Illustrating Bayes theorem with Gaussian mixtures

NCEO Intensive Course on Data Assimilation

University of Reading, 2022

The objective of this activity is for the student to perform experiments with the SIR (simple importance resampling) particle filter in a 0D stochastic system. This is described by the following equation:

$$x_t = ax_{t-1} + bx_{t-1}|x_{t-1}| + v_t, \quad v_t \sim N(0, q^2)$$

1 Description of the code

1.1 Files

These are the python files used in this activity:

- *ControlsLmPf.py*. This is the control file. You will run and modify this file.
- *functionsLmPf.py*. This file has the code to compute the evolution of the 0D stochastic system. It also contains the SIR PF implementation

You will run different sections of the file *ControlsLmPf.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.

2 Exercises

1. Run the model with the following combinations. You will perform DA with the different options, for now just think of the behaviour of the system under different combination of parameters.

a	b	q
0.98	-0.1	0.1
0.98	-0.1	0.025
0.5	-0.5	0.5
0.5	-0.5	0.1

2. Generate an observational data set to experiment with. Start with the first of the following settings, and then repeat the experiments with the rest.

observational period	r
5	0.1
5	0.25
10	0.1
10	0.25

3. Finally, perform the particle filtering. Repeat the experiments with the following ensemble sizes:

M
5
10
20
100
1000

There are two plots coming from this experiment. Can you see the resampling process at the time of the observation? What happens to the weights as the ensemble size increases?

You can turn off the resampling process. However, in this case you have to be careful since the model can diverge if the initial conditions are 'bad'.