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Measurement ratification

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- Sources of information
- How is it done?
  - *Fictional case study*
  - *A bit of advanced stuff*




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What is ratification?

- Retrospective and final calculation of measurement data set
- Establishes and uses calibration and service history
- Connects each measurement to a traceable calibration
- Ensures traceability of final measurement dataset to national metrological standards

What is ratification?

Important point:

- QA/QC procedures do not ensure that the measurement generated by the analyser is the final and most 'accurate' measurement.

- Instead we

  - *Ensure best possible functioning of the analyser*
  - *Collection of extensive calibration information*




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Sources of information

Local Air Quality Management Guidance TG03

Minor reference in the AURN LSO manual

Minor reference in CEN Standards

- *Eg EN 14211 is 91 pages and only reference to measurement processing is*

- "Measured drift in the analyser's response that is less than the action criteria …. shall be corrected for in data processing and not by physical adjustment of the analyser."




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How is it done?

Ambient measurement = SF(Analyser measurement – Zero)

Where SF = Traceable calibration gas / (Span response – zero)

Illustrated by fictional case study

- *Only show work done on the service and calibration history*
- *Only focus on the span factor*




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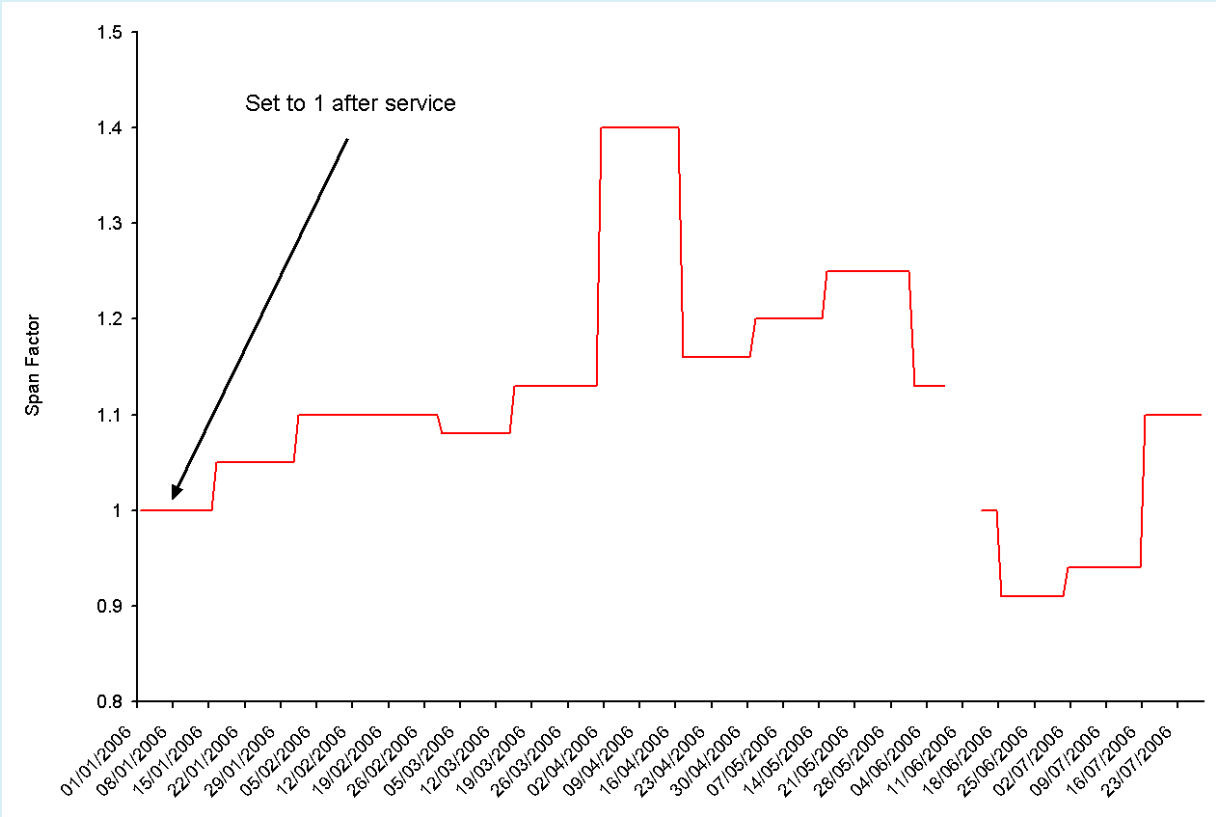
How is it done?



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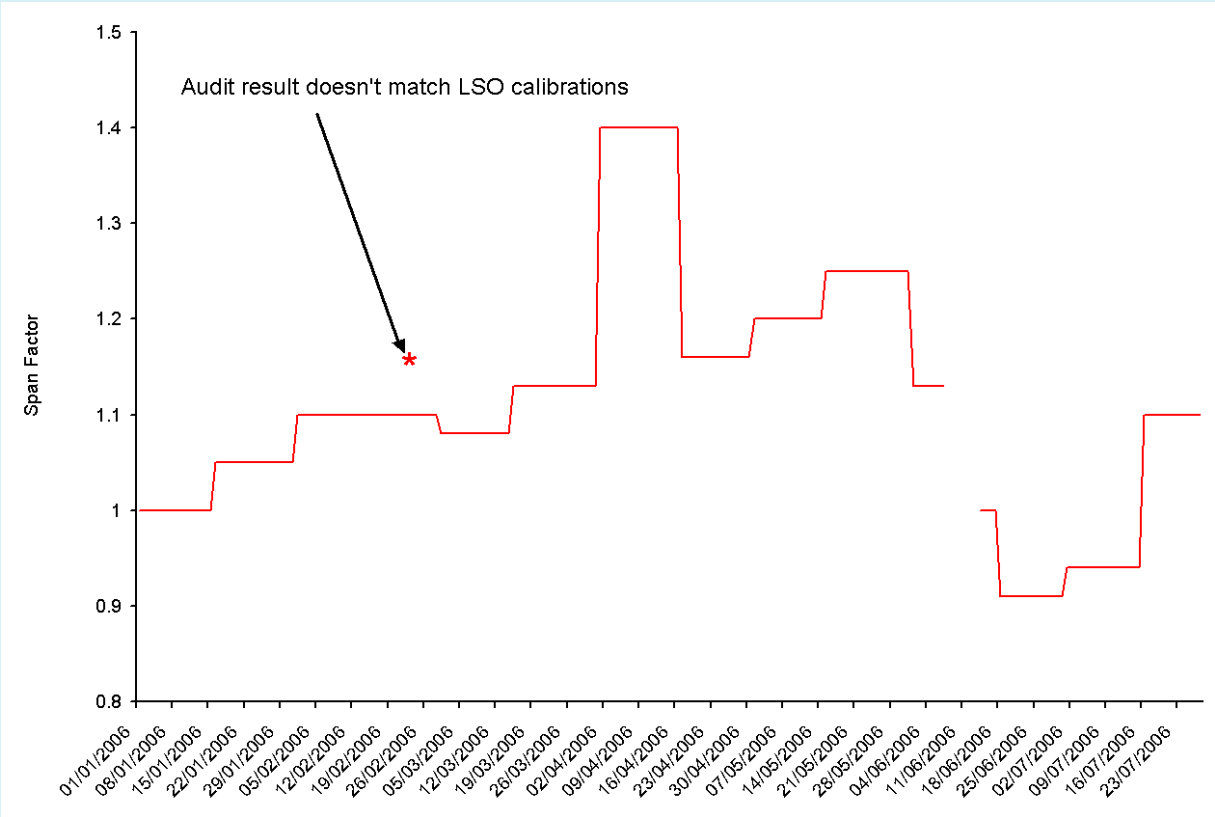

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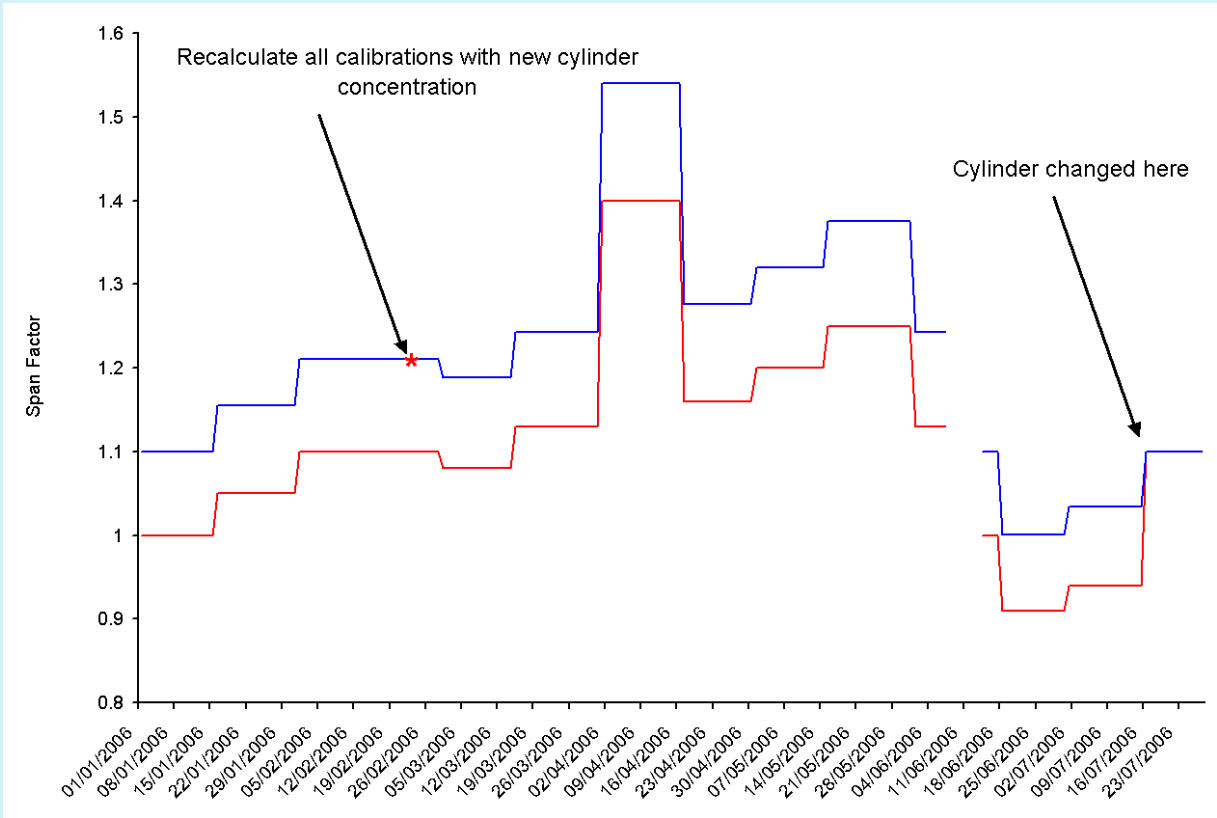

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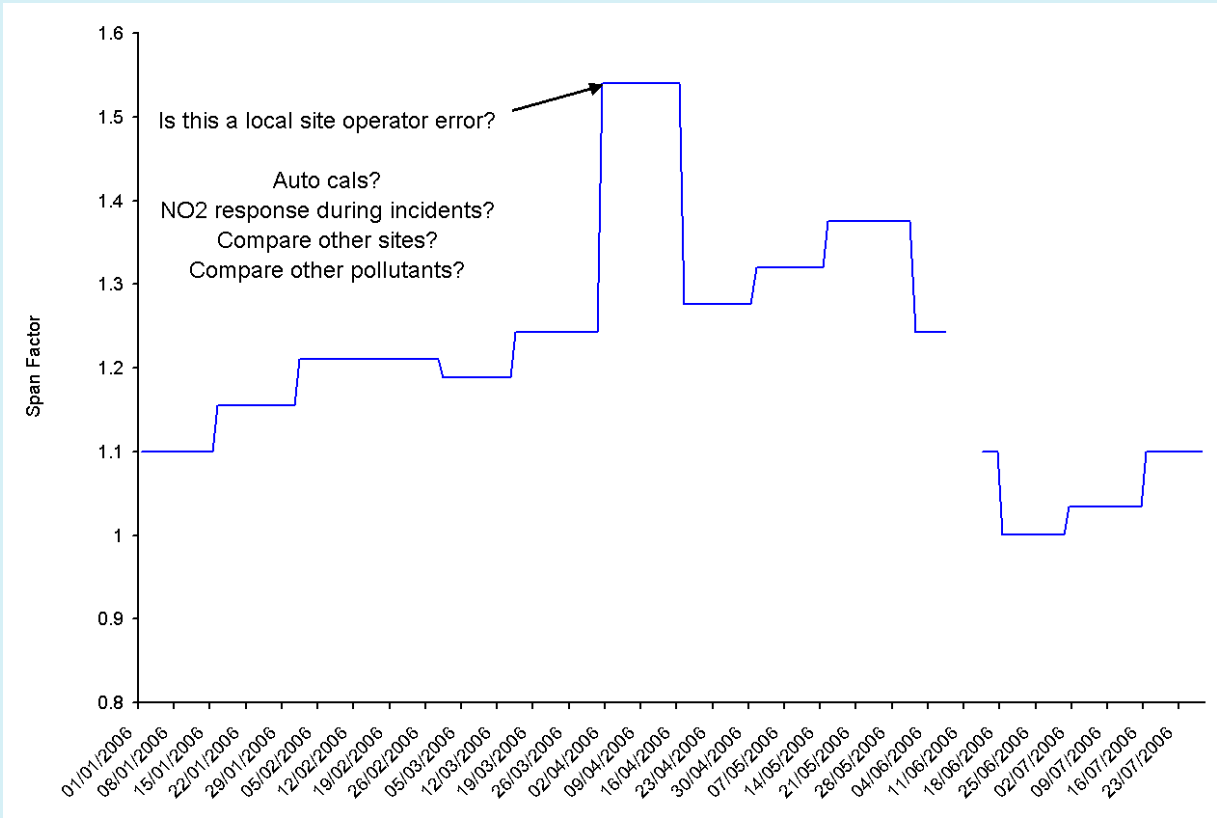

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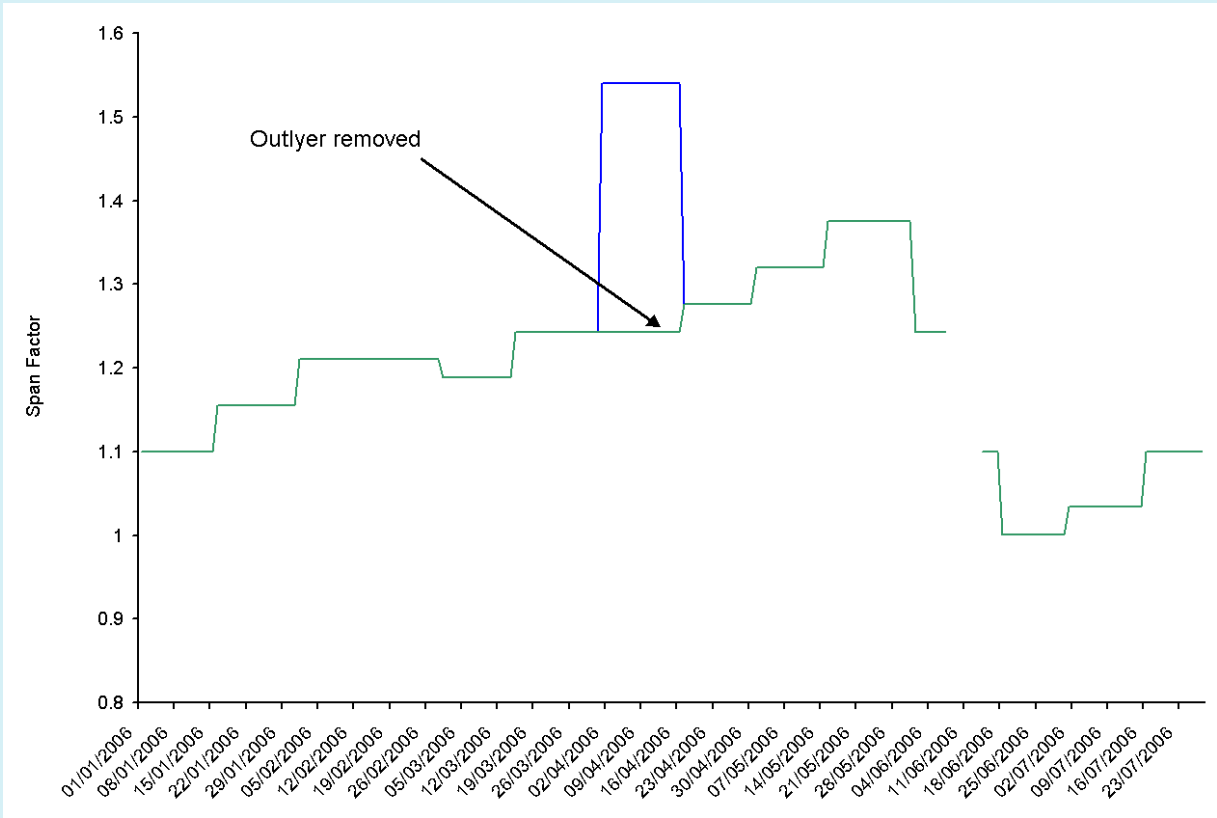




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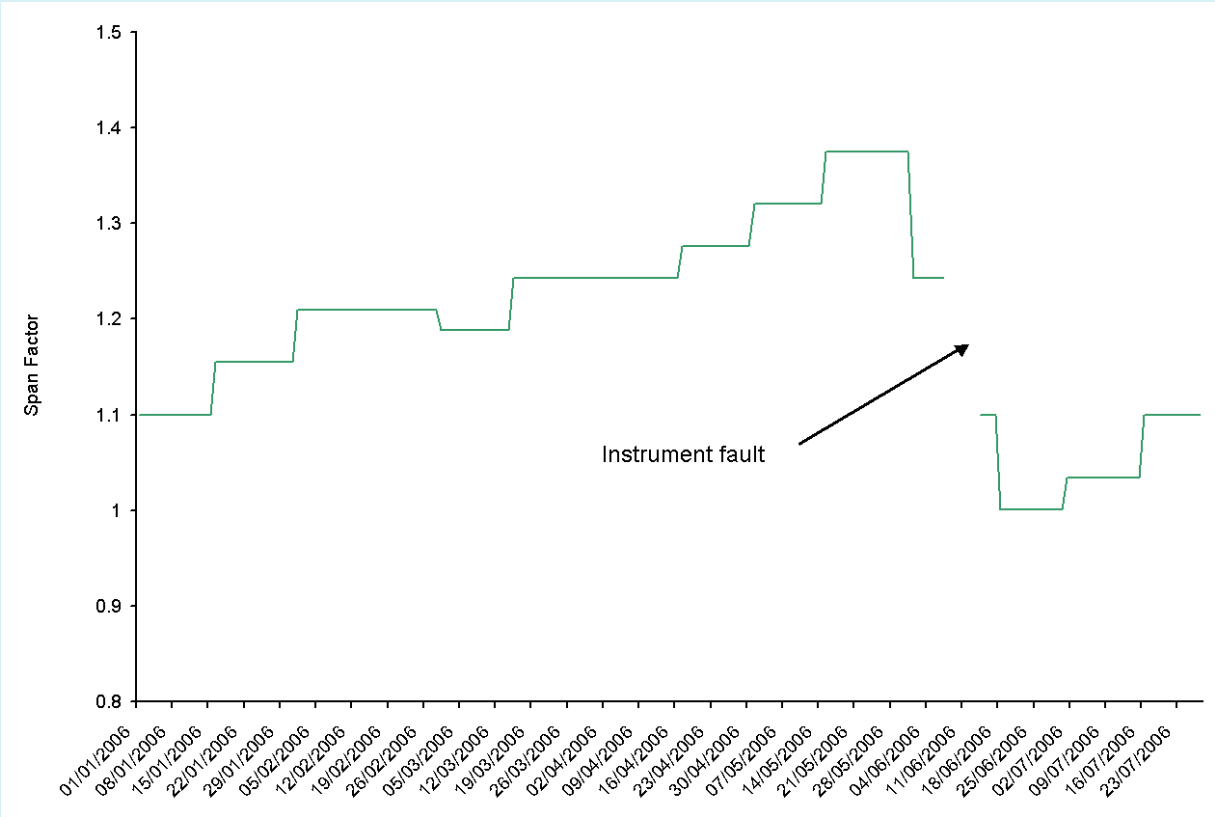




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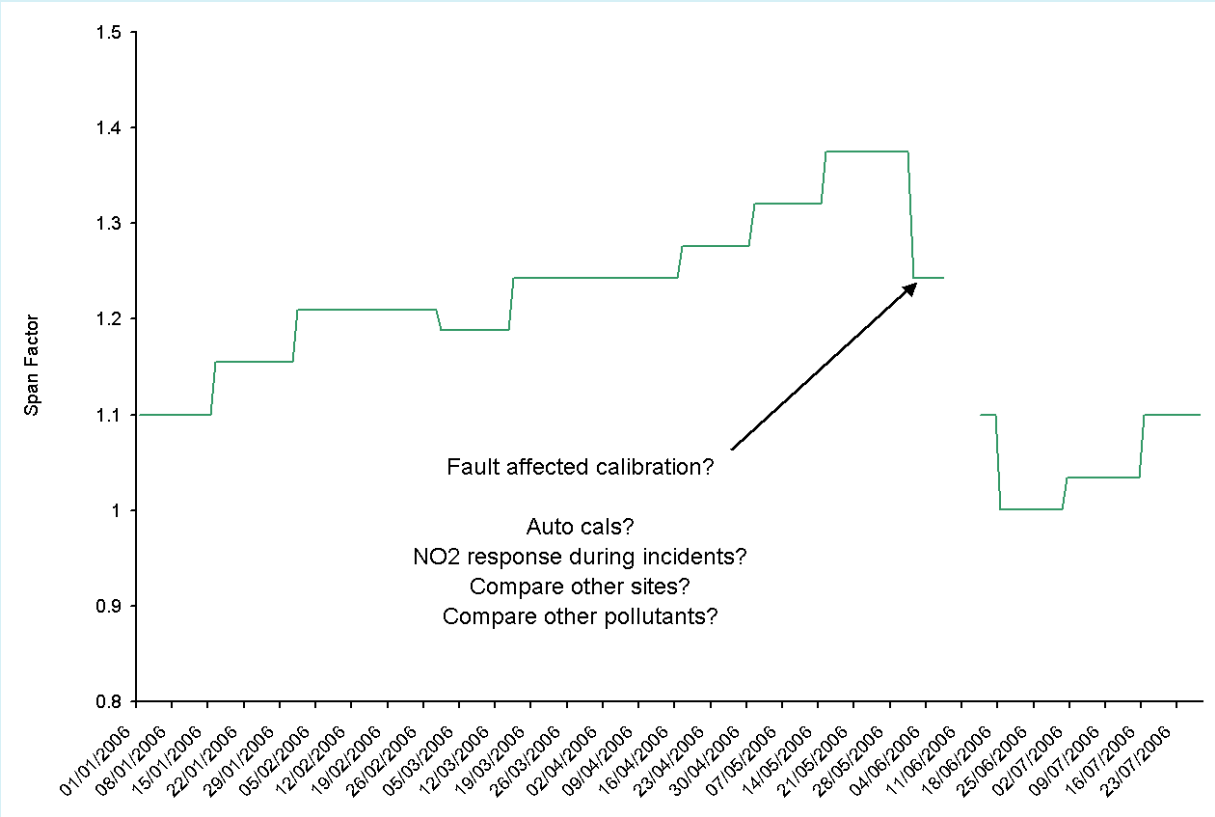




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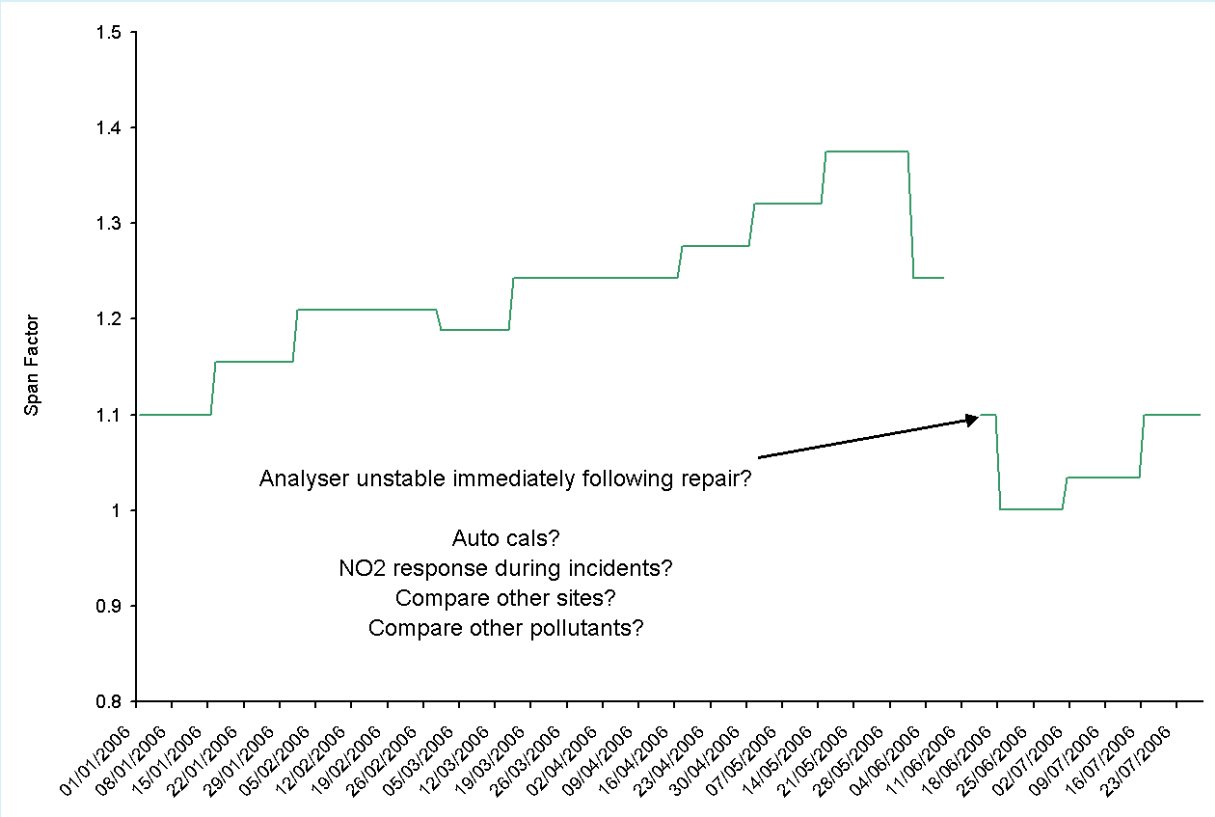




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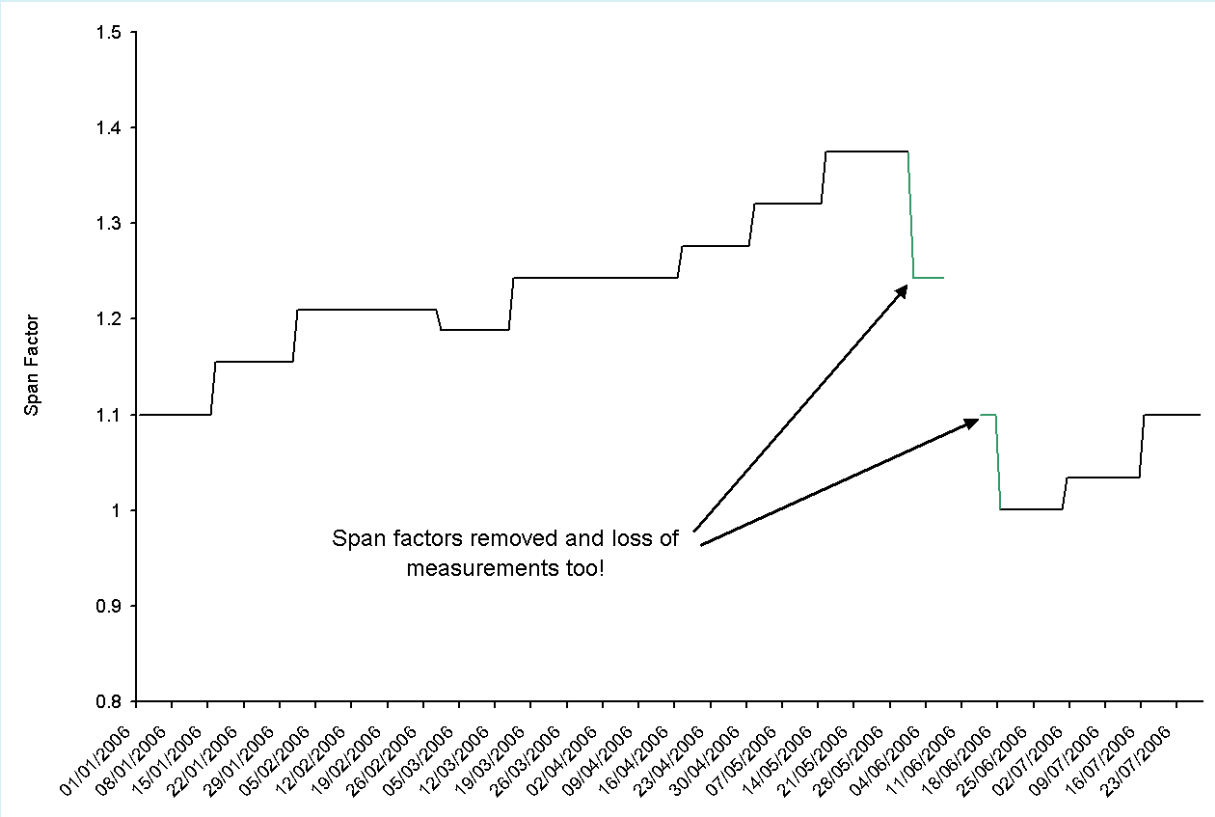




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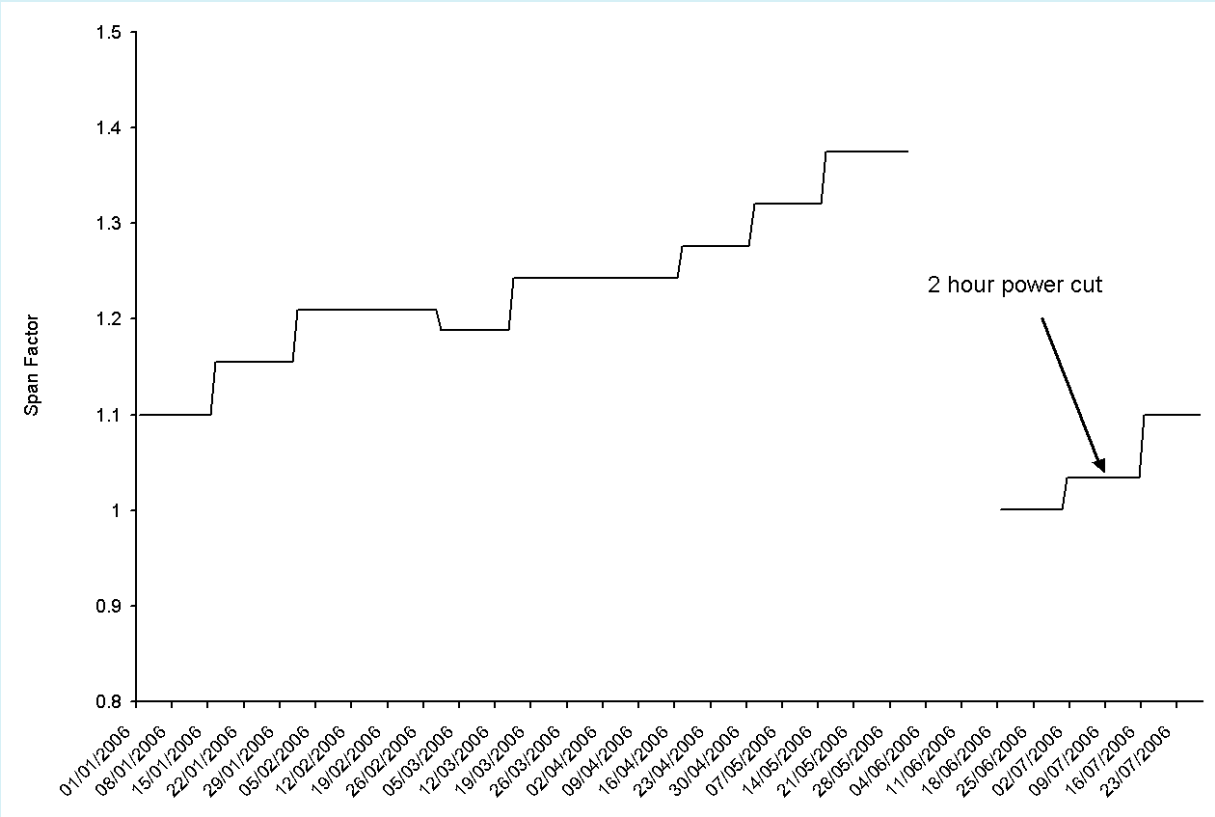




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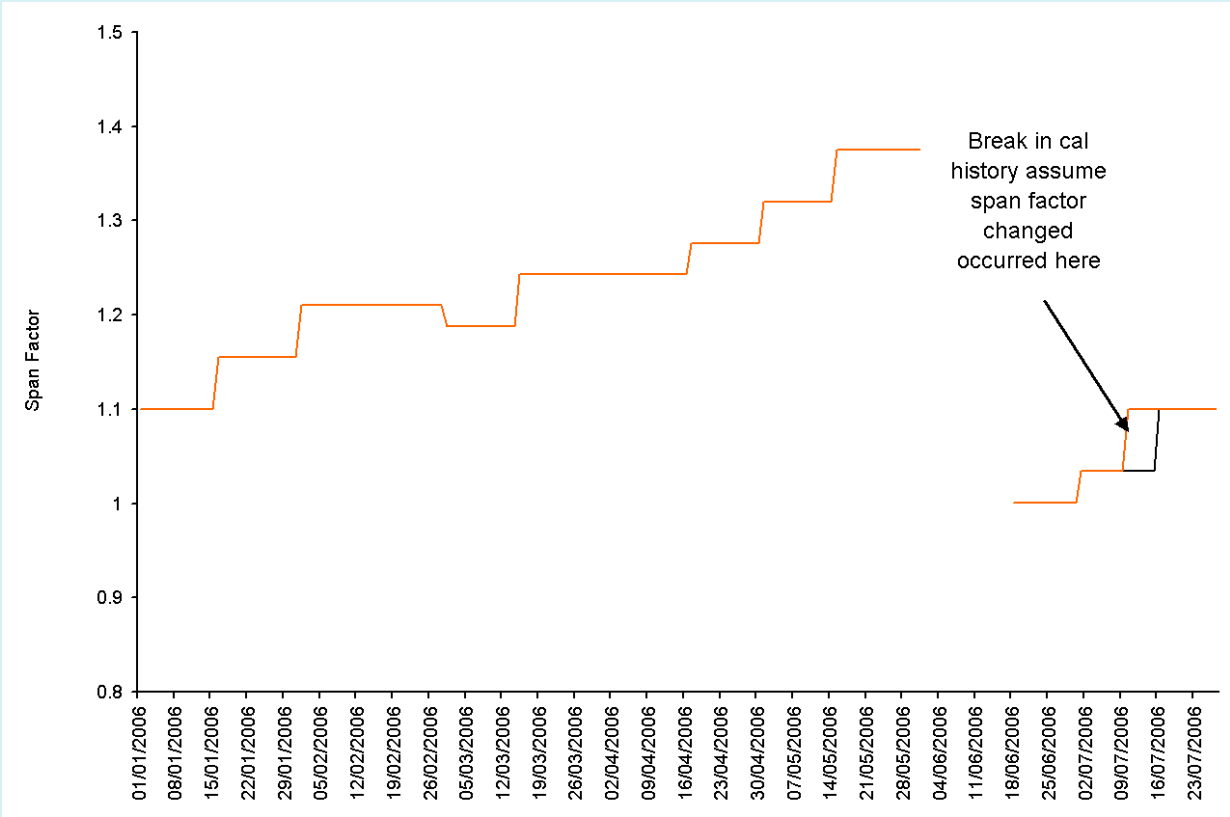

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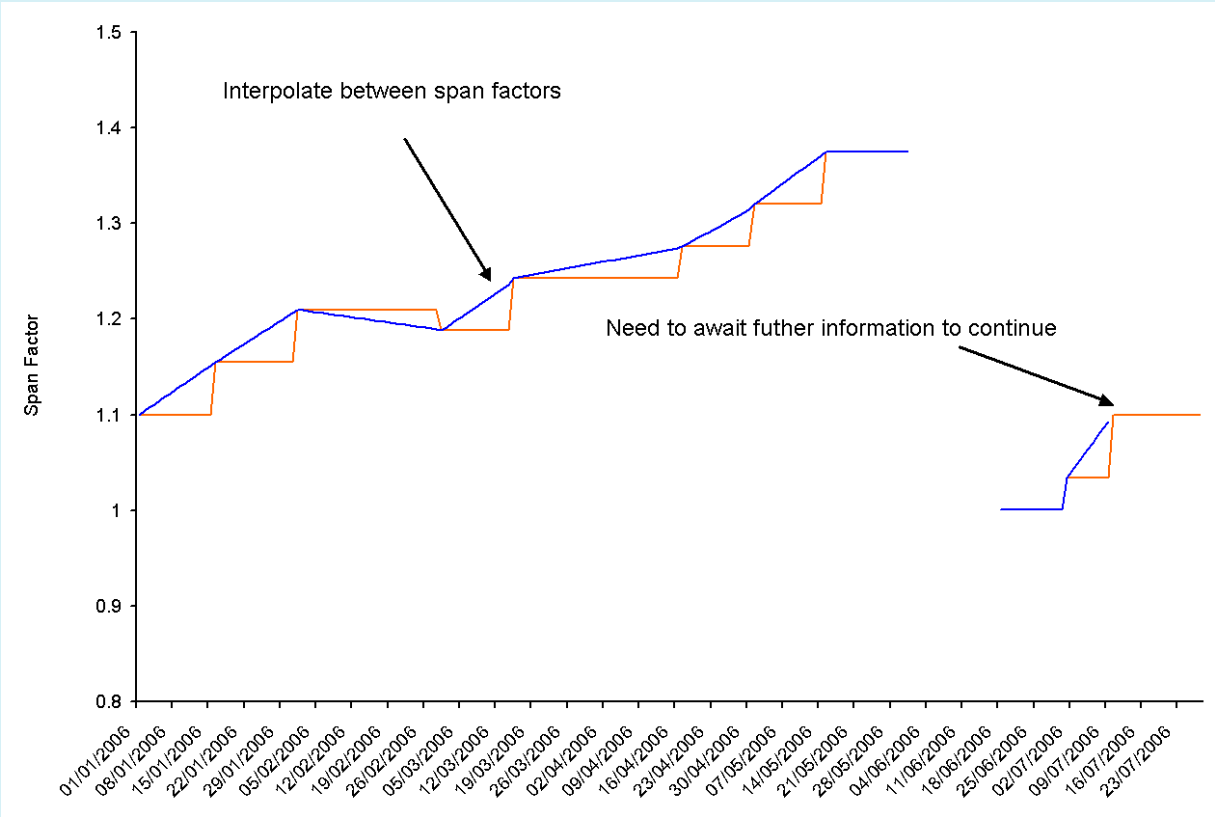




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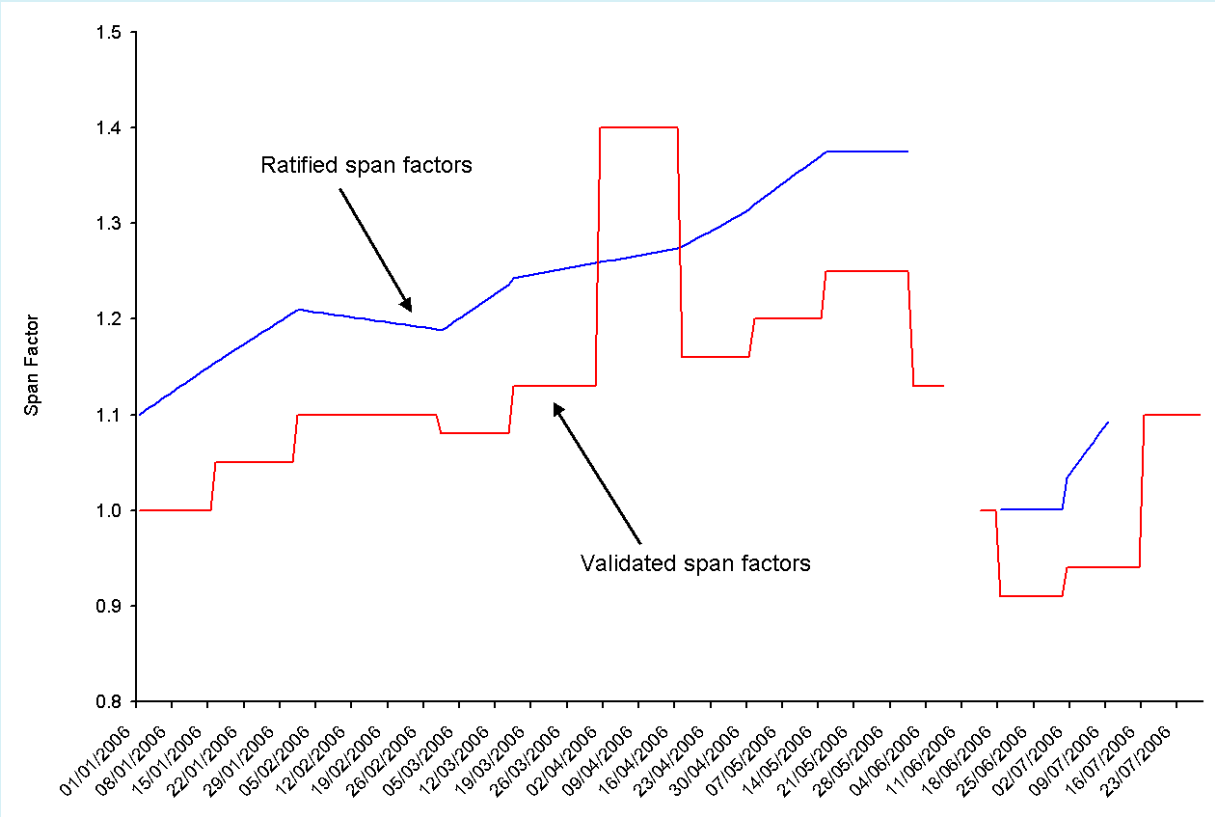




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How is it done?

Simple example and only part of the process…

- *Same process with zero measurements*
  - Changes each span factor
- *Exclude non – ambient data*
  - Review decisions made at validation
  - Exclude further measurements
  - Restored measurements excluded during validation
- *Apply to the measurements*
  - (do all this at 15 min mean resolution in practice)




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How is it done?

Examination of final data set to

- NO2 response during incidents?
- Compare other sites?
- Compare other pollutants?




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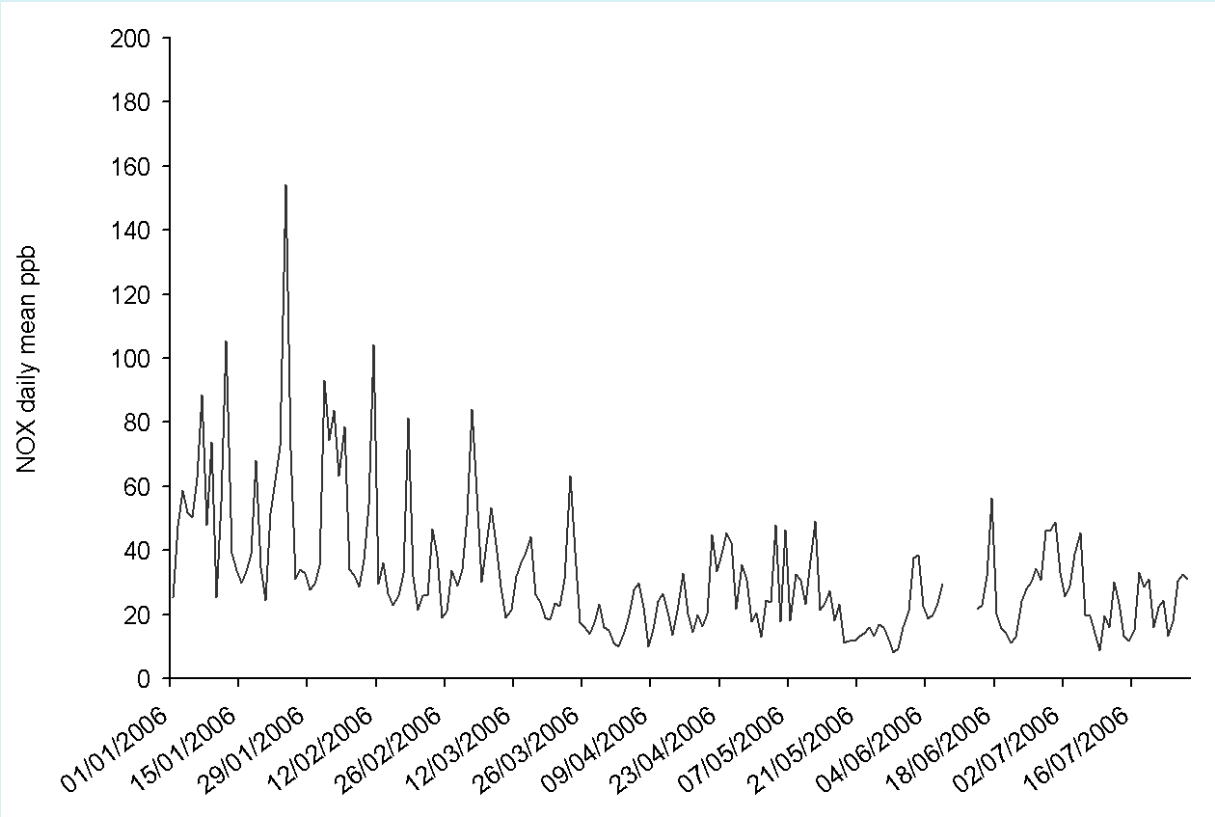
How is it done?



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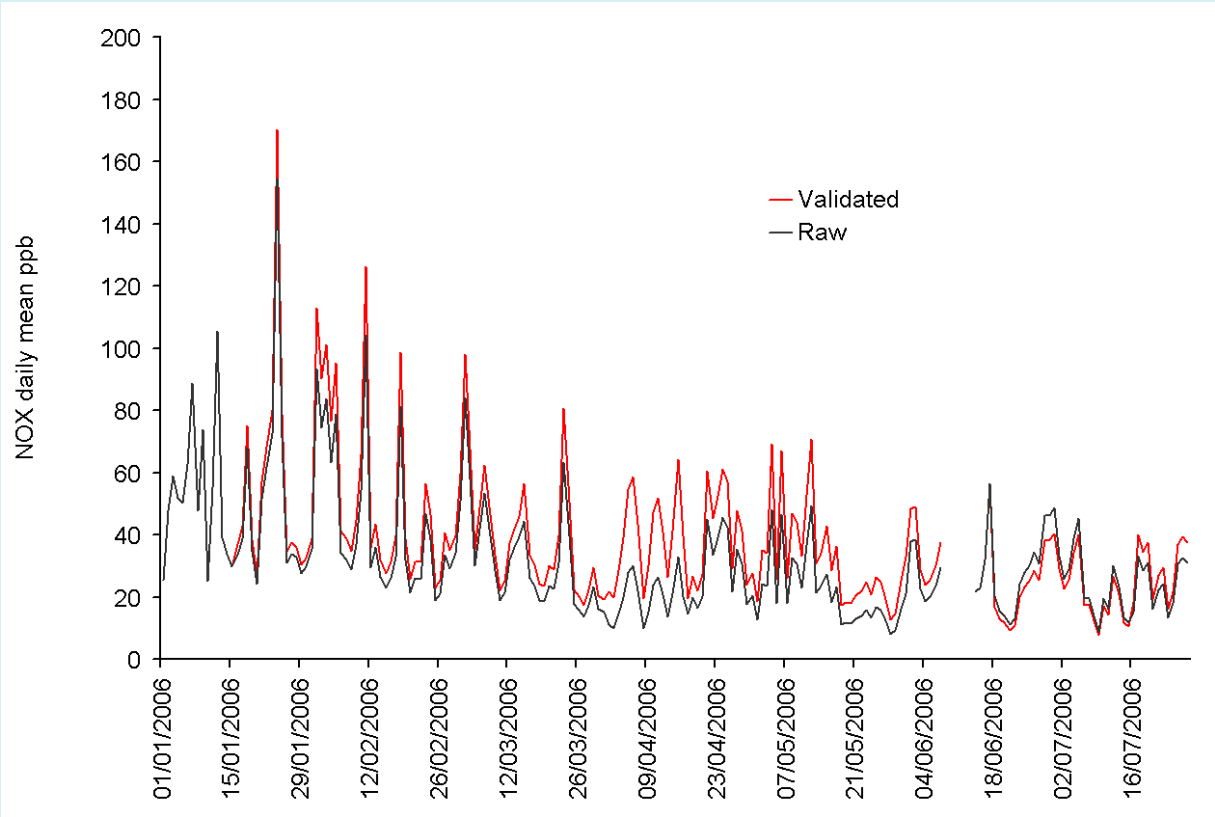




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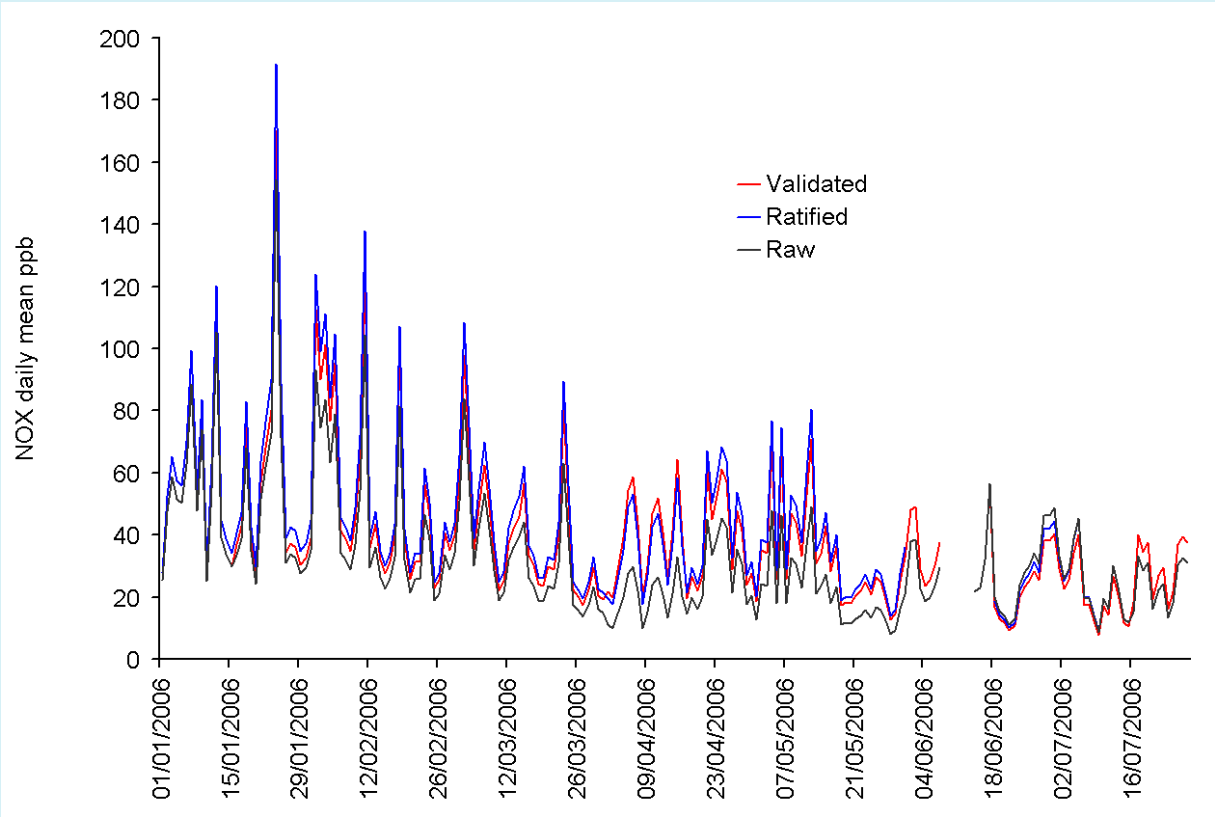




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Some more advanced stuff

- *NOX, NO and NO2*
  - NOX and NO done separately then look at NO2
- *O3*
  - Only calibrated at audit, service and repair
  - Traceablity of ESU photometers?
- *PM10*
  - Little calibration information
  - Filter change artefacts eg noise

More complex cylinder problems eg drift and NO oxidation




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Some more advanced stuff

When did a fault occur?

Eg fault found at 6 monthly audit but should we delete 6 months measurements?

- *Can it be determined from calibration performance?*
- *Traced to service / repair?*




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Some more advanced stuff

Cumulative Sum (CUSUM)

Page (1954) for industrial process control

Other applications include:

- *Epidemiology*
- *Efficacy of treatments*
- *Change points in air quality measurements*
  - *Barratt et al 2006*
  - *Carslaw et al 2006*




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Some more advanced stuff - CUSUM

$$z_i = \frac{x_i - \bar{x}}{\hat{\sigma}_x}$$

x_i is the observed value at time i,
$\bar{x}$ is the desired process mean
$\hat{\sigma}_x$ is an estimate of the standard deviation of the observed values.

These are accumulated over time to compute the CUSUM, S, at each time point i

$$S_i = S_{i-1} + z_i \quad \text{where } S_0=0$$

Separate application to positive and negative deviations, with a 'slackness' factor k

$$S_{Hi}=\max[0,(z_i-k)+ S_{Hi-1}]$$

$$S_{Li}=\min[0,(z_i+k)+ S_{Li-1}]$$




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Some more advanced stuff
– a knotty problem at Watford

During 2005 PM_{10} improved the roadside in Watford

- *It got so good that the annual mean fell below nearby background sites!*
- *No maintenance and service problems*
- *Sustained perfect audit results*




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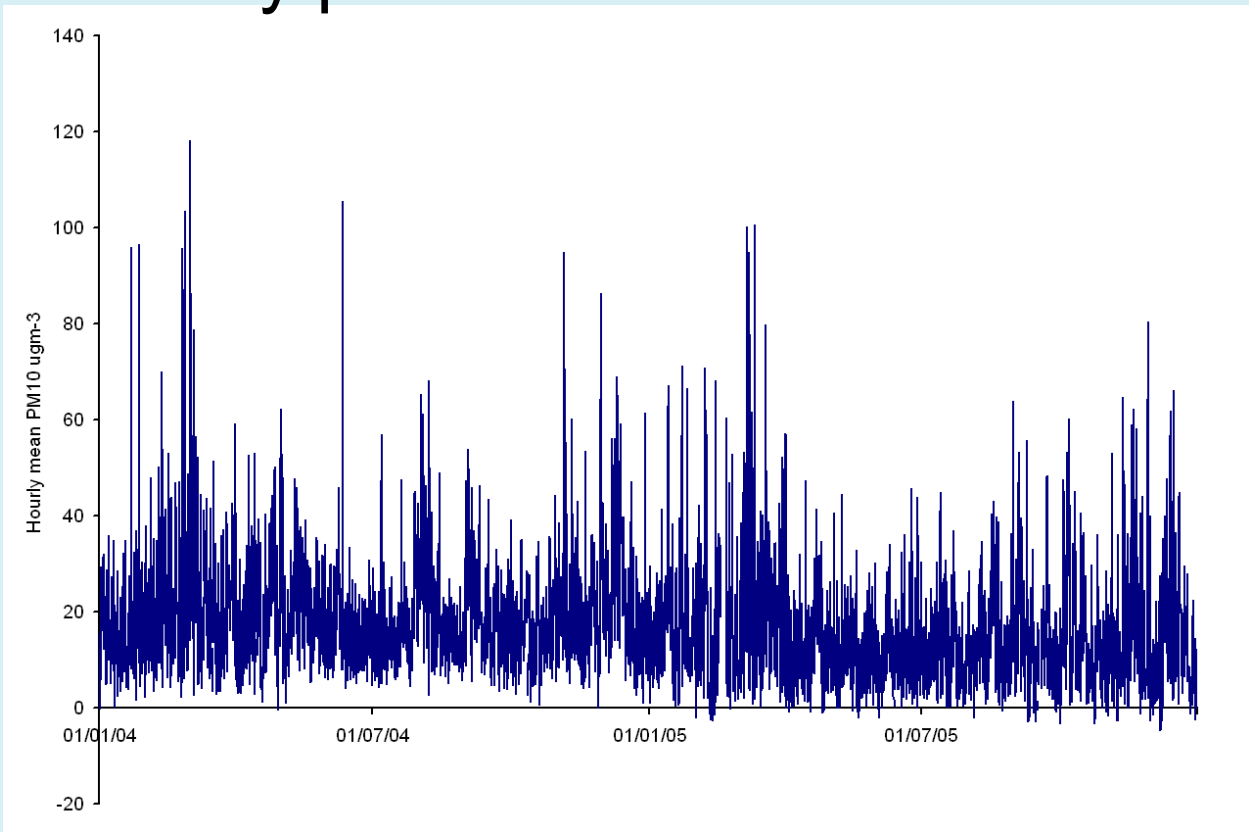
Some more advanced stuff
– a knotty problem at Watford



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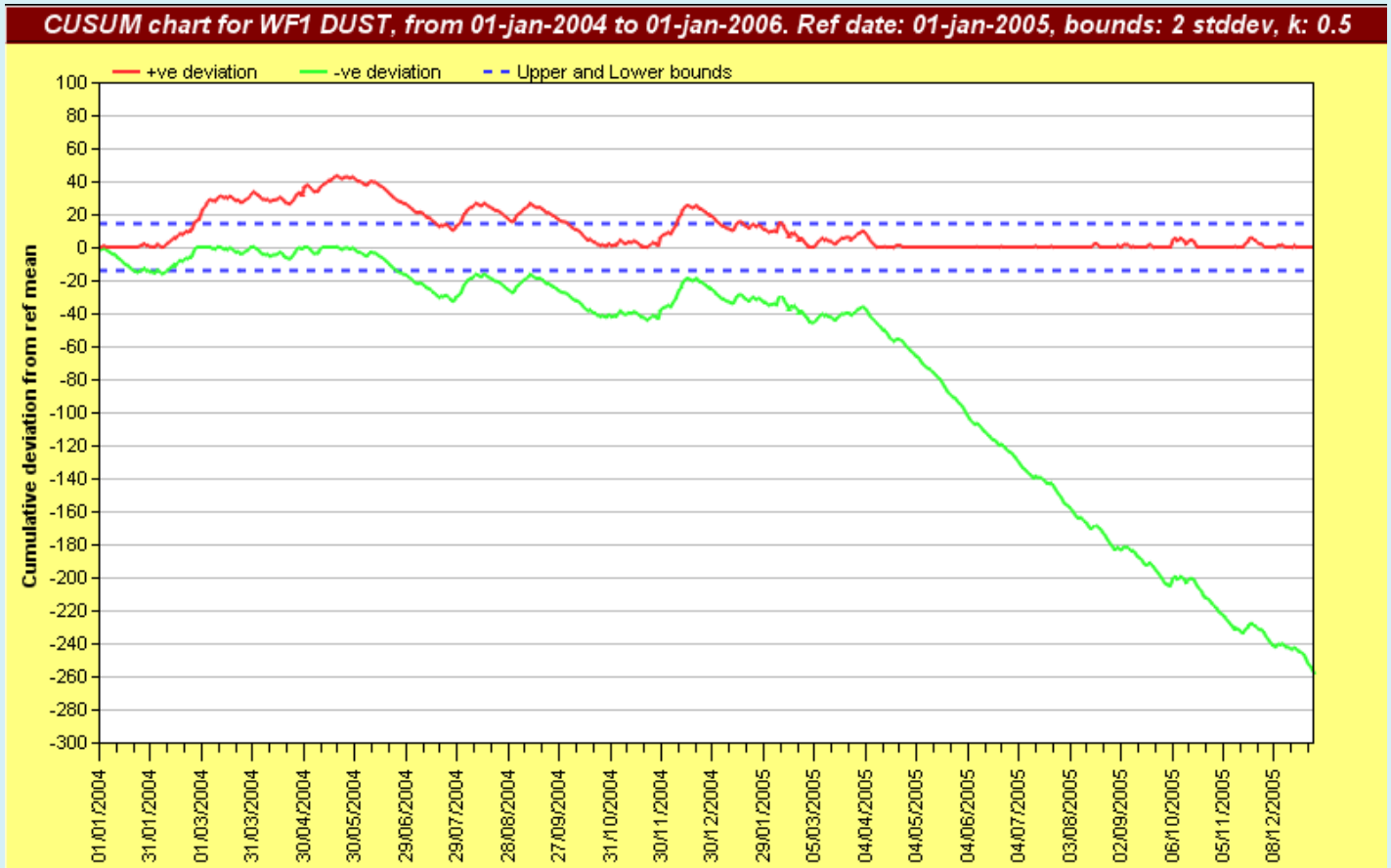




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Some more advanced stuff
– a knotty problem at Watford

CUSUM identified a change at service

Through investigation by new ESU revealed an accidental entry of 6.196 instead of 3 as the TEOM offset by previous ESU

- *TEOM software was corrected*
- *Measurements were recalculated to remove the offset error*




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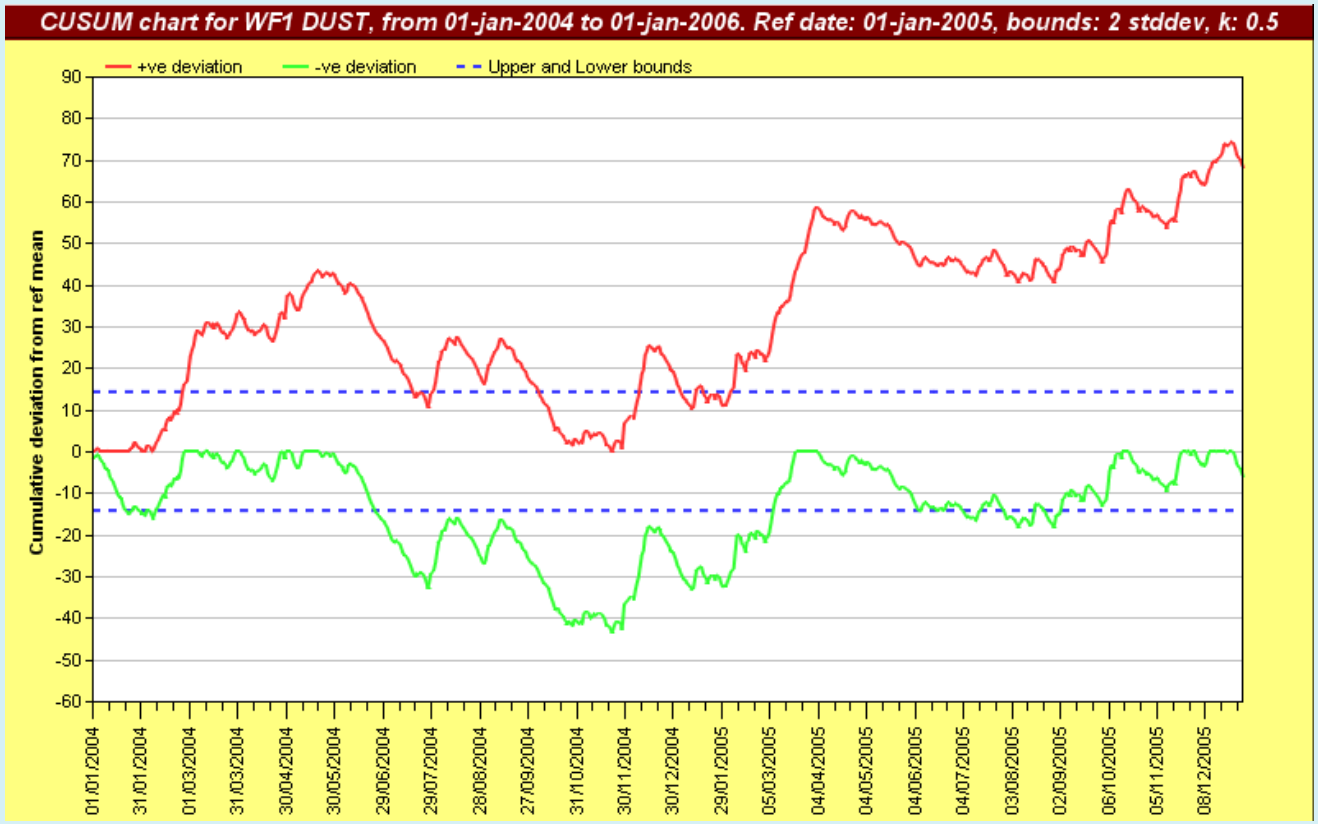
Some more advanced stuff

– a knotty problem at Watford – fixed!



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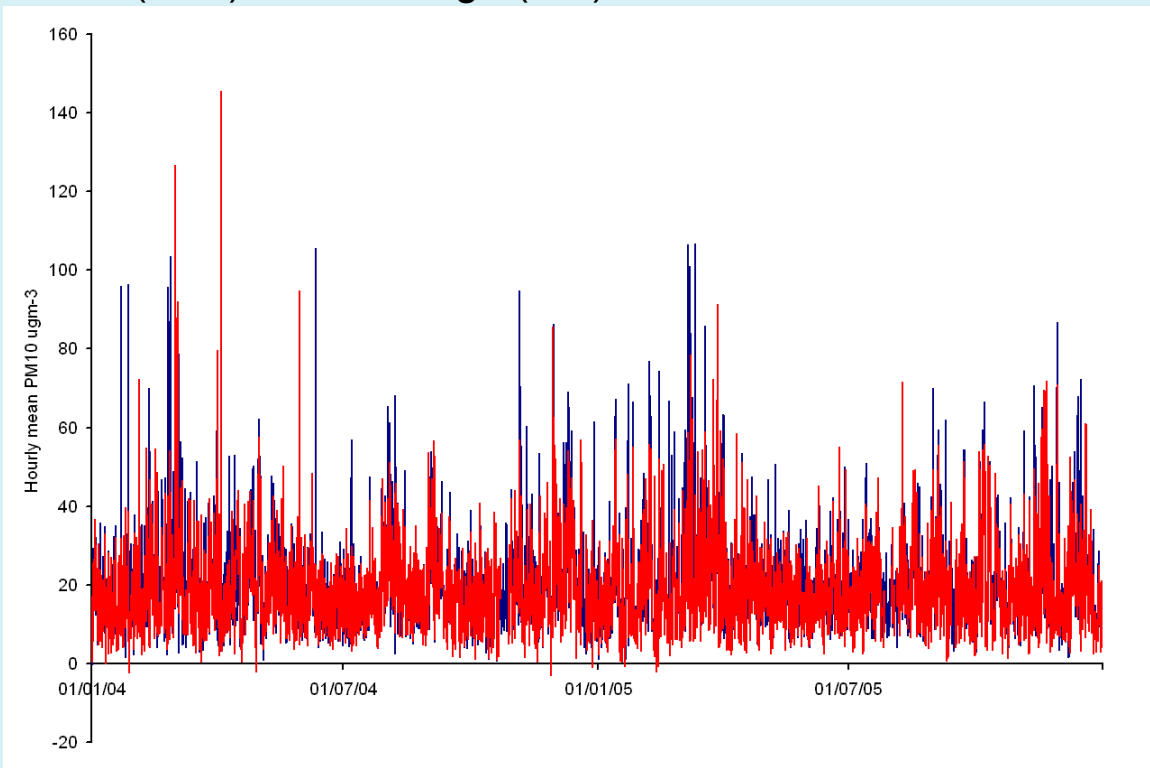
Some more advanced stuff

– a knotty problem at Watford – fixed!

Watford (blue) cf Stevenage (red)



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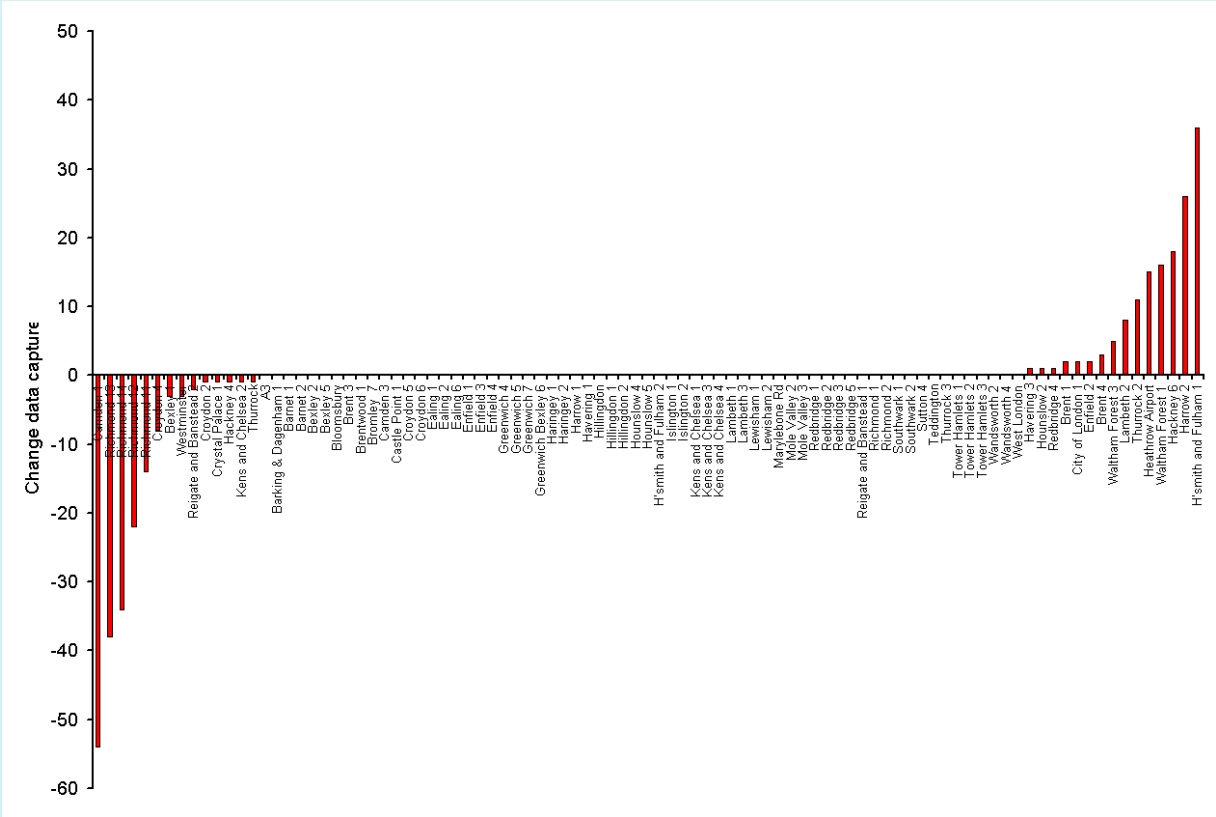
What difference does it make?

Data capture



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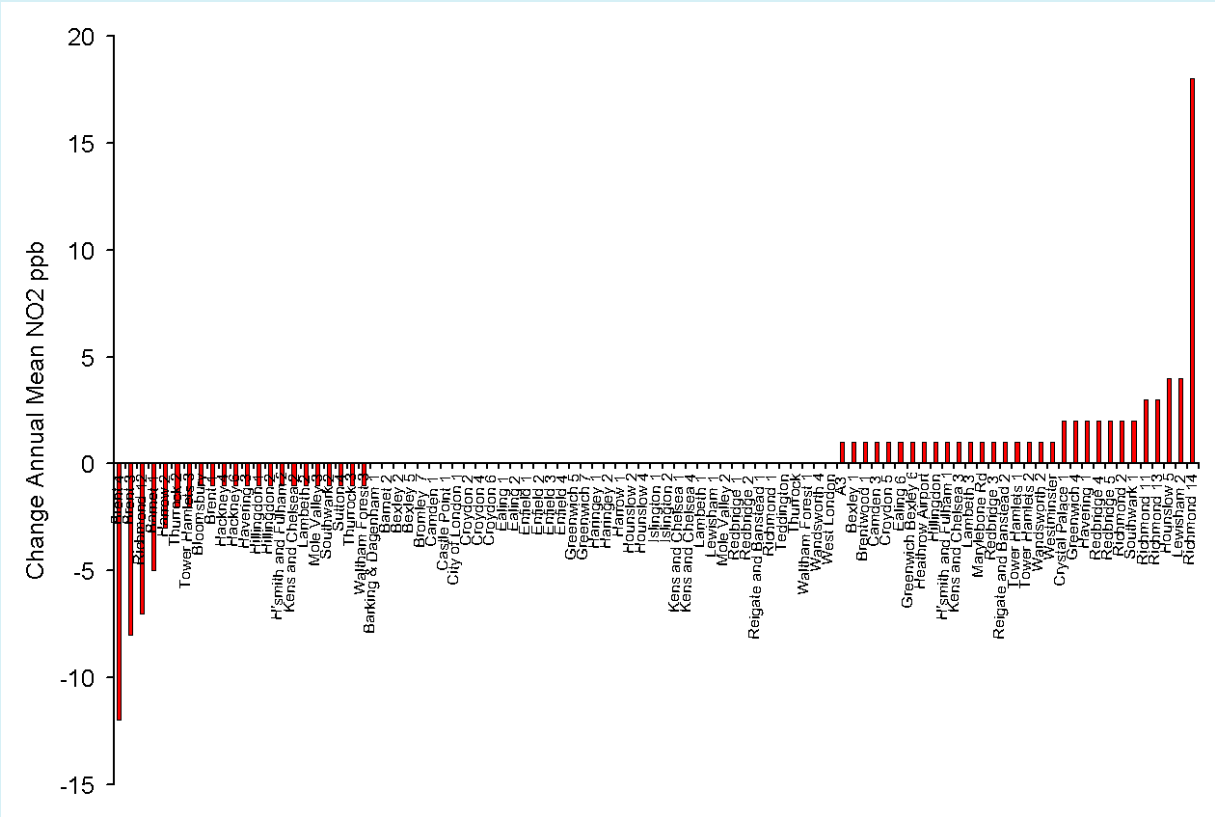
What difference does it make?

Annual mean NO2



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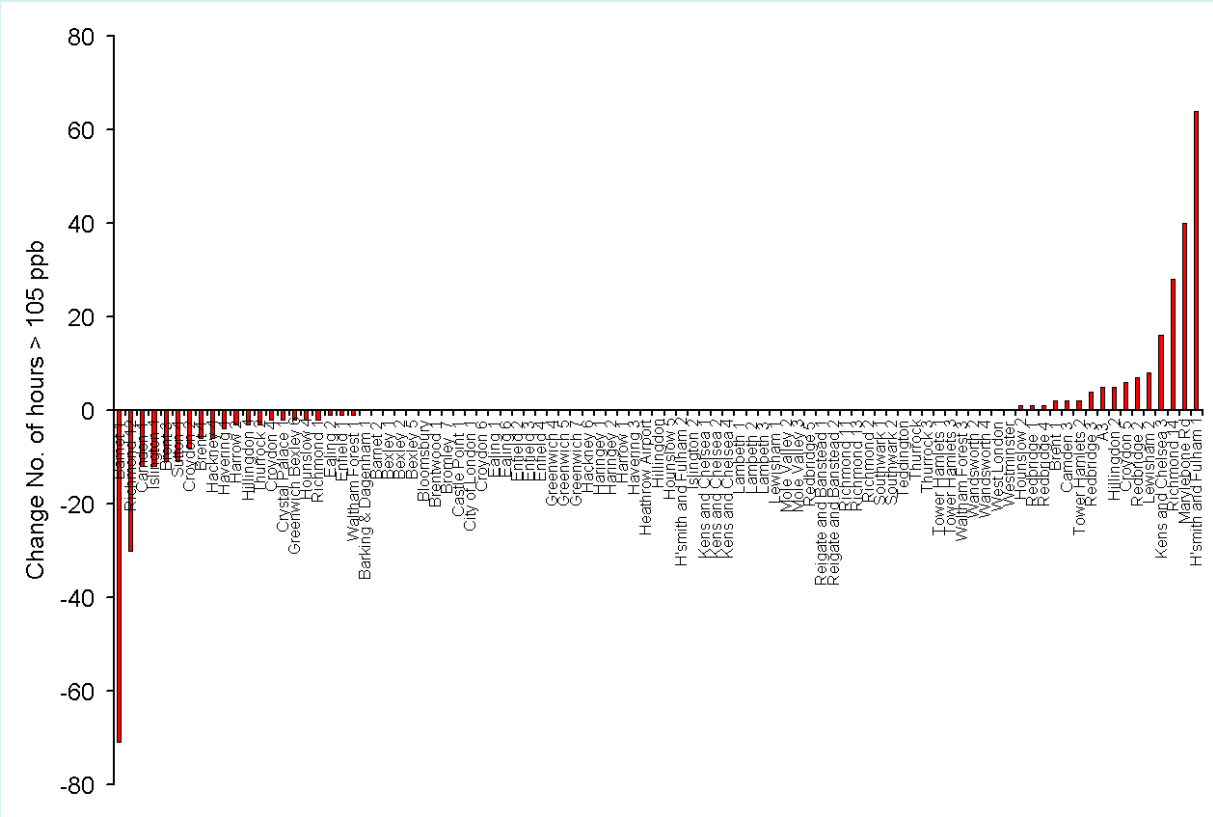
What difference does it make?

Hours > 105 ppb / 200 ugm3



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Summary

- What is ratification?
  - *Retrospective*
  - *Uses calibration and service history*

- How is it done
  - *Fictional case study*
  - *A bit of advanced stuff*