NGGPS Workshop
02/10/2016 College Park, MD

Global Model Test Bed (GMTB)

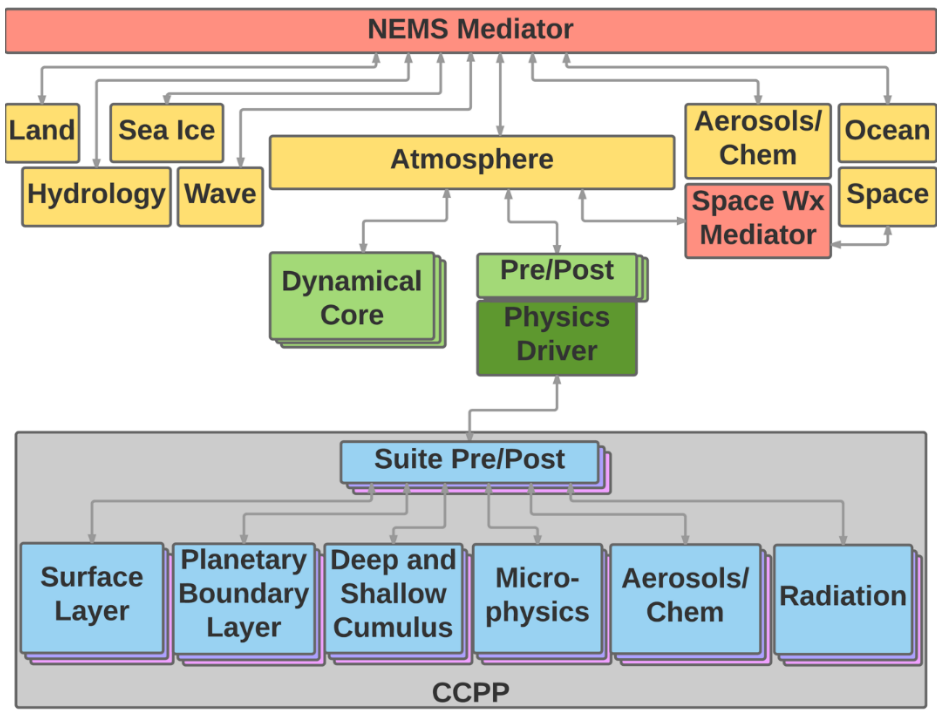
Ligia Bernardet
NOAA/ESRL/GSD & CU/CIRES
Developmental Testbed Center

Acknowledgements
GMTB team
EMC staff
NGGPS collaborators
NUOPC PI team

DTC Developmental Testbed Center

Current foci: 1) improvement of atmos physical parameterizations and 2) sea ice

Motivation for GMTB



NGGPS

New NCEP global model will use community codes – a strategy to enhance rate of transition of research to operations

GMTB

Is a critical mechanism for connecting NCEP to the research community

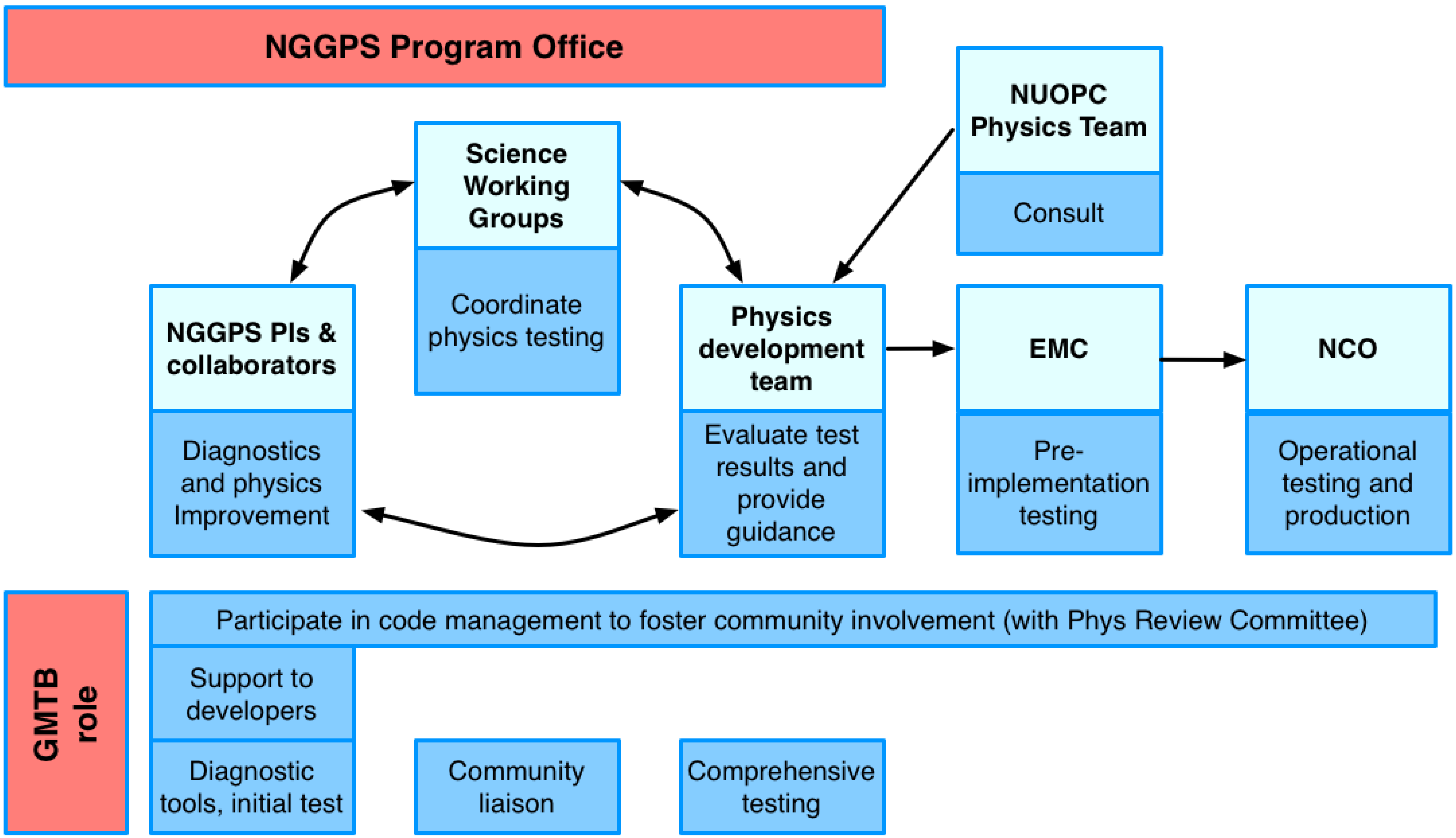
Leverage from the Developmental Testbed Center

GMTB builds on the DTC multi-year of supporting R2O for regional NCEP NWP codes, such as Hurricane WRF and GSI data assimilation

Atmospheric Physics

Supporting development of parameterizations

GMTB's role in physics development



NGGPS code management protocols

https://docs.google.com/document/d/1bjnyJpJ7T3XeW3zCnhRLTL5a3m4_3XIAUeThUPWD9Tg/edit#heading=h.ku78qulk21xh

Code, Data, and Document Management for NEMS Modeling Applications and Suites - DRAFT

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NGGPS OAS

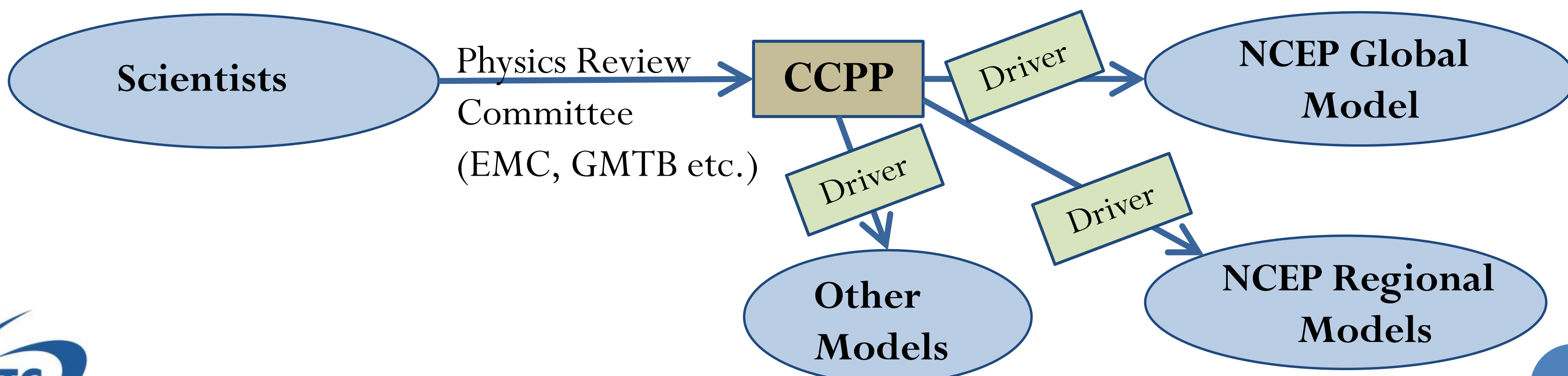
GMTB is collaborating with OAS to create code management protocols for NEMS-based suites

NOAA Virtual Laboratory

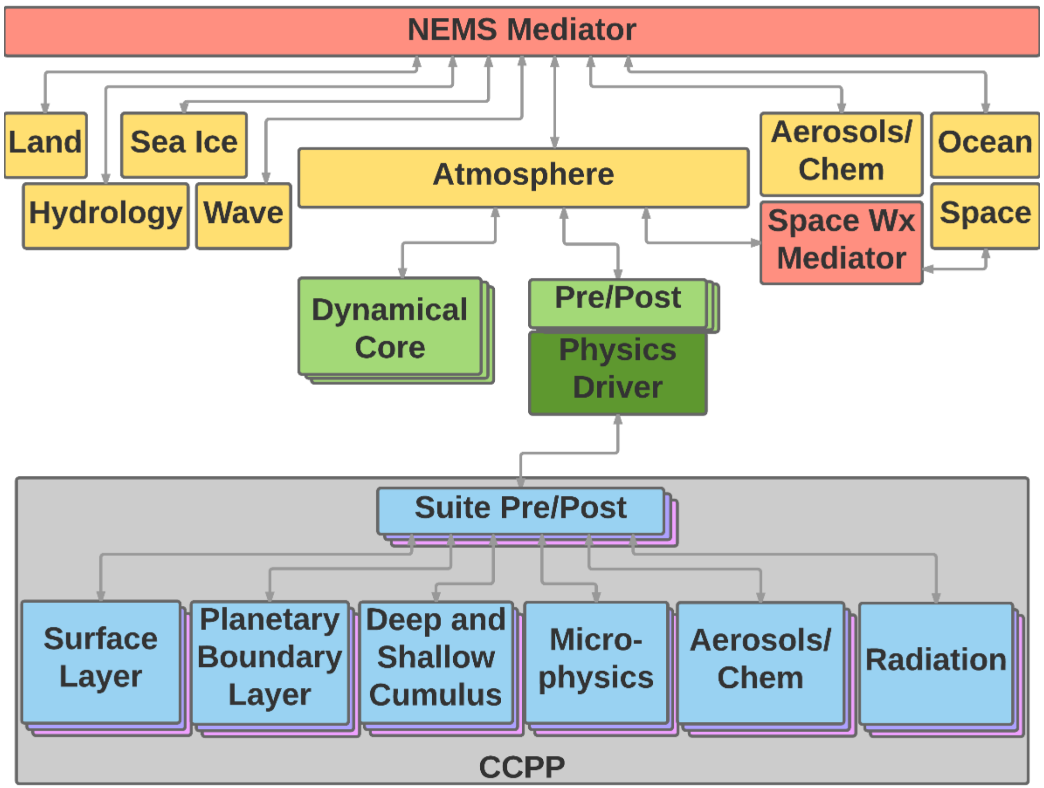
- GMTB started a project on Vlab for development of the Single Column Model
- Gives GMTB experience with Vlab and Git repositories, which will be useful to investigate possible transition of significant part of NGGPS code base to VLab

Proposed vision for Driver & CCPP

- CCPP is a library of dycore-agnostic atmospheric physical parameterizations to be used by NCEP models
  - Start with global, but could be used by regional models as well
  - CCPP could be used with any dycore that connects to the Driver
- Various parameterizations of each category can co-exist in the CCPP, but a Physics Review Committee constrains options based on objective and transparent criteria



Schematic for Driver & CCPP



Pre/Post Physics interfaces have knowledge of dycore

If necessary, they de- and re-stagger, and convert between dycore variables and Driver standard variables.

Pre/Post Parameterization interface has knowledge of the parameterizations

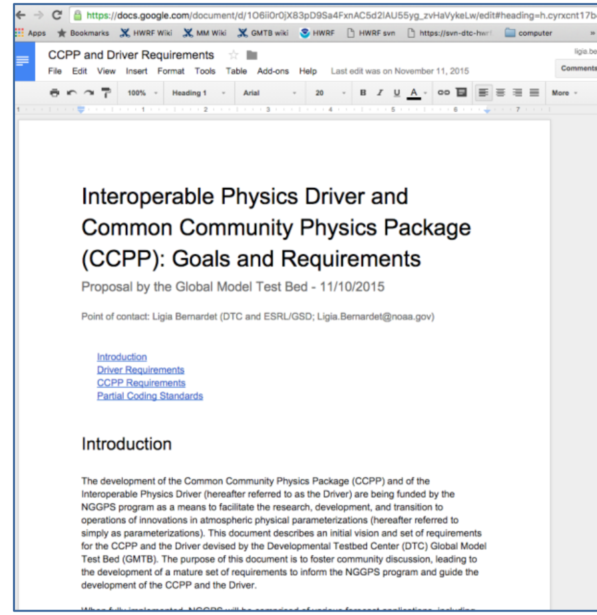
If necessary, they re-order and convert variables between the Driver and the parameterizations https://docs.google.com/document/d/1O6ii0r0jX83pD9Sa4FxnAC5d2lAU55yg_zvHaVykeLw/edit#heading=h.cyrxcnt17b4a

Collaboration with NUOPC PI Team and EMC

CCPP and Driver

CCPP benefits to NOAA

- Community participation in physics development & testing will expedite improvement of NGGPS forecasts
- Hierarchical testing framework including SCM will attract community contributions
- A single library of physics that can be used by all models will minimize need to port new schemes to various NCEP models



Current status

- Initial CCPP capability will be based on operational GFS physics - documentation and testbed preparations are underway
- Goals and requirements for CCPP & Driver proposed and presented by GMTB
  - Requires Driver that can work with parameterizations other than GFS'
  - EMC will further develop the driver, all need to agree on requirements
  - Code management discussions have started but need to progress

Documentation for physical parameterizations in CCPP

GMTB has started preparing documentation for CCPP (starting with operational GFS physics)

- **Introduction**
  - Scientific origin (including references) and history
  - What the scheme calculates and key features
- **Summary of how the scheme works**
- **Diagram depicting calling hierarchy**
- **Source files and associated subroutines and functions**
- **Intra-physics communication**
  - Variables exchanged between routines
- **For each subroutine, further documentation**
  - Description, what is done in the subroutine
  - Argument list: variable names, "intent", shape size, short description, units
  - Overview of the steps of the algorithm
  - If available, algorithm description with equations, discretization, etc.

CCPP Doxygen-based Documentation

GFS Operational Physics Documentation

- GFS Operational Phy
  - GFS Operational P
    - Structure
  - Todo List
  - Bibliography
  - Modules
  - Files

GFS Operational Physics

Documentation for the operational physics suite car

- Radiation - RRTMG
- Turbulent Transport (PBL) - Hybrid EDMF
- Penetrative Convection - SAS
- Shallow Convection - SAS
- Cloud Microphysics - Zhao-Carr
- Gravity Wave Drag - Orographic GWD, Stati
- Ozone Physics - NRL simplified scheme
- Land Surface Model - NOAH

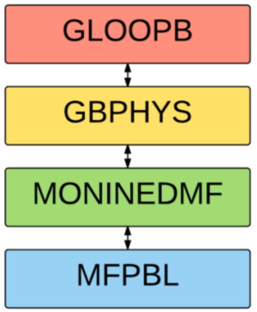
Hybrid Eddy-diffusivity Mass Flux Scheme

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 a
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 Siebesma et al. (2007) [9] for all levels (xlamue) and a default entrainm

Using equations 17 and 7 from Siebesma et al (2007) [9] along with u_* , w_* , and the previously diagnosed PBL height, the initial θ

From the second level to the middle of the vertical domain, the updraft virtual potential temperature is calculated using t
(2007) [9], discretized as

$$\frac{\theta^k_{v,u} - \theta^{k-1}_{v,u}}{\Delta z} = -\epsilon^{k-1}\left[\frac{1}{2}\left(\theta^k_{v,u} + \theta^{k-1}_{v,u}\right) - \frac{1}{2}\left(\overline{\theta_v}^k + \overline{\theta}\right.\right.$$

Parameters

[in]	**ix**	horizontal dimension
[in]	**im**	number of used points
[in]	**km**	vertical layer dimension

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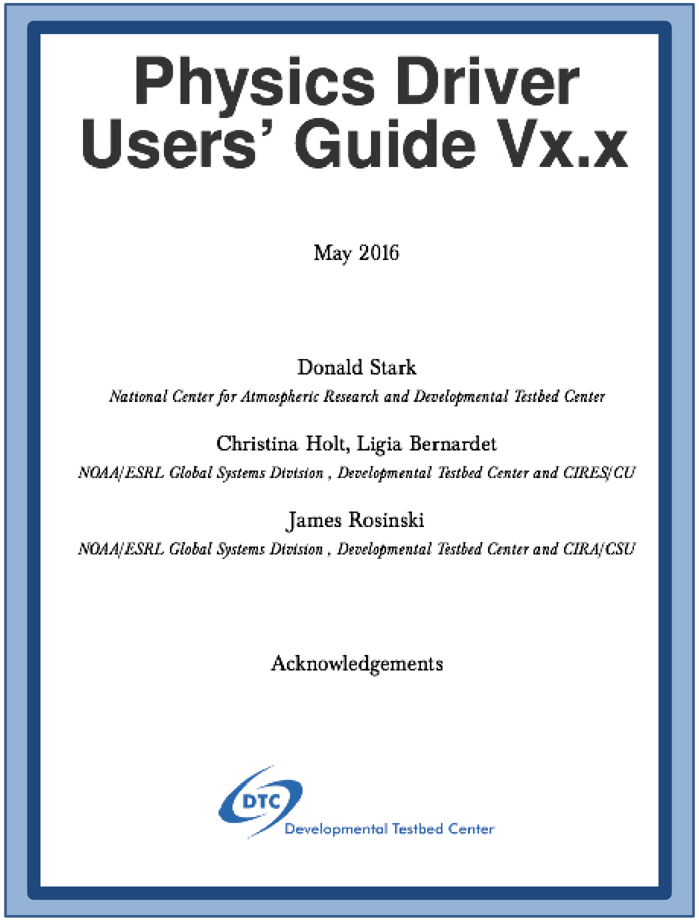
Driver Documentation



Physics Driver Users' Guide Vx.x

May 2016

Donald Stark

National Center for Atmospheric Research and Developmental Testbed Center

Christina Holt, Ligia Bernardet

NOAA/ESRL Global Systems Division , Developmental Testbed Center and CIRES/CU

James Rosinski

NOAA/ESRL Global Systems Division , Developmental Testbed Center and CIRA/CSU

Acknowledgements

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Outline of Documentation

1. Overview
2. Using the Standalone Driver
3. Memory Management
4. Initialization Process
5. Run Process
6. Finalize Process
7. Connecting the IPD with a Dycore
8. Limitations of the prototype
9. Code Management
10. Help and support

GMTB has started preparing documentation for Driver (building on initial EMC effort)

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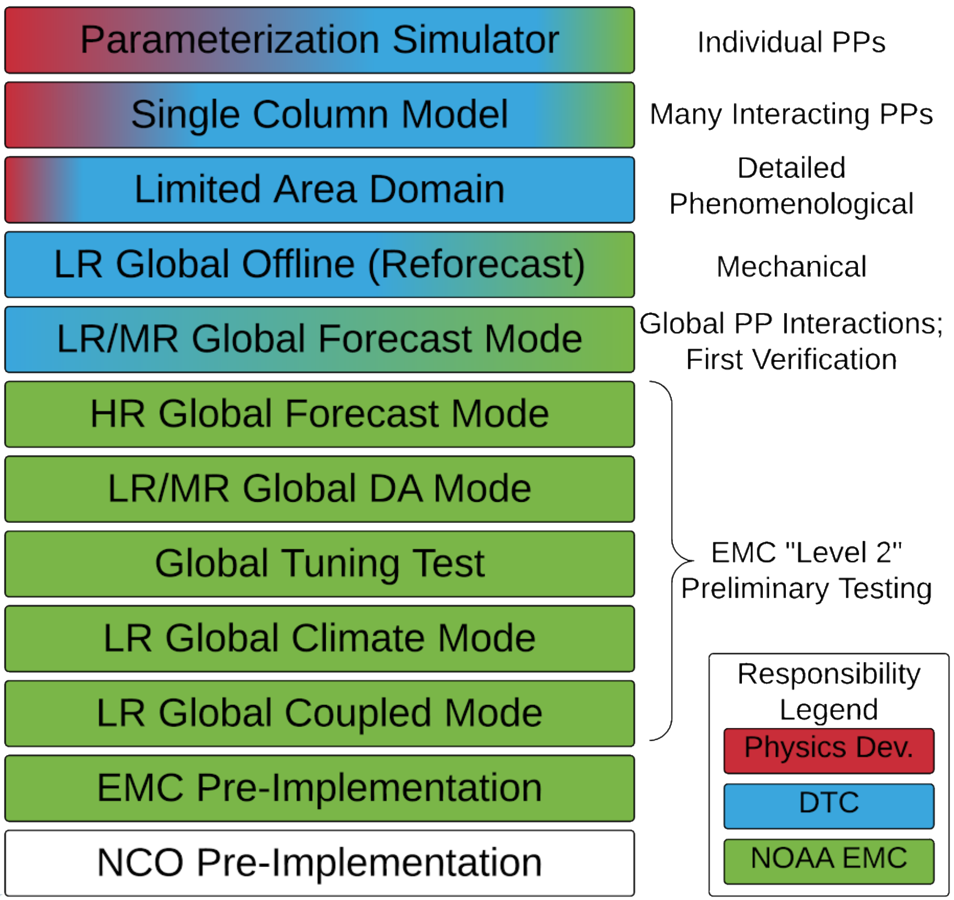
Testbed

Hierarchical testing

GMTB/EMC Testing Hierarchy



GMTB will provide a testbed to the research community for conducting initial testing of physical parameterizations

- Case studies, datasets
- Scrips/Workflow
- Vx, diagnostics
- Documentation and support

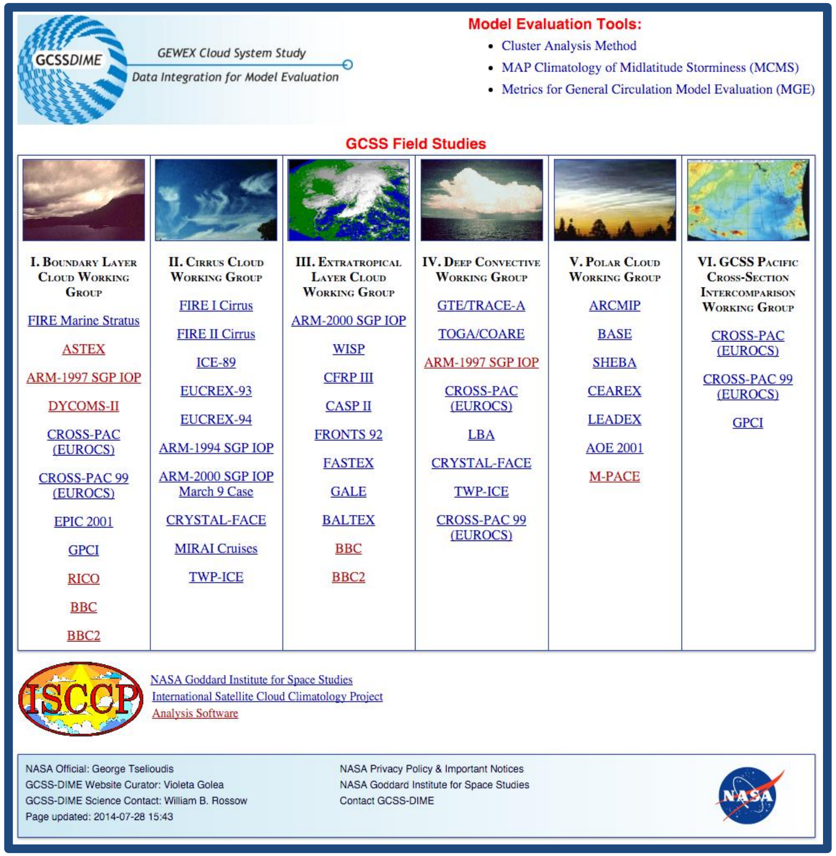
Physical parameterizations that pass initial tests can be transferred to EMC for further testing

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

Status of Single Column Model (SCM)

- **Completed initial design and started a prototype**
  - **Relies on Driver and CCPP** (initially operational GFS physics)
  - Supports multiple vertical grids and numerical methods – adaptable to GFS and new dycore
  - **Prototype uses Python layer to call Driver and CCPP**
    - Python takes care of I/O, initialization, time-integration, applying forcing
    - Python allows quick prototype and has many data analysis & plotting modules
    - Utility *f2py* makes Fortran called from Python
- **Selected case studies and started preparing datasets**

Strategy for using SCM



http://gcss-dime.giss.nasa.gov/

Cases

- Collection of cases spanning large range of meteorological conditions
- Geographically well-distributed
- Draws heavily from GEWEX
  - Well-defined cases based on field campaign
  - Published SCM and LES intercomparisons
  - Data and intercomparisons available

- **GMTB will:** produce baseline for each case using GFS operational physics suite
- **Researchers will:** be able to quickly run SCM cases and compare their results using novel parameterizations against baseline

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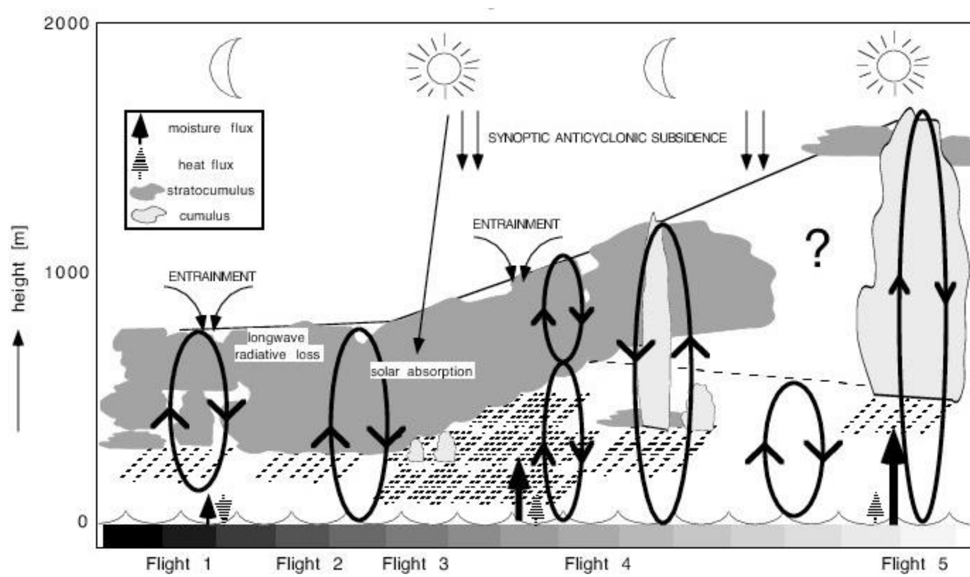
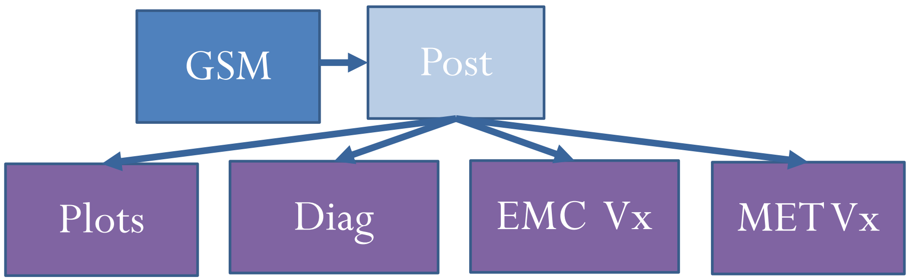
GMTB SCM Initial Case

- **ASTEX Lagrangian** (**A**tlantic **S**tratocumulus to cumulus **T**ransition **Ex**periment)
- Features a precipitating Sc-to-Cu transition (40-h integration from obs)
- Forcings mimic a column being advected from northern Hadley Cell region (stratocumulus) to middle Hadley Cell region (trade-wind cumulus)
- Presents a challenge for SCMs (the transition between regimes is delicate; the timing and details of the PBL decoupling provide important clues about a physics suite's global performance)

This case tests interaction among following scheme types: surface layer, PBL, shallow convection, radiation, and microphysics (deep convection is on, but largely inactive)



Testbed for global model on Theia



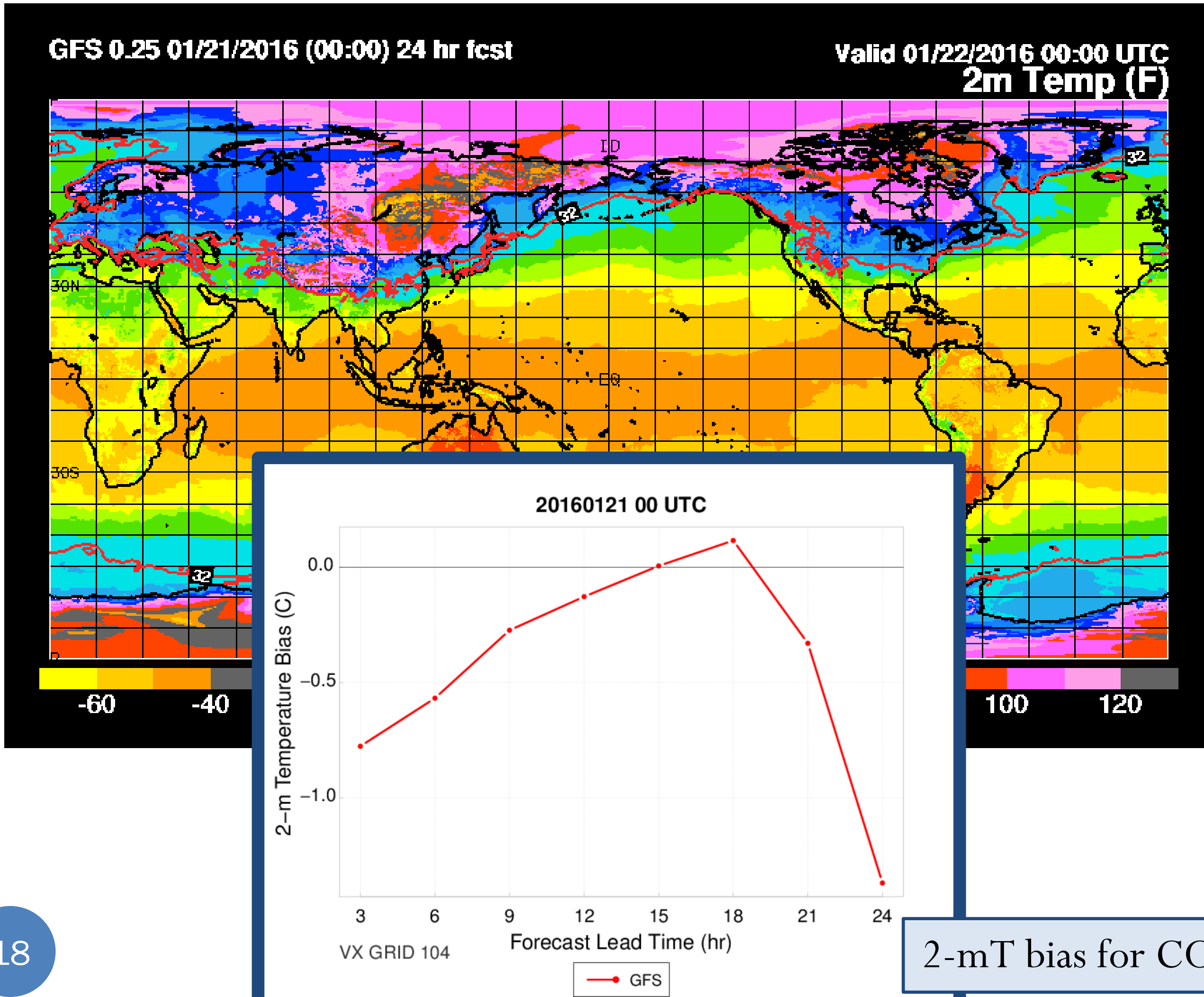
Close collaboration DTC/EMC in setting up scripts/testbed

- Successful ramp up in GMTB staff expertise with GSM
- Issues related to postprocessing being worked out together by EMC/DTC
- Scripts draw libraries, executables and input files from various locations on theia: work ahead in creating a controlled, understandable environment for community

Connection with NGGPS Vx Team

Looking toward unification of NOAA Vx (MET, EMC, GSD/EMB/HIWPP)

Example: GFS 2-m T + MET Vx



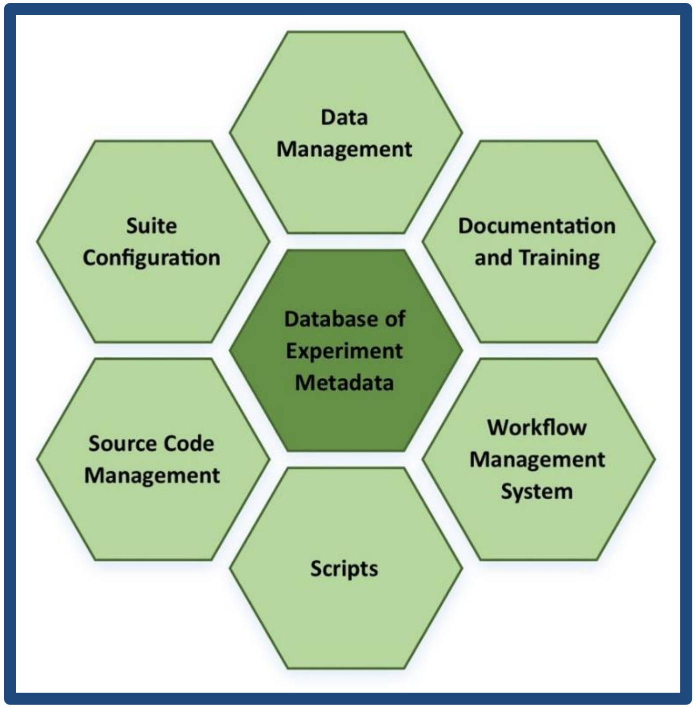
GMTB demo

Operational GFS initialized 20160121_00

Capabilities added to workflow: graphics and verification with MET

2-mT bias for CONUS subdomain (1 case)

A friendlier IT environment for R2O



NWP Information Technology Environment (NITE)

In 2015 DTC prepared a report on elements that would make it more straight forward for community scientists to interact with NCEP modeling suites

- EMC starting to implement aspects of NITE for NGGPS
- GMTB is providing input and will benefit from upgraded environment

Selection of a sea-ice model

Sea Ice Modeling Workshops

- **Committee**
  - J. Intrieri (NOAA, ESRL), M. Holland (NCAR), B. Grumbine (NOAA EMC), C. Bitz (U. Washington), R. Allard (NRL), and A. Mariotti (NOAA OAR/CPO), Eugene Petrescu (NOAA NWS AK)
  - **Participants**: EMC, GMTB, ESRL, NRL, NWS AK, LANL, GFDL, GLERL, UW, E Canada, NPS, ONR, Natl Snow Ice Data Center
- **Date and location**: 2-4 February 2016 at NCAR, Boulder
- **Context**: Back-to-back ONR SeaState and NGGPS sea-ice workshops
- **Goals**: Review state-of-art and lessons from ONR SeaState initiative, candidate models for NGGPS, selection criteria, predictability, performance, skill metrics, testing considerations, R&D needs & opportunities for coordination, recommendations on the selection process

Recommendations to NGGPS

- Recommend possible adoption of CICE due to its extensive use in the community and excellent documentation and resources
- **Justification**
  - Most sea ice models have state-of-the-art physics
  - Instead of investing on intercomparison, test/improve/develop one model
- **Consortium**
  - Intellectual property issues need to be addressed to make CICE a true community model
  - Governance must support NGGPS needs

GMTB Summary

- **Opportunities:** NGGPS offers opportunity to bring the physics community together in a novel way: broad spectrum of expertise focused on a common problem. Given the right framework, group can make fast progress toward improving the NCEP global model

- **Challenge:** Developing a CCPP/Driver package that will effectively facilitate physics advancement and conducting T&E that is relevant to all involved will require close cross-institution coordination (DTC, EMC, physics developers)

Stay tuned for upcoming NGGPS Physics Principal Investigators Workshop Sep 2016