Diagnosis and adaptive tuning of observation-error parameters in a variational assimilation

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SUMMARY

Following the \textit{a posteriori diagnosis} approach proposed by some authors, a practical computation of the expectation of sub-parts of the value of a cost function at the minimum is shown to be feasible by using a randomization technique based on a perturbation of observations or background fields. These computations allow the tuning of observation-error weighting parameters by applying a simple iterative fixed-point procedure. The procedure is first tested in a simplified variational scheme on a circular domain and then in a similar scheme but with the addition of the vertical coordinate. The relationship between the proposed approach and the Generalized Cross Validation is also shown. A test in the French Action de Recherche Petite Echelle Grande Echelle (ARPEGE) three-dimensional variational framework with both simulated observations and background fields is finally performed. It shows that a complete description of observation-error parameters can be retrieved with only a few iterations and, thus, at a reasonable cost.

KEYWORDS: Parameter estimation Variational assimilation

1. INTRODUCTION

Most modern assimilation schemes basically rely on linear estimation theory, or on an extension of this theory. In such an approach, each observation is given a weight that is proportional to the inverse of its specified error variance, measuring the confidence or the precision given to this particular observation. Because of the poor accuracy of certain observations or their sparse density in some areas, practical implementations of operational analysis schemes are based on the use not only of proper observation sets but also of background fields, given by a short-range forecast. In fact, these background fields can be seen as another source of observations (Talagrand 1997) with a given confidence that corresponds to the forecast-error covariances. Because the final analysis is very dependent on the specification of the relative weights given to each source of observations, through the error covariances, and because these errors are not perfectly known, a large potential for improvement on analyses is offered by methods producing a posteriori diagnoses of a mis-specification of a priori errors, or by procedures allowing an adaptive tuning of these parameters.

On the other hand, large operational centres are now using, or have planned to use, assimilation schemes based on a three-dimensional or four-dimensional variational (3D-Var or 4D-Var, respectively) approach, that especially allows the use of a wider range of observations (Lewis and Derber 1985; Courtier and Talagrand 1987). Diagnoses based on statistics of innovations (the differences between observations and background) (Bennett \textit{et al.} 1993), or of departures between observations (including the background) and the minimizing solution (Talagrand 1999) that can be applied in a variational framework, have been proposed. In particular, it has been shown that a simple diagnosis is the value at the minimum of the cost function that measures the distance between observations and analysis.

In that case, the idea is to perform a posteriori statistics of such a criterion on a sufficiently large number of realizations of the analysis process in order to verify the a priori setting of certain parameters.

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