1. Abstract

This study reports the results of a simulation using the PMCAMx-2008 model, which was applied over Europe in order to quantify the changes in fine aerosol (PM$_{2.5}$) mass concentration in response to different controls on anthropogenic and natural emissions of PM$_{2.5}$-relevant semi-volatile organic compounds (SOVCs). The simulation was conducted for 2008 over Europe and compared to observational data from the AERONET network. The model simulates various sources of PM$_{2.5}$, including natural (biogenic) and anthropogenic sources, and the effects on PM$_{2.5}$ concentrations were assessed.

2. Introduction

Emissions from both natural and anthropogenic sources have adverse effects on human health and the environment and have been implicated in the formation of ozone and particle populations. The concentration and changes of the energy balance of the atmosphere, particularly those due to anthropogenic emissions, are a subject of complex models. The research aims to understand how emissions reductions can lead to changes in the concentration of other pollutants. A three-dimensional chemical transport model (PMCAMx-2008) can estimate these source-receptor relations because it directly links emissions to PM$_{2.5}$ concentrations through detailed descriptions of the physics and chemistry of the atmosphere.

3. PMCAMx-2008 Description

PMCAMx-2008 is a chemical transport model applied over Europe creating a 36 km grid resolution with 14 vertical layers covering approximately 6 km. The necessary inputs to the model include monthly and annual emissions, meteorological data, and other parameters such as wind speed and wind direction. The model simulates various processes and is designed to estimate the concentration of PM$_{2.5}$ aerosols.

4. Model Application

PMCAMx-2008 was applied over Europe covering a 36-km grid resolution and 14 vertical layers ensuring high accuracy. The model includes horizontal and vertical advection, wet and dry deposition, and source-receptor analysis for PM$_{2.5}$ and its components. The model is validated against observational data from the AERONET network.

5. Model Evaluation

The model's ability to reproduce the observed PM$_{2.5}$ concentrations in various sites in Europe during the EUCAARI campaign (Bonn et al. submitted) is compared to observational data from AERONET sites. The model is found to be effective in reproducing the observed PM$_{2.5}$ concentrations in Europe.

6. Reduction of NH$_3$ emissions by 50%

PM$_{2.5}$ is predicted to decrease in both periods mainly due to reductions of ammonium nitrate.

7. Reduction of NO$_x$ emissions by 50%

In summer the ammonium reduction exceeds 10% everywhere. The highest reduction is predicted in major PM$_{2.5}$ hotspots such as the United Kingdom and southern France.

8. Reduction of SO$_2$ emissions by 50%

PM$_{2.5}$ is predicted to decrease in both periods mainly due to reductions of sulfate. In summer, PM$_{2.5}$ is predicted to decrease in most of the model domain due to a significant reduction in sulfate.

9. Reduction of VOC emissions by 50%

In winter, the highest reduction of PM$_{2.5}$ is predicted in northern France (approximately 5 g m$^{-3}$ in winter; Fig. 6b). In summer, PM$_{2.5}$ is predicted to decrease in most of the model domain due to a significant reduction in sulfate.

10. Reduction of POA emissions by 50%

During summer, total OA decreases around 0.2 g m$^{-3}$ in southern France, close to Paris (approximately 0.3 g m$^{-3}$ in both winter and autumn).

Conclusions

Reduction of PM$_{2.5}$ is the most effective control strategy for reducing PM$_{2.5}$ levels in both periods. The NH$_3$ strategy results in significant decreases of ammonium.

References


Figure 1.

Figure 2.

Figure 3.

Figure 4.

Figure 5.

Figure 6.

Figure 7.

Figure 8.

Figure 9.

Figure 10.

Table 1.

Table 2.