USING ADMS MODEL TO FORECAST CONTAMINANTS DISPERSION IN MOUNTAINOUS CITIES: A CASE STUDY IN CHONGQING, CHINA

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INTRODUCTION

As air pollution directly affects people's life quality and health standards, air pollution forecast model is an effective method for pollution control (Chen, S. and Z. Liao, 2001). However, at the present time, the prediction results of models, which are recommended by Technical Guidelines for Environmental Impact Assessment in China, exist a certain extent of deviation as applied to complex terrains (Ji, Y., L. He, and X. Zhou, 2006). It brings great difficulties to accurate forecast of air quality in the complicated terrains. Chongqing Municipality is a typical mountainous town, with undulating topography, and is also a large city with comparatively serious air pollution. So studying on prediction model of air pollution in Chongqing Municipality is of great significance. ADMS model as the representative of a new generation of air quality and atmospheric diffusion models, if it could well deal with such a complex terrain like Chongqing, it can be applied to the prediction of air pollution in Chongqing Municipality as well as solve the difficulties of guideline models in atmospheric environmental impact forecast in mountainous cities. Guideline model, known as regulatory atmospheric diffusion model or primary model, is published by government departments in form of "guidelines" documents. In 1993, Chinese government issued Technical Guidelines for Environmental Impact Assessment (GB/T2.2-1993). In the guidelines, the detailed methods of atmospheric environmental assessment are provided, and the atmospheric diffusion models of atmospheric environmental assessment are recommended.

The difference between ADMS model and Guideline model is that, the latter model applies the latest physics knowledge of boundary layer structure parameters on the basis of boundary layer height and Monin-Obukhov length. Moreover, stability classifies are according to the ratio of the Monin-Obukhov length and boundary layer height. The definition of diffusion parameter takes the form of continuous Pervasive function or dimensionless expressions.

APPLICATION OF THE MODEL

This paper chose Anju Town at Tongliang County in Chongqing Municipality as the application area to verify the applicability of ADMS model in complex terrain. In order to minimize the errors of input data, the prediction range was chosen as only a small area of 2×2km2 at Anju Town. There is only one factory in this area, namely Hongdie strontium plant of Tongliang County, and its emissions include three pollutants, i.e. H_2S, SO_2, TSP. However, due to avoid other emission sources contributing to these pollutants, H_2S, the feature pollutant of this plant, was selected as the prediction target. And the source strength of pollution source was acquired according to actual measured data of the exhaust funnel in this plant. In order to test whether the ADMS model is effective in complex terrain and reasonable in still wind condition, 12 continual measuring points were laid every 100m downwind of predominant wind NE direction of the pollution source. Besides, 4 sensitive spots in different directions were set as the measuring points. By way of simultaneous monitoring of continuous pollution source and circumstance, the actual concentration of pollutant at the measuring points could be acquired. Meanwhile, according to the source strength of pollution source, the forecasting concentrations of these points could be calculated by means of ADMS model and then compared with actual concentrations. Weather data used in this paper is the fixed time observation data from weather station in Tongliang County, and the observation time lasted seven days from June 2 to June 8, 2005.

Pollution sources

In order to reduce the impact on the model prediction results from pollution source data, and also avoid the influence on the concentrations of the target pollutant from other pollution sources outside the prediction range, H_2S, which is the feature pollutant of this region, is selected as the prediction target. According to the survey, H_2S inside and outside the study area is only discharged by Hongdie strontium plant. That is to say, H_2S from this plant is the only source of H_2S in the atmosphere. In addition, in order to minimize the deviation of pollution source data, the emission data of H_2S discharging funnel is simultaneously monitored in Hongdie plant, and then the accuracy of actual measuring data is tested according to material balance at the same time. The H_2S discharged from Hongdie strontium plant comes from exhaust gas produced by carbonization, while H_2S is discharged at a high altitude after the exhaust gas treatment. The discharging chimney is 80 meters high, and the inside diameter is 0.25 m. More, the monitoring results of discharge outlet show that the average emission of H_2S is 1.74kg/h and the discharge temperature is the same as environmental temperature 32? . According to the material consumption and chemical reaction formula in the production reports of the plant in June, H_2S consumption was calculated as 229.73kg/t product, that is 1045.13kg/h. The monitoring value of H_2S discharged at a high altitude was 1.74kg/h, except H_2S consumption in sulfur and hypo production, the rest H_2S was unorganized emission. In this study, the unorganized emission of H_2S is considered as a surface source with 10 meters in length and width, and 8 meters in height.

Simultaneous monitoring method

Divide prediction range into 16×16 grids, and use the map of Anju Town at Tongliang County to establish terrain data files by obtaining high-level data of each point. Choose mountain simulation while using ADMS model for prediction, and then introduce the obtained high-level data files. Terrain figure of prediction range is shown as Fig.1.

For the purpose of testing the forecasting results, stationing monitoring in prediction range is needed to achieve the pollutant concentrations. In order to highlight the terrain impact on the concentrations of forecasting points, on account of the two factors, downwind of predominant wind and undulating topography, this study laid 12 continual monitoring points from the boundary, every 100 m in SW direction. Besides, four spots are laid around according as the sensitive points. These four spots are: 1# Silkworm farm, located in NW direction; 2# Anju Town government, located in the west; 3# Anju Town high school, located in SW direction; 4# A certain farmhouse at Anju Town, located in SE direction. Monitoring sites map is shown as Fig.2.

Monitoring time was from June 2 to June 8, 2005, lasted seven days. Daily sampling time was 2:00, 7:00, 11:00, 15:00, 19:00, and 23:00. Use porous glass plate absorber that contained alkaline zinc ammonia complex salt solution for sampling, and the analysis method was Methylene Blue Spectrophotometry, which was recommended by GB/T14673-93. The principle of the method is that, when Hydrogen Sulfide (H_2S) is absorbed by alkaline zinc ammonia complex salt solution, sulfur ions are released in the acidic solution and produce Methylene Blue reacting with para-amidogen-dimethylaniline in the presence of ferric trichloride(FeCl3). The shade of blue is in proportion with the content of sulfur ions, and is calorimetrically quantified by spectrophotometer. By take arithmetic mean value of the monitoring results of every day and different time, the average concentration of H_2S at each monitoring point could be acquired.

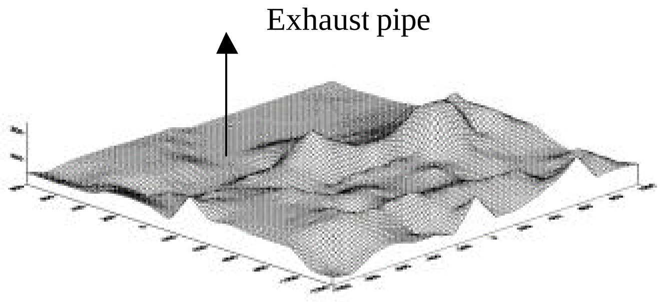

Fig. 1; Terrain figure of prediction range

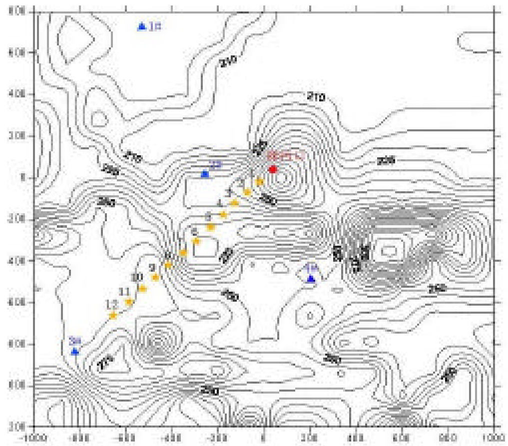

Fig. 2; Places of monitoring points

RESULTS AND DISCUSSION

ADMS model is used to forecast the ground concentration of four points in different direction and twelve points in SSW direction. When using ADMS-EIA to forecast, interfacial roughness is selected as 0.1, the recommendation, and latitudes are set as 29 degrees in Tongliang County. Whether the minimum of Minin-Obukhov is selected, the reaction of H_2S does not take into consideration in the chemical module owing to that H_2S is gaseous contaminant. Accordingly, dry deposition, wet deposition as well as chemical module are not considered either. Terrain document is established on the terrain high-level data and input in the form of terrain document. In the interface of grids, specific sites are selected and the coordinates together with altitudes are then input, which are of four points in different direction and twelve points in SSW direction. Output interface is to output the average concentration of H_2S in 7 days. The forecasting values and monitoring values of Regulatory model and ADMS-EIA model are shown in Table 1 and Table 2. In the tables, parameter modification means to modify the parameters based on the local conditions, e.g. the terrain condition and the meteorological condition.

Table 1. Forecasting date and monitoring data for 4 points in different directions (mg/m3)

monitoring point	guidelines	Before parameter modification	After parameter modification	Monitoring data
1#	0.0024	0.0132	0.0009	0.0013
2#	0.0175	0.0691	0.0095	0.0074
3#	0.0024	0.0047	0.0018	0.002
4#	0.0058	0.009	0.0042	0.0035
mean	0.0070	0.024	0.0041	0.0036

Table 2. Forecasting data and monitoring data for continuous 12 points in SSW direction (mg/m3)

Monitoring point	guidelines	Before parameter modification	After parameter modification	Survey data
1	0.1766	0.349	0.00267	0.0027
2	0.0794	0.11	0.00231	0.0024
3	0.0389	0.0495	0.00296	0.0030
4	0.0223	0.0294	0.00316	0.0021
5	0.0153	0.0188	0.00294	0.0030
6	0.0108	0.0128	0.00258	0.0024
7	0.0079	0.0095	0.00225	0.0018
8	0.0061	0.0088	0.00197	0.0019
9	0.005	0.00804	0.00181	0.0022
10	0.004	0.00637	0.00175	0.0017
11	0.0033	0.00526	0.00176	0.0025
12	0.0028	0.00507	0.00180	0.0019
Mean	0.03103	0.05104	0.00233	0.00228

Due to the data and comparison diagram, the ADMS forecasting values of 1# in WN direction and 3# in WN direction are less than then monitoring values correspondingly. Furthermore, the forecasting values of 2# and 4# in the Western and ES direction are larger than the monitoring values. The forecasting values of 3# and 4# are comparative to the monitoring values but the deviation between the forecasting and monitoring values of 1# and 2# is obvious. For the twelve points in the same direction, ADMS forecasting values and monitoring values are comparative and fluctuate to some extent. At the same time, the deviation of ADMS forecasting values and monitoring values in 4#, 7#, 9# and 11# sites is obvious and that no fluctuation same as the monitoring wave in 4#, 9# and 11#. High regularity is presented that the forecasting values gradually decrease with the augment of distance.

In order to inspect the applicability of ADMS model in the complex terrain, statistic analysis takes these two correlations into account. The statistic results show that in the whole prediction range, although the correlation coefficient of ADMS model cannot demonstrate the correlation, the statistic data as index of coincidence, the average of P/O and the standard deviation of P/O are acceptable. Moreover, mean square deviation is relatively small and system mean square deviation is less than the system non-mean square deviation. Therefore, we may think that the application of ADMS in the prediction range is feasible.

CONCLUSIONS

ADMS model is used to forecast on twelve points in the same direction under two circumstances: considering terrain and not considering terrain. The results show that the forecasting values are larger than the ones not considering terrain, and there is obvious deviation between the two groups of data. Accordingly, ADMS model is sensitive to terrain data, and then its application is feasible.

Because this study has the limitation of the available data and the sampling size, the further study is needed to verify and improve the ADMS model application to mountainous cities.

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