〈 特別講演 3 〉

Air Quality Survey Design

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The temporal and spatial variations of air pollutions are caused by emission of source gases for formation of air pollutants, changes in meterological conditions, photo-chemical reactions in the atmosphere, and removal processes of pollutants. Comprehensive survey design of air quality is to characterize the air quality and predict future distribution by collection and analysis of ambient air, data interpretation using meteorological information and chemical processes, and define air quality standards in order to protect public health and welfare, and earth's environment for future generation. Institutions (government or university) to carry out tasks for each element or combination of elements should be established and funded well in order to maintain a long term program. Four major elements in air quality survey design will be discussed; that is, planning, monitoring, simulation model, and policy making.

1. Planning

The survey design starts with the planning of a program by defining its objectives. The objectives of a program is to define the gases to be monitored and to study the impact of monitoring gases on public health, nation's economy, climate, green house phenomenon, and etc. Each monitoring gas has different effect so that the time scales can vary from hour to year, and the spatial scales can vary from ponit to gloval range. For example, ozone in urban air are produced by chemical reactions involving nitrogen compounds in automobile exhausts and should be monitored hourly within the boundary of a city for the purpose of protecting public health, while ozone in the upper atmosphere should be monitored on a much wider spatial and temporal scales to study its effect on UV radiation and climate. The responsible organization should set priorities of monitoring programs, which is affected, in most of times, by funds available for the activities.

2. Monitoring

The monitoring of air pollution is to measure the components of gases in ambient air within the temporal and spatial scales defined in the planning activity. The measurement methods and techniques can vary for individual gas, and they can be grouped into either direct sampling or indirect remote sensing technique. The direct sampling device is usually available commercially for urban air monitoring and is simple to operate with a little knowledge. It is, however, limited for measurement of one or limited number of gases and difficult to calibrate for accurate interpretation of gas concentration measurement. The remote sensing technique, on the other hand, is more versatile and applicable for various measurement objectives. It is based on the measurement of changes in radiation through the ambient gases to be monitored. Radiation measurement can be achieved either in absorption or emission mode of the Planck function, and usually can be self-calibrated. Sensors used for remote sensing are radiometer, grating spectrometer, interferometer (Fourier transform spectrometer, FTS), laser instrument, resonance fluourescence and chemilumiscence instruement, and etc. The FTS sensors are becoming very popular for application to urban air pollution monitoring, upper atmospheric measurement and laboratory chemistry laboratory.

The sampled data are then calibrated and analyzed to obtain gas concentration distributions. The retrieved results are validated with measurement of the same gas at similar condition of geographics and time using other technique. The results are also validated with theoretically predicted distributions using atmospheric simulation model.

3. Simulation Model

The atmospheric modeling is to predict distributions of gases in time and space using atmospheric transport and chemical reactions scheme with known input informations on meteorological and emission data. The modeling can be performed in various spatial scales on an one, two, or three dimensional coordinate system depending on the objectives of monitoring. The model is checked for its accuracies, and then used for future predctions.

4. Policy Making

Air quality standards are determined based on the measurements and simulation predictions for the benefit of the public. The quality standards are defined in term of allowable emission rates, measurement frequency and locations, and the allowable levels of final gas concentrations. For example, the standard for canbon monoxide in urban air is 35 ppm averaged for one hour or 9 ppm averaged over eight hours, while the standard for upper atmospheric ozone is small percentage variations in monthly averages over more than 10 years on a global scales. The survey dessign modifies itself and repeats the procedures described in sequence.

Three different survey design programs will be presented for urban air, regional air, and global air quality monitoring. Specific examples to be discussed are urban air remote sensing technique using FTS instruement, acid rain modeling, and satellite remote sensing programs such as UARS (Upper Atmosphere Research Satellite of NASA in 1991), ADEOS (Advanced Earth Observing Satellite of Japan in 1995), and EOS (Earth Observing System of NASA in 2000).