The Developmental Testbed Center
WRF Reference Configuration Implementation Plan

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Introduction

The Developmental Testbed Center (DTC) is a distributed facility with components in the Joint Numerical Testbed (JNT) of the National Center for Atmospheric Research's (NCAR) Research Applications Laboratory (RAL) and the Global Systems Division (GSD) of the National Oceanic and Atmospheric Administration's (NOAA) Earth Systems Research Laboratory (ESRL). The DTC has several objectives, one of which is to advance science research by providing and supporting the components of state-of-the-art Numerical Weather Prediction (NWP) systems that function similarly to those used in operations to the research community. Another is to perform extensive testing and evaluation of promising codes emerging from the research community using these DTC-supported systems to demonstrate the potential of new science and technologies for possible use in operations. The ultimate goal of these specific activities is to accelerate the rate at which new technology is infused into operational weather forecasting.

The WRF model is a state-of-the-art NWP system that is highly configurable and suitable for a broad range of weather applications. With the numerous options available in this end-to-end system, it is extremely difficult to test all option combinations. Thus, there is a need within the WRF community for widely publicized verification results from a variety of configurations that have been extensively tested and evaluated.

Goals

To address the need for widely-published baselines or standard statistical results for well-tested, individual configurations of the WRF model, the DTC implemented the concept of WRF Reference Configurations (RCs) to serve both the operational and research communities. By conducting carefully controlled, rigorous testing, including the generation of verification statistics, RCs provide the operational community guidance for selecting configurations with potential value for operational implementation. RCs provide the research community with baselines against which the impacts of new techniques can be evaluated. Statistical results for a RC also aid researchers in selecting a configuration to use for their projects. Moreover, RCs serve as a benchmark to monitor the progress of mesoscale forecast improvement through periodic retesting as the WRF system evolves. An optimal mix of testing new configurations that represent the latest promising developments and retesting past RCs to maintain historical perspective is essential. It is important to note that RCs have a limited scope with a specific purpose and are only one aspect to the DTC's broader testing and evaluation mission; additional types of testing activities (e.g. configuration intercomparisons or diagnostic investigations) to address other community needs are also ongoing. When appropriate, datasets obtained through RC testing and evaluation are leveraged for these additional activities as well.

Experiment Design

Documentation detailing the specifications of the testing conducted is compiled and made widely available to the community through the RC portion of the DTC website (http://www.dtcenter.org/config/). In addition to the details of the model configuration (compile- and run-time settings), specific information on the domain size, location, map projection, grid spacing, forecast length, dates being run and application for which this configuration addresses are included. Finally, the post-processing and verification methodologies utilized are described.

Codes to be Employed

To ensure the results are most relevant to the user community, RC testing is, whenever possible, based on official releases of each software package used in a particular test. Relevant bug fixes identified before the retrospective testing begins are also included. The requirement to use code that is checked-in and tagged within the respective code repositories ensures the code changes have been vetted through a developers committee and run through an initial level of testing. The DTC will also serve the needs of its sponsor agencies by testing a newly contributed technique (a “tagged” version from the WRF repository) that is not yet available in the official release or additional software packages that are not yet supported to the community-at-large, as needed.

In general, the end-to-end forecast system utilized for RC testing will be comprised of a pre-processor (e.g., WRF Pre-processor (WPS) and/or a data assimilation package), the WRF model (including the Advanced Research WRF (ARW) and the Nonhydrostatic Mesoscale Model (NMM) dynamic cores), post-processor (e.g. Unified Post Processor (UPP)) and verification (e.g. Model Evaluation Tools (MET)). Depending on the specific application for each configuration, the exact software packages utilized for each step will vary (e.g., vortex initialization and tracker software will be used for hurricane applications). The system may also be coupled to additional components such as ocean, wave or land surface models.

Domain Configuration, Initial and Boundary Conditions, Forecast Periods

The exact domain, model initialization and the time periods chosen vary depending on the application. RC testing focuses on extended retrospective time periods and the cases selected encapsulate a broad range of weather regimes ranging from null, to weak and strong events. For some configurations these cases may be from all four seasons (e.g. mid-latitude domains for general predictions), while for others, the cases may come from a particular season (e.g., hurricane or convective season).

Physics Suites

The physics suite tested for each RC is chosen from the numerous options available for the specific version of WRF code being tested. A full set of namelist values for each parameterization scheme available as of WRF v3.3 are listed in Table 1, with more detailed information provided in Appendix A.

Table 1. Namelist values of parameterization schemes available in WRF v3.3.

Microphysics	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 13, 14, 16, 85
Radiation SW and LW	1, 2, 3, 4, 5, 99, 98
Surface Layer	1, 2, 3, 4, 5, 7, 10, 88
Land-Surface Model	1, 2, 3, 7, 88
Planetary Boundary Layer	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 99
Convection	0, 1, 2, 3, 4, 5, 6, 7, 14, 99

Post-processing

The WRF output is post-processed using the UPP to compute a variety of diagnostic fields, vertically interpolate fields to isobaric levels, destagger grids and interpolate to specified grids, if needed. The post-processed files include two- and three-dimensional fields in GRIB format, which can be used directly by a number of plotting and verification packages. Additional post-processing with supplementary software packages may be required, depending on the application. For example, hurricane applications require a tracker system to also be run on the output of UPP.

Model Verification

Objective model verification statistics are generated using a DTC-supported community verification package, when possible. The observation datasets and the statistics computed are clearly identified in the information provided to the community with the test results. The verification performed may include grid-to-point comparisons utilized to compare gridded surface and upper-air model data to point observations and grid-to-grid comparisons utilized to verify quantitative precipitation forecasts (QPF). Verification approaches include, but are not limited to, current standard verification statistics in wide use by the NWP community (e.g. RMSE, bias, GSS). In addition, new verification techniques are applied in the evaluation when appropriate. Depending on the application, a range of variables and properties may be evaluated. For example, surface and upper-air predictions for temperature, humidity and wind, as well as precipitation are assessed for general, mid-latitude forecasts, while for hurricane applications, storm properties such as location, intensity and structure are evaluated. Verification statistics generated for each retrospective case are used to compute and plot specified aggregated statistics and each type of verification metric is accompanied by confidence intervals (CIs) where appropriate, computed using the proper statistical method. Additional quantities may be verified as appropriate for a particular application.

Data Archival and Dissemination of Results

Once the verification analyses have been completed, the results are distributed to the user community via the DTC RC webpage (www.dtcenter.org/config) and all input and output data files from several stages of the end-to-end system are archived and made available for a minimum of one year. The naming convention of the posted RC's includes the WRF version, the dynamic core or specific application it was compiled for (e.g., ARW, NMM, HWRF) and the physics suite listed as PS:[microphysics].[lw_rad].[sw_rad].[sfc_layer].[lsm].[pbl].[convection], where the number associated with each parameterization is the value used in the *namelist.input* file when running the WRF model.

Appendix A: Naming Convention for Reference Configurations

WRF_version   Dynamic_core[ARW/NMM]
Physics_Suite(PS):[microphysics].[lw_rad].[sw_rad].[sfc_layer].[lsm].[pbl].[convection]

Microphysics options:

0. no microphysics
1. Kessler scheme
2. Lin et al. scheme
3. WSM 3-class simple ice scheme
4. WSM 5-class scheme
5. Ferrier (new Eta) scheme
6. WSM 6-class graupel scheme
7. Goddard GCE scheme
8. Thompson graupel scheme
9. Milbrandt-Yau scheme
10. Morrison 2-moment scheme
13. SBU, 5-class scheme
14. Double moment, 5-class scheme
16. Double moment, 6-class scheme
85. Etamp_hwrf scheme. Similar to Ferrier, modified for HWRF.
98. Thompson (v3.0) scheme

Long-wave Radiation options:

0. No longwave radiation
1. RRTM scheme
3. CAM scheme
4. RRTMG scheme
5. Goddard scheme
99. GFDL scheme
98. modified GFDL scheme

Short-wave Radiation options:

0. No shortwave radiation
1. Dudhia scheme
2. Goddard short wave scheme
3. CAM scheme
4. RRTMG scheme
5. Goddard scheme
99. GFDL scheme
98. modified GFDL scheme

Surface-layer options:

0. No surface-layer scheme
1. Monin-Obukhov scheme
2. Janjic scheme
3. NCEP Global Forecast System scheme
4. QNSE
5. MYNN
7. Pleim-Xiu surface layer
10. TEMF
88. GFDL surface layer scheme

Land-surface options:

0. No surface temperature prediction
1. Thermal diffusion scheme
2. Noah Land-Surface Model
3. RUC Land-Surface Model
7. Pleim-Xiu Land Surface Model
88. GFDL slab land surface model

Boundary-layer options:

0. No boundary-layer
1. YSU scheme
2. Mellor-Yamada-Janjic TKE scheme
3. NCEP Global Forecast System scheme
4. QNSE
5. MYNN 2.5 level TKE
6. MYNN 3rd level TKE
7. ACM scheme
8. BouLac TKE
9. UW scheme
10. TEMF
99. MRF scheme

Cumulus scheme options:

0. No cumulus scheme
1. Kain-Fritsch scheme
2. Betts-Miller-Janjic scheme
3. Grell-Devenyi ensemble scheme
4. Simplified Arakawa-Schubert scheme
5. Grell 3d ensemble scheme
6. Tiedtke scheme
7. Zhang-McFarlane scheme
14. New SAS
99. Previous Kain-Fritsch scheme