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Iterative Methods for improving Error Covariance Modelling in Variational Assimilation

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ABSTRACT

Variational data assimilation methods are well known and widely applied in geophysical domains to problems affected by uncertainty of short- and long-term model predictions. The strength of this approach is to fuse available information in order to find a compromise between background model predictions and observations where the associated weights are provided by error covariance matrices. A remarkable difficulty in data assimilation is the lack of information for background error covariance modeling. In many industrial applications, due to the absence of historical observations/predictions, the background matrix modelling remains empirical relying on some form of expertise and imposed physical constraints. This can be problematic especially for short term prediction or static reconstruction when the ensemble methods become inappropriate.

Great effort has been made to diagnose the covariance matrices modelling a posteriori. For instance, the meteorology community (e.g. Météo-France) has been a strong contributor to this topic. Several algorithms and analysis were proposed, especially the successful iterative method introduced in [Desroziers & Ivanov, 2001] which adjusts sequentially the error covariance ratios in multivariate systems. Recent efforts are also carried out to apply Desroziers iterative methods in local subspaces, which could make this method more flexible. In this work, under the assumption of a good knowledge of the observation error covariance, we have developed two sequential adaptive methods for improving the assimilation result and rebuilding output error covariance matrices. These two methods formalize existing practice, consisting in repeating several times the assimilation procedure with the same observations. In the framework of twin experiments with both state-independent and state-dependent noises, we show that these methods, as well as the method of Desroziers are helpful in terms of decreasing the error expectation and the innovation quantity (observation-analysis gap).

We have then assessed these methods in a context of a data assimilation chain developed for the purpose of a hydrological problem whose objective is to improve the prediction of the outflow of a watershed.

References

[1] G. Desroziers and S. Ivanov. Diagnosis and adaptive tuning of observation-error parameters in a variational assimilation. *Quarterly Journal of the Royal Meteorological Society*, 127:1433 – 1452, 04 2001.