

# Transport for Greater Manchester Sensor Network

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**Air Quality Measurements Knowledge  
Leader, Ricardo**



# Monitoring of PM<sub>2.5</sub> from Domestic Combustion and Lower-Cost Sensor QA/QC Monitoring in Greater Manchester

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26 March 2025

# AGENDA

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Introduction

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Sensor Network Objectives

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Network Development

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Data Hub and Reporting

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QA/QC and Sensor Performance

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Questions

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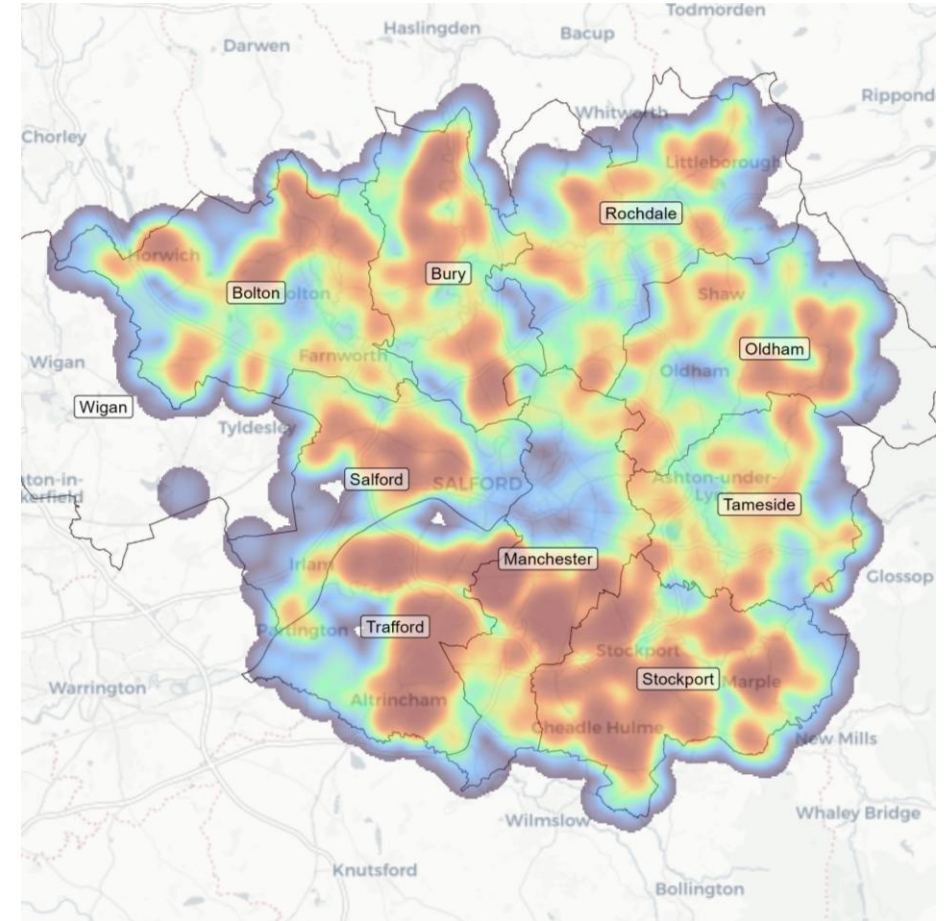
# THE SENSOR NETWORK AND ITS OBJECTIVES

- DEFRA Air Quality Grant funded project to support Greater Manchester's aim to reduce PM<sub>2.5</sub> concentrations through a reduction of domestic burning
- Sensor network to provide an evidence base for PM<sub>2.5</sub> and to assess the impact of behavior change campaigns
- First behavior change campaign will be launched soon targeting the whole of Greater Manchester.
- We aim to improve the uncertainty of MCERTS indicative PM measurements to provide a strong evidence base to feed into research and public communications
- Ricardo have procured and deployed 43 indicative low-cost sensors (LCS) at 41 locations across Greater Manchester
- Along PM<sub>2.5</sub> and PM<sub>10</sub> sensors also monitor NO, NO<sub>2</sub>, CO, O<sub>3</sub> and 10 monitor CO<sub>2</sub>
- On-going QA/QC regime for PM<sub>2.5</sub> & PM<sub>10</sub> measurements. Other pollutants only scaled from co-location (greater measurement uncertainty)



# NETWORK DESIGN

- Four sensors installed per borough and three sensors co-located with the Manchester Piccadilly AURN site
- Limited monitoring of PM<sub>2.5</sub> from domestic burning to guide site selection
- Sites selected based on Heating Equipment and Testing Approval Scheme (HETAS) registration data: two background sites and two domestic burning sites per borough
- 10 CO<sub>2</sub> sensors installed at the five sites with the highest and lowest HETAS registrations within 200 m
- Other site selection criteria:
  - Health & Safety
  - Site access
  - Power Supply
  - Local sources
  - Micro siting criteria – impact on air flow
  - Potential for public interference



# DATA HUB AND REPORTING

- Data and reporting provided to the customer through a bespoke Data Hub
- The Data Hub includes:
  - Project details
  - Monitoring locations
  - Site types
  - Data explorer
  - Data download portal
  - Dynamic reports
- Password protected area due to sensitivity of the project
- Dynamic reports provide regular analysis of the data to increase understanding and accessibility

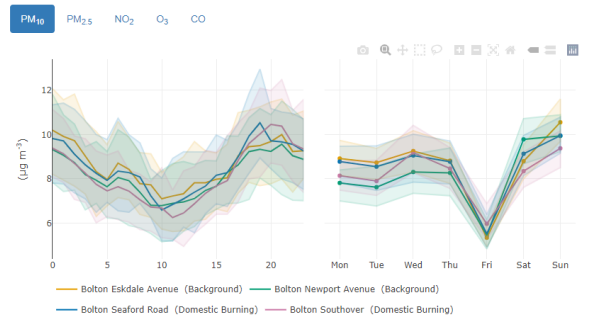
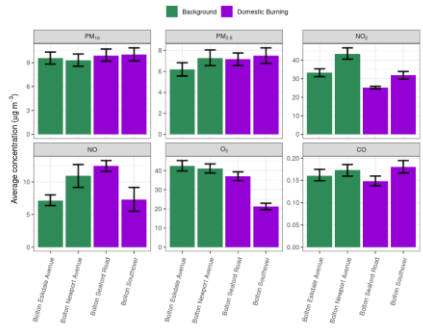
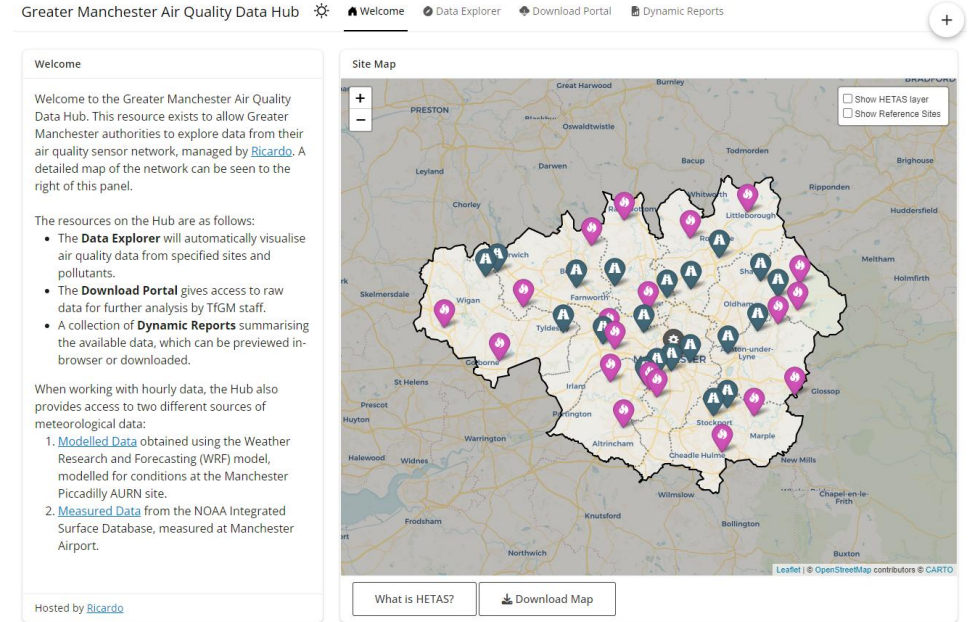


Figure 25: PM<sub>10</sub> time variation plot.



Figure 3: Polar plots for PM<sub>2.5</sub> on map

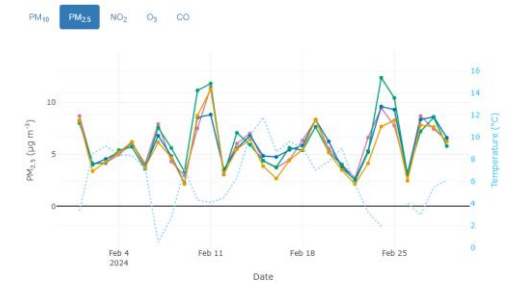
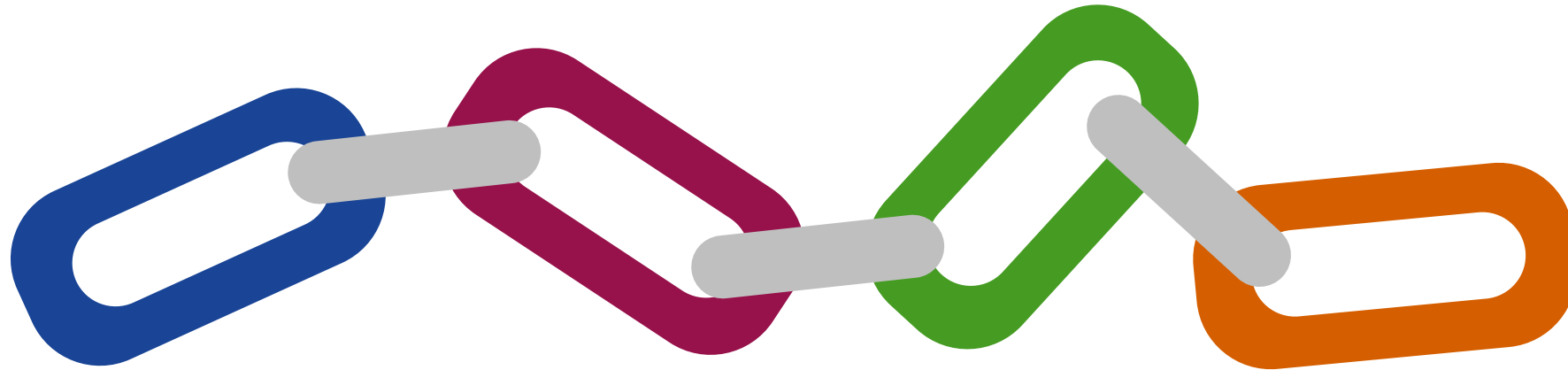


Figure 16: Time series plot of daily average PM<sub>2.5</sub> concentration.

## QA/QC – WHY?

- Need some way of linking lower cost sensor (LCS) measurements to more accurate reference measurements.
- **BUT** also need to know that reference measurements are of the required quality.



**International:**  
European  
Intercomparisons –  
reference instruments  
(BS EN 12341)

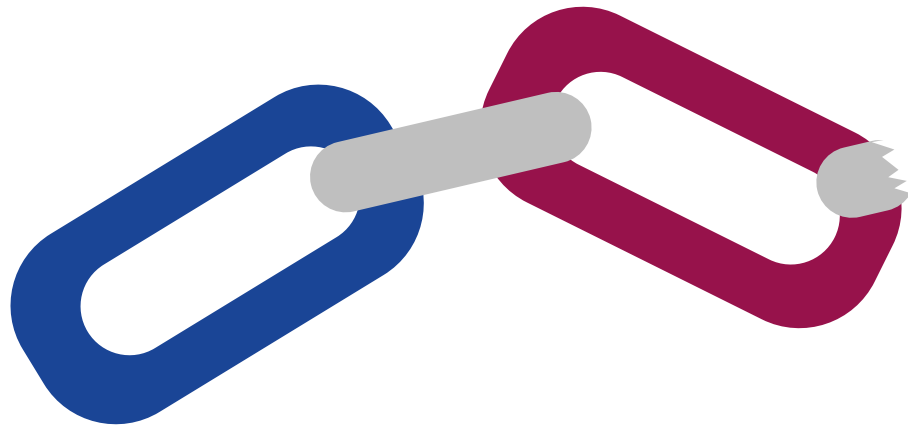
**UK Certification:**  
BS EN 16450  
(MCERTS)  
TS 17660-2 for PM  
LCS

**Local “calibrations”:**  
Co-locations of LCS with  
reference-equivalent  
instruments or other method  
(PAS 4023)

**LCS measurements of  
known accuracy:**  
Indicative?  
 $\leq 50\%$  uncertainty  
relevant PM Limit Value

## QA/QC – WHY?

- Any break in this **traceability chain** and you lose the link to more accurate measurements
- ...**AND** as a result, the ability to assess the accuracy of the LCS measurements, which has direct implications on how you can use the data!



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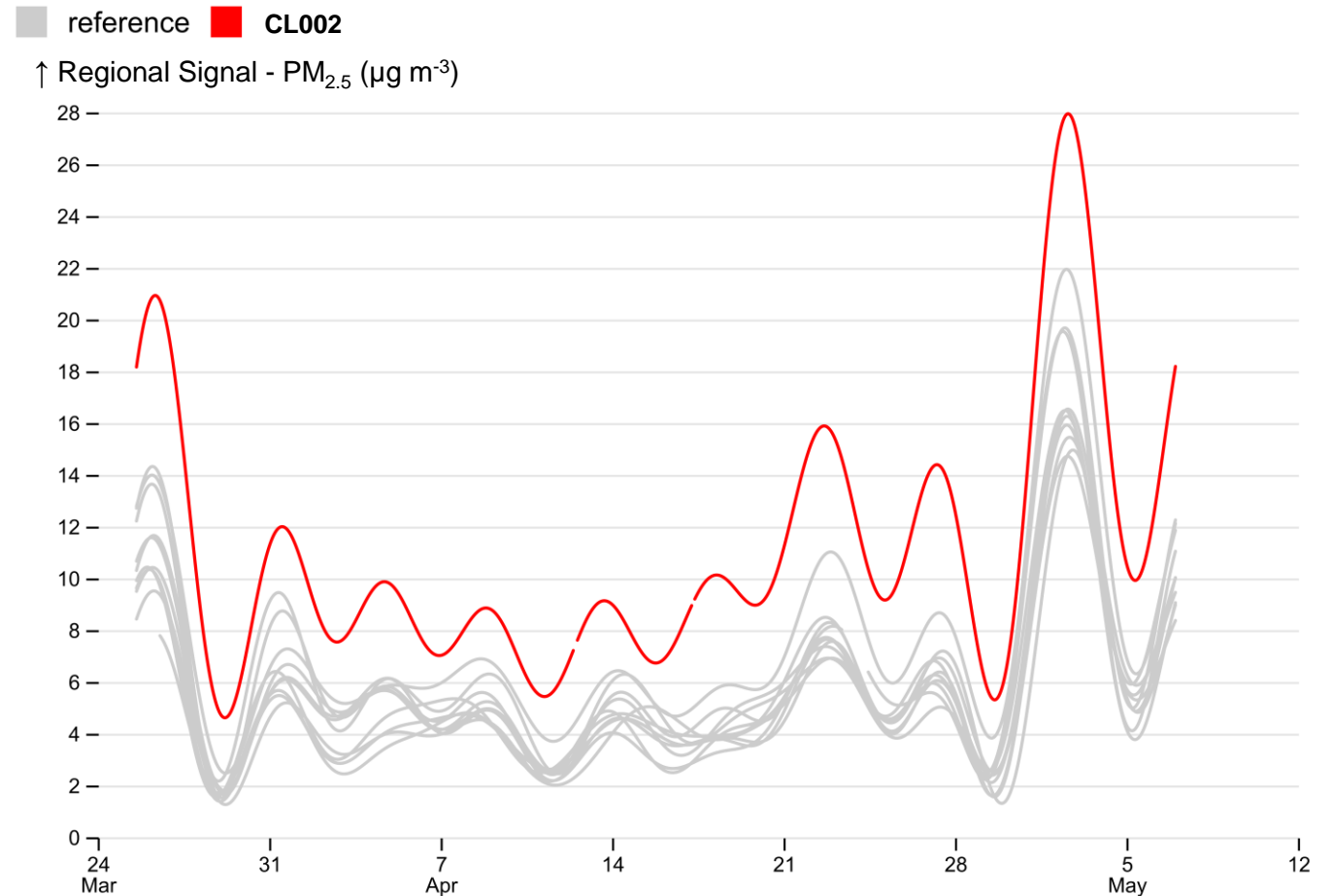
# QA/QC AND NETWORK PERFORMANCE

- Sensor holds MCERTS indicative certification for PM measurements (50% Data Quality Objective for PM at relevant Limit Value)
- On-going QA/QC required to maintain MCERTS standard
- Project aims to improve measurement uncertainty through proven QA/QC methodology
- Initial Co-location at reference station before project commenced
- Co-location of any sensors following repair
- Ongoing co-location of three sensors at Manchester Piccadilly to monitor performance and provide regional adjustment if required
- Sensor datasets scaled automatically based on co-location factor
- Continuous QA/QC with sensor data corrected in near real time and ratified quarterly
- Existing reference network used to further scale the sensor network



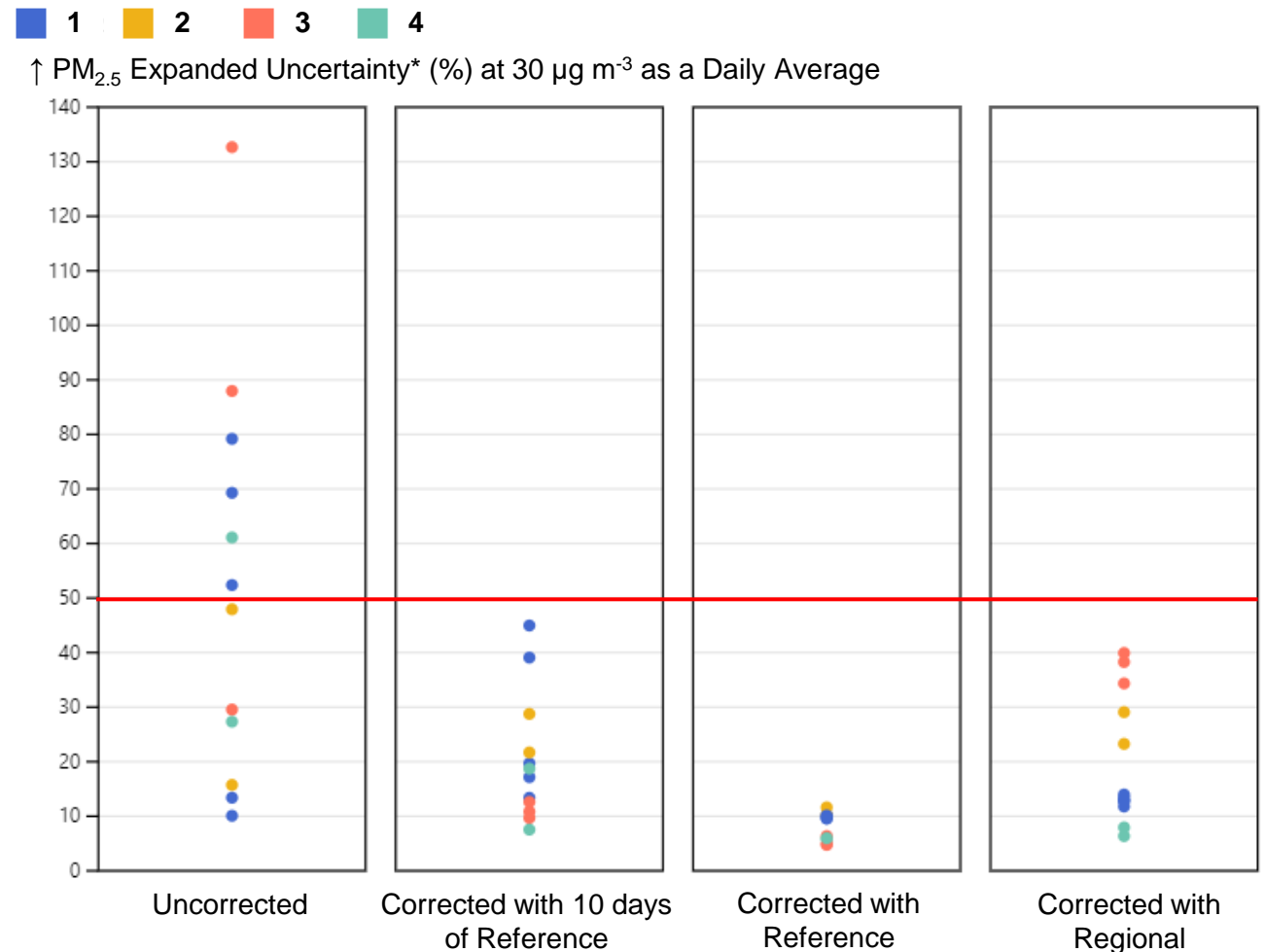
# REGIONAL ADJUSTMENT – EXTRACTING THE “REGIONAL SIGNAL”

- Rural background concentrations consistent across >100 km
- Urban background concentrations consistent across areas of a city
- How can we extract the “regional signal” from measurements:
  - Find commonality across the reference network
  - Frequency analysis - extract low frequency trends e.g. 1-min to hourly peaks due to local sources; background concentrations will vary over several days.



# REGIONAL ADJUSTMENT – TESTING PM<sub>2.5</sub>

- Four co-location sites throughout the UK (mixture of roadside and background)
- **Uncorrected:** wide range of performance!
- **Corrected with 10-day co-location:** Improvement, all LCS pass 50% target, but co-locations are required, and results are not guaranteed on an ongoing basis.
- **Corrected with ongoing co-location:** All perform well as expected but not real life!
- **Corrected with regional:** All achieve < 50% uncertainty providing confidence that indicative measurements can be achieved using a regional correction.

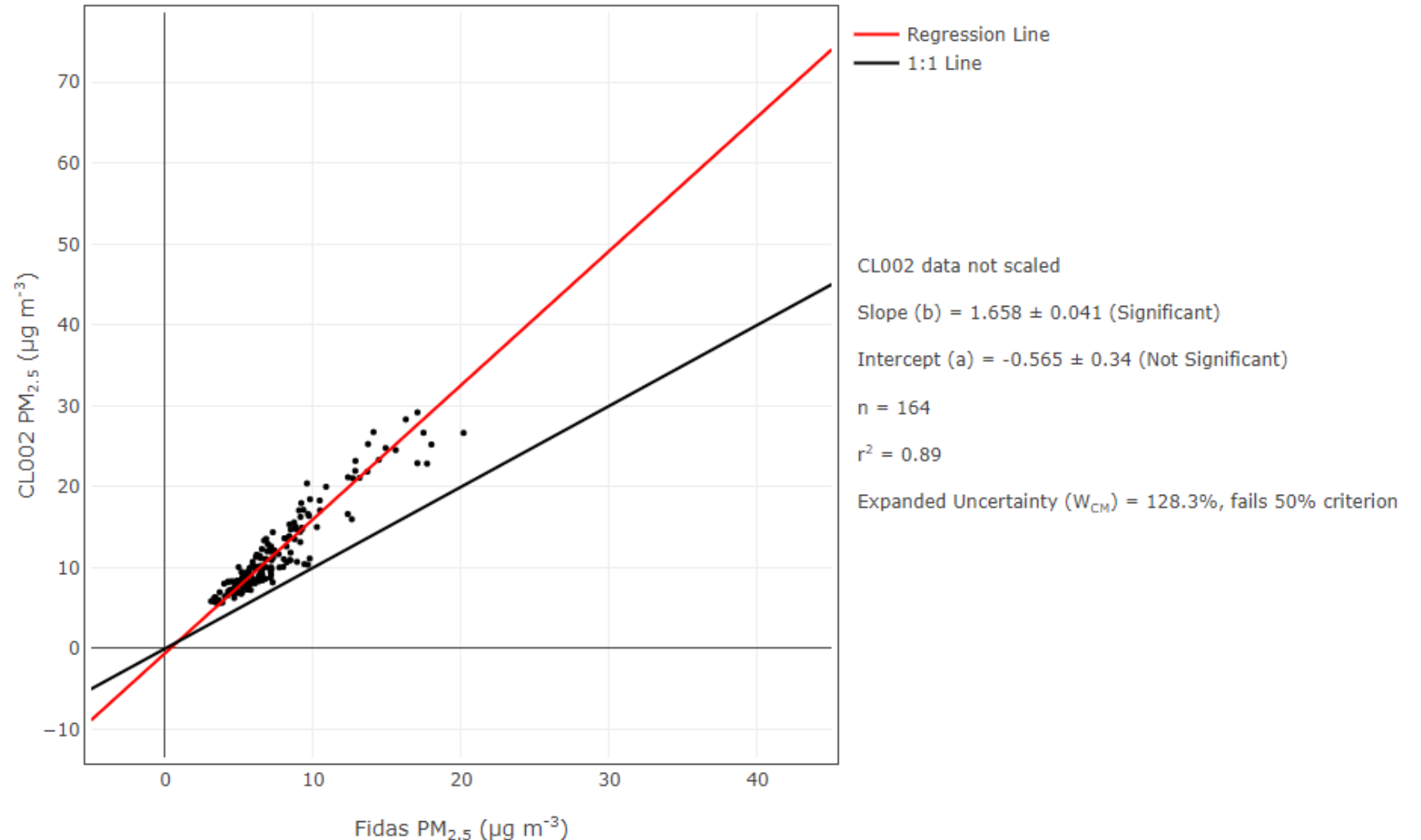


\* Calculated as defined in EN 16450:2017

# ONGOING CO-LOCATION AT MANCHESTER PICCADILLY – RAW DATA

## LCS CL002 – PM<sub>2.5</sub>:

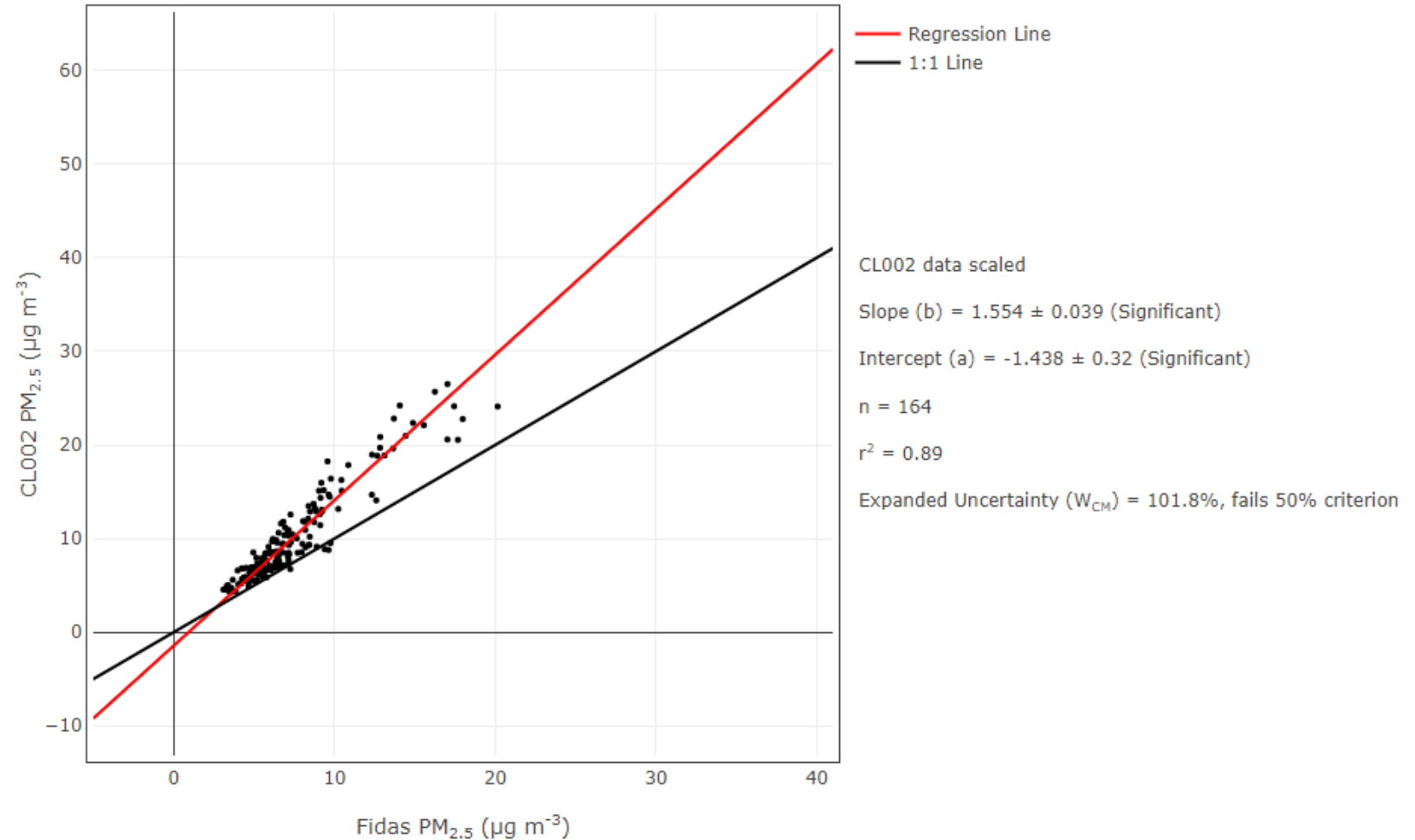
- Unscaled PM<sub>2.5</sub> fails the 50% uncertainty requirement at 30  $\mu\text{g m}^{-3}$  as a daily average (128.3%).
- n - the number of valid daily averages
- $r^2$  - 0 indicates no linear relationship and 1 indicates a perfect linear relationship



# ONGOING CO-LOCATION AT MANCHESTER PICCADILLY – SCALED DATA

## LCS CL002 – PM<sub>2.5</sub> (provisional):

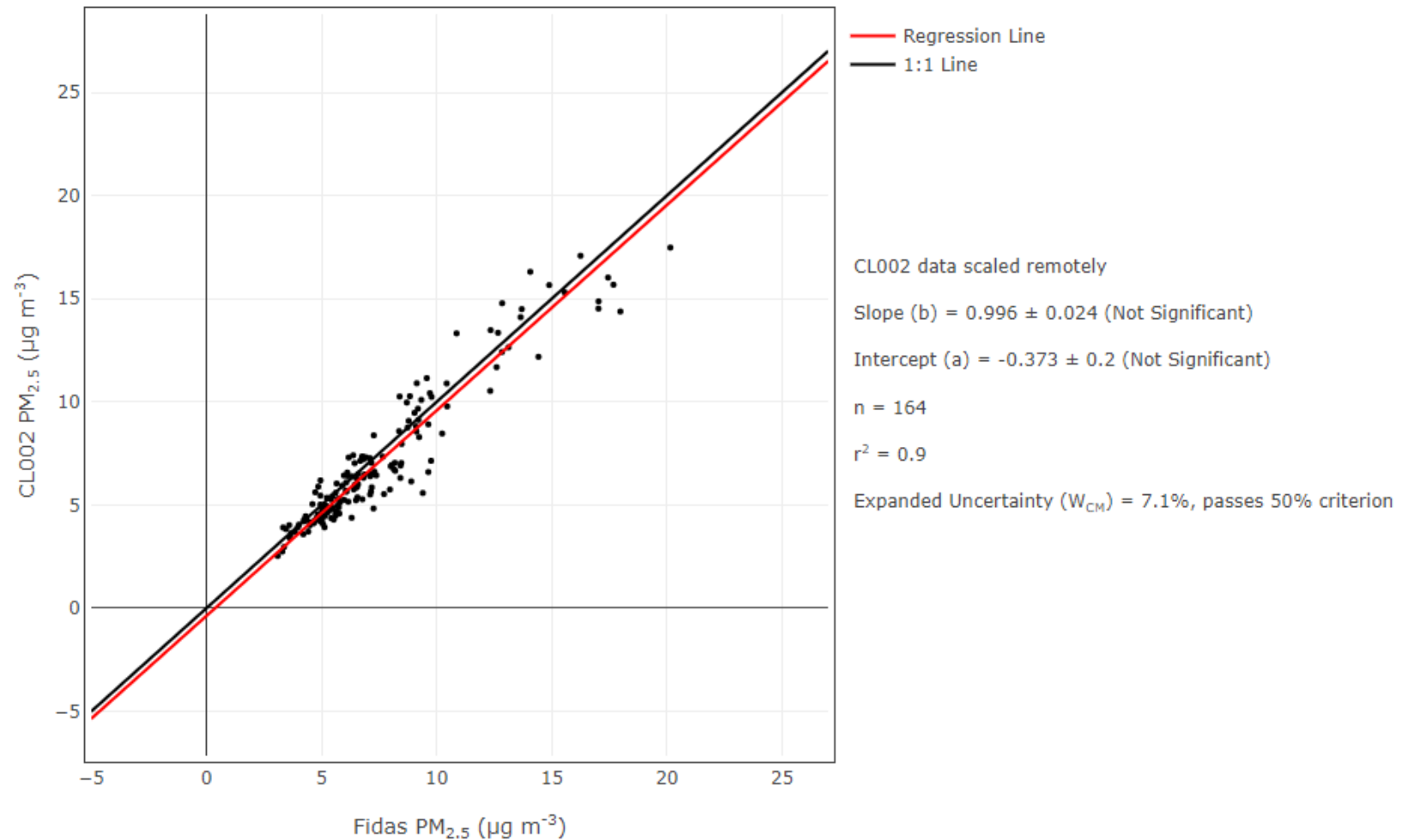
- When scaling the data using the initial co-location, the PM<sub>2.5</sub> fails the 50% uncertainty requirement at 30 µg m<sup>-3</sup> as a daily average (101.8%).



# ONGOING CO-LOCATION AT MANCHESTER PICCADILLY – REGIONALLY SCALED DATA

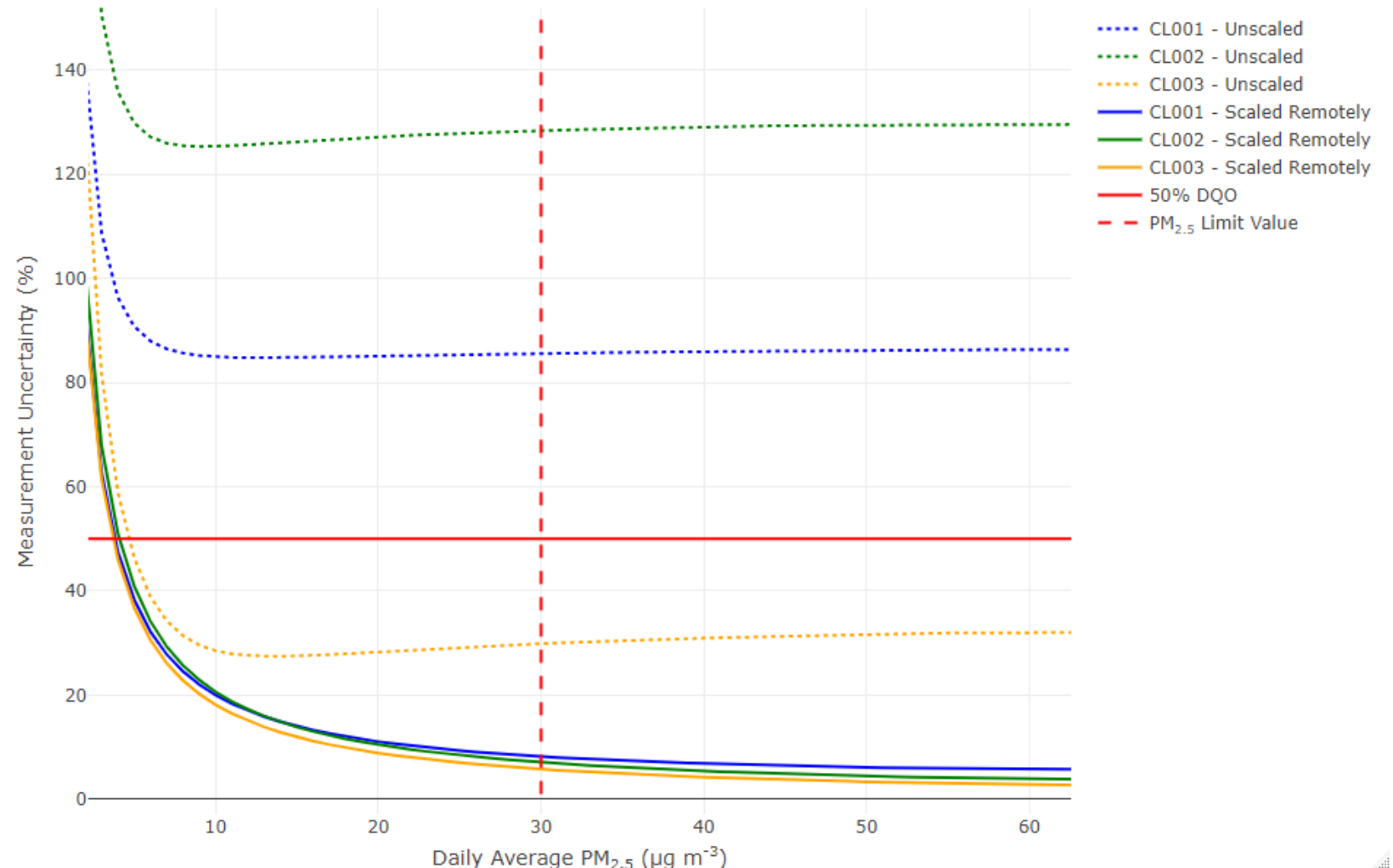
## LCS CL002 - PM<sub>2.5</sub> (provisional):

- When scaling the data using regional signal, the PM<sub>2.5</sub> passes the 50% uncertainty requirement at 30  $\mu\text{g m}^{-3}$  as a daily average (7.1%).



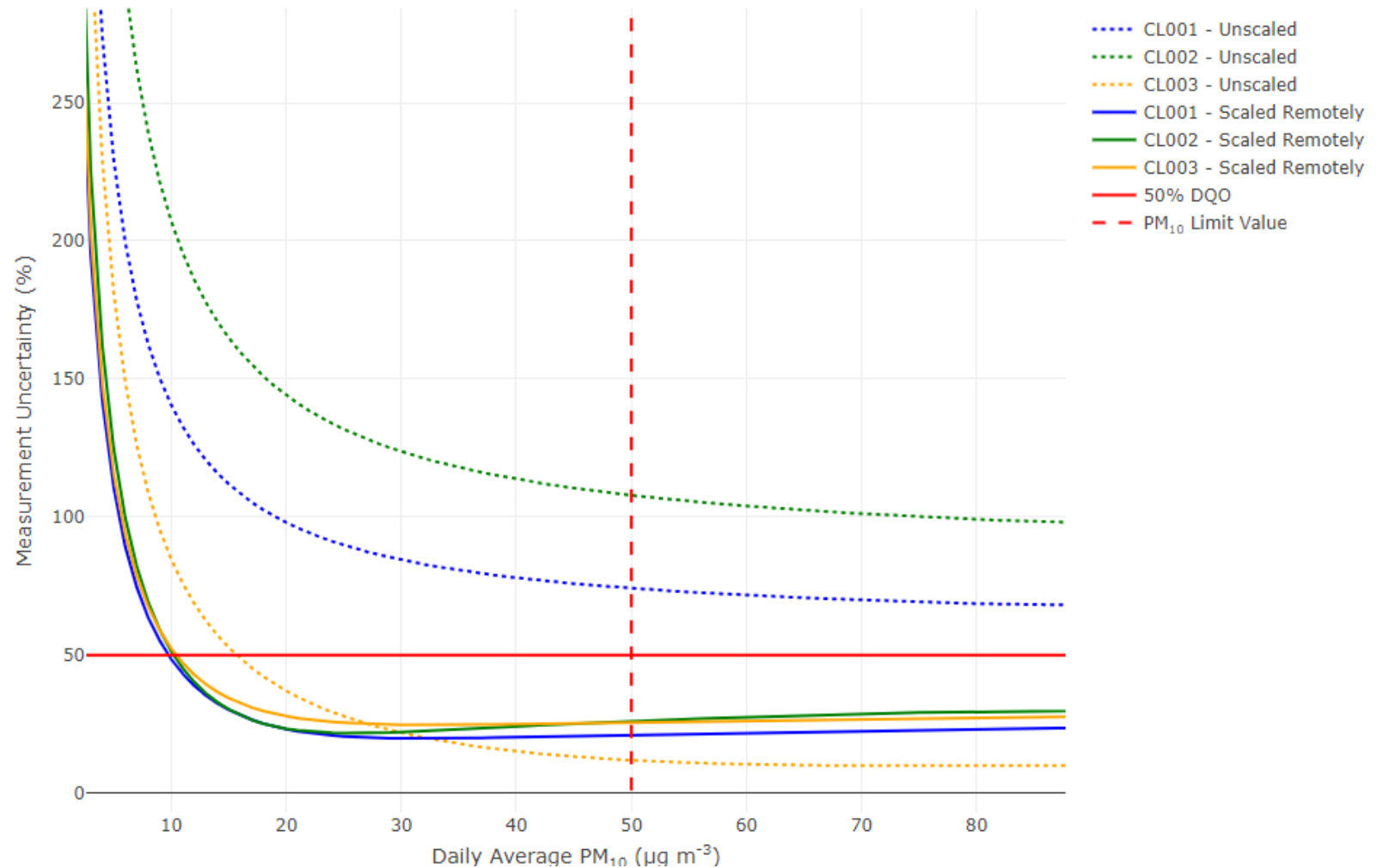
## QA/QC AND NETWORK PERFORMANCE – PM<sub>2.5</sub>

- Chart summarises the PM<sub>2.5</sub> measurement uncertainty across a measurement range for each of the three co-located LCS (CL001, CL002, CL003)
- Regional scaling of PM<sub>2.5</sub> from the three co-located LCS also improves the between-sensor variance



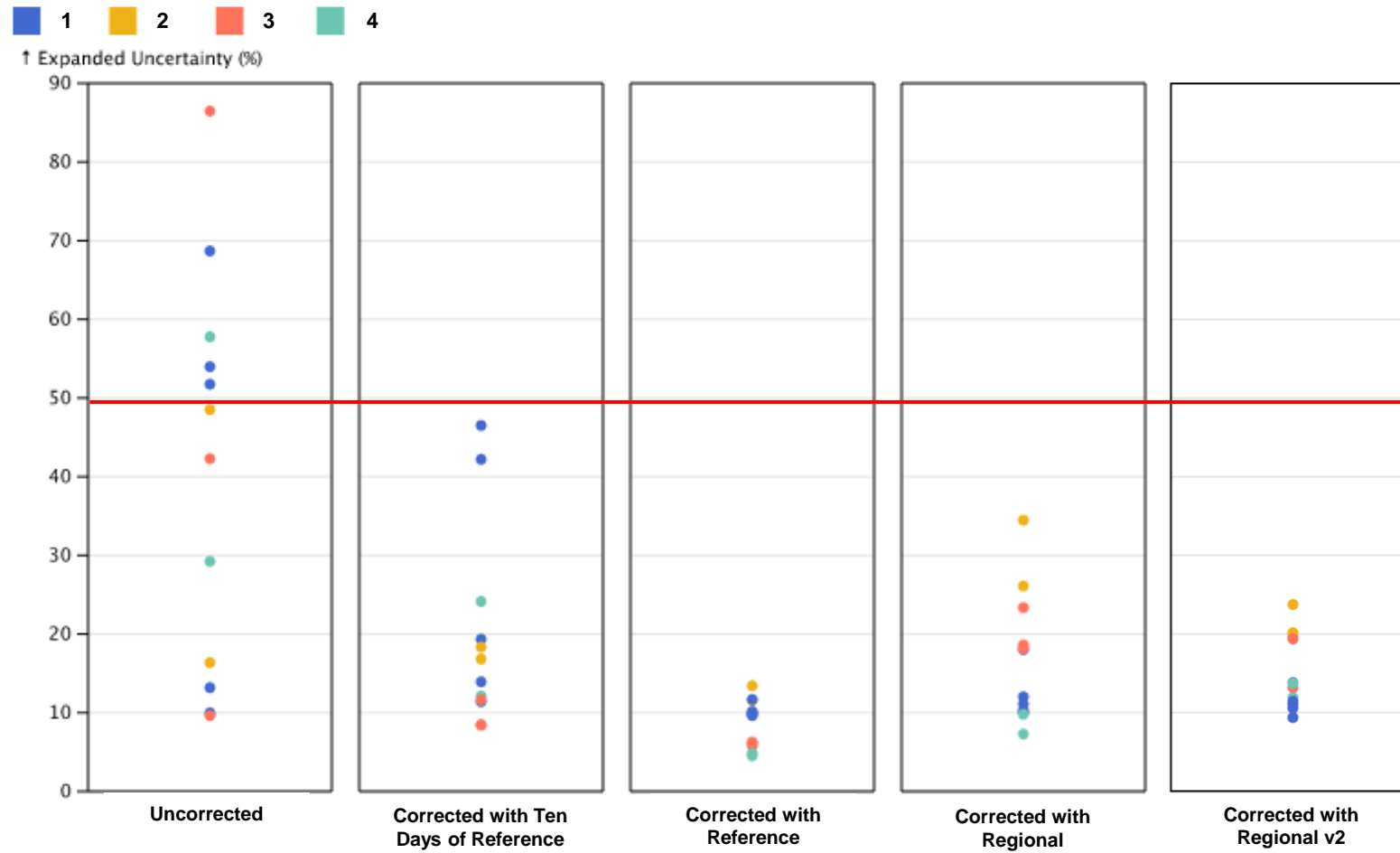
# QA/QC AND NETWORK PERFORMANCE – PM<sub>10</sub>

- Chart summarises the PM<sub>10</sub> measurement uncertainty across a measurement range for each of the three co-located LCS (CL001, CL002, CL003)
- Regional scaling of PM<sub>2.5</sub> from the three co-located LCS also improves the between-sensor variance

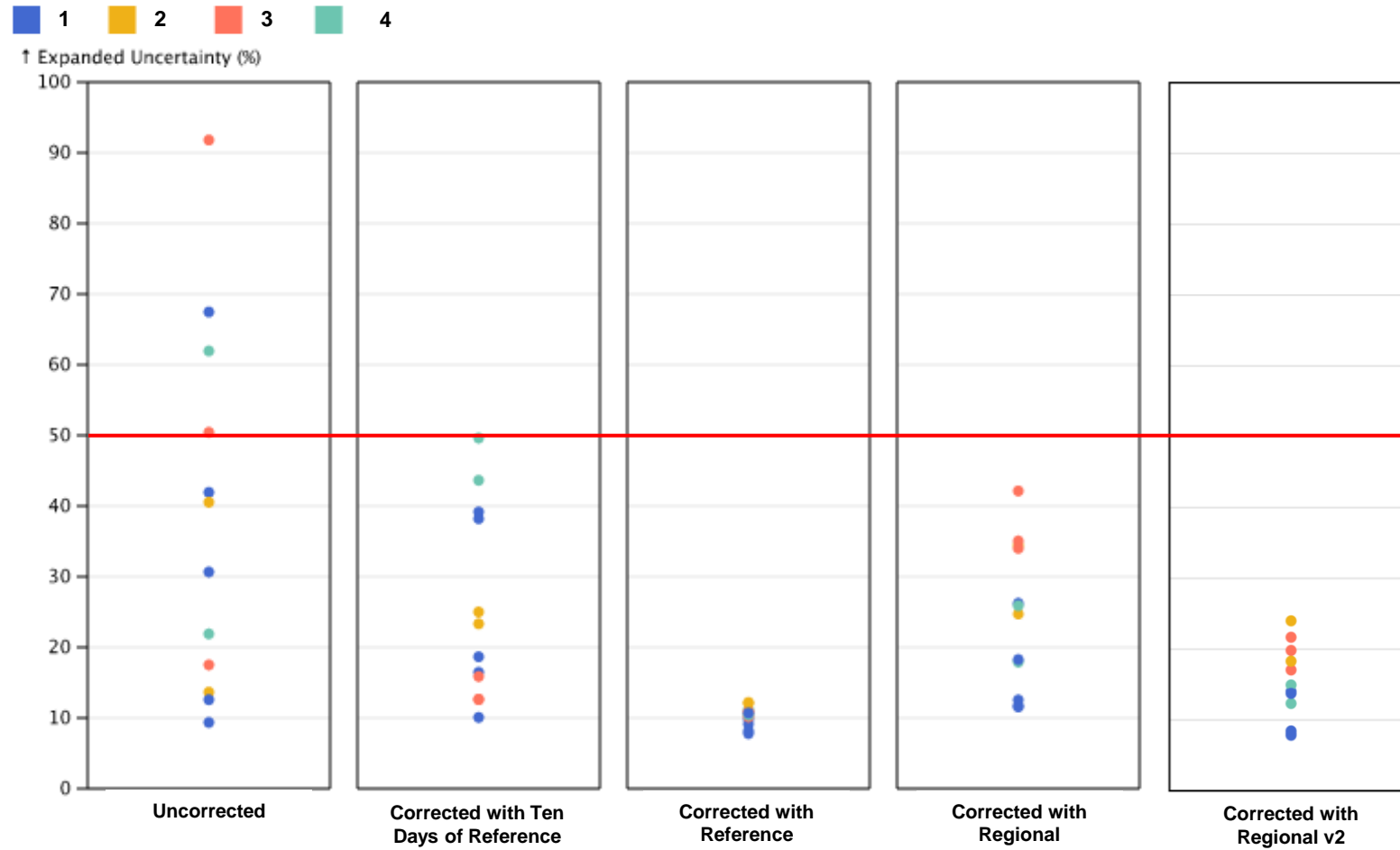




# Method is evolving – PM<sub>2.5</sub>!



# Method is evolving – PM<sub>10</sub>!



# ANY QUESTIONS?

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# THANK YOU!

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