



The NOAA Operational Numerical Guidance System

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NOAA Center for Weather and Climate Prediction (NCWCP)



A.K.A.—the new building

- Four-story, 268,762 square foot building in Riverdale, MD will house 800+ Federal employees, and contractors
 - 5 NCEP Centers (NCO, EMC, HPC, OPC, CPC)
 - NESDIS Center for Satellite Applications and Research (STAR)
 - NESDIS Satellite Analysis Branch (SAB)
 - OAR Air Resources Laboratory
- Includes 40 spaces for visiting scientists
- Includes 465 seat auditorium & conference center, library, deli, fitness center and health unit





NOAA Operational Numerical Guidance Supports the Agency Mission



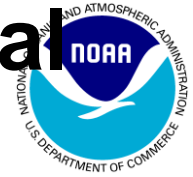
- **Numerical Weather Prediction**
 - **Global Anomaly Correlation Score – “Internal” metric**
 - **Related to ability to meet service-based metrics (below)**

- **National Weather Service GPRA* Metrics**
 - (* Government Performance & Results Act)
 - **Hurricane Track and Intensity Forecast Accuracy**
 - **Winter Storm Warning Lead Time and Accuracy**
 - **Precipitation Threat Accuracy**
 - **Flood Warning Lead Time and Accuracy**
 - **Marine Wind Speed and Wave Height Forecast Accuracy**

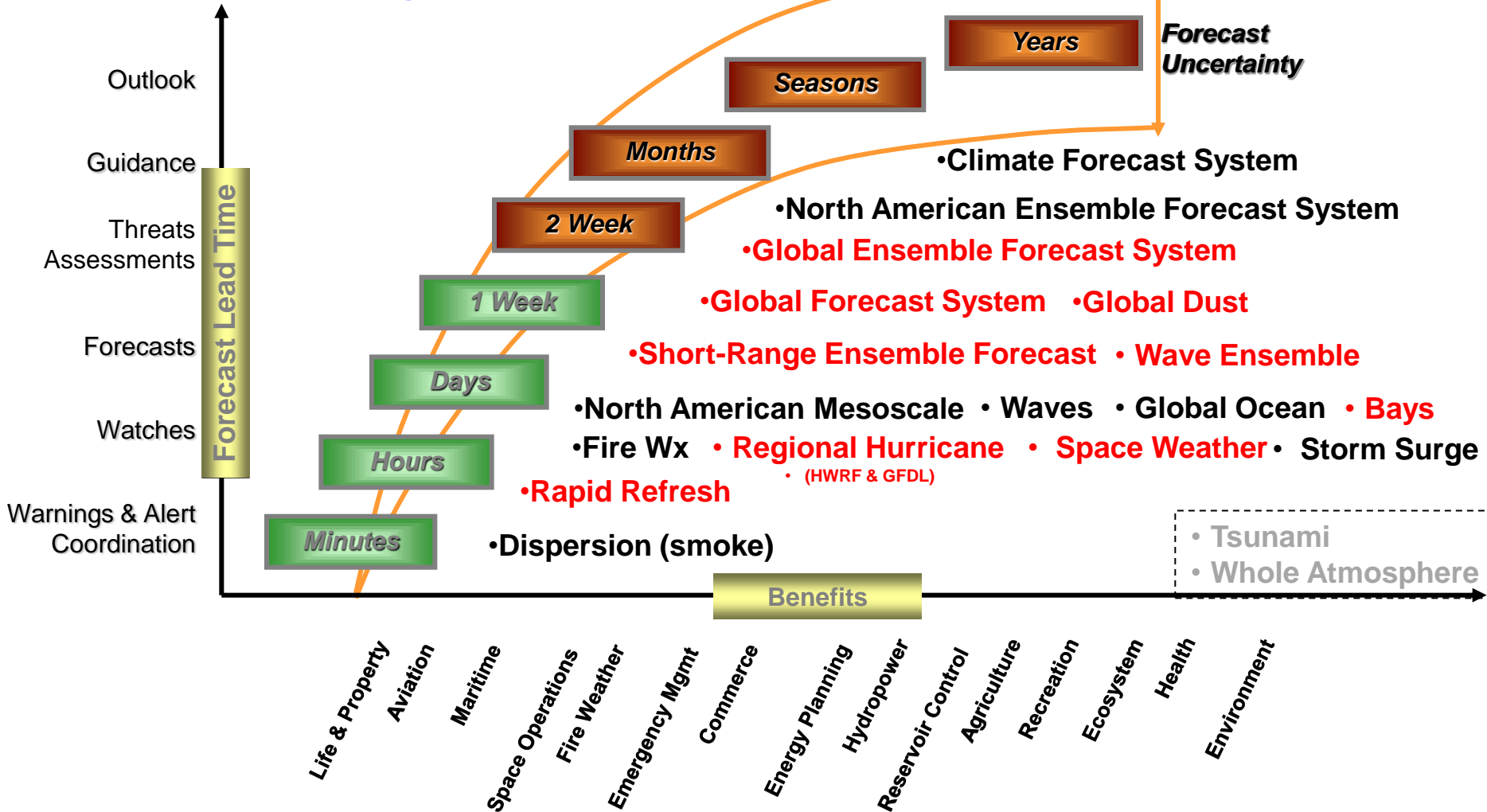
- **Operational numerical guidance:**
 - **Is a foundational tool used by the NWS to meet the above goals**
 - **Used by the public and private industry to improve public safety, quality of life and make business decisions that drive US economic growth**



Seamless Suite of NOAA Operational Numerical Guidance Systems



Spanning Weather and Climate

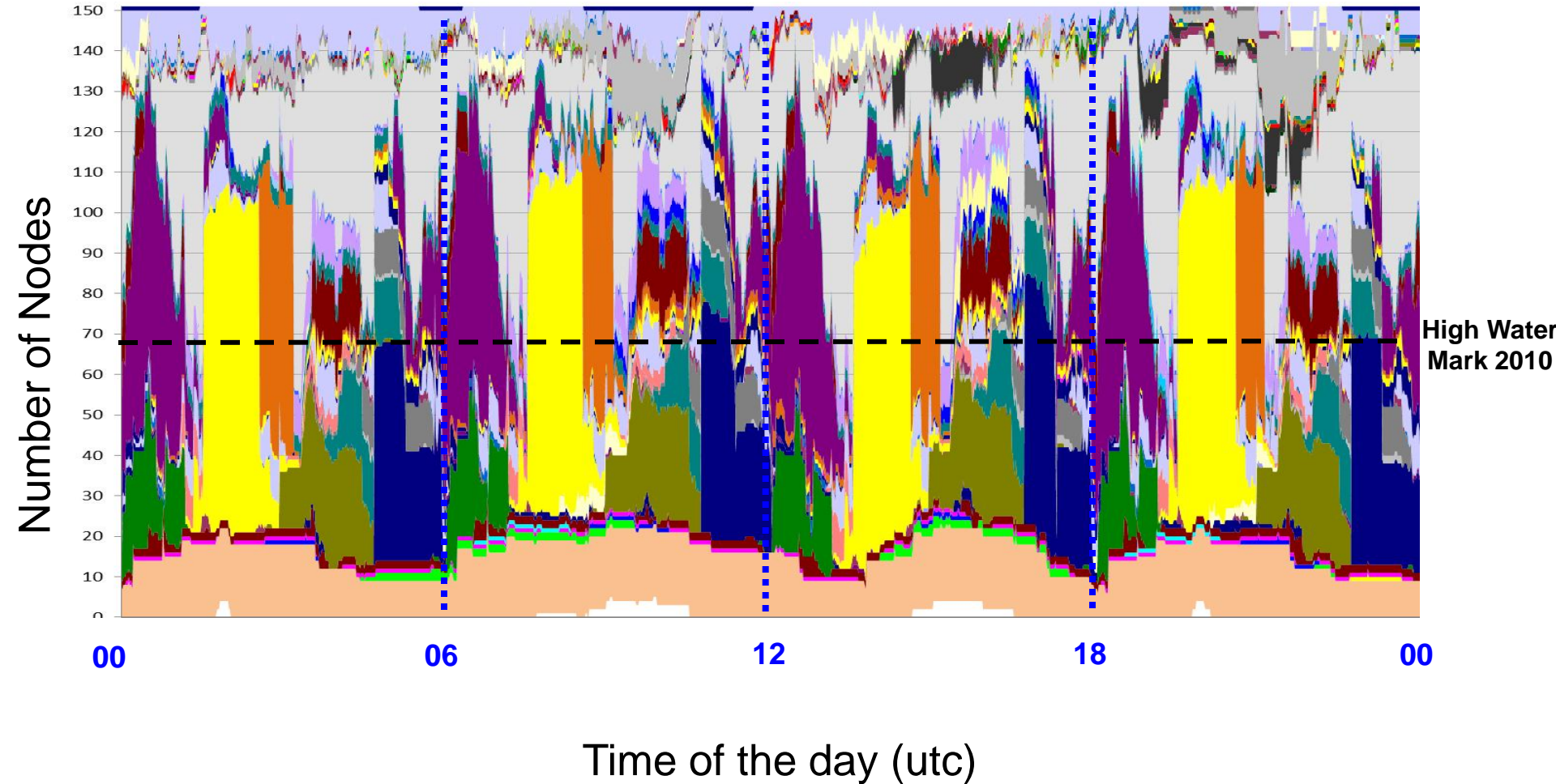




Production Suite on Supercomputer



August 2012





NOAA Operational Computing: IBM iDataPlex System



Location

- Primary
 - Reston, VA (IBM provided facility)
- Backup
 - Orlando, FL (IBM provided facility)

Configuration

- Identical Systems (per site)
 - IBM iDataPlex/Intel Sandy Bridge/Linux
 - 208 trillion calculations/sec
 - 10,048 processing cores
 - 2.59 petabytes of storage
- Performance Requirements
 - Minimum 99.9% Operational Use Time
 - Minimum 99.0% On-time Product Generation
 - Minimum 99.0% Development Use Time
 - Minimum 99.0% System Availability
 - Failover tested regularly

Inputs and Outputs

- Processes 3.5 billion observations/day
- Produces over 15 million products/day

Significance

- Where United States weather forecast process starts for the protection of lives and livelihood
- Produces model guidance at global, national, and regional scales

Examples:

- Hurricane Forecasts
- Aviation / Transportation
- Air Quality
- Fire Weather





Global Data Assimilation System Upgrade



Implemented 22 May 2012

- **Hybrid system**
 - Most of the impact comes from this change
 - Uses ensemble forecasts to help define background error
- **NPP (ATMS) assimilated**
 - Quick use of data after launch
- **Use of GPSRO Bending Angle rather than refractivity**
 - Allows use of more data (especially higher in atmos.)
 - Small positive impacts
- **Satellite radiance monitoring code**
 - Allows quicker awareness of problems (run every cycle)
 - Monitoring software can automatically detect many problems
- **Post changes**
 - Additional fields requested by forecasters (80m variables)
- **Partnership between research and operations**



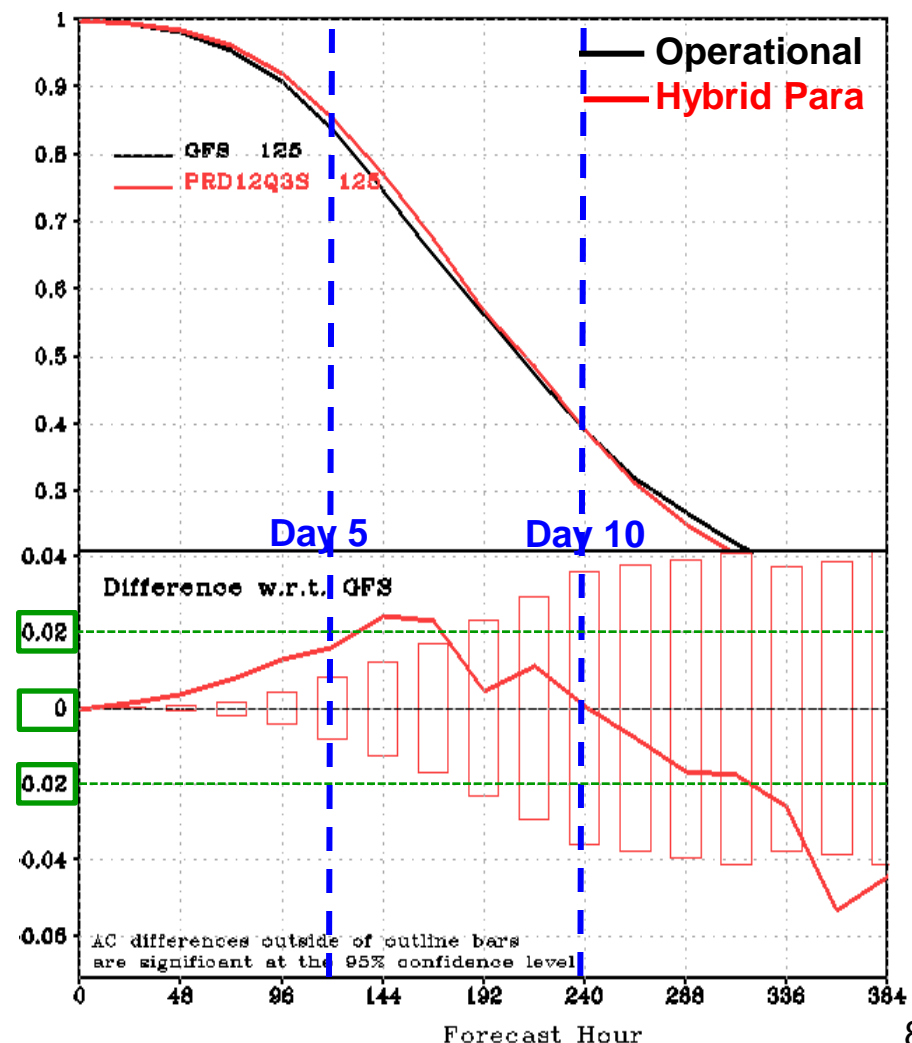
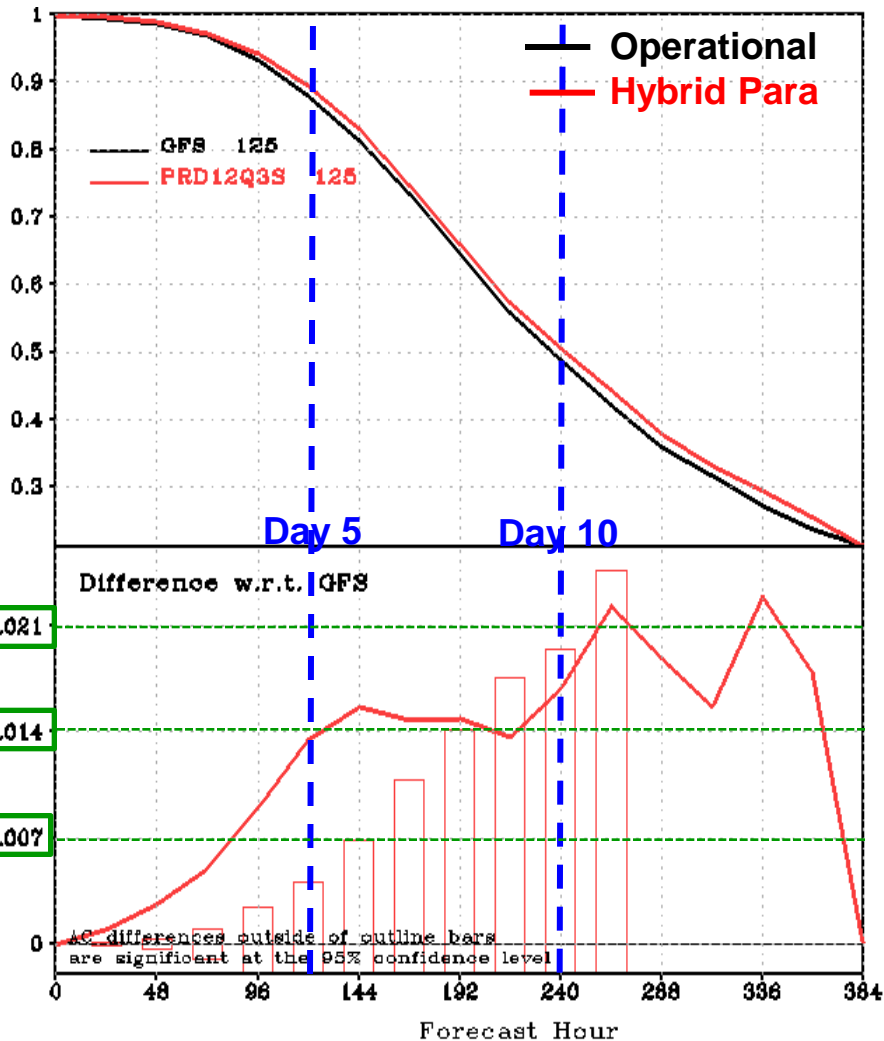
500 hPa Anomaly Correlation for Hybrid GDAS Parallel



8 Jan to 15 May 2012 (00Z cycles only)

Northern Hemisphere

Southern Hemisphere





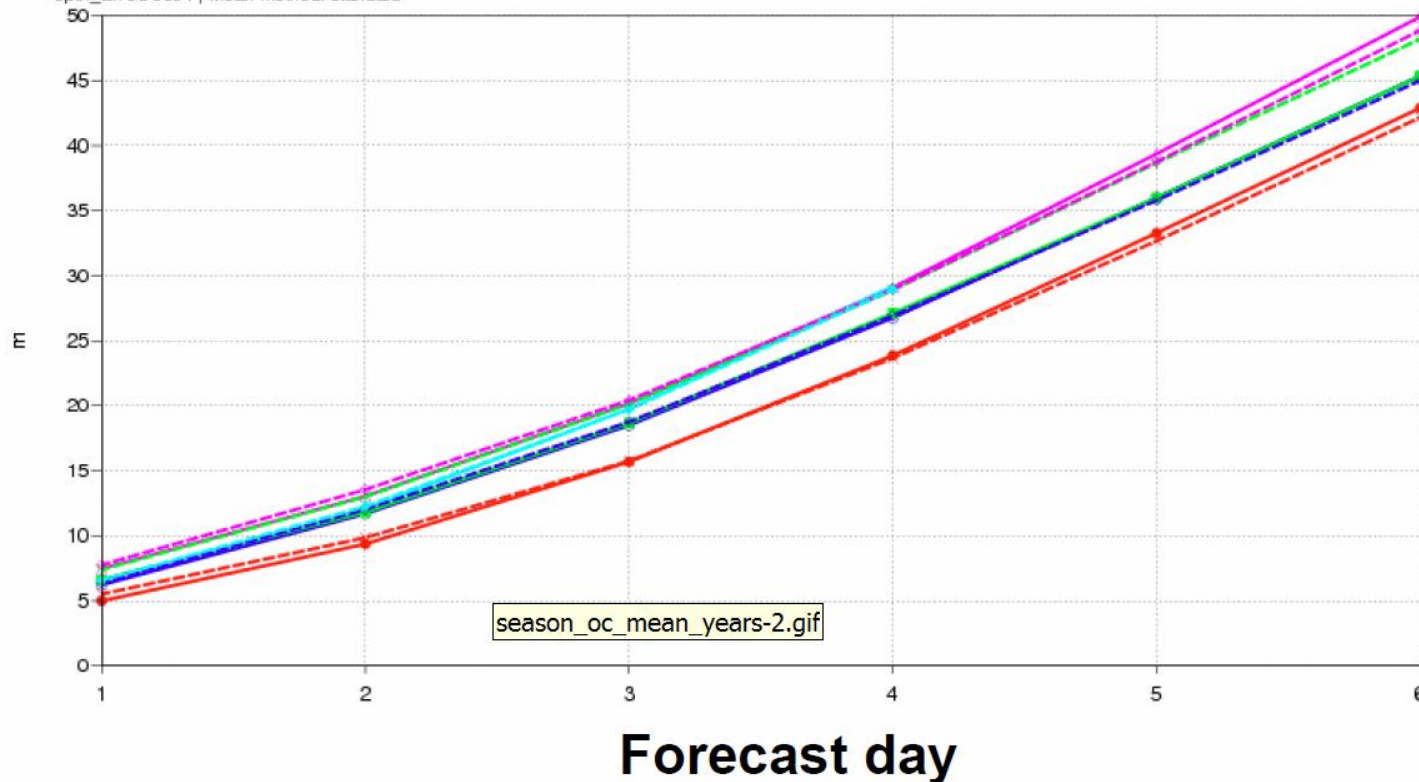
Hybrid Data Assimilation Impact



Comparison with other forecasting centres

500hPa geopotential
Root mean square error
NHem Extratropics (lat 20.0 to 90.0, lon -180.0 to 180.0)
Date: 20110601 00UTC to 20120831 12UTC
oper_an od 0001 | Mean method: standard

- JJA 12 M-F
- JJA 12 CMC
- JJA 12 NCEP
- JJA 12 UKMO
- JJA 12 ECMWF
- - JJA 11 M-F
- - JJA 11 CMC
- - JJA 11 NCEP
- - JJA 11 UKMO
- - JJA 11 ECMWF





Near-Term Operational Global Data Assimilation and Model



- Next window of opportunity for GDAS/GFS upgrade is Nov 2013 to May 2014
- Possible model changes:
 - T878 Eulerian, L64 (ESMF-NEMS framework)
 - T1148 Semi-Lagrangian, L64 (ESMF-NEMS framework)
 - physics upgrades for the radiation and precipitation parameterizations
- Data assimilation upgrade candidates:
 - Initial Cloudy Radiance assimilation
 - Enhanced and additional satellite winds
 - CrIS observations from NPP
 - METOP-B observations
 - SSMI/S observations
 - New integrated bias correction
 - Water Vapour analysis enhancements
 - GPS-RO enhancements
 - Climatological CO₂, Methane, Nitrous Oxide and CO for input in CRTM
 - Consistent cloud water retrieval in quality control



Global Ensemble Systems



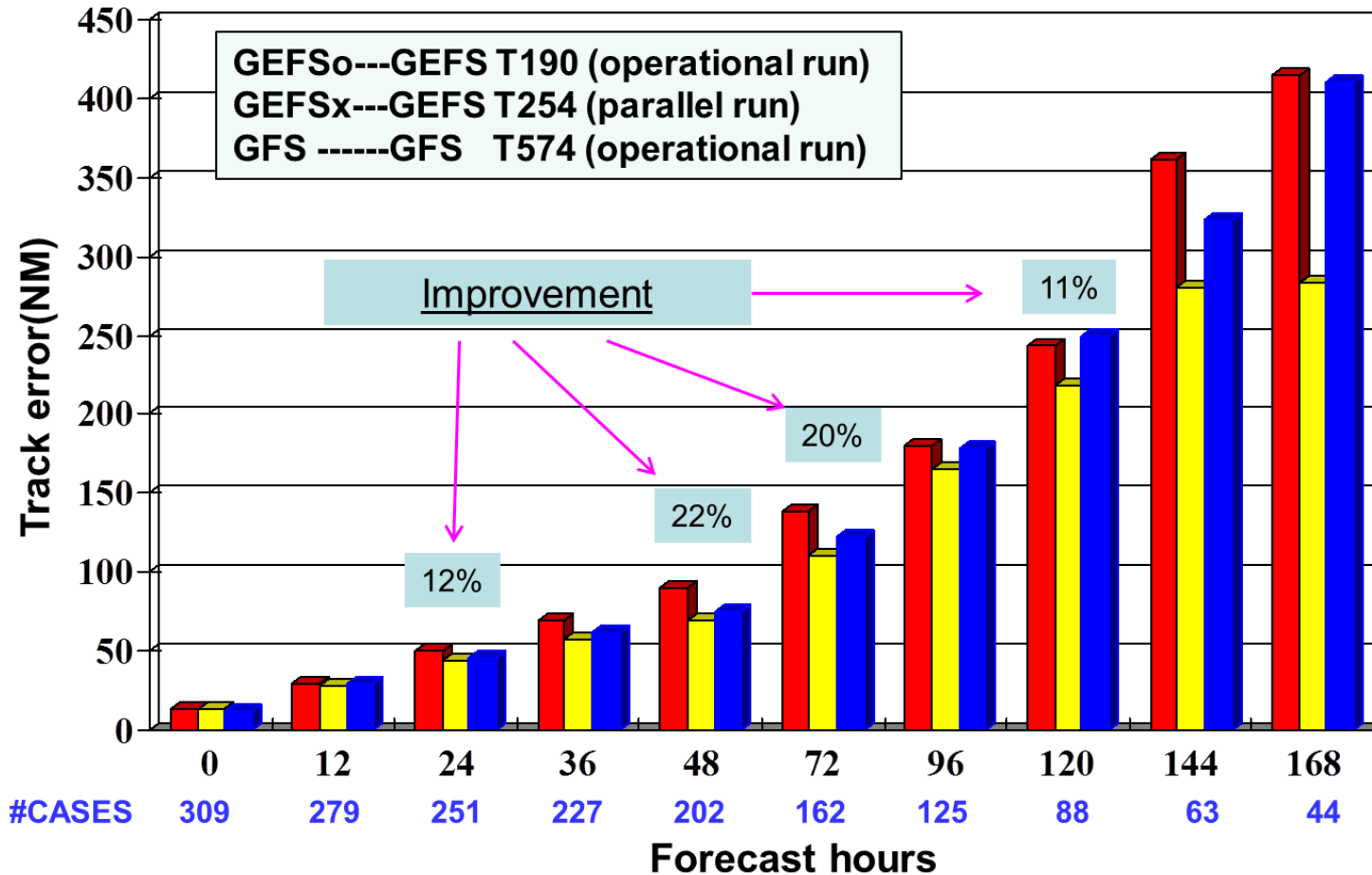
| Parameter | NCEP | CMC | NAEFS |
|------------------------------|--|------------------------------------|-------------------|
| Model | GFS | GEM | NCEP+CMC |
| Initial uncertainty | ETR | EnKF | ETR + EnKF |
| Model uncertainty/Stochastic | Yes (Stochastic Pert) | Yes (multi-physics) | Yes |
| Tropical storm | Relocation | None | |
| Daily frequency | 00,06,12 and 18UTC | 00 and 12UTC | 00 and 12UTC |
| Resolution | T254L42 (d0-d8)~55km T190L42 (d8-16)~70km | (d0-d16) ~ 66km | 1*1 degree |
| Control | Yes | Yes | Yes (2) |
| Ensemble members | 20 for each cycle | 20 for each cycle | 40 for each cycle |
| Forecast length | 16 days (384 hours) | 16 days (384 hours) | 16 days |
| Post-process | Bias correction (same bias for all members) | Bias correction for each member | Yes |
| Last Upgrade | February 14 th 2012 | August 17 th 2011 | |



GEFS Upgrade: 2011 Atlantic Basin TC Track Errors

■ GEFS_o ■ GEFS_x ■ GFS

GEFS_x runs once per day before Oct.





Global Dust/Aerosol Guidance

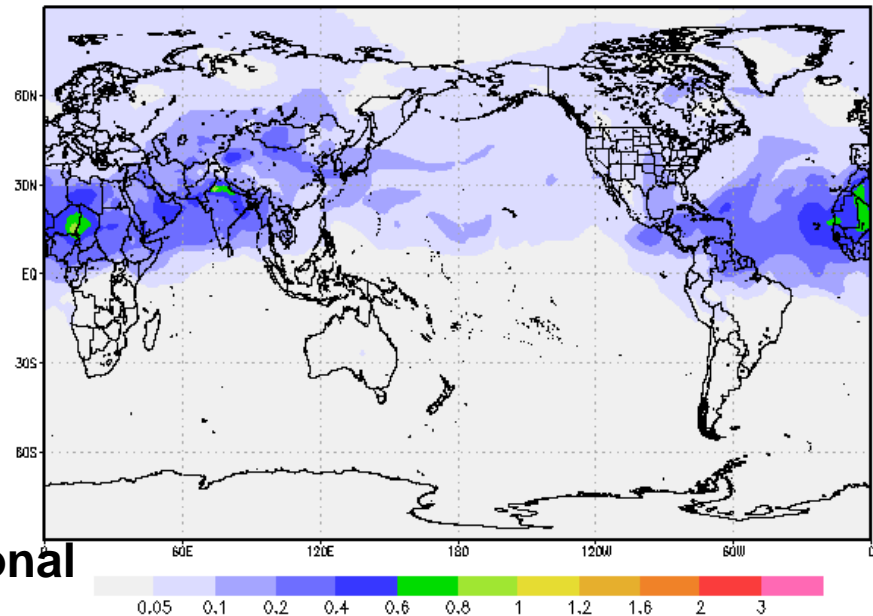
Scheduled Implementation 11 September 2012



Experimental (non-operational)

- Executable compiled from NEMS trunk code repository
- 120-hr dust-only forecast
- Once per day (00Z)
- 3-hourly products: 3d distribution of dust aerosols (5 bins from 0.1 – 10 μm)
- Automatic output archive, post processing and web update since June 11, 2011
- Same physics and dynamics as operational GFS with the following exceptions:
 - Lower resolution (T126 L64)
 - Use RAS with convective transport and tracer scavenging
 - Aerosol-radiation feedback is turned off

2011061700 00hr Fcst ctrl Column AOD at 550nm



Column AOD @ 550nm

National Multi-Model Ensemble (NMME)

that leverages the best US climate models for improved operational predictions on intraseasonal-to-interannual time scales

- **Phase-I (FY11):** Established collaborations and NMME protocol
- **Phase-II (FY12-13):** A more “purposeful” MME Experiment with improved models and an optimal experimental design to address key research questions

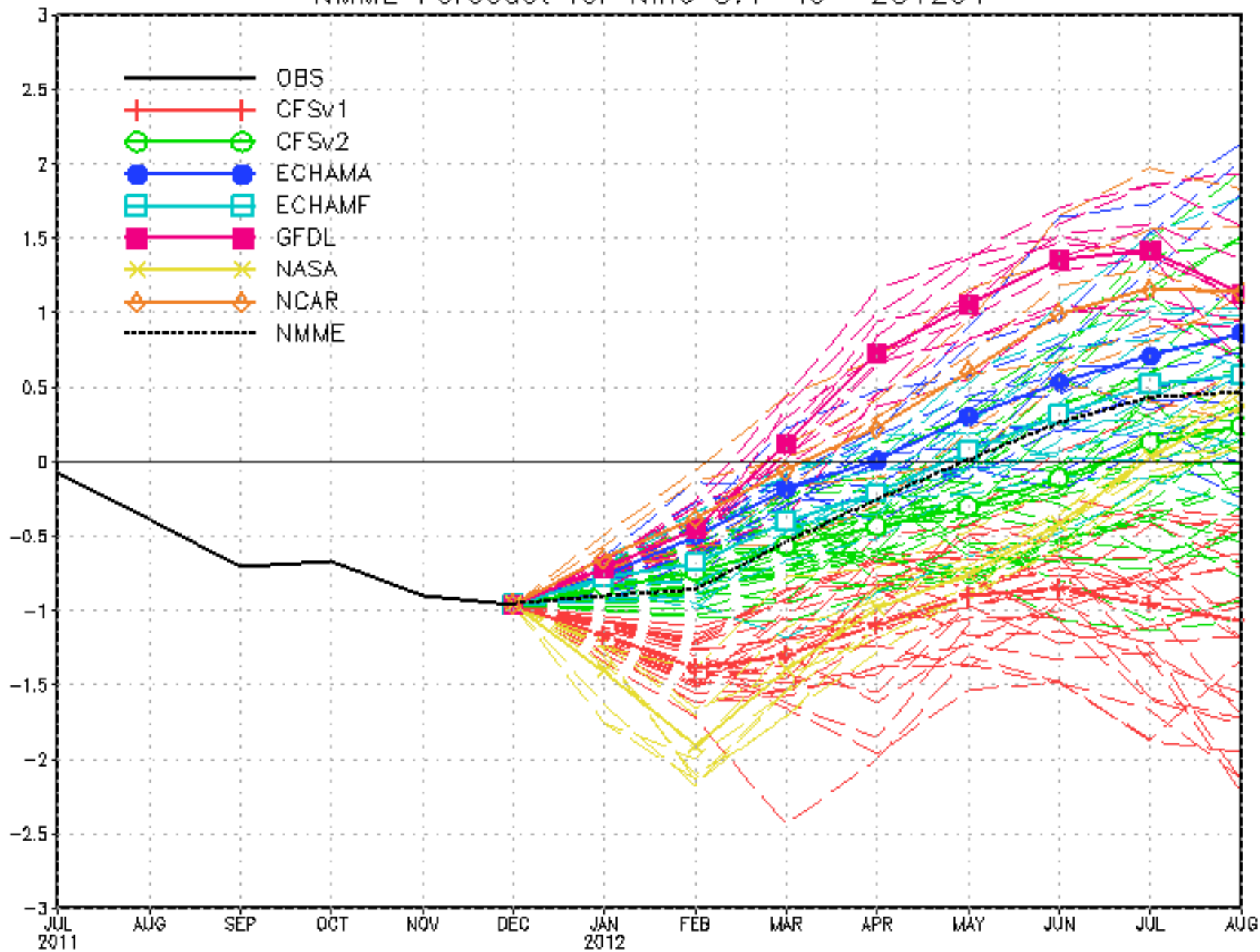
- **Real-time forecasts used by NCEP/CPC operational forecasters**
- **Data (Hindcast and Forecasts) Readily Available to the Community**
- **NMME data for ISI climate predictability and prediction research**

NMME Partners

- **University of Miami**
- **COLA**
- **NCAR**
- **IRI**
- **U of Colorado – CIRES**
- **NASA – GMAO**
- **NOAA/NCEP (CPC & EMC)**
- **NOAA/GFDL**
- **Princeton University**

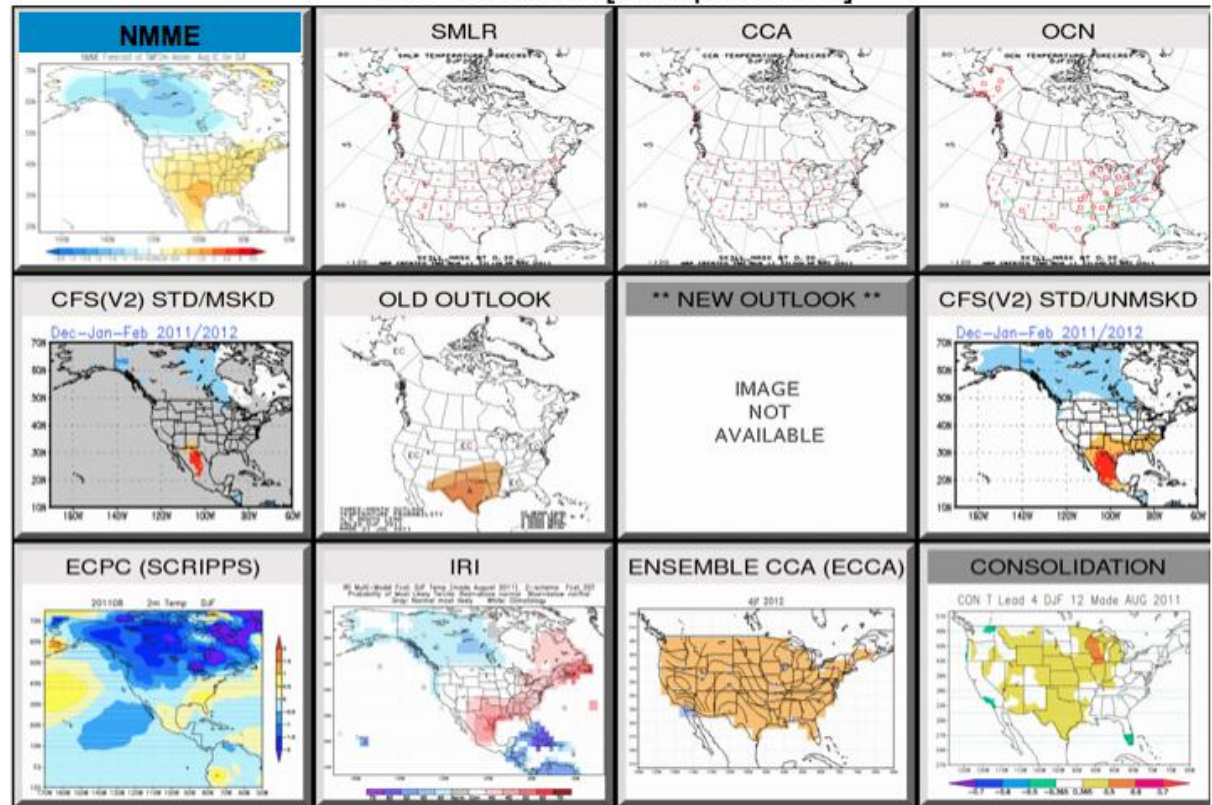
The NMME project is sponsored by NOAA/MAPP, DOE, NASA, and NSF

NMME Forecast for Nino 3.4 IC= 201201



CPC Real-Time Seasonal Forecasting Tools

DJF Season [Temperature]



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Used in Monthly Ocean Briefing

Used for African Desk

CPC Seasonal Prognostic Map Discussion (PMD):

“PROGNOSTIC TOOLS USED FOR U.S. TEMPERATURE AND PRECIPITATION OUTLOOKS FOR JFM THROUGH AMJ 2012 WERE PRIMARILY BASED ON THE NEW NATIONAL MULTI-MODEL ENSEMBLE MEAN FORECAST (NMME). THE FORECASTS STRONGLY AGREE WITH ...”



Operational Ocean Tracer Capability *Implemented August 2012*

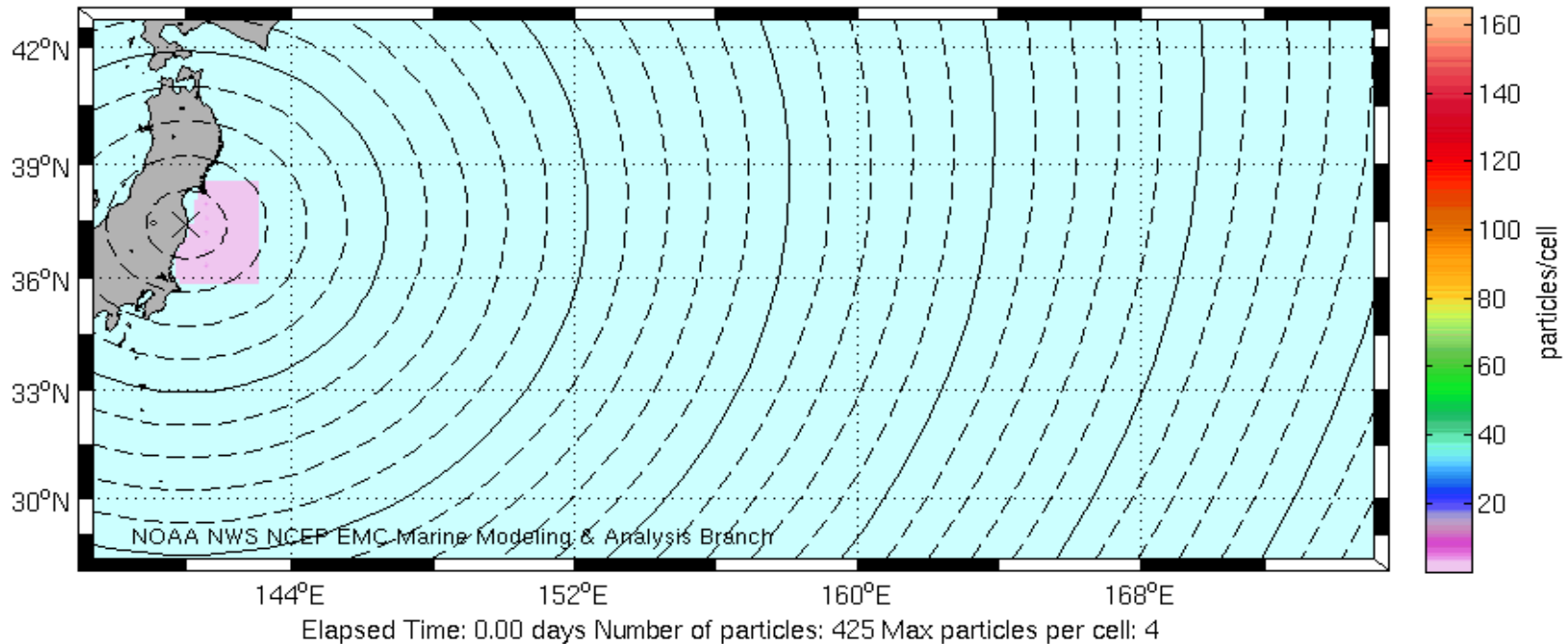


Plume Density Animation for First 54 Days after Initial Release

Plume density (particles/cell) tracked on 0.08° model grid, seeded every 0.125° , (smoothed)

Date: 11 Mar 2011 00Z

Range rings spacing 100 km centered on reactor site



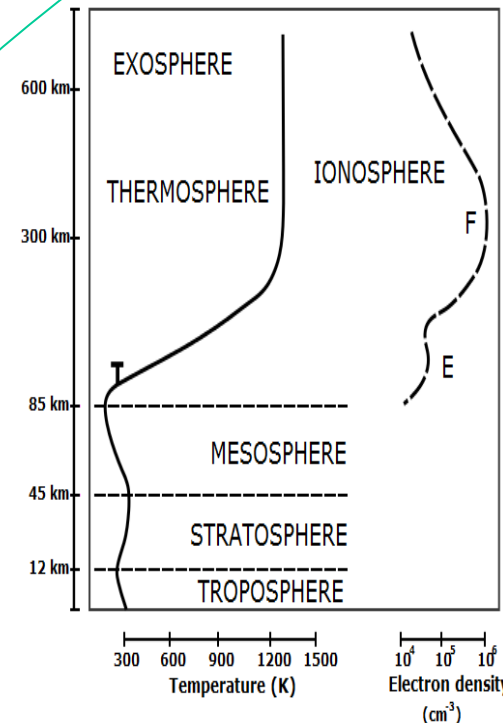
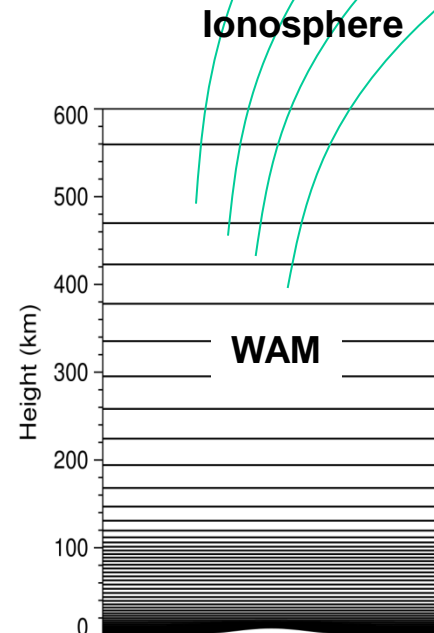
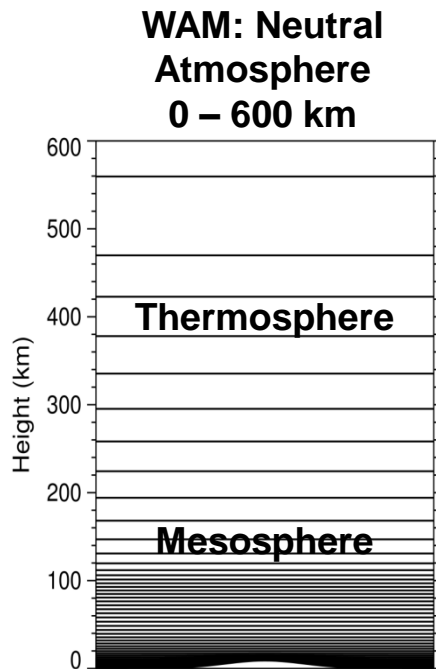
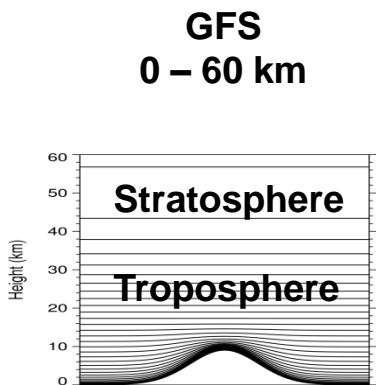


Coupling of Atmospheric Dynamic to the Ionosphere System

Model development includes collaboration with UK researchers and the UK Met Office

Whole Atmosphere Model (WAM = Extended GFS)
 Ionosphere Plasmasphere Electrodynamics (IPE)
 Integrated Dynamics in Earth's Atmosphere (IDEA = WAM+IPE)

Ionosphere Plasmasphere
 Electrodynamics (IPE) Model
 Plasmasphere





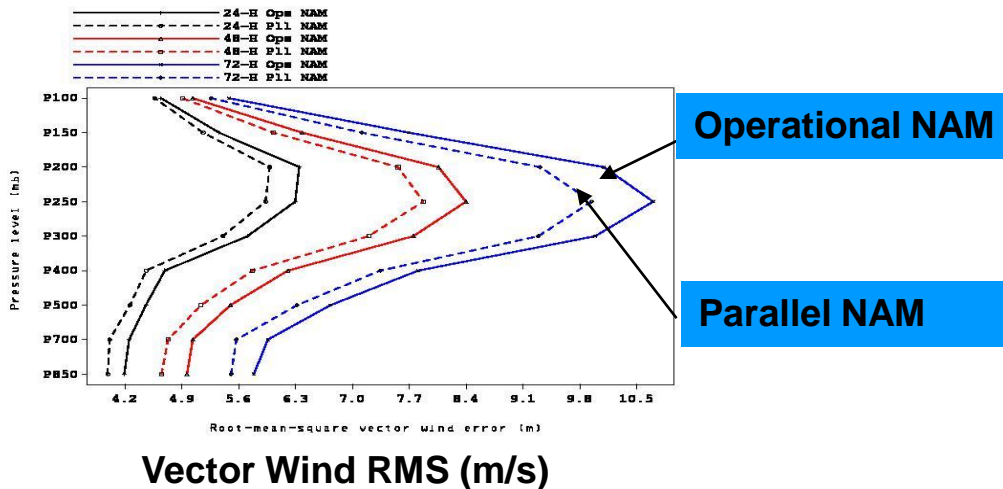
Preliminary Testing for NAM FY13 Upgrade Package



Verification from 1 June – 25 October 2012

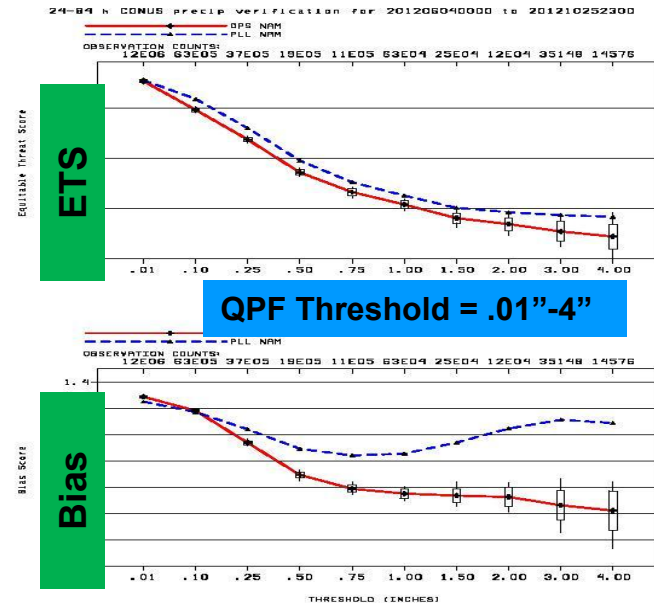
Vector Wind RMS error

RMS vector wind error vs. xrobs over the CONUS for ops NAM and p11 NAM forecasts from 2012060412 to 2012102412



Day 1 = Black
Day 2 = Red
Day 3 = Blue

24-h QPF, All Forecasts



Physics Modifications:

- GWD/mountain blocking; more responsive to sub-grid scale terrain variability
- BMJ convection : moister convective profiles, convection triggers less
- RRTM radiation, latest version
- Remove 4x diffusion of q, cloud water
- Microphysics changes

Data Assimilation Modifications:

- Raob level enhancement in GSI
- Hybrid variational-ensemble analysis with global EnKF



Model Evaluation Group (MEG)



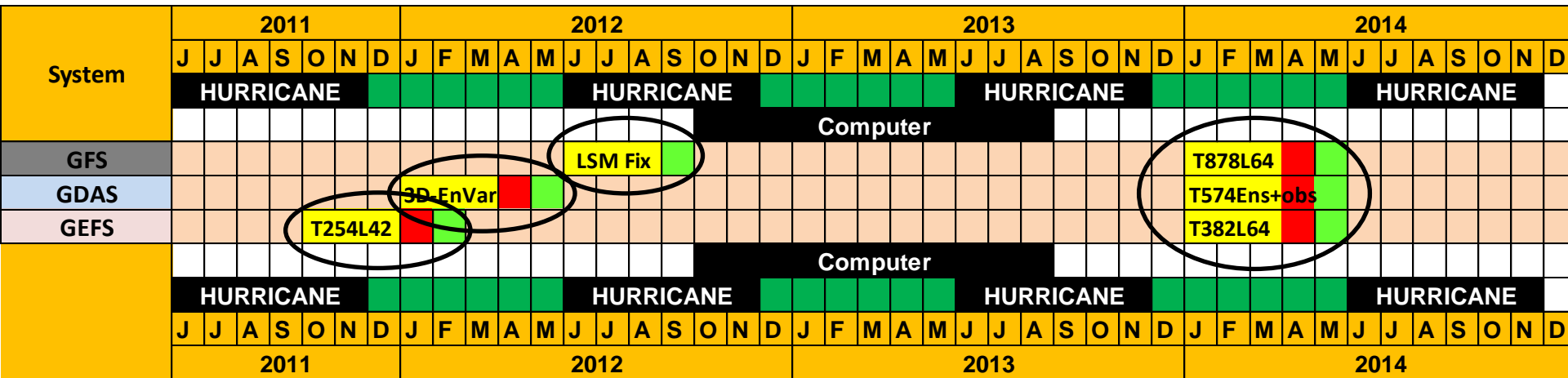
- **Project designed to focus attention on product quality on a daily basis with feedback into the model development cycle**
- **Inspired by monitoring activities at ECMWF, Met Office, GMAO**
- **Evaluates daily performance of EMC forecast/analysis systems from a synoptic perspective and adds verification:**
- **Conduct weekly EMC map discussion of model performance**
- **Project benefits:**
 - **Improves situational awareness and enhances communication**
 - **Provides critical feedback to modelers and branch chiefs**
 - **Provides streamlined feedback to outside users with model concerns**
 - **Can potentially serve as a point-of-contact for all model concerns outside of EMC**



Consolidate Development and Upgrade Cycles for the GFS, GDAS and GEFS?



Compare 2011-2012 and proposed 2014 upgrade cycles



- Combine GFS, GDAS and GEFS into a single development and upgrade cycle

Advantages:

- GEFS uses the operational version of the GFS
- Use EnKF to support GEFS and Analysis (remove 80-member ETR ensemble)
- Forces communication and coordination across global, ensembles and analysis teams—plus stakeholders and downstream products
- Single 30-day NCO/Customer evaluation periods required

Disadvantages

- Stakeholder evaluation focused on multiple systems
- Computational footprint becomes much larger—may need to consider parallel suite testing—burden on NCO and development
- Increased reward/risk—performance in one component impacts others

