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On sequential observation processing in localized ensemble Kalman filters

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The different variants of current ensemble square-root Kalman filters assimilate either all observations at once or perform a sequence in which batches of observations or each single observation is assimilated. The sequential observation processing is used in filter algorithms like the ensemble adjustment Kalman filter (EAKF) and the ensemble square-root filter (EnSRF) and can result in computationally efficient algorithms because matrix inversions in the observation space are reduced to the inversion of single numbers. For large scale applications, ensemble filter algorithms require typically the application of localization. The necessary modification of the algorithm leads to an inconsistency of the update equation for the state error covariance matrix as was noted by Whitaker and Hamill (Mon. Wea. Rev. 130 (2002) 1913). Often, this inconsistency does not lead to a significant impact on the assimilation performance. However, using a simple model, it is demonstrated with the EnSRF algorithm that the sequential observation processing can significantly deteriorate the assimilation performance under some circumstances. The deterioration can reach a level at which intermediate state realizations in the assimilation sequence over all observation can have a larger root-mean square error than the state estimate without assimilating any observations. This effect can be characterized to appear for small ensembles and a rather strong assimilation impact.