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Modelling of sulphur dioxide levels from coal-burning industrial sources using a stochastic estimation technique

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Abstract

The use of a stochastic (Monte Carlo) technique when modelling the potential impact of sulphur dioxide emissions from major industrial coal-burning sources has been investigated. The likelihood that the 1-hour average ground-level concentration of sulphur dioxide will exceed the NEPM(Air) standard of 570μg/m^3 as a result of emissions from a generic coal-fired power station, was predicted. The flexibility to use a different sulphur content distribution for each source allows for a more realistic estimation of the potential impacts of multiple coal-burning sources on the airshed which is important if local and regional airsheds are to be managed effectively.

Keywords: stochastic, Monte Carlo, air quality, sulphur, airshed management

1. Introduction

Analysis of coal samples reveals that the percentage of sulphur in coal, or sulphur content, is not uniform but instead varies depending on the location of the coal seam and within the seam as well. This variability implies that an air quality impact assessment based on dispersion modelling using a single value (typically the highest percentage sulphur content that is expected or allowed) may result in a conservative estimate of the impacts of a coal-burning pollutant source on air quality that is unrealistic.

The choice of representation of the sulphur content of coal becomes increasingly important when considering the impact of a source, either existing or proposed, on an airshed that may already contain a number of sulphur-emitting sources. The effective management of industrial areas that relies on model estimates of the impact of sulphur dioxide emissions on the local and regional airshed will only benefit from a tool that provides a more realistic yet still conservative approach to the estimation of the impact of sulphur dioxide emissions from coal-burning sources.

An additional complication is that each coal-burning source may be fuelled by different coal sources throughout the year. It will be important to model the variability in the sulphur content of coal as the amount of sulphur dioxide emitted from the stacks is directly related to the amount of sulphur present in the coal. In general, it is possible to combine data on the content of sulphur for all of the coal supplies to produce a single probability distribution for each coal-burning source for use with the dispersion modelling. Such a composite probability function may have multiple local maxima.

The random nature of the sulphur content of coal naturally suggests a stochastic approach to the modelling of sources that burn coal. The probability distribution of sulphur content is directly related to the frequency that a particular sulphur dioxide level is emitted from a source. A stochastic approach to the modelling that is able to take into account different coal sources, together with the variability of the sulphur content, both within and between the sources, coupled with an hour-by-hour analysis, will lead to a more realistic representation of the impacts of a source on air quality.

In order to determine the impact from the distribution of coal sulphur contents for various meteorological conditions, all possible combinations of the coal sulphur content will necessarily be considered in combination with these different meteorological conditions. A Monte Carlo simulation can be used to randomly select the coal sulphur content from the sulphur content distribution profiles for each source. When there may exist multiple coal burning sources within the study region, the predicted contribution made by each source can be scaled from the base emission rate used in the modelling. Contributions from each source may then be added together for each hour at each grid point.