P.90 Verifications of Simulated Radar Reflectivity and Echo-Top Forecasts at NCEP

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Introduction

Simulated radar reflectivity and echo top are good indicators of detailed structure of convective clouds and precipitation forecast by mesoscale models, particularly as their resolutions have been increasing in recent years. Although these two products have been generated from NCEP's operational mesoscale models or systems for several years, their forecast performance has not been systematically evaluated nor compared. Recently we have dedicated much effort to do this work over CONUS. This paper summarizes the recent verifications of these two products using hourly 1 km National 88-D Radar Mosaic data as 'truth'. The evaluated mesoscale models include NAM, RUC and 4km-WRF (NMM, ARW of HiRes window), 32km-SREF (Short Range Ensemble Forecast System before and after its upgrade in 2009), and SREF in a downscaled 5 km form. The primary results based on short and long time period data are presented.

Objectives

- **Current prediction performance for reflectivity (composite)**
  - NAM, RUC, Hires (4km) WRF-NMM and ARW, Low res NMM and ARW
- **Improvement in reflectivity (composite) and echo-top (height) ensemble prediction after new SREF implementation (Nov, 2009)**
  - Single SREF-NMM and ARW WRF controls (V2.0 → 2.2 , same scheme but many improvements; Resolution: ARW 45 to 35km,NMM 40 to 32km
  - SREF-ensemble probability forecast
- **Verification of SREF control models over hi-resolution WRF grid (4km) vs over coarse SREF-212 grid (32km)**
  - Downscaling SREF from 32km to 4km grid can improve skill?

Method

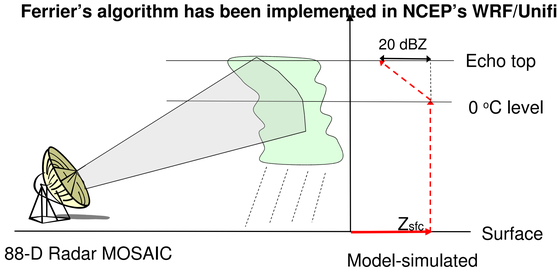
- **Simulated radar reflectivity/echo-top in models (Ferrier)**

Reflectivity Z = Grid-scale Z_{grid} + Convective Z_{conv} (in mm6/m3)

Z_{grid} ~ D6 moment of assumed exp droplet distributions of rain and ice (Rayleigh scattering)

Z_{conv} ~ Z_{sfc}=300*RR_{sfc}1.6 (original NEXRAD 88D algo), where RR_{sfc} – Surface rain rate

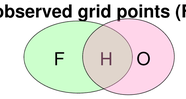
Ferrier's algorithm has been implemented in NCEP's WRF/Unified post



- **Verification Method**
  - NCEP Grid-to-Grid Verification System (G2G)

G2G is a system to validate a model and truth data at all grids in a region to generate verification statistic database (VSDB or partial sum over the region) records based on number of forecast, hit and observed grid points (F.H.O.):

- Single model verification partial sum
- Ensemble verification partial sum



- NCEP Forecast Verification System (FVS)

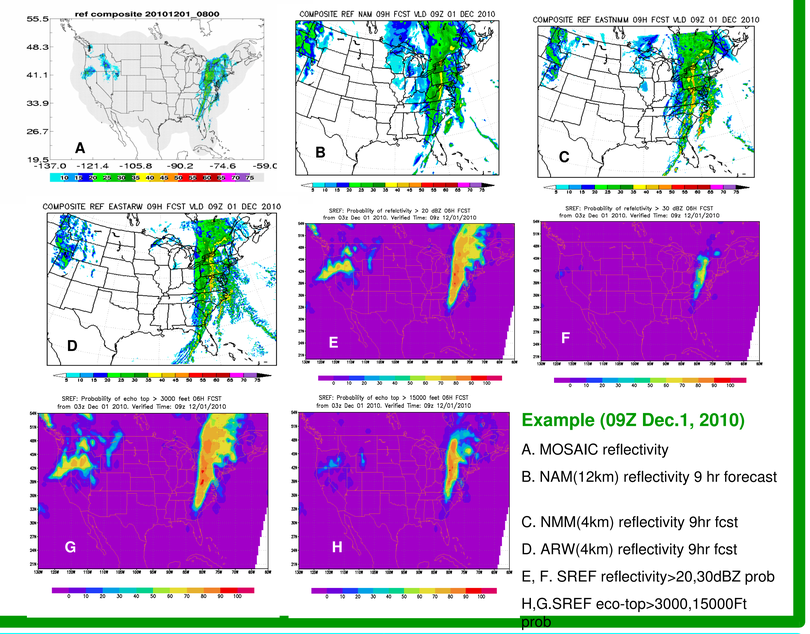
Based on the VSDB records, FVS is applied to generate both deterministic and probabilistic verification measures and scores: e.g.

- **Re-scaling**
  - NCEP copygb tool

If model grid and MOSAIC grid are different, copygb, with nearest-neighbor option, is used to convert different grids to same grid

Data

- **MOSAIC composite reflectivity**
  - Hourly (24 cycels/day) over CONUS. No data over ocean
  - 1km original resolution grid data averaged → to 4 km grid data
  - 4km grid data copygb → grids of NAM , RUC , hires WRF and SREF
- **Single model and ensemble reflectivity forecast data**
  - 12km NAM, 12km RUC, 4km hires NMM &ARW, 32km SREF-control NMM&ARW

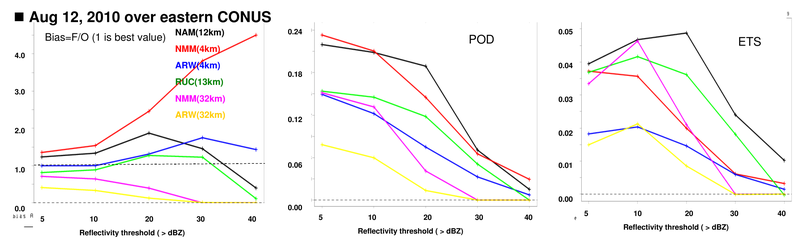


Example (09Z Dec.1, 2010)

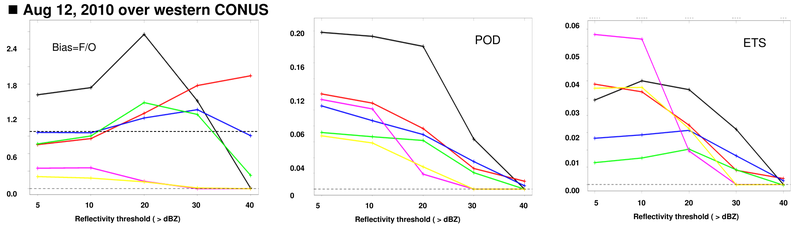
A. MOSAIC reflectivity
B. NAM(12km) reflectivity 9 hr forecast
C. NMM(4km) reflectivity 9hr fcst
D. ARW(4km) reflectivity 9hr fcst
E, F. SREF reflectivity>20,30dBZ prob
H,G.SREF eco-top>3000,15000Ft prob

Results

- **Single models simulated reflectivity verified over hi-res (4km) grids**
  - Aug 12, 2010 over eastern CONUS



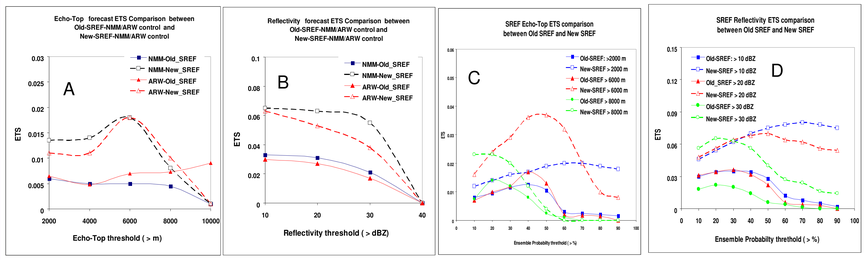
  - Aug 12, 2010 over western CONUS



- Hi-res models have positive bias but better POD, low-res models have negative bias
- Lower reflectivity forecast has higher skill higher reflectivity forecast has lower skill
- Prediction for reflectivity > 40 dBZ has very small skill

- **SERF reflectivity/echo-top prediction improvement after new implementation**

Verification period: Apr 03 ~ Apr 30, 2009: Before new SREF implementation
Apr 06 ~ Apr 27, 2010: After new SREF implementation



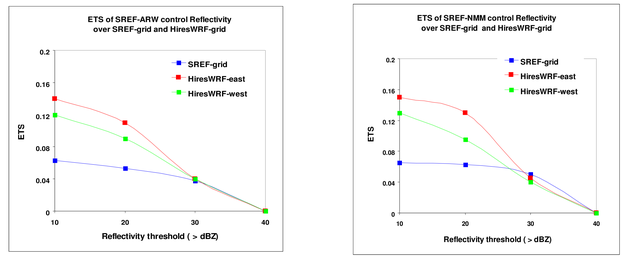
Echo-top (A) and reflectivity (B) ETS for SREF-NMM(32km) and ARW(32km) before and after new SREF implementation for different echo-top and reflectivity thresholds

Echo-top (C) and reflectivity (D) ETS for SREF ensemble probability prediction over various ensemble probability thresholds for different echo-top and reflectivity thresholds before and after new SREF implementation

- New SREF, both control members and ensemble probabilistic prediction, has better performance in echo-top and reflectivity prediction
- Reflectivity prediction performance is better than echo-top before and after new SREF implementation
- Lower echo-top and lower reflectivity have better prediction performance than higher echo-top and reflectivity

- **Comparison between reflectivity verifications over coarse grid and fine grid**

Tested with new SREF's WRF NMM and WRF ARW control members



- Coarse SREF single member verified over fined grid has higher score than over coarse grid

Reason: MOSAIC data is a fine grid product

SUMMARY

Single model and ensemble simulated reflectivity and echo top forecasts from NCEP's NAM (12km), RUC(13m) , SREF's base NMM (32km) and ARW (32km), hi-resolution WRF NMM (4km) and ARW(4km), as well as before and after the new SREF implementation were verified against the national 88-D Radar MOSAIC grid (1km) data in limited time periods over COUNS. The results show that

- Hi-resolution models have generally better detection and prediction skill than low resolution model, particularly for higher dBZ range, but this is in higher positive bias at a cost.
- For all models, lower dBZ and lower echo-top ranges have higher prediction performance
- For all models, prediction of simulated reflectivity is better than that of simulated echo-top
- Coarse model reflectivity verified on fine grid has better score than on coarse grid
- The performance of both reflectivity and echo-top from new implemented SREF is improved
- For reflectivity > 40 dBZ, all models and ensemble system have no prediction skills

Reference

Koch S. E., B. Ferrier, M. T. Stoelinga, E. Szoke, S. J. Weiss and S. Kain, 2005: The use of simulated radar reflectivity fields in the diagnosis of mesoscale phenomena from high-resolution WRF model forecasts, 11th Conf. on Mesoscale Processes, AMS, 22-29 Oct, Albuquerque, NM.

Zhou B., 2008: NCEP grid to grid verification system, available online: http://www.emc.ncep.noaa.gov/mmb/papers/zhou/NCEPGrid2GridVerificationSystem-V2.doc