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Dependence of the minimal ensemble size in the EnKF on the ensemble spread

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This study investigates the dependence of the minimal ensemble size on the ensemble spread in the case of a perfect nonlinear model. In is based on the experiments with the 40-dimensional Lorentz model.

We find that the minimal ensemble size varies between the number of non-decaying Lyapunov modes plus one to the state vector dimension, depending on the degree of constraint of the system. In all experiments the evolution of the ensemble anomalies during integration remains mainly linear, that is the system remains in a weakly nonlinear regime.

This increase of the minimal ensemble size is shown to be accompanied by a growth of "noise" in the projections of the ensemble anomalies on the vectors of the orthogonalised Lyapunov basis corresponding to decaying modes. Therefore, an EnKF system with a perfect model in a weakly nonlinear regime can manifest two distinctly different states. The "strongly constrained" state is characterised by the ensemble staying mainly on the attractor, while a "loosely constrained" state is characterised by a persistent distance off the attractor that is possibly small, but has important implications for the behaviour of the system.