DTC Annual Operating Plan 2013

1 March 2013 – 28 February 2014

1. Introduction

The Developmental Testbed Center (DTC) is a distributed facility with components residing at the National Center for Atmospheric Research (NCAR) and the National Oceanic and Atmospheric Administration's (NOAA) Earth System Research Laboratory (ESRL). The objectives of the DTC are to: (i) advance science research by providing the research community an environment that is functionally similar to that used in operations to test and evaluate the components of state-of-the-art numerical weather prediction (NWP) systems, without interfering with actual day-to-day operations; (ii) reduce the average time required to implement promising codes emerging from the research community by performing the early steps of extensive testing to demonstrate the potential of new science and technologies for possible use in operations; (iii) sustain scientific interoperability of the community modeling system; (iv) manage, provide and support the common baseline of end-to-end community software to users, including dynamic cores, physics and data assimilation (DA) codes, pre- and post-processors and codes that support ensemble forecasting systems; and (v) establish, maintain and support a community statistical verification system for use by the broad NWP community. The fundamental purpose of the DTC is to serve as a coordinating mechanism that acts as a bridge between research and operations, thereby facilitating the activities of both communities in pursuit of their own objectives. For the DTC's AOP 2013, the Office of Oceanic and Atmospheric Research (OAR), the Air Force Weather Agency (AFWA), the National Weather Service (NWS) Hurricane Forecast Improvement Project (HFIP), NCAR, NOAA's U. S. Weather Research Program (USWRP) and the National Science Foundation (NSF) collectively provided approximately $5 M to support the activities of the DTC. The breakdown of funding by sponsor is summarized in Table 1.

The DTC currently has five major task areas (Mesoscale Modeling, Hurricanes, Data Assimilation, Ensembles, and Verification), all of which are overseen by the Director's Office. Each task has an assigned lead responsible for developing the task work plan and ensuring the successful execution of the work plan. All task areas are involved in community outreach and software management activities. The Mesoscale Modeling, Hurricanes, Data Assimilation and Ensembles tasks also undertake testing and evaluation (T&E) of promising new NWP innovations from the research community that are relevant to their focus area. The Verification task provides advice on appropriate statistical methods and interpretation to ensure DTC testing activities provide reliable metrics, using the most advanced methods available to the community. In addition, the DTC collaborates with NOAA testbeds to test and evaluate current and future mesoscale NWP systems. These testbed collaborations contribute to the activities of the appropriate DTC task area(s). This document provides a description of the work the DTC plans to carry out during this performance period, without differentiating the funding sources for each specific task. The breakdown of the new funding by task is summarized in Table 2. Note that the numbers in Table 2 reflect the funding allocations after funding transfer fees have been removed, so the totals for Tables 1 and 2 do not match. The work described in this document also includes activities covered by carry-over funds from AOP 2012, so the overall effort is slightly higher than that represented in Table 2. Tasks are carried out jointly by NCAR and ESRL staff.

Table 1: Funding breakdown by sponsor

Sponsor	Funding (in K)
OAR	$2,790
AFWA	$668
NCAR	$265
GSD	$250
NSF	$100
HFIP	$700
USWRP	$179

Table 2: Funding breakdown by task area

Task	Funding (in K)
Director's Office	$770
Visitor Program	$200
Mesoscale Modeling	$934
Hurricanes	$887
Data Assimilation	$793
Verification	$731
Ensembles	$453

2. Director's Office

The Director's Office provides administrative and management support for all DTC activities. This support includes: (i) managing and coordinating all DTC tasks, (ii) conducting DTC workshops and tutorials, (iii) interacting with DTC partners [e.g., NOAA's National Centers for Environmental Prediction (NCEP) Environmental Modeling Center (EMC), the Mesoscale and Microscale Meteorology (MMM) division of the NCAR Earth System Laboratory (NESL), and AFWA] on collaborative efforts, (iv) creating and maintaining the DTC web site, (v) coordinating the preparation and distribution of a quarterly DTC newsletter, and (vi) providing administrative support for DTC management meetings. In addition to these basic support activities, the Director's Office hosts the DTC Visitor Program.

3. Community Interactions

Maintaining strong ties to both the research and operational NWP communities is critical to the success of the DTC's mission. Strong ties with the operational community are maintained through the DTC's interactions with our partners at the operational centers (i.e., EMC and AFWA) both at the management level and through our task lead interactions with the appropriate team leads and/or focal points at the operational centers. The DTC works towards strengthening its ties to the broader research community through workshops, tutorials and the DTC Visitor Program. The DTC is also working towards engaging the community and opening a dialogue between operations and research through its quarterly newsletter. Information on DTC-sponsored tutorials is provided in Section 4.2.

3.1 Community Outreach Events

During AOP 2013, the DTC will conduct or assist with two workshops and one instructional session. The first community outreach event will be the 14th Weather Research and Forecasting (WRF) Users' Workshop in June 2013, which the DTC co-hosts with NESL's MMM. The annual WRF Users' Workshop provides a forum for presentations on the use of WRF in both research and operational settings. Instructional sessions are also offered on the last day of this workshop. Based on feedback from last year's workshop participants, the DTC plans to offer an instructional session on advanced verification methods at this event. The second community outreach event will be the 2013 Joint DTC-EMC-JCSDA Community Gridpoint Statistical Interpolation (GSI) Workshop on August 8, 2013 at the NOAA Center for Weather and Climate Prediction (NCWCP) in College Park, Maryland. This event will be the second GSI workshop since GSI became a community DA system and will mark the first time the DTC and EMC are co-hosting this event with the Joint Center for Satellite Data Assimilation (JCSDA) onsite at

NOAA, where the primary GSI developers are located. Speakers will be invited to talk about GSI and other related DA techniques, system development, and research.

3.2 Visitor Program

The DTC Visitor Program supports visitors to work with the DTC to test new forecasting and verification techniques, models, model components, and DA approaches for NWP and to perform diagnostic evaluations of the current operational systems. It also offers an opportunity for visitors to introduce new NWP and verification techniques into the community codes supported by the DTC. The goal of this program is to provide the operational weather prediction centers (i.e., NCEP and AFWA) with options for near term advances in operational weather forecasting and to provide researchers with NWP codes that represent the latest advances in technology. During AOP 2013, the DTC will be supporting four of the five visitor projects selected in January 2012 (see Table 3), as well as five visitor projects that were selected in January 2013 (see Table 4). The DTC also plans to distribute an Announcement of Opportunity (AO) for the next round of visitor projects in the fall of 2013 and wrap up the review/selection process by early 2014. In addition to distributing a new AO, the DTC will open its visitor program to off-cycle proposals. Off-cycle proposals will be subjected to the same review process and favorably reviewed proposals will be funded off-cycle if funding is available or they will be incorporated into the next formal cycle if no funding is available.

Table 3: List of visitor projects selected in January 2012 that are continuing into AOP 2013. The DTC offers two types of projects: (PI) projects undertaken by the project's principle investigator and (GS) projects undertaken by a graduate student under the direction of their major professor.

PI	Institution	Type	Project Title	Anticipated completion date
Jonathan Vigh	NCAR	PI	Development of an HWRF Diagnostics Module to Evaluate Intensity & Structure Using Synthetic Flight Paths Through Tropical Cyclones	November 2013
Delia Arnold & Don Morton	Technical U. of Catalonia / U. of Alaska – Fairbanks	PI	Moving The NEMS & NMM-B Into a Broader Community Resource Environment	August 2013
Robert Fovell / Travis Wilson	University of California-Los Angeles (UCLA)	GS	Improvements to Modeling Persistent Surface Cold Pools in WRF	July 2013
Sai Ravela	Massachusetts Institute of Technology (MIT)	PI	Deploying the MIT Field Alignment System & Test-bed (FAST) in DTC	June 2013

Table 4: Same as Table 3, except for visitor projects selected in January 2013.

PI	Institution	Type	Project Title
Adam Clark	University of Oklahoma	PI	Object-based Time-Domain Diagnostics for High-resolution Ensemble Forecasting and Evaluation in NOAA/HWT Spring Forecasting Experiments
Thomas Galarneau	NCAR	PI	Diagnosing Tropical Cyclone Motion Forecast Errors in HWRF
Robert Fovell / Chu-chun Huang (graduate student)	UCLA	GS	Improving HWRF Track and Intensity Forecasts Via Model Physics Evaluation and Tuning
Marion Mittermaier	UK MET Office (UKMET)	PI	Incorporating Observations Uncertainty to a Spatial Probabilistic Verification Framework for km-scale Models
Man Zhang	Colorado State University	PI	Impact Assessment of Cloud-Affected AMSU-A Radiance Assimilation in TC inner-Core Region using Hybrid Data Assimilation Approaches

4. Software Systems

To serve as a bridge between operations and research, the DTC provides a framework for the two communities to collaborate in order to accelerate the transition of new technology into operational weather forecasting. This framework is based on software systems that are a shared resource with distributed development. The current operational systems are generally a subset of the capabilities contained in these software systems. Ongoing development of these systems is maintained under version control with mutually agreed upon software management plans. The DTC currently works with the following software systems:

- WRF – NWP model + pre- and post-processors
- Unified Post Processor (UPP)
- Hurricane WRF (HWRF; set of tools for tropical storm forecasting, including a coupled atmosphere and ocean system and the GFDL vortex tracker)
- NOAA Environmental Modeling System (NEMS)
- GSI DA System
- Ensemble Kalman Filter (EnKF) DA system
- Modular end-to-end ensemble system
- Model Evaluation Tools (MET) – Verification package

With the exception of MET, the DTC does not contribute to the development of new scientific techniques for these software packages. Rather, the DTC contributes to the software management of all of these systems and user support for the publicly-released systems (WRF, UPP, HWRF, GFDL vortex tracker, GSI and MET). All software management and user support activities are collaborative efforts with the developers, where the exact role of the DTC depends on the software package. The main developers of these packages are affiliated with EMC,

ESRL, NCAR, Global Modeling and Assimilation Office (GMAO) of the National Aeronautics and Space Administration (NASA), Geophysical Fluid Dynamics Laboratory (GFDL), University of Rhode Island (URI) and the Hurricane Research Division (HRD) of NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML). DTC activities are currently focused on the regional application of these software systems. In addition to working with these individual software systems, the DTC is involved in an effort to apply the GSI-hybrid DA technique to operational hurricane forecasts, which requires linking the GSI DA system with both an ensemble system and HWRF.

4.1 Software Management

While specific software management plans differ between the various software packages, they all contain the following elements:

- Code repositories that are maintained under version control software.
- Protocols for proposing modifications to the software, whether the modifications are simply updates to current features, bug fixes or the addition of new features.
- Testing standards that proposed software modifications must pass prior to being committed to the code repository.
- Additional testing standards used to more thoroughly check the integrity of the evolving code base.

Given all these software packages continue to evolve over time, all testing standards must be updated periodically in order to meet the maintenance requirements of the code base. The DTC will continue to collaborate with the various developer groups on these ongoing software management activities during AOP 2013. The DTC will also continue to provide a pathway for the research community to contribute to the development of these software systems. Only new activities related to these software systems or work that goes beyond the basic maintenance will be described in this document.

4.1.1 WRF

The WRF software package contains two dynamic cores and numerous options for each type of physics parameterizations. Not all of the physics options communicate appropriately with both dynamic cores. During AOP 2013, the DTC will continue to work on increasing physics interoperability. Allowing more physics parameterizations to be run with both dynamic cores provides the research community with more options to test and additional opportunities to impact a wider range of operational configurations. This type of effort may also help support the transition of similar physics parameterizations into next generation NWP systems in future years. The focus for this performance period will be on making more physics options available to HWRF with the exact focus to be determined through discussions with HWRF developers.

4.1.2 NEMS

As NOAA continues to transition their operations to NEMS, the DTC will continue to strengthen its foundation of expertise with the NEMS software and the science associated with NEMS-based models during AOP 2013. A code management plan for the Community NEMS repository defining the policies and procedures for maintaining the repository at the DTC will be implemented in AOP 2013. The DTC will continue to participate in technical discussions specifically focused on the status of NEMS development and options regarding the integration of

new features or capabilities. Work to transition WRF-based physics schemes into the NEMS framework, specifically for NMMB, will also be explored for particular schemes of interest.

An updated friendly user release of NEMS/NMMB will be packaged and distributed to selected community users during AOP 2013, which will also include introductory documentation on running the system.

4.1.3 GSI-hybrid

A number of operational systems at NOAA are running or will implement the GSI-based hybrid variational-ensemble DA system (GSI-hybrid), which incorporates the flow-dependent information from ensembles into the background error description. Working closely with the GSI-hybrid developers at EMC and ESRL, the DTC will lead an effort to set up a code management plan for the GSI-hybrid development and coordination. The DTC will work with EMC on the maintenance of an EnKF code repository. The EnKF is an ensemble DA system used to update the ensemble perturbations in the NCEP two-way coupled GSI-hybrid system. This effort will also include setting up a procedure for reviewing and committing EnKF code, which will include a code regression test suite.

4.1.4 MET and METViewer Development

To serve as a bridge between research and operations, the DTC needs to make traditional as well as state-of-the-art verification tools available to the NWP community. Hence, the DTC began assembling its MET package in the fall of 2006. This package includes standard verification approaches, as well as a number of more advanced approaches recently developed by the verification community.

To maintain state-of-the-art verification tools, the DTC must engage the international verification community and continue to add new capabilities to MET. For AOP 2013, investigation of new methods will focus on ensemble verification and use of satellite observations. The DTC will also continue to investigate and implement the most useful methods for verification of cloud forecast variables. The DTC will examine different spatial verification methods and identify one operationally useful method for nearer term MET development. To stay apace with needs for verification tool enhancements, support for NetCDF-CF format will be implemented. Work towards integrating land surface model observation sources will also be continued in AOP 2013.

Testing and evaluation of ensemble forecasting is a significant effort within DTC, and new methods for verifying ensemble forecasts are needed to support this effort. The Verification task will work closely with the Ensembles task to investigate, define, develop, and test new tools to support ensemble T&E. These new tools will include enhancements to support data formats and graphics needed for ensemble verification.

Verification of tropical cyclones shares many of the challenges of traditional numerical model verification, but with very different types of forecast and observational data. MET-TC (the Model Evaluation Tools Tropical Cyclone) development will be continued this year to meet many of those challenges. Currently, the MET-TC capability replicates the methods for track and intensity errors used by the National Hurricane Center (NHC) verification system. The initial release of this software will occur in spring of 2013, with additional enhancements continuing throughout the year. The Verification task will work closely with the Hurricane and Data Assimilation tasks to investigate, define, develop, and test new tools to support TC T&E. Community support for these new tools is necessary. Thus, the current met_help email support

will extend to users of the MET-TC software. Also, new lectures and exercises on the MET-TC capabilities will be added to both the in-person and online MET tutorials. Presentations about MET-TC will be given at appropriate meetings to promote use and understanding of the tools by the community.

The DTC developed a software package, METViewer, to build a database of verification metrics produced by MET, and to provide web-based display tools for visualization of these metrics. In addition, METViewer can produce aggregated statistics such as Receiver Operating Characteristic (ROC) curves. METViewer will be updated to include more ensemble tools and other tools or displays as needed to support T&E needs within the DTC. The GUI redesign that was begun in AOP 2012 will continue into 2013, with T&E needs driving the development.

4.2 Publicly-Released Systems

The DTC currently collaborates with developers on six software systems that undergo a public release process: WRF, UPP, HWRF, GFDL vortex tracker, GSI and MET. These packages are on an annual or bi-annual release schedule. Prior to any public release, the DTC conducts extensive pre-release testing on several platforms using multiple compiler options and configurations of the code. Up-to-date documentation and email helpdesk are provided for all publicly-released packages. Documentation, bug fixes, online tutorials and code access are provided through users pages set up for each package. Onsite tutorials are also offered for each package in close collaboration with the code developers. During these tutorials, participants benefit from lectures given by system experts and one-on-one assistance during practical sessions. The MET tutorials also include a half-day dedicated to an introduction to general verification concepts and the MET Users Page includes numerous links to helpful instructional materials about verification. Code release and tutorial plans for AOP 2013 are summarized in Table 5. In the past, the DTC has collaborated with MMM and EMC on Joint WRF Tutorials. Priorities for AOP 2013 are such that the DTC decided to drop the NMM dynamic core talk during the tutorials, but will continue to present the UPP talk at both the summer and winter tutorials. The DTC will also continue to broaden the community's awareness of the HWRF system's availability and capabilities by providing an introduction to the HWRF system at the WRF Tutorials. A Joint DTC-EMC-JCSDA Community GSI Tutorial is scheduled for Aug 5-7, 2013, at NCWCP in College Park, Maryland. This marks the third annual GSI Tutorial since GSI became a community model in 2009, but the first time the DTC and EMC are co-hosting this event with JCSDA on-site at NOAA. Speakers for the GSI tutorial are invited from NOAA, JCSDA, NASA, University of Maryland, and NCAR, providing firsthand information on the GSI code. An HWRF tutorial is also schedule for January 14-16, 2014 at NCWCP in College Park, Maryland.

Table 5: Code release and tutorial schedules.

Software Package	Public Release		Tutorial
	Version	Timing	
WRF	V3.5 V3.5.1	April 2013 August 2013	July 2013 January 2014
UPP	V2.1	April 2013	
HWRF	V3.5a	August 2013	January 2014
GFDL Vortex Tracker	V3.5a	September 2013	
GSI	V3.2	July 2013	August 2013
MET	V4.1	May 2013	January 2014

To expand the awareness of the more recent additions to the publicly-released packages, the DTC will work with its collaborators to publish articles on the community code aspects of GSI and HWRF in the Bulletin of the American Meteorological Society (BAMS).

Anticipated major accomplishments for AOP 2013:

- Expanded capabilities for all software systems
- New versions of WRF, HWRF, GSI, UPP and MET available to the community, including updated documentation
- WRF, HWRF, GSI and MET onsite tutorials
- NEMS/NMMB code management plan implemented and friendly user release
- Manuscripts on GSI effort submitted to BAMS and proposal for HWRF submitted to BAMS

5. Testing and Evaluation

Testing and evaluation undertaken by the developers of new NWP techniques from the research community is generally focused on case studies. However, to adequately assess these techniques, extensive T&E must be performed to ensure that these new techniques are indeed ready for operational consideration. The DTC undertakes two types of rigorous T&E activities: 1) studies for which the DTC generates forecasts and evaluates the skill of these forecasts (end-to-end internal testing), and 2) studies for which the DTC evaluates the skill of forecasts provided by external modeling groups. From time to time, the DTC also undertakes case studies or testing for smaller samples directed at providing a preliminary look at the impact of a new technique.

Internal DTC T&E generally focuses on extended retrospective time periods. The cases selected encapsulate a broad range of weather regimes ranging from null, to weak and strong events. The exact periods chosen vary based on the phenomenon of focus for the test. The technique to be tested must be part of the appropriate code repository to ensure the code has reached a certain level of maturity. The DTC's evaluation of these retrospective forecasts includes standard verification techniques, as well as new verification techniques when appropriate. All verification statistics also undergo a statistical significance assessment when appropriate. By conducting carefully controlled, rigorous testing, including the generation of objective verification statistics, the DTC is able to provide the operational community with guidance for selecting new NWP technologies with potential value for operational implementation. DTC testing also provides the research community with baselines against which the impacts of new techniques can be evaluated. The statistical results may also aid researchers in selecting model configurations to use for their projects.

In addition to internal testing, the DTC occasionally participates in T&E activities in which the model output is produced by a modeling group or groups. These model evaluations can consist of demonstrations of model evaluation capabilities in real-time forecast projects or long-term retrospective evaluations in which the model setup (e.g. initial conditions, resolution, other model system attributes) is well-defined in advance and the model output is provided to the DTC by the modeling group. The DTC's evaluation of these externally generated forecasts follows the same principles applied to the evaluation of the forecasts generated internally by the DTC; objective verification statistics are computed, including standard verification metrics as well as

new verification techniques when appropriate. The verification statistics also undergo a statistical significance assessment when appropriate.

5.1 Mesoscale Modeling

Since its inception, the DTC has undertaken T&E activities directed at assessing the skill of WRF model configurations for mesoscale, mid-latitude applications. While the DTC will continue its WRF-based T&E activities for the foreseeable future, broadening the scope of its internal T&E activities to include new software frameworks (i.e., NEMS) utilized by the relevant operational centers (i.e., NOAA) is necessary in order to continue to serve as a bridge between research and operations. Activities focused on both of these efforts are described in the following sections.

Communication is a key mechanism to serving as a bridge between research and operations. One aspect of making information on DTC activities available to the community is presenting information at relevant conferences or workshops; another is posting information on the DTC website. In addition, the DTC needs to dedicate time to producing journal articles on its key activities. For AOP 2013, continued efforts on preparing manuscripts describing the DTC T&E methodology and outcomes of key Mesoscale Modeling T&E activities will be undertaken.

5.1.1 Mesoscale Modeling Evaluation Testbed

The Mesoscale Modeling Evaluation Testbed was put in place during AOP 2012 in an effort to provide a common framework for researchers to demonstrate the merits of new developments. For the nine cases established last year, the WRF-ARW baseline results will be updated with the latest official release. An additional baseline for each case will be established utilizing the NMMB model with the operational physics suite. A minimum of four additional cases will be included with baseline results established for both the WRF-ARW and NMMB models. Two of the new cases will be specifically focused on atmospheric river (AR) events and the other two will be cases of particular interest to the operational community. An additional ARW baseline will be generated for the AR cases with a physics suite informed by recent work by Dr. David Kingsmill and his colleagues at ESRL. The initialization and observation data sets for these new cases will be gathered and packaged for distribution. The MMET webpage (http://www.dtcenter.org/eval/mmet/) will be enhanced and updated to keep the content relevant and the data accessible.

5.1.2 WRF-based Systems

The WRF model is a mesoscale NWP system utilized in both research and operational forecasting applications. The model has numerous options available and is highly-configurable to the users' requirements. 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 by either the DTC or a member of the WRF community. These evaluations will ultimately support both the research and operational communities. To fill this need, the DTC conducts both model inter-comparison and Reference Configuration (RC) T&E.

In support of facilitating the transfer of new innovations between the research and operational communities, the DTC has the capability to run a WRF-based system in an environment that is functionally similar to AFWA's operations. Included in the end-to-end system is a pre-processor (WPS), data assimilation [i.e., GSI or WRF data assimilation (WRFDA)], the model itself (WRF), and a post-processor (UPP). One WRF-based test will be conducted within this

environment during AOP 2013. The test will focus on an inter-comparison between the AFWA operational configuration and a second configuration identified after consultation with AFWA to determine a promising new technique or feature of interest to extensively test. The testing will be conducted with the most recent WRF package available at the time testing is commenced. The end-to-end system will be set-up, run and analyzed with standard verification metrics applied to meteorological variables including temperature, moisture, wind and precipitation. Advanced verification methods will also be applied when appropriate to provide further diagnosis and evaluate the forecast performance.

To expand the number of baselines for operational or soon-to-be operational models and build a historical record of performance over sequential model versions, the DTC will continue to designate new RCs during AOP 2013. Results of the model inter-comparison will be leveraged and each configuration will be assessed individually to designate it as a RC.

The DTC also recognizes that extensive data sets are being produced by the WRF user community and these data sets provide additional resources to leverage. Members of the university community have been invited to collaborate with the DTC to establish Community Contributed Reference Configurations (CCRCs) in order to take advantage of these data and potentially create a more extensive collection of model verification results across a broader range of forecast applications. During AOP 2013, the DTC will continue to encourage and support the research community to share their results from significant testing activities in a manner that will benefit the community as a whole.

5.1.3 NEMS-based Systems

During AOP 2012, a functionally similar environment to NCEP operations was established to run the NMMB model in the NEMS framework. The end-to-end system includes a pre-processor [NEMS Preprocessor (NPS)], data assimilation (i.e., GSI), the model itself (NMMB), and a post-processor (UPP). One NEMS-based test will be conducted within this environment during AOP 2013. The test will focus on an inter-comparison between the North American Mesoscale (NAM) model operational configuration, while the second configuration will swap in the Thompson microphysics (integrated as an option into NMMB late in AOP 2012 by DTC staff) and RRTMG radiation packages. Similar verification methods will be applied as described in section 5.1.2.

In order to provide baselines for the NMMB performance, the DTC will again leverage the work from the inter-comparison test to assess each configuration individually and designate them both as RCs.

Anticipated major accomplishments for AOP 2013:

- MMET enhanced to include additional baselines and relevant cases.
- Report on WRF-based model inter-comparison tests conducted using AFWA functionally similar operational environment.
- Report on NEMS-based model inter-comparison tests conducted using NCEP functionally similar operational environment.
- New RCs designated based on latest T&E.
- Manuscript(s) submitted to appropriate peer-reviewed journals.

5.2 Hurricanes

During AOP 2013, the DTC will update its operational HWRF functionally similar environment for internal testing. This work will include adopting all changes to run the 2013 operational HWRF, including the use of the GSI-hybrid configured to use NCEP's Global Forecast System (GFS) ensemble to generate a flow-dependent background error covariance matrix. The DTC will utilize this testing environment to perform the T&E activity described below.

Communication of DTC activities related to Hurricanes is important. While the DTC website is one important means of making information available to the community, this method alone is not sufficient. Hence, the DTC's Hurricane task will also dedicate time to producing journals articles on its key T&E activities. For AOP 2013, a manuscript describing HWRF's sensitivity to cumulus schemes will be prepared and submitted to the journal Geophysical Research Letters.

5.2.1 Testing Promising New Capabilities

Using the DTC HWRF functionally similar operational environment, the DTC will conduct a comprehensive test of an alternate HWRF configuration based on promising advances for future EMC operational implementations. The focus of the test has not yet been determined. A DTC HWRF Test Plan will be created outlining the details following discussions with HFIP and EMC about the appropriate focus for this test. Possibilities being considered for testing include HWRF with the Thompson microphysics (for which the DTC conducted case studies in AOP 2012) or the Noah land surface model, which will allow for future connection between HWRF and hydrological models.

5.2.2 Reference Configuration

The control run used for the T&E activity discussed above will be used to designate a Reference Configuration. The primary goals of the RC are to create a benchmark for a) community members to use as a control when evaluating their developments and contributions, and b) the DTC to compare forecasts created with future model versions against in order to assess the improvement of the model over time.

5.2.3 Preliminary Analysis of GFS Five-Day Forecast Errors

The HFIP goals are to improve the skill of 1-5 day hurricane forecasts by 50% in ten years both in terms of track and intensity, and to improve their skill by 20% in five years. A recent evaluation of 2012 GFS hurricane track forecasts shows more than 20% improvement over the HFIP baseline for 1-4 day forecasts, but with very small improvements for five-day track forecasts. At the request of HFIP, the DTC will conduct a preliminary diagnosis of GFS forecast errors, identifying factors that may contribute to the slow improvement in GFS five-day track forecasts.

Anticipated major accomplishment for AOP 2013:

- New HWRF Reference Configuration.
- Report on comprehensive test of the impact of a promising new capability on HWRF performance.
- Report on the diagnosis of GFS five-day hurricane track forecast errors.
- Manuscript(s) submitted to appropriate peer-reviewed journals.

5.3 Data Assimilation

For AOP 2013, the Data Assimilation task will conduct T&E directed at two different applications of GSI: 1) implementation of GSI in AFWA's operational forecast system, and 2) application of GSI-hybrid in NCEP's HWRF forecast system. In addition to these new T&E activities, the Data Assimilation task will work towards publicizing the outcome of key T&E activities by preparing manuscripts on its AOP 2012 work utilizing the EnKF algorithm in the Data Assimilation Research Testbed (DART) software system and aspects of its DA T&E for the HWRF system.

5.3.1 GSI Baseline Tests

The DTC will conduct GSI baseline T&E in applications of interest to AFWA. The DTC will continue to maintain its functionally similar environment to test the GSI code and configurations for AFWA DA implementation. Tests conducted by the DTC will complement the AFWA pre-operational T&E. The DTC will focus on retrospective tests of individual code changes and updates, while some short-term real-time runs may also be conducted to help uncover issues. The focus of this T&E activity will be selected in consultation with the AFWA DA team. In general, the following DA components (but not limited to) could be tested:

- New configuration and workflow
- New DA capabilities/techniques
- New types of observations assimilated
- New applications (domain, season, specific weather phenomena, etc…)

5.3.2 GSI-hybrid tests for HWRF

HFIP has identified the initialization of the HWRF operational forecast system as a key area in need of improvement. The DTC will continue to work with a core group formed under the auspices of HFIP to improve the GSI-hybrid system performance for the HWRF application. The testing components will be set up based on the HFIP DA milestones and in consultation with EMC and other development teams. Some possible tests (but not limited to) are:

- Examine the error representation in ensemble products and test and evaluate alternative ensemble products (GFS ensemble or regional ensemble) or ensemble parameters (e.g., inflation, localization) for GSI-hybrid applications.
- Test alternative configurations, e.g. cycling strategies for HWRF hybrid DA (cold start, warm start, partial cycling, full cycling) and evaluate their impacts on analysis and forecast quality.
- Examine the impact of adding clear-air and cloudy radiance DA to current conventional DA. This test would include investigating the impact of a new bias correction scheme and experimental cloudy radiance DA for the HWRF application.

The DTC will also work on enhancing the diagnostic tools for GSI-hybrid T&E. This work will apply currently available but distributed diagnostic capabilities, especially for the ensemble pieces, and add new testing capability to the system, if needed.

Anticipated major accomplishments for AOP 2013:

- Report on GSI baseline tests
- Report on GSI-hybrid tests for HWRF

- Manuscript submitted to appropriate peer-reviewed journals

5.4 Ensembles

The Ensembles task will focus its AOP 2013 T&E activities on NCEP's Short Range Ensemble Forecast (SREF) system. The T&E will use the DTC's SREF functionally similar environment to perform tests that evaluate the impacts of smaller horizontal grid spacing, use of two dynamic cores (ARW and NMMB) instead of three (ARW, NMMB and NMME), replacing SREF's Ensemble Transform with Rescaling (ETR) technique with a dynamical downscaling perturbations technique, and modifying the representation of model perturbations by replacing the SREF physics suite with a promising physics suite from the real-time Hydrometeorology Testbed (HMT) ensemble. These tests will be performed such that the SREF system is modified in a step-wise manner in order to document the impact of each technique. The T&E addressing initial and model perturbations and horizontal resolution will be conducted in the context of the DTC's collaboration with HMT. The ARW members of the SREF will be the focus of this T&E. Completion of the extensive runs isolating the impacts of initial and model perturbations are carry-over activities from AOP 2012. Additional runs covered by AOP 2013 funding will address the impact of changing the grid spacing of the ARW members from 16 km to 9 km. Testing of the two versus three dynamic core membership will build on the HMT testing where possible. Reports will be prepared on the head-to-head extended period tests for the various techniques that will be provided to EMC and posted on the DTC website to make this information available to the broader NWP community.

Anticipated major accomplishments for AOP 2013:

- Report on the impacts smaller horizontal grid spacing on SREF performance,
- Report on the impacts of alternative initial perturbation techniques,
- Report on the impacts of changes in microphysics parameterizations in the context of precipitation prediction,
- Report on the impact of removing the NMM-E dynamic core from the SREF suite.