2.8

The WRF Developmental Testbed Center: A Status Report

Louisa Nance[1+2], Ligia Bernardet[2+3+4], Hui-Ya Chuang[5], Geoff DiMego[5], Meral Demirtas[1+2], Robert Gall[1+2], Steven Koch[2+3], Ying Lin[5], Andrew Loughe[2+3+6], Jennifer Mahoney[2+3], and Matthew Pyle[5]

[1]National Center for Atmospheric Research, Boulder, CO
[2]Affiliated with the Developmental Testbed Center, Boulder, CO
[3]NOAA Research – Forecast Systems Laboratory, Boulder, CO
[4]Systems Research Group, Inc., Colorado Springs, CO
[5]National Centers for Environmental Prediction, Camp Springs, MD
[6]Cooperative Institute for Research in Environmental Studies, University of Colorado, Boulder, CO

1. Introduction

The WRF Developmental Testbed Center (DTC) is a facility where the Numerical Weather Prediction (NWP) research and operational communities interact to accelerate testing and evaluation of new models and techniques for research applications and operational implementation. A key objective of the DTC is to offer the research community an environment that is functionally similar to that used in operations to test and evaluate the WRF modeling system, without interfering with actual day-to-day operations at the operational centers.

Since its inception in 2003, the DTC has evolved into a distributed facility with two nodes in Boulder, Colorado: one at the National Center for Atmospheric Research (NCAR) and the second at the Forecast Systems Laboratory (FSL). A third node is planned in Monterey, California at the Naval Research Laboratory (NRL). Staff from the various nodes work closely with each other, as well as with the research and operational communities. This paper provides a summary of the current end-to-end forecast system available at the DTC, recent testing activities, as well as a preview of plans for the coming year.

2. DTC End-to-End System

Thorough testing of new models and techniques requires a framework within which testing can be performed. The current end-to-end system available at the DTC includes: WRF Standard Initialization (SI) package and model for two dynamical cores (NMM and ARW), NCEP WRF post processing package, graphical display options, and a verification system. This end-to-end system is available for both the ARW and NMM dynamical cores and can be run on either NCAR's IBM or FSL's iJet.

The WRF SI packages for the ARW and NMM dynamic cores are currently two separate entities and will likely remain so until development of a new WRF SI package is completed. Conversely, the two dynamic cores will likely be distributed as one package either summer or fall of 2005.

The NCEP WRF post processing package performs a vertical interpolation from the model native grid to constant pressure levels, computes diagnostic quantities (e.g., CAPE, simulated radar reflectivity, and visibility), and performs horizontal interpolation from the model native grid to standard output grids (Chuang et al. 2004). The post processing package generates files in NWS and WMO standard GRIB format. Control files are used to specify the vertical levels and fields to output in GRIB format.

Once the model output has been post-processed, NCAR Command Language (NCL) scripts developed by the DTC can be applied to the GRIB files to generate graphical images of the WRF forecast. Other potential options for viewing the post-processed fields are FX-Net and AWIPS, both of which were used extensively during the DTC Winter Forecast Experiment (DWFE) described below.

The DTC verification system includes one surface and upper-air verification package and two approaches for Quantitative Precipitation Forecast (QPF) verification. The surface and upper-air package is NCEP's WRF Verification System, which

Corresponding author address: Louisa Nance, NCAR/DTC, P. O. Box 3000, Boulder, CO 80307.
E-mail: nance@ucar.edu

performs grid-to-point verification (Chuang et al. 2004). The QPF verification packages include NCEP's QPF verification system, which performs grid-to-grid verification (Accadia et al. 2003), and FSL's RTVS system, which performs grid-to-point verification (Loughe et al. 2001). A more detailed description of these systems can be found in Demirtas et al. (2005).

3. DTC Winter Forecast Experiment

DWFE was conducted from 15 January to 31 March 2005. This real-time experiment was motivated by the needs of the National Weather Service (NWS) for improved model guidance to support their winter weather forecast and warning mission. The design of this experiment involved close coordination between the DTC and the operational and research communities.

Two 48-h forecasts for a 5-km grid covering the CONUS were generated daily for the 00 UTC cycle. One forecast was generated using the ARW dynamical core run on NCAR's IBM and the second forecast was generated using the NMM dynamical core run on FSL's iJet. The physics options used for these two configurations are summarized in Table 1. The initial and lateral boundary conditions for both forecasts were based on Eta 212 grids, with initial land surface fields for the ARW specified by a high-resolution land-surface data assimilation system (HRLDAS, Chen et al. 2004). Real-time displays of these forecasts were available either via pre-generated images available on the DTC website (http://www.DTCenter.org), or through FX-Net, which allows the user to interrogate the full three-dimensional dataset. A select subset of two-dimensional fields (primarily surface and precipitation fields) for the NMM forecasts was also made available to local NWS forecast offices for viewing on AWIPS. Verification statistics were computed using the three packages described above. In addition, subjective evaluation of the forecasts was collected from the operational and research communities via online forms.

Table 1: Summary of physics packages used for DWFE

Physics	ARW	NMM
Microphysics	WSM5	Ferrier
Radiation	RRTM/Dudhia	MYJ
PBL	YSU	Eta
LSM	Noah	Noah
Cumulus	None	None

An extensive data archive was compiled for this real-time experiment that is available to the research community. The following files are available on NCAR's Mass Storage System (MSS): netCDF files containing output on the model native grid, GRIB output from the post processing package, verification statistics, and observations in PREPBUFR (surface and upper air) and GRIB (precipitation) formats. The images generated for the real-time web display, as well as corresponding radar composites and Eta forecasts are available via the DWFE catalogue (http://www.joss.ucar.edu/dwfe/catalog/) hosted by the Joint Office for Science Support (JOSS). The DWFE catalogue also contains an archive of the subjective evaluations of the forecasts provided by forecasters and researchers.

4. Community Support

Many new ideas and technologies originate in the university and non-operational research communities. Hence, it will be important for the DTC to reach out to this portion of the NWP community in order to achieve its goal of accelerating the transfer of new NWP technology into the operational environment. The DTC is working toward this goal through its visitor program and by working towards a release of the WRF-NMM core to the research community.

The DTC Visitor Program was initiated in the summer of 2004 with three visitors from the university community (Bill Gallus and Isidora Jankov from Iowa State University and David Dempsey from San Francisco State University) and one visitor from NCEP (Ying Lin). These visitors pursued a number of topics ranging from physics package testing to the development of new verification techniques. The DTC Visitor Program for 2005-06 promises to be significantly larger. Three proposals have already been selected from the submissions in response to the first Announcement of Opportunity (AO) distributed in mid-February. Bill Gallus of Iowa State University and two of his graduate students will be visiting the DTC to study the impacts of grid spacing and physical parameterizations on the Rapid Refresh WRF (WRF-RR) simulations of convective system rainfall and morphology. Paul Roebber of the University of Wisconsin-Milwaukee will be visiting the DTC to work on the development of an events-oriented approach to verifying high resolution forecasts of wintertime precipitation. Hsiao-Ming Hsu of NCAR/RAL will be working with the DTC on a new multiscale wavelet-based verification method. The selection of additional proposals submitted in response to the second AO distributed in mid-April is well underway. Support for visitors includes up to

one month of salary compensation, travel and per diem, as well as access to DTC computational resources.

Over the past few months, the DTC has undertaken the task of preparing the WRF-NMM core for release to the research community. These preparations have included: hiring a new staff member to serve as our WRF-NMM focal point, close interactions with the NMM developers to prepare a User's Guide and documentation, preliminary testing of WRF-NMM on various computing platforms, and preparations for a tutorial to be offered in Fall 2005.

5. DTC Advisory Board

Now that the management and basic staffing for the DTC has been established and the DTC has an end-to-end system in place for testing, the next important step will be to create and convene the DTC Advisory Board. The DTC Advisory Board will be composed of representatives drawn from the WRF DTC's potential user community, including members from NCAR, OAR, NCEP, NRL, ARL, the academic community, AFWA, FNMOC, and possibly the private sector. This Board will be tasked with helping the DTC management shape the overall program of the WRF DTC, by advising on emerging technologies for testing by the WRF DTC, computer resource issues, selecting visitors for the visitor program and acting as a sounding board to assist the DTC management.

6. References

Accadia, C., S. Mariani, M. Casaioli, A. Lavagnini, A. Speranza, 2003: Sensitivity of Precipitation Forecast Skill Scores to Bilinear Interpolation and a Simple Nearest-Neighbor Average Method on High-Resolution Verification Grids, *Wea. Forecasting*, **18**, 918–932.

Chen, F., K. W. Manning, D. N. Yates, M. A. LeMone, S. B. Trier, R. Cuena, and D. Niyogi, 2004: Development of High Resolution Land Data Assimilation System and Its Application to WRF. Preprint, 16th Conference on Numerical Weather Prediction, 11-15 January 2004, Seattle, WA. American Meteorological Society.

Chuang, H.-Y., G. DiMego, M. Baldwin, and WRF DTC Team, 2004: NCEP's WRF Post Processor and Verification Systems. 5th WRF/14th MM5 Users' Workshop, 22-25 June 2004, Boulder, Colorado, 181-183.

Demirtas, M., L. Nance, L. Bernardet, Y. Lin, H.-Y. Chuang, A. Loughe, R. Gall, and S. Koch, 2005: Verification Systems used for the Developmental Testbed Center. 6th WRF/ 15th MM5 Users' Workshop, 27-30 June 2005, Boulder, Colorado.

Loughe, A. F., J. K. Henderson, J. L. Mahoney, E. I. Tollerud, 2001: A Verification Approach Suitable for Assessing the Quality of Model-Based Precipitation Forecasts during Extreme Precipitation Events. Preprint, Symposium on Precipitation Extremes: Prediction, Impacts, and Responses, 14-19 January 2001, Albuquerque, NM. American Meteorological Society.

7. Acknowledgments

The DTC end-to-end system and DWFE are the products of contributions from a large team. At NCAR, Jim Bresch assisted with code porting and the implementation of the automated system for the WRF-ARW forecasts; Kris Conrad assisted with the DTC website; and Wei Wang, Jordan Powers, Dave Gill, Jimy Dudhia, and John Michalakes provided support for the WRF-ARW code. At FSL, Randy Collander developed the NCL scripts used to generate graphical images for the WRF-ARW and WRF-NMM forecasts; Sher Schranz, Jebb Stewart, Paula McCaslin, and Linda Wharton supported the FX-Net and AWIPS display capabilities for DWFE; Christopher Harrop assisted with code porting and automation for the WRF-NMM forecasts; Paul Hyder assisted with archiving and file transfers for DWFE; and Ed Szoke assisted with the forecaster evaluations for DWFE. At NCEP, Tom Black provided support for the WRF-NMM code. And finally, we would like to acknowledge the support and contributions of NWS Western Region, Central Region, and Eastern Region management and forecasters during DWFE.