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Refining Volume Source Dispersion Model Parameters using Coupled Receptor Model Approach

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Abstract-Classical approaches of dispersion model and receptor model are used extensively used in past are complementry in nature. Dispersion models are used to predict pollutant concentrations at receptor provided the emission rates and meteorological conditions. This can be used to determine concentrations from point sources, line sources, and area sources prevailing in a region. Receptor model in other way predict the source contribution at a particular location by using receptor concentration and source profile as input parameters. Chemical Mass Balance (CMB) model are commonly using receptor model to estimate contributions in an area for known source profile data. Positive Matrix Factorization (PMF), Unmix model can estimate the source contribution (source type) as well as source profile (source signature) for a known receptor concentration data more accurately. In the current research work a coupled approach of CMB receptor model and Gaussian dispersion model for Volume source emission has been formulated to predict accurate dispersion model parameters. According to initial parameters, concentration of particles in air, wind velocity etc. can be determined in accurate.

Index terms-Receptor model, Volume source model, Long term –Short term model, CMB.

1 Introduction

Source emission rates can be treated as constant throughout the modeling period, or may be varied by month, season, hour-of-day, or other optional periods of variation. These variable emission rate factors may be specified for single source or for a group of sources. For the Short Term model, the user may also specify a separate file of hourly emission rates for some or all of the sources included in a particular model run .the concentration. The concentration of emission will be proportional to the number of sources [2]. Receptor modeling techniques like chemical mass balance (CMB) on the other hand can be used to attribute pollution levels at a point to different sources. Here we analyze the composition of particulate matter and use the source profiles of each source to estimate quantitative source contributions. The initial parameters include sources, method of emission, distributers. For a given area increase in sources cause increase in concentration of pollutants [1, 3, 5]. Volume source method will trace out concentration of different particles found in different time of a suggested area. In the context of using coupled receptor dispersion model based on genetic algorithms to overcome the limitations of the individual approaches and combine their benefits. an approach that assumes the estimates of emission rates of various sources are known from an emission inventory study [6 , 2, 8]. The dispersion model is used to compute the concentration of the pollutants from these sources at a point. This represents the source contributions arising from the dispersion modeling approach. The contributions can also be estimated using a receptor model from a speciation analysis of samples collected. This step requires the source profile of various sources [7]. The predictions using the two different methods can then be reconciled to accurately determine the rates. The concentrations predicted by the dispersion model are often found to be significantly different from those measured at a receptor.

The proposed combined approach will help us reduce the differences by considering the information from the receptor and dispersion modeling approaches. The meteorological data file for the Short Term model normally consists of a single complete year of meteorological data, beginning with hour 01.00 of January 1 and ending with hour 24.00 of December 31 [10]. For certain applications, such as long term risk assessments, it may be desirable to obtain averages calculated over a period longer than a single year. For these applications, the Short Term model is able to read multiple year meteorological data files in any of the ASCII formats. At the present time, the model is not able to read multiple-year UN formatted meteorological data files.

The Industrial Source Complex (ISC) Short Term model provides options to model emissions from a wide range of sources that might be present at a typical industrial source complex [5]. The basis of the model is the straight-line,steady-state Gaussian plume equation, which is used with some modifications to model simple point source emissions from stacks, emissions from stacks that experience the effects of aerodynamic downwash due to nearby buildings, isolated vents, multiple vents, storage piles, conveyor belts, and the like .Emission sources are categorized into four basic types of sources, i.e., point sources, volume sources, area sources, and open pit sources [2, 7, 9]. The volume source option may also be used to simulate line sources.

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2 Methodologies

Volume source models are largely used for finding the concentration of pollutants, emission rates. Chemical mass balance equations also used for finding concentration of pollutants. The ISC Short Term model accepts hourly meteorological data records to define the conditions for plume rise, transport, diffusion and deposition. The model estimates the concentration or deposition value for each source and receptor combination for each hour of input meteorology, and calculates user-selected short-term averages [1]. For deposition values, either the dry deposition flux, the wet deposition flux or the total deposition flux may be estimated using Equation 1.

$$C(x,y,z) = \frac{QKVD}{2\pi u_s \sigma_y \sigma_z} \exp[0.5(\frac{y}{\sigma_y})^2] \qquad (1)$$

Where,

Q = pollution emission rate

K = scaling co-efficient

V =vertical term

D =decay term

σ_y, σ_z =STD deviation of vertical and lateral concentration

u_s =mean wind speed

$$C(x,y,z) = \frac{Q}{2\pi u_s \sigma_y \sigma_z}\{\exp(\frac{-(z-h_s)^2}{2\sigma^2{}_z}) + \exp(\frac{-(z+h_s)^2}{2\sigma^2{}_z})\}$$

$$\times[\exp(\frac{-(y)^2}{2\sigma^2{}_y})] \qquad (2)$$

The parameters used for the estimation of concentration (C(x, y z)) are K=1*10⁶,V=1.5, D=1, us=5, XR=[2], YR=[1], wd=90, C=12.5, d=1.0857, a=61.141, b=0.9146, p=209.14, q=0.890, v=100, e=100. For the purpose of volume model some modifications has been done in the primary equation (1). The modifications done are σy_0 and σz_0. Henc the equation will be, $x_z = \left(\frac{\sigma z_0}{a}\right)^{1/b}$ and $x_y = \left(\frac{\sigma y_0}{p}\right)^{1/q}$, where $\sigma z_0 = \frac{v}{2.15}$ and $\sigma y_0 = \frac{e}{4.3}$

Values used to calculate σz_0 and σy_0 are, e=100 and v=100, where 'e' is length and 'v' is vertical distance.

The objective function has been defined to optimize the error between receptor and dispersion model source contribution which is given by,

$$J_1 = \|Q - Qest\| + \|S_{dis}(Q) - S_{cmb}\| \qquad (3)$$

The Short Term model can utilize the unformatted sequential files of meteorological data generated by the PCRAMMET and the MPRM preprocessors, provided the data file was generated by the same Fortran compiler as was used for the model, and provided the deposition algorithms are not being used. For the Long Term model, the user can also select output Tables of values for each receptor, and/or tables of overall maximum values. The tables by receptor and maximum value tables can be output for the source group values or for the individual source values, or both. In addition, when maximum values for individual sources are output, the user has the option of specifying whether the values are to be the maximum values for each source independently, or the contribution of each source to the maximum group values, or both.

The ISC models provide options for several types of file output products. One of these options for ISCST is to output an unformatted ("binary") file of all concentration and/or deposition values as they are calculated. These files are often used for special post processing of the data. In addition to the unformatted concentration files, ISCST provides options for three additional types of file outputs. One option is to generate an ASCII formatted file with the same results that are included in the unformatted post processing file. Another option is to generate a file of(X, Y) coordinates and design values (e.g., the second highest values at each receptor for a particular averaging period and source group combination) that can be easily imported into many graphics plotting packages to generate contour plots of the concentration and/or deposition values. Separate files can be specified for each of the averaging period and source group combinations of interest to the user [3, 6]. Recognizing that source contribution information is important to many short term modeling analyses, the ISCST model has been designed to facilitate performing this type of analysis. This is accomplished with an additional model, referred to as the ISC Short Term - EVENT model (ISCEV).

The ISCST model treats source groups independently. The ISCEV (EVENT) model is set up specifically to provide the contributions from individual sources to the concentration values for particular events [2, 5, 10]. These events may be the design concentrations (e.g., the high-second-high 24-hour average concentration for a particular group of sources) that were generated from an execution of the ISCST model. Other events of interest might be occurrences of violations of a particular standard, for which it is necessary to determine whether the source being permitted contributes above a significance level. The models are set up in such a way that both of these types of events can be passed directly from an execution of the ISCST Model to an input file for the EVENT model. There are two basic types of inputs that are needed to run the ISC models. They are (1) the input run stream file, and

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(2) the meteorological data file. The run stream setup file contains the selected modeling options, as well as source location and parameter data, receptor locations; meteorological data file specifications, and output options [1, 4, 6, 9]. The ISC models offer various options for file formats of the meteorological data. These are described briefly later in this section, and in more detail in Sections 2 and 3.

A third type of input may also be used by the models when implementing the dry deposition and depletion algorithm. The user may optionally specify a file of gridded terrain elevations that are used to integrate the amount of plume material that has been depleted through dry deposition processes along the path of the plume from the source to the receptor. The optional terrain grid file is described in [7]. The user also has the option of specifying a separate file of hourly emission rates for the ISCST model.

The Short Term model also incorporates the C screening model dispersion algorithms for receptors in complex terrain, i.e., where the receptor elevation is above the release height of the source. The user has the option of specifying only simple terrain (i.e., ISCST) calculations, only complex terrain (i.e., COMPLEX1) calculations. Simple and complex terrain algorithms. In the latter case, the model will select the higher of the simple and complex terrain calculations on an hour-by-hour, source-by-source and receptor by-receptor basis for receptors in intermediate terrain, i.e., terrain between release height and plume height [5]. The model is capable of handling multiple sources, including point, volume, area and open pit source types. Line sources may also be modeled as a string of volume sources or as Elongated area sources [6, 8, 9]. Several source groups may be specified in a single run, with the source contributions combined for each group. This is particularly useful for Prevention of Significant Deterioration (PSD) applications where combined impacts may be needed for a subset of the modeled background sources that consume increment, while the combined impacts from all background sources (and the permitted source) are needed to demonstrate compliance with the National Ambient Air Quality Standards (NAAQS). The models contain algorithms for modeling the effects of aerodynamic downwash due to nearby buildings on point source emissions, and algorithms for modeling the effects of settling and removal (through dry deposition) of particulates [1, 2, 3, 8]. The Short Term model also contains an algorithm for modeling the effects of precipitation scavenging for gases or particulates. For the Short Term model, the user may specify for the model to output dry deposition, wet deposition and/or Total deposition. Source emission rates can be treated as constant throughout the modeling period, or may be varied by month, season, hour-of-day, or other optional periods of variation.

The ISC models have considerable flexibility in the specification of receptor locations. The user has the capability of specifying multiple [3] receptor networks in a single run, and may also mix Cartesian grid receptor networks and polar grid receptor networks in the same run. This is useful for applications where the user may need a coarse grid over the whole modeling domain, but a denser grid in the area of maximum expected impacts. There is also flexibility in specifying the location of the origin for polar receptors, other than the default origin at (0, 0) in x, y, coordinates [6, 7]. The user can input elevated receptor heights in order to model the effects of terrain above (or below) stack base, and may also specify receptor elevations above ground level to model flagpole receptors. For simple terrain calculations, any terrain heights input above the release height for a particular source are "chopped-off" at the release height for that source's calculations.

Air quality dispersion modeling applications, the user may have a need to know the contribution that a particular source makes to an overall concentration value for a group of sources [4, 10]. This section provides a brief introduction to how these types of source contribution (sometimes referred to as source culpability) analyses are performed using the ISC models.

3. Results and Discussion

The results shows in Table 1 reveals the error in the objective function increases corresponding to the variation in the receptor concentration as 0%, 20%, 40%, 60% and 80%.

Table 1. Result for error in receptor concentration (R) (Distinct source profile for objective function J_1).

Variation in R	Q covered					Error Q	Function J_1
0	0.1	0.2	0.5	0.7	0.9	0.2000	0.200
20	0.086	0.170	0.525	0.655	1.07	0.204	39.60
40	0.100	0.202	0.461	0.699	0.868	0.173	78.91
60	0.088	0.216	0.457	0.758	0.877	0.271	112.8
80	0.094	0.186	0.458	0.726	1.024	0.296	124.3

The expected outcome will depend upon the source. On a particular area the contribution of pollutants will be varying day by day. Volume source modeling the vertical line source contribution also can be found out [2, 10]. The main merit of this method is source contribution at all 3 dimensions can be found out. Source modeling will be done according to the characteristics .Source contribution information is important to many short term modeling analyses, the ISCST model has been designed to facilitate performing this type of analysis. This is accomplished with an additional model, referred to as the ISC Short Term - EVENT model (ISCEV). The ISCST model treats source groups independently. The ISCEV (EVENT) model is set up specifically to provide the contributions from individual sources to the concentration values for particular events [7, 9, 10].

These events may be the design concentrations (e.g., the high-second-high 24-hour average concentration for a particular group of sources) that were generated from an execution of the ISCST model. Other events of interest might be occurrences of violations of particular r standard, for which it is necessary to determine whether the source being permitted contributes above a significance level [9, 8]. The

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models are set up in such a way that both of these types of events can be passed directly from an execution of the ISCST model to an input file for the EVENT model. The user is thus able to run the models in a batch mode to obtain the overall design value results from ISCST and the source contribution information from ISCEV in a single step. The EVENT model can also be run separately and accepts user-specified events for Source contribution processing. so the expected outcome will be difference in the values of assumed parameters and the designed value .so the error function will be neglected [2, 6].

4 Conclusions

Volume method is the part of receptor dispersion modeling. Through this vertical line source contribution can be find out. Plume height is used for calculation of vertical term. In regulatory applications, the maximum projected width is used. The features of the Schulman and Scare method are: (1) reduced plume rise due to initial plume dilution, (2) enhanced vertical plume spread as a linear function of the effective plume height, and (3) specification of building dimensions as a function of wind direction [1, 10]. Industrial Source Complex (ISC) Short Term model provides options to model emissions from a wide range of sources that might be present at a typical industrial source complex. The basis of the model is the straight-line steady-state Gaussian plume equation, which is used with some modifications to model simple point source emissions from stacks, emissions from stacks that experience the effects of aero dynamic downwash due to nearby buildings, isolated vents, multiple vents, storage piles, conveyor belts, and the like. Emission sources are categorized into four basic types of sources, i.e., point sources, volume sources, area sources, and open pit sources. The volume source option and the area source option may also be used to simulate line sources [9, 5]. One of the goals of the ISC reprogramming effort was to make the inputs for the new Short Term and Long Term models as consistent as possible. As a result, the majority of keywords are the same for both models. Because of this similarity, and because the Short Term model is the more widely used of the two, the discussions in the following sections are oriented toward the Short Term model. Any differences in the parameters for a keyword for the Long Term model are highlighted so that they are easily distinguishable [9, 3].

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