Glasgow Low Emission Zone: Simulating the Change in Traffic Flow and the Following Health Outcome

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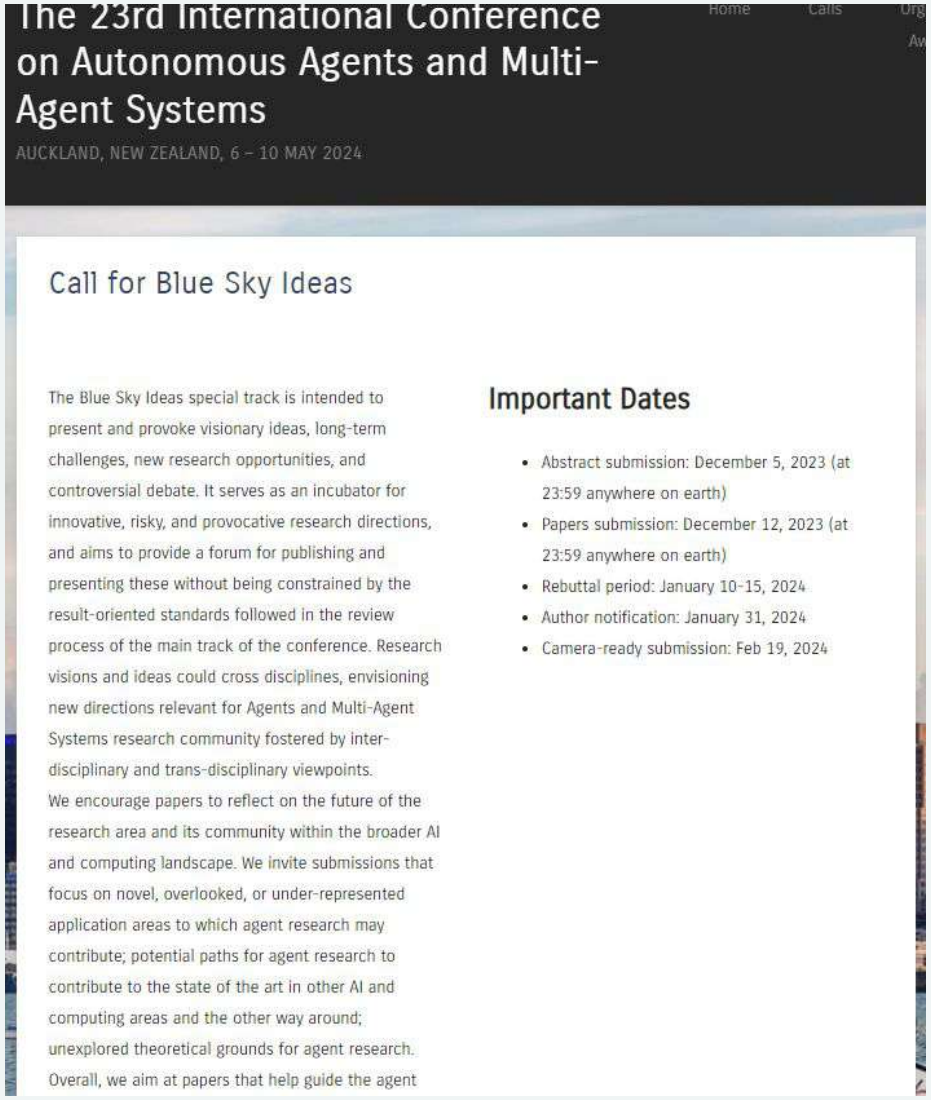
AAMAS 2024 Blue Sky Ideas

Are Low Emission Zones Impactful for Air Quality and Human Health?



1. Context


LOW
EMISSION
ZONE
LEZ
Exemptions
apply
Enforced from 1 June 2023

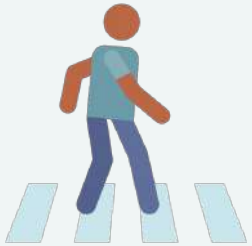
Objective

To develop an agent-based traffic simulation to assess the impact of Glasgow's LEZ Scheme on traffic flows, emissions, and pedestrian exposure

Q1

How does traffic-related emissions affect local air quality?

Q2



Do we see any health effects on pedestrians and drivers before and after LEZ enforcement?

Q3

How can we test different LEZ scenarios?

International Meeting Group: (Bi-)Monthly

Team

- University of Glasgow, University of Leeds, Technical University of Munich (TUM), UU
- Discuss updates every 1-2 months
- Thesis: Sonali Abeysinghe (TUM)
- All interested in ABM and traffic sims

Current agenda

- How to build demand modelling in SUMO
- Activity Based Demand Generation: You can do so by using OD matrices or Counts from collection points

Update Nov 20th!
The Urban Big Data Centre (UBDC) will soon release the OD matrix based on the mobile phone data
Will be released to the members of Glasgow Uni first!

2. What feedback have I received at the ESSA Conf 2023?

Comments

ABMs, even for modelling short-term health outcomes should be very **temporally aggregated**

Air quality reduction vs Air quality impact on health is different so you should be mindful when you build your model

Fixing OSM network? Hmmm...how bad is OSM in Glasgow?

Focus on health impact rather than tweaking the traffic

Why are pedestrians involved in the model?

Comments on and on

ODD's are good but for communication we have other platforms such as **RAT** and **EABSS**

Cars are bad!

Experiment those with a **"Car Free" Scenario** and provide insight for what if we want a zero-emission city

Why SUMO not GAMA?

Policy co-creation requires high-abstract explanation. Would that help your model?

3. Model Development

Project Overview

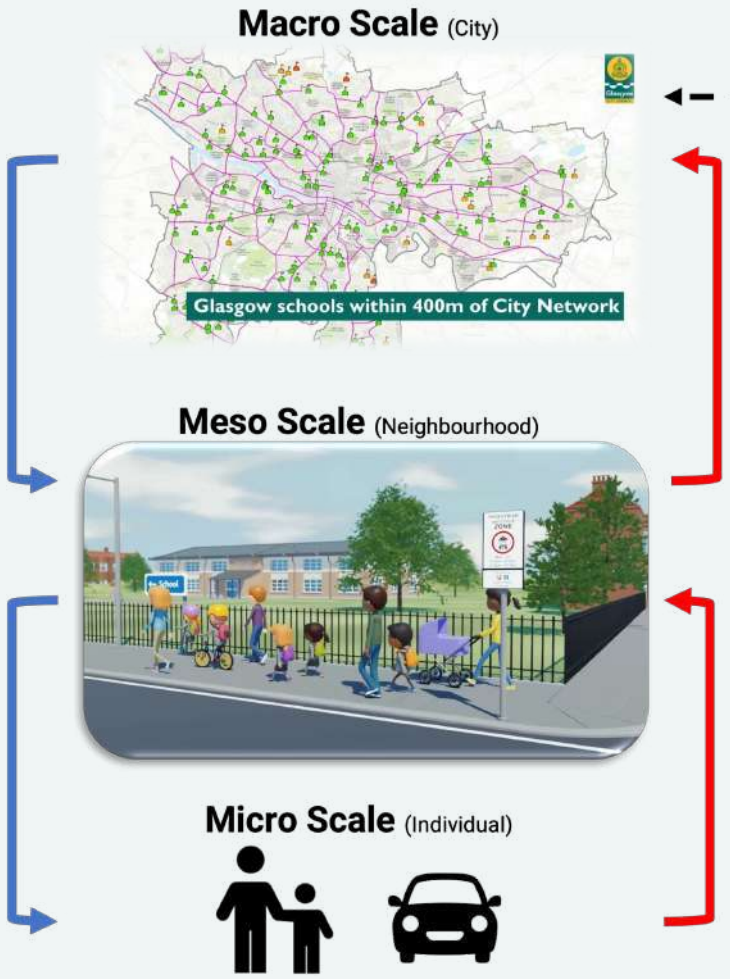
Where we are

1. Data Collection
- Air Pollution
- Fleet

2. Agent Decision making
- Behaviour
- Mobility Patterns

3. Health Vulnerability
- Exposure
- Health Risk

4. Outcome
- Air quality
- Risk by group



Software Vision

Simulation Software:

SUMO
Simulation of Urban Mobility

Our Collaborators

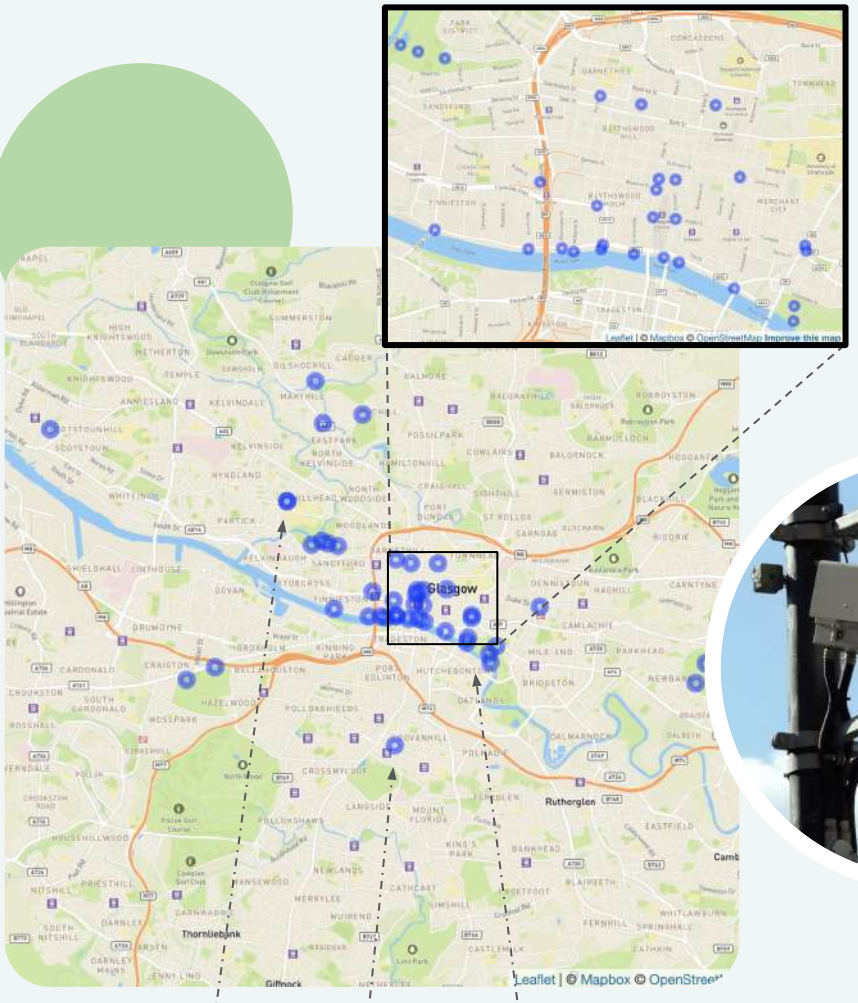
UNIVERSITY OF LEEDS

TU Delft

4. Data Analysis

Traffic & NO2

Using UBDC CCTV Data and the Automatic Urban and Rural Network (AURN)



Traffic Counts
Feb-Oct 2023

UBDC CCTV Data
https://glasgow-cctv.ubdc.ac.uk/

22 CCTV Cameras within the LEZ boundary

YOLO Based Multi-Objective Vehicle Detection and Tracking: 22 out of 61 cameras. Of these cameras:

- 21-25 mainly detects bikes and buses followed by the River Clyde
- The others detecting roads

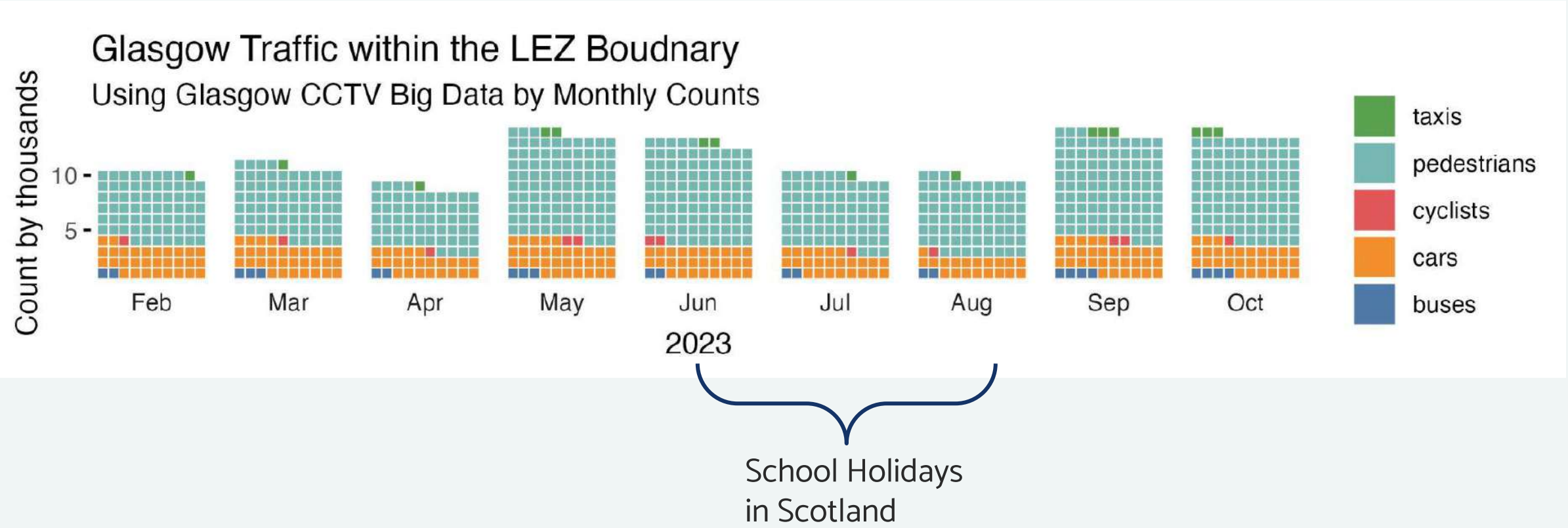
Horizontal

- Killermont St: 58
- George Sq: 425, 458
- Argyle St: 68, 426, 431
- Broomielaw: 18, 20
- Clyde (Segregated): 21-25

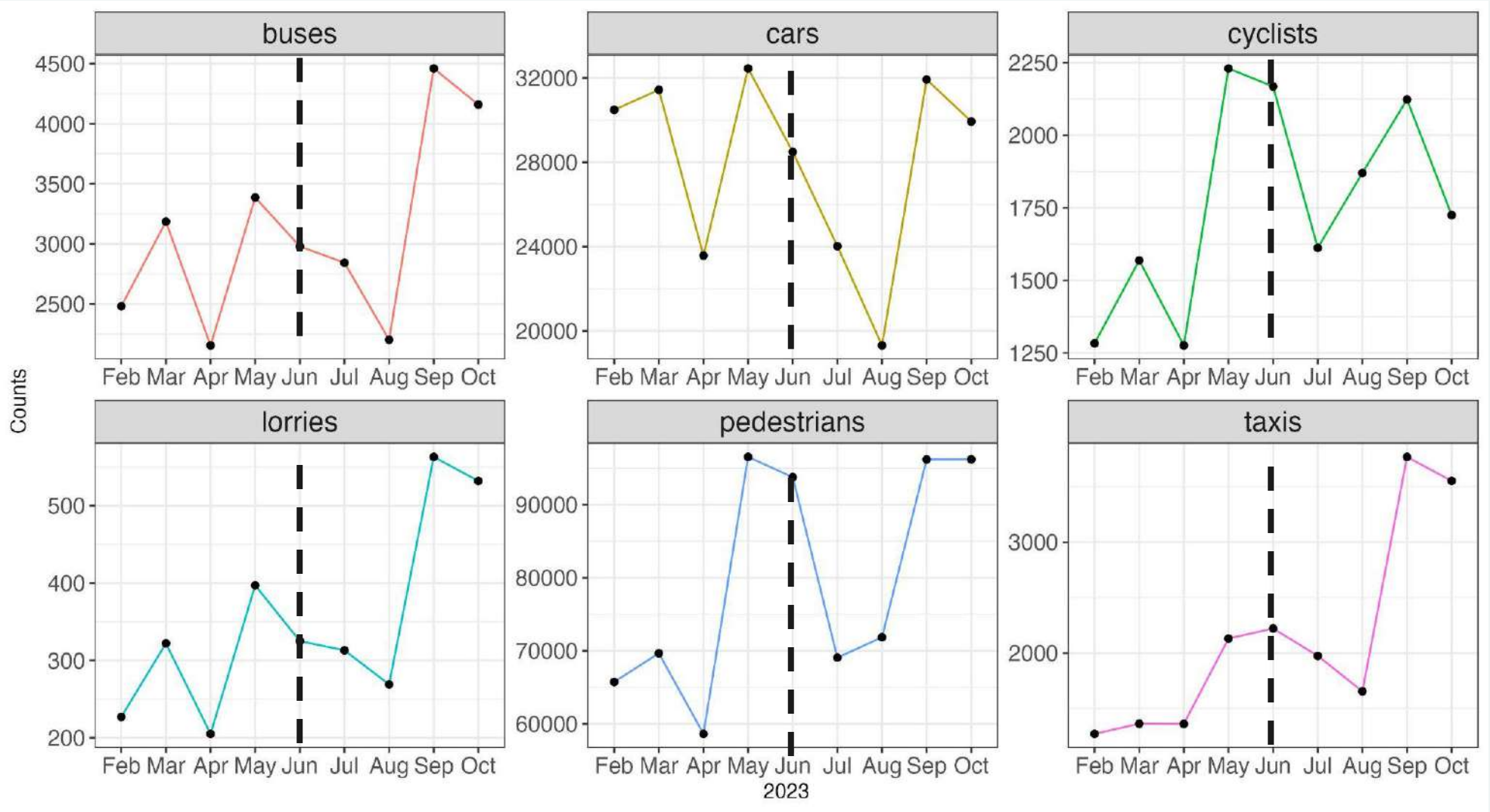
Vertical

- Pitt St: 54
- W Campbell St: 460
- Hope St: 40, 75
- High St: 424, 428

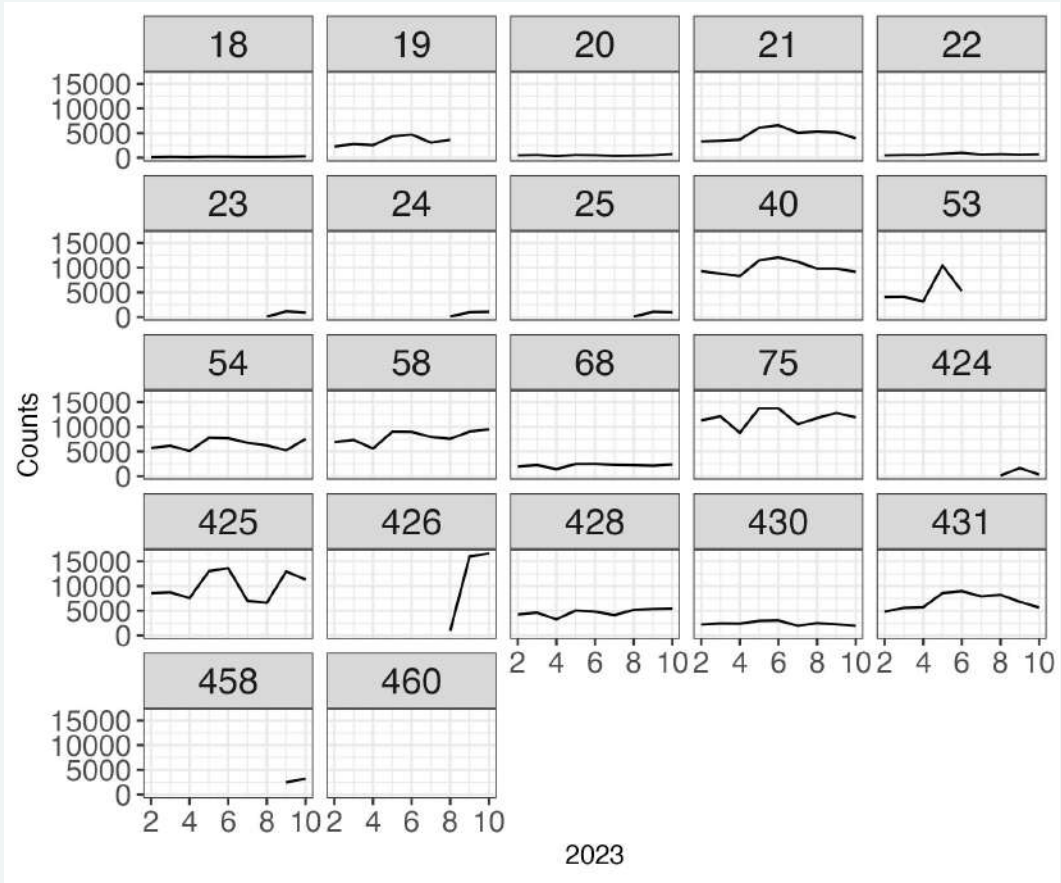
Let's take a look at Glasgow's Traffic flow



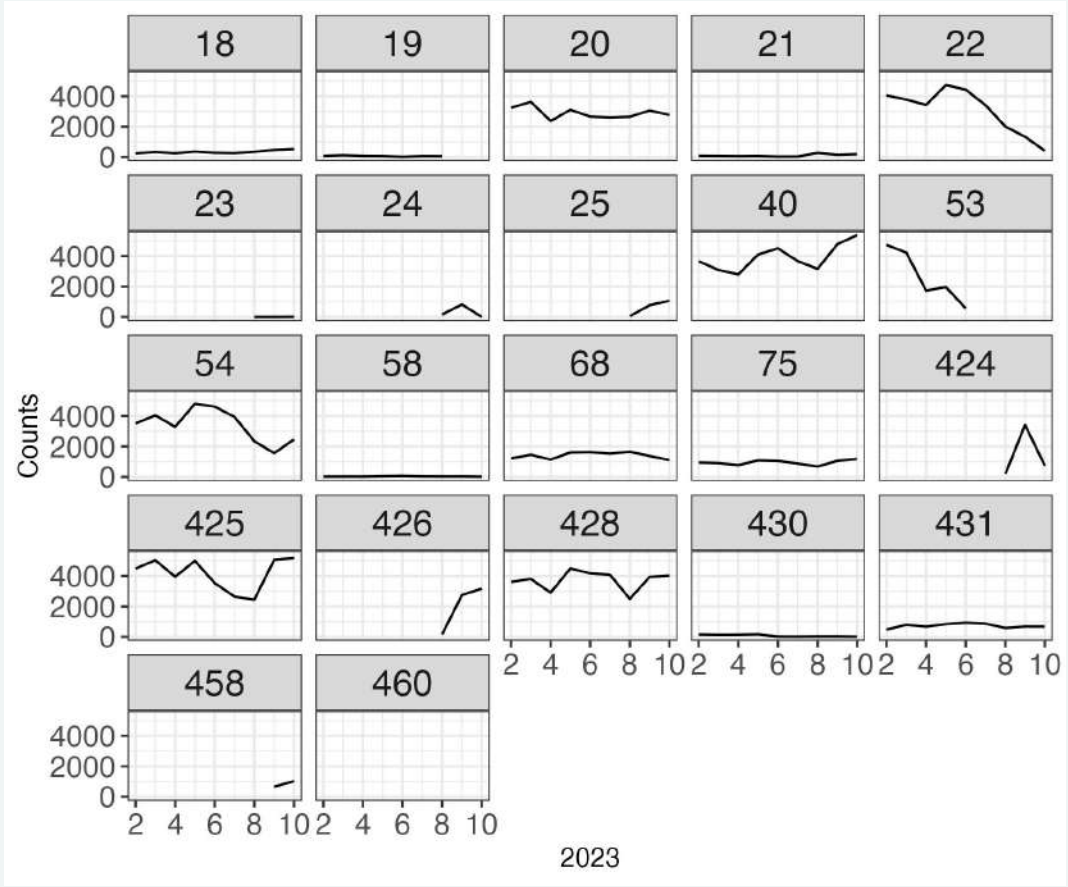
Monthly counts of traffic within LEZ by modes

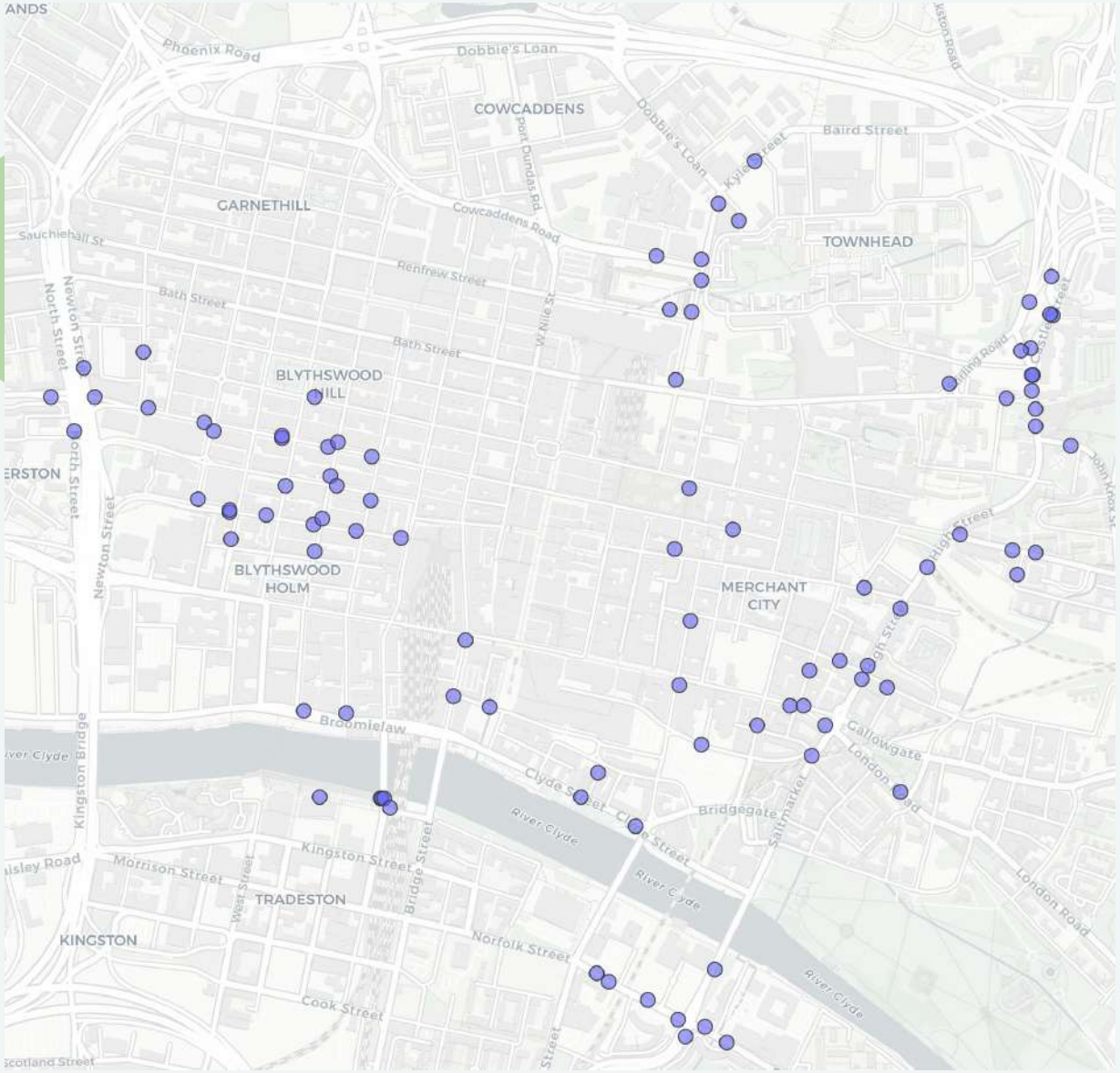


By Pedestrians



By Private Vehicles

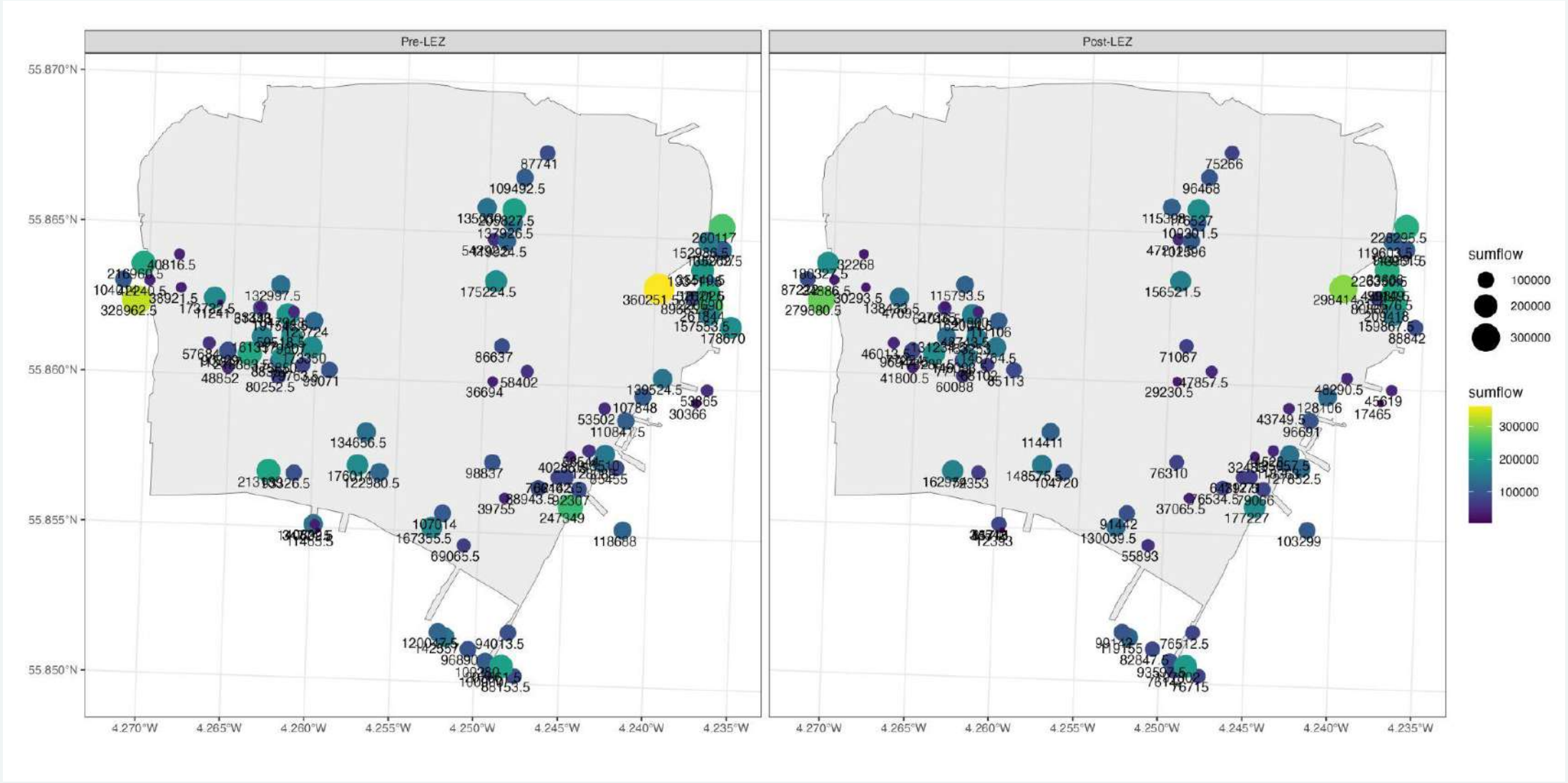




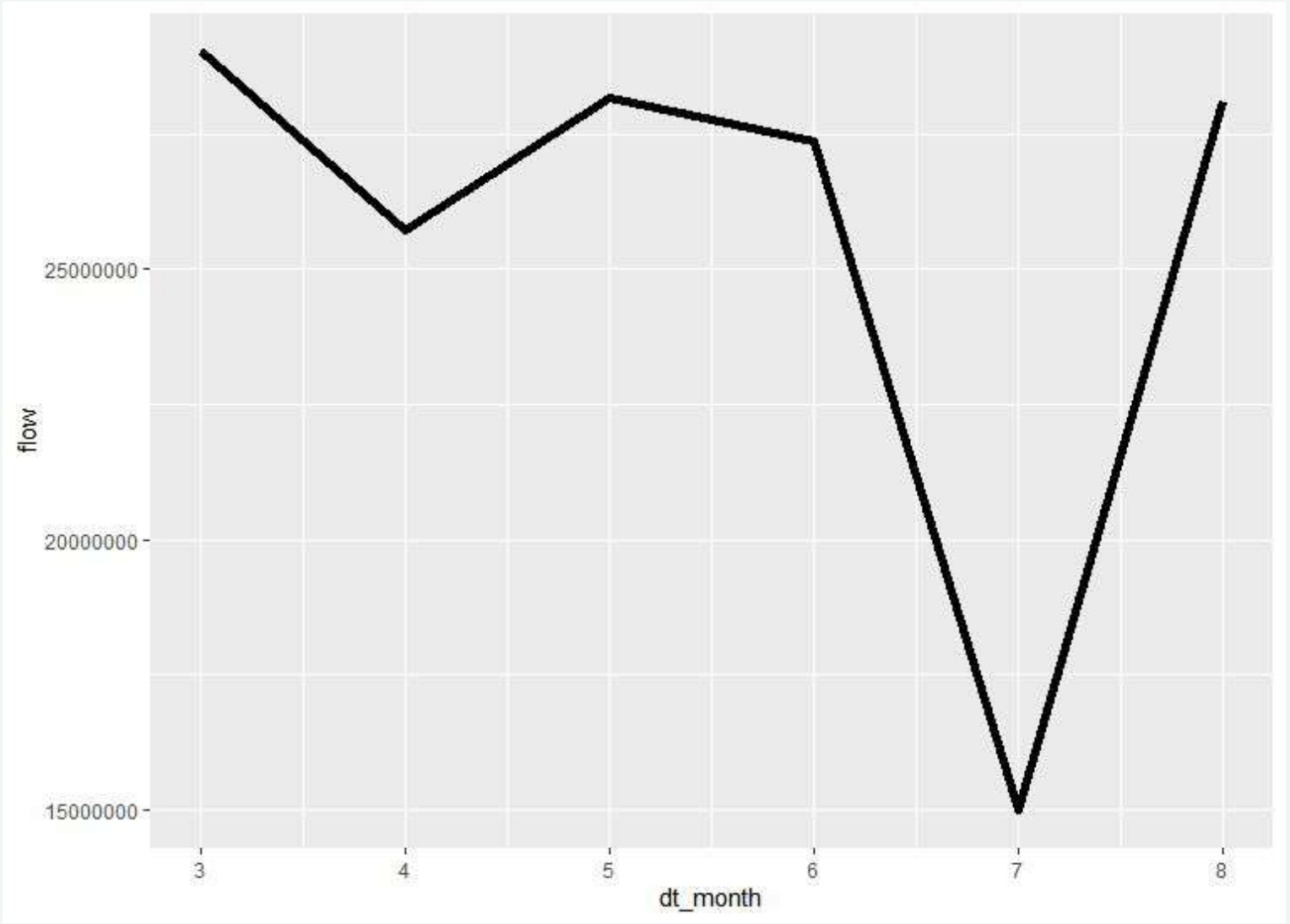
Traffic Counts
Mar-Aug 2023

Glasgow OpenAPI
https://developer.glasgow.gov.uk/api-details#api=traffic&operation=6303582e2bca805cda07be52

Traffic Counts: Pre-LEZ vs Post-LEZ



Monthly counts of SCOOT data within LEZ

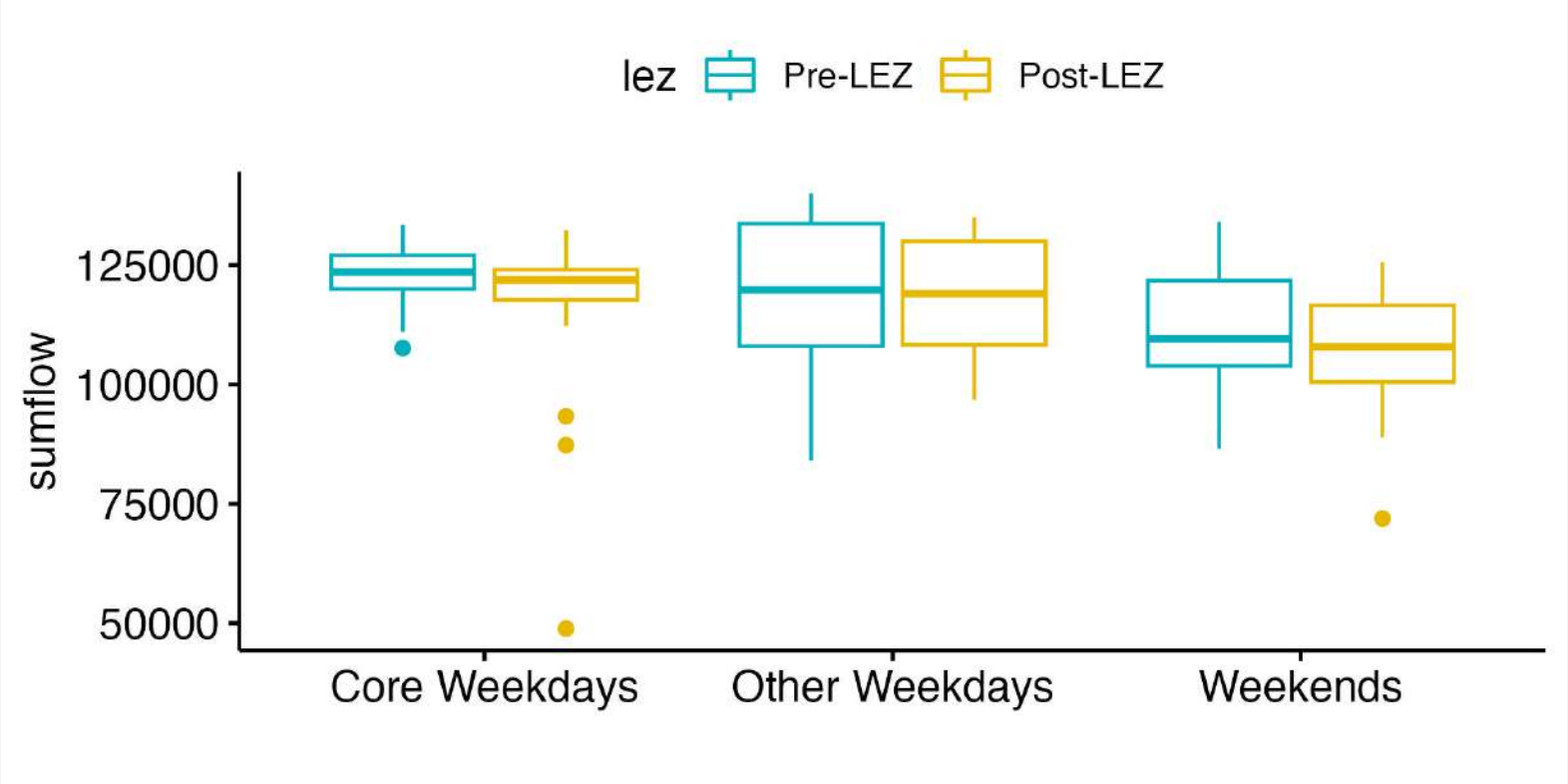


ANOVA: Weekdays Comparison

Core Weekdays:
Tue-Thur

Other Weekdays:
Mon, Fri

Weekends:
Sat-Sun



Effect	DFn	DFd	F	p	p<.05	ges
1 week_group	2	166	10.704	0.0000424	*	0.114
2 lez	1	166	3.077	0.0810000		0.018

ANOVA: Other Results

Pre-LEZ vs Post-LEZ

	Effect	DFn	DFd	F	p	p<.05	ges
1	dt_hour	1	45	13.862	0.000545	*	0.235
2	lez	1	45	1.738	0.194000		0.037

Is there a statistical difference in traffic levels between hours?

	Effect	DFn	DFd	F	p	p<.05	ges
1	dt_date	1	167	2.256	0.135		0.013
2	lez	1	167	0.175	0.676		0.001

Did the volume of traffic vary statistically from day to day?

	Effect	DFn	DFd	F	p	p<.05	ges
1	dt_week	1	24	0.647	0.429		0.026000
2	lez	1	24	0.006	0.941		0.000235

Is there a statistical difference in traffic levels between weeks?

Air Quality

Provided by AURN via the “openair” R Package

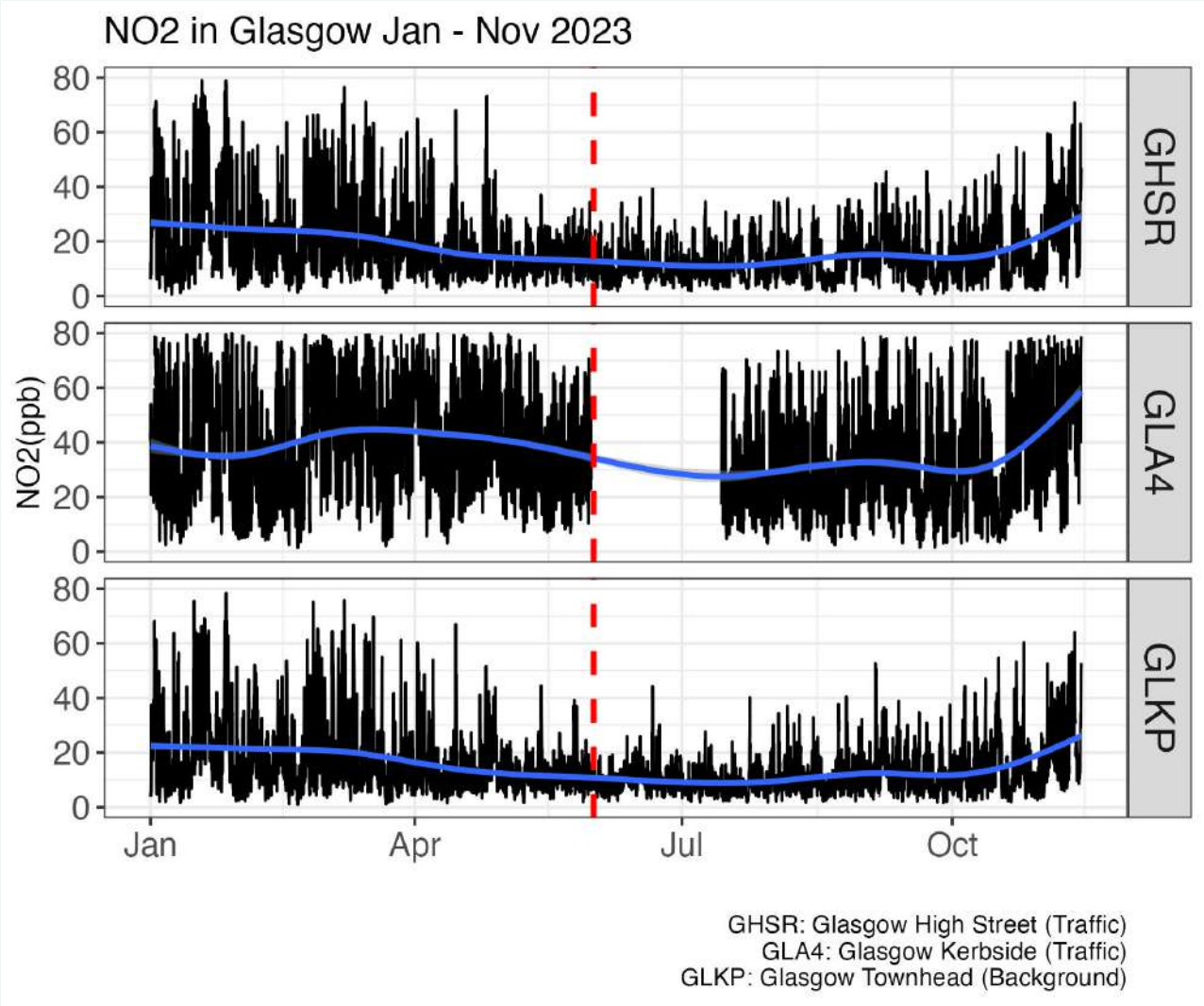
Three Monitoring Stations

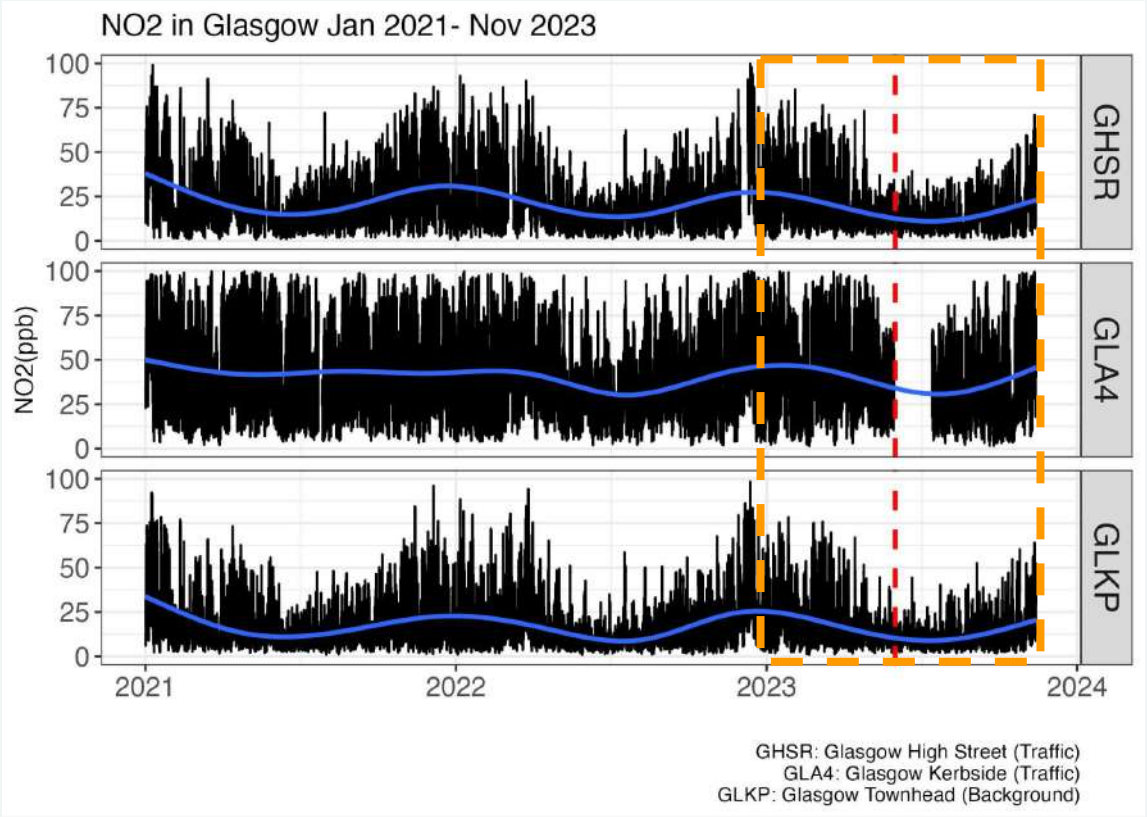
GLA4: Urban Traffic

GLKP: Urban Background

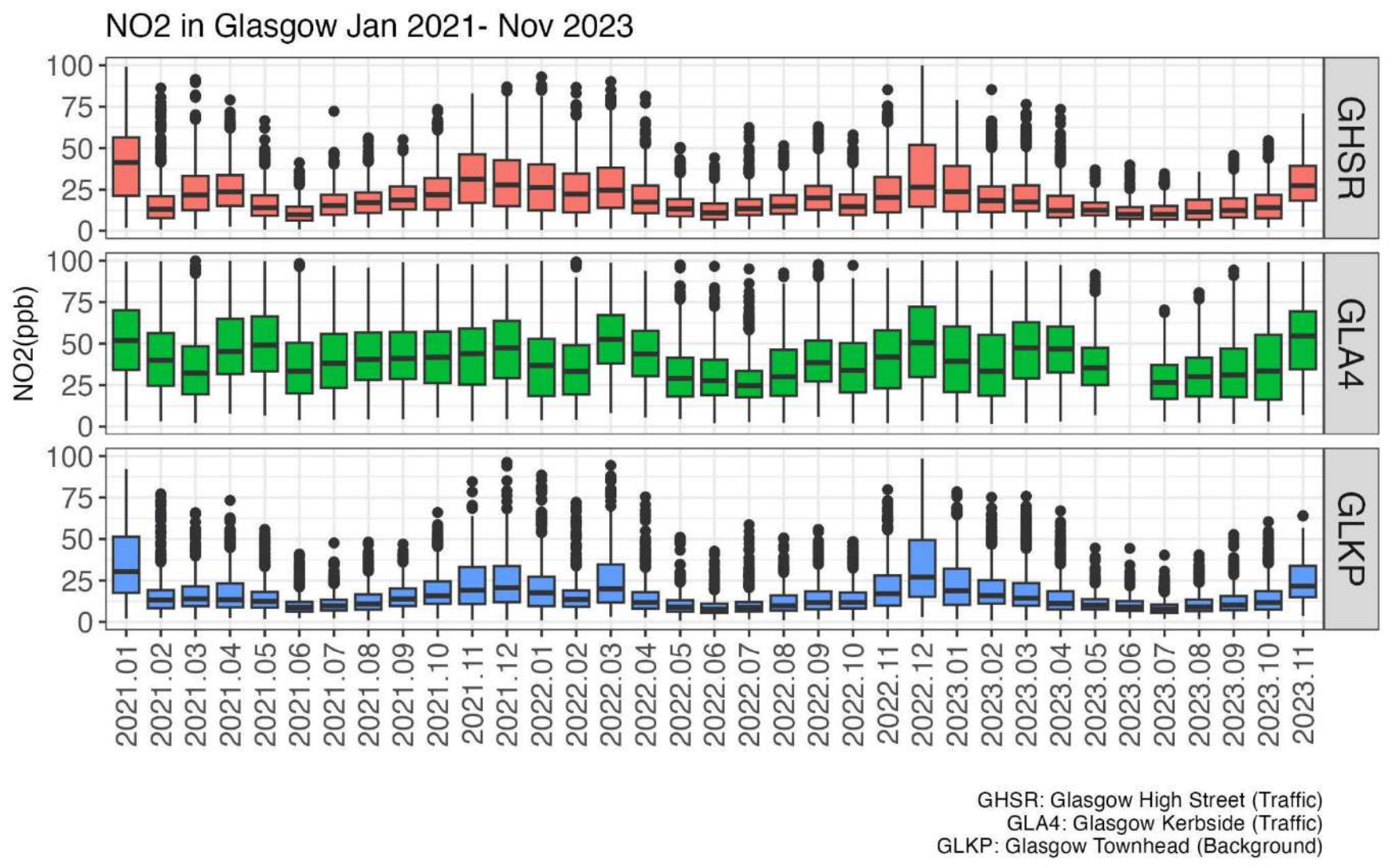
GHSR: Urban Traffic

NO2 over time





NO2 over time



Some Stats

	hour	GHSR	GLA4	GLKP
	<int>	<dbl>	<dbl>	<dbl>
1	0	15.9	28.0	14.8
2	1	13.1	21.7	12.9
3	2	12.4	20.5	12.3
4	3	12.7	19.6	12.3
5	4	14.9	23.8	13.2
6	5	17.8	32.7	15.7
7	6	22.4	44.7	19.7
8	7	26.3	50.5	22.5
9	8	27.4	52.4	22.7
10	9	25.3	50.1	20.3
11	10	23.0	46.6	17.1
12	11	21.7	45.1	15.2
13	12	20.6	42.9	14.0
14	13	20.5	43.5	13.4
15	14	21.3	45.2	13.7
16	15	22.3	48.5	15.0
17	16	23.7	51.7	16.7
18	17	24.5	52.5	18.1
19	18	24.2	51.2	18.8
20	19	22.9	48.1	18.7
21	20	21.8	46.8	18.6
22	21	20.8	45.3	18.6
23	22	19.6	44.1	17.9
24	23	18.1	36.8	16.7

Hourly Measurement

Normally when the sun comes up (increasing ground-level O3) then the NO2 decreases. However, this is not always the case.

Traffic is an important trigger to heighten NO2

NO_x emissions from burning fossil fuels are mainly as NO, but some sources can release a lot of NO_x as NO_2. These **primary** NO_2 emissions are particularly important from diesel vehicles (especially when moving slowly), and can make up as much as 25% of the total NO_x emissions from this source. One reason for this is as a side-effect of measures that have been developed to reduce emissions of **particulate matter** from diesel vehicles by treating the exhaust using diesel **particulate filters**. These primary NO_2 emissions can lead to high concentrations of NO_2 at the roadside, especially where there are many diesel vehicles.

Some Stats

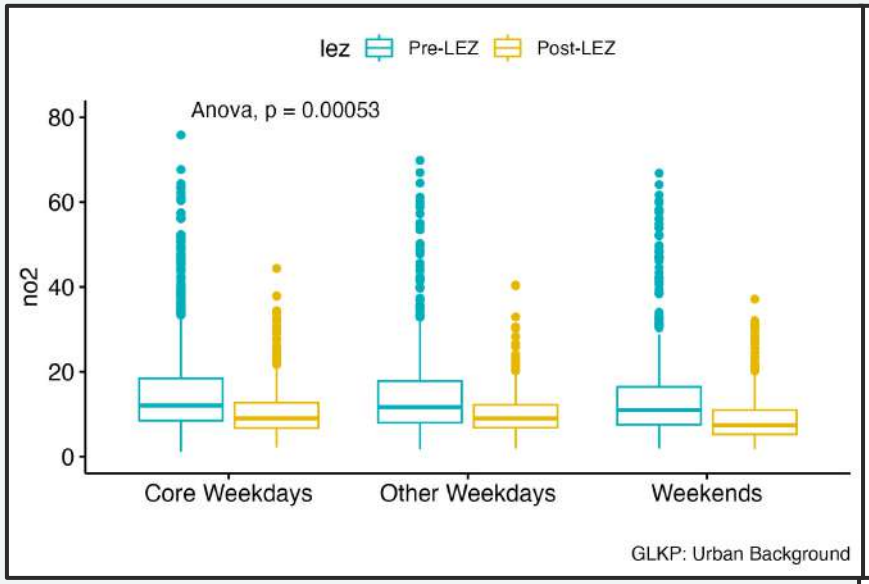
	month	GHSR	GLA4	GLKP
	<dbl>	<dbl>	<dbl>	<dbl>
1	1	32.0	45.2	26.3
2	2	21.2	39.5	17.2
3	3	24.4	46.1	20.3
4	4	20.7	47.4	15.9
5	5	14.9	40.0	12.1
6	6	11.6	34.5	9.73
7	7	14.3	32.2	9.96
8	8	16.0	36.2	11.9
9	9	18.8	40.0	14.2
10	10	19.0	38.7	15.7
11	11	28.4	44.9	22.5
12	12	32.0	50.8	28.7

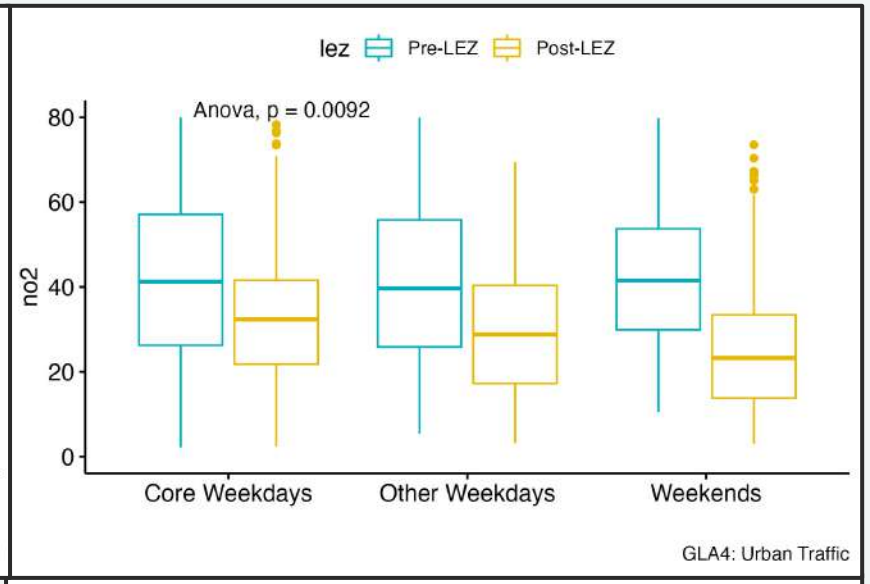
Monthly Measurement

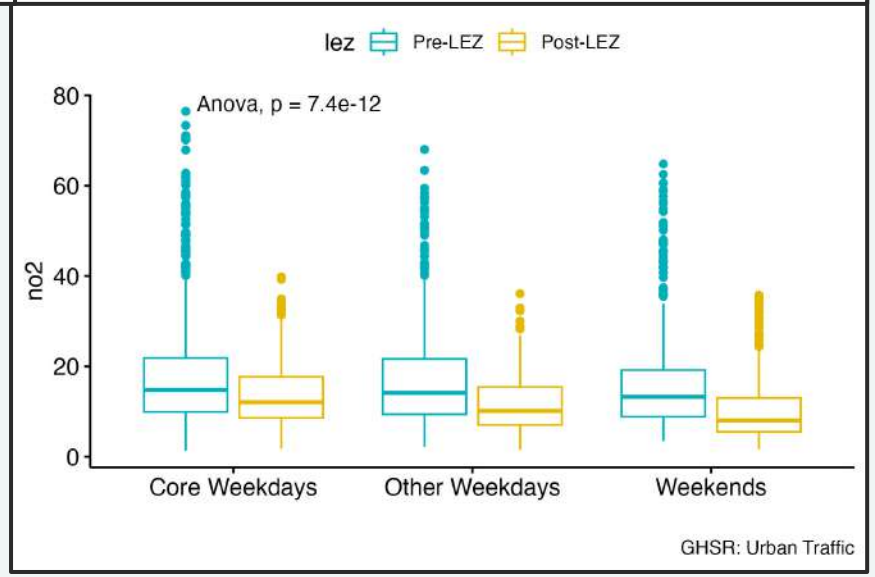
Winter is the most polluted season of the year, even more than summer and far more difficult than spring –except for those suffering from allergies, and autumn.

The culprit is cold, and this in several different ways. On the one hand, colder temperatures increase fossil fuel combustion for heating and often a higher use of personal vehicles for transport triggering spikes of some of the most harmful components, such as fine particulate matter (PM2.5), nitrogen dioxide (NO2) and sulfur dioxide (SO2) but also carbon monoxide (CO) and carbon dioxide (CO2).

ANOVA: Pre-LEZ vs Post-LEZ







Pre-LEZ: Mar - May 2023
Post-LEZ: Jun - Aug 2023

We also added January February October and November and got similar results