

# Global Model Test Bed

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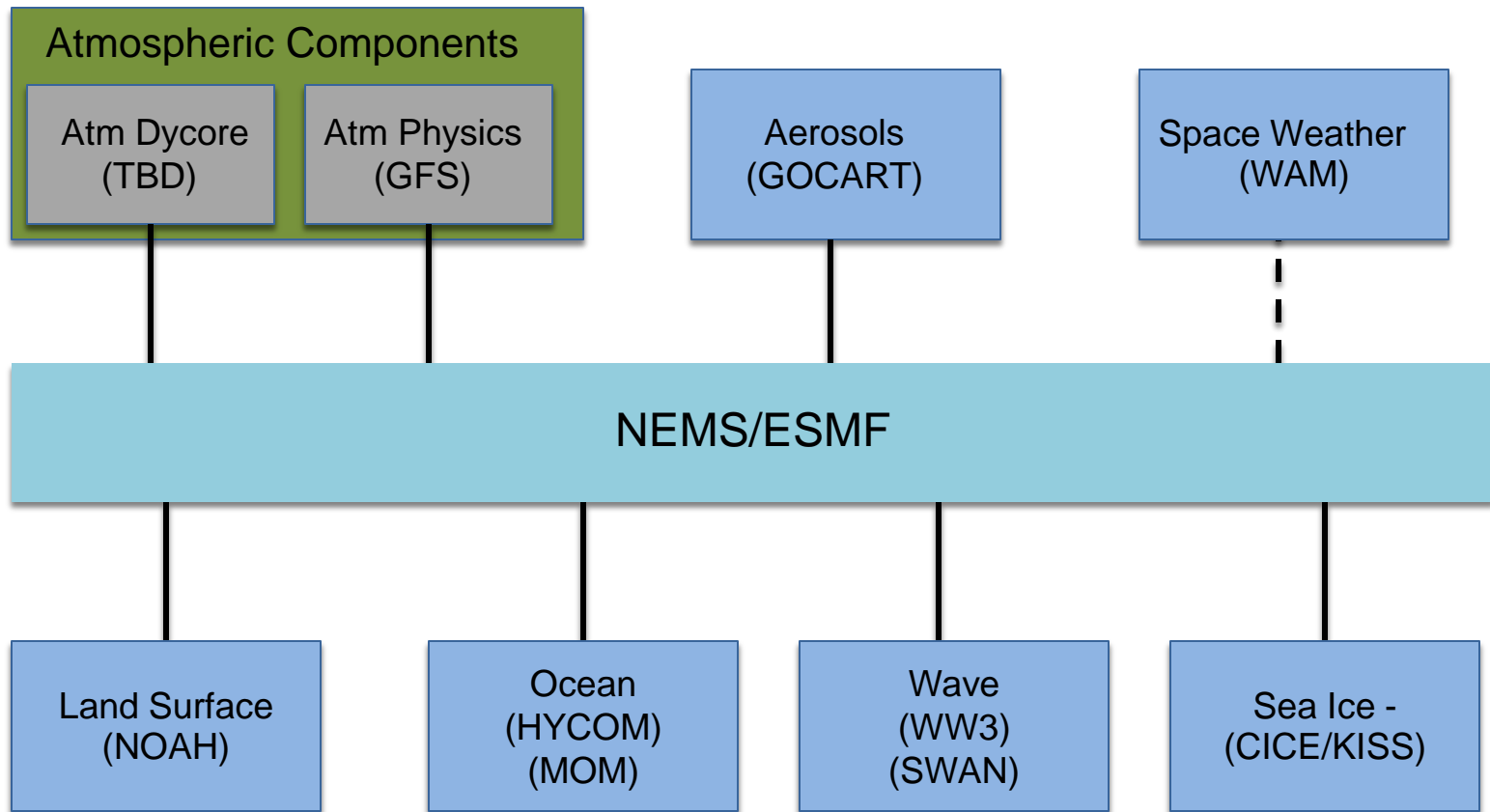


# Next-Generation Global Prediction System (NGGPS)

Goal: A non-hydrostatic, very-high resolution (convection permitting) global model, equipped with advanced data assimilation and physical parameterization.

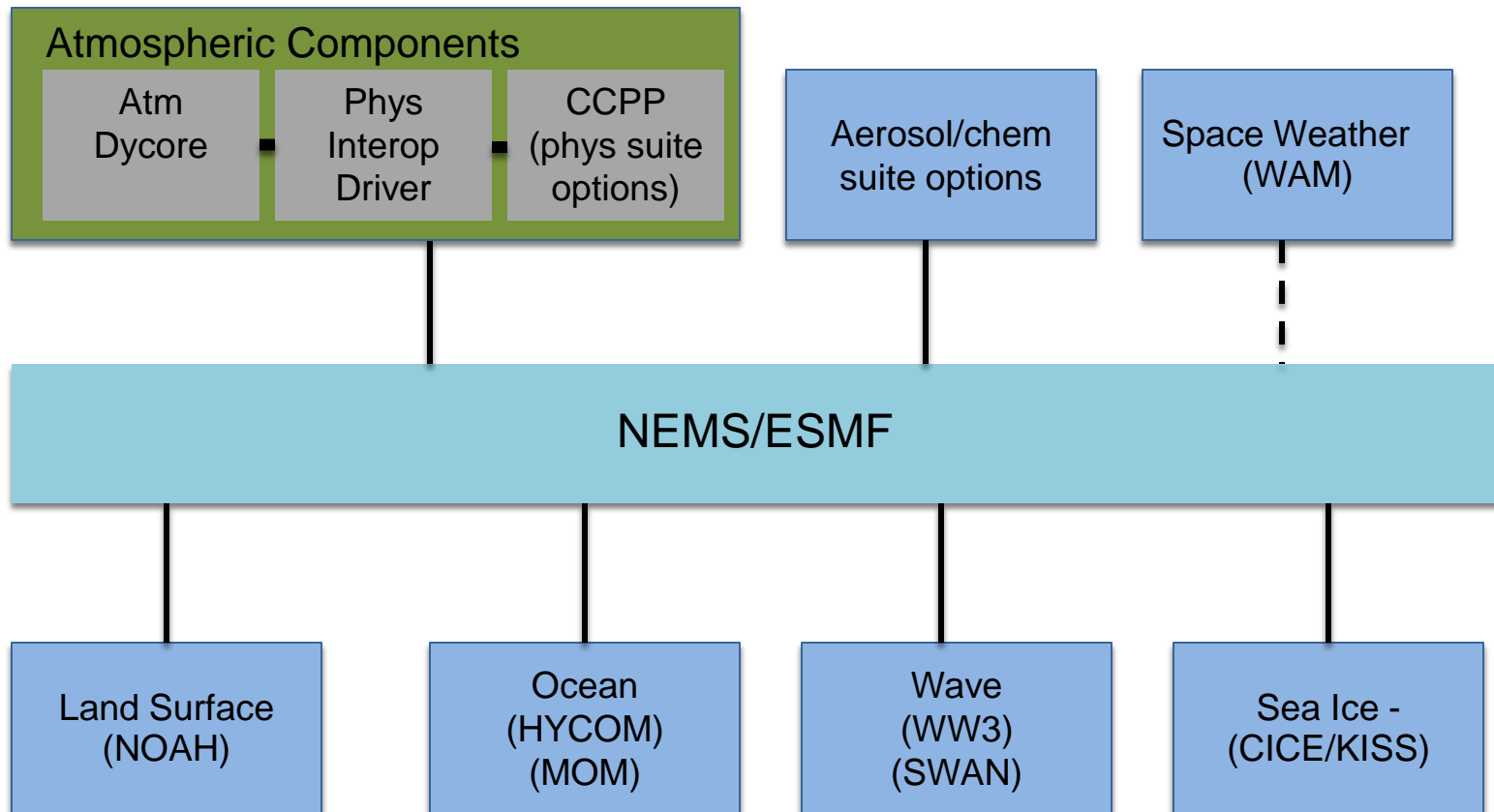
- Provide improved forecasts from a few hours to one month
- A full Earth system model (atmosphere, land, ocean, ice, aerosol, space weather)
- **All codes are expected to be ‘community contributed codes’**
- Project Plan: selection of dynamic core by April 2016
- The development and operation of NGGPS will lead to significant changes in the entire NCEP modeling suite:
  - The function and roles of current regional forecast systems (including hurricane prediction model - HWRF) will need to evolve
  - Provides a basis for “unified modeling framework”
  - UCACN Modeling Advisory Committee (UMAC) will meet in early August to review NCEP production suite

# NGGPS proposed components - original



Courtesy of Fred Toepfer

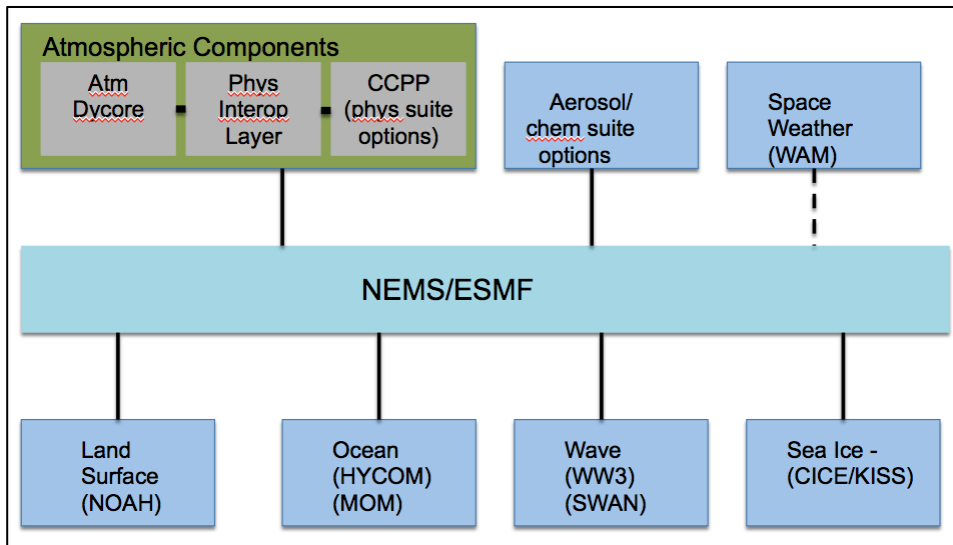
# NGGPS proposed components - modified



# Community codes – 2020 vision

NGGPS system supported to the community through the  
Global Model Test Bed (GMTB)

## Modeling application



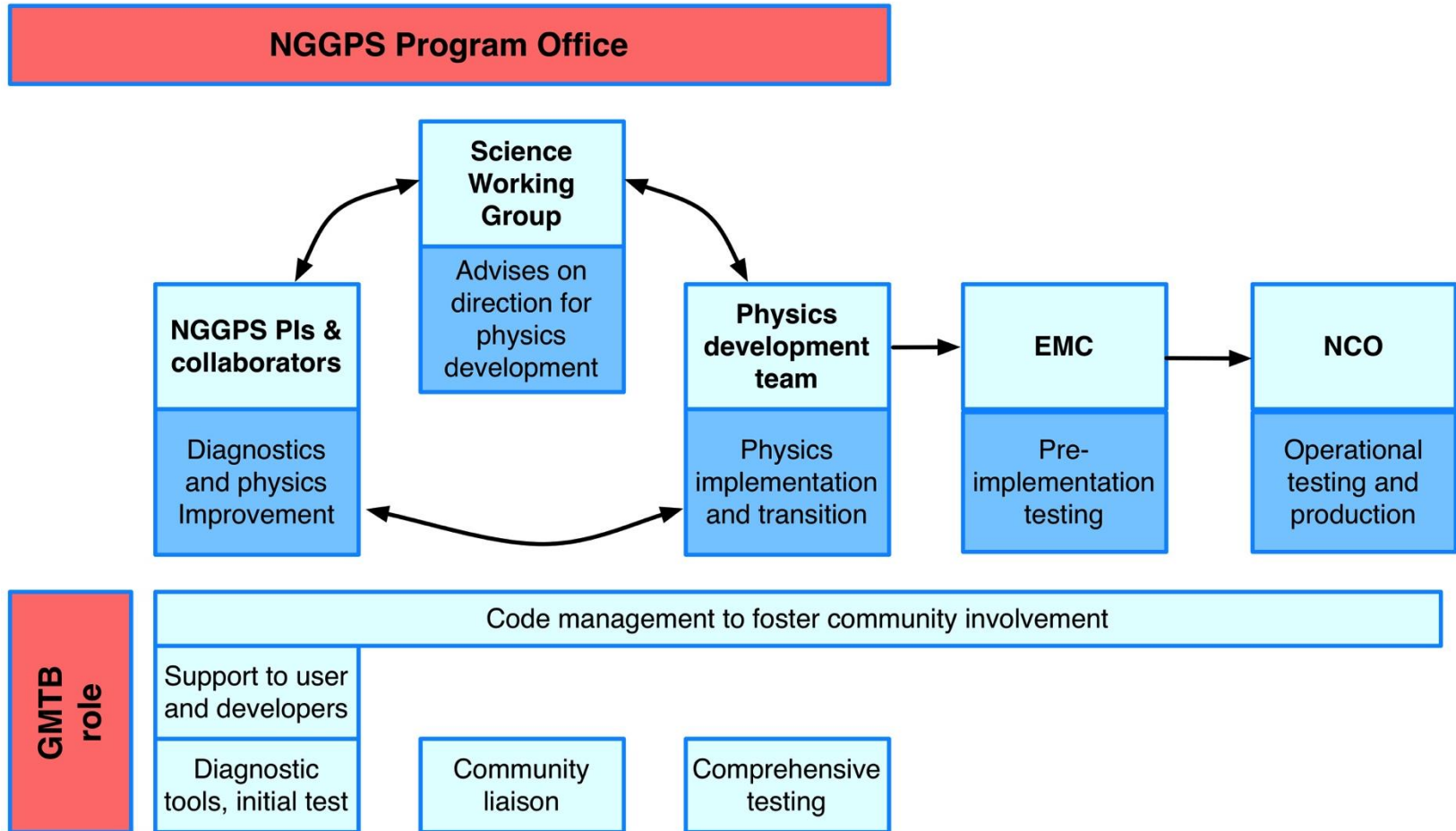
## Additional workflow components

- Pre-processors
- Data assimilation
- Post-processors
- Scripts/Suite control
- Visualization
- Verification

# Global Model Test Bed (GMTB)

- **Purpose:**
  - Enhanced community involvement in ongoing development of operational modeling system
  - Developmental testing of innovations for NGGPS components
- **Focused efforts on:**
  - Code management to foster community involvement
  - Support to NGGPS external developers
  - Support for community use of NGGPS
  - Testing & evaluation of innovations (by developers & DTC)
- Builds off DTC, HIWPP and NGGPS experience with physics and evaluation

# GMTB role in NGGPS Physics



# Initial effort on GMTB

- **Common Community Physics Package**
  - Refactor and modularize GFS physics
  - Support PIs work in diagnostics and testing
- **Interoperable Physics Driver**
  - Allow same physics to be used by different models
  - Support NGGPS level 2 testing
- **Sea ice model**
  - Assist NCEP on the selection of a sea ice model for NGGPS

**Fostering community involvement through user and developer support, code management, and facilitating testing and evaluation**



# Common Community Physics Package

**Transition the latest version of GFS physics into an initial common community physics package**

- **Key Features**
  - Modular individual physics with standardized interfaces
  - Easy access to input and output variables of individual physics scheme
  - Evaluation of conservation properties enabled
- **Development of protocols and coding standards**
  - Standardized exchange of variables across physics schemes
  - On-line and off-line testing and evaluation
- **NGGPS Physics Review Committee** will be established to review and approve changes to the physics package

# ESRL experience with GFS physics

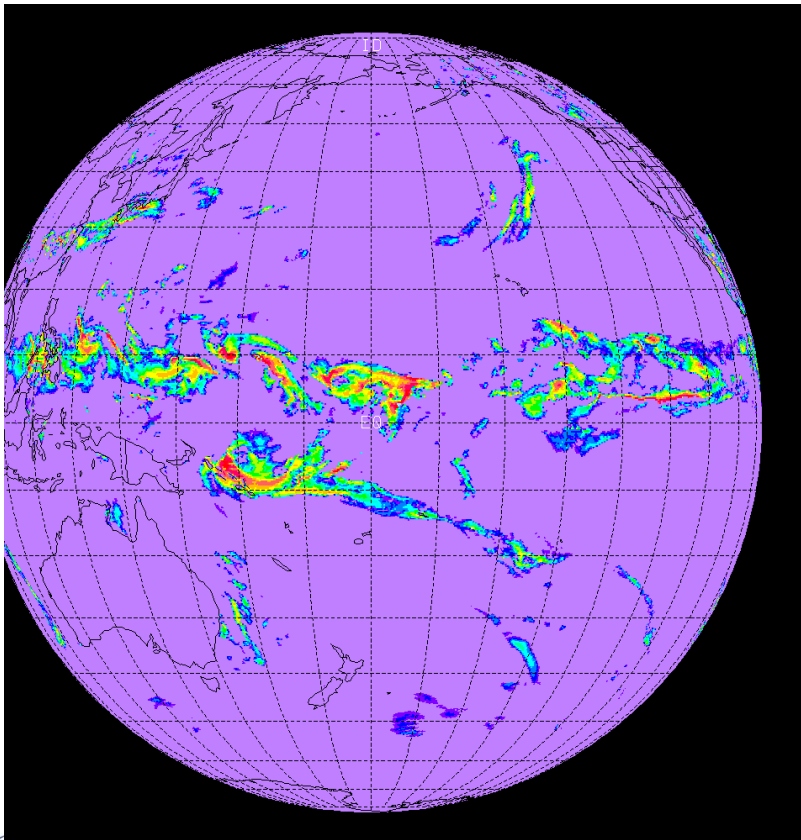
- GFS physics implemented in FIM global model
  - 3 GFS physics versions transitioned to FIM: 2008, 2012 & 2015
  - Challenges
    - Accurate definition of all needed parameters to match GFS performance in FIM
    - Accomplished for all 3 versions but not easily
- GFS physics implemented for non-hydrostatic dynamic cores
  - NIM – 2015 version
  - MPAS – collaboration with NCAR
- ESRL physics (Grell-Freitas cumulus) implemented in GFS model

# NCAR experience with physics

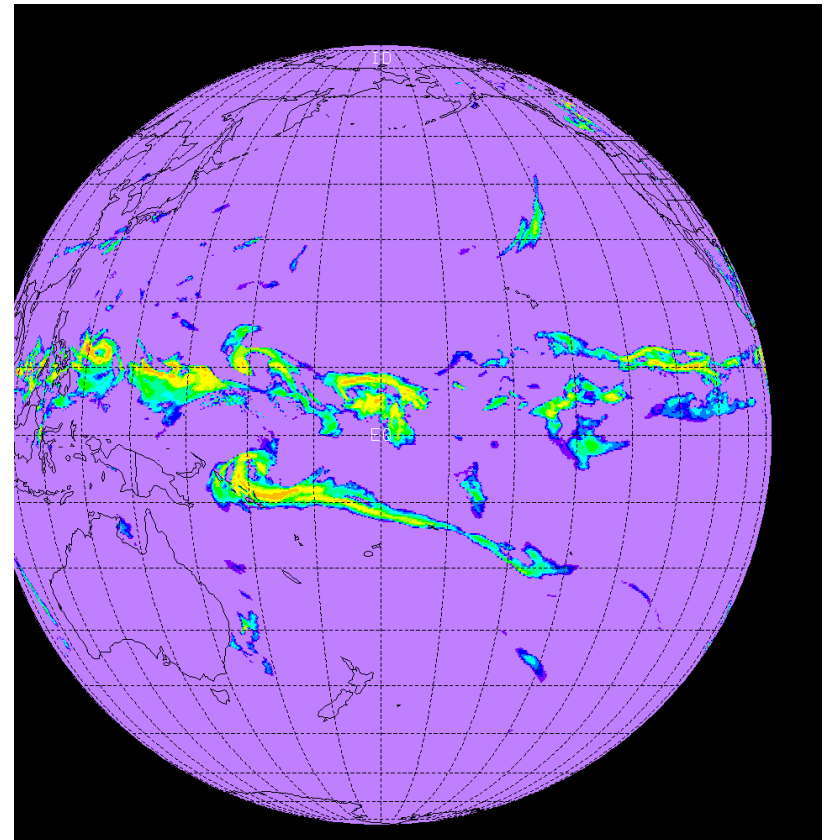
- Implemented ARW and GFS physics in MPAS
- Maintains & supports multiple physical parameterizations packages for WRF/ARW in all areas:
  - Deep convection, shallow convection, microphysics, PBL & radiation
- Collaborates with physics developers on testing & evaluation of physical parameterizations
  - Regression testing for code maintenance
  - Testing & evaluation of physics in simplified framework or full models, in combination with data assimilation
- Significant scientific expertise in physical parameterizations for weather & climate simulations

# Example of GFS physics testing in FIM

SAS



Grell-Freitas



# GMTB physics testing and evaluation

- **Goal**

- Provide a uniform test harness, in close collaboration with EMC, to support the testing & evaluation to be conducted by physical parameterization scientific working group (SWG)

- **Infrastructure**

- Source codes, scripts, diagnostic tools, offline parameterization capabilities (such as single-column model)
- Datasets for initialization and verification for selected cases that are important to operations
- Following the model of the DTC's Mesoscale Model Evaluation Testbed (MMET)

# Mesoscale Model Evaluation Testbed (MMET)

## Motivation

- Assist the research community in efficiently testing and demonstrating merits of new developments
- Provide a common framework for testing; allow for direct comparisons

## What is provided

- Inputs to run models
- Observational datasets for DA & VX
- Model codes, scripts, documentation
- Baselines to benchmark against

**Where:** Hosted by the DTC

http://www.dtcenter.org/eval/meso\_mod/mmet/index.php

NOAA | ESRL | GSD | NCAR | RAL

DTC home | Reference Configurations | Testing & Evaluation | Community Codes | Verification | Visitor Program | Events

### Mesoscale Model Evaluation Testbed | DTC

DTC Home • Testing and Evaluation • Mesoscale Modeling • Mesoscale Model Evaluation Testbed

#### Overview

In order to assist the research community with conducting detailed case study testing of newly developed techniques, the DTC has established and is maintaining the **Mesoscale Model Evaluation Testbed (MMET)**. The motivation of MMET is to assist the research community in efficiently demonstrating the merits of a new development that could positively impact an operational configuration in the future.

**28 April - 4 May 2012 - The first and third rainiest days ever recorded in Nashville took place back-to-back during this flood event**

MMET provides a variety of initialization and observation data sets for a number of routine, high-impact and field campaign cases. Baseline results for select operational configurations are also produced by the DTC in a functionally similar environment to operations and made available through MMET. Through the common framework provided by MMET, researchers have the ability to perform direct comparisons between multiple innovations tested by the research community and/or against the baseline operational configurations established by the DTC.

MMET has also been established to support the broader goal of streamlining the path to potential operational use for promising new science innovations developed in the research community. The [testing protocol document](#) details a three stage process of testing conducted by the research community, DTC and, ultimately, operational centers. It is believed that, with better coordination among the NWP community as a whole, major benefits towards improving modal physics can be realized, resulting in more accurate and reliable operational NWP forecasts.

#### Related Information

- R20 Testing Protocol Document (pdf)
- Nominate community innovations for Stage II testing and evaluation
- Submit recommendations for additional cases to be included in MMET
- Physics Workshop - initial concept definition
- Agenda and Presentations
- BAMS Meeting Summary (pdf)
- Contact Us

#### Publications

- 94th Annual AMS Meeting (Atlanta, GA January 2014)  
Expansion and Enhancement of the Mesoscale Model Evaluation Testbed (MMET)  
Poster
- 14th Annual WRF Users' Workshop (Boulder, CO June 2013)  
Demonstrating the utility of the Mesoscale Model Evaluation Testbed (MMET) in a research environment  
Poster
- Special Symposium on Advancing Weather and Climate Forecasts: Innovative Techniques and Applications (Austin, TX January 2013)  
Utilizing the Mesoscale Model Evaluation Testbed (MMET) to Transition Promising New Research Techniques from Research to Operations.  
Presentation
- 13th Annual WRF Users' Workshop (Boulder, CO June 2012)  
Transitioning Promising New Mesoscale Innovations from Research to Operations: Defining a Process to Bridge the "Valley of Death."  
Poster
- Joint 30th CMOS - AMS 21st NWP/25th WAF Conference (Montreal, Quebec May 2012).  
Bridging the valley of death: Defining a process for transitioning promising new mesoscale innovations from research to operations.  
Presentation

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# MMET Case Inventory

| Date(s)       | Meteorological Scenario                                                             |
|---------------|-------------------------------------------------------------------------------------|
| 20090228      | Mid-Atlantic <i>snow storm</i> -NAM high QPF shifted too far north                  |
| 20090311      | <i>High dewpoint</i> predictions by NAM over upper Midwest and over snow            |
| 20091007      | <i>HIRESW</i> runs <i>underperformed</i> compared to coarser NAM model              |
| 20091217      | “ <i>Snowpocalypse ‘09</i> ”                                                        |
| 20100428-0504 | Historic Tennessee <i>flooding</i> associated w/ an atmospheric river               |
| 20110404      | Record breaking <i>severe</i> report day                                            |
| 20110518-26   | Extended <i>severe weather</i> outbreak over Midwest and eastern states             |
| 20111128      | <i>Cutoff low</i> over SW US                                                        |
| 20120203-05   | <i>Snow storm</i> over Colorado, Nebraska, etc.                                     |
| 20120628      | <i>Derecho</i> that began in Iowa & traveled eastward through Mid-Atlantic states   |
| 20130729      | <i>Mesoscale convective system</i> (MCS) over SE Kansas                             |
| 20130908-14   | Historic Colorado <i>flooding</i> associated w/ long duration & warm rain processes |
| 20140105      | <i>Arctic air outbreak</i> impacting much of the United States east of the Rockies  |
| 20110214-17   | <i>Atmospheric river</i> impacting the West Coast                                   |

# Testing & evaluation of innovations

- GMTB will perform independent testing & evaluation
- Targets for operational implementation
  - Promising upgrades to existing physics schemes
  - New physics schemes/suites to assess its potential
- Tests will be conducted in close collaboration with
  - Developers and subject matter experts
  - EMC and NGGPS program office
  - Connection with forecasters can also be explored

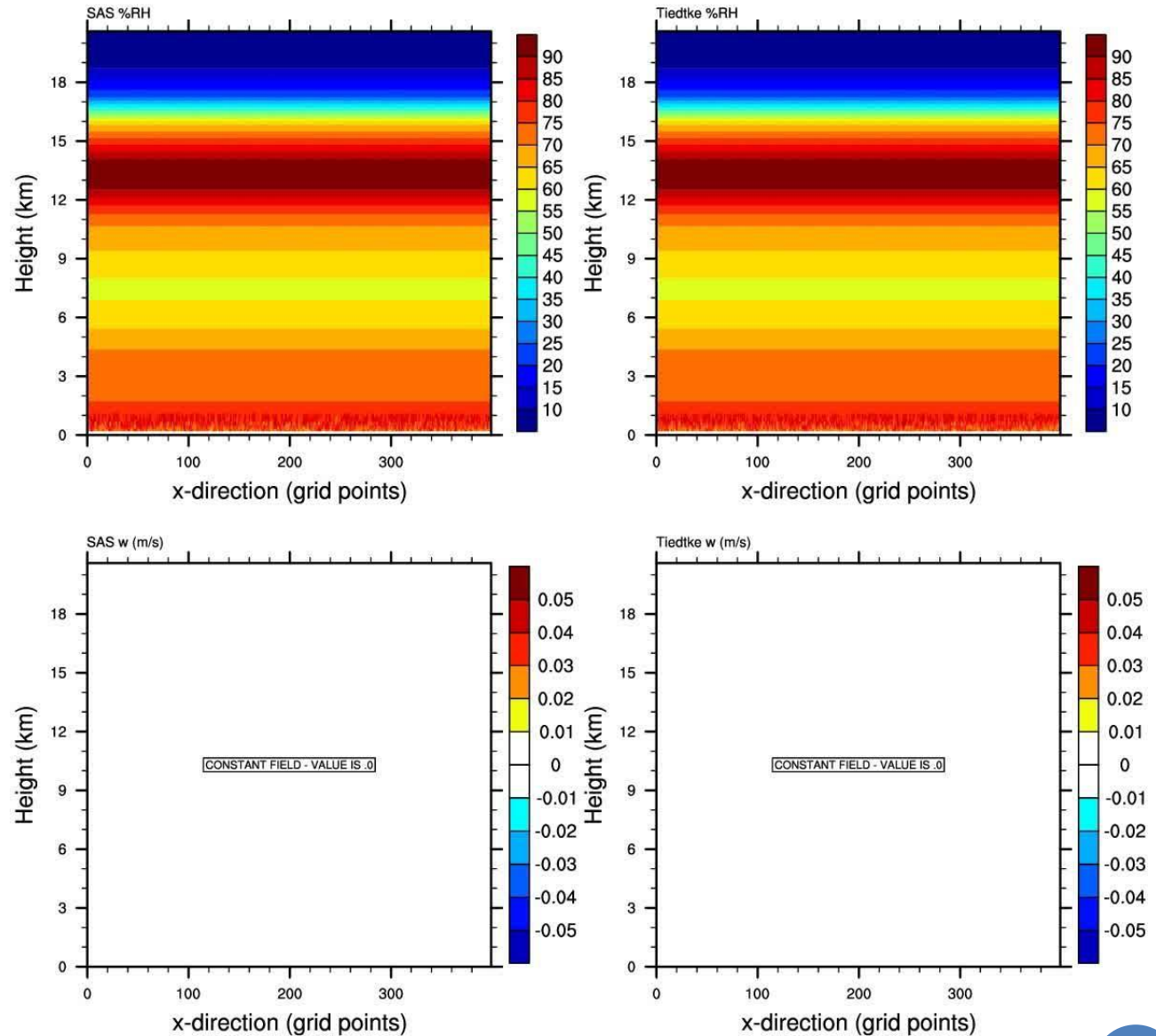
**GMTB will leverage experience with Model Evaluation Tools (MET) and HIWPP**



## 2-D WRF-ARW Idealized %RH and w at 0 hours

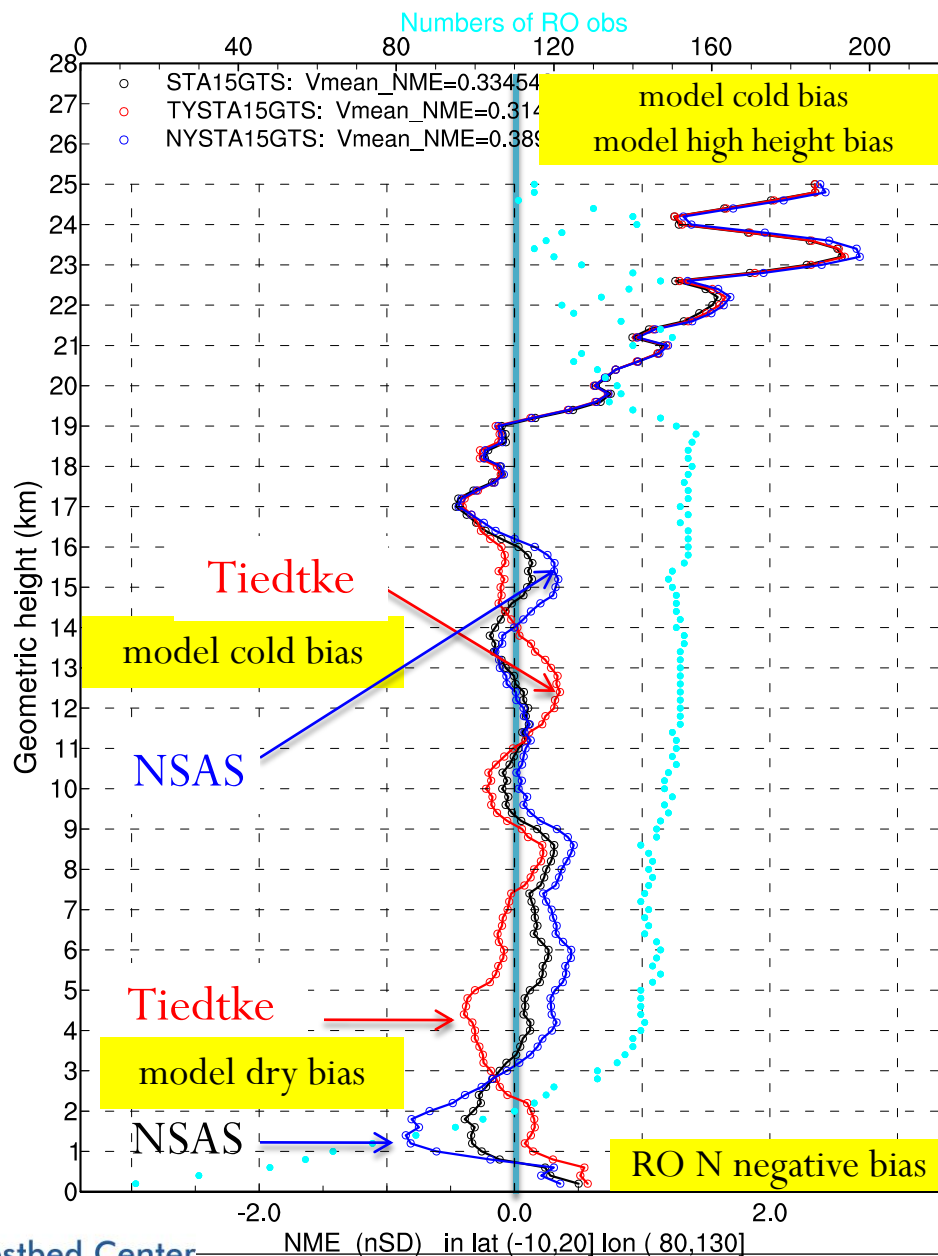
Mid-levels  
begin drying  
by 6 hr into  
simulation

Is NSAS deep  
convection  
too active?

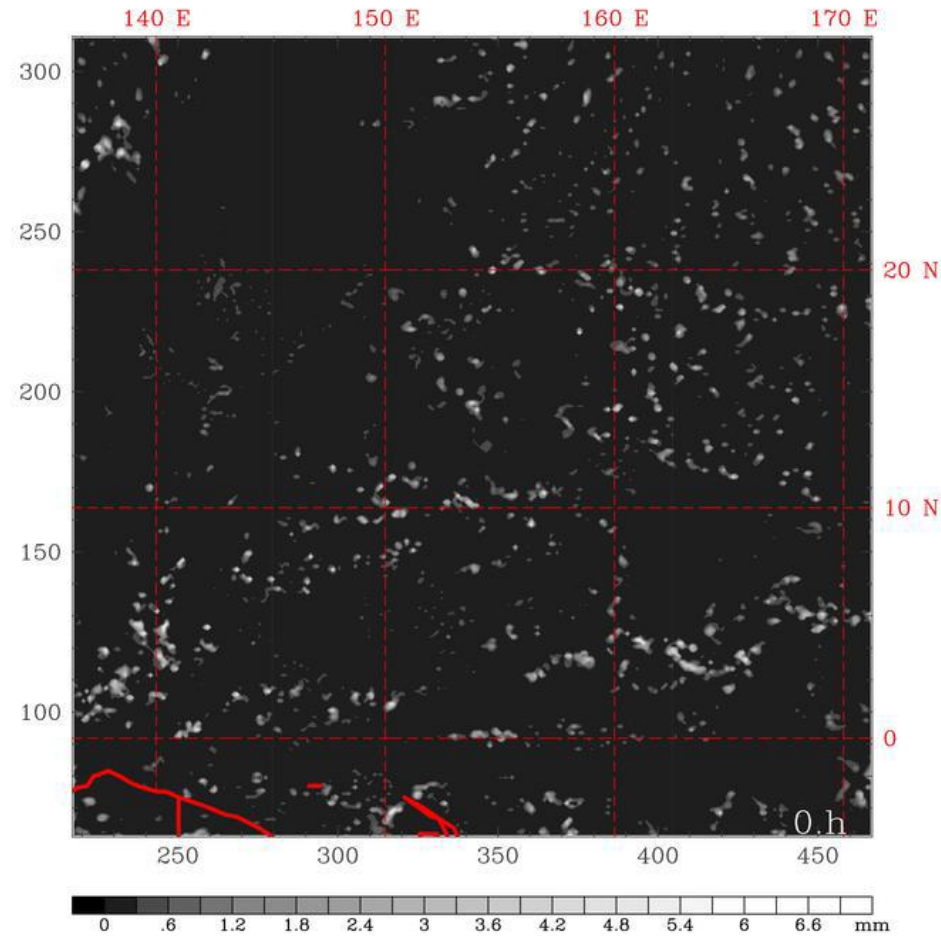
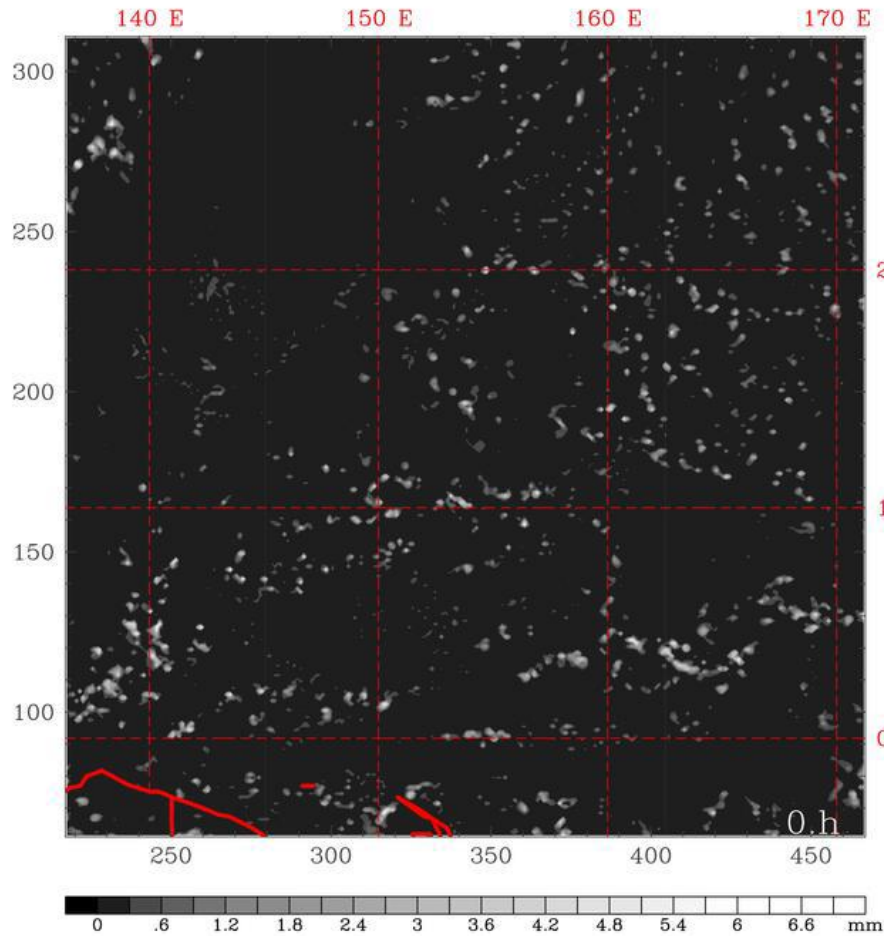


# GPS RO N (refractivity) for model error diagnostics

Normalized ME (F-O/SD)



# Impact of Convective Scheme on Tropical Cyclone Formation



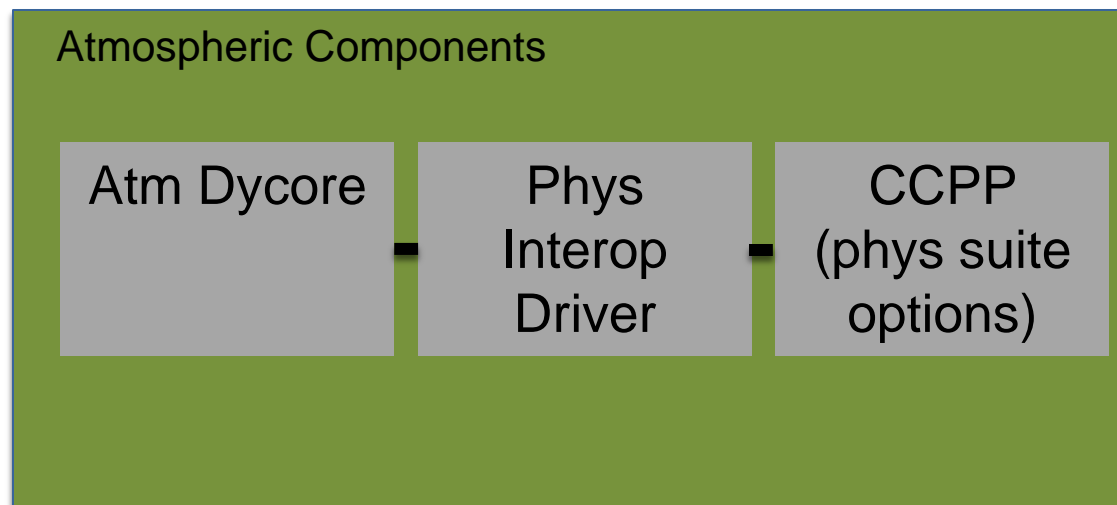
**NSAS scheme**

**Kain-Fritsch scheme**

WRF/ARW, 15 km, Initial condition and other physical parameterization are identical

# Interoperable Physics Driver

- Needed for model inter-comparisons and NGGPS Level 2 test
- Version 1 released by EMC (working w/ NUOPC Physics Interoperability group to use updated Kalnay et al. rules)
- GMTB's role
  - Assist dycore test participants & community with using driver



# Possible Testing Environment for Physics

- Ideas for Physics Working Group to consider (not a DTC decision on this suite idea)
  - **Focus around 2-3 physics suites to integrate development between scientists regarding physics interaction.** (Might be at least weekly)
  - All physics developers would need to affiliate with at least 1 physics suite development team.
  - Consider land-surface model(s) as another component of physics suite(s). Aerosol fields/modeling are another component of physics suite(s).



# Possible Testing Environment for Physics

- **Test level hierarchy to be provided (by DTC) – all global tests. Repeated comparisons with observations/cases and verification over time periods to inform development.**

## Hydrostatic scale

1. Individual cases – Does mod produce desired result even at this level?
2. Short period (~1 week) – GFS analysis IC – out to 7-10 days, no cycling  
(Note: DTC would provide agile verification using combination of scores – 500 AC, upper-air (raobs/grids), precip, cloud, surface, etc. Should be applied for test levels 2-5. Test suite to be coordinated with NCEP.)
3. Longer period (12 months, every 1-3 days) – GFS analysis IC, no cycling
4. AMIP runs out to 6-9 months – CFS analyses. (metrics: cloud, precip, 2m temp, MJO, blocking, etc. – follow CPC/EMC recommendations)
5. Full data assimilation/model forecast cycling.

## Non-hydrostatic scale

1. Initial 12-24h test, compare with observations, TCs, HRRR over CONUS, etc.

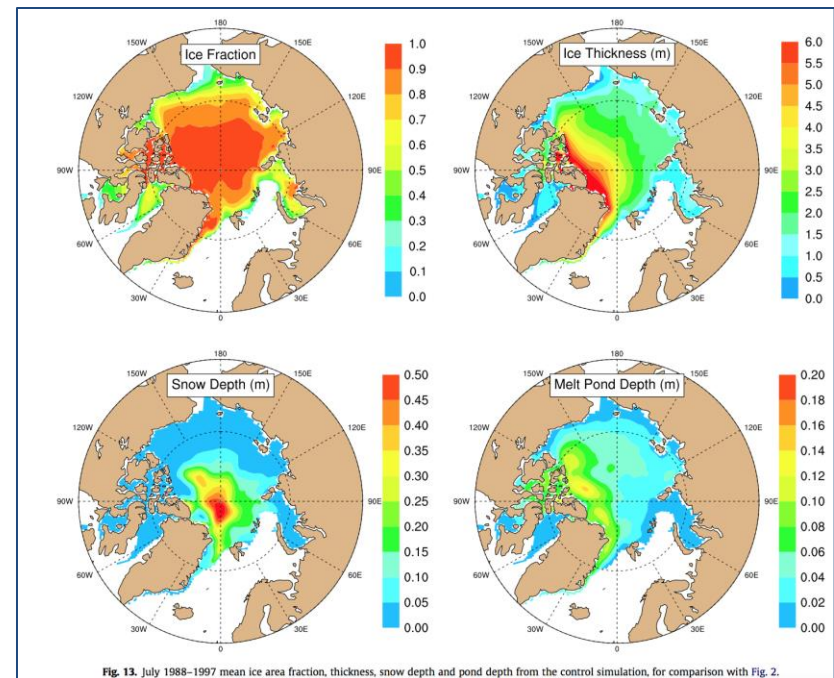




# Sea-Ice Modeling

Assist NCEP w/ the selection of a sea-ice model for NGGPS

- Develop criteria for the selection of sea-ice model
  - Community code? Level of sophistication required?
  - Joint work with EMC, NGGPS & community
- Work w/ candidate sea-ice modeling groups to perform benchmark testing & collect test results
- Convene a community Sea-Ice Modeling Workshop to review benchmark testing results
- Develop a recommendation on sea ice model baseline



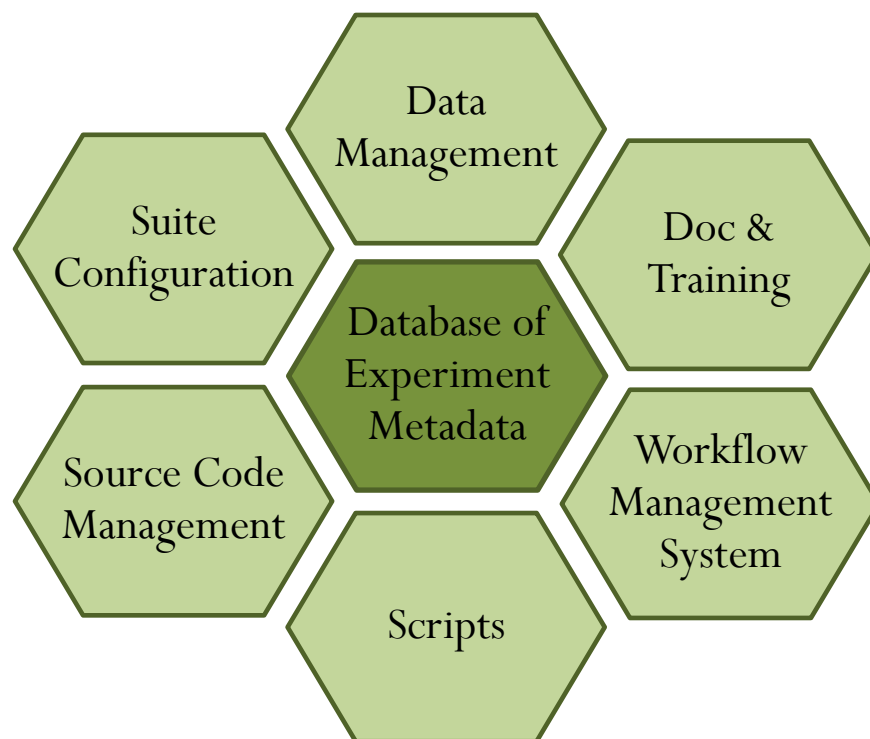
CICE example from Hunke et al. (2013)

# Community Models in DTC

- Extensive experience in supporting NCEP models to community
- Community-accessible code repositories and support for non-NOAA developers

**NITE – a preliminary design to address software infrastructure for NCEP models**

**DTC also participating in NGGPS Software Architecture and Engineering Team (SAET)**





# Codes Supported by DTC

| Software                          | Type                                                    | Developers          | Repository                | DTC's role                                                                                                                                                              |
|-----------------------------------|---------------------------------------------------------|---------------------|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>WRF</b>                        | mesoscale model                                         | NCAR, GSD           | NCAR                      | Assist w/ rep maintenance & community contributions                                                                                                                     |
| <b>UPP</b>                        | post-processor                                          | EMC                 | EMC Community             | Maintain community repository (sync & portability)<br>Community support                                                                                                 |
| <b>NMMB</b><br><i>New in 2015</i> | mesoscale model                                         | EMC                 | EMC<br>DTC                | Portability & friendly user releases<br>Assist w/ community contributions                                                                                               |
| <b>GSI</b>                        | Close collaboration with EMC critical to these efforts! |                     |                           |                                                                                                                                                                         |
| <b>EnKF</b><br><i>New in 2015</i> | ensemble – GSI-hybrid                                   | EMC, GSD            | EMC                       | Working w/ dev to build code mgmt framework<br>Documentation                                                                                                            |
| <b>HWRP</b>                       | tropical cyclone                                        | EMC, HRD, URI, GFDL | Community (10 components) | Chair HWRP Developers Committee<br>Transition ops capability to component repositories<br>Repository maintenance<br>Support for system run scripts<br>Community support |
| <b>MET</b>                        | verification                                            | NCAR                | NCAR                      | Maintain repository and advance capability<br>Community support                                                                                                         |

# Planned GMTB Workshops – Year 1

- Building on past experience with DTC co-sponsored workshops, DTC will organize two workshops in support of the NGGPS Program
  - **Sea-ice Model Workshop**
    - Objective: Bring together community to determine best path forward for NGGPS baseline sea-ice model
  - **NGGPS Physics PI Workshop**
    - Objectives: Bring together researchers funded by NGGPS to work on physics parameterization improvements to
      - Establish buy-in to the code management plan
      - Establish working relationship with these developers
    - HWRF experience: Critical to establish these relationships early in the development process!

# Workshop on Parameterization of Moist Processes for Next-Generation NWP Models

**Goal:** Inform & advise the future directions of moist process parameterization development, w/ emphasis on NWP applications for scales & resolutions ranging from synoptic-scale to convective permitting scale



Organizing committee: Jamie Wolff (DTC), Yu-Tai Hou (EMC), Jim Doyle (NRL), Robert Pincus (CIRES)

27-29 January 2015 @ NCWCP, College Park, MD

80+ scientists from leading centers around the world

In-depth discussions on state-of-the-science and current operational status at NCEP for microphysics, sub-grid scale clouds and turbulence, and deep convection

