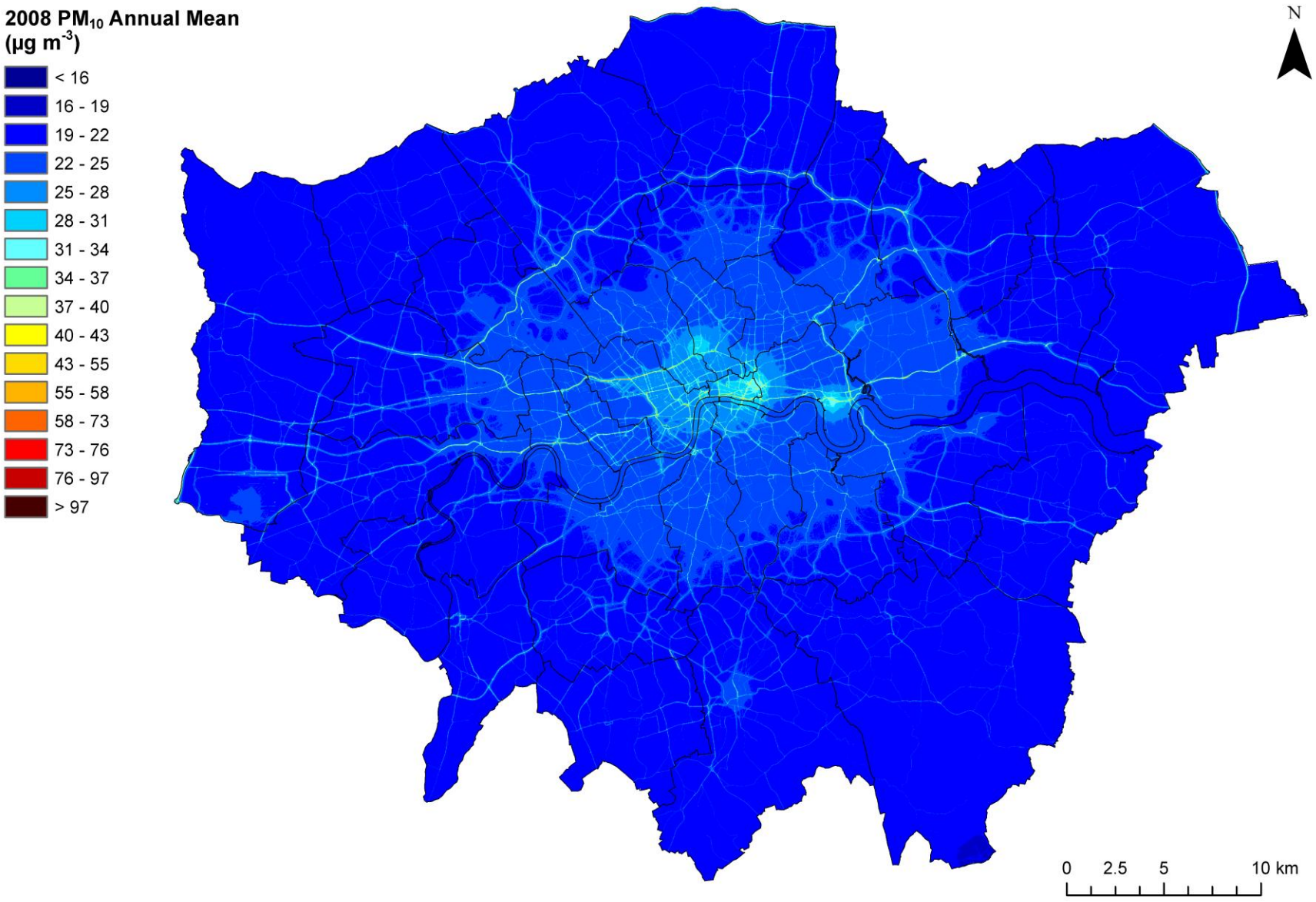
# 2008 $NO_2$ Annual Mean (LAEI2010)



# 2008 $PM_{10}$ Annual Mean (LAEI2008)



# 2008 $PM_{10}$ Annual Mean (LAEI2010)



# Can we predict future Air quality?

•For any past or present year, King's LAQT can be calibrated to account for gap in the emission inventory

That's why

•A change of emissions does not always results in any change of Air quality concentration

But

•Calibrating can affect Future modelling performance

So

•The emission inventory must be improved

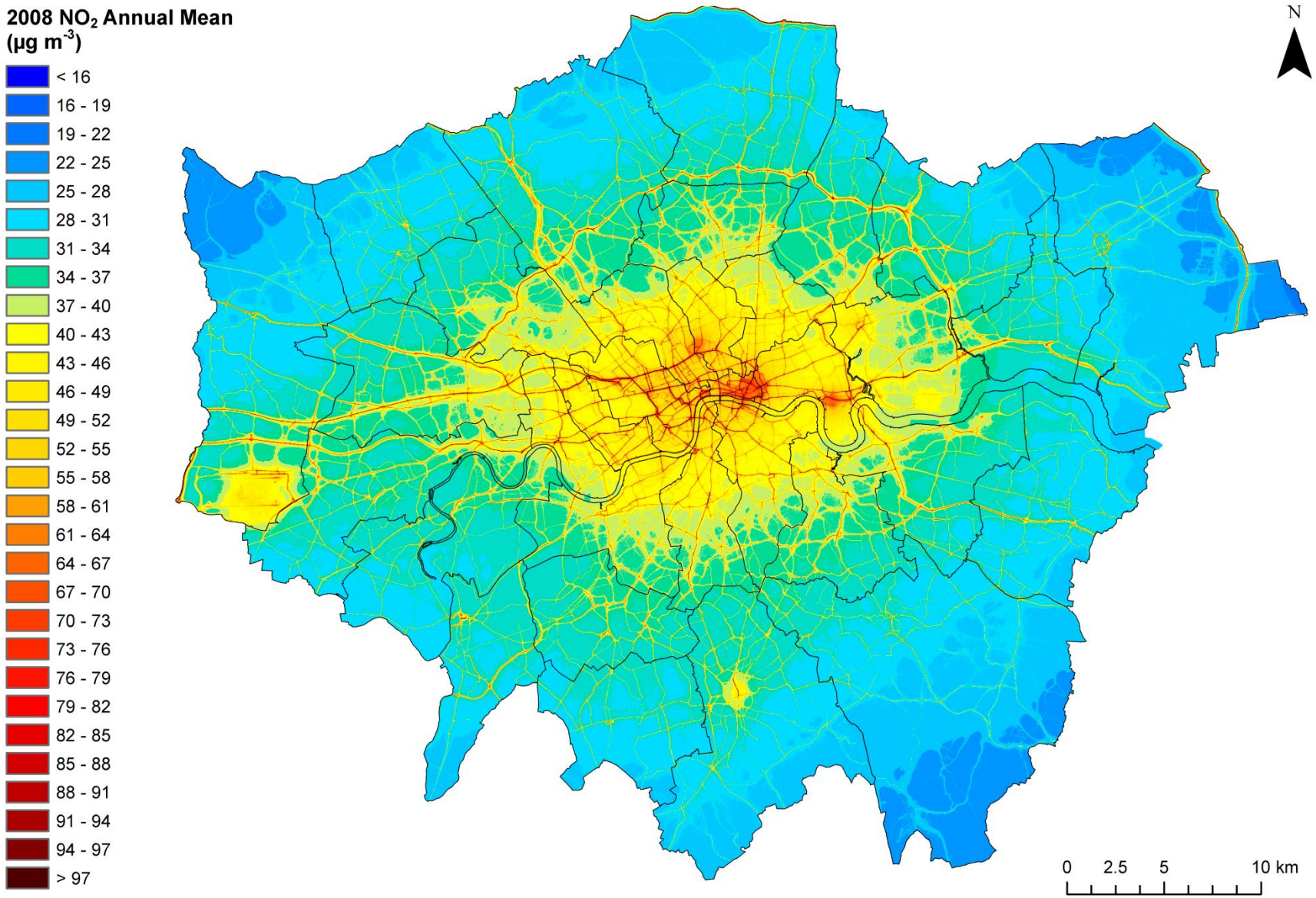
# How can future prediction and reality sometimes disagree so much?

- The LAEI is not perfect and need improvement
- Hard to predict how the LAEI will change in future years
- Hard to find the appropriate emission factor change for new technology such as hybrid or new Euro Engine classification
- Hard to predict the changes from outside of London source

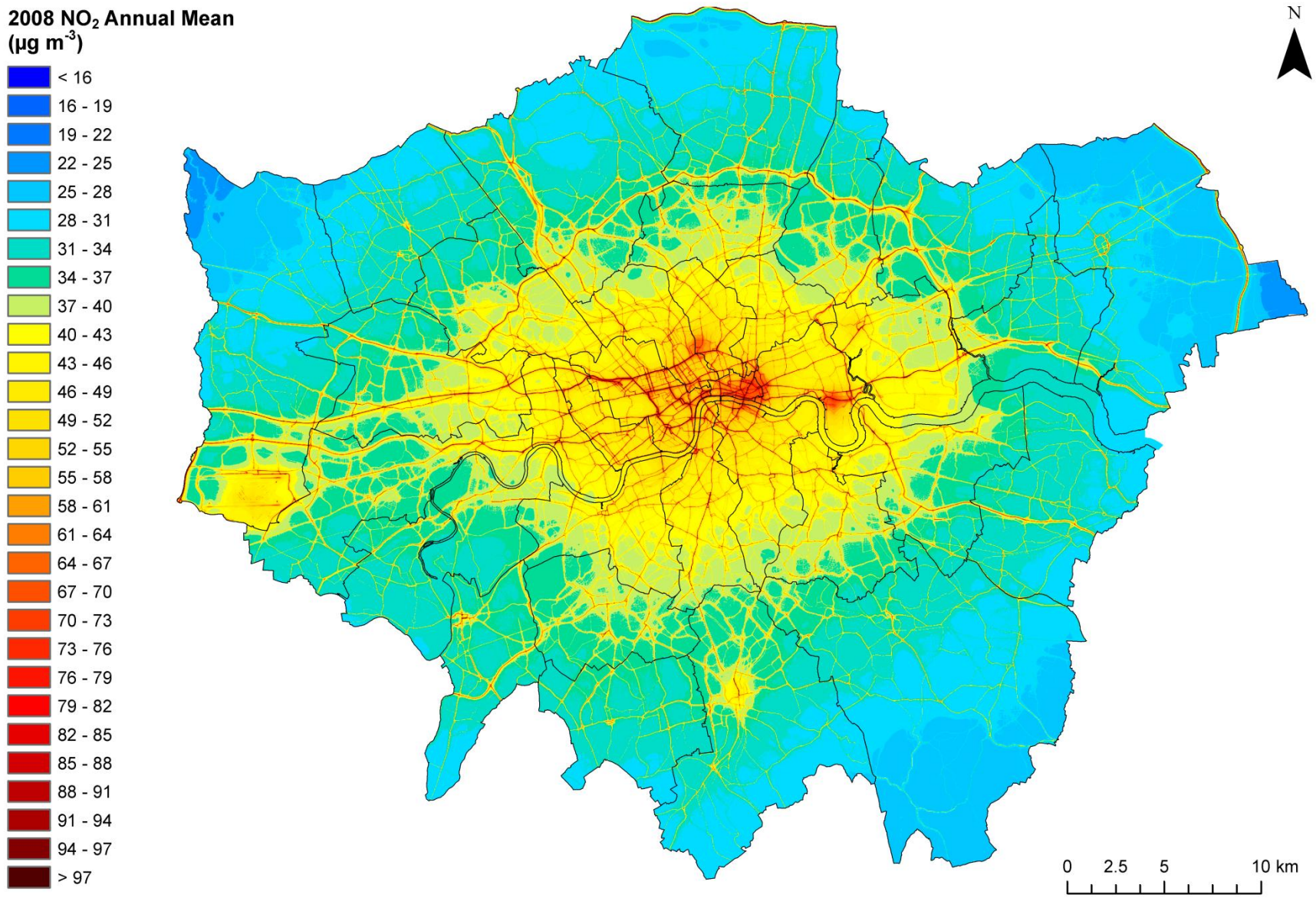
BUT more importantly

- Air quality is very sensitive to Meteorology

# 2008 $NO_2$ Annual Mean Meteorology 2008 (LAEI2010)

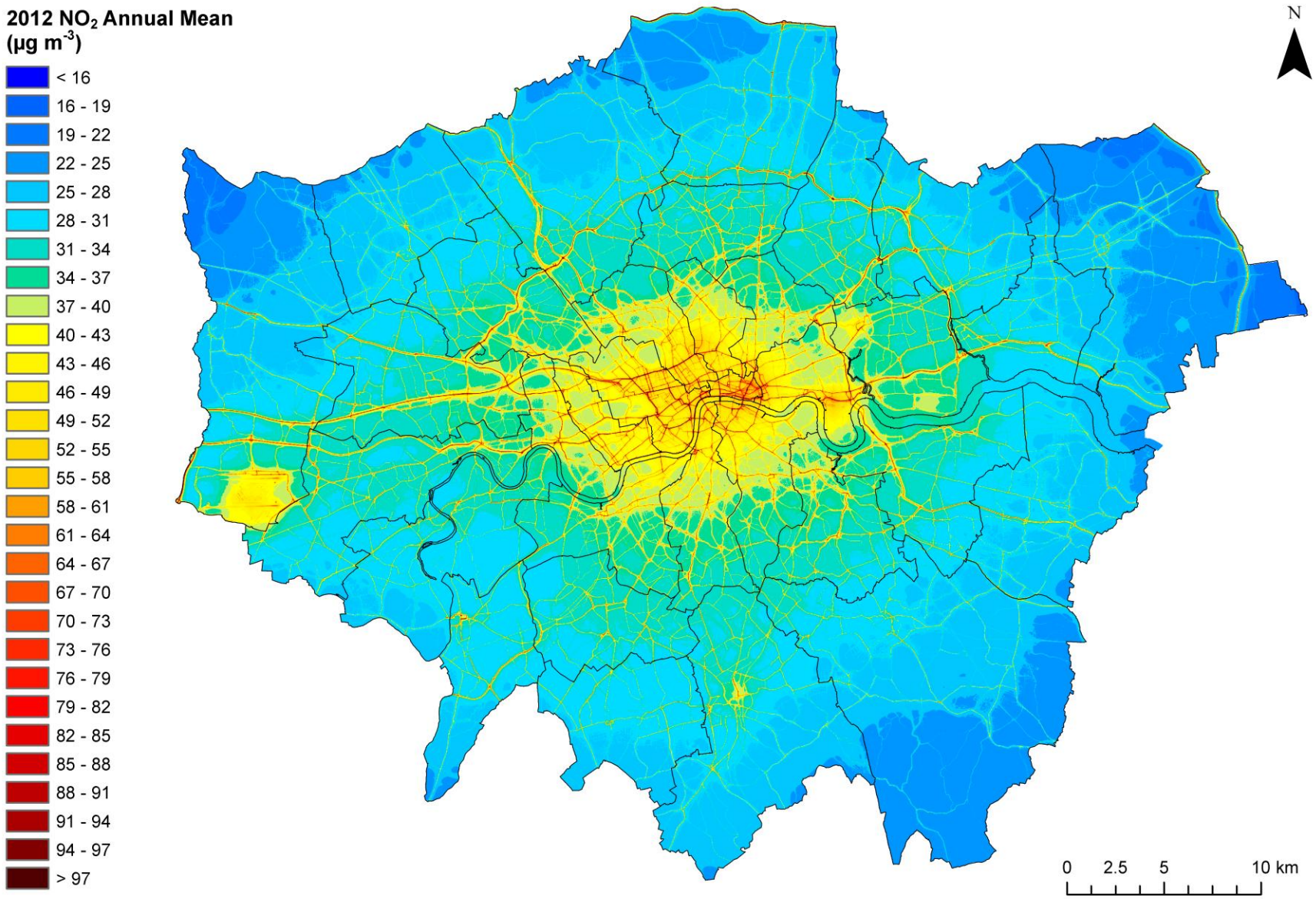


# 2008 $NO_2$ Annual Mean Meteorology 2010 (LAEI2010)

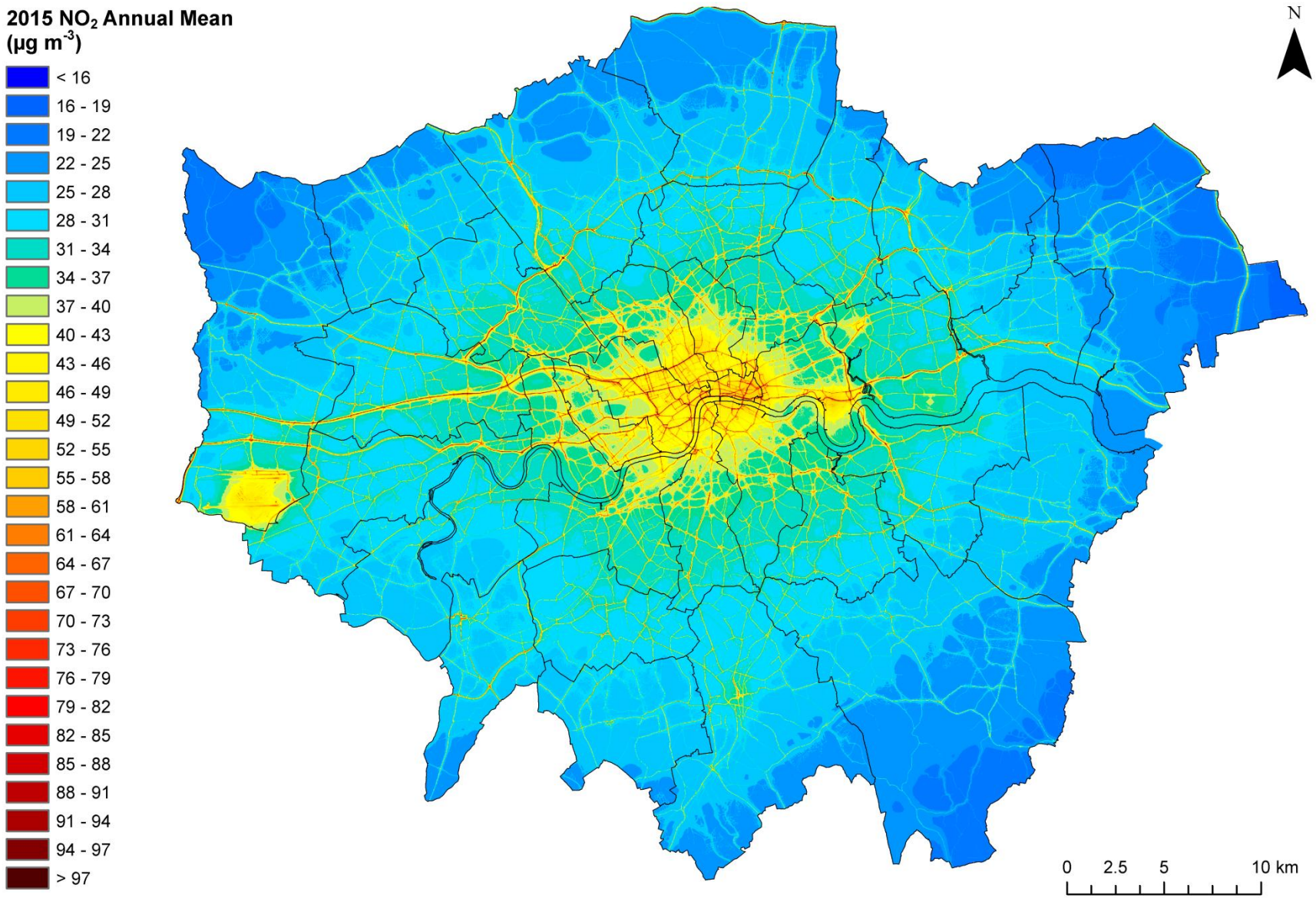


# Future Predictions

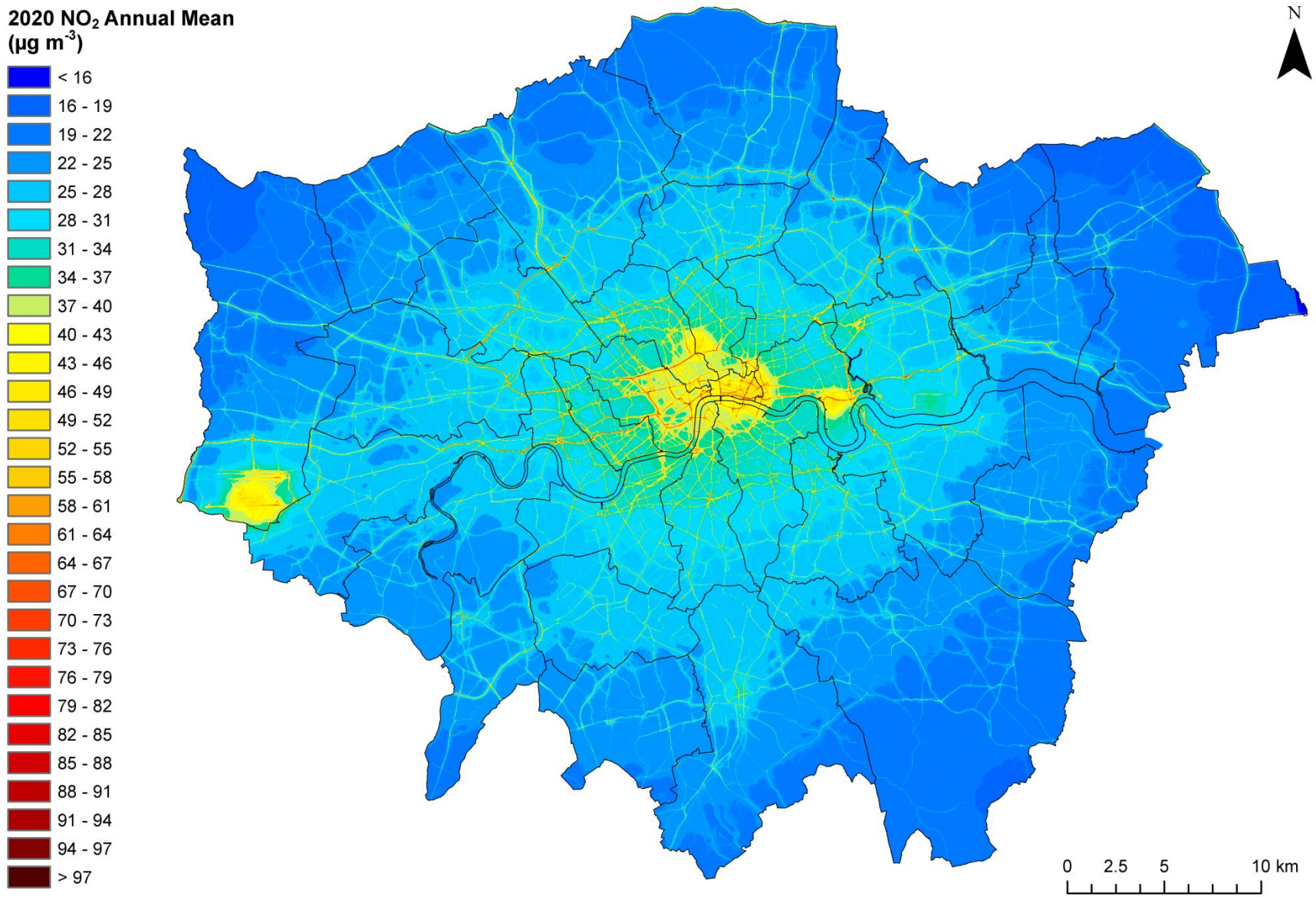
# 2012 $NO_2$ Annual Mean (LAEI2010)



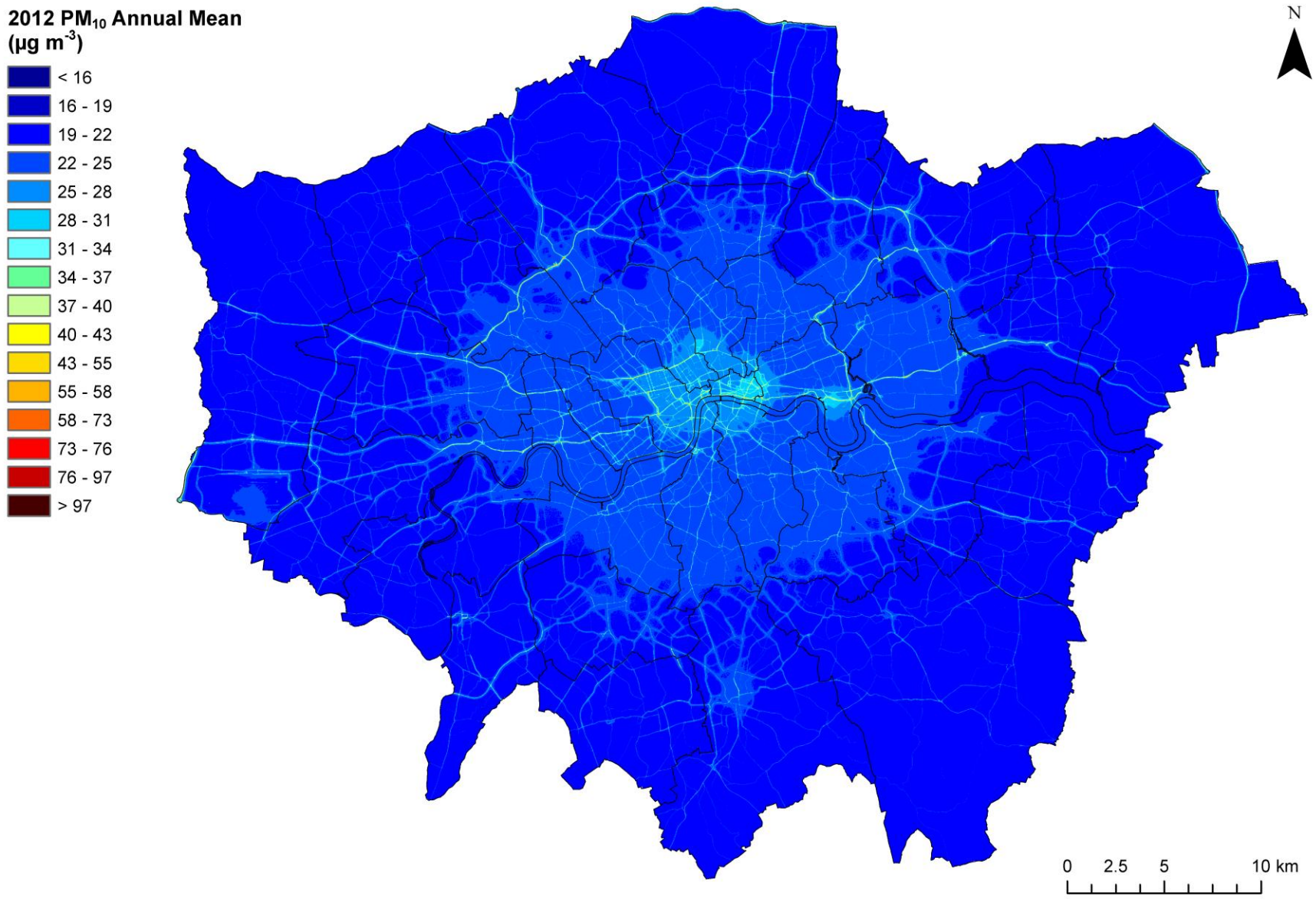
# 2015 $NO_2$ Annual Mean (LAEI2010)



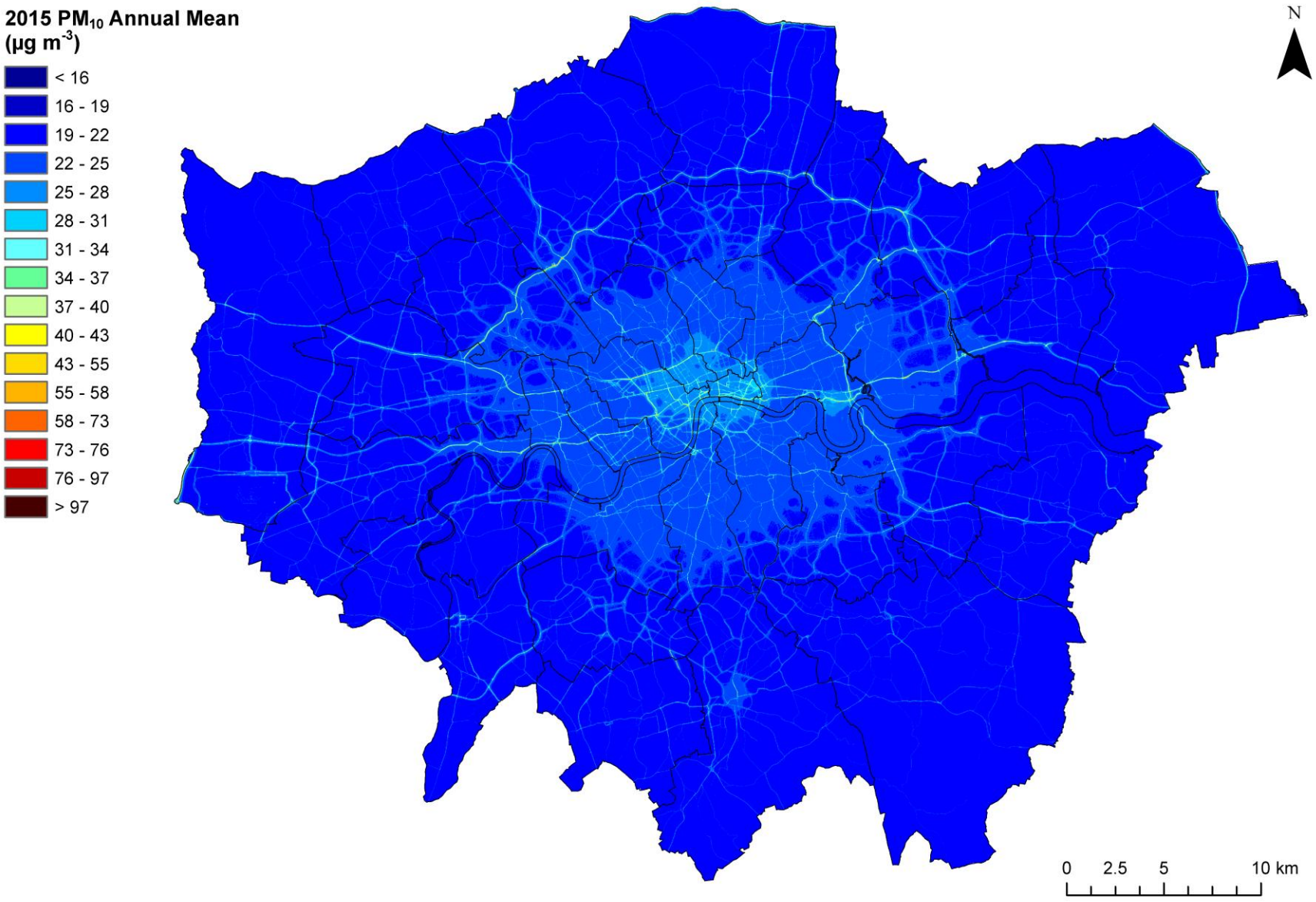
# 2020 $NO_2$ Annual Mean (LAEI2010)



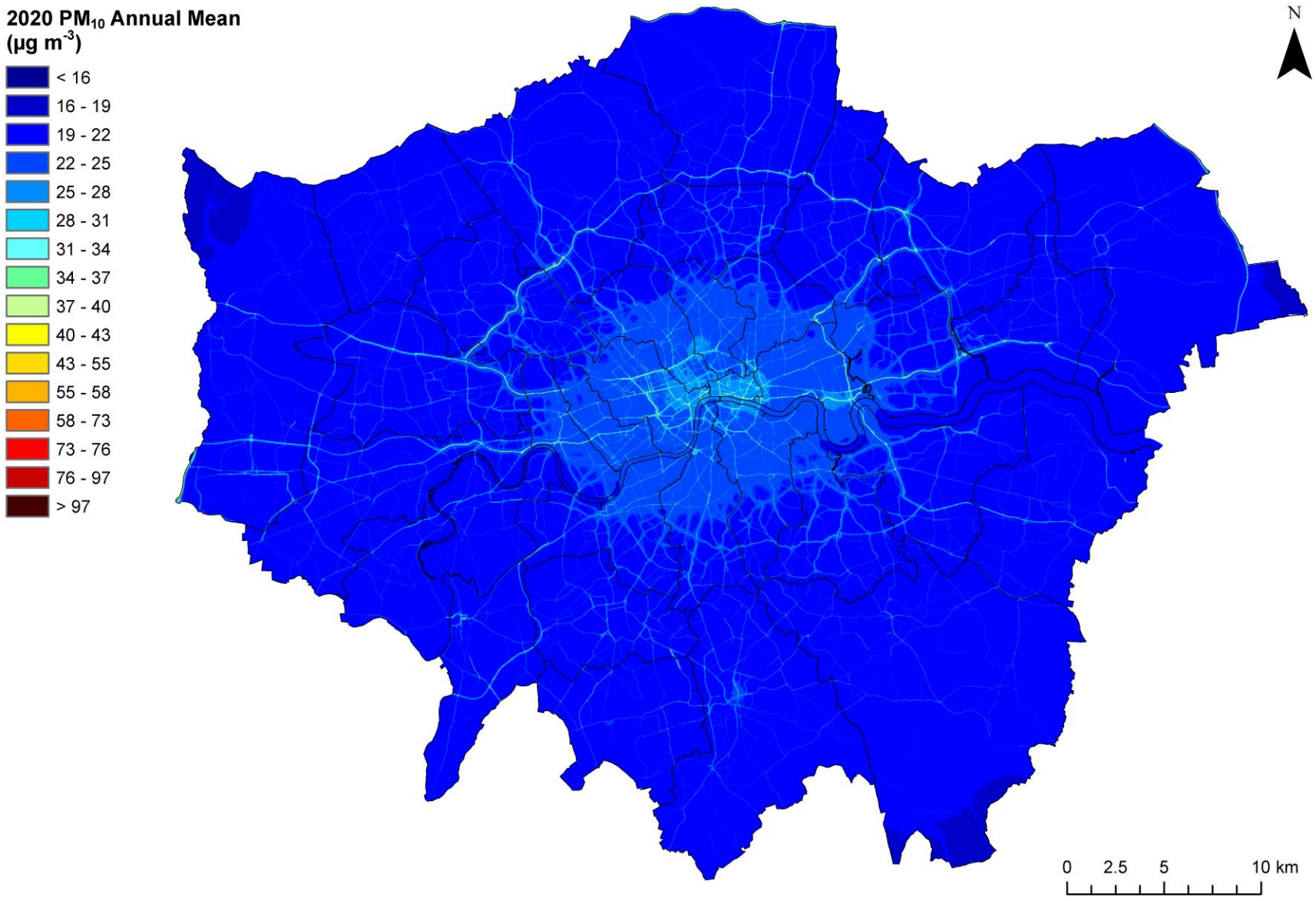
# 2012 $PM_{10}$ Annual Mean (LAEI2010)



# 2015 $PM_{10}$ Annual Mean (LAEI2010)



# 2020 $PM_{10}$ Annual Mean (LAEI2010)



# Take Away Message

1. What is the recipe for mapping London Air quality?

LAEI2010 + dispersion + measurement

2. Are others responsible?

No, Peak of pollution always near local sources

3. LAEI2010 emissions (What is new?)

New source NRMM and road traffic increase ($NO_X$ +13% / $PM_{10}$ +150%)

4. What is main cause of pollution?

Road traffic

5. LAEI2010 mapping (What is new?)

Increase around road network, NRMM, London city (more visible).

6. Future Predictions

Predicting future is always a risk

Use average/more extreme meteorology

Improve the emission inventory

By 2020, $NO_2$ is dropping but remain a problem

And $PM_{10}$ is not changing very much

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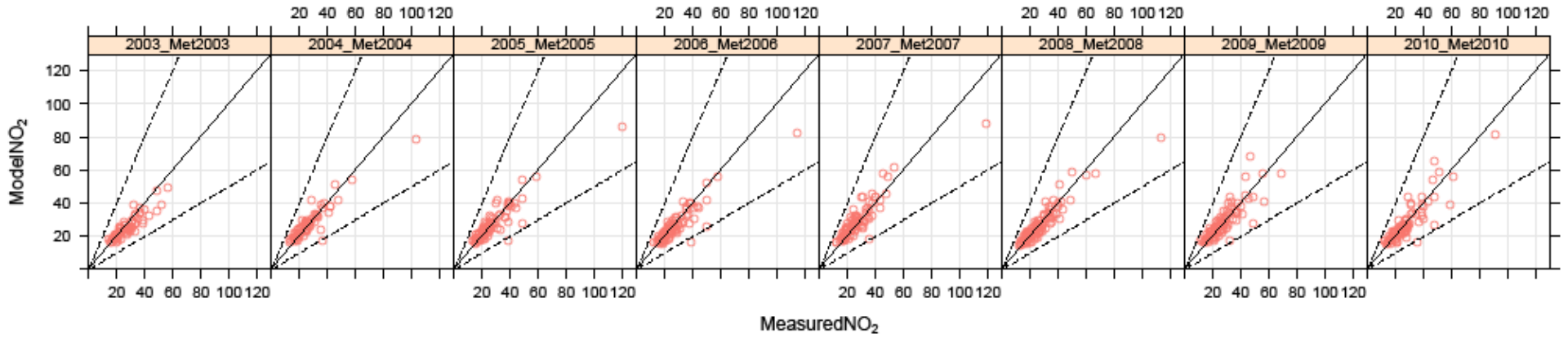
# Remote Sensing New Emission Factors

- Increasing disparity between measured and modelled over recent years
- In previous LAEI, calibration was used for $NO_X$ and $PM_{10}$
- Addition of non-exhaust PM = No calibration for PM in LAEI2010
- New COPPERT EF for NOx (+22%) = Calibration for $NO_X$ in LAEI2010
- King's new EF for NOx (+70%) = No Calibration for $NO_X$ (validation 2003-2010)

**LAQM − NO2, Annual Average, all sites**

| Type | n | FAC2 | MB | MGE | NMB | NMGE | RMSE | r | IOA |
|---|---|---|---|---|---|---|---|---|---|
| 2003_Met2003 | 62 | 1.00 | −2.39 | 3.5 | −0.085 | 0.13 | 4.7 | 0.90 | 0.75 |
| 2004_Met2004 | 70 | 0.99 | 0.48 | 3.3 | 0.018 | 0.12 | 5.2 | 0.92 | 0.79 |
| 2005_Met2005 | 84 | 0.99 | −0.42 | 3.5 | −0.015 | 0.13 | 6.1 | 0.91 | 0.80 |
| 2006_Met2006 | 85 | 0.99 | −1.33 | 3.6 | −0.049 | 0.13 | 6.1 | 0.91 | 0.79 |
| 2007_Met2007 | 90 | 0.99 | 1.83 | 4.2 | 0.068 | 0.16 | 6.0 | 0.90 | 0.74 |
| 2008_Met2008 | 100 | 1.00 | −0.30 | 3.4 | −0.011 | 0.13 | 5.1 | 0.93 | 0.80 |
| 2009_Met2009 | 96 | 1.00 | 0.83 | 4.0 | 0.031 | 0.15 | 5.5 | 0.85 | 0.74 |
| 2010_Met2010 | 87 | 0.99 | −0.37 | 3.9 | −0.014 | 0.14 | 5.8 | 0.89 | 0.77 |



# Thanks for your attention…

Thanks also to colleagues at ERG:

Mark De Jong, Sean Beevers, Nutthida Kitwiroon, David Carslaw, Gary Fuller and David Green

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