Elementary Processes of Convective and Diffusive Transport in Urban Environment and Next-Generation Turbulence Modeling

Yasutaka Nagano
(Nagoya Institute of Technology, Executive Vice-President)

【Outline of survey】

A great amount of energy consumption and commodities in urban areas causes various environmental problems such as the heat-island effect and air pollution. In addition, the population concentration in urban areas can inevitably increase the scale of a disaster. As a fundamental technology for helping us cope with these problems, we are urgently required to construct reliable simulation methods for heat and fluid flows, i.e., turbulence models, that can accurately predict and evaluate the convective and diffusive processes of heat, toxic gases, suspended particulate matter called SPM, etc. The convective and diffusive processes of heat and mass in urban areas are incomparably more complex than those over the plains because of the mutual interference of buildings and complex landscape, e.g., hills. The present study should be promoted based on the concept of engineering turbulence modeling which has been rigorously tested as the standard method for predicting transport phenomena related to engineering equipment. The specific targets of the present study are as follows: 1) to extract elementary processes of heat and mass transport in urban areas; 2) to reveal the characteristics of each elementary process by organic integration of experiment, theory and direct numerical simulation (DNS); 3) to develop turbulence models for the elementary processes on the basis of the knowledge obtained in the above and to unify those models; and 4) to construct next-generation turbulence models which enable accurate prediction and reliable evaluation of various transport phenomena in urban areas.

【Expected results】

A unique approach is adopted for the construction of next-generation turbulence models, in which the engineering turbulence models---almost reaching perfection as a standard tool for analyzing transport phenomena in equipment scale---are evolved so as to be applicable for the prediction of mesoscale (ranging from building to city) transport phenomena. There is a strong societal demand for a reliable simulation method for these mesoscale phenomena, and the method needs to remain accurate even in the analysis of an urban environment having complex interference of buildings and landscapes. The next-generation turbulence models thus developed are expected to become a fundamental technology that can respond to such a societal demand. The results of the present study can not only be used for the prediction and evaluation of the mesoscale convective and diffusive transport of heat and/or harmful substances, but also for developing, for example, a real-time simulation method for transport phenomena arising from disasters.

【References by the principal researcher】

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【Homepage address】 http://heat.mech.nitech.ac.jp/