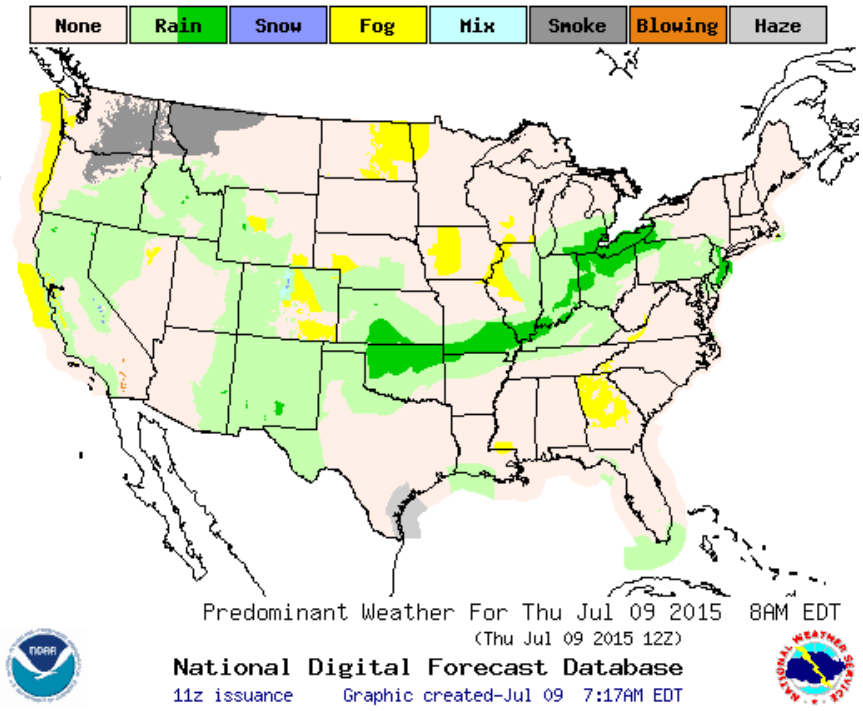
Status of the Next Generation Global Prediction System (NGGPS)

Annual Meeting

July 14-15 2015

Ivanka Stajner



NGGPS Project Overview

- Project Activities and Status
- Community Involvement
- Dynamic Core Testing and Evaluation
- Physics
  - Global Modeling Test Bed
- Model Components

Project Activities and Status

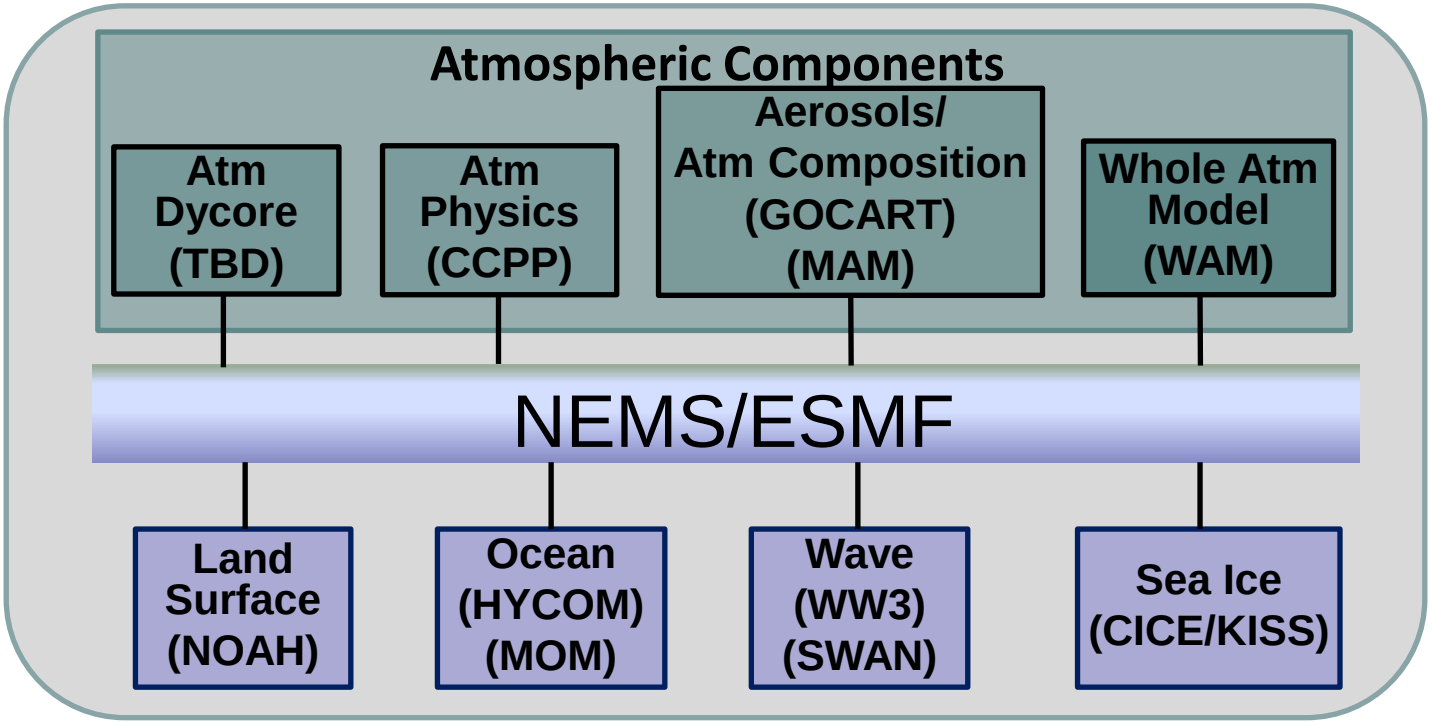
- Develop Implementation Plan
  - Plan drafted
  - Revising team plans
    - Team component leads established/approved
    - Incorporated proposal work into team plans
- Broaden community participation
  - Federal Funding Opportunity: $3.9M awarded to University PI's
  - Internal Announcement: $2.4M awarded to federal labs
  - Use of community codes/components
- Conduct Atmospheric Model Dynamic Core Evaluation
  - Phase 1 testing completed and results assessed
  - Final report and public release being prepared
  - Phase 2 testing begins in FY15Q3
  - GFS Physics driver delivered for dycore testing

Project Activities and Status cont.

- Initiate NGGPS Test Bed activities/ Propose Global Modeling Test Bed
  - Test bed activities defined and funded through FFO
  - Global Modeling Test Bed Proposal approved
    - Includes code management support for common physics package and interoperable physics driver
- Accelerate NEMS - Develop Prototype Coupled System
  - Components (including MOM5, HYCOM, WW3, CICE, NOAH and GFS) to be coupled in a test-ready system by FY16Q2
- Upgrade EMC infrastructure to support community participation
  - Software and Scientific Development at EMC (SciTech Task) being awarded
    - Technical support for NEMS development
    - Software engineering, technical support for infrastructure upgrades
    - R&D for upgrade of global modeling components

NGGPS Components

- Fully coupled (ocean, waves, sea ice, land surface, atmosphere, aerosols and atmospheric composition) system
- Built using NEMS/Earth System Modeling Framework
- Each component model will be community code



Implementation Plan Development Teams

- Atmospheric Prediction - Dynamics
- Atmospheric Prediction – Physics
- Aerosols and Atmospheric Composition
- Atmospheric Data Assimilation
- Ocean Prediction (includes waves, sea ice, and data assimilation)
- Land Prediction
- Nesting (includes hurricanes and convective systems)
- Post-Processing
- Ensemble Design
- Overarching System (architecture and integration including NEMS/ESMF)
- Software Architecture and Engineering
- Infrastructure
- Verification and Validation
- Testbeds

Team participation across NOAA line offices/laboratories, Navy, NASA, UCAR and coordination with the High Impact Weather Prediction Project and the National Earth System Prediction Capability program

Community Participation Through Funding Announcements

- External FFO – 14 NGGPS proposals, 9 Testbed Proving Ground proposals selected
- Internal AO - 13 proposals selected
- Research and development topic areas funded
  - Physics driver and parameterization
  - Aerosol model
  - Atmospheric model and data assimilation
  - Ocean, wave and sea ice models, and associated data assimilation
  - Land surface model and data assimilation
  - Ensemble development
  - Model coupling and efficiency
  - Testbeds

Directed R&D
Internal AO for Fed Labs/Centers

Organization	PI	Proposal Title	Research Subject Area
ESRL/GSD	Georg Grell	Using advanced photochemical and aerosol modules to verify the applicability of GOCART aerosol modules within global weather prediction models	Aerosol Model
		Further Testing and Evaluation of a Scale-Aware Stochastic Convection Parameterization in NOAA's Next Generation Global Prediction System	Atmospheric Physics
	Zoltan Toth	Improved Statistical Post-processing with the Bayesian Processor of Ensemble (BPE)	Ensemble Development
ESRL/PSD	Jian-Wen Bao	Evaluation and Adaptation of Advanced Microphysics Schemes in NOAA's Next Generation Global Prediction System Using the NOAA-HMT Observations	Atmospheric Physics
	Tom Hamill	Probabilistic Forecasts of Precipitation Type and Snowfall Amounts based on Global Ensemble Forecasts	Ensemble Development
	Jeff Whitaker	Testing and implementation of a cycling ensemble data assimilation system for operational hurricane prediction	Data Assimilation
GFDL	Paul Ginoux	Implementation and testing of regional and global dust forecasting	Aerosol Model
	Lucas Harris	Subseasonal hurricane prediction in a prototype variable-resolution global NGGPS model	Model Coupling and Efficiency
NCEP/AWC	David Bright	An Investigation of Reforecasting Applications for Next Generation Aviation Weather Prediction: An Initial Study of Cloud and Visibility Prediction	Ensemble Development
NCEP/EMC	Shrinivas Moorthi	Accelerated Implementation of Scale-aware Physics into NEMS	Atmospheric Physics
	Michael Ek	Satellite-based Land Data Assimilation in the NCEP Operational Global System	Data Assimilation
NCEP/WPC	David Novak	Development of Ensemble Forecast Approaches to Downscale, Calibrate and Verify Precipitation Forecasts	Ensemble Development
NRL	Patrick Hogan	Calibration and bias correction of high resolution ocean and sea ice components of the Next Generation Global Prediction System	Modeling Coupling and Efficiency

Directed R&D NGGPS Competitive FFO

Institution	Principal Investigator	Proposal Title	Research Subject Area
Columbia University	Andrew Robertson	Development and testing of a multi-model ensemble prediction system for sub-monthly forecasts	Ensemble Development
George Mason University	James Kinter	Accelerating Development of NOAA's Next-Generation Global Coupled System for Week-3 and Week-4 Weather Prediction	3-4 Week Model Improvement
Pennsylvania State University	David Stensrud	Advancing Storm-Scale Forecasts over Nested Domains for High-Impact Weather	Convective Modeling
State University of New York, Albany	Sarah Lu	Investigation of Aerosol Effects on Weather Forecast using NCEP Global Forecast System	Aerosol Model and Radiation Interactions
State University of New York, Stony Brook	Ping Liu	Calibration and Evaluation of GEFS Ensemble Forecasts at Weeks 2-4	Ensemble Development
University of Colorado - CIRES	Fuller-Rowell	Integrating Unified Gravity Wave Physics into the Next Generation Global Prediction System	Gravity Wave Physics
University of Illinois	Zhuo Wang	Developing Physics-oriented Diagnostic Tools for Model Evaluation and Improvement	Model Evaluation Tools
University of Maryland-ESSIC	Christopher Hain	Enhancing NCEP GFS Forecasts via Assimilating Satellite Soil Moisture and Snow Observations	Land Data Assimilation
University of Maryland	Daryl Kleist	Improved tropical cyclone initialization for NCEP operations through direct assimilation of storm information	Data Assimilation
University of Maryland	Steve Penny	An Operational Hybrid 3DVar/EnKF Ocean Assimilation System at NCEP	Ocean Data Assimilation
University of Maryland	Zhanqing Li	Evaluating the Impact of Cloud-Aerosol-Precipitation Interaction (CAPI) Schemes on Rainfall Forecast in the NGGPS	Impact of Aerosols on Clouds and Precipitation
University of Oklahoma - CIMMS	Xuguang Wang	Improving Global and Hurricane Predictions by Using Minimum-Cost Large Ensembles in GFS 4DEnVar Hybrid Data Assimilation System	Ensemble Development
University of Washington	Clifford Mass	Subseasonal Prediction over the Western US	Data Assimilation/Down Scaling
University of Wisconsin CIMSS	James Jung	Development of Advanced Data Assimilation Techniques for Improved use of Satellite-Derived Atmospheric Motion Vectors.	Data Assimilation

Directed R&D
Test Bed Support

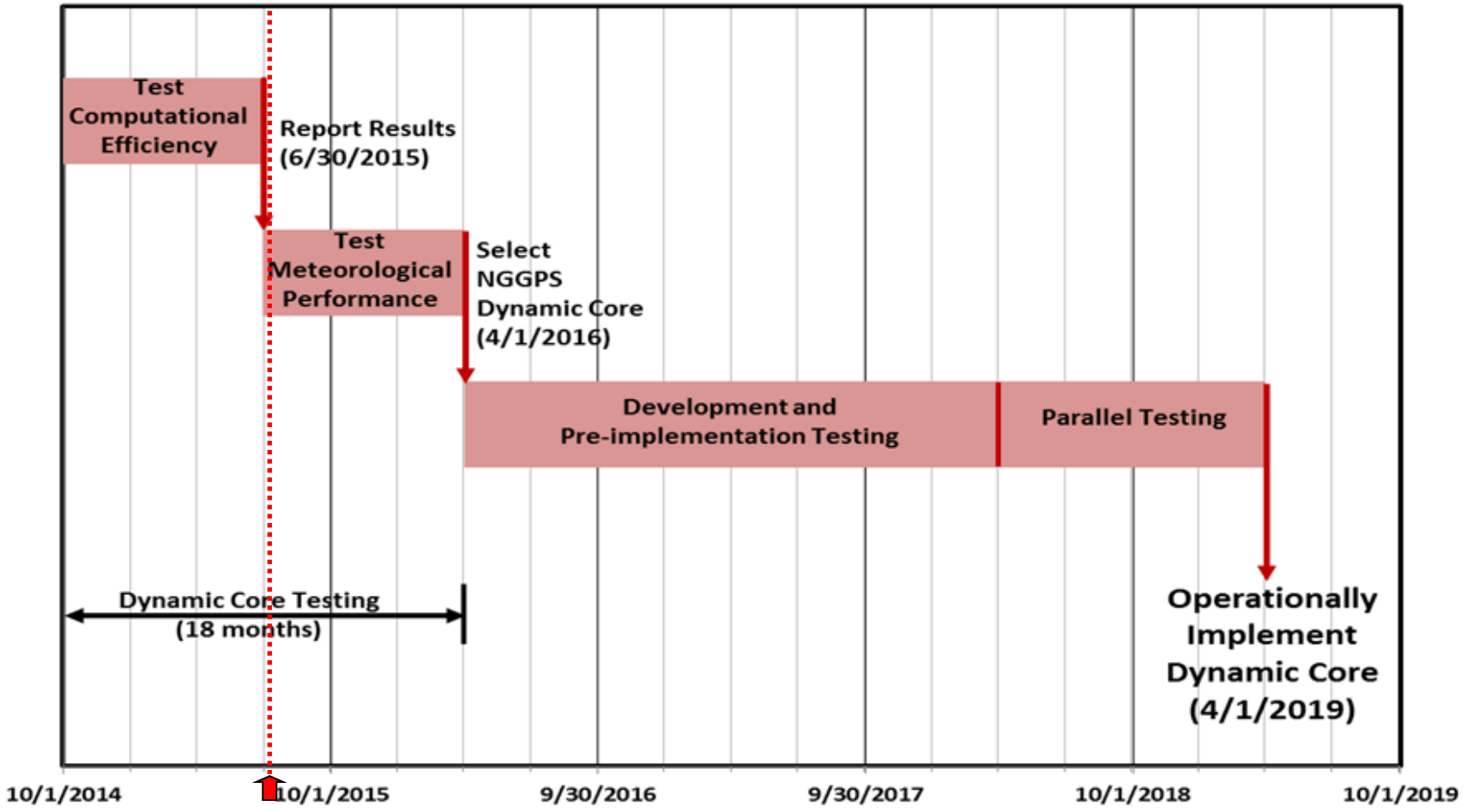
University/ Organization	PI	Testbed	Proposal Title
NOAA/NESDIS STAR	Ivan Csiszar	JCSDA	Incorporation of near-real-time Suomi NPP Green Vegetation Fraction and Land Surface Temperature data into NCEP Land modeling suite
NOAA/NWS/NCEP	Jae-Kyung Schemm	CTB	Application of a Hybrid Dynamical-Statistical Model for Week 3 to 4 Forecast of Atlantic/Pacific Tropical Storm and Hurricane Activities
University of North Dakota	Xiquan Dong	HWT	Improvement of Convective/Severe Weather Prediction through an Integrative Analysis of WRF Simulations and NEXRAD/GOES Observations over the CONUS
University of Oklahoma	James Correia	HWT	Test and Evaluation of Rapid Post-Processing and Information Extraction From Large Convection Allowing Ensembles Applied to 0-3hr Tornado Outlooks
	Israel Jirak	HWT	Information Extraction and Verification of Numerical Weather Prediction for Severe Weather Forecasting
	Travis Smith	HWT	Data Mining of High-Resolution Storm-Scale Datasets
State University of New York, Albany	Christopher Thorncroft	JHT	Exploitation of Ensemble Prediction System Information in support of Atlantic Tropical Cyclogenesis Prediction
	Lance Bosart	HMT	An Investigation of the Skill of Week Two Extreme Temperature and Precipitation Forecasts at the NCEP-WPC
State University of New York, Stony Brook	Brian Colle	DTC	Validation of Significant Weather Features and Processes in Operational Models Using a Cyclone Relative Approach

Selecting a New Operational Atmospheric Dynamic Core

- Evaluate, select and implement a replacement to current Global Spectral Model
- Parallels efforts initiated at UKMO and ECMWF
- Next-Generation computing paradigm will require scaling across potentially 100,000's processors or more
- Dynamic Core Evaluation Participants
  - MPAS (NCAR) – Unstructured grid with C-grid discretization
  - FV3 (GFDL) – Cubed sphere, finite-volume
  - NIM (ESRL) – Non-hydrostatic Icosahedral Model
  - NEPTUNE (Navy) – Flexible grid with adaptive mesh Refinement
  - NMMB-UJ (EMC) – Finite difference, Uniform Jacobian cubed sphere grid, global extension of regional model (new grid replacing lat/long grid)

Global Spectral Model not included – Non-hydrostatic version not available

Atmospheric Dynamic Core Implementation Schedule



Atmospheric Model Dynamic Core Testing Overview

Phase 1 Testing

Status	Activities
Complete	HIWPP Idealized Tests
Complete	Computational performance and scalability testing and software evaluation by Advanced Computing Evaluation Committee (AVEC)
Complete	HIWPP 3-km, 3-Day Simulations
Complete	Phase 1 Testing Report
Complete	Dycore Test Group (DTG) assessment of Phase 1 testing results
Complete	Phase 1 testing results briefing to NCEP (Dr. Bill Lapenta) and NWS (Dr. Louis Uccellini)

Note: Specific details on Phase 1 testing and associated criteria provided later in brief

Atmospheric Model Dynamic Core Testing Overview

Phase 2 Testing Evaluation Criteria (Assessed by DTG on 29/30 June)

Phase 2 Eval #	Evaluation Criteria
1	Option to relax the shallow atmosphere approximation (deep atmosphere dynamics)
2	Accurate conservation of mass, tracers and entropy
3	Robust model solutions under a wide range of realistic atmospheric initial conditions using a common (GFS) physics package
4	Computational performance with GFS physics
5	Demonstration of variable resolution and/or nesting capabilities.
6	Stable, conservative long integrations with realistic climate statistics under idealized forcing with simple physics
7	Code adaptable to NEMS/ESMF

Note: Phase 2 testing will be conducted with a stand-alone GFS based physics package – initial standardized interface/physics package delivered 18 June

Atmospheric Dynamic Core Phase 1 Testing

- Fair process to assess attributes and criteria for selecting the next dynamic core
- Phase 1
  - Advanced Computing Evaluation Committee (AVEC)
    - Benchmarks Testing
    - Software Evaluation
  - HIWPP
    - Idealized Tests
    - 3-km, 3-Day Simulations
  - Strict schedules with deadlines were followed
  - Each candidate model's configurations were reviewed and agreed upon by the other modeling groups

Incorporated Non-hydrostatic Dynamic Core Testing from HIWPP

Common Physics Package/Driver

- Snapshot of GFS physics will be used in dynamic core Phase 2 testing
  - GFS physics and prototype driver interface delivered June 2015
  - NUOPC Physics Interoperability leading design effort for driver interface
- EMC/NUOPC Physics Interoperability group have been coordinating requirements
  - GFS Physics Driver Software Requirements Specification (V1.0 rev. 3 of 13 Feb 2015) prepared
- EMC/NGGPS Physics Team to work specifications for common community physics package
  - Scale-aware physics parameterizations
  - Suitable for variable-resolution grids

Global Modeling Test Bed

- Extension of current DTC (NCAR and GSD partnership)
- Pre-implementation testing of new functionality
- Fosters community involvement in ongoing development of operational modeling systems
  - Community code management
  - Test platform management
  - Provides necessary infrastructure for community to interact with code system
  - Supports code system to external developers
  - Independent test and evaluation of proposed upgrades to operational system from external community

GMTB Proposal Summary

- Task 1: Development and Testing of a Common Community Physics Package
  - Code management and community support
  - Testing and evaluation of innovations in physical parameterizations
- Task 2: Code Management and User Support for Interoperable Physics Driver
- Task 3: Development and Testing of a Sea Ice Model for NGGPS
- Task 4: Program Management Support

Summary

- NGGPS Implementation Plan revision and team planning moving forward
- Coordinating proposal driven scientific development by universities, federal labs, and testbeds (integrated in team plans)
- Dynamic core testing in progress with final decision anticipated spring 2016
  - Phase 1 testing complete / NWS endorsement received on recommended way ahead to Phase 2 testing
  - Further dynamic core development and parallel testing required after dycore selection
- Initial implementation of physics development plan is in progress – includes planning for development of community code (focus will be on scale aware physics)
- Focus on accelerated development of model components
  - As community code

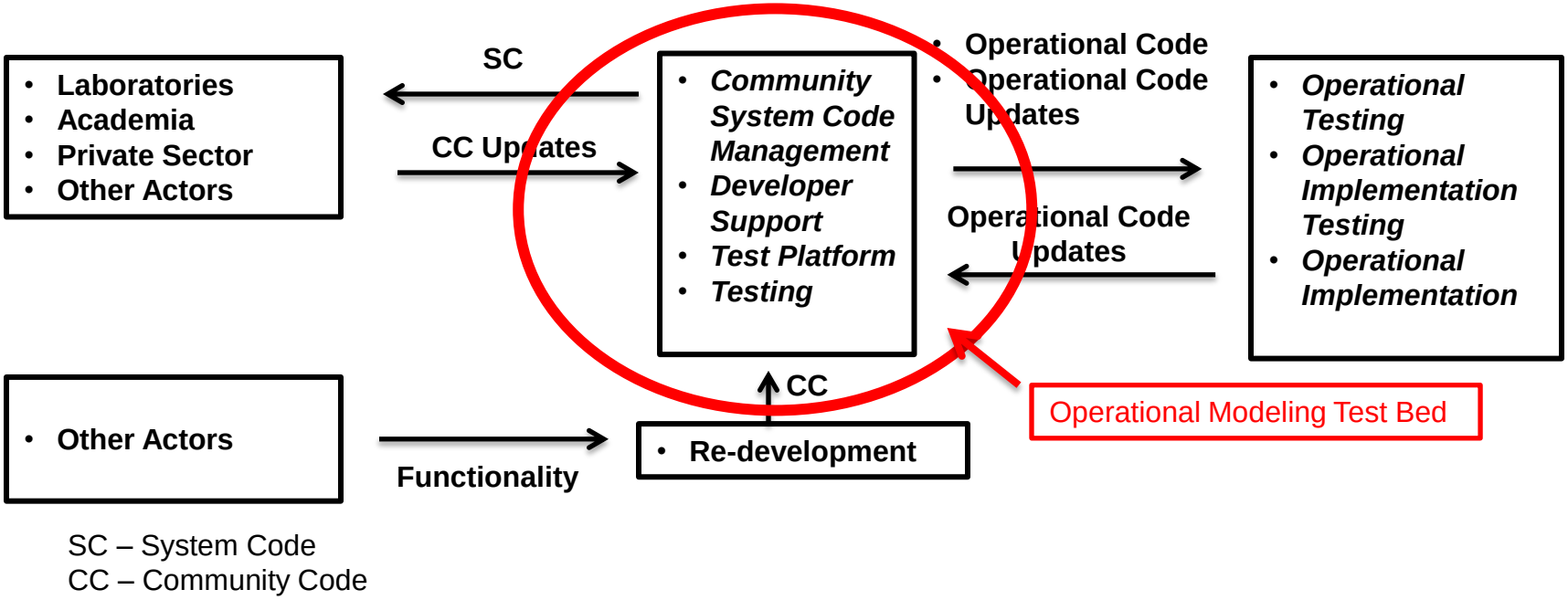
Questions?

NGGPS Website:

http://www.nws.noaa.gov/ost/nggps

Back-up

Global Modeling Test Bed (GMTB) Concept



SC – System Code
CC – Community Code

- Implements concept of *Community Development*
- System Code based on Operational Code (O to R)
- Community System Code supports both Operations and Research
- Proposal for first year activities in development
  - Common community physics package
  - Ice modeling package

Overall Deliverables

- Annual upgrades to operational data assimilation
- Upgrades to NEMS infrastructure
- Upgrades to component models (ocean, atmosphere, ice, land surface, wave, aerosols) for a coupled system
  - As coordinated effort delivering community code
- Coupled global system using re-engineered system component models
- Improved utilization of HPC resources and cost effective implementation of science
- Agile HPC environment with quicker operational transition of research and development efforts

To design, develop, and implement the Next Generation Global Prediction System and maintain world-class forecast capability

Strategy for Years 3 - 5

- Demonstrate increased skill out to longer time scales
  - 7-day skill extended to 14 days
  - Increased predictability of severe weather
- Accelerate development of model components and improve coupling capabilities
- Research from community should start translating into operational development plans
- Improve system and software architecture to increase performance and interoperability
  - Efficient transfer to fine-grain computing platforms
- Operationally implement the fully coupled global ocean-atmosphere-ice-wave prediction system