PHY2506
Atmospheric Data Assimilation

Lecture 12

Supplementary Slides

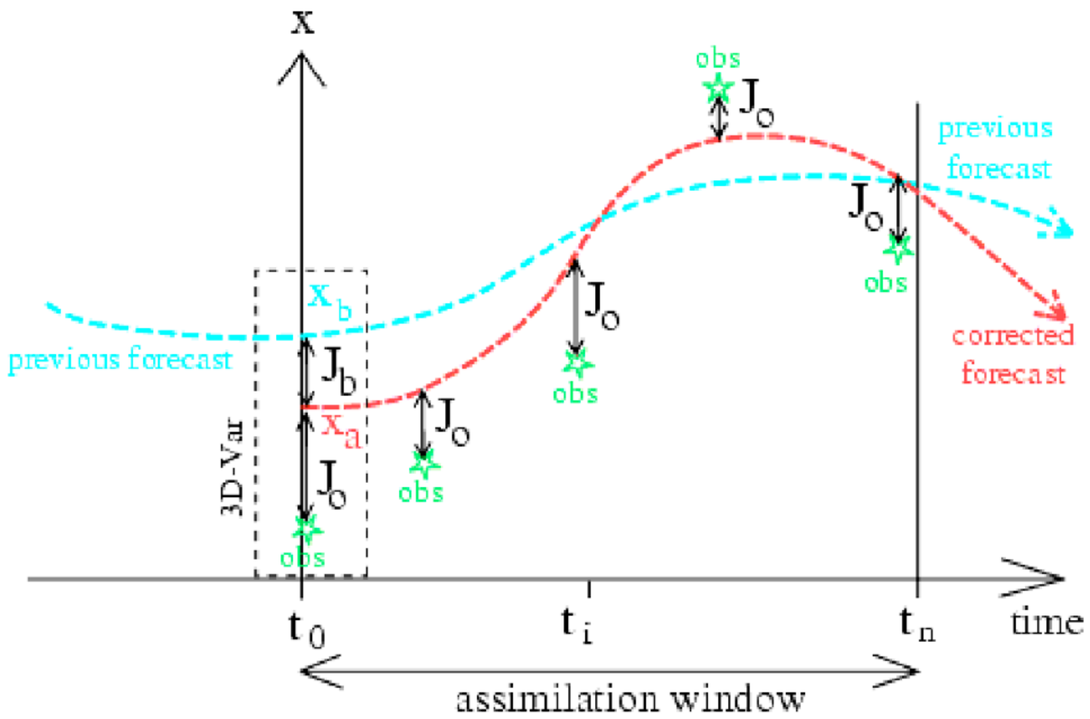

Figure 12. Example of 4D-Var intermittent assimilation in a numerical forecasting system. Every 6 hours a 4D-Var is performed to assimilate the most recent observations, using a segment of the previous forecast as background. This updates the initial model trajectory for the subsequent forecast.

[ECMWF Lecture Notes, 2003]

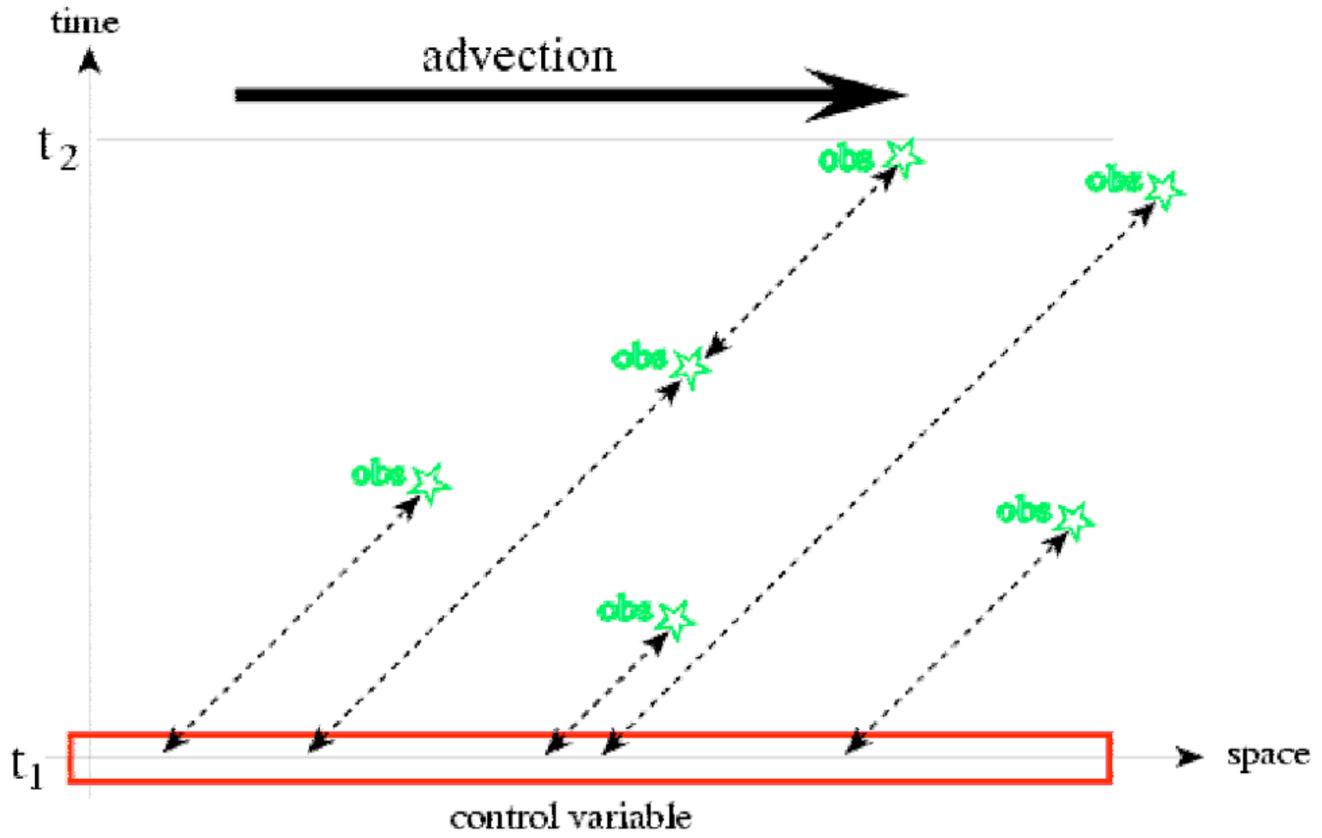

Figure 13. Example of propagation of the information by 4D-Var (or, equivalently, a Kalman filter) in a 1-D model with advection (i.e. transport) of a scalar quantity. All features observed at any point within the 4D-Var time window (t_1, t_2) will be related to the correct upstream point of the control variable by the tangent linear and adjoint model, along the characteristic lines of the flow (dashed).

[ECMWF Lecture Notes, 2003]

- 4D-VAR can be run for assimilation in a realistic NWP framework because it is computationally much cheaper than the KF or EKF.
- 4D-VAR is more optimal than the (linear or extended) KF inside the time interval for optimization because it uses all the observations at once, i.e. it is not sequential, it is a smoother.
- unlike the EKF, 4D-VAR relies on the hypothesis that the model is perfect (i.e. $\mathbf{Q} = 0$).
- 4D-VAR can only be run for a finite time interval, especially if the dynamical model is non-linear, whereas the EKF can in principle be run forever.
- 4D-VAR itself does not provide an estimate of $\mathbf{P}_f$, a specific procedure to estimate the quality of the analysis must be applied, which costs as much as running the equivalent EKF.

Ref: Ghil 1989, Lacarra and Talagrand 1988, Errico *et al*. 1993.

[ECMWF Lecture Notes, 2003]