Self-Breeding: A new Approach to the Estimation of Uncertainty Structures in Meso-Scale NWP models

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The estimation of fast growing error modes of a system is a key interest of ensemble data assimilation when assessing uncertainty in initial conditions. Over the last two decades three methods (and variations of these methods) have evolved for global numerical weather prediction models: ensemble Kalman filter, singular vectors and breeding of growing modes (or now ensemble transform). While the former incorporates a-priori model error information and observation error estimates to determine ensemble initial conditions, the latter two techniques directly address the error structures associated with Lyapunov vectors. However, in global models these structures are mainly connected to global wave patterns.

When using meso-scale limited area models, these perturbations structures are therefore often included using perturbed boundary conditions while the initial perturbations (when used) are often generated with a variant of an ensemble Kalman filter which does not necessarily focus on the fast-growing error structures.

In the framework of the European regional reanalysis project of the Hans-Ertel-Center for Weather Research we use a meso-scale model with an implemented nudging data assimilation scheme which does not support ensemble data assimilation. In preparation of an ensemble-based regional reanalysis and for the estimation of three-dimensional atmospheric covariance structures, we implemented a new method for the assessment of fast growing error modes for meso-scale limited area models: The so-called self-breeding is an adaption of the breeding of growing modes technique which can be used to identify uncertainty structures arising from short time scale phenomena such as convection.

In the self-breeding system, initial perturbations are integrated forward for a short time period and then rescaled and added to the initial state again. Iterating this rapid breeding cycle provides estimates for the initial uncertainty structure (or local Lyapunov vectors) given a specific norm for an arbitrary time step (not necessary an analysis time step). We present results from case study experiments, which show the ability of the self-breeding cycle to produce reasonable uncertainty structures for convective events.