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Citation	Annual Report of FY 2003, The Core University Program between Japan Society for the Promotion of Science (JSPS) and National Centre for Natural Science and Technology (NCST). 2004, p. 71-74
Version Type	VoR
URL	https://hdl.handle.net/11094/13110
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OUR ENVIRONMENTAL ANALYSIS TOOLS PREPARED AND THE APPLICABILITY TO JOINT RESEARCH WITH VIETNAM

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ABSTRACT

Examples of the environmental analysis tools which our laboratory (Laboratory of Engineering for Atmospheric Environment) has prepared were introduced, and the applicability to the joint research with Vietnam was examined. They are, Atmospheric Environment Numerical Simulator, Atmospheric Environment Experimental Model, Emission Source Estimation Model from Atmospheric Environmental Observation, and Multimedia Model for Dynamic Behavior Analysis of Harmful Chemicals. It was surmised that these are applicable effectively now or in the near future also in the joint research with Vietnam.

KEYWORDS

Atmospheric environment, Numerical simulator, Experimental model, Source estimation, Multimedia model

INTRODUCTION

In our laboratory, several environmental analysis tools have been developed until now. They have been applied to our joint researches with Korea, Indonesia and Nepal. In this paper, some of them are introduced and the applicability to the joint research with Vietnam is examined.

ATMOSPHERIC ENVIRONMENT NUMERICAL SIMULATOR

This tool is prepared for carrying out the computer simulation of the meteorological condition and transportation of air pollutants in meso-scale, by solving numerically the fundamental equations of the transport of air, heat, moisture and pollutants, and is named OASIS (Osaka University Simulation System). With this tool, we have analyzed the meteorological phenomena and the transport of air pollutants in the Osaka bay area, Japan. This tool is also applied now to the analysis of the atmospheric environment in Yosu City, South Korea. For the use of this tool, the data of geographical feature, land use, and the distribution of emission amount of pollutants are required as input. For the application to Vietnam, the detailed survey of the emission amount distribution of pollutants may be an important and hard subject.

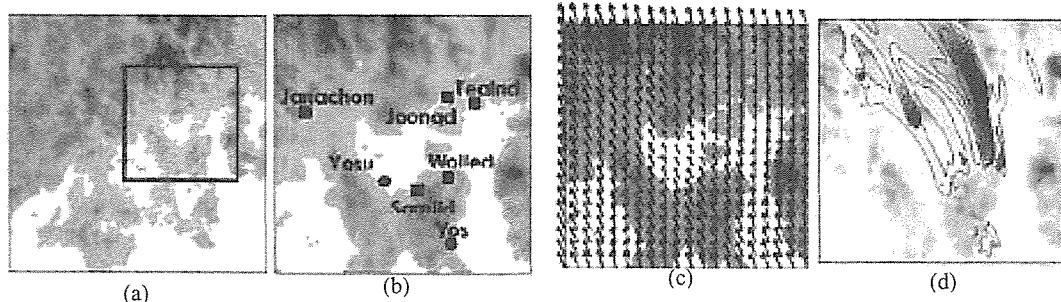


Fig.1 Application of Numerical Simulator to Yosu [(a),(b) map, (c) wind field, (d) SO₂ concentration]

ATMOSPHERIC ENVIRONMENT EXPERIMENTAL MODEL

This tool is prepared for analyzing experimentally the air pollution phenomenon in the place of special geometric form, or the phenomenon under special meteorological conditions. We have developed the technique of visualization of phenomena and of image processing as an efficient analysis means. They are PIV (Particle Image Velocimetry) for velocity distribution, thermo-crystal technique for temperature distribution, and the tracer luminosity analyzing method for mass transport. This tool is now used for the analysis of the winter high concentration in the Katmandu Valley, Nepal. In this experiment, the strong inversion layer and the cool pond generated in the valley at the winter night were reproduced by controlling the temporal change of bottom temperature of a water tank model. This tool is used also for the analysis of automobile exhaust gas dispersion near a road surrounded by buildings. Although, in Vietnam, there will be no special meteorological condition which prevents atmospheric dispersion greatly, the tool will be effective as an effect prediction in the case of planning the pollution exposure relief to the pedestrians by the wall or tree planting near heavy traffic roads.

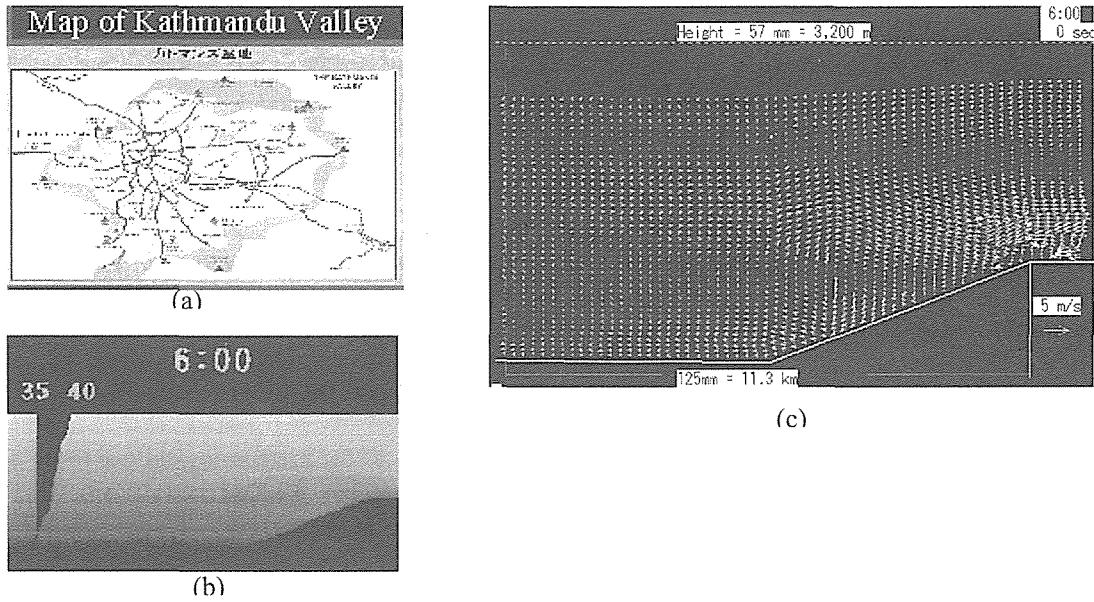


Fig.2 Application of Experimental Model to Katmandu[(a) map, (b) temperature, (c) wind velocity]

EMISSION SOURCE ESTIMATION MODEL FROM ATMOSPHERIC ENVIRONMENTAL OBSERVATION

This tool has been developed for correcting the uncertainty of the emission amount of air pollutants from the observation result of atmospheric environment by using the simple dispersion formula currently used also in environmental assessment of Japan. The concentration of chemical i ($i = 1 \sim I$) in observing point k ($k = 1 \sim K$), $C_{i,k}$, is given by the following equation as the sum of the contribution from source j ($j = 1 \sim J$). Here $Q_{i,j}$ is emission amount.

$$C_{i,k} = \sum_j Q_{i,j} F_{j,k} \quad (1)$$

The function $F_{j,k}$ expresses the transportation in the atmosphere, and is given by the following equation, considering the meteorological conditions during the observation.

$$F_{j,k} = \sum_{l,m,n} D_{l,m,n} f_{j,k}(u_l, W_m, S_n) \quad (2)$$

Here u_l is the wind velocity, W_m is the wind direction, S_n is the atmospheric stability, $D_{l,m,n}$ is the appearance frequency and $f_{j,k}$ is the plume or puff model formula. For an uncertainty correction of the amounts $Q_{i,j}$, it is expressed as the product of the assumed value $Q_{i,j,assum}$ and the correction coefficient, $\varepsilon_{i,j}$,

$$Q_{i,j} = \varepsilon_{i,j} Q_{i,j,assum} \quad (3)$$

and calculate $\varepsilon_{i,j}$ from the condition that the square of the difference between estimated and observed values,

$$E = \sum_{i,k} \left[C_{i,k,obs} - \sum_j \varepsilon_{i,j} Q_{i,j,assum} F_{j,k} \right]^2 \quad (4)$$

becomes minimum. In fact, since $C_{i,k,obs}$ includes an observation error, the number of $\varepsilon_{i,j}$ calculated has to be much lower than $I \times K$. It requires the use of same $\varepsilon_{i,j}$ for each source category. Therefore, a certain amount of accuracy is required for $Q_{i,j,assum}$. This tool was used for the analysis of atmospheric environment in Jakarta, Indonesia. As $C_{i,k,obs}$, the atmospheric concentration of NOX, SOX, TSP, and metallic components in TSP (Na, Al, Fe, Pb, K, Zn, Ti, Br, Mn, Cu, Cr, Ni, V) measured at 20 points through a year were used. For the calculation of $\varepsilon_{i,j}$, GE (Genetic Algorithm) was used to limit the range of the solution of $\varepsilon_{i,j}$. In case of applying to Vietnam, this tool should be used for the collection of emission estimation after collecting observation value and surveying the source, and then the Atmospheric Environment Numerical Simulator should be used as the following stage.

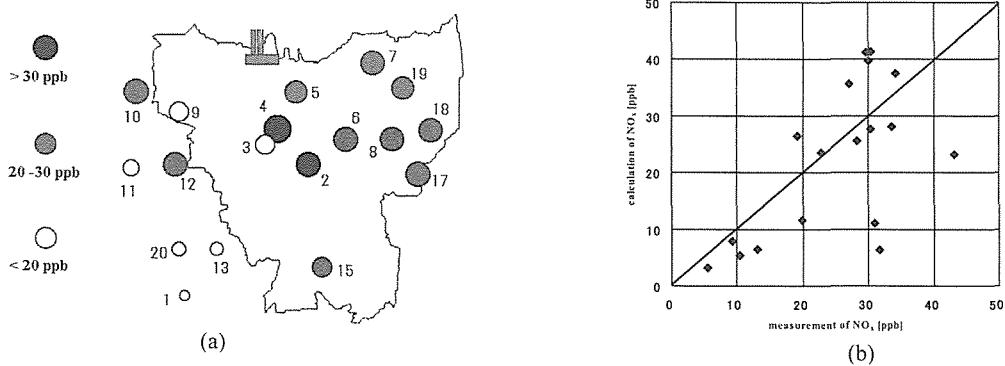


Fig.3 Application of Source Estimation to Jakarta[(a) C_{obs} of NOX, (b) comparison between C_{obs} and C_{cal} using corected emission]

MULTIMEDIA MODEL FOR DYNAMIC BEHAVIOR ANALYSIS OF HARMFUL CHEMICALS

This tool has been developed for analyzing the dynamic behavior of the substances which are distributed in multimedia (atmosphere, lithosphere, hydrosphere and biosphere), and remains over a long time in the environment, such as POPs (Persistent Organic Pollutants). Although this tool is under development and each media is expressed by one box now, it will be developed to multi-box structure to reflect geographical feature by the aid of meteorological and hydrological model. This tool was used for the analysis of the dioxin in the Kakogawa Basin, Hyogo Prefecture, Japan. Mass flux $J_{i,j}$ between media i and j was basically expressed by the form,

$$J_{i,j} = K_{i,j} (C_i - H_{i,j} C_j) \quad (5)$$

Here $K_{i,j}$ is mass transfer coefficient, C_i , C_j are concentrations in media i and j , and $H_{i,j}$ is partition coefficient. The simultaneous differential equations of C_i with time was solved numerically to obtain the temporal change of C_i from the past to the future. Since it is thought that there are many substances which need analysis also in Vietnam, such as harmful component included in the agricultural chemicals used in the past, we hope to apply this tool to these chemicals if the statistics of the past amount of discharge is available.

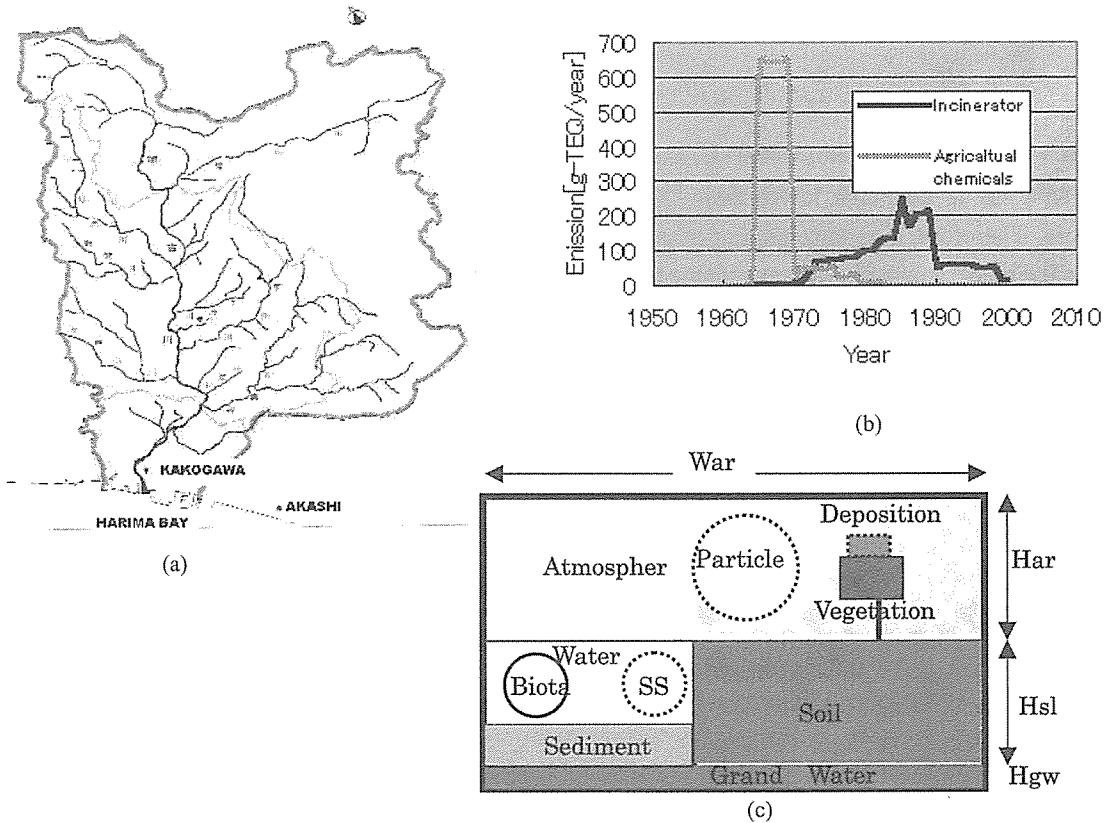


Fig.4 Application of Multimedia Model to Kakogawa Basin[(a) map, (b) emission of dioxins, (c) model structure]

CONCLUSIONS

Examples of the environmental analysis tools which our laboratory (Laboratory of Engineering for Atmospheric Environment) has prepared were introduced, and the applicability to the joint research with Vietnam was examined. Atmospheric Environment Experimental Model is applicable at present, but the technology transfer of this technique is not easy. Emission Source Estimation Model from Atmospheric Environmental Observation will applicable in the near future, and may be easy to transfer technology. Atmospheric Environment Numerical Simulator is regarded as effective in the following stage. For technology transfer, Japanese stay of an eager student will be required. Multimedia Model for Dynamic Behavior Analysis of Harmful Chemicals is applicable now if the statistics of the past amount of discharge is available, and may be easy to transfer technology.