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Model bias dynamics in the ensemble Kalman filter: application to assimilation of CO column retrievals

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Data assimilation is widely used in geophysical sciences to integrate model and observational data in a statistically consistent framework. In-situ or remotely sensed measurements are often assimilated into chemical transport models to generate historical reanalyses or initial conditions for chemical weather forecasts. The ensemble Kalman filter (EnKF) is a popular assimilation technique, and is relatively simple to implement, accounts for model non-linearity and dynamically evolves background covariances. An EnKF assimilation system has been coupled to the Danish Eulerian Hemispheric Model (DEHM), a hemispheric-scale, offline, chemistry-transport model.

Initial assimilation experiments with the DEHM-EnKF system suggested that there may be systematic biases for some chemical species modelled (e.g. carbon monoxide). This is problematic in itself, and violates a key assumption underlying the EnKF. Consequently, the DEHM-EnKF was extended to allow concurrent estimation of model bias.

Two different treatments are considered for the evolution of the bias field: persistent biases or time-varying biases. Time-varying biases are evolved using a technique called “tagging”, whereby a perturbation to the concentration field is tracked during integration of the full non-linear model. These two treatments are applied to the problem of assimilating satellite retrievals of carbon monoxide column concentrations. Additional simulations are presented for comparison, including a free run (without data assimilation) and a run with the bias-blind EnKF scheme. The results are verified against measurements from ground-based monitoring stations, representing an independent set of observations.