Testing and evaluation of physical parameterization innovations for NOAA’s Next-Generation Global Prediction System

L. Bernardet\textsuperscript{1,3,*}, J. Hacker\textsuperscript{2,*}, M. Harrold\textsuperscript{2,*}, M. Zhang\textsuperscript{1,3,*}, G. Firl\textsuperscript{2,*}, J. Wolff\textsuperscript{2,*}, L. Nance\textsuperscript{2,*}, B. Kuo\textsuperscript{2,*}, V. Tallapragada\textsuperscript{4}, and G. Grell\textsuperscript{1}

\textsuperscript{1}NOAA/ESRL Global Systems Division
\textsuperscript{2}National Center for Atmospheric Research
\textsuperscript{3}CU Cooperative Institute for Research in the Environmental Sciences
\textsuperscript{4}NOAA/NCEP Environmental Modeling Center

*Developmental Testbed Center
GMTB is funded by the NOAA Next-Generation Global Prediction System to foster community involvement in the development of NCEP’s global prediction systems

GMTB activities

1. Development and maintenance of testing infrastructure
   • Single column model, global workflow, verification, diagnostics

2. Testing and evaluation

3. Common Community Physics Package
   • A collection of physical parameterizations, grouped in suites, that can be used with multiple dynamic cores
   • A framework that enables collaborative development and R2O
(Re)forecast workflow description

Workflow supplied by NOAA EMC

Initialization → Preproc → Forecast → Postproc

Workflow developed by GMTB

Verification

Complementary workflows

EMC workflow
• GMTB keeping pace with EMC procedures
• GMTB/EMC collaborate to resolve issues on both sides

GMTB workflow
• Highly flexible and configurable
• EMC verification methods in DTC’s Model Evaluation Tools (MET)
Test of Grell-Freitas Cu scheme in GFS

Test plan created jointly with EMC, NGGPS Program Office, and developer (G. Grell)

<table>
<thead>
<tr>
<th>SCM</th>
<th>Cu</th>
<th>Res (km)</th>
<th>Run by</th>
<th>IC</th>
<th>Period</th>
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<tbody>
<tr>
<td>GF</td>
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<td>GMTB</td>
<td>GEWEX Tropical Warm Pool Summer case</td>
<td>1 field campaign</td>
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<tr>
<td>SAS</td>
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<td>Operational GFS analyses</td>
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Connecting GF to GFS correctly was a multi-month iterative process with developer – effort should not be underestimated!
SCM: tool to quickly identify code issues

Problem in GF code identified using SCM, led to fix by developer:
Erroneous near zero deep convection (dashed green line) in implemented GF code
SCM: tool to understand physics suite

**Vapor tendencies**

Grell-Freitas r85909 (current version)

Partition between **convection** and **microphysics**: in runs with GF, microphysics play a larger role

Low level equilibrium between **convective drying** and **boundary layer moistening**: larger extremes in runs with SAS
500 hPa height anomaly correlation

**S Hemisphere:** GF has statistically significant lower AC for a few lead times later in forecast period (but by then AC below usable 0.6)

**N Hemisphere:** SAS and GF similar

Quite similar results between the two model configurations
Better configuration depends on variable, level, and lead time

**NH JJA 2016 Score card**: p-values show statistical differences

<table>
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<th>Bias</th>
<th>Temp</th>
<th>RH</th>
<th>Wind</th>
<th>Temp</th>
<th>RH</th>
<th>Wind</th>
<th>RMSE</th>
<th>RH</th>
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- SS differences favor SAS
- Advantage of SAS diminishes w/ lead time, esp. for T bias
- Points to limitation of test (no cycled DA)
- SAS T bias increases w/ lead time, particularly noticeable over land, whereas increasing trend much smaller for GF

**CONUS JJA 2016 2m T bias (K)**

Red=SAS better
Green=GF better
Strategy for NCEP physics evolution

NGGPS Physics Workshop (Nov 2016; 80 scientists)

- Priorities and gaps for physics advancements were put forth
  - Focus on scale awareness, stochasticity, and aerosols
- Advancement of interactions among parameterizations is key
- Need transparent, well-defined criteria for testing and adopting changes in physics
- Need a collaborative framework for experimenting and developing physical parameterizations

http://www.dtcenter.org/events/workshops16/nggps
Way ahead: the Common Community Physics Package (CCPP)

A framework for community involvement in physics development. NOAA will benefit by having scientists in multiple institutions to run and develop a common set of physics

- CCPP is a collection of dycore-agnostic, vetted, physical parameterizations. There can be multiple of each type (PBL, cumulus etc.) to support various applications (high-res, climate etc.) and maturity level (operational, developmental)
- **Dycore agnostic** means that the parameterizations can be used with any dycore
- **Vetted** means that there is a process to determine what is included in CCPP at each layer
Workflow for Physics Development

- **Call for developments**
  - Developer answers call; connects scheme to IPD interface; introduction to code/doc standards

- **Physics Testbed**
  - Tier 1
  - ... Tier N

- **Regression + Comp. Perf. Testing**

- **Initial Review**
  - Physics:
    - Evidence of improvement?
    - Oper./Res. demand?
  - Technical:
    - Passed regression test?
    - Comp. performance?
    - Code/doc standards met?

- **Test Plan**
  - More Physics Testbed runs + external testing (i.e. EMC pre-implementation, parallels, friendly "Beta")

- **Final Review**

**Scheme Status**

- Developer's initial code
- Code resides in CCPP repo branch
- Improved code through iteration
- Standards-compliant + passed initial review
- Code admitted to CCPP trunk
CCPP Ecosystem
A single code to serve a variety of needs and facilitate R2O
Summary

- GMTB has been established to support the evolution of atmospheric physical parameterizations in NCEP global modeling applications
- A hierarchical testbed has been established and used to assess an experimental convective parameterization
- A CCPP is being created to facilitate engagement from the broad community on physics experimentation and development