period of time (e.g., 5 minutes).

Couple With Mesoscale Models

As mentioned above, the time-varying inflow condition for micro-scale environment simulation could be derived from mesoscale meteorological models (Kunz *et al*., 2000; Liu *et al*., 2012; Sanchez *et al*., 2017; Wyszogrodzki *et al*., 2012; Zheng *et al*., 2015). In such kind of multi-scale simulations, the coupling method between microscale and mesoscale models should be mentions. Kunz *et al*. (2000) mentioned the coupling method consisted of three elements, including a 3D spatial interpolation scheme, a spatial adjustment of values, such as wind velocity and temperature, within the surface layer, and the formulation of the lateral boundary conditions to introduce the interpolated values into the microscale models. In the interpolation scheme, the fraction of a partial volume to the whole volume was taken as the interpolation weighting factor. The similarity theory was used in adjusting the interpolated values, where the microscale wind speed in the surface layer is either calculated by a power law or a logarithmic law (Kunz *et al*., 2000). Differences between the turbulence models in mesosacle and microscale simulations should be also coupled (Temel *et al*., 2016, 2018;). Using the reported wind data from the mesoscale meteorological model, e.g., WRF, the lateral and top boundary conditions in the micro-scale simulations, varying with time, could be performed, for example, changing gradually from one wind data to the next. In this case, the variation of inflow conditions would be assumed in gradually variation style, as shown in Figure 5(a). The open/ zero-gradient boundary conditions (Wyszogrodzki *et al*., 2012) could be applied at outflow boundaries. In most of the reviewed literatures, the gradual variation mode (or linearly interpolation method) was often selected to trace temporal variation of the inflow wind (Cui *et al*., 2013; Liu *et al*., 2012; Tewari *et al*., 2010; Wyszogrodzki *et al*., 2012).

Some Other Methods

The two methods introduced above have been validated as feasible for micro-scale simulations. However, there are some other methods that have been proposed for some other purposes, which could be useful for simulating the natural background wind conditions (Efthimiou *et al*., 2017; Garcia-Sanchez *et al*., 2014, 2017; Gorle et al., 2015; Lucas *et al*., 2016; Thorarinsdottir and Johnson, 2012; Valero *et al*., 2014).

Thorarinsdottir and Johnson (2012) proposed a method for forecasting wind gust, which could contribute to the determination of the wind gust probability. Valero *et al*. (2014) also studied the forecasting method of wind strength from observed daily wind gust data. These statistic methods would be useful for future studies. Garcia-Sanchez *et al*. (2014, 2017) investigated the quantifying inflow uncertainties from an ensemble of 729 RANS simulations.

Overall, methods in performing time-varying boundary conditions need further investigations. Firstly, all the methods should be validated according to measurements. Fortunately, some wind tunnel or in-situ measured wind and/or pollutant concentration data have been published, which may be helpful in model validations (Brown et al., 2013; Garcia-Sanchez *et al*., 2014; Kunz et al., 2000; Liu *et al*., 2012; Sun *et al*., 2016; Tse *et al*., 2017; Wyszogrodzki *et al*., 2012; Zhang *et al*., 2012). Secondly, effects of variation styles of inflow wind speed and/or direction on airflow characteristics within urban street canyons should be investigated. As pointed in this work, inflow wind speed and/or direction might change in a slow or fast ways. Simulated results under these two different variation styles have not been compared. And also, the balances on mass, momentum, and TKE should be satisfied in simulations as well (Kunz *et al*., 2000; Temel *et al*., 2018).

SUMMERY

Meteorological observation data show that natural wind has characteristics of regular time-variation in speed and/or direction. Currently, the time-varying inflow conditions are usually simplified as a constant wind profile in simulation on airflow and pollutant dispersion in UCL. Recent studies have revealed that the flow features could vary significantly influenced by lateral boundary conditions, including the predominant wind direction and speed. The values of VTT of pollutant under the real-time boundary conditions are clearly higher than those under the stable boundary conditions. Thus, simulations under natural background wind conditions are of importance.

The time-varying inflow conditions can be performed through in-situ measured wind data or via forecasting data obtained from the mesoscale model. Gradual and/or stepped variation styles of wind data would be expected. To prevent the numerical divergence in simulations, the controlling on variation process of inflow wind is important.

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SUPPLEMENTARY MATERIAL

Supplementary data associated with this article can be found in the online version at http://www.aaqr.org.

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