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Treating sample covariances for use in strongly coupled atmosphere-ocean data assimilation

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Covariance information derived from an ensemble can be used to define the a priori atmosphere-ocean forecast error cross covariances required for variational strongly coupled atmosphere-ocean data assimilation. Due to restrictions on sample size, ensemble covariances are routinely rank deficient and/ or ill-conditioned and marred by sampling noise; thus they require some level of modification before they can be used in a standard variational assimilation framework. Here, we compare methods for improving the rank and conditioning of multivariate sample error covariance matrices in the context of strongly coupled atmosphere-ocean data assimilation. The first method, reconditioning, alters the matrix eigenvalues directly; this preserves the correlation structures but does not remove sampling noise. We show it is better to recondition the correlation matrix rather than the covariance matrix as this prevents small but dynamically important modes from being lost. The second method, model state-space localisation via the Schur product, effectively removes sample noise but can dampen small cross-correlation signals. A combination that exploits the merits of each is found to offer an effective alternative