Investigating Collaboration Tools for Sandy Supplemental Project HIWPP

Bonny Strong, ESRL/GSD

Outline

1. Overview of HIWPP project
2. Collaboration needs for HIWPP

What is HIWPP?

High Impact Weather Prediction Project

A "Sandy Supplemental" project

Tim Schneider, ESRL/GSD
HIWPP Project Manager

Hurricane Sandy, October 28, 2012; image captured by GOES-13 satellite.
NASA Earth Observatory image by Robert Simmon

HIWPP Objectives

In an unprecedented way, the Hurricane Sandy Supplemental funding provides an opportunity to bring together the nation's global weather modeling community and focus them on a common goal:

developing the world's best medium-range weather forecast model by the end of the decade

to improve our time-zero to two-week prediction of nature's most dangerous storms such as hurricanes, floods, and blizzards, over the whole globe.

HIWPP Six-Point Strategy

1. Drive the current generation (hydrostatic) of global NWP models to max performance & resolution (10km-20km), to medium-range and beyond
2. In parallel, accelerate the development of the next generation (non-hydrostatic) of high-resolution (3km) medium-range global and nested NWP models
3. Utilize the latest hybrid assimilation techniques (4D-En-Var) and scale-aware physical parameterizations
4. Migrate models to newer and faster HPC technologies (MPFG/GPU)
5. Provide new tools to quickly access, visualize, and analyze massive amounts of gridded data
6. Engage with the weather community for feedback and an open process

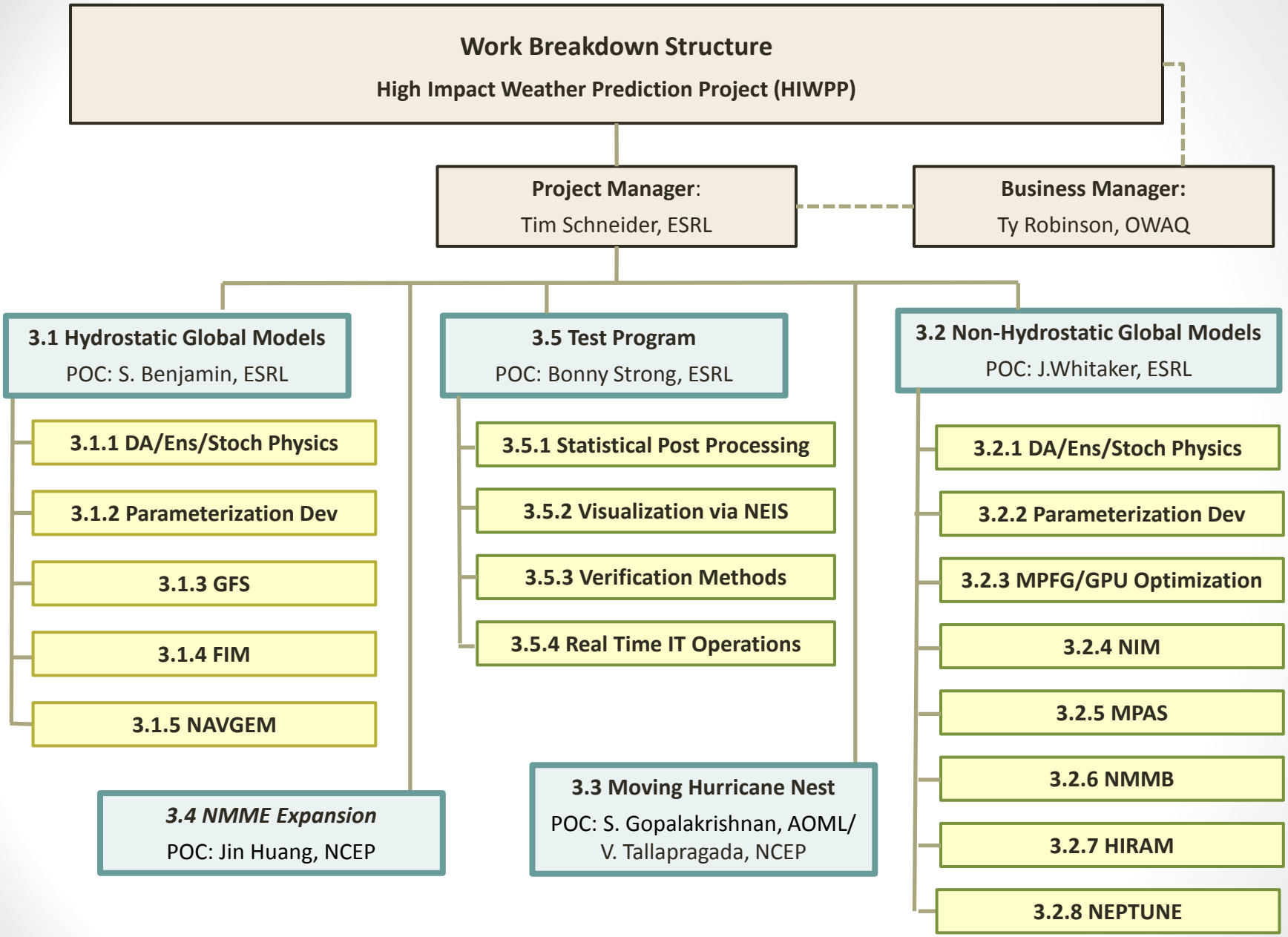
HIWPP at a Glance

"Just the facts…"

- HIWPP is an OAR "Sandy Supplemental" Project
  - $12.905M
  - *Public Law 113-2, the FY2013 Disaster Assistance Supplemental*
  - Funds expired 30 September 2014
  - 36 months to execute via contracts and grants
- 12 organizations, coast-to-coast:
  - AOML; ESRL/GSD; ESRL/PSD; GFDL;
  - NCEP/CPC; NCEP/EMC;
  - CICS-P; CIMAS; CIRA; CIRES;
  - NCAR; NRL
- Project is comprised of
  - 5 Subprojects
  - 19 Tasks

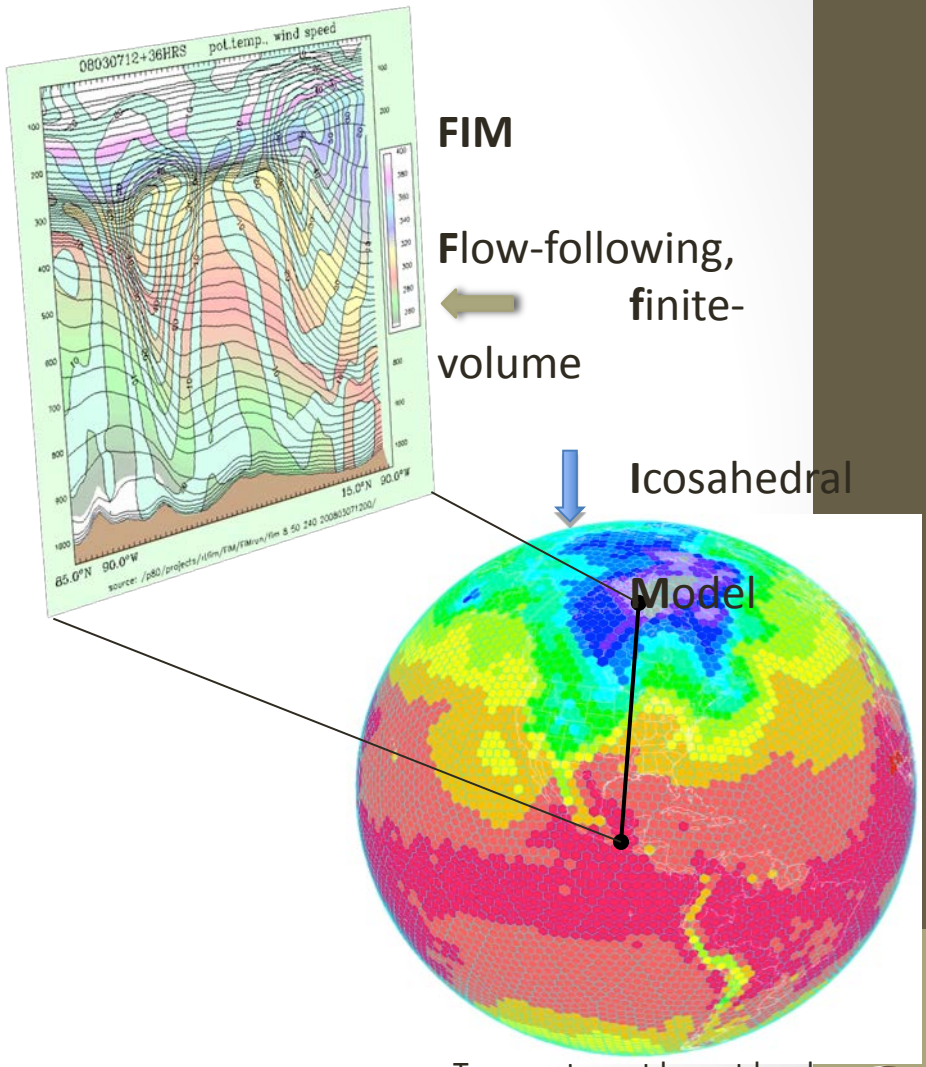
How are we going to do it?

- Through partnerships…
  - HIWPP funding can help to unify and focus the NWP community
- Building on existing efforts
- And enhance & accelerate them
  - Drive the science to a higher technical readiness level


Work Breakdown Structure
High Impact Weather Prediction Project (HIWPP)
Project Manager:
Tim Schneider, ESRL
Business Manager:
Ty Robinson, OWAQ
3.1 Hydrostatic Global Models
POC: S. Benjamin, ESRL
3.1.1 DA/Ens/Stoch Physics
3.1.2 Parameterization Dev
3.1.3 GFS
3.1.4 FIM
3.1.5 NAVGEM
3.4 NMME Expansion
POC: Jin Huang, NCEP
3.5 Test Program
POC: Bonny Strong, ESRL
3.5.1 Statistical Post Processing
3.5.2 Visualization via NEIS
3.5.3 Verification Methods
3.5.4 Real Time IT Operations
3.3 Moving Hurricane Nest
POC: S. Gopalakrishnan, AOML/
V. Tallapragada, NCEP
3.2 Non-Hydrostatic Global Models
POC: J.Whitaker, ESRL
3.2.1 DA/Ens/Stoch Physics
3.2.2 Parameterization Dev
3.2.3 MPFG/GPU Optimization
3.2.4 NIM
3.2.5 MPAS
3.2.6 NMMB
3.2.7 HIRAM
3.2.8 NEPTUNE

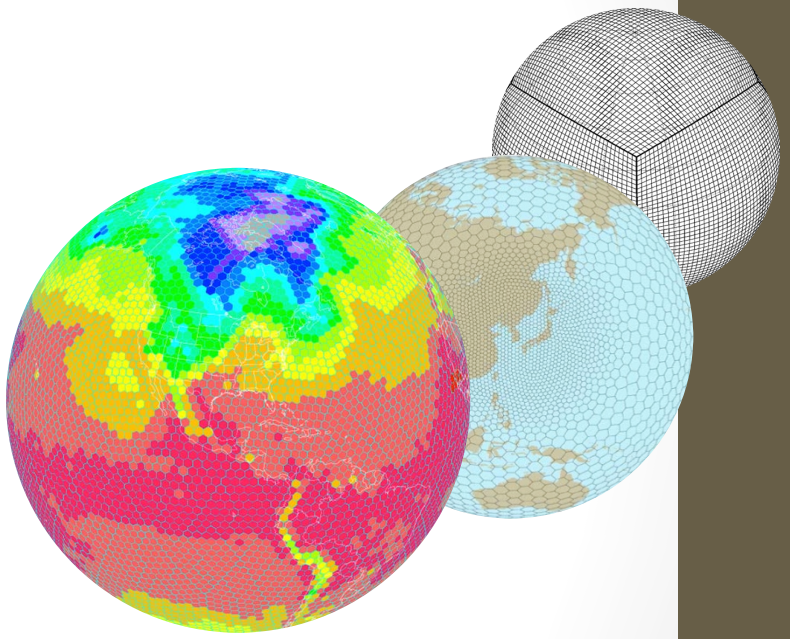
Goal: Hydrostatic Global Models

- Improve the current generation of global NWP models
  - Near-term impact: 1-3 years
- Work with three existing models:
  GFS; FIM; NAVGEM
  - Run at higher resolutions
    (sub-20km)
- Develop and implement scale-aware physical parameterizations
- Develop and implement new 4D-En-Var hybrid assimilation techniques
- Serves as baseline for the non-hydrostatic models



Goal: Non-Hydrostatic Global Models

- Next generation of medium-range (0-16 days), global NWP models
  - By the end of the current decade (2020)
  - 3km resolution; convection and cloud resolving
- Thoroughly evaluate and test five existing dynamical cores
  - NIM
  - MPAS
  - NMMB
  - HiRAM
  - NEPTUNE
- Migrate one or more models to newer and faster Massively-Parallel, Fine-Grain (GPU) HPC technologies



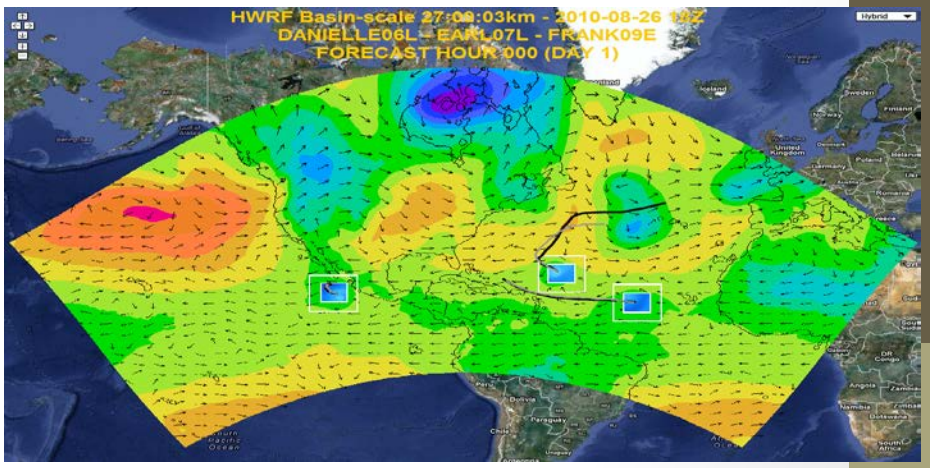
Goals: Moving Hurricane Nests and Seamless Long-range Weather Forecasts

Moving Hurricane Nest:

- Integrate HWRF into NMMB
  - fully two-way interactive moving nested, multi scale, non-hydrostatic modeling system using NMMB/NEMS framework
- Options to test HWRF nests in NMMB/NEMS framework with initial and boundary conditions from other models
- Proof of concept of global tropical cyclone model with multiple moveable nests placed around all tropical systems in the world and an open process

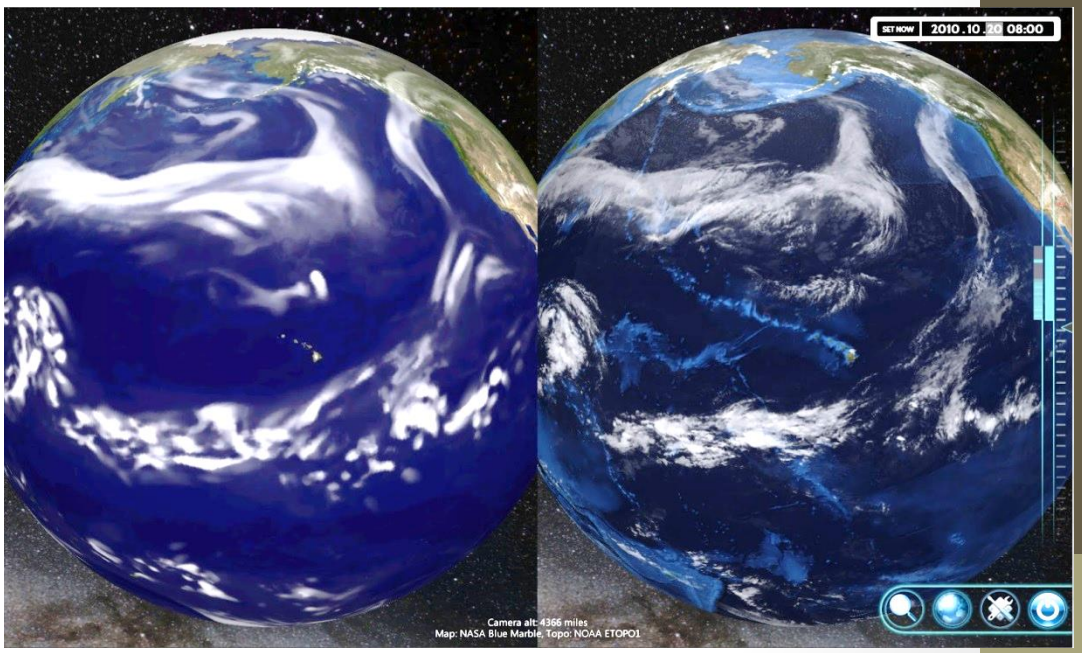
NMME Expansion:

- Evaluate & establish the predictive capability of hurricanes & other high-impact weather events out to several months
- Leveraging activity to build a seamless suite of medium- to long-range weather forecasts



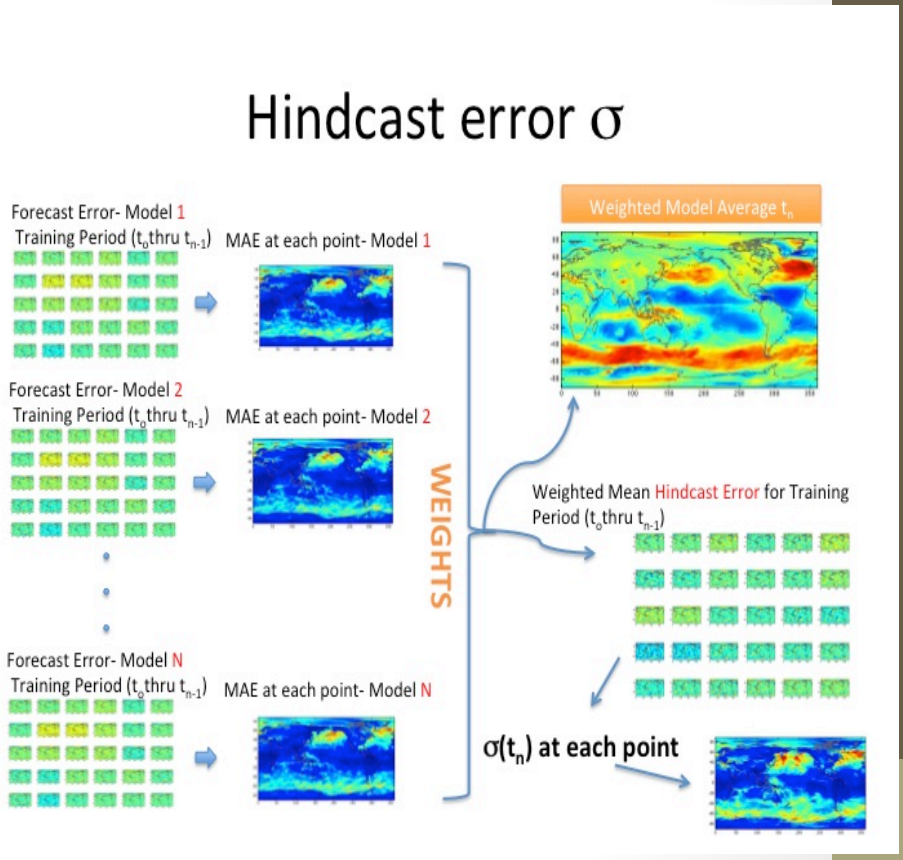
Goal: Test Program

- **Statistical Post-Processing:**
  - Statistical post-processing of high-resolution HIWPP deterministic models and of coarser-resolution ensembles
- **NOAA Earth Information System (NEIS):**
  - A new tools to quickly access and visualize massive amounts of gridded data
- **Verification:**
  - Consistent and uniform assessments across all of the models
- **Real time IT Operations:**
  - Getting data where it needs to be; when it needs to be there
  - Building tools for Open Data Initiative



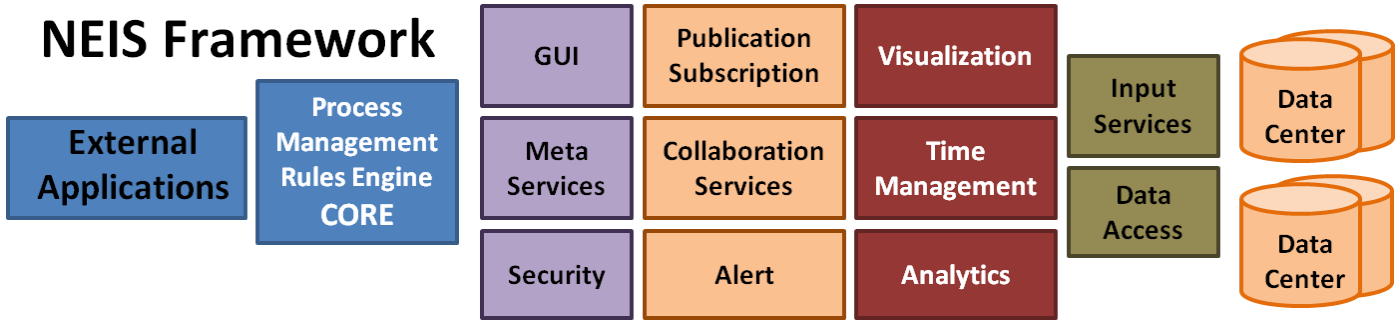
Test Program: Statistical Post-Processing

- Investigation of experimental statistical post-processing techniques
- Inputs: HIWPP research models and available operational model data, both deterministic and ensemble
- Output: “best” model estimate



NOAA Earth Information System (NEIS) -The Concept

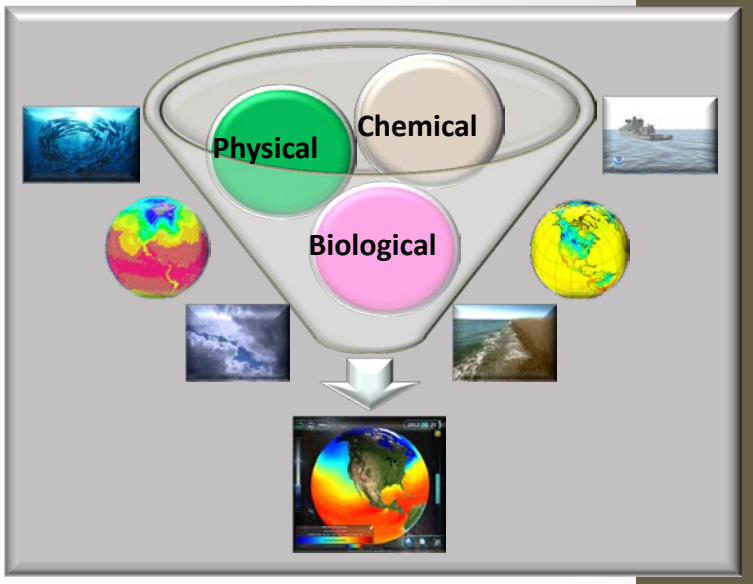
NOAA Earth Information System (NEIS) is a framework of layered services designed to help NOAA's mission areas by facilitating the discovery, access, integration, and under-standing of all NOAA (past, present, and future).



Framework provides the capability to answer questions that require data from different data sources regardless of format or location.

NEIS - http://neis.noaa.gov/

Impacts

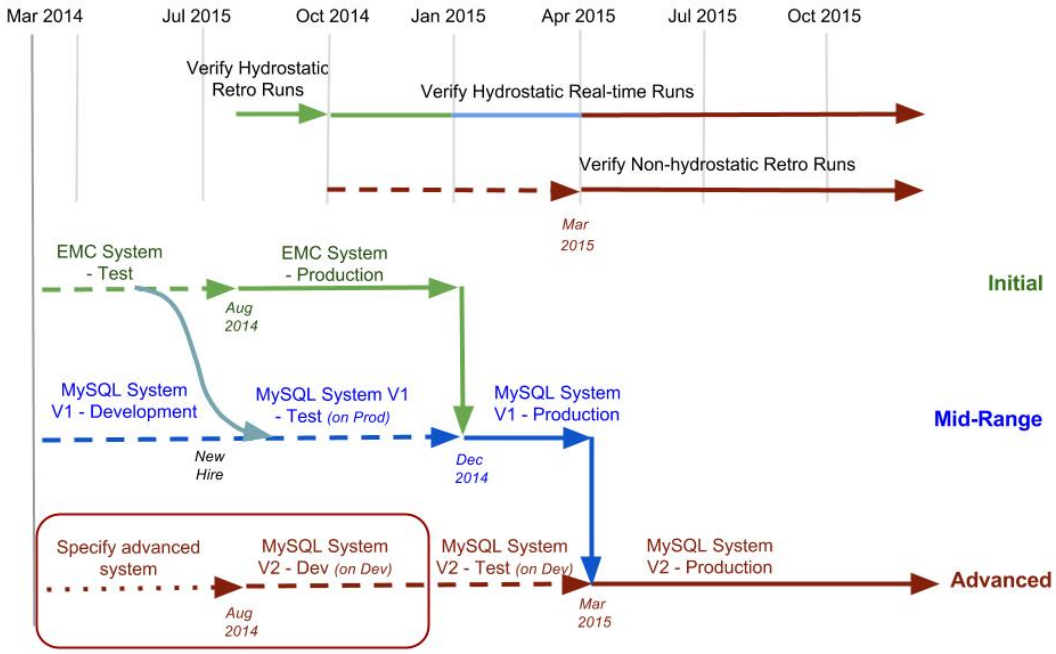


Framework built towards standards, not data.

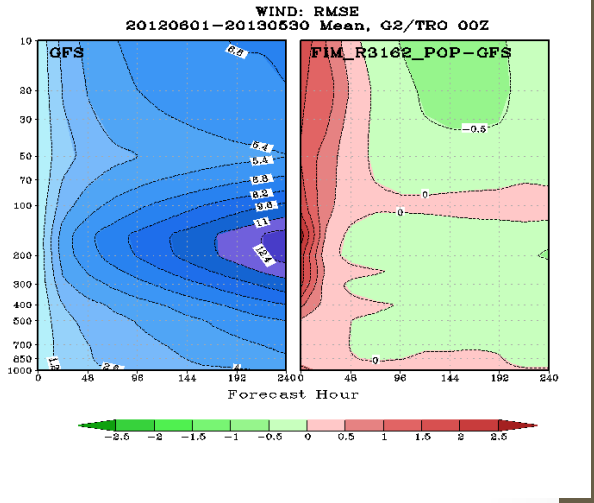
Important Because:

- NOAA and other data ready for action. Services model facilitates agile response to events. Services can be combined or reused quickly, upgraded or modified independently.
- Any data available through framework can be operated on or combined with other data. Integrated standardized formats and access.
- New and existing systems have access to wide variety of NOAA data. Any new data added, easily incorporated with minimal to no changes required.

Verification System



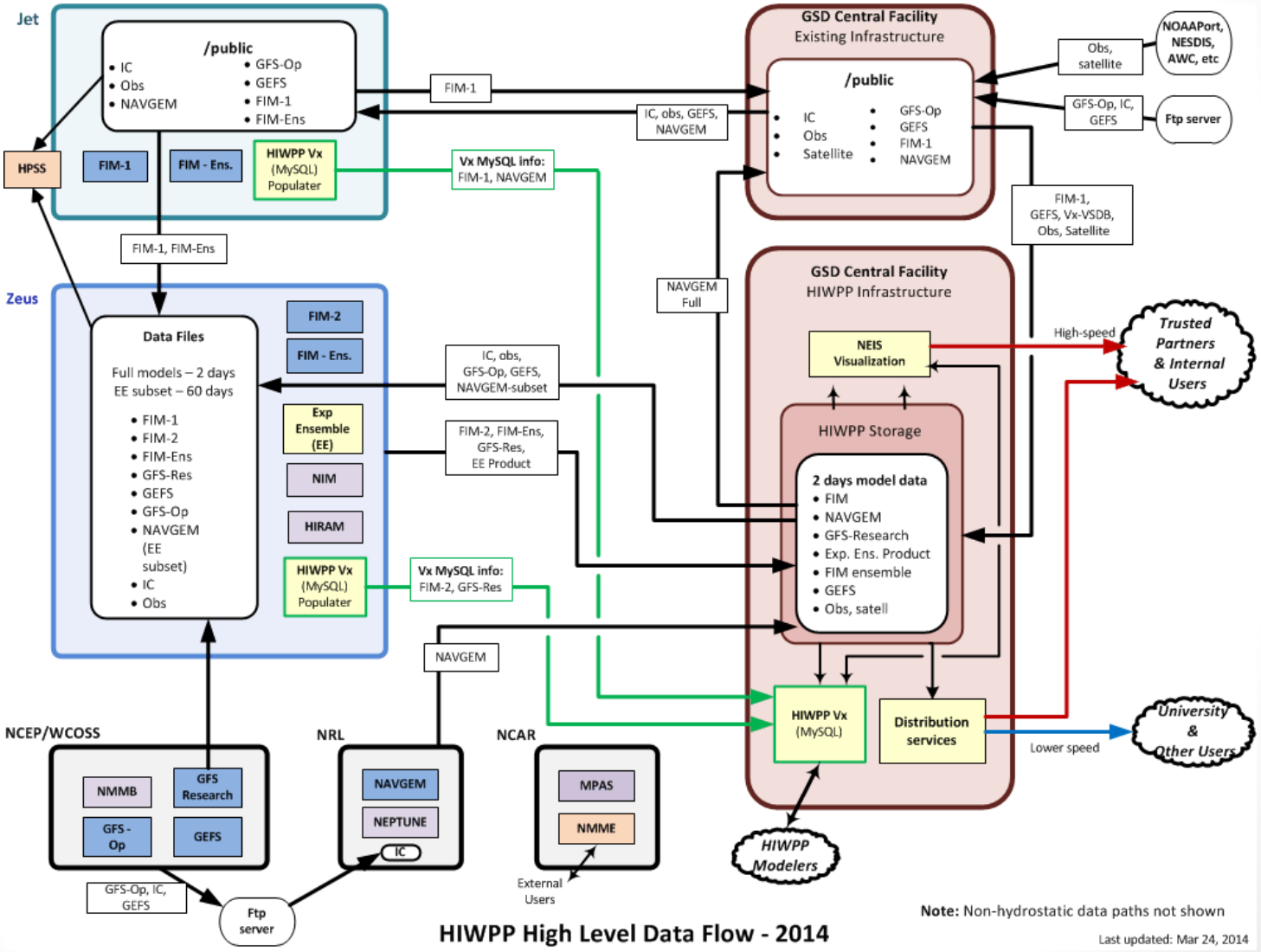
HIWPP Verification System Development Timeline



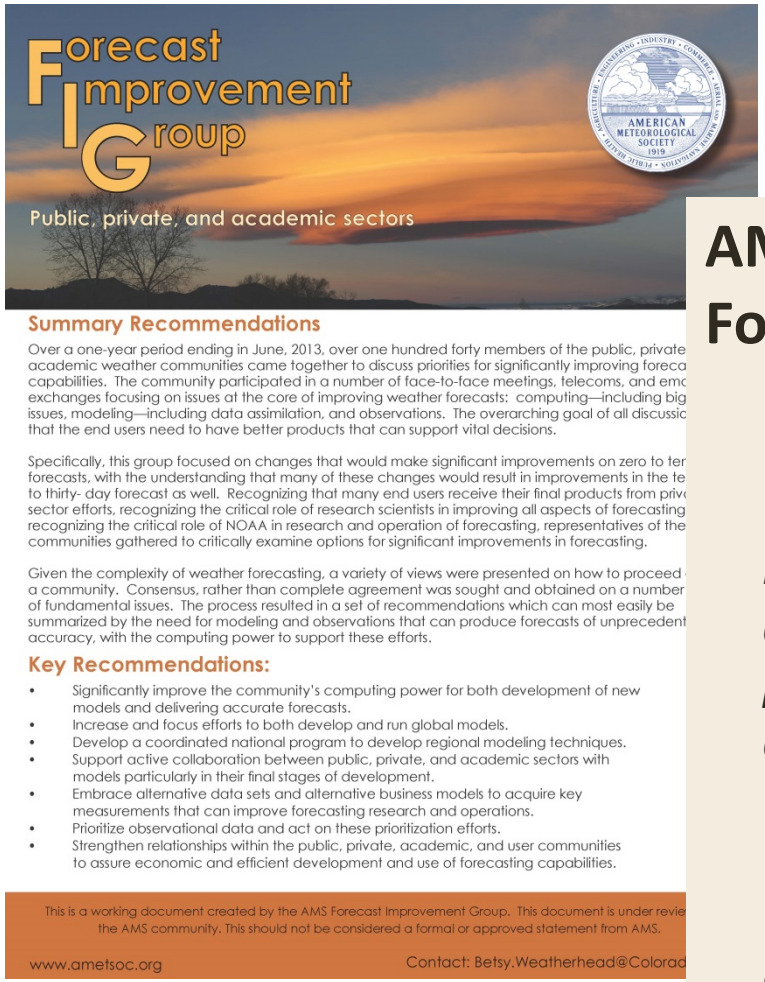
- Building on existing systems at ESRL/GSD and NCEP/EMC
- Developing new methods and observations for verifying global precipitation

Collaborative effort between ESRL/GSD and NCEP/EMC

Real-time Operations:
Data Flow Diagram



HIWPP Open Data Initiative



Forecast Improvement Group

Public, private, and academic sectors

AMERICAN METEOROLOGICAL SOCIETY 1919

Summary Recommendations

Over a one-year period ending in June, 2013, over one hundred forty members of the public, private academic weather communities came together to discuss priorities for significantly improving foreca capabilities. The community participated in a number of face-to-face meetings, telecoms, and emc exchanges focusing on issues at the core of improving weather forecasts: computing—including big issues, modeling—including data assimilation, and observations. The overarching goal of all discussic that the end users need to have better products that can support vital decisions.

Specifically, this group focused on changes that would make significant improvements on zero to ter forecasts, with the understanding that many of these changes would result in improvements in the te to thirty- day forecast as well. Recognizing that many end users receive their final products from priv sector efforts, recognizing the critical role of research scientists in improving all aspects of forecasting recognizing the critical role of NOAA in research and operation of forecasting, representatives of the communities gathered to critically examine options for significant improvements in forecasting.

Given the complexity of weather forecasting, a variety of views were presented on how to proceed a community. Consensus, rather than complete agreement was sought and obtained on a number of fundamental issues. The process resulted in a set of recommendations which can most easily be summarized by the need for modeling and observations that can produce forecasts of unprecedent accuracy, with the computing power to support these efforts.

Key Recommendations:

- Significantly improve the community's computing power for both development of new models and delivering accurate forecasts.
- Increase and focus efforts to both develop and run global models.
- Develop a coordinated national program to develop regional modeling techniques.
- Support active collaboration between public, private, and academic sectors with models particularly in their final stages of development.
- Embrace alternative data sets and alternative business models to acquire key measurements that can improve forecasting research and operations.
- Prioritize observational data and act on these prioritization efforts.
- Strengthen relationships within the public, private, academic, and user communities to assure economic and efficient development and use of forecasting capabilities.

This is a working document created by the AMS Forecast Improvement Group. This document is under revie the AMS community. This should not be considered a formal or approved statement from AMS.

www.ametsoc.org Contact: Betsy.Weatherhead@Colorad

From http://www2.ametsoc.org/cwce/

AMS
Forecast Improvement Group

Key recommendations include:

"Support active collaboration between public, private, and academic sectors with models particularly in their final stages of development"

Real-time Research

HIWPP will support such collaboration through its **Open Data Initiative**

HIWPP Open Data Initiative

- Provides an opportunity to engage in the development of the next generation of global medium-range weather models, and help to improve them
- Two components of HIWPP research will be made available to interested users:
  - NEIS advanced visualization tool with data access
  - Real-time model output, including
    - High resolution hydrostatic models: FIM, GFS, NAVGEM
    - Experimental ensembles
    - Statistical post-processing output
- Encourage users to provide feedback for model developers
- Available January 12, 2015

  For announcements on access: hiwpp.noaa.gov/engage.html

Collaboration

- Collaboration is key for this project
  - Large project
  - Geographically and organizationally diverse
  - Many interconnected work elements

- Areas of collaboration:
  - Project coordination
  - Project management
  - Software development
  - Open Data Initiative

Project Coordination and Information Sharing

Collaboration amongst team members

- Share info such as
  - Project plan
  - Presentations
  - Other key documents
  - Team members and contact info
  - Milestones and status
  - Research results
- Coordination
  - Meetings
  - Reports
- Model intercomparison information

Project Management

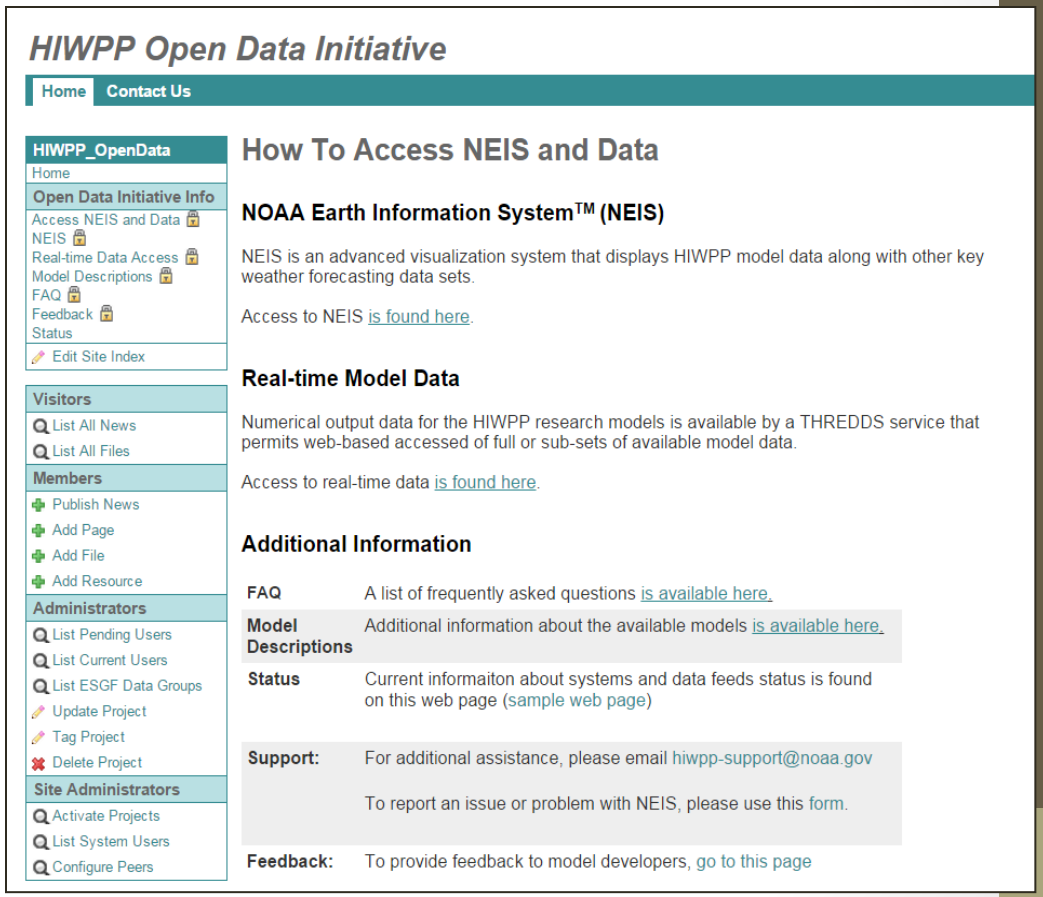
Collaboration between management and team

- Tracking milestones
- Tracking issues and actions
- Gantt charts

Open Data Initiative

Collaboration with public

- User authentication
- User instructions, documentation, and support
- User feedback

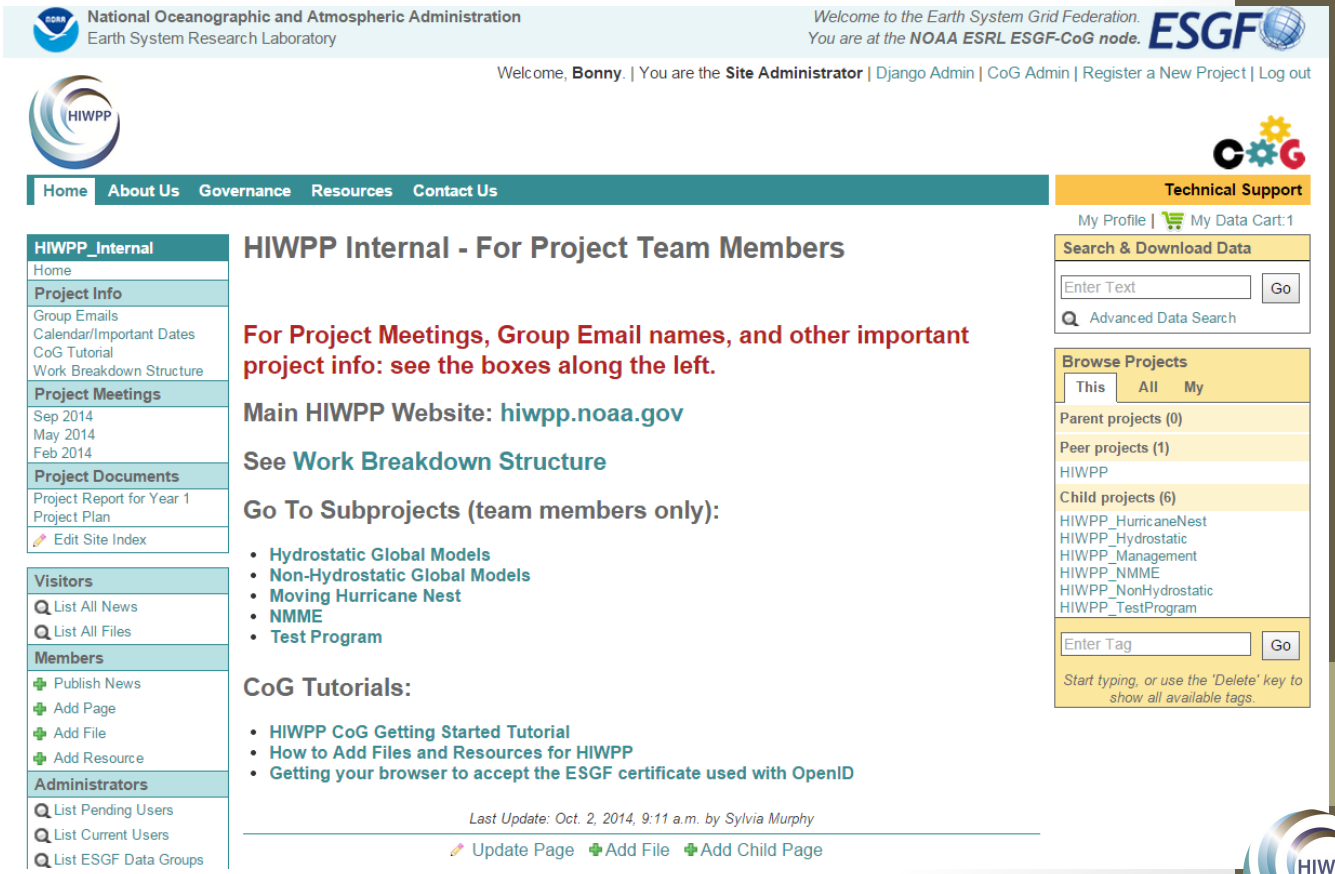


Collaboration Tools – CoG

CoG (Community of Governance)

- Initially used in the project based on modelers experience using it for DCMIP

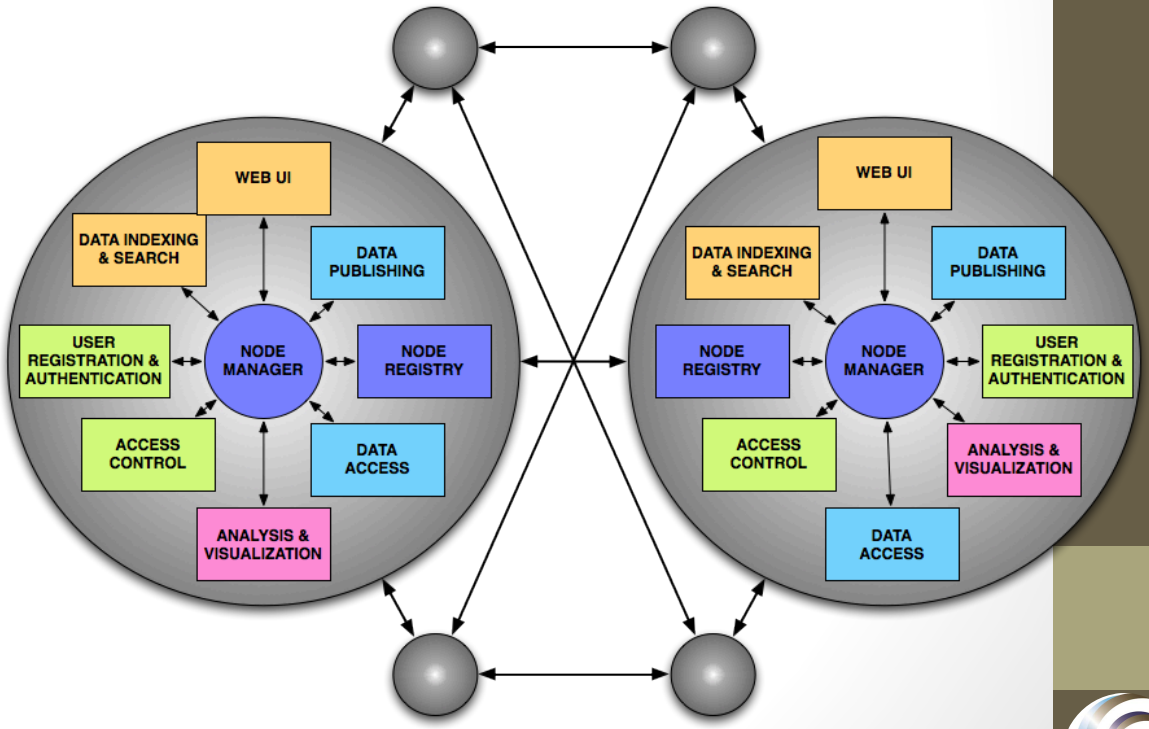
- NOAA's NESII team, headed by Cecelia DeLuca, has worked with HIWPP to develop new features
- Has worked well for project coordination internally



http://cog-esgf.esrl.noaa.gov/projects/hiwpp_internal/

Collaboration Tools – ESGF

- **ESGF (Earth System Grid Federation)**
  - Mechanism for user authentication with OpenID
  - Serving HIWPP real-time data through a THREDDS service in the ESGF network
  - Mechanism for metadata



https://www.earthsystemgrid.org/home.htm

Collaboration Tools – VLab

- Became aware of VLab following seminar by Ken Sperrow at ESRL
- For HIWPP:
  - Project management tools
  - Software development tools
    - Shared development between ESRL/GSD and NCEP/EMC
  - Forums for user feedback
- HIWPP needs to support users outside NOAA
  - Partners in project
  - Public for Open Data Initiative
- Integration of CoG/ESGF and VLab features?
  - OpenID

More Information:

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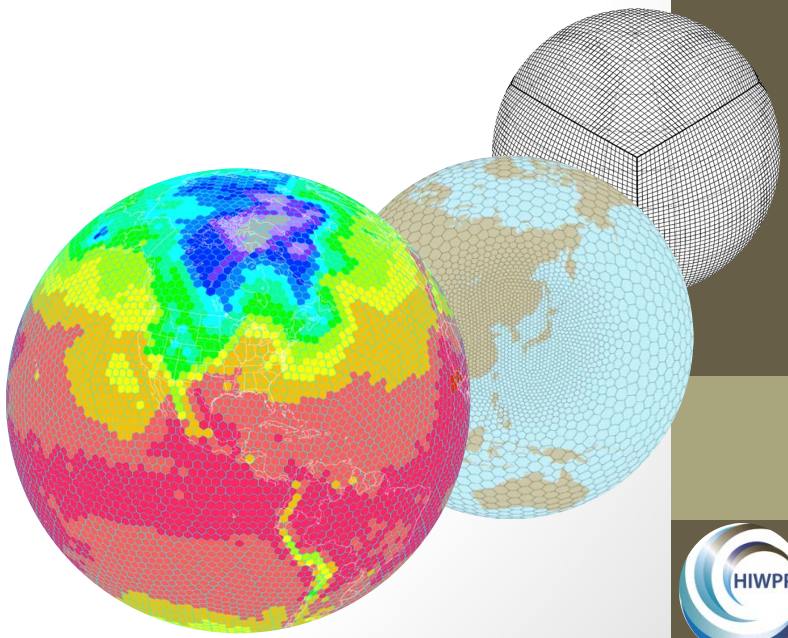
On the Web:

http://hiwpp.noaa.gov/



Questions?

Thank You!

ADDITIONAL SLIDES

Structure: HIWPP Partnerships

Organization	Role/ Expertise	Notes
NOAA OAR/Laboratories	Applied R&D expertise (model development, high resolution nesting, physics, statistical post-processing, new data assimilation); verification; HIWPP data & visualization infrastructure; R2O	AOML, ESRL/GSD, ESRL/PSD, GFDL
NOAA NWS/NCEP	Operational numerical weather prediction and model development (GFS, NMMB, NAEFS, physics, data assimilation); verification, R2O	EMC; CPC
NOAA Cooperative Institutes	Academic and applied R&D in partnership with NOAA labs and centers	CICS-P, CIMAS, CIRA, CIRES
NSF/UCAR	R&D model development of non-hydrostatic model (MPAS); NMME data system	NCAR
Navy	R&D and operational modeling with NAVGEM (hydrostatic) & NUMA/NEPTUNE (non-hydrostatic)	NRL
Weather Enterprise	Interface with public perceptions and commercial needs, and academia; evaluation and feedback	HIWPP Open Data Users, AMS community (FIG)

Quick Dive: HIWPP Hydrostatic Models

Model	Agency	Resolution (at 40° Lat.)	Initial Output Freq. & Resolution		Vertical Levels	NEMS ready	Initial Condit.	Notes
FIM Flow-following, finite-volume Icosahedral Model	ESRL/GSD	15km to 16day (10 km in future)	1 hr	1/8°	64	Y	GFS T1534	Icosahedral grid; isentropic sigma vertical coordinates; finite volume core GFS 2012 (w/updates) physics;
GFS Global Forecast System	NCEP	13km to 10 days 27km to 16 days	1 hr (0-12 hrs) 3 hrs (12+ hrs)	1/4°	64	Y	GFS T1534	Spectral core (spherical harmonic basis functions w/transformation to a Gaussian grid); vertical sigma pressure hybrid coordinate; GFS 2014 physics;
NAVGEM Navy Global Environmental Model	Navy	25km	3 hrs	1/4°	64	N	GFS T1534	semi-Lagrangian, semi-implicit core; vertical sigma pressure hybrid coordinate ; NAVGEM physics package

Quick Dive:
HIWPP Non-Hydrostatic Models

Model	Organization	Characteristics
HiRAM High Resolution Atmospheric Model	GFDL	Finite-volume dynamical core on a cubed-sphere grid. Developed as a global climate model, with capability to simulate statistics of tropical storms; parameterized convection helps the resolved scale convection, parameterization of shallow convection by Bretherton et. al. (2004)
MPAS Model for Prediction Across Scales	NCAR	Comprised of geophysical fluid-flow solvers that use spherical centroidal Voronoi tesselations (nominally hexagons) to tile the globe and C-grid staggering of the prognostic variables; supports non-uniform horizontal meshes and/or nests; terrain following height coordinate or hybrid coordinate relaxed at constant height. Advanced WRF physics package
NEPTUNE Navy Environmental Prediction sysTem Utilizing NUMA corE	Navy	Based on NUMA (Non-hydrostatic Unified Model for the Atmosphere), a spectral element/discontinuous Galerkin dynamical core; uses cubed-sphere grid; adaptive mesh refinement under development
NIM Non-hydrostatic Icosahedral Model	ESRL/GSD	Multi-scale model based on 3D finite-volume solver. Vertical coordinate system is physical heights. GFS and WRF physics options. Evolving from the FIM, NIM was designed for and is currently being tested on massively parallel fine grain computers (GPU)
NMMB Non-hydrostatic Multi-Model on B-Grid	NCEP	Based on NEMS framework; global versions uses lat-long grid. Horizontal differencing preserves properties of differential operators and conserves energy and enstrophy; 1-way and 2-way nesting supported; WRF NMM's physics

Key HIWPP Milestones

Test Program: New hardware purchased, installed, and tested	6/30/14
Hydrostatic Global Models: Real-time research high-resolution runs of hydrostatic models begin; real-time cycling of 4D-En-Var begins; initial verification system in place	10/1/14
Non-Hydrostatic Global Models: Idealized test cases for non-hydrostatic models are completed	10/1/14
Test Program: NEIS (visualization) version 1 completed including Experimental Ensemble output; real-time data distribution system to Trusted Partners in place	10/1/14
Moving Hurricane Nests: Preliminary tests of hurricane nests within a research version of NMMB completed	12/30/14
NMME Expansion: Evaluations of NMME-based hurricane seasonal outlook completed	1/31/15
Test Program: Advanced verification system with new capabilities completed	3/30/15
Hydrostatic Global Models: Report on hydrostatic real-time test results submitted to journal	9/30/15
NMME Expansion: Evaluation of NMME-based severe weather environmental factors completed	9/30/15
Test Program: NEIS version 2 completed	9/30/15
Non-Hydrostatic Global Models: Completion of retrospective forecasts for non-hydrostatic models and report on all testing results. Selection of 1-2 models for porting to MPFG	10/30/15
Moving Hurricane Nests: Near real-time demo of multi-nested NMMB/NEMS model for hurricanes and report	12/30/15
Non-Hydrostatic Global Models: Optimization of code for selected non-hydrostatic model/s on new MPFG system completed; ready for runs on new system in March 2016	3/30/16