The NOAA Operational Numerical Guidance System:

Recent Changes and Moving Forward

William. M. Lapenta
Acting Director
Environmental Modeling Center

NOAA/NWS/NCEP

Geoff DiMego, John Derber, Yuejian Zhu, Hendrik Tolman, Vijay Tallapragada, Shrinivas Moorthi, Mike Ek, Mark Iredell, Suru Saha
Presentation Outline

• Why NOAA Conducts Operational Numerical Weather Prediction

• The NOAA Operational Numerical Guidance Suite
  – Computational Aspects
  – Data Assimilation System
  – Global Forecast Systems
  – CONUS Mesoscale

• Moving The Suite Forward
  – Emphasis on global systems

• Questions
NOAA Operational Numerical Guidance Supports the Agency Mission

- Numerical Weather Prediction at NOAA
  - Related to ability to meet service-based metrics (below)

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

- Customer Service Provider
  - Operational numerical guidance provides foundational tools used by Government, public and private industry to improve public safety, quality of life and make business decisions that drive US economic growth
NOAA’s Operational Numerical Guidance Suite

Global Forecast System

Climate Forecast System
- GFS
- MOM4
- NOAH Sea Ice

Hurricane
- GFDL
- HWRF

Regional DA
- WRF NMMB

Regional NAM

Short-Range Ensemble Forecast
- WRF: ARW, NMM

North American Ensemble Forecast System
- GFS, Canadian Global Model

Space Weather
- ENLIL

Global Data Assimilation

~2B Obs/Day
Satellites + Radar
99.9%

Dispersion
- ARL/HYSPLIT

Severe Weather
- WRF NMM/ARW
- Workstation WRF

Air Quality
- NAM/CMAQ

Rapid Refresh for Aviation

NOS – OFS
- Great Lakes
- Northern Gulf of Mex
- Columbia R. Bays
- Chesapeake
- Tampa
- Delaware

NOAA Land Surface Model

Sea Nettle Forecast

Sea Nettle Forecast
Numerical Guidance Suite Execution on the Operational NOAA Supercomputer

24-h Snapshot 20 August 2012

Number of Nodes

Time of Day (UTC)

High Water Mark 2010
NOAA Operational Product Delivery: Reliable, Timely and Accurate….

Emphasis on Customer Service

- TOC Received within 15 minutes
- Posted within 15 minutes
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 7 months 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

- **Partnership between research and operations**
  - (NASA/GMAO, NOAA/ESRL, Univ OK, and NOAA/NCEP)

- **Consolidation across systems**
  - Unify operational data assimilation system for global, regional and hurricane applications
  - Cost effective—O&M
  - Configuration management
NCEP achieved significant improvement in 2012 for day 3 and beyond

NCEP is now similar to UKMO skill in this metric and AC

Solid line lower than dashed indicates improvement between 2011 and 2012

NCEP Only System to show improvement between 2011 and 2012
Global Model Track Guidance for Hurricane Sandy

Sequence of 5-day forecasts
22 October to 30 October 2012

NCEP GFS

ECMWF
Planned GFS/GDAS 2014 Operational Upgrade

- Next window of opportunity for GDAS/GFS upgrade
  - Nov 2013 to May 2014
  - Follows WCOSS Moratorium

- Model configuration
  - T1148 Semi-Lagrangian, L64 (~16km)
  - Physics upgrades for the radiation and precipitation parameterizations

- Data assimilation upgrade
  - 3D-En-Var Dual Resolution
    - 80-member ensemble at 27-km and a 16-km analysis with 64 vertical levels
  - New and enhanced observations
    - Cloudy Radiance
    - Satellite winds
    - CrIS from NPP
    - METOP-B
    - SSMI/S GPS-RO enhancements
  - New integrated bias correction
  - Water Vapour analysis enhancements
  - Climatological CO2, Methane, Nitrous Oxide and CO for input in CRTM
  - Consistent cloud water retrieval in quality control
## Global Ensemble Systems and Multi-Ensemble Systems

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

**North America Model (NAM)**
- Implemented 18 October 2011
- NEMS based NMM
- Outer grid at 12 km to 84hr
- Multiple Nests Run to ~48hr
  - 4 km CONUS nest
  - 6 km Alaska nest
  - 3 km HI & PR nests
  - 1.3km DHS/FireWeather/IMET

**Rapid Refresh (RAP)**
- Implemented 1 May 2012
- WRF-based ARW
- Use of GSI analysis
- Expanded 13 km Domain to include Alaska
- Experimental 3 km HRRR
NOAA Center for Weather and Climate Prediction: “A Game Changer”

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 465 seat auditorium & conference center, library, deli, fitness center and health unit

• Includes 40 spaces for visiting scientists

• Represents a “Game Changer” in our ability to do business