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Correcting TEOM Measurements using the KCL Volatile Correction Model

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- Model Development Context
- UK PM Monitoring Problem
- Model derivation
- Model testing
- Proposed monitoring strategy for the UK

Model Development Context

- January LAQN Seminar – London FDMS
- Defra funded work early 2007
 - *Grounded in statistics used to demonstrate equivalence*
 - *UK wide applicability*
- Named it: “Volatile Correction Model”
- Future steps

PM₁₀ Monitoring Problem

Reference Method



TEOM

FDMS

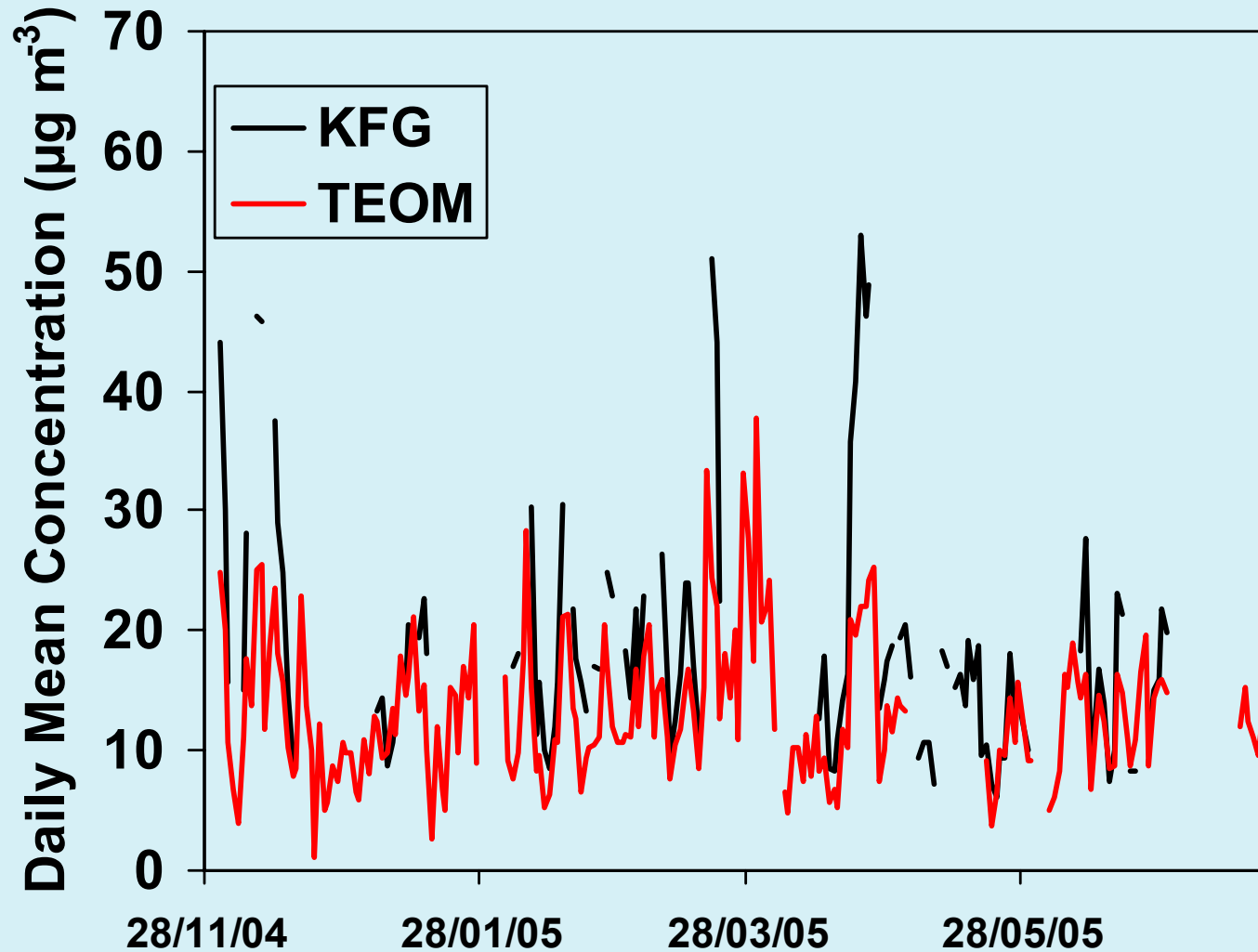


BAM

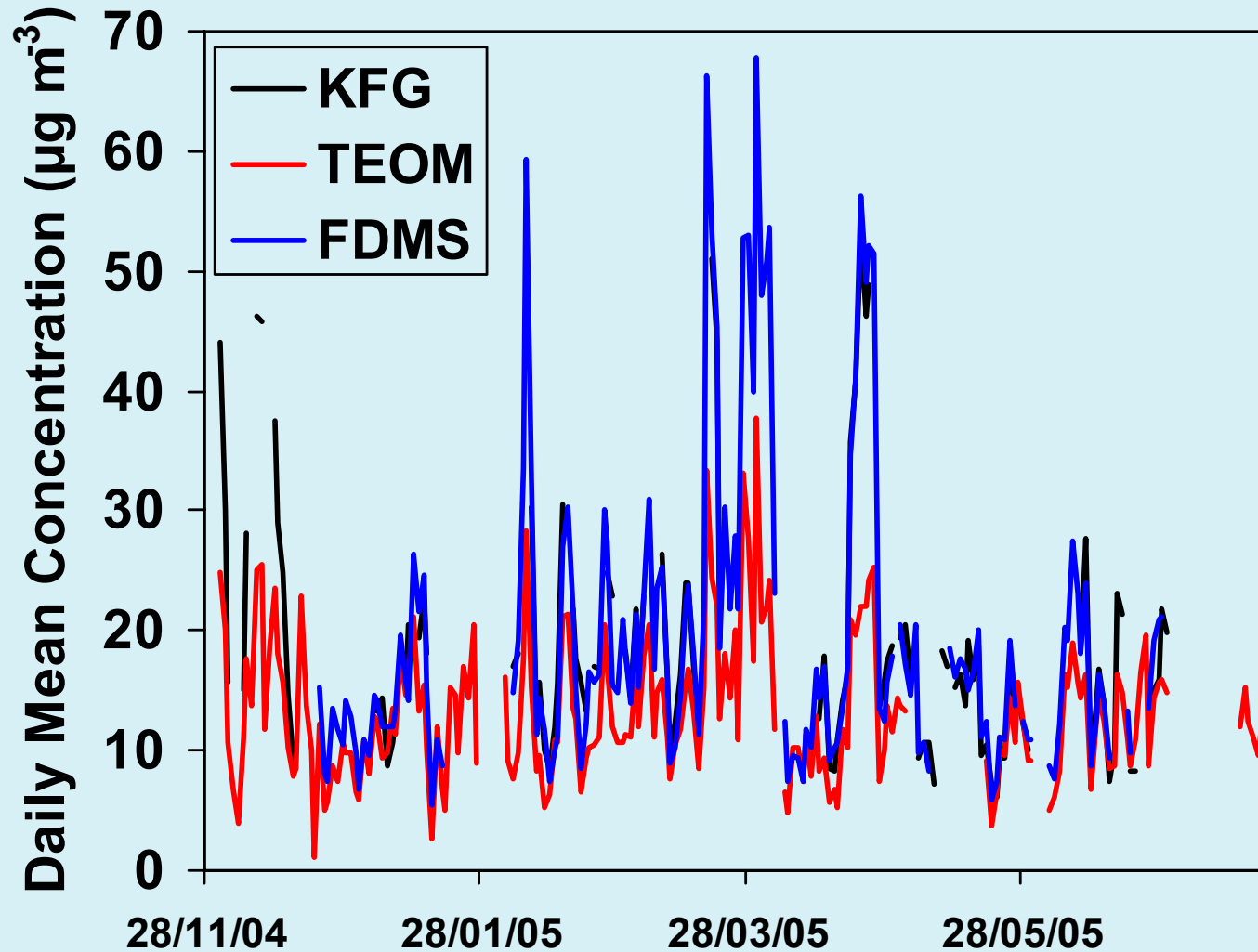


- Complex pollutant
 - *Different components*
 - *Constantly changing*
- Reference Method
 - *Labour intensive*
 - *Poor time resolution*
 - *Slow data dissemination*
- TEOM
 - *Heats sample inlet to 50°C to eliminate water but loses volatile PM*
- FDMS
 - *Uses a diffusion dryer to eliminate water and retain a sample temperature of 30°C*
 - *Equivalent to Reference*
- UK Monitoring Networks
 - *Predominately TEOM*
 - *Need to use equivalent methods for reporting to EU*

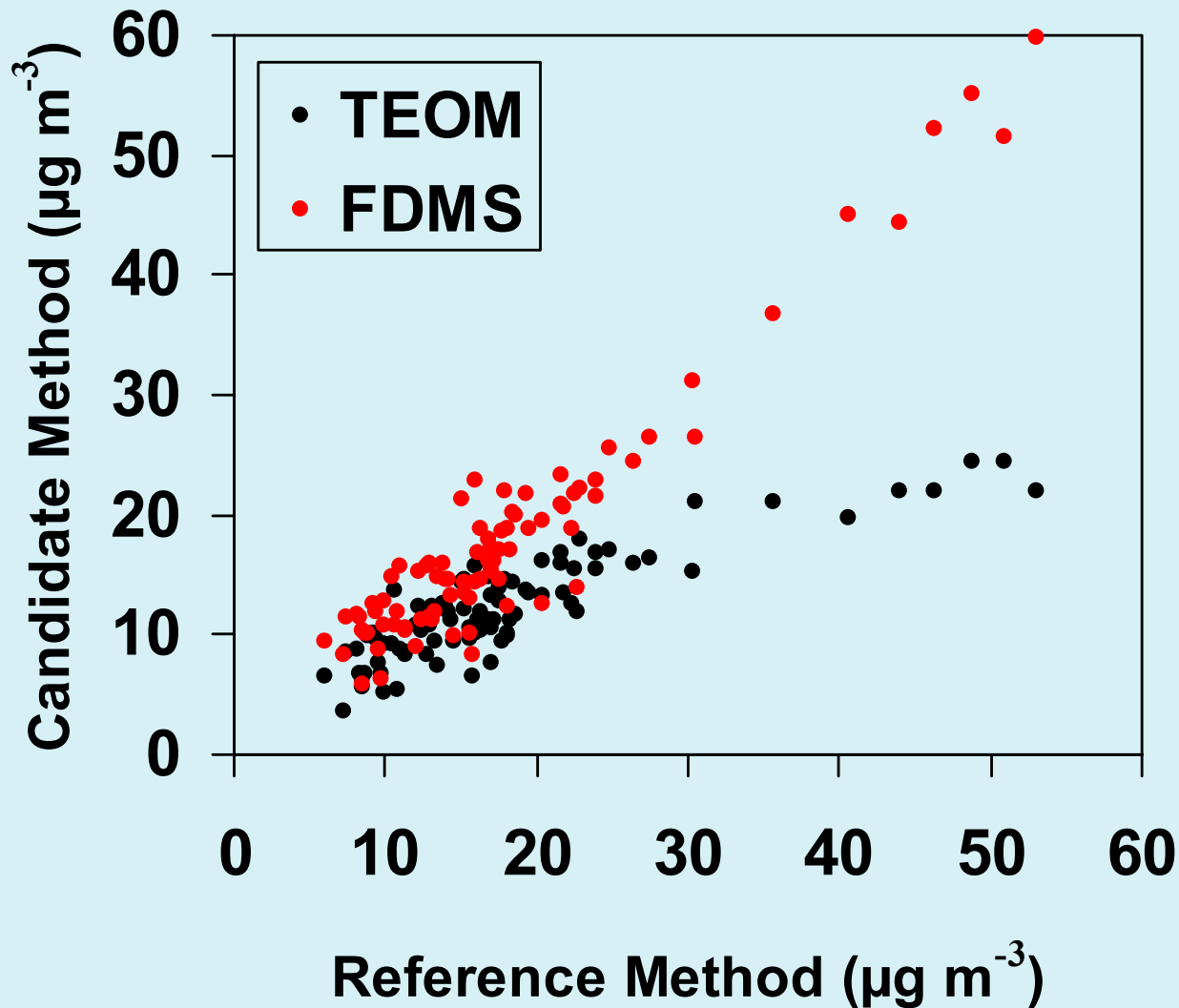
PM₁₀ Measurement Time Series



PM₁₀ Measurement Time Series



PM₁₀ Measurement Correlation



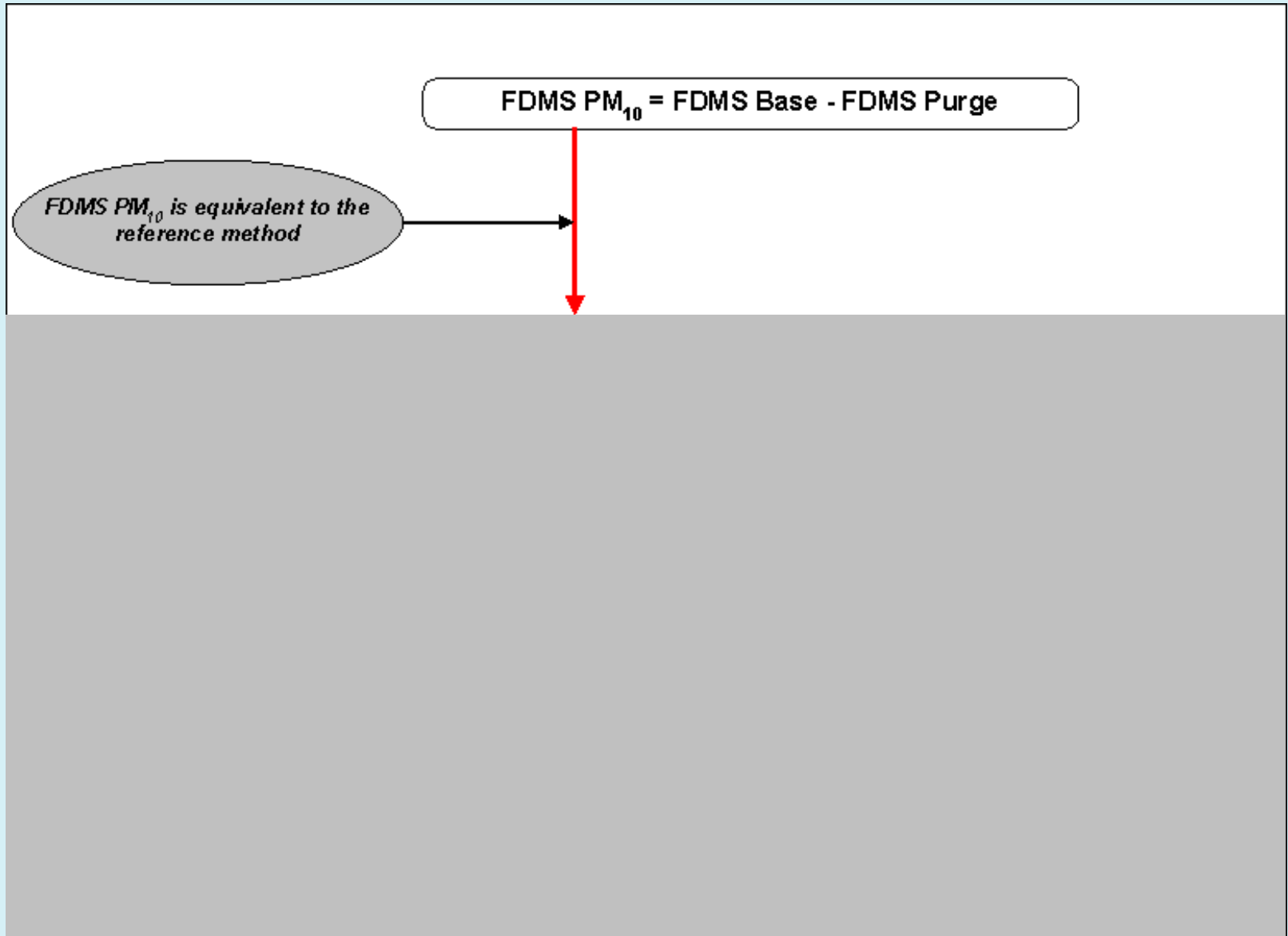
How do we achieve an Equivalent Network?

- Upgrade TEOM to FDMS
 - *Expensive (capital)*
 - *Retains some continuity of measurement*
- Change monitoring equipment
 - *Gravimetric*
 - (capital and revenue)
 - Loose continuity of measurement
 - Delay in reporting time
 - *BAM*
 - Expensive (capital)
 - Loose continuity of measurement
- A ‘Third Way’?
 - *Using FDMS measurements of volatile PM to correct TEOM measurements*

KCL Volatile Correction Model

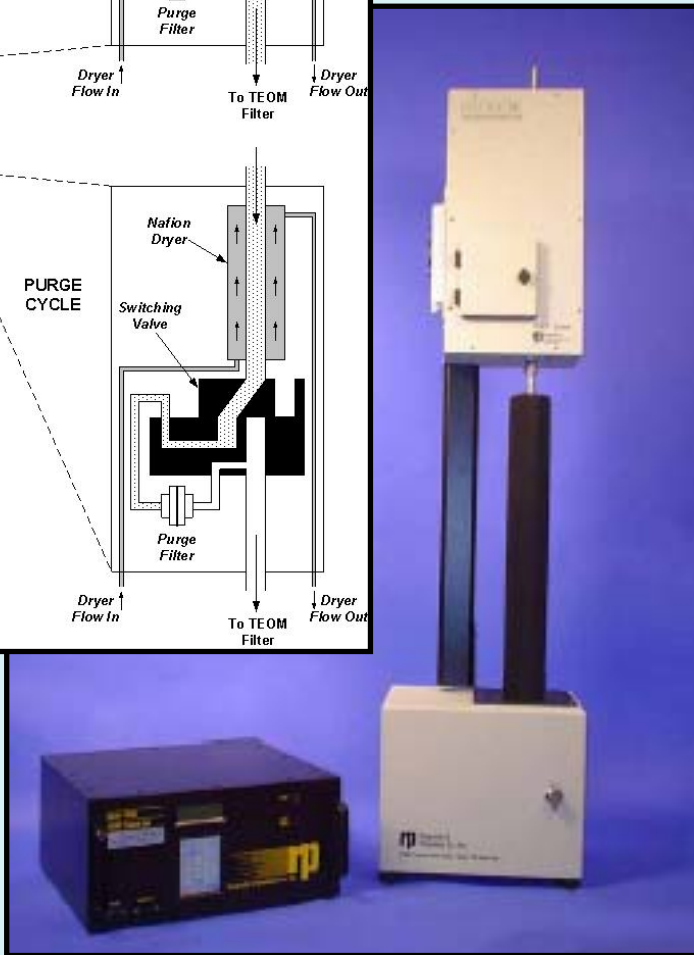
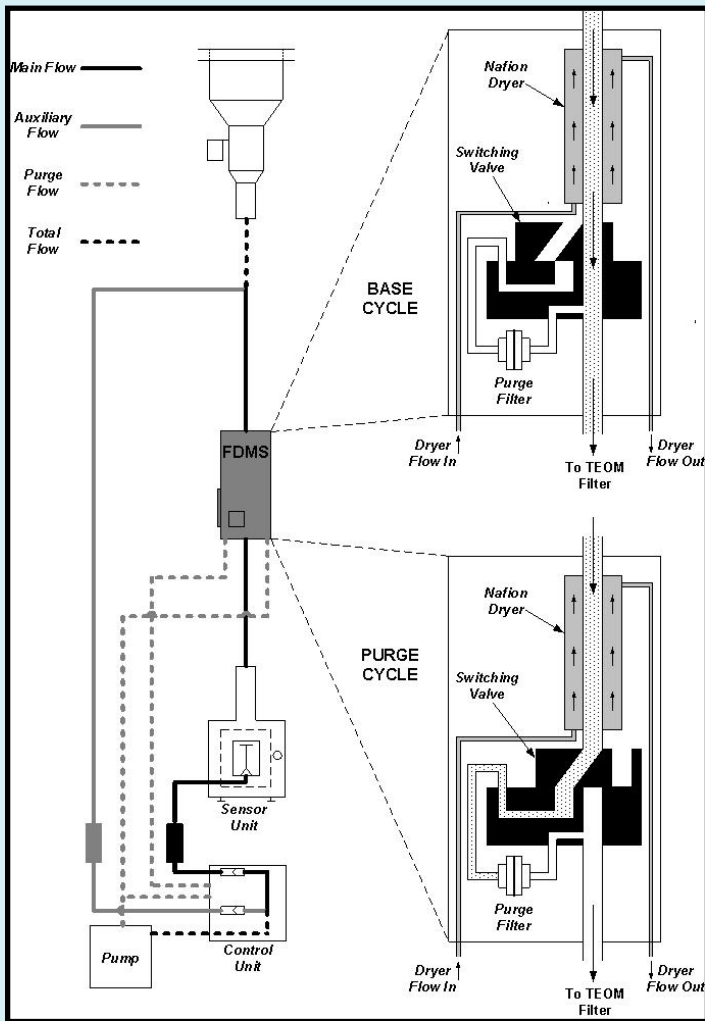
- Provides a daily, site specific correction factor for TEOM measurements
- Correction based on FDMS purge measurement made some distance away
- Results in reference equivalent daily mean concentration within the 25% expanded uncertainty specified by the AQ Directive

Model Derivation



FDMS – Filter Dynamics Measurement System

- 2 measurement modes:
 - *Base (analogous to standard TEOM)*
 - *Purge, which measures mass lost from the filter when particle free air is passing through it*
- $\text{FDMS Mass} = \text{Base} - \text{Purge}$

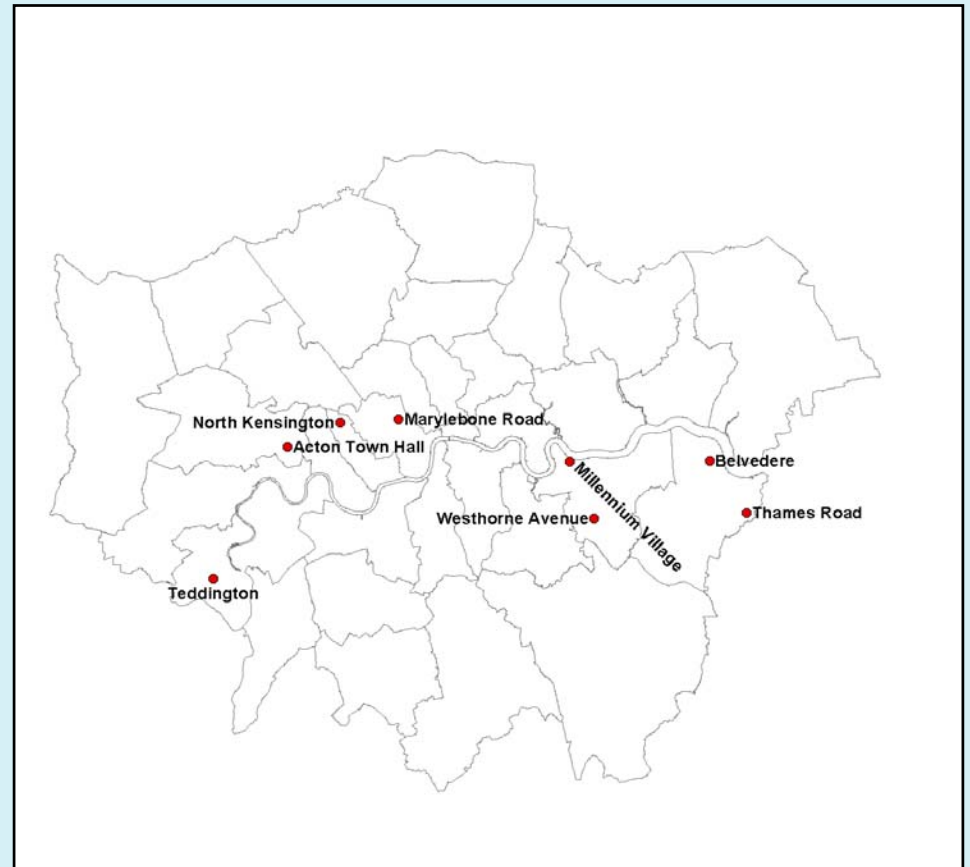
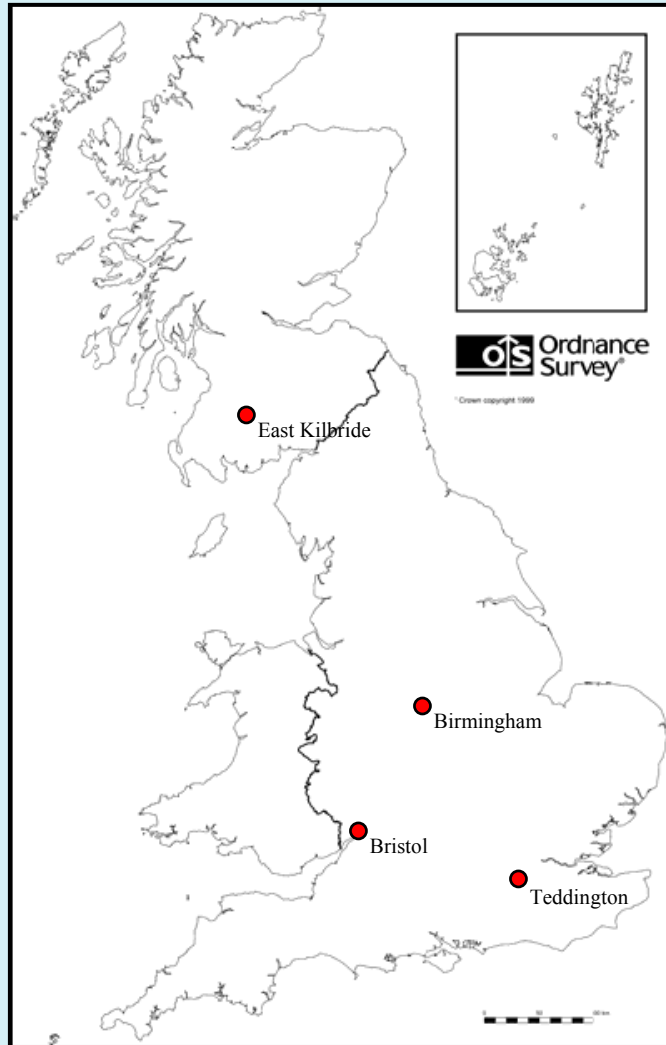


Model Derivation

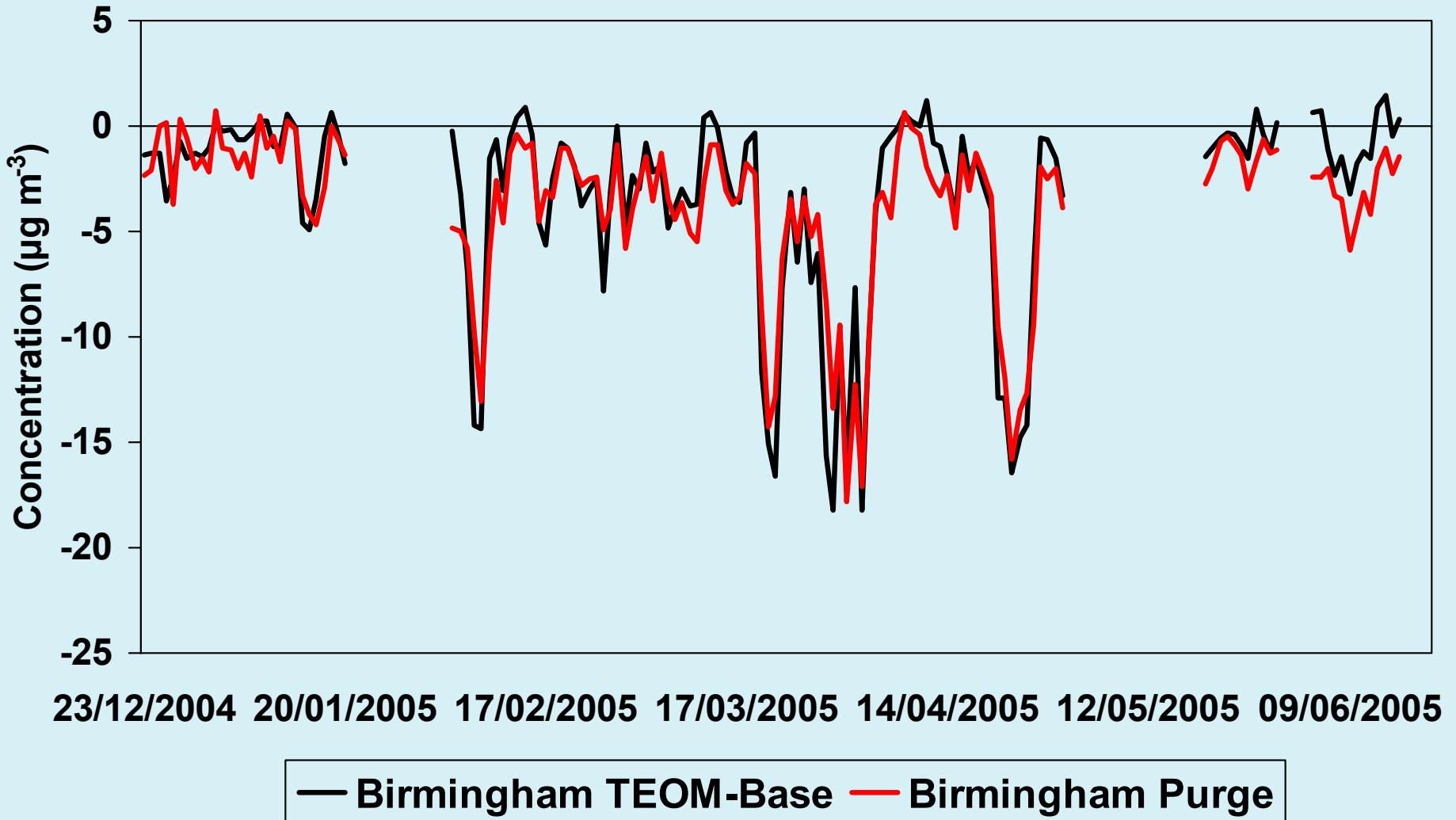
Reference Equivalent $PM_{10} = \text{FDMS Base} - \text{FDMS Purge}$

$\text{FDMS Base} = \text{TEOM} - (0.87 \times \text{FDMS Purge})$

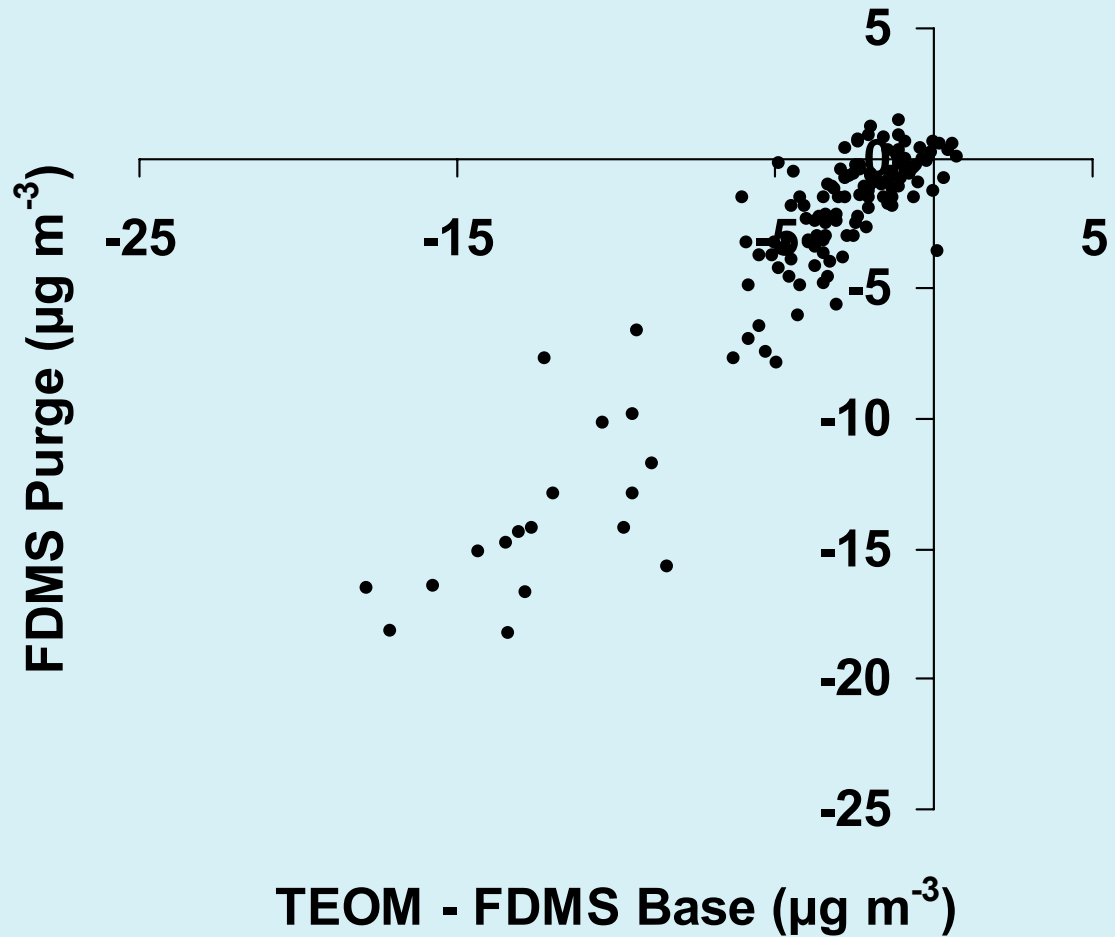
TEOM and FDMS Monitoring



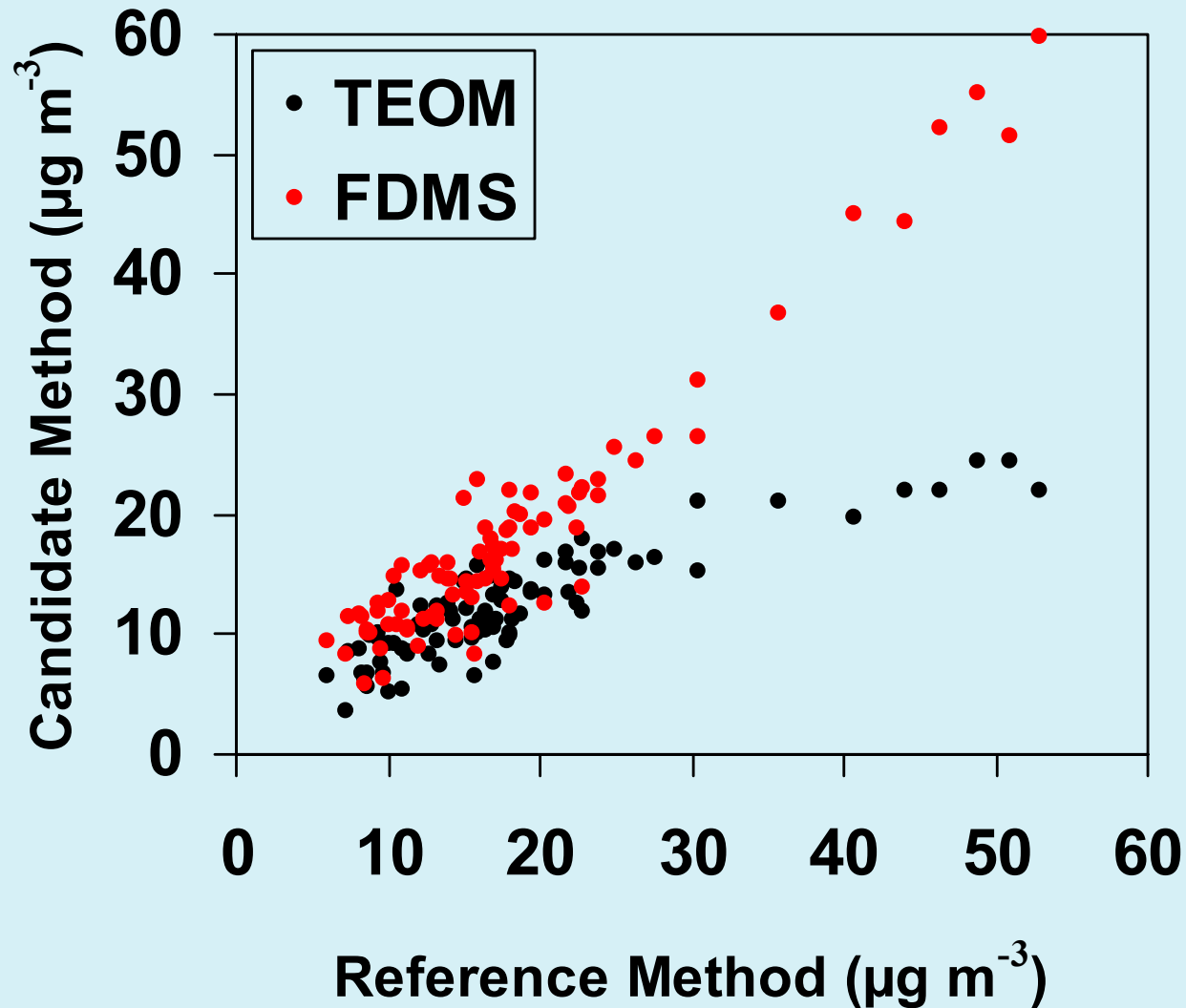
TEOM – Base vs. FDMS Purge



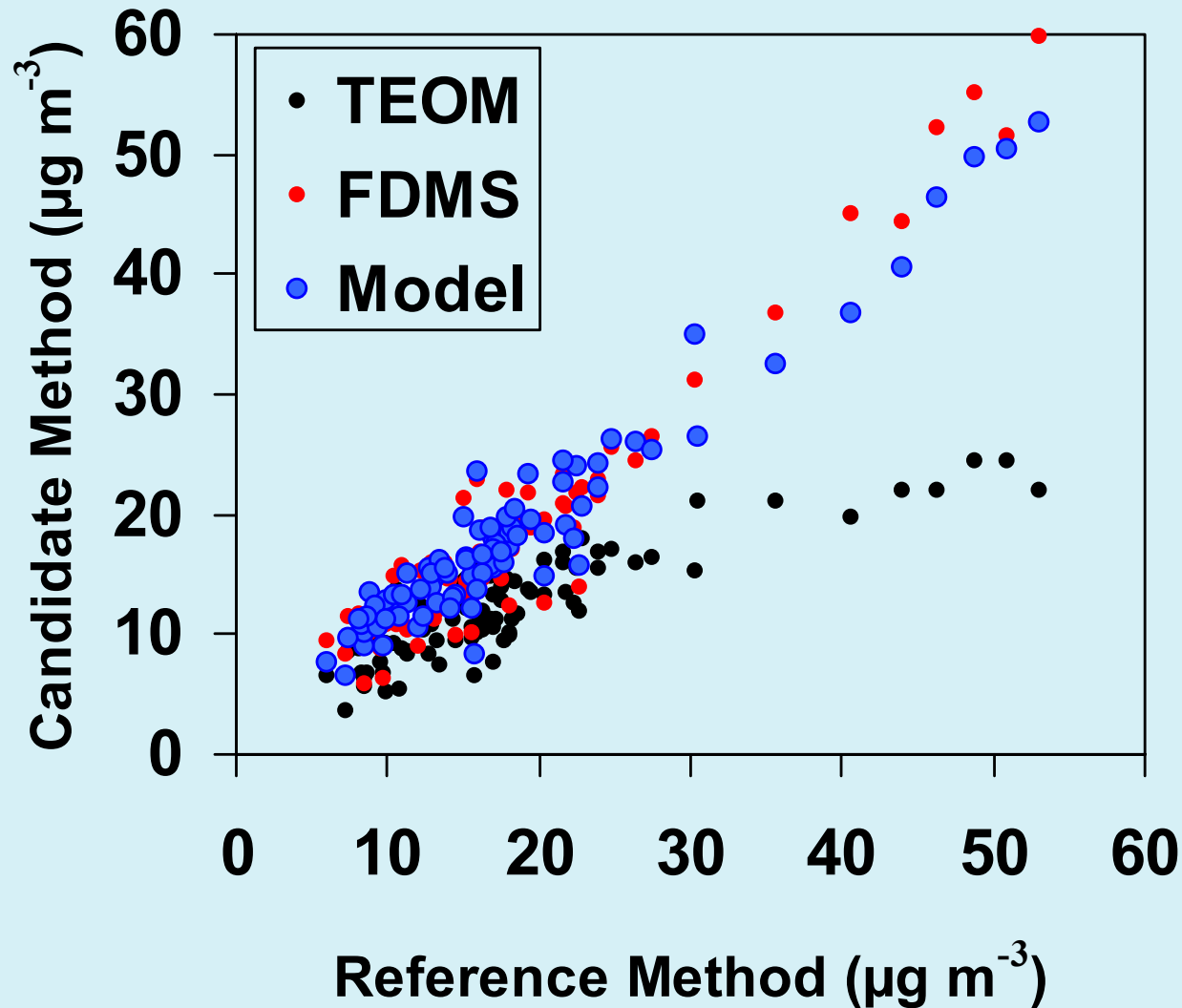
TEOM – FDMS Base vs. FDMS Purge



PM₁₀ Measurements

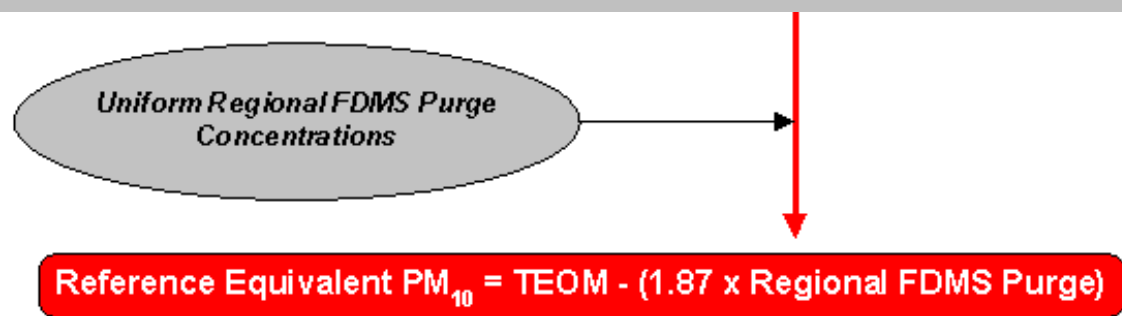


PM₁₀ Measurements



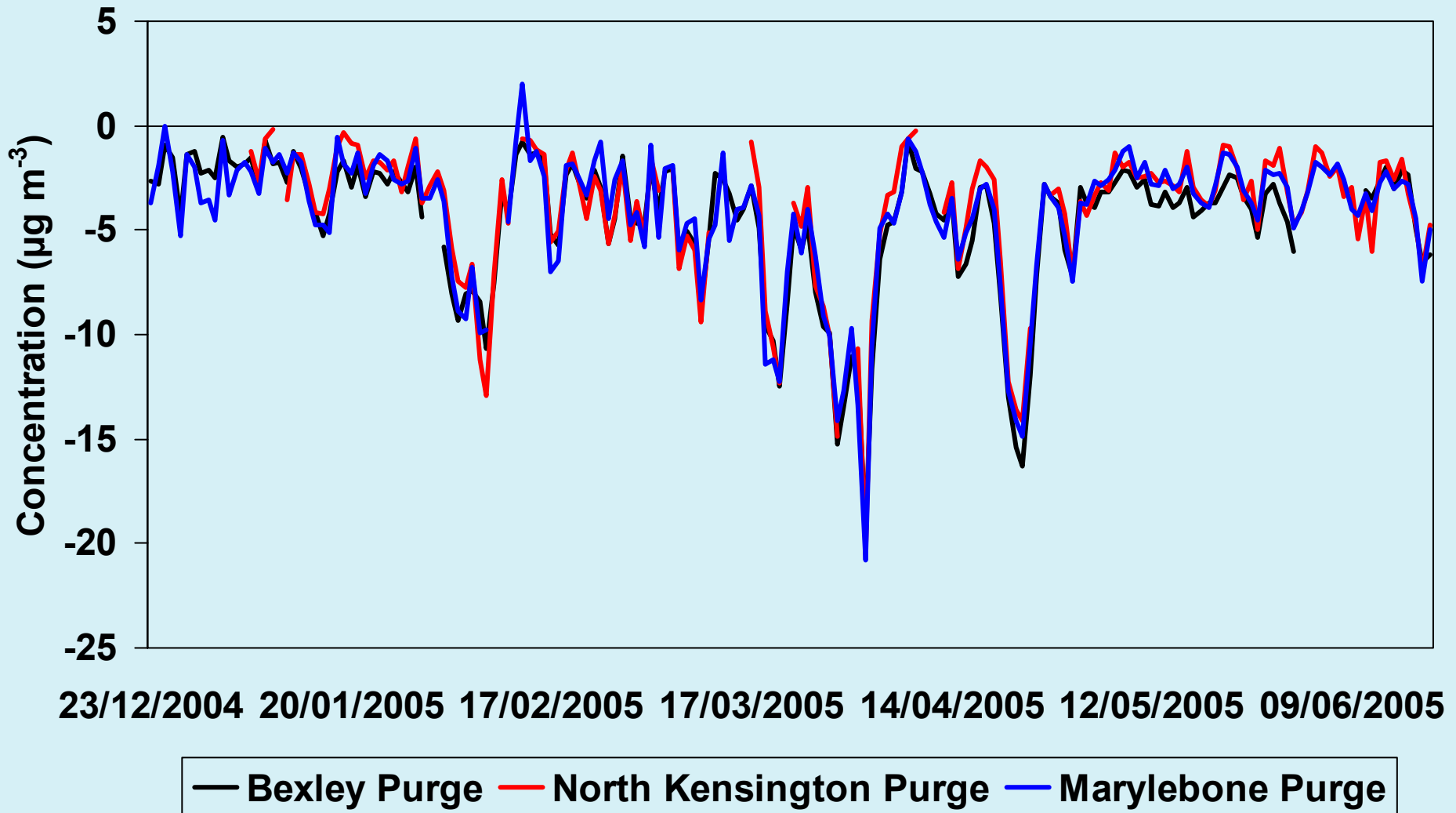
Model Derivation

Uniform Regional FDMS Purge Concentrations

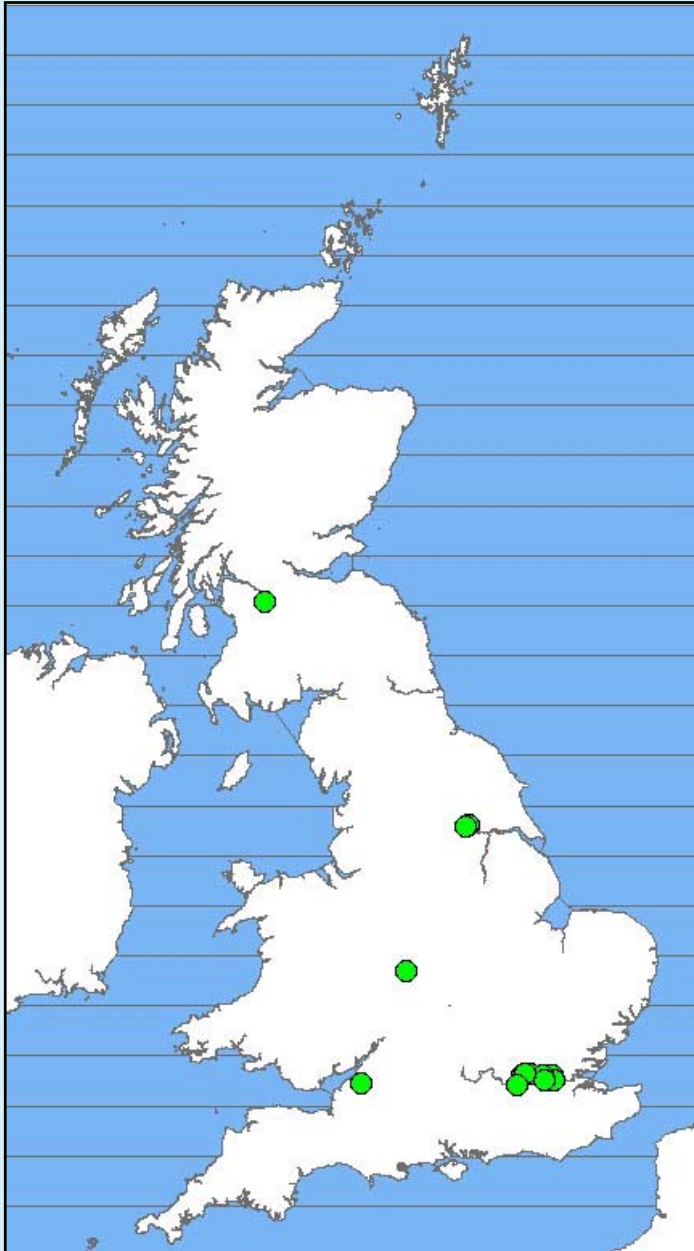


Reference Equivalent PM_{10} = TEOM - (1.87 x Regional FDMS Purge)

Uniform FDMS Purge Concentrations



Equivalence Testing

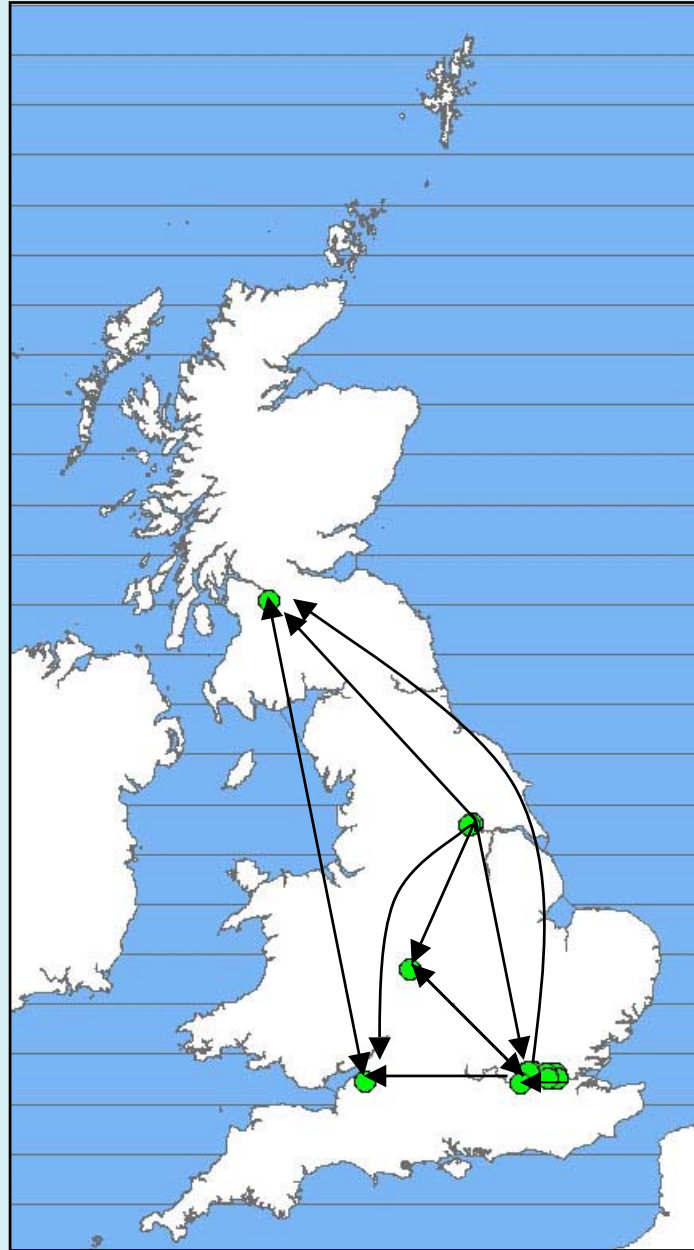


Criteria

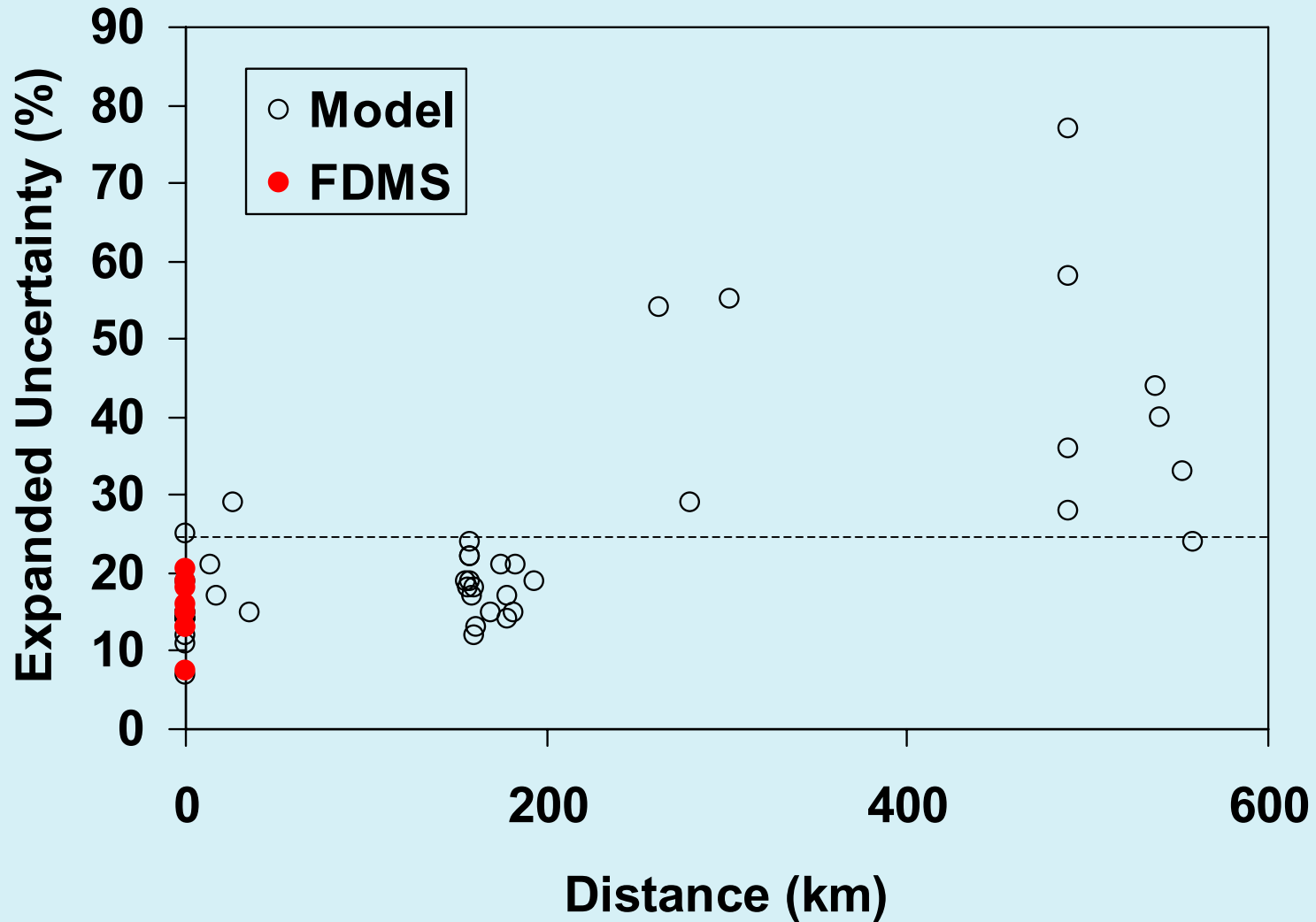
| | |
|---------------------------------------|-----------------------------|
| n | ≥ 40 |
| n ≥ 50 % of limit value | $\geq 25\%$ |
| Between reference sampler uncertainty | $\leq 2 \mu\text{g m}^{-3}$ |
| Between candidate sampler uncertainty | $\leq 3 \mu\text{g m}^{-3}$ |
| Expanded Uncertainty | $\geq 25\%$ |

- Experiment 1 – test the model at the equivalence programme sites *excluding* regional aspects
- Experiment 2 - test the model at the equivalence programme sites *including* regional aspects

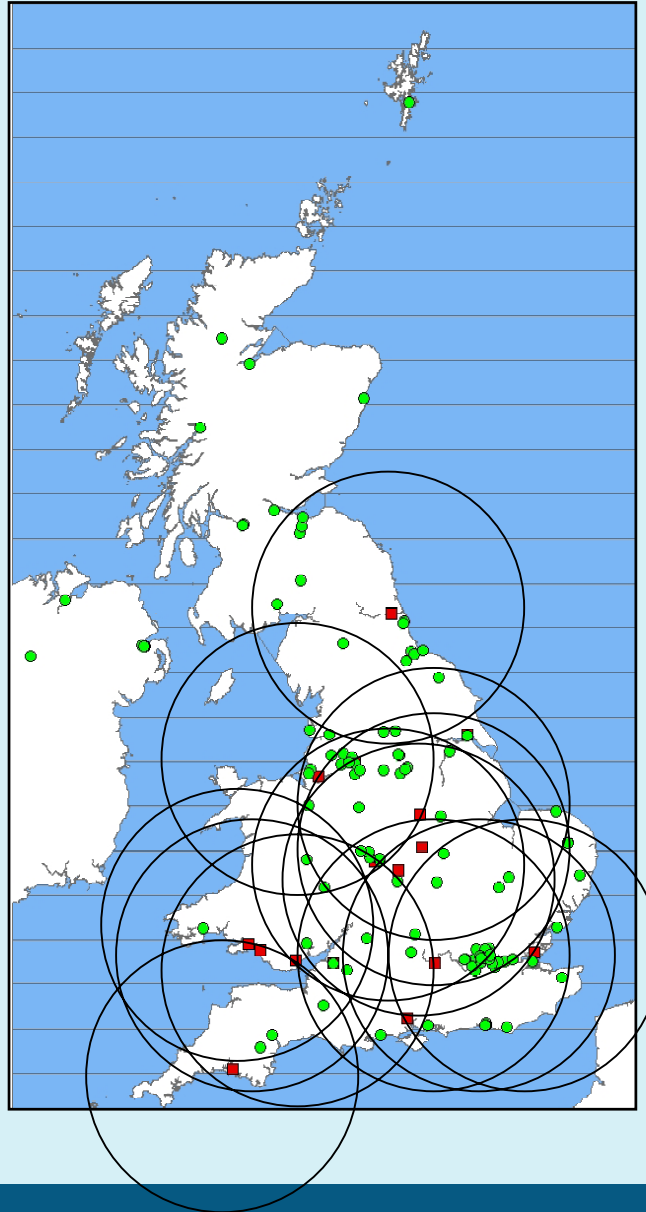
Experiment 2



Expanded Uncertainty



Monitoring Strategy based on the VCM Model



Conclusion

- Model provides a daily, site specific correction factor for TEOM measurements to provide a reference equivalent measurement:

$$\text{Reference Equivalent } PM_{10} = TEOM - 1.87 \text{ FDMS purge}$$

- Works up to a distance of 200 km
- Allows smaller number of FDMS instruments to correct larger network of TEOMs
 - *Financial and data continuity implications*
- Further work...

Further Work

- Physical and chemical basis for model
 - *Concentrations on TEOM and FDMS filters*
 - Ammonium nitrate
 - Volatile organic compounds
 - *Collocated measurements*
 - Ammonium nitrate
 - Volatile organic compounds
 - *Water*
- Extend to hourly public dissemination
- Provide method for local authorities to use the model
- Extend to $PM_{2.5}$

Acknowledgements

- Defra
- London Borough of Bexley
- London Borough of Greenwich
- London Borough of Ealing
- City of Westminster
- Royal Borough of Kensington and Chelsea
- Air Monitors

Thank you for you attention!