The role of additive and multiplicative noise in filtering complex dynamical systems

John Harlim

Department of Mathematics, North Carolina State University, USA, jharlim@ncsu.edu

Covariance inflation is an ad-hoc treatment that is widely used in practical real-time data assimilation algorithms to mitigate covariance underestimation due to model errors, nonlinearity, or/and, in the context of ensemble filters, insufficient ensemble size. Here, we systematically derive an effective "statistical" inflation for filtering multi-scale dynamical systems with moderate scale gap, $\varepsilon = O(10^{-1})$, to the case of no scale gap with $\varepsilon = O(1)$, in the presence of model errors through reduced dynamics from rigorous stochastic subgrid-scale parametrizations.

We will demonstrate that for linear problems, an effective covariance inflation is achieved by a systematically derived additive noise in the forecast model, producing superior filtering skill. For nonlinear problems, we will study an analytically solvable stochastic test model, mimicking turbulent signal in regimes ranging from a turbulent energy transfer range to a dissipative range to a laminar regime. In this context, we will show that multiplicative noise naturally arises in addition to additive noise in a reduced stochastic forecast model. Subsequently, we will show that a "statistical" inflation factor that involves mean correction in addition to covariance inflation is necessary to achieve accurate filtering in the presence of intermittent instability in both the turbulent energy transfer range and the dissipative range.

Reference:

[1] G. Gottwald and J. Harlim, "The role of additive and multiplicative noise in filtering complex dynamical systems**"** ***Proc. R. Soc. A*****, 2013. (in press)**