

Meteorological Aspects of Air Quality

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1. Energy and air quality

In the vast majority of cases, the problems being addressed today by "air pollution meteorologists" (a rather diffuse title covering numerous subdisciplines) are related to either energy production or utilization. While the fate of effluents from industrial processes is of concern (especially in the metals refining industry), it is the use of both fossil and nuclear fuels, both in stationary and mobile sources, that has been the major impetus for the development of the field loosely termed "air pollution meteorology." In essence, the problem that is finally being addressed is, will the total impact of the use of various fuels (coal, oil, gas, nuclear) be more "costly" (in the total sense of the word) than the benefits derived from their utilization. The profession is engaged in a massive "cost-benefit" analysis study of energy resources.

Our recent experiences with oil supply reliability have resulted in numerous pressures to rapidly exploit our vast supplies of oil shale, low-sulfur coal, and high-sulfur coal. The use of this latter fuel raises the specter of numerous and widespread violations of SO₂ air quality standards developed in response to the Clean Air Act. Removal of the sulfur before or during the use of the fuel is a marginally developed technology at this time. If higher stacks are built to avoid excessive ground level concentrations, do we sufficiently understand the ultimate fate of the sulfur compounds ejected into the atmosphere (the "sulfate problem")? Alternately, SCS (supplementary control strategies) programs utilizing fuel-switching are proposed which allow burning of high-sulfur fuels only on days when dispersion conditions permit. But, how reliable are our capabilities to forecast these conditions with sufficient lead time to be practical or economically useful while keeping the number of "errors" acceptably low? All in all, if this nation is to achieve energy independence, there are meteorological inputs at several key points in the decision-making matrix.

The air pollution meteorologist also becomes involved in the debate as to whether or not the air quality standards are unnecessarily strict. Is the estimated \$16 billion annual damage total due to air pollution realistic? What would be the additional total costs if standards were relaxed? There are charges, at least from certain quarters, that many state implementation plans (SIPs) are guilty of "overkill" in restricting emissions. It has been suggested that by reformulating the SIPs using even existing dispersion models instead of more simplistic "rollback" techniques, the fuel-burning patterns of urban areas can be significantly changed. For example, dispersion models indicate that higher sulfur fuel could be burned (using tall stacks) in New York City, thus saving \$150 million per year. There seems (at least to the writer) to be a pattern of doing the minimum

amount of meteorology necessary for any given program (usually running to a "workbook"). It is very likely that proper application of "air pollution meteorology" could potentially result in savings into the billions of dollars per year.

At virtually every phase of energy production (the mining, processing, or consumption of fuel) there are critical decisions to be made involving meteorology, which it must also be admitted, is an imperfect tool. Some examples:

1) Fossil-fuel power plants are being constructed in the mountainous desert southwest. The application of crude dispersion models to a given facility suggested the need for over tens of millions of dollars in sulfur removal devices. The model used was totally unvalidated, and was filled with assumptions (such as the plume's complete impingement on higher terrain) that were highly questionable. Yet it was a typical evaluation tool available at the time for modeling air quality in complex terrain. On the other hand, well-formulated (and validated) models can result in equally dramatic savings.

2) As monitoring of pollutants increases across the country, many areas are unexpectedly finding photochemical oxidant levels in excess of standards. Many air quality regions appear unable to meet 1976 standards. Have the proposed federal automobile emission standards been formulated too rigorously (as stated by the auto industry) or are they in fact too lenient (meaning yet even higher car prices)? Are we even sure the high oxidant levels are totally anthropogenic in nature? And do we understand what happens as oxidants are transported for distances of over 50 km?

3) Portions of the nation are being declared "air quality maintenance regions," entrusted with the responsibility of seeing that once standards are met, they do not relapse. It is becoming increasingly clear, however, that the air quality in many localities is being significantly affected by the "sins of emission" of other legal and political jurisdictions over which the offended region has absolutely no control. In many cases, we are not discussing emissions from the next county, but from 150 to over 1500 km away. The lack of proper meteorological understanding of mesoscale and long-range transport of pollutants (and their chemical transformations) threatens to make a shambles of much of the legal structure of the Clean Air Act. In Europe, numerous cases of international pollution transport have been revealed.

2. Suggested basic and applied research

There are a host of programs needed in the air quality field if intelligent and cost-effective answers are to be obtained for the questions generated by the "energy crisis." Just a few of the more obvious (to the writer) are listed.

1) Our knowledge of the mesometeorology and diffusion characteristics in complex mountainous terrain is

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limited. There are no diffusion models sufficiently validated by field data now in use that appear capable of providing proper air quality guidelines for these regions. Work should continue to be fostered in this area—both observational studies and numerical models working in tandem. This, in fact, is true in all areas.

2) A similar situation exists in shoreline and offshore regions. The large number of tall stack power plants in coastal regions and the proposed development of offshore nuclear power parks make increased understanding of transport and diffusion in this environment mandatory. Continued studies must be made on modeling sea/lake breeze effects, diffusion over water (especially during stable conditions), and the coastal boundary layer. Almost 50% of the U.S. population resides within 40 km of a major body of water, yet the complex meteorology of this region is poorly understood.

3) There are gaps in our knowledge of transport of both gaseous and solid pollutants in the mesoscale and subsynoptic ranges. While global scale transport is hardly well understood, more seems to be known about the fate of high-altitude pollutants circling the globe than the processes affecting Ohio River Valley power plant plumes as they drift from West Virginia into New York State.

4) There is a growing need for an improved air pollution climatological data base. For two decades EPA and other agencies have attempted air pollution climatologies (for modeling essentially micro- and mesoscale phenomena) based upon data collected by synoptic-scale upper-air stations. The curtailment of the NOAA EMSU radiosonde system as an "economy move" appears to have been diametrically opposed to what should have occurred. Long-range planning is necessary. Five years of climatic data can't be collected in six months.

5) Even greater efforts should be made towards the standardizations of pollution measurement and calibration procedures. Recent problems intercomparing California oxidant measurements attest to this.

6) The thrust towards the use of remote sensing technology for monitoring both meteorological and air-quality parameters on the mesoscale should be continued, including such devices as lidars, acoustic sounders, LANDSAT satellites, and other more sophisticated approaches.

7) The use of physical models (wind tunnels, etc.) to provide solutions to problems that prove mathematically or observationally intractable should be further encouraged. The determination of least cost stack designs can save millions of dollars.

8) The atmospheric effects of cooling towers are of

great interest, yet it appears there may well be a surplus of models, with a real lack of validating field data concerning the plume behavior in different environments.

9) Similarly, talk of 20 000 to 40 000 MW power production parks reveals the prospects of vast amounts of waste heat released into the atmosphere. Do we understand the result in terms of affecting—or generating—convective storms?

10) The need for improving our mesoscale forecasting capability is clearly relevant to the success of SCS fuel-switching efforts. Not to be ignored is the fairly primitive state-of-the-art of analysis and display of the large amount of data involved. The computer (with associated graphic displays) should be plotting the latest Service A data. The meteorologist should be thinking—not plotting the n th straight surface chart!

11) Finally, the need for better understanding of "fair weather" meteorology continues. Also, nothing substitutes for site-specific measurements. The use of handbooks and workbooks should be a "last resort" whenever possible. What has developed as "good engineering practice" in air quality studies often turns out to be rather bad meteorology.

3. Suggested actions by the AMS and others

1) There appears to be a potential shortage in well-trained manpower in "air pollution meteorology." As pointed out by the Air Pollution Control Association (APCA) in 1974, the sharp curtailment of Federal manpower training funds will be felt for some time to come. The result will undoubtedly be that meteorological decisions will be frequently made by those from other disciplines who have had time only to "dabble" in the field. The AMS should consider some sort of manpower need/availability study and propose appropriate actions. The 1975 Workshop on Meteorology and Environmental Assessment is an excellent example of AMS efforts at "continuing education" and the production of valuable review literature.

2) Both fundamental and especially applied research in air pollution meteorology at times seem to be a hot potato. Who has the responsibility, the funds, etc.? Who is in charge? Is there a need for a review of Federal spending in the air quality area?

3) The AMS and APCA could encourage the private sector (especially utilities) to continue increasing their "bankrolling" of applied meteorological research rather than waiting for the government to some day arrive with the answer.