Probabilistic Noise Reduction

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Abstract

State estimation is an important factor in the production of accurate forecasts. Great effort is expended in reducing the noise inherent in observations, to produce a best estimate of the true system state. But noisy observations necessitate a probabilistic, not a deterministic, approach to state estimation. A state's probabilistic description is rarely Gaussian, and requires information beyond variance magnitude; the correct distribution is restricted by the underlying structure of the system attractor. The concepts of finite-time stable and unstable sets are introduced and data assimilation-based methods for their estimation are developed. 4-dimensional variational assimilation proves adept at finding the finite-time stable set valid at the beginning of assimilation windows while the ensemble Kalman filter is capable of approximating the finite-time unstable set at any time that an observation is available. Combining the results of the two schemes produces a probabilistic estimate of the system state that is superior to either in isolation.