A ENSEMBLE RADAR DATA SYSTEM FOR IMPROVING VERY-SHORT-TERM AND SHORT-TERM STORM PREDICTION

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ABSTRACT

An ensemble radar data assimilation system has been recently developed at the Naval Research Laboratory (NRL) for improving very-short-term (0 – 6 hour) and short-term (0-48 hour) storm forecasts for the US Navy. An ensemble Kalman filter (EnKF) is employed to assimilate radar observations of Doppler radial velocity and reflectivity into a mesoscale model. A multi-scale localization algorithm was also developed that allows the mesoscale, convective-scale, and inside-storm microscale structures observed by the Doppler radars to be assimilated into the model to enhance the characterization of storms in the model's initial fields. Experiments have been carried out to test the system with real data and to address some challenging issues associated with ensemble radar data assimilation. Results from recent studies show that the ensemble radar data assimilation has significantly improved the nowcasting and forecasting of severe storms.

1. INTRODUCTION

At the US Naval Research Laboratory (NRL), radar data assimilation systems (both variational and ensemble-based) have been developed in the past years to assimilate radar observations from different platforms into the Navy's Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS®). The goal is to improve the model's capability and accuracy in very short-term and short-term prediction of severe storms that are usually poorly observed and predicted but often affect the navy's operations. Among these systems, an ensemble-based radar data assimilation system for multi-scale radar data assimilation is the most recent developed by NRL. There are several reasons for developing such an ensemble-based radar data assimilation system. First, the flow-dependent background error covariance can be estimated from the ensemble forecasts to adapt the complexity and rapid change in storm structures. Second, uncertainties in storm observations and model prediction can be consistently evaluated and updated in a timely fashion by the ensemble data assimilation system (with a sufficiently large ensemble size). Third, storm structures of different scales (e.g., mesoscale, convective scale, and microscale) observed by a radar network can be all assimilated into the EnKF with a multi-scale localization algorithm.

This paper gives a brief description of the ensemble radar data assimilation system and demonstrates the impact of the radar observations on improving the forecasts of storms at different scales.

2. SYSTEM DESCRIPTION

The ensemble square root filter developed and tested in this study has its origins in a research version of the EnKF originally developed by Snyder and Zhang (2003). Since adoption, several major changes and improvements have been made to the EnKF to make it more suitable for COAMPS applied both in an operational environment and for scientific research at NRL. The EnKF has the ability to assimilate all types of observations, including radar data.

The EnKF assimilates volume scans of Doppler radial velocity and reflectivity from multiple radars in observational space. Before the assimilation, super observations (super-obs) of radar data are compressed to reduce the information redundancy and eliminate the spatial correlation of radar observations (Xu et al. 2007), especially near radar locations using the algorithm developed by Lu et al. (2011).

One of the advantages of the EnKF is its ability to assimilate storm observations from as many radars as available in an area of interest. In one of our case studies, the EnKF assimilated radar observations from 22 WSR-88D radars. This enables simultaneous assimilation of mesoscale, convective-scale and microscale storm structures into the model. Another major capability of the system is the concurrent assimilation of radar observations with other types of sensor data. This allows two-way interactions between radar observations and other types of sensor data to maintain the dynamical balances and consistencies in model's initial fields, which is critical for nowcast applications.

3. IMPROVEMENT IN STORM FORECASTS

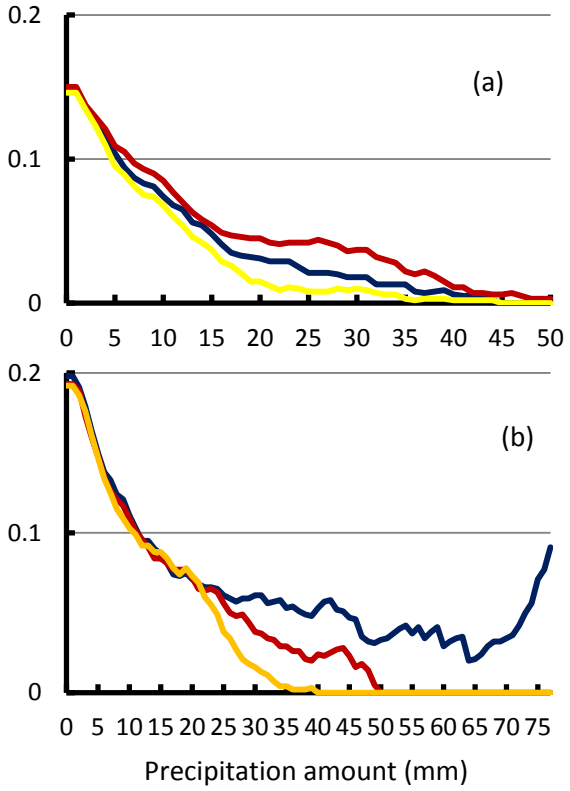

Figure 3. Equitable threat scores of (a) 0-24 hour and (b) 24-48 hour precipitation forecasts from the EnKF without radar data assimilation (yellow), EnKF with Doppler radial velocity data assimilation (blue), and EnKF with Doppler radial velocity and reflectivity data assimilation (red).

The ensemble radar data assimilation system is currently under an extensive test with real data to study the impact of the multi-scale ensemble radar data assimilation on storm prediction and also to address some challenging issues associated with ensemble radar data assimilation. Experiment results from our recent studies with the radar data assimilation have shown some very remarkable improvement in storm forecasts.

As an example, figure 3a shows the equitable threat score (ETS) of the 0 - 24 hour precipitation forecasts from three experiments: the EnKF without radar data assimilation (yellow), the EnKF with Doppler radial velocity assimilation (blue), and the EnKF with both Doppler radial velocity and reflectivity assimilation (red). Figure 3b gives the same scores for the 24-48 forecast hours. It is clear that radar data have positive impact on precipitation forecasts, especially for the heavy precipitation amounts. Results from our recent experiments also show that the EnKF with radar data assimilation improves the wind forecasts. This has significant implications for storm nowcasting.

4. SUMMARY

A multi-scale ensemble radar data assimilation system has been developed at NRL. The system is currently being tested, and results show very encouraging improvements in storm nowcasting and forecasting. This is an ongoing study and more results will be presented at the conference.

REFERENCES

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