

KING'S College LONDON

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# Correcting TEOM Measurements using the KCL Volatile Correction Model

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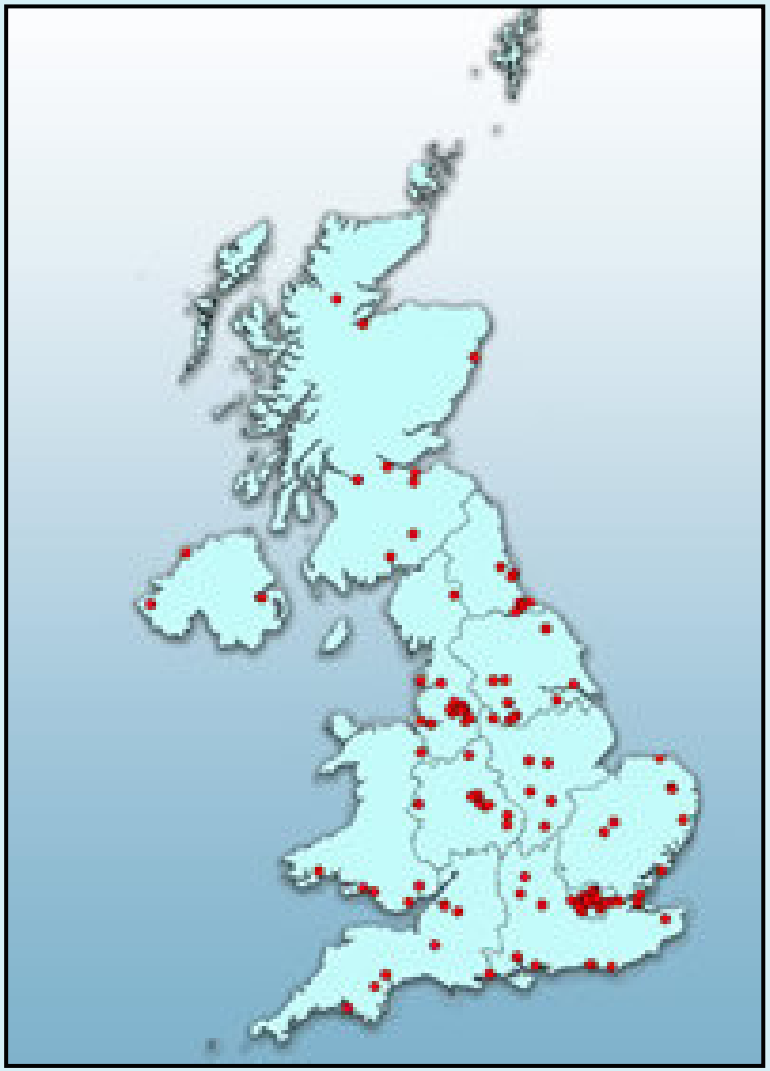
# UK PM Monitoring Problem



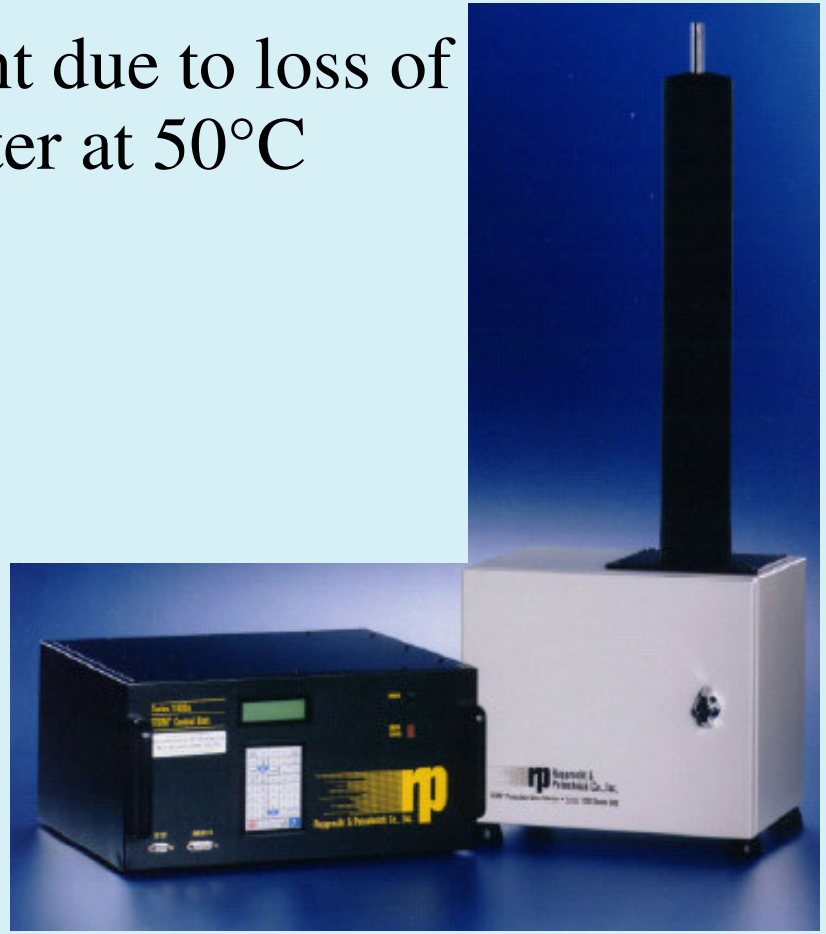
- AURN
  - *75 TEOMs*
  - *14 Gravimetric*
- Local government monitoring
  - *100s of TEOMs*
  - *Few BAMs*
  - *Few Gravimetric*
- Need to use equivalent methods for reporting to EU
  - *Gravimetric*
  - *BAM*
  - *FDMS*
  - *Not the TEOM!*

# Solutions

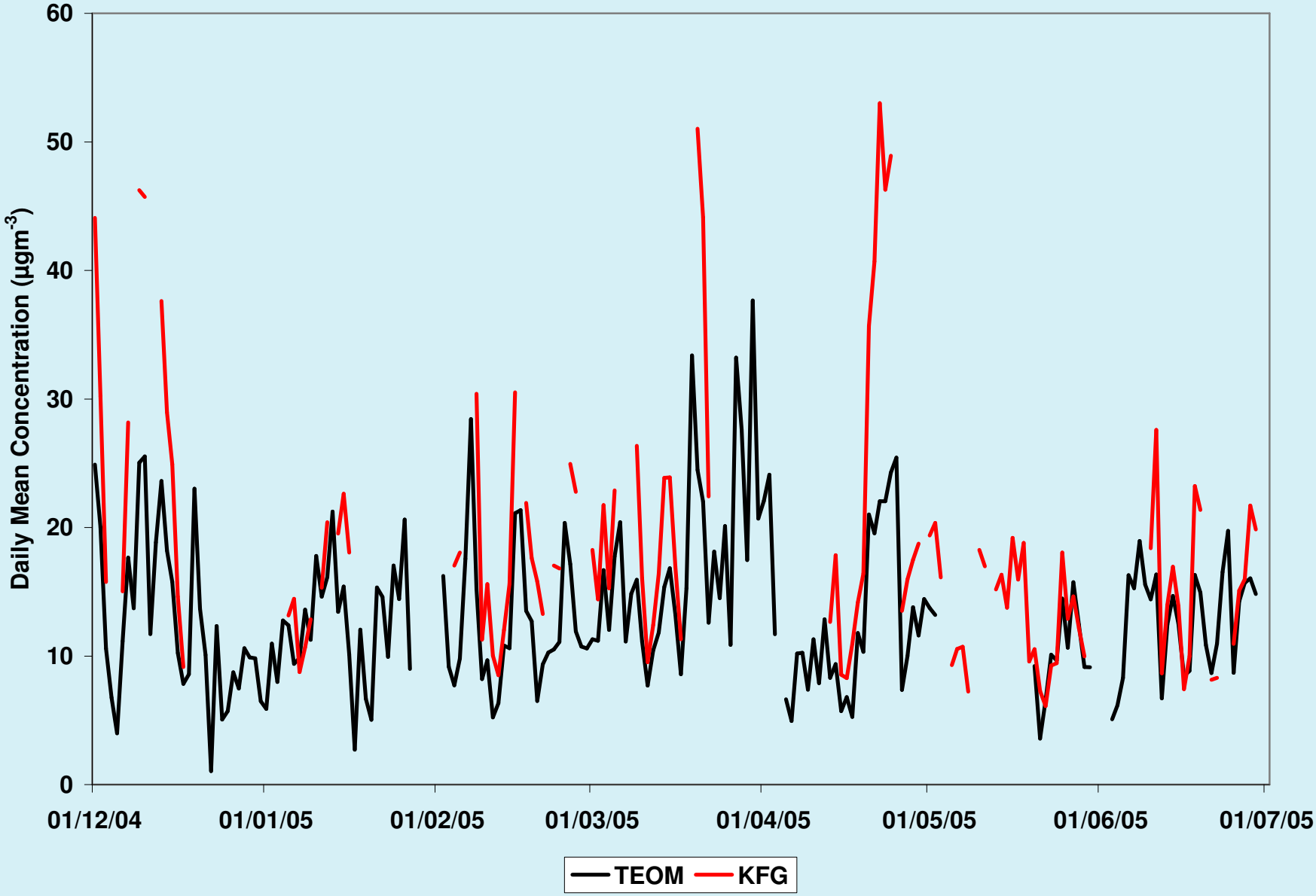
- Upgrade TEOMs to FDMS
  - *Expensive (capital)*
  - *Retains some continuity of measurement*
- Change monitoring equipment
  - *Gravimetric*
    - (capital and revenue)
    - Loose continuity of measurement
    - Delay in reporting time
  - *BAM*
    - Expensive (capital)
    - Loose continuity of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

# TEOM

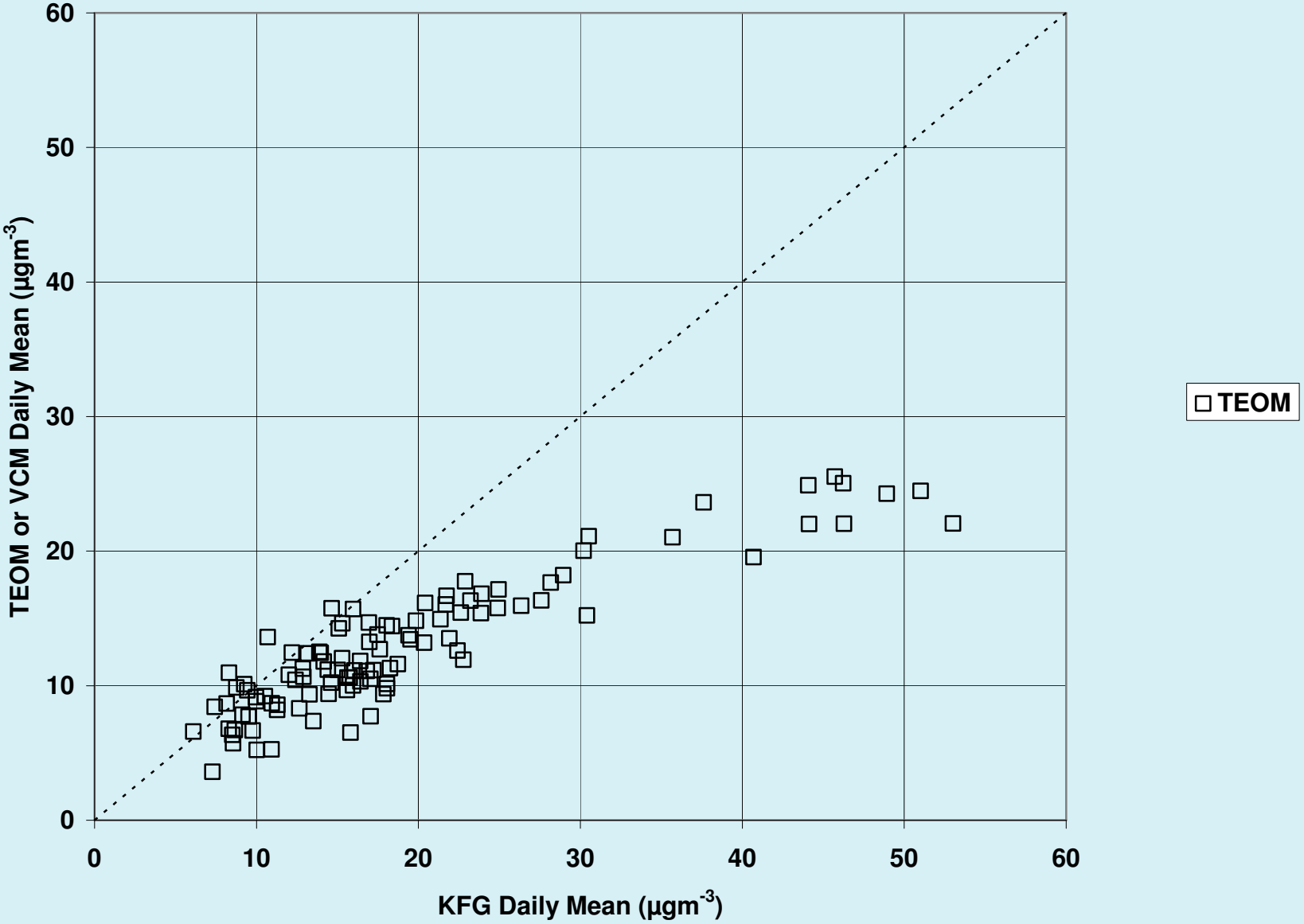
- Widely used on national and local authority networks
- Not reference equivalent due to loss of volatile particulate matter at 50°C sample temperature



# Gravimetric and TEOM - Time Series

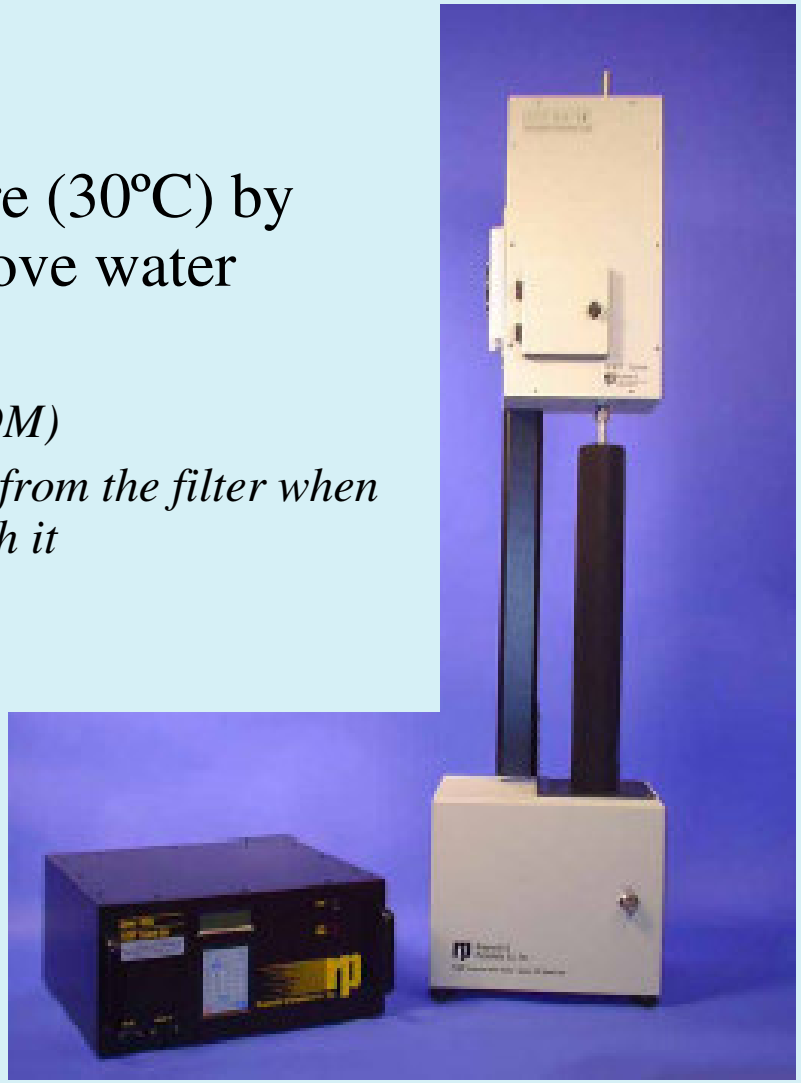


# Gravimetric and TEOM– Correlation

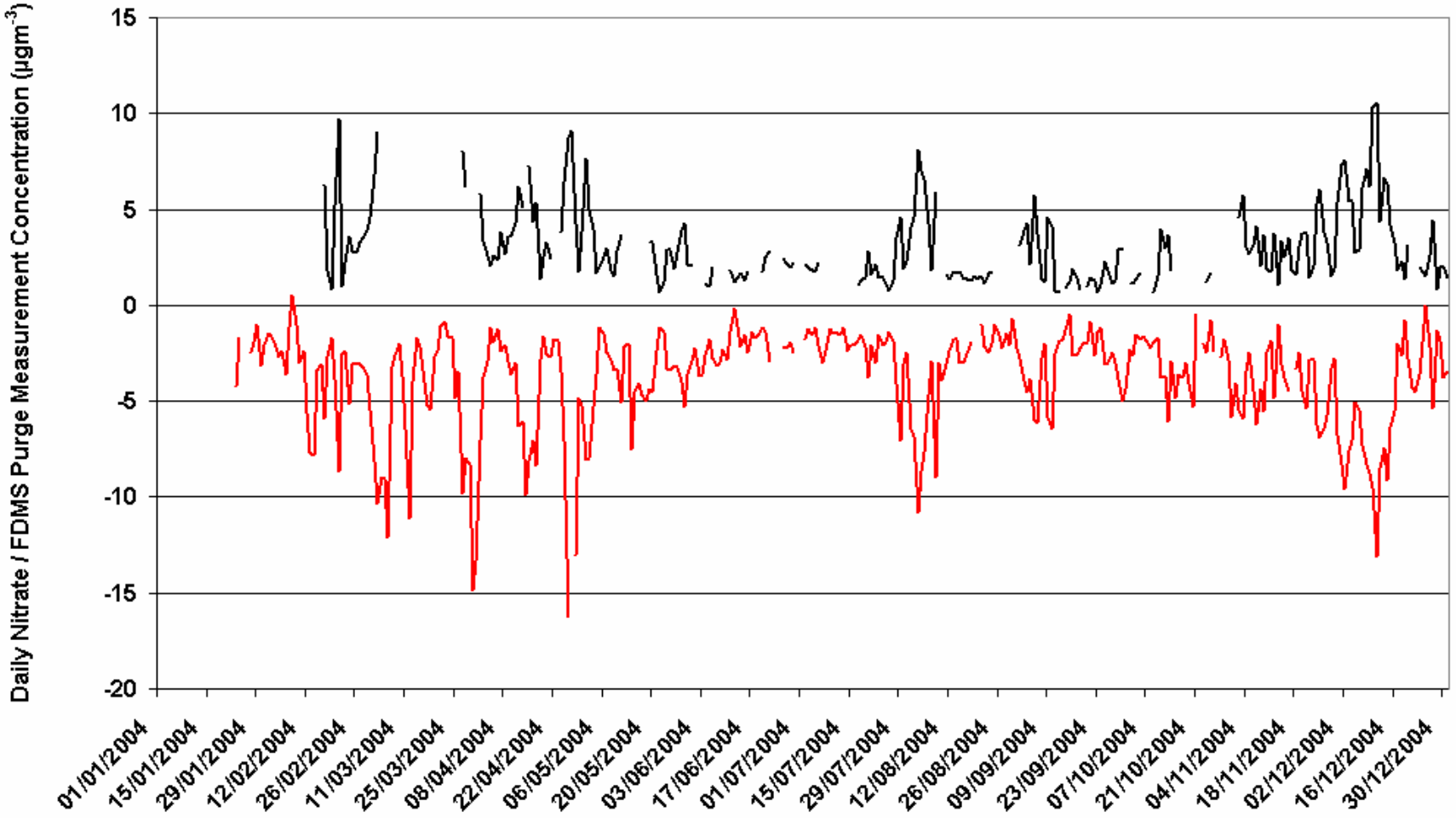


# Filter Dynamics Measurement System (FDMS)

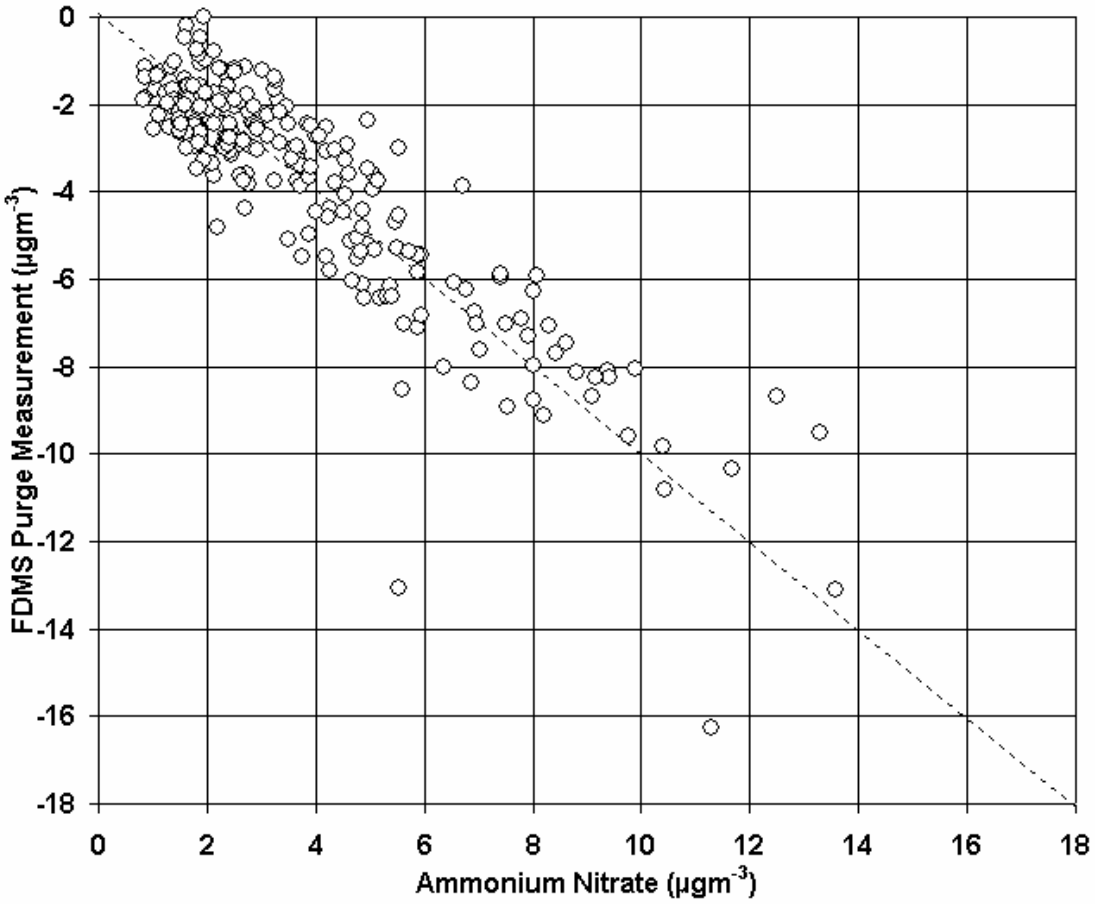
- Add on to the TEOM
- Reference equivalent
- Samples at lower temperature (30ºC) by using diffusion dryer to remove water
- 2 measurement modes:
  - *Base (analogous to standard TEOM)*
  - *Purge, which measures mass lost from the filter when particle free air is passing through it*
- FDMS Mass = Base - Purge



# What is the FDMS Purge Measurement?

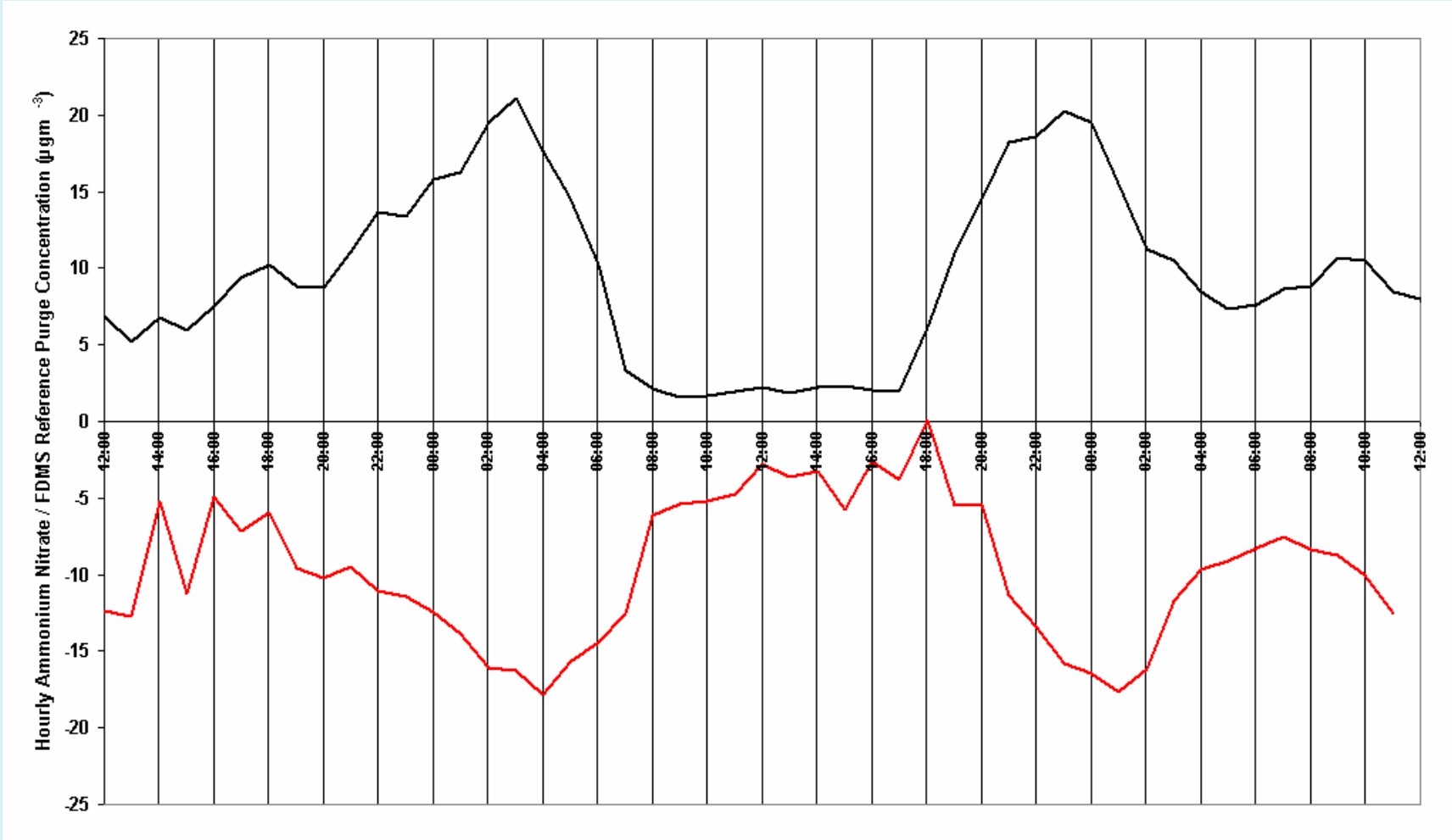


# FDMS Purge Measurement vs. $PM_{2.5}$ $NH_4NO_3$




| | |
|---|---|
| Slope | -1.01 |
| Intercept | 0.09 |
| SDSlope | 0.03 |
| SDIntercept | 0.39 |
| Mean Ammonium Nitrate (µgm$^{-3}$) | 3.9 |
| Mean FDMS Purge (µgm$^{-3}$) | -3.9 |
| R | -0.89 |

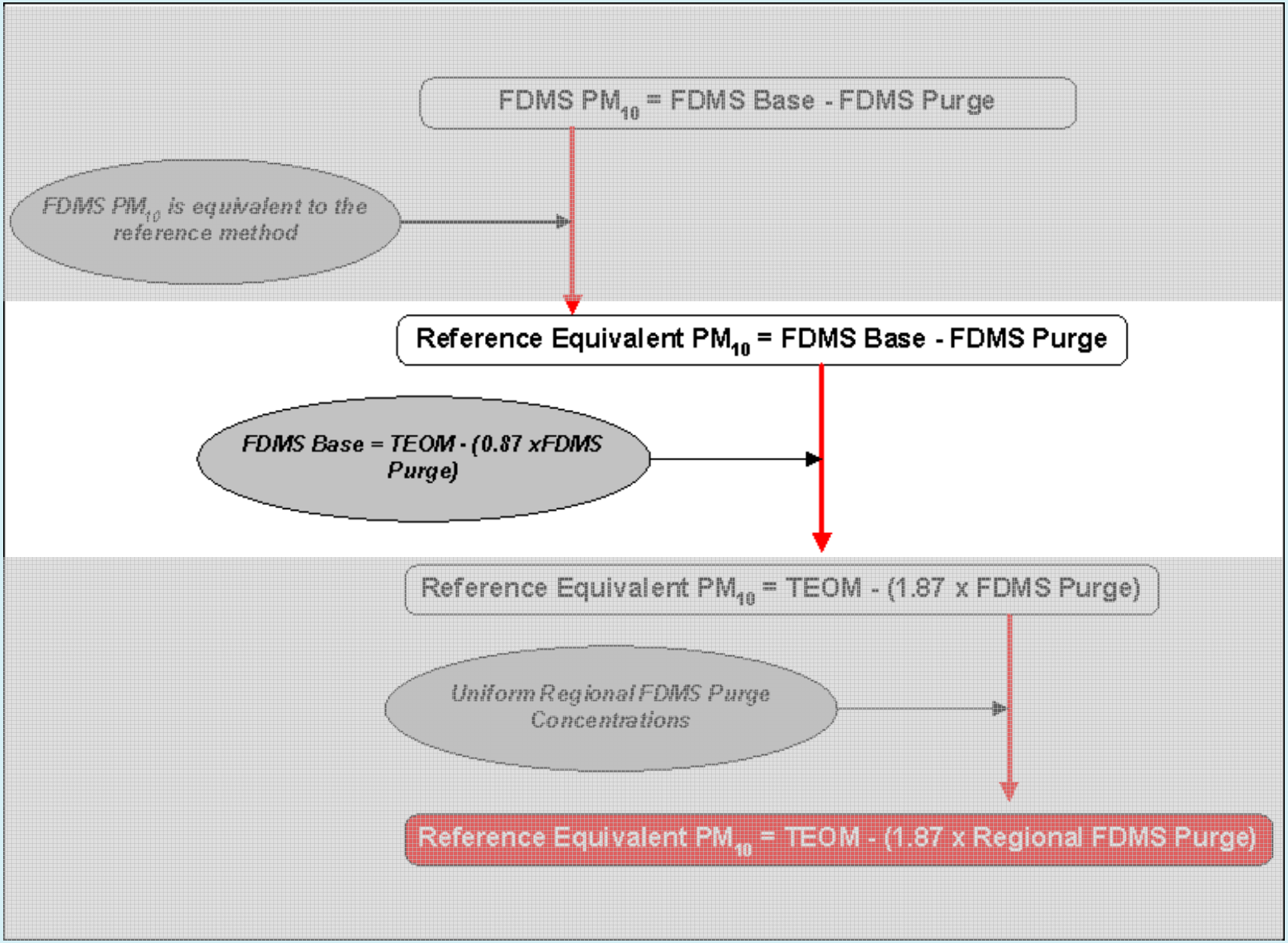
# Lag in volatile loss from filter



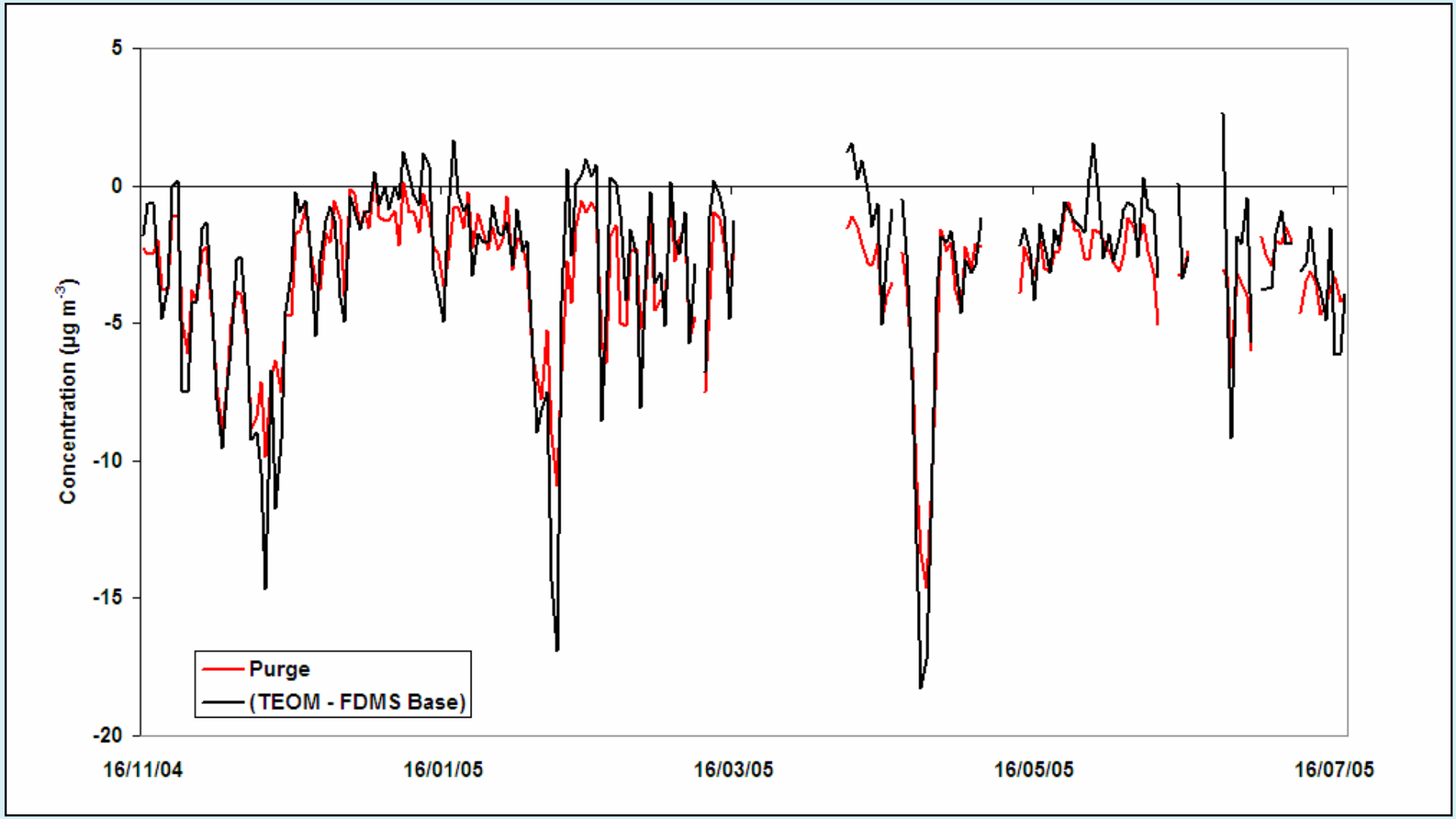
# KCL Volatile Correction Model

- 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



# Relationship between TEOM and FDMS Base



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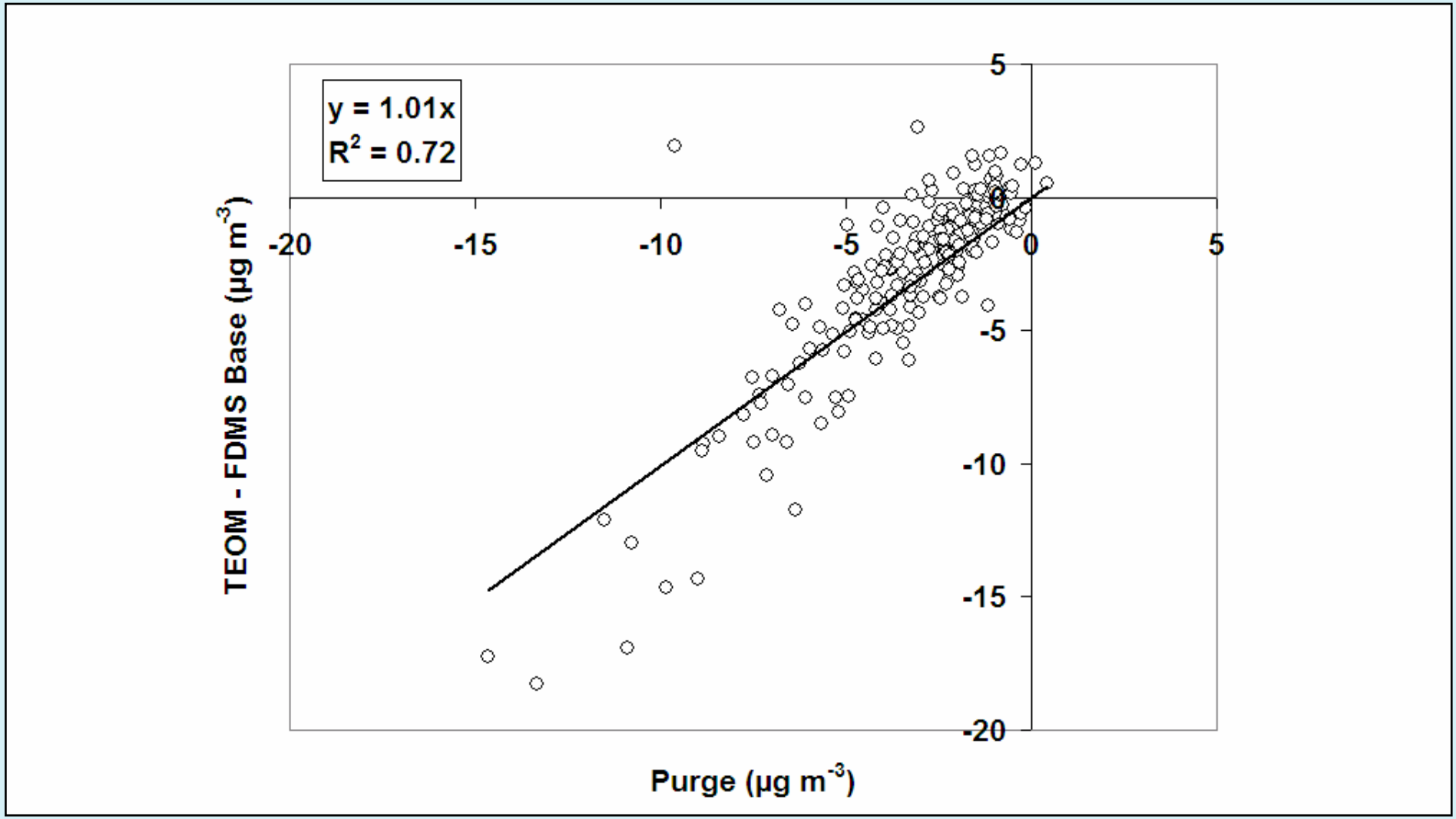
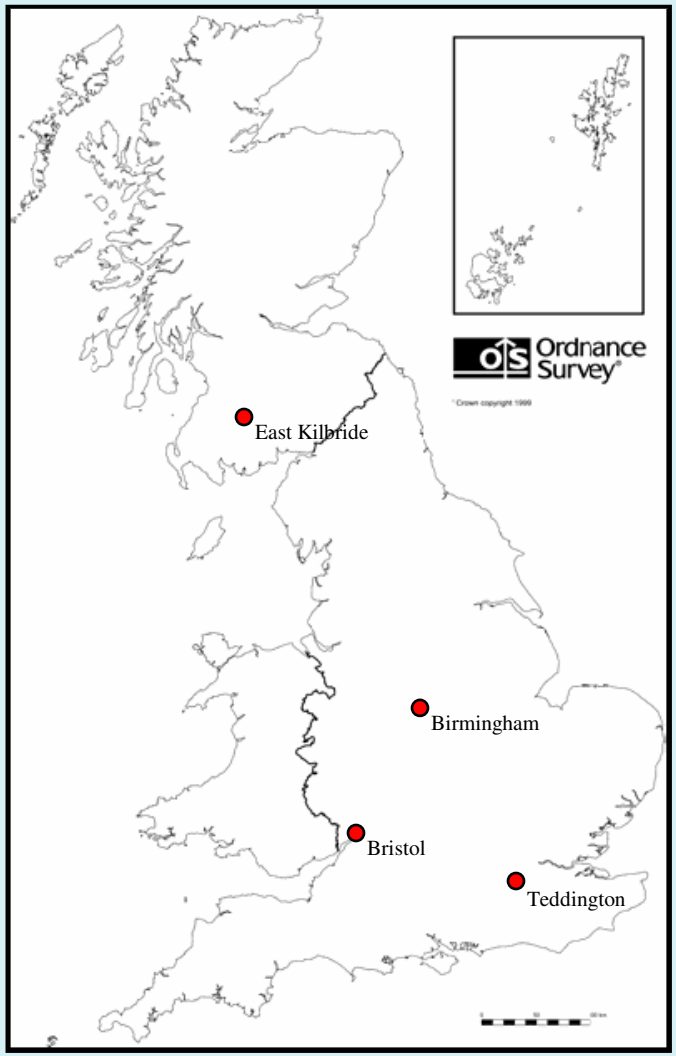
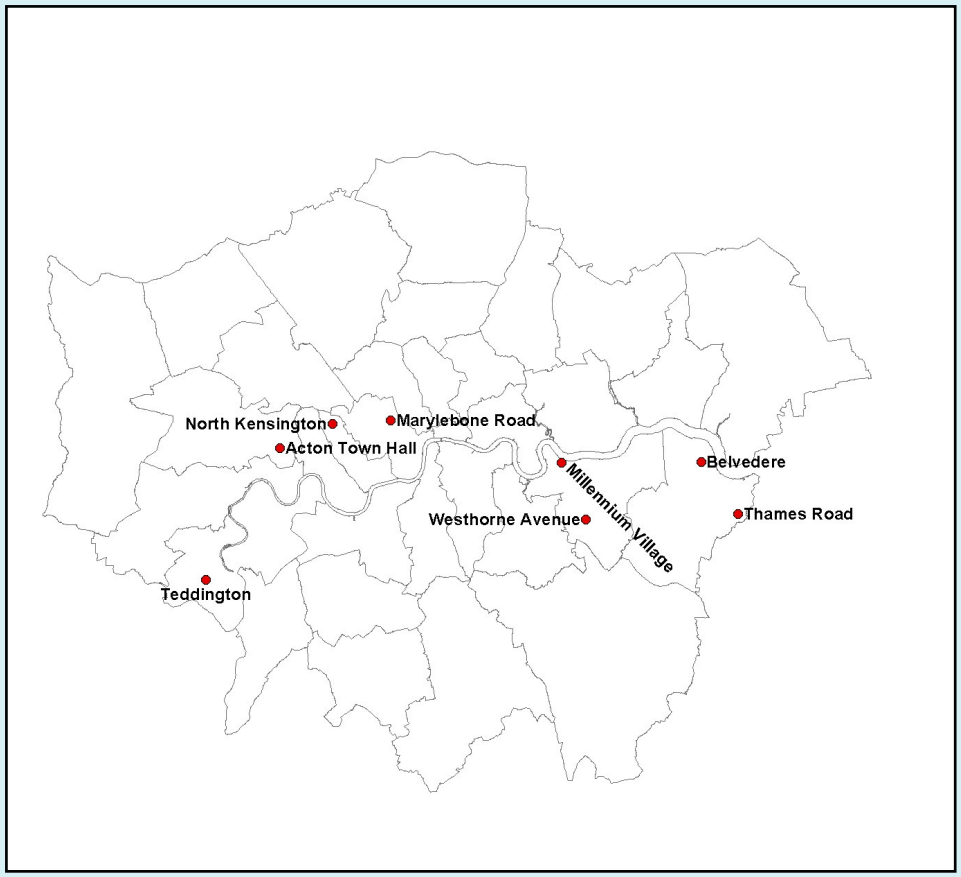


# TEOM and FDMS Monitoring



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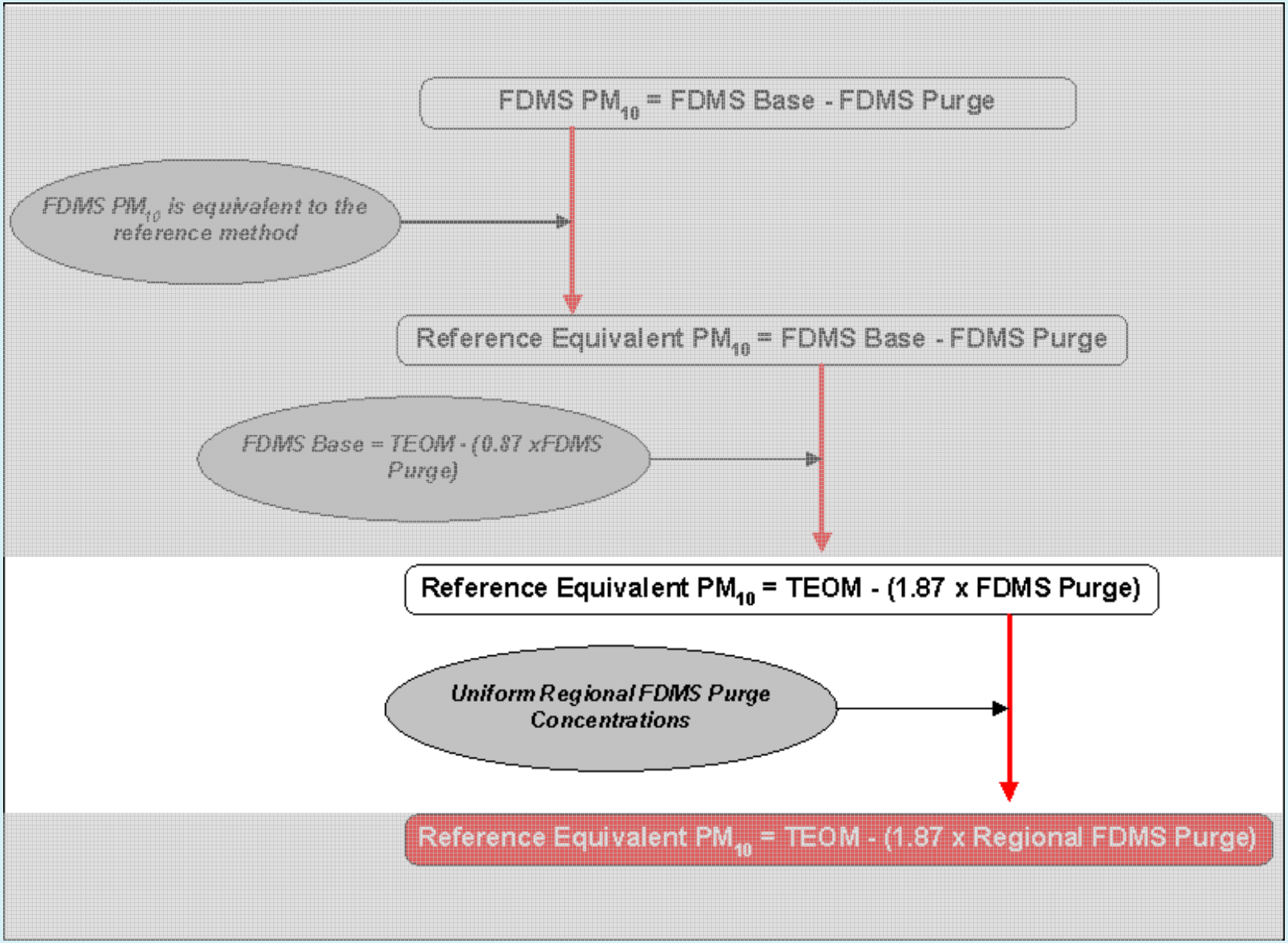
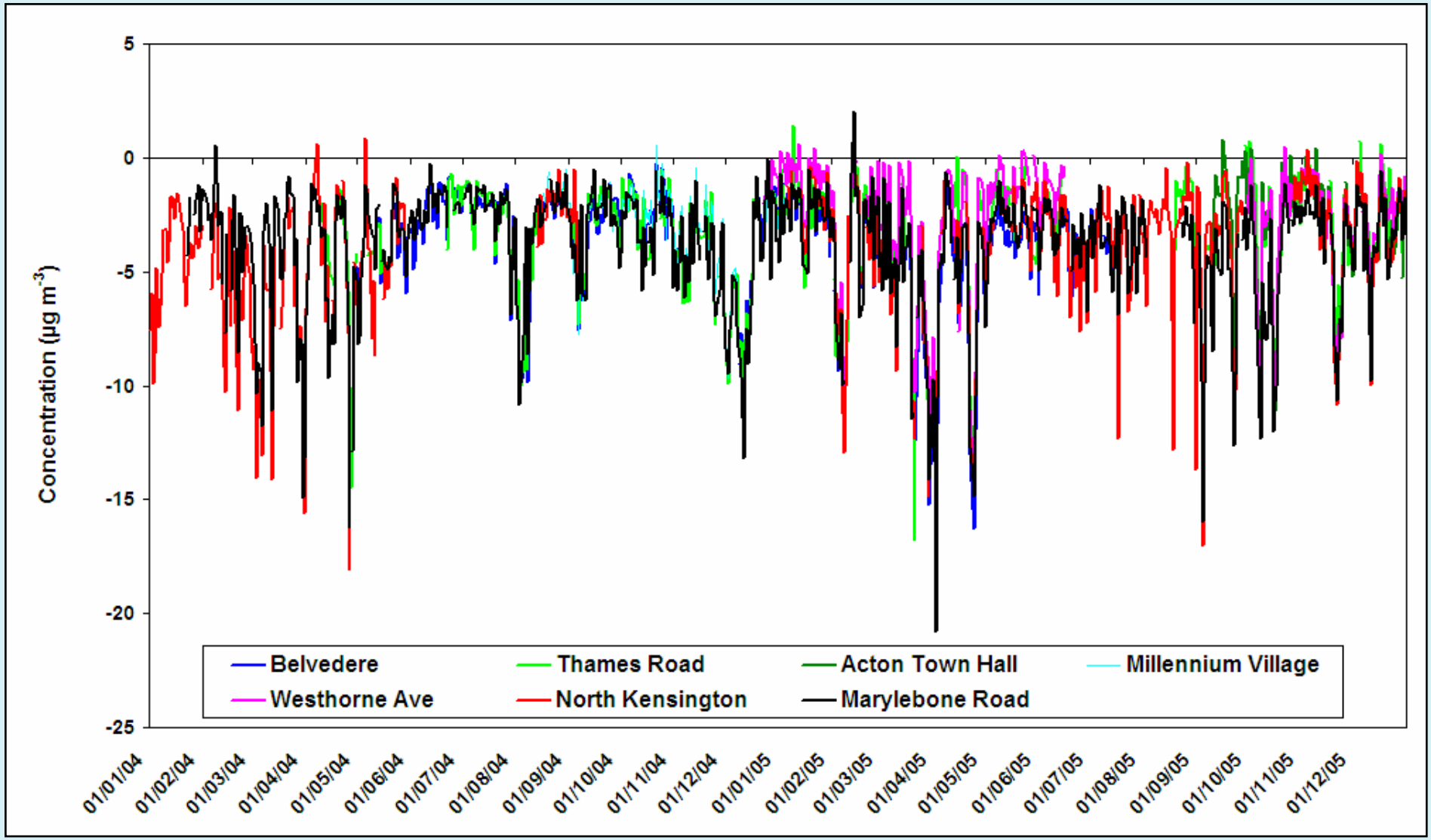


# Uniform Regional FDMS Purge Concentrations



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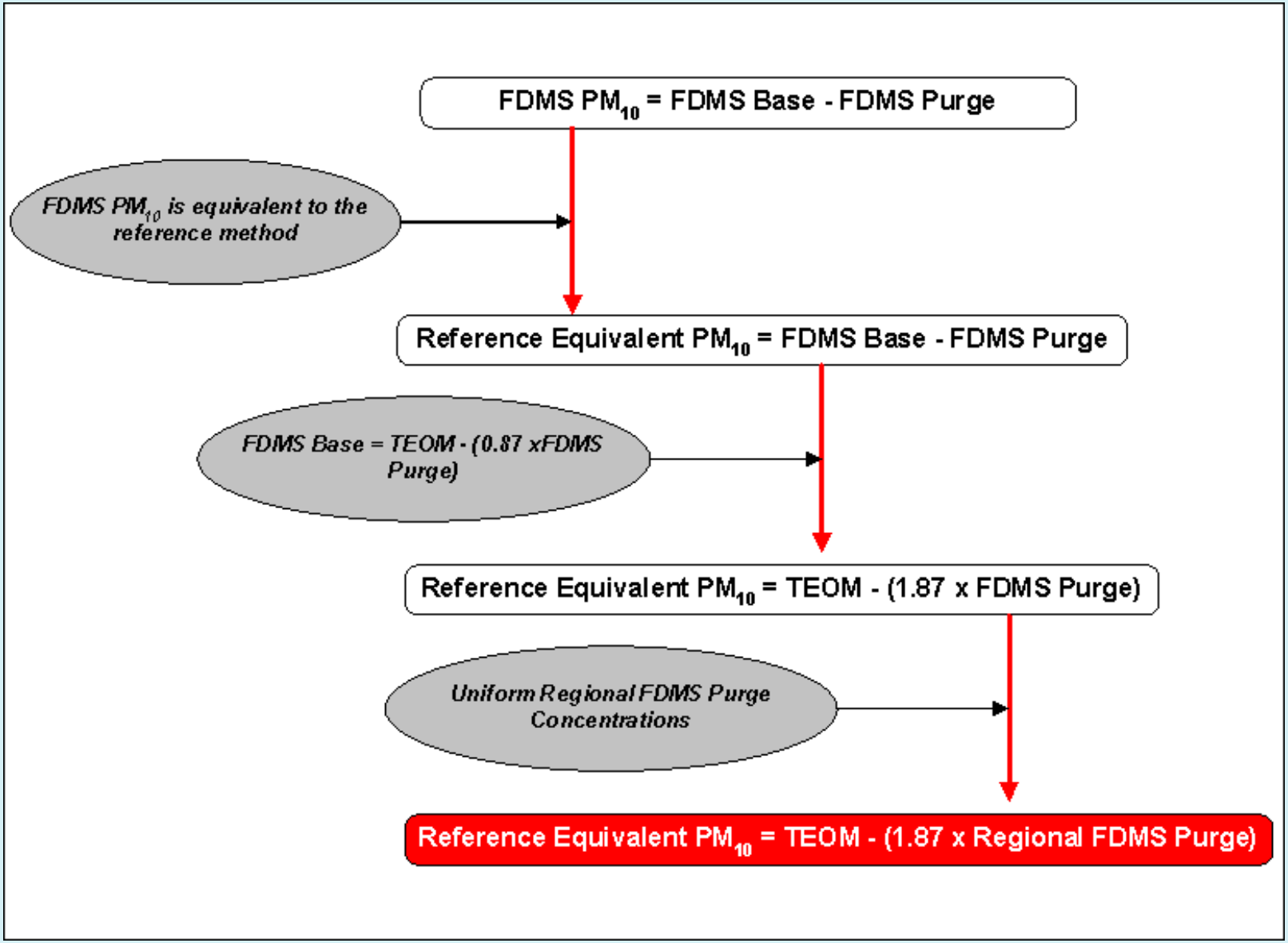
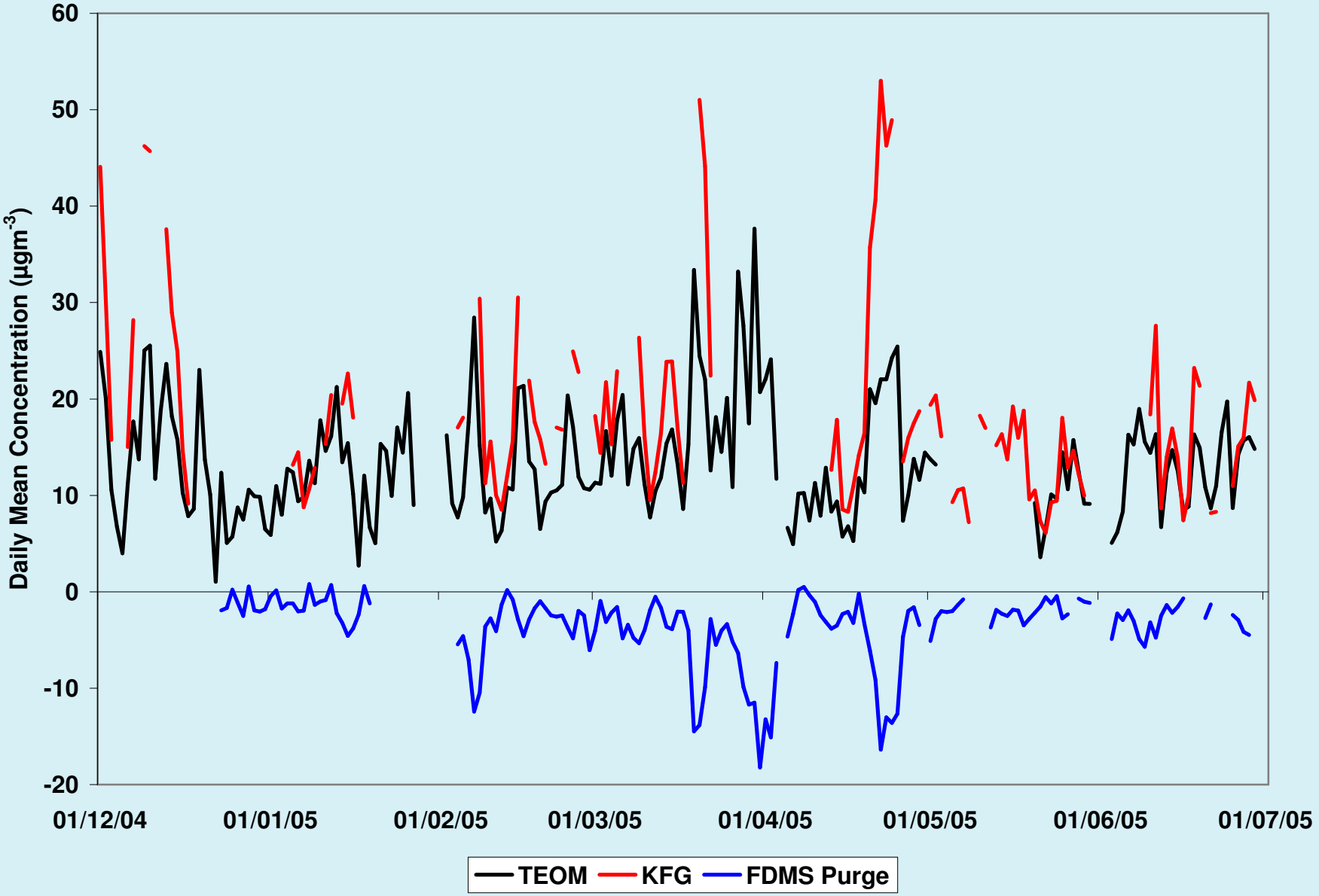


# Model Application – Time Series






*Presented by David Green*

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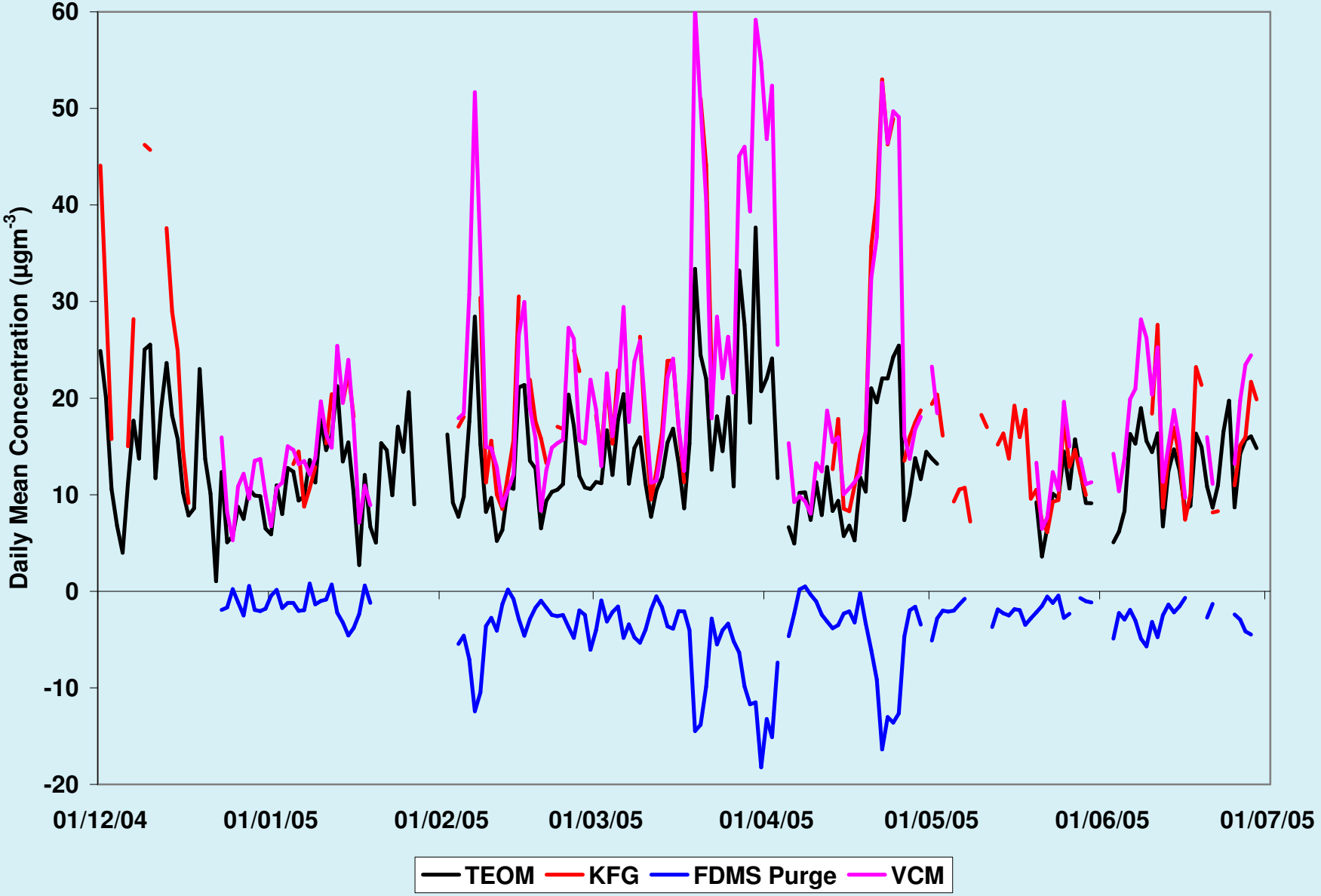




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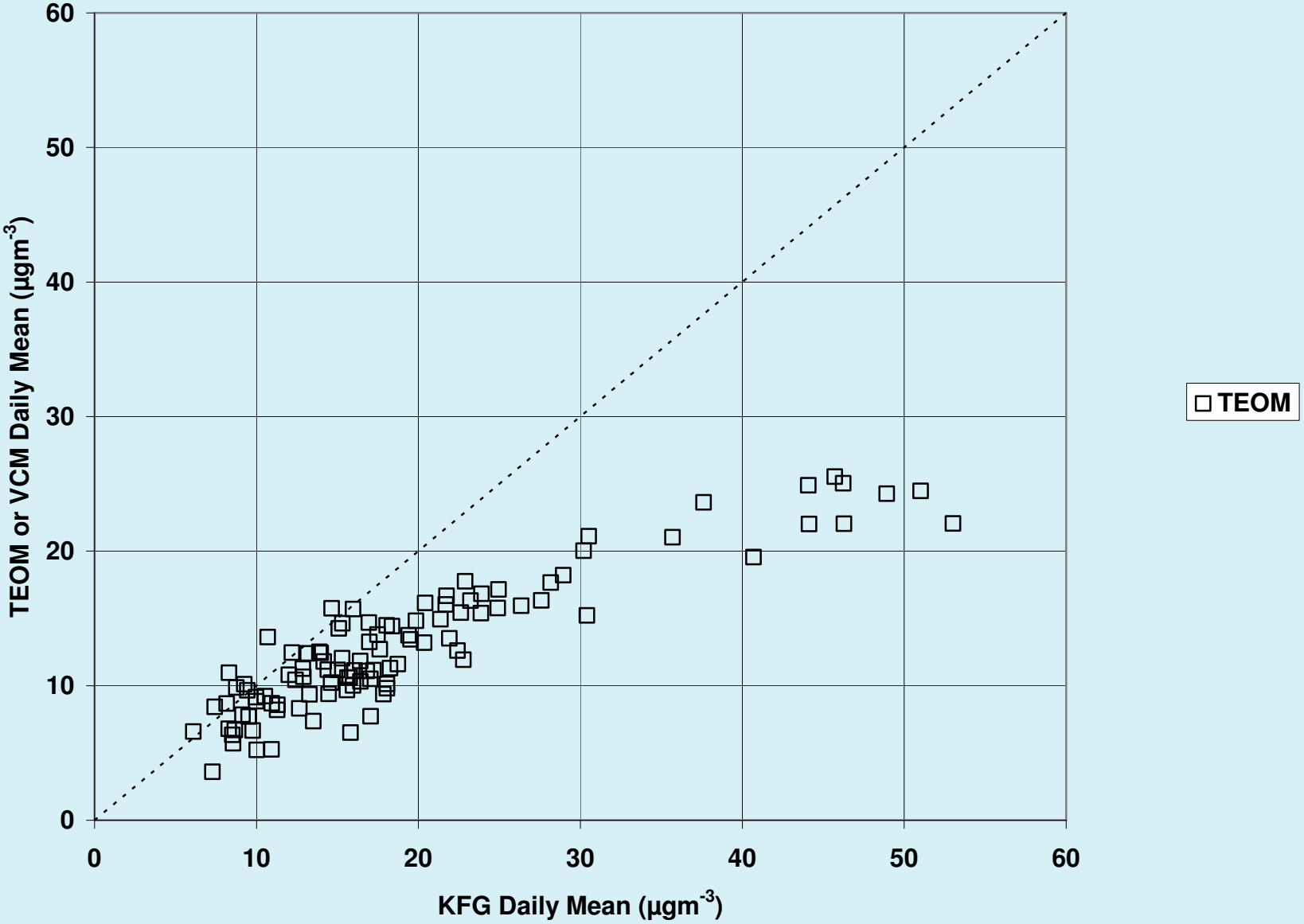

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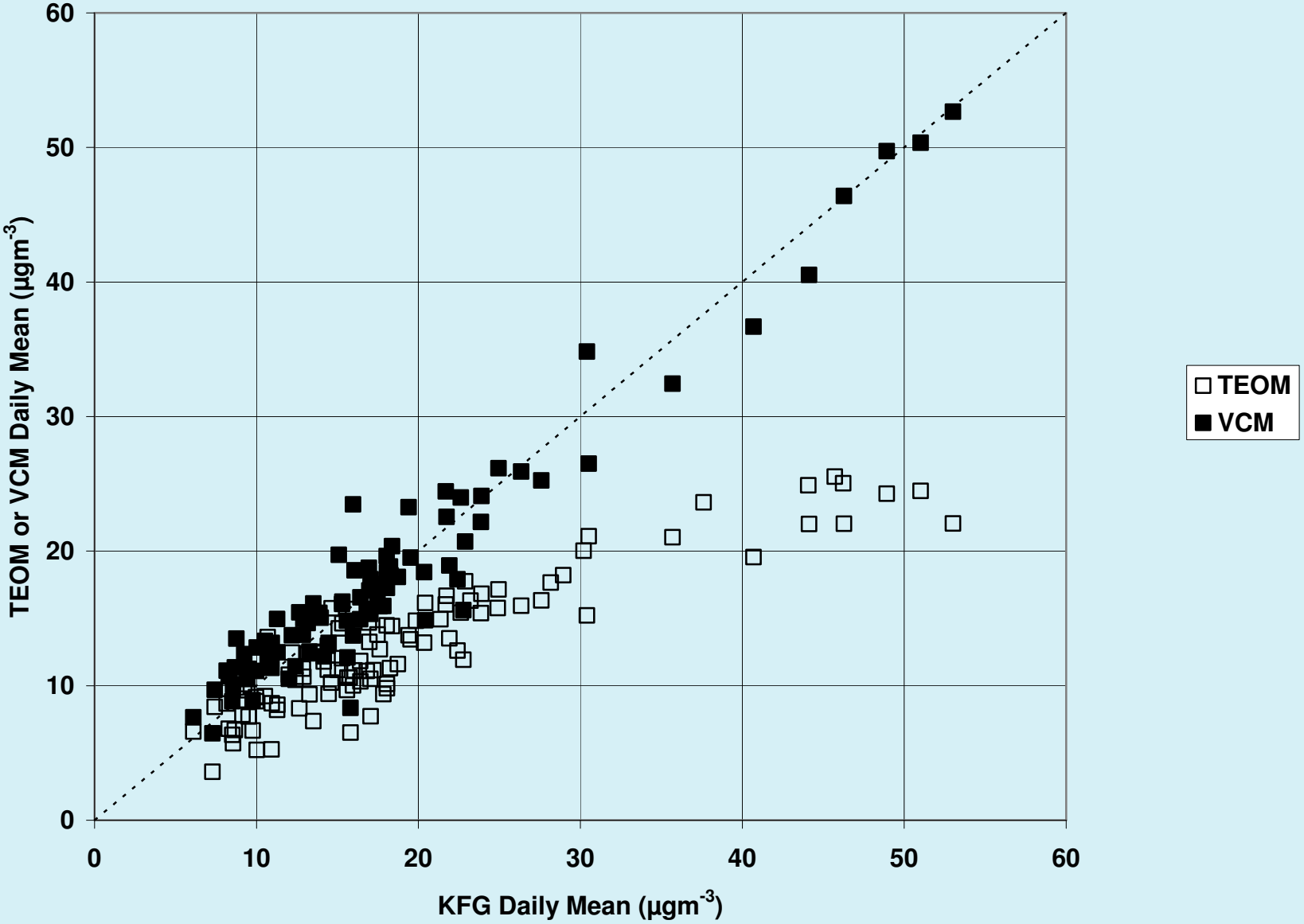
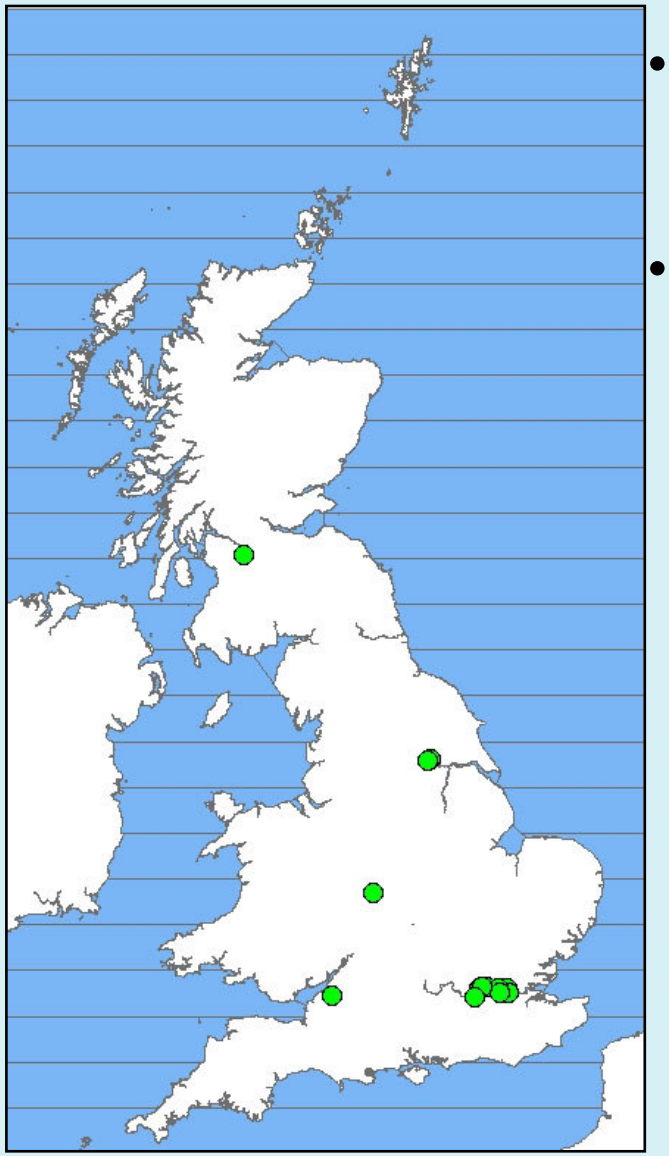


# Equivalence Testing

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

# Equivalence Testing

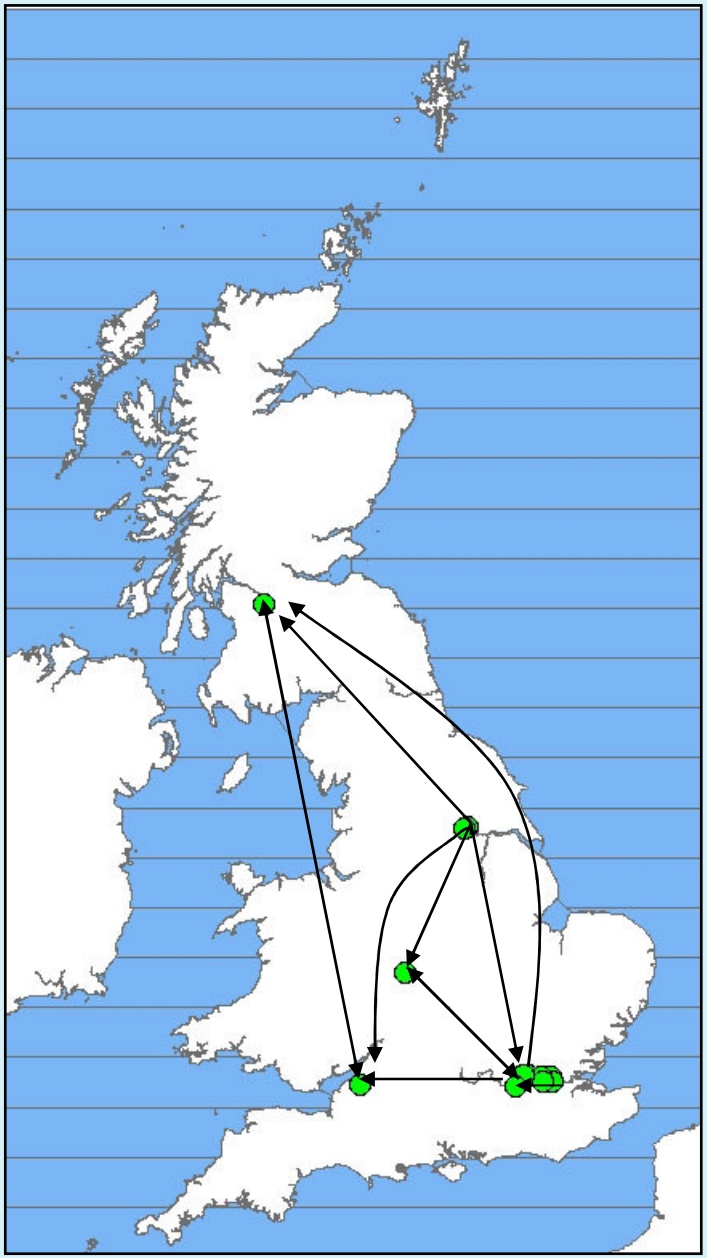


- Experiment 1 – test the model at the equivalence programme sites *excluding* regional aspects
- Experiment 2 - test the model at the equivalence programme sites *including* regional aspects

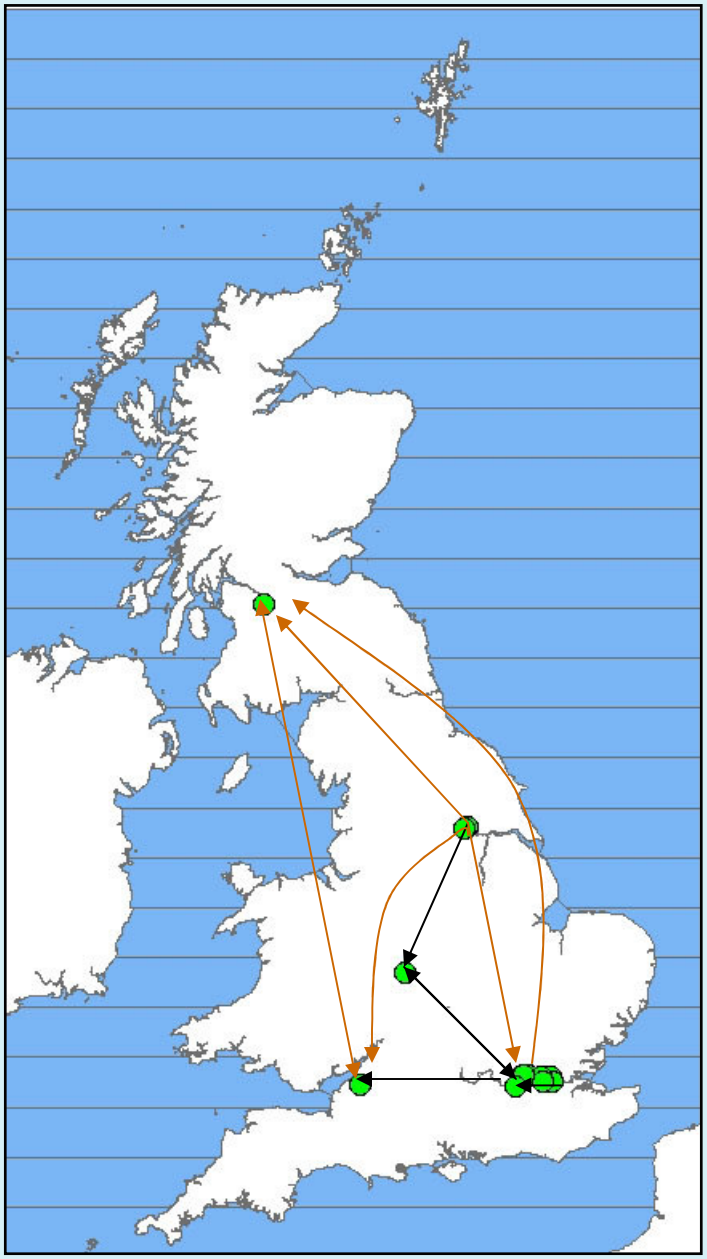
# Results - Experiment 1

- Between sampler uncertainty 0.88 µg $m^{-3}$
- Slopes of the individual and combined datasets are both greater and less than 1
  - *winter range: 0.84 to 1.26*
  - *summer range: 0.93 to 1.06*
- Intercepts are both greater and less than zero
  - *winter range: -1.05 to 3.37*
  - *summer range: -0.21 to 4.50*
- The expanded uncertainty was less than 25 % for all but four combinations at East Kilbride in the summer.

# Experiment 2



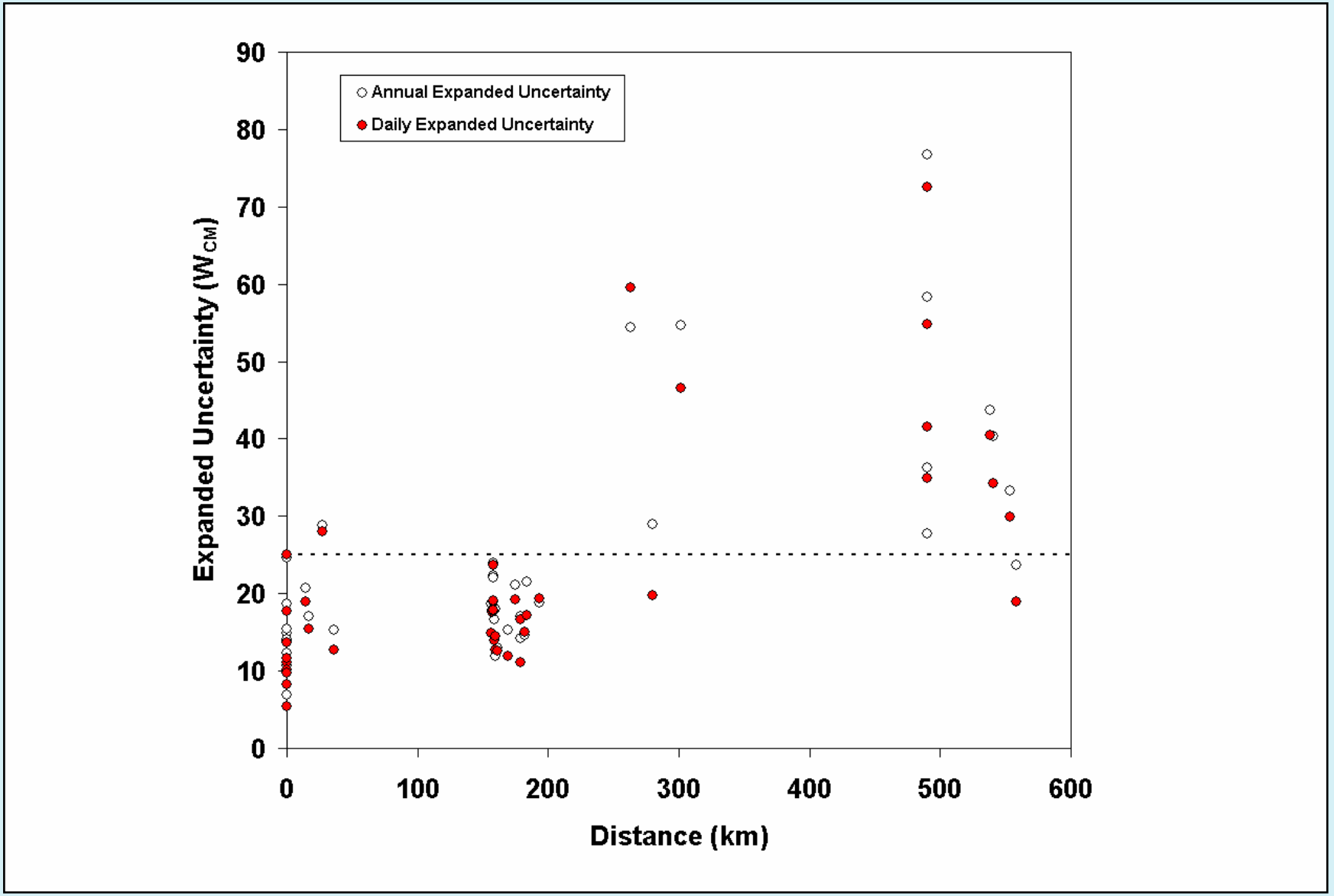
# Experiment 2



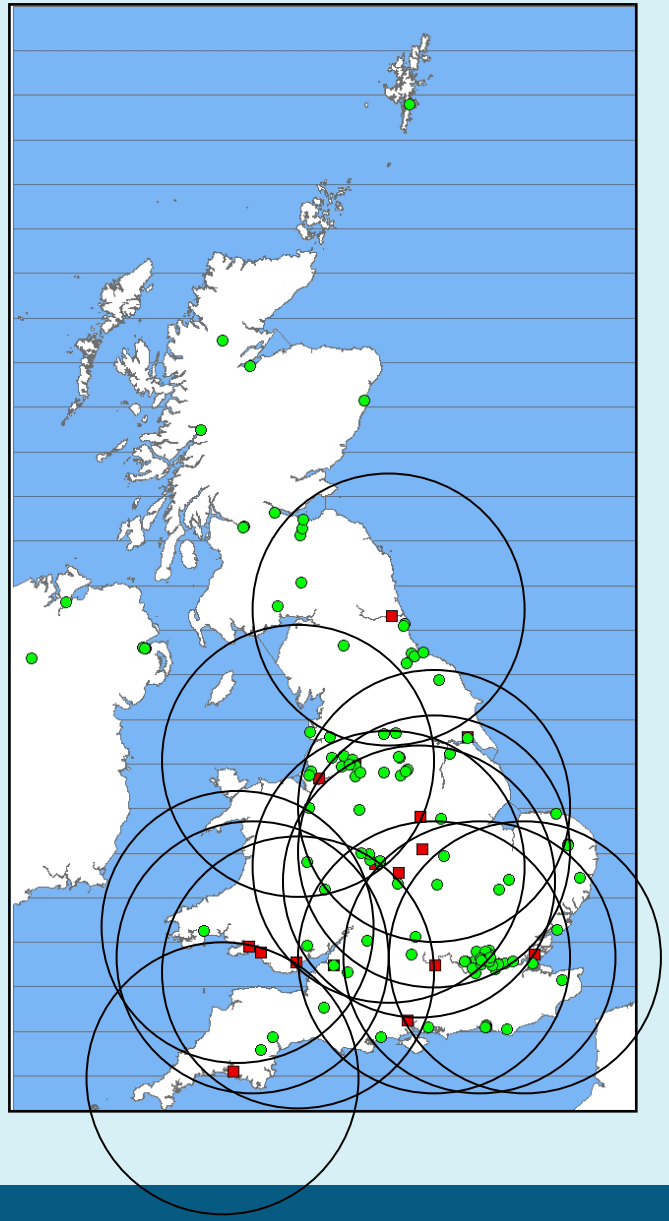
# Results - Experiment 2

- Between sampler uncertainty 0.89 µg $m^{-3}$
- Slopes of the individual and combined datasets are both greater and less than 1
  - *range: 0.67 to 1.29*
- Intercepts are both greater and less than zero
  - *range: -0.21 to 8.26*
- The expanded uncertainty was less than 25 % for all but 10 combinations
  - *All but one of these the distance between the sites was greater than 200 km*

# Expanded Uncertainty with Distance



# FDMS Monitoring Strategy



# Implications for Forecasting and Modelling

- UK Air Quality Information System descriptors (Low, Moderate, High, Very High)
  - *Forecasting*
  - *Will need to include volatile (secondary) component of $PM_{10}$*
- Modelling for Air Quality Management will need to include volatile (secondary) component of $PM_{10}$

# Conclusion

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

  *Reference Equivalent $PM_{10}$ = TEOM – 1.87 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