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Impact of an improved WRF-urban canopy model on diurnal air temperature simulation over northern Taiwan

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This study evaluated the impact of urbanization over northern Taiwan using the Weather Research and Forecasting (WRF) model coupled with the Noah land-surface model and a modified Urban Canopy Model (WRF-UCM2D). In the original UCM coupled in WRF (WRF-UCM), when the land use in the model grid is identified as “urban”, the urban fraction value is fixed. Similarly, the UCM assumes the distribution of anthropogenic heat (AH) to be constant. Such not only may lead to over- or underestimation of urban fraction and AH in urban and non-urban areas, spatial variation also affects the model-estimated temperature. To overcome the above-mentioned limitations and to improve the performance of the original UCM model, WRF-UCM is modified to consider the 2-D urban fraction and AH (WRF-UCM2D).

The two models were found to have comparable temperature simulation performance for urban areas but large differences in simulated results were observed for non-urban, especially at nighttime. WRF-UCM2D yielded a higher correlation coefficient (R2) than WRF-UCM (0.72 vs. 0.48, respectively), while bias and RMSE achieved by WRF-UCM2D were both significantly smaller than those attained by WRF-UCM (0.27 and 1.27 vs. 1.12 and 1.89, respectively). In other words, the improved model not only enhanced correlation but also reduced bias and RMSE for the nighttime data of non-urban areas. WRF-UCM2D performed much better than WRF-UCM at non-urban stations with low urban fraction during nighttime. The improved simulation performance of WRF-UCM2D at non-urban areas is attributed to the energy exchange which enables efficient turbulence mixing at low urban fraction. The achievement of this study has a crucial implication for assessing the impacts of urbanization on air quality and regional climate.