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Particle filters for high-dimensional non-linear systems: a revised implicit equal-weights particle filter

Javier Amezcua (2,3), Jacob Skauvold (1), Peter Jan van Leeuwen (2,3)

(1) Norwegian University of Science and Technology, Norway, (2) University of Reading, Department of Meteorology, United Kingdom, (3) National Centre for Earth Observation, United Kingdom

With ever increasing model resolution and more complex observation operators the data-assimilation problem becomes more and more nonlinear, asking for a fully nonlinear data-assimilation method like a particle filter. While the standard particle filter is degenerate in high-dimensional systems recent developments have opened the way for new particle filters that can be used in these systems.
The implicit equal-weights particle filter (IEWPF) is a very efficient particle filtering scheme which avoids filter degeneracy by forcing all particle to keep equal weights by construction. This allows the filter to be used in very high-dimensional systems with a large number of independent observations. To achieve this, the method uses implicit sampling whereby auxiliary vectors drawn from a proposal distribution undergo a transformation before they are added to each particle. The mapping used for the transformation includes a parameter which is different for each particle, and must be determined by solving a nonlinear scalar equation.
In the original formulation of the IEWPF, the proposal distribution has a gap causing all but one particle to have an inaccessible region in state space, which can lead to biased estimates. In this work we modify the proposal distribution to eliminate the gap, and discuss conditions that should be satisfied by the mapping in order to ensure complete coverage, keeping in mind the aim of re-sampling as few particles as possible. The resulting filter is tested in synthetic experiments using the Lorenz96 model with varying dimensions, to develop a particle filter that performs independent of the dimension of the system.