Convection/Boundary Layer SWG breakout group (BOG) synopsis

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The BOG addressed the suggested bulleted discussion topics as follows:

Timeline/selection criteria

Our SWG discussed a two-phase implementation strategy (with time gates) for advanced physics. This concept underlies the rest of our recommendation. The time gates plus use of unified weather-climate metrics are key strategies to determining parameterizations that are sufficiently promising for serious R2O efforts on short and medium time scales.

Phase 1:
April 2017: Select cloud microphysics parameterization
Oct 2017: Determine remaining parameterizations, with the "evolved" versions of the current GFS physics as the defaults. This decision should be led by EMC.
Oct 2018: Tuned and optimized version of Phase 1 suite considered by EMC for parallel forecast/DA evaluation before possible operational GFS implementation in early 2019.

Phase 2:
Mid 2018: Determine parameterizations to compose NGGPS 'advanced physics' Phase 2 suite, based on GMTB testing and based on a new unified weather-climate metrics suite.
Early 2019: NGGPS organizes a physics suite intercomparison, in which the Phase 2 suite is entered along with other available choices (e. g. operational GFS physics, GFDL, HRRR physics?) This intercomparison should be jointly run by EMC and the broader model development community, and will be used as guidance for operational implementation of a new GFS physics suite.

We collectively agreed that the overall physics parameterization components that are to comprise each suite need to be developed and tuned as a group for up to a year before they ready for final pre-implementation testing. That full year is needed for two reasons:

(1) We would like to optimize the GFS to a broader set of metrics than are currently used operationally, with more focus on long-lead ensemble forecasts and climate biases (see below), so that it is a reasonable foundation for GEFS and building CFSv3 or beyond. This is responsive for the NCEP priority for evolving GFS toward a core component of a unified modeling suite for weather and climate applications.
(2) It is likely that that FV3 will be operationalized in GFS at or before the 2019 release, which is likely to affect the tuning process for physical parameterizations including Cu and PBL.

For both phases, the selection of parameterization for the physics suite should be based mainly on overall skill in meeting the weather-climate metrics described below, and to a lesser extent expert judgement about the relative physical correctness and completeness of different parameterization choices across the range of relevant grid spacings, as well as their extensibility to future capabilities (e. g. aerosol awareness). Within these constraints, consideration of various possible parameterization approaches should be encouraged with NGGPS.

We agreed that early selection (within 6 months) of a microphysical scheme will be very useful to our SWG efforts for Phase 1. Because both 1 and 2-moment versions of the Thompson scheme, and the 2-moment Morrison scheme are based on much more modern science, have already been implemented into GFS, and are all successfully used by other weather and/or climate models, any of them would be a progressive and answer-changing starting point for further convection/PBL development, and it is more important to choose a scheme and optimize it rather than keep investigating multiple options for a year or more. Since an aerosol scheme is unlikely to be implemented in Phase 1, efficiency and good precipitation and cloud predictions are more important than 2-moment microphysics, especially since a 2-moment scheme requires ad-hoc assumptions above detrained hydrometeors that the SAS convection parameterization does not currently include.

However, an interactive aerosol scheme is a good goal to aspire to in Phase 2. It will be much easier to tune Phase 1 convection and PBL schemes jointly with a known microphysics scheme. In particular, we noted that this would improve the chance that any of the NGGPS advanced cumulus parameterizations (Chikira-Sugiyama, Grell-Freitas) and PBL schemes (SHOC) could be ready for Phase 1 implementation. A quick GFS implementation of the updated RRTMGP radiation parameterization would also be useful in our efforts, as it more conveniently enables separate specification of the microphysical properties of cumulus and stratiform cloud within the radiation scheme.

Metrics

We discussed the need for GFS model evaluation metrics to be responsive to NCEPs strategic goal of heading toward unified weather-climate modeling, hopefully for Phase 1 and certainly for Phase 2. In addition to the current set of primary EMC weather metrics (500 hPa anom corr, CONUS precipitation ETS and T2m, tropical winds, tropical cyclone track/intensity), we suggested the following additions:

(1) Day 1 thermodynamic soundings vs. sondes (for severe convection, fire weather and air pollution, and as an important test of model biases and suitability for data assimilation).
(2) Global precipitation distribution
(3) Week 2 skill (T2m, global circulation and precipitation)

(4) Rudimentary suitability tests for seasonal forecasting, in ocean-coupled mode, including geographical distribution of seasonal SST, TOA OLR and TOA reflected shortwave patterns during the first forecast year, or longer, using a coarse-resolution version of the coupled model (T126 or equivalent would suffice for testing), as well as a check for global energy, moisture and mass conservation in both the atmosphere and ocean to within adequate tolerances.

(5) GEFS suitability: Forecast spread vs. lead time for ensembles of 20-40 hindcasts using a set of perturbed initial conditions drawn from an operational GEFS, to assess the reliability of the ensemble as measured by the spread-skill ratio at various forecast lead times.

Note that GMTB would need to support these metrics additions as well as the capability for coarse-resolution coupled modeling by the end of 2017 to allow effective use of GMTB for Phase 2 testing. In addition, GMTB needs to archive a suitable set of initial conditions (including land surface, ice etc.) for enough cases for representative hindcast testing. Ideally, one would also have ICs from another modeling center (e.g. ECMWF) for comparison.

Diagnostics

A limited set of metrics is used to holistically compare forecast skill between various model versions using robust observational comparisons. Diagnostics support the evaluation and improvement of physics parameterizations. The SWG discussed both single-column model (SCM) and coarse-grid global model diagnostics and suggested some useful additional diagnostics for convection and PBL processes. To be broadly accessible and useful, these diagnostics would need to be incorporated into the MET (Model Evaluation Tools) software in GMTB.

SCM diagnostics

It would be very helpful to add the capability of extracting forcings at a particular location from a GFS forecast run and configuring the SCM to run at that location and forecast period for detailed process diagnosis.

For most GASS benchmark cases, an LES or CRM intercomparison was also run. Since such models naturally allow better process fidelity than an SCM for turbulent or convective flows, it would be useful to have a set of comparison LES/CRM statistics (e. g. vertical velocity variance, cumulus updraft strength PDF, updraft and downdraft mass flux profiles and properties) appropriate to each case.

Global model diagnostics

Capability to output time-height sections of tendencies of heat, moisture and momentum from each parameterization, averaged across a user-specified horizontal regions such as a lat/lon range.

Tropical equatorial wave diagnostics (Wheeler-Kiladis diagram)
RMM analysis for MJO forecast evaluation

Seasonal forecast 'test harness' a la CFSv2 (under development by S. Saha's group)