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Probabilistic air quality simulation and Bayesian filtering using POLYPHEMUS/DLR

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A large part of the uncertainty in air quality forecasts is caused by our lack of knowledge about pollutant emissions. While it is certainly possible to improve on existing emission inventories and models, no truly convincing solution for the provision of anthropogenic emission information is in sight. As a consequence, we believe it is necessary to quantify the resulting uncertainty. This goal can be achieved using probabilistic modelling using an ensemble of model runs representing the spectrum of potential situations regarding emissions or other input parameters. Such an approach is of special interest for air pollution, since we are often interested in whether a certain threshold is exceeded or not.
In such a situation, answers given by a single model may easily be wrong even if the model itself is reasonably good. In fact we may say that the best possible answer is given by providing a probability of the threshold exceedance.

In order to address this task, information on the error of the emissions including spatiotemporal covariances is required. Since such information is hardly available, the resulting ensemble needs some form of calibration in order to provide a realistic probability distribution.

In this study we demonstrate that a Bayesian filtering technique using in-situ observations can be used to provide an a-posteriori calibration of the ensemble probability and at the same time perform data assimilation. While usually geophysical problems appear to be unsuited to Bayesian filters, the convergent nature of air quality models allows their successful application. We will use the POLYPHEMUS/DLR regional air quality model to create an ensemble of forecasts for the area of Southern Germany. Different ways of ensemble generation will be considered by including uncertainties of different input parameters such as emissions and meteorology. In this way an a-priori estimate of the model uncertainty is obtained that will be the basis of further analysis.

We demonstrate that the use of a Bayesian filter based on in-situ observations provides a significant improvement of the ensemble mean. Furthermore we will analyze the resulting probabilities for threshold exceedance. This work is performed in the context of the FP7 project PASODOBLE and is intended to ultimately result in an operationally used system.