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High-resolution modelling for air quality in Hong Kong using Large-eddy simulation (LES)

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Abstract

Air quality in urban areas is difficult to simulate due the complex air flows in the cities and the heterogeneous emission sources. Therefore, high model resolution is required to better represent the spatial distributions and temporal variations of the chemical pollutants between the neighborhoods and at the street level. This work exploits the Weather Research and Forecasting (WRF) model with a large-eddy simulation (LES) component and with coupled chemistry to conduct high-resolution simulations in Hong Kong, a polluted megacity with multi-type pollution sources as well as complex topography. The segregation effect by the turbulence-chemistry interactions is evaluated in the LES simulations. The results show that the segregation intensity is largely influenced by the inhomogeneity in the surface emissions, as well as the complexity in the topography. The coupled multi-resolution simulations from mesoscale to LES scales are evaluated by comparing the calculated fields with ozone sounding profiles and with the observations at surface monitoring stations. The evaluation shows that both mesoscale and LES simulations reproduce well the mean concentrations of the chemical species and their diurnal variations at the background sites; however, the mesoscale simulations largely underestimate the NO_X concentrations and overestimate O_3 near roadside stations due to the coarse representation of the traffic emissions. The LES simulations improve the agreements with the measurements near the road traffic, and the LES with highest spatial resolution (33 m) provides the best results. The LES simulations show more detailed structures of the spatial distributions of chemical species than the mesoscale simulations, indicating the capability of LES of resolving high-resolution photochemical transformations in urban areas like Hong Kong.