$PM_{2.5}$ on the London Underground

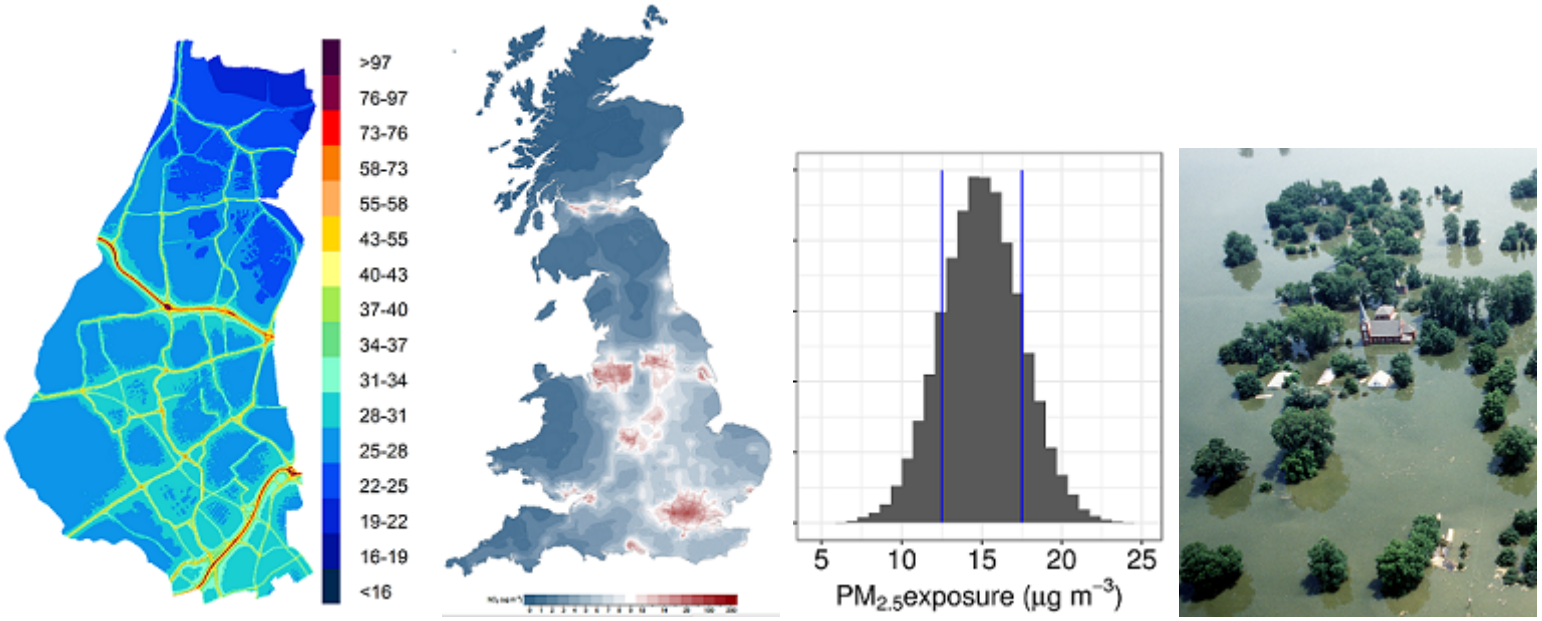
Dr James David Smith

8 January 2020

Introduction

About me

- MSc in GIS at UCL
- PhD / Researcher at King's College London
- The London Hybrid Exposure Model / Air quality GIS 'stuff'



- Now at Guy Carpenter (Model development, Re-insurance)

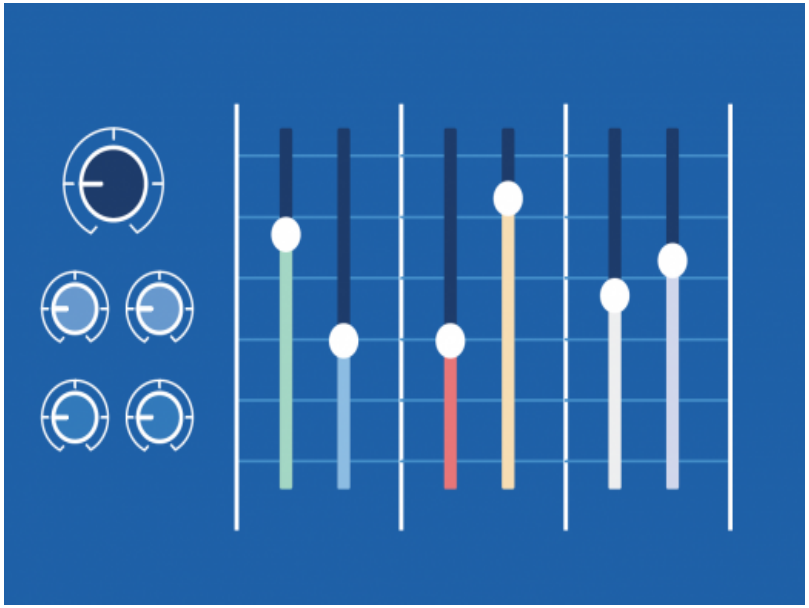
Why measure air on the tube

- Exposure to particles on subway systems > important
- Seaton et al 2005, but …
  - Tox. mechanisms
  - Susceptible populations
  - Analytical techniques

Aims

What we tried to do

- Measure variations in $PM_{2.5}$ between lines and stations
- Characterise the chemical composition
- Calculate calibration factors for optical instruments
- Provide a spatially resolved dataset for future analysis



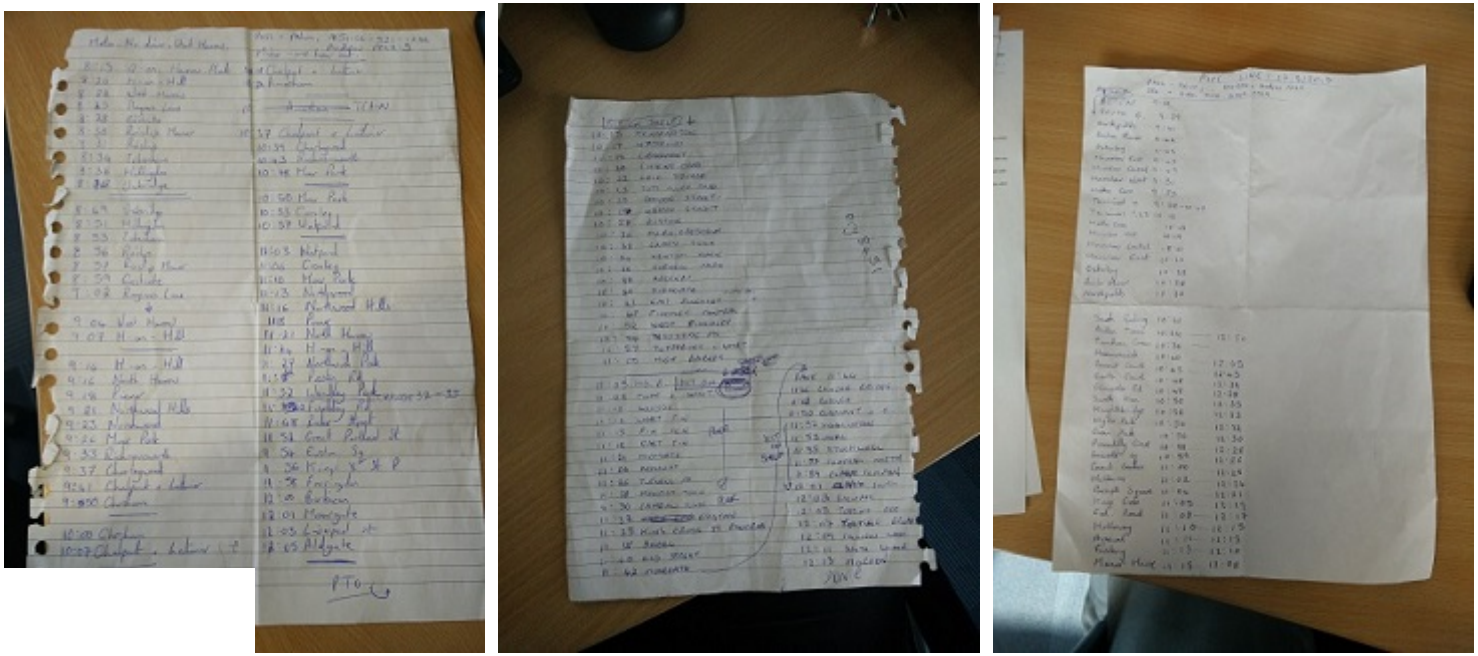
Method

Mobile Measurement campaign

- TSI AM510 SidePak (PM2.5)
- Philips Aerasense (numbers and size of particles)
- 31 hours
- All lines
- 89% of stations (NE Central, SW Piccadilly)

Geo-tagging data

- Need to link air quality measurements to locations
- No GPS signal on large sections of the network
- Considered using timetables / interpolating between known locations
- Ended up using a notepad



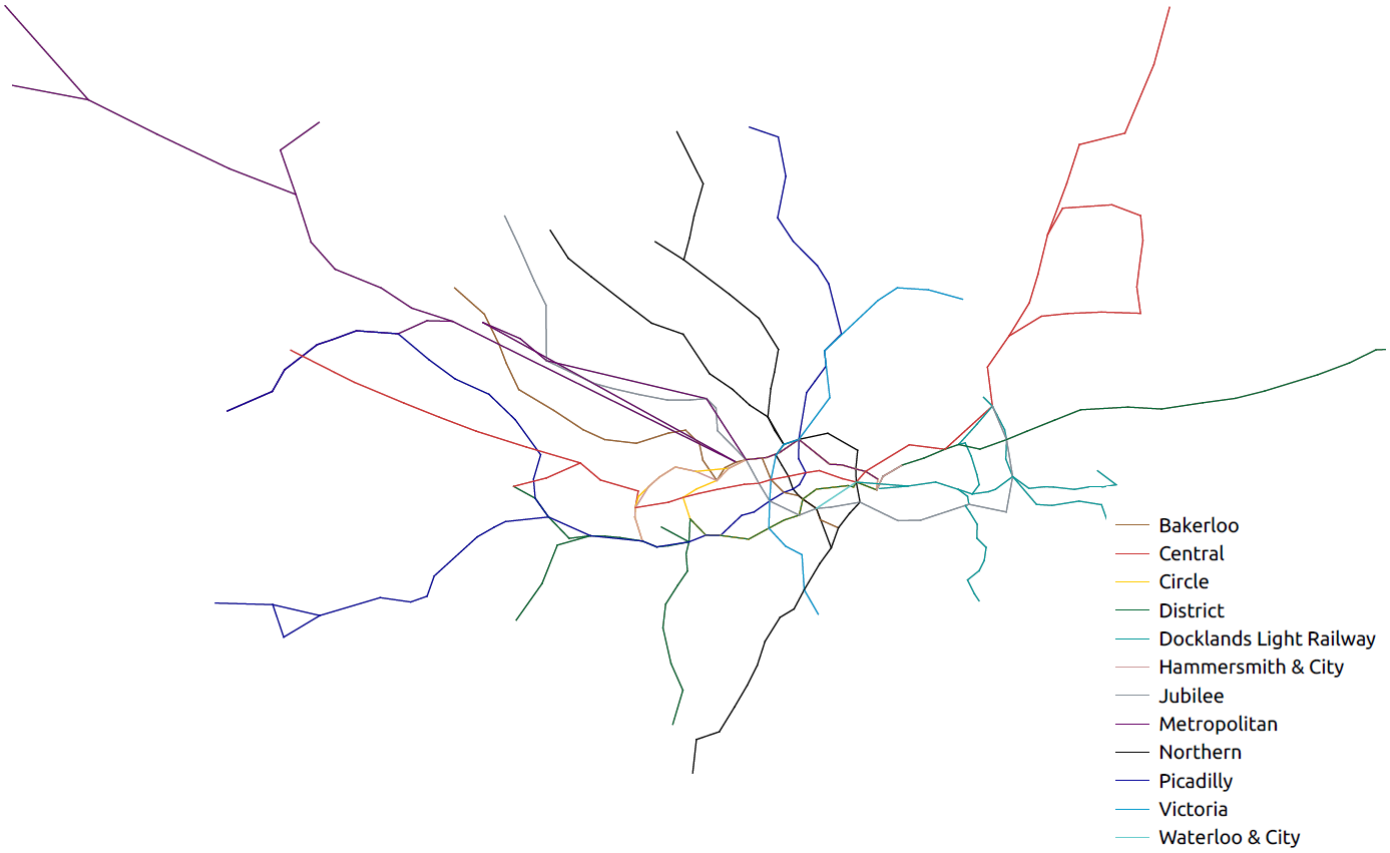
Characterisation & Calibration

- Tricky installation at Hampstead
- Particles collected on filters over 5 days measuring composition & amount
- High time resolution equipment installed
  - Aethalometer / TSI Dustrak / 2 TSI Sidepaks / Micro-aethalometer

Passenger-weighted stations

- 2015 tap in/tap out, Underground performance report
- Annual in/out for each station
- Mean $PM_{2.5}$ measured at each station
- Passenger rank * air quality rank = passenger-weighted ranking

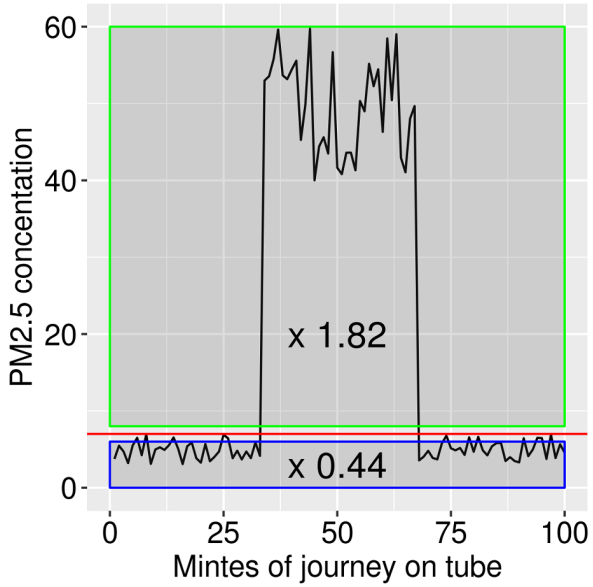
Spatial representation of the tube



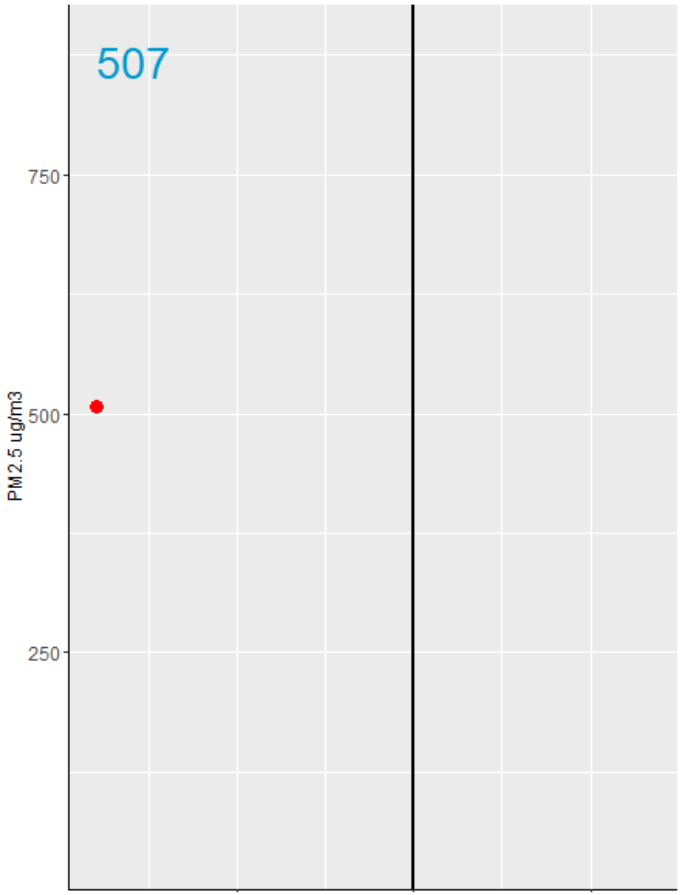
Results

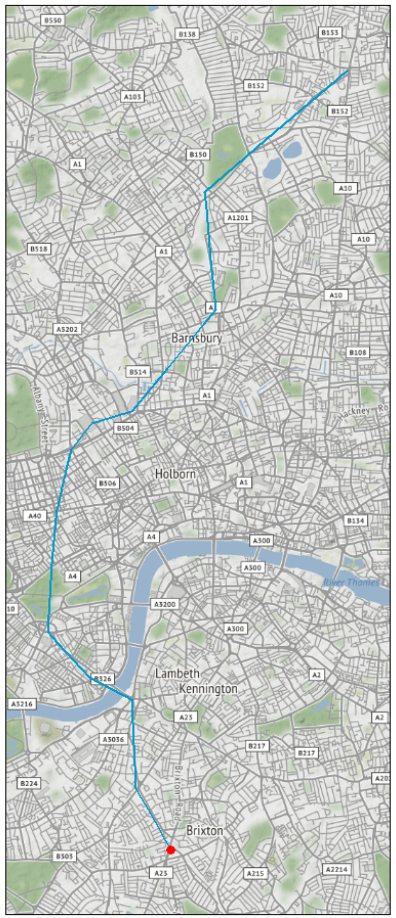
Calibration factors

- Linear model to calculate correction factors for mobile monitoring equipment
- Mobile monitoring equipment co-located in tube station v. outdoor

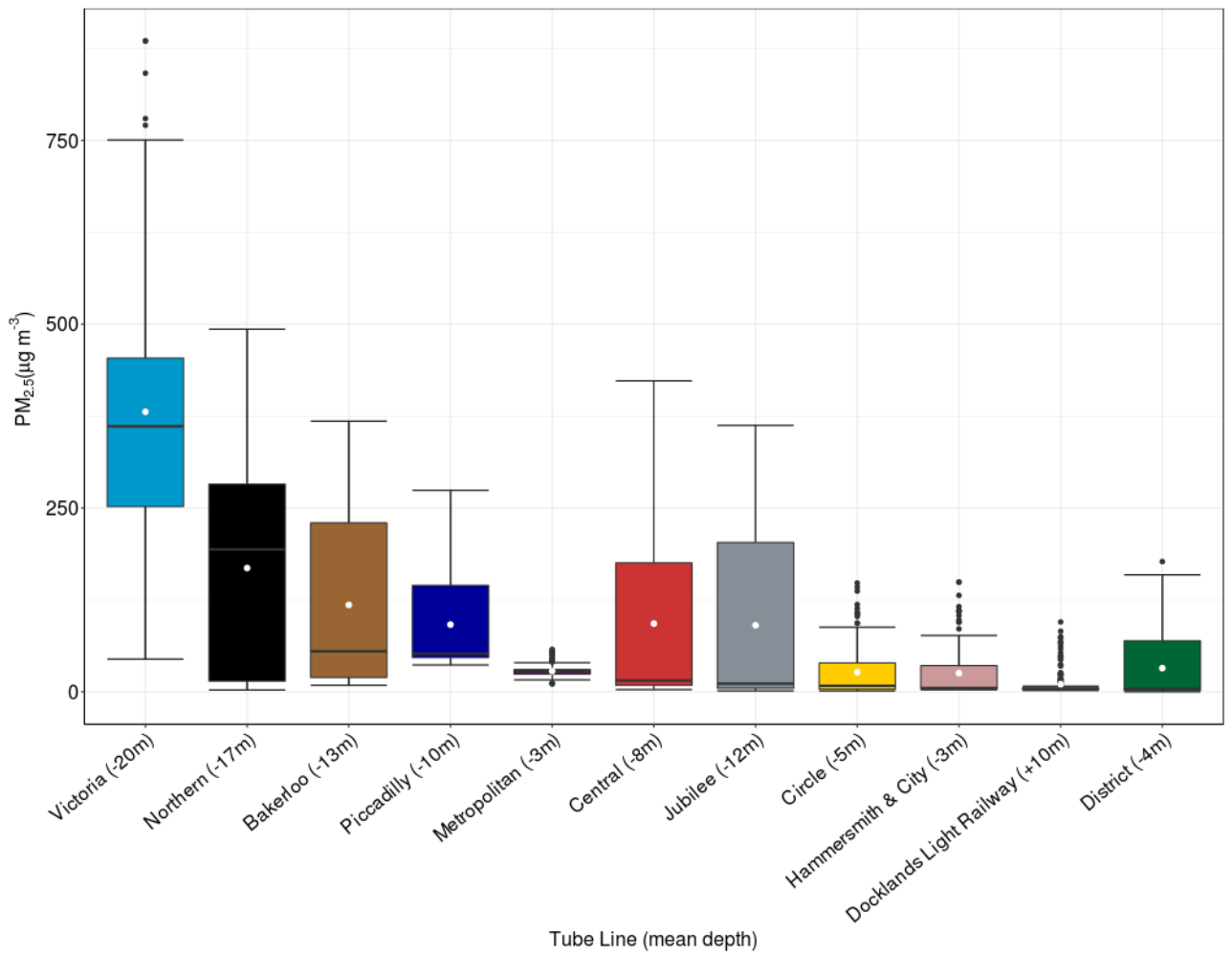


The Victoria Line

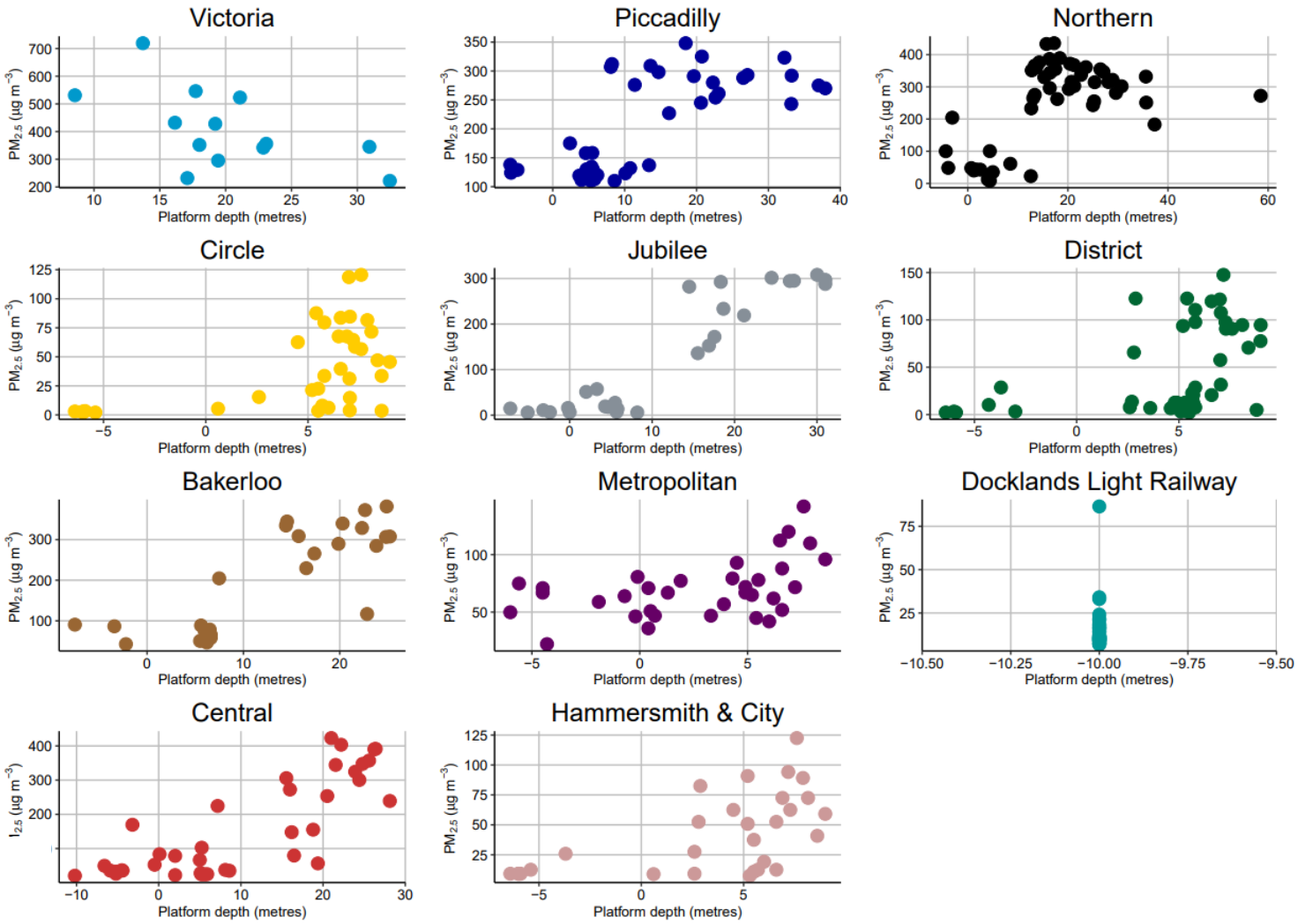




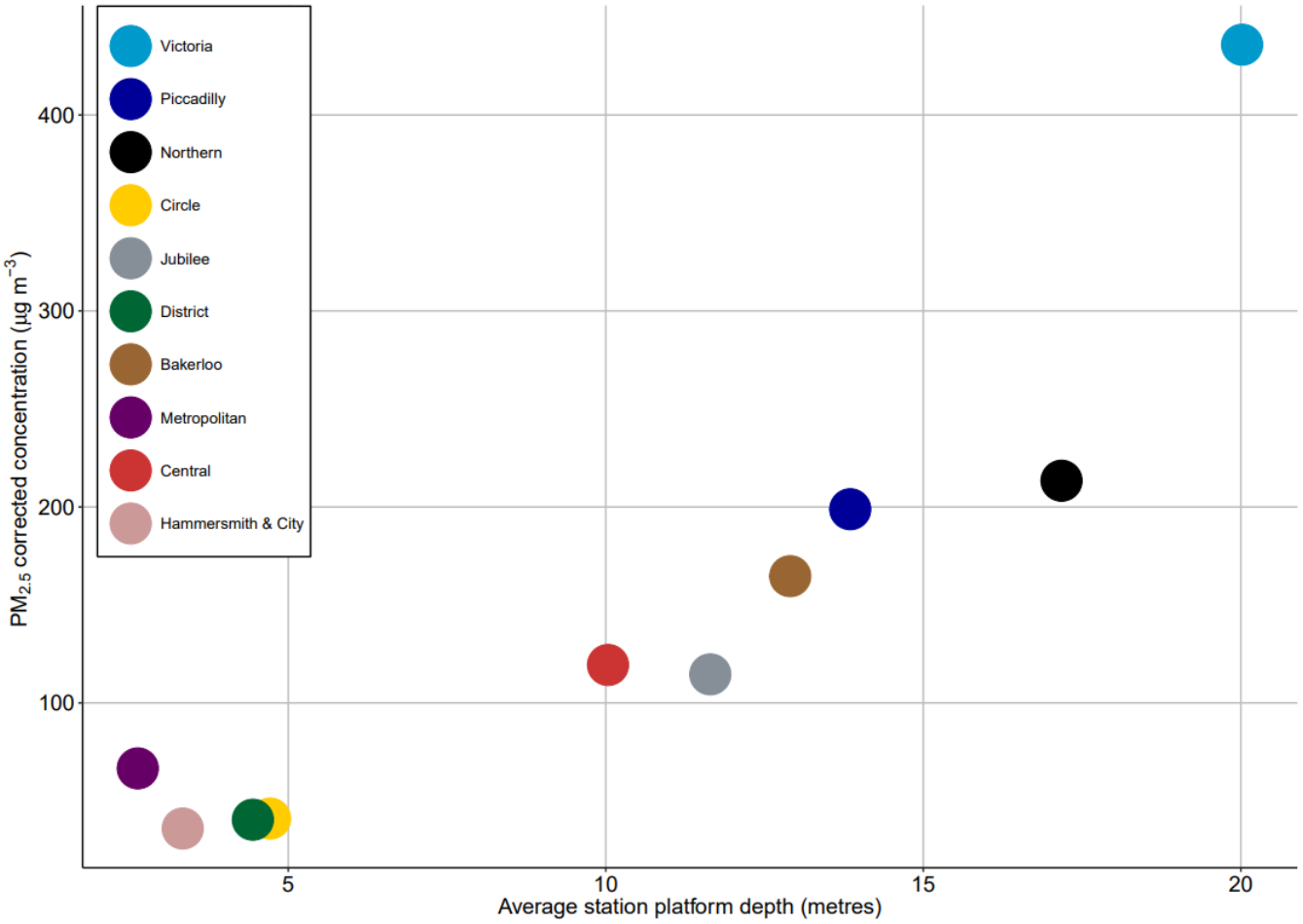
Line averages



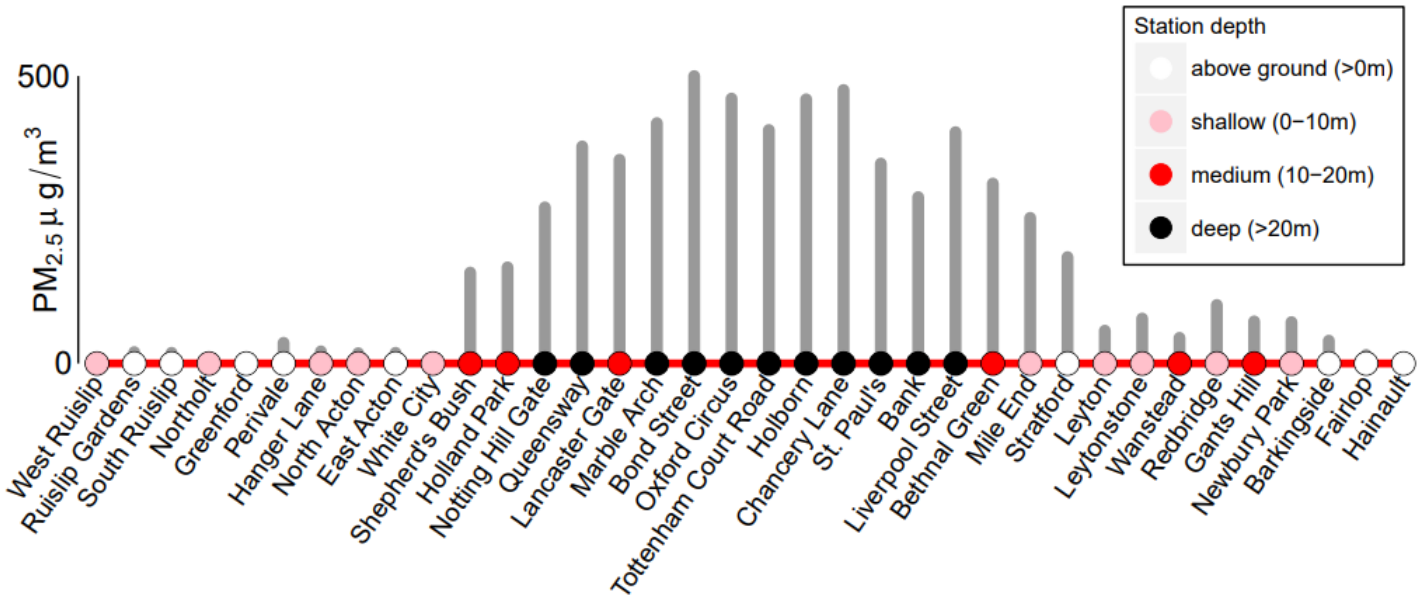
Station depth 1



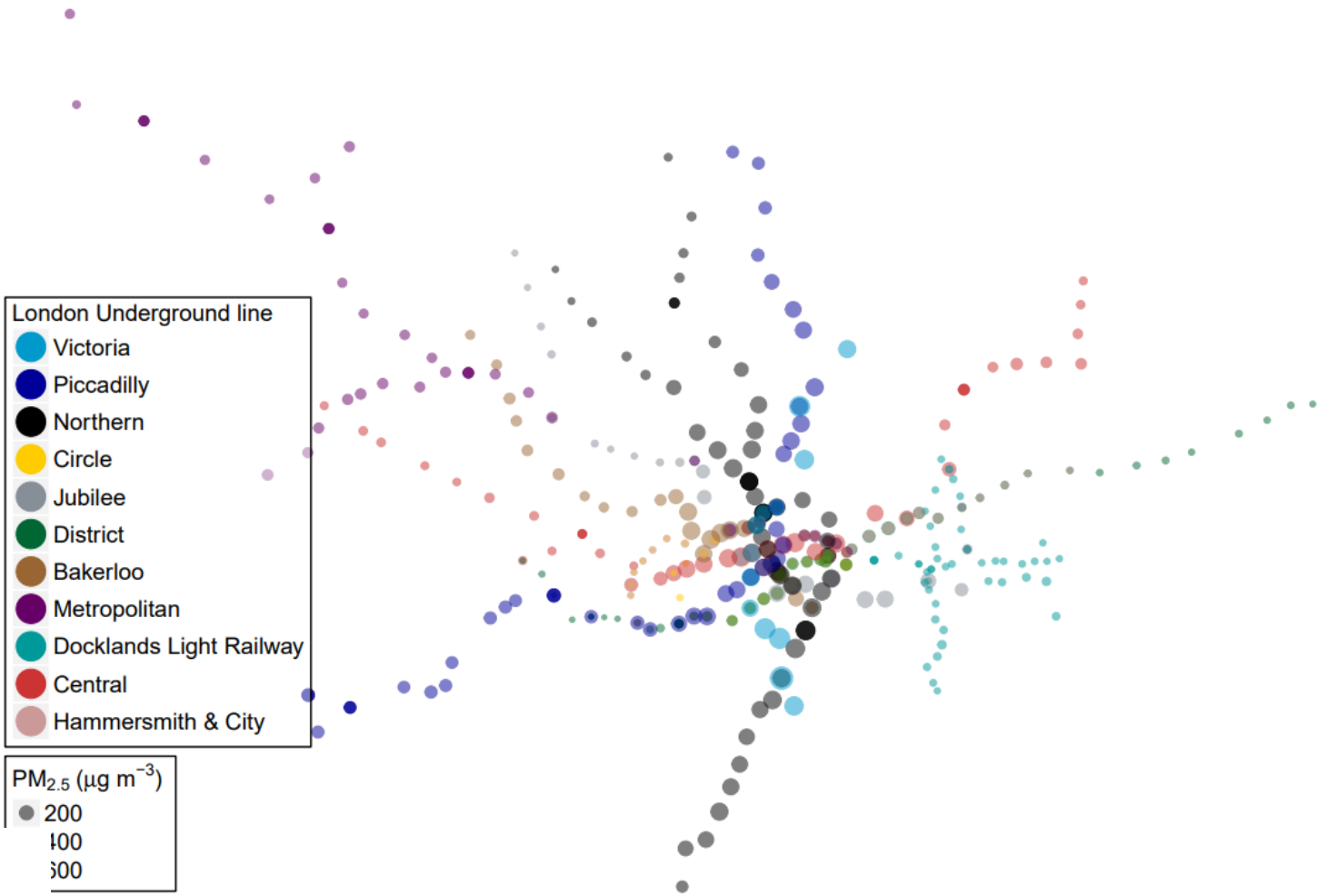
Station depth 2



Depth on the Central Line



$PM_{2.5}$ Map


London Underground line
Victoria
Piccadilly
Northern
Circle
Jubilee
District
Bakerloo
Metropolitan
Docklands Light Railway
Central
Hammersmith & City
PM2.5 (µg m−3)
200
100
300

$PM_{2.5}$ online map

Online

London Underground $PM_{2.5}$

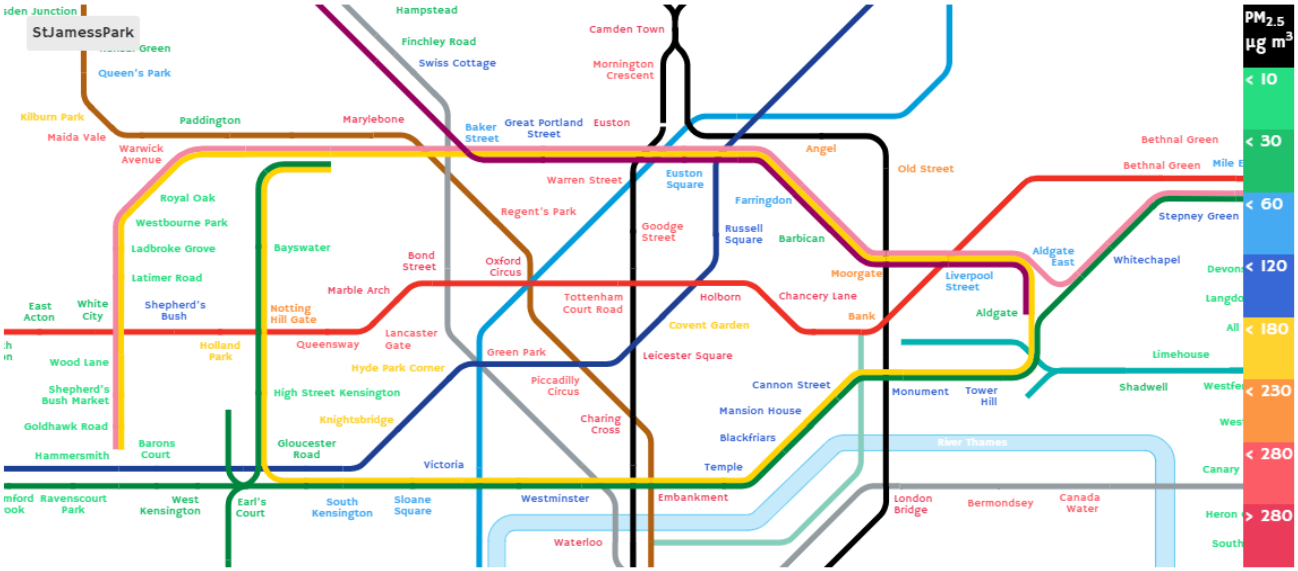
The following is an interactive map of the London Underground transportation network. The stations are coloured based upon their measured $PM_{2.5}$ value and where they fall on our colour scale (right).

- Use the mouse wheel to control the zoom
- You can click on any Tube Line or Station to enable/display their colouring
- Hovering over a station will display the raw $PM_{2.5}$ values for each line at a station

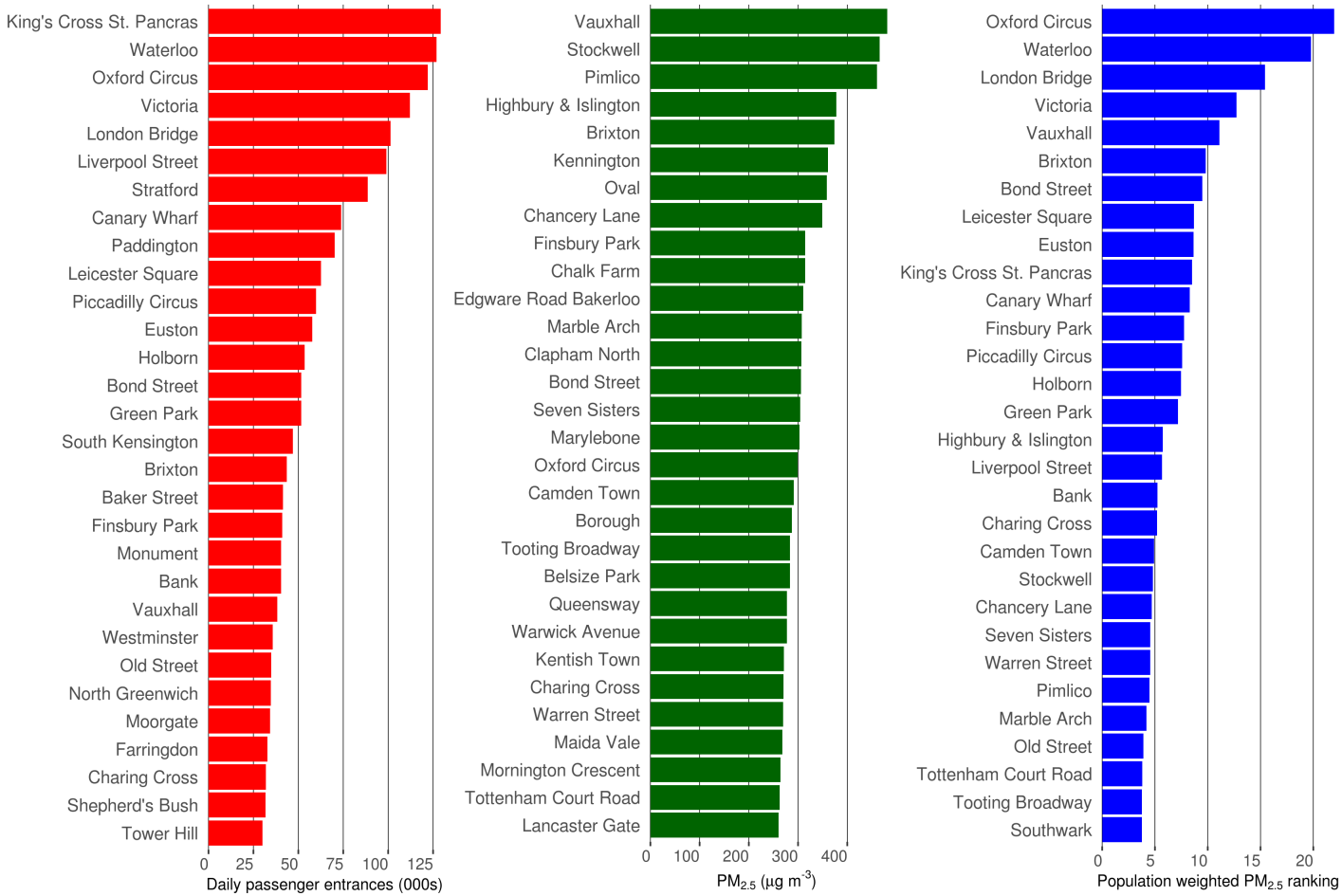
The full paper can be found at https://www.sciencedirect.com/science/article/pii/S0160412019313649?via%3Dihub.

The dataset is available at https://data.mendeley.com/datasets/tv56txbpcw/1.

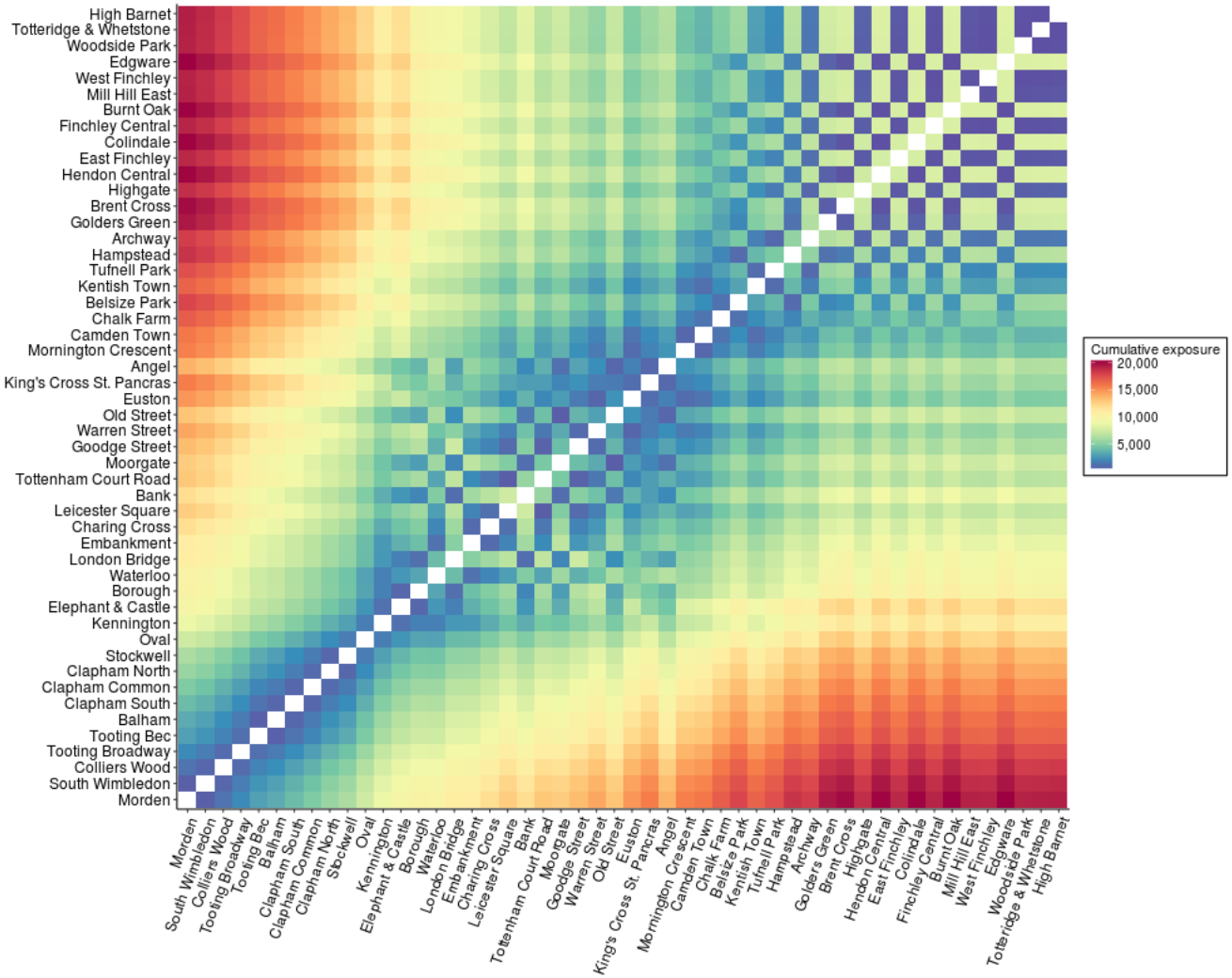
Please note: Data was recorded over 31 hours of travel in 2015 with each station measured on 2 -5 occasions, this data may not reflect current concentrations.



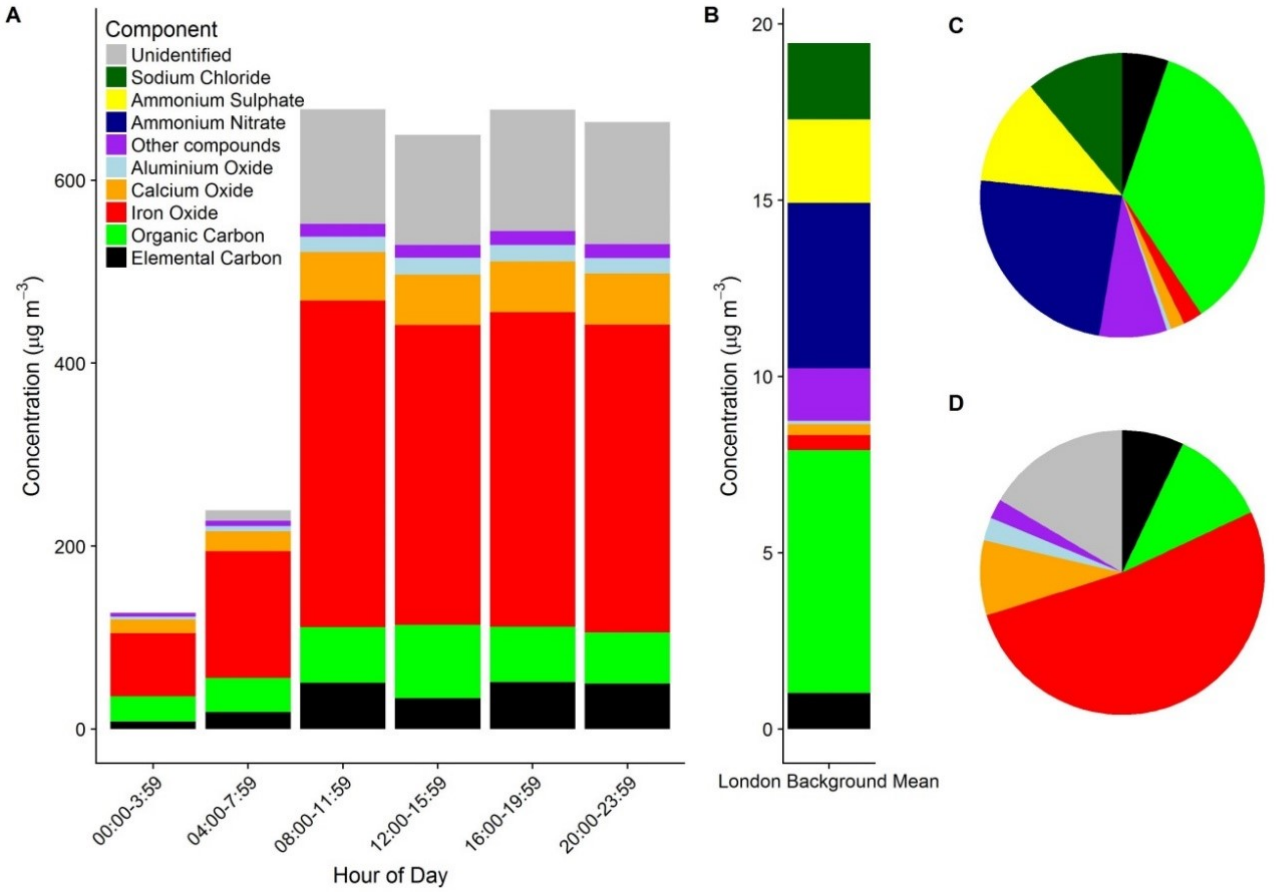
Passenger-weighted stations



Origin-Destination matrix



Characterisation



Conclusions

Conclusions

- Particles tend to be larger in diameter than those at background or roadside environments
- More particles
- $PM_{2.5}$ varied between lines & locations
  - lowest Hammersmith & City (Mean 25 µg/m3), similar to roadside
  - highest Victoria (381 µg/m3), 15 x higher than roadside

Conclusions 2

- General relationship between ‘depth’ and air quality
- Oxford Circus, Waterloo, London Bridge, Victoria and Vauxhall at top of passenger-exposure ranking
- 79% of $PM_{2.5}$ characterised
  - 47% iron oxide, 7% elemental carbon, 11% organic carbon, 14% metallic and mineral oxides
- Previous studies using light-scattering may under-report PM

What next

What was planned

- ~~Characterise the remaining 11%~~
- ~~More measurements accross the network to improve understanding~~
  - ~~train frequency~~
  - ~~passenger numbers~~
  - ~~time of year~~
- ~~Interventions?~~
- ~~Develop inclusion in exposure modelling~~

What happened

The end

Publication, Contact & Data

ELSEVIER

Environment International

Volume 134, January 2020, 105188

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J.D. Smith [a], B.M. Barratt [a, b], G.W. Fuller [a], F.J. Kelly [a, b], M. Loxham [c, d], E. Nicolosi [a], M. Priestman [a], A.H. Tremper [a], D.C. Green [a]

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