A DTC Proposal for the NGGPS Program Office

Global Model Test Bed

Year 5

1 July 2019 – 30 June 2020

Background

The Global Model Test Bed's (GMTB) primary mission is to accelerate the research-to-operations (R2O) transition of broad community innovations in physical parameterizations and suites to NOAA Unified Forecast System (UFS) operational applications in order to improve numerical guidance. The mission is multifaceted, and includes supporting the community in using the Common Community Physics Package (CCPP), an evolving library of physical parameterizations along with an infrastructure that enables its use with the FV3-based NCEP models and other models, maintaining a hierarchical testbed for DTC staff and community collaborators to assess physics at various complexity levels, providing a basic level of support for users of the UFS weather application, and conducting testing and evaluation (T&E).

By the end of the previous performance period, the GMTB will have publicly released the third version of the CCPP along with the GMTB Single-Column Model (SCM) containing a number of suites, worked with EMC to integrate the CCPP with the UFS Weather application for global and regional use, provided updated CCPP and SCM documentation to the community, conducted training at EMC, and put in place procedures for code management and governance. The main goal for this period of performance is to work with EMC and the UFS community to integrate the CCPP with other UFS applications, which involves working with application leads to create a transition plan to insert CCPP hooks in the relevant build systems and workflows, adding physical parameterizations and expanding the CCPP code coverage to capabilities only available today through the Interoperable Physics Driver v4 (IPDv4), expanding documentation and providing training. This work will enable EMC to transition to only using CCPP compliant physics in the UFS no later than June 2020. We also propose to invest resources in the CCPP-Framework development as part of the ongoing partnership with NCAR to develop a shared infrastructure.

With the CCPP transition to EMC and its adoption by the UFS development community, we anticipate a larger number of contributions to the CCPP-Physics. It will be important to continue, and even enhance, code management, governance, and support activities to address the expected additional demand. We anticipate that GMTB will review new code submissions for UFS-related physics. In addition, GMTB will work with the UFS community to create a portability policy for the CCPP-enabled forecast component of the UFS weather application (UFS Atmosphere), with emphasis on Cheyenne and the GNU compiler, in order to reach a broader pool of users and developers going beyond those that use the NOAA platforms. The GNU compiler allows the use of low-resolution configurations of the UFS Weather application on a Mac laptop, lowering the bar for community participation. Additionally, the ability to use the GNU compiler opens the door for running UFS in cloud computing environments, such as Amazon Web Services, a new frontier of much interest to NOAA.

By the start of this period of performance, GMTB will have enhanced the hierarchical testing framework (HTF) for physics development in various ways. In its simplest tier, the HTF contains the GMTB SCM with various experimental cases for a variety of meteorological applications. More complex tiers involve the ability to run the UFS Weather application in regional standalone or global configuration and compute a number of verification and diagnostic measures that complement EMC's current verification system.

Examples of verification measures computed using MET/METplus include precipitation scorecards, scorecards against point observations, and precipitation fractional skill scores. Examples of diagnostics that provide insight on physics behavior and their shortcomings to inform development that were demonstrated during the Advanced Physics Testing are spectral decomposition of forecasts, sounding properties such as Convective Available Potential Energy, energy budget, temporal-mean state of precipitation, as well as relationships between precipitable water and various quantities such as relative humidity, precipitation, and diabatic heating rate.

Further development of the HTF will be largely supported by the Hurricane Supplemental program on two fronts. Firstly, the SCM will be enhanced with additional experimental cases, visualization capabilities, ability to be driven by fields saved from UFS runs, and enhanced ease of use. Secondly, case studies will be developed in conjunction with the EMC Model Evaluation Group (MEG) and made available to developers so they can assess their progress. Initial conditions, baselines, and utilities to assess specific challenges posed by the cases will be developed. Given these activities are already funded through the hurricane supplemental, we do not propose allocating NGGPS funding to enhance the HTF during this period of performance.

In the previous period of performance, GMTB conducted runs and analysis for the Advanced Physics Test to provide information toward a choice of physics suite for GFS v16. In this period of performance, GMTB will use the HTF, in particular the SCM, to analyze in more detail the strengths and weaknesses of the four suites tested in order to inform further development of the suite selected for GFS v16. Evaluation results will be made available to developers of the GFS v16 suite and will highlight areas that can be improved, possibly with the adoption of aspects of other developmental suites.

Finally, in the current period-of-performance, GMTB will considerably expand the scope of the community support it provides. As in previous years, GMTB will continue to support physics development by the community through the CCPP and its connection to the SCM and the UFS. GMTB will release updated CCPP code, provide updated documentation and offer a short class and a tutorial. New this year, GMTB will provide basic support to the global UFS weather application by contributing to a code release led by EMC, by leading a collaborative effort for creating documentation, and by providing a tutorial with extensive contribution from EMC. Superseding the GMTB helpdesk, a community forum, with separate areas devoted for CCPP and UFS questions, will be set up to increase peer-to-peer communication and enhance community building.

Scope

Area 1. CCPP development required for adoption in research and UFS applications

Area 1.1 Add new parameterizations to CCPP and support EMC in establishing a timeline for phasing out non-CCPP parameterizations and configurations from UFS

- Work with leads of UFS applications (e.g. Weather, S2S, air quality, etc) to create a transition plan detailing what is needed to create a CCPP-based configuration to reproduce necessary IPD capabilities and replace current systems. Transition plan will include aspects such as reproducibility, testing, and validation. Make parameterizations CCPP compliant, add regression tests to exercise them, and add NEMSfv3gfs code coverage and capabilities (see list in https://docs.google.com/spreadsheets/d/1GGtgVaz4UF-r4z4WZwtW-K9HUbKhG7th6tmyxNydeY0/edit#gid=0)
- Maintain a list of physics parameterization in CCPP

Additional details pertaining to all activities and timeline will be provided in the transition plan.

Area 1.2 Enhancements to CCPP-Physics

- Change the metadata format currently used by CCPP parameterizations to the new format agreed upon by NCAR and GMTB. NCAR has provided a tool for automatic conversion of most of the information contained in the metadata tables of the current physics to the new format. With the new format, metadata for each CCPP scheme will be in separate, associated files instead of an excessively-wide and unwieldy table in the same file with the scheme. The new format will be compliant with more Fortran compilers, be more user-friendly and easier to teach, and enable a higher level of functionality that comes with the ability to add attributes.

Area 1.3 Further implementation of CCPP-Framework requirements

- Advancements in the CCPP autogeneration code and streamlining of the CCPP build options in the UFS will facilitate further integration between GMTB and NCAR, and provide good capability/flexibility for the NWS and the community while maintaining current computational performance. The CCPP prebuild step, which checks the connection between physics and dynamics and generates software caps, will be upgraded from using the current *ccpp_prebuild.py*, to the NCAR-provided *capgen.py*, which works with the new metadata described in Area 1.2 and had additional steps to check the correctness of the variables passed between the physics and the host model. GMTB will include *capgen.py* in the build system for the UFS applications, which will be further upgraded to phase out the dynamic and hybrid build configurations in favor of the multi-suite static build, which allows multiple physics suites to be used at runtime as long as the options are specified at build time. This advancement is important to meet EMC's needs (code correctness, high-performance and flexibility) while maintaining unity with NCAR's path for implementation of the CCPP-Framework in their models.

Area 2. Physics testing and evaluations

Area 2.1: Testing and evaluation (T&E) of physics innovations.

- As a result of the advanced physics test executed during the previous PoP, the independent review panel found that the physics suites that are most similar to the current operational suite provided the best objective performance while some intriguing aspects of the forecasts were improved for suites 3 and 4. In particular, both suites 3 and 4 demonstrated better skill representing low-level inversions and convective instability. Suite 4 demonstrated further improvement for tropical precipitation, low-level temperature bias, and warm-season maritime stratus shields over eastern boundary currents. Assuming an evolutionary approach to improving model physics is adopted by EMC, it is important to understand how suites 3 and 4 were able to improve the model's representation of the processes listed above and whether a similar level of improvement can be gained by evolving the chosen suite. The HTF, specifically the GMTB SCM, can be a useful tool for developing that understanding and for evaluating whether evolutionary changes to the chosen physics suite show promise for more computationally-intensive (global NWP) testing. GMTB will use the SCM, leveraging additional functionality and cases implemented as part of the hurricane supplemental work, to shed light on why suites 3 and 4 lead to some of the specific improvements listed above and whether it is possible to gain similar improvement from an incrementally-evolved set of physics. Past experience with this type of investigation under the DTC core funding indicates this type of approach can prove fruitful when the team established a close collaboration with the appropriate physics experts. In addition, GMTB will provide support to EMC in the evaluation and improvement of the GFS v16 physics suite using the global configuration

of the UFS Atmosphere; the scope of this support and timeline will be developed in collaboration with EMC and documented in a testing and evaluation plan.

Area 3. Community support

Area 3.1 CCPP governance and code management

- **Ongoing code management and governance**. Evolve, document, educate and enforce rules for governance and development, including procedures for development (how to fork branch, and submit contributions for inclusion in the authoritative repository). Maintain a wiki page in the CCPP/CCPP framework GitHub repositories that include all documentation for training, code management, policies, governance, etc. All documents should be version controlled. Coordinate with the Infrastructure SIP WG to ensure the CCPP code management and governance are aligned with the overall UFS repository plan.
- **Identify parameterization duplicates**. As the HWRF parameterizations are added to CCPP through Hurricane Supplemental projects, and as advanced versions of radiation (RRTMGP) and land (Noah-MP) parameterizations are added to CCPP, it will be necessary to create pathways to reduce the number of duplicates, through unification or retirement of older schemes. This process must be done in concert with developers and UFS application leads. GMTB will work with the UFS community to create plans for unifying schemes with significant divergence (e.g. RRTMG radiation, Noah land model) and complete code unification for schemes with less extensive divergence.

Create portability policy for the UFS Atmosphere. Work with the UFS community to create a policy for portability for the UFS Atmosphere (e.g. for Cheyenne and GNU) via code reviews before commits, frequent code testing, and reporting on problems (e.g. via community forum). Demonstrate this policy for Cheyenne and for the GNU compiler.

Area 3.2: Support CCPP and SCM users and developers

- **Improve public-facing presence.** Maintain the public website for CCPP, add updated documentation and tutorial materials, and transition user and developer support from a helpdesk to a forum format in order to encourage community engagement and allow public-searchable issues and solutions.
- **Support use and development of CCPP.** Provide support to keep parameterizations up-to-date and upgrade/add parameterizations working with community developers. Provide a public release to go along with SCM and UFS with updated documentation, a short course at the 2020 AMS annual meeting, and a community tutorial. For teaching CCPP with UFS, GMTB will partner with others (GMTB will teach CCPP aspects and FV3GFS use (see Area 3.3), while others will teach FV3 development and overall Apps). All documentation will be maintained in the GitHub repository and version controlled.

Area 3.3: Support FV3GFS users

Further details describing this task can be found in the following document: https://docs.google.com/document/d/1bifLV8f_0twfdsvwF6tmKo-FTmAhyEw_iwR5D7hpgtg/edit?usp=sharing

- **Community release.** Coordinate with EMC for pre-release planning, and assist with pre-release testing of the selected configurations, datasets and platforms.
- **Documentation.** Coordinate with EMC to produce the necessary documentation for a community release of FV3GFS. Contribute content for the User's Guide.
- **Tutorial.** Plan and conduct a community tutorial. GMTB will partner with others (EMC) to teach the FV3GFS for community users.
- **User support.** Provide user support via a user forum, including FAQs, with assistance from EMC.
- All documentation will be maintained in the GitHub repository and version controlled.

Area 4. Program management support

- Quarterly joint GSD/NCAR written report to the DTC Executive Committee.
- As required joint GSD/NCAR coordination meeting with STI program office to discuss progress and impediments
- Monthly NCAR written report
- Monthly GSD written report

Milestones

#	Milestone/subtask	Start Date	End Date	Deliverable	Notes
1.0	**CCPP development needed for adoption in research and UFS applications**				
1.1	**Add new parameterizations to CCPP and support EMC in establishing a timeline for phasing out non-CCPP parameterizations and configurations from UFS**	Jul 2019	Jun 2020	Transition plan to phase out non-CCPP configs. New parameterizations and code coverage in CCPP (timeline for activities associated with this milestone will be provided in the transition plan).	Depends on CCPP being validated and accepted for phase 1 capabilities (2018 PoP). Depends on availability of application leads
1.2	**Enhancements to CCPP Physics**	Jul 2019	May 2020	Parameterizations in CCPP with new metadata format	Ensure this new data format does not impact the transition to operation
1.3	**Further implementation of CCPP-Framework requirements**	Jul 2019	Jun 2020	Transition UFS build system to use *capgen.py*; phase out dynamic and hybrid builds from UFS	Ensure this new build does not impact the transition to operation
2.0	**Physics testing and evaluations**				
2.1	**T&E activity**	Jul 2019	Jun 2020	Collaborative briefings with EMC on findings from HTF activities	Scope and timeline of GMTB evaluation activities involving UFS Atmosphere will be defined collaboratively with EMC once test plan for GFSv16 is finalized.
3.0	**Community support**				

3.1	**CCPP governance and code management**	Jul 2019	June 2020	Quarterly report to NGGPS PO on code management activities including the status of addressing parameterization duplicates. Portability policy for the UFS Atmosphere. Update to documents (in GitHub) related to code management and governance as needed	Includes information on portability, code management, and use of the repository by community
3.2	**Support CCPP users and developers**	Jul 2019	Jun 2020	Updates to the website describing supported capabilities, Users' Guide, ongoing user and developer support. CCPP release and associated tutorial. Updates to the CCPP Github wiki page	Should be coordinated with release and tutorial for UFS Weather application
3.3	**Support FV3GFS users**	Jul 2019	Jun 2020	Updates to the website describing supported capabilities, ongoing user support, and FV3GFS user tutorial. Establish a Github wiki page containing user support information	Should be coordinated with release and tutorial for CCPP
4.0	**Program management support**				
4.1	**Reports**	Jul 2019	Jun 2020	Monthly and quarterly reports	
4.2	**Work plan**	July 2019	July 2019	Initial version of work plan including detailed activities and timeline	