Next Generation Global Prediction System (NGGPS) Overview

Principal Investigators Meeting

August 2, 2016

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NGGPS PI Meeting Objectives

- PI's will present results of work funded through the NWS STI 2015 Federal Funding Opportunity to accelerate critical research for development of NGGPS

- The NGGPS Implementation Team Leads and EMC scientists will provide collaborative feedback to the investigators

NGGPS Goals and Objectives[1]

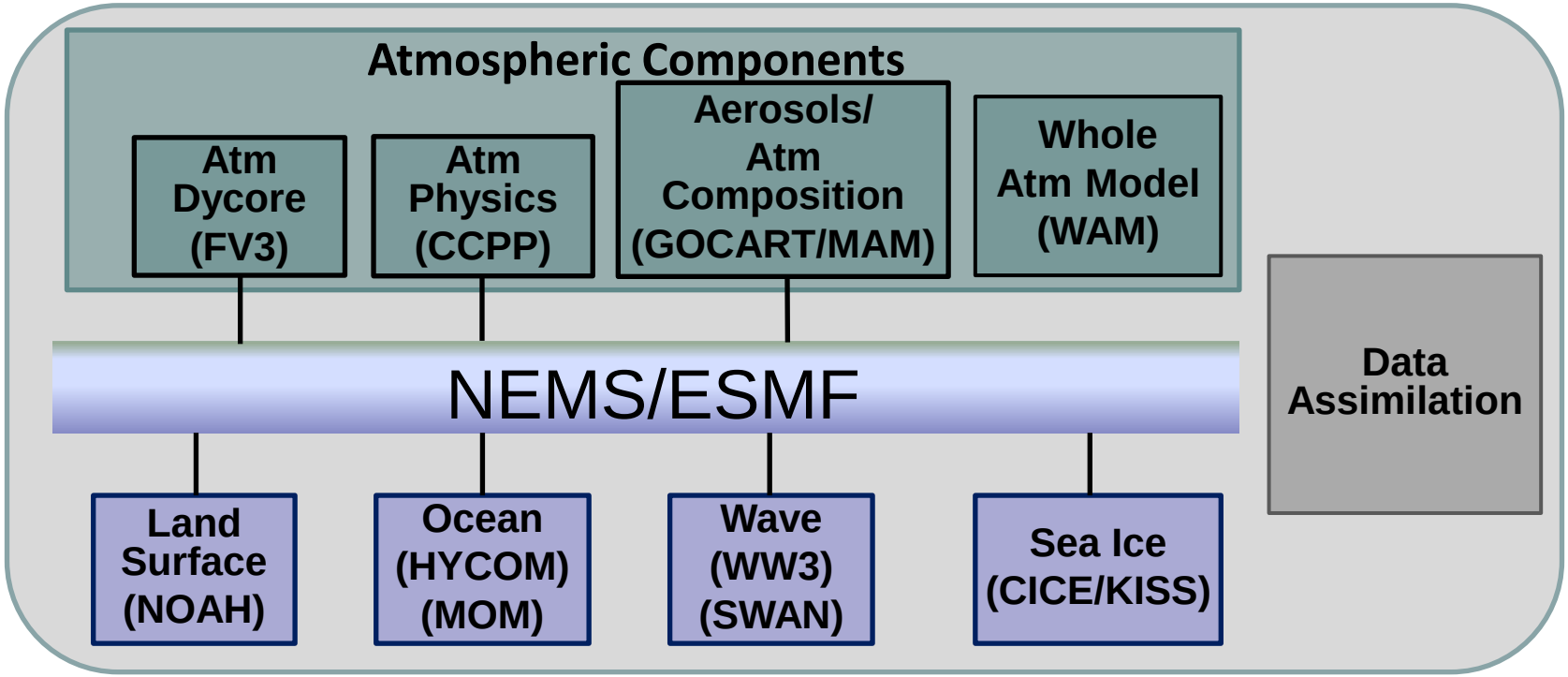
- Design/Develop/Implement NGGPS global atmospheric prediction model
  - Non-hydrostatic scalable dynamics
- Improve data assimilation and physics
- Position NWS for next generation high performance computing
- Engage community in model/components development
- Reduce implementation time
- Increase effectiveness of product distribution
  - Post-processing, assessments, and display

World's Best Global Forecast Guidance

[1]From NWS Budget Initiative proposal to OMB

NGGPS Description

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

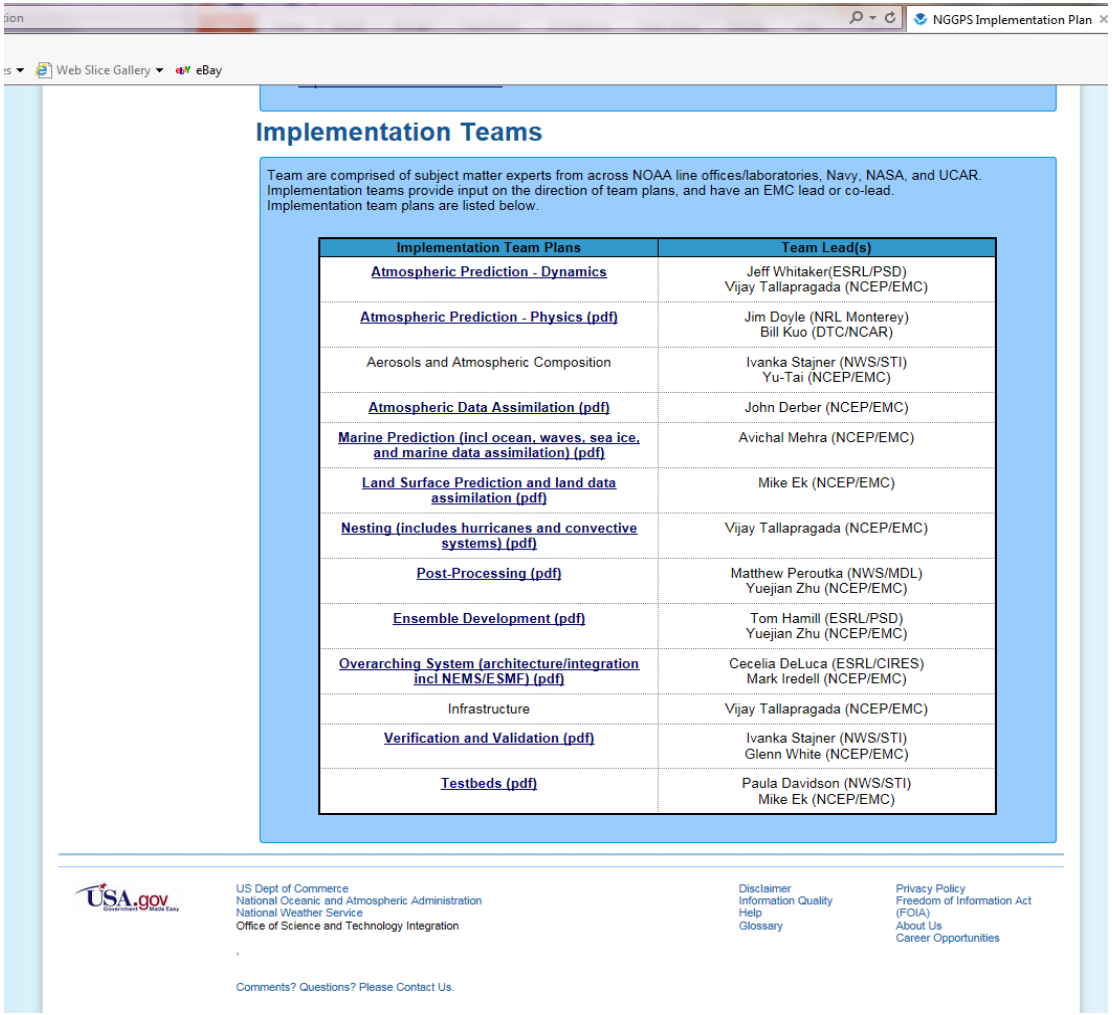


Project Activities and Status Highlights

- Develop Implementation Plan
- Broaden community participation
- Select the dynamical core
- Accelerate NEMS - Develop Prototype Coupled System
  - GSM, LIS/Noah, HYCOM, MOM5/6, CICE, are WW3 are all integrated into NEMS. GSM, MOM5, and CICE are now coupled
  - Workshop planned for Fall 2016
- Upgrade EMC infrastructure to support community participation
  - Software and Scientific Development at EMC (SciTech Task) awarded
  - NEMS development, software engineering, technical support for infrastructure upgrades, R&D for upgrade of global modeling components - Physics and DA development are in progress
  - Transition of MET+ into EMC environment - in progress

NGGPS Implementation Plan

- **Developed Implementation Plan**
  - 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
  - Team Plans posted on NGGPS website:



http://www.weather.gov/sti/stimodeling_nggps_implementation

Enhanced Community Participation Since 2015

2015 Federal Funding Opportunity (FFO):

- 14 NGGPS proposals selected, $5M funded over two years
- 9 NGGPS testbeds proposals selected, $3.4M funded over two years
- 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

The new CSTAR website lists all grants http://www.weather.gov/sti/stigrants

Expanded Community Participation in 2016

- 2016 Federal Funding Opportunity (FFO) – *pending GMD approval*
  - *11 NGGPS proposals recommended, $1.9M for first year*
  - *6 NGGPS testbed proposals recommended, $1M for first year*
- Funding community participation in coordination with other programs
  - Coordination and co-funding with CPO and USWRP
  - Coordination with R2X
- Accelerating development and use of community components
- NGGPS Test Bed Activities/Global Modeling Test Bed (GMTB)
  - Developmental testing of new functionality
  - Facilitates community involvement in ongoing development of operational modeling systems (e.g. code management, test and evaluation of operational system upgrades proposed by external community)

GMTB – current focus

- **Atmospheric physics**
  - Create and support a Common Community Physics Package (CCPP) with carefully vetted physics suites for global modeling at various resolutions
  - Develop a design and implementation plan to evolve current Interoperable Physics Driver (IPD) to meet the needs of NGGPS
  - Implement a testbed for innovations
  - NGGPS Physics Workshop planned for Fall 2016

- **Sea ice model evaluation**
  - Participate in efforts to create a plan for fostering community collaboration in Los Alamos Sea Ice Model (CICE) development

NGGPS Global Atmospheric Model Technical Strategy

- **Reduce implementation time and risk by separating dynamic core and model physics**
- **Identify and implement an advanced dynamical core for global weather forecast applications**
  - Highly scalable
  - Non-hydrostatic
- **Accelerate evolution of model physics**
  - Develop/Implement Common Community Physics Package (CCPP)
    - Based on current GFS physics package
    - Integration of best of other existing physics packages
    - Scale-aware
- **Develop a new community approach**
  - Employ Global Modeling Test Bed (GMTB)/Developmental Testbed Center (DTC) and a more robust Joint Center for Satellite Data Assimilation (JCSDA) to encourage and facilitate community interaction
  - Accelerate O2R & R2O

NGGPS Phase 1
Candidate Dynamical Cores

- MPAS (NCAR) – Unstructured grid with C-grid discretization

NCAR | National Center for Atmospheric Research
UCAR | National Science Foundation

- FV3 (GFDL) – Cubed sphere, finite-volume

GFDL Geophysical Fluid Dynamics Laboratory

- NIM (ESRL) – Non-hydrostatic Icosahedral Model

Earth System Research Laboratory
Serving Society through Science

- NEPTUNE (Navy) – Flexible grid with adaptive mesh Refinement

U.S. Navy

- NMMB-UJ (EMC) – Finite difference, cartesian grid, global extension of regional model

Environmental Modeling Center

- GSM-NH (EMC) – Non-hydrostatic extension of Semi-Lagrangian Global Spectral Model

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

NGGPS Phase 1 Dynamical Core Evaluation

- Evaluate technical performance
  - Scalability
  - Integration of scheme stability and characteristics
- Proceed to Phase 2 testing and evaluation with two dynamical cores: FV3 and MPAS
  - low technical risk
  - no unique dynamical core quality will be lost

Evaluation Criteria	How evaluation was done
Bit reproducibility for restart under identical conditions	Query model developers (AVEC)
Solution realism for dry adiabatic flows and simple moist convection	Perform series of idealized tests and evaluate solutions
High computational performance and scalability	Benchmarks run by AVEC
Extensible, well-documented software that is performance portable	Subjective evaluation of source code by AVEC
Execution and stability at high horizontal resolution (3 km or less) with realistic physics and orography	72-h forecasts with realistic physics and orography using operational GFS initial conditions (Moore tornado and Hurricane Sandy)
Lack of excessive grid imprinting	Evaluate idealized test case solutions

Briefed to NWS and OAR Assistant Administrators, July 2015

NGGPS Phase 2 Dynamical Core Testing Criteria

#	Evaluation Criteria*
1	Plan for relaxing shallow atmosphere approximation (deep atmosphere dynamics)
2	Accurate conservation of mass, tracers, entropy, and energy
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, including supercell tests and physically realistic simulations of convection in the high-resolution region
6	Stable, conservative long integrations with realistic climate statistics
7	Code adaptable to NEMS/ESMF
8	Detailed dycore documentation, including documentation of vertical grid, numerical filters, time-integration scheme and variable resolution and/or nesting capabilities
9	Evaluation of performance in cycled data assimilation
10	Implementation Plan (including costs)

- Integrate with operational GFS Physics/CCPP
- Evaluate meteorological performance
- Results publicly available; report in preparation
  http://www.weather.gov/sti/stimodeling_nggps_implementation_atmdynamics

*** Evaluation criteria approved by DTG consensus in January 2016**

NGGPS Phase 2 Dynamic Core Recommendation

- Overall assessment and NGGPS Program Manager recommendation:

Select GFDL FV3 and proceed to NGGPS Phase 3 dynamical core integration and implementation

- The FV3 core represents the lowest risk, lowest cost candidate for the new NGGPS atmospheric model
  - Meets all technical needs
  - Higher readiness for implementation
  - Significantly better technical and computational performance
  - Nothing in results precludes eventual global/convective-scale unification based on FV3
- Briefed to NOAA Administrator and Chief Scientist in July 2016
- NOAA News & Features, July 27, 2016: NOAA to develop new global weather model http://www.noaa.gov/noaa-develop-new-global-weather-model

Strategy to Implement Community Model Environment

- FY17Q1: Hold a workshop to collect input on how to structure the community model environment, including:
  - Code hosting environment (e.g. github)
  - Processes for O2R and R2O
  - Governance
  - How will support be provided?
  - What models will be supported (ocean, land…)?
- Develop detailed documentation, including users guide
- FY18Q1: Code released, with documentation
- FY19Q1: First users workshop/tutorial

Next Steps

- Develop a NOAA Modeling Strategic Plan
- Implement selected dynamical core
- Implement Common Community Physics Package
- Implement improved data assimilation (4DEnVar with 4D incremental analysis update and stochastic physics)
- Develop enhanced post-processing, ensemble methods; verification and validation; visualization tools and techniques
- Initiate community model environment, beginning with DTC, GMTB and JCSDA
- Conduct robust and ongoing testing and evaluation of components and systems, with community involvement

Summary

- Teams continue to identify, prioritize and develop model component and system improvements for NGGPS
- Community Involvement
  - coordinate proposal driven scientific development by universities, federal labs, and testbeds; establishment of GMTB and recommendations for 2016 FFO selections.
- Global model dynamical core selected
- Future focus areas
  - Phase 3 dynamical core integration
  - Accelerate evolution of model physics - develop/implement Common Community Physics Package (CCPP)
  - Data assimilation improvements
  - Continue to accelerate model component and system development and integration

STI Modeling Program Website:

http://www.weather.gov/sti/stimodeling

Information NGGPS:

http://www.weather.gov/sti/stimodeling_nggps

Information on Grants:

http://www.weather.gov/sti/stigrants

Back-up

NGGPS Over-Arching Objectives

- Re-establish US as the World leader in Global Weather Prediction
  - Extend forecast skill beyond 8 to 10 days
  - Improve hurricane track and intensity forecast
- Extend Weather Forecast to 30 days
  - Implement a fully-coupled NWP System Atmosphere, Ocean, Sea Ice, Land Surface, Waves, Aerosols and Atmospheric Composition
  - Support development of products for weeks 3 and 4
- Support unification of the NWS Numerical Weather Prediction Suite
- 5-year Community Effort

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