Informatics Research
Institute of Toulouse

Seminar

Tuesday 20 February 2018
12h15 – 13h00
INP-ENSEEIHT, Salle des thèses

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Dynamics-based reduction of data assimilation for chaotic models and the role of covariance inflation in reduced-rank filters

Abstract: Data assimilation in geophysics handles huge sets of data. As opposed to big data techniques, data assimilation uses high-dimensional dynamical models to make sense of these data. For the sake of consistency and computational efficiency, there are several pragmatic ways in geophysical DA to discard irrelevant data, through quality control, thinning, etc; and others to reduce the model complexity: upscaling, parametrizations, etc. Quite differently, we will show how certain features of the dynamics of chaotic models could be used to alleviate such big data problem.

This talk will focus on the impact of the unstable and neutral subspace, i.e. the space spanned by the backward Lyapunov vectors with non-negative exponents, on (ensemble) Kalman filtering and smoothing techniques. We will demonstrate that, in the linear and perfect model case, the error covariance matrix is asymptotically supported by the unstable and neutral subspace only [Gurumoorthry et al, 2017; Bocquet et al., 2017]. The extension of these results to linear noisy systems is considered and the impact of noisy on the optimal design of the ensemble setup is studied [Grudzien et al., 2017]. We will then examine what becomes of this picture in the weakly nonlinear, possibly imperfect model case, and will also discuss how this extends to new techniques such as 4D nonlinear ensemble variational methods [Bocquet and Carrassi, 2017].

Finally, utilizing the dynamical properties of the filtration for the backward Lyapunov vectors, we will describe the intrinsic role of covariance inflation in reduced rank, ensemble based Kalman filters [Grudzien et al., 2018]. Our derivation of the forecast error evolution describes the dynamic upwelling of the unfiltered error from outside of the span of the anomalies into the filtered subspace. Analytical results for linear systems explicitly describe the mechanism for the upwelling, and the associated recursive Riccati equation for the forecast error, while nonlinear approximations are explored numerically. These investigations suggest how the cost of representing the uncertainty in chaotic dynamical systems could be significantly reduced.

Co-publication with :

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