All-Sky satellite radiance data assimilation using Gain-form of Local Ensemble Transform Kalman Filter within MPAS-JEDI: implementation, tunning, and evaluation

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The Gain-form of Local Ensemble Transform Kalman Filter (LGETKF) has been implemented in the Joint Effort for Data assimilation Integration (JEDI) with the Model for Prediction Across Scales - Atmosphere (MPAS-A) (i.e., MPAS-JEDI). LGETKF applies vertical localization in model space and is particularly convenient for assimilating satellite radiance data, which do not have an explicit vertical height assigned for each channel. The additional efforts are made to optimize ensemble analysis procedures and improve the computational efficiency in the cycling workflow of MPAS-JEDI's LGETKF analysis. The quality control, bias correction, all-sky observation error model, and cloudy observation operator within the JEDI framework are employed to enable MPAS-JEDI's LGETKF to assimilate satellite radiance observations in all-weather situations, in addition to conventional observations and clear-sky radiances. To optimize assimilation configurations in LGETKF, a series of sensitivity experiments are conducted in evaluating the impact of adding all-sky window-channel AMSU-A radiances above the conventional observations and clear-sky radiances from AMSU-A's temperature sounding channels and MHS's water vapor channels. It is found that a combination of relaxation to prior perturbation (RTPP) and relaxation to prior spread (RTPS) aids LGETKF in maintaining the ensemble spread across cycles, and a smaller horizontal localization scale proves preferable for all-sky AMSU-A radiance assimilation. The performance of all-sky radiance assimilation in LGETKF is evaluated through two one-month global cycling experiments with 80 ensemble members at 60 km grid spacing, with and without assimilation of all-sky AMSU-A radiances. Verification against Global Forecast System (GFS) analyses illustrates the benefits of all-sky assimilation in reducing short-term and 7-day forecast errors of almost all variables, despite some slight degradations on temperature. Further observation space verification demonstrates that the all-sky assimilation of LGETKF can improve the forecasts with a better fit to satellite winds and all-sky radiances. In addition, short-term ensemble forecasts initialized from LGETKF analyses are used as ensemble background error covariance (BEC) in deterministic cycling hybrid-3DEnVar. The results underscore the advantages of using the ensemble BEC from all-sky LGETKF over that from clear-sky LGETKF. Overall, MPAS-JEDI's LGETKF shows robust and stable performance in all-sky radiance assimilation and holds great potential for both research and operation applications.