Global Model Test Bed

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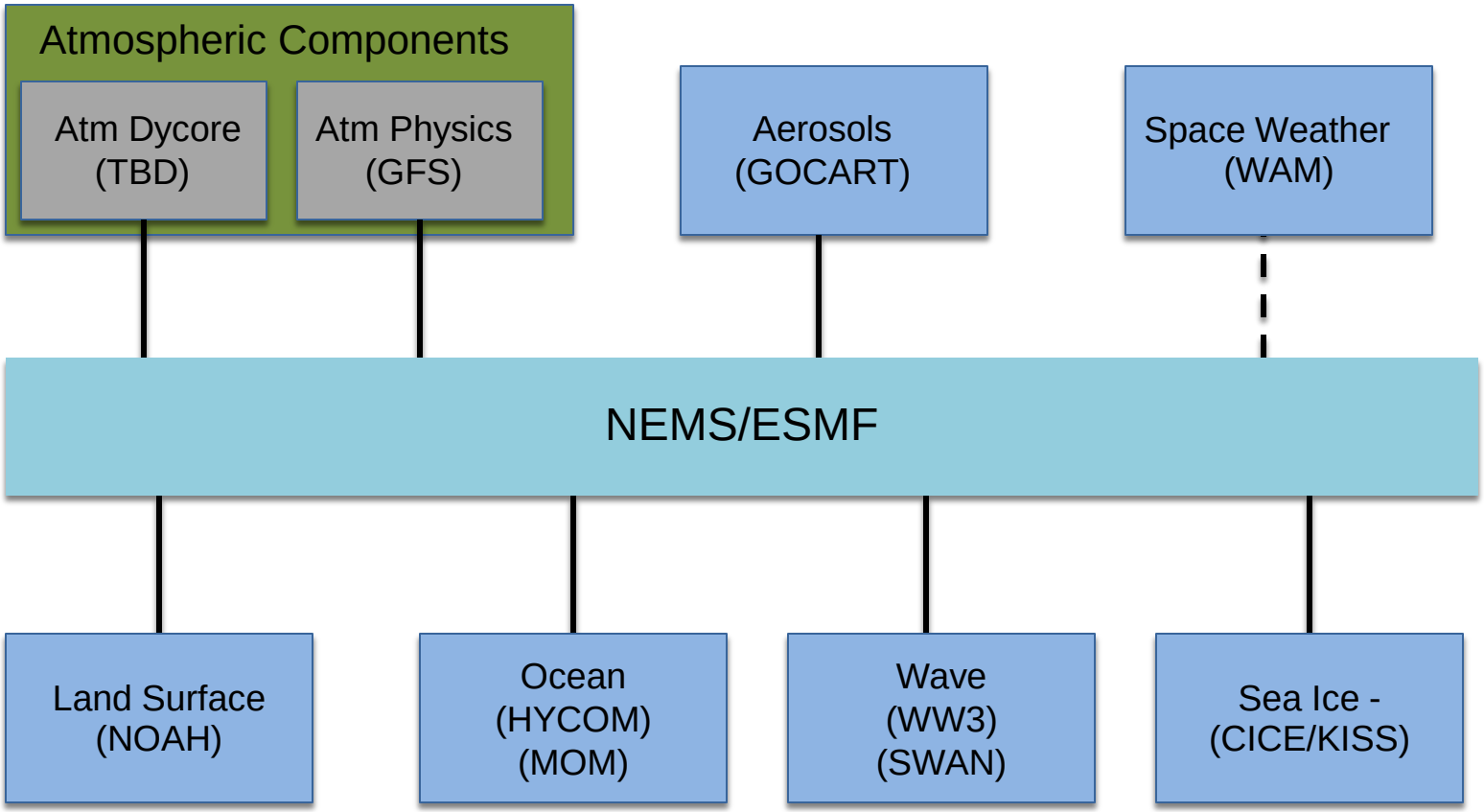
Next-Generation Global Prediction System (NGGPS)

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

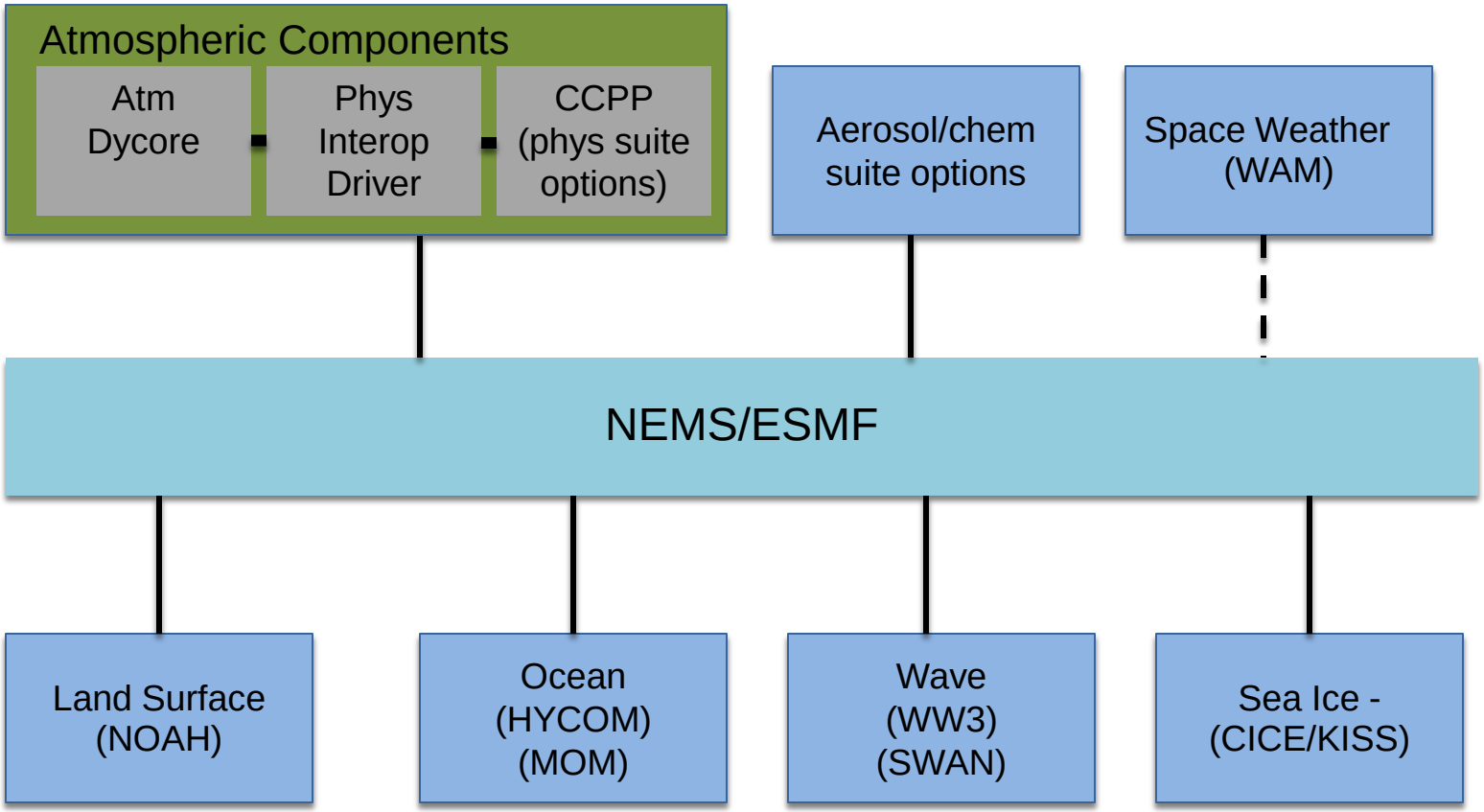
- Provide improved forecasts from a few hours to one month
- A full Earth system model (atmosphere, land, ocean, ice, aerosol, space weather)
- **All codes are expected to be 'community contributed codes'**
- Project Plan: selection of dynamic core by April 2016
- The development and operation of NGGPS 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

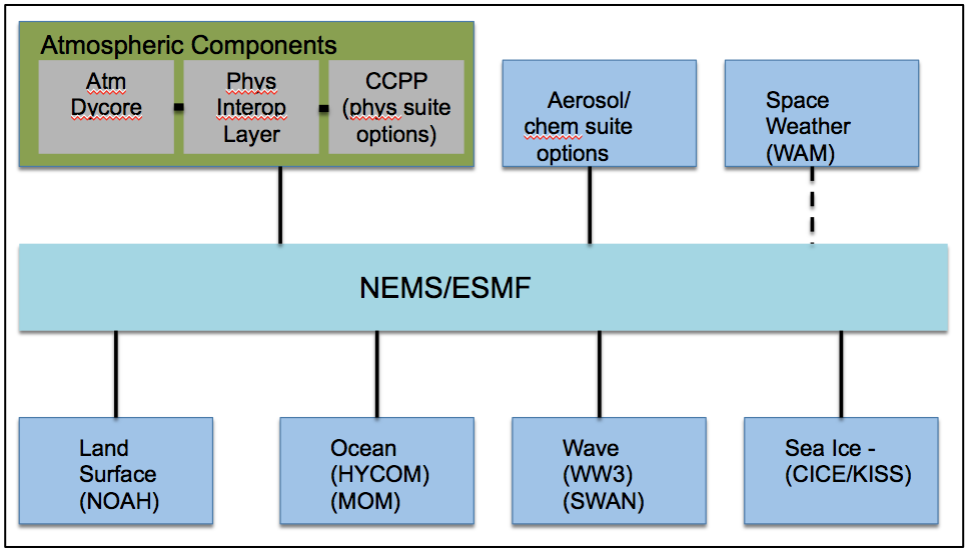
NGGPS proposed components - modified



Community codes – 2020 vision

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

Modeling application



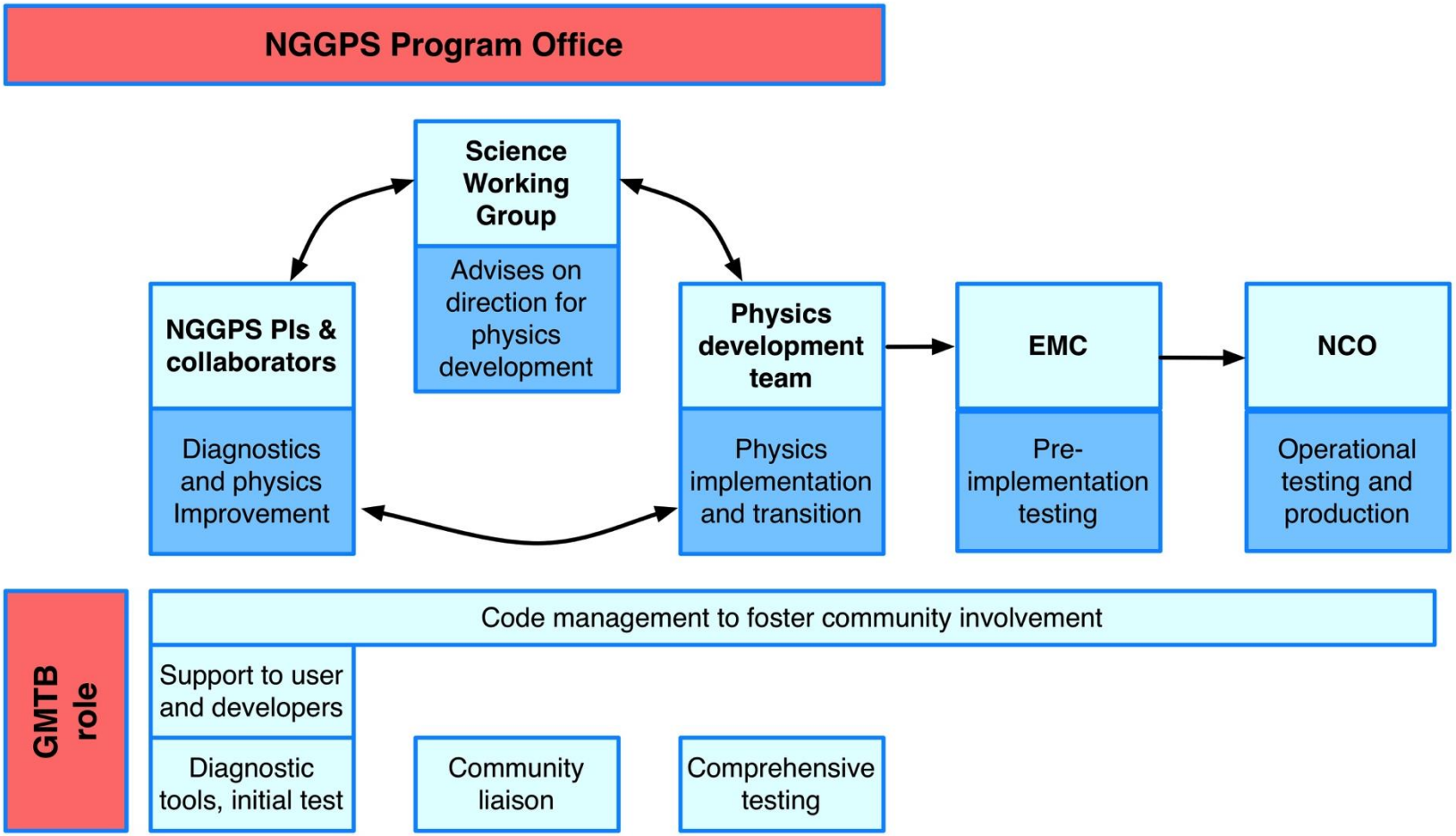
Additional workflow components

- 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

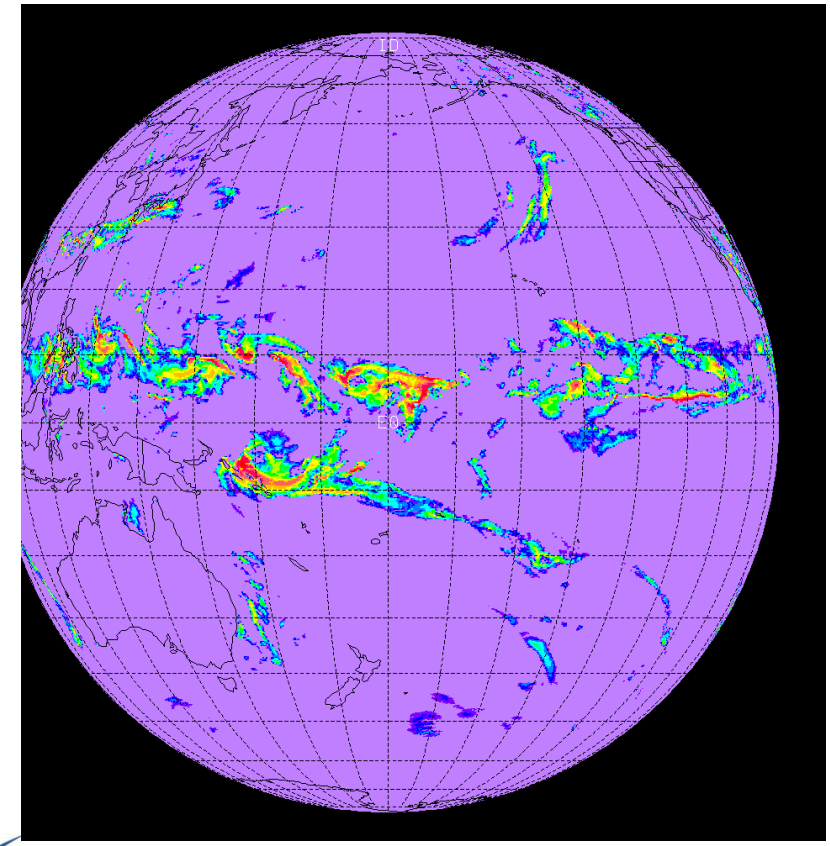
- GFS physics implemented in FIM global model
  - 3 GFS physics versions transitioned to FIM: 2008, 2012 & 2015
  - Challenges
    - Accurate definition of all needed parameters to match GFS performance in FIM
    - Accomplished for all 3 versions but not easily
- GFS physics implemented for non-hydrostatic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

NCAR experience with physics

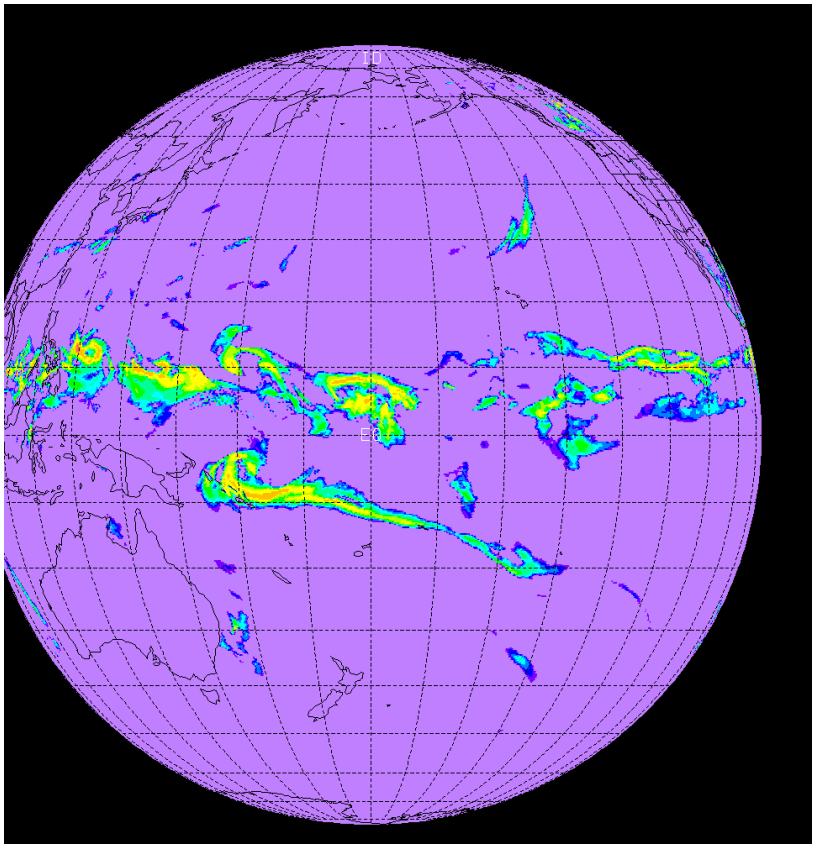
- Implemented ARW and GFS physics in MPAS
- Maintains & supports multiple physical parameterizations packages for WRF/ARW in all areas:
  - Deep convection, shallow convection, microphysics, PBL & radiation
- Collaborates with physics developers on testing & evaluation of physical parameterizations
  - 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)

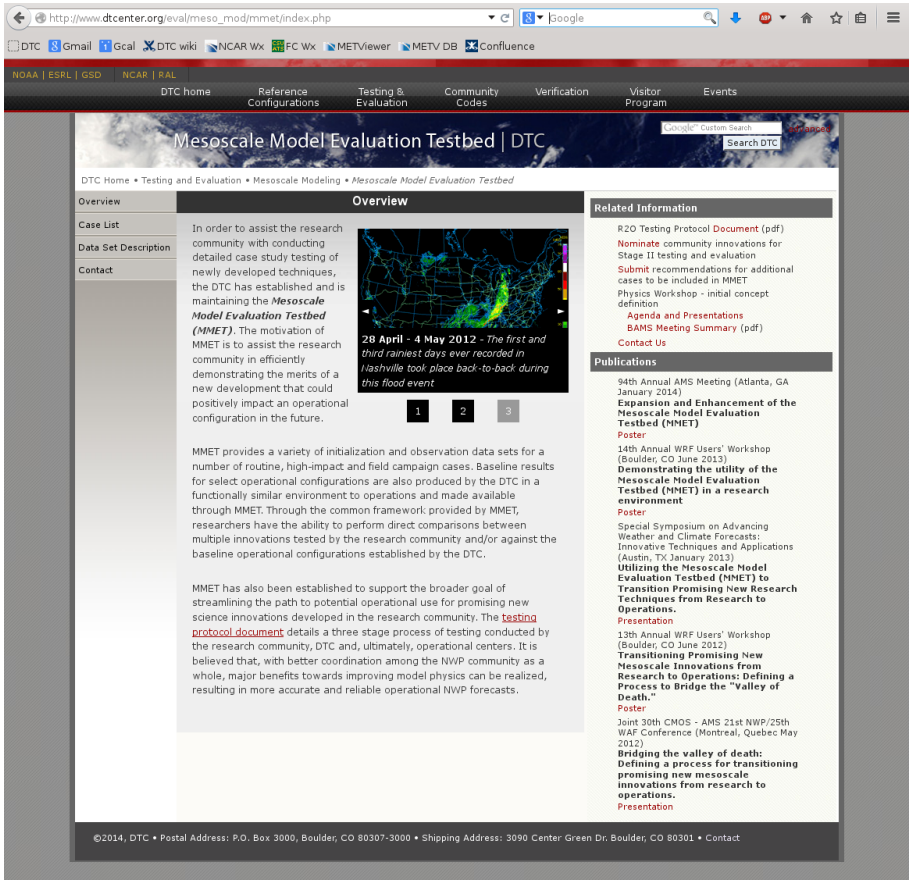
Motivation

- 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

MMET Case Inventory

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

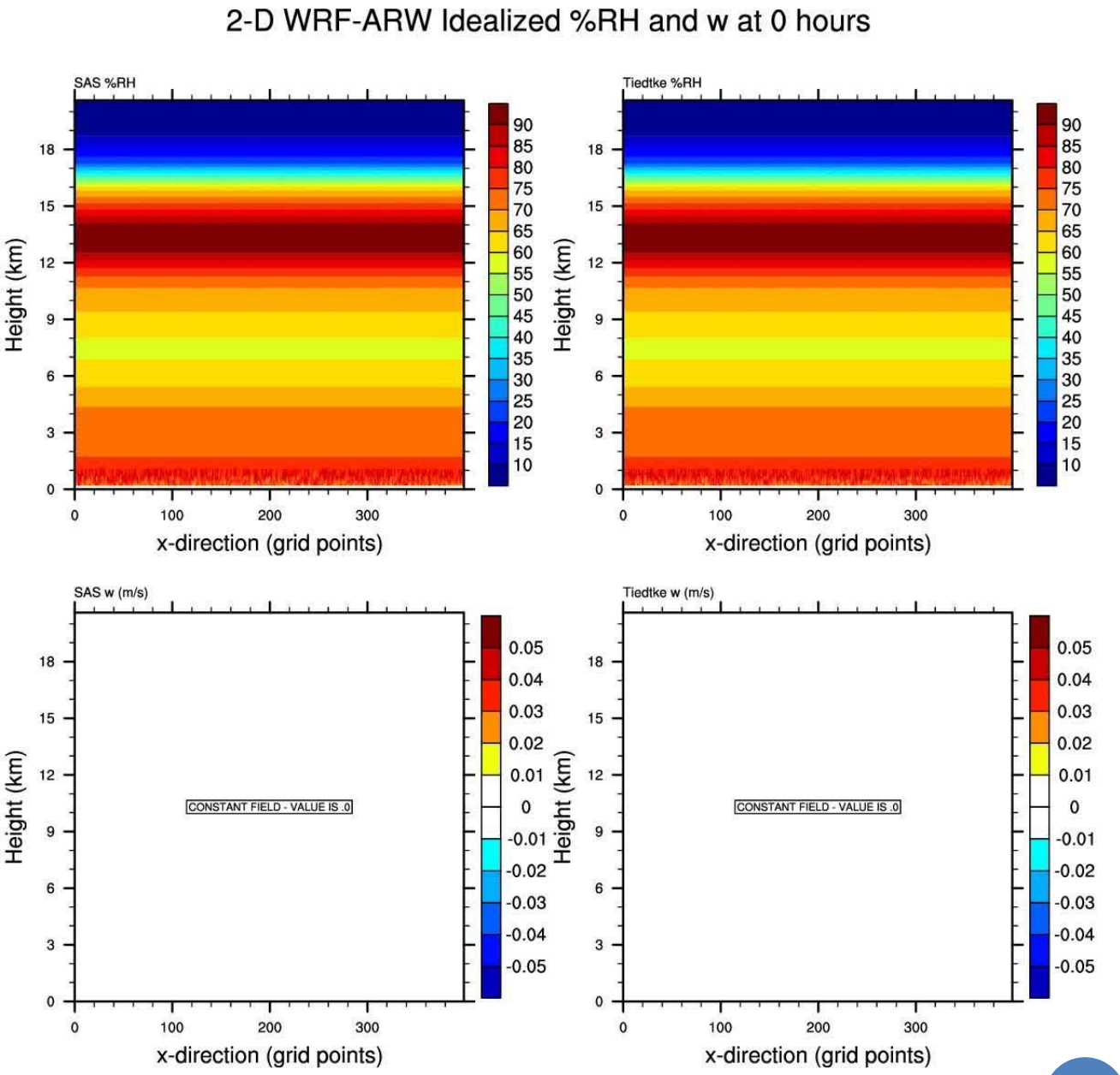
Testing & evaluation of innovations

- 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

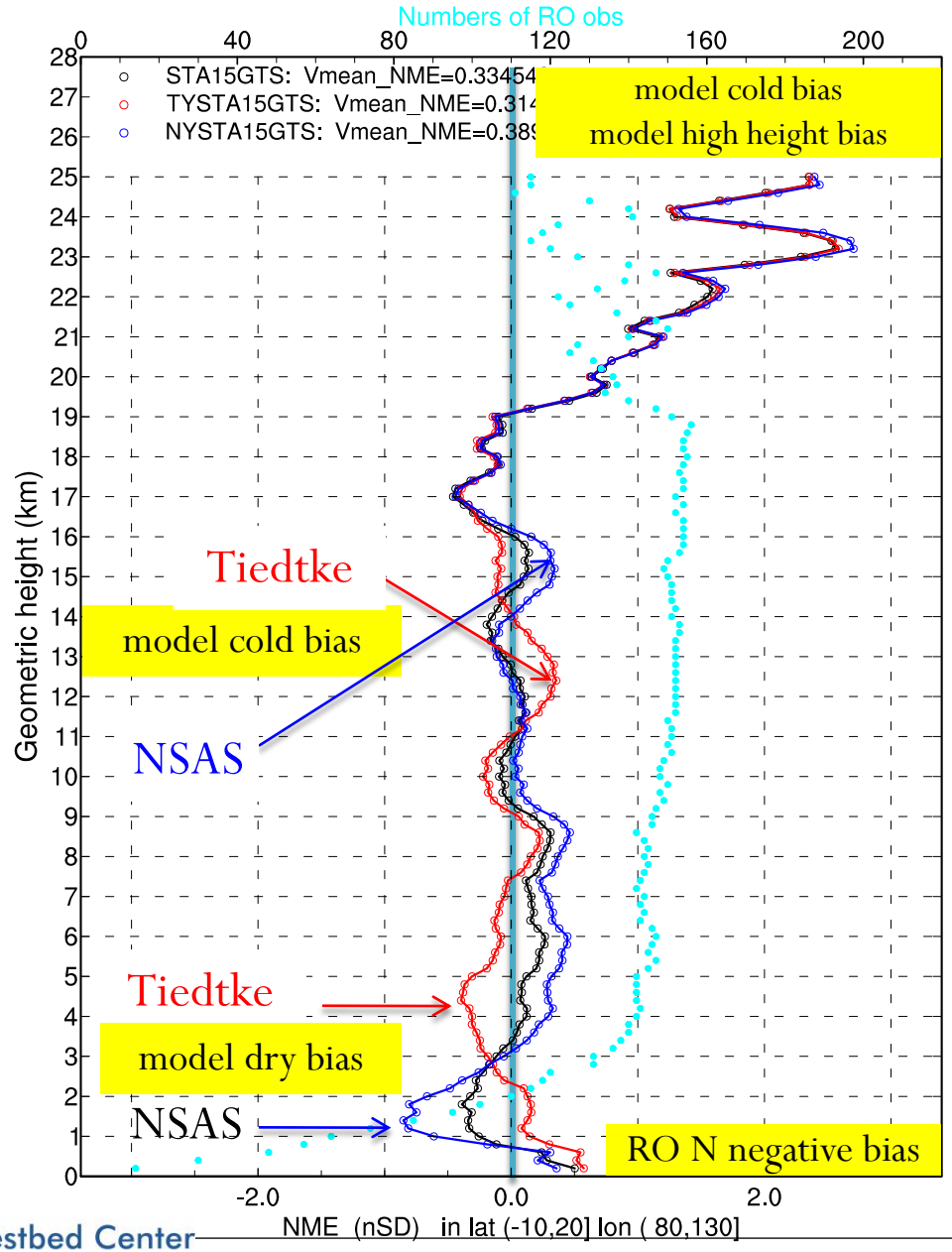
Mid-levels begin drying by 6 hr into simulation

Is NSAS deep convection too active?

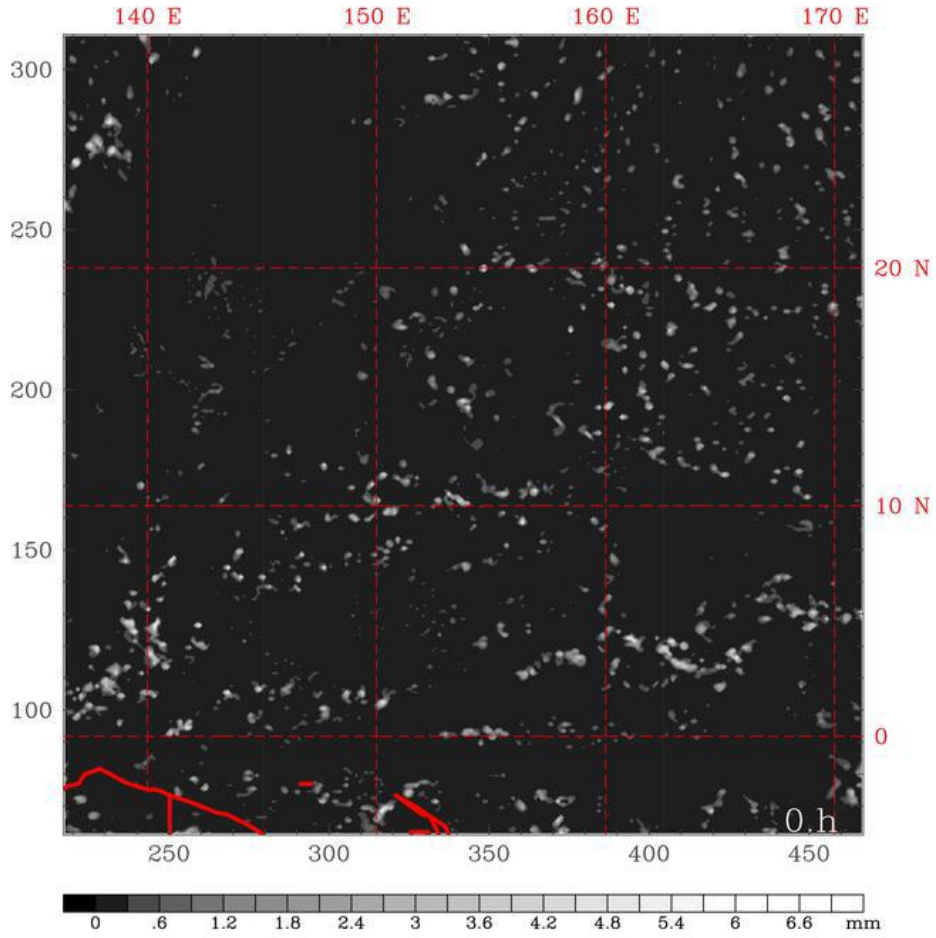


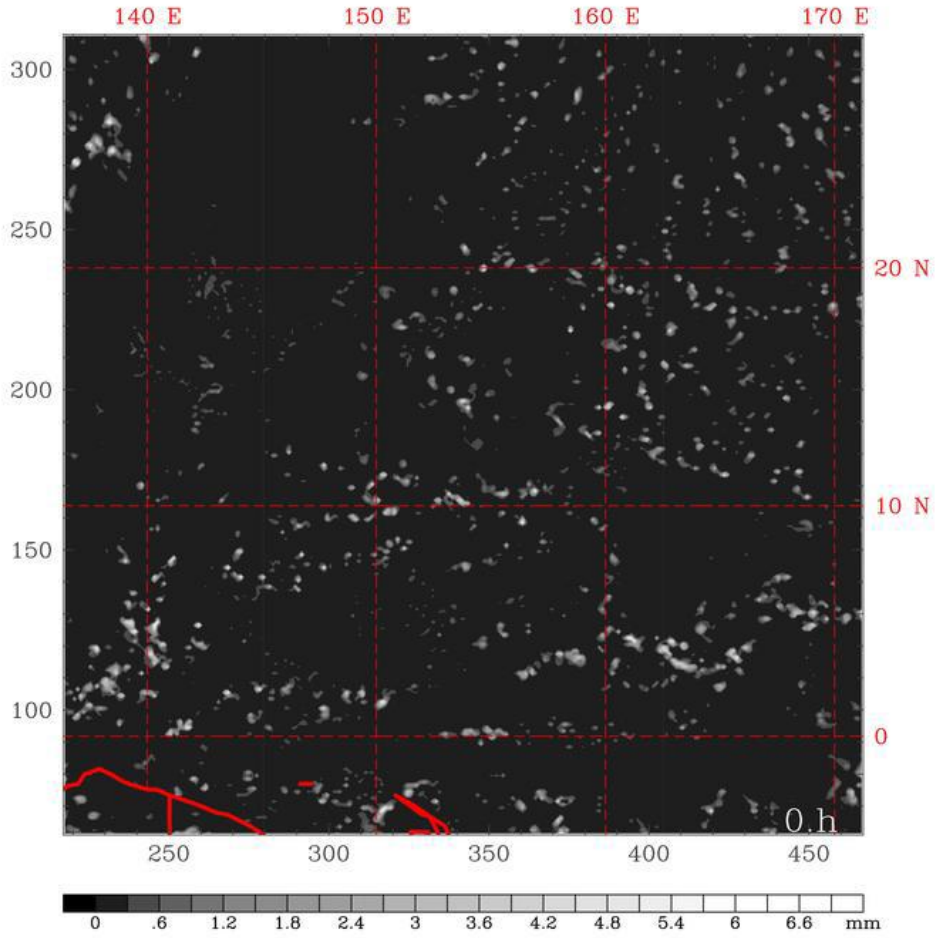
GPS RO N (refractivity) for model error diagnostics

Normalized ME (F-O/SD)



Impact of Convective Scheme on Tropical Cyclone Formation



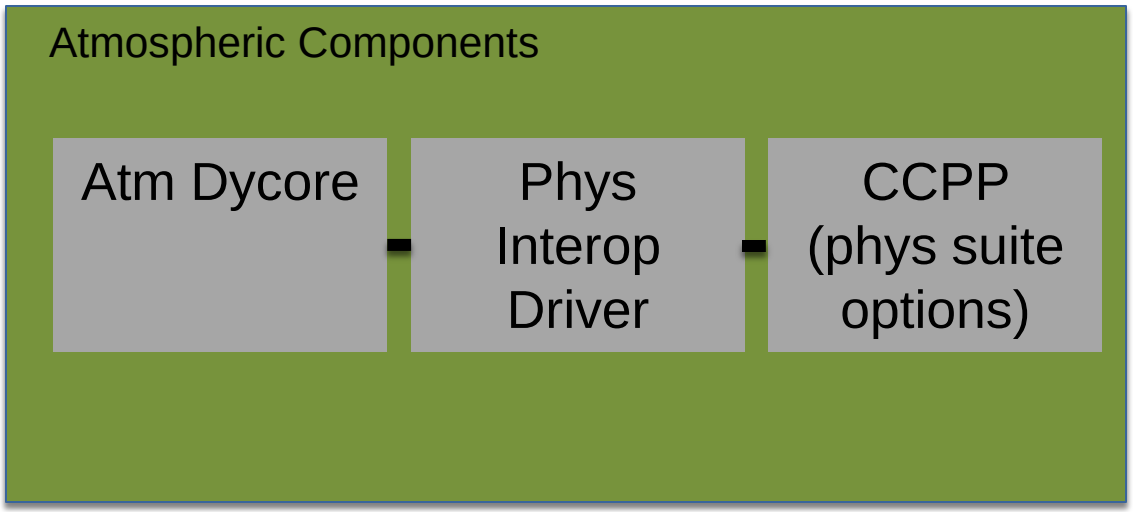


NSAS scheme **Kain-Fritsch scheme**

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

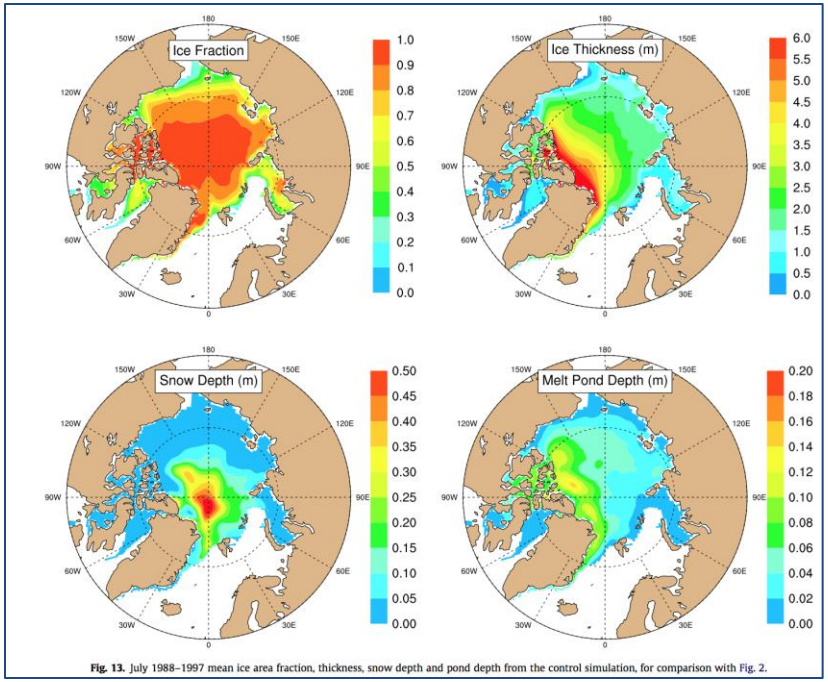


Fig. 13. July 1988–1997 mean ice area fraction, thickness, snow depth and pond depth from the control simulation, for comparison with Fig. 2.

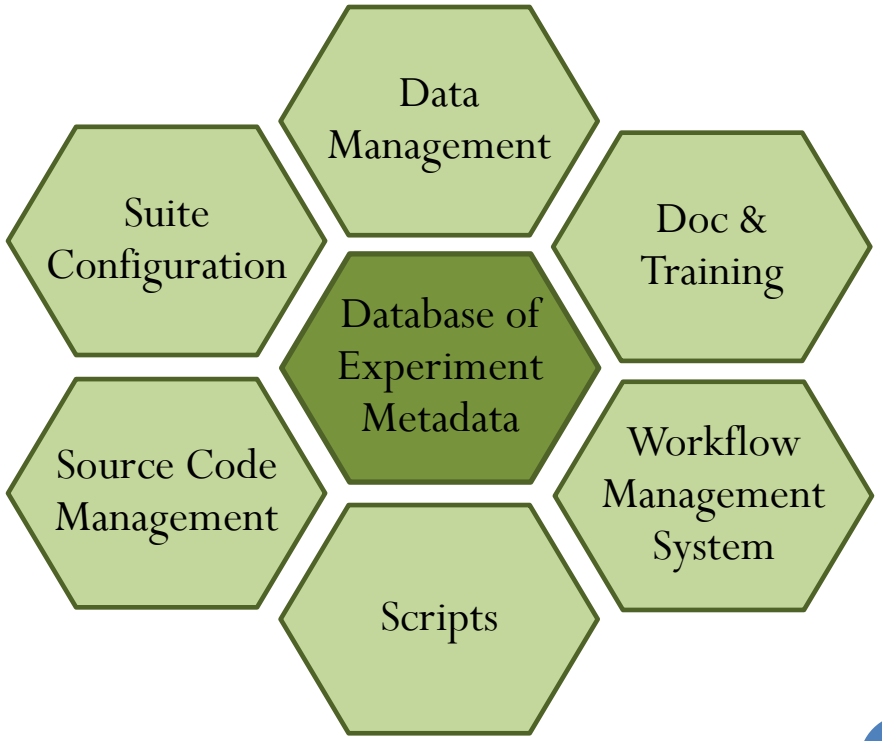
CICE example from Hunke et al. (2013)

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
WRF	mesoscale model	NCAR, GSD	NCAR	Assist w/ rep maintenance & community contributions
UPP	post-processor	EMC	EMC Community	Maintain community repository (sync & portability) Community support
NMMB New in 2015	mesoscale model	EMC	EMC DTC	Portability & friendly user releases Assist w/ community contributions
GSI				lity)
EnKF New in 2015	ensemble – GSI-hybrid	EMC, GSD	EMC	Working w/ dev to build code mgmt framework Documentation
HWRF	tropical cyclone	EMC, HRD, URI, GFDL	Community (10 components)	Chair HWRF Developers Committee Transition ops capability to component repositories Repository maintenance Support for system run scripts Community support
MET	verification	NCAR	NCAR	Maintain repository and advance capability Community support

Close collaboration with EMC critical to these efforts!

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