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Large-Eddy Simulation on Turbulent Flow and Plume Dispersion over A 2-Dimensional Hill

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The dispersion analysis of airborne contaminant including radioactive substances from industrial or nuclear facilities is the important issue for maintenance of air quality or safety assessment. Many studies on the plume dispersion behavior in the simulated atmospheric boundary layer flow over flat plain have been conducted mainly by wind tunnel experiments. However, many nuclear power plants are located at complex coastal terrains in Japan. In this case, topographical effects on the turbulent flow and plume dispersion should be investigated. Therefore, we perform Large-Eddy Simulations (LES) on turbulent flows and plume dispersions. As the first step of this study, we try it for a 2-dimensional hill flow and investigate the characteristics of mean and fluctuation concentrations.
In order to produce a realistic turbulent boundary layer flow, we set up two computational domains. One is the driver region for generating the spatially-developing boundary layer flow and the other is the main computational region for plume dispersion over a 2-dimensional hill. Near the inlet of the driver region, roughness blocks for generating a thick turbulent boundary layer are placed. The inflow turbulence data obtained in the driver region are imposed at the inlet of the main computational domain at each time step. The sizes of driver and main computational regions are 46.25H×6.25H×25.0H and 37.5H×6.25H×25.0H (H: the height of a 2-dimensional hill) in x-, y- and z-directions, respectively. Here, x, y and z indicate streamwise, spanwise and vertical directions, respectively. The number of grid points of driver and main computational regions are 400×100×90 and 400×100×90 in x, y and z directions, respectively. A 2-dimensional hill model has 5.45H length and are placed at a distance of 10.4H downstream from the inlet of the main computational region. A release point of a tracer gas is located at a distance of 9.09H upstream from a 2-dimensional hill top and elevated with the height of 0.45H. In the present study, LES is performed using the standard Smagorinsky model (Smagorinsky,1963) and immersed boundary method (Fadlun et al.,2000) is applied at a hill surface.
As the results, we can capture the unsteady behavior of turbulent flow and plume dispersion over a hill and clarify the difference between mean concentration profiles over the flat plain and a hill.