Development of the Boundary Layer Model based on LES model for Fog Simulation

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Many modeling studies have been performed in order to better understand the physics and microphysics of fog. Particularly, One-dimensional (1-D) models have often been used to investigate the role of physical processes on radiation fog. There are several 1-D models incorporating significant physical process on fog formation and its life cycle such as vegetation effect and detailed microphysics process. Since they used 1-D ensemble-average turbulence models, however, they cannot simulate explicitly turbulent motions, which are important to the growth of fog. Recently, owing to improvement of computer performance , three-dimensional large-eddy simulation (LES) models have also been used for fog simulation (e.g. Nakanishi, 2000). Until today, however, most LES models for fog studies have been limited to horizontally uniform surface and introduced only very simple physical schemes.

In this research, we develop a LES model with detailed treatments of microphysics, radiation, vegetation and urban effects. Additionally, we perform fog simulation using the LES model focusing on radiation fog events observed during the Paris-Fog field experiment, called ParisFog (Haeffelin et al. 2010).

In this talk, we will briefly describe the LES model developed in this study at first. Dynamics part of our model is based on Ikeda et al. (2012). Numerical and physical schemes in the LES model are listed in Table 1. A bin microphysical scheme (Geresdi 1998; Rasmussen et al. 2002, Xue et al., 2010) has been implemented in the LES model since fog simulation requires detailed treatments of aerosol and drop size distributions that cannot be represented by bulk schemes. The radiation schemes, which are taken from WRF, have been modified to be capable of considering effects of absorption, reflection and scattering in the atmosphere above top of the computational domain. The LES model has also been coupled with multi-layer vegetation canopy model developed in this study. Effect of dew deposition on leaves can be considered in this model.

Several model verification tests are performed focusing on typical radiation fog events during the period of Parisfog in that the fog and aerosol properties have been measured. The preliminary results of this study are presented here.

Table 1: Model description.

Basic equations	Boussinesq approximation
Coordinate	Cartesian
Discretization approach	Finite difference method
Grid system	Arakawa-C staggered
Time integration scheme	3rd order Runge-Kutta
Spatial difference	2nd order central or 3rd order upwind
Solution method for the equations	SMAC
Solution method for the poisson equation	Bi-CGStab method
SGS model	Smagorinsky or Deardorff
Short-wave radiation	Dudhia (1989)
Long-wave radiation	Mlawer et al. (1997)
Surface model	Bulk, Mascart (1995)
Vegetation model	Multi-layer
Cloud physics	Warm-rain bulk or Warm-rain bin

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