Exploring the NAM's fully cycled hybrid Variational-EnKF data assimilation system for high impact weather system

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Introduction

In the current operation regional hybrid data assimilation at NCEP/NOAA, the global ensembles are used and not cycled/affected by the regional data assimilation process(Wu, et al., 2016). Hence, a convection-allowing GSI-based hybrid Variational-EnKF data assimilation system is being explored using regional ensembles cycled by the EnKF subsystem and direct assimilation of radar reflectivity. Various strategies and schemes mainly leveraging the continually progressing GSI are explored on the basis of recent experiences/progresses at EMC in this respect.

The prototype system of the hybrid regional data assimilation at EMC/NCEP is developed on the basis of NAMv4 as shown in Fig.1

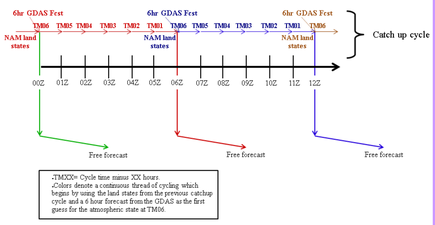

Fig.1. The flow chart for the hourly cycles with 6 hour analysis-forecast time windows.

At the beginning of each analysis-forecast 6 hour window, the global GDAS and its accompanying global ensembles of ensemble size 80 generated by the accompanying global EnKF on reduced resolutions in the global DA process provides initial and lateral boundary conditions for both the deterministic regional runs and regional ensembles of the ensemble size 40, which will be cycled by the EnKF system attached with the regional hybrid DA system.

Direct data assimilation of radar reflectivity

The observation operator of radar reflectivity is strongly nonlinear, which could cause obvious degrading effects in the direct variational assimilation of radar reflectivity. To mitigate this, the radar reflectivity is taken as the control variable and the update of other analysis variables are realized by the ensemble sampled covariances as in the augmented observation variable methods used in EnKF analysis. However, it was first used in the variational analysis by Wang and Wang (2017).

The radar reflectivity data used for the direct assimilation are from the MRMS QC's data on titles and the observation window for each analysis time is 5 min.

The forecast model is NMMB in the current work, while the current DA system is flexible to be adjusted for any models like FV3.

Hybrid DA with direct data assimilation of radar reflectivity on targeted domains for severe weathers

- The global ensembles based data assimilation is run on the parent domain (Black,Fig3) (Wu, et al, 2017).
- The test case is the severe weather process on Oct. 30, 2015 around central Texas. The hourly data assimilation window : 12-18 UTC , Oct, 30, 2015

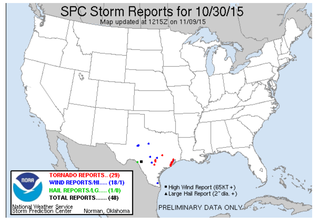

Fig. 2 The storm prediction center storm reports of 30 October 2015. There were several reports of tornadoes and damaging winds on this day.

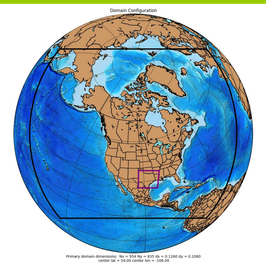

Fig. 3 The domain configuration for the case of z18, Oct. 30,2015. the fully cycled regional ensemble based hybrid DA was run in the targeted small domain (Purple).

Table 1: Experiments setup

Ens3DVa	Ensemble (regional ensembles are hourly cycled)	Cloud analysis	Direct DA of dBZ
Glob_ens	80 global members	Yes	No
Reg_cycle	40 regional members	Yes	No
Reg_dbz	40 regional members	No	Yes

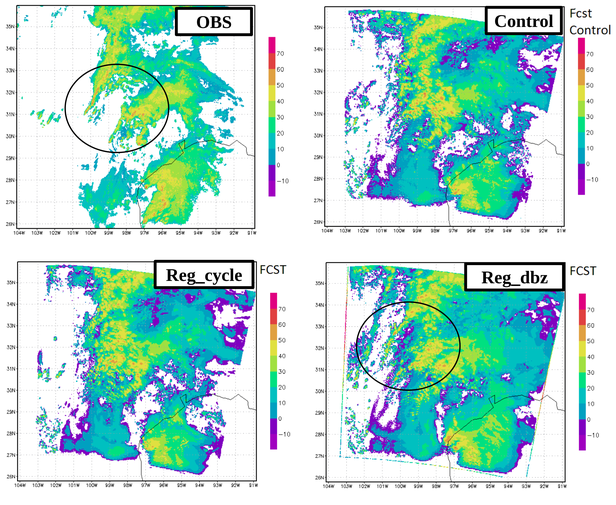

Fig. 4: Composite reflectivity valid at 19UTC,20151030 (top left), 1 hour forecast from Glob_ens (the control run, top right), reg_cycle (bottom left) and reg_dbz respectively (bottom right) .

Composite reflectivity verification

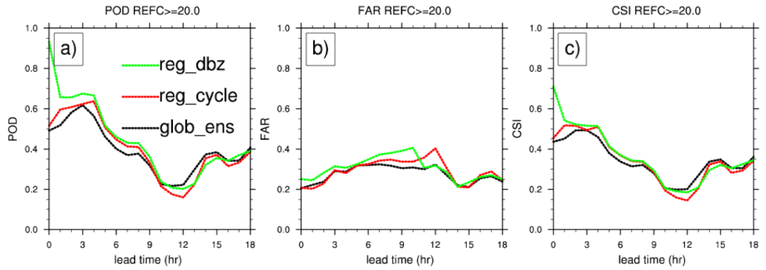

Fig.5 The probability of detection (POD) (a) , False Alarm (FAR) (b) and Critical Success Index (CSI) (c) are calculated against 3d reflectivity mosaic at NCEP.

Verification for the 18Z cycle on Oct. 30th was performed for composite reflectivity over an 18 hour forecast period. Initial results show, from this single case, improvement in the probability of detection for the first 6 hours though FAR slightly increased. CSI shows an improvement in the first 6 hours.

Hybrid Dual-resolution DA run on CONUS

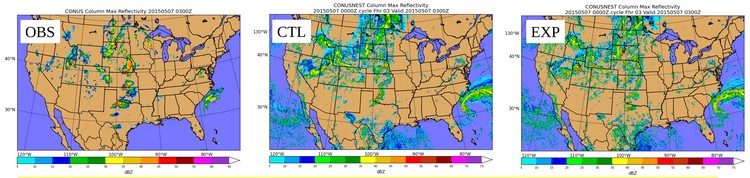

Fig. 6 Observed radar reflectivity, 3 h forecast from NAMv4 and from Hybrid-EnKF valid at 2015050703 UTC

Summary

A prototype system of fully cycled regional ensemble based Hybrid DA system with direct assimilation of radar data has demonstrated encouraging results. In the future, we plan to adapt the NGGPS-selected FV3 forecast model in continuation of these efforts.

References

- Wu, W., D. Parrish, E. Rogers, and Y. Lin, 2017: Regional Ensemble-Variational Data Assimilation Using Global E semble Forecast. *Wea. Forecasting*, **32**, 83–96.
- Wang Y. and X. Wang, 2017: Direct Assimilation of Radar Reflectivity without Tangent Linear and adjoint of the Nonlinear Observation Operator in the GSI-Based EnVar System: Methodology and Experiment with the 8 May 2003 Oklahoma City Tornadic Supercell. Mon. Wea. Rev., online..

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