2.2 PROGRESS IN REGULATORY AIR POLLUTION METEOROLOGY – A STATE'S AIR PROGRAM PERSPECTIVE

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1. INTRODUCTION

State air quality programs are charged with developing and implementing regulations aimed at protecting public health and the environment from the effects of air pollution. Meteorologists working with state programs are usually responsible for assessing current and projected future air quality, either through state permitting programs or for general planning purposes. New regulatory programs combined with new analysis tools and increased data availability has put new demands on state air pollution meteorologists. These demands are requiring greater skills in using these tools for air quality analysis and more knowledge of atmospheric processes. These skills include using numerical weather prediction models and complex chemical transport models. Increased knowledge is required, beyond previous needs, in atmospheric chemistry and boundary layer meteorology. The need for environmental data, as used in the more sophisticated air quality models, is integral to the state meteorologist's work.

2. BACKGROUND

State air pollution meteorologists provide a number of services to air quality programs. The educational background in meteorology is necessary and unique for understanding how air pollutants are transported and dispersed in the atmosphere, and this knowledge is used to analyze the impact of industrial sources. State meteorologists also provide basic data analysis of air quality and meteorological data, support monitoring of air quality and meteorological parameters, and, more recently, have started air pollution forecasting on an operational basis.

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Air pollution meteorologists have been a part of air quality programs in most states for 25 years or longer. The Clean Air Act of 1970 and its subsequent amendments in 1977 and 1990 laid the foundation for permitting programs and general air quality planning requirements that necessitated the need to predict or estimate future air quality as a result of proposed changes in air pollutant emissions. In the 1970's, workbooks ("Turner's Workbook") using basic information about the source of the air pollutant emissions and some basic Gaussian dispersion formulations with graphs of dispersion curves provided a means to estimate ground-level pollutant concentrations. Environmental data used in these calculations was minimal, consisting of some basic meteorological data (e.g., wind speed, temperature, and cloud cover).

Coding of these formulations into computer programs allowed for the direct calculation of long-term averages. Air quality models like CRSTER and RAM were some of the first of this generation. These models required the use of more extensive environmental data including hourly surface meteorological data and twice-daily upper air data. In addition, some information about the local land-use was required to determine whether to use urban or rural dispersion coefficients. For areas where significant terrain features affected pollutant dispersion, simple idealized hills were invoked in lieu of actual spatial elevation changes. Through the 1980's and 1990's, these Gaussian plume models (e.g., Industrial Source Complex model) incorporated more features that can use additional environmental data, if needed, such as precipitation and terrain elevations.

During this same period, more sophisticated trajectory models (current example CALPUFF) and Eularian grid models (current example Urban Airshed Model) were developed. These models are capable of incorporating complex chemistry and wind fields, and require more detailed environmental data to drive the more detailed physics. These data often cover a domain of thousands of kilometers and include three-dimensional meteorological fields, land-use/land-cover, and terrain elevations. Most state programs do not have the specific experience or the computer hardware to effectively use these more advanced air quality models. As a result, many state air programs contract with a small number of private consulting firms capable of providing these services, often at considerable expense, to fulfill Clean Air Act requirements for this type of work.

3. PROGRESS

Today, progress in state air programs applying more sophisticated methods and theories of air pollutant dispersion, transport, and transformation has been driven largely by the advance in fast and inexpensive computers, and access to large amounts of environmental data. A number of state air programs are already using some of these more sophisticated analysis techniques. All state air pollution meteorologists have to at least learn the principles behind these methods in order to manage and evaluate work done by contractors.

Examples of some new programs and new tools used by state meteorologists and their implications to State air programs are listed below.

AERMOD/AERMET/AERMAP – This new steady-state plume model incorporates current boundary-layer theory to estimate downwind concentrations of air pollutants. This is a mainstream air quality model that all state air pollution meteorologists will be using. Resources are relatively minimal and environmental data resources should be readily available and consist of single-station meteorological data, USGS terrain elevations, albedo, Bowen ratio, and surface roughness. Personal computers are more than adequate. State air pollution meteorologists will need to brush-up on boundary-layer theory in order to effectively use and explain model results.

CALPUFF/CALMET – This multi-layer, multi-species non steady-state puff model incorporates three-dimensional meteorology and current boundary-layer theory to estimate pollutant concentrations or deposition. The model is geared toward long-range transport and utilizes limited chemical transformation processes. Many state air pollution meteorologists use this model for its long-range application in federal class 1 areas. Resources for this model are moderate. Three-dimensional wind fields can be generated using a diagnostic wind model with existing surface and upper air meteorological data, and land-use and terrain data. Prognostic meteorological data from a forecast model (e.g., MM5) nudged by four-dimensional data assimilation can also be input. Assembling these datasets is much more complicated requiring skill on the part of the meteorologist to assure reasonable wind fields. Personal computers can be used (except for MM5), but very large amounts of data need to be dealt with. Meteorologists must become adept at managing large data sets and, usually, additional visualization software is necessary to view and analyze model performance.

PHOTOCHEMICAL GRID MODELS – These models (e.g., UAM-V, CMAQ) fully implement the basic mass conservation equations to numerically solve for pollutant concentrations and deposition. Great skill and considerable resources are required to properly run and evaluate these models. Except for a few cases, state air pollution meteorologists do not have the experience or resources to effectively use these models. Personal computers are not viable at this time since most of the development of these models is UNIX-based in a workstation environment. People-resources are also greater; full-time dedication is required of possibly two or more meteorologists. Nevertheless, many state air programs are slowly moving ahead to develop this function.

AIR QUALITY FORECASTING – Many state air pollution meteorologists are now making air quality forecasts. Up until a few years ago, this was not a part of any air quality program. Current forecasting is primarily for the pollutant ozone (photochemical smog). Since air quality forecasting is largely weather forecasting, state air pollution meteorologists have to dust off their old forecasting texts or hire “kids” fresher in this skill. This aspect of the program is becoming more popular as citizens begin to demand this information.

4.CONCLUSION

Considerable progress has been made in the ability of State air programs to analyze and evaluate air quality. State air pollution meteorologists are charged with the job of completing much of this function. In the last 20 years, the complexity of air quality analysis has changed as technology has progressed and the amount of environmental data has increased. Further, through Internet access, these data are available cheaply and quickly to everyone, thereby enhancing its use. The state air pollution meteorologist's must keep up with these changes through continuing education.

5. REFERENCES

Scire, J, et. al., 2000: A Users Guide for the CALPUFF Dispersion Model

U.S. Environmental Protection Agency, 1997: Revised Draft Users Guide for the AMS/EPA Regulatory Model - AERMOD