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A Multi-Time-Scale Four-Dimensional Variational Data Assimilation Scheme and Its Application to Simulated Radial Velocity and Reflectivity Data

Abstract

A multi-time-scale four-dimensional variational data assimilation (MTS-4DVar) scheme is developed for assimilating radar observations in this study. The MTS-4DVar uses multiple time windows of varying lengths within the incremental 4DVar framework of the Weather Research and Forecasting Data Assimilation (WRFDA) system. Its goal is to enable 4DVar to extract multiscale information from radar data. The study reveals that the nonlinearity of reflectivity grows faster than radial velocity, suggesting that the time window for assimilating reflectivity should be shorter than for radial velocity. Single observation tests and observing system simulation experiments (OSSEs) are conducted to evaluate the scheme's performance. Results show that MTS-4DVar effectively captures both larger-scale information from longer windows and local-scale features from shorter ones. The cost function is properly minimized with this approach. When assimilating radar radial velocity alone, MTS-4DVar reduces analysis and forecast errors, improving precipitation forecasts compared to standard incremental 4DVar. Further assimilation of reflectivity enhances these forecasts, demonstrating that radar reflectivity is effectively assimilated using MTS-4DVar.

Keywords

4-Dimensional Variational assimilation

Reference

Sun, T., Chen, Y. D., Sun, J. Z., Wang, H. L., Chen, H. Q., Wang, Y. B., & Meng, D. M. (2020). A Multi-Time-Scale Four-Dimensional Variational Data Assimilation Scheme and Its Application to Simulated Radial Velocity and Reflectivity Data. *Monthly Weather Review*, 148(5), 2063-2085. https://doi.org/10.1175/Mwr-D-19-0203.1