Assimilation of PM 10 measurements in the air quality model AURORA by using Kalman filtering techniques

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1 Introduction

Data assimilation is the common name given to several numerical techniques that combine the outputs of a numerical model with observational data in order to improve the quality of the model predictions. This work presents the results of using data assimilation techniques such as the Ensemble Kalman Filter (EnKF)[1] and the Deterministic Ensemble Kalman Filter (DEnKF) [2], for improving the PM 10 (particles with diameters ranging from 0 to 10 micrometers) estimations of the air quality model AURORA. The EnKF and the DEnKF are built around a stochastic formulation of the model, where some of its parameters are assumed to be uncertain. The uncertainty in these parameters turns out to be the main reason behind the differences between the model predictions and the real measurements. The filters estimate these parameters as well as the PM 10 concentrations by using ground-based measurements provided by IRCEL, the Belgian Interregional Environment Agency. The assimilation experiments are carried out over a region that consists of Belgium, Luxembourg, and some small parts of Germany, France and the Netherlands. The horizontal domain is divided into 59 x 49 grid-cells with a resolution of 5 km. Regarding the vertical domain, 22 layers are used to span an altitude of 2000 m. The model was set up for simulating a period of 12 days starting on January 20th, 2010 at midnight. This period is of special interest since within it a PM 10 episode took place, that is, elevated PM 10 concentrations were registered. In this study, we used the measurements provided by 21 air quality stations. These stations were split into two groups: (i) assimilation stations and (ii) validation stations. The first group was used in the assimilation process to obtain the optimal estimate of the state. The second group was not used in the assimilation, but only to verify the results.

2 Results and Future research

Figure 1 shows the average of the PM 10 concentration over the validation stations. Notice that AURORA is not able to properly follow the data. In spite of the big gap between AURORA and the measurements, both data assimilation techniques manage to notably reduce this gap. For the case of the EnKF, the error is decreased by 65.39% in the assimilation stations and by 53.44% in the validation stations. For the DEnKF the error in the assimilation and validation stations is reduced by 68.27% and 55.88% respectively. Future work will be focused on performing assimilation experiments for longer periods, e.g., 6 months or 1 year, while keeping the current spatial domain and the resolution of 5 km.

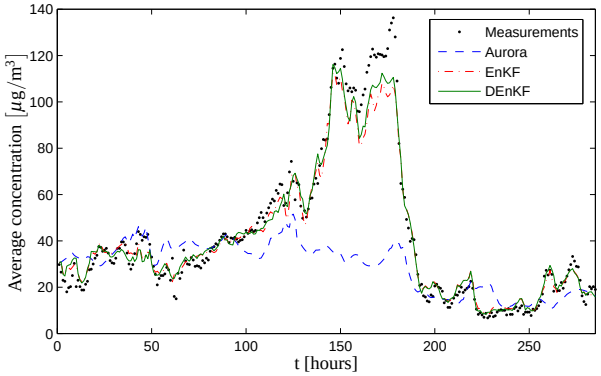

Figure 1: Average of the PM 10 concentration over the validation stations. Starting date: January 10th, 2010.

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