The Scottish Government

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Particulate Matter Study

Research study to investigate particulate matter monitoring techniques in Scotland

Stephen Stratton, 4th March 2020

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Introduction

- Context
- The aim of the project
- The monitoring site and sampling methods being investigated
- Some initial results
- Something extra…

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Context

- Previous study carried out by Ricardo Energy and Environment, Kings College London and Bureau Veritas in the southern England to assess the relationship between automatic PM measurements and reference method gravimetric samplers found the following:
    - The relationship between the reference method (SEQ) and Partisol samplers is excellent.
    - Daily average PM_{10} concentrations generally follow BAM > FDMS > FIDAS – only 2-3 µg m^{-3} across the entire range **BUT** significant in terms of the Scottish annual mean air quality objective of 18 µg m^{-3}.
    - It is possible that as the traffic increases, the FIDAS fails to measure the finest particles (<180 nm), which potentially causes it to under read compared to the FDMS.
    - Data suggest that this apparent FIDAS under read is strongly correlated to black carbon concentrations; and is worst when the sampling inlet is less than 0.5 m from the kerb of a heavily trafficked road.

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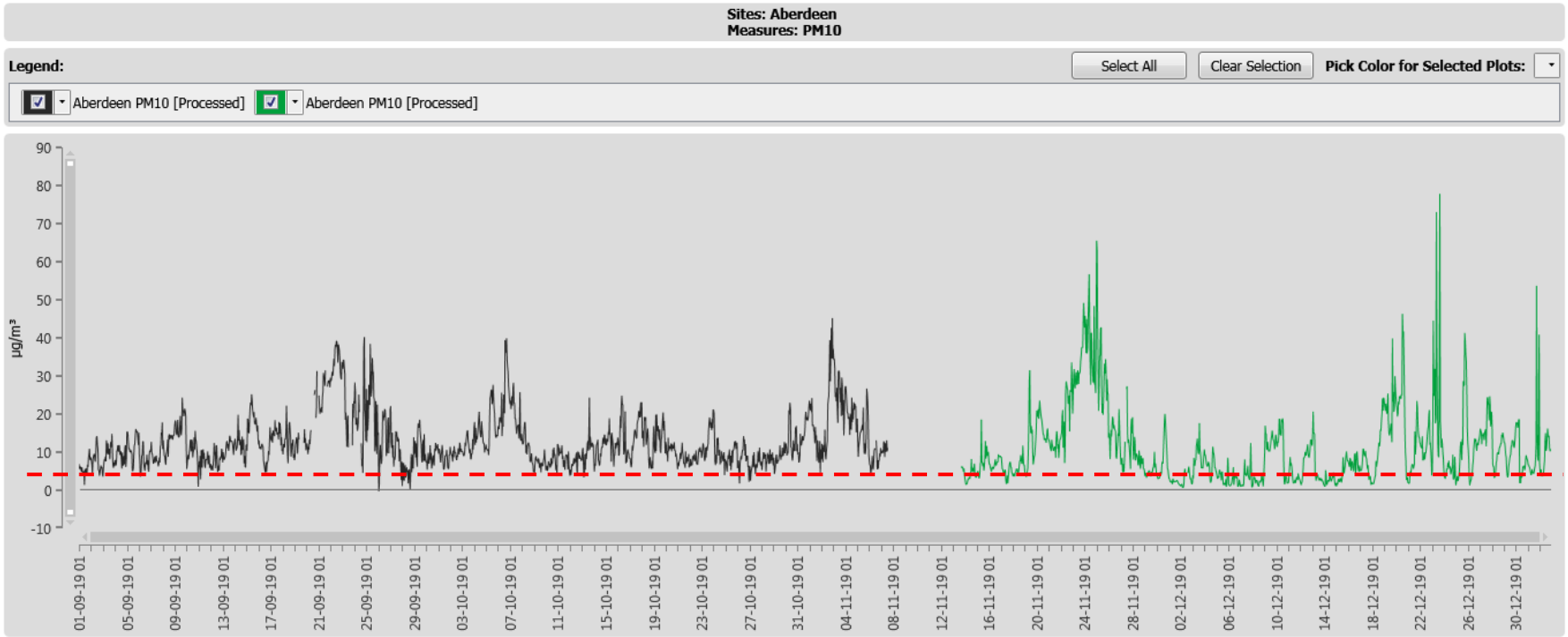
Context, Part 2…

- Trend analysis using SAQD data identified a potential drop in PM_{10} concentrations with the introduction of a FIDAS (previously an FDMS).
- The findings for the previous study do not explain why this would be as the FIDAS under-read should only be seen at very busy kerbside locations. So, there must be other contributing factors – offsets and noise.
- This is an example of an offset seen at Aberdeen Errol Place – you can see a drop in the baseline with the installation of the FIDAS:



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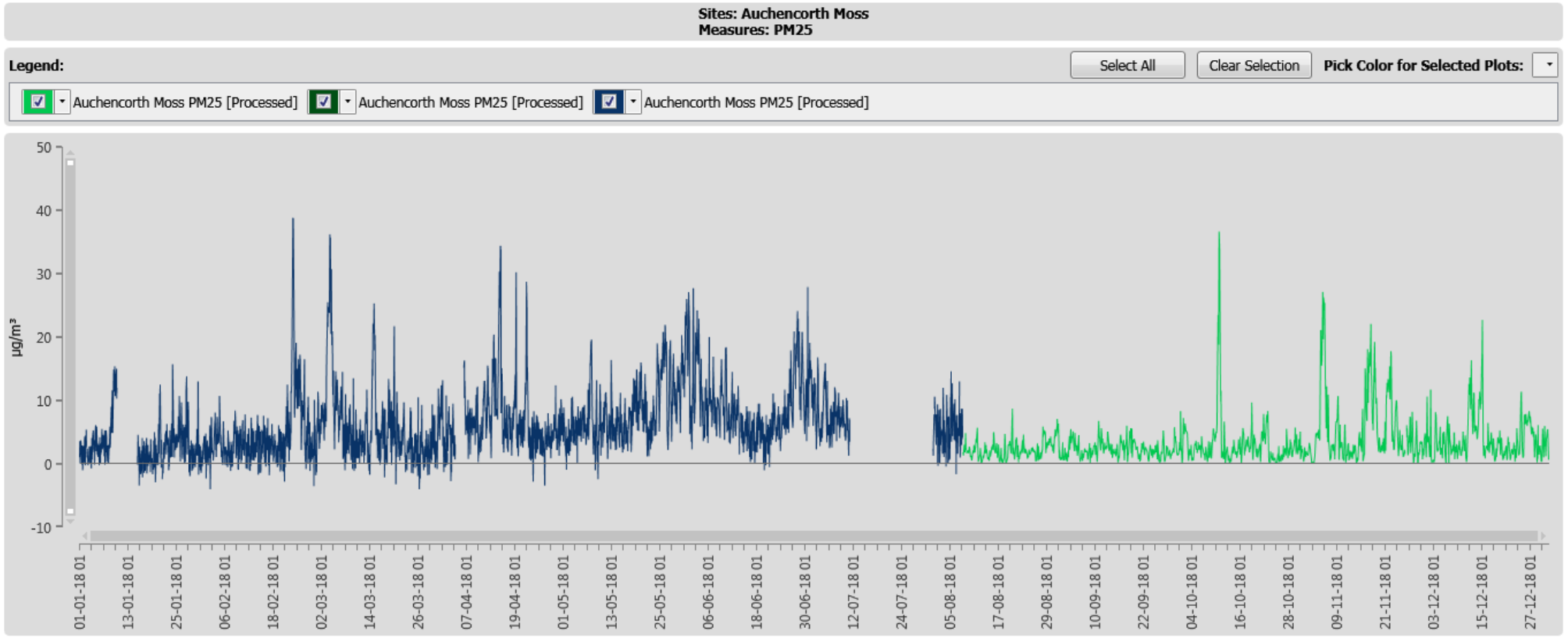
Context, Part 2…

- In this case the $PM_{2.5}$ measure by the FDMS at Auchencorth Moss are much noisier than the FIDAS and there is a drop in concentrations
- Typically, the limit of detection (LoD) of an FDMS is 5 μg m^{-3} (6 μg m^{-3} for a BAM), which can be clearly seen with the low measured concentrations. The FIDAS LoD is lower…
- This makes it hard to identify whether there is an offset and the extent of any offset.



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Context, Part 3!

- Ongoing equivalence data currently available for the UK is based on measurements at a background location in London but:
    - the relationship between reference and candidates is very dependent on a) concentration ranges and b) seasonality. Hence the current equivalence trails are not comprehensive enough, resulting in the need for these ongoing assessments.

- Revocation of PM_{10} Air Quality Management Areas in Scotland – with the low annual mean objective, we need to be sure that revocation is appropriate.

- Study required to investigate how automatic monitoring methods perform in Scottish pollution and meteorological environment.

Important to note that all the methods used within the SAQD have been assessed as equivalent to the EU reference method.

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Project Aims

- PM_{10} and $PM_{2.5}$ monitoring carried out over six months.
- Assess the relationships between all analysers in use in Scotland.
- Investigate new FIDAS algorithm.
- Investigate measurement uncertainty of all the analysers as a function of concentration.
- Provide a better understanding about the affect the apparent under read of the FIDAS analyser has on concentrations measured in the SAQD.
- Provide the evidence to decide whether any additional adjustments need to be made when reporting local PM measurements.

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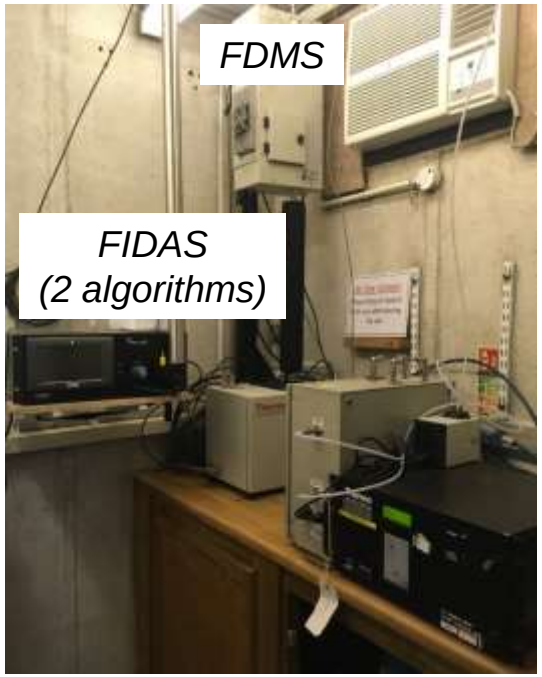
Glasgow Hope Street



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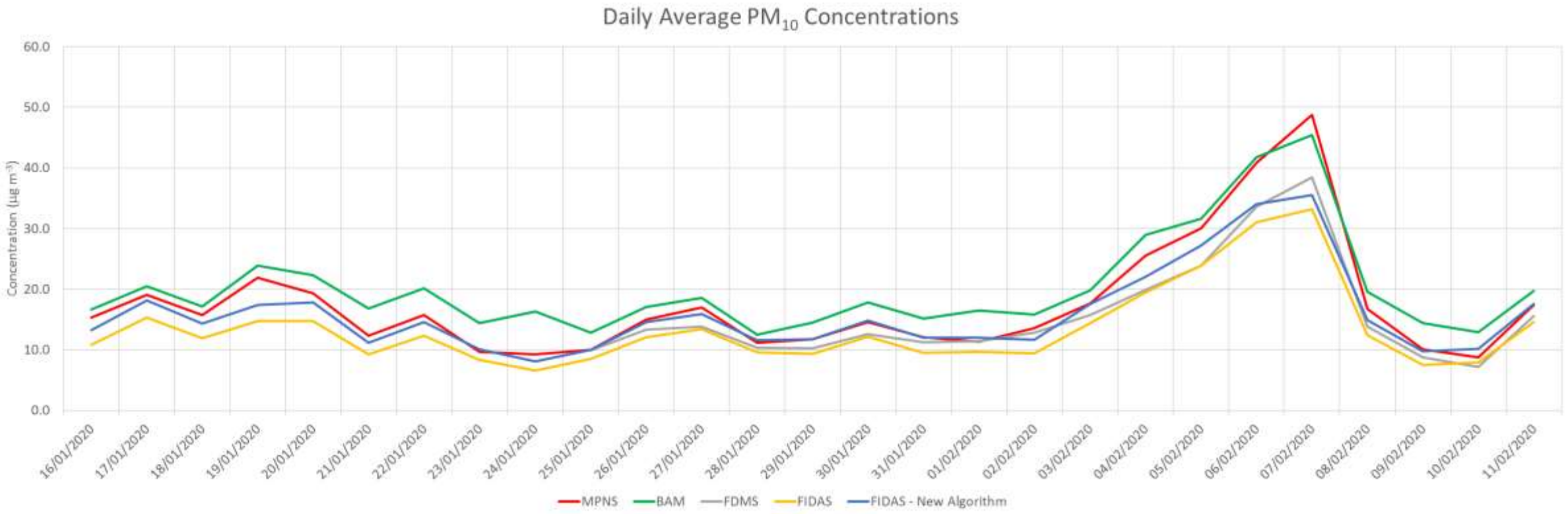
Some very provisional results…

- All analysers are generally doing the same thing – the BAM might have an offset
- Baseline checks are being carried out as part of the project to identify potential offsets



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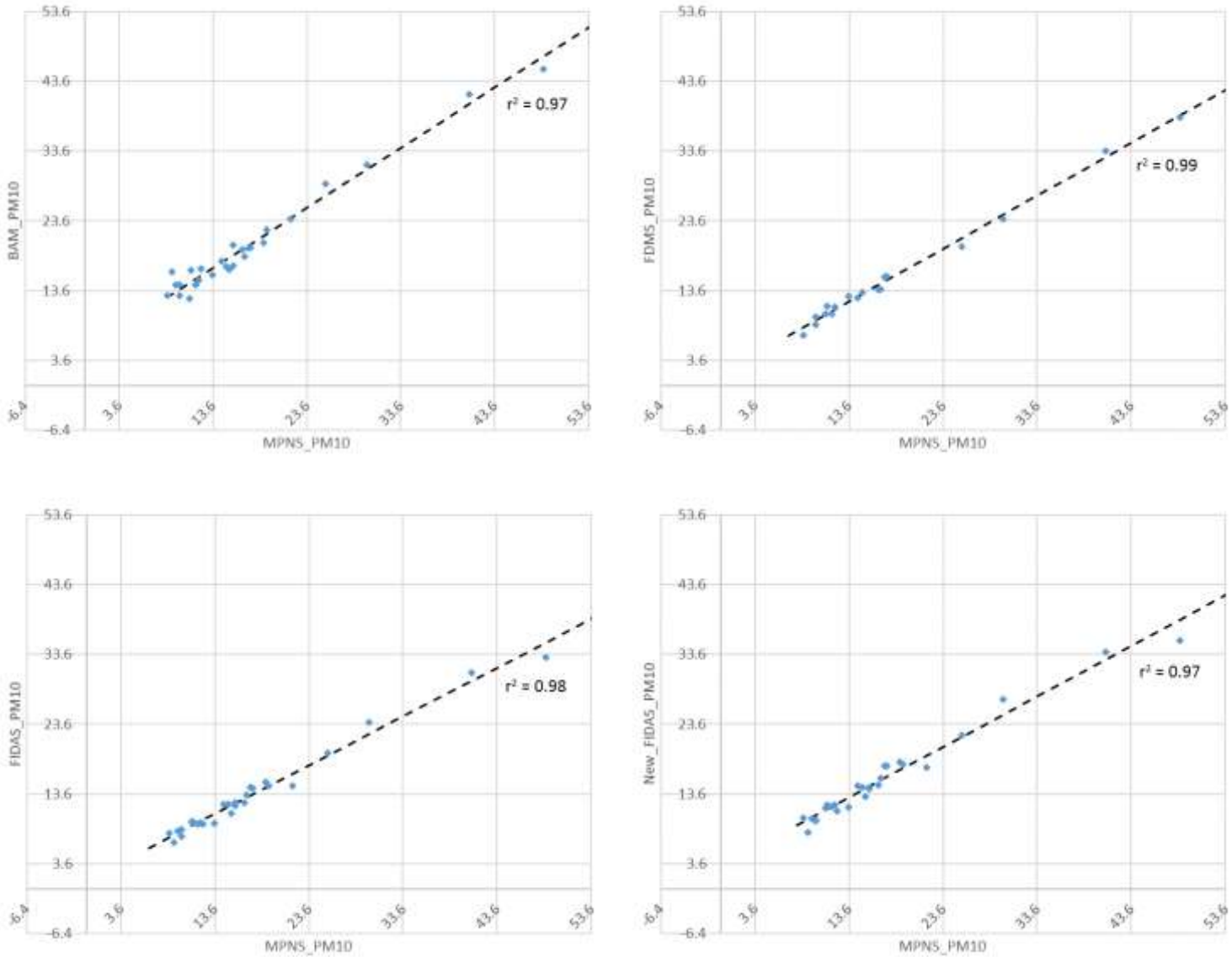
Regression – PM_{10}

- Regression plots confirm the correlation between the automatic analysers and reference sampler is good.



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BAM/FDMS/FIDAS

- BAM>FDMS>FIDAS, as expected

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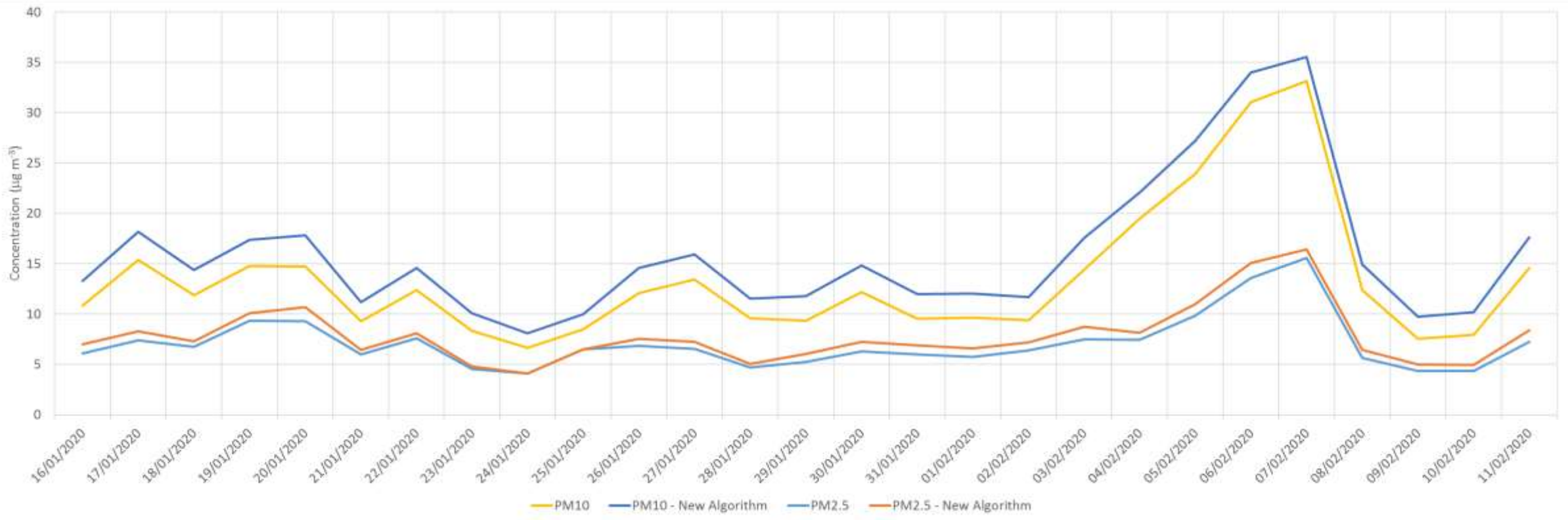
FIDAS Algorithms

- The FIDAS - New Algorithm > FIDAS
- Not clear how the new algorithm is calculating the mass concentrations – we would expect to see a greater proportional increase in $PM_{2.5}$ concentrations if the FIDAS is accounting for the mass in PM <180 nm



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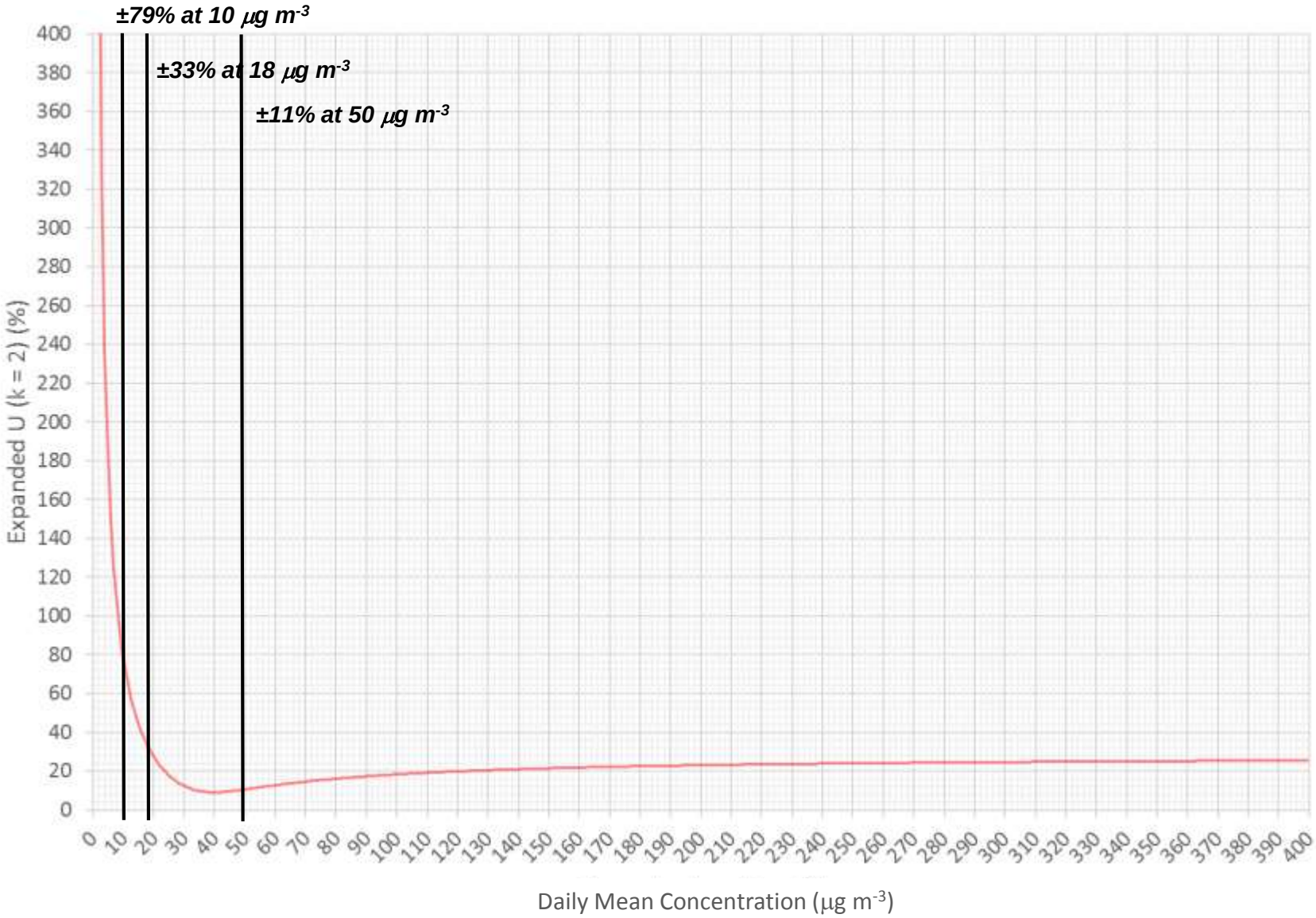
Measurement Uncertainty

- Data Quality Objective (DQO) uncertainties are currently quoted as a percentage of the relevant short-term limit value (LV).

- At 50 μg m^{-3}, it is relatively easy for the analysers to pass the ±25% limit. Once you start reducing the LV concentration, it gets progressively harder to pass this.



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Final Thoughts

- The inter-relationships between automatic analysers are as expected, so far.

- The correlation between the reference sampler and each automatic analyser is good, as expected.

BUT

- Only very provisional results – we need more data especially at or above 50 μg m^{-3}.

- Results are due to be published in August, assuming good data capture.

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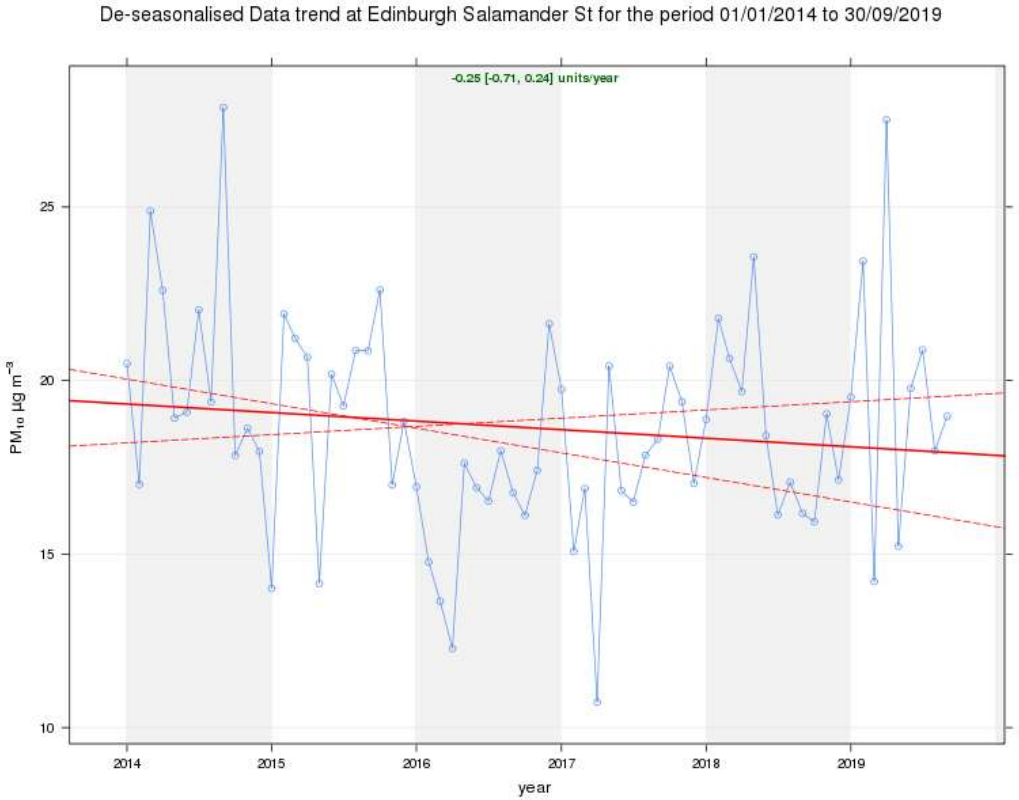
Something extra…

- A reminder of the analysis tools available to local authorities when investigating, for example:
  - whether it is appropriate to revoke an AQ;
  - potential sources of pollution.

http://www.scottishairquality.scot/data/openair



Example analysis – potential sources, Edinburgh

- Monitoring site at Salamander St, just south of Leith port has historically measured PM_{10} concentrations in excess of or close to the annual mean objective
- New PM monitoring site installed at Tower St using a FIDAS is measuring lower concentrations of PM, well below the objective levels
- Leith port operators argue that there is no longer an issue with PM_{10} and that the higher concentrations measured at Salamander St must be due to another source
- The following analysis is a very quick example of the power of the openair package…

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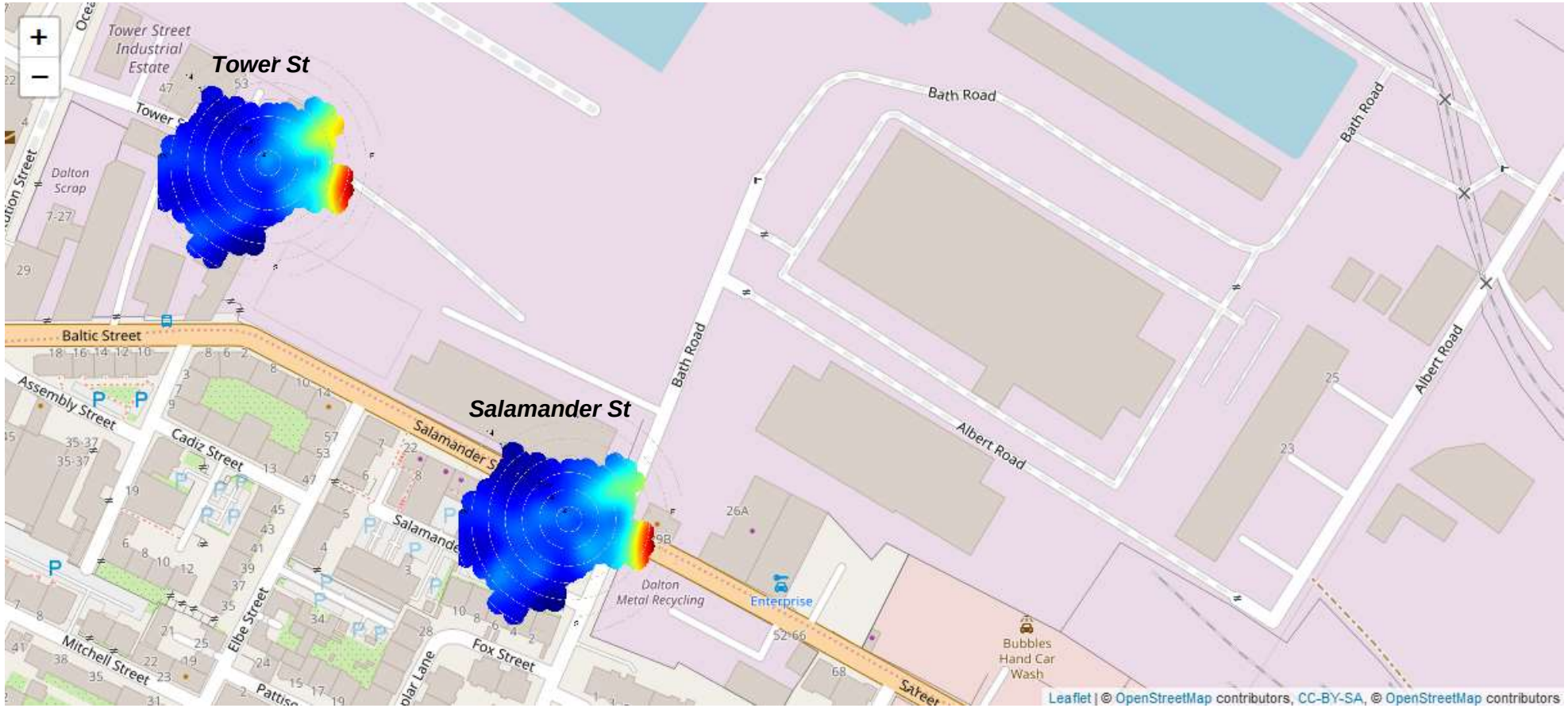
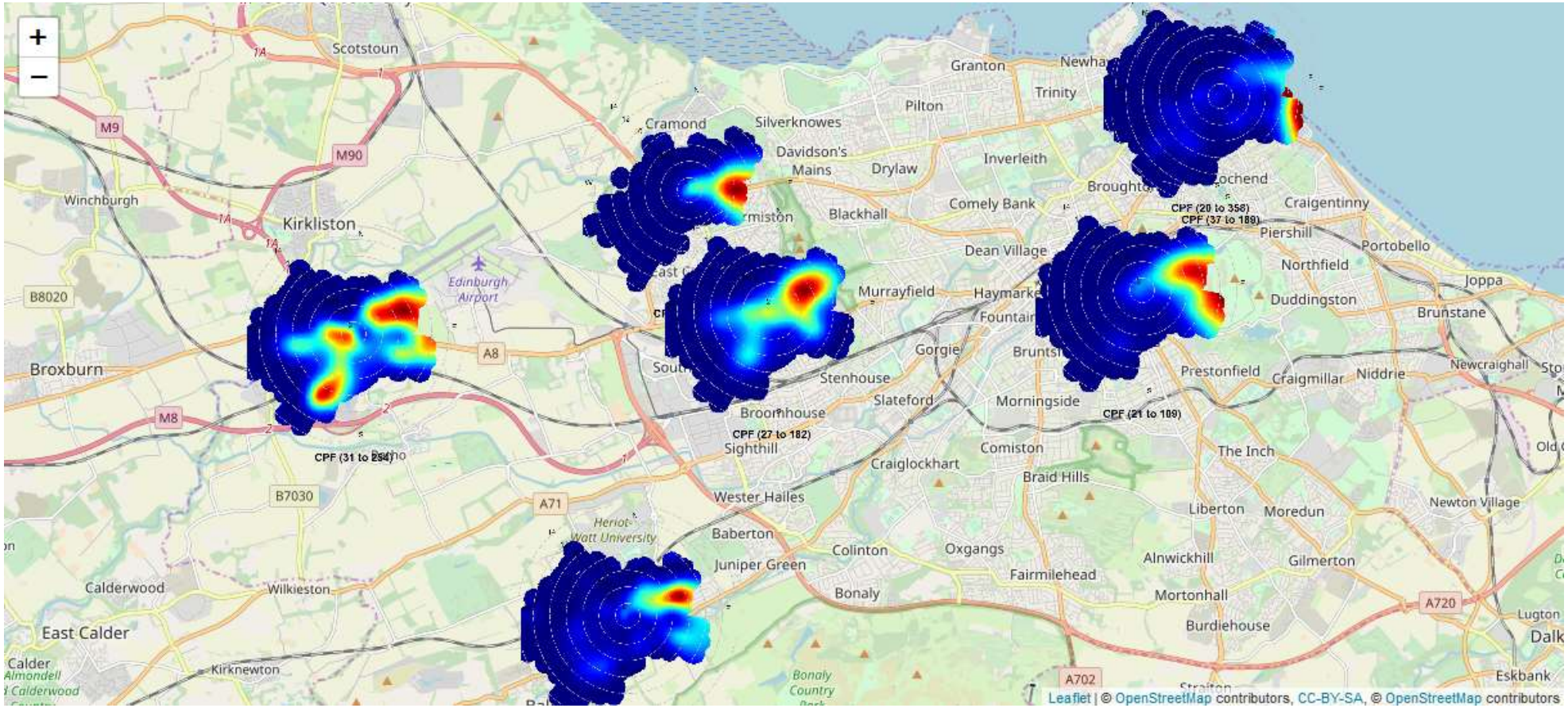
Sources of PM_{10}

- Plot shows that there's a source of highest PM_{10} concentrations to the east of the Salamander St and Tower St, Edinburgh - Leith Port? High wind speed in this case suggests transboundary PM_{10} (note that met from Edinburgh Gogarbank has been used in this case).



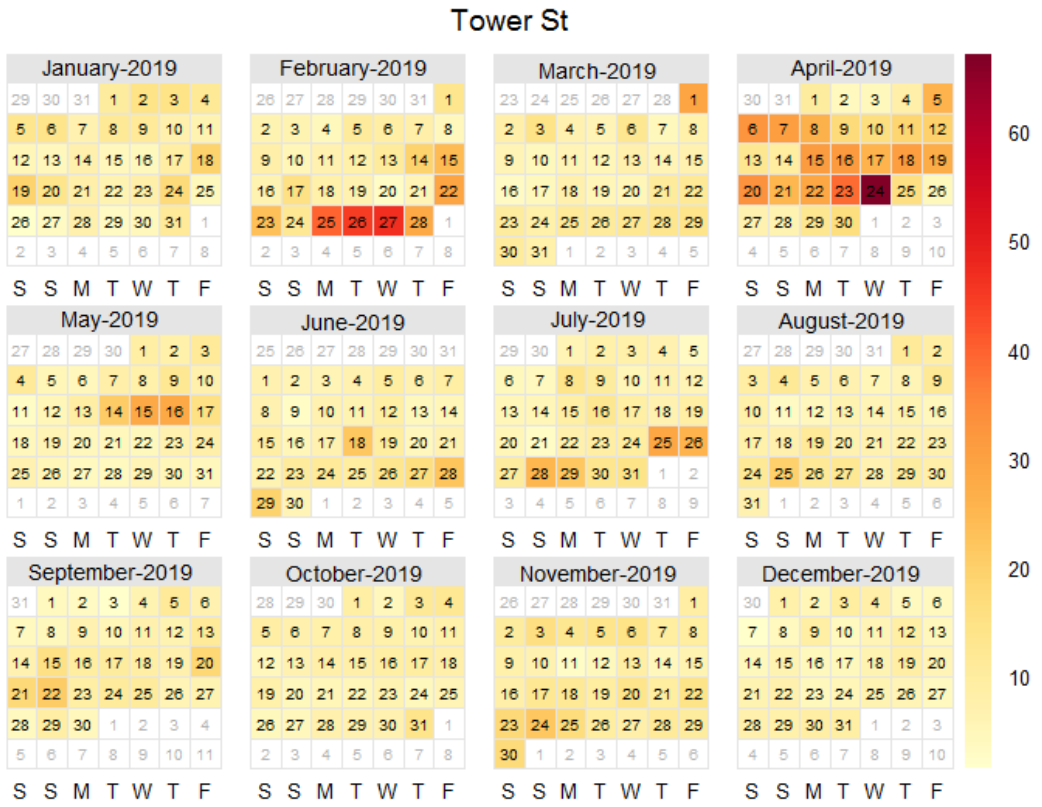
90th Percentile PM_{10} – is there a transboundary component?

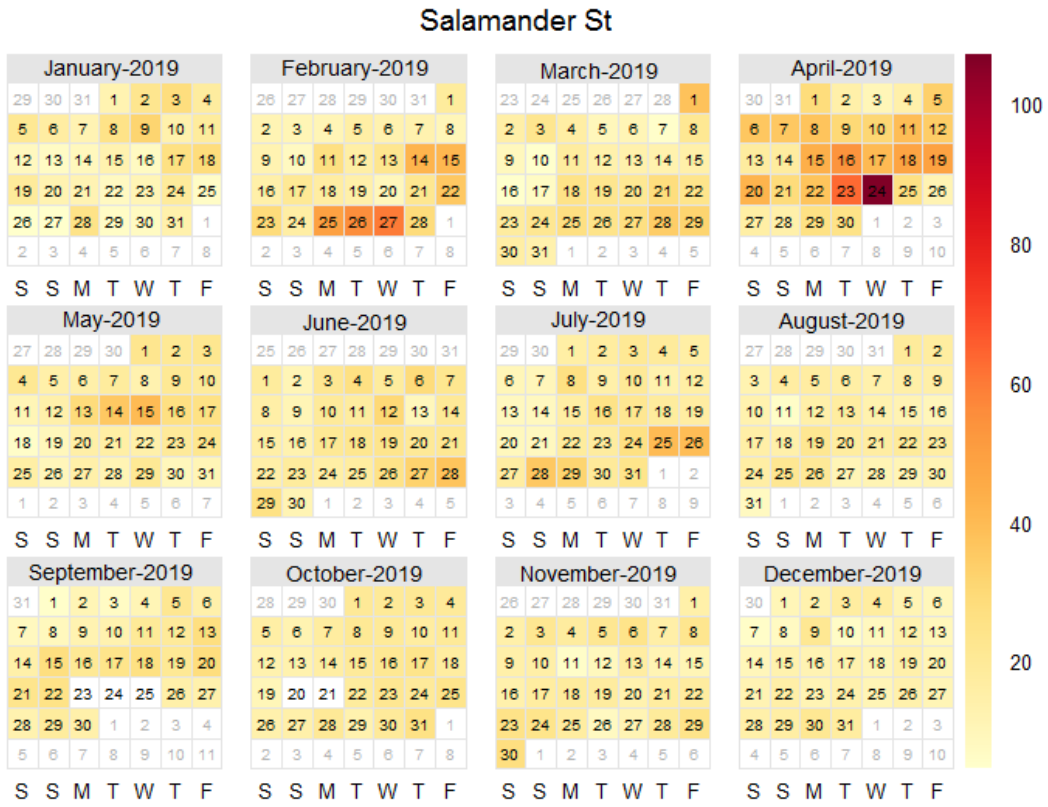
- Highest concentrations seen with relatively strong winds from the east, suggesting transboundary PM_{10} - April fires in Europe?
- Queensferry Road bucks the trend, but we know a new housing development is underway to the south - Maybury Rd, and next to the site.



When were the highest PM10 concentrations measured?

- Highest concentrations seen during the episode in Apr (fires in Europe).
- Another episode in Feb-19 caused.





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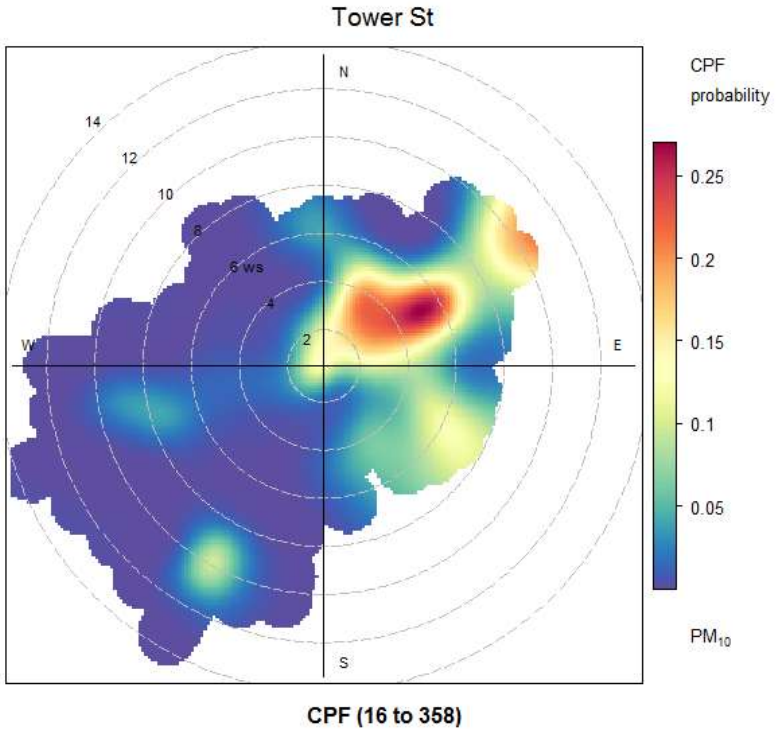
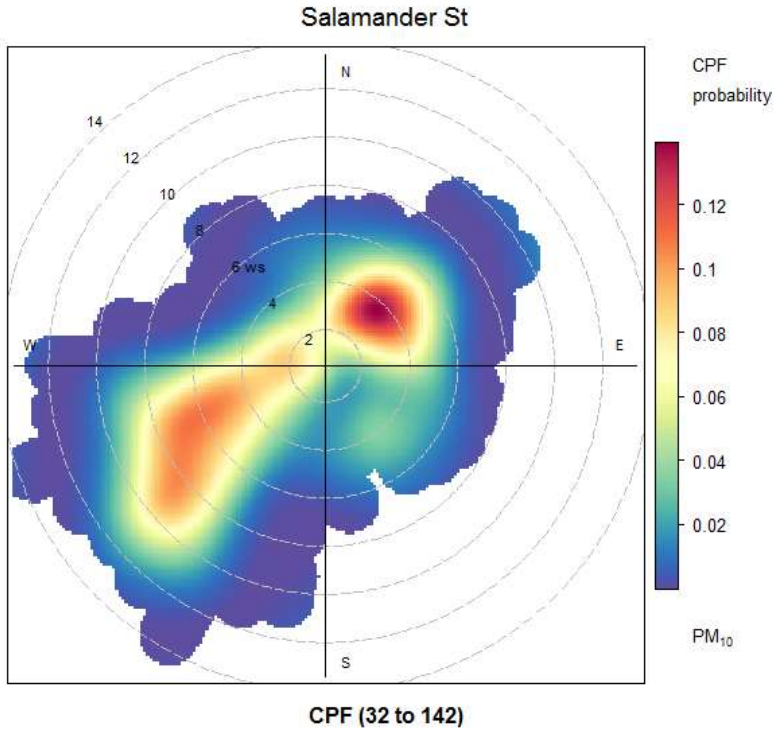
90th Percentile PM_{10}, May to Dec-19

- The highest 10% of PM10 hourly concentrations between May and Dec-19 show a source to the north east of both Tower St and Salamander St.





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Powerful analysis tools

- Analysis tools available on the Air Quality in Scotland website: http://www.scottishairquality.scot/data/openair

- If you want to download R, not much code required to carry out a lot of analysis:

```
library(openair)
library(openairmaps)
library(dplyr)

mydata <- importSAQN(site = c("ed012","ed9","ed1","ed11","ed5",
                              "ed8","edns","ed3", "ed10"),
                     year = 2019, meta = TRUE)

mydata <- mutate(mydata, pnratio = pm10/nox)


polarMap(mydata, pol = "pm10", key = TRUE,
         latitude = "latitude", longitude = "longitude", type = "site")

polarMap(mydata, pol = "pnratio", key = TRUE,
         latitude = "latitude", longitude = "longitude", type = "site")
```

- openair manual available here: https://davidcarslaw.com/files/openairmanual.pdf

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Questions?

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