UNIVERSITY OF BIRMINGHAM

The Effects of London Ultra Low Emission Zone and Its Expansion

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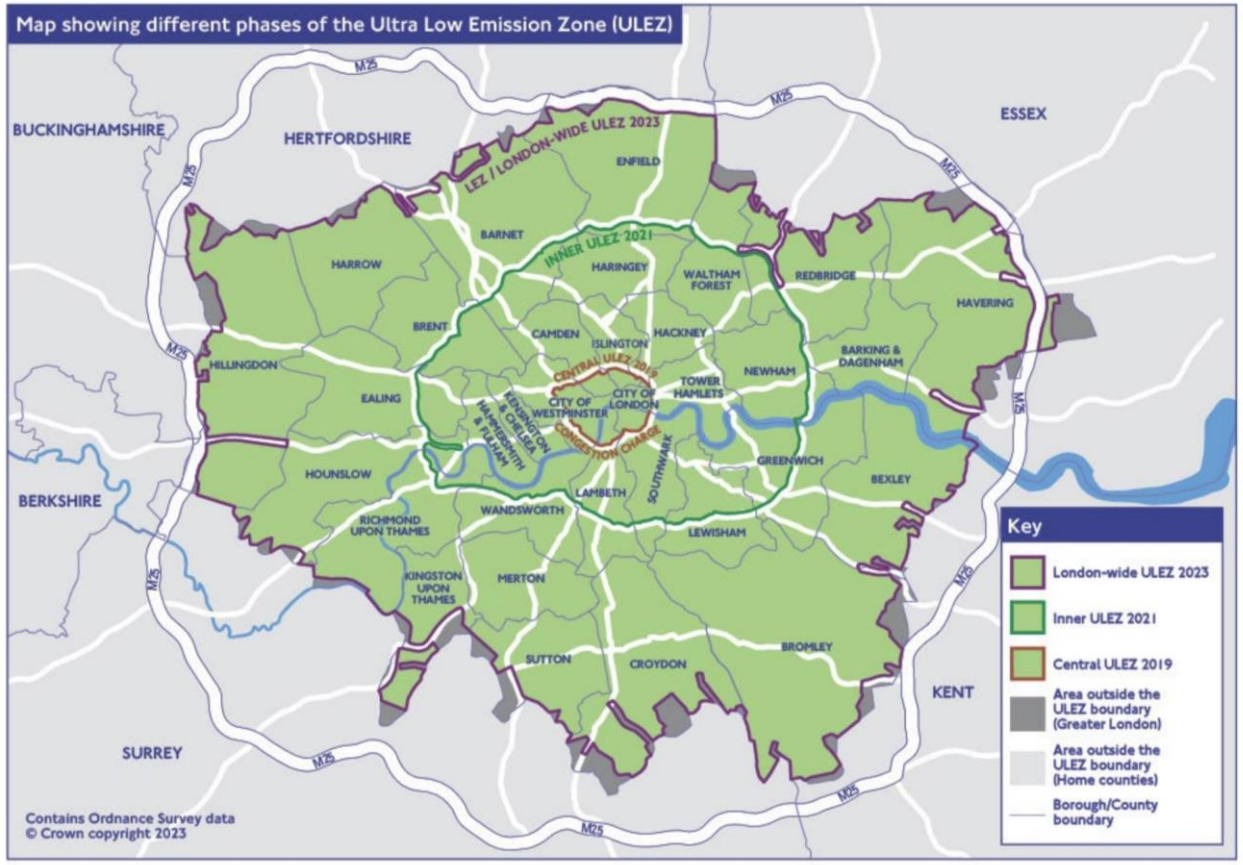
Background



Source: London-wide ULEZ Six Month Report

If your vehicle doesn't meet the ULEZ emissions standards and isn't exempt,
you need to pay a £**12.50** daily charge to drive within the zone.

Time and Area:

On **8th April 2019** the Mayor of London introduced the world's first 24-hour Ultra Low Emission Zone (ULEZ) in central London.

On **25th October 2021** the zone was expanded up to, but not including, the North and South Circular Roads.

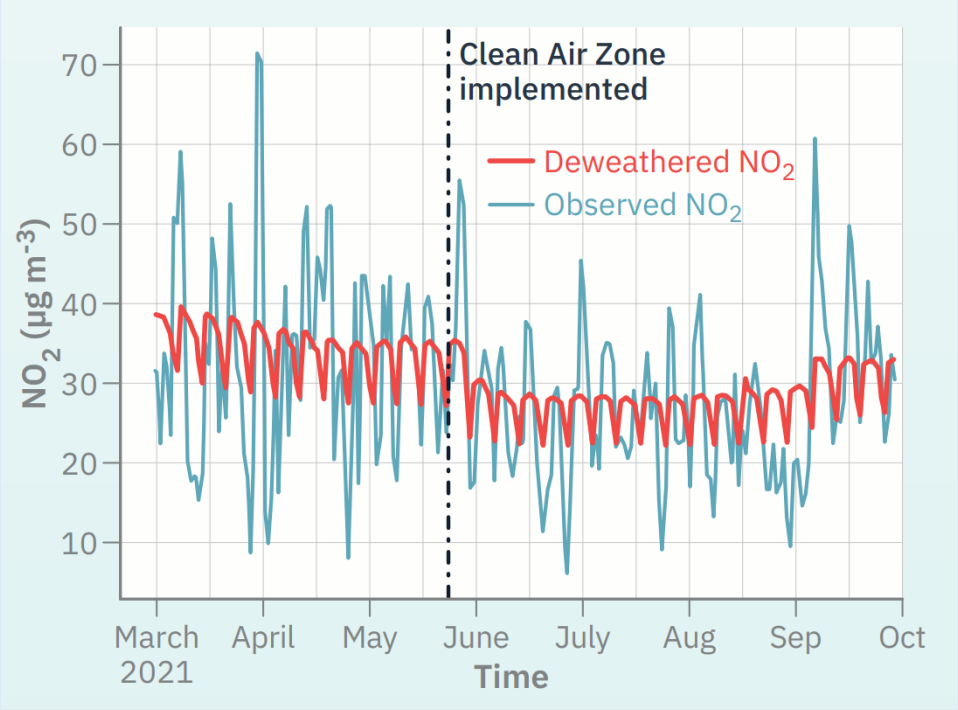
On **29th August 2023** the zone expanded

Source: TFL

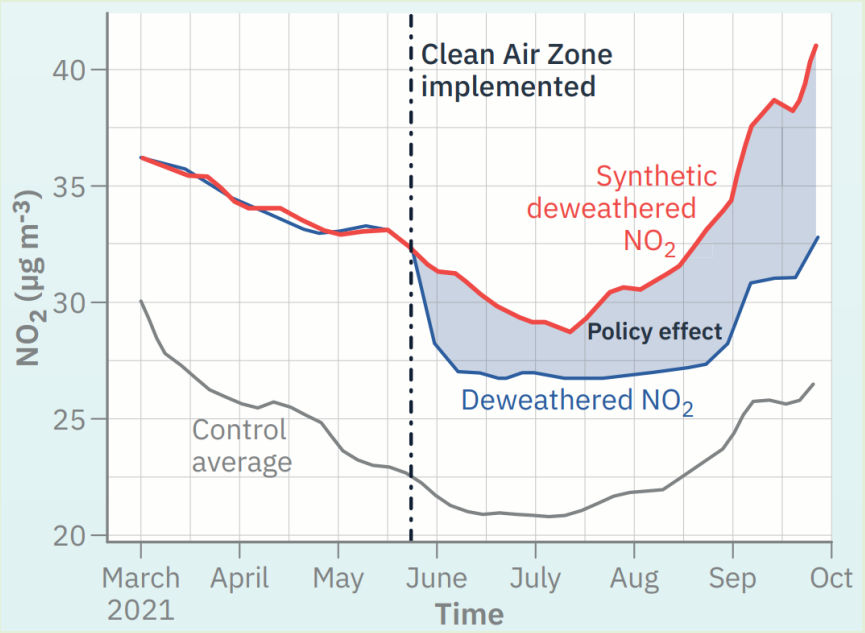
Method

A causal Framework to quantify policy intervention effect

1.Deweathering: Machine learning for weather normalisation



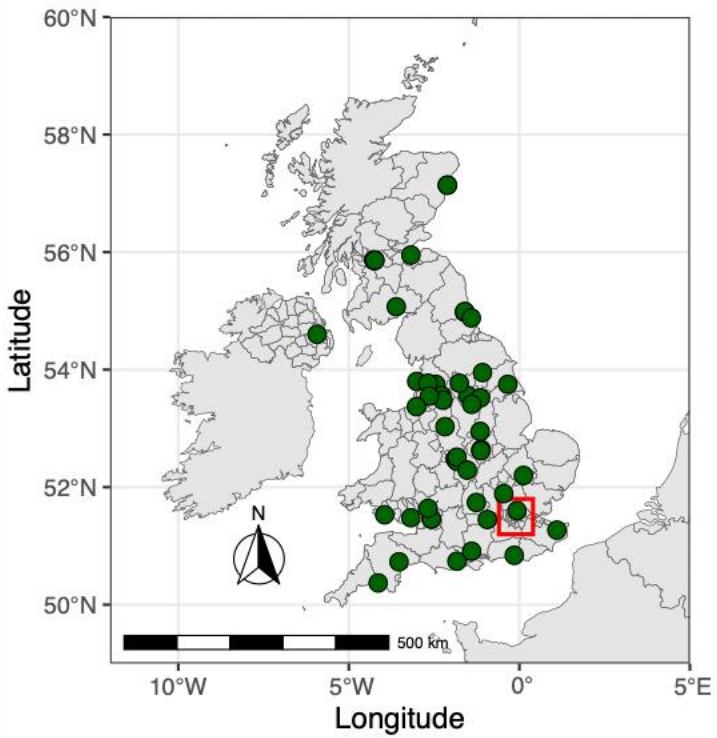
2. Causal Inference

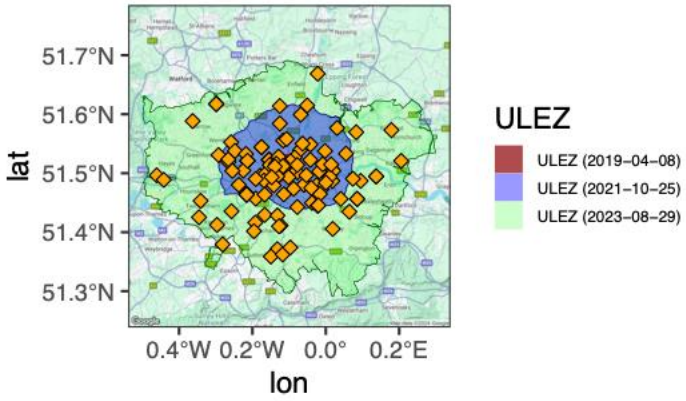


Data

Air quality data From AURN and LAQN
(Ensure the quality of the data capture)

- Urban background sites
- Urban Traffic sites





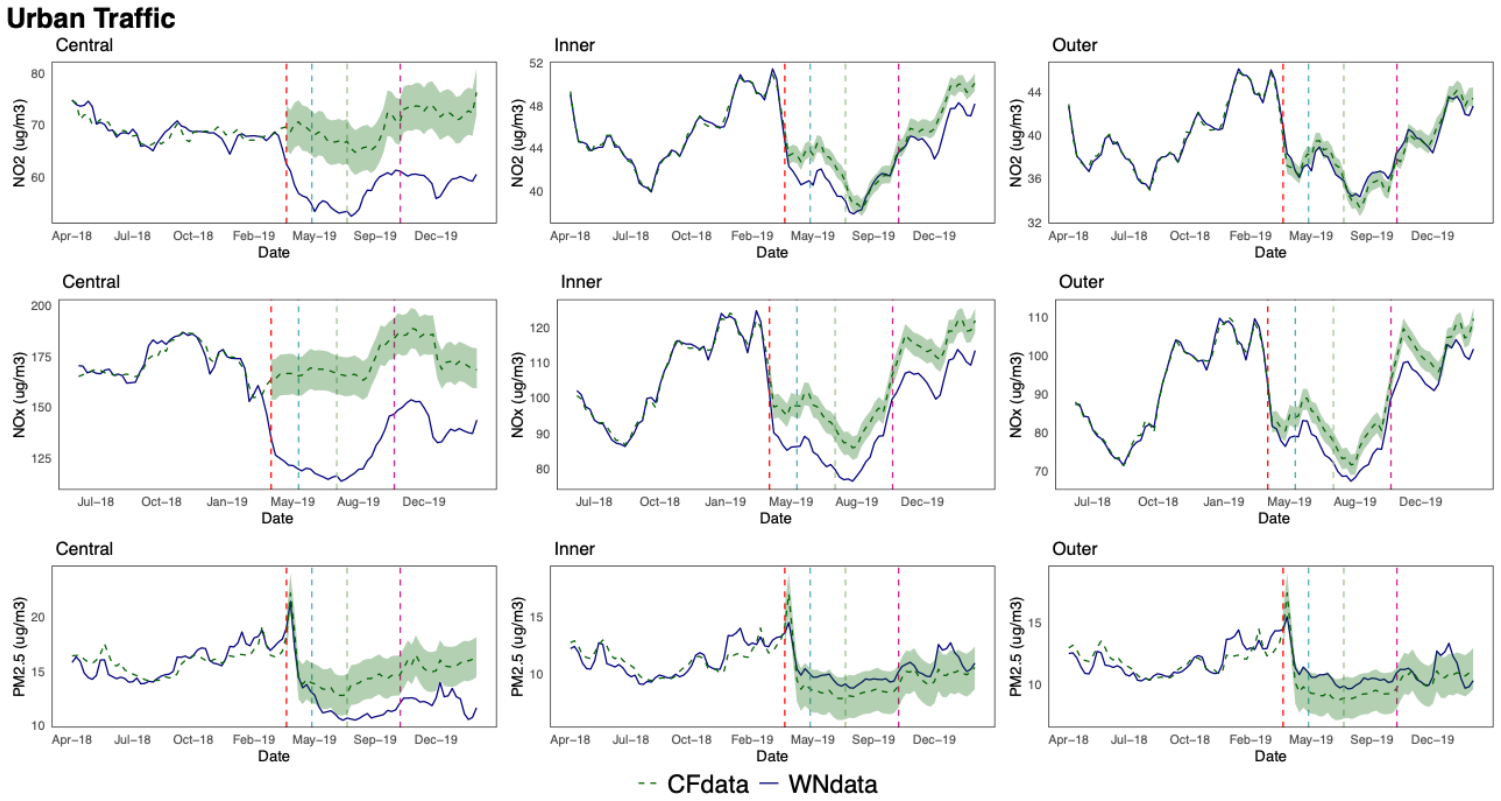
Meteorological data

- NOAA: Temperature, relative humidity, wind speed and wind direction

- ERA5: surface net solar radiation, total precipitation, boundary layer height, total cloud cover and surface pressure extracted from ERA5 reanalysis data

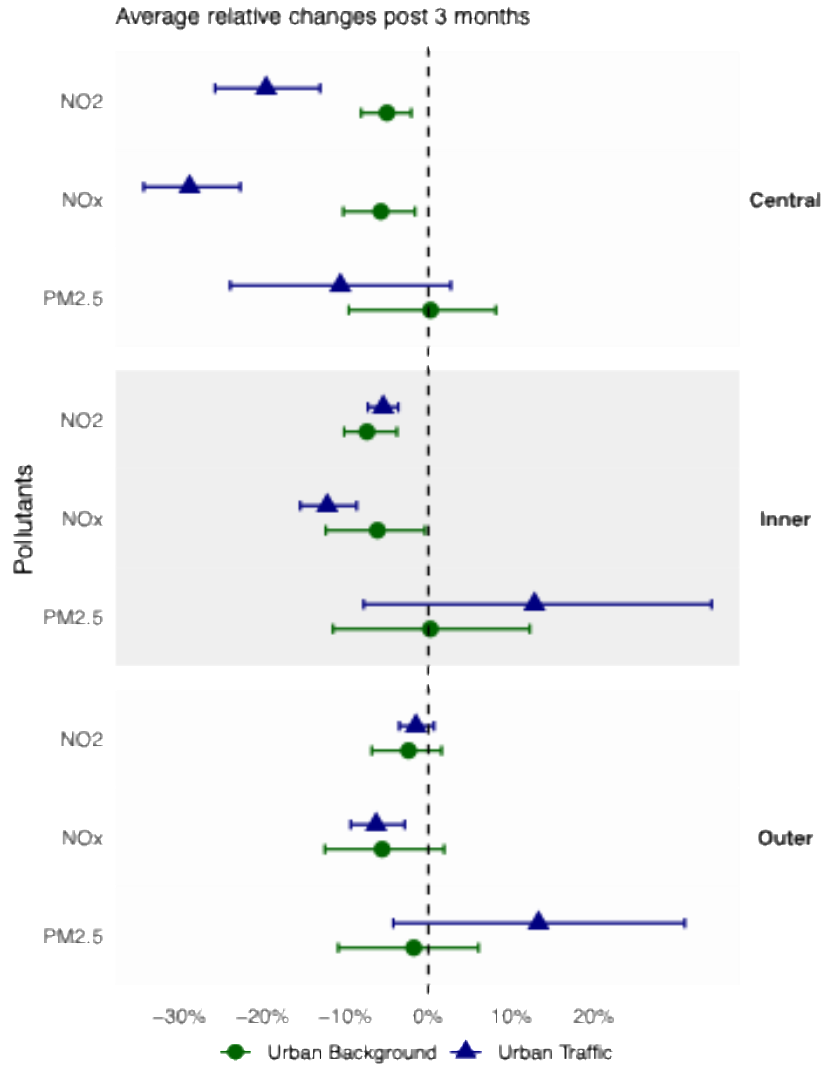
Results

ULEZ_Central 2019-04-08



Counterfactual data compared with Weather normalization data

$$P = \frac{C_{\mathbf{wn}} - C_{\mathbf{Counterfactual}}}{C_{\mathbf{Counterfactual}}} \times 100\%$$

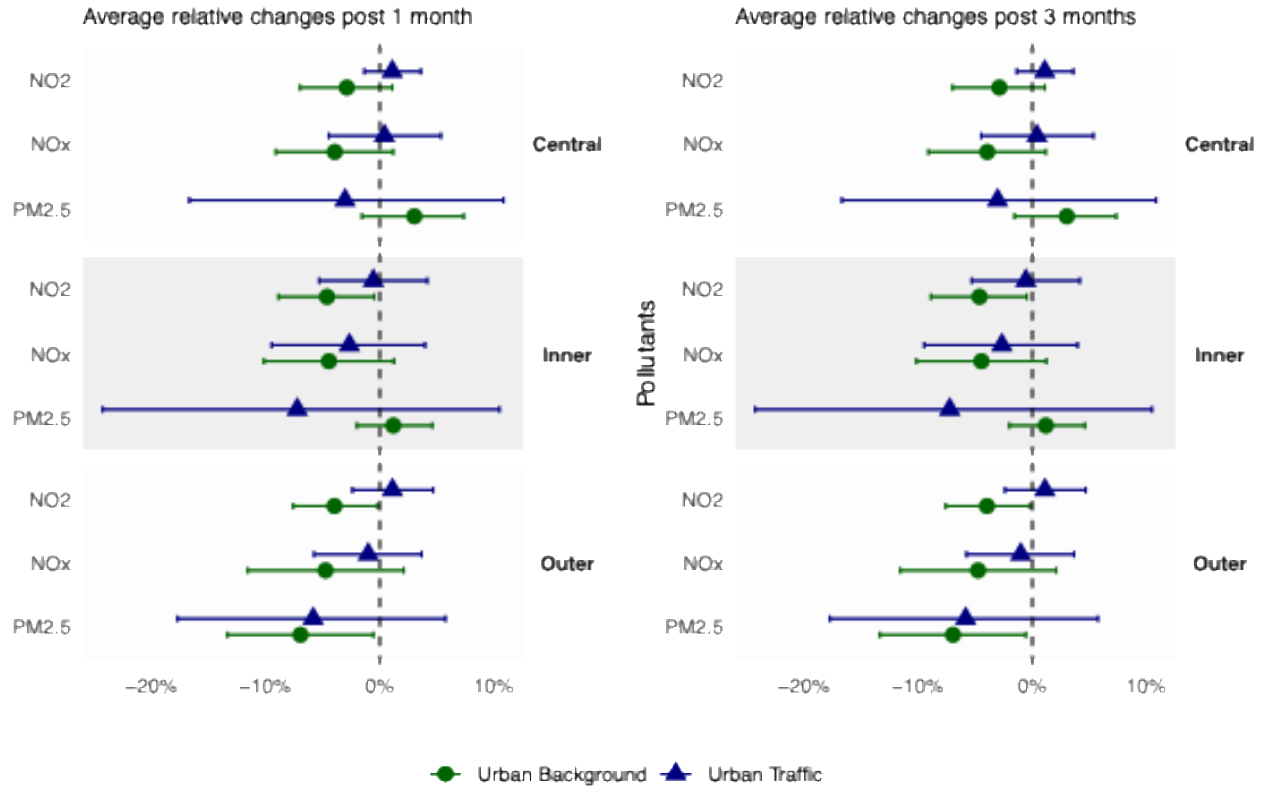


- Three months for Central London average 19.6% and 28.8% for NO_2 and NO_x.

Results

ULEZ Expansion (ULEZ_Inner and ULEZ_Wide) effect

ULEZ_Wide post 1 month and 3 months results



ULEZ_Central, ULEZ_Inner, ULEZ_Wide, effects on NO_2 for Urban Traffic sites

Area\Policy	ULEZ_Central		ULEZ_Inner		ULEZ_Wide	
	1 month	3 months	1 month	3 months	1 months	3 months
Center	-19%	-19.6%	+5%*	NA	+0.8%*	+1.1%*
Inner	-5.4%	-5.4%	+3%*	NA	-1.2%*	-0.5%*
Outer	-0.4%	-1%*	-5%	NA	+1%*	+1.1%*

* Means that the figure is not significant

Discussion

ML+ASCM compared to other methods

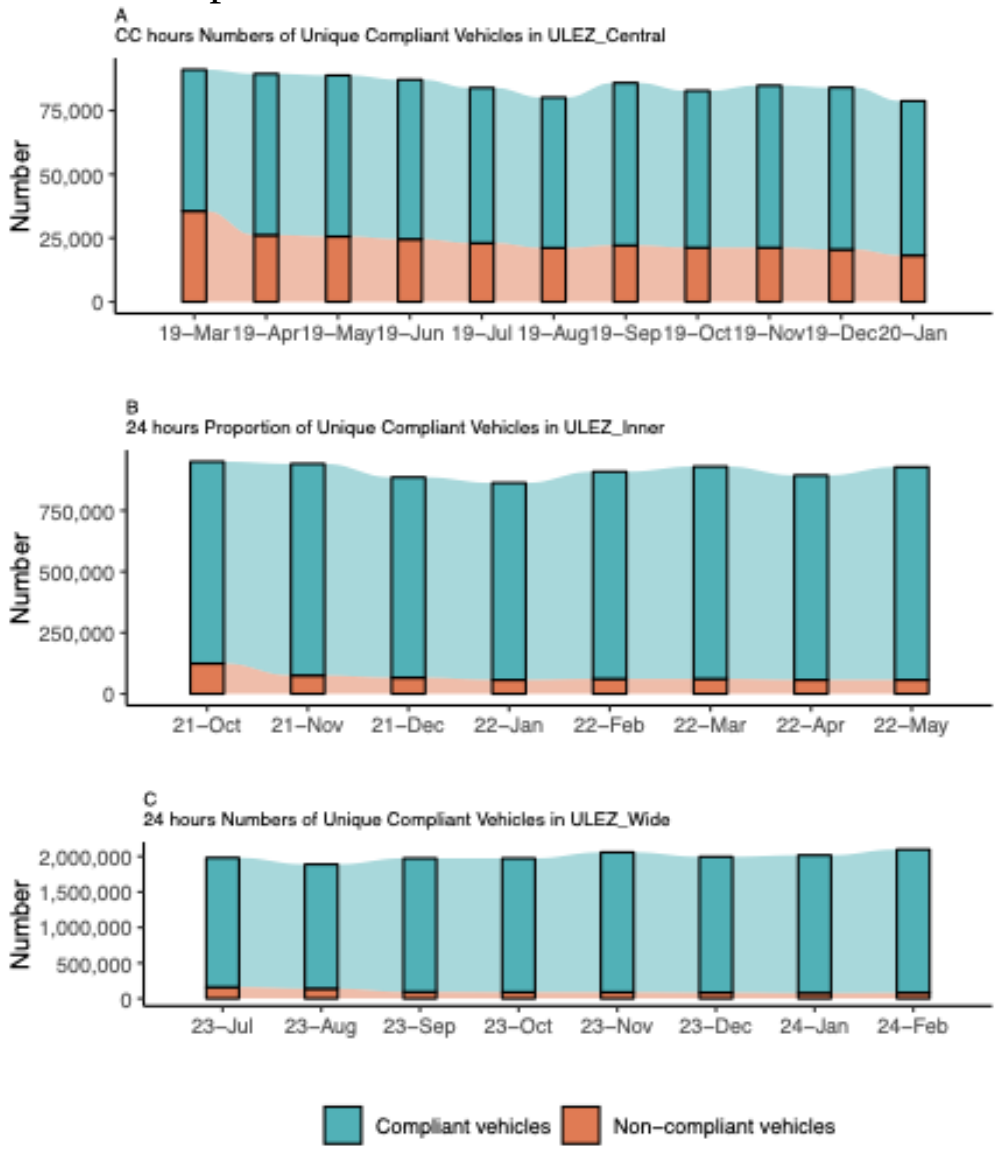
Pollutants ($\mu g/m^{-3}$)		ML+ASCM	Observation + ASCM	ML+RDD (Ma et al. (2021))
ULEZ_Central	NO_2	-13.24 (-17.4, -8.7)	-15.0 (-34.7, 5.72)*	-4.55 (-7.27,-1.84)
	$PM_{2.5}$	-0.44 (-2.17, 1.29)*	0.74 (-5.1, 6.7)*	2.23 (0.71, 3.75)
ULEZ_Wide	NO_2	0.32 (-0.55, 1.23)*	1.98 (-4.08,8.24)*	2.48 (1.22,3.73)
	$PM_{2.5}$	-0.15 (-1.46, 1.20)*	0.17 (-5.97,6.59)*	0.65 (-0.08,1.36)*

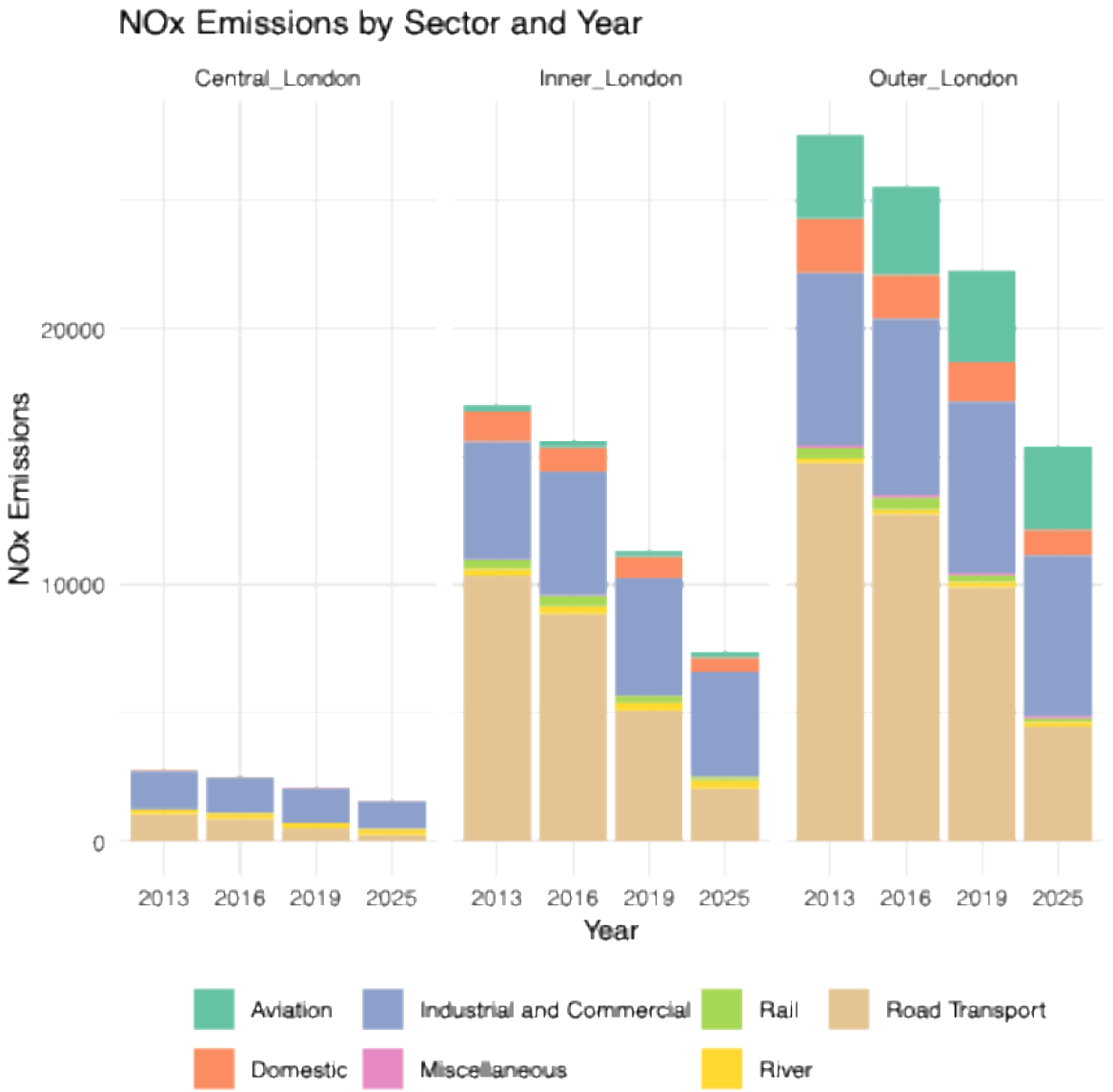
Pollutants ($\mu g/m^{-3}$)		Simple Difference (WN)	Simple Difference (Ob)	Method from Mayor of London report
ULEZ_Central	NO_2	0.05	0.60	-15.83
	$PM_{2.5}$	-0.19	-2.97	-0.85
ULEZ_Wide	NO_2	-0.41	1.77	-14.85
	$PM_{2.5}$	-0.75	1.46	0.3

* Means that the figure is not significant

Discussion

Traffic compliant rate





Conclusion

- 1. Advanced ML + ASCM methods were applied to analyse the impact of ULEZ and its expansion.
- 2. ULEZ_Central has a significant impact on NO_2 and NO_x concentrations, with a significant reduction, especially at Urban Traffic monitoring sites.
- 3. ULEZ_Central exhibits a clear positive spillover effect, with significantly reductions in NO_2 and NO_x outside the ULEZ_Central area.
- 4. The expansion of ULEZ shows less impact NO_2 and NO_x compared to ULEZ_Central.
- 5. The ULEZ policy has an insignificant effect on $PM_{2.5}$ levels, highlighting that non-exhaust emissions require more attention for $PM_{2.5}$ reduction.
- 6. The major reason for ULEZ_Central's effectiveness is the substantial reduction in non-compliant vehicles.
- 7. Emissions from commercial, industrial, and residential sources remain key contributors to the emission of NO_x in London, indicating the need for emission control beyond just Road traffic.

Reference

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Thank you

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Appendix: Weather normalization

Variables for building a Machine learning model:
"date_unix","day_julian", "weekday", "hour", "temp", "RH", "ws ","wd", "ssr", "tp", "blh", "tcc", "sp"

Time variables

Meteorological Variables

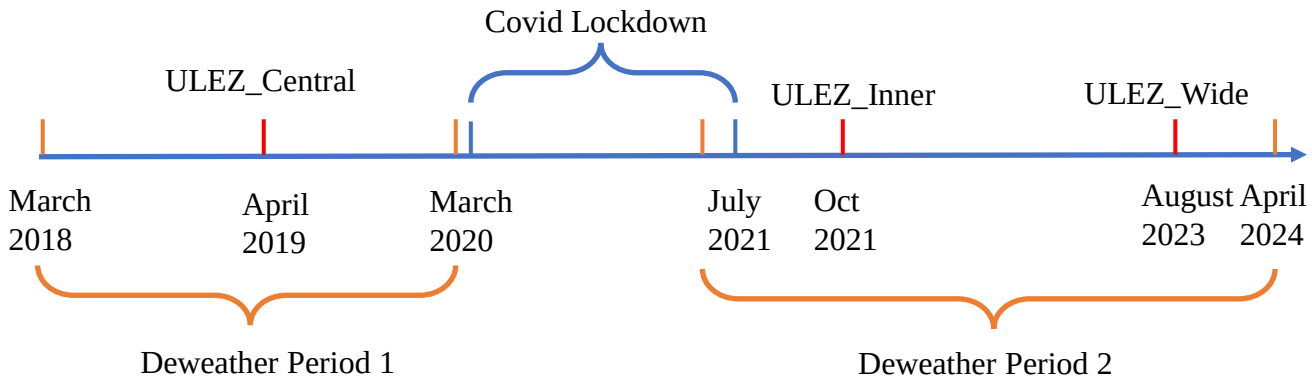
9:00 am 8th April 2021 for a pollutant like NO_2

Randomly resampled without replacement from historical Meteorological database, 9:00 am at 2 weeks before and 2 weeks after 8th April in each year.

Predict 150 times by ML model

Take the average = deweathered concentration

Deweather period



Appendix: Causal Inference

Causal impact: Augmented Synthetic Control Method (ASCM)

Control Group: Other sites in the UK (Urban background and Urban Traffic)

Aberdeen_Union_Street_Roadside, Belfast_Centre, Birmingham_A4540_Roadside, Bristol_Temple_Way…

Treatment Group: London sites: Aggregated by site types and areas