The Performance of Dispersion Modelling for the Prediction of Nitrogen Dioxide in the UK Review and Assessment Process

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UK Review and Assessment Process

- In 1997 the Environment Act created a process where local authorities were required to carry out a regular assessment of air quality in their areas, these must be regularly updated

- Intended to identify whether "air quality objectives" would be met by their relevant target years

- Air quality objectives mirror the EU Limit Values but generally their target years are before those of the EU

- Overall guidance has been produced by the UK's National Government although this allows for many different approaches to be used for the assessments

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UK Review and Assessment Process

- **Most assessments are carried out using dispersion modelling**

- **Selection of dispersion models are used**
  - ADMS
  - Caline
  - Airviro
  - Some bespoke models

- **Most of these assessments report the model's ability to predict nitrogen dioxide concentrations**

- **Provides us with a large database of results that we can use to assess model performance**

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Performance of Dispersion Models

- **Collation of the results allows assessment of model performance that can include both user and input data errors**

- **Provides a "Real World" assessment of model performance**

- **Allows assessment of the risk of an exceedance of an air quality standard/limit value**

- **Nearly 60 model validation studies were available containing 623 and 349 validation points for nitrogen dioxide and nitrogen oxides respectively**

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Use of Models in the UK

| Model Name	Number of Studies
AAQUIRE	7
ADMS (version not specified)	2
ADMS -Roads	22
ADMS-Urban	12
Airviro	3
Caline	6
Kings College ERG Model	3
AEA Model LADS	10

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Purpose of the Study

- **Intended not as an assessment of individual model performance**

- **Intended as an assessment of the overall ability of a community of model users to predict nitrogen dioxide concentrations**

- **Model has concentrated on nitrogen dioxide rather than nitrogen oxides**

- **Where nitrogen oxides have been examined many of the studies have estimated NOx concentrations from NO_2 diffusion tubes measurements**

- **Introduces significant errors**

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Comparison of Predicted and Measured NOx Concentrations
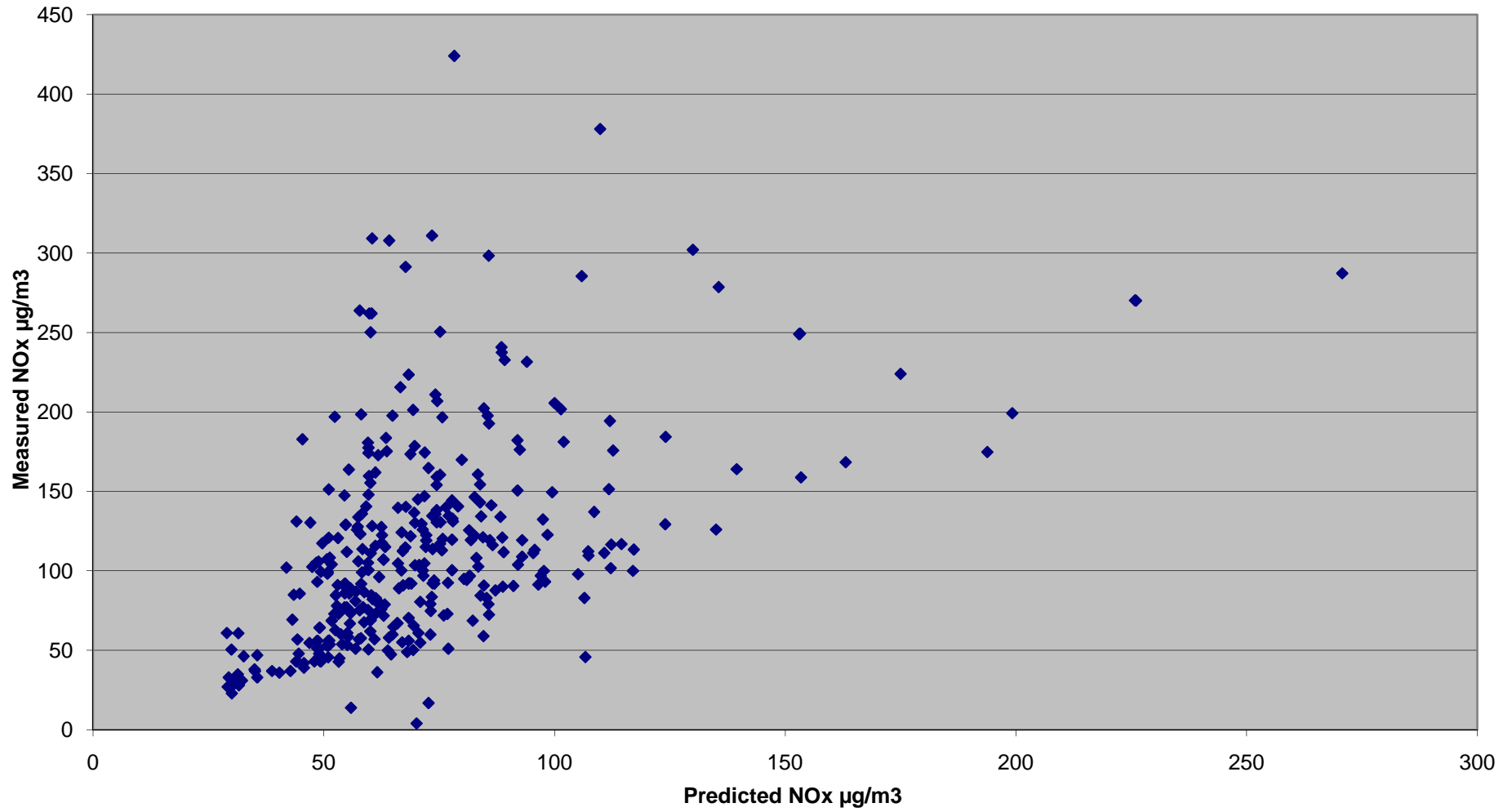
# Raw results – nitrogen dioxide
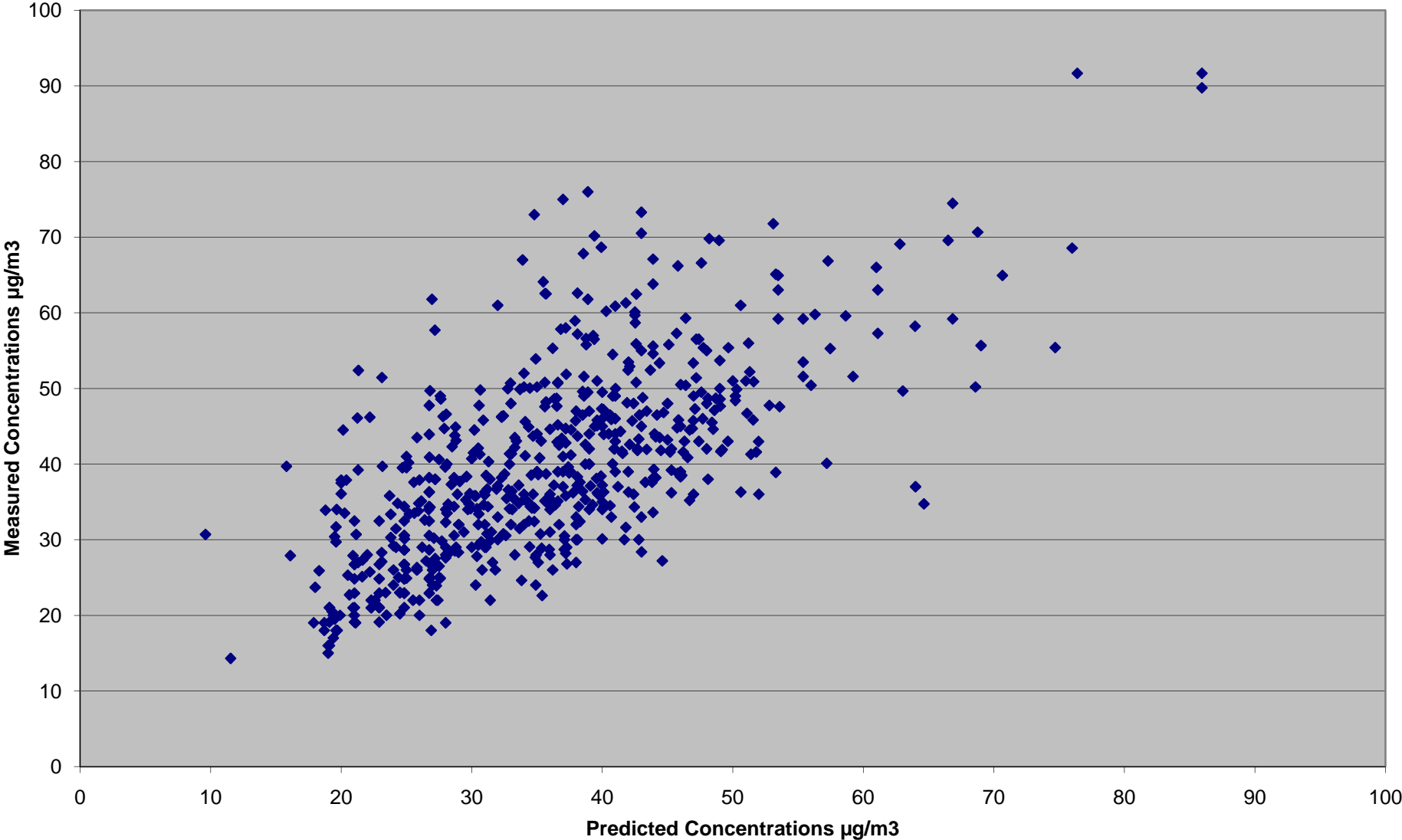
Results – Nitrogen Dioxide

- Some evidence of a trend in under-prediction of concentrations

- 67% of modelled values lower than measured (limited NOx results suggest similar)

- Analysis using Boot software confirms underprediction

Data	Mean	Standard Deviation	Bias	Corr	Fractional Bias
Measured	39.95	12.59	NA	NA	NA
Predicted	35.84	11	4.11	0.688	0.108

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Further analysis of NO2 results

- Can "bin" data into concentration ranges

- Results placed into 5µg/m^3 bins of predicted values

- So for example all results where a concentration of between 35-40 µg/m^3 were analysed to examine mean and standard deviation within each bin

- Allows an assessment of the spread of results within each predicted range of concentrations

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Binned NO2 data
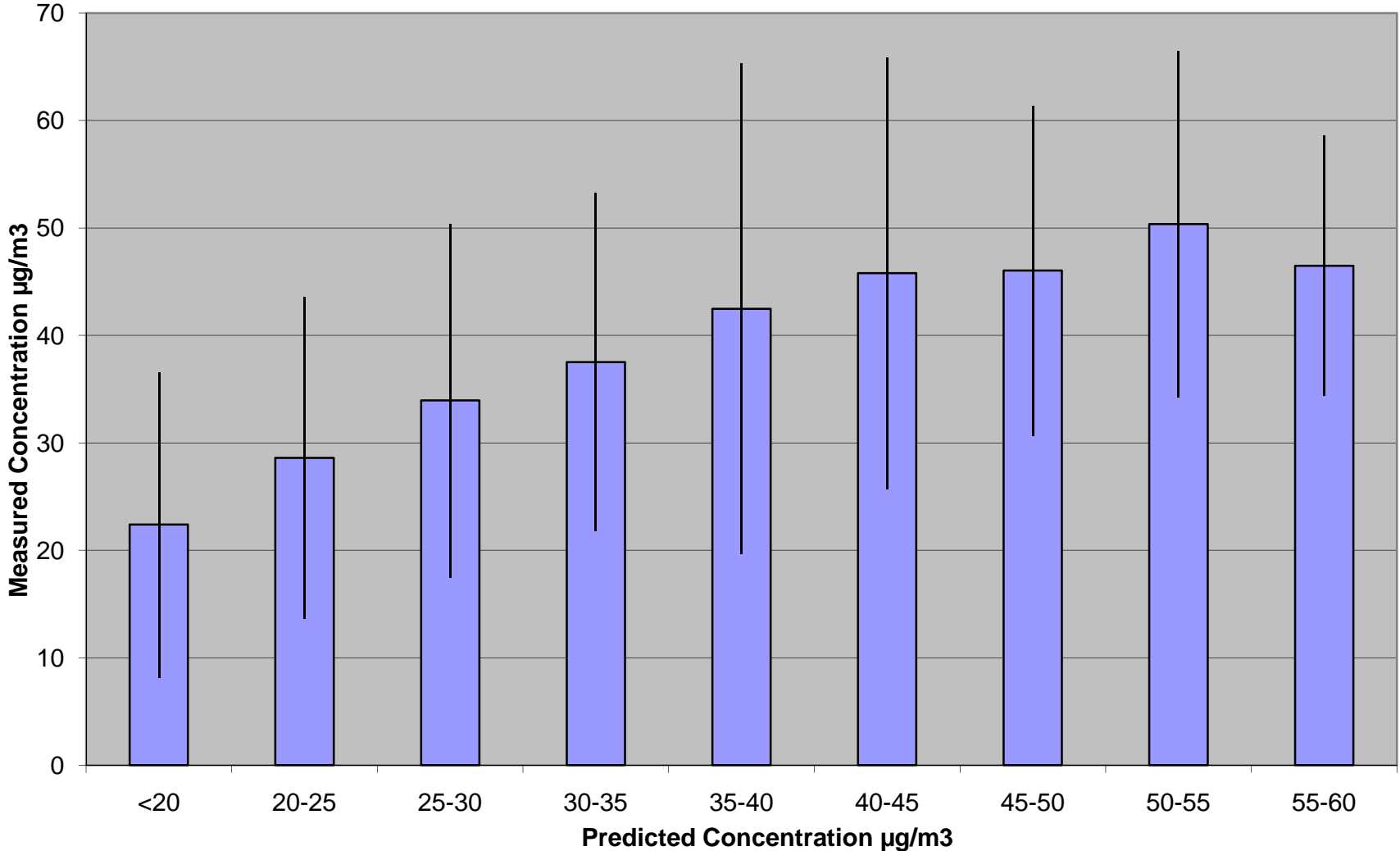
Results from "Binning" data

- Tendency for under-prediction is evident

- On average the measured value is 4.5 µg/m^3 higher within each concentration bin

- Standard deviation is typically some 25% of the median value

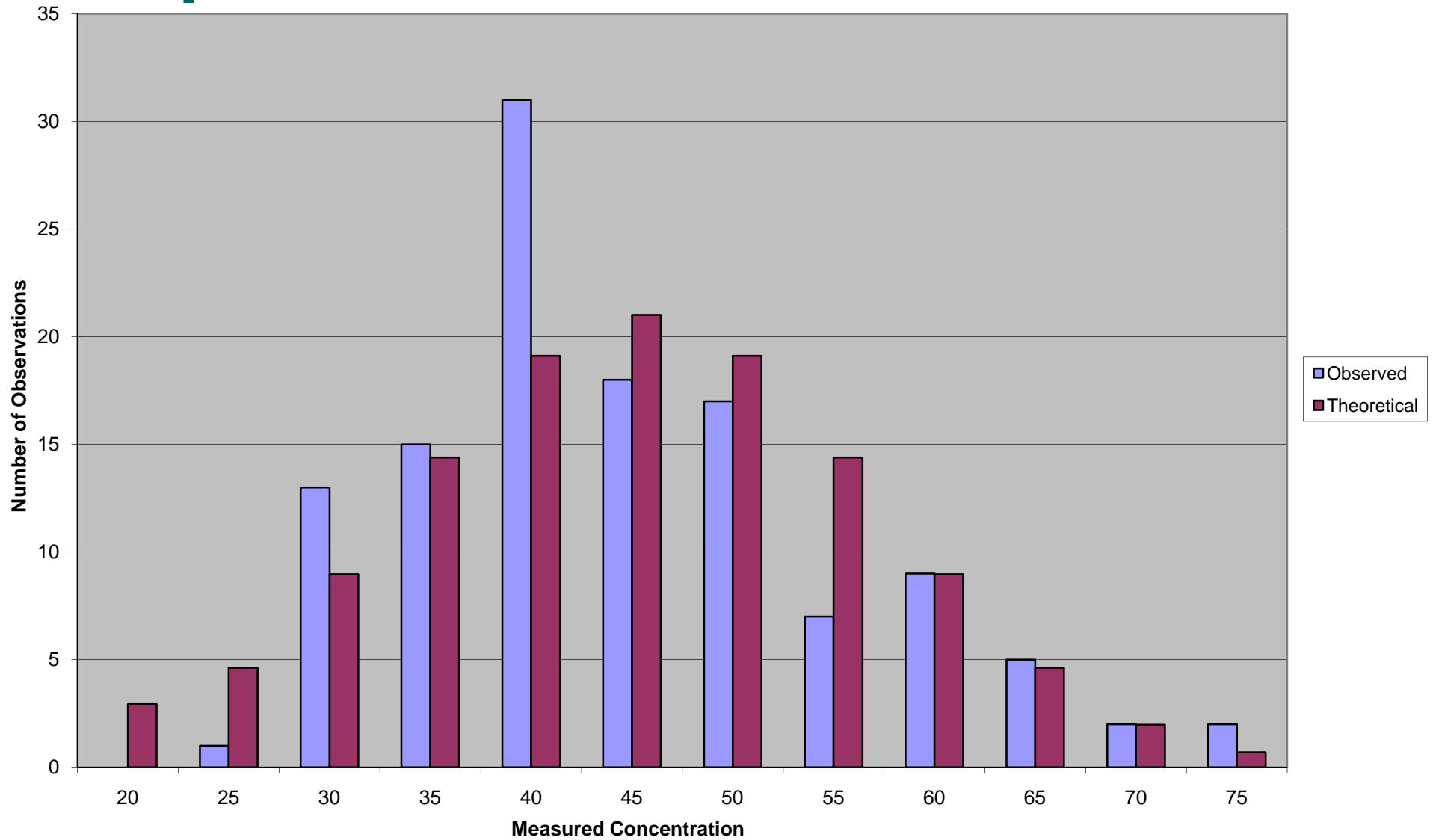- Can examine further the spread of results within each concentration bin

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Predicted Concentration 35-40µg/m³
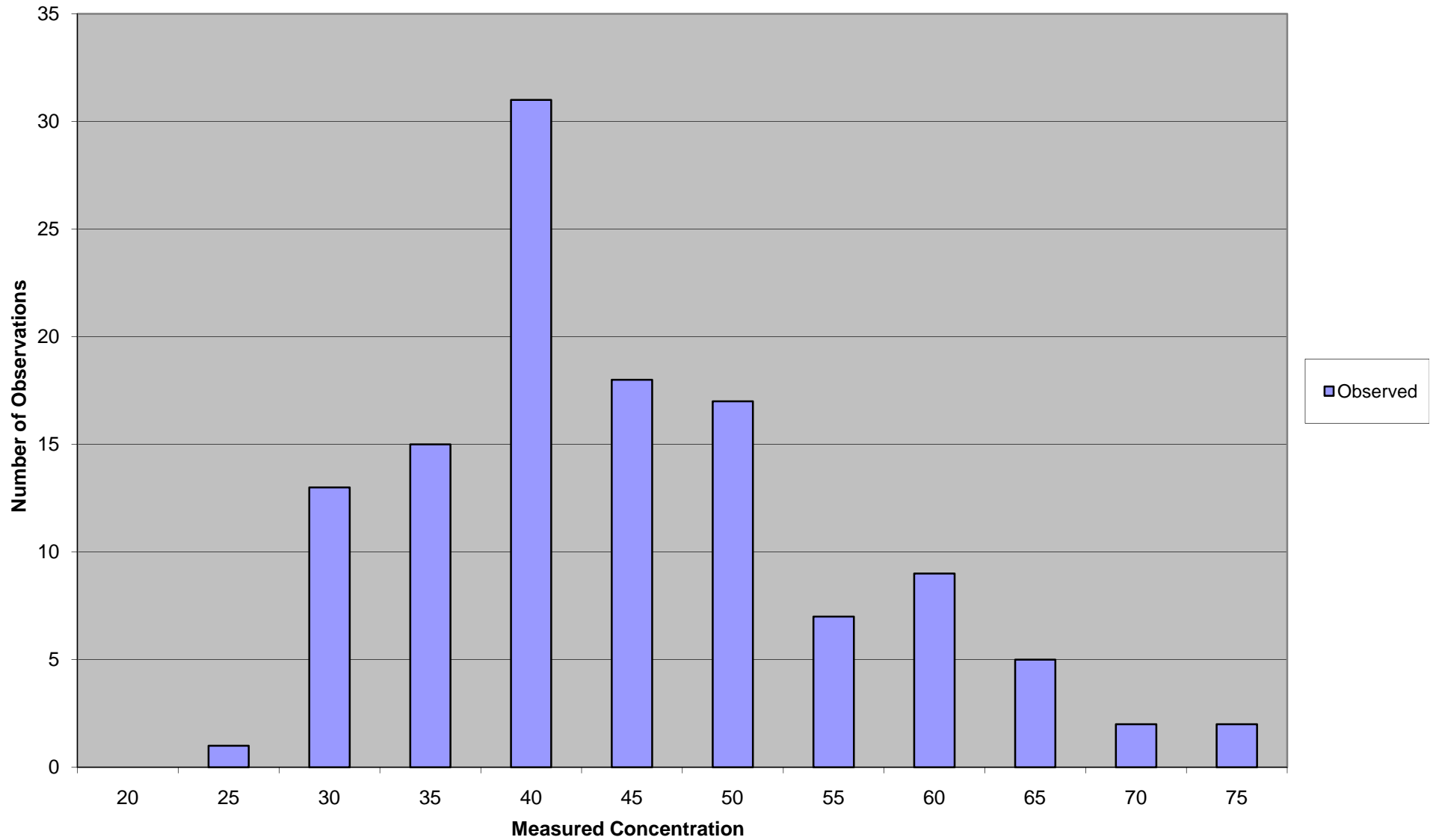
# Analysis of data

- **In practise a narrow 5μg/m^3 range in predicted concentrations is represented by a very wide range of measured concentrations**

- **Possible to use results to assess the probability of an exceedance of an objective/limit value rather than interpreting results as absolute concentrations**

- **Can compare results with theoretical distributions derived from mean/standard deviations of observed data**

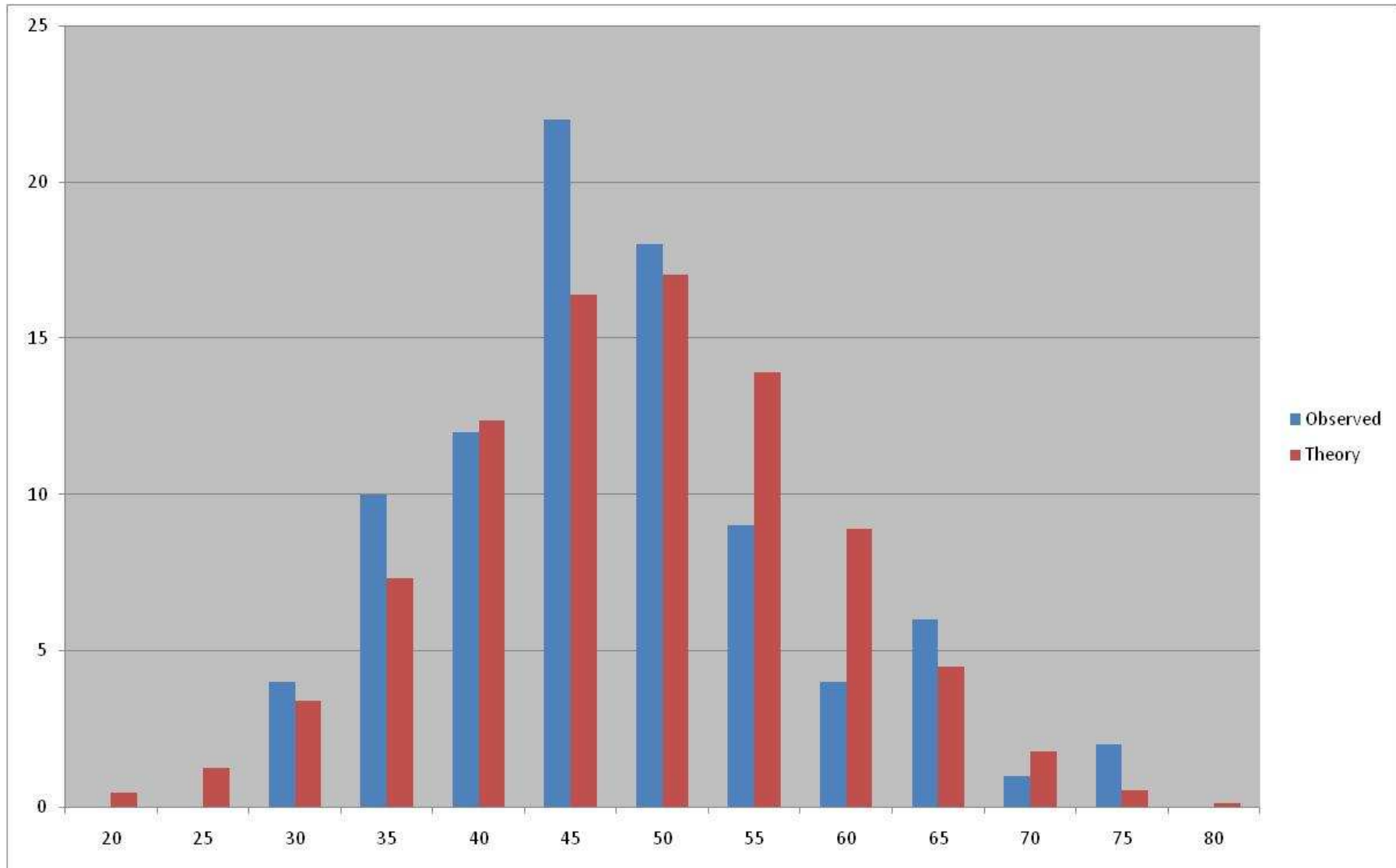- **In this case a normal distribution has been used**

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Predicted concentration 40-45 μg/m³

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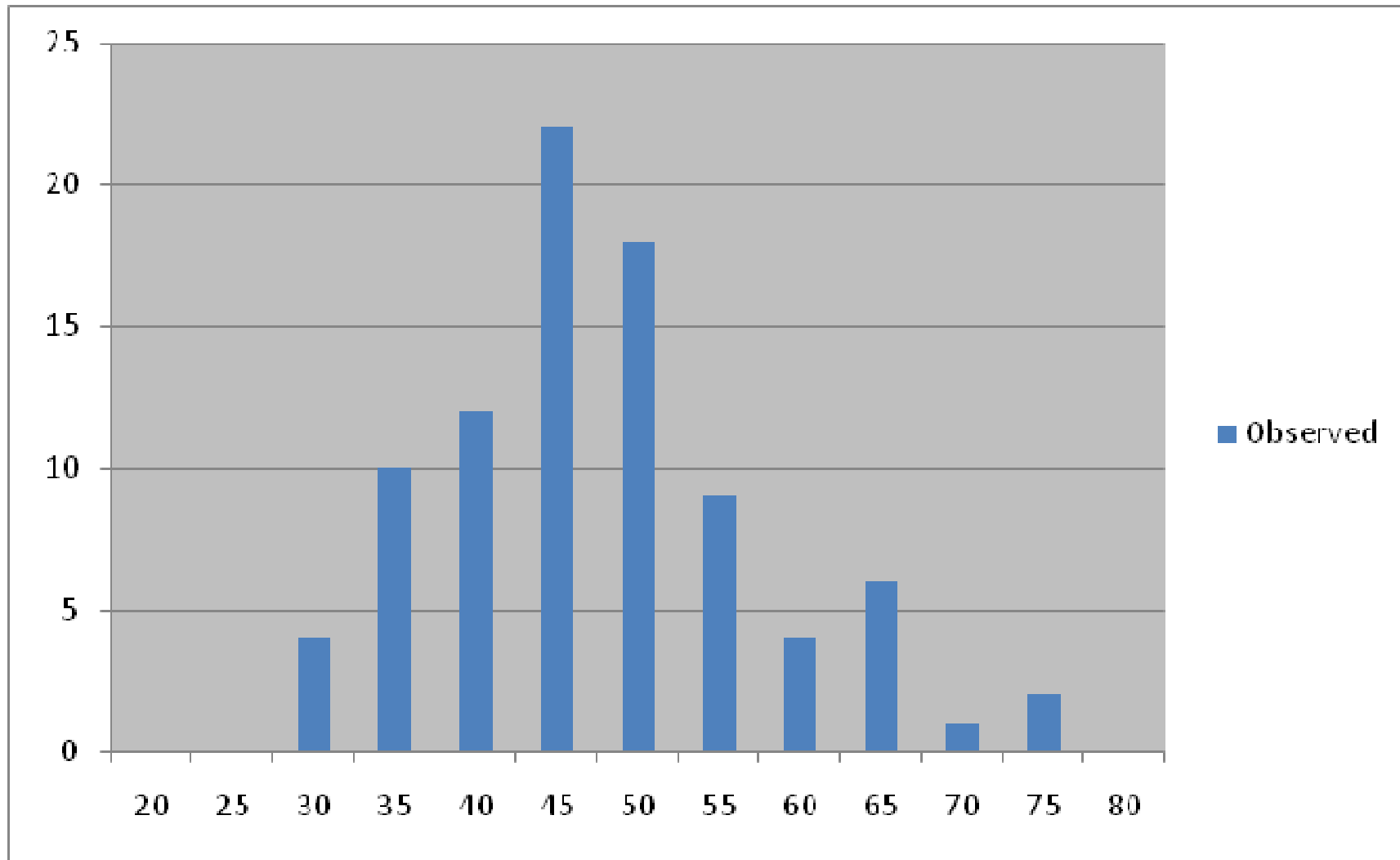
Compare with Normal Distribution

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Assessing risk of exceedance of limit value

- If a normal distribution is assumed then for a predicted concentration, it is possible to calculate the probability that the actual measured concentration will be above a particular value

- So – for each predicted 5µg/m^3 range in concentration the probability the limit value of 40µg/m^3 will be exceeded can be calculated

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Probability of exceedance of 40µg/m³
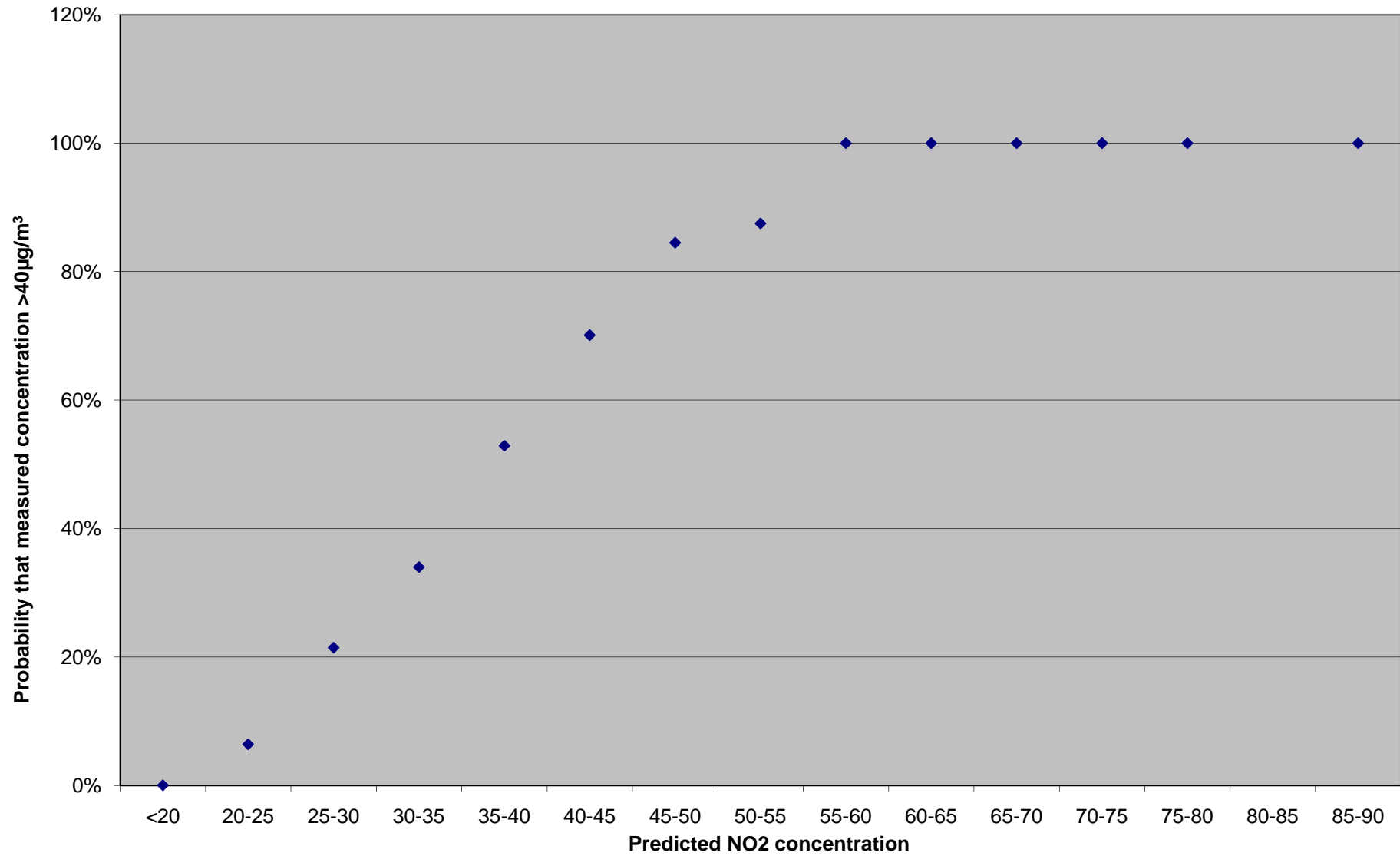
Conclusions

- The prediction of nitrogen dioxide concentrations is subject to considerable uncertainty although on average, there is reasonable agreement between modelled and measured values although with some evidence of under-prediction

- Analysis of the results by "binning" the data into $5\mu g/m^3$ concentration ranges allows for further examination of the data

- Analysis demonstrates of model usage by a wide pool of model users suggests a considerable range in model performance

- This range can be taken into account using a risk based approach for interpreting the results

- Approach can be used by regulators to consider the uncertainties in the results of dispersion modelling

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