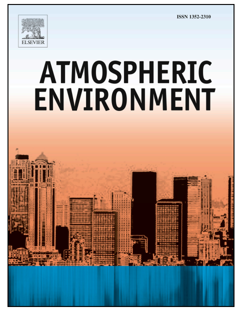

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Assessment of a high resolution annual WRF-BEP/CMAQ simulation for the urban area of Madrid (Spain)

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Abstract

Urban air quality has become one of the main environmental issues worldwide and there is an increasing need for modelling tools able to accurately reproduce the complex atmospheric phenomena that determine pollutant concentrations within cities. Eulerian 3D mesoscale models can consistently describe a wide range of spatial scales. However, urban areas present features that are usually missed by land-surface and PBL modules commonly implemented in such models. The Weather Research and Forecasting model (WRF) incorporates urban parameterizations to take into account changes in albedo, roughness length and thermal properties imposed by buildings. In this study, a model configuration based on the multi-layer Building Effect Parameterization (BEP) scheme is tested over the city of Madrid with the primarily aim of understanding the effect that the use of this urban canopy model may have on routinely (annual) air quality modelling activities in this urban area using the Community Multiscale Air Quality (CMAQ) model. To do so, the results for the main meteorological variables (temperature, planetary boundary layer height and wind fields) are compared with those from the WRF reference configuration (based on the BULK simple scheme) that has been used in the past for practical applications in this urban area. Both model outputs are compared with observations to assess changes in model performance. It was found that the BEP-based configuration improved significantly wind speed results over built areas, with an annual average bias of -0.3 m s^{-1} in comparison with the 1.6 m s^{-1} yielded by the reference WRF run. Meteorological outputs from the two alternative configurations were used to feed the CMAQ model to assess the influence of this urban parameterization on air quality predictions. The effect was a clear improvement of the model performance regarding the most relevant pollutants, reducing NO_2 underestimation to only 1.6 µg m^{-3}. Model skills to reproduce O_3 and $PM_{2.5}$ ground-level concentration were also substantially improved. The results from this study clearly support the use of the BEP-based configuration for annual CMAQ runs despite the increase of the computational time and input data requirements. Seasonal and day-night time performance differences indicate that future efforts should be aimed at improving energy balances within BEP under stable conditions. Also, the development of methods to provide better land-use information and more