The Developmental Testbed Center
GFS/NAM Precipitation Forecast Comparison Test Plan

Point of Contact: Jamie Wolff
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1. Introduction

The Developmental Testbed Center (DTC) will be performing an evaluation of the quantitative precipitation forecasts (QPF) from the Global Forecast System (GFS) and the North American Mesoscale (NAM) operational models. The evaluation will be performed utilizing version 3.0 of the Model Evaluation Tools (MET), corresponding to the current public release. Any known relevant bug fixes to MET at the time of testing will also be incorporated. Upon completion of the test, the results will be made available to the modeling community on the DTC website.

2. Goals

The overarching goal of the GFS/NAM QPF comparison is to quantify the differences in precipitation forecasts produced by the two modeling systems, which vary significantly in horizontal resolution. Traditional verification metrics will be computed for each model; however, such metrics may unfairly penalize higher resolution models with finer detail. Thus, more advanced spatial verification techniques will also be applied and summary measures demonstrated in an attempt to associate QPF differences with the different horizontal scales of each model. Forecast verification statistics will be computed for the two models and the verification analysis will be based on the objective statistics of the output. A secondary goal of this test and evaluation will be to demonstrate a fraction of the capabilities available in MET.

3. Experiment Design

The end-to-end system will consist of several steps, including regridding the forecast and observations to a common grid, running MET, generating spatial and verification graphics, archiving all input and output datasets, and disseminating the results.

3.1 Codes to be Employed

The baseline code utilized will be the official released versions of the WRF Post Processor (WPP; v3.2) and MET (v3.0). Relevant bug fixes will be incorporated if any are known by the final software acquisition deadline. The requirement to use code that has been publicly released ensures the results will be meaningful to, and closely reproducible by, the WRF user community.

3.2 Model Output

Precipitation output from each of the models begins on the respective native domain, E-grid domain with approximately 12-km grid spacing for the NAM and global Gaussian grid with 0.5 x 0.5 degree resolution for the GFS.

3.3 Forecast Periods

Forecasts initialized daily at 00 UTC from 18 December 2008 through 15 December 2009 will be assessed. The forecasts will be examined out to 84 hours with precipitation accumulation output available every 3 hours.

3.4 Post-processing

The *copygb* program within WPP will be used to regrid the forecasts and observations to a common domain on a Lambert-Conformal map projection. A 15-km and a 60-km contiguous U.S. (CONUS) grid will be employed in this test, with the two domains covering an identical area (Fig. 1). The 15-km domain is 400 x 280 gridpoints, for a total of 112,000 gridpoints. The 60-km domain is 100 x 70 gridpoints, for a total of 7,000 gridpoints.

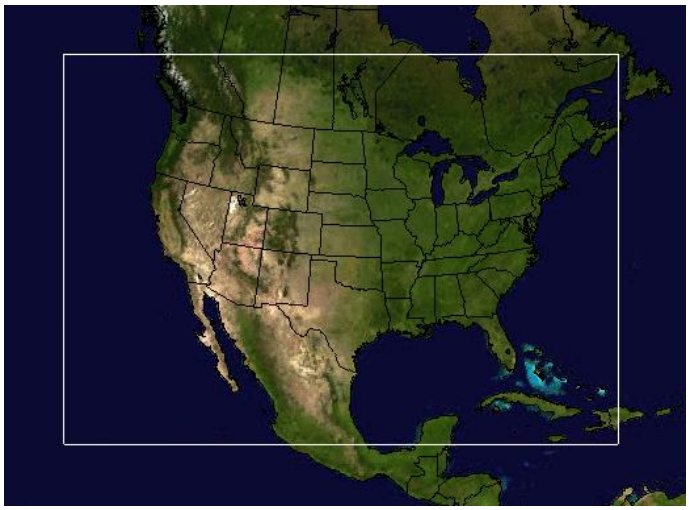

Figure 1. Map showing the boundary (white box) of the 15-km and 60-km CONUS domains.

3.5 Model Verification

Objective model verification statistics will be generated using the MET package and presented for the entire CONUS domain (Fig. 2). For this test, grid-to-grid comparisons will be performed to verify model QPF.

Figure 2. Map showing the boundary of the CONUS verification domain.

For the NAM model output, the precipitation forecasts will be interpolated to both the 15-km and the 60-km domains, while for the GFS, the precipitation forecasts will only be interpolated to the 60-km domain. The precipitation analyses will also be interpolated to those same 15- and 60-km domains and then compared to the forecasts. Precipitation accumulation periods will be 3 h and 24 h, with the lead times of 12-, 24-, 36-, 48-, 60-, 72-, and 84-h examined for the 3-h accumulations and 36-, 60- and 84-h examined for the 24-h accumulations. The observational datasets will be the National Centers for Environmental Prediction (NCEP) Stage II analysis for the 3-h accumulation and the NCEP Climate Prediction Center (CPC) daily gauge analysis for the 24-h accumulation (valid at 12 UTC).

The traditional metrics computed will include the frequency bias and the equitable threat score (ETS). More advanced spatial verification techniques to better associate precipitation differences with different model horizontal scales will also be applied. In particular, an object based verification approach, Method for Object-based Diagnostic Evaluation (MODE), and a neighborhood verification method, Fractional Skill Score (FSS), will be used. Many unique attributes can be examined when looking at MODE output, including centroid distance, boundary distance, angle difference, area ratio and intersection area ratio. For FSS, the forecast skill will be examined with varying spatial scale. The verification statistics will be stratified by lead time.

Since every forecast will be available for both the GFS and NAM, the presentation of the ETS results will take advantage of the pair-wise nature of the test. With this methodology, differences between the verification statistics for each individual initialization and lead time for the two model configurations will be computed in order to assess statistical significance (SS). Because frequency bias is not amenable to a pair-wise difference comparison due to the nonlinear attributes of this metric, the more powerful method to establish SS could not be used.

For the traditional verification metrics, the individual and pair-wise verification statistics will be accompanied by confidence intervals (CIs) at the 99% level, which will be computed using a bootstrapping technique.

A website for viewing the verification results will be made available to the staff conducting the test, NCEP/Environmental Modeling Center (EMC) staff and the general community.

3.6 Graphics Generation and Display

Graphics showing the forecast and observed fields will be generated using National Center for Atmospheric Research (NCAR) Command Language (NCL).

The suite of forecast and observation images will be comprised of:

- 3-h accumulated total precipitation every 3 h (out to 84 h for the forecast images)
- 24-h accumulated total precipitation valid at 12 UTC (for the 36-, 60- and 84-h lead times for the forecast images)

3.7 Data Archival and Dissemination of Results

Input and output data files from several stages of the end-to-end system will be archived on the NCAR Mass Storage System (MSS). The results of the analysis will be summarized in a report and delivered to NCEP/EMC and made available on the DTC Testing and Evaluation Projects webpage. Papers and presentations may be prepared for presentation at national conferences.

4. Computer Resources

- Processing resources:
  All calculations will be computed on a DTC LINUX workstation.
- Storage resources:
  All archival will be done on the NCAR Mass Storage System.
- Web resources:
  Model forecast and verification graphics will be accessed through a web interface available on the DTC website.

5. Deliverables

The NCAR Mass Store System will be used to archive the files produced by the forecast system. The following files will be stored:

- GFS and NAM model output.
- Datasets used for forecast verification (Stage II and CPC precipitation analyses).
- Output of the ***copygb*** component of the WPP.
- Output of MET.
- Images produced by NCL.

Additionally, all source codes and executables used will be stored.

These files will be made available to the DTC and to the user community for further studies.

The DTC will produce a report outlining the results and conclusions from this test.

6. References

Davis, C., B. Brown, R. Bullock, 2006: Object-Based Verification of Precipitation Forecasts. Part I: Methodology and Application to Mesoscale Rain Areas. *Mon. Wea. Rev.*, **134**, 1772-1784.

Roberts, N. M., H. W. Lean, 2008: Scale-Selective Verification of Rainfall Accumulations from High-Resolution Forecasts of Convective Events. *Mon. Wea. Rev.*, **136**, 78-97.

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