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# Parameter adaptation as machine learning in the synchronization approach to data assimilation

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The proper goal of data assimilation is to synchronize two dynamical systems, one describing ‘‘truth" and the other a computational model, by passing limited information through a noisy channel linking the two systems unidirectionally. A large body of research in the dynamical systems community on synchronized chaos can thus be brought to bear on the problem of data assimilation. The synchronization approach is equivalent to the usual methods (3DVar or Kalman Filtering) except in highly nonlinear regions of state space, where synchronization can be used to provide a theoretical basis for ad hoc corrections such as covariance inflation.

Where there is model error, one needs to exploit the non-identical correspondence, or "generalized synchronization" between truth and model. The best way to do this is typically not to decipher a commonly intractable correspondence function, but to extend the dynamical equations so as to effect a slow adaptation of model parameters. The main result is that it is surprisingly easy to prescribe such deterministic equations for model parameters, for situations ranging in complexity from a pair of Lorenz systems to a pair of quasigeostrophic channel models.

The parameter adaptation equations in all cases can be argued to monotonically decrease the value of a Lyapunov function that is bounded below, and thus will cause model parameters to converge to true parameters except where the Lyapunov function has local minima. The use of a stochastic component, in combination with the deterministic equations, to escape such local minima is explored. The stochastic component might later be extended to a genetic algorithm for qualitative model adaptation. In a broader view of data assimilation as machine perception, with synchronized chaos playing the role of synchronicity in the Jungian view, the parameter adaptation scheme proposed here defines an approach to machine learning.