Developmental Testbed Center | DTC

Acadia National Park in autumn

ISSUE 12

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Transitions

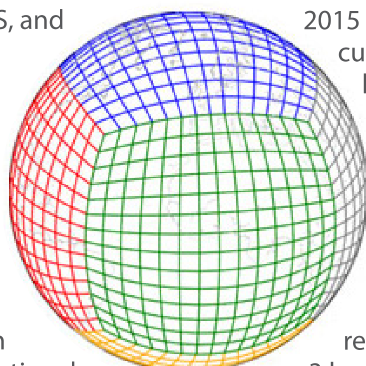
Newsletter Autumn 2016

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

NOAA Selects GFDL's Dynamical Core

A first step toward building NOAA's Next Generation Global Prediction System (NGGPS) was the selection of a new dynamical core that accurately represents the atmosphere.

In August 2014, numerical weather prediction modelers attended a workshop to discuss dynamic core requirements and attributes for the NGGPS, and developed a battery of tests to be conducted in three phases over 18 months. Six existing dynamical cores were identified as potential candidates for NGGPS.



During Phase 1, a team of evaluators ran benchmarks to look at performance, both meteorological and computational, and the stability of the core. The performance benchmark measured the speed of each candidate model at the resolution run currently in National Centers for Environmental Prediction (NCEP) operations, and at a much higher resolution expected to be run operationally within 10 years. They also evaluated the ability of the models to scale across many tens of thousands of processor cores.

Assessment of the test outcomes from Phase 1 resulted in the recommendation to reduce the candidate pool to two cores, NCAR's Model for Prediction Across Scales (MPAS) and GFDL's Finite-Volume on a Cubed Sphere (FV3), prior to Phase 2.

In Phase 2, the team evaluated the two remaining candidates on meteorological performance using both idealized physics and the operational GFS physics package. Using initial conditions from operational analyses produced by NCEP's Global Data Assimilation System (GDAS), each dynamical core ran retrospective forecasts covering the entire 2015 calendar year at the current operational 13 km horizontal resolution. In addition, two cases, Hurricane Sandy in October 2012, and the May 18-20, 2013 tornado outbreak in the Great Plains were run with enhanced resolution (approximately 3 km) over North America. The team assessed the ability of the dynamical cores to predict severe convection without a deep convective parameterization, using operational initial conditions and high-resolution orography.

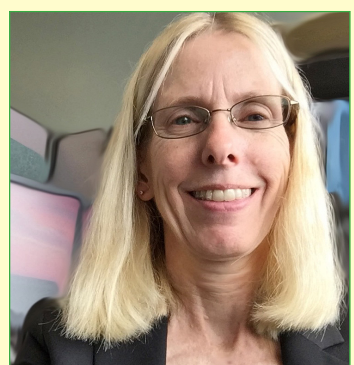
The results of Phase 2 tests showed that GFDL's FV3 satisfied all the criteria, had a high level of readiness for operational implementation, and was computationally highly efficient. As a result, the panel of experts recommended to NOAA leadership that FV3 become the atmospheric dynamical core of the NGGPS. NOAA announced the selection of FV3 on July 27, 2016.

*(**Dynamical Core** continued on page two.)*

Director's Corner

By Paula Davidson

NOAA's testbeds and proving grounds (NOAA TBPG) are an important link between research advances and applications, and especially NOAA operations. Some are long-recognized, like the Developmental Testbed Center (DTC), while others have been chartered more recently. With the 2015 launch of the Arctic Testbed in Alaska, twelve NOAA TBPG follow execution and governance guidelines to be formally recognized by NOAA. These facilities foster and host competitively-selected, collaborative transition testing projects to meet NOAA mission needs. Projects are supported through dedicated or in-kind facility support, and programmatic resources both internal and external to NOAA. Charters and additional information on NOAA TBPG, as well as summaries of recent coordination activities and workshops, are



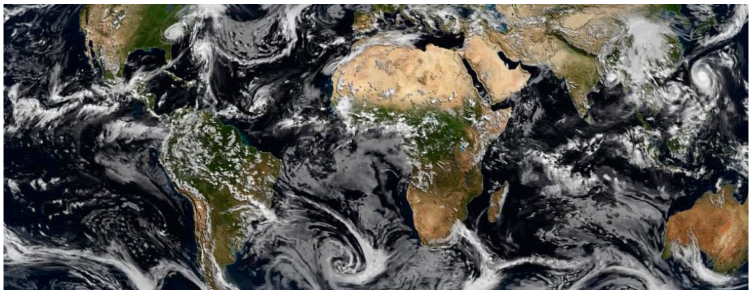
Paula Davidson
NWS

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

(**Dynamical Core** continued from page one.)

Phase 3 of the project, getting underway now, will involve integrating the FV3 dynamical core with the rest of the operational global forecast system, including the data assimilation and post-processing systems. See results, https://www.weather.gov/sti/stimodeling_nggps_implementation_atmdynamics.

Contributed by Jeff Whitaker. ■



Hindcast of the 2008 hurricane season, simulated by the FV3-powered GFDL model at 13 km resolution.

NGGPS Dynamical Core: Phase 1 Evaluation Criteria

- Simulate important atmospheric dynamical phenomena, such as baroclinic and orographic waves, and simple moist convection
- Restart execution and produce bit-reproducible results on the same hardware, with the same processor layout (using the same executable with the same model configuration)
- High computational performance (8.5 min/day) and scalability to NWS operational CPU processor counts needed to run 13 km and higher resolutions expected by 2020
- Extensible, well-documented software that is performance portable
- Execution and stability at high horizontal resolution (3 km or less) with realistic physics and orography
- Evaluate level of grid imprinting for idealized atmospheric flows

Phase 2 Evaluation Criteria

- Plan for relaxing the shallow atmosphere approximation (deep atmosphere dynamics) to support tropospheric and space-weather requirements.
- Accurate conservation of mass, tracers total energy, and entropy that have particular importance for weather and climate application.
- Robust model solutions under a wide range of realistic atmospheric initial conditions, including strong hurricanes, sudden stratospheric warmings, and intense upper-level fronts with associated strong jet-stream wind speeds using a common (GFS) physics package
- Computational performance and scalability of dynamical cores with GFS physics
- Demonstrated variable resolution and/or nesting capabilities, including physically realistic simulations of convection in the high-resolution region
- Stable, conservative long integrations with realistic climate statistics
- Code adaptable to NOAA Environmental Modeling System (NEMS)/ Evaluated Earth System Modeling Framework (ESMF)
- Detailed dycore (dynamical core) documentation, including documentation of vertical grid, numerical filters, time-integration scheme and variable resolution and/or nesting capabilities.
- Performance in cycled data assimilation tests to uncover issues that might arise when cold-started from another assimilation system
- Implementation plan including costs

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

posted at the web portal. See www.testbeds.noaa.gov.

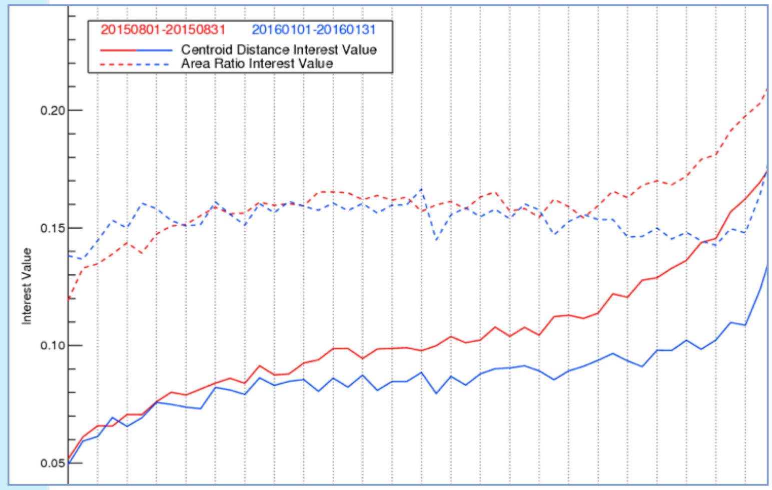
Along with adopting systematic guidelines for function, execution, and governance of NOAA TBPG, in 2011 NOAA instituted formal coordination among the TBPG, to better leverage progress across the spectrum of testing, and provide a consistent voice and advocacy for programs and practices involving the TBPG. The coordination committee hosts annual workshops featuring collaborative testing on high-value mission needs, fosters practices consistent with rigorous, transparent testing and increased communication of test results, and provides a forum to advance program initiatives in transitions of research to operations and of operations to research.

NOAA's TBPG conducts transition testing to demonstrate the degree of readiness of advanced research capabilities for operations/applications. Over the past two years, these facilities completed more than 200 transition tests, demonstrating readiness for NOAA operations for more than 70 candidate capabilities. More than half have already been deployed. Beyond the simple transition statistics, NOAA TBPG have generated a wealth of progress in developing science capabilities for use by NOAA and its partners through more engaged partnerships among researchers, developers, operational scientists and end-user communities. Incorporating appropriate operational systems and practices in development and testing is a key factor in speeding the integration of new capabilities into service and operations.

DTC, in collaboration with public and private-sector partners, plays an increasingly important role in NOAA transitions of advanced environmental modeling capabilities to operations, and with rigorous testing to evaluate performance and potential readiness for NOAA operations. Readiness criteria include capability-specific metrics for objective and subjective performance, utility, reliability and software engineering/production protocols. DTC facilitates R&D partners' use of NOAA's current and developmental community modeling codes in related research, leading to additional evaluation and incorporation of partner-generated innovations in NOAA's operational models.

NOAA programs that have recently supported projects conducted at NOAA TBPG, and especially at DTC, include the Next Generation Global Prediction System (NGGPS), Collaborative Science and Technology Applied Research Program, Climate Program Office, the US Weather Research Program, and the Hurricane Forecast Improvement Program. Under NGGPS auspices, the DTC added a new unit for testing prototypes for the NOAA's next global prediction system. DTC's contributions to the success of NGGPS will be the foundation for improved forecasts in critical mission areas such as high-impact severe/extreme weather in the 0-3 day time frame, in the 6-10 day time frame, and for weeks 3-4. As chair of NOAA's TBPG coordinating committee, I am excited about the tremendous opportunity and capability that the DTC brings to these efforts to enhance NOAA's science-based services. ■

Object-based Verification Methods



Average MODE centroid distance and area ratio interest scores for Aug 2015 (red lines) and Jan 2016 (blue lines) plotted as a function of observed object size.

As visitors to the DTC in 2015, Jason Otkin, Chris Rozoff, and Sarah Griffin explored using object-based verification methods to assess the accuracy of cloud forecasts from the experimental High Resolution Rapid Refresh (HRRR) model. Though the forecast accuracy could be assessed using traditional statistics such as root mean square error or bias, additional information about errors in the spatial distribution of the cloud field could be obtained by using more sophisticated object-based verification methods.

The primary objective of their visit to the DTC was to learn to use the Meteorological Evaluation Tools' Method for Object-Based Diagnostic Evaluation (MODE). Once they learned how MODE defines single objects and clusters of objects, they could use MODE output of individual objects and matched pairs to assess the forecast accuracy.

The team also wanted to develop innovative methods using MODE output to provide new insights. For example, they were able to calculate and compare how well certain characteristics of the forecast cloud object, suchs as its size and location, match those of the observed cloud object.

One outcome of their DTC visit was the development of the MODE Skill Score (MSS). The MSS uses the interest values generated by MODE, which characterize how closely the forecast and observed objects match each other, along with the size of the observed object, to portray the MODE output as a single number.

For their project, they assessed the 1-h experimental HRRR forecast accuracy of cloud objects occurring in the upper troposphere, where satellite infrared brightness temperatures are most sensitive. They used simulated Geostationary Operational Environmental Satellite (GOES) 10.7µm brightness temperatures generated for each HRRR forecast cycle, and compared them to the corresponding GOES observations. Forecast statistics were compiled during August 2015 and January 2016 to account for potential differences in cloud characteristics between the warm and cool seasons.

Overall, the higher interest value scores during August indicate that the sizes of the forecast objects more closely match those of the observed objects, and that the spatial displacement between their centers' of mass is smaller. They also found smaller cloud objects have less predictability than larger objects, and that the size of the 1-h HRRR forecast cloud objects is generally more accurately predicted than their location.

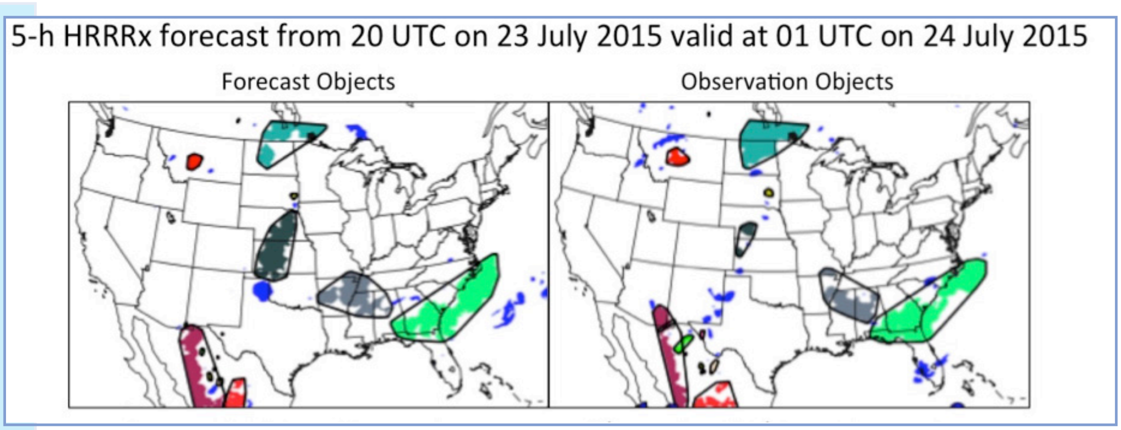
The researchers hope this knowledge helps HRRR model developers identify reasons why a particular forecast hour or time period is more accurate than another. It could also help diagnose problems with the forecast cloud field to make forecasts more accurate.

This type of work benefits and informs the HRRR development process and will help make forecasts more accurate.

Curtis Alexander, HRRR Modeler

Otkin, Rozoff, and Griffin were visiting from the University of Wisconsin-Madison Space Science and Engineering Center and Cooperative Institute for Meteorological Satellite Studies. They were hosted by Jamie Wolff of NCAR. The DTC visitor project allowed the team to discuss methods, insights, and results face-to-face. The team feels this project scratched the surface of how to use satellite observations and object-based verification methods to assess forecast accuracy, and that the door is open for future collaboration.

Contributed by Jason Otkin, Sarah Griffin, and Chris Rozoff. ■



Comparison of forecast and observed MODE objects.

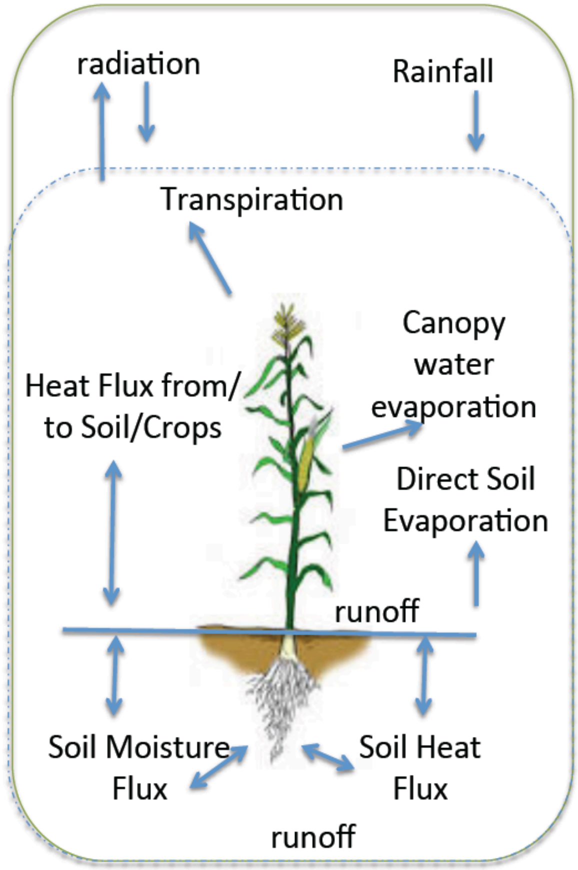
Importance of Croplands

Xing Liu is a Ph.D. Candidate in Ecological Science and Engineering from Purdue University. She received her B.S. in Applied Meteorology from China Agricultural University and M.S. in Agricultural Meteorology from Purdue. Xing's research focuses on large-scale crop modeling and the simulation of cropland-atmospheric interactions. By linking crop, land surface, and weather models, she is trying to understand how climate variability impacts crop yield and how cropland impacts weather.

Croplands play an important role in land-atmosphere interactions and in modifying regional weather and climate. However, in areas dominated by croplands, significant warm temperature biases found in the current version of the coupled WRF/NOAA model cause croplands to be poorly represented.

For the DTC visitor program, Xing proposed a project that aims to improve the WRF model performance by enhancing the representation of croplands in the Noah-MP (Noah-Multiparameterization) Land Surface Model. During Xing's two-summer DTC visit, she collaborated with Fei Chen and Michael Barlage from NCAR RAL. They introduced dynamic corn and soybean growth simulations and field management (e.g., planting date, cultivar selection) into Noah-MP. They also evaluated the enhanced model (Noah-MP-Crop) at both field scale and regional scale in the offline mode using crop biomass datasets, surface heat fluxes, and soil moisture observations.

Compared to the generic dynamic vegetation and prescribed-leaf area index (LAI) driven methods in Noah-MP,



The role of crops in land-atmospheric interactions.

the Noah-MP-Crop showed improved performance in simulating the LAI and crop biomass. This model is able to capture the seasonal and annual variability of LAI. Improved simulations of crop phenology in Noah-MP-Crop led to better surface heat flux simulations, especially in the early period of growing season where current Noah-MP significantly overestimated LAI (Liu et al., 2016). The addition of crop yields as model outputs expand the application of Noah-MP-Crop to regional agricultural studies, such as regional crop yield prediction. The coupled runs are still under testing and they hope to release the coupled WRF-Crop model next year. Currently, the offline model is available via NCAR RAL's website, see https://www.ral.ucar.edu/solutions/products/wrf-crop.

Xing has visited NCAR several times since 2012 and she enjoyed working with people in DTC. Xing says, "The DTC Visitor Program provides great resources and scientists here are very helpful and reachable; probably the best work environment you can have. And it's in Boulder, nobody can say no to Boulder." Outside her research, Xing likes hiking in the Rocky Mountains, paddle boarding on the Longmont reservoir and drinking coffee on Pearl Street.

Xing would like to thank her DTC hosts Michelle Harrold and Louisa Nance. For more information, you can reach Xing at liu744@purdue.edu.

Contributed by Xing Liu. ■

Who's who in the DTC

Kathryn Newman

As a graduate Atmospheric Science student, at the University of North Dakota (UND), Kathryn Newman organized 25 weather labs for hundreds of aviation students that were required to take Meteorology (ATSC 110). Kathryn jokes, "Thank me the next time the pilot says something intelligent about the current weather conditions". The multi-tasking and organizational skills she developed come in handy as the DTC Hurricane Task Lead to oversee transitioning hurricane modeling research to EMC. "It's challenging to keep track of all the moving parts between the research and operational communities," she says, "But it is exciting to be involved at this level--to know what goes into the models." She also contributes to the Data Assimilation and Verification teams.

She earned her B.S. and M.S. from UND. Her Master's work included ground validation of satellite products for atmospheric cloud radiative forcing. Kathryn has been with NCAR since 2009, arriving only a few weeks after defending her thesis. She first worked with the Air Force Weather Agency to help determine an appropriate initial configuration for their operational data assimilation system using the Gridpoint Statistical Interpolation.

Kathryn grew up Anoka, Minnesota where she remembers trying to get her Halloween costume over her snowsuit during the great Halloween Blizzard of 1991. In college, she braved the cold with other students to stand in line to get the best seats for UND hockey games. Signs outside the arena said: "Stand at your own risk," with a thermometer nearby for bragging rights. She and her husband road-trip to Omaha, Colorado Springs, Grand Forks, or even Minneapolis to catch college hockey games in their spare time.

In addition to college hockey, she says she and her husband like to do typical "Colorado stuff;" ski, hike, hang out with their beagle Lucy, and visit craft breweries. Avery Brewing Co. is currently at the top of her list. ■

Did You Know

Did you know there are suggested topics for Visitor Projects that receive special consideration?

- Advance the forecast skill of the DTC-supported HWRF modeling system through improved physics and/or initialization
- Advance the analysis capability of the DTC-supported Gridpoint Statistical Interpolation and/or the NOAA Ensemble Kalman Filter (EnKF) Data Assimilation systems through development, testing, and evaluation of advanced data assimilation techniques and the addition of new data types or measurements
- Transition innovations in atmospheric physical parameterizations to NOAA's Next-Generation Global Prediction System (NGGPS)
- Add new capabilities to the Model Evaluation Tools
- Advance the design and use of ensembles for forecasting and data assimilation, especially regional high-resolution ensembles

For more information and to apply, go to http://www.dtcenter.org/visitors/. ■

Announcements and More

SOFTWARE RELEASES

GSI and EnKF: The DTC is pleased to announce the release of Version 3.5 of the Community Gridpoint Statistical Interpolation (GSI) data assimilation system and Version 1.1 of the Community Ensemble Kalman filter (EnKF) data assimilation system, on 5 August 2016.

The updated GSI system assimilates a variety of new satellite data including all sky data from AMSU-A, clear air water vapor and atmospheric motion vectors from GOES, and more. Algorithm and application updates include a 4D hybrid EnVar option, a new Atmospheric Motion Vector algorithm, and added quality control for regional assimilation of GPS Radio Occultation bending angle.

Major updates to the EnKF include code optimization, and new capabilities to update multiple-time background ensembles.

GSI and EnKF are currently the operational data assimilation systems for the National Centers for Environmental Prediction (NCEP) Global Forecast System (GFS). GSI is also used by other operational systems/models, e.g., the North American Mesoscale (NAM) forecast system, Hurricane Weather Research and Forecasting (HWRF) model, the Rapid Refresh system, the Goddard Earth Observing System (GEOS), etc. EnKF shares the same observation operators with GSI.

In addition to updated GSI/EnKF code and user's guide, the on-line tutorial was redesigned and more cases were added to help broader range of users.

The released package for GSI and EnKF and the documentation for each can be accessed through the respective websites:

- ***GSI user's page:*** http://www.dtcenter.org/com-GSI/users/index.php
- ***EnKF user's page:*** http://www.dtcenter.org/EnKF/users/index.php. ■

MET: The DTC is pleased to announce the release of MET v5.2, on 15 August 2016. This release includes better handling of GRIB files and the World Wide Merged Cloud Analysis product from the Air Force. Grid-area and cosine latitude weighting was added for evaluation of global or large domain datasets. It also has new capabilities to help with event-relative verification and enhancement to MODE to run multiple thresholds in one call. METv5.2 is available for download:

- ***MET user's page:*** http://www.dtcenter.org/met/users/downloads/index.php. ■

EVENTS

- ***Global/Regional Assimilation Prediction System-GRAPES WRF Workshop***, Boulder, CO; 20-21 Oct 2016.
- ***NGGPS Atmopheric Physics Workshop***, College Park, MD; 8-9 Nov 2016. See http://www.dtcenter.org/events/workshops16/nggps/ ■

JOB ANNOUNCEMENT

Cooperative Institute for Research in Environmental Sciences (CIRES) at the University of Colorado in Boulder, Colorado and the NOAA Earth System Research Laboratory (ESRL) Global Systems Division (GSD) have an immediate opening for a Research Associate with experience in numerical weather prediction (NWP). The individual will work as part of a team in support of NWP projects, including those of the Developmental Testbed Center (DTC). In particular, the scientist will join the Hurricane Task of the DTC and provide community support in using and adding innovations to the Hurricane Weather Research and Forecasting (HWRF) modeling system. For additional details and to apply please visit:

https://cu.taleo.net/careersection/2/jobdetail.ftl?job=06830

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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