Diagnosis of error statistics in observation space

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Most main operational assimilation systems are now based on the variational formalism (Lewis and Derber 1985; Courtier and Talagrand 1987, Rabier *et al* 2000). Such a formalism allows the use of a large spectrum of observations and in particular satellite data that are not directly and linearly linked with model variables. However, those variational algorithms still rely on the theory of least-variance linear statistical estimation. In the linear estimation theory, each set of information is given a weight proportional to the inverse of its specified error covariance. The pieces of information are classically given by observations and a background estimate of the state of the atmospheric flow. Analysis systems are then dependent on appropriate statistics for observation and background errors. Unfortunately those statistics are not perfectly known and their determination remains a major challenge in assimilation systems.

One source of information on the observation and background errors is contained in the statistics of the innovations, that is the differences between observations and their background counterparts (Hollingsworth and Lönnberg 1986, Andersson 2003).

On the basis of linear estimation theory (Talagrand 1997), it can be shown (see Desroziers et al, 2006) that simple consistency diagnostics should be fulfilled in an optimal analysis. These diagnostics can potentially provide an information on unperfectly known observation and background error statistics. Another advantage of these diagnostics is that they are nearly cost-free and can be applied to any analysis scheme.

The application of the computation of the diagnostics on analyses issued from the operational French 4D-Var system shows likely diagnosed values for observation and background errors (see Fig. 1). Even if the values of background errors cannot be directly used in model space assimilation scheme, the study of these errors can be quite useful to understand the relative impact of observations in the analysis for observations that are not directly related to the state variables. This is in particular the case for satellite data for which the diagnosed errors can also be compared to randomized estimates of background errors. Since the observation operator includes the model integration in a 4D-Var scheme, the proposed diagnostic can be similarly used to diagnose the implicit evolution of background errors in 4D-Var.

Furthermore, it can be shown that it is possible to adapt the values specified in an analysis scheme by an iterative method. This can be useful to adapt observation errors but also background errors in observation space that are classically used in the first-guess check control of observations.

The use of such consistency diagnostics also seems to be a promising way to tackle the problem of the estimation of correlation between observation errors.

Another domain of interest is the use of the diagnostic of estimation error in observation space that will have to be investigated in the future.

Nevertheless, such diagnostics also have to be well understood at the same time from a theoretical and practical point of view. In particular it can be shown that a spectral vision can be helpful in this perspective, by highlighting the role of a scale separation between background and observation errors.

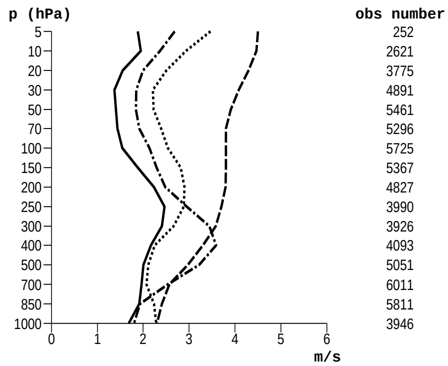

Figure 1: Vertical profiles of diagnosed square-roots of background (solid line) and observation errors (dotted line) for wind radiosonde observations in Northern Hemisphere, compared to profiles of corresponding specified variances of background (dash-dot line) and observation errors (dashed line). All values are in m/s. The numbers of observations used to compute statistics are indicated on the right side of the figure.

References

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