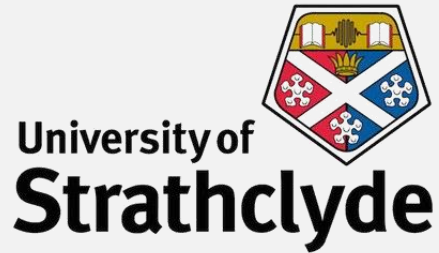


Black Carbon and Nitrogen Ratios at Two Governmental Air Quality Monitoring Stations Using Computer Modelling.

- A Brief Presentation by
Sam Grainger



About me.



> PhD - University of Strathclyde [Pending]

Thesis Title: Air quality implications of developing the United Kingdom's unconventional petroleum resources, with a focus on geological drilling and other analogous environments.

Engineering the Future Scholarship.

> PgCert - University of Strathclyde [Pending]

CARDIFF > MSc - Cardiff University.
UNIVERSITY

Applied Environmental Geology.

Don Keeble Scholarship : Paul Murphey Early Career Geologist Award

UNIVERSITY OF
EXETER > BSc - University of Exeter

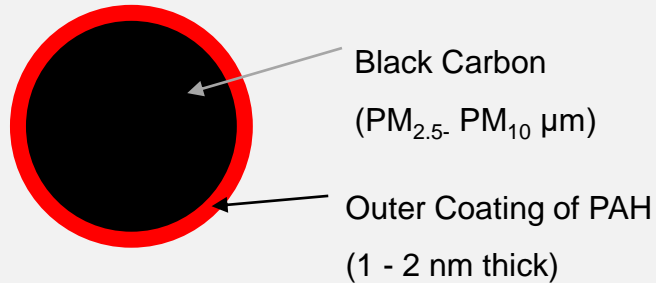
Engineering Geology and Geotechnics.

Scottish Mining Trust Scholarship

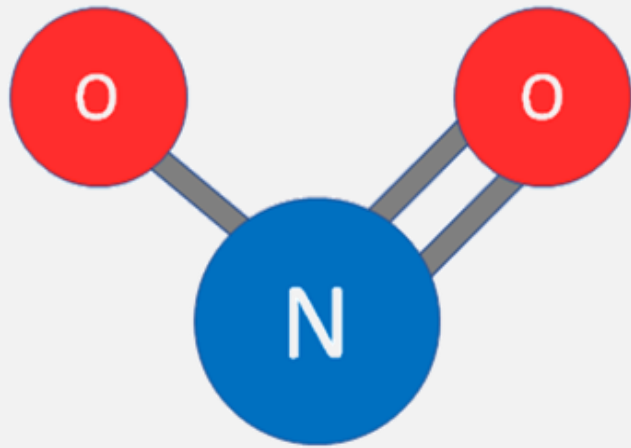
- > Fellow of the Geological Society (FGS)
- > Associate of the Camborne School of Mines (ACSM)
- > Associate of the Institute of Occupational Safety and Health (IOSH).
- > Graduate Member Chartered Institute of Water and Environmental Management (CIWEM).
- > Graduate Member of the Chartered Association of Building Engineering (CABE).



Nitrogen Dioxide and Black Carbon.



BC is a subcategory of fine particulate matter comprising amorphous elemental carbon coated by poly-aromatic hydrocarbons (PAH). BC can account for a significant proportion of PM_{2.5} or PM₁₀ emissions from fires and vehicular exhaust.



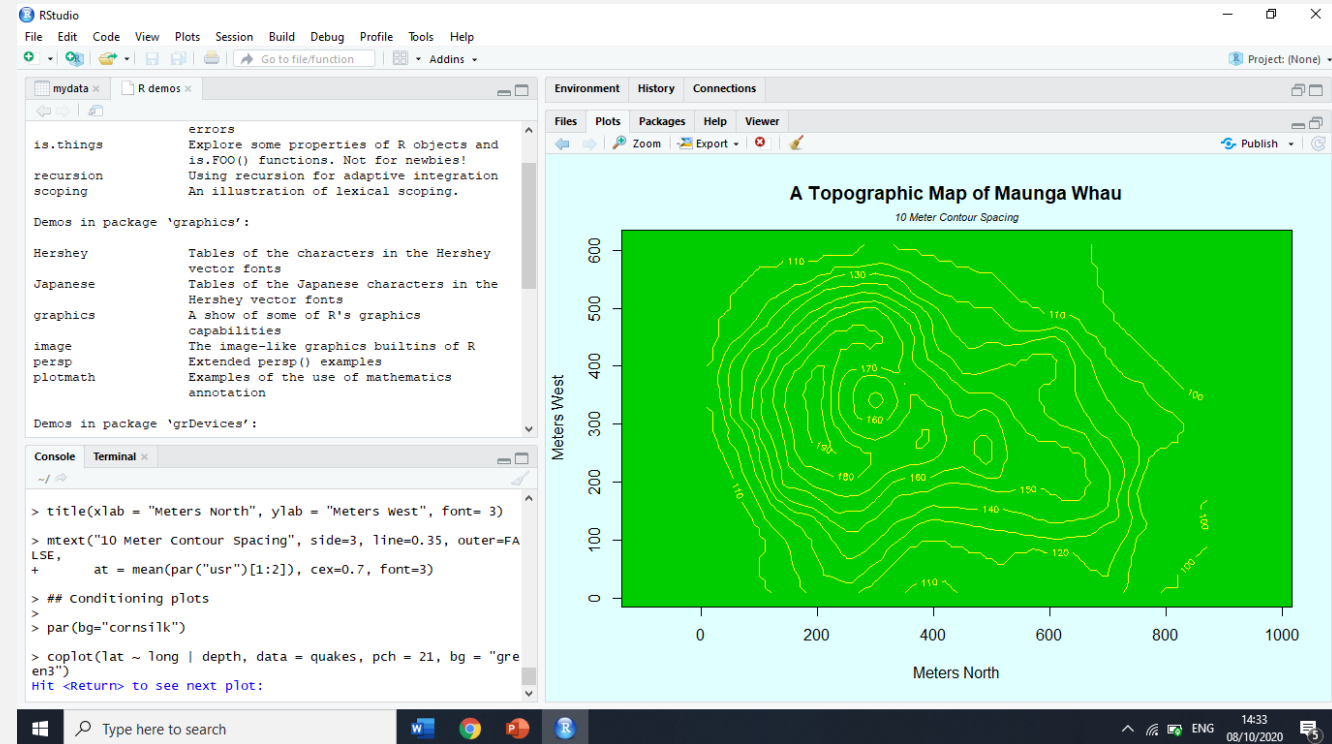
Nitrogen accounts for 80% of the air we breathe and is inert in standard conditions. There are a variety of nitrogen compounds which can be generated through natural and anthropogenic sources. Natural processes include thunderstorms, volcanic eruptions, forest-fires and nitrification. However, most NO₂ is formed through anthropogenic activities rather than natural processes, these anthropogenic sources include; road transport, fossil fuel power stations, combustion of natural gas (e.g. for domestic heating and cooking) and agricultural activities.



R, RStudio, and OpenAir.

This chapter uses ‘RStudio’ an open-ware statistical computing platform, with the ‘openair’ toolset. This platform was used to produce graphs of the temporal and the spatial contribution of air pollution, (Carslaw and Ropkins 2012). The ‘Openair’ toolset works similarly to functions in spreadsheets in that calculations are performed on the user’s data without having to code “from scratch”. Further information, including a toolset manual, can be found on the project’s website at: ‘davidcarslaw.github.io/openair/’.

The scripting can be quite temperamental so I have included my magic bullet script, which helps the project load correctly in my experience. Though variations of this formula may be required for each time zone.



```
mydata <- read.csv(file.choose(), header=TRUE)
install.packages("openair")
library(openair)
mydata$date <- as.POSIXct(strptime(mydata$date, format = "%d/%m/%Y %H:%M", tz = "GMT"))
summary(mydata)
summaryPlot(mydata)
```

Ratio? Nitrogen Dioxide and Black Carbon.

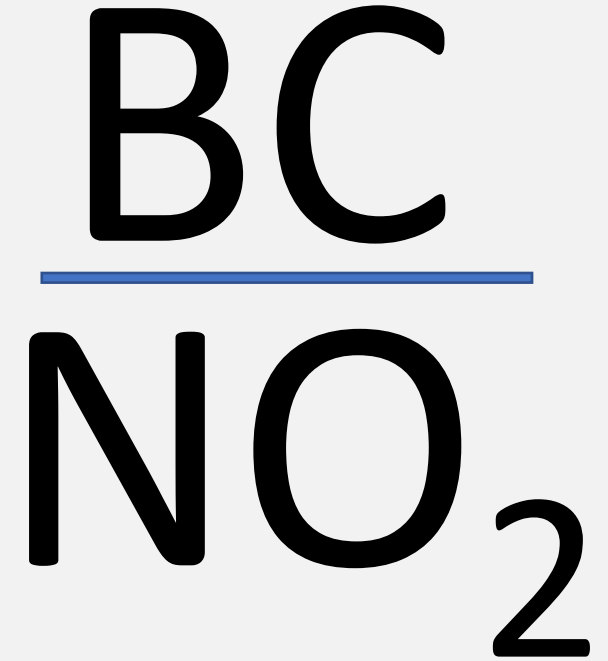
This work however uses the ratio between NO₂ vs BC to focus on more distant pollution sources (for brevity this paper focusses on NO₂ but these principles apply equally to other nitrogen oxides).

This ratio assumes that in normal ambient environments the ratio of BC to NO₂ is low. Sources of BC mainly stem from industrial processes, uncontrolled fires, vehicles or from re-suspension of BC from these sources.

At source NO₂ is generally released in far greater concentrations than BC, indeed a BC to NO₂ ratio of 10.57% ±1.86% was present along Hope Street (another street within the city), and contrastingly industrial diesel engines from UNG activity in Poland had a NO₂/BC ratio of around 10:1 (~10%).

Whilst NO₂ is much greater at source, it can quickly mix with ambient air and degrade, whilst BC can become resuspended or even be brought in from air settling regionally.

It is argued that when the ratio between BC and NO₂ is high, sources of nitrogen are taken to be present such as vehicular and industrial emissions.



Data Repository.

- Two Monitoring Stations were chosen for analysis, these were Glasgow Townhead and High Street (information on these stations will be covered in more depth on the following pages).
- Monitoring data was available from the UK Air Data Selector on an Government Open Licence.
- Data was available from the 7th October 2012 to the 1st March 2019 on an hour by hour basis, for NO₂, BC, and metrological information.
- Particulate monitoring used TEOM-FDMS technology whilst Nitrogen Monitoring used Chemiluminescence. A more advanced explanation can be found here>

Screenshot of the UK Air Data Selector webpage, where any monitoring station data from anywhere in the UK can be downloaded.

SOURCES:

UK Air Data Selector: uk-air.Defra.gov.uk/data/data_selector.

Site Information: uk-air.Defra.gov.uk.

Screening Criteria.

Both datasets were filtered according to two main criteria, these were:

- 1.** Each entry must contain a complete record of meteorological information, NO₂ and BC. Where a data entry does not have a full a set of recordings, the entry was screened out of the analysis.
- 2.** Only ‘verified’ data was permitted i.e. partial, provisional, and unverified data entries were screened out of the analysis.

Screening of the data led to almost 20,232 rows of data being screened out from High Street, whereas only 4,684 rows of data were screened at Townhead. This was due to High Street only being installed in 2015 (three years after the start of the trial period), and that High Street has been prone to mechanical breakdown since its installation.



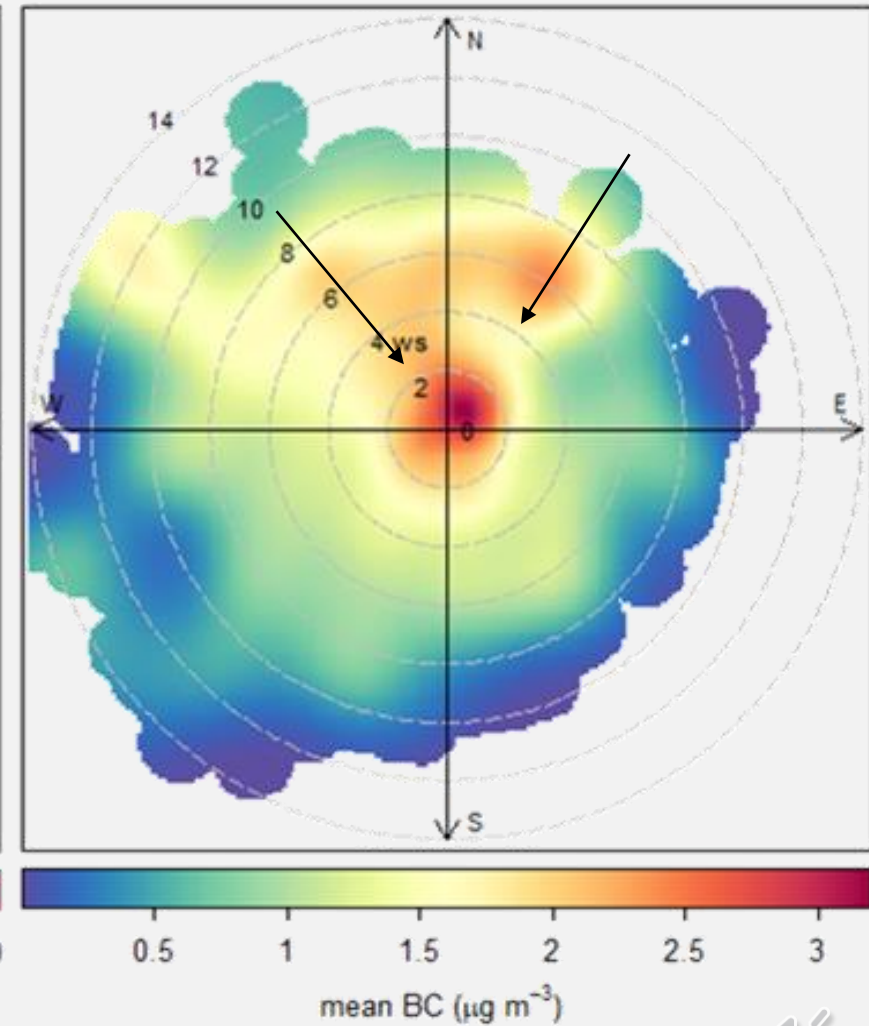
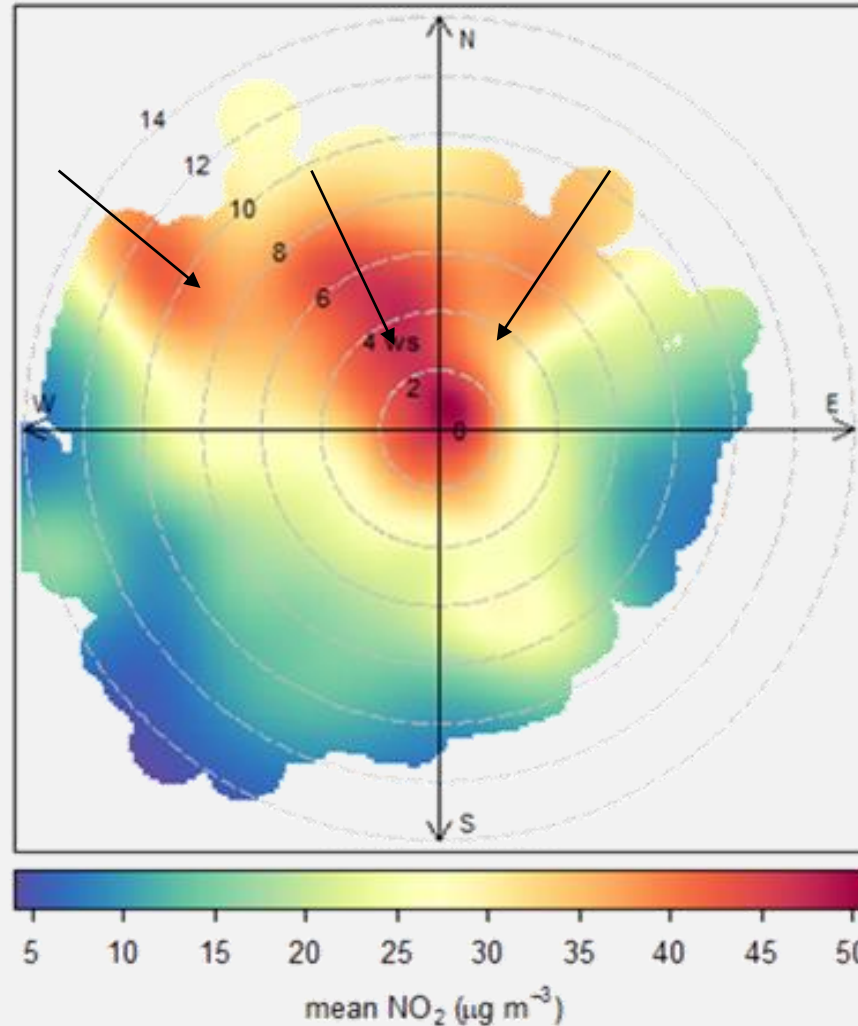
Glasgow Highstreet – Introduction.

Two of the most researched monitoring stations in the UK are located at Glasgow High Street (which measures roadside air quality) and Townhead (which measures urban ambient air). While these monitoring stations are well researched, the supply of air pollution within these complex inner-city locations are poorly understood due to the overwhelming impact of nearby road emissions.

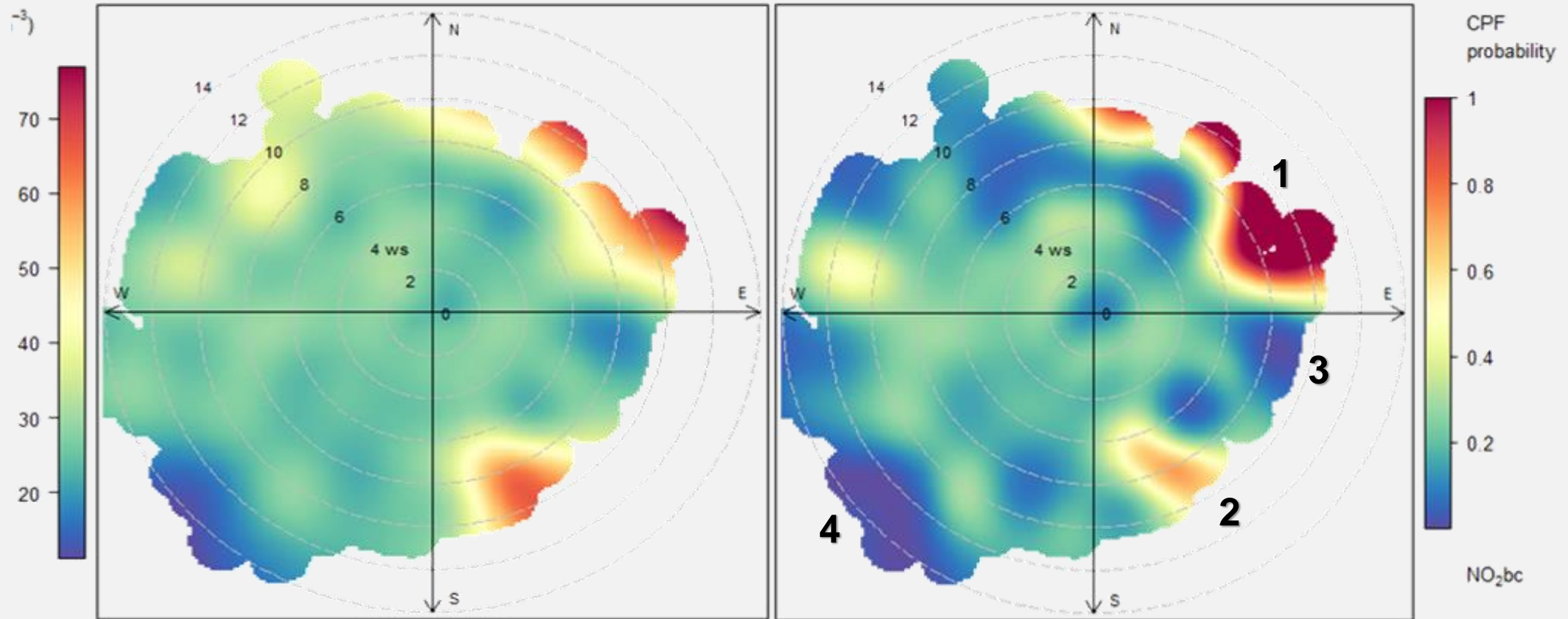


Gl Glasgow Highstreet – Single Pollutant Polar Plots.

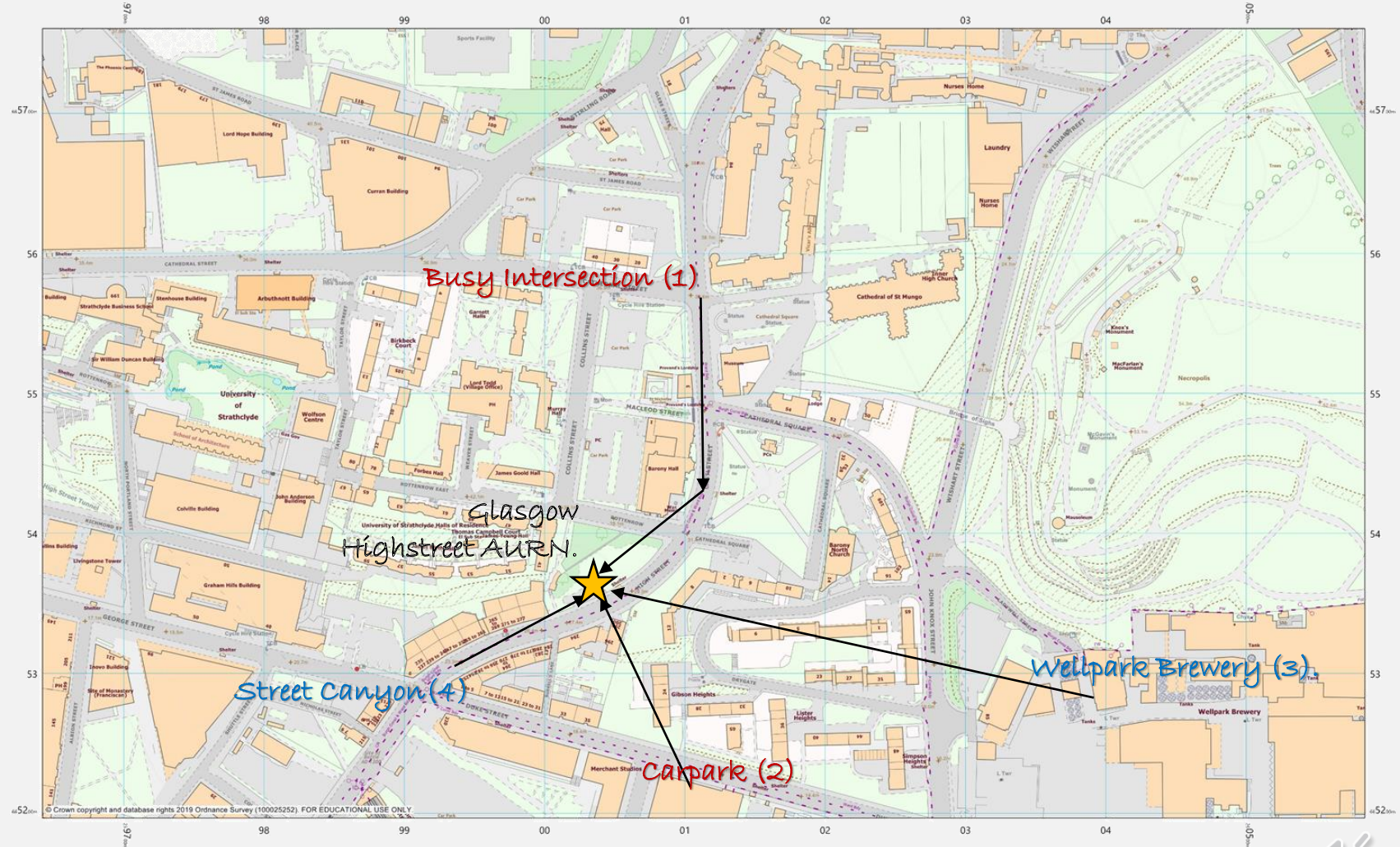
- The NO₂ and BC concentrations are distributed around the centre, i.e. having a low wind speed increases the concentration of both pollutants.
- There are high concentrations to the north of the monitoring station.
- Some features can be delineated on the single element polar plots especially on the BC chart.



Glasgow Highstreet – Ratio Pollution Polar Plots.



Glasgow Highstreet – Discussion.



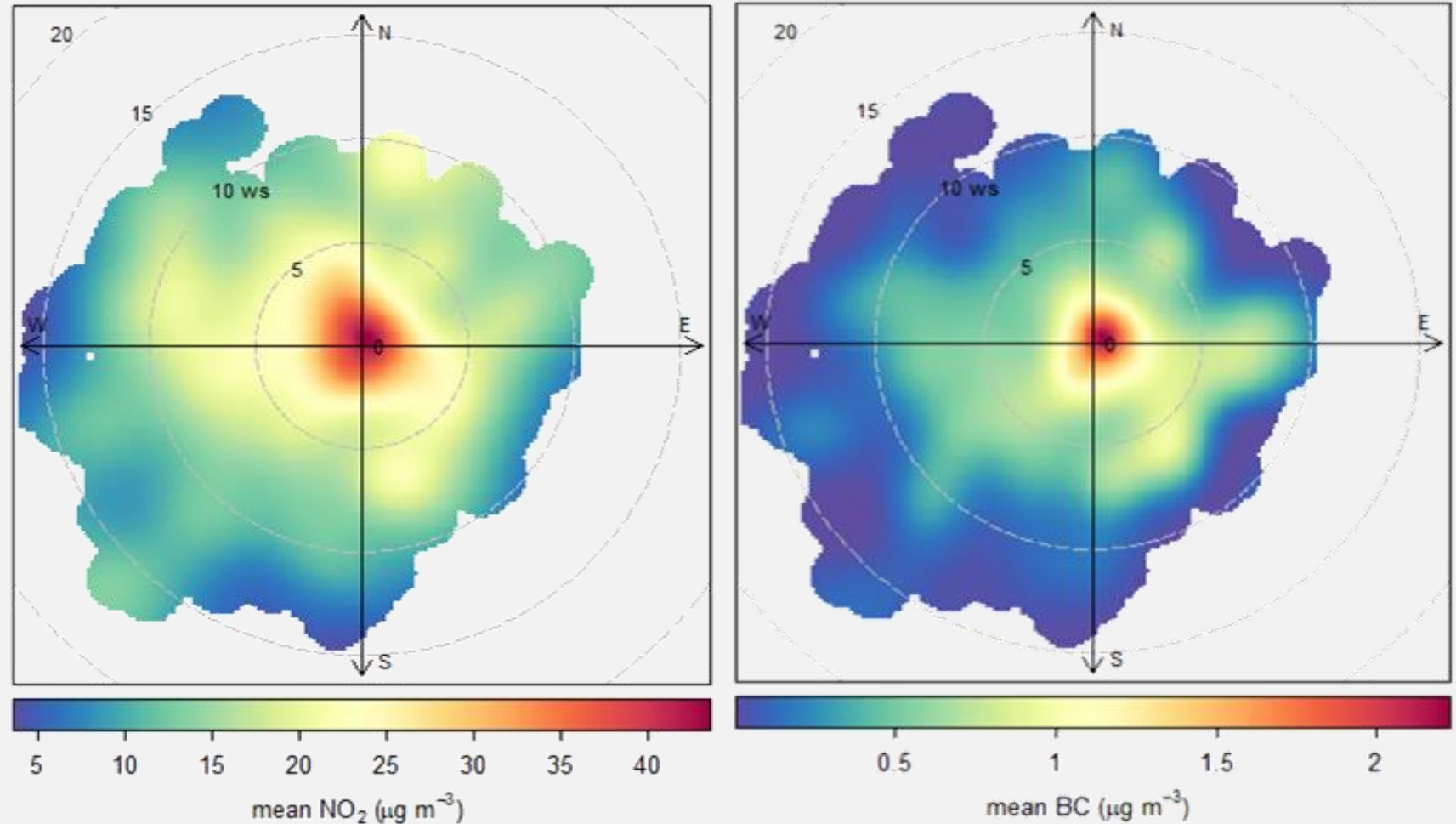
Glasgow Townhead – Introduction.

Two of the most researched monitoring stations in the UK are located at Glasgow High Street (which measures roadside air quality) and Townhead (which measures urban ambient air). While these monitoring stations are well researched, the supply of air pollution within these complex inner-city locations are poorly understood due to the overwhelming impact of nearby road emissions.

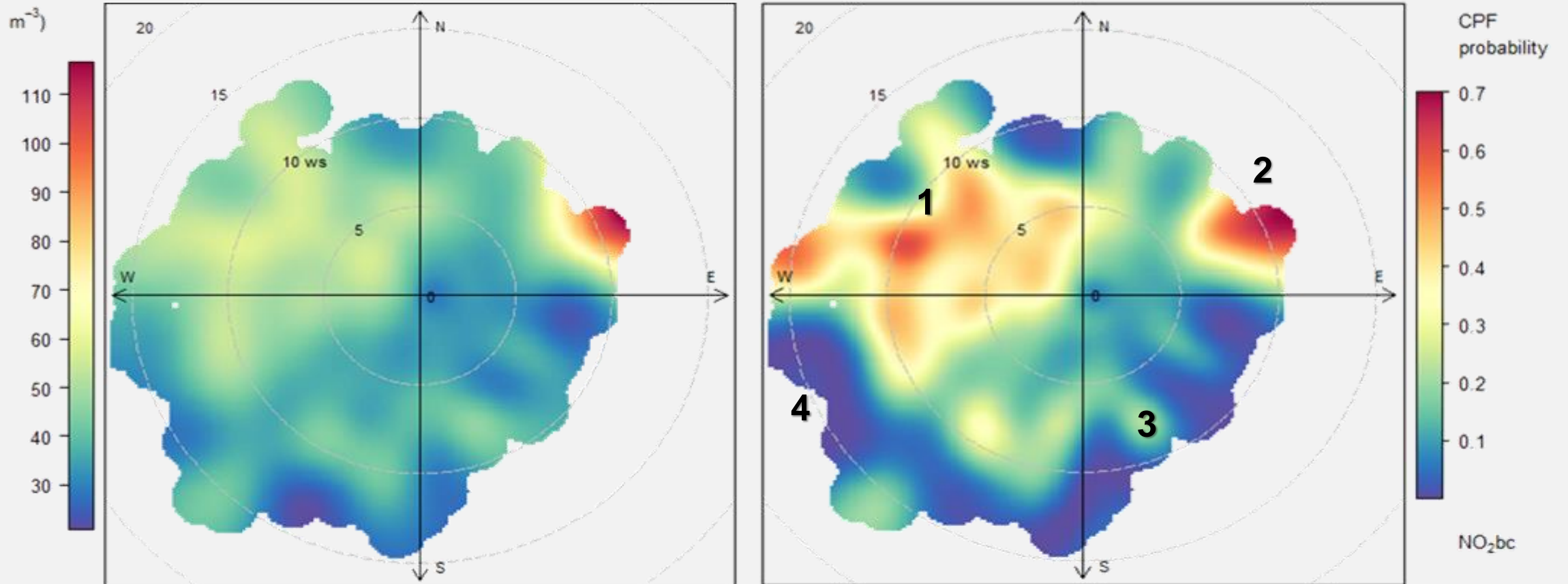


Glasgow Townhead – Single Pollutant Polar Plots.

- The NO₂ and BC concentrations are distributed around the centre, i.e. having a low wind speed increases the concentration of both pollutants.
- Whilst some features can be seen provisionally within the hotspot concentrations, these are not clear on these plots and blend into background concentrations.



Glasgow Townhead – Ratio Pollution Polar Plots.



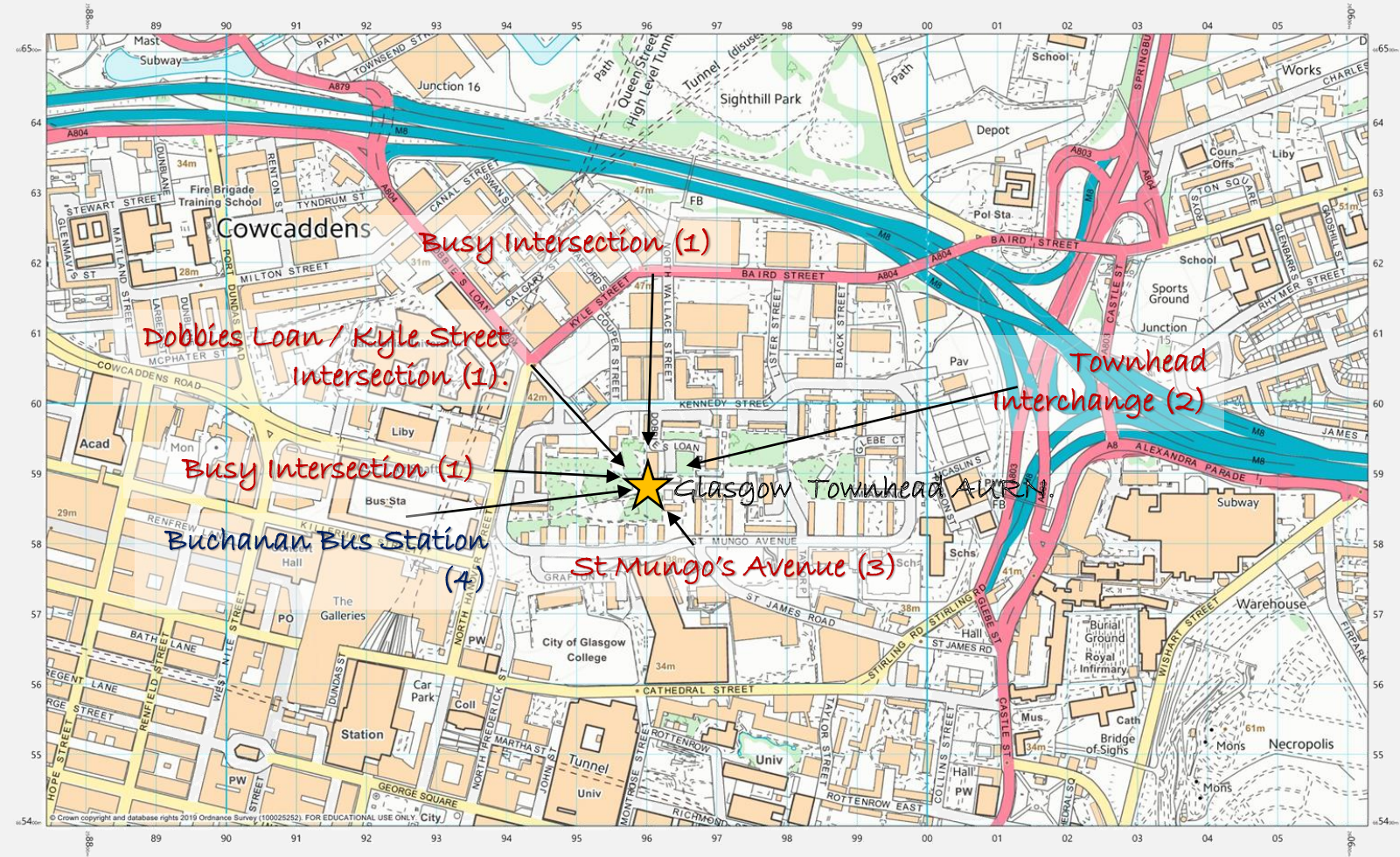
Glasgow Townhead – Discussion.



Dobbies Loan / Kyle Street



Buchanan Bus Station



Digimap®
Ordnance Survey

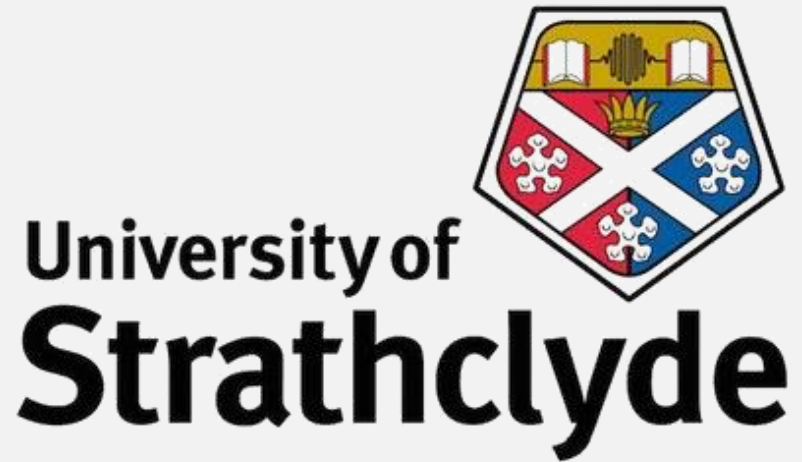
Scale 1:5000
0 50 100 150 200 250 300 350 400 450 500 m
Projection: British National Grid

Mar 03, 2019 02:34
Samuel Grainger
University of Strathclyde

Conclusions.

- The ratio pollutant concentrations between BC and Oxides of Nitrogen (in this case NO₂) are highly useful for source identification studies.
- Conditional Probability Functions (CPF) also help to create a clearer understanding of the meteorological impact and underlying variability of the source.
- In contrast, nitrogen-rich areas may show relatively recent combustion sources such as vehicular emissions.
- New, and previously undiscovered, sources of air pollution were identified at the well-studied Glasgow High Street and Townhead Monitoring Stations.
- The sources of nitrogen supply at the High Street Monitoring Station involve the A8 High Street, road junctions, car parking facilities, and Wellpark Brewery (a previously unknown source of BC).
- The Townhead Monitoring Station had similar sources of nitrogen-rich air from nearby roads, including the A804, North Hanover Street, St Mungo Avenue, and importantly, the Townhead Interchange (J15 M8).





Thank You for Listening

- Sam Grainger

Email: [Samuel_{\(dot\)}Grainger_{\(At\)}Strath_{\(dot\)}ac_{\(dot\)}uk](mailto:Samuel.Grainger@Strath.ac.uk)

