# Measurements of $NO_x$ & $CO_2$ at high resolution:

## What insights can we gain?

Carys Williams
cw1781@york.ac.uk

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Natural Environment Research Council

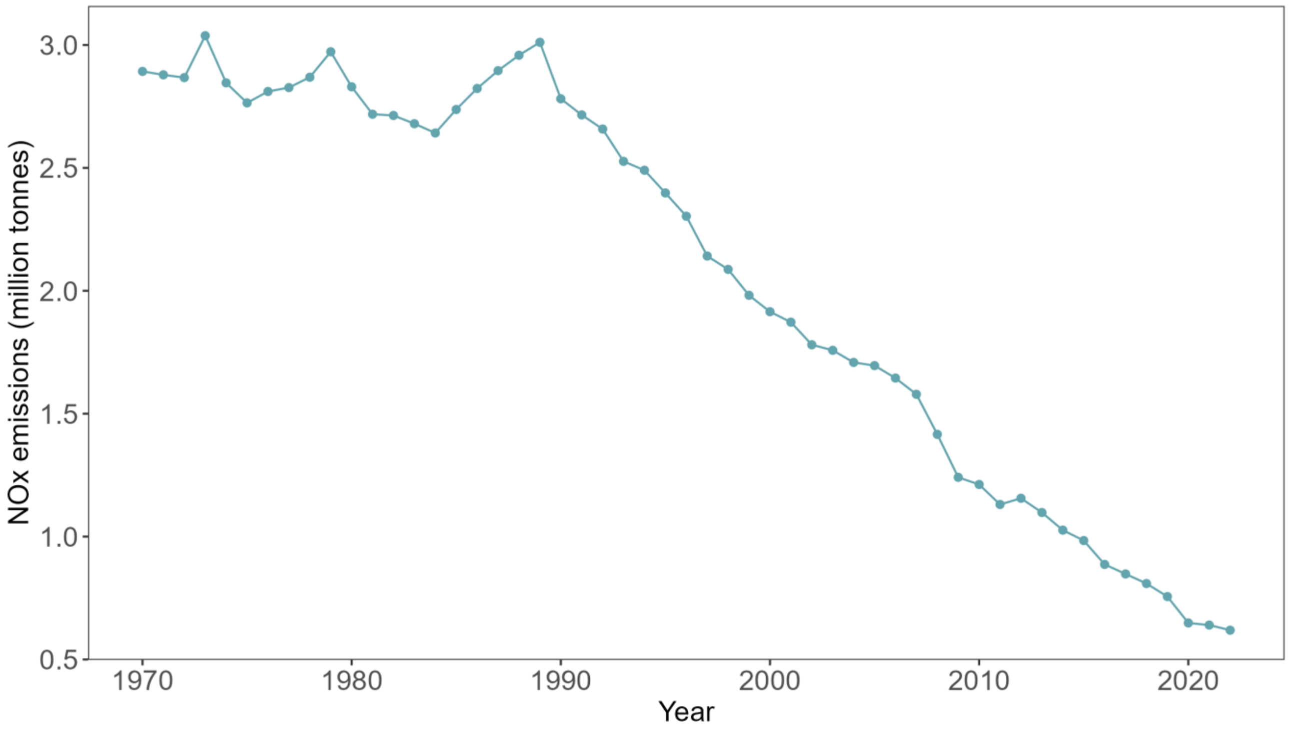
UNIVERSITY of York

*James D.Lee, Sarah J.Moller & Will S.Drysdale*

# $NO_x/CO_2$ emission ratios

## $NO_x = NO + NO_2$

- $NO_x$ has negative impacts on both **public health** and the **environment**
- $NO_x$ emissions have **decreased by 78%** in the UK since 1970[1]



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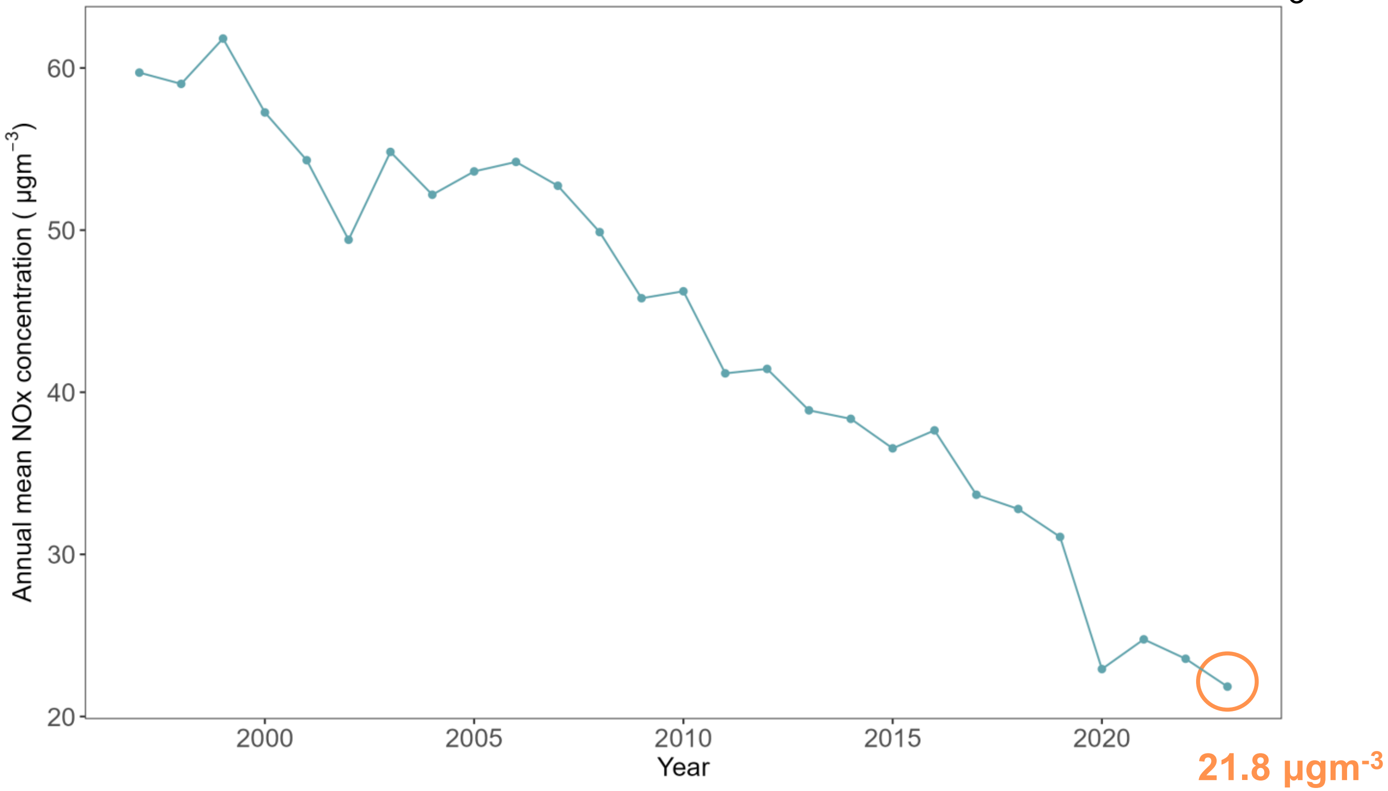
- $NO_x$ emissions have **decreased by 78%** in the UK since 1970[1]
- The latest WHO annual guideline level[2] of $NO_2$ is at an ambitious **10 µgm⁻³**
- This adds pressure to continue reducing emissions





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- Roadside $NO_x/CO_2$ ratios provide valuable information on the vehicle fleet
- They can be used to evaluate **emissions standards** compliance, but also give insight into **vehicle type**, **vehicle age**, **driving conditions** & performance of **emission control technology**

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Mobile monitoring reveals congestion penalty for vehicle emissions in London

Shona E. Wilde[a,*], Lauren E. Padilla[b], Naomi J. Farren[a], Ramón A. Alvarez[b], Samuel Wilson[a], James D. Lee[a], Rebecca L. Wagner[a], Greg Slater[c], Daniel Peters[b], David C. Carslaw[a]

*[a] Wolfson Atmospheric Chemistry Laboratories University of York YO10 5DD*
*[b] Environmental Defense Fund 18 Tremont Street Boston MA 02108 United States*
*[c] Environmental Defense Fund Europe 3rd Floor 41 Eastcheap London EC3M 1DT United Kingdom*

- Vehicle class

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- Emission ratios were **2X higher in inner London** despite the presence of the **ULEZ**[5]

- **High levels of congestion** and stop-start driving allow for **non-optimal conditions** for vehicle after-treatment technology – resulting in higher $NO_x$ emissions

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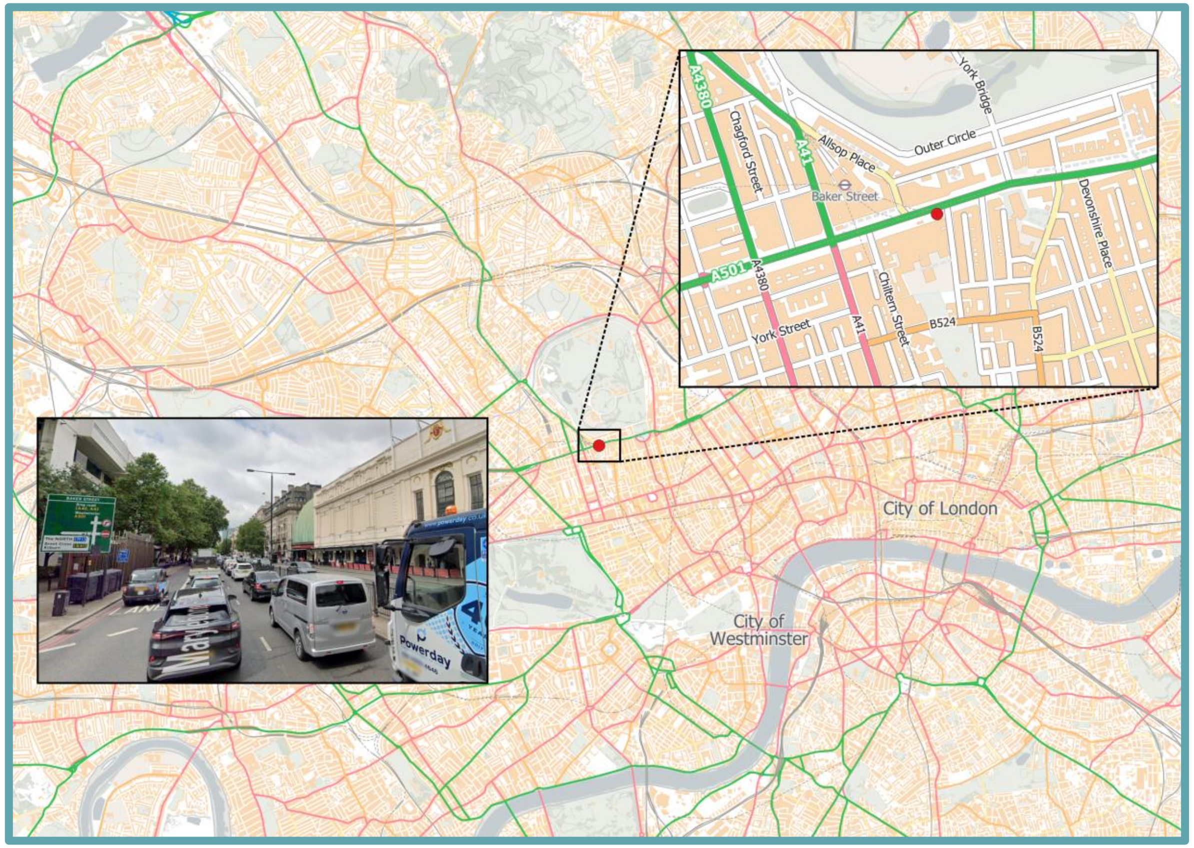
**To continue reducing $NO_x$ emissions, it is essential that we improve our understanding of on-road emissions**

# Data Collection - London

- **I**terative **C**avity **E**nhanced **A**dsorption **S**pectrometer (ICAD)
- Measures every 2 secs
- Located at Marylebone road air quality site in London
- Feb 2024 – July 2024
- 72% data coverage

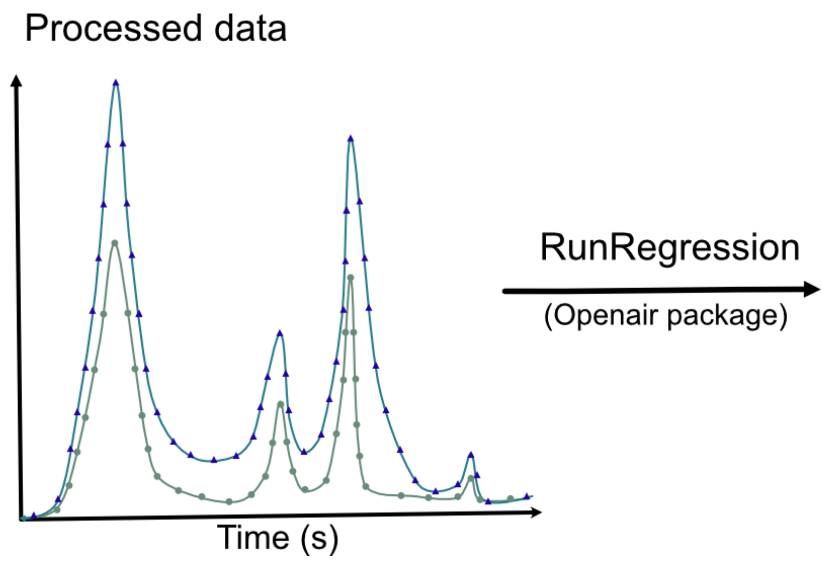



# Data Collection - Manchester


- Comparison data set collected by Sam Cliff as part of the **OSCA** campaign
- Three weeks in July 2021 & three weeks in Feb 2022

# Calculation of ratios

- Followed a plume dilution rolling regression method developed by Farren et al[6]



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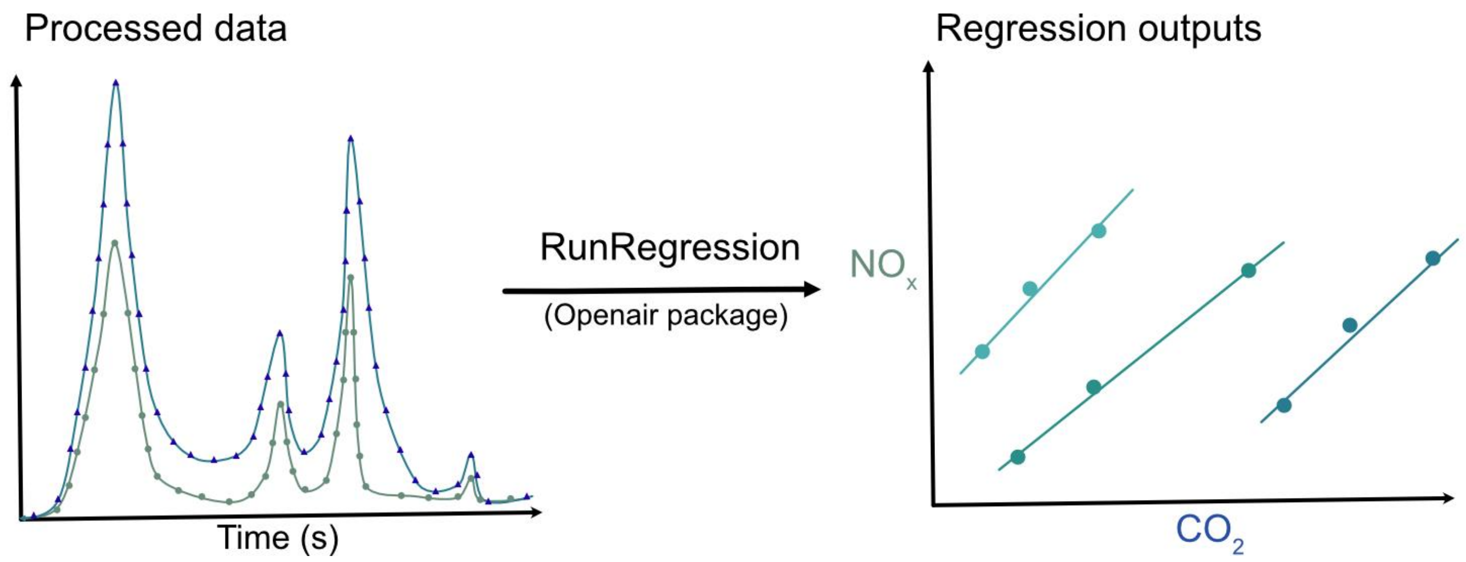

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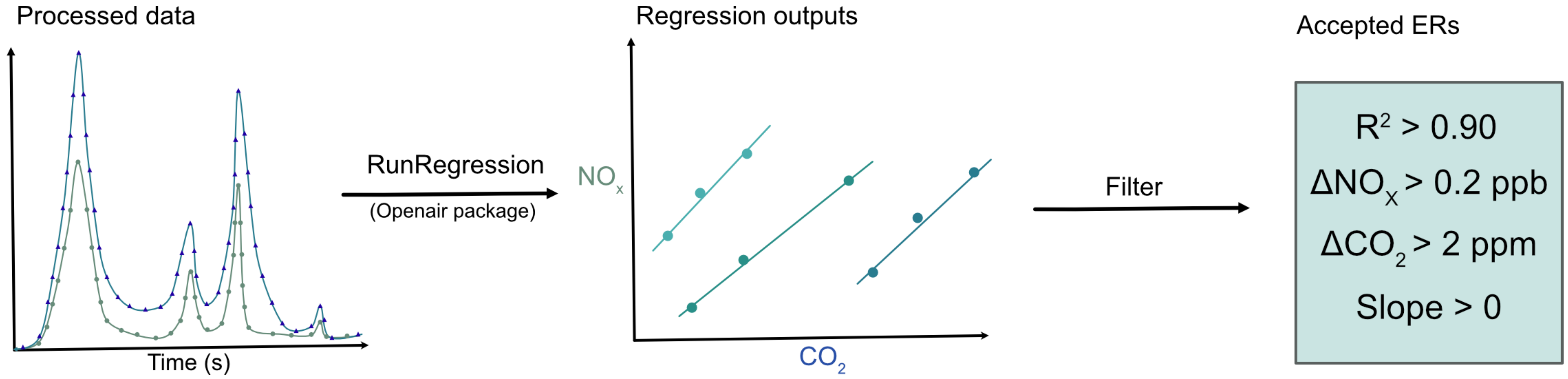

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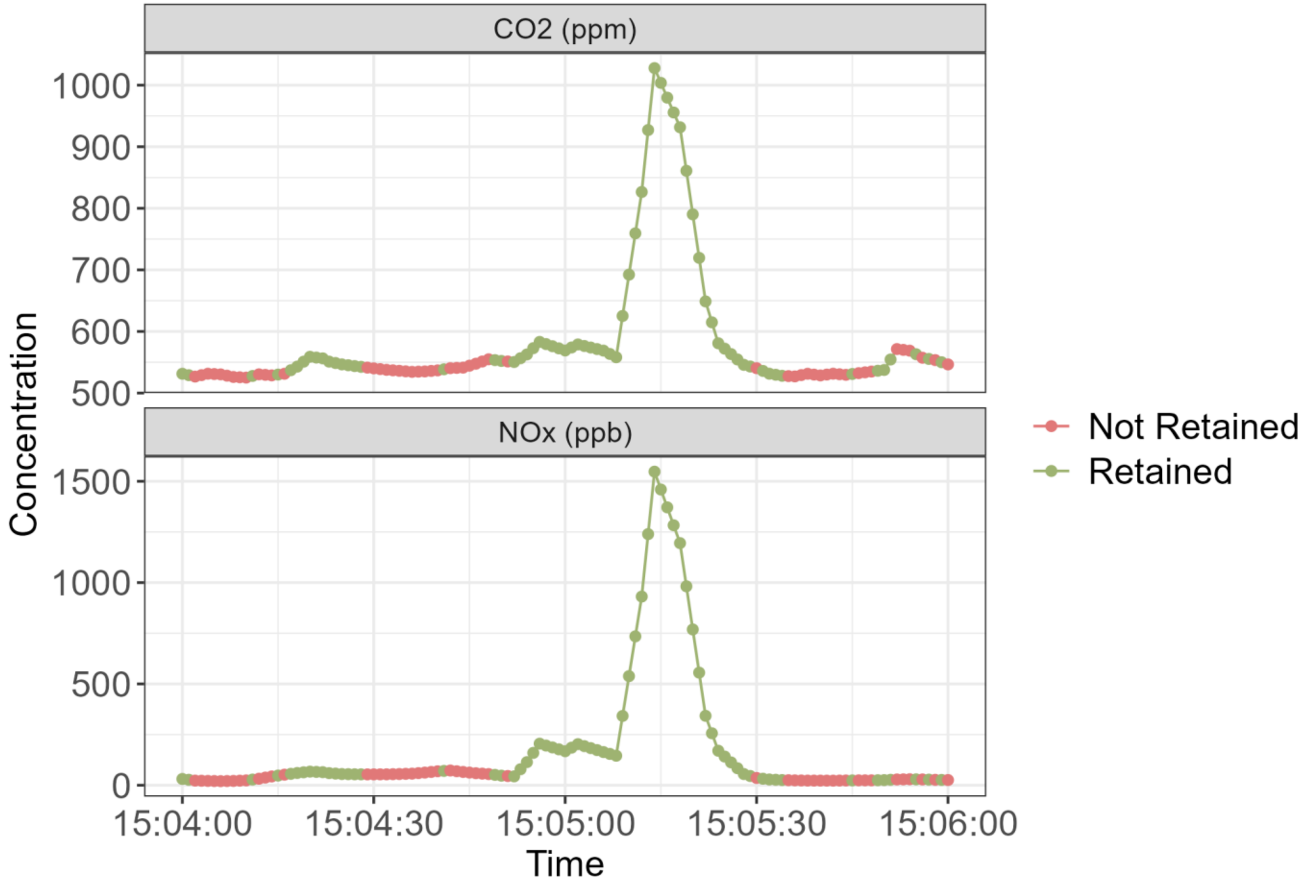
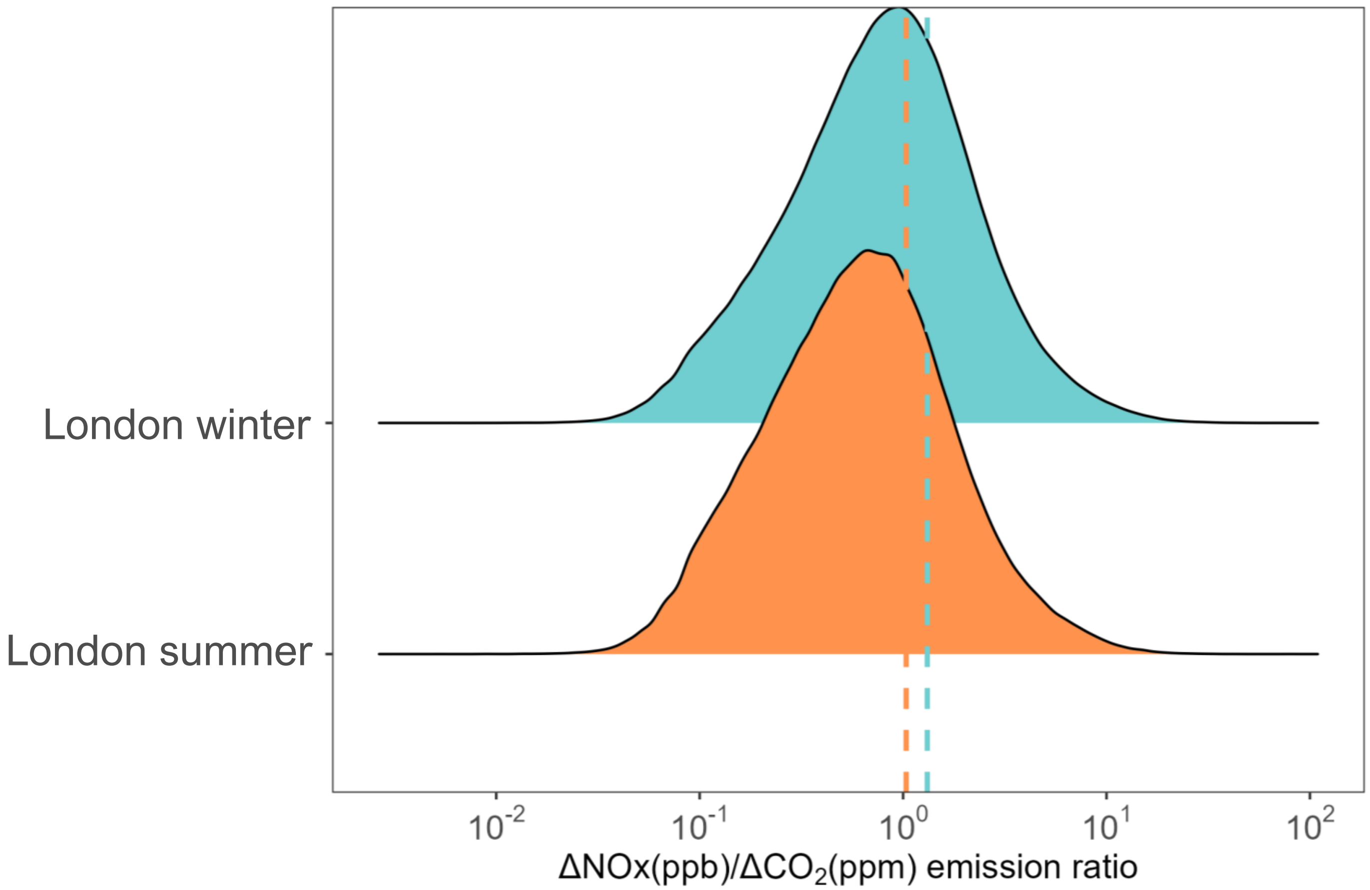


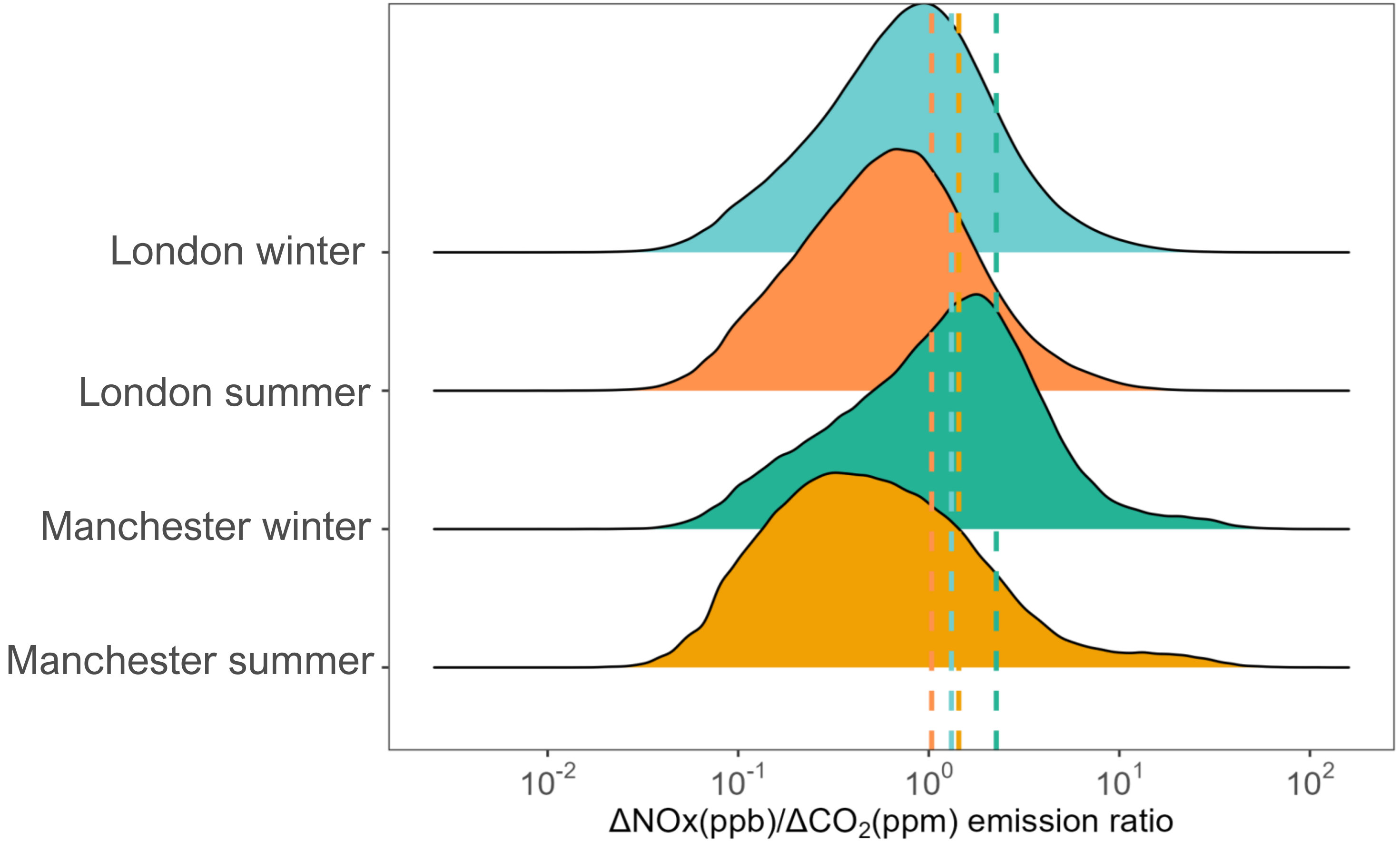

- Retained data shows strong correlation between $NO_x$ and $CO_2$
- 23% of data is retained after filtering

# Calculated emission ratios




- There is a spread in emission ratios
- Emission ratios are on average higher during typical 'winter' vs 'summer' months.

# Calculated emission ratios




- Emission ratios are on average higher at the Manchester site

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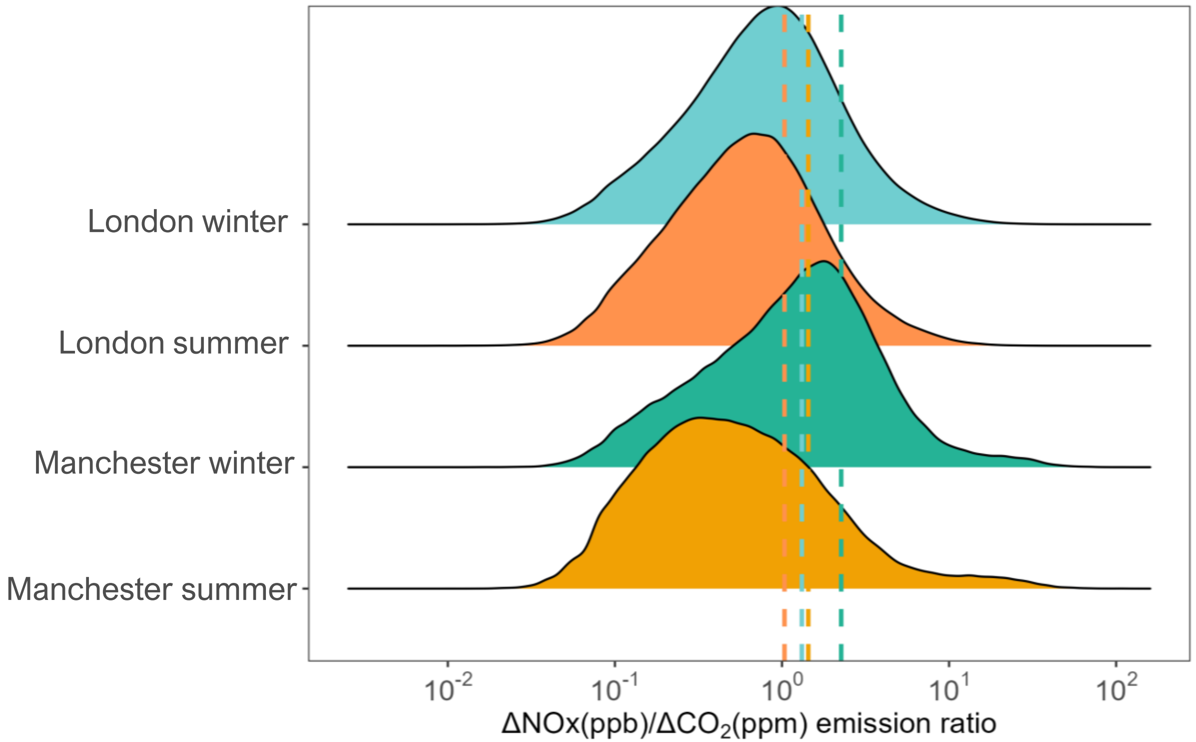
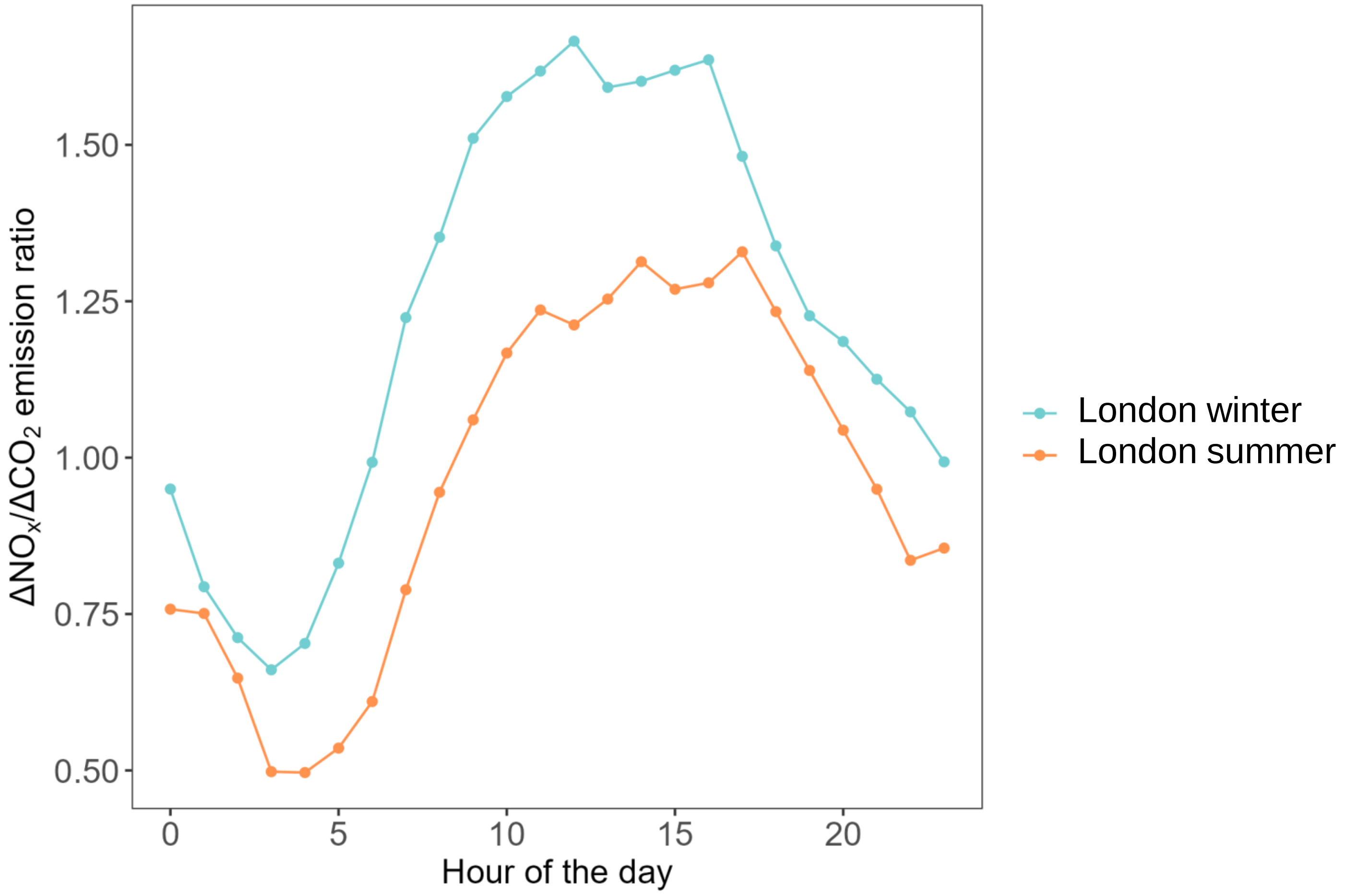



| Campaign | Mean emission ratio | Dates |
|---|---|---|
| London winter | 1.315 | Feb-March 2024 |
| London summer | 1.035 | June-July 2024 |
| Manchester winter | 2.261 | Feb 2022 |
| Manchester summer | 1.437 | July 2021 |

# Diurnal trends




- Ratios are higher during the day than at night

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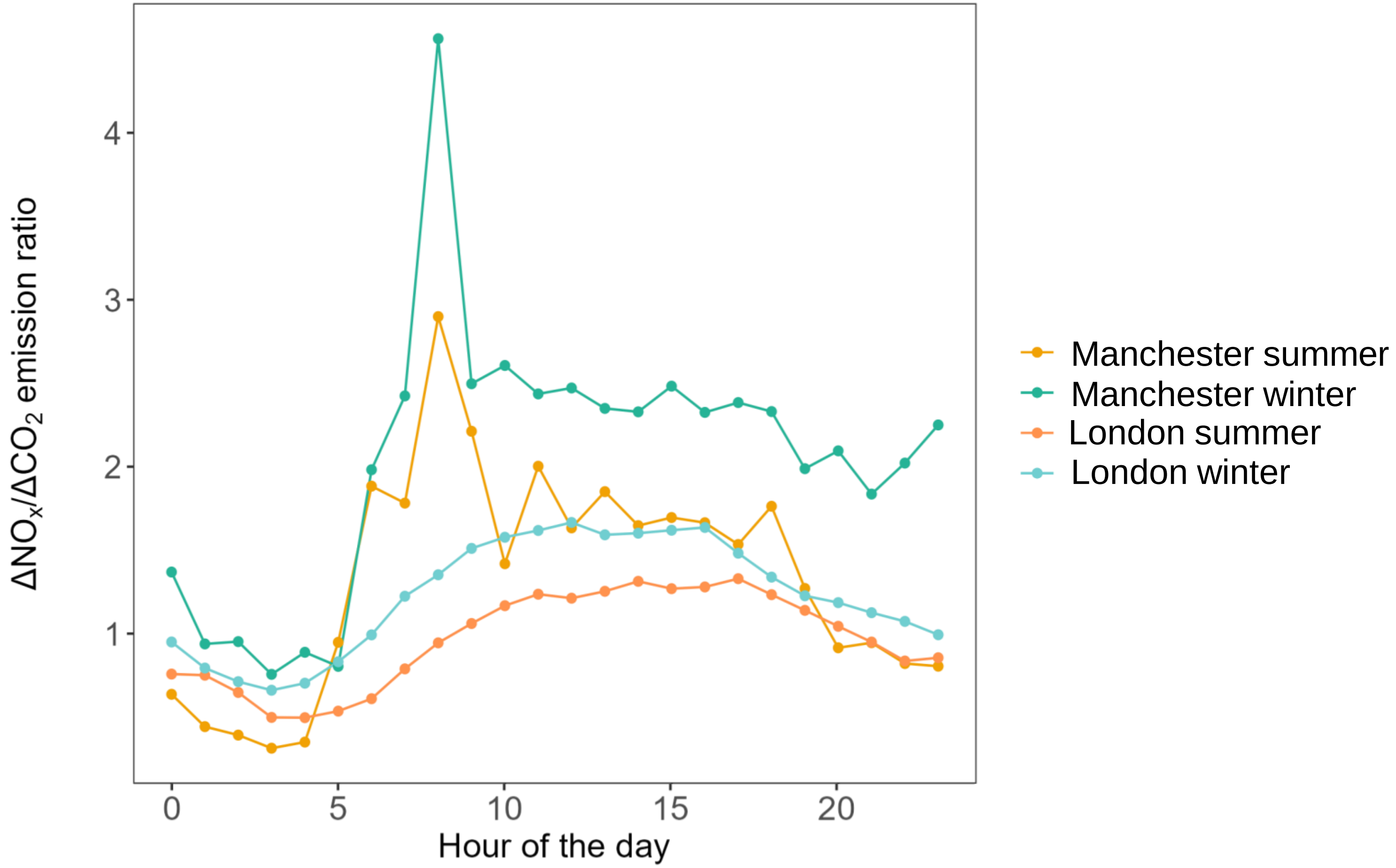
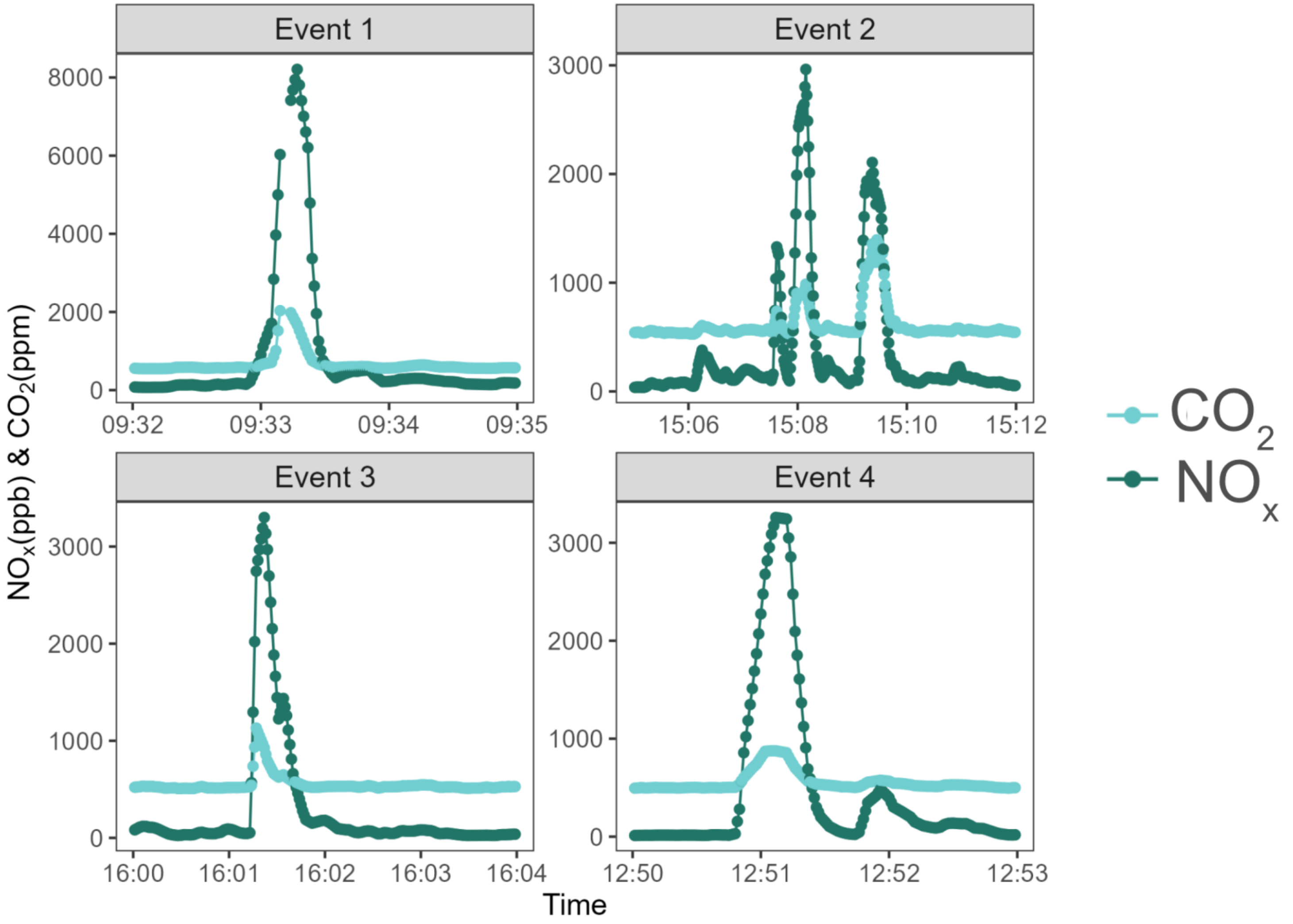



- Distinctive morning peaks in emission ratio at the Manchester site
- Differences in driving behaviour

# High emission events



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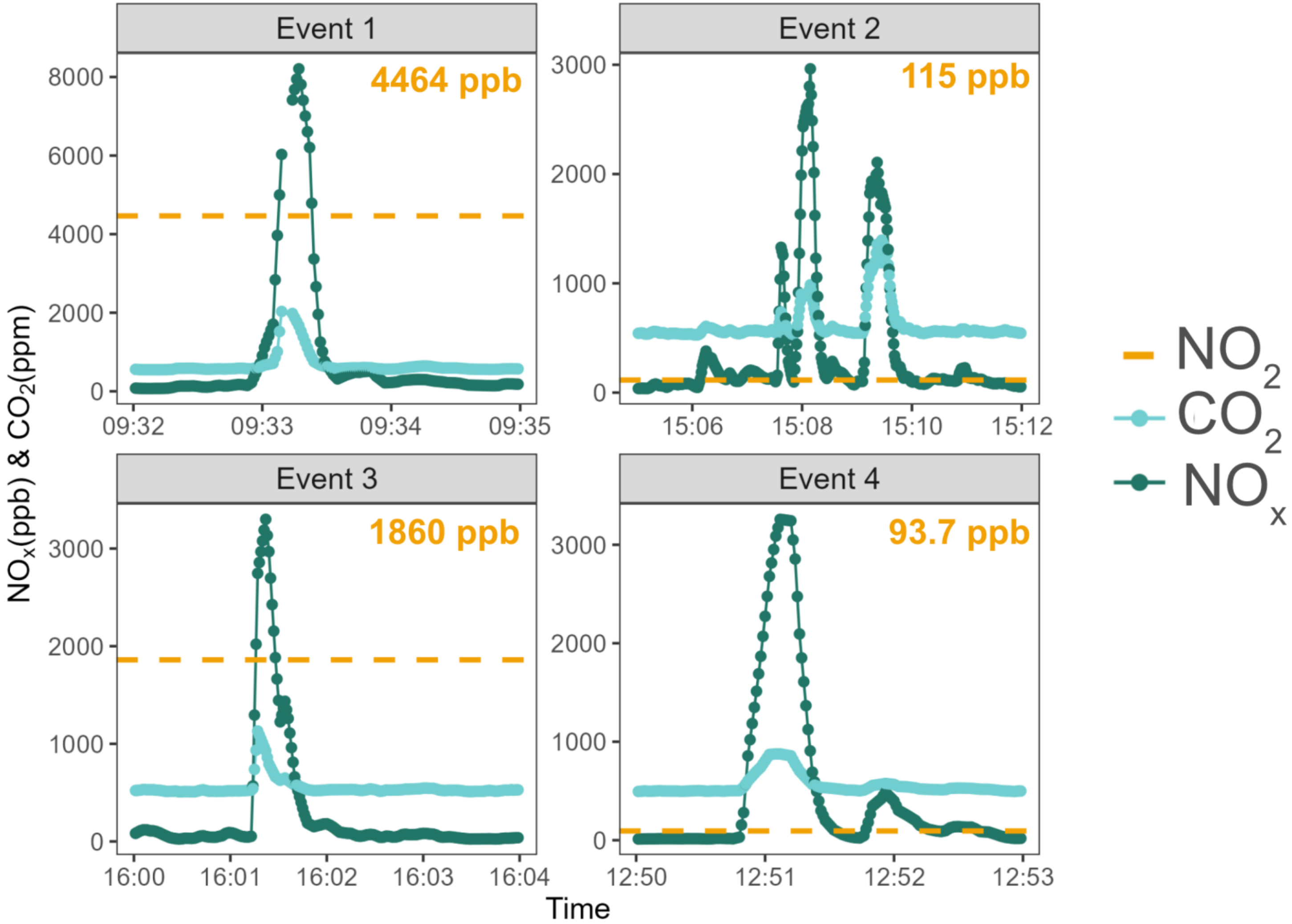

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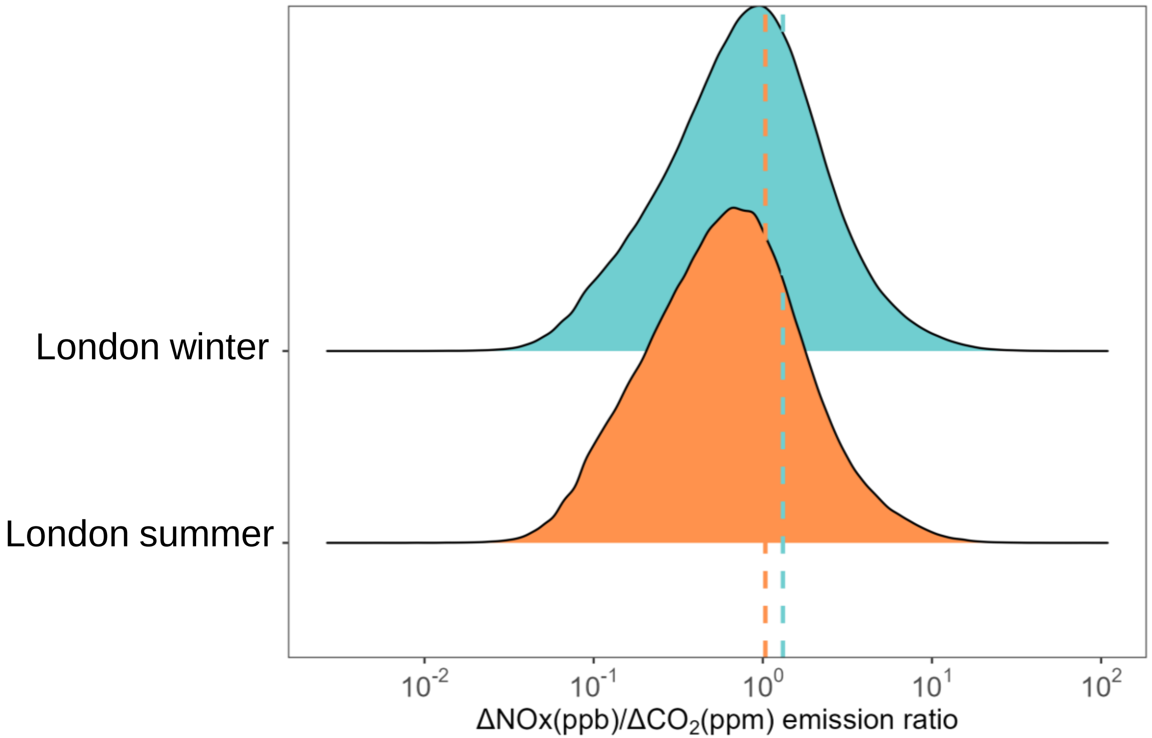

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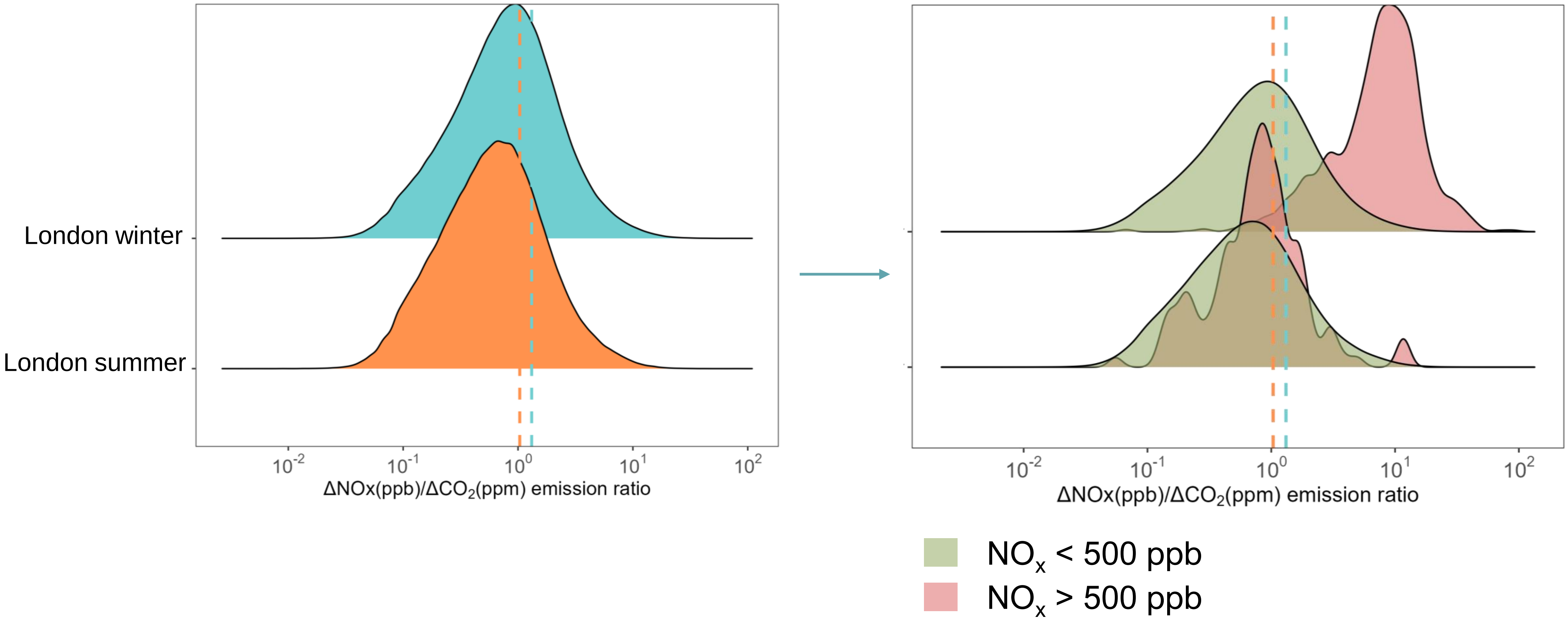
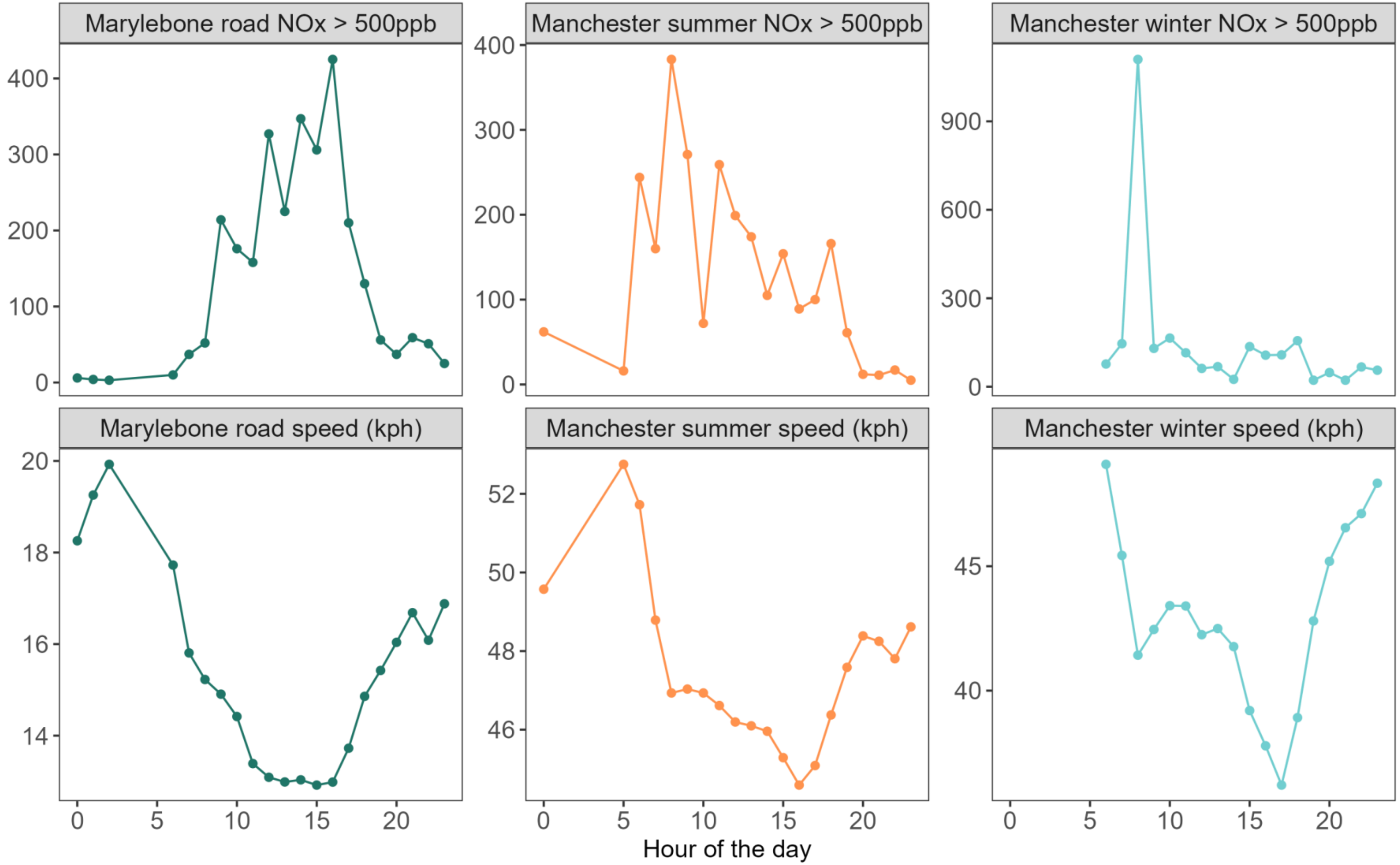


# High emission events – link with vehicle speed?



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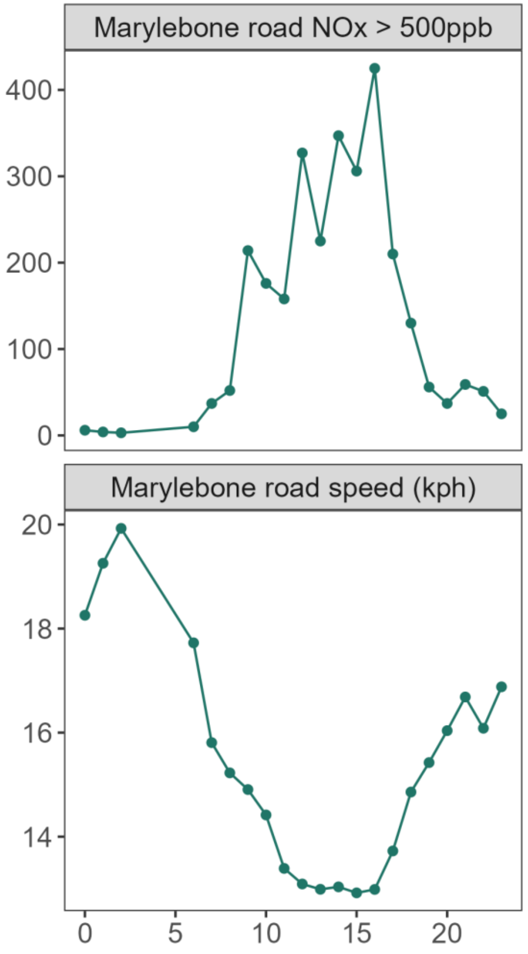


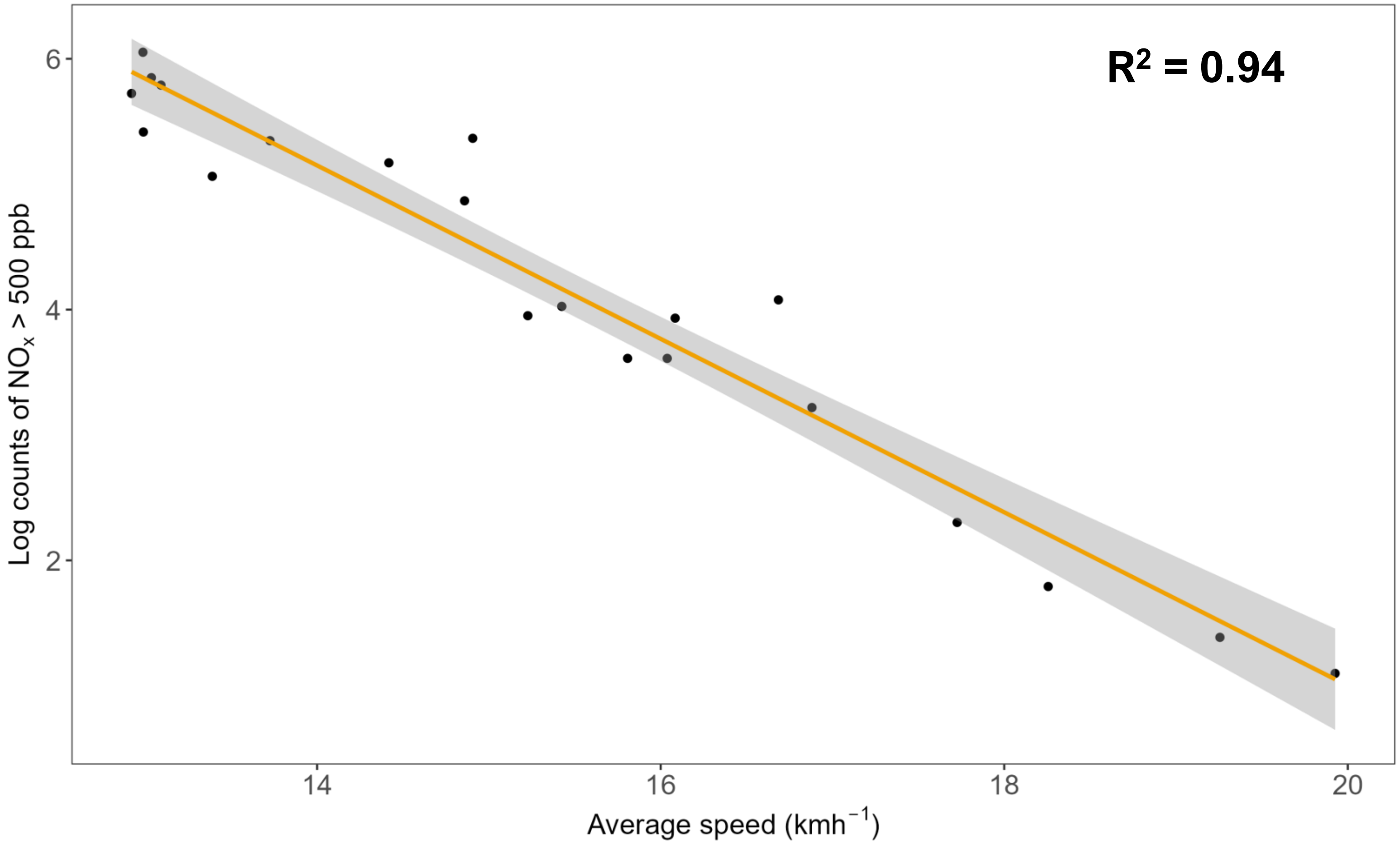

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Can we explain changes in emission ratio?

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| Temperature | -1.19E-02 | 1.13E-03 | -10.58 | <2e-16 |
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TfL traffic data split by vehicle class

Dataset 1
- Class1
- Class 2
- Class 3

Dataset 2
- Car
- Bus
- LGV
- OGV1
- OGV2
- Motorbike

# Conclusions and Future Work

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- A wide range of $NO_x/CO_2$ emission ratios are calculated at a roadside site
- Emission ratios vary diurnally & seasonally
- High resolution measurements and co-location with $CO_2$ can provide us with more information than is currently available at roadside sites

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**Contact: cw1781@york.ac.uk**

# Any questions?

## References:

## LinkedIn:

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