Ensemble Kalman Filter

Earth Observation Summer School 2018

1 Exercises with the Lorenz 1963 model

1. Run the Lorenz 1963 model to a maximum time $t = 10$ and plot the trajectory. This nature run will be the basis of our experiments

2. State estimation 1. In the Lorenz 1963 system we only have 3 variables, so we can easily afford to run more ensemble members than variables. There is not a well-defined 'physical distance' between these variables, so the concept of localisation does not apply. For this first experiment let us fix the observational standard deviation $\sqrt{2}$, and vary the following: the observational frequency, the observation density, the ensemble size. Select ETKF as method.

Obs frequency	Obs density	Ensemble size
10	xyz	100
””	””	10
””	y	100
””	””	10
20	xyz	100
””	””	10
””	y	20
””	z	20

   How does the observational frequency influence the estimation? What about the observational density? What about the ensemble size? Repeat the experiments (or some of them) with SEnKF and compare the results.

3. State estimation 2. Now let us try a more challenging setting by limiting our ensemble size to $N_e = 3$, using ETKF first and then SEnKF. In this case it is possible you will need inflation to make the filter work. Suggestion: try values of $\mathcal{O}(10^{-2})$ for frequent observations, and $\mathcal{O}(10^{-1})$ for infrequent observations

Obs frequency	Obs density
10	xyz
””	y
””	z
20	xyz
””	y
””	xz

   How are the results in this case? What happens as you increase the inflation values? Can you always find an inflation value that ensures a good result?

2 Exercises 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

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 'land-sea' configuration.