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Validation of a chemical data assimilation system

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Data assimilation can be used with air quality models to improve historical simulations or initial conditions for forecasts. We present two data assimilation schemes coupled to the DEHM (Danish Eulerian Hemispheric Model), a three-dimensional, off-line chemical transport model with full photo-chemistry. The first scheme was a local ensemble transform Kalman filter, a variant on the ensemble Kalman filter, which uses a low-dimensional stochastic representation of the background errors. The second scheme involved the three-dimensional variational method, with a climatological background error model, in which correlations are assumed to be homogeneous and isotropic in the horizontal plane (i.e., depending only on the separation distance), and non-separable in the horizontal, vertical and chemical dimensions.

Retrievals from polar-orbiting satellites of multiple atmospheric trace gases were assimilated. These were: OMI tropospheric column NO_2, SCIAMACHY total column CH_4, MOPITT partial column CO, and TES partial column O_3, CO and CH_4. Data for each species were assimilated independently of one another. Other species were only adjusted indirectly via the model's chemistry and dynamics. Assimilation results were compared against measurements from surface monitoring stations and other satellite retrievals, and preliminary validation results are presented.

The initial results show are promising. For example, reference simulations (i.e., without assimilation) grossly underestimate surface CO concentrations, and both assimilation schemes eliminate this large and systematic bias. At the surface, the assimilation improved to the spatial correlation for CO, and the winter-time temporal correlation for NO_2. However, results for O_3 and CH_4 suggest that further work is needed for these species, in terms of the observation operator or the choice of which level to assimilate. Finally, the potential for improving modelled surface concentrations is discussed in relation to the vertical sensitivity of the retrievals.