Developmental Testbed Center | DTC

Transitions

Newsletter Summer 2016

Jacob Edminston's Monarch Butterfly /Orlando

ISSUE 11

INSIDE THIS ISSUE

ASSISTING WITH THE TRANSITION OF PROMISING NWP TECHNIQUES FROM RESEARCH TO OPERATIONS

The Need for a Community Physics Package

Improvement of NWP model parameterizations offers a fruitful path for improving models. But challenges in physics development are numerous, including dependence on grid length and the need to reformulate physics to properly accommodate scales now resolved in high-resolution models.

While national modeling centers can benefit from the expertise in the broader community of parameterization developers, the social and technical barriers to a community researcher implementing and testing a new parameterization or set of parameterizations (a physics suite) in an operational model are high.

Physical parameterization codes are often implemented so that they are strongly linked to a particular model dynamical core, with dependencies on grid structure, prognostic variables, and even time-stepping scheme. Dependencies amongst schemes are also common. For example, information from a deep convection scheme may be needed in a gravity wave drag scheme. While the dependencies are generally justified based on computational efficiency arguments, it complicates the replacement of parameterizations and of suites, marginalizing tremendous scientific talent.

To address these difficulties, and engage the broad community of physics developers in the National Weather Service's Next-Generation Global Prediction System (NGGPS), the DTC's Global Model Test Bed (GMTB) is participating in developing the Common Community Physics Package (CCPP). The schematic (on page two) shows the DTC's proposed modeling meta-structure for NGGPS, with the CCPP shown in the gray box. Specific parameterizations in the CCPP shown here are for example only; other parameterizations or sets of parameterizations could be displayed in the blue boxes.

> *"The emerging CCPP is a critical element to bridge research and operations."*

Although requirements are sure to evolve depending on priorities and funding, an initial set is in place to inform the CCPP design. They reflect the following vision for the CCPP: (1) a low barrier to entry for physics researchers to test their ideas in a sandbox, (2) a hierarchy of testing capabilities, ranging from unit tests to global model tests, (3) a set of peer-reviewed metrics for validation and verification, and (4) a community process by which new or modified parameterizations become supported within the CCPP. We recognize that an easier technical implementation path for a physical parameterization does not replace the scientific expertise necessary to ensure that it functions correctly or works well as part of a suite. A test environment

*(**CCPP** continued on page two.)*

Director's Corner

by Vijay Tallapragada

My association with the Developmental Testbed Center (DTC) dates back to early 2008 when the NCEP operational Hurricane Weather Research and Forecast (HWRF) modeling system developed at Environmental Modeling Center (EMC) was adopted to create a community modeling framework for hurricane model develop-

Vijay Tallapragada
EMC

ment supported by the Hurricane Forecast Improvement Project (HFIP). I enjoyed working with DTC in various capacities as the Hurricane Team Leader at EMC and the Development Manager of HFIP.

Operational hurricane model development undoubtedly has been

*(**Director's Corner** continued page two.)*

(*CCPP continued from page one.*)

intended to ease that process is also under development at GMTB, beginning with a single-column model linked to the GFS physics.

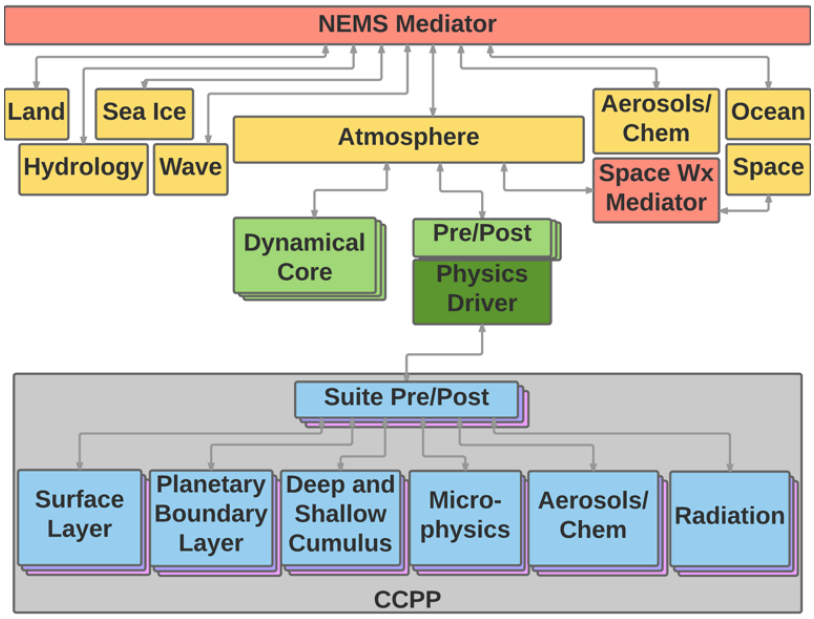


Diagram of the proposed Common Community Physics Package (CCPP)

The low barrier to entry implies a highly modular code and clear dependencies. Dependencies, and the interface between physics and a dynamical core, will be handled by a thin "driver" layer (dark green box in the schematic). Variables are defined in the driver, and exchanged between model dynamics and various parameterizations. The current driver, being used for the NGGPS dynamic core test participants to run their models with the GFS physics suite, is a descendant of the National Unified Operational Prediction Capability (NUOPC) physics driver requirements. Going forward it will be called the Interoperable Physics Driver. Continuing NUOPC input is critical to success, and the Driver development is proceeding with the NUOPC physics group's knowledge and input.

The DTC is uniquely qualified to fulfill a leading role in physics development and community support, and the emerging CCPP is a critical element to bridge research and operations. The result will be a capability for operational centers to more rapidly adopt codes that reflect evolving scientific knowledge, and an operationally relevant environment for the broad community of physics developers to test ideas.

Contributed by Joshua Hacker. ■

(***Director's Corner*** *continued from page one.*)

one of the most successful initiatives by HFIP that enabled a process for effective transition of research to operations (R2O), and the outcome is clearly evident in terms of tangible improvements in hurricane track and intensity forecast guidance from operational HWRF as demonstrated in real-time in the past few years. HWRF model has evolved as a unique high-resolution atmosphere-ocean-wave coupled system for all global tropical cyclones, serving various operational forecast agencies, researchers and private industry. HWRF is the only operational hurricane model in the world freely distributed and supported to the research community through extensive documentation, in-person and online tutorials, and user guides.

While HWRF's development is centralized at EMC, it incorporates contributions from a variety of scientists spread over several governmental laboratories and academic institutions. This distributed development scenario poses significant challenges: a large number of scientists need to learn how to use the model, operational and research codes need to stay synchronized to avoid divergence, and promising new capabilities need to be tested for operational consideration. The DTC's contributions to HWRF are pivotal in the areas of code management, advanced support for model developers and general users, and extensive testing and evaluation of innovations.

My recent transition to Chief of the Global Climate and Weather Modeling Branch (GCWMB) at EMC coincided with two other major initiatives – the National Weather Service (NWS) Next Generation Global Prediction System (NGGPS) project, and the expansion of the DTC's role into global modeling through the creation of the Global Model Test Bed (GMTB). Operational global modeling at NOAA/NCEP is the most significant attribute for the entire US weather enterprise. The NCEP Global Forecast System (GFS) stands as a back bone for the whole operational production suite. GCWMB at NCEP/EMC is responsible for developing, implementing and advancing the global modeling system that spans from weather to climate scales. With support from the NGGPS project, a new non-hydrostatic dynamic core is being selected for replacing the current spectral model for serving the future needs of the NWS. A community based NOAA Environmental Modeling System (NEMS) architecture will enable seamless development and integration of atmosphere, ocean, land, sea-ice, waves, and aerosols for weather, sub-seasonal and seasonal forecast capabilities. Similar to HFIP, the emphasis of NGGPS is to foster enhanced R2O capabilities for accelerated model development and transition to operations. GMTB has embarked on designing a Common Community Physics Package (CCPP) within NEMS that allows for systematic evaluation of advanced physics.

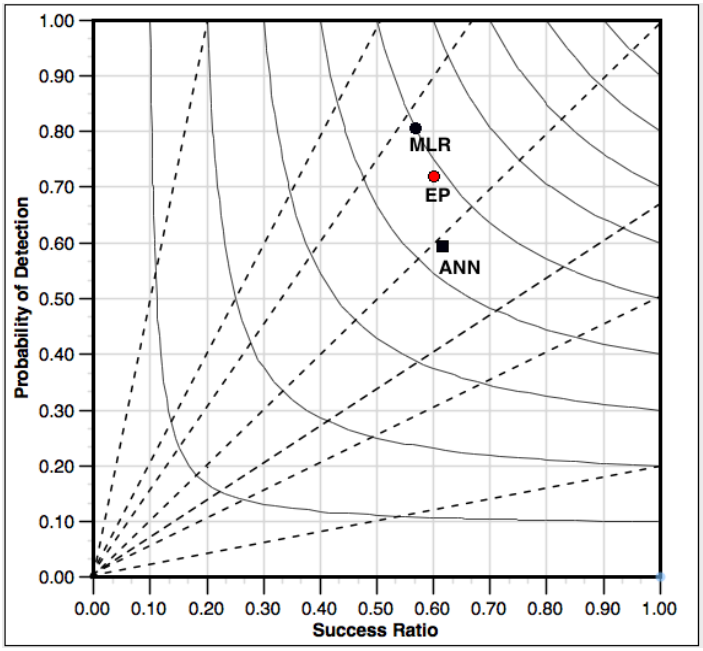
There is enormous talent in the US NWP community that has largely been untapped. With a focused approach, we can bring together the best in the field by adopting the community modeling concept. I am looking forward to continuing to work with DTC to strengthen the relationship between operational and research communities, and to realize the goals of NGGPS in becoming second to none in global weather prediction. ■

Harnessing the Power of Evolution for Weather Prediction

As a DTC Visitor in 2015, Paul Roebber explored an idea for generating ensemble weather predictions known as evolutionary programming (EP). The method relies on a gradually and increasingly restrictive cost function to produce and evaluate succeeding generations of a population of algorithms until a best ensemble solution is determined based on cross-validation. The approach was developed by Roebber to produce baseline prediction equations equivalent to linear or nonlinear multiple regression equations (a kind of model output statistics or MOS) modified by if-then conditionals and using observations as well as numerical weather prediction (NWP) model output.

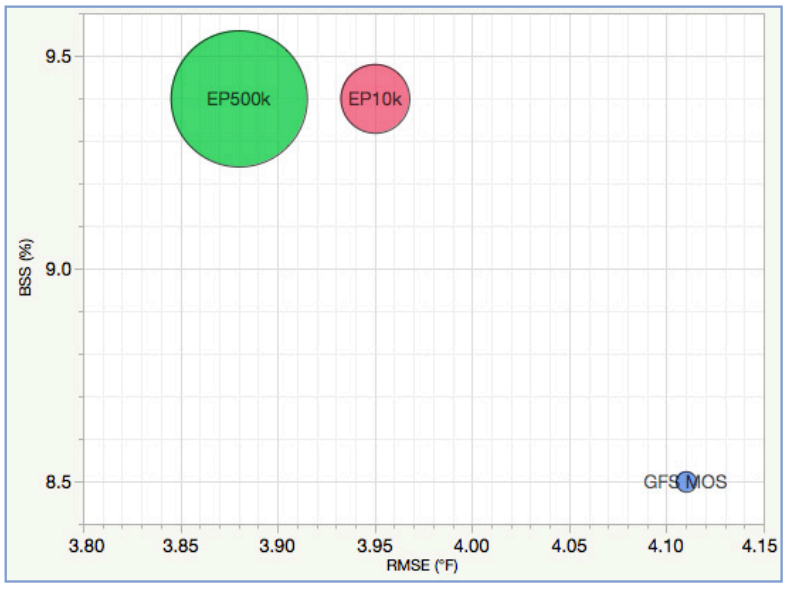
The prime objective of his DTC Visitor project was to explore if increasing ensemble diversity improves the performance of the EP models. A first step, using the Yellowstone supercomputer, was to consider the relative contribution of very large ensemble populations, numbering from 3,000 to as many as 500,000 possible members, to ensemble diversity. Numbers of ensemble members in meteorology usually range from 10-100. The figure below illustrates how smaller as well as very large EP ensembles outperform the GFS-21 member ensemble in both a deterministic (RMSE) and probabilistic (Brier Skill Score; BSS) sense for 60 hour forecasts of minimum temperature. However, the increase in ensemble size (indicated by the size of the bubbles) provides only minor additional skill.

Specific issues explored in the context of next-day heavy convective rainfall forecasting included: the performance of the method regionally and locally, compared to multiple logistic regression (MLR) and artificial neural networks (ANN); and ensemble member selection for use in bias calibration such as Bayesian Model Combination.



Performance Diagram

A performance diagram for regional forecasts of rainfall in excess of 1.5 inches, shown above, illustrates how the MLR and EP demonstrate comparable skill, and both superior to that of a trained ANN. The slightly different performance characteristics (higher hits and false alarms versus lower hits and false alarms) of the three methods suggests information about how each model over-forecasts or under-forecasts an event could be useful information for situational awareness in operations. Insights gained from this work are leading to several collaborations with NOAA scientists related to adaptive systems and deep learning networks. Contributed by Paul Roebber. ■



Skill Plot

Did You Know

- *Evolutionary Programming (EP) is a strategy that uses simulated "evolution" as a learning process that will make model smarter. An initially random population of trial solutions is created. Mutations are then applied to each trial solution to create new solutions. Mutations vary in the severity of their effect on the behavior of the solution. The new solutions are then compared in a "tournament" to select which should survive to form the new population.*
- *An adaptive system (or a complex adaptive system, CAS) is a real or abstract system that changes its behavior in response to its environment. The adaptive change that occurs is often relevant to achieving a goal or objective.*
- *Deep-learning software attempts to mimic the activity in layers of neurons in the neocortex. The software learns, in a very real sense, to recognize patterns in digital representations of sounds, images, and other data.* ■

Hongli Jiang

Hongli Jiang explained "scale-aware" physics parameterizations using her office and a printer as an example. She has always been excited about physics and atmospheric sciences, and wanted to make sure I understood the concept. If you have a large grid box the size of your office, the size of your printer is insignificant in that space. If the grid box is the size of your desk, the size of the printer now impacts that space, and you need to include the printer in your description of your desk. Hongli is from Tianjin, a large port city near Beijing.

Hongli has been a CSU Cooperative Institute for Research in the Atmosphere (CIRA) Research Scientist for 21 years. After working in the NOAA Earth System Research Lab (ESRL) /Chemical Sciences Division with aerosol and cloud modeling, she wanted to change her focus to work with the real-time cloud-scale modeling on 0-3 hour time scales. Now she is working with longer time scales - out to 48 hours. Her role in the DTC is in the Global Modeling Testbed working with the NGGPS to test several suites of physics.

Away from the office, Hongli loves to be outdoors, and volunteers in Longmont's "Clean-Up Green Up" campaign to make area parks, trails and open spaces more beautiful. She also likes to travel and experience the contrasts of places such as the Pacific Northwest rainforests compared with New York City - both are full of life, just different kinds. Indoors, she enjoys classical music and live productions--witnessing the Berlin Philharmonic in person was a dream-come-true. ■

Christina Holt

A small town on the border of Alabama and Georgia produces an unusually high number of students that pursue careers in science. Ranburne, Alabama, population 300, is the hometown of Christina Holt. Christina credits Mr. Jason Cole, her high school physics teacher, for creating opportunities for his students to shine and pushing them to do their best. After high school, she went on to attend the University of South Alabama, and completed her graduate work at Texas A&M. Just a few days after defending her PhD in 2014, she began her career in modeling at ESRL/GSD.

Christina's major role in the DTC has been to support the HWRF model. She loves to work on a team that pushes research advances into operations, while also pushing computational boundaries forward. "Weather gives immediate feedback," she says, "so we can ultimately make the forecast better in actual operations in a matter of months." She works to keep lines of communications open with the end users at NCEP. Regular HWRF development meetings provide the opportunity to ask questions, learn about developers' experiences and focus areas, and discuss the next steps.

Christina also serves as Chairperson of the CU Cooperative Institute for Research in Environmental Sciences (CIRES) Member's Council; her goal is to build a strong connection between CIRES staff at Boulder's David Skaggs Research Center and CIRES staff on the CU campus. She pushes herself to face her fears – from emceeing the CIRES Rendezvous for the first time in front of hundreds to people, to rock climbing - "Let's try it!" Christina has made the most of living in Colorado by learning to ski, hike, and storm chase, and loves her dogs "Toots" (like "Tootsie Roll") and "Roscoe."

Her favorite book is "Isaac's Storm," about the 1900 Galveston Hurricane, but she also treasures her copy of "The Storm of the Century" by Al Roker about the same event. Her aunt and uncle chased down Mr. Roker on a recent national tour for an autographed copy – the only one he granted that day! ■

Announcements, Presentations and More

WORKSHOPS, TUTORIALS, EVENTS dtcenter.org/events

The 7th NCEP Ensemble Users Workshop was held at NCWCP in College Park, MD on 13-15 June, 2016. The purpose of the workshop was (i) to bring together experts and users involved in the generation and use of NCEP ensembles, (ii) to review progress on the generation and use of operational products since the last meeting in March 2014, and (iii) to discuss plans for future efforts and collaborations.

The workshop supports the NWS in its transition from single value to probabilistic forecasting and efforts to convey forecast uncertainty in a user-relevant form. Collaborative work on the national (National Unified Operational Prediction Capability (NUOPC)) and international (North American Ensemble Forecast System (NAEFS), and North American Multi-Model Ensemble (NMME)) scale were also discussed. See http://www.dtcenter.org/events/workshops16/ensembles/. ■

The 17th WRF Users Workshop will be held in Boulder, CO on 27 June to 01 July 2016 at the NCAR Center Green Campus. The primary objectives for the Users' Workshop are to provide WRF modeling system updates, to discuss model development and issues, and to present evaluations and applications of the model. ■

SOFTWARE RELEASE

Upcoming release of GSI and EnKF: The DTC will release the Gridpoint Statistical Interpolation (GSI) and the NOAA Ensemble Kalman Filter (EnKF) data assimilation systems in mid-summer, 2016. Users can obtain a copy of the code and documentation from their webpages. For GSI, see http://www.dtcenter.org/com-GSI/users/index.php; For EnKF, see http://www.dtcenter.org/EnKF/users/index.php. ■

EVENTS

- ***7th NCEP Ensemble Users Workshop***, College Park, MD; 13-15 June 2016.
- ***17th WRF Users Workshop*** to be held in Boulder, CO; 27 June -1 July 2016.
- ***Mesoscale Model Evaluation Testbed (MMET)*** instructional session at the WRF Workshop on July 1 8:30-10:30 am (NCAR, Boulder, Center Green campus). https://www.mmm.ucar.edu/wrf-workshop-0
- ***NGGPS Annual Meeting*** College Park, MD; 2-5 Aug 2016.
- ***NEMS Code, Data, and Document Management Workshop***, College Park, MD; 1-2 Sept 2016 (tentative).
- ***DTC Science Advisory Board Meeting*** at NCAR, Boulder, CO; 14-15 Sept 2016.
- ***UCAR Community Advisory Committee for NCEP (UCACN) Review of DTC*** at NCAR, Boulder, CO; 21-23 Sept 2016.
- ***Global/Regional Assimilation Prediction System--GRAPES WRF Workshop***, Boulder, CO; 20-21 Oct 2016.
- ***NGGPS Physics Principle Investigators Workshop***, College Park, MD; 7-9 Nov 2016. ■

VISITOR PROJECT AWARDS

Michael Iacono (Atmospheric and Environmental Research) Testing Revisions to RRTMG Cloud Radiative Transfer and Performance in HWRF.

Robert Fovell (SUNY-Albany) Impact of planetary boundary layer assumptions on HWRF. ■

DTC & THE COMMUNITY

DTC Hurricane Team Participates in AMS Conference

The DTC Hurricane team had a strong presence during the American Meteorological Society 32nd Conference on Hurricanes and Tropical Meteorology held 17-22 April 2016 in San Juan, Puerto Rico. The team presented papers covering DTC community code, training, and support, as well as examples of successful Research to Operational (R2O) transitions using DTC strategies to streamline new developments into the operational Hurricane Weather Research and Forecasting Model (HWRF). Establishing the connection between the DTC visitor program and past successes gained further interest in the DTC visitor program from the research community. Our talks highlighting testing and evaluation activities were also well received. Evaluation of the performance of species-advecting microphysics schemes and explicitly resolved sub-grid clouds in HWRF were

presented; while DTC supported tools for tropical cyclone (TC) verification were demonstrated to highlight capabilities available to the broader tropical cyclone user community.

Finally, contributions from the DTC were also recognized during presentations from operational and research colleagues. In addition to a plethora of interesting papers covering topics including numerical modeling, physics, data assimilation, TC intensification, convection, and TC genesis, the conference facilitated an opportunity for fruitful discussions with both research and operational counterparts. Recorded presentations from the AMS Hurricanes and Tropical Meteorology Conference can be accessed at: https://ams.confex.com/ams/32Hurr/webprogram/32HURRICANES.html

Contributed by Kathryn Newman. ■

COMMUNITY CONNECTION

DTC Visitor Program

The DTC Visitor Program supports visitors to work with the DTC to test new forecasting and verification techniques, models and model components for numerical weather prediction (NWP). The goal is to provide the operational weather prediction centers (e.g., NOAA National Center for Environmental Prediction and Air Force) with options for near–term advances in operational weather forecasting, and to provide researchers with NWP codes that represent the latest advances in the technology. This program also offers an opportunity for visitors to introduce new techniques into the DTC Community Codes that would be of particular interest to the research community. See http://www.dtcenter.org/visitors/opportunity/ ■

Helen Newcastle photo.

Recent **2016** visitor project awards:

Visitor	Affiliation	Project
Michael Iacono	Atmospheric and Environmental Research	Testing revisions to RRTMG cloud radiative transfer and performance in HWRF
Robert Fovell	SUNY Albany	Impact of planetary boundary layer assumptions on HWRF

Past **2015** visitor project awards in process:

Jason Otkin	University of Wisconsin Madison	Object based verification for the HRRR model using simulated & observed GOES infrared brightness temperatures
Gretchen Mullendore	University of North Dakota	Mesoscale Model Intercomparison at Convection-Allowing Resolution using MODE
Dev Niyogi	Purdue University	Improving WRF Weather Forecast through Enhanced Representation of Cropland-Atmosphere Interactions
Joel Bedard	University of Quebec Montreal	Implementation and validation of a geo-statistical observation operator for the assimilation of near-surface winds in GSI

Sponsors

DTC's primary sponsors are the National Oceanic & Atmospheric Administration (NOAA), the Air Force, the National Center for Atmospheric Research (NCAR), and the National Science Foundation.

The **DTC** is a distributed facility where the NWP community can test and evaluate new models and techniques for use in research and operations.

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