Using the EnKF in L96

NCEO Intensive Course on Data Assimilation

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The objective of this practical is to perform DA experiments in L96 with the ensemble Kalman filter using localisation. We focus on model space localisation in the stochastic EnKF. The domain localisation needed for LETKF is very slow without parallel implementation, so we do not perform that in this exercise.

1 Instructions for Lorenz 96

- *ControlL96EnKF.py*. This is the control file. You will run and modify this file.
- *L96model.py*. This file contains all the instructions to run the L96 model.
- *L96misc.py*. This file generates different observation operators, creates the observations, and generates a simple background error covariance matrix.
- *L96Kfs.py*. This file contains the routines to perform SEnKF and ETKF.
- *L96plots.py*. This file has instructions for different plots.

You will run different sections of the file *ControlL96Var.py*. These are enumerated as comments of the file (recall that in python # is used for comments). To run **only** a section of a file you can highlight the desired instructions with the mouse, and the press F9.

1.1 Instructions

- The first lines of the file import the different packages that the file uses: numpy, matplotlib, and the functions we have created for this activity.
- *Section 1.* This section generates the **nature** run of the experiment, i.e. what we consider to be the true system. You can change the initial conditions, the final time (consider that the model time step is 0.025 time units), and the initial guess from which the assimilation will start. For speed in computations and to display figures in an easier manner, we have selected $N_x = 12$ variables. This model can be run from some given initial conditions, but the default is to spin it up from a perturbation around the unstable fixed point of the system. You will get a Hovmoller diagram (a contour plot showing the time evolution of the different variables in a circle of latitude), as well as a figure with N_x panels. This section also defines the initial guess for the data assimilation

- *Section 2.* This section is related to the observations. You can select to observe different variables with three options: $'all'$ corresponds to observing all variables, $'1010'$ corresponds to observing every other variable, and $'landsea'$ corresponds to observing only half of the domain (a challenging setting). Different options will create a corresponding observation matrix. The **R** matrix is designed to be diagonal (common assumption), but you can choose the observational variance. You can also choose the observational period (in number of model steps). In this model the time auto-correlation is quite small, so we recommend to experiment with observational periods of no larger than 4 time steps.

- *Section 3.* This section contains the DA experiments using ETKF, SEnKF and L-SEnkF. You can vary the type of function used in the localisation: $cutoff$ for a window function and GC for Gaspari-Cohn (a compact-support approximation to a Gaussian). The parameter lam is the half-width of the localisation. The system displays a tileplot of the localisation matrix.

2 State estimation with the Lorenz 1996 model

1. Run the Lorenz 1996 model to a maximum time $t = 4$ and plot the trajectory. This nature run will be the basis of our experiments. Generate a synthetic observation set with some of the options mentioned next.

2. Localisation. This model has variables in which we can define a physical distance, so we can explore the use of localisation. This will be specially important when the number of ensemble members is smaller than the number of state variables. In this case we will only experiment with the localised SEnKF using the Gaspari-Cohn function for localisation. We leave the observational frequency at 2 model steps, the observational error standard deviation at $\sqrt{2}$, and the observational density 1010. Try the following configurations:

Ensemble size	Inflation	Localisation radius
24	0	None
””	””	2
8	0	None
””	0.1	””
””	0.5	””
””	0	1
””	””	4
””	0.2	3

What is the effect of using localisation? Is there a simple interaction between inflation and localisation? If you have time, try the more challenging 'landsea' configuration.