28*th* IUGG Conference on Mathematical Geophysics, June 7-11, 2010, Pisa, Italy
Session 8: Data assimilation and model validation

Ensemble Local H-infinity Filter for data assimilation

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Keywords: *data sssimilation, Kalman Fitler, H-infinity filter, Ensemble Kalman Filter*

In this work we consider the H-infinity filter and its variants for data assimilation. The H-infinity filter is derived by minimizing the loss in the worst case, a criterion different from the minimum variance used in the Kalman filter. Thus by design, the H-infinity filter is more robust than the Kalman filter, in the sense that the estimation error in the H-infinity filter has a bounded growth rate with respect to the uncertainties in estimation, while the estimation error of the Kalman filter does not possess such a guarantee. Despite the difference between the criteria in deduction, it turns out that the H-infinity filter bears a very similar structure to that of the Kalman filter. In fact, it can be shown that the Kalman filter is a special case of the H-infinity filter, while the H-infinity filter algorithm itself can be constructed based on that of the Kalman filter.

The original form of the H-infinity filter contains global constraints (in time), which may be inconvenient to solve for recursive filters. Therefore here we introduce a variant, which requires solving some local constraints instead, hence will be called the local H-infinity filter. Furthermore, analogous to the ensemble Kalman filter (EnKF), we also propose the concept of ensemble local H-infinity filter (EnLHF). We give the general form of the EnLHF, and discuss some of its special cases. We show that these special cases are similar, or even identical, to some of the EnKF methods with covariance inflation in the literature. We also use two numerical examples to illustrate the relative robustness of the EnLHF in comparison to the EnKF method (without covariance inflation), in the presence of larger than expected uncertainties in data assimilation.