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A backtracking algorithm that deals with particle filter degeneracy

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Particle filters are an excellent way to deal with stochastic models incorporating Bayesian data assimilation. While they are computationally demanding, the particle filter has no problem with nonlinearity and it accepts non-Gaussian observational data. In the geoscientific field it is this computational demand that creates a problem, since dynamic grid-based models are often already quite computationally demanding. As such it is of the utmost importance to keep the amount of samples in the filter as small as possible. Small sample populations often lead to filter degeneracy however, especially in models with high stochastic forcing. Filter degeneracy renders the sample population useless, as the population is no longer statistically informative. We have created an algorithm in an existing data assimilation framework that reacts to and deals with filter degeneracy based on Spiller et al. [2008]. During the Bayesian updating step of the standard particle filter, the algorithm tests the sample population for filter degeneracy. If filter degeneracy has occurred, the algorithm resets to the last time the filter did work correctly and recalculates the failed timespan of the filter with an increased sample population. The sample population is then reduced to its original size and the particle filter continues as normal. This algorithm was created in the PCRaster Python framework, an open source tool that enables spatio-temporal forward modelling in Python [Karssenberg et al., 2010] . The framework already contains several data assimilation algorithms, including a standard particle filter and a Kalman filter. The backtracking particle filter algorithm has been added to the framework, which will make it easy to implement in other research. The performance of the backtracking particle filter is tested against a standard particle filter using two models. The first is a simple nonlinear point model, and the second is a more complex geophysical model. The main testing criterium is computational time, as the backtracking algorithm allows for more efficient filter calculations.

References
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