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Parameter field estimation for atmospheric dispersion: application to the Chernobyl accident using 4D-Var

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Off-line atmospheric chemistry and air quality numerical models are driven by uncertain forcing fields: emissions, boundary conditions, wind fields, vertical turbulent diffusivity, kinetic chemical rates, etc. Data assimilation can help assess these parameters or fields of parameters. Because the parameters are a priori much more uncertain than the fields diagnosed in meteorology and oceanography, data assimilation is much more an inverse modelling challenge in this context. In this study we experiment on these ideas by revisiting the Chernobyl accident dispersion event over Europe. We develop a fast four-dimensional variational scheme (4D-Var) which seems appropriate for the retrieval of large parameter fields and for the retrieval of parameters that are non-linearly related to concentrations. The 4D-Var, and especially an approximate adjoint of the transport model, are tested and validated using several advection schemes, quite influential on the forward simulation as well as for the data assimilation results.

Firstly, the inverse modelling system is applied to the dry deposition and the wet deposition parameters. It is then applied to the emission field and larger parameter fields, such as horizontal and vertical diffusivities, or even dry deposition velocity field. The crucial question of deciding whether the inversions are just tuning of parameters, or retrieval of physically meaningful quantities is discussed. As a by-product, the choice of parameters for the Chernobyl dispersion simulation used so far in the literature is shown to be supported by the study, while the inversion of some of the parameter fields are shown to improve the skills of the simulation significantly.