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#### ACCEPTED MANUSCRIPT

# 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 9 increasing need for modelling tools able to accurately reproduce the complex atmospheric 10 phenomena that determine pollutant concentrations within cities. Eulerian 3D mesoscale models can 11 consistently describe a wide range of spatial scales. However, urban areas present features that are 12 usually missed by land-surface and PBL modules commonly implemented in such models. The 13 Weather Research and Forecasting model (WRF) incorporates urban parameterizations to take into 14 account changes in albedo, roughness length and thermal properties imposed by buildings. In this 15 study, a model configuration based on the multi-layer Building Effect Parameterization (BEP) 16 scheme is tested over the city of Madrid with the primarily aim of understanding the effect that the 17 use of this urban canopy model may have on routinely (annual) air quality modelling activities in 18 this urban area using the Community Multiscale Air Quality (CMAQ) model. To do so, the results 19 for the main meteorological variables (temperature, planetary boundary layer height and wind 20 fields) are compared with those from the WRF reference configuration (based on the BULK simple 21 scheme) that has been used in the past for practical applications in this urban area. Both model 22 outputs are compared with observations to assess changes in model performance. It was found that 23 the BEP-based configuration improved significantly wind speed results over built areas, with an 24 annual average bias of -0.3 m s<sup>-1</sup> in comparison with the 1.6 m s<sup>-1</sup> yielded by the reference WRF 25 run. Meteorological outputs from the two alternative configurations were used to feed the CMAQ 26 model to assess the influence of this urban parameterization on air quality predictions. The effect 27 was a clear improvement of the model performance regarding the most relevant pollutants, reducing 28 NO<sub>2</sub> underestimation to only 1.6 µg m<sup>-3</sup>. Model skills to reproduce O<sub>3</sub> and PM<sub>2.5</sub> ground-level 29 concentration were also substantially improved. The results from this study clearly support the use 30 of the BEP-based configuration for annual CMAQ runs despite the increase of the computational 31 time and input data requirements. Seasonal and day-night time performance differences indicate 32 that future efforts should be aimed at improving energy balances within BEP under stable 33 conditions. Also, the development of methods to provide better land-use information and more 34

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