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Data assimilation: using Indistinguishable States to solve Berliner's problem of chaotic likelihoods

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Berliner (1991) points out a number of difficulties in applying the Bayesian paradigm to state estimation in chaotic systems. Even in the perfect model scenario, likelihood methods have difficulty in providing good estimate of the initial condition (or the model parameters). In large part, the difficulty lies in the failure to skillfully meld information in the dynamics of the non-linear system itself with that from the observations. A new approach using indistinguishable states (Judd and Smith, 2001) is shown to be effective both for parameter estimation and in data assimilation (state estimation). An Indistinguishable States Importance Sampler (ISIS) is shown to successfully combine information from both observations and dynamics, thereby locating high likelihood states, an aim demonstrated to be impossible by traditional methods in Berliner's paper. In short, Berliner shows that the relative likelihood surface is extremely complicated, and that states with relatively high relative likelihood are almost certain to be very improbable, given the observations and the noise model. By identifying indistinguishable states in the original problem posed by Berliner (1991), ISIS overcomes the difficulties he identified with chaotic likelihoods and successfully finds high likelihood candidates for the true state.

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