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Estimation and modelling of observation error correlations for numerical weather prediction

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Variational data assimilation algorithms are designed using the ideas of Bayesian statistics to compute the most probable state of the atmosphere taking into account the uncertainty in the available observational and forecast data. Thus for good results, accurate specification of the forecast and observation error distributions is vital. Remote sensing data often have correlated errors, arising from observation pre-processing and mismatches between observation and model resolutions. However, the correlations are typically ignored in operational numerical weather prediction. This approximation is made since the details of the correlation structure are often unknown. It also allows a simplification of the calculations and a reduction in computational cost. Problems are avoided by some combination of data thinning, bias correction, and increasing the size of the observation error variance used in the assimilation. Unfortunately, these measures do not fully exploit the observations and significant information is lost in the assimilation.

Our recent work using the IASI instrument with the UK Met Office assimilation system has shown that it may be possible to estimate observation error correlations using data assimilation output diagnostics. In this paper, we present some simplified model studies examining how well we can expect such an approach to approximate the true observation error covariances. The results are extremely encouraging and show that, if care is taken to include sufficient statistics, diagnostic approaches to estimation of error correlations can produce a good estimate of the true observation error correlations. We also investigate computationally efficient approximations of correlation matrices that may be feasible for operational applications and their effect on analysis accuracy. The results demonstrate that it is often better to model error correlation structure incorrectly than not at all, and that including error correlation structure in data assimilation algorithms is both feasible and beneficial.