# P.5 Community Hurricane WRF support by the Developmental Testbed Center

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## 1. Introduction

The Developmental Testbed Center (DTC) began supporting the Community Hurricane WRF (HWRF) in April 2010. The community HWRF model is closely related to the operational HWRF, a National Oceanic and Atmospheric Administration (NOAA) model for hurricane forecasting that became operational in 2007 and has the following components: WRF atmospheric model with Nonhydrostatic Mesoscale Model (NMM) dynamic core, Princeton Ocean Model for Tropical Cyclones (POM-TC), and National Centers for Environmental Prediction (NCEP) coupler and Vortex Initialization. Additionally, it uses the NOAA Geophysical Fluid Dynamics Laboratory (GFDL) external vortex tracker. As part of community support, DTC is providing code management, code downloads, datasets, documentation, tutorials, and a helpdesk.

This paper describes how the Community HWRF code was created by merging the operational NCEP code based on WRF v2.0 onto the WRF community code repository in order to create a single code for research and operations. The forecast skill of the Community HWRF code will be discussed, and the Community HWRF user support and testing and evaluation activities of the DTC will be presented.

## 2. System description and community support

HWRF is an atmosphere-ocean coupled hurricane forecast system. Its atmospheric component employs the NMM dynamic core, runnning on an outer domain and vortex-following nest of 27- and 9-km horizontal grid spacing, respectively. The physical parameterizatons include the Simplified Arakawa-Schubert cumulus scheme, the Geophysical Fluid Dynamics Laboratory (GFDL) model surface layer parameterization, the Global Forecasting System (GFS) boundary layer parameterization, and the tropical Ferrier microphysics scheme. Additionally, a vortex initialization technique is used. HWRF's oceanic component is POM-TC, a version of the Princeton Ocean Model adapted for tropical cyclones at the University of Rhode Island (URI).

Figure 1 is a schematic flowchart of the Community HWRF components. Storm messages issued by the NOAA National Hurricane Center (NHC), including storm location and intensity, are used to define the HWRF domain. The WRF Preprocessing System is used to generate preliminary initial and boundary conditions based on the GFS analysis and prognoses. The initial condition and the NHC storm message are input to the vortex initialization process to improve the initial vortex representation. If a previous 6-h HWRF forecast is available, it is used in the vortex initialization process; otherwise a bogus vortex based on HWRF climatology is used. A features-based ocean initialization process generates initial conditions for the oceanic component POM-TC. HWRF atmospheric and oceanic components then run parallel and exchange information through the coupler: the

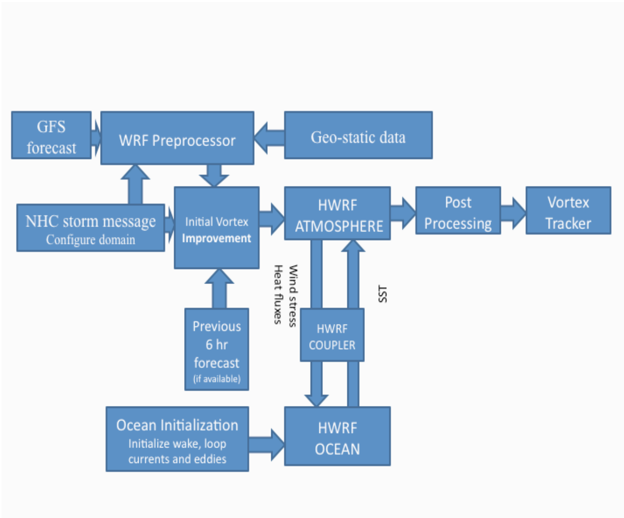


*Figure 1: Schematic flowchart of the community HWRF system components.*

atmospheric model calculates and sends the momentum and heat fluxes to the ocean, while the ocean model sends the sea surface temperature to the atmosphere. The model output is post-processed with the WRF Post Processor (WPP) and run through the GFDL Vortex Tracker, which extracts the tropical cyclone's track, intensity and structure from the model output. Additional information can be found in the [HWRF Scientific Documentation].

The operational HWRF model run at NCEP is based on WRF v2.0. During its development, numerous features were implemented to improve performance. However most of these advances are not available to the research community. Meanwhile, the general WRF model has evolved from v 2.0 to v 3.2 with contributions from the research community, but these contributions do not have a clear path to benefit operations at NCEP. To create the Community HWRF code, all atmospheric components of the operational HWRF, including physics packages, modifications to the dynamics, and the vortex-following movable nest have been added to the general WRF repository. This work was completed in the beginning of 2010, therefore the atmospheric component of the Community HWRF can be configured from WRF v3.2, which was released in April 2010.

For the non-WRF components of the Community HWRF, such as the vortex initialization, ocean model, coupler, and vortex tracker, code repositories have been set up at the DTC. While the operational HWRF was designed to run on IBM mainframes, the Community HWRF has the added capability of running on Linux Systems with both the Portland Group and Intel compilers. The differences between the Community and operational versions of the non-WRF components of HWRF are limited to changes related to platform portability and to fixes to code bugs uncovered in the porting process.

A beta version of the Community HWRF was released in February 2010, at the time of the first WRF for Hurricanes Tutorial, organized jointly by DTC, NOAA NCEP Environmental Modeling Center (EMC) and the Mesoscale and Microscale Meteorology (MMM) division of the National Center for Atmospheric Research (NCAR). The first official public release of HWRF is scheduled for the near future. In order to run the Community HWRF, users can download all components from the WRF for Hurricanes website and follow directions in the HWRF Users' Guide to configure the system as HWRF. This website also contains code release notes, answers to frequently asked questions, test datasets, and information on how to access the helpdesk.

The differences between the operational and Community versions of HWRF are summarized in Table 1. Besides the differences in non-WRF code and WRF release number described above, there are differences in model initialization. The operational HWRF is initialized from the spectral GFS in 64 hybrid vertical levels processed through the WRF Standard Initialization (SI). Since the SI is no longer supported, the Community HWRF uses the WRF Preprocessing System (WPS), which ingests the gridded GFS on isobaric levels in GRIB format. The GFS gridded data commonly distributed to the community has 27 isobaric levels. Additionally, the DTC does not yet provide support for the use of the Gridpoint Statistical Interpolation (GSI) with HWRF.

| | Pre-proc | GSI | WRF | Non-WRF | Initial Data |
|---|---|---|---|---|---|
| **Oper HWRF** | SI | Yes | V2.0 | Original code | Spectral GFS with 64 hybrid levels |
| **Comm HWRF** | WPS | No | V3.2 | Modified code | Gridded GFS with 27 isobaric levels |

*Table 1: Main differences between the operational and Community HWRF.*

## 3. Skill of the Community HWRF model

The DTC has conducted a test to evaluate the forecast skill of the Community HWRF. The control run for this test was the HWRF model run operationally in 2008, while the variant was a rerun using a version of Community HWRF just prior to the WRF v3.2 release. There are no significant differences between this version of code and the v3.2 public release. The operational non-WRF components of HWRF (vortex initialization, POM-TC, coupler and GFDL vortex tracker) were used in this test, in order to isolate changes in skill due to the use of the operational or Community versions of the WRF atmospheric model. Both of these runs were done on the NCEP IBM mainframes.

This test employed 177 cases from 8 Atlantic- basin tropical storms in the 2008 season. Results indicate that the operational and the Community HWRF have similar track forecast skills (Fig. 2). Result from a climatology and persistency model, Clipper, are shown for reference. The intensity forecast skill is mixed: the Community HWRF has inferior intensity forecast skill in the early stages but superior skill after 72 hours, when compared to the operational HWRF. Results for the NOAA GFDL model are also shown for reference.

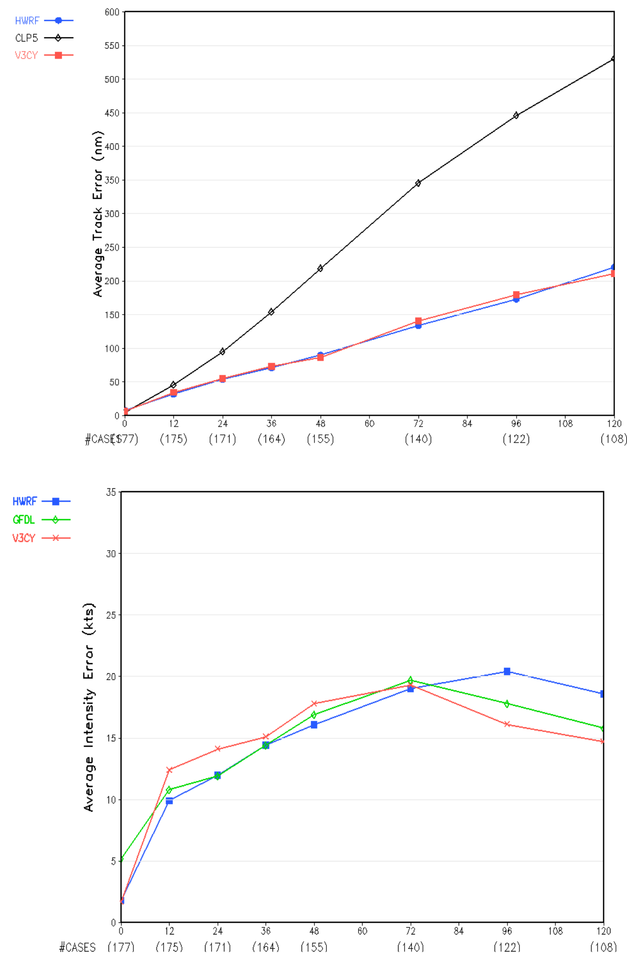


*Figure 2. Average top) track and bottom) absolute intensity error of HWRF as a function of forecast lead time (h). HWRF denotes the operational model and V3CY the Community model. The Clipper (CLP5) and GFDL model errors are also shown. The sample size is indicated in parenthsis below the forecast lead time.*

Differences between the forecast skill of the operational and Community HWRF forecasts in this test can be attributed to a variety of reasons. The two runs were initialized from different datasets: spectral GFS with 64 vertical hybrid levels processed with the SI for the operational model and gridded GFS with 27 isobaric levels processed with WPS for the community model. Additionally, the operational model employed GSI, while the community model did not. Numerous changes have been made to the WRF model as a whole as it evolved from v2.0 to v3.2, some of those involving significant infrastructure modifications. Finally, the possibility of incorrect porting of the operational HWRF features to the community model cannot be discarded.

Additional tests are currently being conducted to identify the sources of differences. Future tests will be performed using all the components of the Community HWRF, and not just the atmospheric model. The goal of these additional tests will be to give users information about the forecast skill of the hurricane model supported by the DTC, so that any improvements made upon the model can be compared against a baseline. Our intention is that the Community HWRF will be one of the WRF Reference Configurations (RCs) maintained by the DTC, as described in Wolff et al. (2010).

## 6. Concluding remarks

The goal of DTC is to serve as a bridge to facilitate the transfer of new developments from research to operations (Bernardet et al. 2008). A step in this process has been taken with the creation of the Community HWRF code and its support to users. Pending the demonstration of forecast skill of the community model through a number of upcoming tests, NCEP has shown commitment to drawing code from the community HWRF model to use in operations starting in 2011. Furthermore, NCEP has expressed willingness to make any new developments part of the community code, keeping the operational code synchronized with the community code in subsequent years. With this code management process, research and operations will be using the same code base, making it much more effective for new research and developments to be adopted in operations.

In the future, the DTC intends to expand the capabilities of the Community HWRF by extending the support to additional basins (currently only North Atlantic is supported) and adding new components as they become part of the operational code. The DTC is currently interfacing with NCEP and the general community to devised a strategy for continued collaboration as the operational models are transitioned from the WRF to the NOAA Environmental Modeling System software framework.

The role of the DTC with HWRF goes beyond community support. DTC is assembling a functionally equivalent operational environment to test and evaluate new HWRF developments over extended retrospective periods. The National Weather Service will benefit from the evaluation of the strengths and weaknesses of new NWP advances prior to consideration for operational implementation, and the research community will have available a baseline configuration against which any further developments can be evaluated. The test described in this paper was the first in a series of tests that the DTC intends to conduct over the next year.

## 7. Acknowledgments

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