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基于CMAQ模型的随机响应曲面不确定性传递分析方法实现与评价

Implementation and evaluation of uncertainty propagation using stochastic response surface method based on the CMAQ model

关键词：随机响应曲面法 不确定性传递 CMAQ模型 蒙特卡洛法

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摘要：针对蒙特卡洛法在复杂环境模型进行不确定性传递分析时对计算机和时间资源需求巨大的缺点,本文引进快速高效的随机响应曲面法,并将其成功应用于CMAQ区域空气质量模型的不确定性传递分析,建立了基于CMAQ区域空气质量模型的不确定性分析概念框架.采用2阶和3阶随机响应曲面法,研究了排放清单不确定性对臭氧模拟结果的影响,并与1000次蒙特卡洛模拟结果进行对比.结果表明:3种模拟情景下臭氧浓度的均值几乎相同,模拟结果的概率分布曲线也基本一致,而采用随机响应曲面法可以极大节省模拟所需时间,提高计算效率,显示随机响应曲面法具有在复杂大气环境模型中进行不确定性传递分析的潜在价值.

Abstract：A computationally efficient method named stochastic response surface method (SRSM) for uncertainty propagation was used in this study to address extensive requirements for computational resources and time by the Monte Carlo (MC) approach. A conceptual framework for uncertainty propagation analysis based on the Community Multi-scale Air Quality (CMAQ) model was established. The 2-order and 3-order SRSM were implemented to estimate the impacts of uncertainties in emission inventories on simulated ozone concentrations, and the outputs were compared with those from the traditional MC approach with 1000 times of simulation. The results showed that average ozone concentrations at three uncertainty propagation scenarios were almost the same and three probability density functions at peak ozone concentrations agreed well. The SRSM approach can significantly reduce the simulation time and improve the calculation efficiency, implying its potential in conducting uncertainty propagation analysis of complex atmospheric environmental models such as the CMAQ model.

Key words：SRSM uncertainty propagation CMAQ Monte Carlo