INTRODUCTION

The Center for Analysis and Prediction of Storms (CAPS) has been carrying out real-time storm-scale ensemble forecasts (SSEFs) since 2007 as part of the NOAA Hazardous Weather Testbed (HWT) Spring Forecast Experiment (SFE) where emerging concepts and techniques concerning the optimal design of ensemble forecasts at convection-allowing/convection-resolving resolutions are tested and evaluated. A distinct feature of the CAPS SSEFs is the assimilation of full-volume radial velocity and reflectivity data from the WSR-88D radar network using a 3DVAR/complex cloud analysis procedure [1]. During the past decade, rapid progress has been made with the ensemble Kalman filter (EnKF) technique [2] for storm-scale radar data assimilation (DA). The EnKF method is especially useful at the convection scale because of its ability to handle complex and highly nonlinear microphysical processes in the assimilation model, and in the forward observation operator (e.g., those for reflectivity). In 2013, CAPS has started to run real-time experimental EnKF DA using the CAPS parallel EnKF system [3], followed by a deterministic forecast over a central US domain for HWT. Since then, this system has been extended to the continental United States (CONUS) domain with cycled EnKF DA between 1800 and 0000 UTC.

In the HWT SFEs of 2016 and 2017, cycled EnKF DA was performed over a 6-hour period using a combination of the HCEP Gridpoint Statistical Interpolation (GSI)-based EnKF system and an EnKF system developed by CAPS. The CAPS EnKF system assimilates radar data between 2300 and 0000 UTC at 15-minute intervals while the GSI-EnKF assimilates all operational data, except for satellite and aircraft data, used by the Rapid Refresh in hourly intervals (Figure 1). The EnKF DA uses 40 members with multiple PBL schemes and the Thompson microphysics scheme with perturbed graupel density. Sixty-hour ensemble forecasts of 10 members are run from the final EnKF analyses at 0000 UTC. The EnKF forecasts are able to maintain the storm structure and reflectivity in the next hour. The power saturates at almost all scales by hour 3.

The EnKF forecasts are able to maintain the storm structure throughout the first 2 hours at all scales. Only scales greater than 100 km grow in the next hour. The power saturates at almost all scales by hour 3.

Objective

Develop an EnKF DA system that can effectively and efficiently assimilate all operational data sets plus full-volume radial velocity and reflectivity data.

Optimize 3-km-grid-spacing, real-time CONUS domain EnKF-En3DVAR hybrid DA systems providing ensemble initial conditions for an SSEF forecast model.

Determine the optimal design, configurations, and post-processing of storm-scale ensemble prediction and provide the probabilistic forecast products for evaluation by forecasters, researchers, and model developers, as well as test storm-scale DA methods.

CONFIGURATIONS FOR CAPS EnKF DA

Forecast model: Weather Research and Forecasting Mode (WRF)-Advanced Research WRF (ARW) v3.8.1
DA schemes: GSI-EnKF (conventional observations) and CAPS parallel EnKF (radar)
Microphysics scheme: Thompson with perturbed graupel density (414–673 kg/m³)
Multi-PBL schemes: WJ1, YSU, and MYNN
Radiation (SW and LW): RRTMG
Land Surface Model: Noah
Forecast domain: Continental United States at 3 km grid spacing
Observations: surface, sounding, profiler, and radar rainfall velocity and reflectivity
40 ensemble members
Covariance inflation: Relaxation-to-prior spread (RTSP) + multiplicative inflation (2–5 dBZ)
Initial and lateral boundary conditions: (ICs and UBCs): 1800 UTC North American Mesoscale Forecast System (NAM, 12 km) analysis + 152 Short Range Ensemble Forecast System (SREF, 16 km)
For a parallel experiment using a 3DVAR/cloud-analysis system, the 0000 UTC NAM analysis was used as a background, assimilating surface, mesonet, and radar observations.

REFERENCES