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Insensitivety to initial condition/prior in data assimilation for the case of the optimal filter and deterministic model

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Data assimilation is a term used to describe efforts to improve our knowledge of a system by combining incomplete observations with imperfect models. This is more generally known as filtering, which is 'optimal' estimation of the state of a system as it evolves over time, in the mean square sense. In a Bayesian framework, the optimal filter is therefore naturally a sequence of conditional probabilities of a signal given the observations and can be updated recursively with new observations with Bayes' formula. When, the dynamics and observations errors are linear, this is equivalent to the Kalman filter. In the nonlinear case, deriving an explicit form for the posterior distribution is in general not possible.
One of the important difficulties with applying the nonlinear filter in practice is that the initial condition, the prior, is required to initialise the filtering. However we are unlikely to know the correct initial distribution accurately or at all. A filter is called stable if it is insensitive with respect to the prior, that is, it converges to the same distribution, regardless of the initial condition.
A body of work exists showing stability of the filter which rely on the stochasticity of the underlying dynamics. In contrast, we show stability of the optimal filter for a class of nonlinear and deterministic dynamical systems and our result relies on the intrinsic chaotic properties of the dynamics. We build on the considerable knowledge that exists on the existence of SRB measures in uniformly hyperbolic dynamical systems and we view the conditional probabilities as SRB measures 'conditional on the observation' which are shown to be absolutely continuous along the unstable manifold. This is in line with the result of Bouquet, Carrassi et al [1] regarding data assimilation in the "unstable subspace", where they show stability of the filter if the unstable and neutral subspaces are uniformly observed.

[1] M. Bocquet et al. "Degenerate Kalman Filter Error Covariances and Their Convergence onto the Unstable Subspace". In: SIAM/ASA Journal on Uncertainty Quantification 5.1 (2017), pp. 304–333. url: https:

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