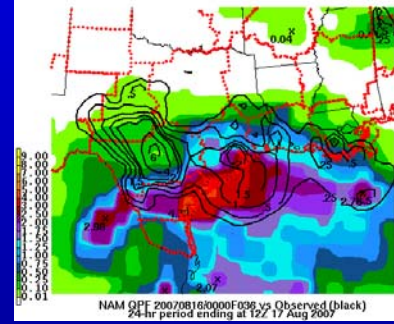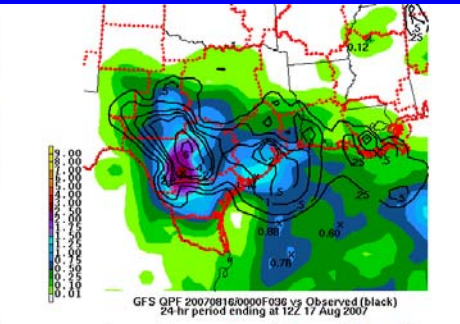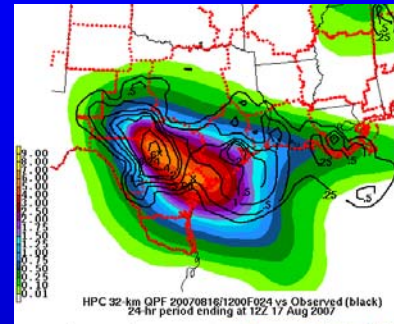# Hydrometeorological Prediction Center 2007 Review
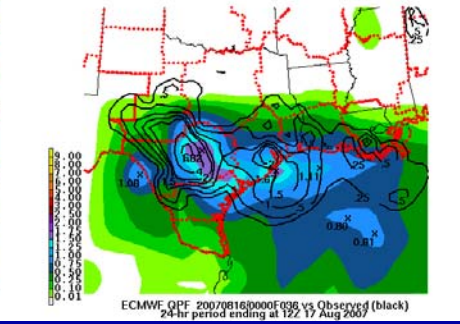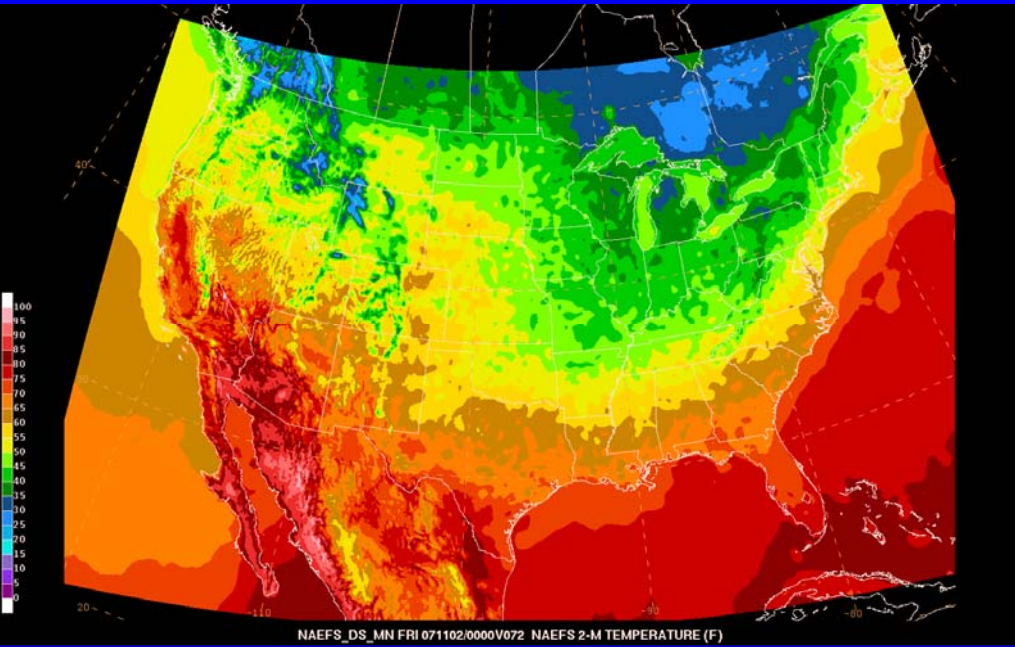
Michael J. Brennan
Science and Operations Officer

2007 NCEP Production Review Meeting
11 December 2007

Outline

- Model performance from HPC perspective
- HPC observed model biases
- Evaluation of recent NCEP model upgrades
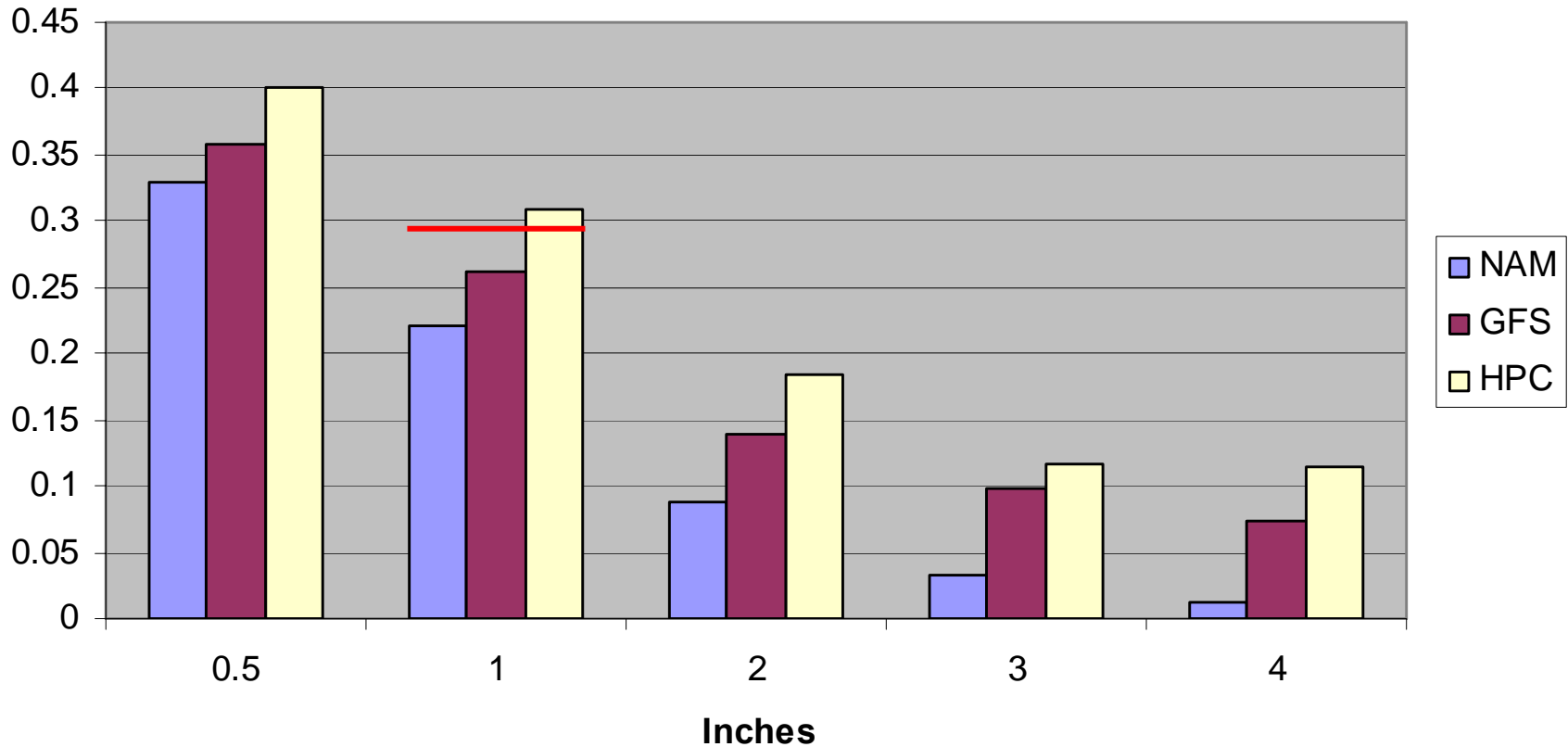- Other HPC notes

FY07 QPF – D1 Threat Score
HPC vs. NAM/GFS

FY07 Threat Score

HPC shows largest improvement in skill over
the NAM for all threshold values

FY07 QPF – D1 Bias
HPC vs. NAM/GFS
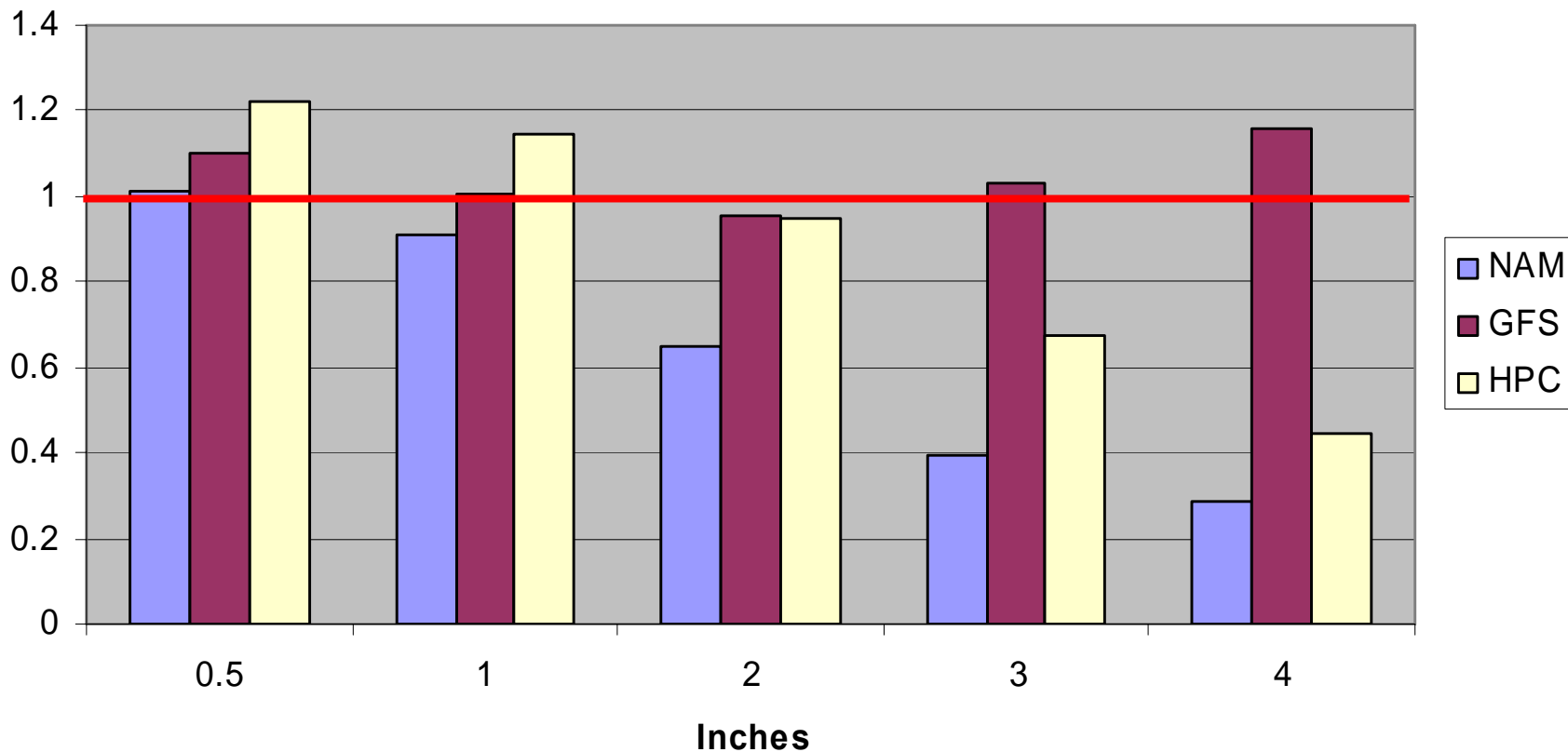
NAM has large low bias for high precip amounts, while GFS has slight high bias
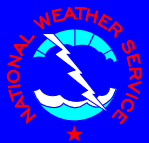
Overall QPF Skill Trends

- HPC level of improvement over NCEP models has remained relatively constant since 2004 for D1 1" threshold
  - ~ 20% improvement over GFS
  - ~ 30% improvement over NAM
- HPC threat scores continues to increase, remaining ahead of both GFS & NAM

HPC % Improvement to NCEP models
1-Inch Day 1 QPF Forecast

24-Hour 1-Inch Day 1 QPF Verification
Annual Threat Scores
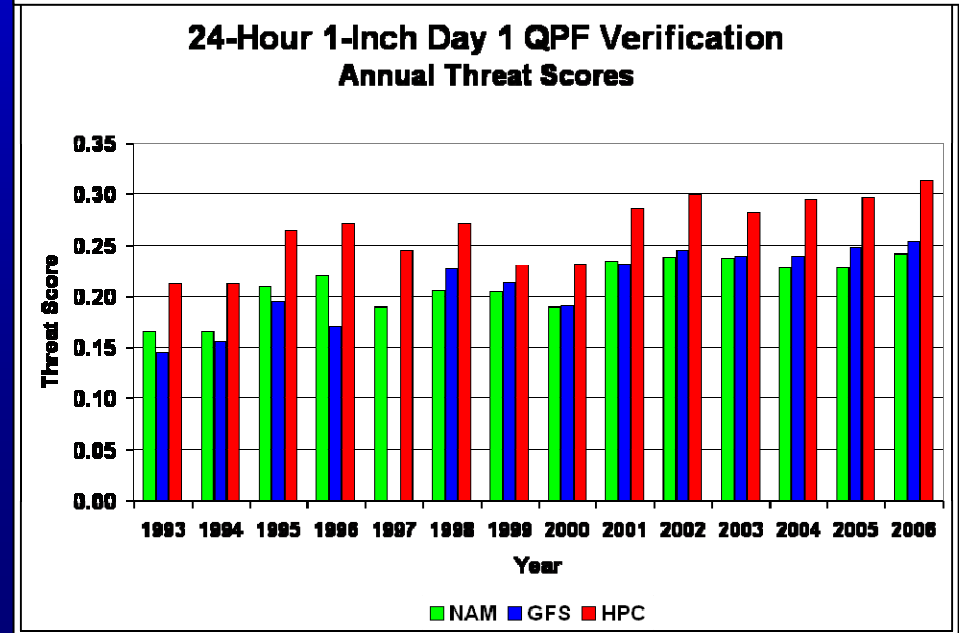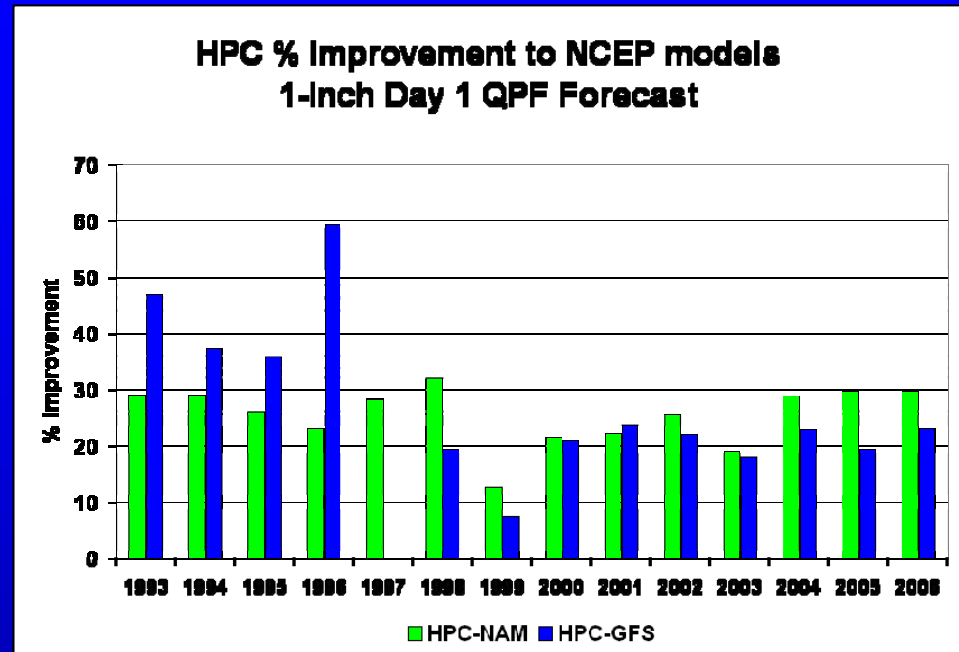
2007 Tropical Cyclone QPF

GFS QPF 20070816/0000F036 vs Observed (black)
24-hr period ending at 12Z 17 Aug 2007
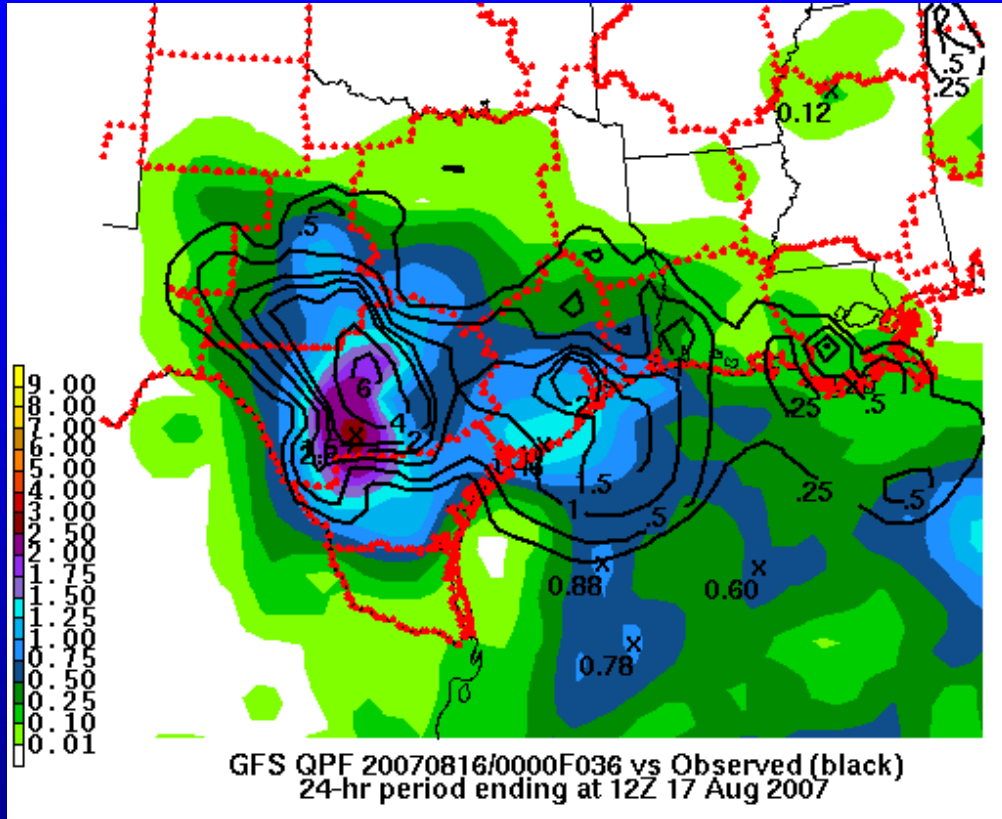
8 TCs:

Andrea
Barry
Erin
Gabrielle
Humberto
Henriette (EPAC)
TD #10
Noel
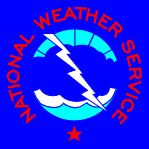
Day 1–3 threat score and bias from 8 TCs
(regional verification)

All 2007 Storms
Day 1 Verification

Summary Statistics for Landfalling Tropical Cyclones-2007
Day 1 Threat Score and Bias
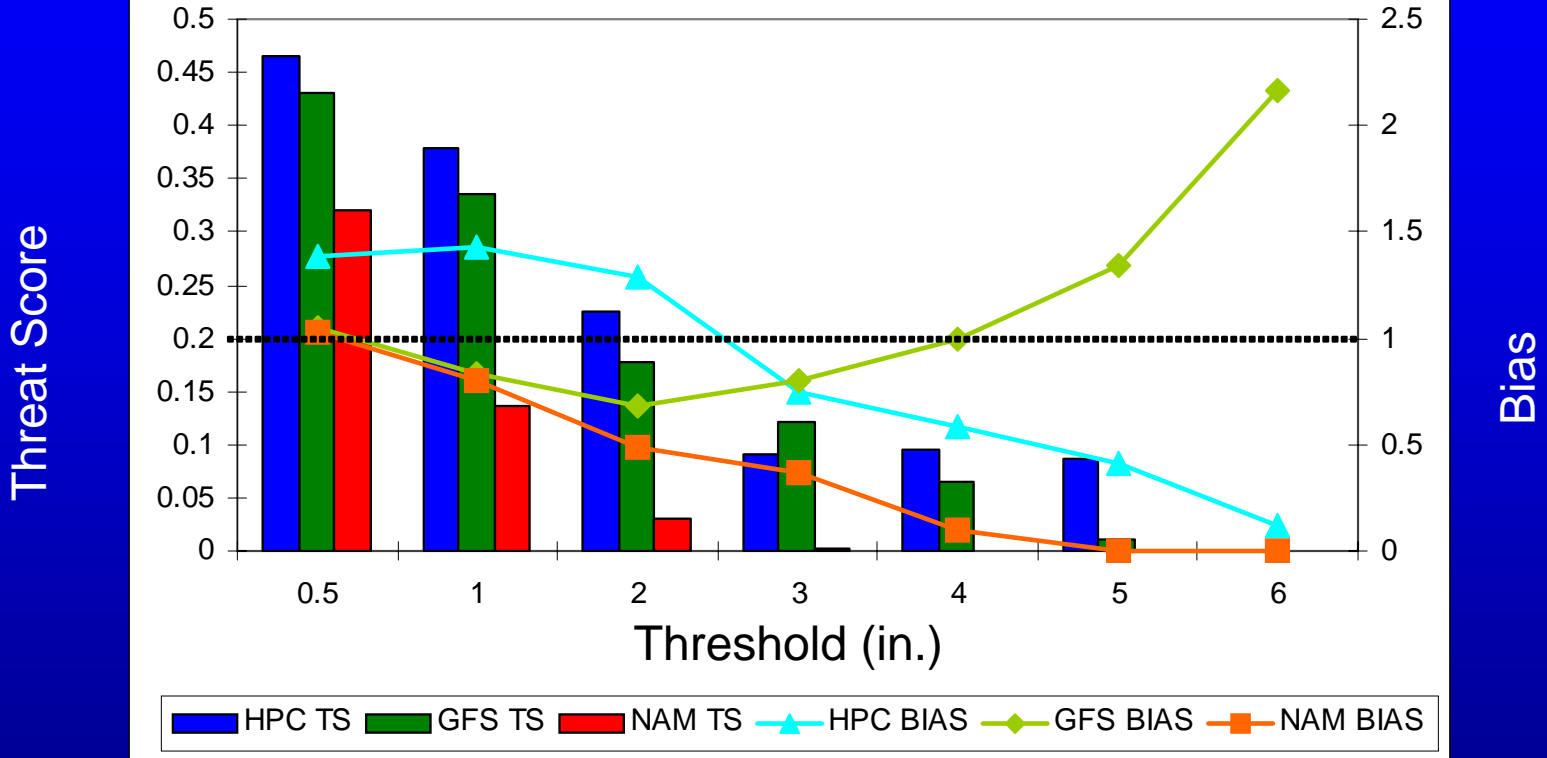
- **HPC had best overall TS (lost to GFS at 3")**

- **HPC had high bias at lower amounts and low bias at higher amounts; opposite of GFS and consistent with overall HPC QPF bias**

- **NAM skill consistently decreased for higher amounts**

All 2007 Storms
Day 2 Verification

Summary Statistics for Landfalling Tropical Cyclones-2007
Day 2 Threat Score and Bias

- **HPC had best TS at amounts ≤ 2"; GFS had best TS at amounts ≥ 3"**

- **NAM had best overall bias through 5"; biases generally low for all guidance**

- **HPC had low bias for amounts ≥ 2", but not as low as the GFS for amounts 2–5"**

All 2007 Storms
Day 3 Verification
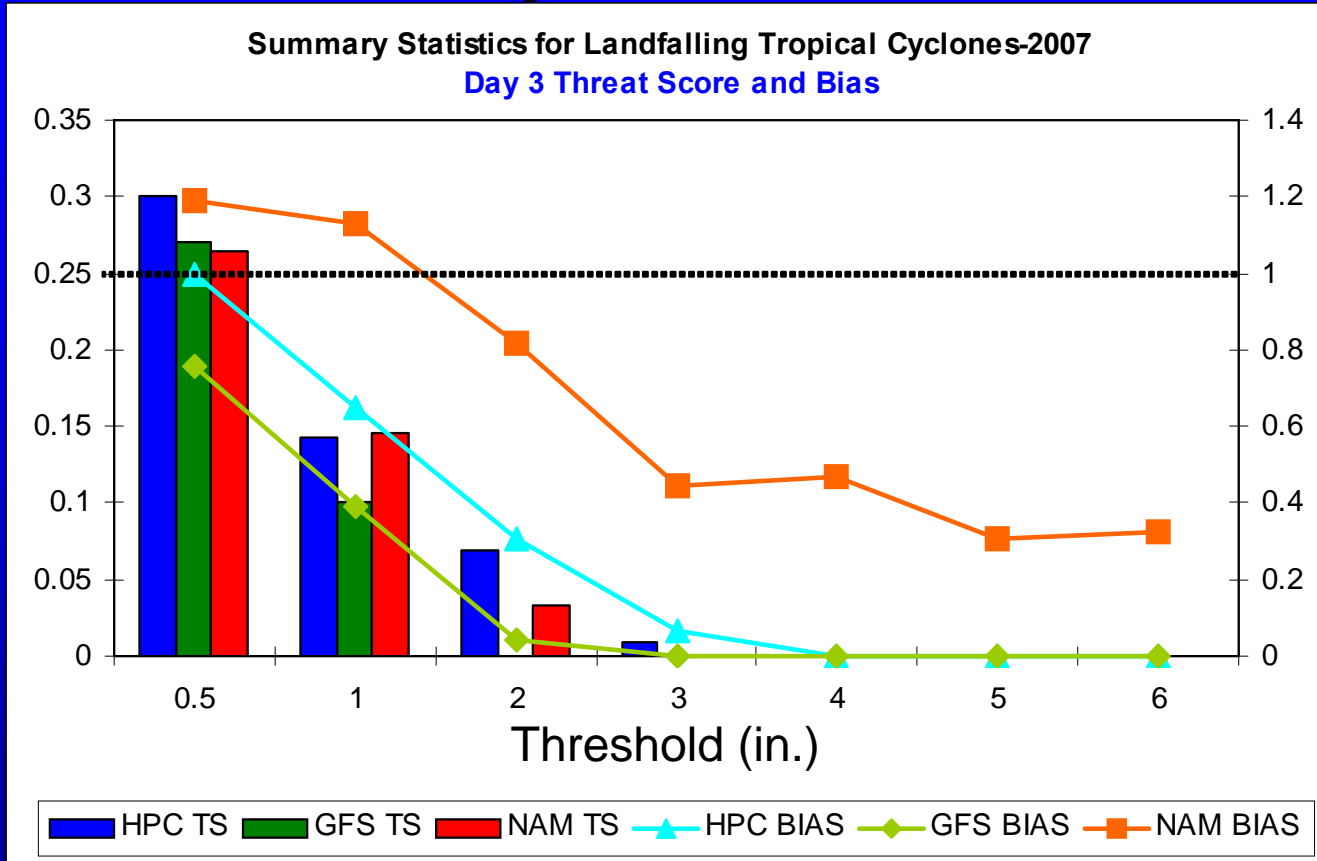
Summary Statistics for Landfalling Tropical Cyclones-2007
Day 3 Threat Score and Bias

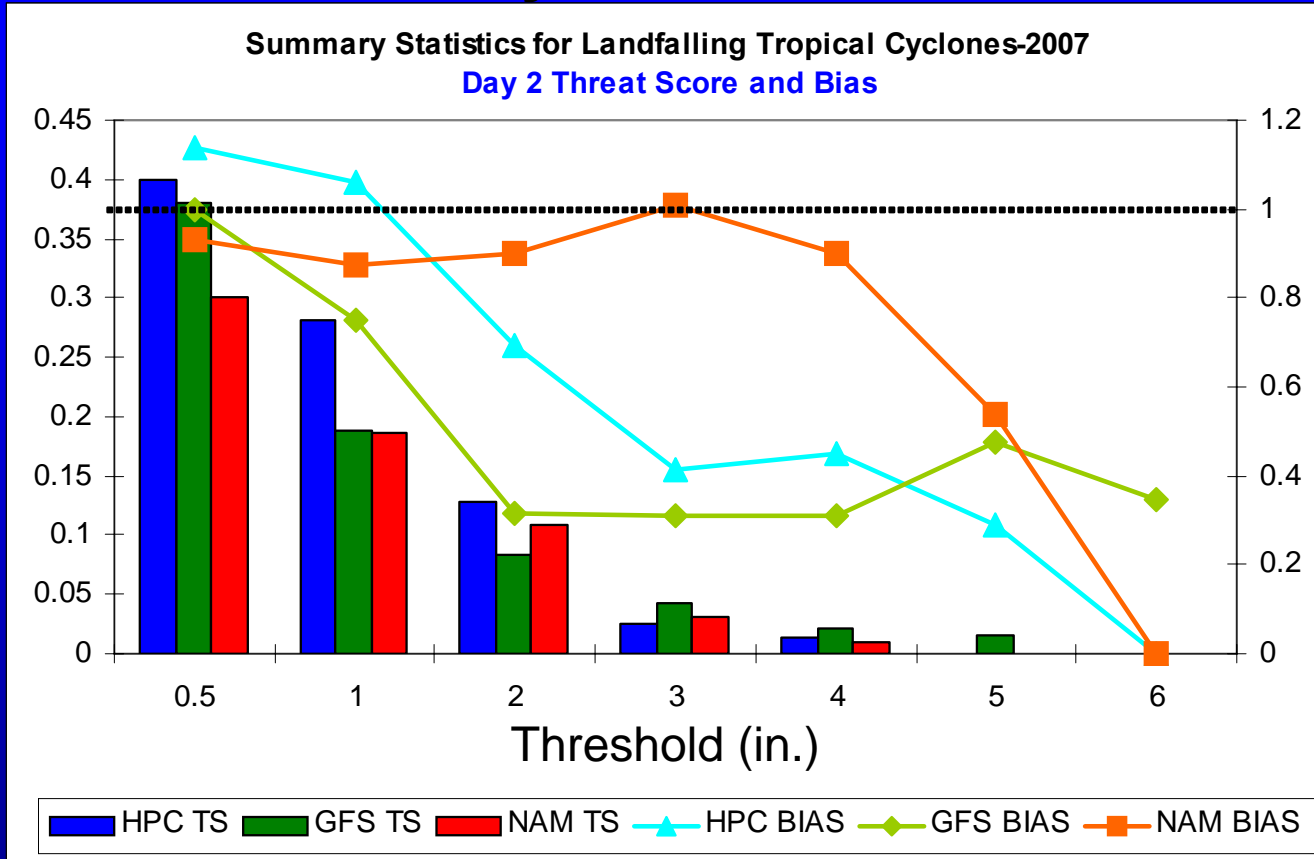- **Skill for all guidance at D3 significantly less than D1–2 (TS max out between 0.25–0.30)**

- **HPC had highest overall TS for amounts ≤ 3" (except outscored by NAM for 1")**

- **NAM has best bias for amounts ≥ 1"**

TS Erin
24-hrs ending 12Z 17 Aug.

HPC

HPC 32-km QPF 20070816/1200F024 vs Observed (black)
24-hr period ending at 12Z 17 Aug 2007

GFS

QPF factor of 3 too low

GFS QPF 20070816/0000F036 vs Observed (black)
24-hr period ending at 12Z 17 Aug 2007
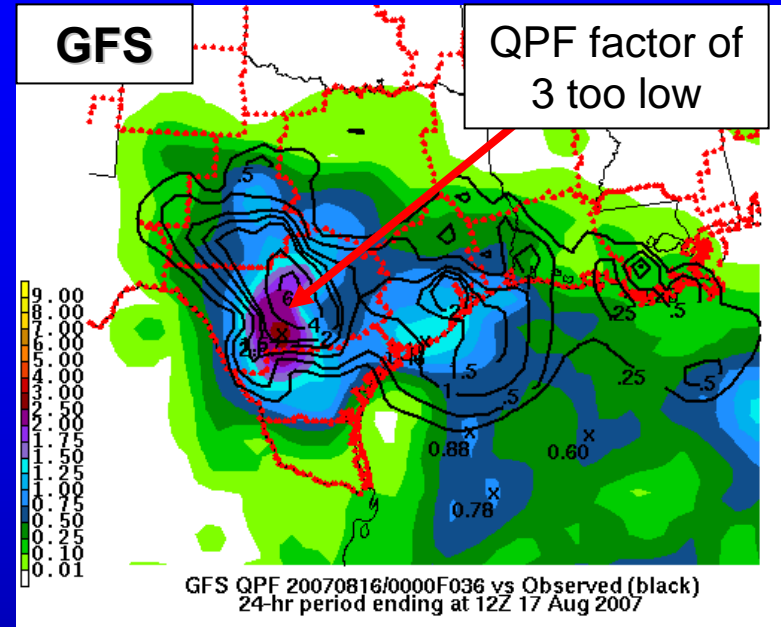
NAM

Missing inland precip max

NAM QPF 20070816/0000F036 vs Observed (black)
24-hr period ending at 12Z 17 Aug 2007
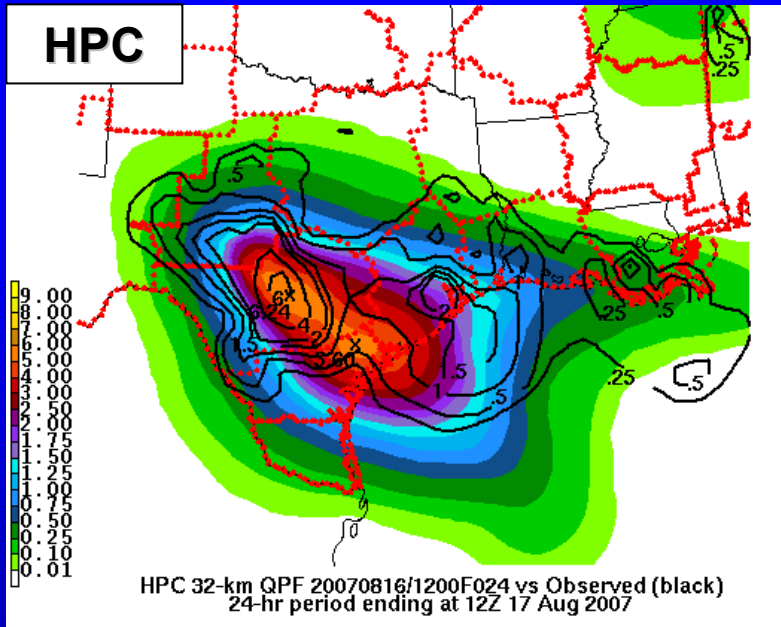
- D1 QPF (shaded)

- Observed rainfall (contours)

- GFS greatly under-forecast amounts along track of Erin, but does take max. rainfall inland along track

- NAM has amounts too high along the coast but completely misses inland max

TC QPF Overview

- HPC QPF best for TCs that produced heaviest, most widespread precipitation
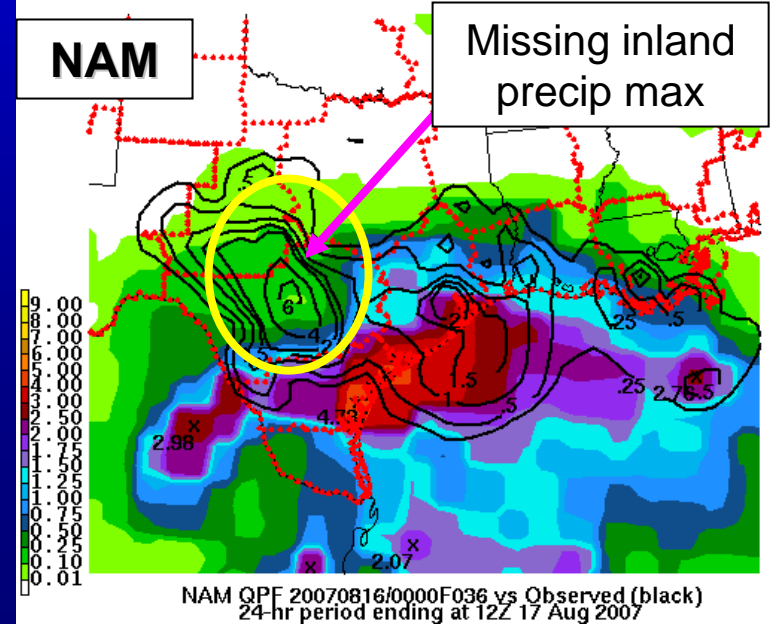 - HPC TS showed largest overall improvement over the models for Erin
  - HPC showed most improvement over the guidance for heavier amounts (4"–5") on D1
- GFS (NAM) performed best on D1 (D3)
- All forecasts showed large drop in skill D3 compared to D1–2
- GFS TS higher than ECMWF for all amounts D2 and for D1 amounts > 1"
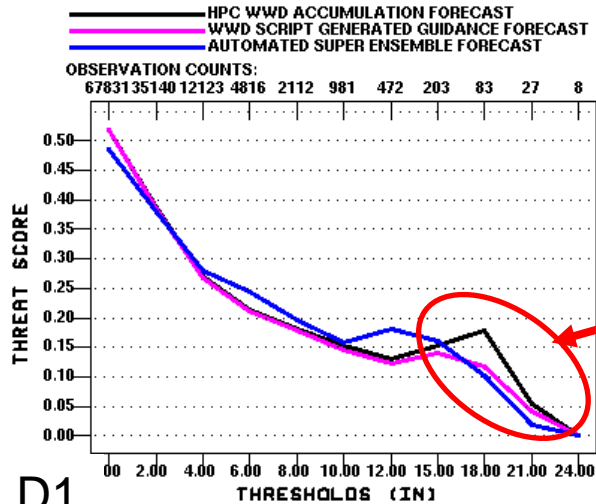
HPC Winter Weather Desk
2006–2007 Verification – Snow/Sleet

SNOWFALL 24-H FORECASTS VERIFYING 20061001 THRU 20070430 OVER CONUS REGION

D1

HPC adjustments show largest improvement over model guidance for snow > 12"

SNOWFALL 48-H FORECASTS VERIFYING 20061001 THRU 20070430 OVER CONUS REGION

D2
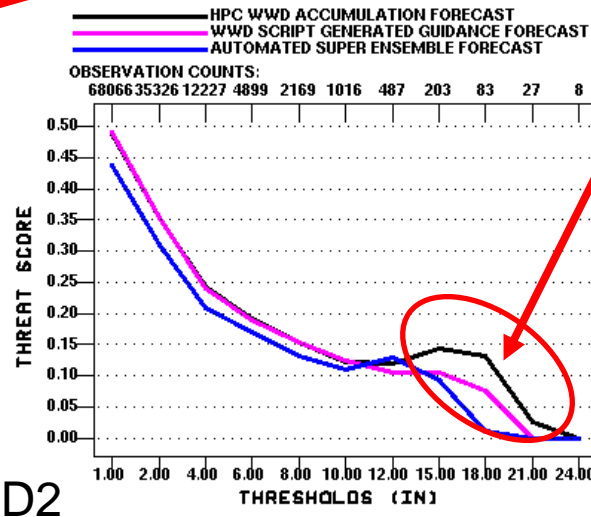
SNOWFALL 72-H FORECASTS VERIFYING 20061001 THRU 20070430 OVER CONUS REGION

D3
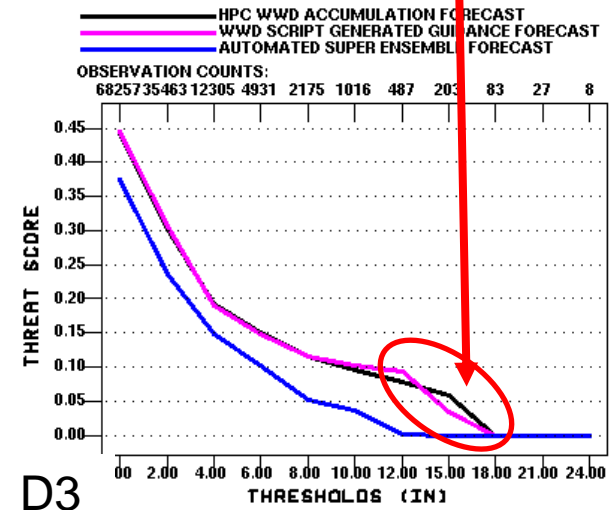
Winter Weather Low Track Trends
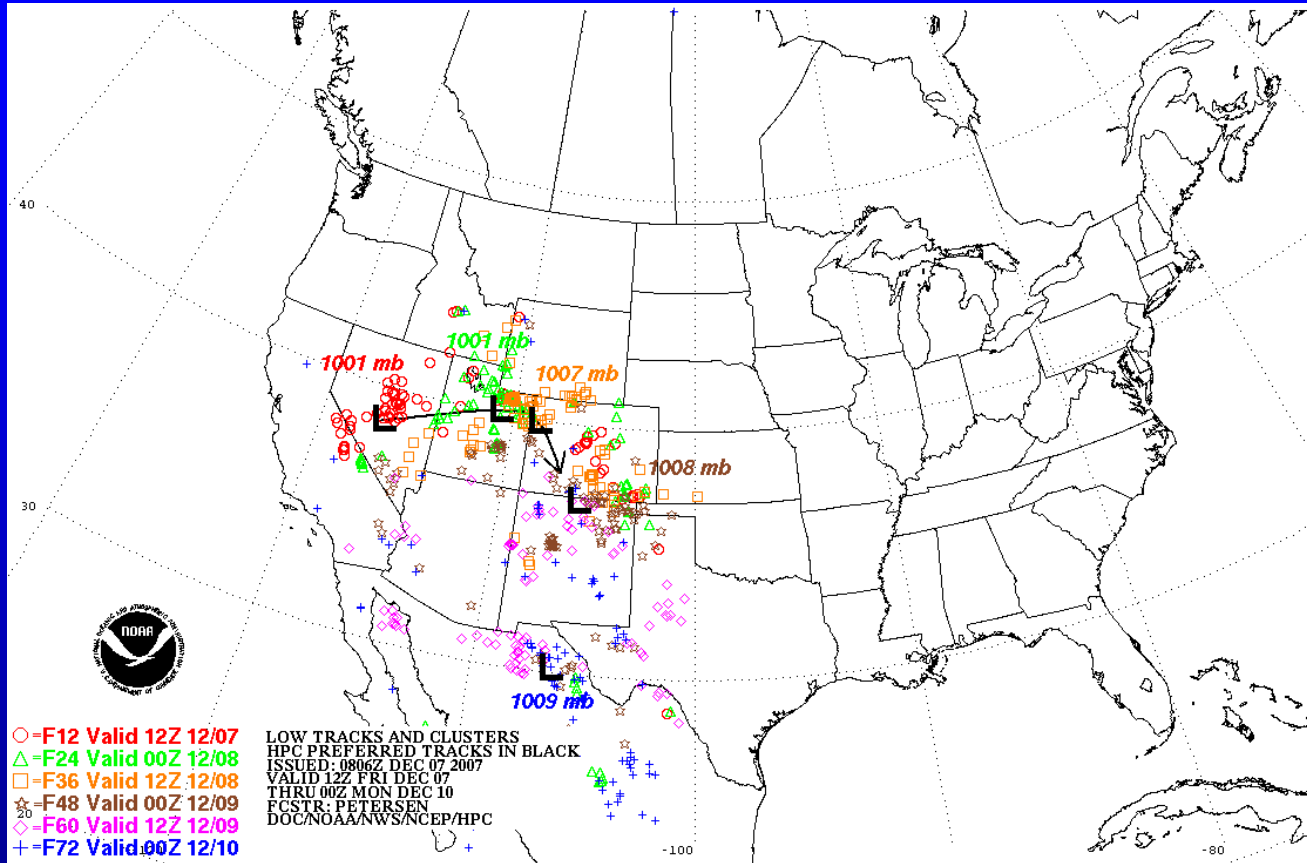
Verification on position forecasts of surface lows
associated with "significant" winter weather

Winter Weather Low Tracks
24-h RMSE Trend

24-h Winter Weather Low Track RMSE Trend

GFS/NAM blend has smallest RMSE at F24

Legend: HPC, GFS, NAM, GFS+NAM, GEFS MEAN, SREF MEAN

RMSE (nm) — axis: 0, 20, 40, 60, 80, 100, 120, 140, 160, 180, 200

Year: 2004-2005, 2005-2006, 2006-2007
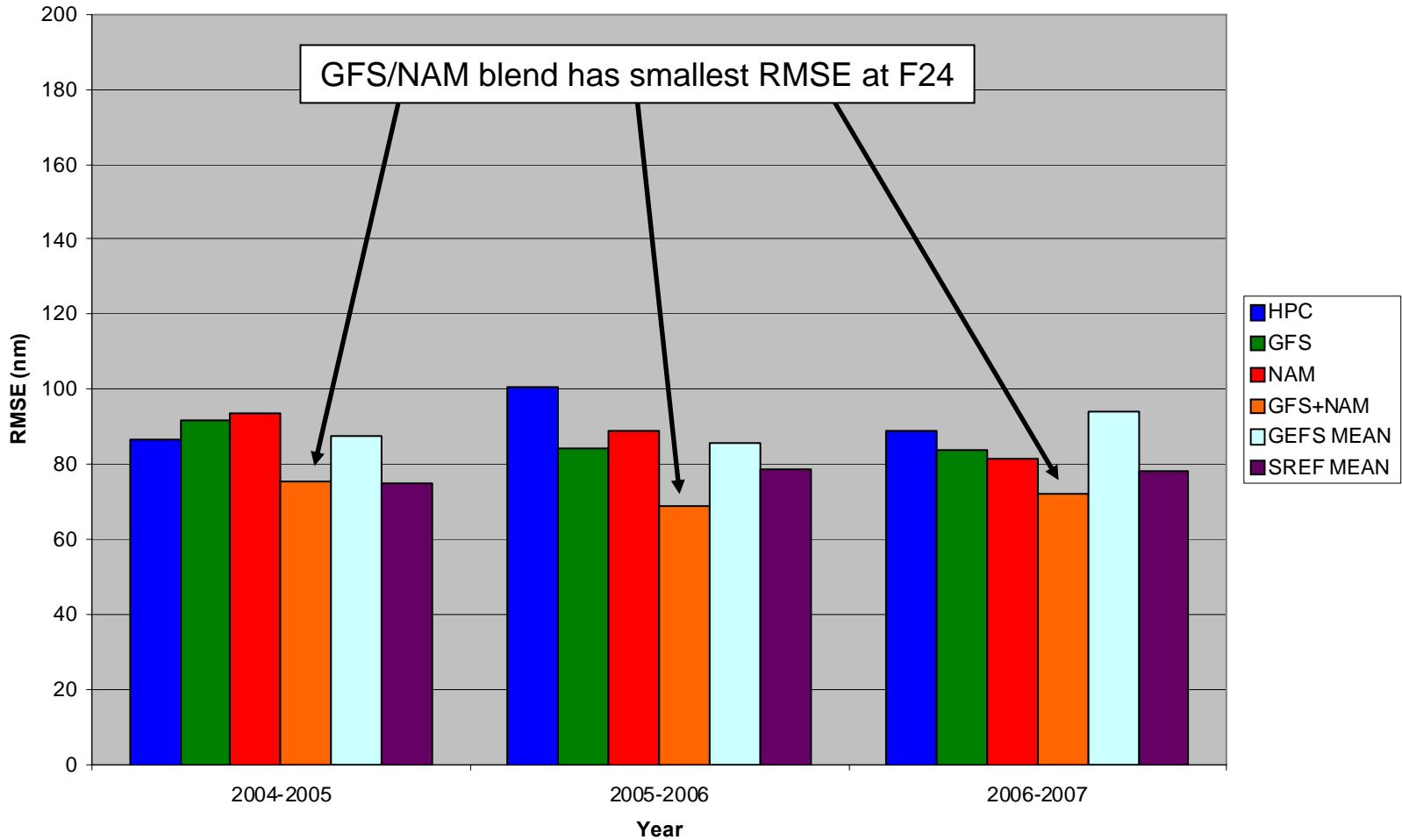
Winter Weather Low Tracks
48-h RMSE Trend

48-h Winter Weather Low Track RMSE Trend

HPC errors at F48 on decreasing trend despite increasing/neutral error trend in most guidance

Legend: HPC, GFS, NAM, GFS+NAM, GEFS MEAN, SREF MEAN
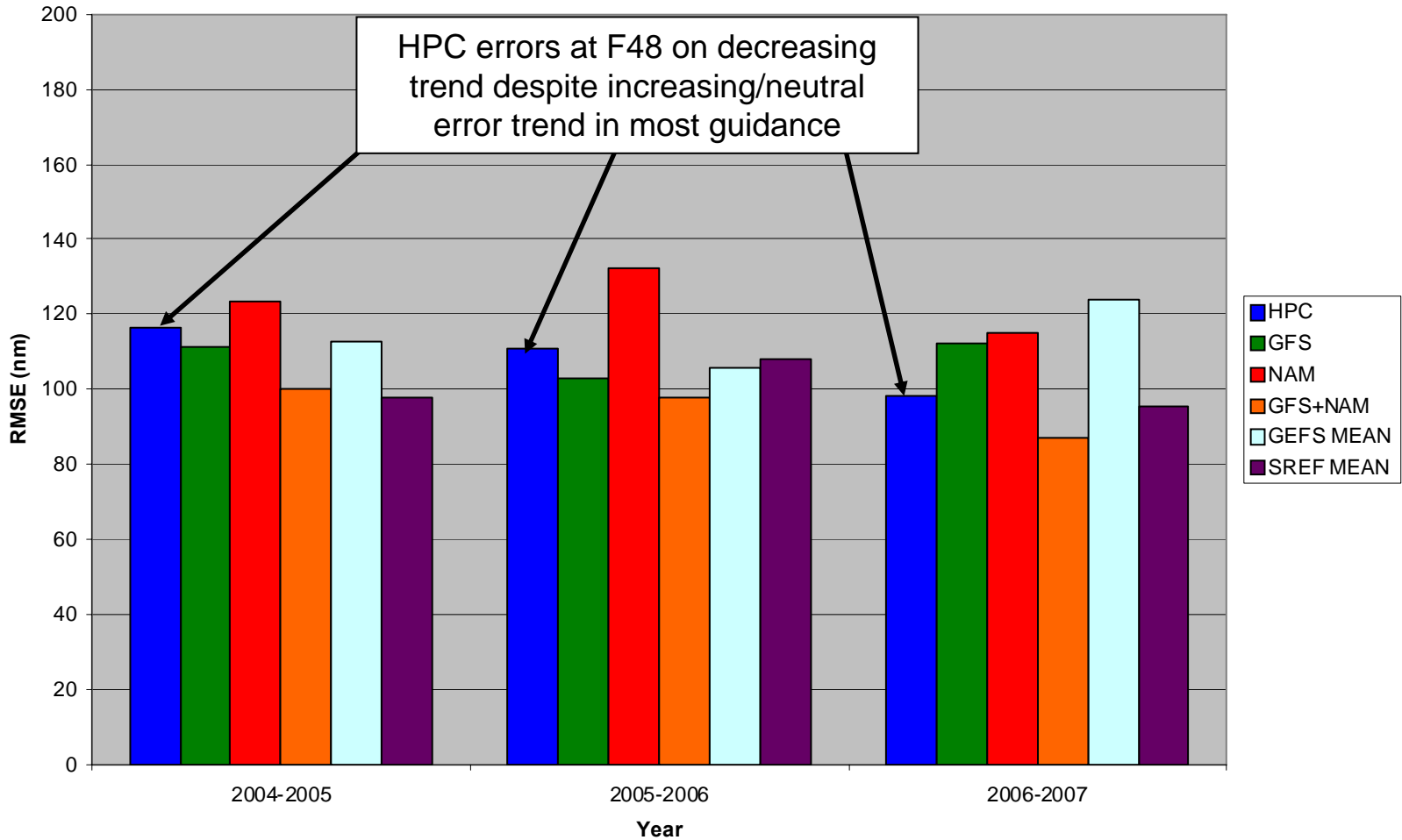
Winter Weather Low Tracks
72-h RMSE Trend

72-h Winter Weather Low Track RMSE Trend

Ensemble means more competitive with NAM/GFS blend at F72

Legend: HPC, GFS, NAM, GFS+NAM, GEFS MEAN, SREF MEAN

RMSE (nm)

Year: 2004-2005, 2005-2006, 2006-2007
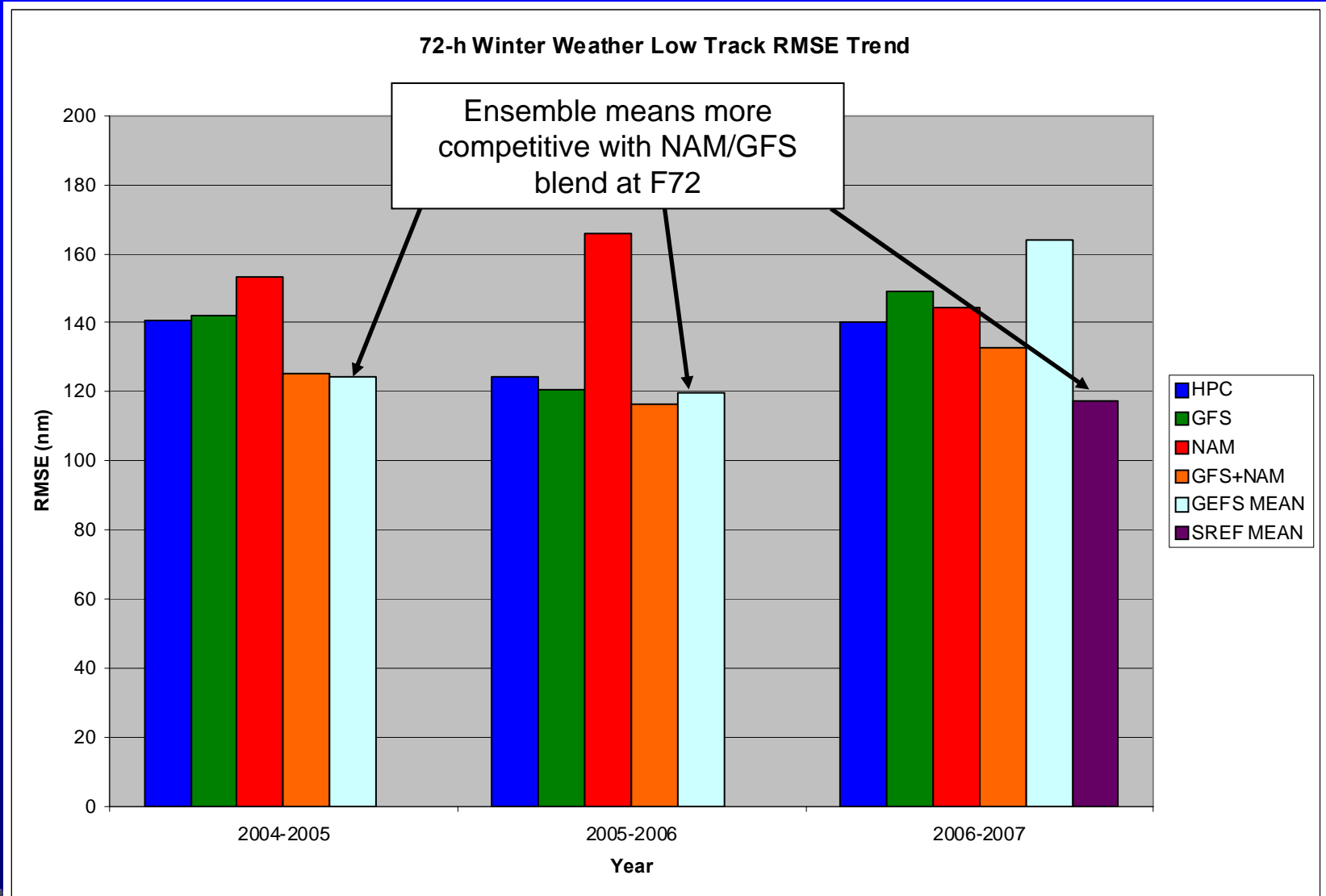
Winter Weather Low Track

- Simple NAM/GFS blend continues to outperform ensemble means, particularly on D1-2

- SREF mean appears to have best skill at D3, however only available for one year of verification

- HPC has shown most improvement on D2 over the past 3 years

HPC Observed Model Biases

Observed Model Biases
HPC Model Diagnostic Desk

- NAM tends to over-amplify the upper-level pattern beginning 18–24 h into the model cycle
  - Not a problem with initialization, develops during the model run

- NAM and GFS tended to over-develop weak surface waves associated with MCSs propagating from Northern Plains to Great Lakes
  - Seen for several model cycles from 30 June through 2 July 2007

Surface Wave Overdevelopment
With convective complex over Nrn Plains/Grt Lakes
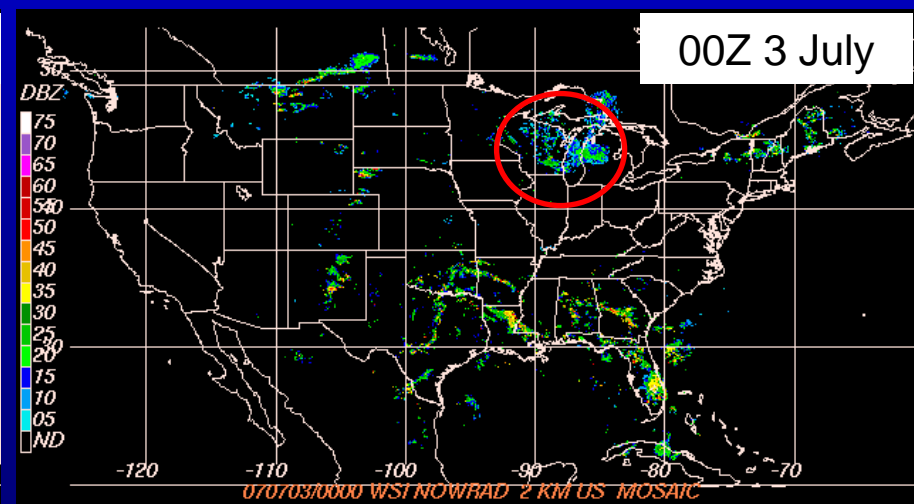
Surface Wave Overdevelopment
With convective complex over Nrn Plains/Grt Lakes
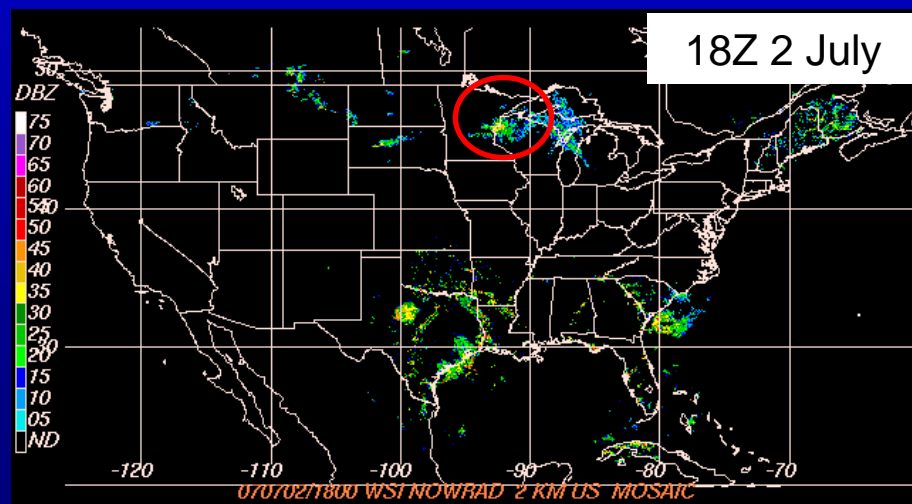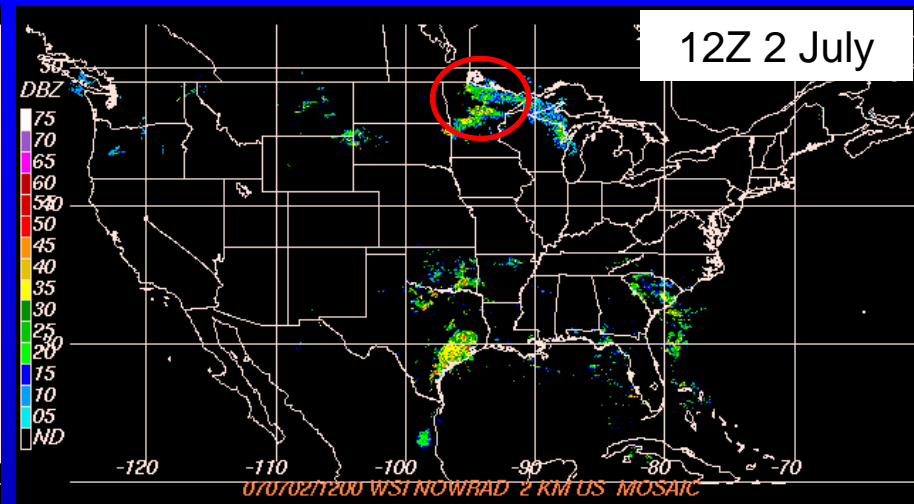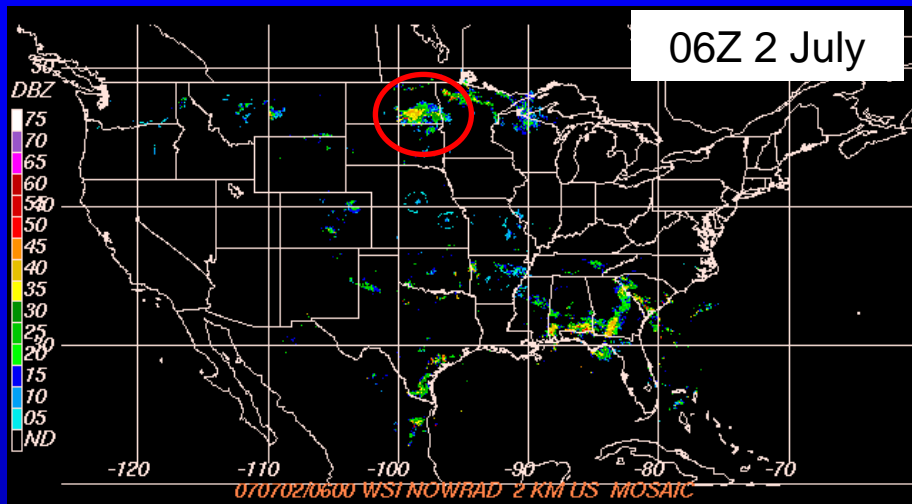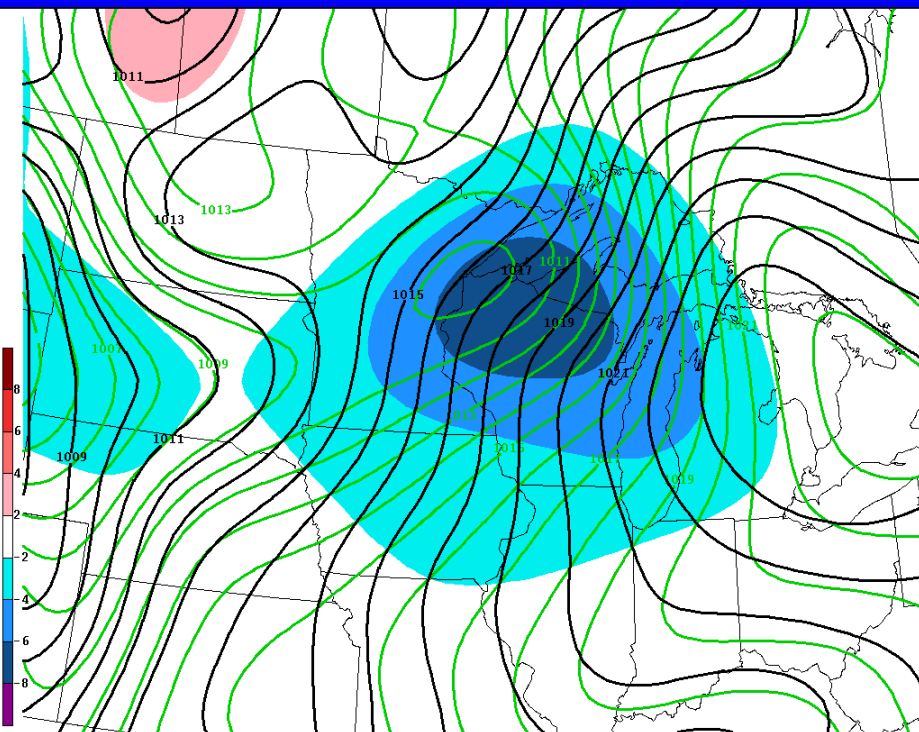

GFS MSLP 72-H Forecast (Green) Analysis (Black) Valid 3 Jul 2007 00Z

GFS 500MB HGHT 60-H Forecast (Green) Analysis (Black) Valid 3 Jul 2007 00Z

72-h GFS MSLP forecast vs. analysis valid 00Z 3 July
MSLP values 6–8 mb too low with spurious surface wave development over WI/MN

60-h GFS 500-mb height forecast vs. analysis valid 12Z 2 July
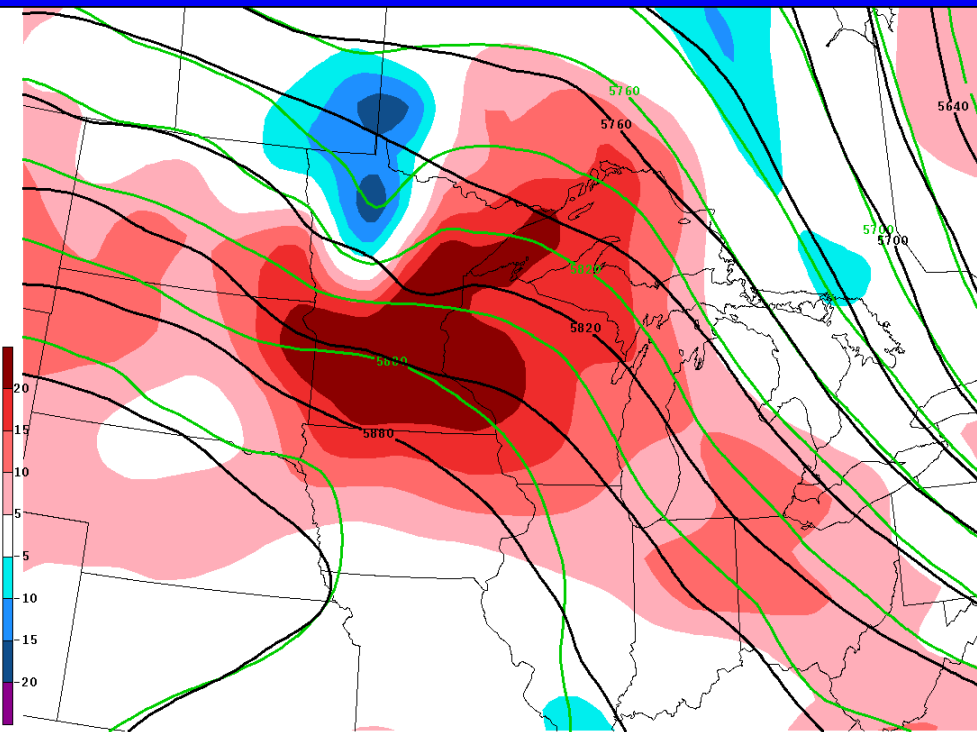GFS clearly over-amplified 500-mb pattern and shortwave in MN

Surface Wave Overdevelopment
With convective complex over Nrn Plains/Grt Lakes

GFS MSLP 48-H Forecast (Green) Analysis (Black) Valid 3 Jul 2007 00Z

NAM MSLP 48-H Forecast (Green) Analysis (Black) Valid 3 Jul 2007 00Z
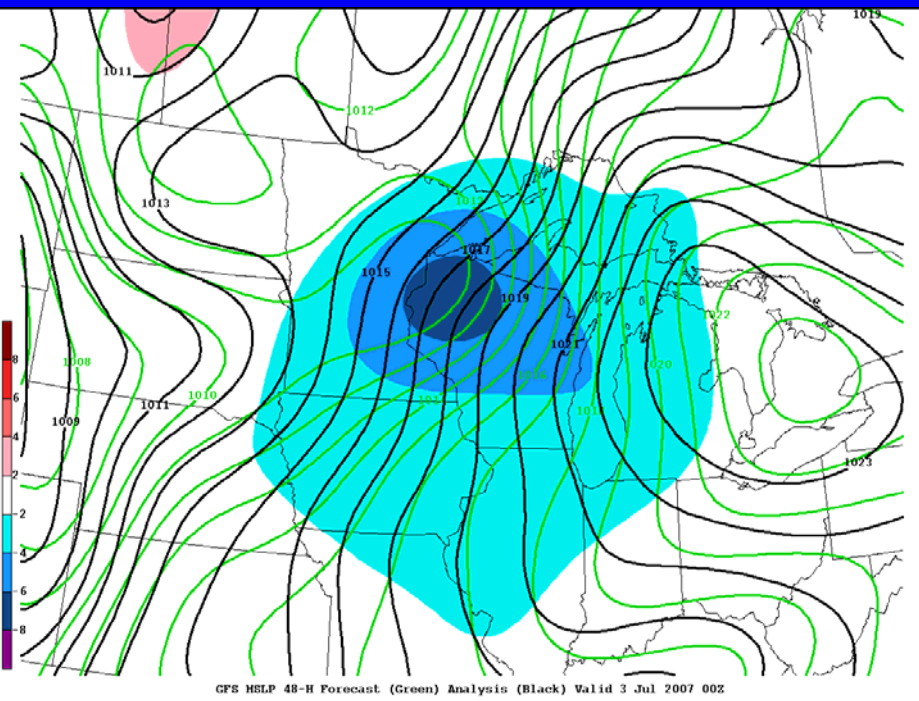
GFS forecast MSLP values 6–8 mb too low with spurious surface wave development over WI/MN
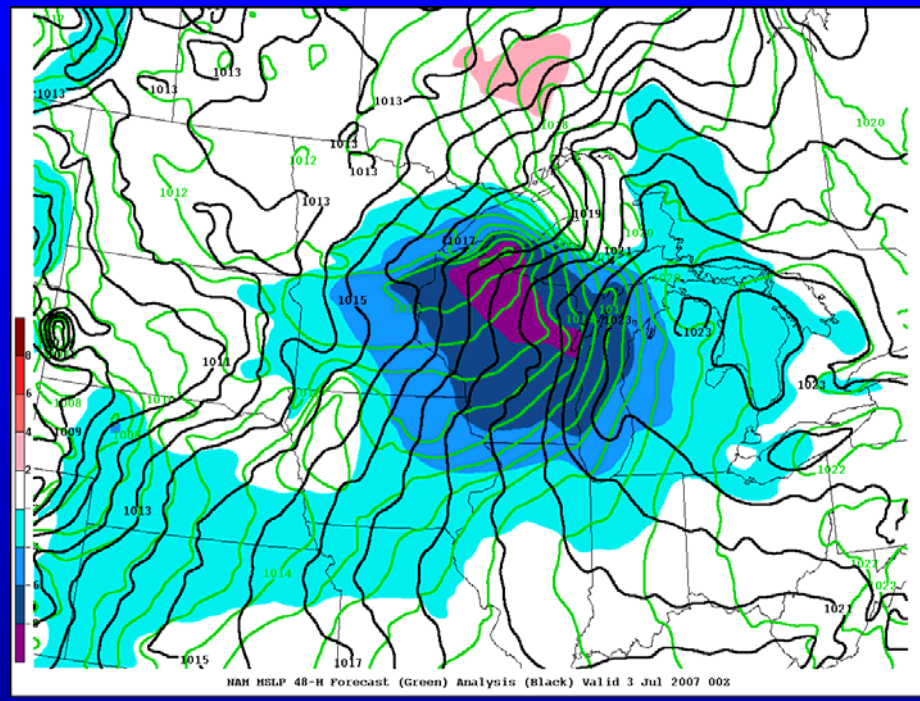
NAM shows closed low and MSLP values > 8 mb too low over WI/MN

Overdevelopment continued with next model cycle
and also seen in NAM 48-h forecast vs. analysis valid 00Z 3 July
SREF mean was preferred solution, supported by ECMWF and Canadian

GFS QPF vs. Obs

GFS 6-h QPF ending 06Z 2 July
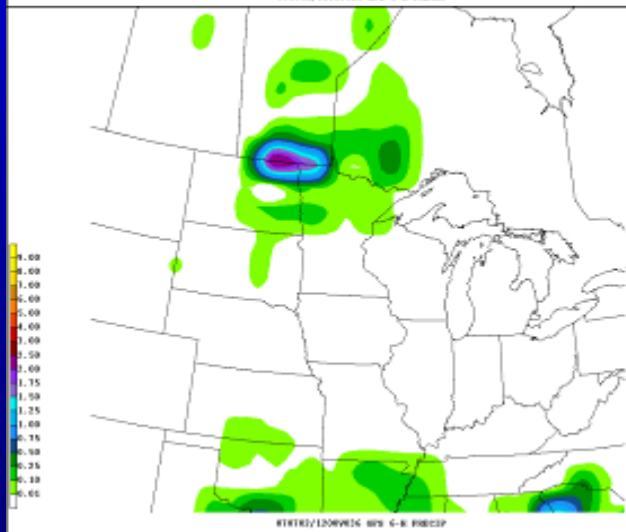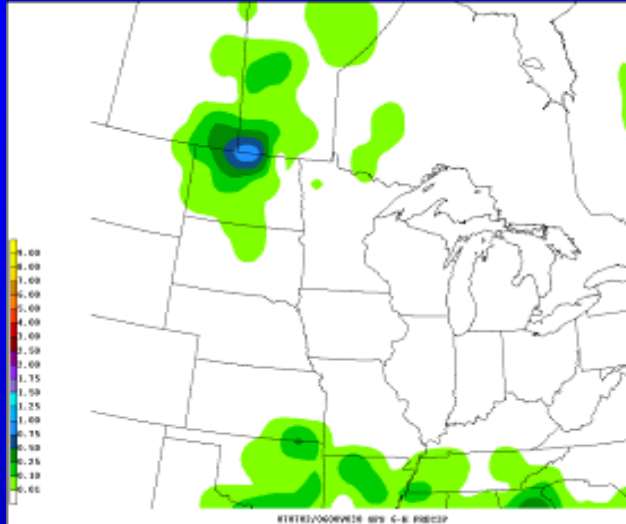
6-h QPE ending 06Z 2 July
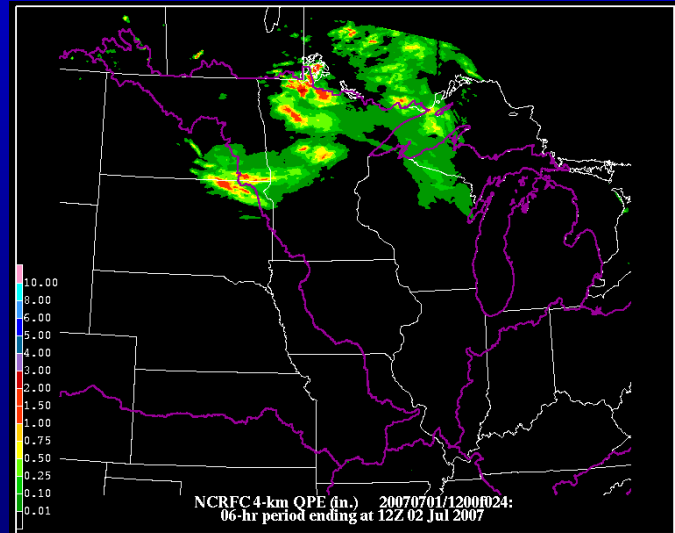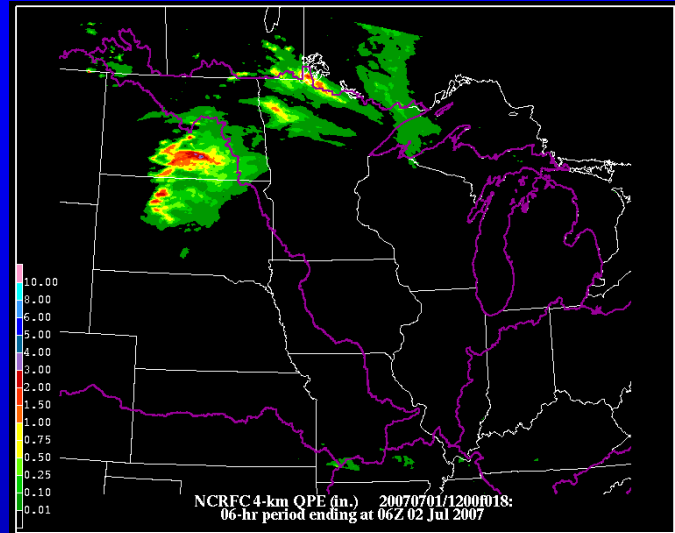
GFS 6-h QPF ending 12Z 2 July

6-h QPE ending 12Z 2 July

GFS Low-Level PV

1.75 PVU max
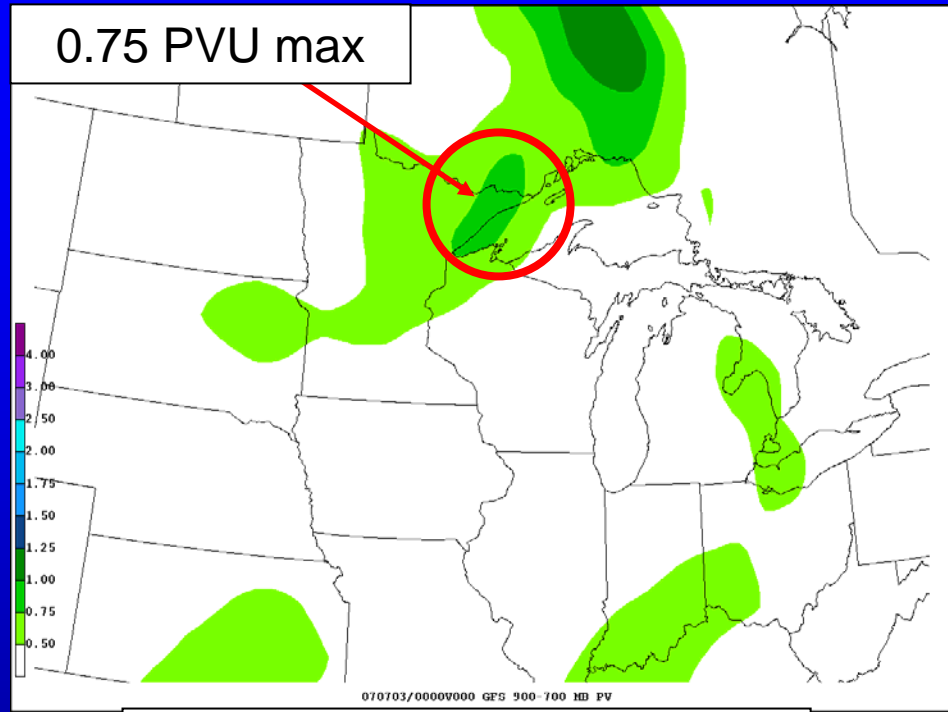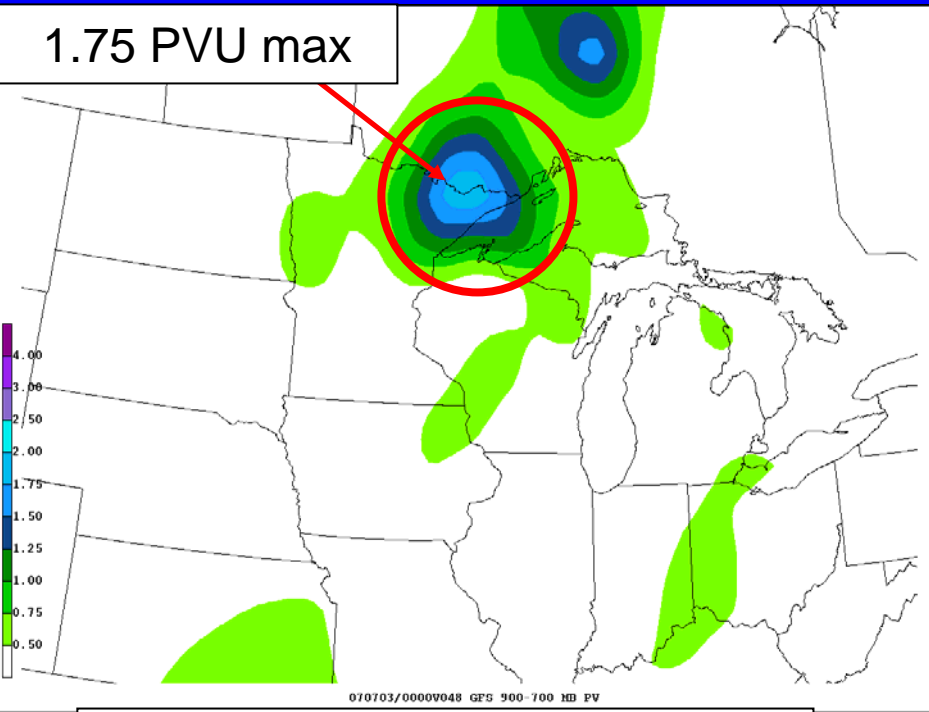
GFS 48-h Forecast 900-700 mb PV

0.75 PVU max

GFS Analysis 900-700 mb PV

Spurious heavy precip in GFS along US/Can border
likely led to over-development of lower tropospheric PV
maximum and surface wave

Observed Model Biases
HPC QPF Desk

- Forecasters noticing "too little QPF in the warm sector" and "too much QPF in the cold sector" with the NAM
  - Example from 30 March 2007

NAM 24-h QPF
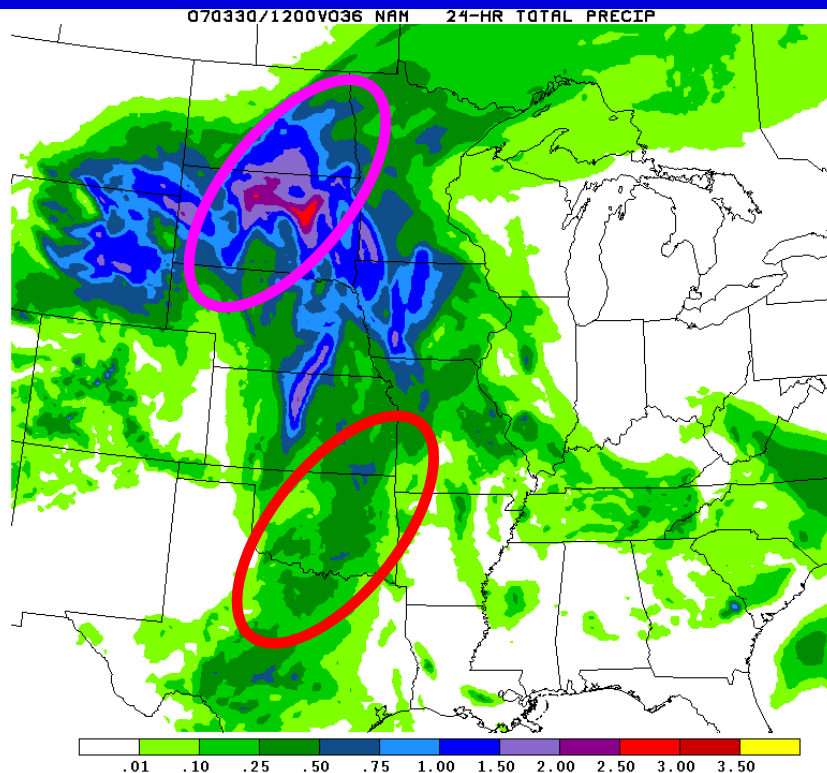
24-h Stage IV Precip Analysis

Images courtesy Geoff Manikin/EMC
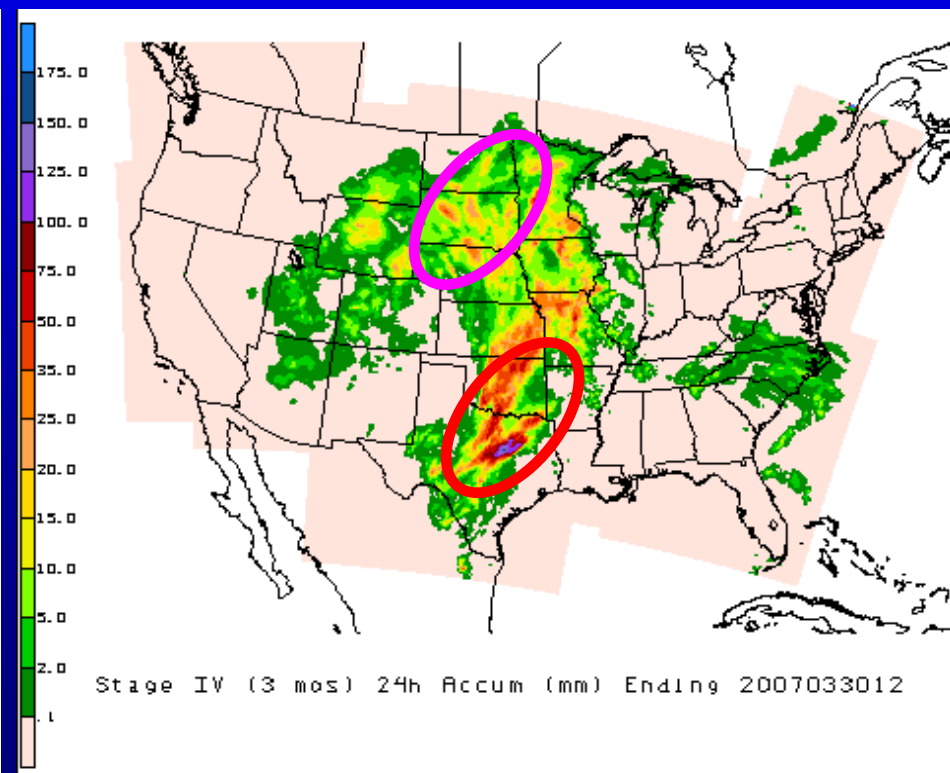
Observed Model Biases
HPC Winter Weather Desk

- Model Temperatures
  - GFS has persistent cold bias in 850–700-mb layer
    - East of a cyclone with southerly flow component, model too slow to warm inversion layer
  - NAM better at resolving inversions in the 850–700-mb layer

- NCEP dominant p-type algorithm output favors ZR in isothermal near freezing soundings
  - Tie breaking rules tend toward ZR

GFS Cold Bias Example

GFS 070113/1200F024 TOP (Model Forecast)
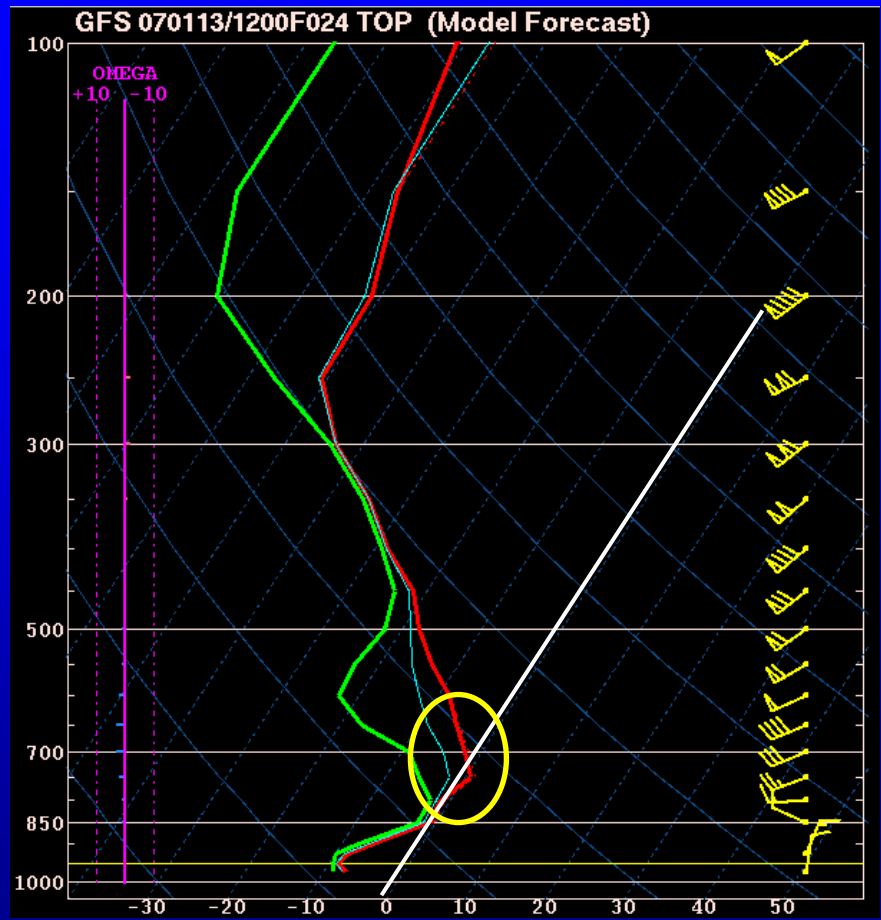
GFS 24-h Forecast Sounding @ Topeka

TOP 070114/1200 (RAOB)
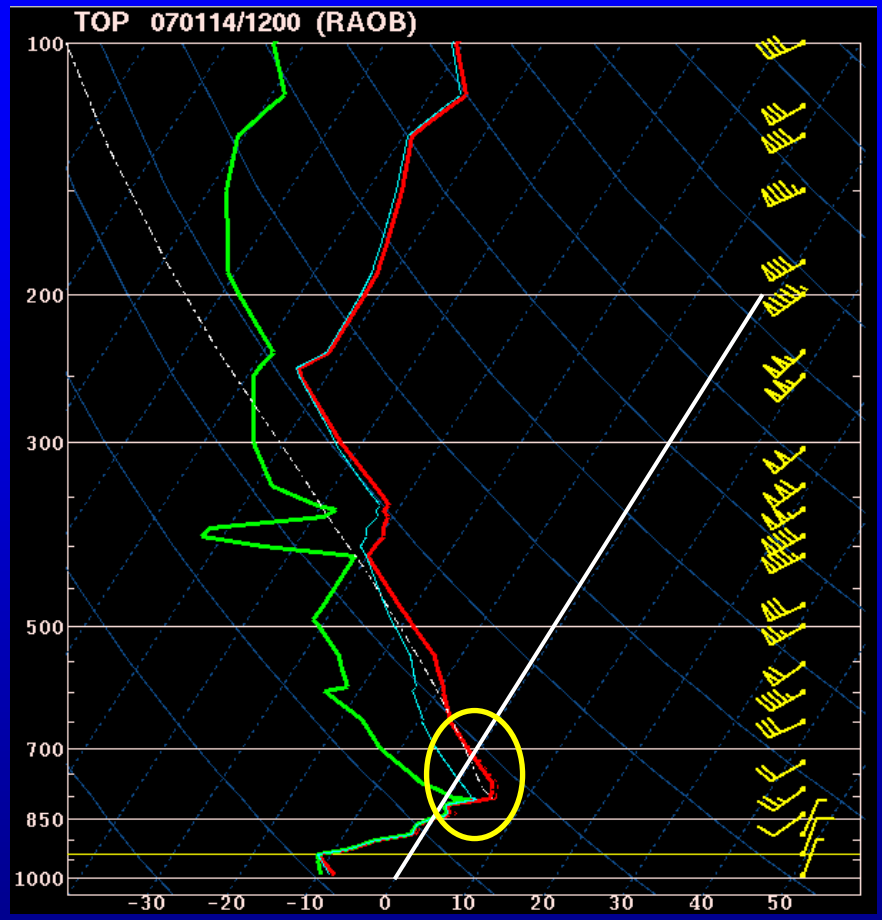
Observed TOP sounding 12Z 14 Jan 2007

GFS forecast fails to predict the ~ +5°C warm nose observed

NAM Better....

NAM 070112/1200F024 TOP (Model Forecast)

TOP 070114/1200 (RAOB)
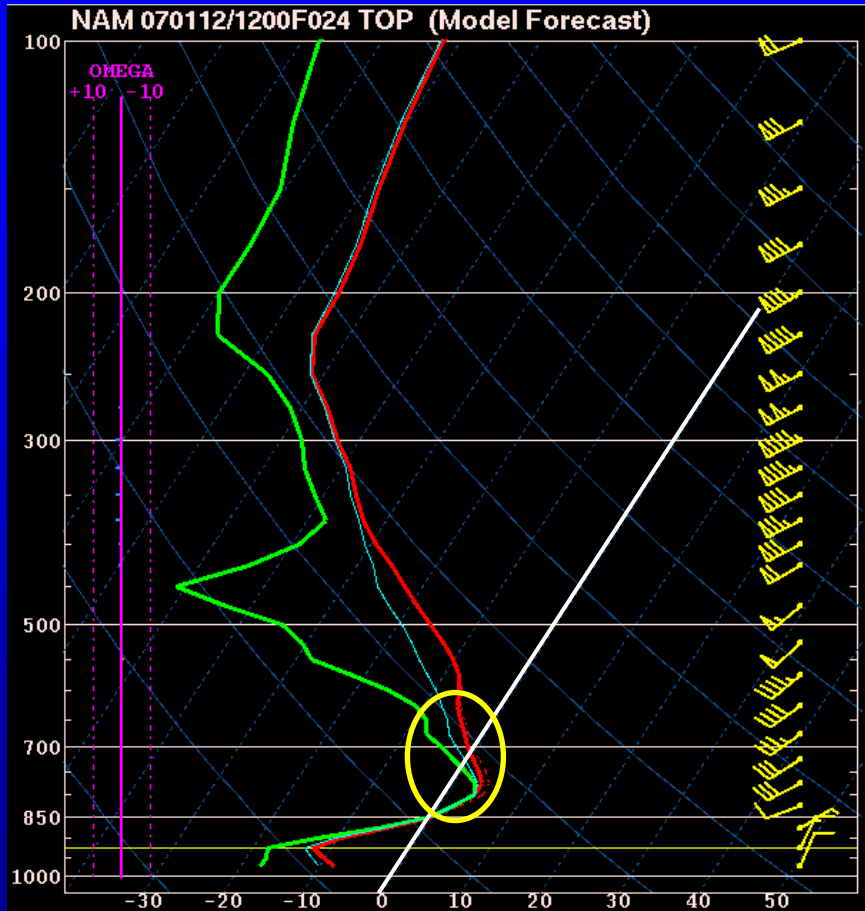
NAM 24-h Forecast Sounding @ Topeka
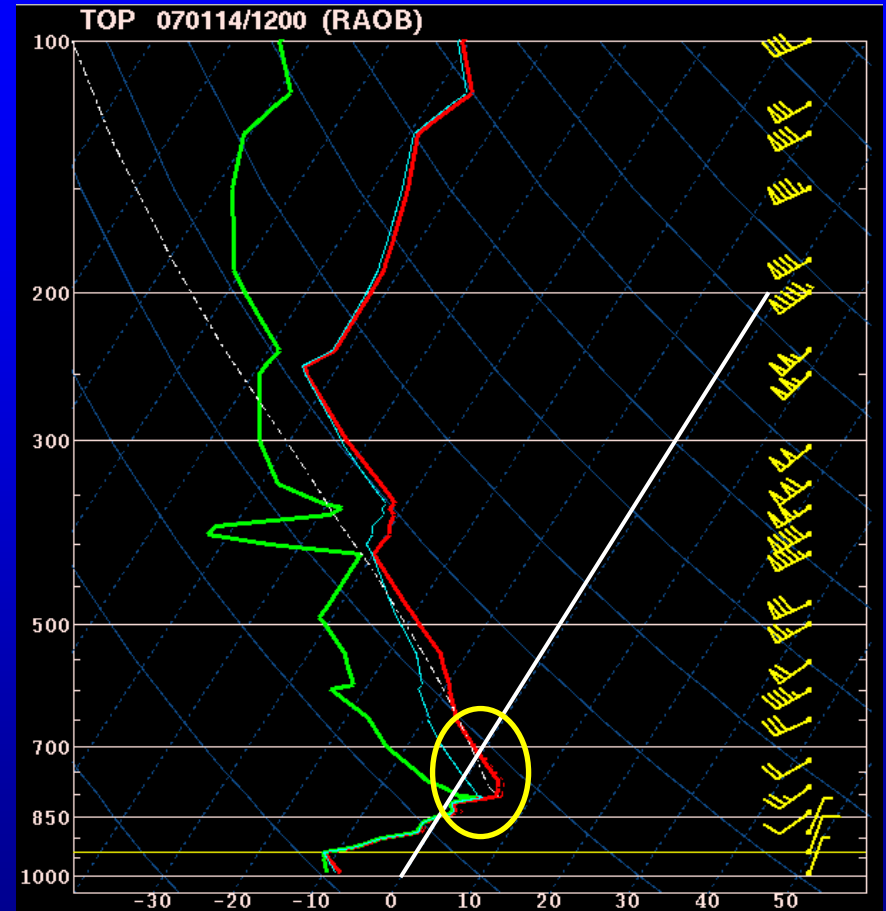
Observed TOP sounding 12Z 14 Jan 2007

NAM better resolves warm nose, but too dry at surface

HPC Evaluation of New Implementations

NAEFS Implementation

- HPC evaluation → addition of Canadian members has somewhat alleviated issue of GEFS trending too close to GFS

- Additional uncertainty information (e.g., percentile probabilities, mode, etc.) and availability of downscaled temperature information could have large positive impact on medium range forecasting

- Still concerns about performance of bias correction in rapidly changing flow regimes

- Would like to see more verification of bias correction on NAEFS – how much is it helping (hurting)?

NAEFS_BC_MN SAT 071103/1800V066 NAEFS MSLP
NAEFS_BC_SP SAT 071103/1800V066 NAEFS MSLP SPREAD
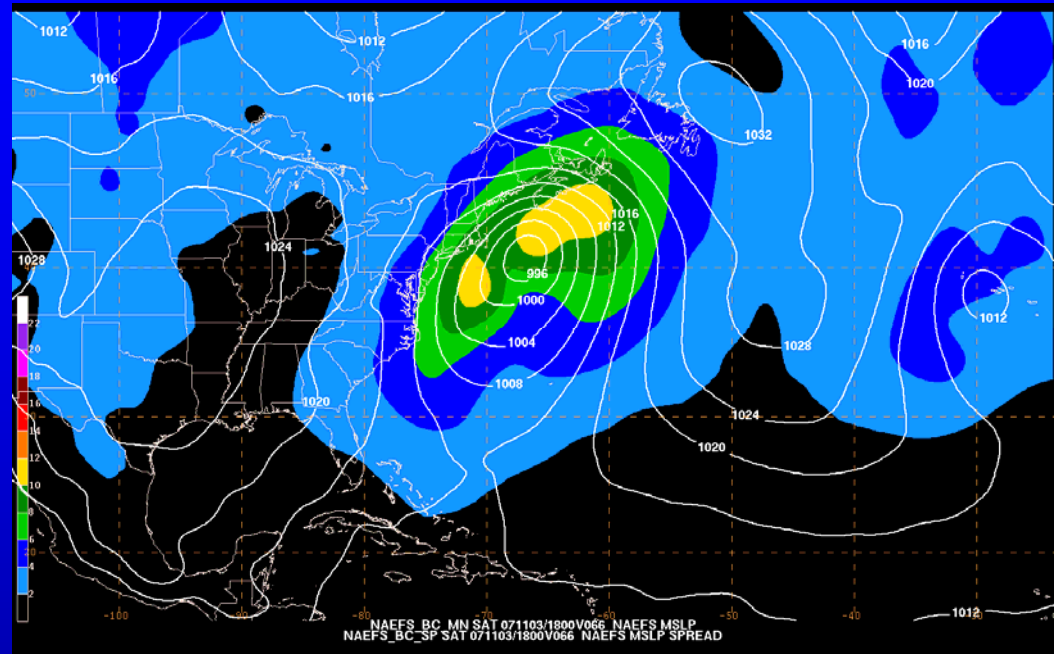
- NAEFS ensemble mean forecast from 00Z 31 October showed ET version of Noel tracking farther west than GEFS ensemble mean
  - Closer to the eventual track as cyclone passed east of New England

SREF Upgrade

- Impact of bias-corrected output likely small, but positive for HPC applications

- Inconsistency between bias corrected thermal structure and model p-type (not bias corrected) is an HPC concern

    – Output from winter weather blender may not be consistent with fields viewed by forecasters

- Similar concerns as with NAEFS for quality of bias correction in rapidly evolving flow patterns

071104/0000V087 SREF MEAN 500 MB-HGHT (DK GRN) SREF MEAN BC 500-MB HGHT (LT GRN)
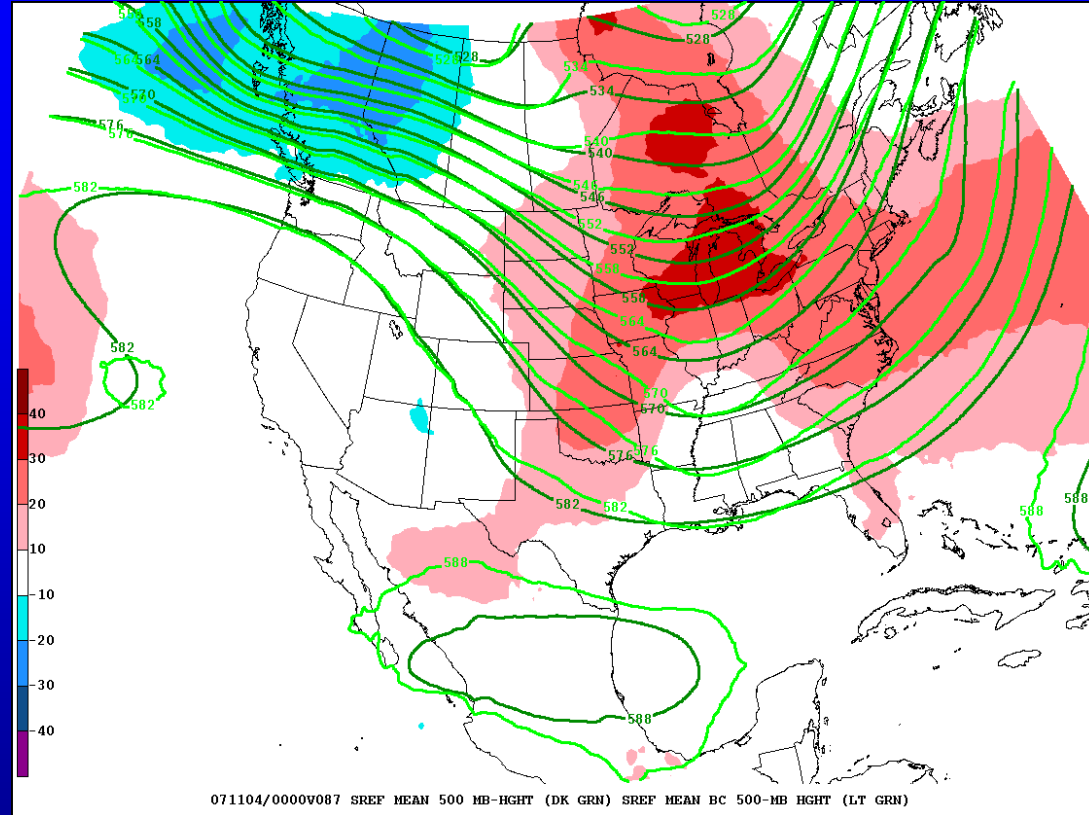
Magnitude of bias correction for 87-h 500-mb height forecast

Other HPC Notes

HPC Alaska Desk

- Working with EMC to provide additional uncertainty information for medium range guidance for Alaska WFOs
  - HPC deterministic forecast → mode
  - 10th and 90th percentile probabilities computed from downscaled NAEFS and adjusted with HPC forecast for Min/Max T & wind speed

Mode
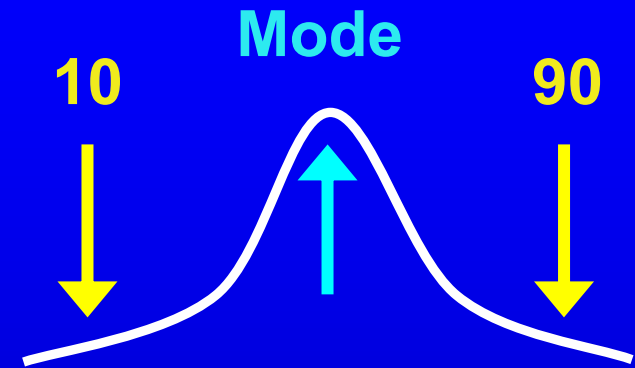
10   **90**

- Remaining issues
  - How to downscale for max/min T occurring at widely varying times?
  - Quality of RTMA over Alaska (for downscaling and verification)
  - Potentially very large spreads for temperature, wind speed – is 10/90 best range?
  - Desk will begin issuing experimental products in December
  - Opportunity to try new things – if successful may be transitioned to CONUS medium range

HPC Model Diagnostic Desk

- Based on results of survey of WFOs, several changes will be made to HPC MDD product suite
  - Creation of model trends graphics to supplement (and shorten) trends section (already done)
  - Generation of mass field preference and HPC preferred 500-mb pattern graphics
  - Issuance of PMDHMD earlier with NAM/GFS preference and incorporate other models into later release
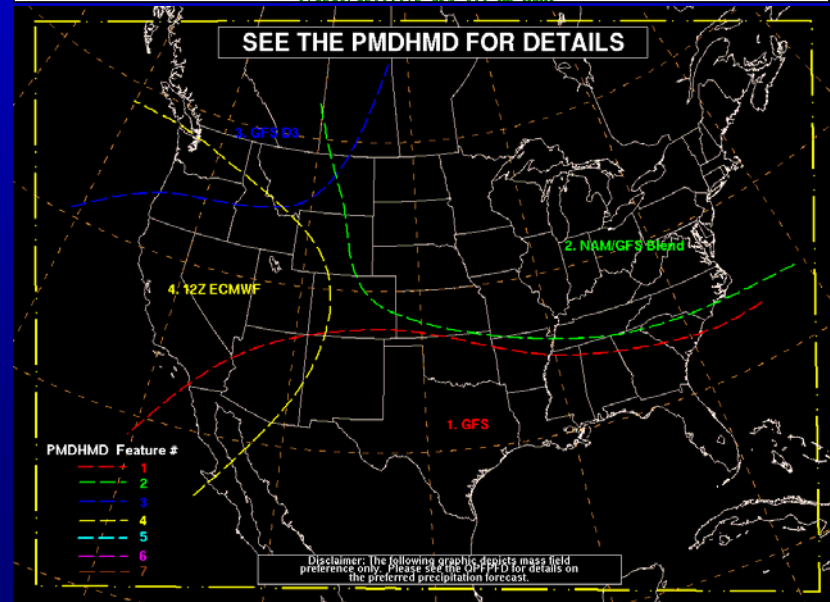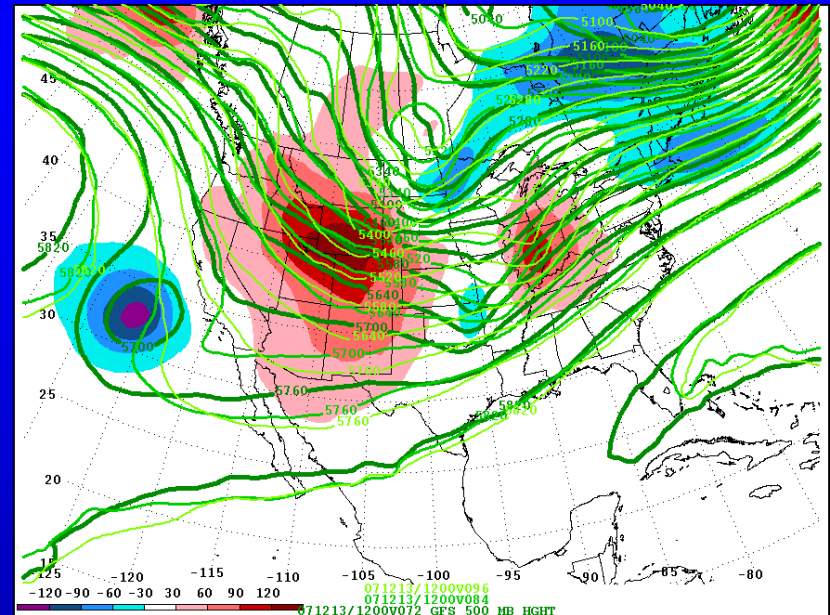
SREF Based Winter Weather Impact Graphics

- Will be made operational by the end of Q1 of FY08

EXPERIMENTAL – Automated SREF (09Z 20071030 run) Derived mean event total S/IP accum (inches)
F48 output valid 09Z THU NOV-01-2007 (NOAA/NWS/NCEP EMC HPC SPC)

FCST: F006 VALID: Tue 20071211/1500 UTC   NOAA/NWS Storm Prediction Center, Norman, OK
EXPERIMENTAL: Chance S/IP/ZR detected on road (rel to normal) VALID at TUE 071211/1500V006

Ground Temperature 32F Isotherm: SREF MEAN (dashed), All Members 32F or Colder (solid)
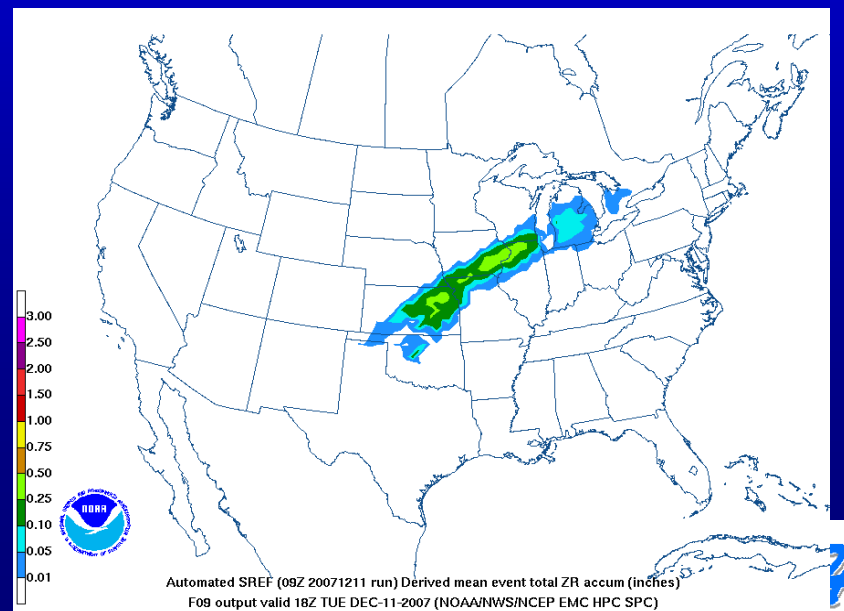Experimental product depicting the likelihood of winter precipitation (S/IP/ZR) being detected on a road surface (relative to normal) given that winter precipitation occurs. Values < 1 (warm colors) indicate that road surface temperatures may be a limiting factor to accumulation on road surfaces. Values ≥ 1 are associated with equal or above normal probabilities of winter precipitation accumulating on roadways.
Note: The guidance is conditional that S/IP/ZR actually occurs, and precipitation rates are not considered in the calculation such that high precipitation rates increase the likelihood of accumulation.

Automated SREF (09Z 20071211 run) Derived mean event total ZR accum (inches)
F09 output valid 18Z TUE DEC-11-2007 (NOAA/NWS/NCEP EMC HPC SPC)

HPC Precipitation Type ftp Site Being Retired

Index of ftp://ftp.hpc.ncep.noaa.gov/prcptype

Up to higher level directory

README=Site terminates 15May2008   1 KB 01/03/2007 12:00:00 AM

gfs   12/06/2007 11:45:00 AM

gif   11/10/2003 12:00:00 AM

nam   12/06/2007 11:46:00 AM

ruc   12/06/2007 02:00:00 PM

to_spc_verify.web.gz   1192 KB 12/06/2007 12:34:00 PM
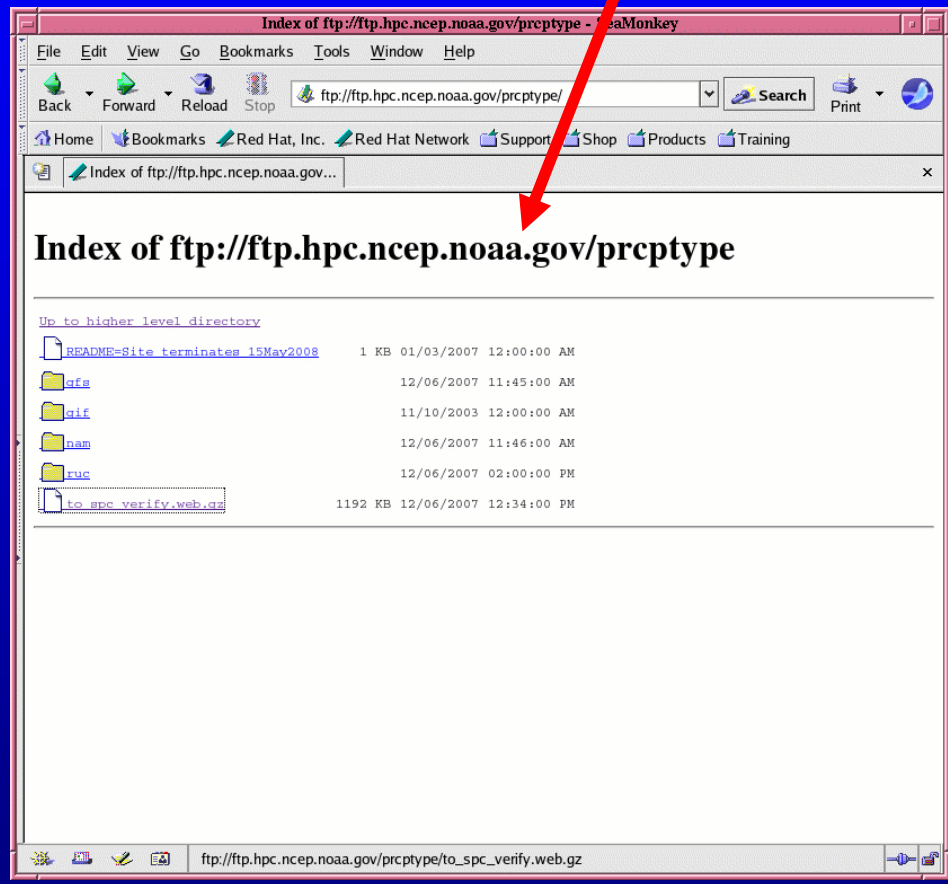
- Last operational date is 15 May 2008

- EMC has implemented precip type algorithms in NAM & GFS

- Dominant precip type from the algorithms is output by model post in grids

Acknowledgements

- Mark Klein

- Jessica Clark

- Mike Eckert

- Joshua Scheck

- Marty Rausch

- Dan Petersen

- Keith Brill