### **Global Model Test Bed**

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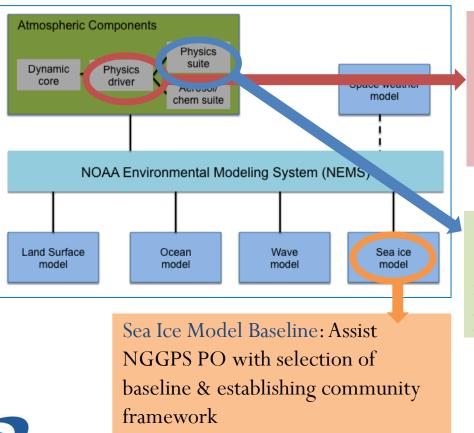
Developmental Testbed Center

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# Next-Generation Global Prediction System (NGGPS)

Community participation & solid support for Research to Operations (R2O) key to accelerating development to meet planned 2019 deployment



Interoperable Physics Driver (IPD): Standards that allow testing new parameterizations/suites in various dynamic cores, enabling inter-agency collaboration

Common Community Physics Package (CCPP): Engaging community to address identified priorities for development in physical parameterizations

## GMTB - Year 1

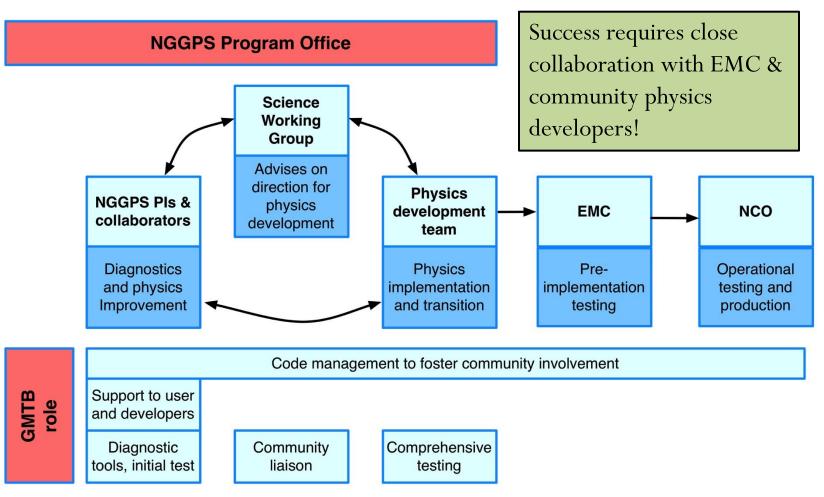
Activities – Atmospheric Physics	Status	
IPD/CCPP deliverables:		
Requirements document	Complete	
Coding standards	Complete	
Code management plan	Complete	
Technical documentation	Complete	
Testing & evaluation deliverables:		
• Design & development plan for Physics Testbed	Complete	
• Initial implementation of Physics Testbed	Complete: Single column model and global model workflow	
Report on physics parameterization test	Grell-Freitas Cu scheme selected for	
report on physics parameterization test	testing – finalizing code	
Community outreach:		
Physics PI Workshop	Dates: 7-9 November 2016	
	Scope broadened to include Physics Team	
	meeting	

## GMTB - Year 1

Activities – Sea Ice Model	Status
Deliverables: • Sea Ice Modeling Workshop	Complete: 2-4 February 2016 – report
<ul> <li>Recommendation on sea ice model baseline</li> <li>Demonstration test of sea ice model within a global application</li> </ul>	posted on DTC website Complete: included in workshop report Test of CICE underway



# Global Model Test Bed (GMTB): Facilitating NGGPS physics development





## GMTB physics team members



Ligia Bernardet



Man Zhang



Hongli Jiang



Louisa Nance



Grant Firl

**NCAR** 



Michelle Harrold





Christina Holt



Judy Henderson



Jim Rosinski



Jamie Wolff



Laurie Carson



Josh Hacker



Don Stark

# Doxygen-based documentation for GFS physics suite

### **GFS Operational Physics Documentation**

GFS Operational Phy
GFS Operational Phy

Structure Todo List Bibliography

- ▶ Modules
- ▶ Files

#### **GFS Operational Physics**

Documentation for the operational physics s

- Radiation RRTMG
- Turbulent Transport (PBL) Hybrid EI
- Penetrative Convection SAS
- · Shallow Convection SAS
- Cloud Microphysics Zhao-Carr
- Gravity Wave Drag Orographic GWI
- · Ozone Physics NRL simplified scher
- Land Surface Model NOAH

#### Hybrid Eddy-diffusivity Mass Flux Scheme

The Hybrid EDMF scheme is a first-order turbulent transport scheme used for subgrid-scale vertical advection in the F used and improved over the last several years with a more recent scheme that uses a mass-flux approach to calculate

#### **Detailed Description**

The PBL scheme's main task is to calculate tendencies of temperature, moisture, and momentum due to vertical diffus amalgamation of decades of work, starting from the initial first-order PBL scheme of Troen and Mahrt (1986) [11], imp down mixing due to stratocumulus layers from Lock et al. (2000) [6] and replacement of counter-gradient terms with a (2004) [10]. Recently, heating due to TKE dissipation was also added according to Han et al. (2015) [3].

#### **Calling Hierarchy Diagram**

#### **Detailed Algorithm**

Since the mfpbl subroutine is called regardless of whether the PBL is convective, a check of the convective PBL flag is performed output variables set to the initialized values) if the PBL is not convective.

Determine an updraft parcel's entrainment rate, buoyancy, and vertical velocity.

Calculate the entrainment rate according to equation 16 in Siebesme et al. (2007) [7] for all levels (vlemus) and a default entrainment

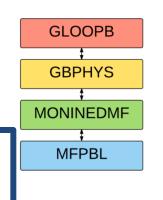
Using equations 17 and 7 from Siebesma et al (2007) [9] along w

From the second level to the middle of the vertical domain, the up (2007) [9], discretized as

#### **Parameters**

[in]ixhorizontal dimension[in]imnumber of used points[in]kmvertical layer dimension

Available through EMC page on Vlab and at <a href="DTC website">DTC website</a>



## Hierarchical testing

#### **GMTB/EMC Testing Hierarchy**

Parameterization Simulator Single Column Model Limited Area Domain Phenomenological LR/MR Global Reforecast/Forecast HR Global Forecast Mode LR/MR Global DA Mode **Global Tuning Test** LR Global Climate Mode LR Global Coupled Mode **EMC Pre-Implementation** 

**NCO Pre-Implementation** 

Individual PPs

Many Interacting PPs Detailed

Mechanical, Global PP Interactions, First

Verification

EMC "Level 2" **Preliminary Testing** 

> Responsibility Legend Physics Dev.

> > DTC

**NOAA EMC** 

GMTB is developing a test harness (initial tiers) the research community can use for conducting tests of physical parameterizations

Physical parameterizations that pass initial tests can be transferred to EMC for further testing

LR/MR/HR=low/medium/high-resolution

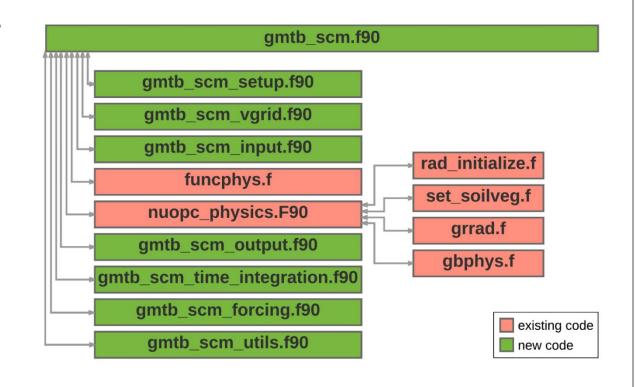


# Initial implementation of physics testbed: Single Column Model

Development, configuration for testing convective schemes, and preliminary results

## SCM development

- Code utilizes IPD, which calls the GFS physics suite
- SCM forcing, vertical grid, and numerical methods are configurable and expandable





## SCM configuration

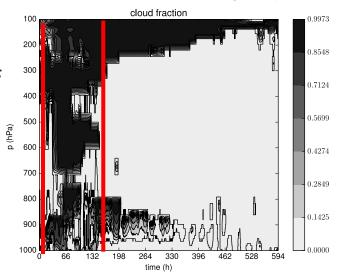
- 25-day runs with 10-min timesteps (20 min for radiation)
- 64 sigma levels as GFS, T574 (35km)
- Forcing used in the preliminary tests
  - Fixed SST
  - Prescribed temporally variable horizontal advection terms and vertical motion

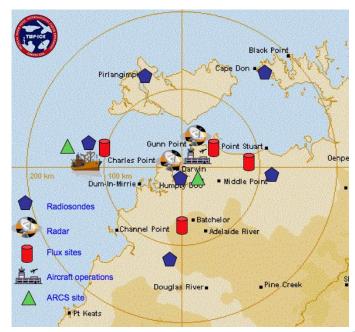
Physics Scheme	Control	GF
Surface	Noah (run over ocean)	Same
Radiation	RRTMG	Same
PBL	Hybrid EDMF	Same
Microphysics	Zhao-Carr	Same
Convection (deep & shallow)	SAS (latest)	<b>Grell-Freitas</b>

## Case description

- Deep convective GCSS case based on TWP-ICE field campaign
  - Near Darwin, Australia from 20 Jan − 12 Feb 2006
  - Features "active" and "suppressed" convective states
  - Model intercomparison studies using this case
    - For CRMs: Fridland et al. (2012, JGR)
    - For SCMs: Davies et al. (2013, JGR)

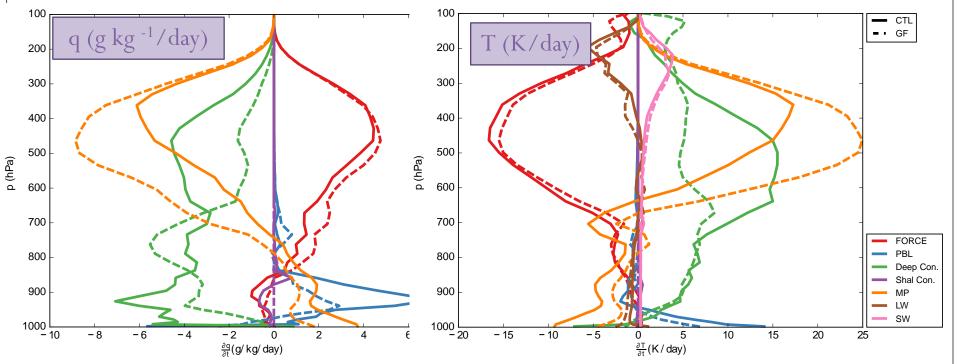
Both active and suppressed regimes occur, as depicted in the simulated cloud fraction field





TWP-ICE field campaign domain

## Analysis of tendencies



SCM results reveal contribution from each parameterization

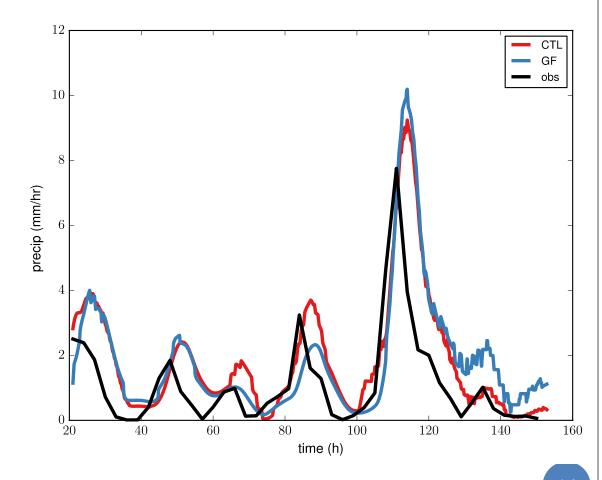
- Forcing approximates effect of environment on column
- G-F produces weaker tendencies due to deep convection with stronger microphysical tendencies

## Precipitation during active phase

Subtle differences between simulations with SAS and GF

- Both schemes are in ballpark of observations, but overestimate peaks
- Both schemes

   capture temporal
   variability but last 4 6 hours longer





# Initial implementation of physics testbed: Global workflow

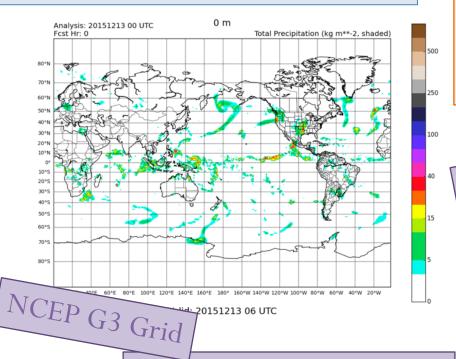


## Global reforecast/forecast workflow

Global Initialization Pre-processing Atmospheric data sets Model Global model workflow – GSM scripts transitioned Post-processing from EMC to GMTB Flexible & portable **GEFS 5-day fcst** framework GEFS 10-day fcst GEFS 15-day fcst developed by Graphics Verification Diagnostics **GMTB** Community contributions

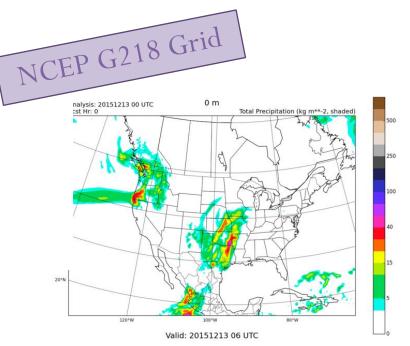
## **GMTB** workflow: Graphics

### **Accumulated Total Precipitation**

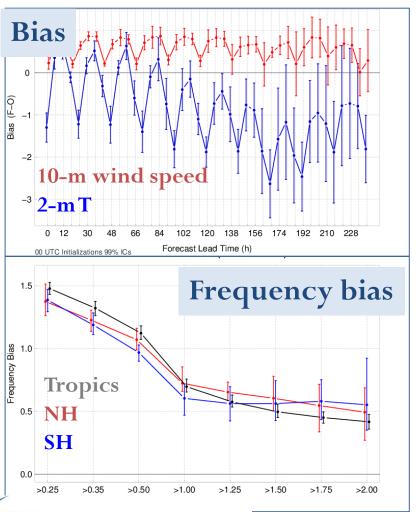


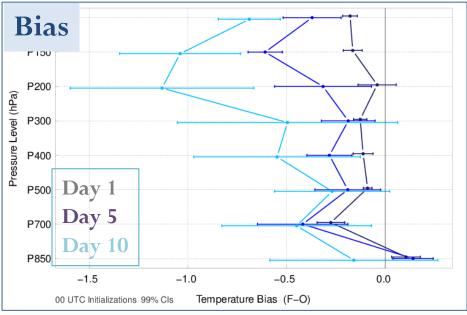
Standard, automated graphics on the same grids as verification

Flexible Python graphics with configuration options for different regions



### **GMTB** workflow: Verification with MET





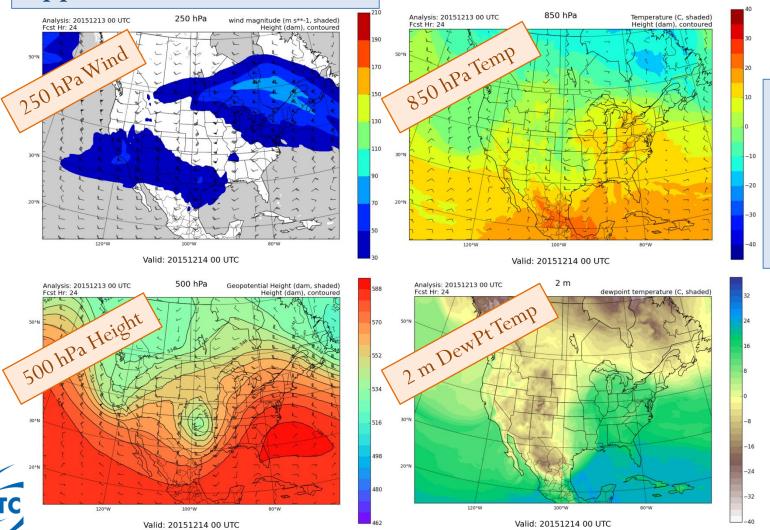
Sample of two-week evaluation of reforecast GFS (against surface obs, RAOB, and CMORPH) using MET



## **GMTB** workflow: Graphics

### Upper air and surface fields

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Many more...
• 2 m:T,Td
• 850:T, RH,

**HGT** 

• 700:T,W

500:T, HGT 250:T, Wind

## GMTB - Year 2

#### Activities – Atmospheric Physics

#### IPD/CCPP deliverables:

- Software design that meets the requirements for the IPD/CCPP concept
- Implementation plan for IPD/CCPP capability
- Initial IPD/CCPP capability
- Code management plan and testing suite that are consistent with current IPD/CCPP capability
- Refined/enhanced documentation for GFS operational physics suite within CCPP

#### Physics Testbed infrastructure:

- Enhanced SCM capabilities
- Initial parameterization simulator capability
- Enhanced workflow capability for low/medium resolution global reforecast/forecast mode

#### Testing and Evaluation:

Report(s) on physics testing activities

Manuscript on Physics Testbed submitted to appropriate journal



## GMTB - Year 2

#### Activities – Sea Ice Model

#### Deliverables:

• Support to NGGPS Program Office for engaging the sea ice modeling community in the process of setting up a community sea ice modeling framework

CICE Consortium Workshop scheduled for 25-27 October 2016



## Moving forward...

- Community support (O2R)
  - Provide community support for NGGPS modeling system (expanding beyond support to atmospheric physics)
  - Facilitate community participation in NGGPS physics development
  - Make CCPP/driver available to other modeling systems
- Transfer of innovations to operations (R2O), with focus on atmospheric physics
  - Expand CCPP to include advanced physical parameterizations, expanding the options for NGGPS
    - Improvement in driver needed
    - Additions to CCPP vetted through Physics Review Committee
  - Facilitate testing and evaluation of innovations

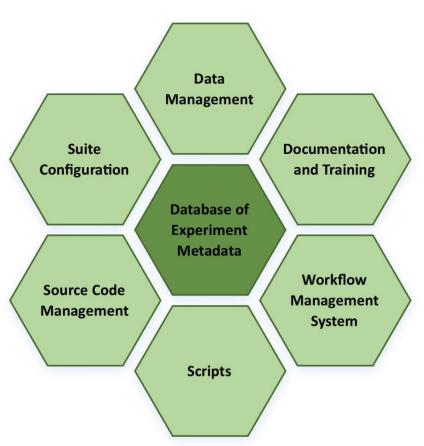
These are collaborative activities with EMC and the NGGPS community

# Supporting NGGPS as a Community Model through NITE (NWP IT Environment)

Creating a strong community for NGGPS will require easy access to a highly configurable modeling system that can be used for research.

Operational configuration should be a subset of the community system

Source codes need to be accessible to all developers, with a well defined path for contributing innovations



Bernardet, L., L. Carson, and V. Tallapragada 2016: The design of a modern information technology infrastructure to facilitate research to operations transition for NCEP's modeling suites. BAMS, accepted.

http://www.dtcenter.org/eval/NITE/

## Access needed for effective R20

- All source codes
- Datasets used in operations
- Scripts and workflows to run and evaluate the experiments
- HPC platforms, migrating toward cloud computing
- Database to record and retrieve experiment configurations, so EMC is sure of their relevance
- Documentation, tutorials, and user/developer support