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Efficient implementation of inverse variance-covariance matrices in variational data assimilation systems

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The inverse variance-covariance matrices of observation and model errors are key components in the cost functions of variational assimilation systems. However, these matrices are often assumed diagonal under the assumption that errors are uncorrelated. One of the main reasons for doing so is that the inversion and direct inclusion of full variance-covariance matrices in cost functions could only be done at prohibitive computational costs.

In this research, we demonstrate that neglecting the correlation between errors artificially increases the confidence on the accuracy of the retrieved parameters. It is thus necessary to include information on the correlation of errors when performing assimilation. We show how this can be done when error correlations can be represented by a series of exponential functions. In these instances, variance-covariance matrices can be easily inverted and matrix-vector multiplication be efficiently performed by use of simple stencils. These properties allow the direct inclusion of simple yet non-trivial inverse matrices in cost functions. Because of its simplicity, this method is well suited for experiments with correlated errors in assimilation systems.