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Multiscale data assimilation in geophysics: optimising the geometry of control space

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In geophysical data assimilation the observations are shedding light on a control parameter space, through a model, a statistical prior and an optimal combination of these sources of information. This control space can be a set of discrete parameters, or, more often in geophysics, part of the state space which is distributed in space and time.

When the control space is continuous, it must be discretised for numerical modelling. This discretisation, which we call a *representation* of this distributed parameter space, is almost always fixed a priori. Here the representation of the control space is considered a degree of freedom on its own. The goal is to show that one could optimise it to perform data assimilation in optimal conditions.

A possible mathematical framework is proposed for multiscale data assimilation. The optimal representation is chosen over a large dictionary of adaptive grid representations involving several space and time scales. In order to keep the developments simple, a measure of the reduction of uncertainty is chosen as a very simple optimality criterion. A cost function based on this criterion is built in order to select the optimal representation. It is a functional of the control space representation itself. A regularisation of this cost function, based on a statistical mechanical analogy, guarantees the existence of a solution. This allows to perform numerical optimisation on the geometry of control space.

The formalism is then applied to inverse modelling in atmospheric chemistry at continental scale, using synthetic and real data. The gain for data assimilation from this optimal geometry is quantified.