P2.137 The community Hurricane Weather Research and Forecast (HWRF): System description, forecast skill and Developmental Testbed Center support

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1. Introduction

HWRF is a specialized version of the Weather Research and Forecast (WRF) model that has been designed to simulate and predict tropical cyclones. It was developed at EMC/NCEP based upon WRF version 2.0 and became operational in the 2007 hurricane season. 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 version 2.0 to version 3.2 with contributions from the research community, but these contributions do not have a clear path to benefit operations at NCEP.

The Developmental Testbed Center (DTC) is a joint effort between the National Center for Atmospheric Research (NCAR) and the Global Systems Division (GSD) at the NOAA Earth System Research Laboratory in Boulder, Colorado. The dual mission of the DTC is to accelerate the infusion of promising new numerical weather prediction (NWP) and data assimilation capabilities developed by the research community into operational applications, while also making an entire end-to-end operational NWP model code available and supportable to the research community.

Over the past two years, the DTC has taken on the challenge of providing the operational HWRF running at the NOAA NCEP to the community. This presentation summarizes what the DTC has accomplished thus far towards this goal and describes the DTC version of HWRF system and its forecast skill.

2. HWRF porting

HWRF is an atmosphere-ocean coupled hurricane forecast system. Its atmospheric component includes the Non-hydrostatic Mesoscale Model (NMM) dynamic core, the Simplified Arakawa-Schubert (SAS) cumulus scheme, the Geophysical Fluid Dynamics Laboratory model surface layer parameterization, the Global Forecasting System boundary layer parameterization, the tropical Ferrier microphysics scheme, the vortex-following movable grid nesting technique, and the bogus vortex and vortex relocation initialization techniques. HWRF's oceanic component is a version of the Princeton Ocean Model adapted for tropical cyclones (POM-TC), which was developed at the University of Rhode Island. The atmospheric and oceanic components communicate through a coupler developed at NCEP. HWRF postprocessing includes a vortex tracker, which can extract the tropical cyclone's track, intensity and structure from the model output.

All the HWRF components mentioned above have been successfully ported to the supercomputers at NCAR and ESRL that are used by the DTC. All atmospheric component of HWRF, including physics packages, modifications to the dynamics, and the vortex-

following movable nest grid have been merged into the general WRF repository. Therefore, HWRF can be configured using WRF version 3.2, which was released in April 2010. Code repositories have been set up for the non-WRF components of HWRF, such as the vortex initialization, ocean model, coupler, and vortex tracker. The DTC version of HWRF has had a beta-release in February 2010. The first official release of HWRF to public is scheduled for the near future.

There are a few differences between the operational and the current community versions of HWRF, which are listed in Table 1. Besides the differences in WRF release, there are differences in model initialization. The operational HWRF is initialized from the 64-level GFS processed through the SI. Since the SI is no longer supported, the community version of HWRF uses WPS, which can only ingest the GFS gridded data. Additionally, the DTC does not currently provide support for the Gridpoint Statistical Interpolation (GSI) with HWRF.

	Pre-processor	GSI	WRF-NMM	Initial Data
Operational version of HWRF	Standard Initialization (SI)	Yes	V2.0	Spectral GFS with 64 hybrid levels
Community version of HWRF	WRF Preprocessor (WPS)	No	V3.2	Gridded GFS with 27 isobaric levels

Table 1: Main differences between the operational and community versions of HWRF.

Figure 1 is a schematic flowchart of the community HWRF components. Storm messages issued by the National Hurricane Center, including storm location and intensity, are used to define the HWRF domain. The WRF preprocessor (WPS) is used to generate preliminary initial and boundary conditions. The initial condition is input to the vortex initialization process to improve its initial vortex representation. If a previous 6 hr forecast is available, it is used in the vortex initialization process; otherwise a bogus vortex based on HWRF climatology is used. An ocean initialization process generates initial conditions for the oceanic component POM-TC. HWRF atmospheric and oceanic components then run parallel and exchange information through a coupler: the atmospheric model calculates and sends the momentum and heat fluxes to the ocean, while the ocean model sends the sea surface temperature (SST) to the atmosphere.

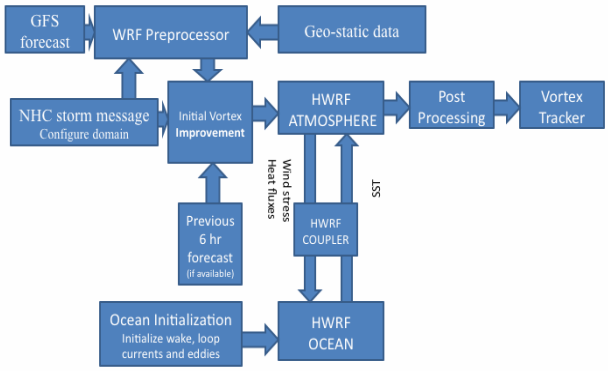

Figure 1: Schematic flowchart of the community HWRF system components.

3. HWRF testing

The operational version of HWRF was developed based upon WRF 2.0, and had since then diverged from the general WRF code, which had evolved to WRF V3.1 when DTC started the porting work. To reconcile the many differences between these two versions, the DTC, in collaboration with EMC, has added all WRF-related HWRF capabilities to the WRF community repository and conducted extensive

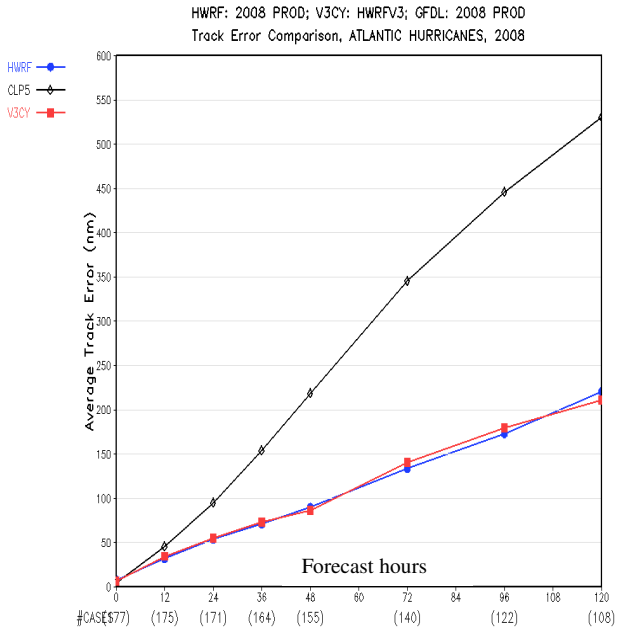

Figure 2: Average track forecast error of the operational and the community versions of HWRF. HWRF denotes the operational version, V3CY the community version, CLP5 the statistical CLIPER 5 model. 177 cases from 8 Atlantic basin storms in 2008 hurricane season were used in this test.

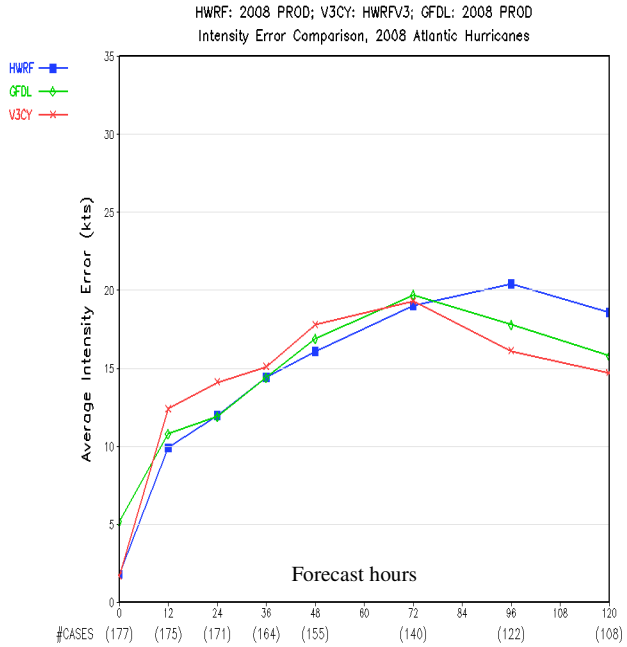

Figure 3: Average intensity forecast error of the operational and the community versions of HWRF. HWRF denotes the result from the operational version, V3CY the community version, GFDL the GFDL model. 177 cases from 8 Atlantic basin storms in 2008 hurricane season were used in this test.

tests. These tests included dynamics, physics schemes, vortex following moving nest, and initial conditions, leading to several bug fixes.

Figures 2 and 3 showed the results of a test using 177 cases from 8 Atlantic basin tropical storms in the 2008 season. The results of this test show that the operational and the DTC community versions of HWRF appeared to have similar track forecast skills. The result of intensity forecast skill is mixed: the DTC community version degraded the intensity forecast in the early stages but improved after 72 hours. More testing will be conducted to include more cases in 2008 and 2009, in both Atlantic and East Pacific basins.

HWRF will be one of the WRF Reference Configurations (RCs) maintained by the DTC. A RC is defined by the compile-time and run-time options used for extensive testing undertaken by the DTC for either a released version of WRF or a tag from the repository. Once the DTC has completed its evaluation, information on the configuration and its performance will be posted on the DTC website.

4. Community support

The DTC has organized HWRF scientific and technical documentations. A WRF for hurricanes tutorial was successfully held jointly by DTC, NCEP and NCAR/MMM in February 2010. DTC has started providing community support for HWRF users since the WRF for hurricanes tutorial, when a beta-version of HWRF was released. The HWRF help desk, as a component of the WRF help desk, has been set up and is in service. An HWRF website (http://www.dtcenter.org/HurrWRF/users) has been established where the users can find documentation, source codes, datasets etc.

5. HWRF code management

The goal of DTC is to serve as a bridge between research and operations to facilitate the

activities of both halves of the NWP Community. For the research community, DTC provides functionally equivalent operational environment to test and evaluate new NWP methods over extended retrospective periods. The operational communities benefit from DTC test and evaluation of strengths and weaknesses of new NWP advances prior to consideration for operational implementation.

A code management plan for HWRF has been established between DTC and EMC. According to this plan, the general WRF code repository will be used for the development and support of the HWRF system. HWRF will be fully integrated with the general WRF code, and will represent one of many possible configurations of WRF.

On the operational side of HWRF, EMC will manage and maintain its own operational HWRF code repository. To avoid the divergence of the code in the WRF repository and the code at EMC, a synchronization of the two repositories will be performed on a monthly basis.

6. Concluding remarks

As a part of DTC's effort to bridge the NWP research and operation communities, HWRF has been ported from EMC to DTC, upgraded to WRF V3.2, extensively tested and merged into the general WRF repository. DTC provides HWRF community support including documentation, tutorial and help desk. More testing will be conducted to make sure that the community and operational versions of HWRF have similar forecast performance. Meanwhile, the operational version of HWRF will have upgrades at NCEP EMC, which will include improvements to current components, new components (such as wave and storm surge components) and bug fixes. DTC will work on porting and testing these upgrades and providing community support. The goal of these efforts is to have the operation and research communities use the same HWRF code, and to promote the collaboration between the two communities which will accelerate the improvement of HWRF and operational hurricane prediction.

7. Acknowledgment

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