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Covid-19 and the impact of Air Quality in Wales

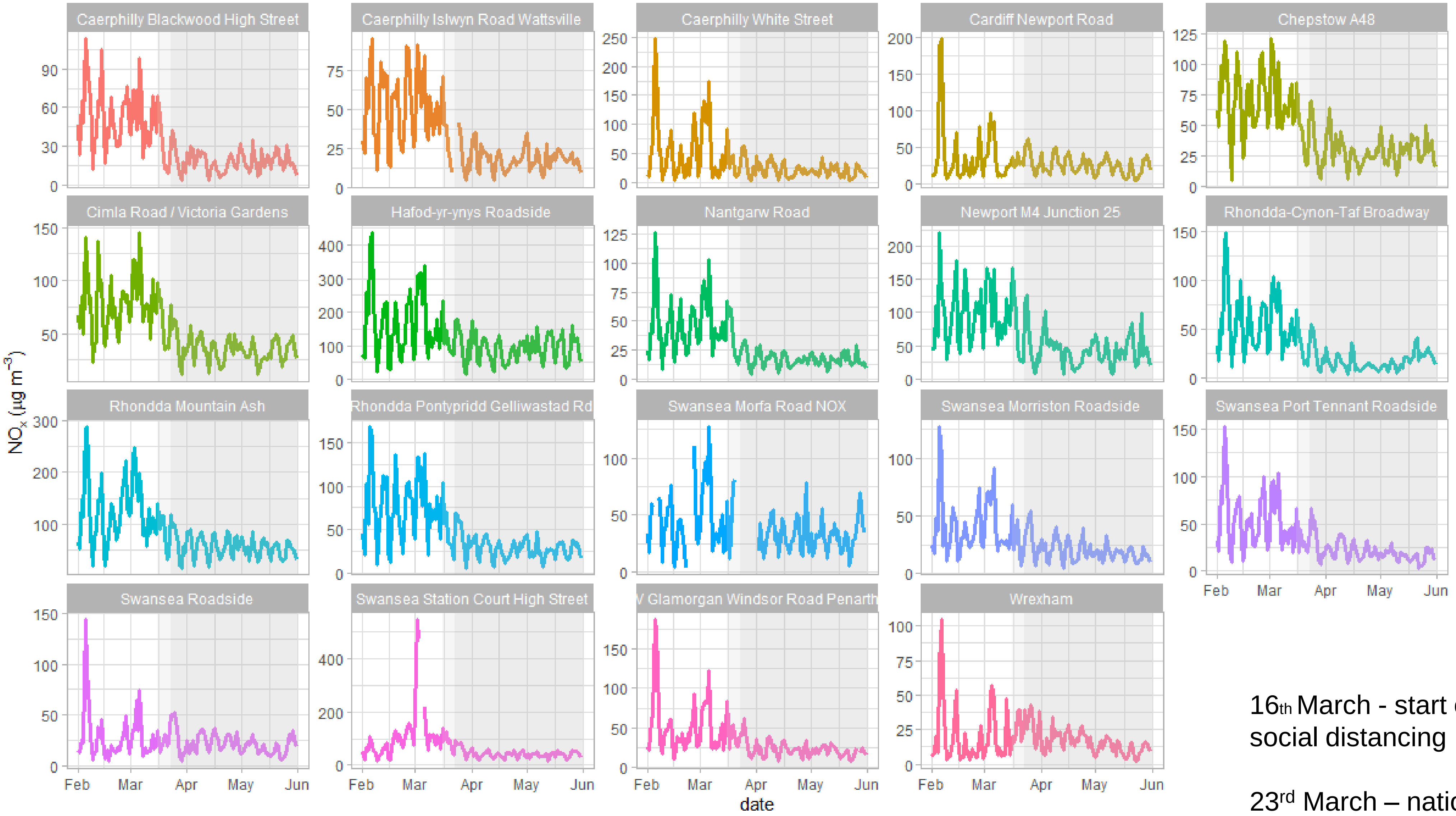
Welsh Air Quality Forum
22nd October 2020

www.ricardo.com

Background

- How has air pollution in Wales been affected by Covid-19 actions?
- How have levels of different air pollutants (e.g. NOx, O_3, PM) changed during lockdown?
- What is the best way to quantify changes and take into account meteorological variations?

Initial look at NOx concentrations at Traffic Sites



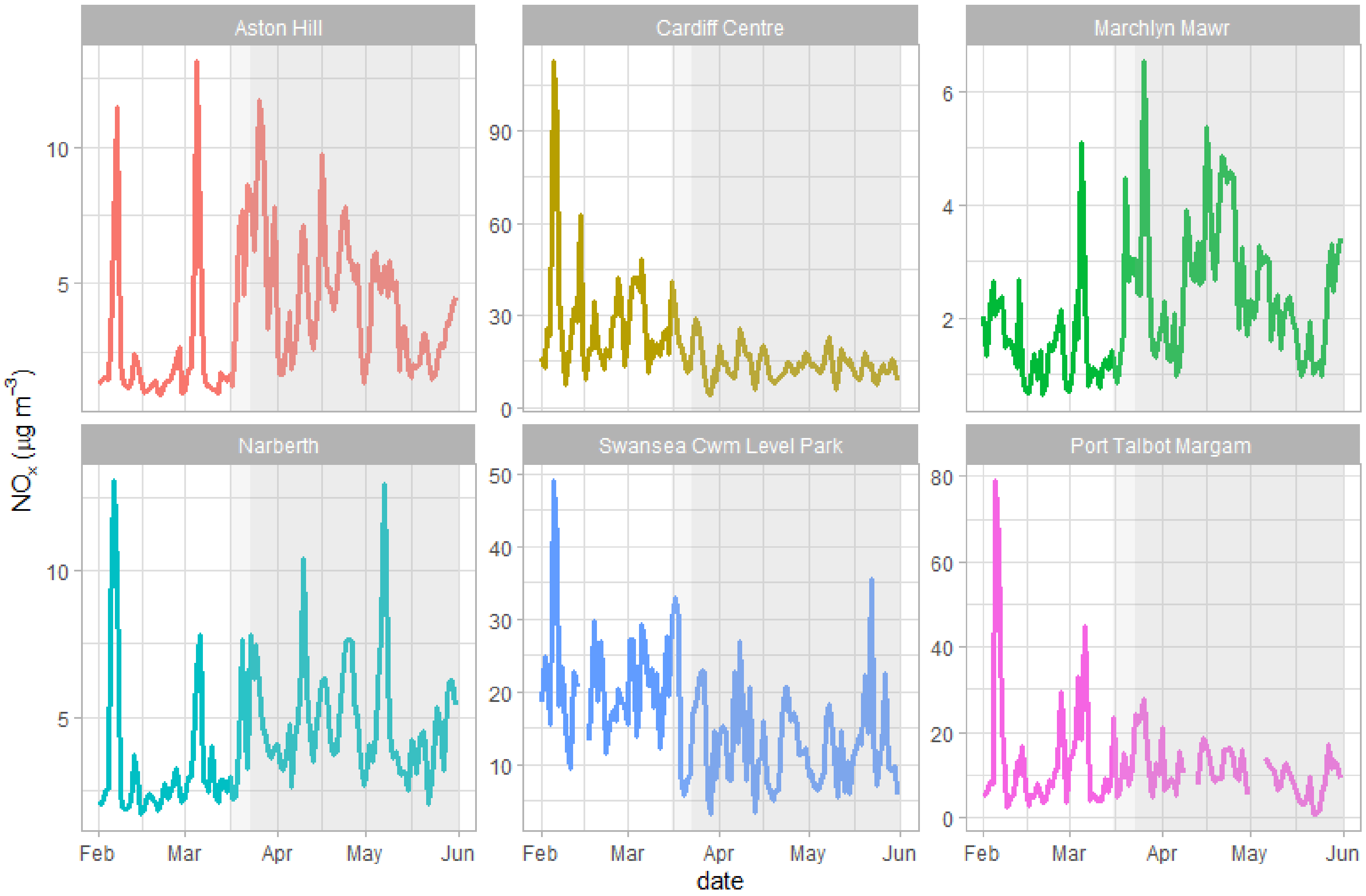
16th March - start of recommended social distancing

23rd March – national lockdown

Measurement data is preliminary from “Air Quality in Wales” website https://airquality.gov.wales/

NOx concentrations at Non-Traffic Sites

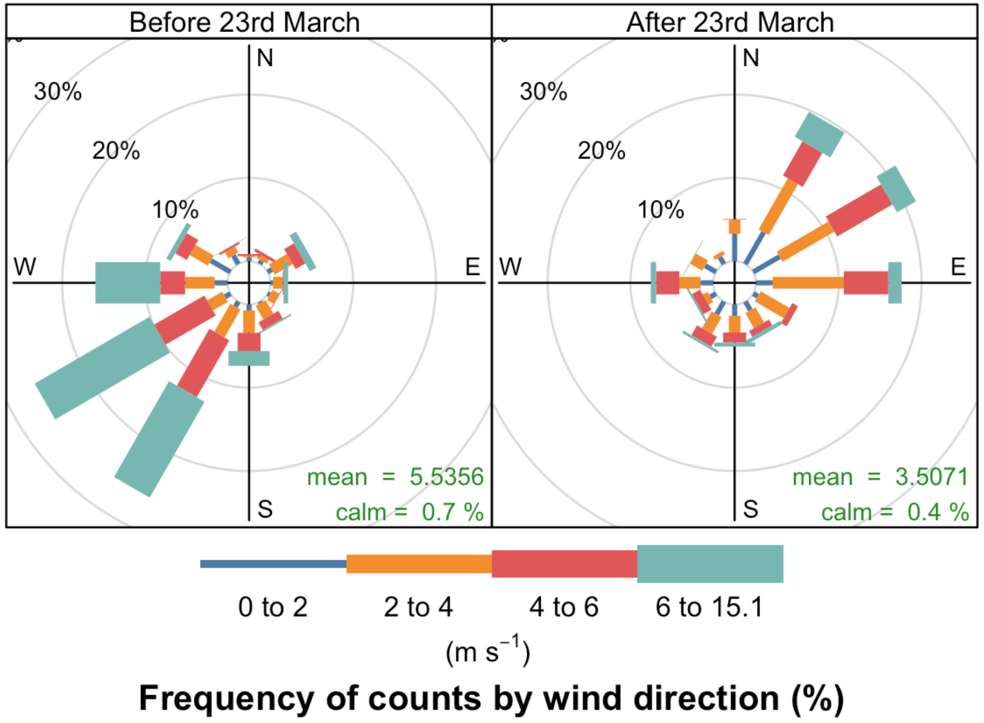
Rural | Urban Background | Remote



Rural | Urban Background | Industrial

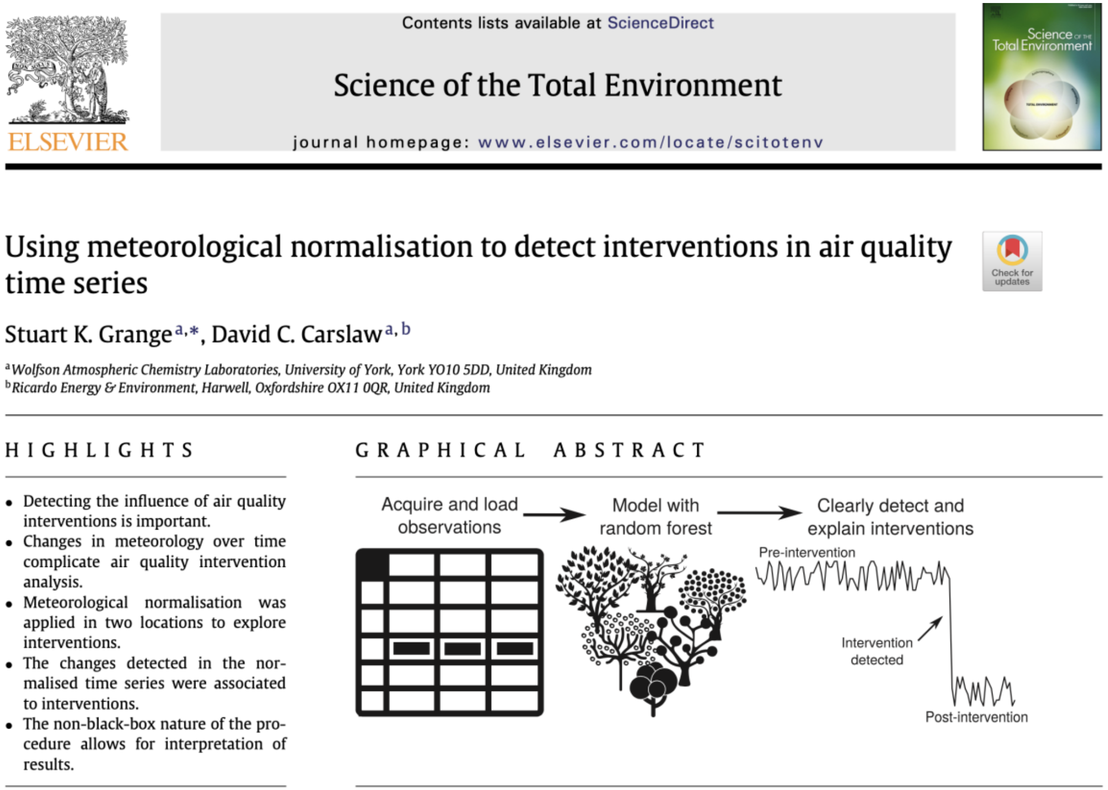
The (exceptional) weather factor

- The weather greatly complicates matters
  - Especially for before-after comparisons
  - Even if you try and account for variation in past 5 years
- February 2020 was the **windiest month since *at least* January 1980** at London Heathrow!
- The six weeks since lockdown was in the **highest 0.1%** of any six-week periods in terms of easterly winds
- Spring 2020 **sunniest since records began**
  - Effect on ozone and $PM_{2.5}$ concentrations, and atmospheric chemistry in general?



Accounting for meteorological variation

- Ideally, we need the **counterfactual** i.e. *the concentrations of pollutants if Covid-19 had **not** happened*
  - Use statistical models to explain hourly concentrations in terms of meteorological variables
  - Build and test models for each site and pollutant over a few years up to mid-February 2020
  - Predict from mid-February onwards – the **Business as Usual** (counterfactual)
- Compare Business as Usual with measured concentrations


Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Using meteorological normalisation to detect interventions in air quality time series

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HIGHLIGHTS

- Detecting the influence of air quality interventions is important.
- Changes in meteorology over time complicate air quality intervention analysis.
- Meteorological normalisation was applied in two locations to explore interventions.
- The changes detected in the normalised time series were associated to interventions.
- The non-black-box nature of the procedure allows for interpretation of results.

GRAPHICAL ABSTRACT

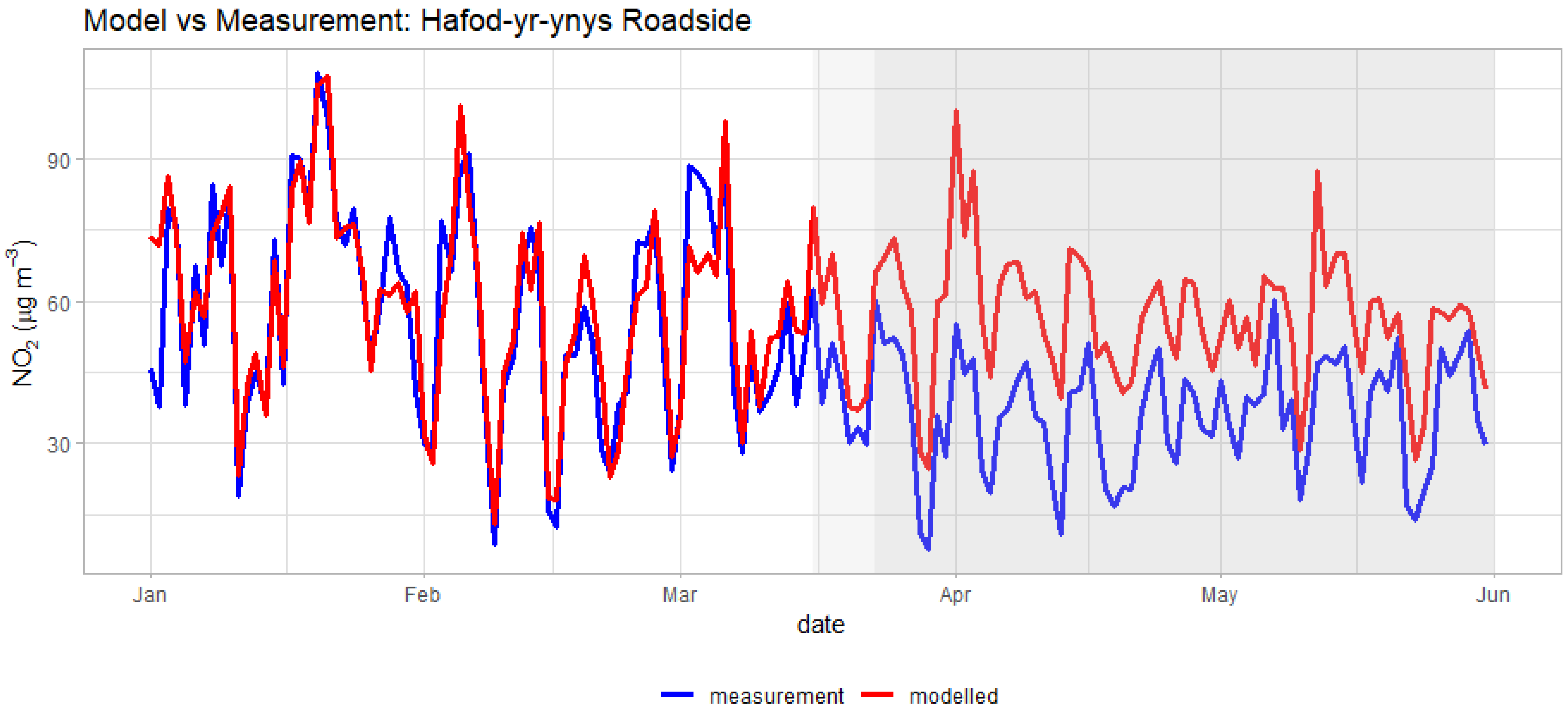
Carslaw, D.C. and P.J. Taylor (2009). Analysis of air pollution data at a mixed source location using boosted regression trees. *Atmospheric Environment*. Vol. 43, pp. 3563–3570.

Carslaw, D.C., Williams, M.L. and B. Barratt A short-term intervention study — impact of airport closure on near-field air quality due to the eruption of Eyjafjallajökull. (2012) *Atmospheric Environment*, Vol. 54, 328–336.

Grange, S. K. and Carslaw, D. C. (2019) 'Using meteorological normalisation to detect interventions in air quality time series', *Science of The Total Environment*. 653, pp. 578–588. doi: 10.1016/j.scitotenv.2018.10.344.

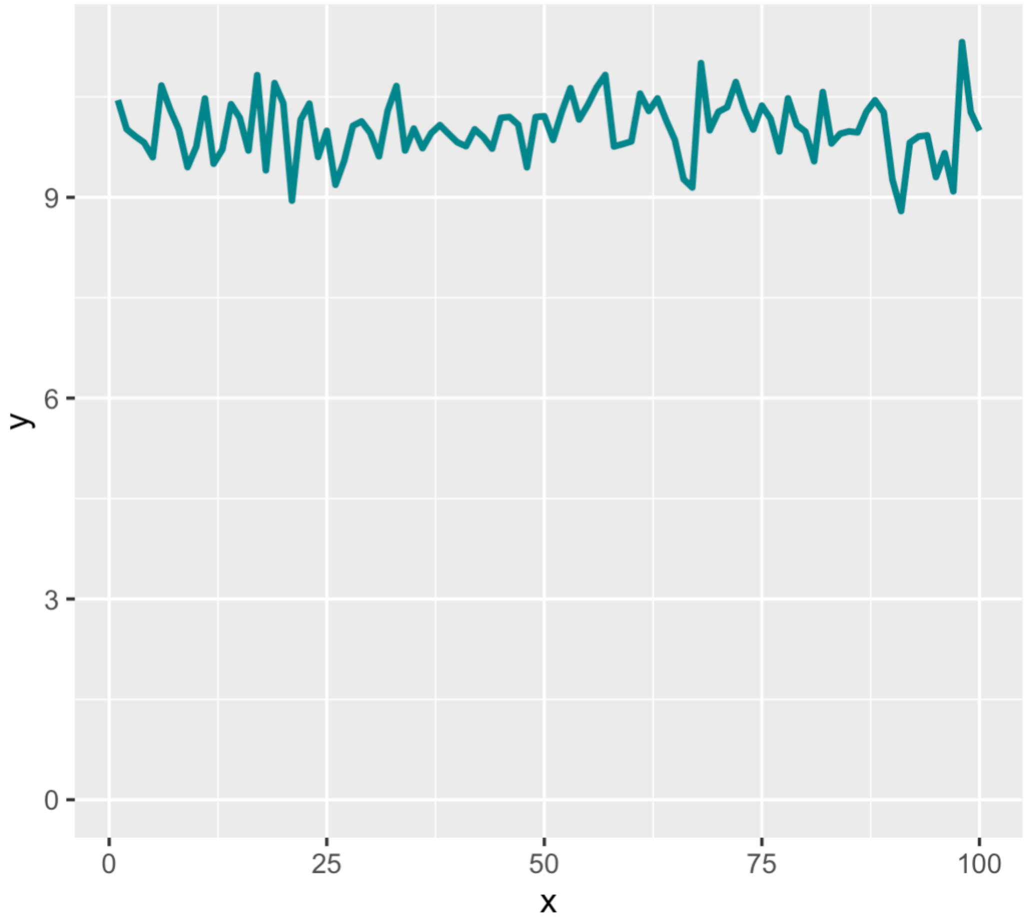
Example for NO_2 at the Hafod-yr-ynys Roadside site

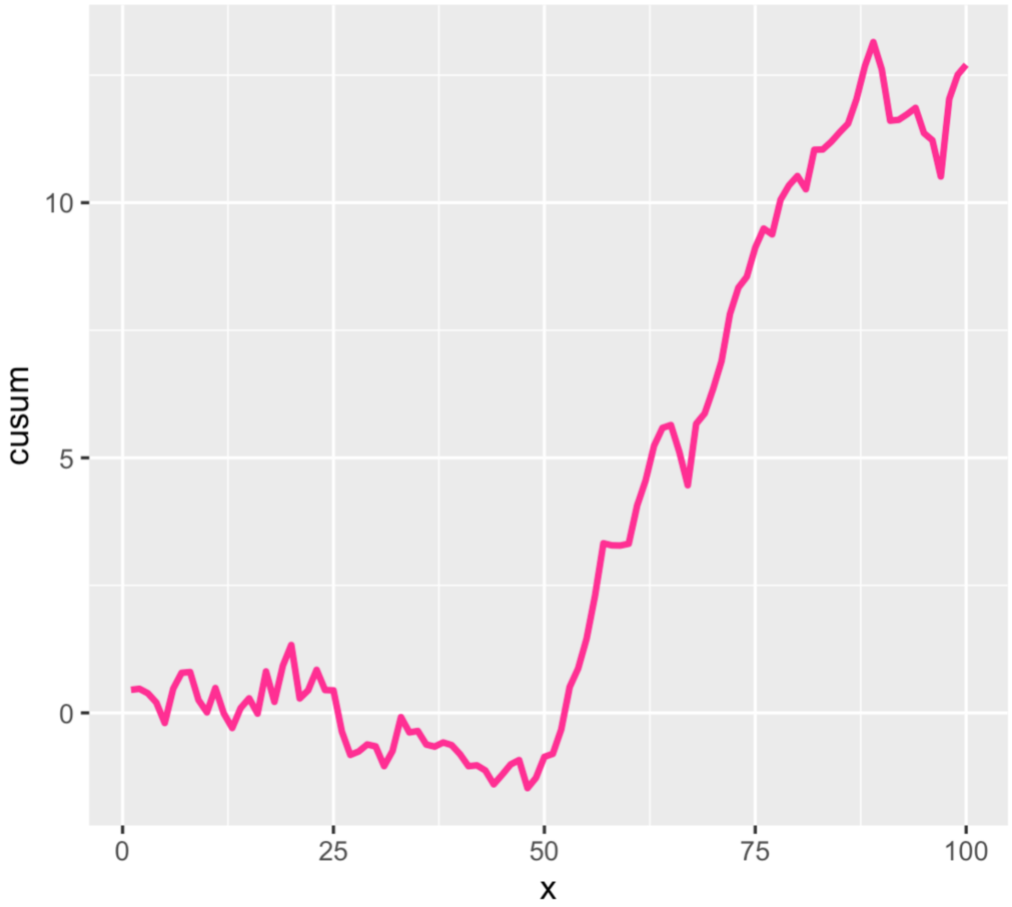
- **Red** shows Business as Usual values
- **Blue** shows measured values



Timing of changes – cumulative sum (cusum) analysis

- Graphical approach to detect small changes
- Can be developed further to consider **change-point dates and their uncertainties**
- Works well when we are comparing against a Business as Usual

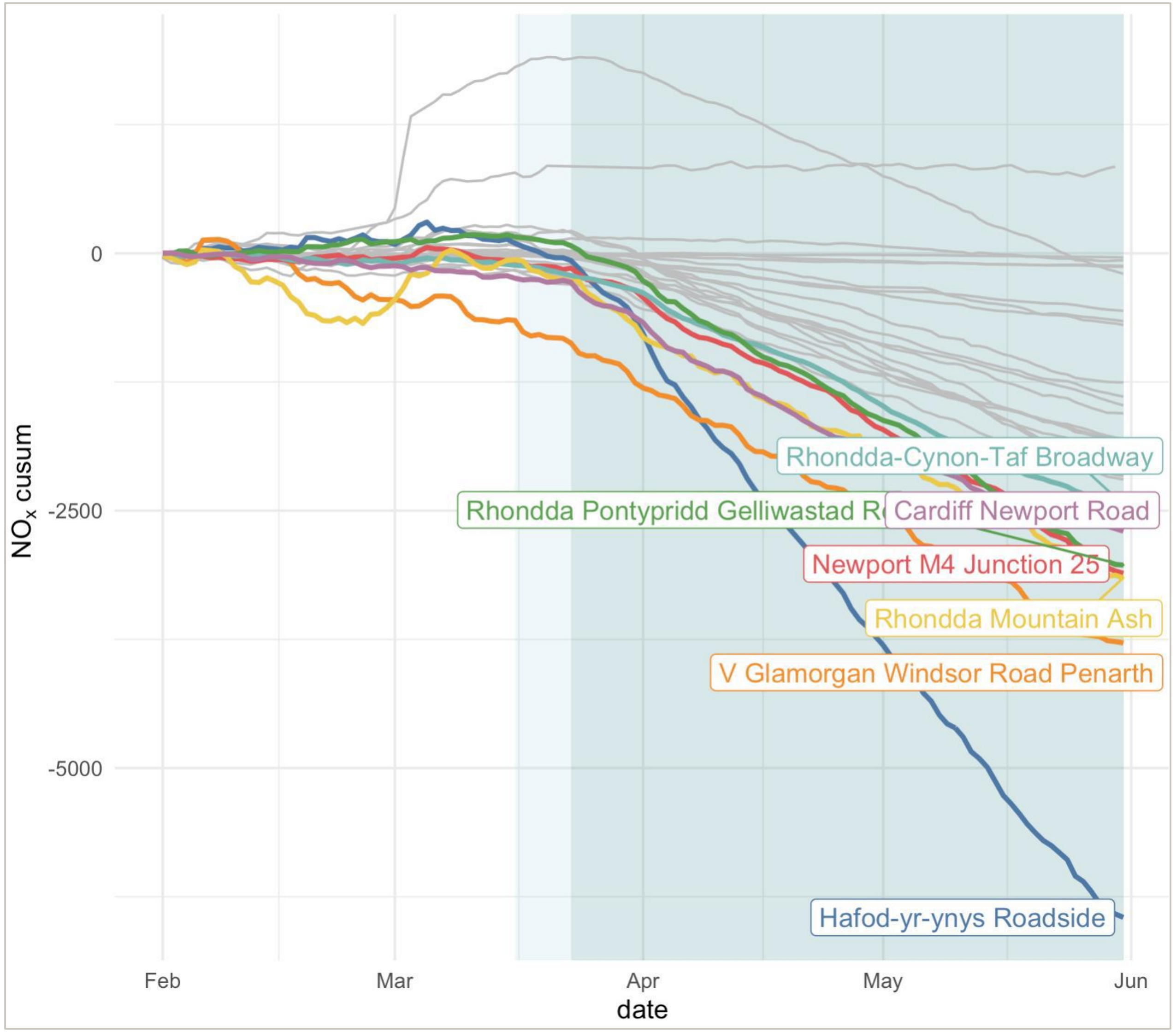




Cusum changes for NO_x

- Nearly all sites show a decrease in NO_2
- The biggest changes in NOx are at roadside sites
- Suggests local actions will be important
- The smallest changes tend to be rural and background sites
- Typically the change in NO_2 is less than that for NOx

Site type	% NOx change	% NO_2 change
Remote	-22.8	-21.5
Rural background	-20.8	-37.1
Traffic	-48.3	-37.9
Urban background	-39.8	-35.1
Industrial background	-38.5	-40.5



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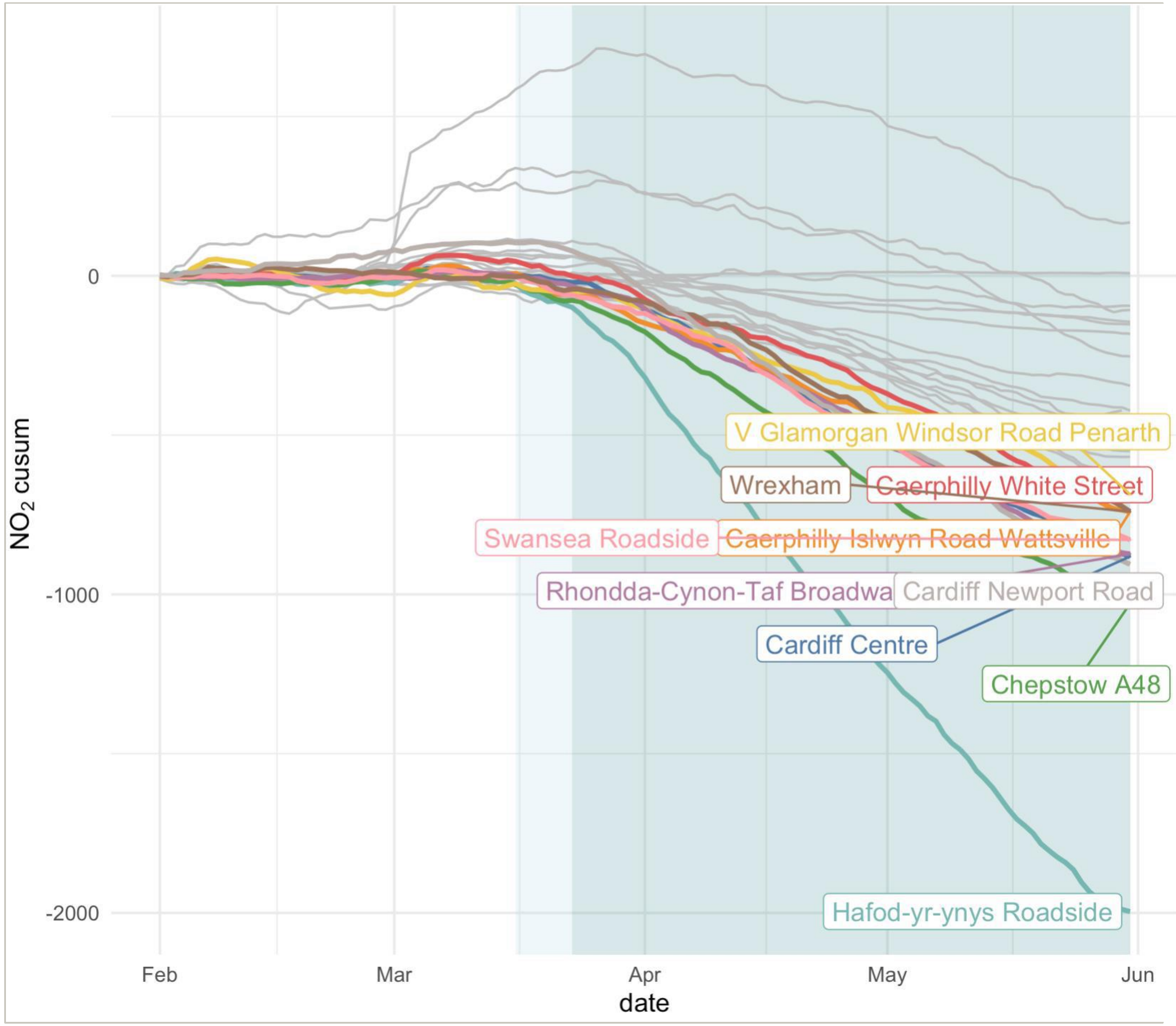
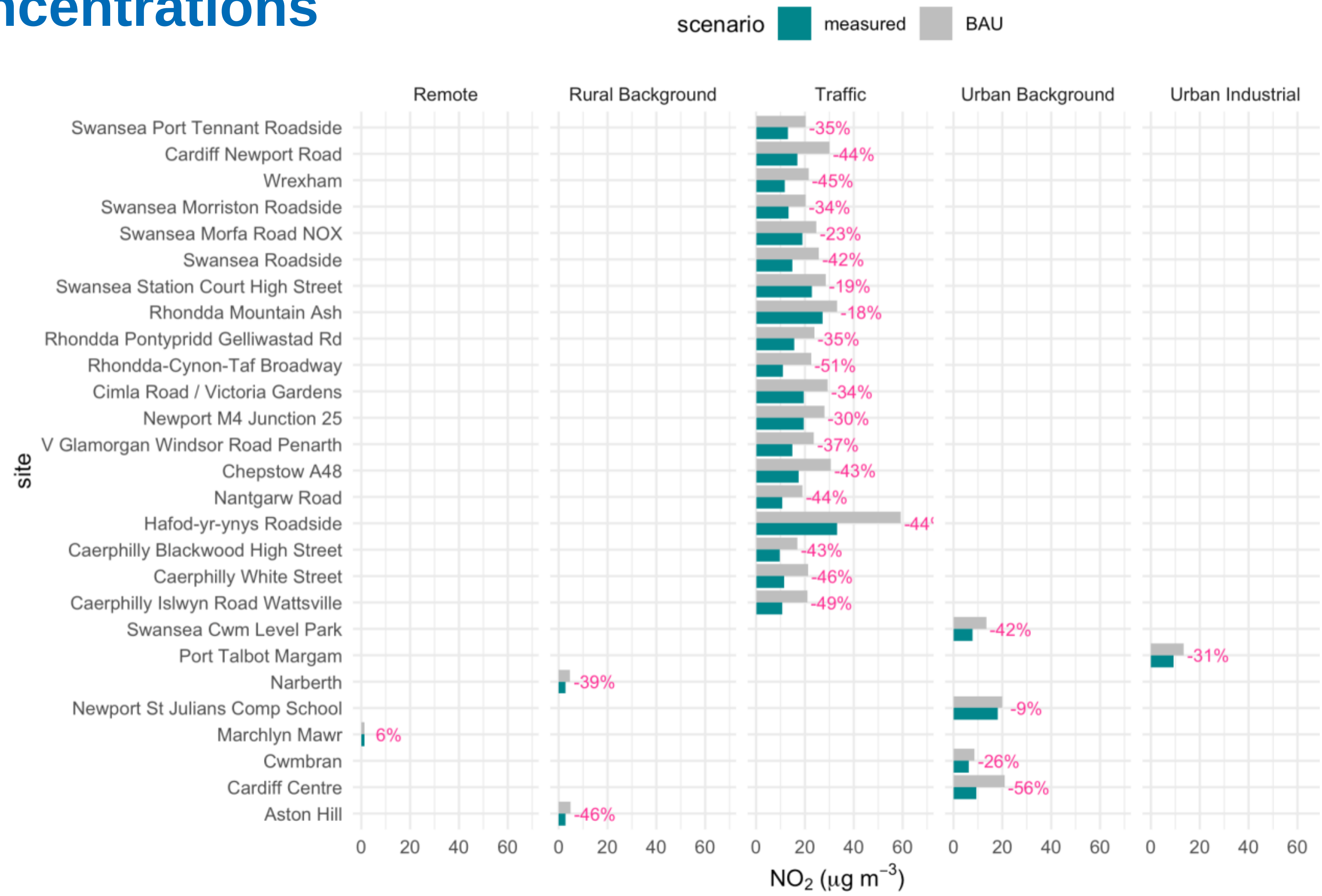
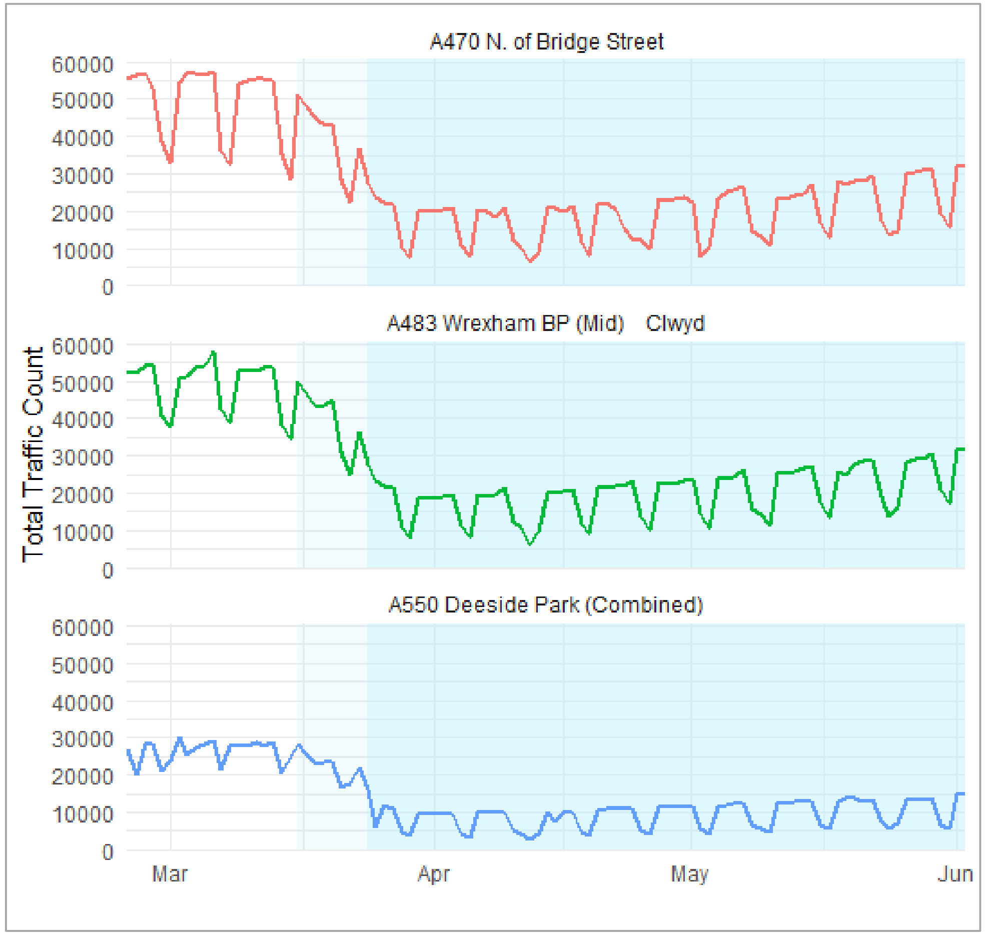


Measured and estimated business as usual NO_2 concentrations

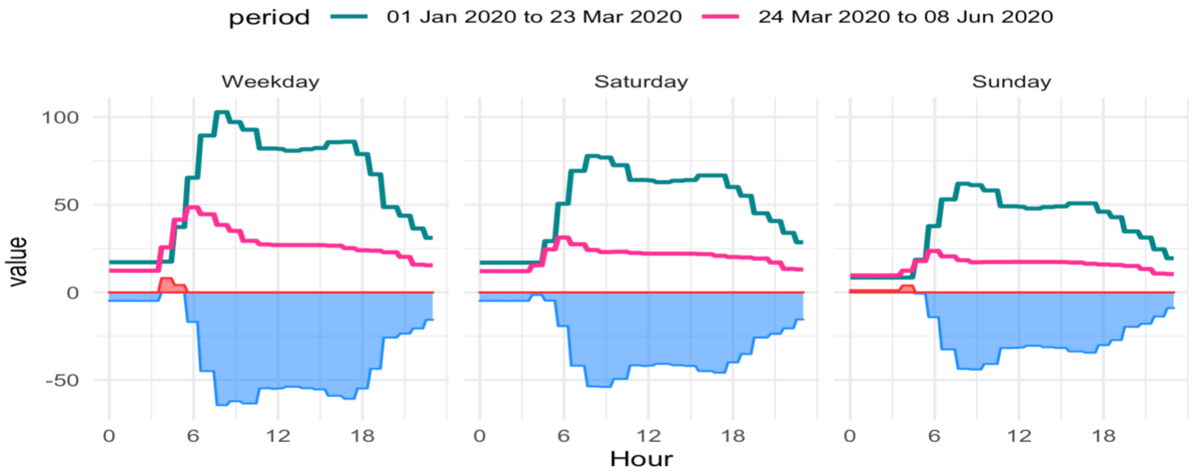


Impact of Traffic Emissions

- Information from traffic counts indicates the volume of traffic decreased after lockdown



Meteorologically adjusted NO_x diurnal increment at the Chepstow A48 before and after lockdown

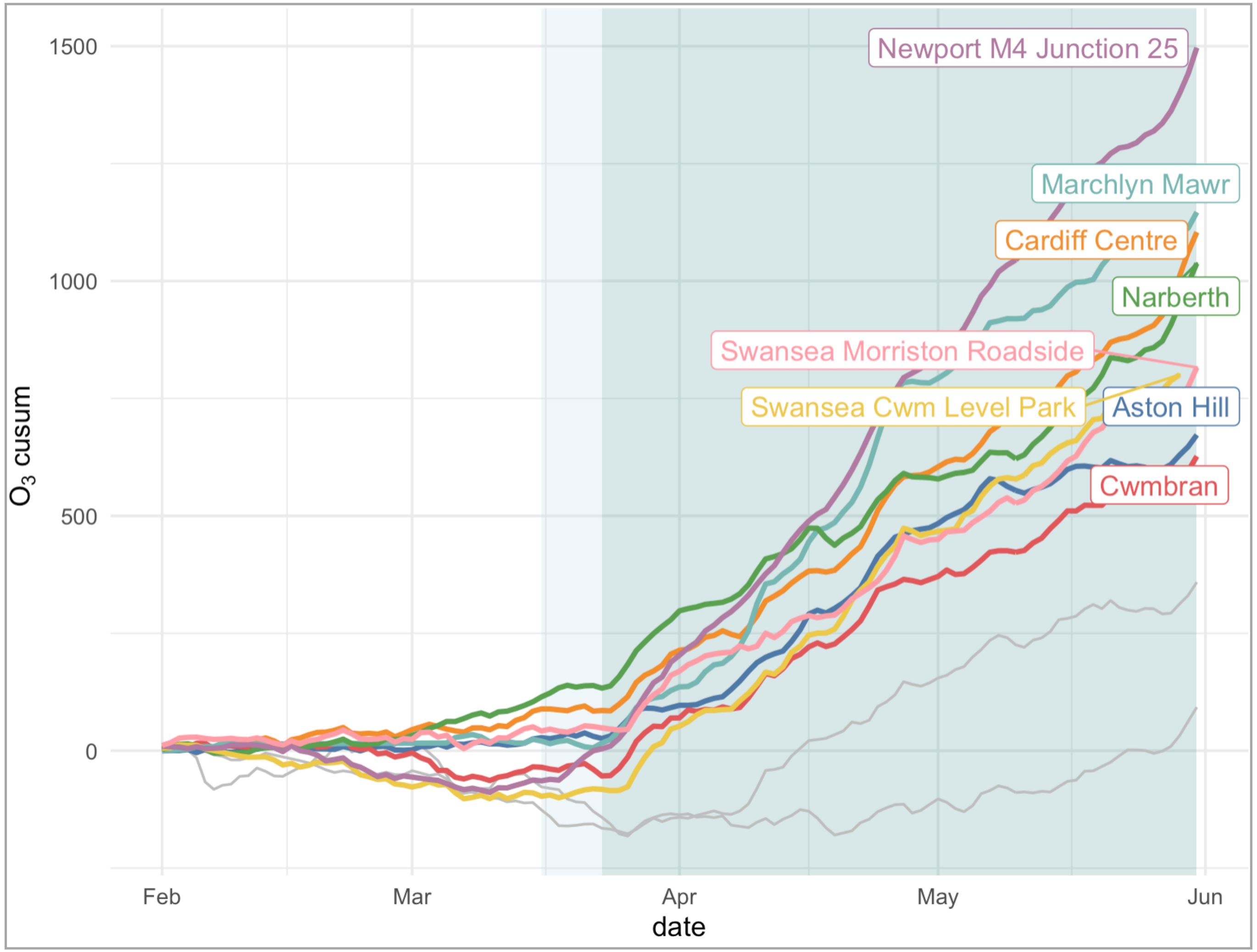


- Before lockdown (green line) the diurnal profile in NOx shows a typical profile associated with vehicle emissions.
- After lockdown (pink line) NOx levels are lower and the profile has changed.
- Decreases (shaded blue) occur in the daytime and consistent with a pattern of reduced road traffic.

Cusum changes for O_3

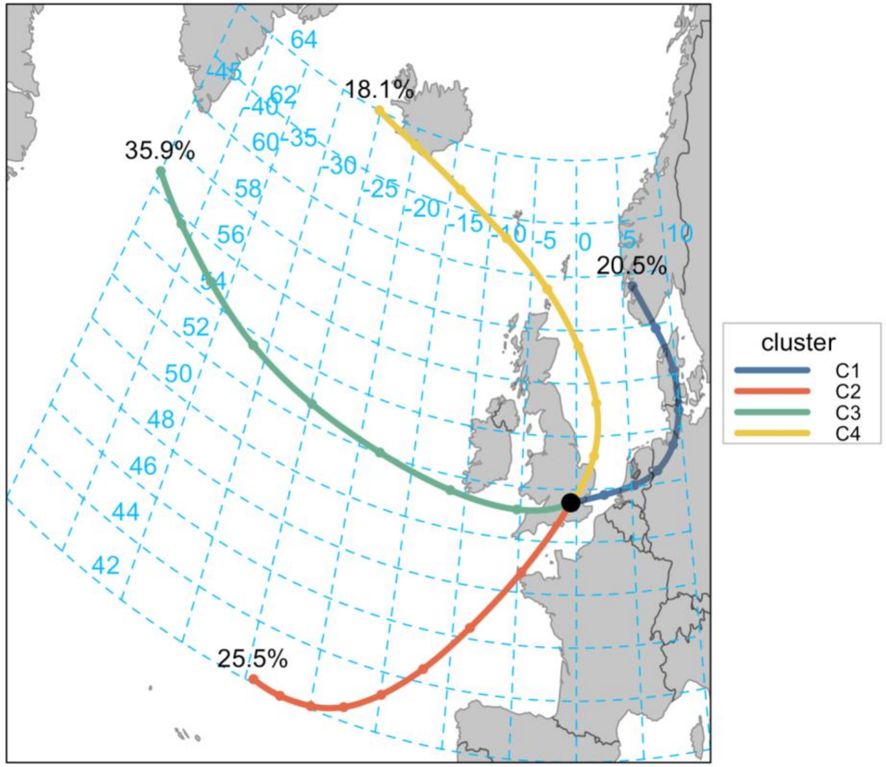
- Concentrations of ozone typically **increased** after lockdown - particularly for sites that would normally have higher concentrations of NOx.

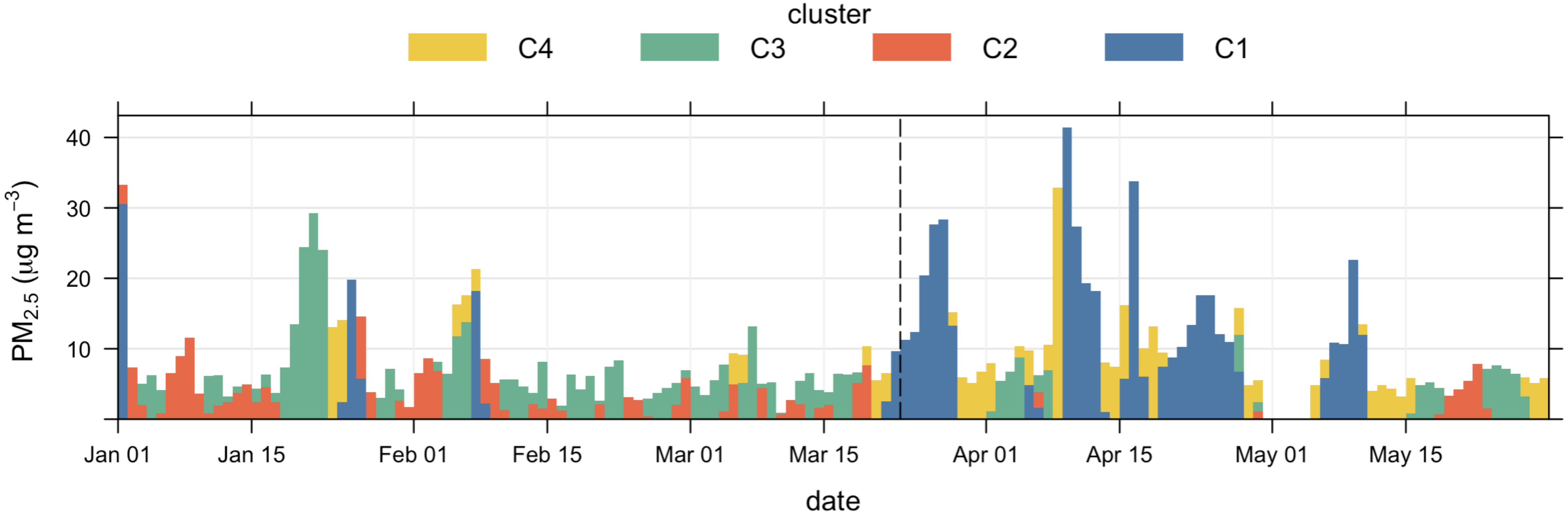
- This result shows the importance of considering **individual air pollutants** when discussing air quality changes



Impact of lockdown on $PM_{2.5}$

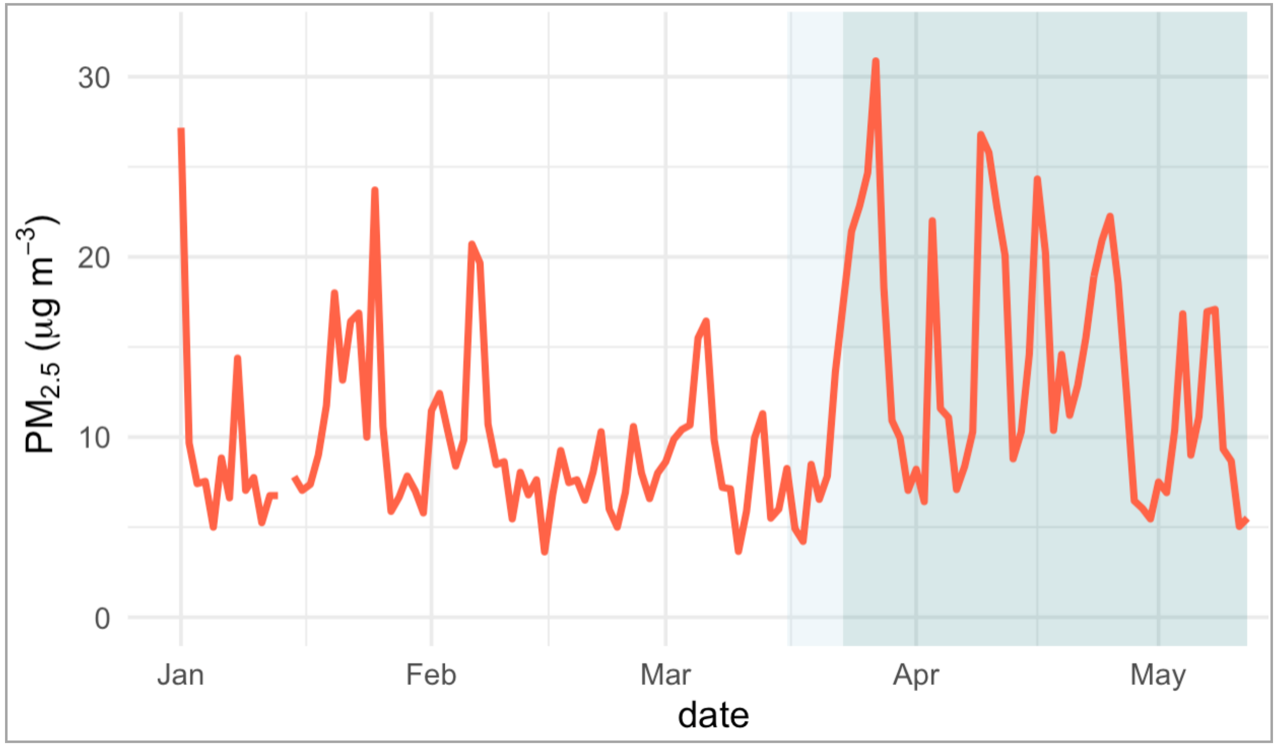
- For PM, the contribution from regional transport should be taken into consideration
- High proportion of air mass origins from mainland Europe post lockdown
- Associated with **higher $PM_{2.5}$** concentrations
- Care needed to determine a ‘Covid-19’ effect





Impact of lockdown on $PM_{2.5}$

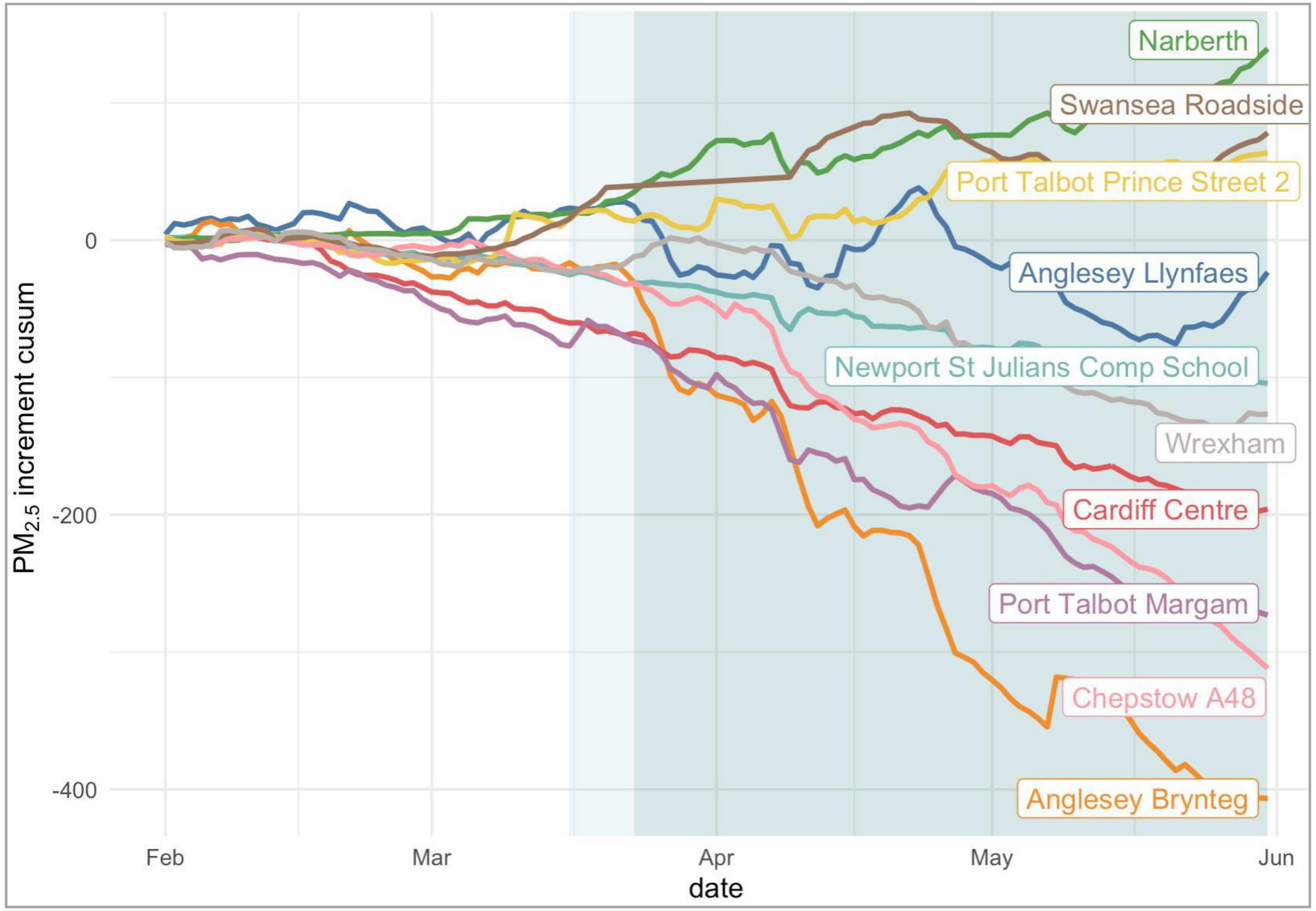
- From the time series it appears that $PM_{2.5}$ has **increased** since lockdown
- The increase is likely to be associated with $PM_{2.5}$ from long-range transport rather than local (road transport) sources
- Across all $PM_{2.5}$ sites, the average concentrations post-lockdown were higher (11.4 μm^{-3}), when compared to pre-lockdown concentrations (8.2 μm^{-3}).



Consider instead the **increment in $PM_{2.5}$** above background levels

Cusum changes for $PM_{2.5}$

- The increment in $PM_{2.5}$ concentrations has decreased at many sites since lockdown
- However, the largest decreases are not necessarily at roadside sites
- Understanding the impact of lockdown on PM is more complex and challenging than for NOx and NO_2



Overall changes in air quality in Wales related to Covid-19

Pollutant	Change
NO_x	↓↓↓↓
NO_2	↓↓↓
O_3	↑↑
$PM_{2.5}$	↓

- Clearest changes associated with NO_x and NO_2 at urban sites and decreases are consistent with a pattern of reduced road traffic
- Reductions in the local contribution to $PM_{2.5}$ concentrations is small – other unknown local factors may be important here

Take home messages

- Clear that Covid-19 has had an impact on air quality in Wales
- However, need to consider **individual air pollutants** and not ‘air pollution’ overall
- Further analysis will help reveal important **information on sources** (local versus regional) and how air quality responds when emissions are changed
- As we move to a “new normal” – how can we ensure air quality does not return to pre-Covid levels?