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Diagnosing observation error statistics for numerical weather prediction

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With the development of convection permitting numerical weather prediction the efficient use of high resolution observations, such as Doppler radar radial winds and geostationary satellite soundings, is becoming increasingly important. These observations are now routinely assimilated in operational systems, though to avoid violating the assumption of uncorrelated observation errors it is necessary to reduce the density of the observations both by the use of superobservations and observation thinning. Taking into account the full, potentially correlated, error statistics will allow the quantity of observations used to be increased and may improve the impact that the observations have in the assimilation. A number of methods for estimating correlated observation errors exist, but a popular method is a diagnostic that makes use of statistical averages of background and analysis innovations. The accuracy of the results it yields is unknown as the diagnostic is sensitive to the difference between the exact background and exact observation error covariances and those that are chosen for use within the assimilation. It has often been stated in the literature that the results using this diagnostic are only valid when the background and observation error correlation length-scales are well separated. Here we develop new theory for the multivariate case that demonstrates that it is still possible to obtain useful results when the background and observation error length-scales are similar. We are able to the show the effect of changes in the assumed error statistics used in the assimilation on the estimated observation error covariance matrix. We support our theoretical results with simple illustrative examples and show how they can be useful in interpreting the derived covariances estimated using an operational system for Doppler radar radial winds and SEVIRI satellite data.