P444 Community Hurricane Weather Research and Forecast (HWRF) at the Developmental Testbed Center

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1. Introduction

HWRF is an atmosphere-ocean coupled hurricane forecast system. Its atmospheric component is a specialized version of the Weather Research and Forecast (WRF) model that has been designed to simulate and predict tropical cyclones, which 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 post-processing includes a vortex tracker, which can extract the tropical cyclone's track, intensity and structure from the model output.

HWRF 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 were not available to the research community. Meanwhile, the general WRF model had evolved from version 2.0 to version 3.1 with contributions from the research community, but these contributions did not have a clear path to benefit operations at NCEP.

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. Gridpoint Statistical Interpolation (GSI) is used to assimilate observational data into the initial fields. 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. GFDL vortex tracker is used to obtain the tropical cyclone track and intensity from the post-processed HWRF forecast.

The Developmental Testbed Center (DTC) is a joint effort between NCAR and the Global Systems Division (GSD) at the NOAA Earth System Research Laboratory. The main 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.

Over the past three 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 community version of HWRF system and its forecast skill.

The hurricane work at DTC contributes to the Hurricane Forecast Improvement Project (HFIP), whose main goal is to reduce track and intensity errors by 50% in first 5 days of forecast.

2. HWRF porting

All the HWRF components mentioned above have been successfully ported to the IBM/AIX and Intel/Linux supercomputers 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. A HWRF Beta version was released in March 2010. In the Beta version, HWRF can be configured using WRF version 3.1.1, which was released in July 2009 and currently supported by DTC. WRF version 3.3 will be released in March 2011. The HWRF capabilities from its atmospheric component will be merged into and be available in WRF v3.3. The next HWRF release will use WRF v3.3 and contain the capabilities used in the EMC 2011 operational baseline version.

Code repositories have been set up for the HWRF components which did not previously had community code repositories, namely the vortex initialization, ocean model, coupler, and vortex tracker. The community 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. The 2010 operational HWRF uses WRF version 2.0, while the community version uses WRF version 3.1.1. Note through the collaboration between DTC and EMC, WRF version 3.2.1 has been used in EMC's 2011 baseline version of HWRF and will be implemented in 2011 operational version with some minor modifications. Besides the differences in WRF release, there are differences in model initialization. The operational HWRF is initialized from the 64-level GFS spectral forecast data processed through the WRF Standard Initialization (SI). Since the SI is no longer supported, the community version of HWRF uses WPS to digest the GFS forecast.

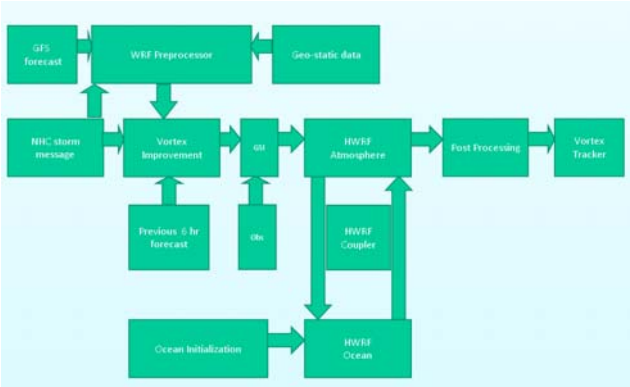

Figure 1: Schematic flowchart of the community HWRF system components.

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.

3. HWRF testing

The operational version of 2010 HWRF was developed based upon WRF 2.0, which diverged from the community WRF code, which had evolved to WRF v3.1 when DTC started the porting work and has now evolved to WRF

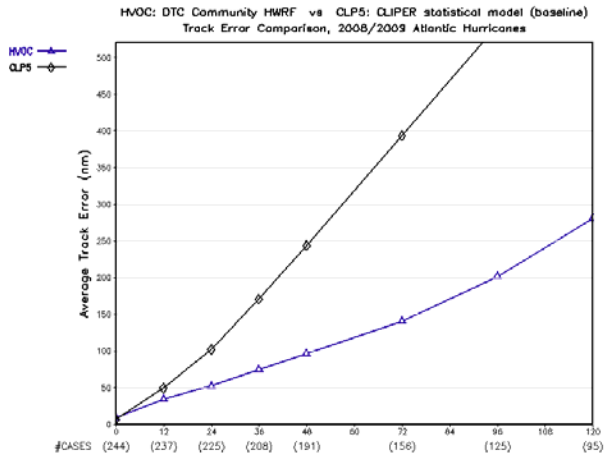

Figure 2: Average track forecast error of the community versions of HWRF. HVOC denotes the community version of HWRF, CLP5 the statistical benchmark CLIPER 5 model. 244 cases from Atlantic basin storms in 2008/2009 hurricane seasons were used in this test.

v3.2.1. After the many differences between these two versions were reconciled, the DTC, in collaboration with EMC, has conducted extensive tests. These tests focused on dynamics, physics schemes, vortex following moving nest, and initial conditions, leading to several bug fixes in the porting process.

Figures 2 and 3 show the results of a test using 244 cases from the Atlantic basin tropical storms in the 2008 and 2009 hurricane seasons. The operational (not shown) and the DTC community versions of HWRF appeared to have similar track and intensity forecast skills. More

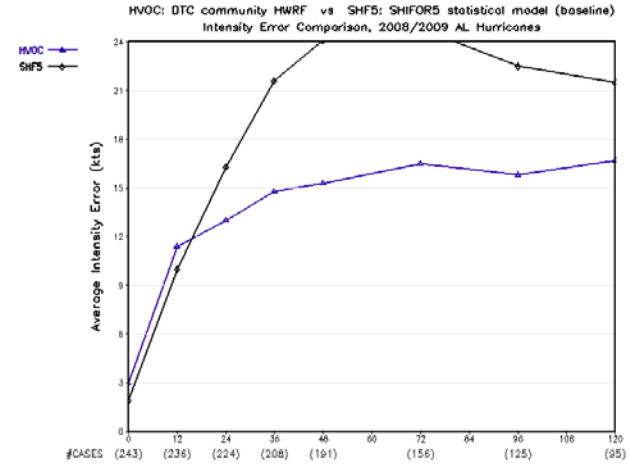

Figure 3: Average intensity forecast error of the community versions of HWRF. HVOC denotes the community version of HWRF, CLP5 the statistical benchmark CLIPER 5 model. 244 cases from Atlantic basin storms in 2008/2009 hurricane seasons were used in this test.

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. In addition to the tests for porting verification and reference configuration, DTC will also conduct tests to test promising new capabilities so they can be considered for operational implementation.

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. The next WRF for hurricanes tutorial is scheduled for April 2011 (The registration page is at http://www.dtcenter.org/HurrWRF/hurricane_tutorial_2011.php).

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. There are 161 registered HWRF users.

5. 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 V3.2.1, 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.

6. Acknowledgment

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