Evaluation of the Grell-Freitas convective scheme within the NOAA Environmental Modeling System (NEMS)-based Global Spectral Model (GSM)

Michelle Harrold*[1,5], Judy Henderson[2,5], Man Zhang[2,3,5], Jamie Wolff[1,5], Ligia Bernardet[2,3,5], Hongli Jiang[2,4,5], Louisa Nance[1,5], and Christina Holt%[2,4,5]

1 National Center for Atmospheric Research/Research Applications Laboratory • 2 NOAA/Earth System Research Laboratory/Global Systems Division

3 Cooperative Institute for Research in the Environmental Sciences • 4 Cooperative Institute for Research in the Atmosphere • 5 Developmental Testbed Center

*harrold@ucar.edu

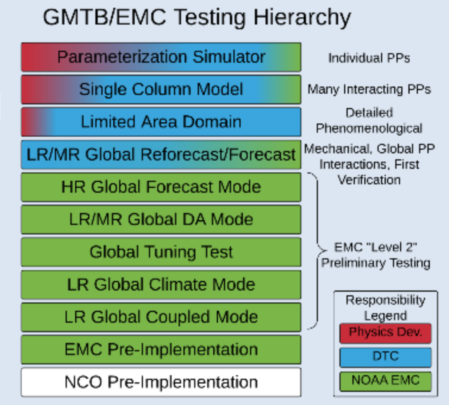
Motivation

The Global Model Test Bed (GMTB) team was established within the Developmental Testbed Center (DTC) to facilitate community involvement in the development of the Next Generation Global Prediction System (NGGPS) by supporting a hierarchical testing framework.

The GMTB is actively developing a uniform 'test harness' to enable in-depth investigation of various physical parameterizations and advanced physics suites. The goals of the hierarchical testing framework are to provide:

- A common infrastructure for testing physics developments that works across all temporal and spatial scales and facilitates an efficient R2O pipeline
- Simple-to-complex testing
- A framework for evidenced-based decision making
- Streamlined testing to accelerate transfer of worthy improvements into operations

GMTB/EMC Testing Hierarchy



The hierarchical testing capability within the GMTB was used to support a testing and evaluation effort to compare the GFS's operational convective parameterization [Simplified Arakawa Schubert (SAS)] against an experimental configuration using a more advanced, scale-aware convective parameterization, the Grell–Freitas (GF) scheme.

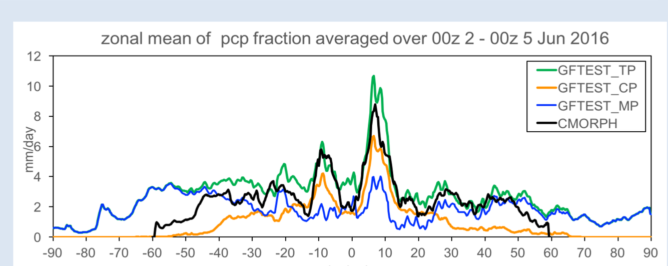
Connecting GF to NEMS-GSM

- Worked with GF developer, G. Grell:
  - Iterative process to perform initial tests
  - Successfully implemented GF scheme in the GSM
- Developer re-structured code to be more portable among models
  - Separated GF driver from GF deep and shallow code itself – deep and shallow routines independent of dynamic core
  - Capability for SPP and use of memory
- Code supplied used in test was committed to NEMS branch
- For full DTC testing of GF scheme: No tuning was performed, no cycling was employed, SPP and memory were not hooked up, mid-level scheme was not used for initial tests

Parameter Specification for GF Test

	imfdeepcnv	imfshalcnv	imid	ichoice	ichoice_s	ichoicem	dicycle	dicycle_m
SAS	1	1	--	--	--	--	--	--
GF	3	3	0	0	2	0	1	0

- **SAS** (Option 1)
  - ✓ 2016 operational
- **GF** (Option 3)
  - ✓ Deep and shallow convection turned on; mid turned off
  - ✓ Closure (ichoice=0): average of all possible closures
  - ✓ Diurnal cycle adjustment employed (dicycle=1)



Testing was done to ensure the GF was properly hooked up to the NEMS code, including checking the breakdown of total, convective, and non-convective precipitation

Test Plan & Workflow

- Test plan was created jointly with EMC, NGGPS Program Office, and developer (G. Grell)
- Invokes concept of hierarchical testbed
  - See poster 595 by G. Firl on Single Column Model for results with GF and SAS

Verification

- **Grid-to-grid**
  - ✓ Precipitation (6-h and daily accum.)
    - Frequency bias
    - Equitable threat score
  - ✓ 500 hPa height
    - Anomaly correlation
- **Grid-to-point**
  - ✓ Upper-air (T, RH, wind, height)
    - Bias, RMSE, BCRMSE
  - ✓ Near-surface (T, RH, wind, PRMSL)
    - Bias, RMSE, BCRMSE
- **Performed over:**
  - ✓ Global sub-domain (Grid 3, 1°×1°)
  - ✓ CONUS sub-domain (Grid 218, ~12km)

Initialization Data → Pre-processing → Forecast → Post-processing → Graphics → Verification

Workflow Supplied by EMC
- ✓ GMTB keeping pace with EMC
- ✓ GMTB & EMC collaboration

Cu	Res (km)	Run by	IC	Evaluation Period
GF	T574	GMTB	Operational GFS analyses (cold start)	20160601 – 20160831 00 UTC initializations 240-h forecasts (10 days)
SAS				
SAS	T1534	NCEP	Operational GFS analyses (fully cycled)	

GMTB Workflow
- ✓ Highly flexible and configurable
- ✓ Python for graphics
- ✓ DTC's Model Evaluation Tools for verification

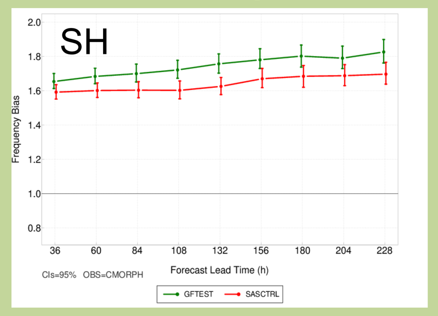
Verification Results

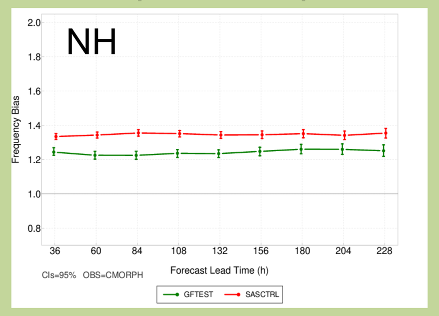
Evaluation Period: 20160601 – 20160831, 00 UTC Initializations

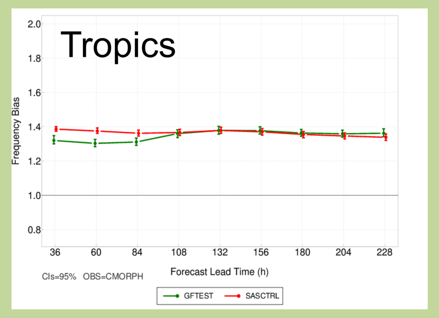
GF SAS GF-SAS

Global Sub-domain Evaluation

Precipitation Bias (>0.25")

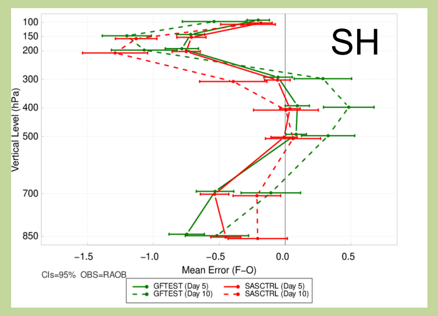


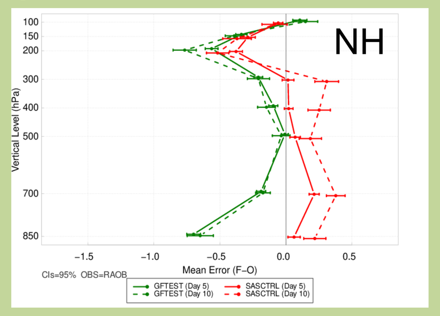


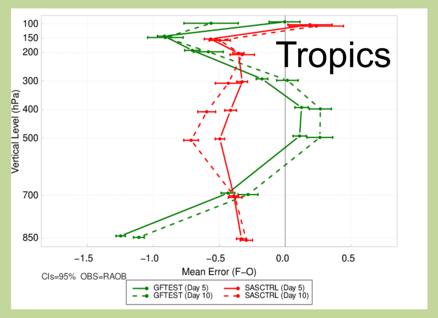


- Both have SS high bias at all lead times for all regions
- SH: Highest bias of all regions that increases with lead time; GF has higher bias
- NH: SAS has SS higher bias
- Tropics: After f84, similar performance

Upper Air Temperature Bias

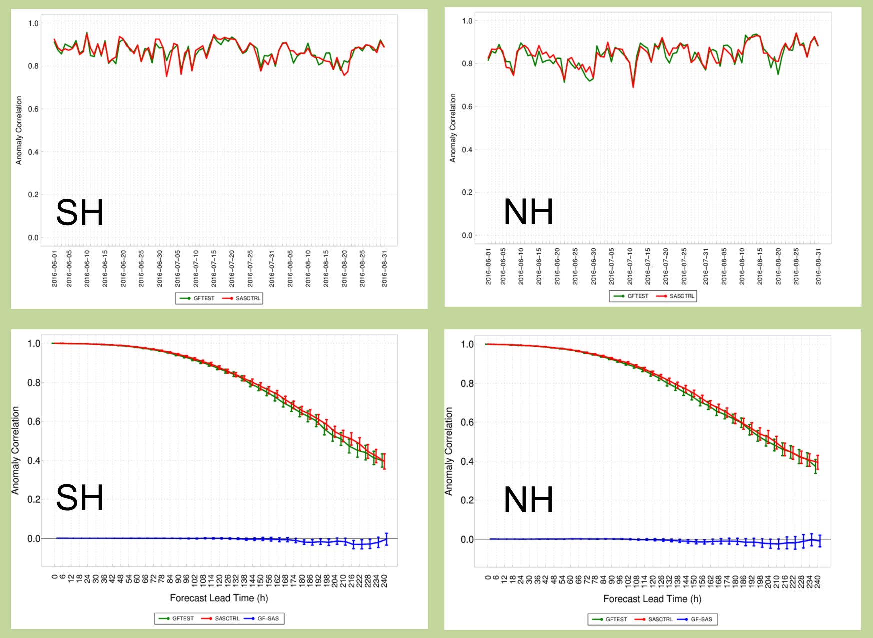






- GF typically has a cooler bias in the lowest levels, with an increasing bias in the mid-levels
- Tropics: SAS and GF have differing bias profiles in low- and mid-levels; interactions with convective, BL, and MP?

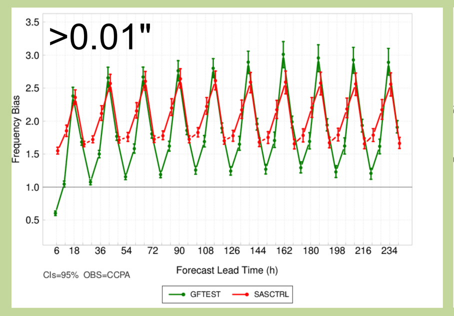
500 hPa Anomaly Correlation

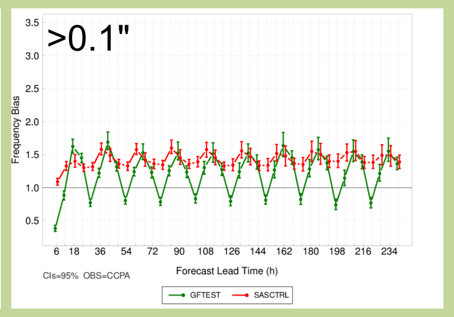


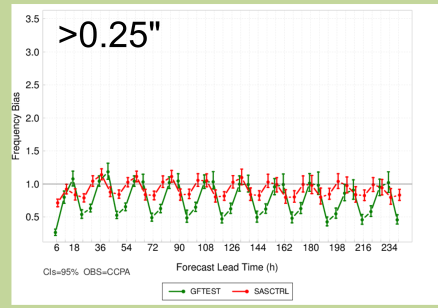
- At 120-h, AC values similar between SAS and GF in NH and SH (top plots)
- General decrease in skill with lead time (bottom); SS differences in SH at long lead times, favoring SAS

CONUS Sub-domain Evaluation

Precipitation Bias over CONUS

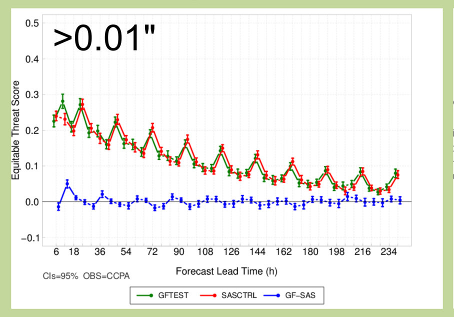


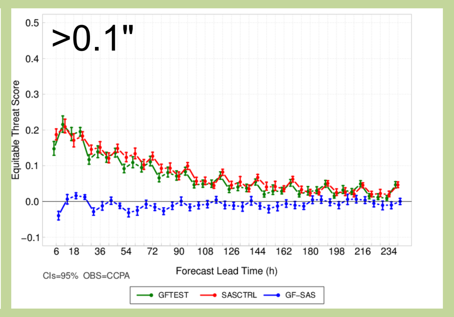


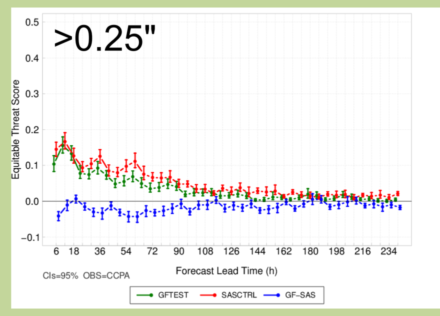


- Diurnal signal at all thresholds (most prominent at >0.01"); max high bias ~18 UTC
- As threshold increases, bias transitions toward <1
- GF: larger diurnal variation; peaks similar to SAS but has lower magnitude minimums

Precipitation ETS over CONUS

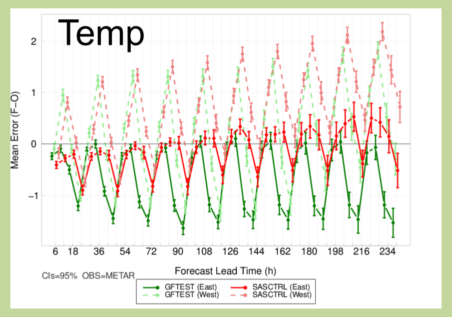


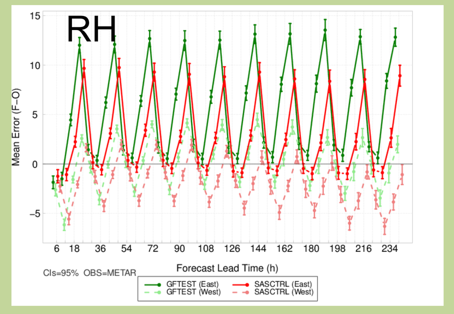


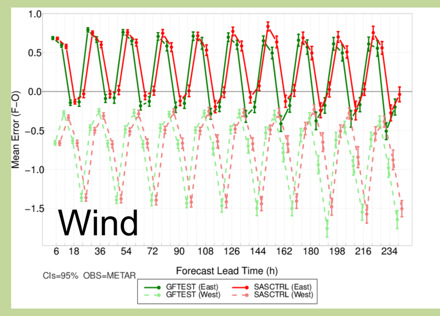


- Diurnal signal at all thresholds (most prominent at >0.01"); max GSS typically at 00 UTC
- As lead time increases, general decrease in GSS
- At 0.1" and 0.25", SS pair-wise differences show SAS better at several lead times

Near Surface Bias over East and West Regions







- Temp: More amplified in West; cooler bias in East; largest diff. (GF-SAS) at 00 UTC
- RH: Higher bias in East; in both regions, GF typically more moist than SAS
- Wind: In West, low bias at all lead times

Conclusion & Next Steps

- GMTB successfully implemented a framework for performing coarse resolution global forecasts – including pre-processing, forecasts, post-processing, graphics, and verification
- GF test illustrates complexity of adding new scheme to GSM
- Superior configuration depends on variable, metric, vertical level, domain and lead time
- Progress to next tier of testing? – higher resolution and/or cycling? Computer intensive, would need partnership with EMC
- For future testing and tuning, would be beneficial to enable output of tendencies

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% Currently affiliated w/ Spire in Boulder, CO.