Reliability Of Atmospheric Dispersion Models Used In Assessing The Impact Of Radioactive Discharges On Food Safety

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1 INTRODUCTION

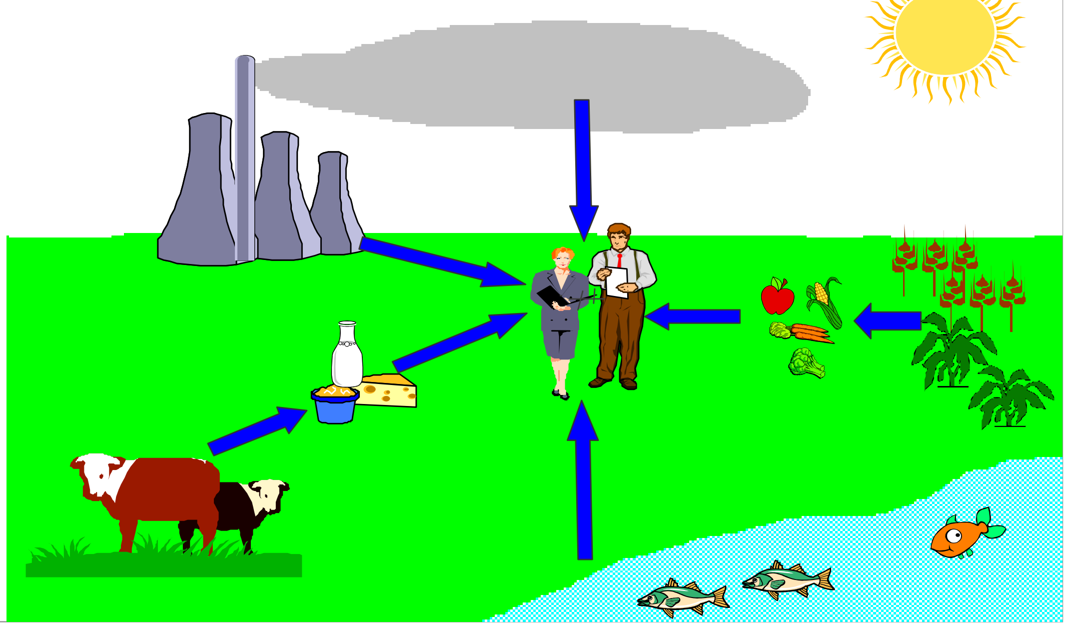
Discharges of radioactive wastes to the environment in England and Wales are regulated by the Environment Agency (EA) and in Scotland by the Scottish Environment Protection Agency (SEPA) under the Radioactive Substances Act 1993 (RSA93), as amended by the Environment Act 1995. Under RSA93 as amended, the Food Standards Agency (FSA) is a statutory consultee of EA and SEPA on proposed authorisations to discharge radioactive wastes. As part of its responsibilities, the Food Standards Agency (FSA) advises EA and SEPA on the foodchain implications of discharges from a large number of sites in the United Kingdom including nuclear sites as well as hospitals, research laboratories and small industrial premises.

Radioactivity released into the environment can reach members of the public via various exposure pathways (Figure 1). To ensure the safety of food, the FSA uses computer models to predict the levels of radioactivity in foodstuffs that might result from radioactive releases to the environment. In assessing the impact of proposed radioactive discharges on food, the FSA require a high level of confidence that radioactive discharges will not result in unacceptable doses to members of the public via the foodchain. Models must therefore be reliable, flexible and suitable for a wide range of applications. Atmospheric dispersion models, such as R91 and ADMS, are used by the FSA as a starting point in the calculation process of radiation doses from routine and accidental releases of radioactivity from nuclear installations. This paper presents the main factors affecting model performance and recommends areas where further work is needed to improve model performance and reliability.

2 MODELS USED BY FSA

The atmospheric dispersion models used by FSA include R91-STAR (Short-Term Atmospheric Release(Clarke,1979)), R91-ALTER (Atmospheric Long-Term Release (Holyroyd *et al*, 1991)) and ADMS (Atmospheric Dispersion Modelling System (CERC, 1995)). R91-STAR is used for short-term releases and R91-ALTER for routine releases. ADMS is used for both short-term and routine releases. In recent years, a number of dispersion models have been developed that are based on an increased understanding of the processes involved in the transport and diffusion of material released to atmosphere. Despite this, the Gaussian Plume model R91 continues to be widely used by operators and regulators. However, the advanced models presented by UK ADMS and AERMOD provide significant advantages over older models, particularly in their treatment of the boundary layer and of complex terrain. These models are still, however, in state of development and improvement are needed to increase their reliability

Figure 1. Transfer pathways of



3 MODEL RELIABILITY

In order to obtain a high level of confidence that radioactive discharges will not result in unacceptable doses to members of the public via the foodchain, the FSA requires the models used to be reliable, flexible and suitable for a wide range of applications. There are many factors affecting the performance of models and these need to be considered to improve model reliability (Figure 2). At present most of these factors have not been fully addressed in atmospheric dispersion modelling. Results for air dispersion models are used in decision making and it is essential to establish a degree of confidence in these results.

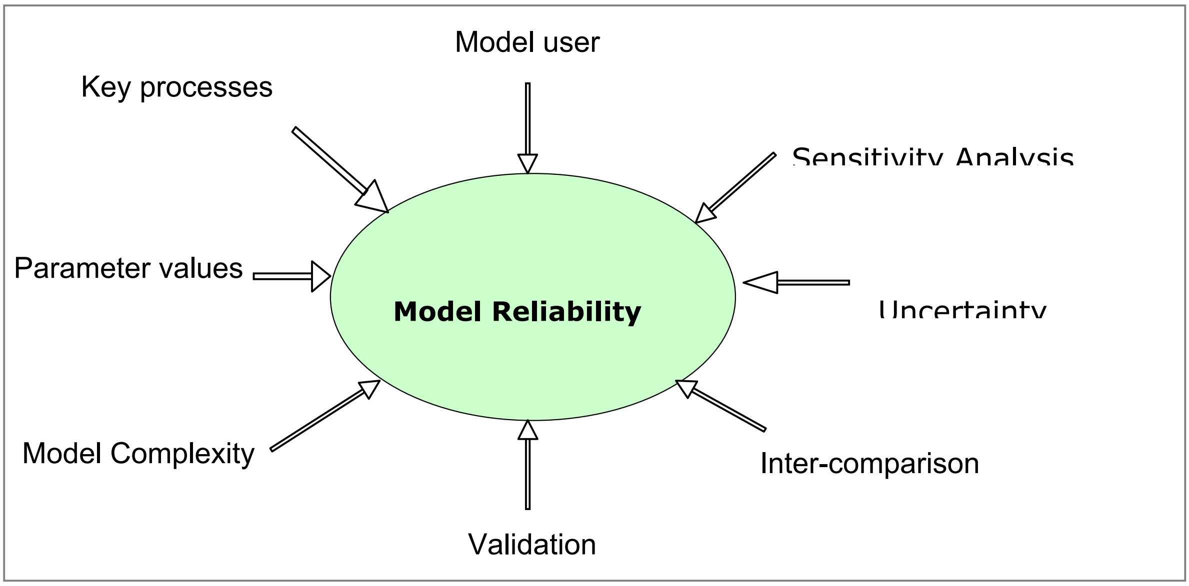


Figure 2. Factors affecting model

3.1 Key processes

It is important that the relevant processes are properly incorporated in the model to allow an accurate simulation. The key processes need to be understood and quantified so that models can be robust in their simulation. If processes are different from one model to another, then this will inevitably lead to differences in model predictions. For example, this is the case for the characterisation of boundary layer in R91, ADMS and AERMOD.

3.2 Parameter values

Appropriate parameter values needed to drive the model should be made available to the user. This is the case for the deposition velocity parameter in ADMS where default values are not provided to the user. Model predictions can have large uncertainties when generic parameter values are used in the absence of site-specific data. A good understanding of the model and processes involved is very important for increased confidence in model predictions. The accuracy of model predictions can be affected by the availability of site-specific parameter values. Since atmospheric dispersion modelling is the starting point in radiological assessment for gaseous discharges, any uncertainty on input parameters will cascade through the calculation process.

3.3 Model validation

Models must be tested against measurements before their predictions can be considered as reliable. Testing simulation models against independent data is an essential task in testing the reliability of model predictions. Model developers/users should take every opportunity to test the accuracy of model predictions. Given the complexity of atmospheric dispersion and environmental conditions, air dispersion models are still to be validated on a wide range of atmospheric conditions and scenarios.

3.4 Model complexity

Model performance is not related to model complexity. Simple models can perform as well as complex models if not better in some cases. Simple air dispersion models, such as R91, are very useful particularly in the case of an emergency where a quick answer is needed to obtain an early indication of the extent of contamination. Such models also require little input data to perform calculations. A model should not be judged on its level of complexity but on the basis of its predictive accuracy and the degree of uncertainty in its predictions.

3.5 Sensitivity analysis

Sensitivity analysis is important in identifying those parameters that are most sensitive and affect model predictions. Parameter sensitivity analysis is an important tool not only in identifying important parameters but also in identifying areas where further research or experiments will be most productive. This will help improve the model and increase its reliability. Sensitivity analyses for air dispersion models such as R91 and ADMS are needed.

3.6 Uncertainty analysis

Atmospheric dispersion models are used for a variety of purposes in support of air pollution regulatory requirements. Since most atmospheric pollution problems are inherently complex, there remains a degree of uncertainty in model estimates and a strong need for further research to reduce uncertainty. Because models are merely approximation of reality, their predictions will be always associated with some level of uncertainty. However, identification of sources of uncertainty and evaluation of the degree of confidence in model predictions are necessary. For example, there is great uncertainty over the extrapolation of meteorological data from one site to another. Also, the pre-processing of meteorological data is different between models and this inevitably leads to uncertainty in model predictions.

3.7 Model inter-comparison

Different models are used in the UK for regulatory purposes. This inevitably leads to differences in model predictions. Large differences may have significant effects on regulatory decisions and may imply substantial cost to industry. Model inter-comparison studies can be undertaken for comparing modelling approaches and identifying errors in coding or data entry. This will help explain the differences between model predictions and can be used to improve models. However, there have been very few inter-comparisons between atmospheric dispersion models such as R91 and ADMS. To evaluate model performance, model inter-comparisons need to be conducted over a wide range of atmospheric conditions and release scenarios.

3.8 The model user

The experience of the model user is an important factor affecting the accuracy of model predictions. It is important for the user to have a very good understanding of both the model and the scenario being modelled. Model predictions depend very much on the assumptions made by the user. For example, the experience and judgement of the user affect the selection of parameter values particularly when the input data are incomplete or unavailable. Also, a model in a hand of a non-experienced modeller can produce unreliable results. The model user and the model should not be considered separately.

3.9 Other factors

Other areas that need to be addressed to improve the reliability of atmospheric dispersion models include the following:

a The effects of building entrainment and topography.
b Uncertainty in pre-processing meteorological data for different models.
c Modelling of very short-term releases.
d Improving the running time of models (e.g. ADMS)
e Modelling of chemical transformation following release.

4 SUMMARY

Results for air dispersion models are used in decision making and it is essential to establish a degree of confidence in these results. Atmospheric dispersion models are used by the Food Standards Agency as a starting point in the radiological assessment process as part of its responsibility to ensure food safety. Model performance and reliability depend on the factors discussed above which need to be addressed to improve model reliability. At present most of these factors have not been fully addressed in atmospheric dispersion modelling. Areas such as uncertainty analysis and model validation may be given priority in addressing model reliability. This should help reduce uncertainty in model predictions and increase model reliability.

5.REFERENCES

CERC (1995). ADMS3 User guide. Final draft, 26th January 1999

Clarke R. H., 1979. A model for short and medium range dispersion of radionuclides released to the atmosphere. Chilton, NRPB-R91 (1979) (London, HMSO).

Holroyd RJ and Perkins RJ. (1991). R91ALTER. A computer code for the analysis of long term releases using the R-91 model. CERC report to MAFF. Report No. FM35A/91.