Implicit sampling and its connection to variational data assimilation

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Implicit sampling is a Monte Carlo importance sampling method and we present its application to data assimilation. The basic idea is to construct an importance function such that the samples (often called particles) are guided towards the high-probability regions of the posterior pdf, which is defined jointly by the model and the data. This is done in two steps. First, the high-probability regions are identified via numerical minimization; second, samples within the high-probability regions are obtained by solving data dependent algebraic equations with a random right-hand-side. Specifically, one first finds the mode of the posterior pdf and then solves algebraic equations to obtain samples in the neighborhood of this mode. In variational data assimilation, one finds the mode of the posterior pdf. There is thus a connection between implicit sampling and variational data assimilation. In particular, one can turn variational codes into implicit sampling methods (filters or smoothers) by adding a sampling step (i.e. solving simple algebraic equations). The benefit can be that implicit sampling can be used to obtain the conditional mean, which is the minimum mean square error estimate, as well as quantitative information about the uncertainty of this state estimate. We present an example in detail to explain the implicit sampling and the resulting data assimilation algorithms in their variational implementation.