Abstract

An enhanced version of the hybrid ensemble-3DVAR data assimilation system for the WRF model is applied to the assimilation of radial velocity (Vr) data from two coastal WSR-88D radars for the prediction of Hurricane Ike (2008) before and during landfall. In this hybrid system, flow-dependent ensemble covariance is incorporated into the varitional cost function using the extended control variable method. The analysis ensemble is generated by updating each forecast ensemble member with perturbed radar observations using the hybrid scheme itself. The Vr data are assimilated every 30 minutes for 3 hours immediately after Ike entered the coverage of the two coastal radars. The hybrid system is compared with the WRF 3DVAR results after tuning to its background error covariance correlation scale.

The hybrid method produces temperature increments showing rainband structures and positive increments in the vortex core region, and a warm core throughout the hurricane depth in the final analysis. In contract, the 3DVAR produces much weaker and smoother increments with negative values at the vortex center at lower levels. The unturned WRF 3DVAR produces wind increments that are inconsistent with the hurricane vortex circulations. Forecasts from the hybrid analyses fit the observed radial velocity better than that from 3DVAR, and the 3-h accumulated precipitation forecasts are also more skillful. The track forecast is slightly improved by the hybrid method and slightly degraded by the 3DVAR compared to the forecast from GFS analysis. All experiments assimilating the radar data show much improved intensity analyses and forecasts compared to the experiment without assimilating radar data. The forecast results indicate that the hybrid method produces dynamically more consistent state estimations that lead to lower error growth in the forecast than the 3DVAR method does, and there is little benefit of including the static component of background error covariance for hurricane and radar data assimilation.