Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

AAS022-11 Room:104 Time:May 25 11:15-11:30

CFD model considering meso-scale disturbance for gas dispersion in an urban district

Takenobu Michioka[1*], Ayumu Sato[1]

[1]CRIEPI

With the increasing availability of powerful supercomputers, numerical simulations have become a very attractive tool for simulating transport and dispersion of airborne materials in an urban district. A normal computational fluid dynamics (CFD) model, however, cannot estimate 1-hour averaged concentration which is usually used in an environmental impact assessment because a large-scale turbulent motion like a meso-scale disturbance cannot be considered in the computational domain. In the present study, a CFD model coupled to a mesoscale model is developed to estimate 1-hour averaged concentration in an urban district. FrontFlow/Red (Unemura et al. 2004) is employed for CFD model, which is based on a finite volume method with an unstructured grid system to resolve a flow structure in a complex geometry. As for a meso-scale model, the Advanced Regional Prediction System, which developed at the Center for Analysis and Prediction of Storms at the University of Oklahoma (Xue et al. 2000, 2001) is applied. Both the CFD and mesoscale models are based on a large-eddy simulation (LES). The detailed method of LES for meso-scale flows is described in Michioka and Chow (2008). The velocities obtained by the mesoscale model are directly given as the boundary conditions for the CFD model without change of velocity variables. To evaluate the performance of the developed CFD model, the model is applied to simulate tracer gas dispersion released from the roof of the building in Komae Research Laboratory at CRIEPI (Central Research Institute of Electric Power Industry) in Japan, where field experiments were conducted in 3 February 2005.

Figure 1 shows the ground concentration which are averaged over 1 hour (15:30 - 16:30). During the period, the wind direction was almost North and the atmospheric stability was nearly-neutral. The concentration C* is noramalized by the reference velocity, Uref, and source strength, Q. It is found that the ground concentration estimated by normal CFD model is larger than that in the field experiment. This is attributed to the fact that normal CFD models do not consider a large-scale turbulent motion like a meso-scale disturbance. It also means that normal CFD models tend to overestimate 1-hour averaged ground concentration. On the other hand, the gas concentration obtained by the developed model is widely distributed compared to that in the normal CFD model owing to large-scale turbulent motion generated in the meso-scale model, and the concentration are nearly equal to that in the field experiment.

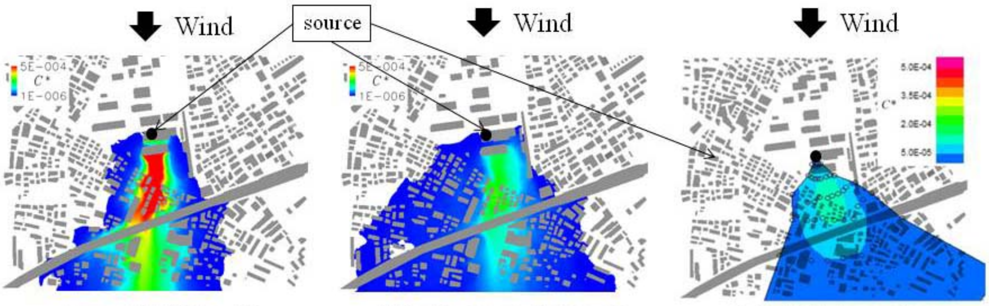
References

Unemura, T., Zhang, H. Taniguchi, N., 2004. Development of the Fluid Dynamic Simulation Software FrontFlow/Red, Monthly Journal of the Institute of Industrial Science, University of Tokyo, 56, 40-43 (in Japanese).

Xue, M. et al., 2000. The Advanced Regional Prediction System (ARPS): A multi-scale nonhydrostatic atmospheric simulation and prediction tool. Part I: Model dynamics and verification. Meteor. Atmos. Pys., 75, 16-193.

Xue, M. et al., 2001. The Advanced Regional Prediction System (ARPS): A multi-scale nonhydrostatic atmospheric simulation and prediction tool. Part II: Model physics and applications. Meteor. Atmos. Pys., 76, 143-165.

Michioka, T., Chow, F. K., 2008. High-resolution large-eddy simulations of scalar transport in atmospheric boundary layer flow over complex terrain. J. App. Meteor. Soc., 47, 3150-3169.



a) a normal CFD model b) the developed CFD model c) the field observation

Figure1 1-hour averaged ground concentration

Keywords: Gas dispersion, 1-hour averaged concentration, Meso-scale model, Large-eddy simulation, Urban district