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Urban roughness sublayer characteristics: sensitivity to planetary boundary layer schemes and multi-layer urban models

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The Pearl River Delta (PRD) region in China is characterized by a large fraction of urbanized areas of which the growth rate is unprecedented. Modelling a realistic meteorological field for such a region is challenging mainly due to the uncertainties in the meso-scale numerical model, and the paucity of high-resolution profiler-type observations. In this study, we aim to improve the understanding of the urban effects on the modelled meteorological field in the PRD region by applying different fine-tuned planetary boundary layer (PBL) schemes coupled with two multi-layer urban models and leveraging the high spatial-temporal wind LiDAR observations. Particularly, the momentum in the urban roughness sublayer (RSL, about three times the building height) will be thoroughly investigated using long-lasting profiler-type observations.

The Weather Research and Forecast (WRF) model offers a variety of PBL schemes which may feature a non-local transport algorithm under unstable atmospheric conditions. Most PBL schemes utilize the surface layer fluxes calculated based on the Monin-Obukhov similarity theory, acting on the first model layer only. Although this bulk parameterization of surface layer fluxes is appropriate for urban areas occupied predominantly by low-rise buildings, it is unable to reflect the momentum drag and thermal exchange processes when the average building height (H) within a model cell greatly exceeds the height of the lowest model. Multi-layer urban models, Building Effects Parameterization (BEP), and Building Energy Model (BEM) can be coupled with PBL schemes to provide a more realistic interaction between buildings and air within the RSL. Required input for initializing the multi-layer urban models include H and average street width, which can be simply prescribed (assumed) or derived from the local climate zones.

Despite many efforts have been made to study the improvements by urban models on the surface meteorological variables, such as 10-m wind speed, 2-m temperature and moisture, little investigation of modelled results has been carried out focusing on the RSL and the entire boundary layer over a long-time series due to scarce observations. Recently, three wind LiDAR units were deployed in Hong Kong, providing us with a valuable opportunity to monitor wind profile evolution continuously at a 25-m and 1-hr resolution and to reveal the transport of surface layer fluxes to the overlying RSL. In the result section, we first present the wind speed profiles to understand the benefits of a multi-layer urban model compared to the bulk parameterization,

justified by the LiDAR observations. Secondly, as the non-local PBL scheme can transport the surface fluxes to non-adjacent cells, a comparison of the momentum flux profile will be presented between local and non-local PBL schemes under different stabilities.