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Performance of the multiscale alignment ensemble filter in reducing vortex position errors

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Position errors in coherent features have been a challenging problem for data assimilation (DA) due to their high nonlinearity. To effectively reduce position errors, a multiscale alignment (MSA) method was introduced to compute ensemble Kalman filter (EnKF) updates on a sequence of model states at low to high resolutions (large to small scales). Large-scale state has less nonlinearity due to position errors, therefore linear EnKF updates are optimal. The large-scale analysis increments are then utilized to compute the displacement vectors that warp the model grid, reduce position errors and precondition the state at smaller scales before the EnKF update is computed again. This study further tests the performance of the MSA method in an idealized vortex model. The asymptotic behavior is documented for a multiscale solution as number of scales (N_s) increases. We show that the optimal N_s depends on the degree of nonlinearity caused by the position errors. When feature-based observations (such as the vortex position) are used, the MSA performs well with N_s 3 no matter how large the position errors are. A challenging scenario is identified for the MSA method, when the large-scale background flow is incoherent with the small-scale vortex position error (deviation from coherence assumption). In cycling DA experiments, the MSA performs better than the traditional EnKF at equal cost (using decreased ensemble size for MSA to compensate for its increased cost when N_s >1), showing good scalability for real application and potential for improving prediction skill in many multiscale Earth systems.