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A comparison study of data assimilation algorithms for ozone forecasts

L. Wu (1, 2), V. Mallet (1, 2), M. Bocquet (2, 1), and B. Sportisse (2, 1)

(1) INRIA, Paris-Rocquencourt research center, France, (2) Université Paris-Est, CEREA, joint laboratory ENPC - EDF R&D, France (Lin.Wu@inria.fr)

There is a recent diffusion of data assimilation expertise from numerical weather prediction (NWP) to air quality community. However, the atmospheric chemistry-transport models (CTM) are stiff but stable systems; the perturbations on initial conditions tend to be smoothed out rather than amplified. Therefore the conclusions from meteorological experiences cannot be applied directly. We perform a comparison study of assimilation algorithms. Hopefully this could serve as a base point for the design of assimilation algorithms suitable for one-day ozone forecasts in realistic applications.

The underlying CTMs are highly uncertain [Hanna et al., 1998, Mallet and Sportisse, 2006]. The main difficulty of the ozone data assimilation problem is how to account for the strong model uncertainties. Four assimilation methods have been considered, namely optimal interpolation (OI), reduced-rank square root Kalman filter (RRSQRT), ensemble Kalman filter (EnKF), and four-dimensional variational assimilation (4DVar). The model uncertainties are either parameterized with homogeneous error correlations or estimated by perturbing some sources of the uncertainty. The four assimilation algorithms are compared under the same experimental settings. It is found that the assimilations significantly improve the ozone forecasts. The comparison results reveal the limitations and the potentials of each assimilation algorithm. In the four-dimensional variational method, it is shown that the model error has to be accounted for to further improve the forecasts. In the sequential methods, the ensemble approach demonstrates great potential for the forecasts during the end of the prediction periods. The sensitivities of assimilation performances to the algorithm parameters are

also investigated.