PAPER FOR NSCA MEETING

Risk based pragmatic approach to address model uncertainty

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1.0 Introduction

The Environment Agency's recent modelling workshop (11th June in Cardiff, http://www.environment-agency.gov.uk/subjects/airquality/) concluded that model uncertainty is an important issue. No appropriate uncertainty range applicable to all dispersion model predictions could be set up based on the current knowledge on atmospheric dispersion; and sensitivity analysis is a useful tool to address the issue.

Methods addressing model uncertainty have been discussed in many publications, e.g. ADMLC (2001). Model uncertainty can be analysed and described in many ways, including, for example,

- Sensitivity analysis
- Monte Carlo method
- Qualitative method, e.g., categorising the deviation from ideal conditions
- Statistical method
- Numerical values

However, due to the complexity of the issue (e.g., there are many factors introducing uncertainty into model predictions and the factors vary case by case), there is no agreed generic approach for addressing model uncertainty for regulatory purposes.

The Environment Agency worked with external experts in air quality in a subsequent workshop (8th October in Cardiff) to develop pragmatic approaches for dealing with model uncertainty. The proposed approach can be used by the Agency to produce guidance on how to take model uncertainty into account in auditing air quality assessments in authorisation application.

2.0 Boundary of the pragmatic approach

Considering that most authorisation applications to the Agency deal with continuous elevated point source emissions, the proposed approach is to be focused on addressing the uncertainty from modelling elevated point source emissions only. Given the complexity of the issue, a boundary was drawn for developing the pragmatic approach:

- Uncertainty is loosely defined as the degree to which the set of model predictions differs from the equivalent set of observations. Uncertainties addressed in the pragmatic approach are those which remain after the modeller has made the best judgement with regard to input parameters and carried out the study according the principles of best-practice.
- It is assumed that the modelling study has been carried out properly.
- The model used is widely validated (and/or acceptable) and fit for purpose.
- The approach will focus on the use of model predictions for use in helping the determination of authorisation/variation applications.

- The emphasis of the approach is not on comparing model predictions with measurements of ambient concentrations of pollutants, but rather on the concept of model headroom described below.
- Uncertainties due to the use of screening models are not considered.
- Only elevated point source (stack) emissions are considered. Uncertainty from modelling area, volume and line sources are not considered by the approach.

3.0 Risk-based approach

The delegates agreed at the Agency's October workshop that the approach should be mainly qualitative. For regulatory purposes, the approach should be risk-based. Model uncertainty needs to be addressed in relation to a model headroom. The model headroom can be defined as

$$\text{Model headroom} = (\text{AQS} - \text{background} - \text{model prediction})/\text{AQS} \qquad (1)$$

where AQS stands for relevant air quality standards or Environment Assessment Levels (EAL) (IPPC H1, 2000). Although background concentration itself contains uncertainty, the issue of uncertainty in background concentration is not considered in this paper.

A generic approach addressing model uncertainty for regulatory purposes is expressed in Figure 1.

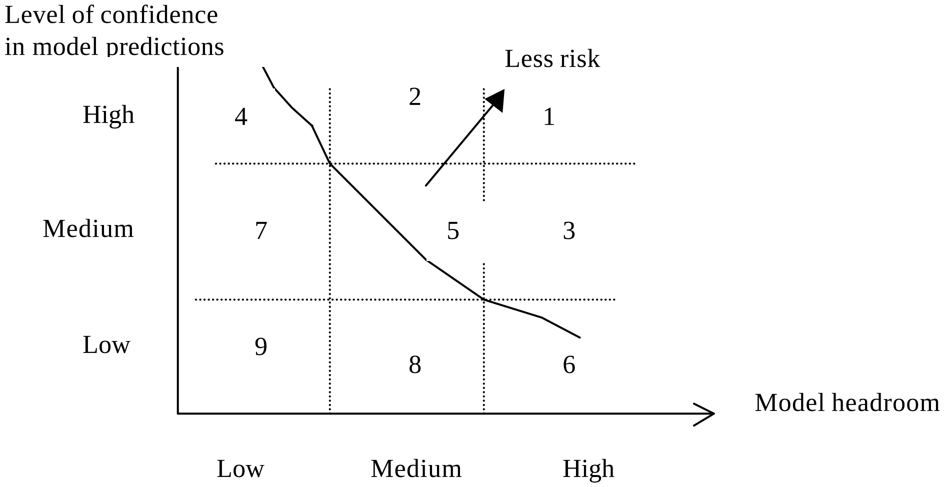

Figure 1. A pragmatic approach for addressing model uncertainty for regulatory purposes.

<u>Modelling of long-term concentrations</u>

Table 1 shows interpretation of the broad relationship between Low, Medium and High levels of model headroom and descriptions of model confidence level for long term concentrations (e.g. annual means). The Agency's H1 guidance

(Environment Agency, 2000) was referred in setting up the criteria for model headroom.

Table 1. An interpretation of Low, Medium and High levels of model headroom and indicators of model confidence levels for long-term concentrations (e.g. annual means).

	High	Medium	Low
Model headroom	> 0.3	0.1-0.3	< 0.1
Model confidence level	Flat terrain (slope < 1 in 10), no buildings (or buildings height < 0.25 stack height), 5 years representative met data*1	(1) Single rectangular building, or (2) complex terrain, or (3) met data < 5 years but > 3 years	(1) Groups of buildings, or (2) irregular and/or non-solid buildings, or (3) non- representative met data, or (4) any combinations of those in the "Medium" box

*1. Data capture rate should be larger than 90%.

<u>Modelling of short-term concentrations</u>

Table 2 shows a similar interpretation for short-term concentrations (e.g. high percentile of hourly means). The Agency's H1 guidance (Environment Agency, 2000) was again referred in setting up the criteria for model headroom.

Table 2. A definition of Low, Medium and High of model headroom and model confidence levels for short-term concentrations (e.g. hourly maximum or high percentile of hourly means).

	High	Medium	Low
Model headroom	> 0.8	0.3-0.8	< 0.3
Model confidence level	Flat terrain, no buildings (or buildings height < 0.25 stack height), 5 years representative met data, no coastal effect	(1) Single rectangular building, or (2) complex terrain , or (3) met data < 5 years but > 3 years, or (4) Predictions for specific receptors (e.g., school, resident areas)	(1) Groups of buildings, or (2) irregular and/or non-solid buildings, or (3) non- representative met data, or (4) any combination of those in the "Medium" box

4.0 Decision making

Decision making based on model predictions should take into account both the model headroom and model confidence level. Modelling predictions in categories 1, 2 and 3 (see Figure 1) are considered to be low risk/impact, therefore, no further work is required. When modelling outputs fall into categories 4, 5 and 6, further analyses/discussions (e.g. sensitivity analysis) should be shown in authorisation application reports to demonstrate whether

AQS will be breached when taking model uncertainty into account. And more detailed work should be done for predictions falling into grids 7, 8, and 9.

It should be noted that the risk-based pragmatic approach only provides guidance in risk/impact assessment. There are situations where modelling experiences are important. For example, for the case of flat terrain and groups of buildings, the model confidence level is low according to Figure 1 and Tables 1 & 2. However, if the receptors of interest are far away from the stack, then building effects may not be important and therefore, the actual model confidence level can be high.

5.0 Conclusions

A risk-based pragmatic approach has been proposed to address model uncertainty for regulatory purposes. The approach requires the assessment of both model headroom and model confidence level, the details of which are subject to further refinement.

Acknowledgement

The opinions expressed in this paper are those of the authors only and do not necessarily represent the policy of the Environment Agency.

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Yvonne Brown	Casella Stanger
Bernard Fisher	Environment Agency
Richard Griffiths	UMIST
Neil Haines	Corus
David Hall	Envirobod
Tim Hill	PowerGen
Travis Hughes	ERM
Arthur Jones	NRPB
Gwyn Jones	Entec
Ian Lowles	Westlakes
Zitouni Ould-Dada	Food Standard Agency
Keith Pearce	BNFL MAGNOX
Colin Powlesland	Environment Agency
Roger Timmis	Environment Agency
Ivan Vince	Ask Consultants
Ciara Walsh	NRPB
Roland Woodbridge	Atkins

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References

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