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

AAS022-05 Room:104 Time:May 25 09:30-09:45

Large-eddy simulation of atmospheric boundary layer flow with artificial inflow turbulence

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Due to the rapid growth of computer resources, the boundaries between mesoscale meteorological model (MMM) and engineering large-eddy simulation (eLES) models are overlapping. Recently, there are some examples of very high-resolution MMM and some examples of eLES that deal with very large computational domains. As the next phase of such simulation studies, attempts to merge MMM and eLES are being made. However, the conventional concepts of MMM and eLES are different because an apparent spectral gap has existed between both models. There are various differences associated with 1) turbulence scale, 2) physical processes, 3) variables and parameters, etc., between MMM and eLES; namely, there are many difficulties to merge MMM and eLES seamlessly.

For merging MMM and eLES, the boundaries for eLES are basically given from the output obtained with MMM. However, small-scale fluctuations required for eLES, in particular, small-scale velocity fluctuations at the inflow boundary (inflow turbulence), cannot be obtained from MMM in which the grid resolution is coarser than that of eLES. Thus, to generate inflow turbulence appropriately is one of the most important issues for successful coupling eLES with MMM.

In this study, we conduct LES computations for an atmospheric boundary layer (ABL) flow with artificial inflow turbulence. The inflow turbulence is generated using an artificial method based on a prescribed energy spectrum in the wave number domain proposed by Lee et al. (Phys. Fluids, 1992). A remarkable advantage in their method is that the continuity condition can be easily imposed on the generation procedure. On the other hand, the artificial method of Lee et al. (1992) can generate only homogeneous isotropic turbulence. In order to apply the artificial method to the analysis of ABL (anisotropic turbulence flow), therefore, we divide the inflow boundary into several vertical layers and apply the generation method with different target turbulence intensity and length scale for each layer.

Keywords: Large-Eddy Simulation, Turbulence, Inflow Turbulence, Atmospheric Boundary Layer, Energy Spectrum, Inverse Fourier Transform