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Uncertainty and Sensitivity Analysis in Code Environmental Model for Risk Assessments from Industrial Source Complex

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Abstract

The objectives of paper are the application of uncertainty and sensitivity analysis methods in atmospheric dispersion modeling to case study for predicting the dispersion of pollutants in the atmospheric environment. Gaussian Plume Model is used to study the impact of meteorology on the dispersion of emissions from industrial source complex. Quantitative uncertainty analysis has become a common component of risk assessments. Uncertainties were defined a priori in each of the following variables: wind speed, wind direction and pollutant emission rate. In order to get information about the uncertainty of computer code results, a number of code runs have to be performed using tolerance limits method. Monte Carlo method is used for propagating uncertainty across of code. Spearman rank correlation coefficient is used as sensitivity measure.

Keywords: Uncertainty analysis; Sensitivity analysis; Monte Carlo method; Pollutant; Gaussian Plume Model

1. Methodology and Analysis of case study for assessing uncertainty

Introduction

The Gaussian dispersion models are used to estimate or to predict the downwind concentration of air pollutants emitted from sources such as industrial plants. Such models are important to governmental agencies tasked with protecting and managing the ambient air quality. The concentration of a pollutant in the atmosphere (SO_2 emissions) is a random variable that cannot be predicted accurately. The model presupposes that the dispersion associated with the polluting species can be described by a modified Gaussian or Normal probability distribution. The model equation is derived from basic considerations of the diffusion of gaseous matter in three-dimensional space.

The objectives of work are the application of uncertainty and sensitivity analysis methods in atmospheric dispersion modeling to case study. The goals of this work are to: a) study the robustness of the model with respect to potential changes in inputs and parameters; b) provide quantitative estimates of the overall uncertainty incorporated in model predictions; and c) perform global sensitivity investigations by using correlation coefficients between the output and the input parameters; as a result of sensitivity analysis we can get the importance of the input parameters.

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Uncertainty Analysis

The aim of sensitivity and uncertainty analysis is to identify the main contributors (parameters) to the possible variations of the results. A total number of n code runs are performed varying simultaneously the values of all uncertain input parameters, according to their distribution. The n values of the considered output parameters are ordered. Therefore, the name-order statistics is used for Wilks'formula (Wilks, (1941, 1942)). Uncertainty in predictions is estimated by Monte Carlo simulation with each parameter selected either from independent distributions. The contribution of each parameter to model uncertainty is determined by statistical analysis of simulation results. The uncertainty of results is assessed by means of statistical tolerance intervals or tolerance limits (Conover, (1980)).

Sensitivity Analysis

Sensitivity analysis was performed in connection with uncertainty analysis in order to see the combined influence of all the potentially important uncertainties on the result. Sensitivity measures indicate the influence of the uncertainty in input parameters on calculation results. For example, the Spearman rank correlation coefficient is used as sensitivity measure. Positive sign means that input parameter value and result tend to move in the same direction, that is, an increase of uncertain input parameter value tends to increase the SO_2 concentration and vice versa (Hofer (1999)).

Results

Because the on-side evaluations for probability 0.95 and confidence 0.95 were selected, the number of Gaussian model runs should be at least 59. In the analyzed case 60 Gaussian runs were performed. This limit contains at least 95% of the combined influence of all quantified uncertainties at a classical statistical confidence level of at least 95% (Fig. 1). The most important parameter uncertainty is the wind speed. Ground-level concentration is very sensitive to wind speed (Fig. 2).

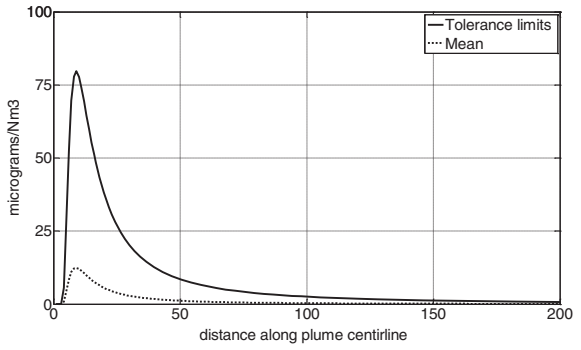

Figure 1.On-sided tolerance limits

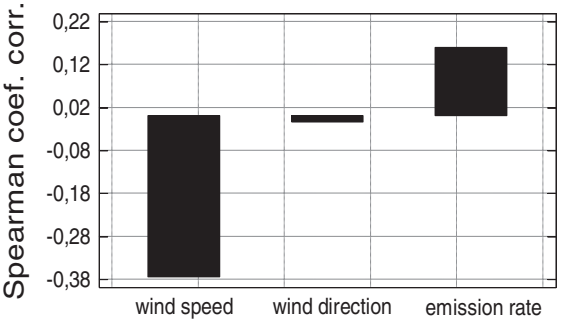

Figure 2 Spearman rank correlation coefficient

2. References

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