National Weather Service Modernization and Restructuring (MAR) Program: NCEP Perspective

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NRC Committee on the Assessment of the National Weather Service's Modernization Program

March 8, 2011

"Where America's Climate, Weather, Ocean and Space Weather Services Begin"

NWS Modernization

- The NWS modernization and restructuring of the 1990s has led to dramatic improvements in weather, water and climate products and services to the Nation.
- Americans are now reaping the benefits of this $4.5B investment through longer lead times, more accurate and timely information for extreme events.
- Improvements are a result of new observing systems (NEXRAD, ASOS, Satellites); new modern information technology workstations (AWIPS); new high speed supercomputer (Central Computing System); reorganized field structure; and extensive training of forecasters.
- National Meteorological Center (NMC) restructuring into the National Centers for Environmental Prediction (NCEP) WAS NOT part of the original modernization plan.
- NCEP supercomputer upgrade which added speed and precision to NWS forecasts WAS part of the modernization; instrumental for improved models to support forecasts made by NWS meteorologists and by commercial forecasters and the private sector industry; ultimately led to our 99.9% on-time delivery of products.

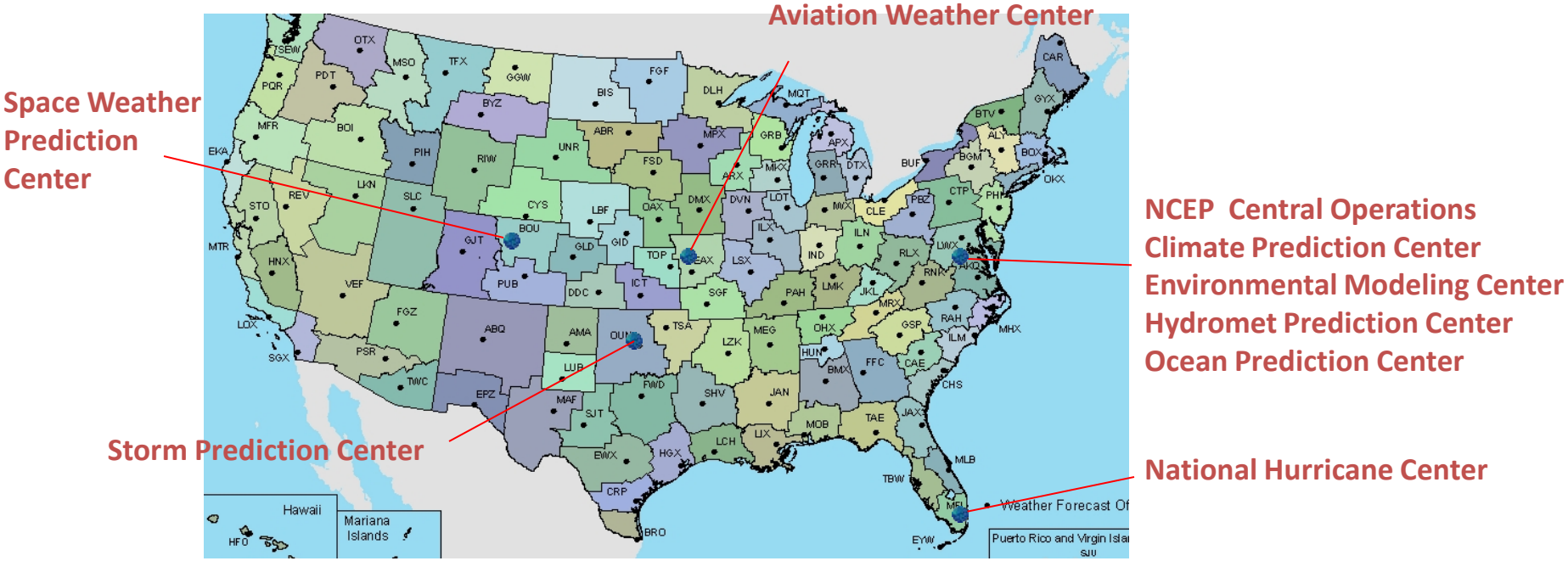
Outline

- Define NCEP/CCS
- Measures of Success
- Forces for Change
- Summary

NCEP Supports the NOAA Seamless Suite of Climate Weather and Ocean Products

Organization: Central component of NOAA National Weather Service

Mission: NCEP delivers science-based environmental predictions to the nation and the global community. We collaborate with partners and customers to produce reliable, timely, and accurate analyses, guidance, forecasts and warnings for the protection of life and property and the enhancement of the national economy.



Vision: The Nation's trusted source, first alert and preferred partner for environmental prediction services

NATIONAL CENTERS for ENVIRONMENTAL PREDICTION

OFFICE OF THE DIRECTOR
8 FTE

CLIMATE PREDICTION CENTER
Climate Monitoring and Forecasts
Week 2, Monthly, Seasonal, Multi-Seasonal
Global
50 FTE

NATIONAL HURRICANE CENTER
Tropical Weather Guidance and Forecasts
Tropical Cyclone Watches & Warnings
0-5 Days
Atlantic and Pacific, 0-30° N
47 FTE

HYDROMETEOROLOGICAL PREDICTION CENTER
Hydrometeorological Forecasts
0-7 Days – Weather
0-5 Days – QPF
Winter Weather Desk
Alaska Desk
US
45 FTE

OCEAN PREDICTION CENTER
Marine Boundary Layer and Ocean Surface Guidance, Warning and Forecasts
0-5 Days
Atlantic and Pacific, North of 30° N
27 FTE

STORM PREDICTION CENTER
Hazardous Weather Guidance
0-8 Days – Severe Weather
0-8 Days – Fire Weather
Continental US
34 FTE

AVIATION WEATHER CENTER
Weather Guidance, Warning and Forecasts for Domestic and International Aviation
0-2 Days
Global
55 FTE

SPACE WEATHER PREDICTION CENTER
Space Weather Monitoring, Warning and Forecasting
0-3 Days
Global
48 FTE

NATIONAL CENTERS FOR ENVIRONMENTAL PREDICTION
65 FTE

ENVIRONMENTAL MODELING CENTER

Numerical Weather and Ocean Automated Analysis and Prediction
0-16 Days
Global

Numerical Climate Prediction
Months
Global

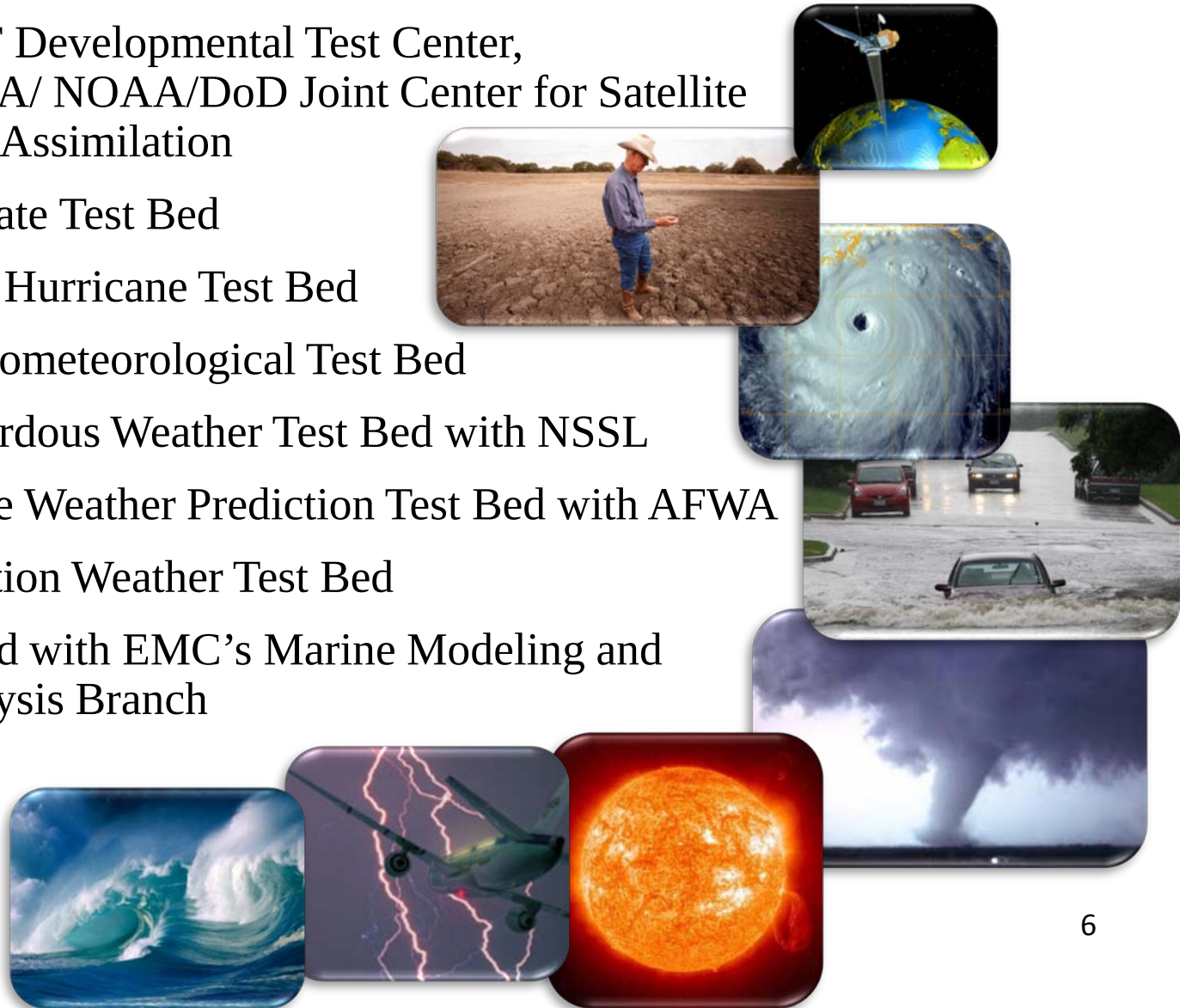
52 FTE

FTE:	431
Contractors:	210
Visitors:	61
NOAA Corps:	5

Test Beds

Service – Science Linkage with the Outside Community

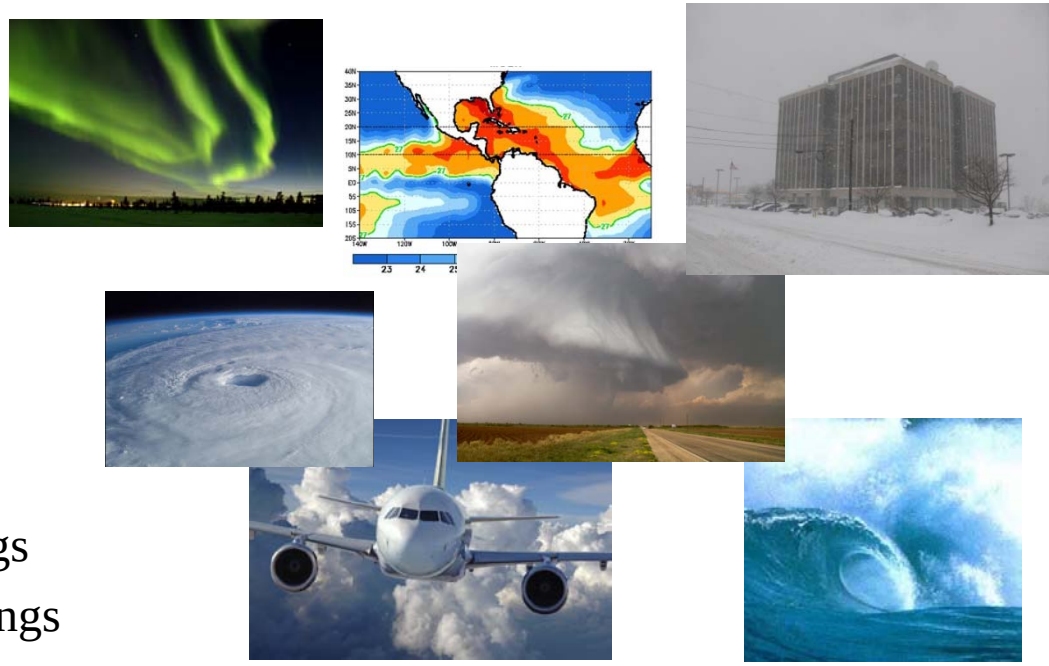
- EMC — WRF Developmental Test Center, NASA/ NOAA/DoD Joint Center for Satellite Data Assimilation
- CPC — Climate Test Bed
- NHC — Joint Hurricane Test Bed
- HPC — Hydrometeorological Test Bed
- SPC — Hazardous Weather Test Bed with NSSL
- SWPC — Space Weather Prediction Test Bed with AFWA
- AWC — Aviation Weather Test Bed
- OPC — linked with EMC's Marine Modeling and Analysis Branch



What Does NCEP Do?

"From the Sun to the Sea"

- Solar Monitoring, Warnings and Forecasts
- Climate Seasonal Forecasts
- El Nino – La Nina Forecast
- Weather Forecasts to Day 7
- Extreme Events (Hurricanes, Severe Weather, Snowstorms, Fire Weather)
- Aviation Forecasts and Warnings
- High Seas Forecasts and Warnings



- Model Development, Implementation and Applications for Global and Regional Weather, Climate, Oceans and now Space Weather
- International Partnerships in Ensemble Forecasts
- Data Assimilation including the Joint Center for Satellite Data Assimilation
- Super Computer, Workstation and Network Operations

NCEP Central Computer Capability

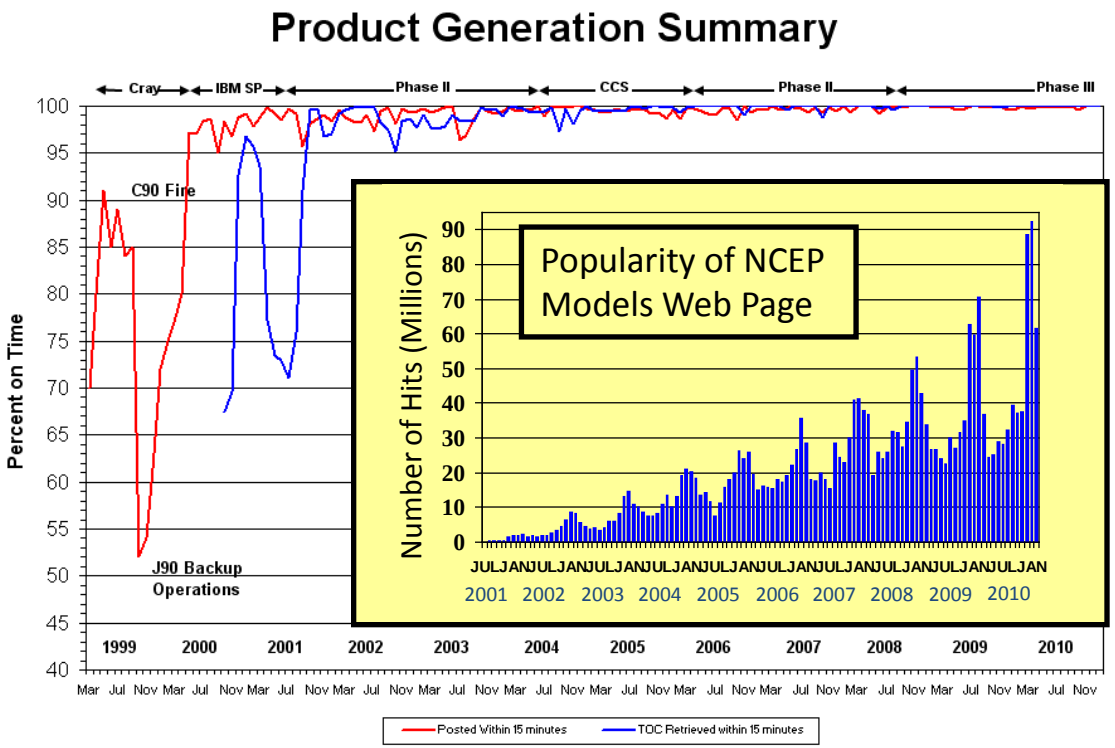
- New contract to IBM let in 1998
- Will run through 2013
- NCEP was the first operational weather center to transition from vector to parallel processing
- Leasing arrangement allowed for systematic upgrades during lifetime of the contract
- Contract modifications provide for climate prediction and backup computer

Measures of Success

Computing Capability

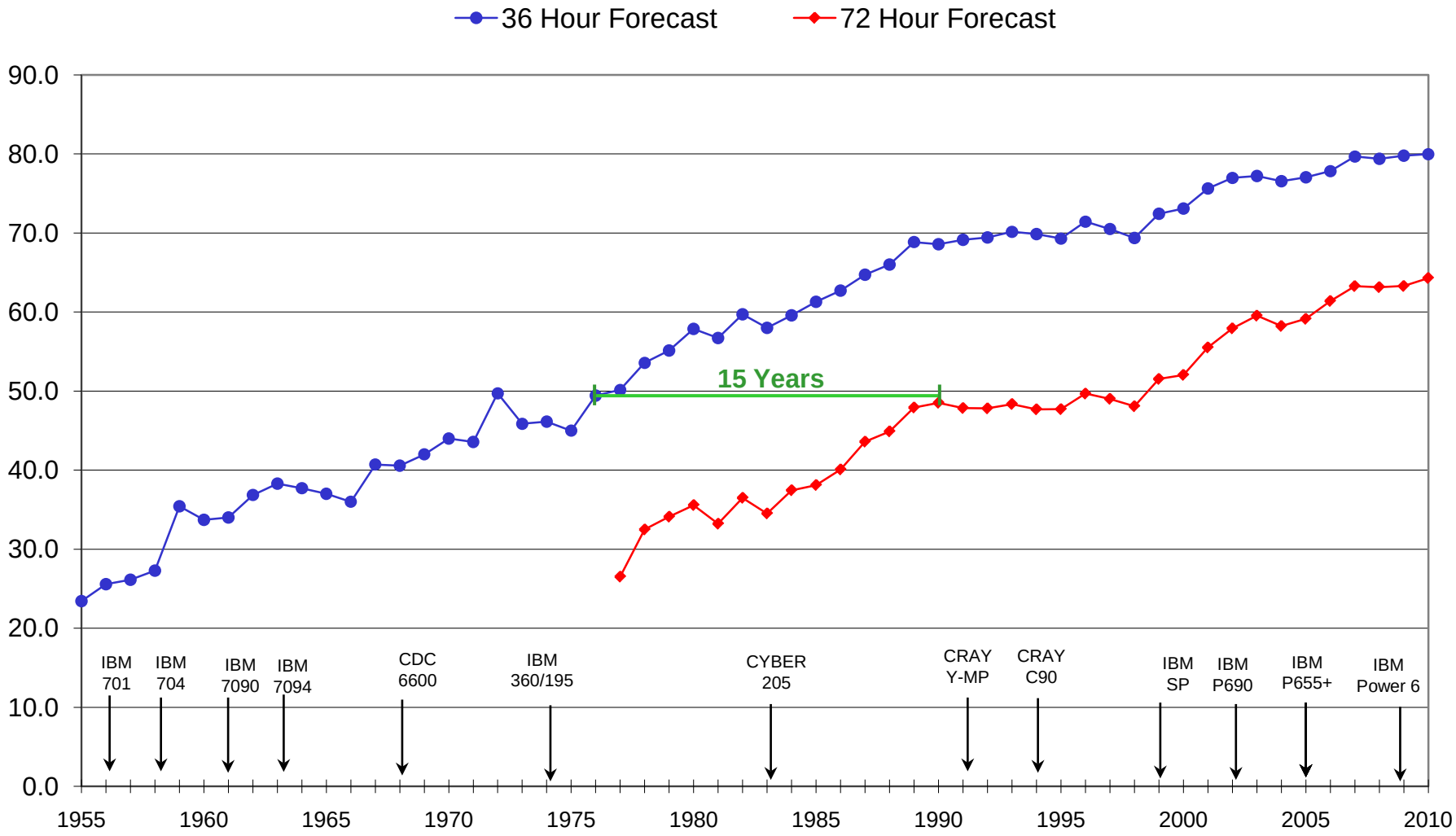
"reliable, timely and accurate"

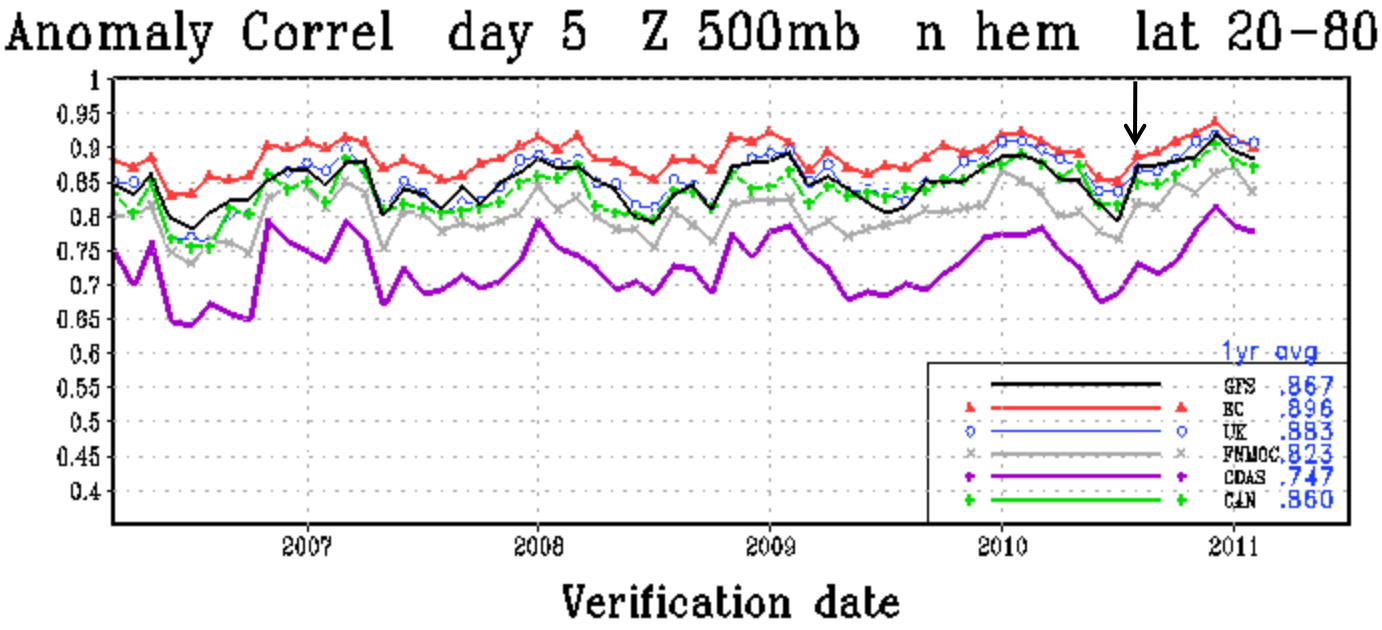
- Transition to IBM Power 6 complete
  - Declared operational August 12, 2009
  - 73.1 trillion calculations/sec
  - Factor of 4 increase over the IBM Power5
  - 156 POWER6 32-way nodes
  - 4,992 processors
  - 20 terabytes of memory
  - 330 terabytes of disk space
  - 3.5 billion observations/day
  - 27.8 million model fields/day
- Primary: Gaithersburg, MD
- Backup: Fairmont, WV
  - Guaranteed switchover in 15 minutes
  - Web access to models as they run on the CCS

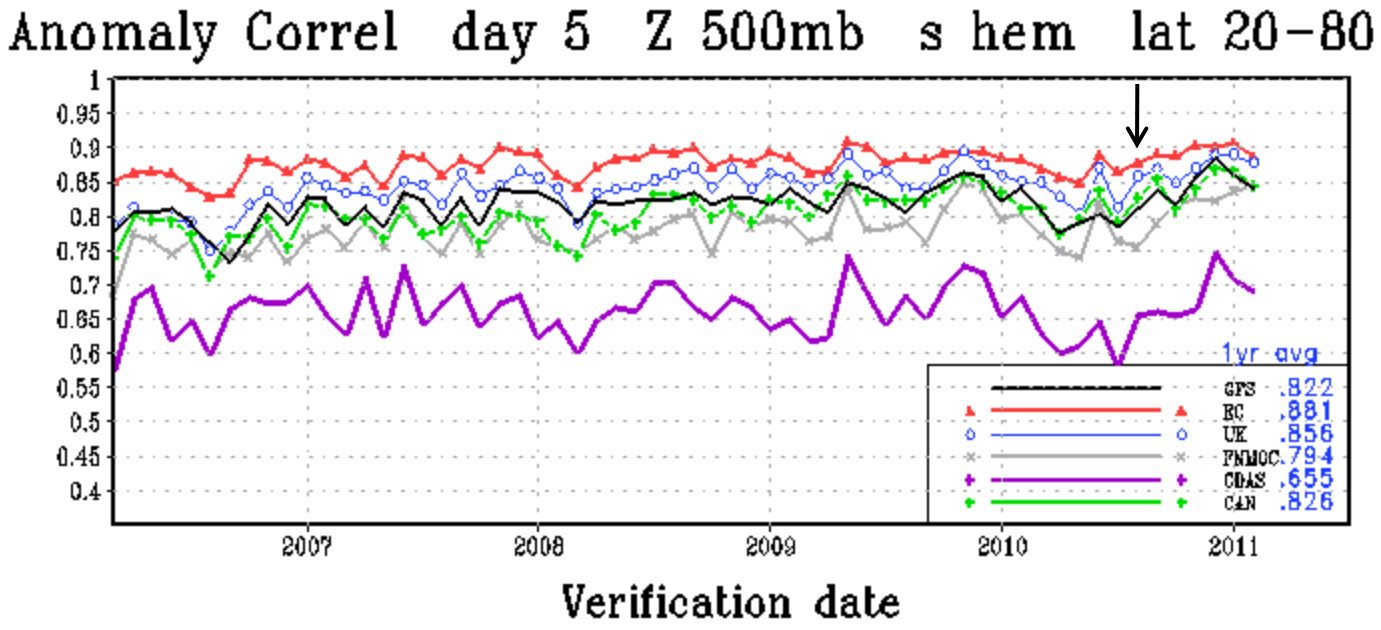


NCEP Operational Forecast Skill

36 and 72 Hour Forecasts @ 500 MB over North America
[100 * (1-S1/70) Method]




Anomaly Correl day 5 Z 500mb n hem lat 20-80
1
0.95
0.9
0.85
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
2007
2008
2009
2010
2011
Verification date
1yr avg
GFS .867
EC .896
UK .883
FNMOC .823
CDAS .747
CAN .860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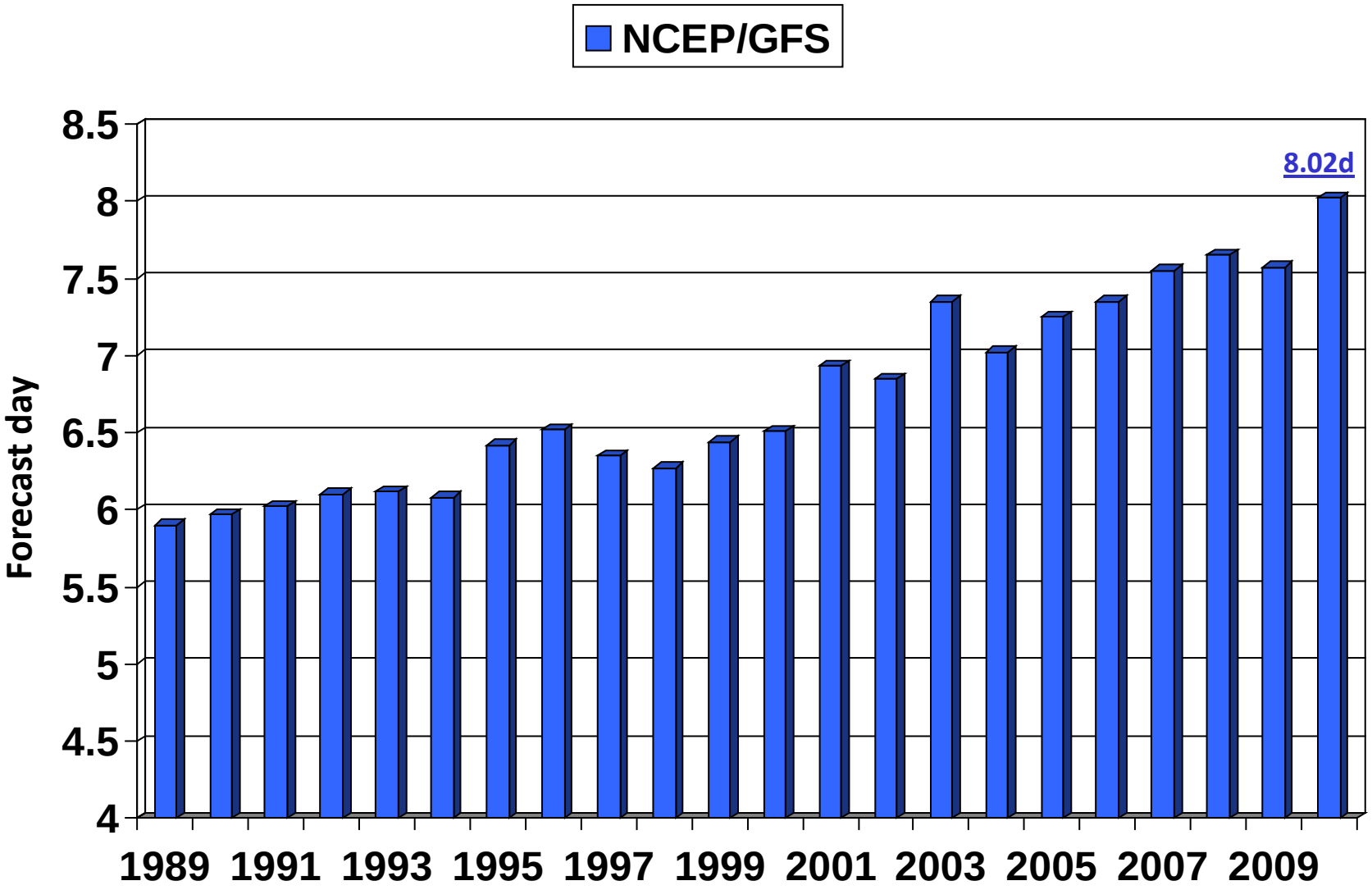
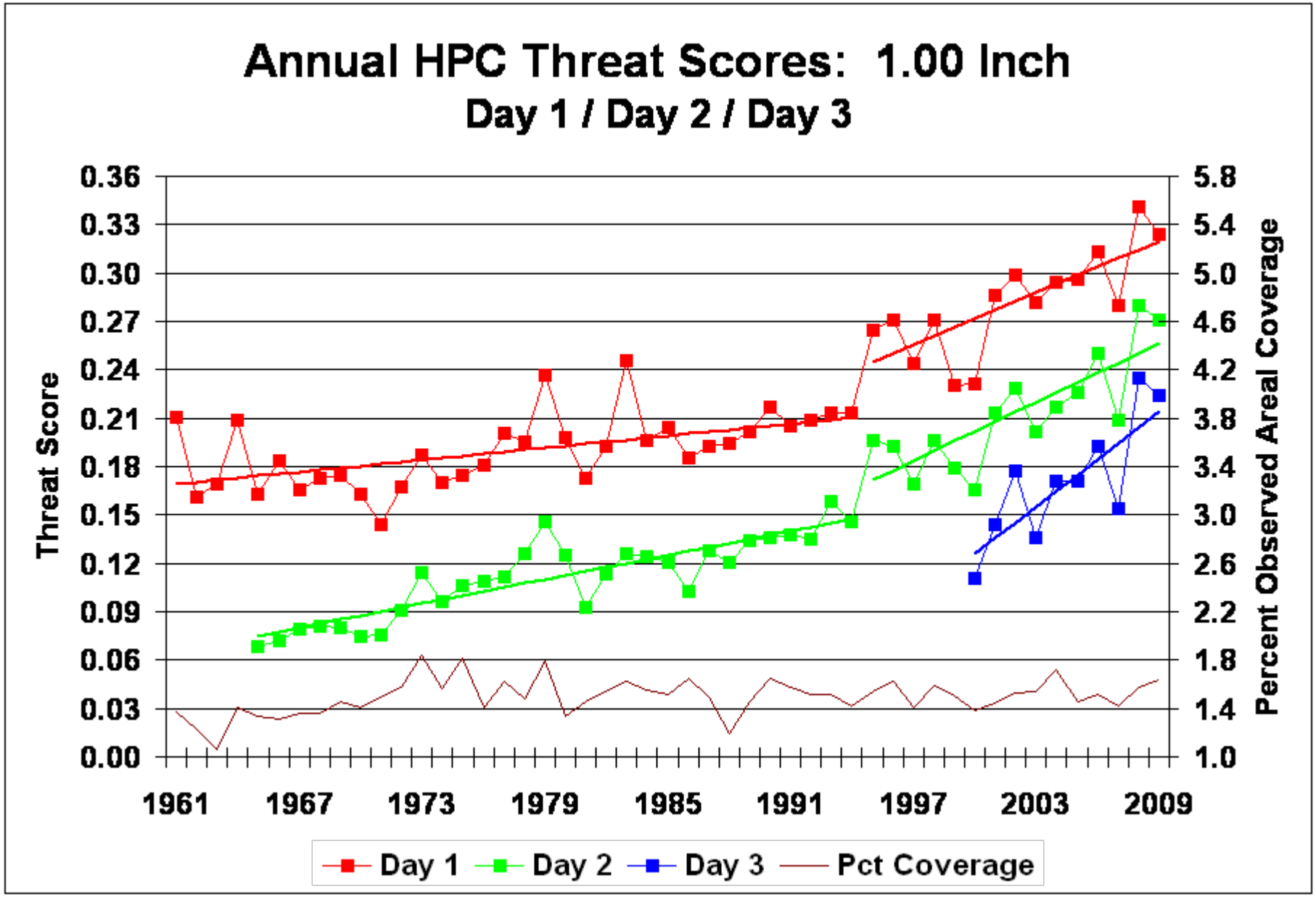
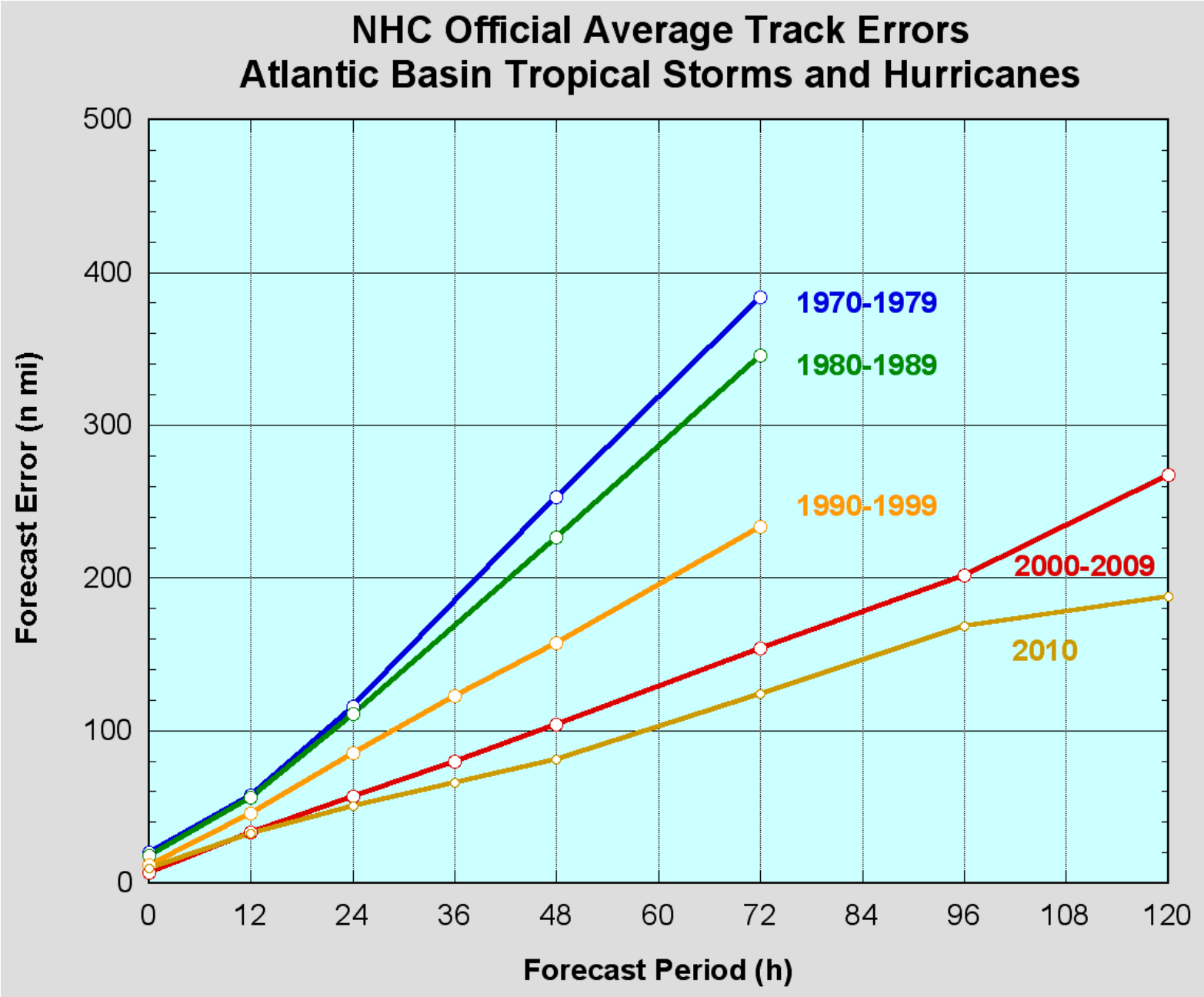
0.7
0.65
0.6
0.55
0.5
0.45
0.4
2007
2008
2009
2010
2011
Verification date
1yr avg
GFS .822
EC .881
UK .856
FNMOC .794
CDAS .655
CAN .826

Day at which forecast loses useful skill (AC=0.6)
N. Hemisphere 500hPa height calendar year means




Annual HPC Threat Scores: 1.00 Inch
Day 1 / Day 2 / Day 3
Threat Score
0.36
0.33
0.30
0.27
0.24
0.21
0.18
0.15
0.12
0.09
0.06
0.03
0.00
Percent Observed Areal Coverage
5.8
5.4
5.0
4.6
4.2
3.8
3.4
3.0
2.6
2.2
1.8
1.4
1.0
1961
1967
1973
1979
1985
1991
1997
2003
2009
Day 1
Day 2
Day 3
Pct Coverage

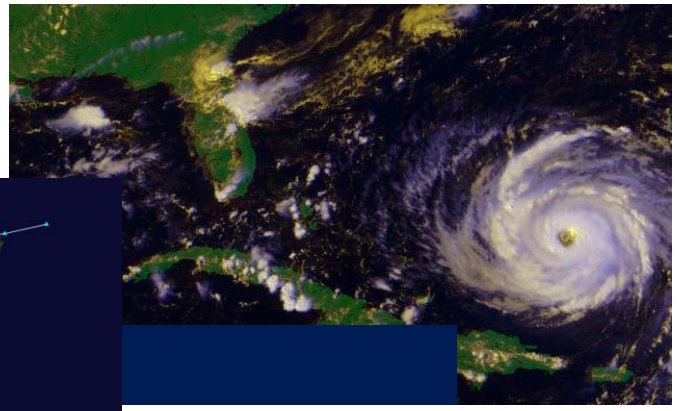

NHC Official Average Track Errors
Atlantic Basin Tropical Storms and Hurricanes
Forecast Error (n mi)
500
400
300
200
100
0
0
12
24
36
48
60
72
84
96
108
120
Forecast Period (h)
1970-1979
1980-1989
1990-1999
2000-2009
2010

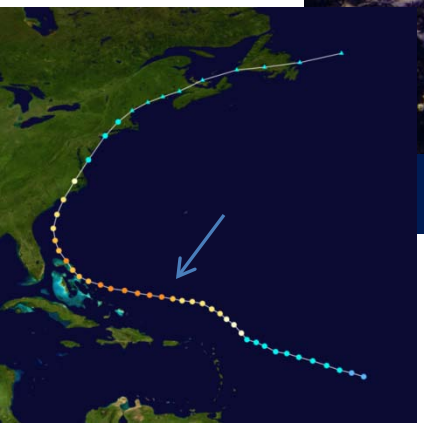
Hurricane Floyd vs Hurricane Earl

Comparisons from MikeSmithEnterprises.com

Hurricane Floyd - 1999

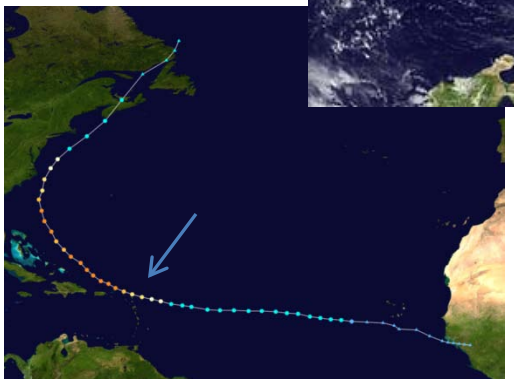
- Category 5
- Hurricane warnings along 1500 miles of coastline
- Mass evacuations overwhelmed highways in SE US
- Largest peacetime evacuation ever in U.S.





Hurricane Earl - 2010

- Category 4
- Hurricane warnings along 450 miles of coastline
- Some selective evacuations in NC (Outer Banks)
- Savings from 1050 miles of coastline not warned = $700M



Rapidly Developing Pacific Storm: Not Predicted

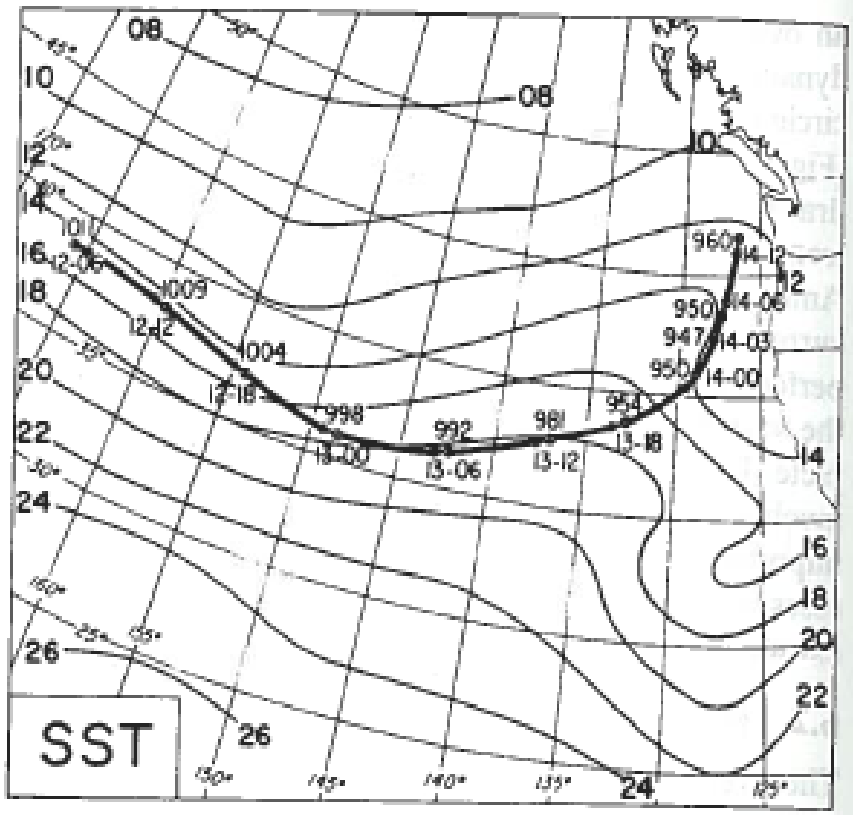


FIG. 6.4. Storm track for an intense oceanic cyclone. The 6-h positions and corresponding central pressures are marked for the period from 06 UTC 12 November to 12 UTC 14 November. Light solid lines are sea-surface temperature (°C)

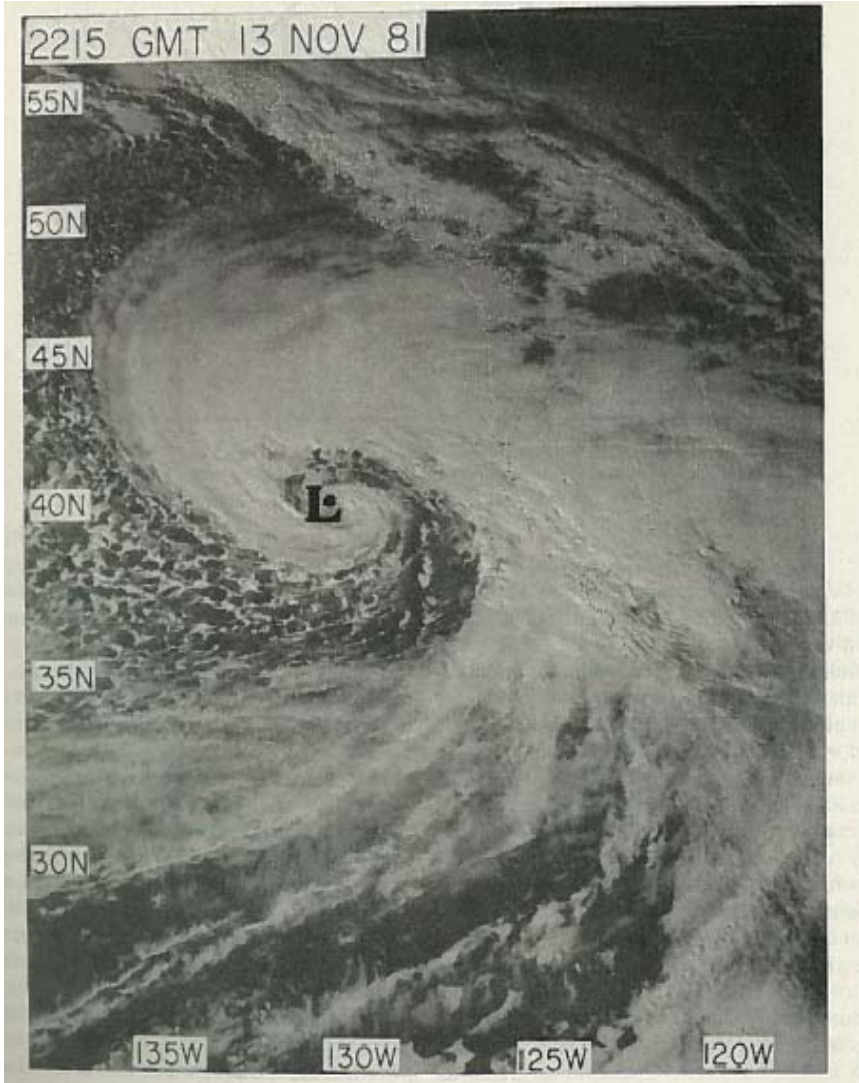


FIG. 10. GOES-W visible image 2215 GMT 13 November 1981.

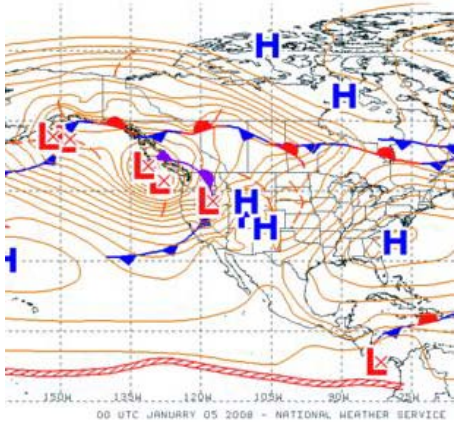
Reed and Albright, MWR, 1986

January 3-7, 2008
West Coast Rain/Snow Event

- Snowfall in CA mountains of up to 10 feet.
- Many locations with multiple feet of snow.

- Localized flooding caused by heavy rains at lower elevations
- Rainfall amounts 2-10 inches.

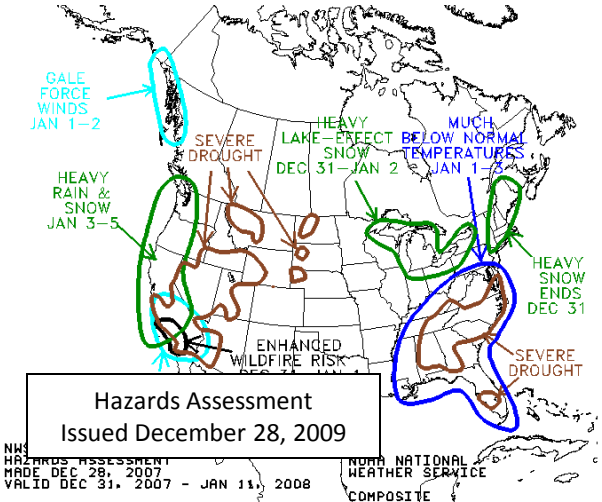
00Z 5 January, 2008



3 Weeks Prior to Event

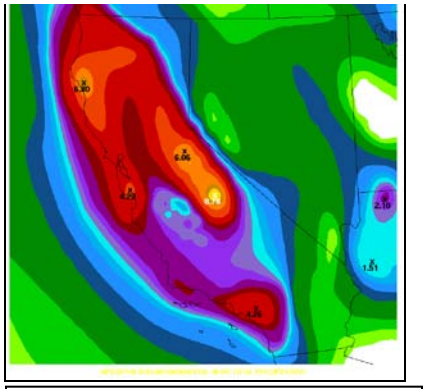
MJO Update: **issued by Climate Prediction Center**
December 24, 2007
"Some *potential exists for a heavy precipitation event* tied to tropical convection by week 3 … along *the west coast of the US* "

6 Days Prior to Event



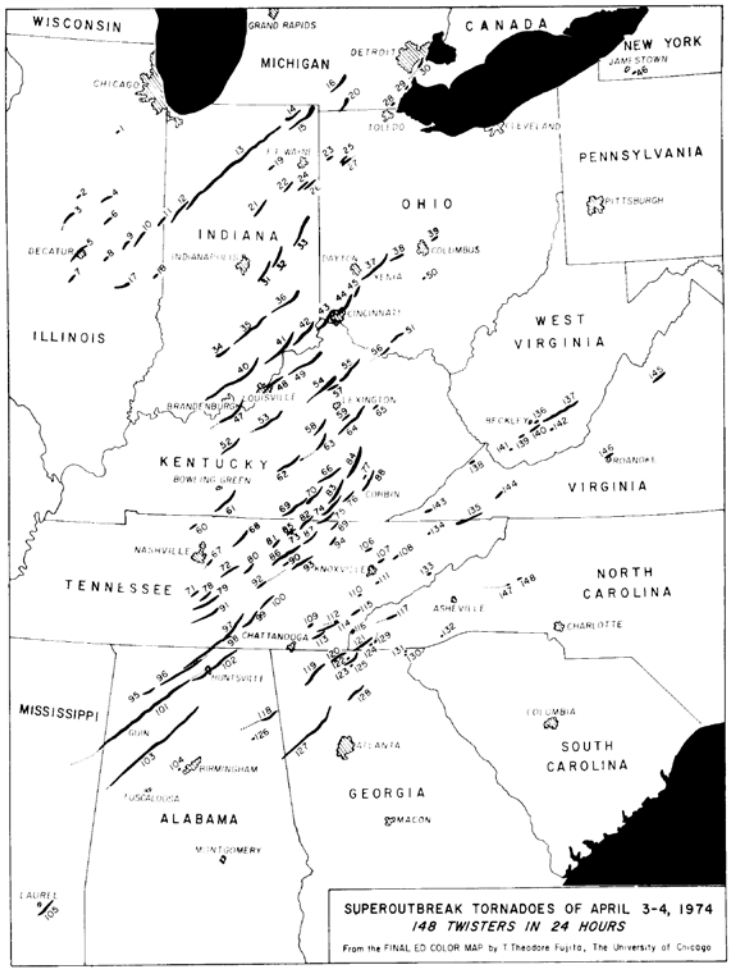
Hazards Assessment
Issued December 28, 2009

4 Days Prior to Event

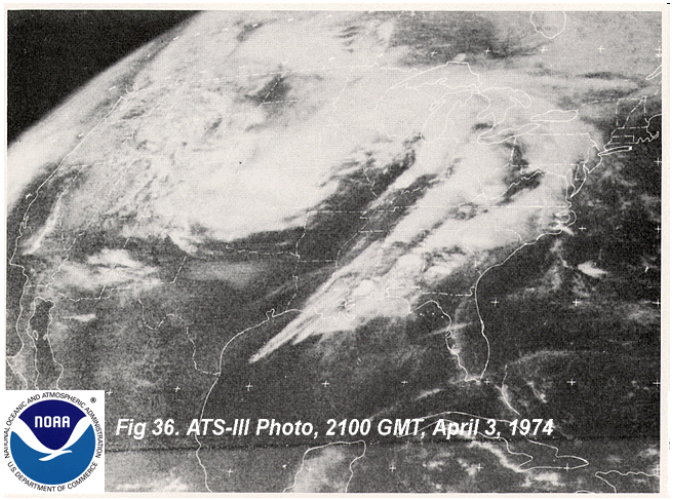


HPC 48-h QPF ending 00Z 6 Jan
Issued 00Z 1 Jan
Day 4-5 forecast

April 3-4, 1974 Super Outbreak



Tornado Tracks
12Z April 3 – 12Z April 4, 1974

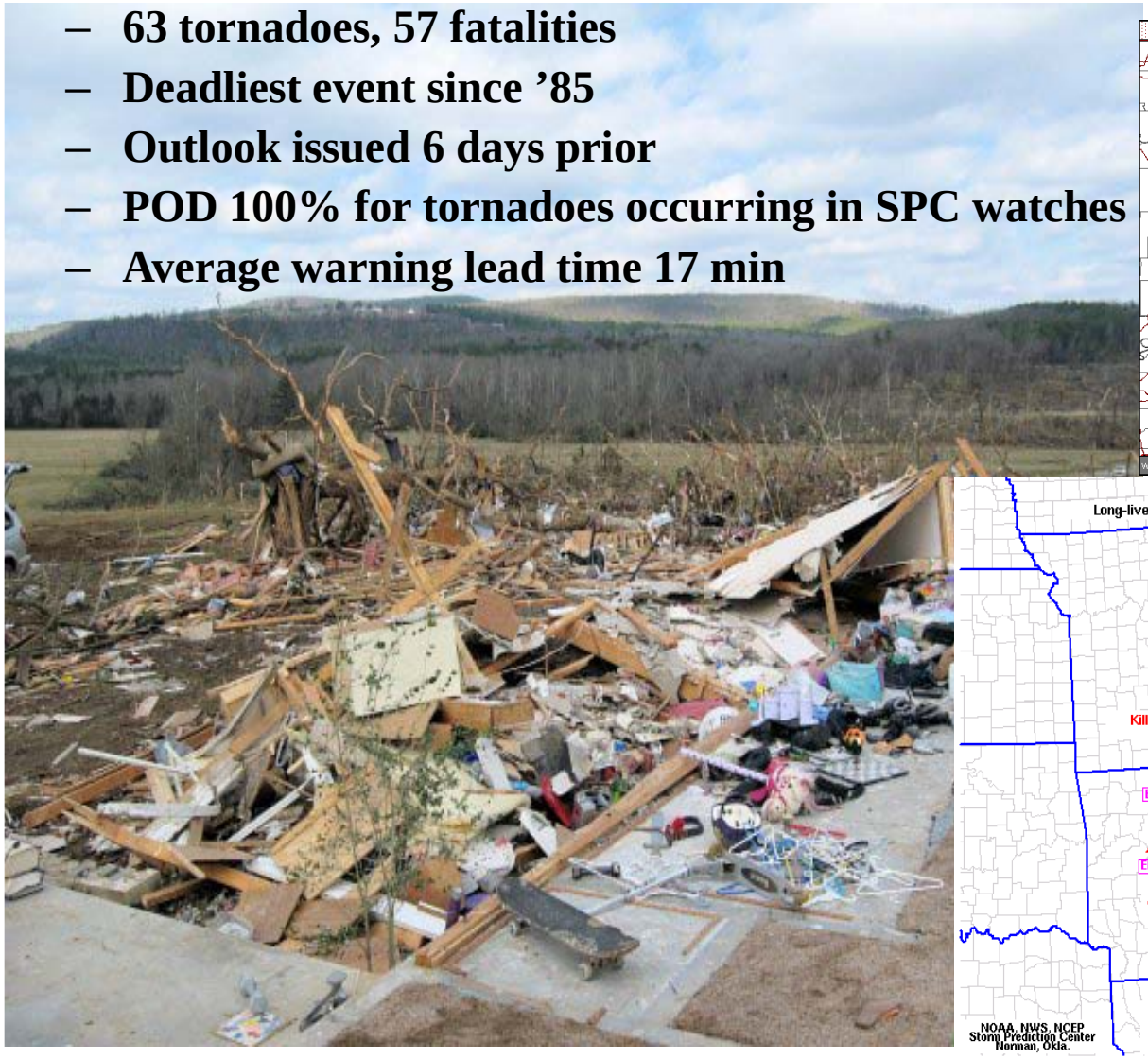


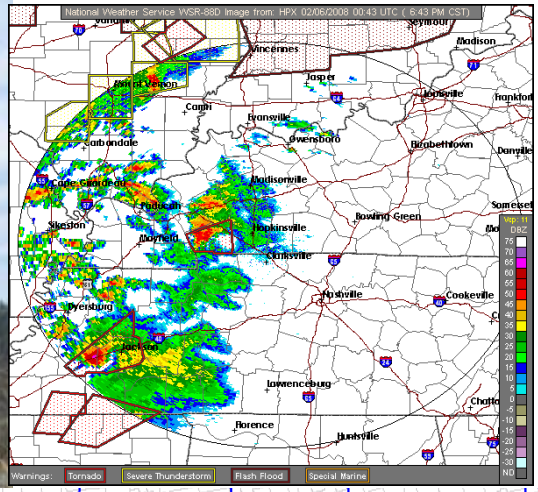
- One of the deadliest tornado outbreaks in the 20th Century (330 fatalities)
- Involved over one-quarter of the country
  - 148 tornadoes in 13 states
- Magnitude of event not realized until evening news – April 3

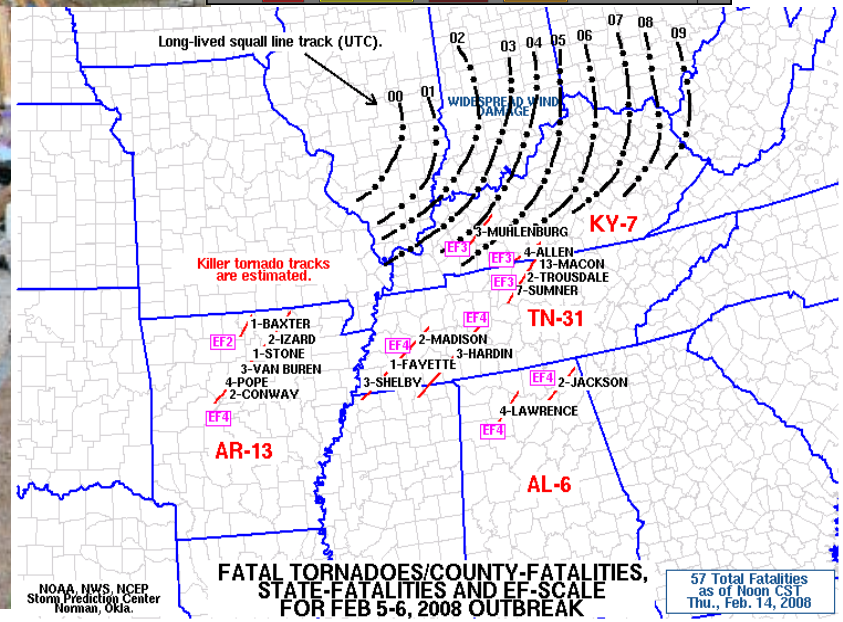
Super Tuesday Tornado Outbreak

February 5-6, 2008

- **63 tornadoes, 57 fatalities**
- **Deadliest event since ’85**
- **Outlook issued 6 days prior**
- **POD 100% for tornadoes occurring in SPC watches**
- **Average warning lead time 17 min**

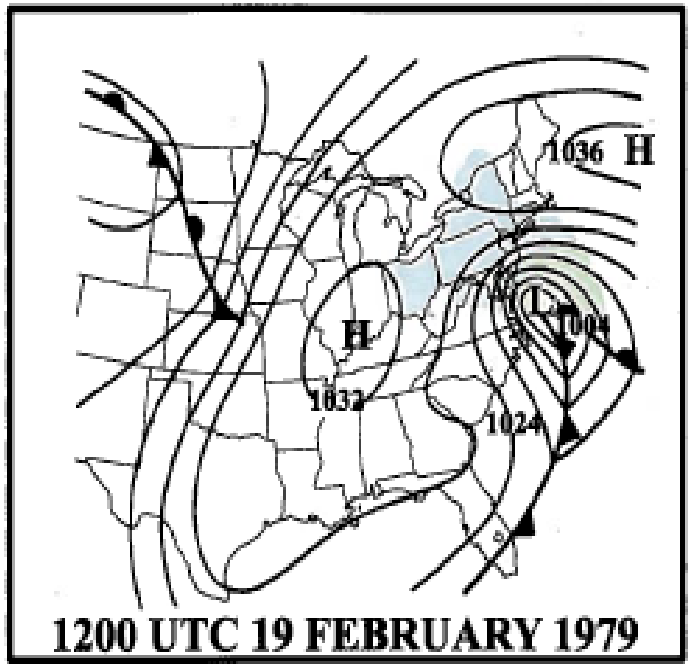






East Coast Storms

Presidents' Day Storm 18-20 February, 1979



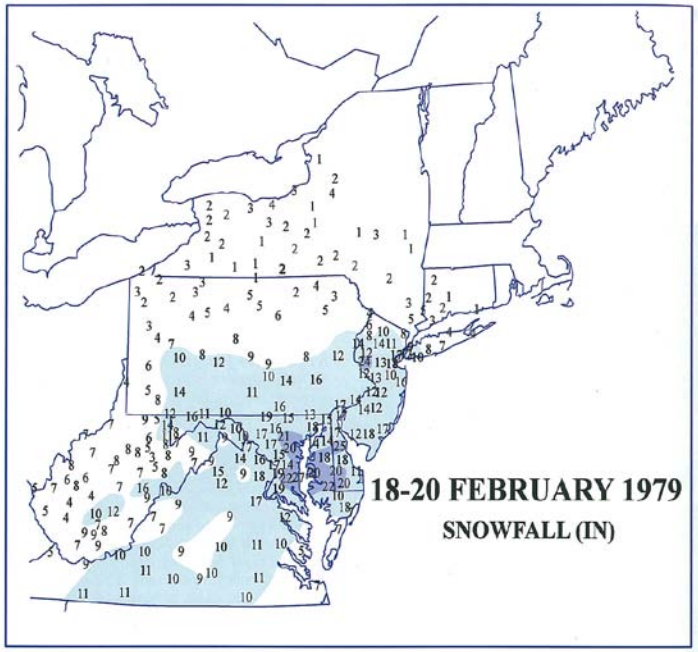
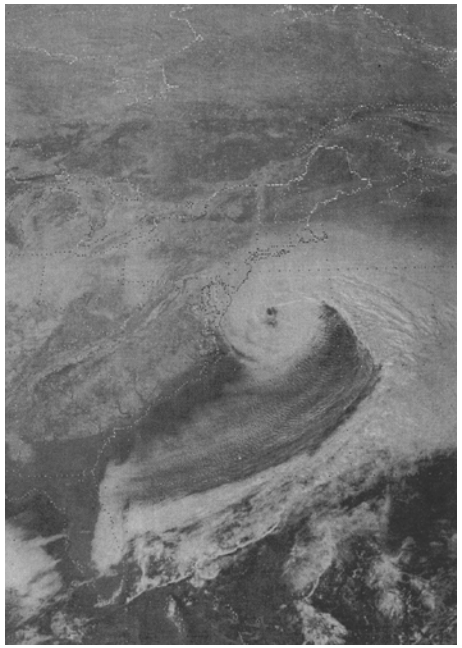


FIG. 10.18-1. Snowfall (in.) for 18–20 Feb 1979. See Fig. 10.1-1 for details.

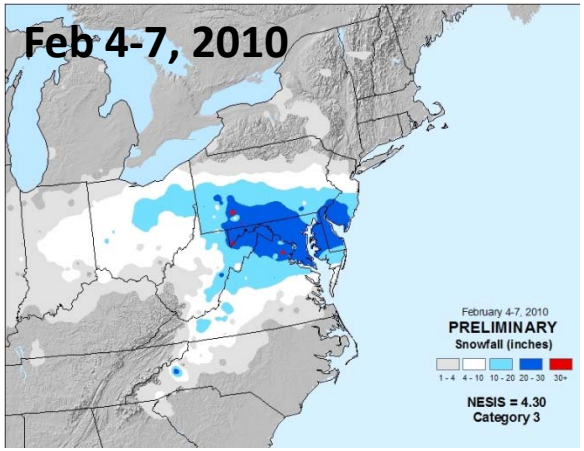


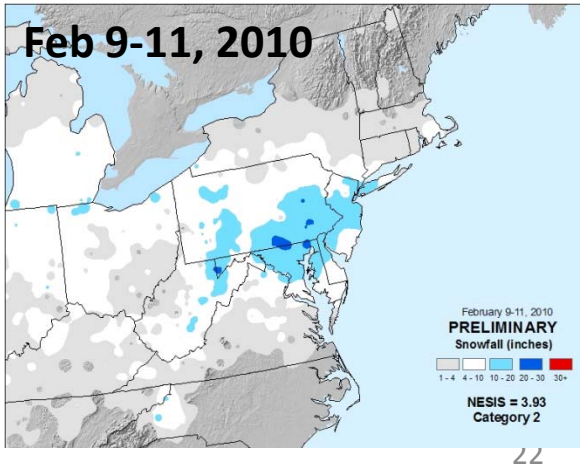
1830Z 19 Feb 1979

- 22 inches of snow buries Washington D.C. area
- Rapid cyclogenesis off the coast
- Not predicted even hours in advance

February 4-11, 2010: “Snowmageddon”

- February 4-7, 2010: massive winter storm paralyzes mid-Atlantic region
  - Locations in Maryland, Pennsylvania, Virginia, and West Virginia recorded more than 30 inches of snow.
  - Washington DC’s two-day total of 17.8 inches ranked as the fourth highest total storm amount in history.
  - Philadelphia’s 28.5 inches ranked as the second highest amount
  - Baltimore’s 24.8 inches ranked as its third highest storm total amount
- Strong blizzard during February 9-11 affects same areas still digging out from earlier storm.
  - Produced as much as 14 inches in the D.C. area, 20 inches in Baltimore, 17 inches in New Jersey, more than 27 inches in Pennsylvania, and 24 inches in northern Maryland.
- Storm system predicted 7+ days in advance; potential for heavy snow 3-5 days in advance
- States implement COOP plans, airlines cancel flights, retail industry pre-stocks shelves

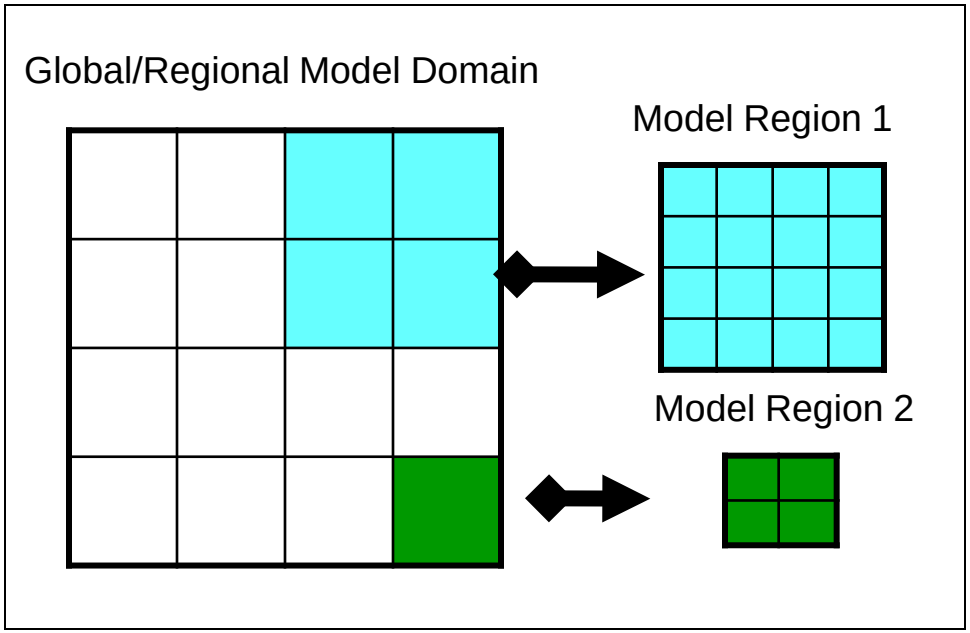




Forces for Change

- Increasing emphasis on multi-model ensemble approaches that build on the NCEP model suite – support for Decision Support Services
  - SREF
  - NAEFS
  - Climate Forecast System (EUROSIP)
- Entering the JPSS era
  - More rapid access to hyperspectral data
  - GPS soundings
  - Higher resolution surface radiance data
- All models run within ESMF
  - Models run concurrently
  - Hybrid vertical coordinate
  - Coupled
  - Spanning all scales
- Operational Earth System model – more explicit hydro, climate and ecosystems applications

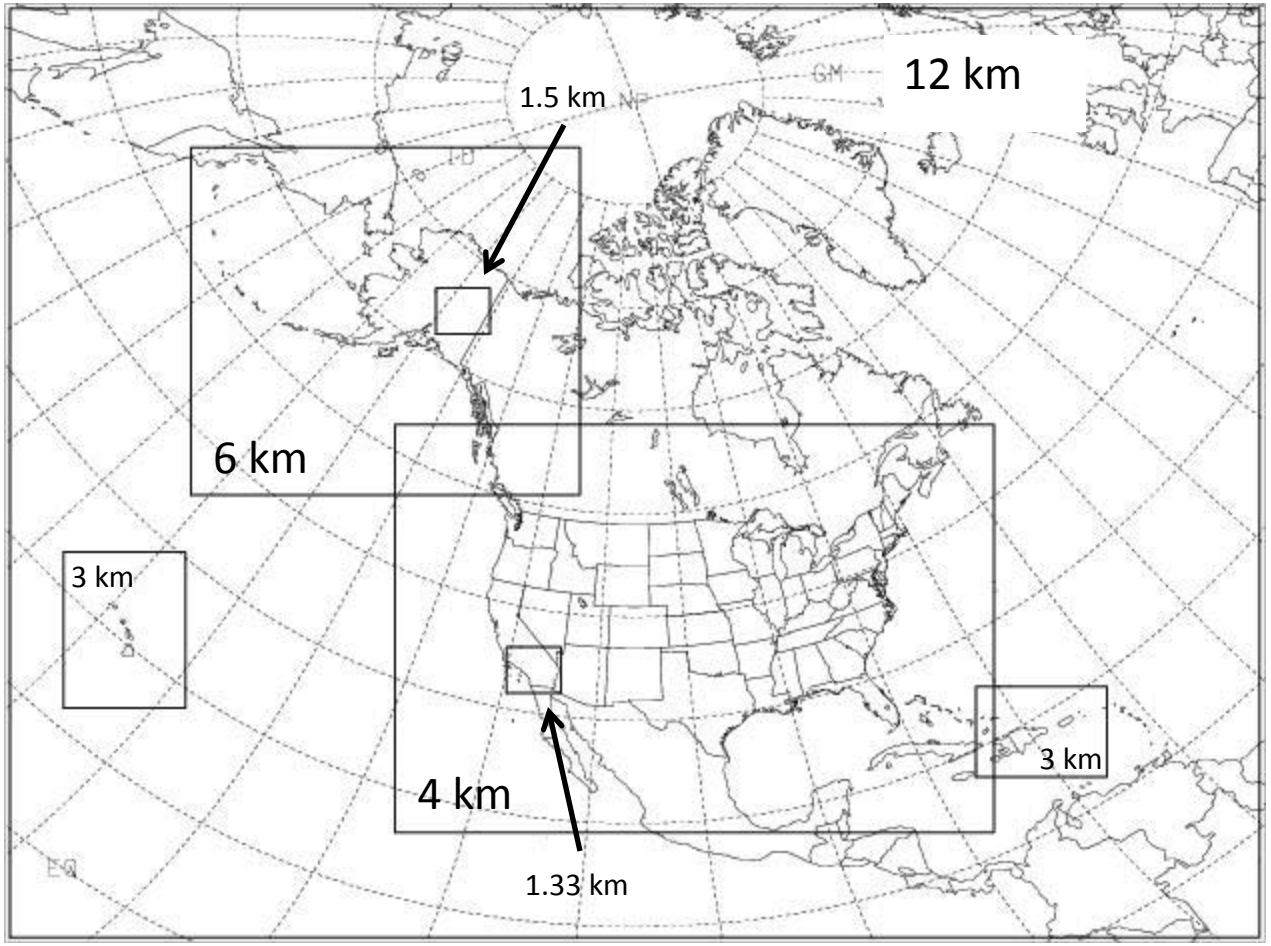
ESMF-based System



Climate Forecast System (CFS) Planned Upgrade for Q2FY11

Attribute	Operational Configuration	Q1FY11 Configuration
Analysis Resolution	200 km	38 km
Atmosphere model	1995: 200 km/28 levels Humidity based clouds	100 km/64 levels Variable CO2 AER SW & LW radiation Prognostic clouds & liquid water Retuned mountain blocking Convective gravity wave drag
Ocean model	MOM-3: 60N-65S 1/3 x 1 deg. Assim depth 750 m	MOM-4 fully global ¼ x ½ deg. Assim depth 4737 m
Land surface model (LSM) and assimilation	2-level LSM No separate land data assim	4 level Noah model GLDAS driven by obs precip
Sea ice	Climatology	Daily analysis and Prognostic sea ice
Coupling	Daily	30 minutes
Data assimilation	Retrieved soundings, 1995 analysis, uncoupled background	Radiances assimilated, 2008 GSI, coupled background
Reforecasts	15/month seasonal output	25/month (seasonal) 124/month (week 3-6)

National Environmental Modeling System FY11; Q3



Parent (12 km)
– 84 hrs
Children (6, 4 & 3 km)
– 60 hrs
IMET (1.5 & 1.33 km)
– 36 hrs

Nonhydrostatic Mesoscale Model (NMM) → NonHydrostatic Multiscale Model on B grid (NMMB)
-- Physics retuned for NMMB
-- Additional data sets: Windsat, ASCAT, ACARS humidity, NOAA-19 (HIRS and AMSU-A), IASI radiances, AQUA (AMSU-A), GPS (radio occultation)

New Building Status

- The developer stopped work in December 2008 when NCWCP construction was 80% complete.
- In May 2009, the developer filed a claim in **Federal Court** to recover "damages" from the Government. This claim was dismissed <u>without prejudice</u> in August 2010. In October 2010, the developer filed an appeal
- In June 2009, the developer filed for bankruptcy with the **County Court**. In response, the court appointed a "Receiver" to complete the project. In November 2010, the court approved the Receiver's plan and granted the receiver permission to resume construction.
- In December 2010, the Receiver petitioned the U.S. Court of Appeals for the Federal Circuit for dismissal of the previous claim filed by Maryland Enterprises. The Federal Court granted the motion on February 9, 2011 and dismissed the claim filed by the developer.
- These actions cleared away all remaining legal obstacles for the restart of work on the NCWCP project.
- All parties signed Service Level Agreement 3/7/11
- GSA's goal is to reach project completion approximately 12 months after re-start of construction. GSA's most current estimate for the building's substantial completion is March 2012 with complete move-in by July 2012.

Summary

- NCEP was connected to MAR planning through the upgrade of the central computer
- Significant/accelerated progress in forecast and warning programs linked to this computer acquisition
- Improvements in workstation technology and collaborative forecasting also have improved Service Center – WFO products/services → "collaborative" forecasts
- Ongoing efforts in Testbeds, AWIPS2, and community models will be important for moving NCEP forward and extending prediction beyond weather and climate
- For next "modernization" effort, NCEP Centers have to be better integrated into plans and related implementations and advancements from Day 1.