Variational methods: 3DVar and SC-4DVar

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. 3DVar. In this case the following parameters can vary: the frequency of observations in time (in model steps), the density of observations in space, the observational error covariance (here we consider it to be diagonal with the same variance for the all observed variables), the background error covariance (we let it be fixed as obtained by the code). Do experiments with the combinations indicated in the following table:

Obs frequency	Obs density	Obs std
10	x,y,z	1
” ”	” ”	$\sqrt{2}$
” ”	” ”	2
” ”	x	1
” ”	” ”	$\sqrt{2}$
20	x,y,z	1
” ”	” ”	$\sqrt{2}$
” ”	y	1
” ”	” ”	$\sqrt{2}$
20	z	0.5

How does the observational frequency influence the estimation? What about the observational density? Are all variables of this model equally 'informative'?

3. 4DVar. In this case we have another parameter to vary: the length of the assimilation window. In this exercise it expressed in number of observational times per window. Try the following numbers: $\{1, 2, 4, 6\}$ for some of the configurations of the previous exercise. What is the difference between 3DVar and 4DVar with only 1 observational time? How does the performance change as you include more and more observational times? Is this a steady behaviour?

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. 3DVar. In this case we will fix the observational standard deviation to $\sqrt{2}$. The following parameters can vary: the frequency of observations in time and the density of observations in space. Do experiments with the combinations indicated in the following table:

Obs frequency	Obs density
2	all
""	1010
""	land-sea
4	all
""	1010
""	land-sea

What can you say this time about the different observational densities and the observation frequency?

3. 4DVar. As before we vary the length of the assimilation window. Try the following number of observational times per window: $\{1, 2, 4\}$ for some of the configurations of the previous exercise. What is the influence of the length of the assimilation window in the performance of the DA? How does this change with respect to the observational network?