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Inclusion of Saharan dust in an integrated air quality forecasting system for Europe

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The complex atmospheric conditions in southern Europe during summer involve the superposition of phenomena occurring at different scales that exert a high influence in the levels of particulate matter and its composition. Namely, the contribution of mineral aerosols is very high due to the existence of semiarid soils and specially the frequent occurrence of Saharan dust events in southern Europe. When considering only anthropogenic emissions, chemistry-transport model simulations recursively underestimate the PM10 and PM2.5 concentrations using the current knowledge about aerosol physics and chemistry. Therefore, the introduction of boundary conditions for Saharan dust is necessary in order to model correctly the PM mass over Europe. Dust peaks cannot be represented by introducing boundary conditions derived from a dust climatology due to the highly episodic nature of the events in the region (1-4 days average duration).

In order to account for the local/regional pollution and the Saharan dust contribution, the Barcelona Supercomputing Center the BSC-CNS currently operates high-resolution air quality forecasts for Europe with WRF/ARW-EMEP-CMAQ modelling system under the umbrella of the Caliope project (http://www.bsc.es/caliope/) and Saharan dust forecasts over Europe with ETA/DREAM (http://www.bsc.es/projects/earthscience/DREAM/). The resolution of the air quality forecasts has been improved from existing forecasting systems for 12 km and 1-hr thanks to the calculation capacity of the MareNostrum supercomputer.

The objective of this work is to provide an operational PM10 and PM2.5 product for air quality forecasting in Europe by on-line adding the Saharan dust contribution from DREAM to the anthropogenic output of CMAQ. This addition is performed by using a bi-linear interpolation of CMAQ and DREAM integration grids into a unique common grid. The necessity of coupling both aforementioned systems in an integrated framework is addressed by the study of an entire year (2004). As a first approach, the natural dust contribution from ETA/DREAM is added on-line to the anthropogenic output of CMAQ. The performance of the model has been quantitatively evaluated with discrete and categorical (skill scores) statistics by a comparison of the first-layer simulations results of CMAQ+DREAM and the values measured in the European stations belonging to the EMEP network with available data for the year 2004 (26 stations for PM10 and 17 stations for PM2.5). The results indicate an improvement in the discrete statistics for particulate matter (the normalised bias improves from -20% to -9% and the normalised error from 36% to 30% when considering all the stations in Europe for an annual cycle) and skill-scores evaluation (accuracy, critical success index and probability of detection) of PM10 and PM2.5 concentrations when using CMAQ+DREAM compared to CMAQ-alone simulations. This improvement in the quality of the predictions becomes more important in those southern stations undergoing larger impacts of Saharan dust outbreaks (the normalised error improves from 40-60% to 30-40% for PM10 and from 30-40% to 25-30% for PM2.5 concentrations).

The results of this work demonstrate that this first approach to the coupling of CMAQ anthropogenic outputs with DREAM natural dust forecasts in an operational way is necessary in order to improve the prediction of the particulate matter mass over southern Europe and to achieve the standards set in European Directives for modelling applications.