Priority Subjects — **Further Improvement of Facility Operations and Maintenance Technologies**

Development of Comprehensive Assessment Techniques for the Impact of Thermal Power on Atmospheric Environment

Background and Objective

Japan's dependence on thermal power generation and interest in the generation of geothermal power, which is renewable and can be stably supplied, have been increasing concurrent with the long-term stoppage of nuclear-power-plant operation. Prompt and low-cost assessment of the environmental impact from the construction, extension, and replacement of thermal and geothermal power plants has been required. Thermal power plants are suspected to be the emission sources of secondary-air-pollution-precursors, such as particulate matter with a diameter of 2.5 μm or less ($PM_{2.5}$) and photochemical oxidants. Thus, some measures from a scientific viewpoint will likely be demanded in the future. The objective of this research is to develop a method and a tool (software) for easy, rapid, and inexpensive assessment of atmospheric environments. In addition, an assessment method for secondary air pollution is developed to clarify the impact of emission sources and contribute to the formulation of rational measures against the emission of these agents.

Main results

1 Development of an atmospheric environmental assessment support tool for thermal power generation

The research team developed an atmospheric environmental assessment support tool applicable in a wide range of tasks from preliminary environment impact assessment to the preparation of assessment reports for the construction, extension, and replacement of thermal power plants. When source conditions (*e.g.,* position and height of stacks, specifications of emission gas) are input, the dispersion of emission gas in the atmosphere is calculated to draw a distribution of the concentration of the dispersed emission gas on a map. In addition, the support tool automatically acquires publicly available environmental concentration data to enable easy assessment of the impact of the emission gas on the surrounding environment. Furthermore, the support tool can calculate the dispersion of the emission gas from multiple sources then automatically determine particular meteorological conditions and geographical properties that may cause a high concentration of emission gas using source information and geographical data (Fig. 1) (V13020).

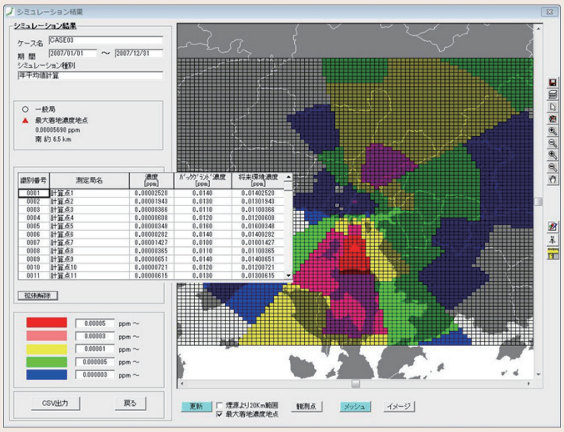
2 Development of a dispersion prediction numerical model for atmospheric environmental assessment of geothermal power generation*1

The research team has begun developing a numerical model that can replace the wind tunnel experiments generally used in dispersion prediction to speed up the time taken for atmospheric environmental assessment of geothermal power generation and reduce the associated cost. The research team constructed a simplified model that is applicable to a relatively simple geography and developed its prototype model for rapid numerical analysis. For a detailed model that covers complicated geography and the effect of reactor buildings, the results of the calculation using the model were compared with those of wind tunnel experiments to determine the precision of the turbulent-flow model used as the base model and to clarify the problems of the developed model (Fig. 2).

3 Development of an assessment method for impact of emission source on secondary air pollution

Ozone is a secondary air pollutant synthesized in the presence of nitrogen oxide and organic compounds. It is also closely related to the generation of $PM_{2.5}$. As an assessment method of the impact of the emission source on ozone concentration,*2 the applicability of a high-precision and high-sensitivity analysis method*3 and a tracer tagging method*4 with low calculation cost was compared. The result indicates that the latter overestimates the impact of the emission source on the environment close to the source compared with the former. When a similar analysis was carried out by introducing a concept that considers ozone depletion (potential ozone*5), the results obtained using the above two methods were in good agreement. From this finding, the tracer tagging method was demonstrated to be an effective assessment method for impact of the emission source on ozone concentration (Fig. 3). The achievement of this research will be utilized to assess the impact of thermal power generation on secondary air pollution.

*1 Jointly developed with New Energy and Industrial Technology Development Organization (NEDO).
*2 Index of the percentage impact of emission source in surrounding areas (countries) on atmospheric ozone concentration measured at assessment target points. This index is useful in developing efficient measures against the emission source.
*3 Method of calculating the extent of impact from the response (sensitivity) of atmospheric concentration with respect to the emission of precursors.
*4 Method of calculating the extent of impact by tagging emitted precursors and tracing their activities.
*5 Ozone disappears by chemical reaction with nitrogen monoxide to generate nitrogen dioxide. During this reaction, the concentration of potential ozone (= ozone + nitrogen dioxide) is maintained.



Main functions

- -Coupled with geographic information system (GIS)
- -Operation using graphical user interface
- -Import of meteorological data from Japan Meteorological Agency and related agencies
- -Correction of wind velocity depending on altitude
- -Determination of atmospheric stability and its conversion depending on altitude
- -Determination of particular meteorological conditions
- -Dispersion equations (puff and plume models)
- -Automatic import of environmental concentration
- -Setting of multiple stacks in one area
- -Polymerization calculation of annual mean and daily mean

Fig. 1: Display of results obtained using an atmospheric environmental assessment support tool

The results of dispersion calculation with an input of the calculation period and smoke-source conditions are displayed on a map. The color contour indicates distribution of annual mean concentration and the triangle indicates position of maximum ground concentration. The locations of air pollution monitoring stations around the smoke source and related data are automatically extracted from a public database of the National Institute for Environmental Studies to tabulate the current environmental concentrations.

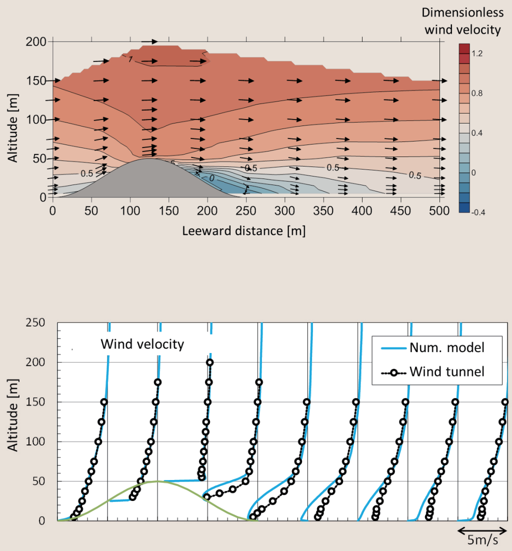


Fig. 2: Result of wind tunnel experiment (upper) and result obtained using atmospheric dispersion numerical model (detailed) for geothermal power generation (lower)

A detailed model is currently being developed using a turbulent-flow model as a base model to reproduce a complicated atmospheric current. When the result of the calculation using the model is compared with that of the wind tunnel experiment with simple geography, the general turbulent-flow model tends to underestimate the wind velocity in the main flow direction at the back of the target geography.

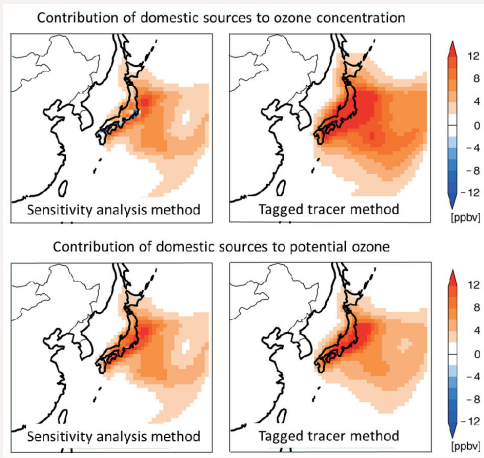


Fig. 3: Impact of domestic emission source analyzed by a high-precision and high-sensitivity analysis method and tracer tagging method

The impact of the emission source that caused a high ozone concentration exceeding the atmospheric environmental limit in springtime was evaluated. The impact of the emission source on ozone concentration in the surrounding vicinity evaluated by the tracer tagging method (upper right) tended to be larger than that evaluated by the high-precision and high-sensitivity analysis method (upper left). By introducing the concept of potential ozone, this tendency was markedly suppressed and the agreement between the results of the two methods improved (lower). Domestic emission sources include all manmade sources such as power plants and automobiles.