WM-NET ZERO

wellcome

WM-NETZERO@CONTACTS.BHAM.AC.UK

@WMNETZERO

Air Quality Policy Evaluation Tool (AQPET)

Yuqing Dai [1], Bowen Liu [2], Chengxu Tong [1], Zongbo Shi [1]

[1] School of Geography, Earth and Environmental Sciences
[2] Birmingham Business School

WM-NET ZERO
A Health-centred Systems Approach towards Net-Zero: Transforming regional climate mitigation policies

UNIVERSITY OF BIRMINGHAM

wellcome · THE UNIVERSITY OF BIRMINGHAM · CERC · West Midlands Combined Authority · Coventry City Council · UNIVERSITY OF SURREY · University of York · Birmingham City Council · Sandwell Metropolitan Borough Council · Department for Environment Food & Rural Affairs · Solihull Metropolitan Borough Council · wsp · UK:100 · CLEAN AIR FUND

What is air pollution?

Pollutants in the air that interferes with human health, welfare or produces other harmful environmental effects

- NOx
- O_3
- $PM_{2.5}$
- …

Source: BBC News

What are Interventions for Air Pollution?

Intentional *and* ***unintentional*** *actions or strategies that reduce air pollution.*

Policy

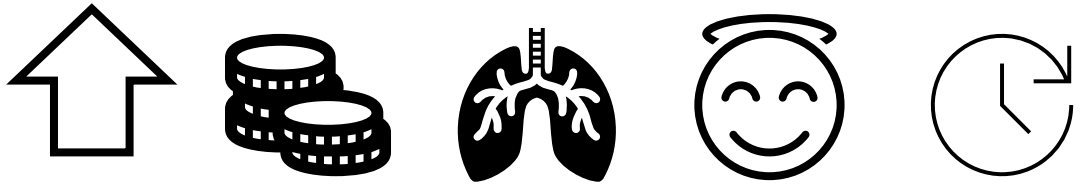
Clean Air Zone (e.g., London, Birmingham)

Technology

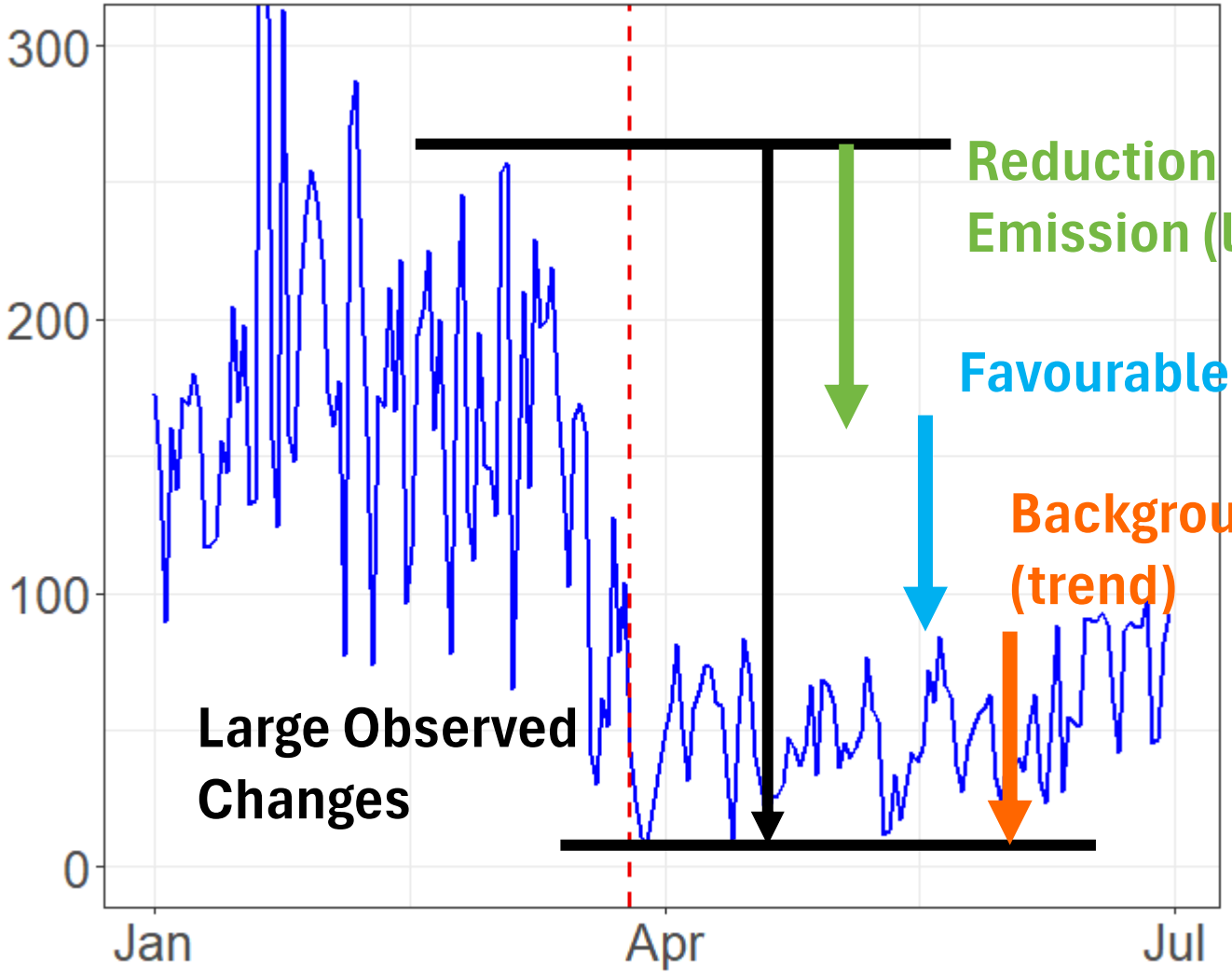
Car Electrification

Behaviour changes

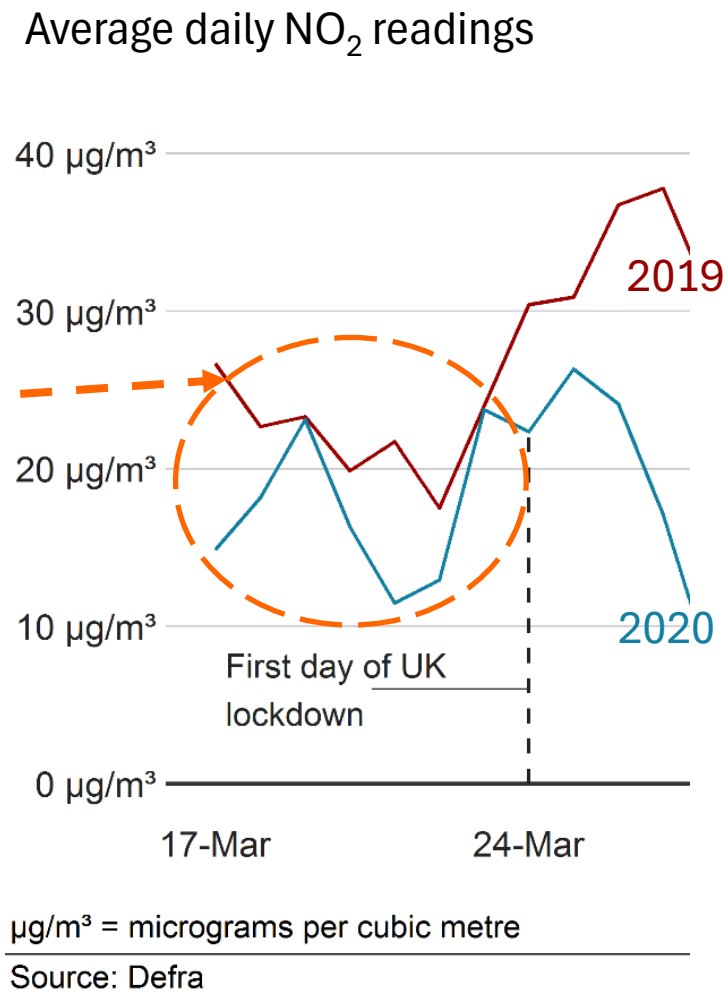
Carpooling



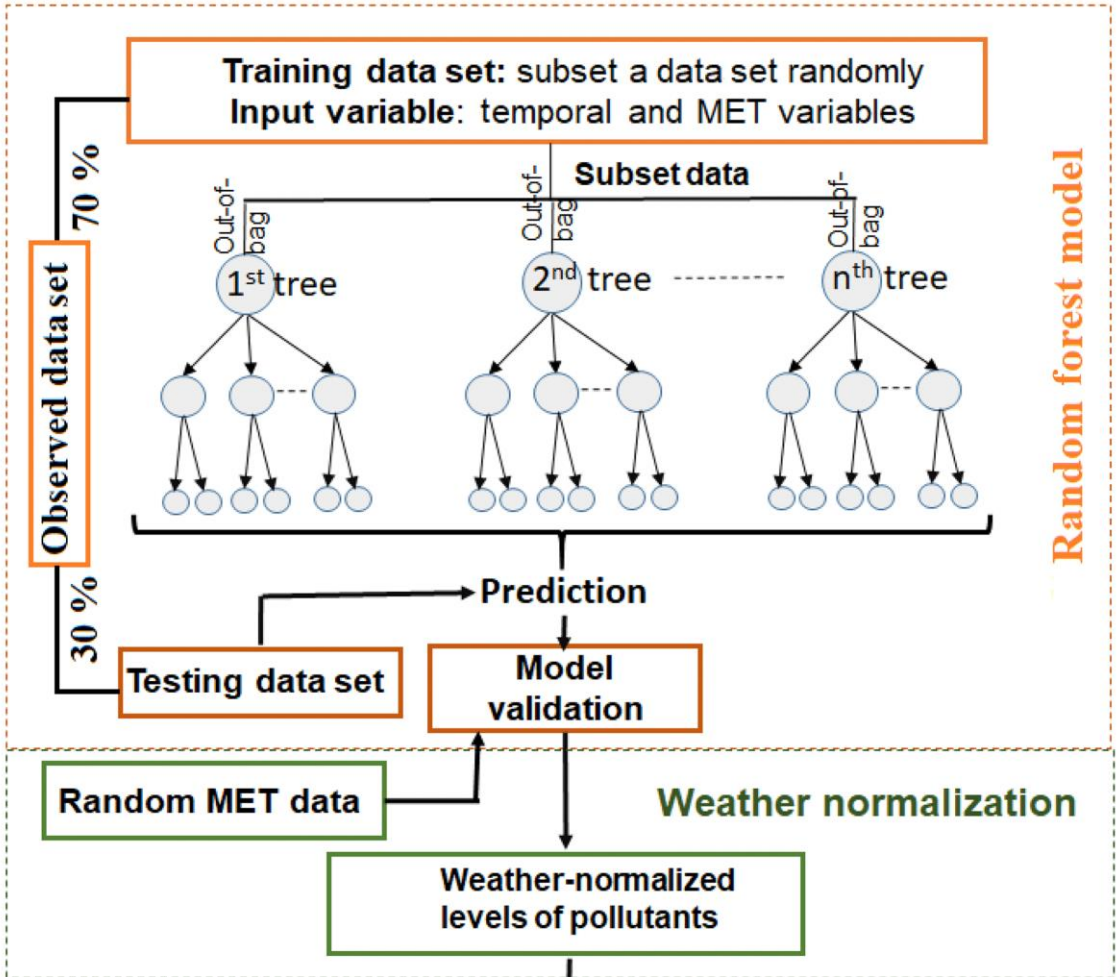
Complex Task: COVID-19 impacts on NO_X

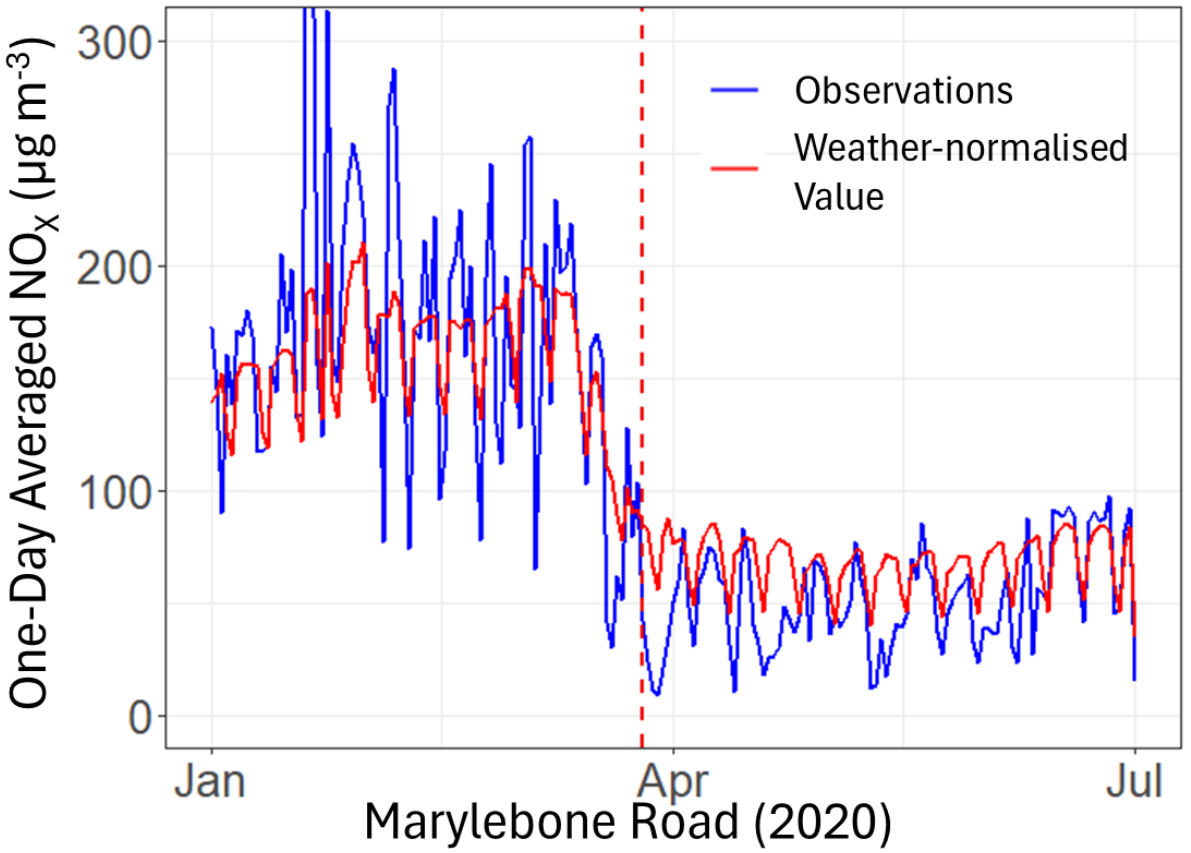


NO_X ($\mu g\ m^{-3}$) at Marylebone Road (2020)



* Solution: Weather impacts



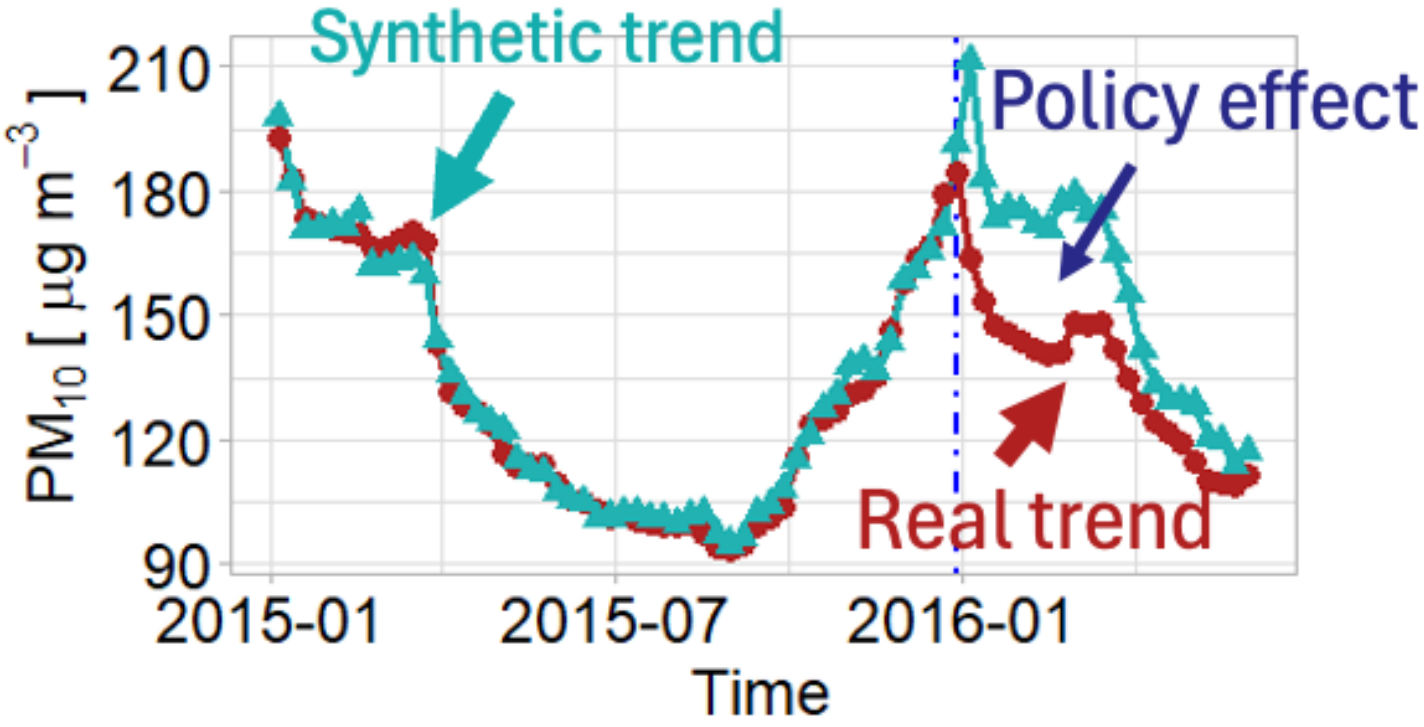


"Weather Normalisation" using machine learning (Grange and Carslaw, 2018; 2019)

* Solution: Trend impacts

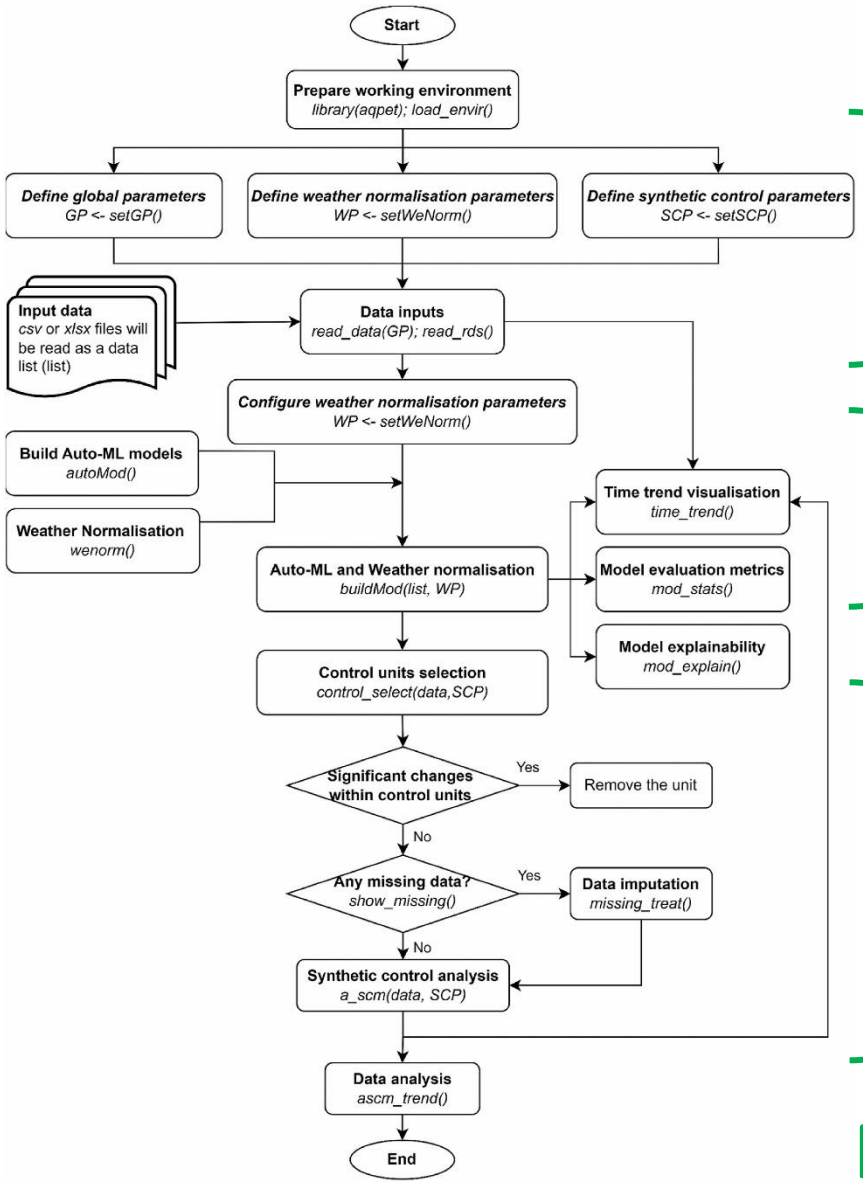
"Detrending" using Augmented Synthetic Control Method (Abadie et al, 2010):
what the pollutant would have been if the policy had not been implemented?

- **No Intervention:** Cities similar but without the intervention.
- **No Anticipation:** Unaware of the intervention beforehand, no influence on their behaviour or outcomes.
- **No Interference:** The intervention given to one city does not affect the outcomes of other cities.



Example: The Impact of Chinese Environmental Inspection on PM_{10} in Hebei.

AQPET (all-in-one)

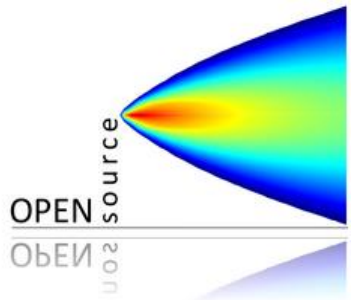


Data Preparation

Remove Weather Impacts

Remove "Trend" Impacts

Policy effects



Citation: *Dai, Y., Liu, B., Tong, C. and Shi, Z., 2024. Aqpet—An R package for air quality policy evaluation. Environmental Modelling & Software, 177, p.106052.*

Overview of input data

Data Template (time series)

datetime

meteorology

emission proxy

datetime	ws	wd	temp	RH	blh	week	weekday	hour	month	NOx
01/01/2017 00:00	3.77	208.22	6.23	96.76	448.43	1.00	7.00	0.00	1.00	194.71
01/01/2017 01:00	3.43	216.96	6.07	97.59	462.61	1.00	7.00	1.00	1.00	359.60
01/01/2017 02:00	3.60	210.00	6.00	97.58	460.04	1.00	7.00	2.00	1.00	304.88
01/01/2017 03:00	3.10	200.54	5.90	98.01	431.64	1.00	7.00	3.00	1.00	269.80
01/01/2017 04:00	3.27	195.19	5.20	97.57	430.33	1.00	7.00	4.00	1.00	249.06
01/01/2017 05:00	2.60	196.53	5.83	98.00	436.74	1.00	7.00	5.00	1.00	222.49
01/01/2017 06:00	3.43	206.51	5.97	98.01	433.02	1.00	7.00	6.00	1.00	158.26
01/01/2017 07:00	3.10	186.70	6.47	98.02	407.03	1.00	7.00	7.00	1.00	182.80
01/01/2017 08:00	3.27	190.00	6.90	98.45	398.44	1.00	7.00	8.00	1.00	299.69
01/01/2017 09:00	3.60	201.51	7.77	98.67	416.69	1.00	7.00	9.00	1.00	345.41
01/01/2017 10:00	2.93	210.00	8.33	98.04	319.02	1.00	7.00	10.00	1.00	312.85

Daily (or finer) data to build the model is recommended

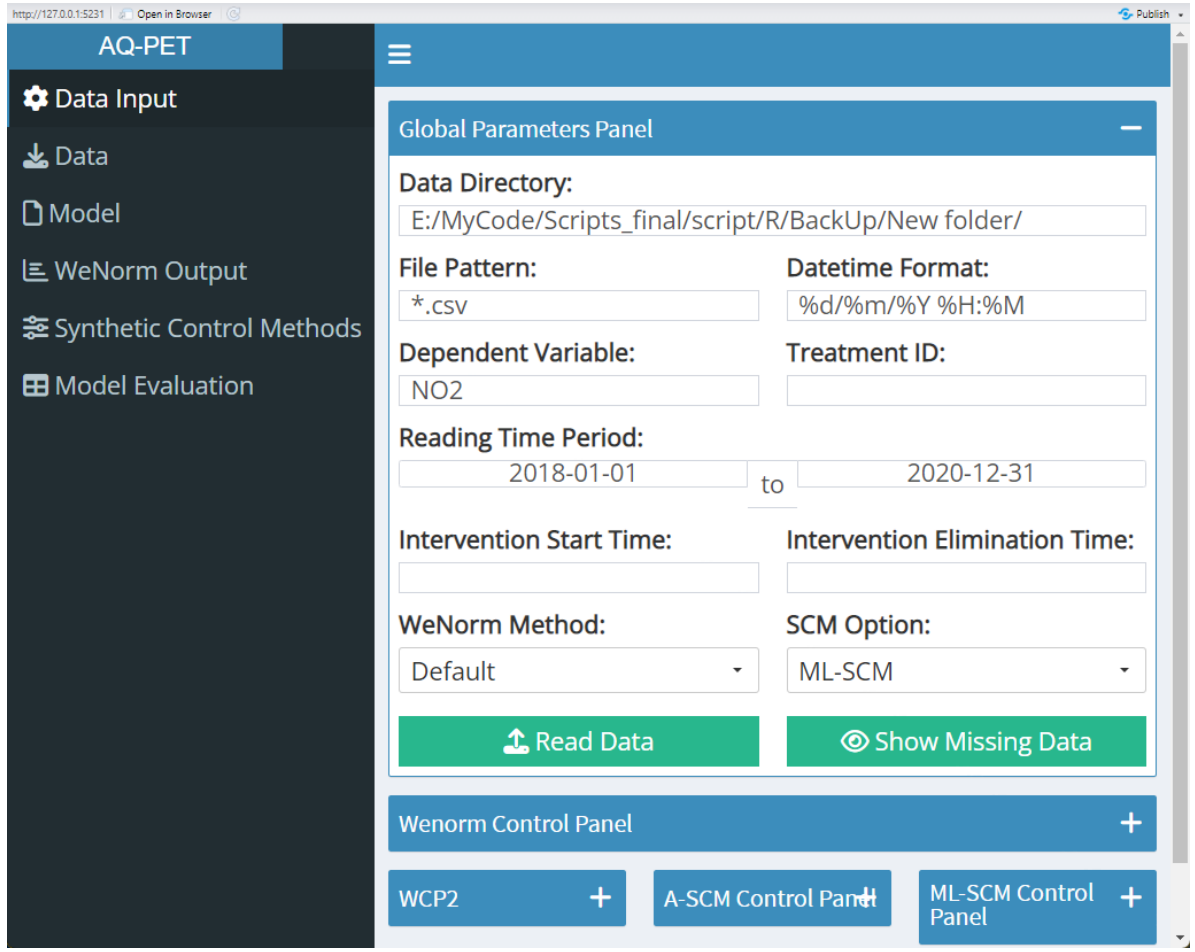
pollutant

Operating Requirement

- Compatible with Win/Mac
- R (>= 4.3.3) + R studio
- https://github.com/clnair-ascm/aqpet/

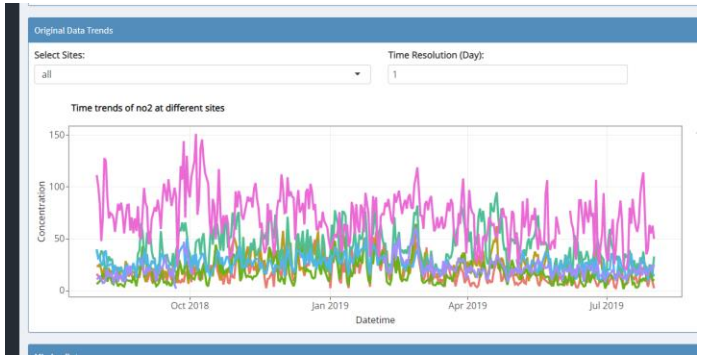
```
# install.packages("pak")
library(pak)
pak::pak('clnair-ascm/aqpet')
library(aqpet)
load_envir()

# gfortran must be installed for 'bcp' package on macOS:
brew install gcc
mkdir -p ~/.R
nano ~/.R/Makevars
```

For Non-Coders

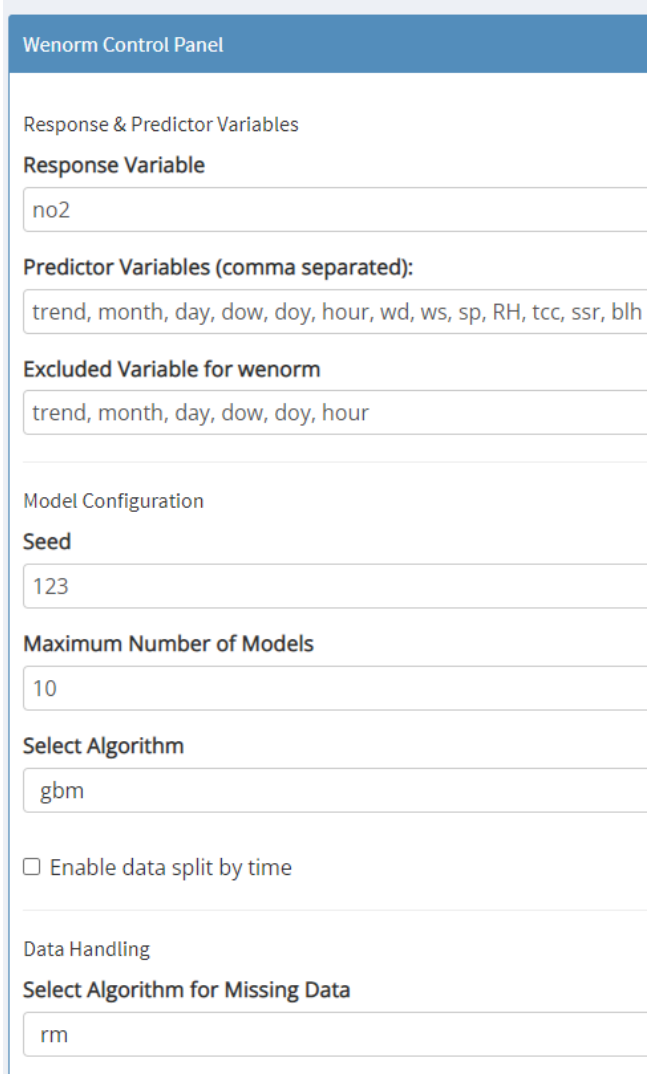


AQPET APP

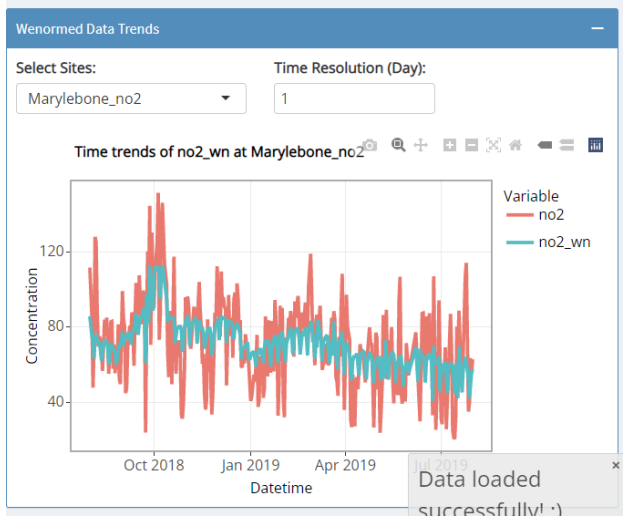
- View Data

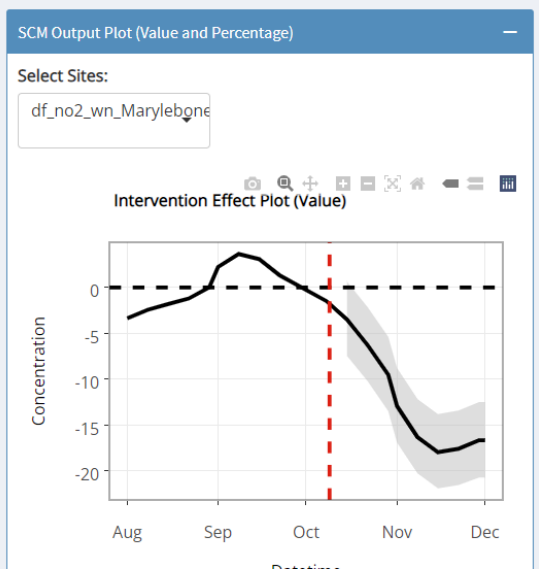


- Build ML model



- Results Visualisation





Reference (additional resources)

- Grange, S.K. et al., 2018. Random forest meteorological normalisation models for Swiss PM 10 trend analysis. *ACP*.
- Vu, T.V., et al., Assessing the impact of clean air action on air quality trends in Beijing using a machine learning technique. *ACP*.
- Ben-Michael, et al., 2021. The augmented synthetic control method. *JASA.*
- Xu, Y., 2017. Generalized synthetic control method: Causal inference with interactive fixed effects models. *PA*.
- https://docs.h2o.ai/h2o/latest-stable/h2o-docs/automl.html.
- Python Version: https://normet.readthedocs.io/

Example of application

- Song, C. et al., 2023. Attribution of air quality benefits to clean **winter heating policies** in China: combining machine learning with causal inference. *EST.*
- Cole, M.A. et al., 2020. The impact of the Wuhan **Covid-19 lockdown** on air pollution and health: a machine learning and augmented synthetic control approach. *ERE.*
- Liu, B., et al., 2023. Assessing the impacts of **Birmingham's clean air zone** on air quality: estimates from a machine learning and synthetic control approach. *ERE*.

WM-NET ZERO

wellcome

WM-NETZERO@CONTACTS.BHAM.AC.UK

@WMNETZERO

Acknowledgement

This work is funded by Wellcome Trust WM-NET ZERO (Ref: 227150/Z/23/Z); University of Birmingham Institute of Global Innovation Clean Air Theme; Natural Environment Research Council WM-Air (Ref: NE/S003487/1).

Contact

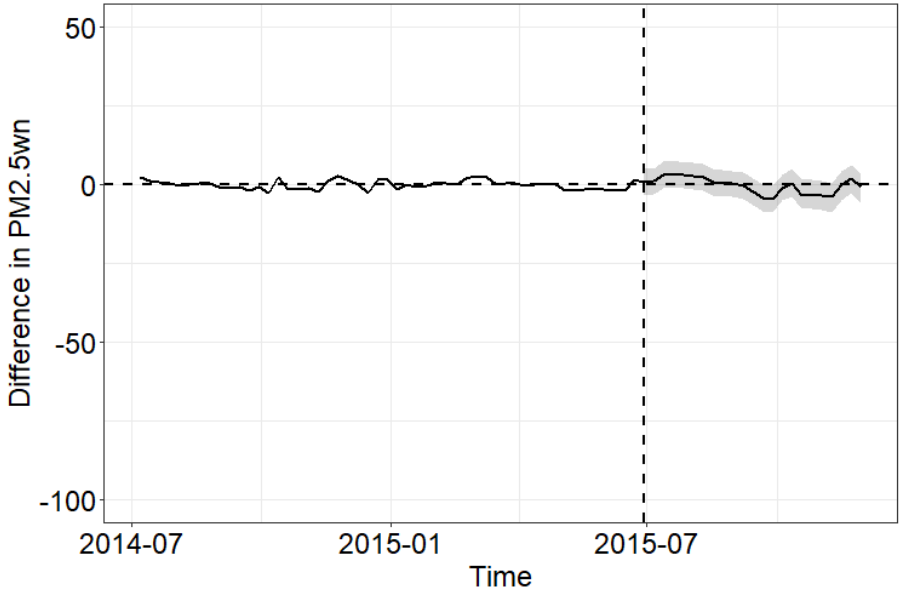
Yuqing Dai y.dai.2@bham.ac.uk
Bowen Liu b.liu.1@bham.ac.uk
Zongbo Shi z.shi@bham.ac.uk

UNIVERSITY OF BIRMINGHAM

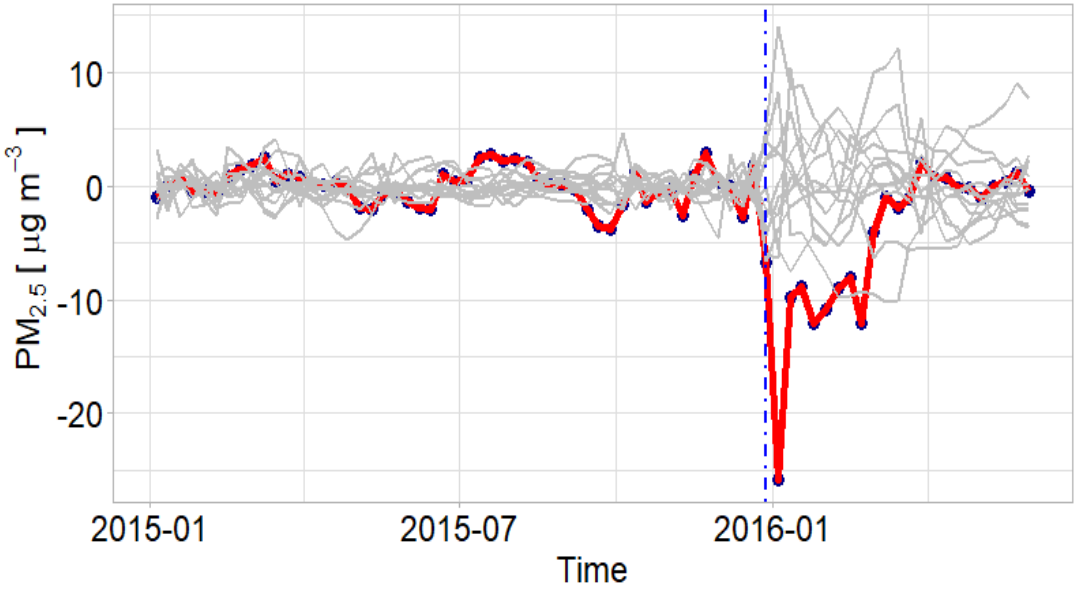
wellcome · THE UNIVERSITY OF BIRMINGHAM · CERC · West Midlands Combined Authority · Coventry City Council · UNIVERSITY OF SURREY · UNIVERSITY of York · Solihull Metropolitan Borough Council · Birmingham City Council · Sandwell Metropolitan Borough Council · Department for Environment Food & Rural Affairs · wsp · UK:100 · CLEAN AIR FUND

Robustness and Diagnostic Checks

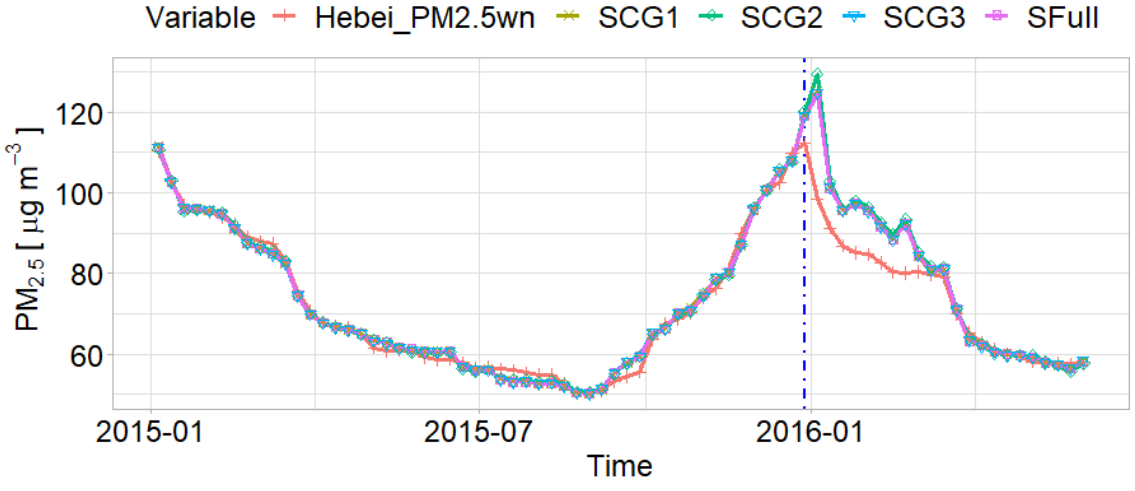
1. In-time placebo tests (Backdating)



2. In-place placebo tests



3. Alternative control groups tests



UNIVERSITY OF BIRMINGHAM

WM-NET ZERO