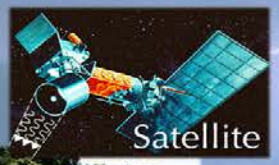
Global Systems Division

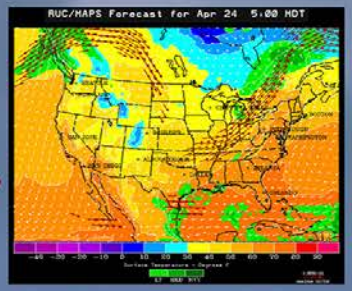
Observing Systems



Aircraft

Modeling, Assimilation, & Computing

Assimilate and Model



Advanced Computing

Information Dissemination

Geophysical Information Systems

Education and Outreach

Public

Transferring science and technology to the Nation's weather and climate services

- GSD Makeup
- New Innovations for many uses
  - Global to local models and analysis
  - Massively Parallel Fine Grain (MPFG) computing
  - NOAA Earth Information System (NEIS)

Global Systems Division

- 6 Branches and Office of Director
- Approximately 180 staff and affiliates made up of Federal, Cooperative Institute, contractor, and guest workers
- Team is made up of about:
  - 60 Federal Staff
  - 83 University Employees
  - 30 Contractors
- ~ $28M in new funds each year
- New Funds:
  - 25% Direct Congressional Appropriations
  - 41% from Other NOAA Appropriations
  - 34% Non-NOAA (Other Fed, Private Sector, International)
- Major University affiliations with:
  - University of Colorado – Boulder
  - Colorado State University – Fort Collins

Science on a Sphere
EU Celebration at the Embassy of France
Washington DC, Dec 2008

Global, Regional, and Local Modeling and Forecasts

Data Assimilation Systems

- Enhanced Kalman Filter (EnKF)
- Gridpoint Statistical Interpolation (GSI)
- Space Time Mesoscale Analysis System (STMAS)

Global Models:

- FIM Flow-following- finite-volume Icosahedral Model
- FIM Chemistry
- I-HYCOM (Icos – Hybrid Coordinate Ocean Model)
- NIM – Non-hydrostatic Icos Global Model

Regional Models:

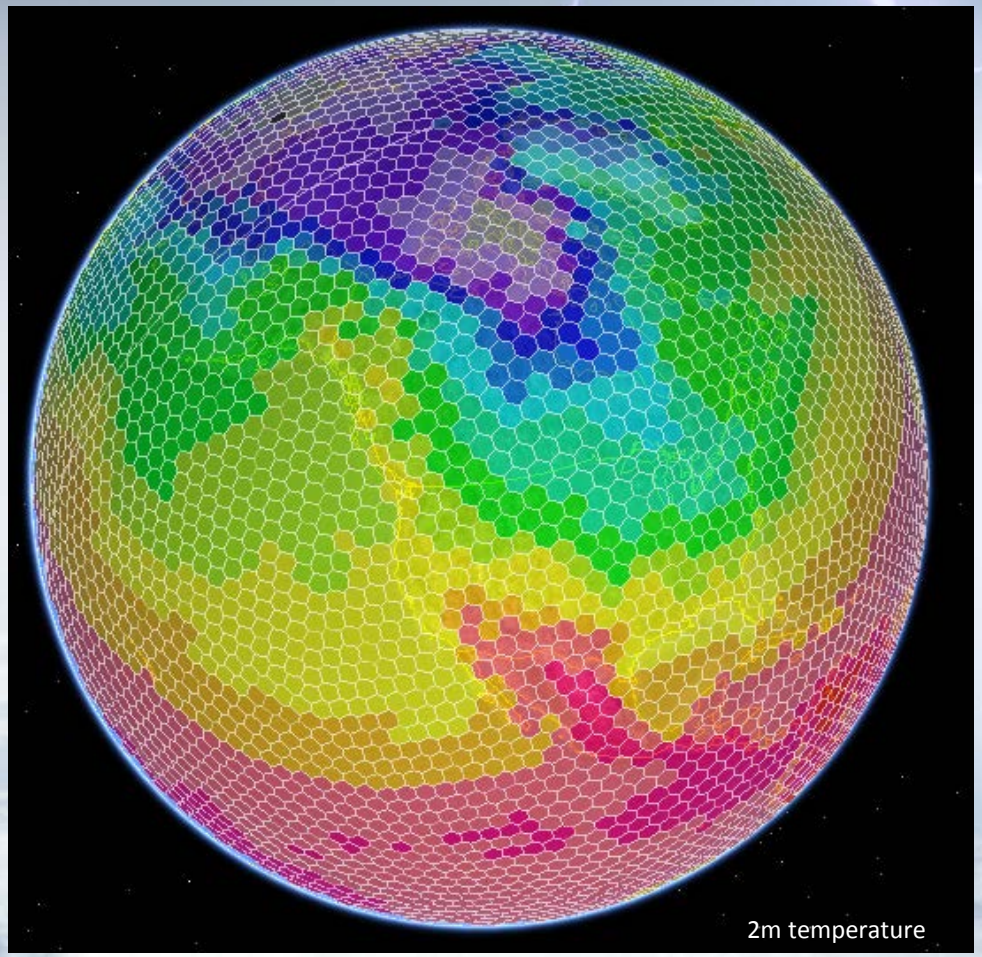
- Rapid Refresh (RAP)
- RR – Air Chemistry
- High Resolution Rapid Refresh (HRRR)

Local Models/Analysis:

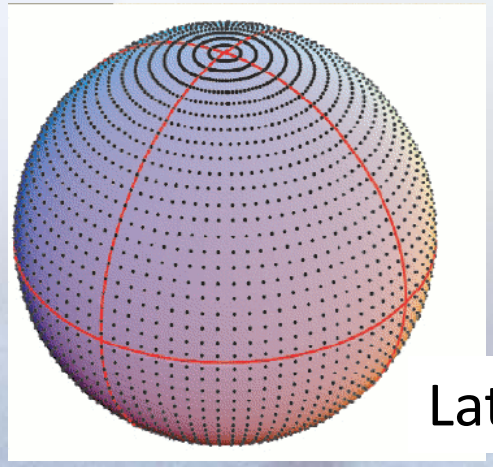
- Local Area Prediction System (LAPS)

Ensemble Techniques and Observation System Evaluation

Global Forecast Models – FIM* and FIM-Chemistry



- Clear advantages over common latitude, longitude grids
- Superior performance for hurricane track
- Includes coupled air chemistry for global scale events
- Precursor to short range climate prediction and HRRR precision on global scales

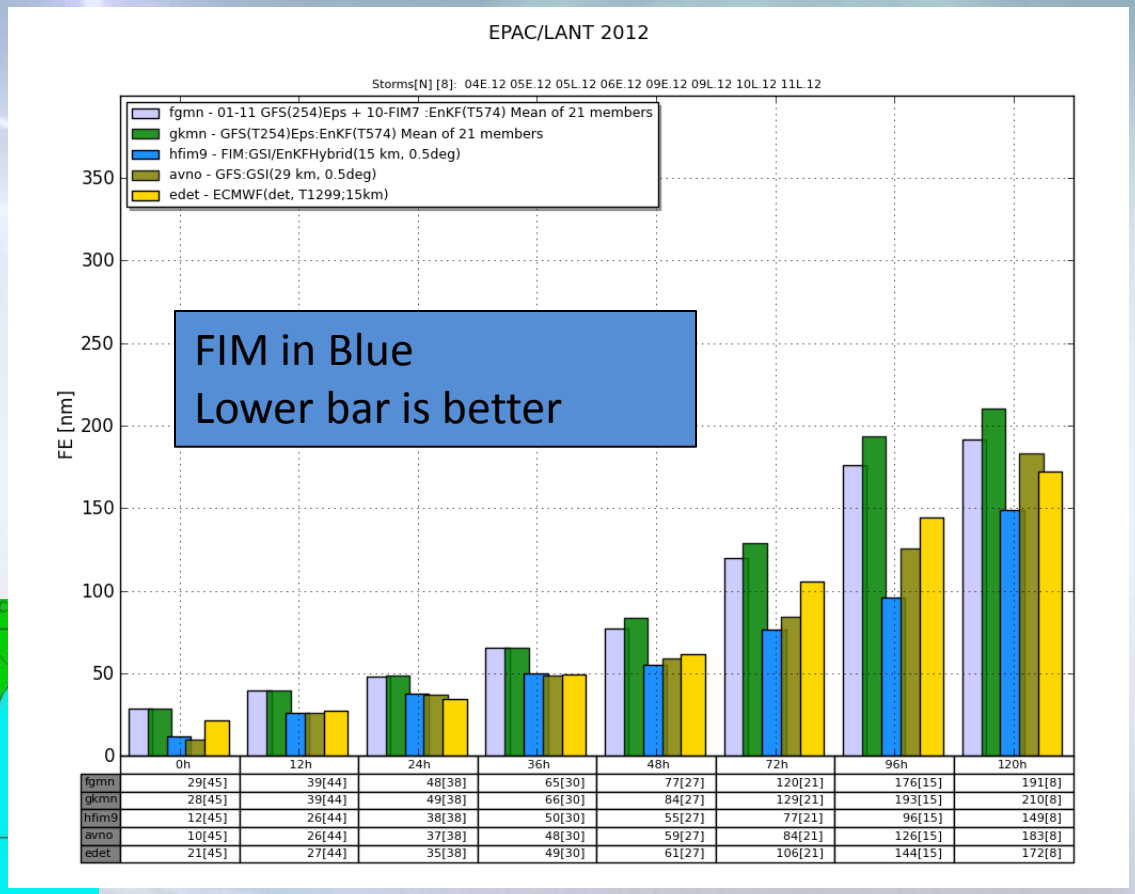


Lat-lon grid

* Flow-following, Finite Volume, Icosahedral Model (FIM)

Global Forecast Models – FIM*

- FIM consistent top performer on eight 2012 Hurricane tracks
- FIM provides best hurricane track forecast for Hurricane Isaac.

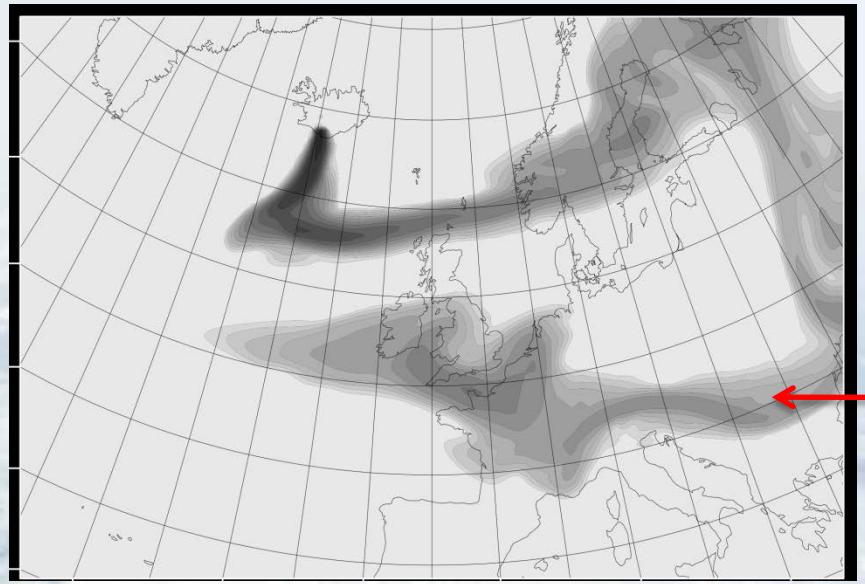


	0h	12h	24h	36h	48h	72h	96h	120h
fgmn	29[45]	39[44]	48[38]	65[30]	77[27]	120[21]	176[15]	191[8]
gkmn	28[45]	39[44]	49[38]	66[30]	84[27]	129[21]	193[15]	210[8]
hfim9	12[45]	26[44]	38[38]	50[30]	55[27]	77[21]	96[15]	149[8]
avno	10[45]	26[44]	37[38]	48[30]	59[27]	84[21]	126[15]	183[8]
edet	21[45]	27[44]	35[38]	49[30]	61[27]	106[21]	144[15]	172[8]

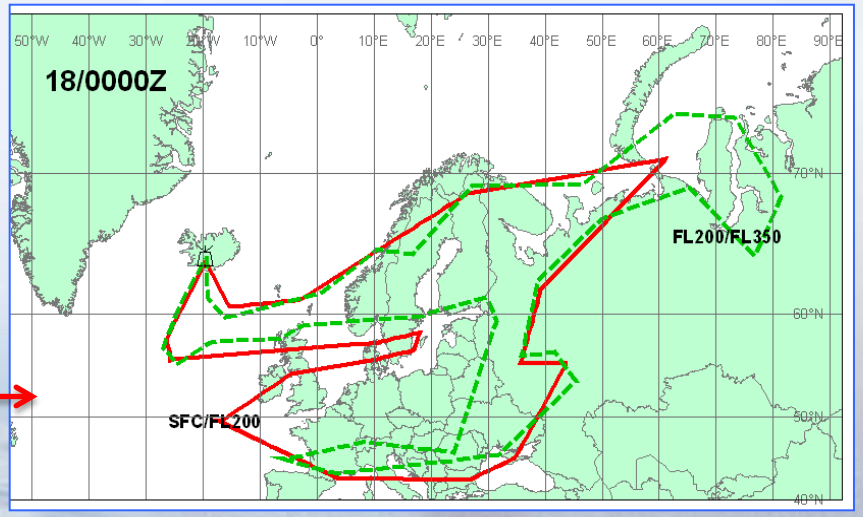
* Flow-following, Finite Volume, Icosahedral Model (FIM)

FIM Chemistry - Eyjafjallajökull volcano in Iceland

- FIM-Chem is the first US global inline chemistry model
- FIM-Chem provides chemical transport forecasts incorporating weather for both emergent and ongoing concerns.



FIM-chem – inline ash forecast valid 0z 18 Apr



Forecast from London Volcanic Ash Advisory Center – valid 00z 18 Apr 2010

Regional Models - High Resolution Rapid Refresh (HRRR)

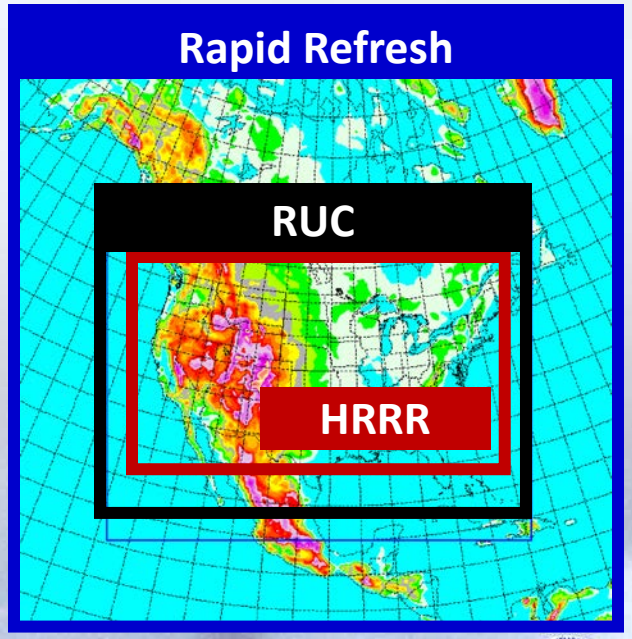
A new weather prediction model in development and test.

Running on NOAA High Performance Computers in Boulder and West Virginia

First hourly updated CONUS storm-scale model
Assimilation (including radar data) from RUC/RR

Great promise for big improvements in:

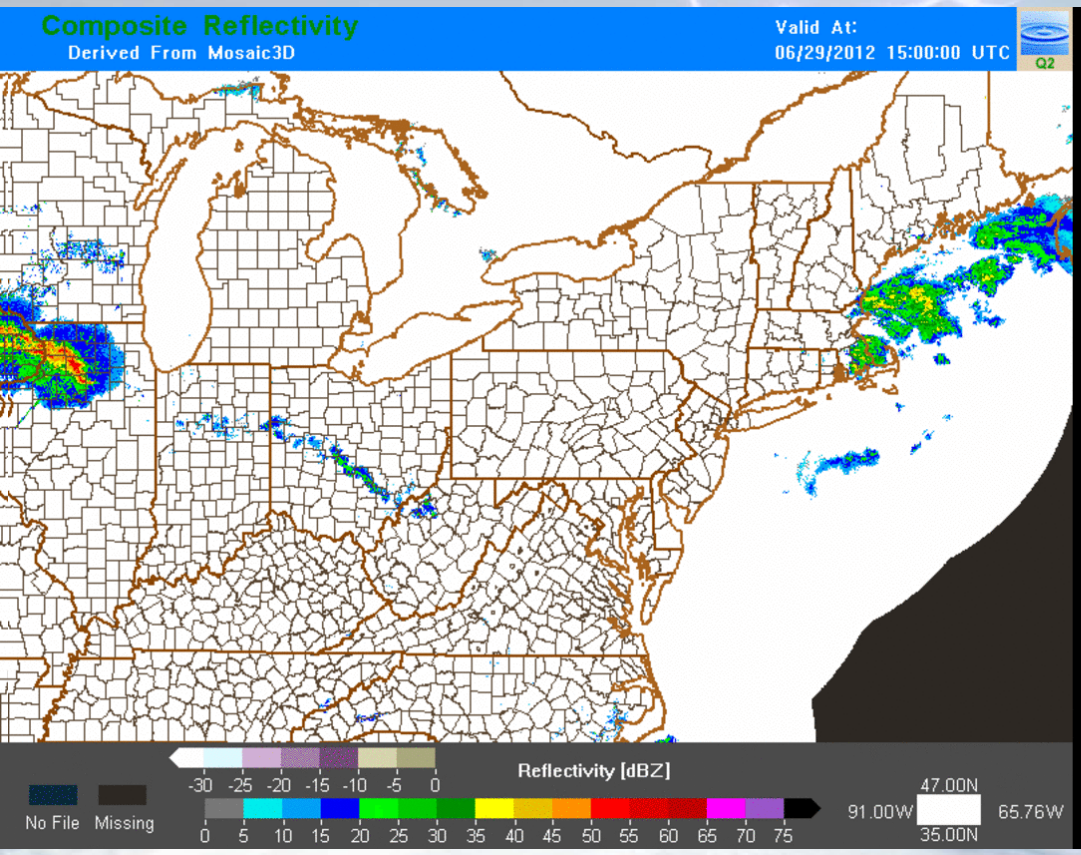
- Severe Weather and Flash Flood
- Aviation Weather Forecasting
- Renewable Energy
- Road Weather



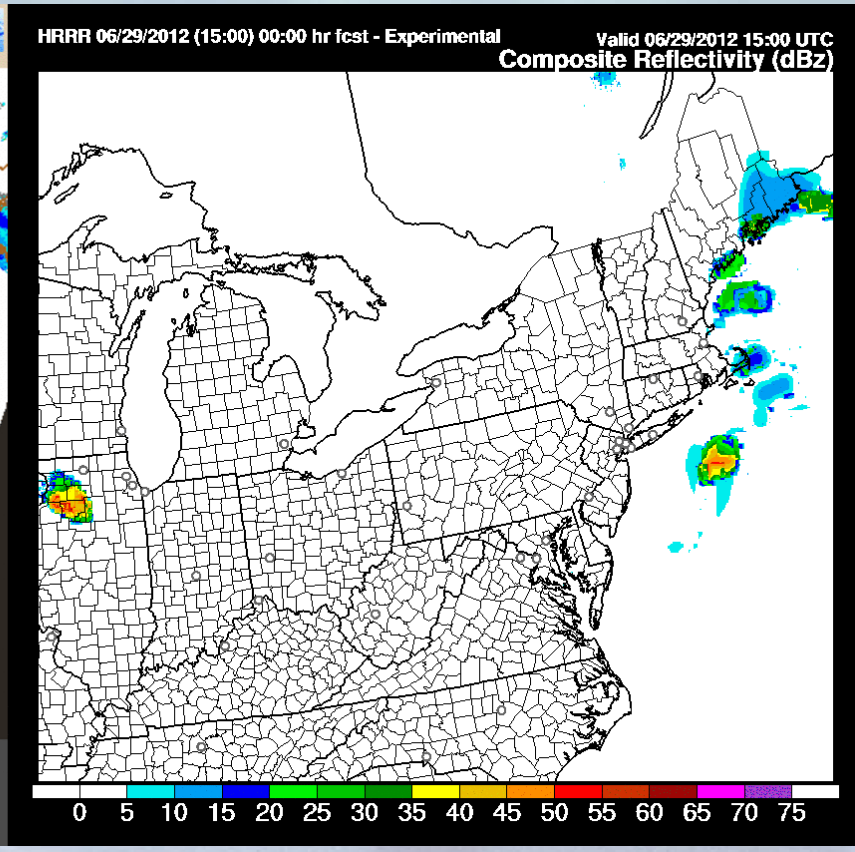
Rapid Update Cycle (RUC), Rapid Refresh (RAP), and HRRR domains

HRRR Predicts Washington D.C Derecho at 15 hours

Observed Radar Reflectivity



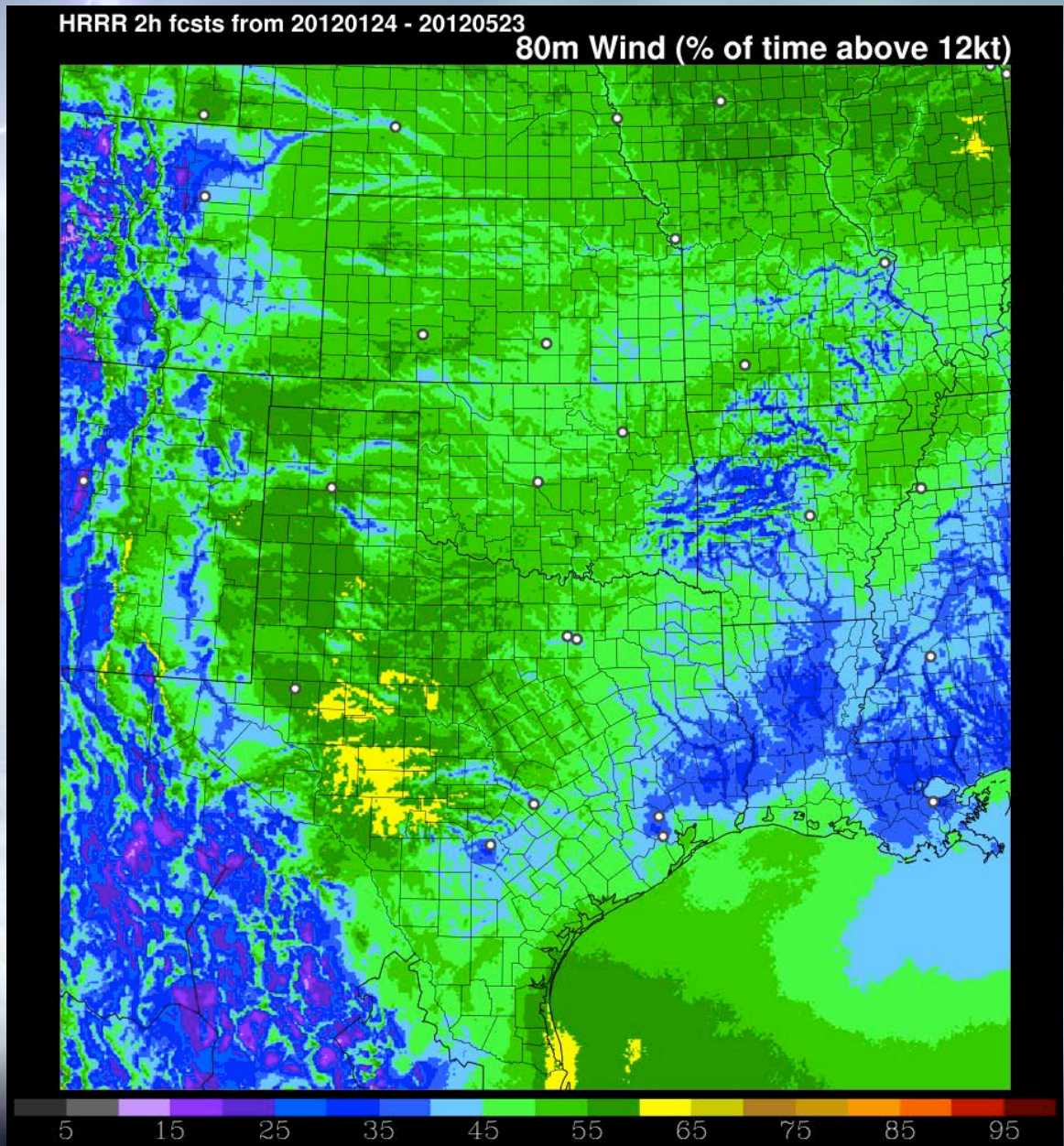
HRRR Forecast



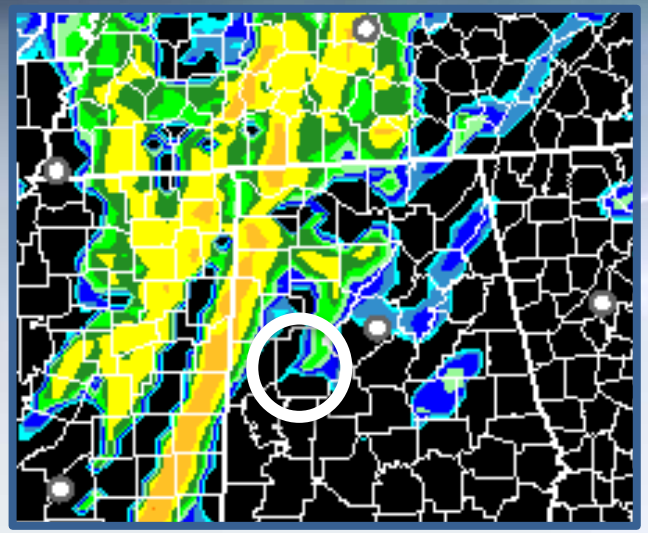
HRRR Wind Energy Forecast

% of time that 80-m Winds > 12 kts January – May 2012

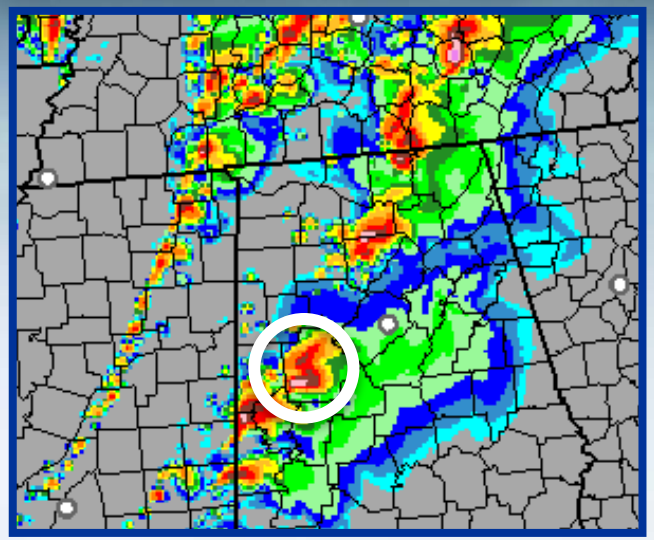
- Sites for best promise for Wind Energy Generation can be identified
- Most efficient use of wind resources can be planned
- Work done in partnership with the Department of Energy



HRRR at Storm Resolving Scale Changes the Forecast

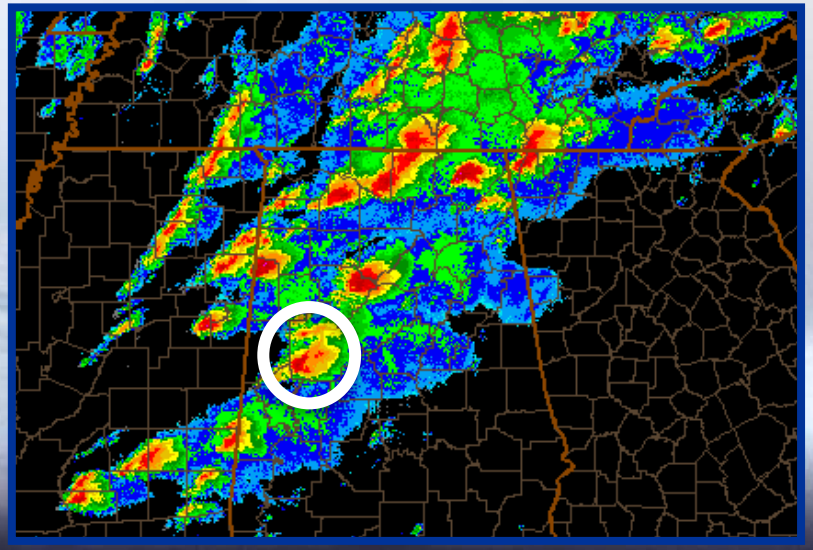


***In Forecast Office at Event*:**
<u>13km RUC</u> 9-h forecast of thunderstorms for 27 April 2011, valid 5pm Eastern Time.



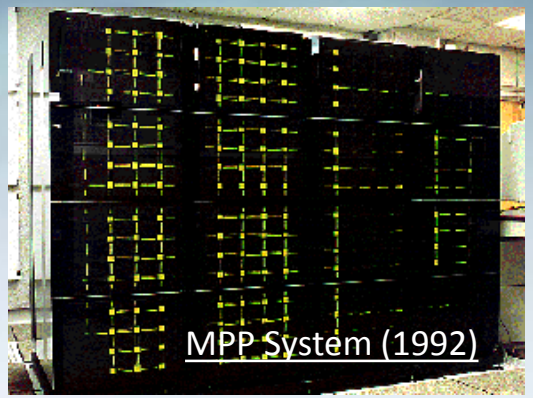
***HRRR Forecast*:**
<u>3km HRRR</u> 9-h forecast of thunderstorms for 27 April 2011, valid 5pm Eastern Time.

REALITY:
<u>Observed thunderstorms</u> for 27 April 2011, valid 5pm Eastern Time. The **Tuscaloosa, AL tornadic storm cell** is indicated by the white circle.



High-performance Computing Architectures and Methods

GSDs history of successful innovation:



- ***Massively Parallel Infrastructure (MPI) (1992)***
  - now the worldwide standard for distributed memory application on the worlds largest systems (Jaguar-DOE, K-Japan)

- ***First Federal off-the-shelf commercial cluster based on Linux -Jet (2000)***
  - All current NOAA HPC systems are clusters
  - 95% of NOAA HPC cycles will be from Linux clusters in 2012

- ***First major adoption of commodity processors in a NOAA HPC system – iJet 2002***
  - 90% of Top500 system use commodity based x86 processors including Gaea, Zeus, and Jet use x86 processors

- ***2008 GSD began exploring the use of Graphical Processing Units (GPUs)***

Massively Parallel Fine Grain Computing Driver

- **NOAA's objective: Find cost effective, reliable, energy efficient means to allow weather and climate prediction using the best available forecast and prediction models.**
- **This requires affordable Peta-flop computing**
- **This will soon become unattainable with current operational computing architectures.**
- **GSD is finding the path to Peta-flop beyond current computing constraints.**

Xbox 360

Peta Flop Computing in 2012

DOE – Fastest Current US system

Jaguar System

- 2.3 PetaFlops
- 250,000 CPUs
- 284 cabinets
- 7000 KW power
- **Cost: ~ $100 million**
- **Building: $75 million**
- **Reliability in hours**

Equivalent MPFG

- 2.3 PetaFlop
- 600 Kepler GPUs
- 10 cabinets
- 200 KW power
- **Cost: ~ $5 million**
- **Reliability in weeks**

	CPU cost	**GPU cost**
– Power & Cooling:	$8.4 M / year	$0.2M / year
– System Cost:	$100M	$5 M
– Facilities	$75M	$0.8M

- GPU-based systems will dominate super-computing within 3 years
  - 75 percent of HPC customers are expected to use GPUs in 2014 (HPC study, 2012)

NOAA Earth Information System (NEIS)

Objective:

Any data, Any platform, Any time

- Hundreds of generally incompatible systems are used in the US to visualize environmental information.
- Much of this data cannot be easily unified.
- How do we easily understand and make decisions with this difficult access to environmental data?
- We are developing the NEIS to help solve this problem.

GSD Innovation

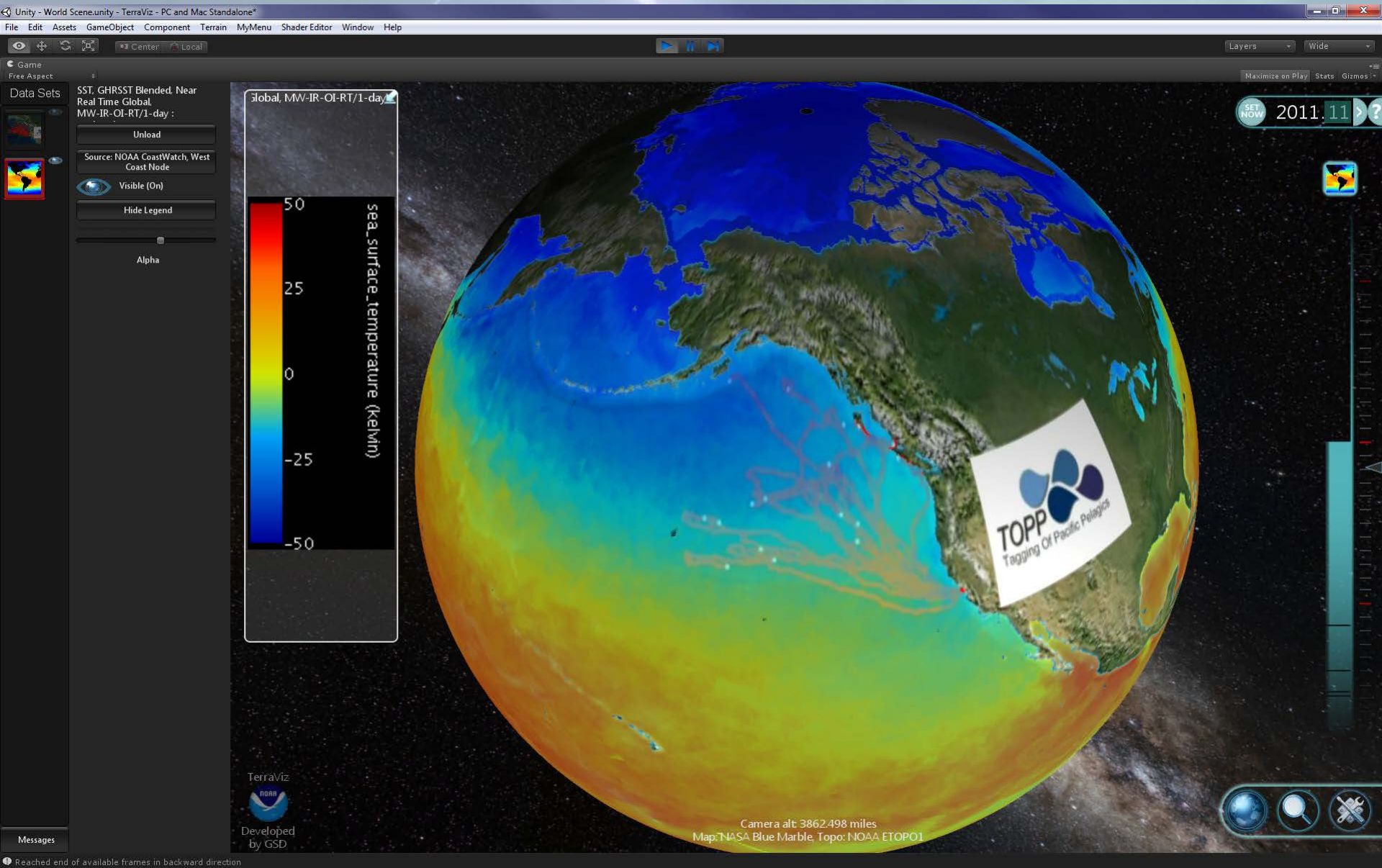
Building on years of Research and Development
Leadership GSD is:

Helping Create the Weather Forecast of Tomorrow,
Through Cutting Edge Forecast Models,
Affordable Computing,
New Information Understanding.

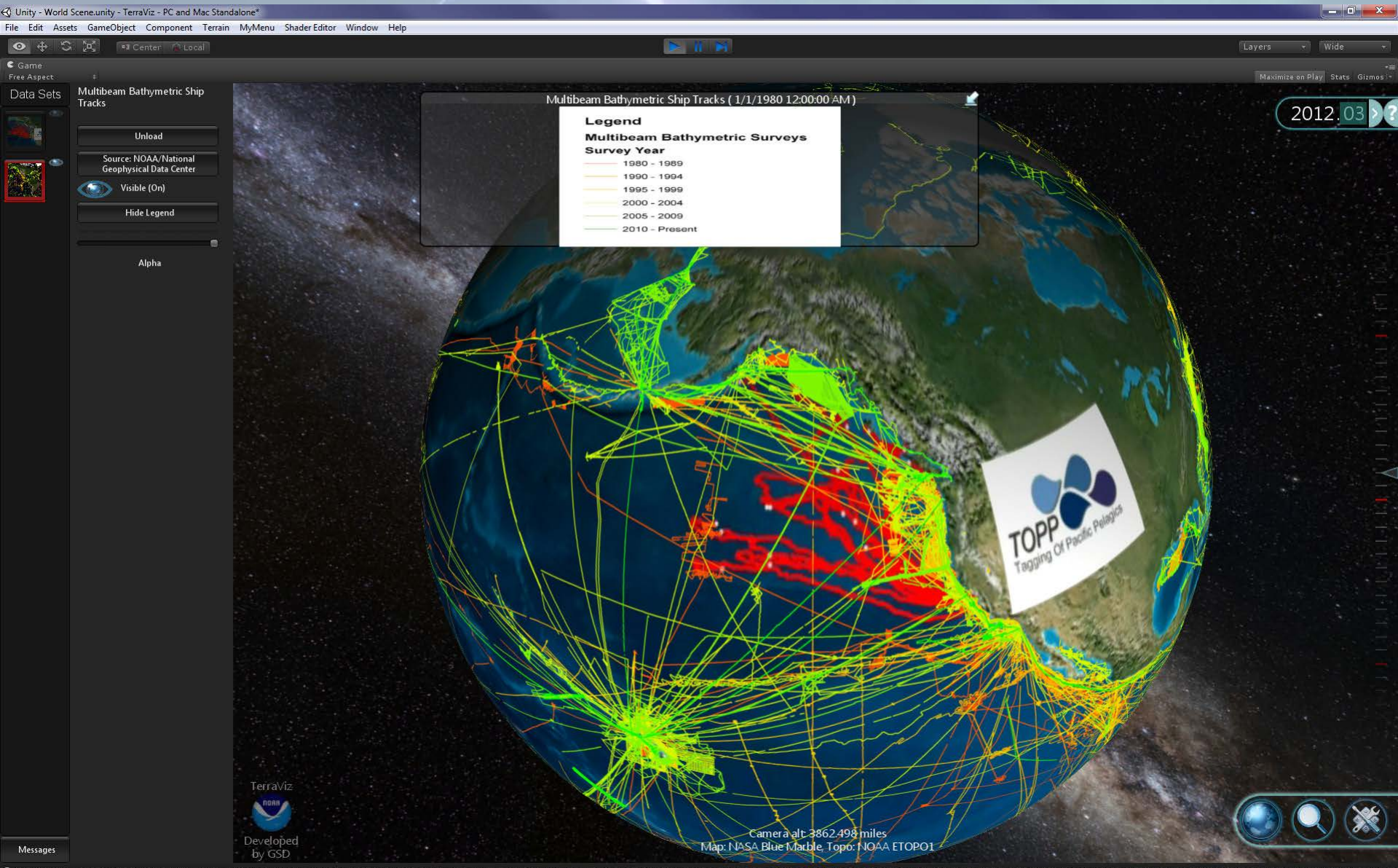
John P. Schneider
Acting Director, Global Ssystems Division
Earth System Research Laboratory
John.P.Schneider@noaa.gov

NOAA Earth Information Service (NEIS)

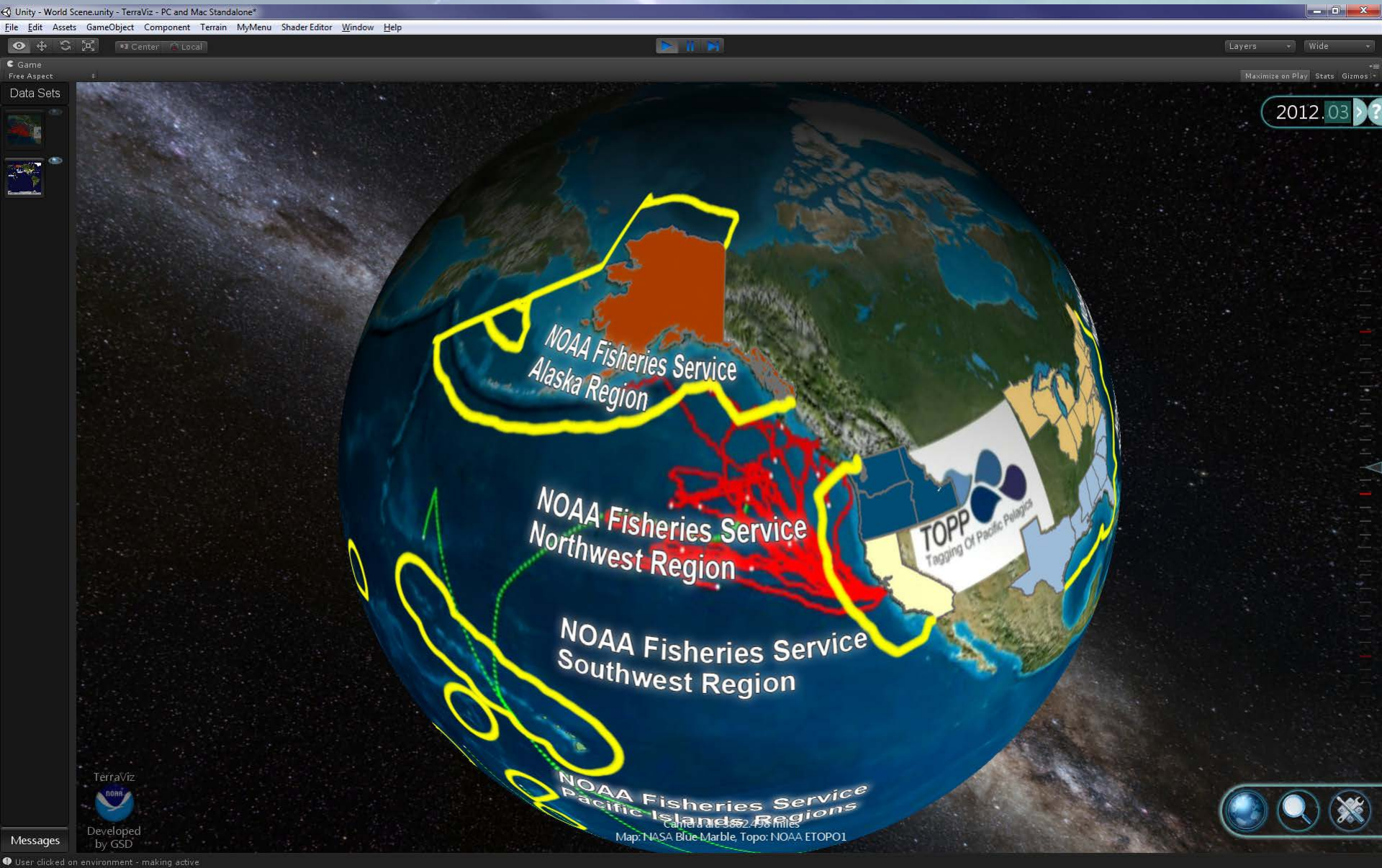
NOAA Earth Information Service (NEIS)



NOAA Earth Information Service (NEIS)

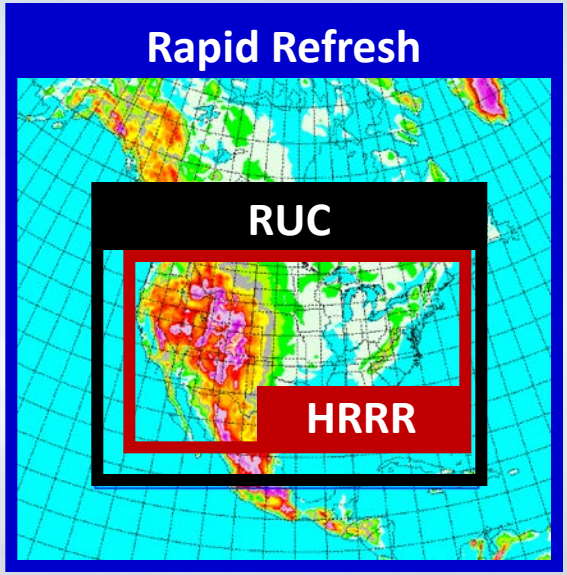


NOAA Earth Information Service (NEIS)



History of Innovative Development

Pioneering work on rapid cycling forecast systems and thunderstorm prediction



Rapid Update Cycle (RUC)

- *First NCEP hourly cycling model*
- *First NCEP reflectivity assimilation*

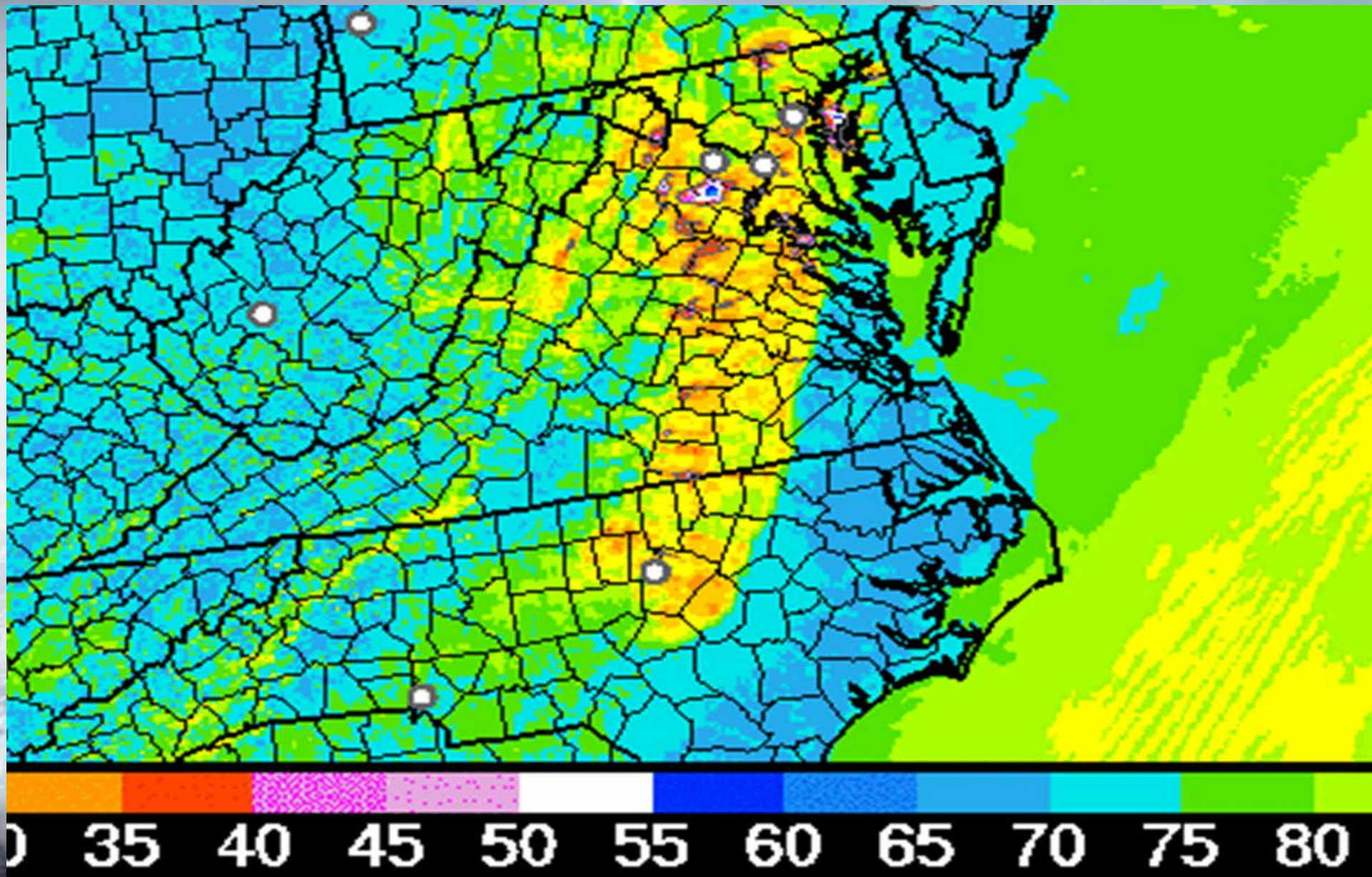
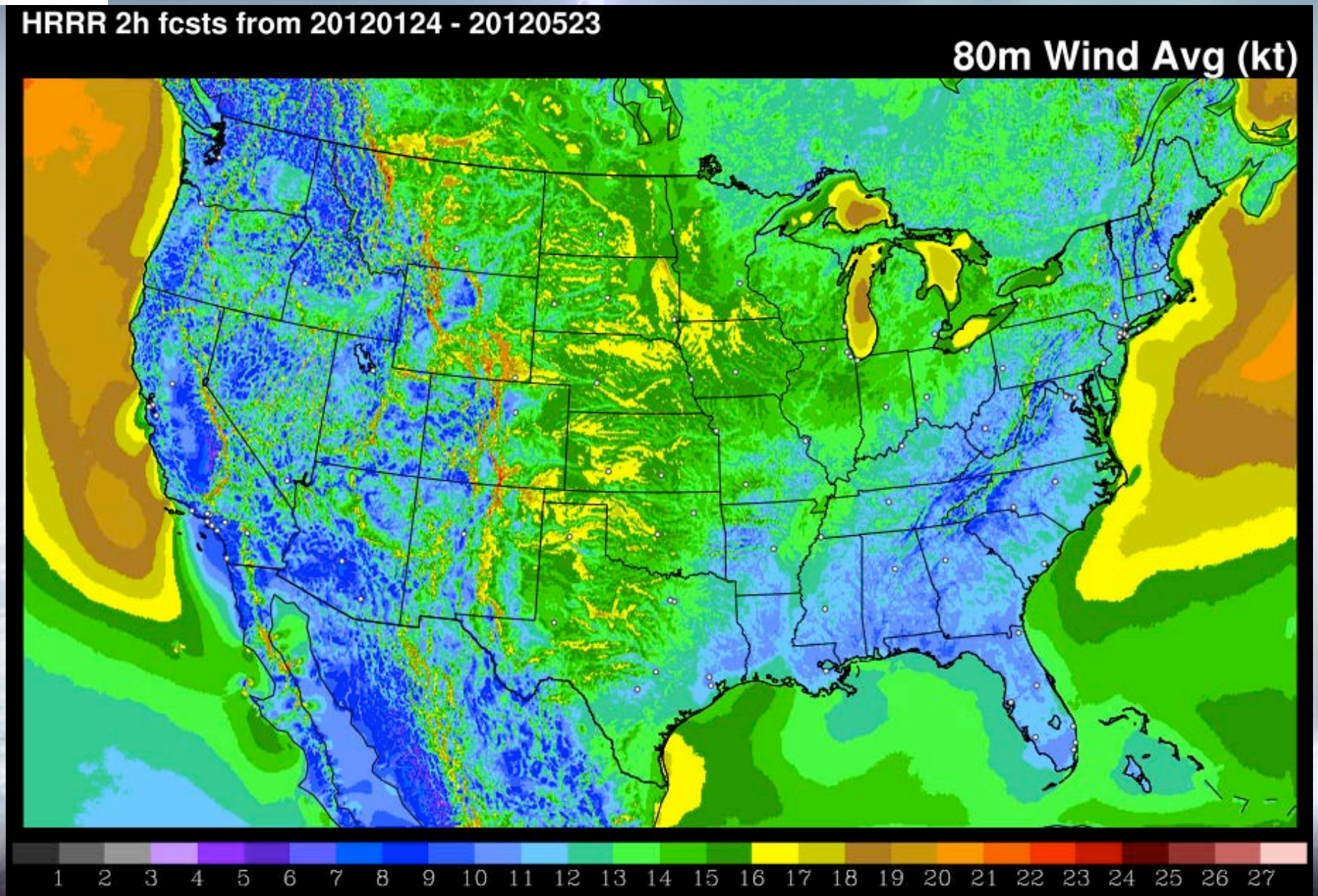
Rapid Refresh (RR)

- *First North American hourly cycling*
- *Community codes (GSI, WRF ARW)*

High-Resolution Rapid Refresh (HRRR)

- *First hourly updated CONUS storm-scale model*
- *Assimilation (including radar data) from RUC/RR*

ESRL/GSD's HRRR model predicted a 65 knot gust in the DC area 12 hours in advance.



HRRR Mean 80-m Winds from 2h forecasts