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Evaluation of MM5 PBL schemes in an urban coastal site over the western Mediterranean by LIDAR and meteorological data

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Boundary layer and land surface processes have critical implications on air quality. In this contribution, meteorological fields are simulated with the Fifth Generation Penn State-NCAR Mesoscale Model (MM5), a three-dimensional non-hydrostatic prognostic model applied in Barcelona which is a coastal urban site surrounded by complex orography located over the western Mediterranean basin. Three different PBL schemes with high horizontal (9, 3 and 1 km) and vertical (29 σ-layers) resolution are evaluated with LIDAR and radiosounding data: the Gayno-Seaman (GS) PBL, based on Mellor-Yamada TKE prediction (Gayno et al., 1994); the MRF PBL, based on Troen-Mahrt representation for countergradient term and K profile in the well mixed PBL (Hong and Pan, 1996); the Pleim-Chang (PC) PBL, the Asymmetric Convective Model, using a variation on Blackadar's non-local vertical mixing (Pleim and Chang, 1992).

Two different scenarios are analysed: winter and summer. The synoptic situation in the winter day is characterised by an anticyclone centered over the Iberian Peninsula (IP) and North Africa, surrounded by three low-pressure areas over the Atlantic Ocean, Northern Europe and Central Europe inducing north-western flows over the study area. The PBL height reaches a maximum value of 1000 m agl. The summer situation is characterised by the absence of large-scale forcing, the development of the Iberian thermal low and compensatory subsidence over the western Mediterranean basin and breeze circulations over the study area. The PBL remains under 600 m agl due to

thermal internal boundary layer formation and large mesoscale subsidence.

The discussion focuses on the ability of the 3 parameterisations to reproduce the observations (temperature, humidity, horizontal winds, and the diurnal cycle of the PBL height (LIDAR)). The differences between the various meteorological simulations are solely due to differences in the PBL schemes. Nevertheless, since the methods for diagnosing the PBL height by MM5 depend on the PBL scheme used, we also rediagnose the PBL heights using a common method (Holtslag et al., 1990), in which the PBL height is determined where the bulk Richardson number exceeds a critical value. Both possibilities are generally present in the pre-processors of air quality modelling systems such as CMAQ/MODELS3. Differences are pronounced in some cases: the GS scheme underpredicts the PBL height (in more than 100 % in the winter and summer cases) when using the MM5 TKE threshold value while it overpredicts the PBL height in less than 50 % in the summer case and slightly underpredicts the PBL height in the winter case when using the Richardson number method; the MRF scheme overpredicts the PBL height in the summer and winter cases but while the differences are between 80-100 % when using the MM5 diagnose, they are substantially reduced (less than 25%) when using the Ricahrdson number method from Holtslag et al. (1990). Only slight differences are observed between different high horizontal resolutions (9, 3 and 1 km).

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