UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

DATE: FEB 3 1981 file; Modeling Issues

SUBJECT: Criteria for SO_2 Modeling/SIP Control Strategy

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TO: Harley Laing, Chief
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Per your recent telephone request for information concerning the required level of technical analysis for major SO_2 SIP revisions, I will be discussing the current requirements through examples of both acceptable and deficient SIP actions recently submitted by certain States.

First, I would like to present the screening techniques and subsequent refined dispersion modeling currently being employed in the State of North Carolina. The State is reanalyzing the acceptability of the existing emission limits for every utility and industrial boiler in the State. Considering the extreme number of sources involved, both large and small, the State through its contractor, PEDCo, has worked closely with EPA to develop acceptable screening techniques for limiting the number of sources required to undergo refined dispersion modeling. The approved modeling scenario being applied is fully described in the attached documents. However, I am summarizing the major criteria in the following discussion for your information.

For all sources less than 200 x 10^6 Btu/hr, a general screening procedure was adopted to eliminate from further consideration those sources which would clearly not pose a threat to attaining and/or maintaining the NAAQS for SO_2. General representative configurations along with selected specific source configurations were determined for 50, 100, 150 and 200 x 10^6 Btu/hr sources. These configurations were then modeled using the PTMAX model. The criteria for exemption from further analysis was if all the maximum estimated ground-level concentrations resulting from each source's emissions were less than one-half the 24-hour and 3-hour NAAQS for SO_2. General source characteristics considered in the screening analysis were stack height, stack gas temperature, and stack gas velocity. The maximum concentration for each configuration was selected regardless of the wind speed and stability class thus assuring the estimated concentrations were under worst case conditions. Then actual, individual source configurations were compared with the selected configurations and their concentrations estimated. Stack downwash was not considered.

Those sources with predicted concentrations of less than one-half the NAAQS were eliminated from further consideration. For those sources indicating concentrations in excess of one-half the NAAQS, individual PTMAX runs using specific plant configurations were made. If the maximum 1-hour concentrations converted to 3-hour and 24-hour concentrations exceeded one-half the NAAQS, detailed modeling was conducted. Otherwise, the sources were eliminated from further analysis.

background included?

When refined modeling was required, the following classifications and conditions were used:

- Single or multiple sources
- Flat or complex terrain
- Urban or rural land use
- Area specific meteorology (five years)
- Modeling techniques consistent with state of the art methodologies
- Receptor sites sensitive to worst case individual stacks as well as combined source impacts
- 3-hour and 24-hour concentrations

Each source or group of sources was classified according to its location and paired with the most appropriate meteorological data base and dispersion model. The model selection procedure was designed to use the source classification; i.e., complex or flat terrain, etc., as the primary criteria for choosing the most appropriate dispersion algorithm. Thus, each source was classified by each of the first three points in the above listing. The model dictated by the responses to the above criteria was chosen from the following: Valley, RAM-II, MPTER, or CRSTER. It should be noted that some consideration of measured air quality data must be given. Especially in areas where monitored data show concentrations of one-half the NAAQS or more. In such instances, detailed modeling should be required regardless of the screening results.

The preceding discussion of the techniques and modeling utilized in the North Carolina study would be transferable to another State in a conceptual sense. However, the specific criteria of source size cutoffs, stack heights, consideration of background, etc., has to be tailored to each State's particular situation.

EPA has exercised reasonableness in allowing recent SIP revisions to be processed where the technical support documentation (dispersion modeling study) had been performed prior to recent Agency decisions on dispersion modeling criteria. Recent SO_2 SIP relaxations for both New York (Niagara Frontier) and the District of Columbia for SO_2 were processed as final rulemaking actions where annual average models, CDM and AQDM, were used, respectively, with no short-term modeling being performed. These revisions were approved after consideration of the significant period of that time that has elapsed since submittal of the revisions by the States plus the lack of significant point sources being affected by the revisions. In my opinion, such control strategy demonstrations would not be acceptable if performed today.

Deviations from current modeling guidance for such items as less than five years of meteorological data, lack of consideration of multiple operating loads, and the refined receptor network have been allowed in recently published Federal Register notices after consideration of the time of submittal by the States and the type of sources affected.

Such judicious use of this grandfathering mechanism by EPA to prevent unnecessary disruption of the SIP process is not a basis for approving inadequate technical justifications submitted for future SIP revisions.

I hope this information has been of help.

Attachments

cc: D. Wilson

But verbally, it appears OAQPS will go along, as in the past, with lesser detailed modeling for area-wide SIPS.

I have lots of questions about the N.C. study e.g. for sources that pass the screen, are they modeled as part of the background when detailed modeling is required? They should be if they are nearby to the source in question.

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PROPOSED SCREENING METHODOLOGY

The following methodology is proposed in order to review the current sulfur dioxide (SO_2) emission limitation for stationary fuel burning sources in North Carolina. The purpose of the following simple screening procedures is to determine which sources would clearly not pose a threat to the 24-h or 3-h SO_2 National Ambient Air Quality Standard (NAAQS) if permitted to emit 2.3 lb $SO_2/10^6$ Btu, and therefore, would not require that further detailed modeling efforts be conducted for these sources. Conversely, those that fail the screening will undergo further, more detailed analysis.

1.0 GENERAL SCREENING PROCEDURES

The purpose of these screening procedures is to eliminate from further consideration those existing stationary fuel burning sources which would clearly not pose a threat to attaining and/or maintaining the NAAQS for SO_2 in North Carolina through the application of 2.3 lb/10^6 Btu emission limit. General representative configurations along with selected specific source configurations were determined through a field investigation (survey of the files) and previous engineering experience (Table 1) for 50, 100, 150, and 200 x 10^6 Btu/h sources (typical sizes for boilers in N.C.). These configurations were modeled using the PTMAX model, a simplified Gaussian dispersion model in the EPA UNAMAP series. PTMAX produces 1-h average maximum concentrations from individual point sources as a function of wind speed and stability. The criteria for exemption from further, more detailed analysis was met if all the estimated maximum ground level concentrations resulting from each source's emissions were less than one half the

TABLE 1. SOURCE CONFIGURATIONS FOR SCREENING ANALYSIS

	10^6 Btu sources			
	50	100	150	200
hs (ft)				
30	x	x		
50	x	x	x	
75	x	x		
100	x	x	x	x
175				x
200			x	
250				x
T_s (^{o}k)				
422			x	x
478	x	x	x	x
533			x	x
561	x	x		
644	x	x		
V_f (m^3/s)				
2.34				
3.56				
4.68				
4.85				
5.9	x			
7.37				
8.97	x			
9.7				
11.26			x	
11.8	x			
12.22		x		
15.02				x
16.89			x	
18.59		x		
22.52			x	x
24.45		x		
30.03				x

24-h and 3-h NAAQS for SO_2 (i.e., less than 182 μg/m^3 or 650 μg/m^3) under worst case meteorological and source conditions. The worst case meteorological and source conditions were defined in this case as those atmospheric, emission, and stack parameters that lead to the maximum 1-h predicted concentration. These 1-h concentrations were used to estimate the 3-h and 24-h SO_2 concentrations via the averaging time conversion techniques presented in the Guidelines For Air Quality Maintenance Planning and Analysis Volume 10: Procedures for Evaluating Air Quality Impact of New Stationary Sources.

2.0 CAPPED STACKS

The addition of rain caps on small boilers has been shown through field observation to deplete vertical plume rise resulting in a broad flat plume which significantly lowers the effective stack heights for these sources. As a result, the emissions from these sources would result in a somewhat higher maximum ground level concentration at distances closer to the source than would be otherwise expected without these rain caps. Presently, no EPA approved technique exists for considering these configurations. Therefore, in order to more reasonably screen "capped" sources (i.e., those whose stacks have rain caps) a "half-rise" assumption was incorporated into the PTMAX runs and the same configurations as those used in the normal full plume rise case (Table 1) were reevaluated. By cutting the plume rise in half, the model output provides estimations of ground level SO_2 concentrations resulting from these "capped" sources. Halfed plume rises were calculated by multiplying the Brigg's plume rise formula by 0.5 for unstable and neutral conditions since maximum concentrations were expected under these conditions for "uncapped" sources. The same criteria as that used for the general screening, i.e., one half the 24-h and 3-h SO_2 NAAQS SO_2, was used for determining if sources with capped stacks should undergo more detailed modeling analysis.

3.0 COMPLEX TERRAIN

Topographical features affect plume behavior thereby affecting the accuracy of the predicted concentrations estimated by flat terrain models. Adverse effects due to terrain features are a potential concern in certain portions of the state. Thus, the concentrations obtained with flat terrain assumptions and models such as the PTMAX, were cautiously evaluated in terms of representativeness for sources in mountainous terrain. In situations where the terrain was higher than the plume rise and impaction upon the terrain feature was expected, complex terrain screening was conducted in lieu of using the results from the flat terrain analysis. An inventory of facilities in the western part of North Carolina was analyzed in order to generate source and terrain configurations typical to this region. The source configurations were those which provided the maximum concentrations for the PTMAX runs (Table 2). These worst case configurations were then input into the Valley model, a sector averaged Gaussian dispersion model recommended for screening in complex terrain. It was determined, as a result of reviewing topographical maps, that the worst case gradient was from 0 to 1000 ft within approximately 1 km of the source. Based on a review of the source locations in the western part of the state, it was determined that the terrain features were approximately .5 to 1.5 km from the source. Table 3 presents a summary of the terrain configuration used in the screening analysis. Again, the criteria for determining whether more detailed analysis was necessary are whether the maximum estimated SO_2 concentration was less than half the 24-h and 3-h NAAQS at all the designated receptors.

4.0 ACCUMULATED IMPACT FROM SEVERAL SOURCES

While an individual source's impact might meet the criteria which would indicate that it would not adversely affect the attainment and maintenance of the 24-h and 3-h NAAQS, a number of these sources, if located close enough together, could have a

TABLE 2. SOURCE CONFIGURATIONS USED IN ROUGH TERRAIN SCREENING

Capacity	Stack height (m)	Temperature (^{o}k)	Flow rate (m^3/s)
50	9.14	478	11.8
100	9.14	478	24.5
150	15.2	422	22.5
200	30.5	422	30.0

TABLE 3. TERRAIN CONFIGURATIONS FOR ROUGH TERRAIN SCREENING ANALYSIS

Receptor number	1	2	3	4	5	6	7
Height of terrain (ft)	0	0	100	250	1000	250	100
Distance (km)	.32	.6	.9	.13	1.6	1.9	2.2

combined significant impact. This impact would indicate that a more detailed air quality analysis must be conducted.

As a result of visits to the State of North Carolina's District offices and the three major local agencies in the State and conversations with field personnel, it was determined that there were no sources which are located close enough to each other (i.e., within several km) to cause a potential problem with respect to the 24-h and 3-h SO_2 NAAQS. However, in order to provide a cross-check to ensure that no problems could occur even though none were noted, any county which had over five sources with a total generating capacity for each source of greater than 100×10^6 Btu/h was evaluated in terms of the actual distances between these sources. If any of these sources were within 5 km of each other, they were subjected to a more rigorous screening analysis using a multi-source model, MPTER. Again, the same criteria as noted previously with respect to half the 24-h and 3-h SO_2 NAAQS was used to determine if these sources should be subject to a more detailed modeling analysis. For multiple sources meeting the above criteria in complex terrain, the Valley model was still used along with a receptor grid that maximized the contribution of each source.

5.0 METEOROLOGICAL DATA

Meteorological data from the appropriate locations across the state were reviewed to determine the frequency of occurrence of the conditions used in the screening analysis which produced the maximum concentrations. This information provided an indication of the probability of the worst case conditions existing within certain areas of the state.

6.0 COMPARISON TO CRSTER RESULTS

In order to provide a cross check on the screening analysis, a detailed single source modeling analysis was conducted using CRSTER. One year's worth of meteorological data from the Greensboro station was used to evaluate the predicted concentrations estimated by the screening techniques. The emission rates, stack parameters, and source configurations for each of the boiler sizes which provided the highest concentrations in the screening analysis were input into the CRSTER model along with the Greensboro weather data.

Was 1 yr representative?
What were results?

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Proposed Modeling Methodology

The following proposed methodology outlines a procedure for modeling fuel burning sources in North Carolina which fail to meet the one-half NAAQS screening criteria discussed in the proposed screening methodology.

1.0 Source Classification

Model selection decisions are determined in a three stage classification process. Sources are identified and classified by the following three characteristics:

1) Is the surrounding terrain flat or complex?
2) Is the source located within an urban or rural area?, and
3) Is the source an isolated single source or is it surrounded by other sources of SO_2 (multiple source situation)?

Once these three questions have been answered, the most appropriate algorithm can be selected to model the source and the representative meteorological data and appropriate receptor network can be identified for input into the selected model.

1.1 Complex vs. Flat Terrain

Complex terrain as defined for the purpose of dispersion modeling is topography where the height of the surrounding terrain features is greater than the height of the lowest stack. The qualification of the term "surrounding terrain" is that terrain identified by screening techniques to pose a potential impaction problem. For example, topographical features 15 km from a source would not be considered if screening techniques

How does screening modeling take terrain features into account?
If A-stability gives short down wind max close to source, may still have problem with complex terrain further away.

estimated maximum concentrations at distances between one to two kilometers from the source. Therefore, only topography at the distances indicated by the values estimated with the initial screening techniques would be considered for the purpose of this analysis. Don't like this – [illegible]

1.2 Rural vs. Urban Classification

An urban/rural classification must be determined for proper selection of dispersion coefficients. The following land use procedure as outlined by Auer[1] is proposed as it is currently the most reliable classification procedure for urban/rural determination considering the given data base. The procedure calls for:

1. Circumscribing a 3 km radius circle around the source location on a United States Geological Survey Land Use Map.
2. Classifying the area using the meteorological land use typing scheme listed below in Table 1.

TABLE 1. METEOROLOGICAL LAND USE TYPES[1]

Type	Description
1	Heavy industrial
2	Light-moderate industrial
3	Commercial
4	Compact residential
5	Common residential
6	Estate residential
7	Metropolitan natural
8	Agricultural rural
9	Undeveloped
10	Undeveloped rural
11	Water surfaces

3. If land use types one through four account for less than 50 percent of the circumscribed area, the area should be classified rural. Otherwise, a model with urban dispersion coefficients should be selected.

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[1] Auer, A. H., Jr. Correlation of Land Use and Cover with Meteorological Anomalies. Journal of Applied Meteorology, 17, May 1978, 636-643.

1.3 Single vs. Multiple Source Classification

Single source as defined in air quality dispersion modeling is a facility with one isolated stack or several similar or collocated stacks grouped closely together. Sources with only one stack are clearly defined as single sources. For situations where facilities have more than one stack, the main criteria for source classification determinations, i.e. single source vs. multiple source, are stack separation and distance to expected maximum concentrations. In general, sources categorized as singular have a total stack separation of less than one-tenth the distance to the expected maximum concentration as determined by screening techniques (Note: Classifying facilities with several closely located stacks as single sources results in some additional conservatism in terms of predicted concentrations).

What is justification for this. Guidance is for 100 m separation criteria.

2.0 Model Selection

After the source has been classified using the procedure outlined in Section 1.0, proper model selection can be determined. Figure 1 represents a model selection flowchart.

Sources meeting the criteria for complex terrain classification will be modeled using the Valley model modified for buoyancy induced dispersion. Although Valley, a Gaussian dispersion algorithm, is a screening and not a refined analytical technique, it is currently the method that is being used for complex terrain situations. This should only be done if terrain ht > plume ht. If plume ht > terrain > stack ht, VALLEY may give 0

If the surrounding terrain is not considered complex but the source is located within an urban area, RAM, a Gaussian plume multiple source air quality algorithm, will be selected.

For sources located within non-complex terrain and rural areas, CRSTER, a single source Gaussian plume algorithm, will be used.

If the source does not meet the single source criteria but is located in a non-complex terrain and rural area, MPTER, a multiple point Gaussian dispersion algorithm will be selected for the purpose of this analysis.

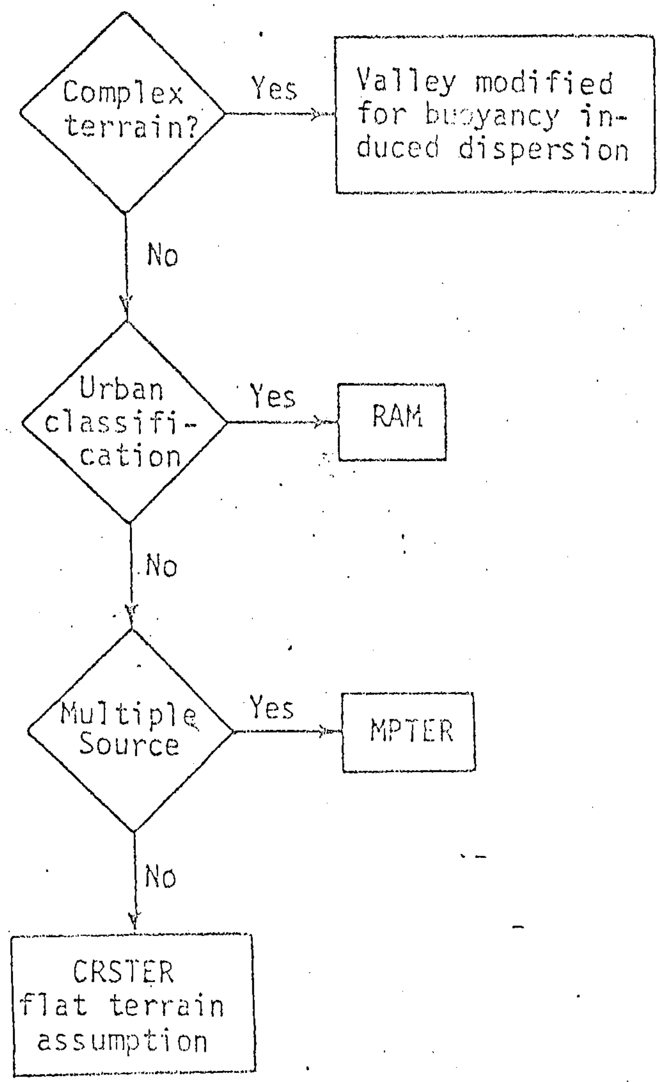

Figure 1. Model selection flow chart.

For the purpose of this analysis, the background level of SO_2 is assumed to be zero. The impact of non fuel burning sources of SO_2 will be considered on a case-by-case basis using any existing modeling or monitoring data as appropriate. When is it "appropriate"?

3.0 Selection of Receptor Network

Proper receptor location and grid determination affects the accuracy of concentration estimates and the probability of identification of the maximum predicted concentration. The appropriate receptor network can be determined through analysis of meteorological joint frequency distributions and preliminary screening model estimations.

A PTMAX model will be run on each source which does not meet the initial screening criteria in order to identify the distance to the highest estimated concentration for several stability class and wind speed combinations. In order to locate the maximum concentration, the receptor distances will reflect the distance estimated by PTMAX and will incorporate a sufficiently dense array of receptors so as to show concentration gradients around the maximum value. What about PTPLU?

For multiple source situations, predominant wind directions from representative meteorological frequency distributions and the sources' relative contributions will be assessed prior to final network selection since plume interaction may play an important role in selecting appropriate receptor locations.

For the purpose of this analysis, receptor locations within 0.3 km from the source will not be considered as they are assumed to represent the property line for the source. There may, however, be situations especially where several sources are involved where receptor locations less than 0.3 km may be warranted. These situations will be discussed with EPA and the State of North Carolina on a case-by-case basis if such situations arise.

4.0 Meteorological Data Selection

Once the applicable algorithm has been identified, an appropriate, representative meteorological data base must be determined.

Table 2 lists the surface and upper air data sets selected for this analysis by EPA Region IV, OAQPS, and PEDCo Environmental. These combinations represent five consecutive years worth of meteorological conditions. The most representative five year meteorological data set for each case will be selected for input into the CRSTER, RAM, and MPTER models. Since Valley considers only Pasquill-Guifford stability class, wind speed, and wind direction, the following worst case assumption will be input for 24-hour averages: 1) stability class F, 2) wind speed of 2.5 m/s, and 3) six hours of occurrence. Wind speed and stability class frequency data from the STAR program will be reviewed for the Greensboro and Charlotte weather stations to obtain some indication of the frequency of occurrence of F stability and a wind speed of 2.5 m/s. If the frequency of occurrence for F stability and wind speed of 2.5 m/s is quite low, this will be discussed with the State of North Carolina and Region IV to determine if any changes would be warranted in terms of using F stability and wind speed of 2.5 m/s for the Valley runs, in the final analysis of sources located in complex terrain.

Conditions at Greensboro & Charlotte may be completely different from those in complex terrain areas.

TABLE 2. METEOROLOGICAL INPUT

Surface Data	Upper Air Data	Years
Raleigh, NC	Greensboro, NC	1974-1978
Greensboro, NC	Greensboro, NC	1974-1978
Charlotte, NC	Greensboro, NC	1974-1978
Charleston, SC	Charleston, SC	1970-1974
Norfolk, VA	Greensboro, NC	1970-1974
Norfolk, VA	Charleston, SC	1970-1974