Intensive Course on Data Assimilation
Buenos Aires, Argentina
27 October - 7 November 2008

MATLAB EXERCISES

OPTIMAL INTERPOLATION – 3DVAR. (Matlab code developed by Shu-Chi Yang)

1) Run the 3 variables Lorenz's model for 2000 time steps using two slightly different initial conditions.
a) Using the "plot3" function draw the 3D model trajectory.
b) Using the plot function, draw the evolution of the first 100 time steps of both simulations in the X variable. Explain the behavior of both evolutions. What would you say is the limit for the predictability of the Lorenz's model?

2) Perform 1000 assimilation cycles (8 time steps long) assuming that observations for each variable are available.
a) Display B, H and R matrices. Explain the meaning of each component.
b) Plot the last 100 values of the first component of Xa, Xb, Xo and Xt in the same figure.
c) Compute the error of the analysis, the background error and the observation error. Check if the relation between them is as expected.
d) Repeat the experiment but only with available observations for y and z.
e) Repeat the experiment but only with available observations for z. Why is the error so big in this case? Compare for example with an experiment assimilating only observations for x.

3)
a) How could B be estimated from the previous experiment? Compute the components of B from the result of some of the previous experiment. Is it possible to apply this idea to the atmosphere? Why? (hint: you can use Matlab´s covar function to compute a covariance matrix)
b) Using the provided scripts estimate and compute the error variance and covariance for the Lorenz 63 model. Is the covariance matrix independent of model state?
c) If the time between two assimilation cycles gets larger, what would be the impact over the diagonal of B? Why?
d) Set the number of time steps between two assimilations to 16 but use the same B.

4) Repeat the assimilation cycle experiment assuming that:
a) The observed variable is X+Y+Z:
Modify the assimilation scheme to use this information and generate the corresponding pseudo observations from the true state. Find an example of this type of observation in the atmosphere.

5) Using the script error covariance plot the components of the covariance matrix as a function of the position of the system in the X-Y plane. Which is one of the limitations of the 3DVAR approach?

ETKF (Matlab code developed by Shu-Chi Yang)

6) Using the ETKF code for the 3 variable Lorenz' s model repeat exercise 2 and compare the results with those obtained with OI.

ADITIONAL OI EXERCISES

7) Assume that we have two locations where we want to estimate the wind speed. At those two locations the background value of the wind speed is 8 m/s and 12 m/s, while the observed wind speed is 9 m/s and 14 m/s respectively. What are the analyzed values of the wind speed and the expected standard deviation of the errors at the two locations for the following values of the background and observational errors:
a) The standard deviation of the background error and the observation error is 1 m/s independently of the location and the errors between the different locations are uncorrelated.
b) The standard deviation of the background error and the observation error is 1m/s independently of the location, the observation errors are uncorrelated, but the covariance between the background errors at the two locations is 0.5.
c) The standard deviation of the background error and the observation error is 1 m/s independently of the location, the background errors at the two locations are uncorrelated with eac other, but the covariance between the two observations is 0.5.
d) What happens when we increase the correlation to 0.9 in b) and c)?

8) Assume that the background is the same as in previous problem, but only one of the two observations is available, the one that measured 9 m/s. What are the analyzed values of the wind speed and the expected standar deviation of the errors at the two locations for the following values of the background and observational errors:
a) Repeat 5) a) and b) under this assumption.