NCEP/HPC MEDIUM RANGE FORECASTING
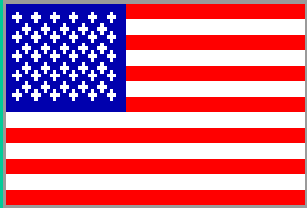
BASIC WX / SURFACE

QPF / WINTER WEATHER

FRANK ROSENSTEIN

STEVE FLOOD

HPC MEDIUM RANGE DESK TWO FORECASTER TEAM

Michael Schichtel
DOC/NOAA/NWS/NCEP/HPC
CAMP SPRINGS, MARYLAND, USA
HTTP://WWW.HPC.NCEP.NOAA.GOV

NOAA Science Center
World Weather Building
Camp Springs, MD USA
(Since 1975)

The NOAA Center for Weather and Climate Prediction 50-acre section of the University of Maryland's M-Square Research and Technology Park. The 268,762 square-foot building will be the new home for NOAA's Satellite and Information Service, Air Resources Laboratory and the National Centers for Environmental Prediction
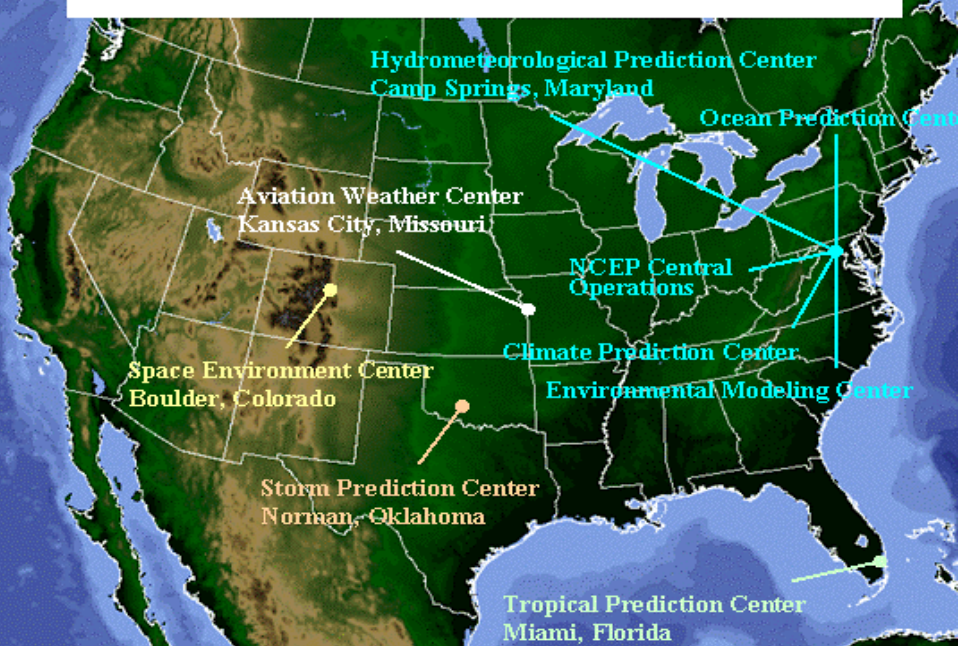
~Early 2009

Conference Center

NOAA Center for Weather and Climate Prediction (NCWCP)
College Park, Maryland

Construction Picture Oct 23, 2007

NATIONAL CENTERS FOR ENVIRONMENTAL PREDICTION

Hydrometeorological Prediction Center
Camp Springs, Maryland

Ocean Prediction Center

Aviation Weather Center
Kansas City, Missouri

NCEP Central Operations

Space Environment Center
Boulder, Colorado

Climate Prediction Center

Environmental Modeling Center

Storm Prediction Center
Norman, Oklahoma

Tropical Prediction Center
Miami, Florida

HPC Medium Range Desk (Days 4-7)

Forecast Discussions
Surface Fronts and Pressures
500 MB Heights
WSR Targeted Observations Support
Tropical Systems (TPC / NHC Back-up)
QPF
Excessive Heat Index
Max and Min Temperatures
Probability of Precipitation
Cloud Cover
Weather Type
Dew point Temperatures
Wind Speed and Direction

WFOs

RFCs
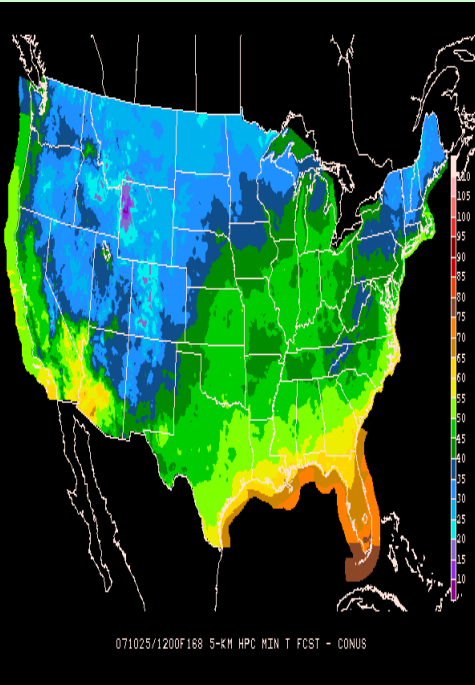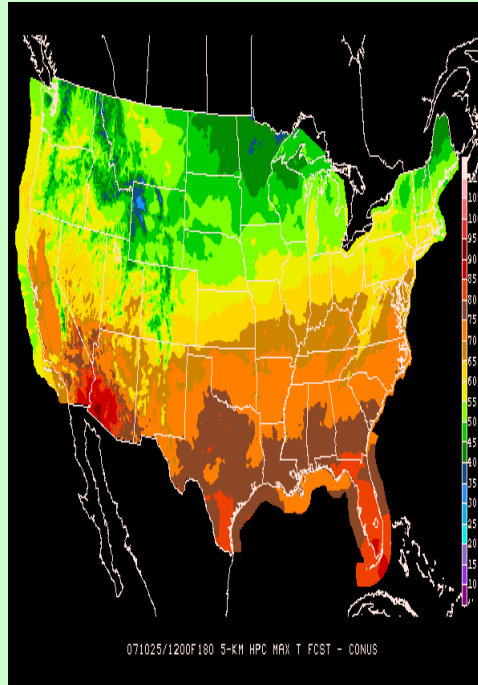
AKRFC

NERFC

NWRFC

NCRFC

MARFC

CNRFC

MBRFC

OHRFC

CBRFC

ABRFC

SERFC

LMRFC

WGRFC
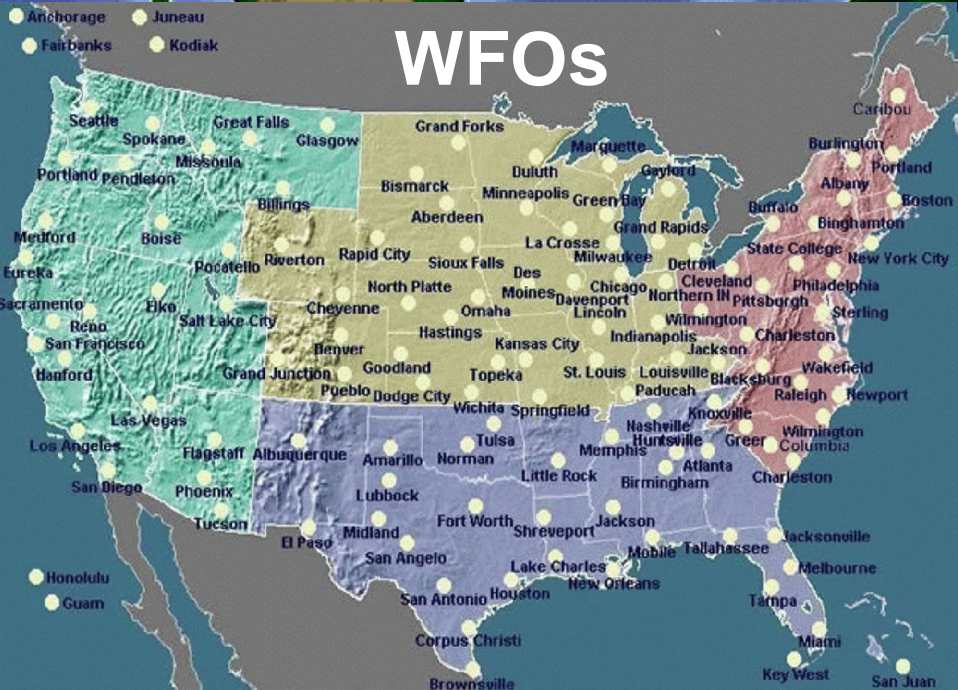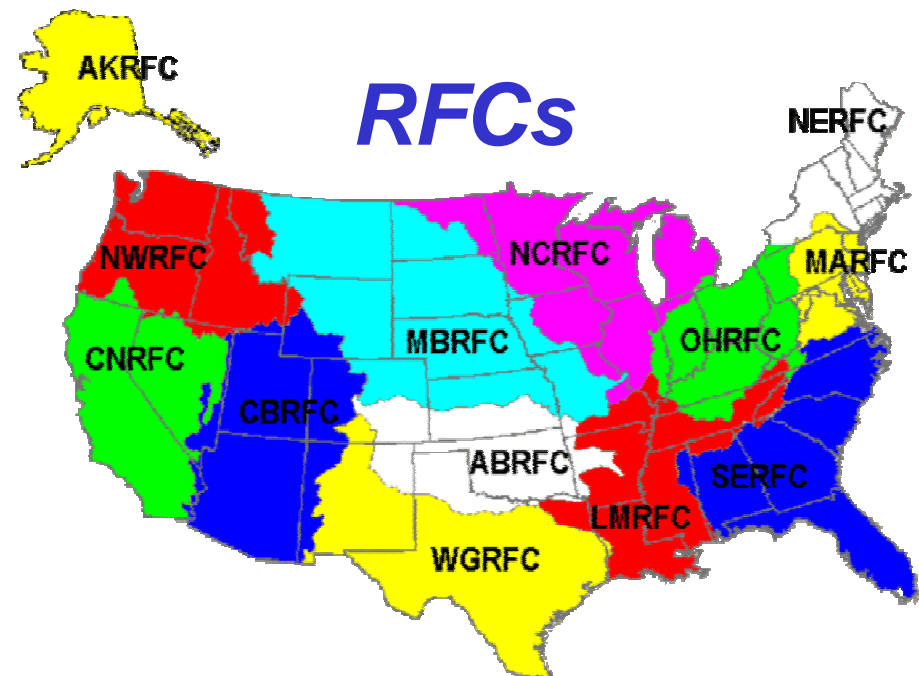
Background topography courtesy Ray Sterner, Johns Hopkins University

Current single value forecast format: Medium range 5 km grids

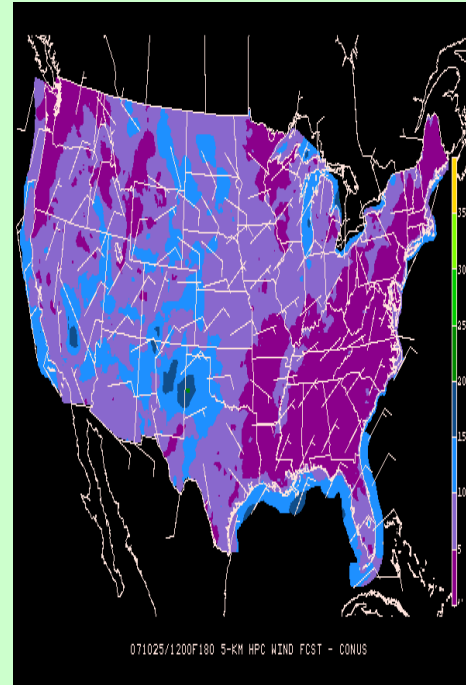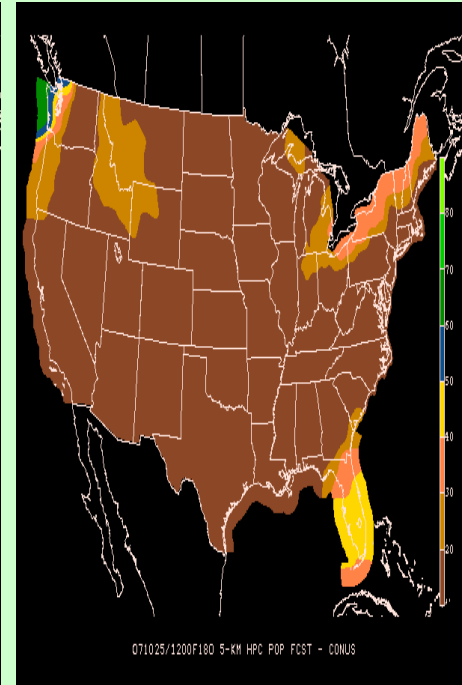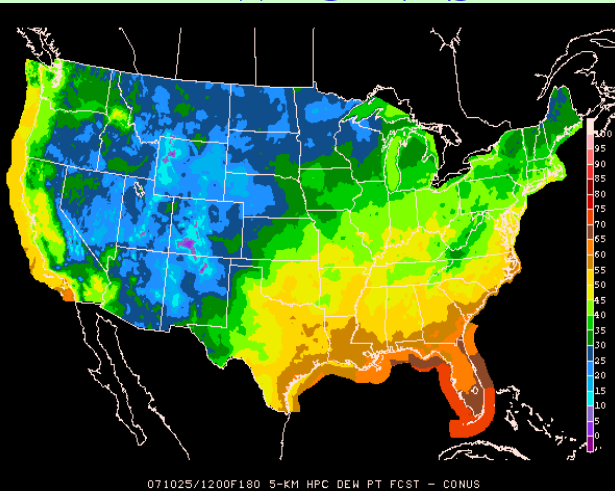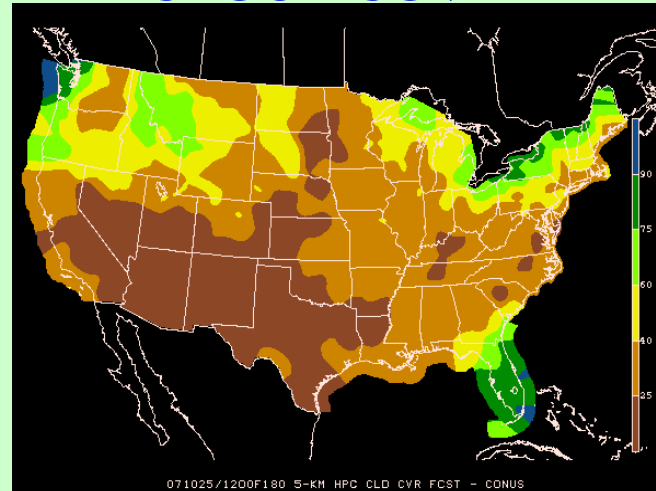## MIN TEMPS

MAX TEMPS

WINDS

12 HOUR POPS

071025/1200F168 5-KM HPC MIN T FCST - CONUS

071025/1200F180 5-KM HPC MAX T FCST - CONUS

071025/1200F180 5-KM HPC WIND FCST - CONUS

071025/1200F180 5-KM HPC POP FCST - CONUS

DEWPOINTS

CLOUD COVER

WEATHER TYPE

071025/1200F180 5-KM HPC DEW PT FCST - CONUS

071025/1200F180 5-KM HPC CLD CVR FCST - CONUS

LEGEND:
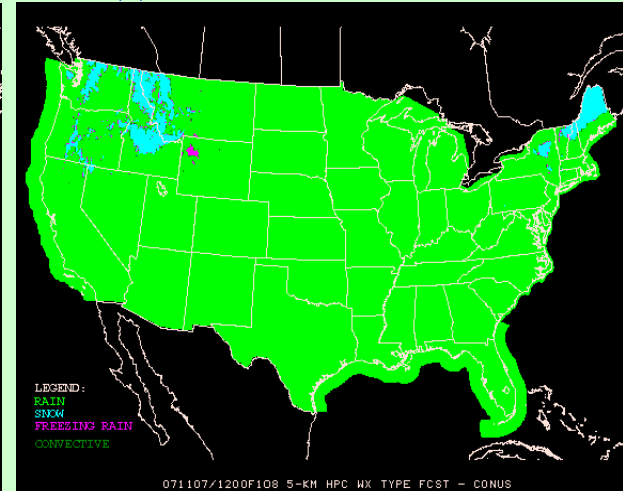RAIN
SNOW
FREEZING RAIN
CONVECTIVE

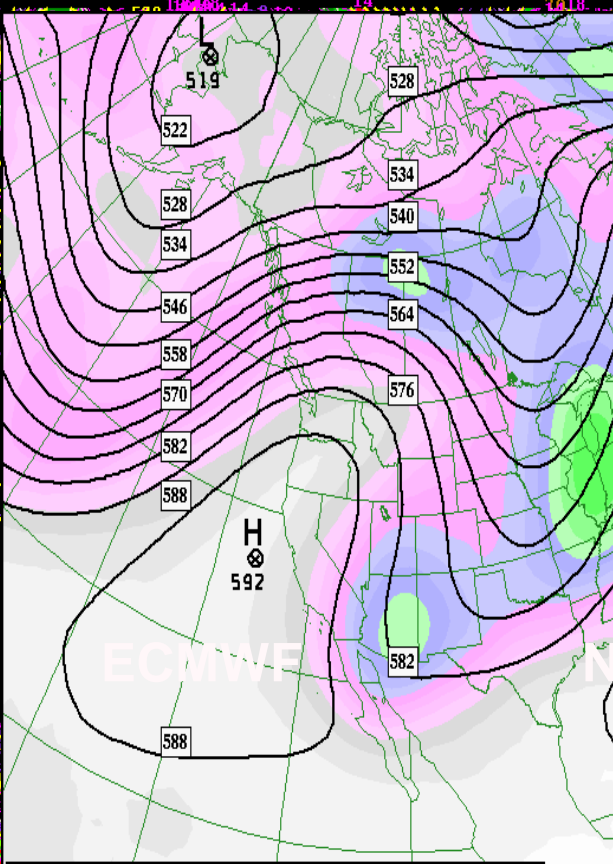071107/1200F108 5-KM HPC WX TYPE FCST - CONUS

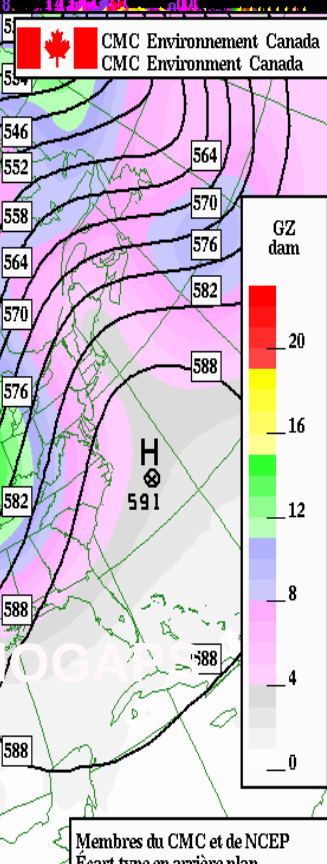# Primary Medium Range Models/Ensembles used at HPC

| Model	Cycle (UTC)	Run Duration (Days)	Approx Min Horizontal Grid Spacing (km)	Members per Day
DGEX	06, 18	8	15	2
ECMWF	00, 12	10	20	2
ECMWF Ens.	00, 12	10	40	102
GFS	00, 06, 12, 18	16	40	4
GEM Global	00, 12	10/6	40	2
UKMET	00, 12	6	40	2
FNMOC	00, 06, 12, 18	8	55	4
NAEFS	00, 12	16	80	40
FNMOC Ens.	00	10	80	10
GFS Ens.	00, 06, 12, 18	16	80	80
GEM Ens.	00, 12	16	80	40

UKMET
GFS
GFS ENSEMBLE
DGEX

CMC Environment Canada
CMC Environnement Canada

GZ
dam

20
16
12
8
4
0

H 592
H 591
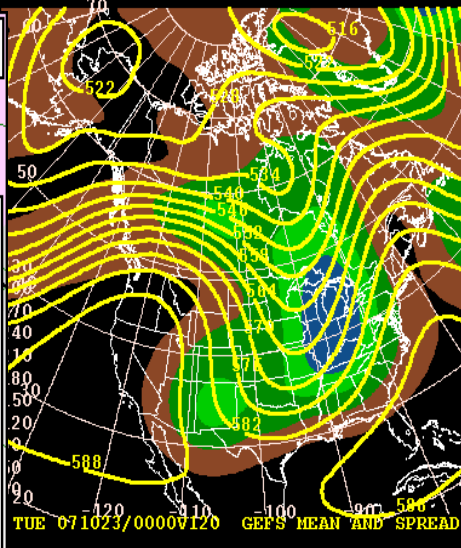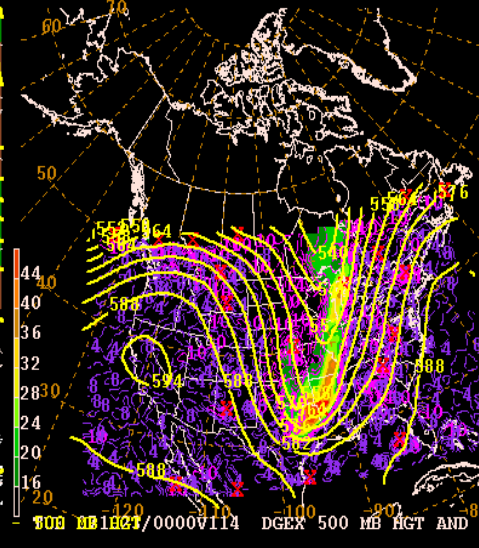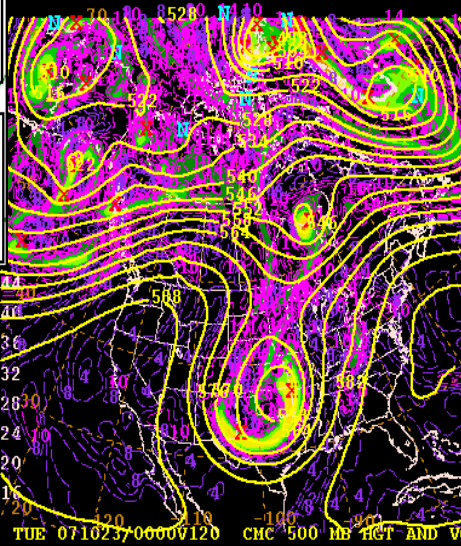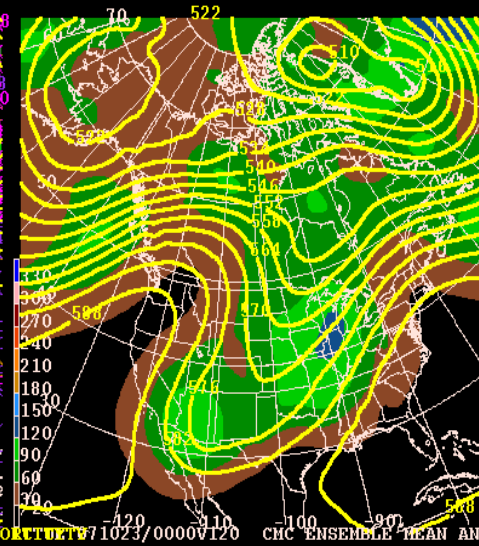
Prévision 120H Forecast Valide–Valid Mar–Tue 00Z 23 Oct–Oct 2007
Mean & Standard Deviation Chart for --- Geopotential at 500 hPa ---
Carte de moyenne et écart type pour --- Géopotentiel à 500 hPa ---
issued on 20071018 at 00Z   émises le 20071018 à 00Z

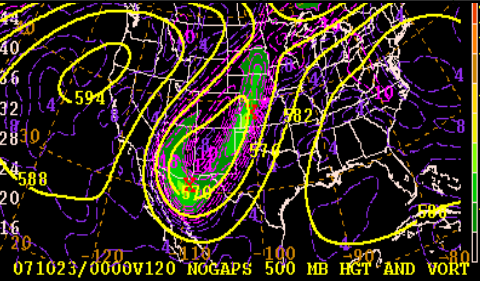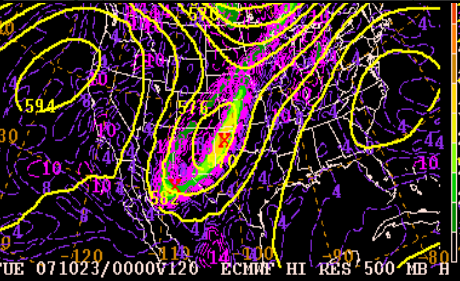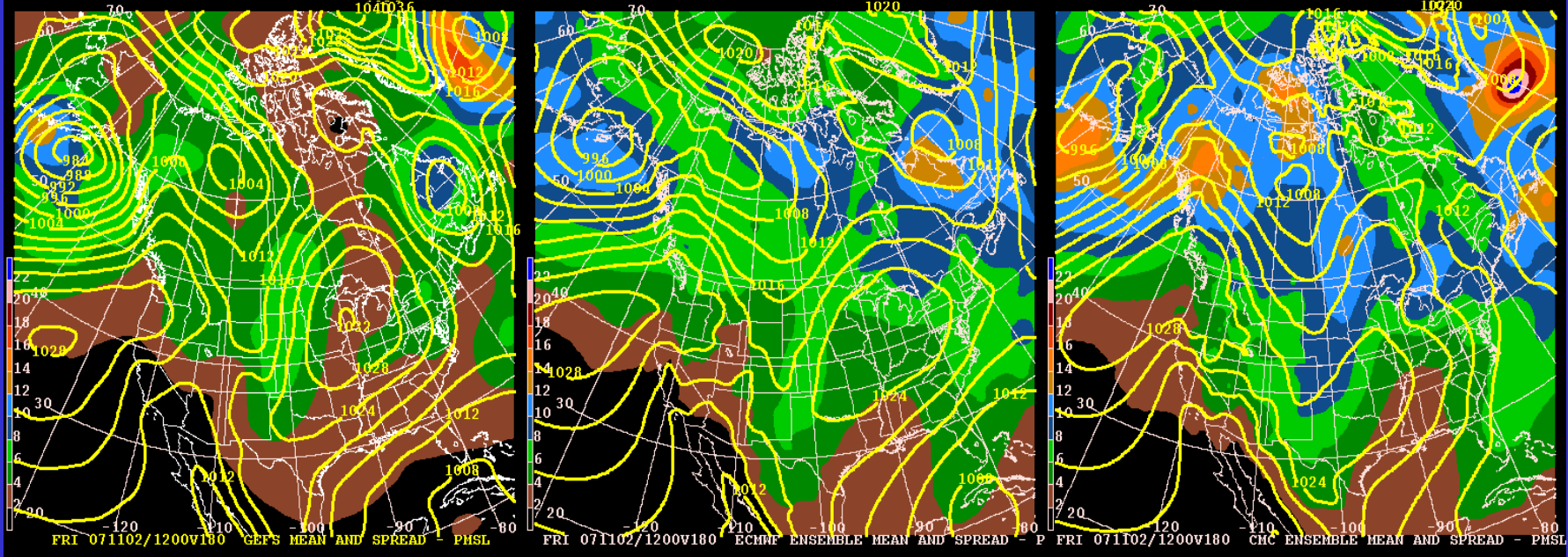Membres du CMC et de NCEP
Écart type en arrière plan
6 dam entre les contours
CMC & NCEP members
Standard Deviation as background
6 dam between contours

CMC
MSC ENSEMBLE

TUE 071023/0000V120   GFS MEAN AND SPREAD   TUE 071018/0000V114 DGEX 500 MB HGT AND G

TUE 071023/0000V120 ECMWF HI RES 500 MB H   071023/0000V120 NOGAPS 500 MB HGT AND VORT   TUE 071023/0000V120 CMC 500 MB HGT AND VORTICITY   TUE 071023/0000V120 CMC ENSEMBLE MEAN AND
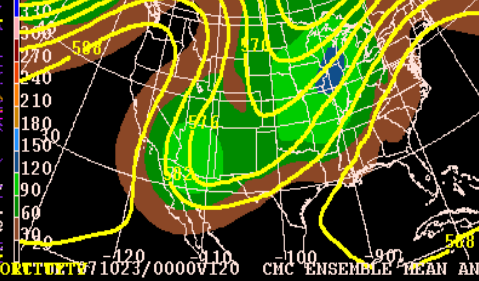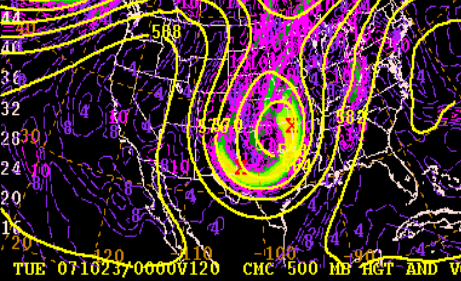
Ex. Day 7 Global Model & Ensemble PMSL Guidance / Spread in N-AWIPS

GFS

ECMWF

CMC

FRI 071102/1200V180 GFS PMSL, 1000-500 MB THICKNESS

FRI 071102/1200V180 ECMWF HI RES PMSL, 1000-500MB THKN

FRI 071102/1200V180 CMC PMSL, 1000-500 MB THICKNESS

FRI 071102/1200V180 GEFS MEAN AND SPREAD - PMSL

FRI 071102/1200V180 ECMWF ENSEMBLE MEAN AND SPREAD - P

FRI 071102/1200V180 CMC ENSEMBLE MEAN AND SPREAD - PMSL
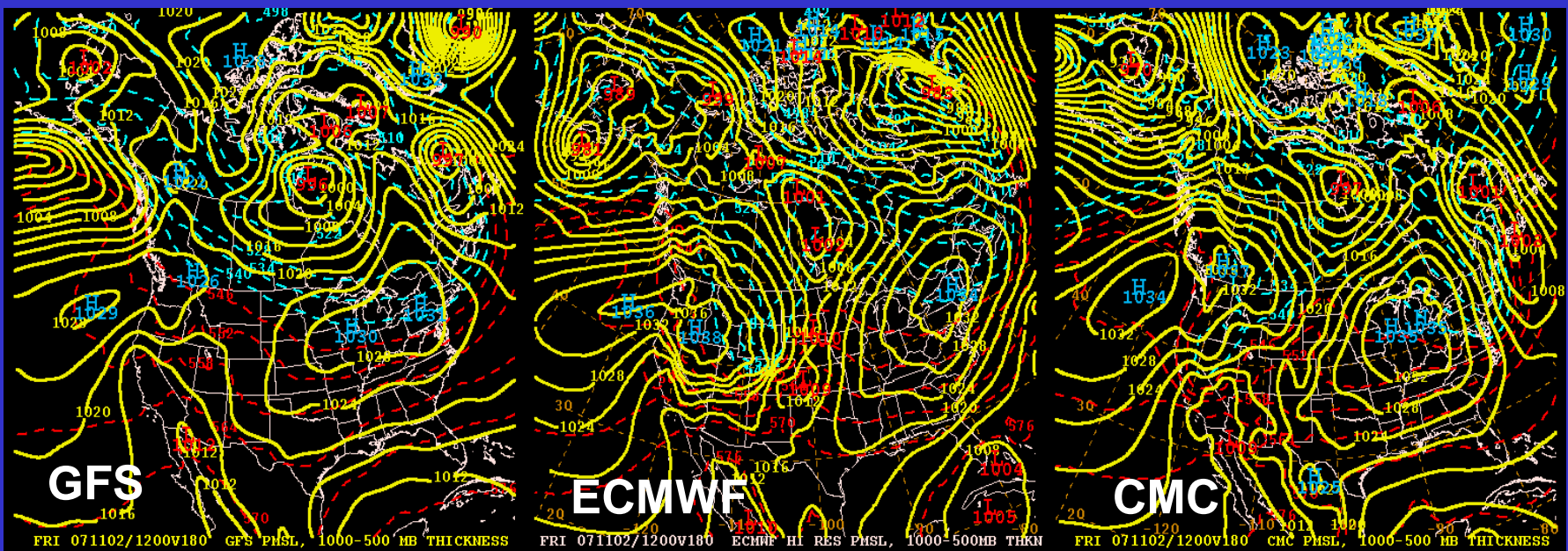
GFS Ensembles   **ECMWF Ensembles**   **CMC Ensembles**

HPC Masterblender Graphical User Interface

GFS

MON 071008/1200V132 GFS 48 HOUR TOTAL PCPN

ECMWF

1008/1200V132 ECMWF HI RES 48-HR PRECIPITATION

GEFS Mean

MON 071008/1200V132 GEFS MEAN 48-HR PCPN
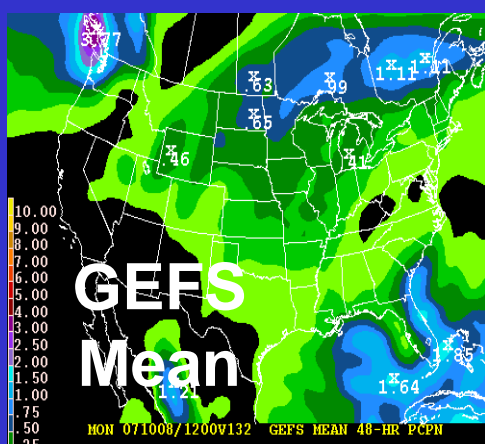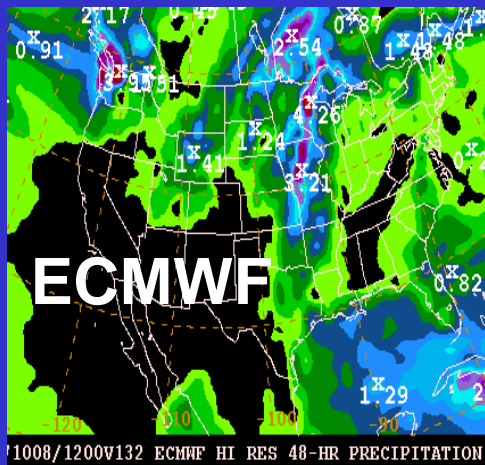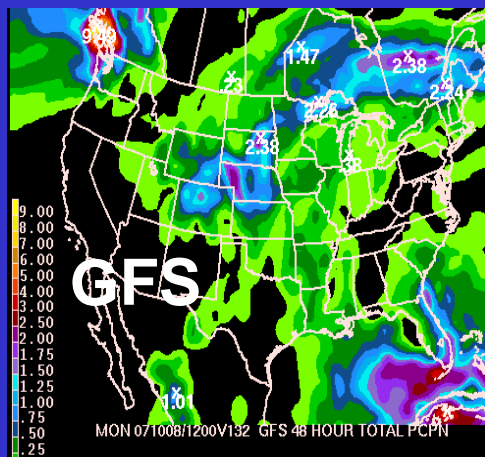
1. FIRST select a template:

- Medr pmsl
- Medr 500
- Day45 Morn
- d1qMidPre
- d1qMidFin
- Day45 Aftn
- d1qDayPre
- d1qEveFin
- Bawx Day
- d23MidPre
- d23MidFin
- Bawx Nite
- d23DayPre
- d23DayFin
- Misc
- MDD Day
- MDD Nite
- Alaska
- Medr Nite

FMIN 132
FMAX 132
INCR 6

2. Select model preferences for all forecast hours

Fhr clr all clear F0 copy int copy all
132

Total Blend at f132: 100%

3. Press CREATE or Preview

CREATE   Preview

Medr 12h pres help
Medr file help

□ debug

NAM 0   Cycle   0 □ Ydv
SREF Mean 0   Cycle   0 □ Ydv
GFS 30   Cycle   0 □ Ydv
GFS #2 0   Cycle   0 □ Ydv
GFSP 0   Cycle   0 □ Ydv
ECMWF (hr) 30 Cycle   0 □ Ydv
ECMWF #2 (hr) 0 Cycle 0 □ Ydv
UK 0   Cycle   0 □ Ydv
0   Cycle   0 □ Ydv
GEFS Mean 40 Cycle   0 □ Ydv
CMC 0   Cycle   0 □ Ydv
DGEX 0   Cycle   6 □ Ydv
NOGAPS 0   Cycle   0 □ Ydv
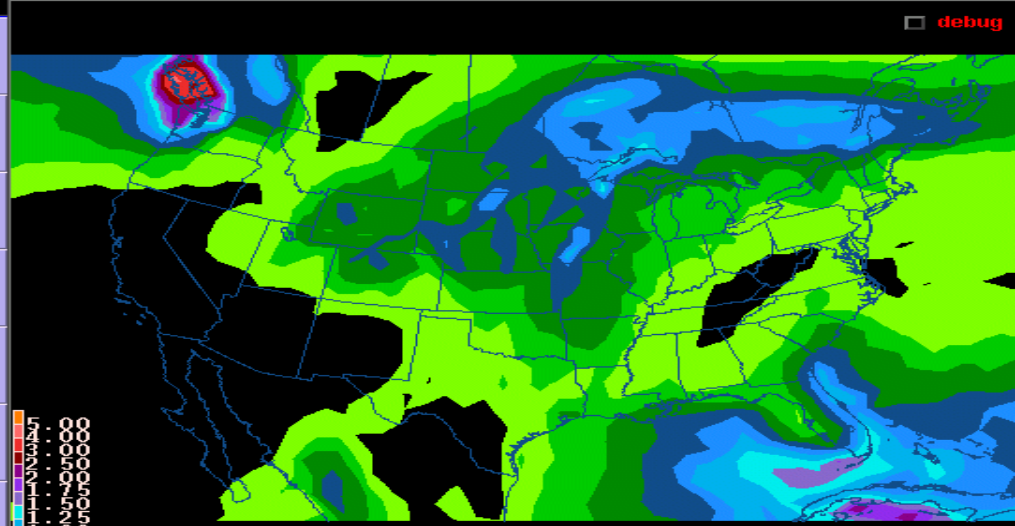
Blended GFS / ECMWF / and GEFS mean 84-132 hour QPF (weights chosen by forecaster)

FcstrID & Confidence   Lo Avg Hi
HPC

SEND500

Opt Text
Copy Text   Clear All Text

Buttons below are for info and can not be changed unless Misc template selected.

Ref Cycle   Domain
◆ 00Z ◇ 12Z   ◆ US   □ PMSL
◇ 06Z ◇ 18Z   ◇ W US   □ 500 mb   OutputFormat
◇ 24Z   ◇ Medr   □ Thck   ■ VGF
                 ◇ AK   □ QPF   ■ Grid
                 ◇ MDD   ■ D45QPF

EXIT

4. Select days to rename pmsl files.

Days
□ d3   □ d4   ■ d5   □ d6   □ d7
□ d3.5 □ d4.5 □ d5.5 □ d6.5 □ d7.5
all   intermediates   clear all

Fronts
□ d3f □ d4f ■ d5f □ d6f □ d7f
select all fronts   clear all fronts

5. Press RENAME PMSL FILES

RENAME PMSL FILES   rename help
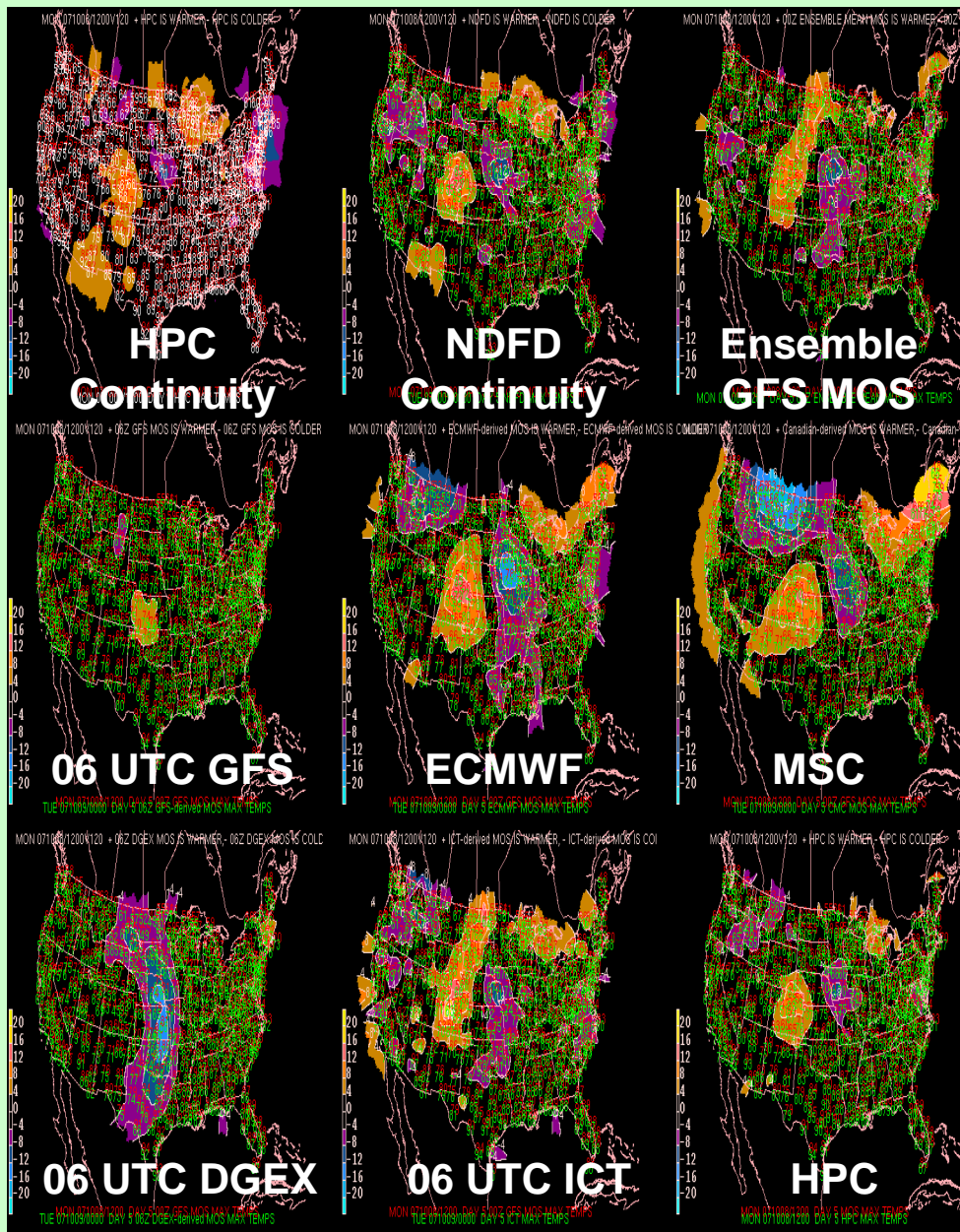   undo rename

show pmsl blended files below

This version of the blender is now template driven.
Please select a template for your shift before proceeding.
If a template is missing or needs to be modified, please contact Alan.

Model Output Statistics (MOS)

Maximum Temps vs. GFS MOS

- **HPC can adjust GFS MOS to address GFS differences with other guidance**
  - Ex: Maximum temperature
    - Compare 1000 – 500 hPA thickness and 2-meter temperatures of other models to the GFS
      - Parameter choices are limited to common model availability
    - A weighting factor adjusts GFS MOS based on verification analysis and as a function of forecast day

Verification shows concentrated human adjustments to guidance in areas of high forecaster confidence and blender usage lead to max added value

There is a low false alarm rate but a low probability of detection of big changes

Preliminary HPC Percentage Improvement Over 00z MOS
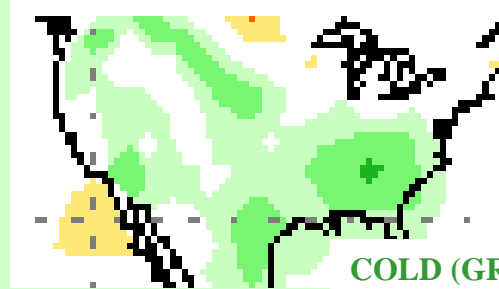### Min T MAE (Adjusted Station Only) - September 2006 - August 2007

>5°C

~1°C

Day 4 – 7 Percent improvements

4　　5　　6　　7

Percent of total grid points adjusted by human

Day 4　　Day 5　　Day 6　　Day 7

Forecast Day

% Improvement
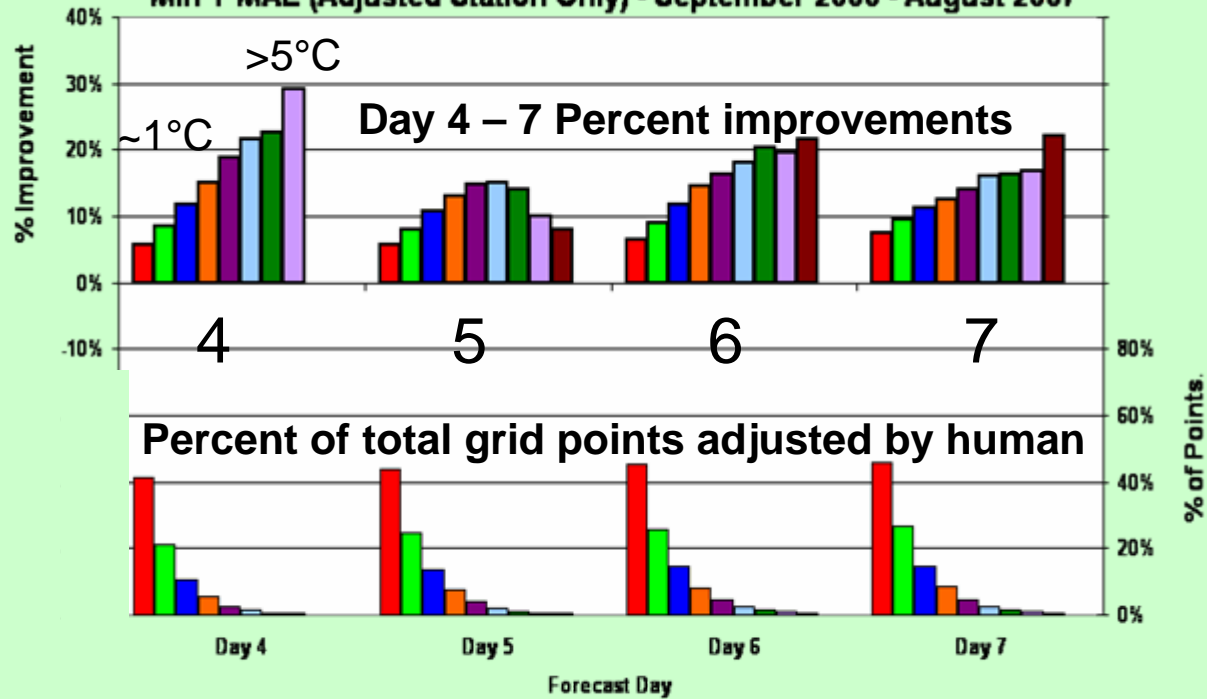
% of Points.

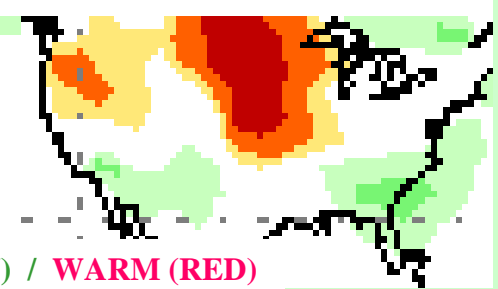| ■ % Improv >=1 deg	■ % Improv >=2 deg	■ % Improv >=3 deg	□ % Improv >=4 deg	■ % Improv >=5 deg
□ % Improv >=6 deg	■ % Improv >=7 deg	□ % Improv >=8 deg	■ % Improv >=9 deg	□ % Improv >=10 deg
■ % of points >=1 deg	■ % of points >=2 deg	■ % of points >=3 deg	■ % of points >=4 deg	■ % of points >=5 deg
□ % of points >=6 deg	■ % of points >=7 deg	□ % of points >=8 deg	■ % of points >=9 deg	□ % of points >=10 deg

Day 5 Maximum Temp Forecast

USA

Green > ~5° C
Human Change
to MOS

Bigger changes are regional in scale
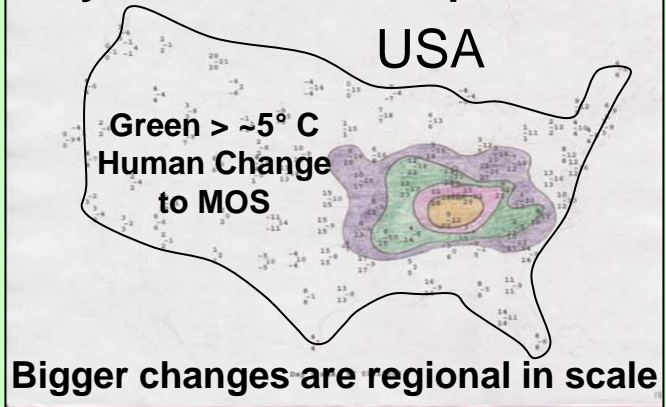
Arctic Airmass Bias Challenge

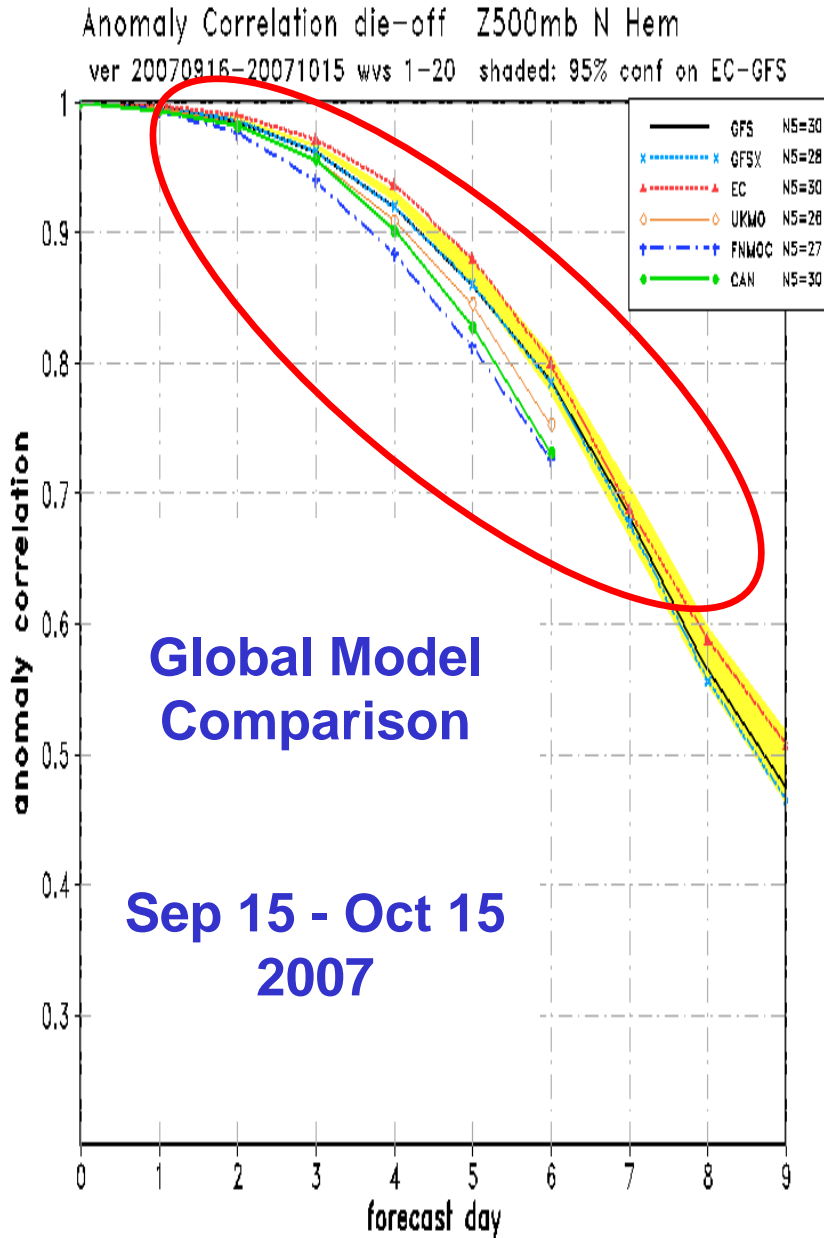**MAR 2004 2M TEMP BIAS**　　**JAN 2004 2M TEMP BIAS**

COLD (GREEN) / WARM (RED)

BIAS WITHOUT MANY LOW LEVEL COLD AIRMASSES　　**BIAS WITH SIGNIFICANT LOW LEVEL COLD AIRMASSES**

Day 0-10 NORTHERN HEMISPHERE 500 MB A.C. SCORES

Anomaly Correlation die-off Z500mb N Hem
ver 20070916-20071015 wvs 1-20   shaded: 95% conf on EC-GFS

GFS	N5=30
GFSX	N5=28
EC	N5=30
UKMO	N5=26
FNMOC	N5=27
CAN	N5=30

Global Model Comparison

Sep 15 - Oct 15 2007

Global Model vs. Ensemble Mean Comparison

SUMMER 2007

Ensemble mean improvement vs. control

NCEP/EMC

Changing Atmosphere

Responses to: "Look at the ensembles."

August 2003:

Why? It just tells us that there is uncertainty in the forecasts. We already knew that.   (Erich Wolf prior to retirement from HPC)

October 2007:

"Show me!"   (Frank Rosenstein / HPC)

"It's like Christmas! (more ensembles in N-AWIPS)   (Jim Cisco / HPC)

"Who cares?" (Anonymous / HPC…not everyone agrees yet)

RNK_3: rah…basically blending the previous forecast with hpc's which looks like it is going with the average of the ensembles. Tuesday looks like a bust day for the forecast. showing a spread of the ensembles for Roanoke from high of 80 to a high of 59.
(WFO Blacksburg, VA 12Planet coordination chat to Raleigh, NC)

It would be important to hear a range of temperatures instead of just one number. I could make more informed decisions. But…what do you think will be the real temperature?   The TV guy said 75. (my wife)

NOAA/National Weather Service Strategic Goals
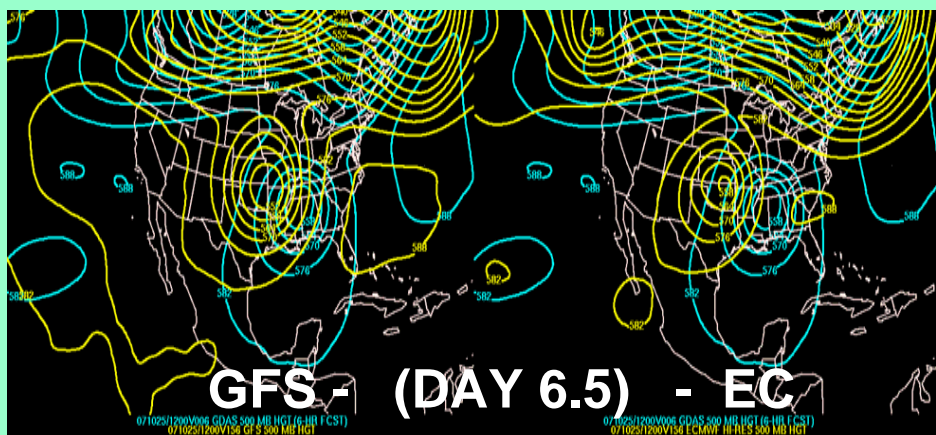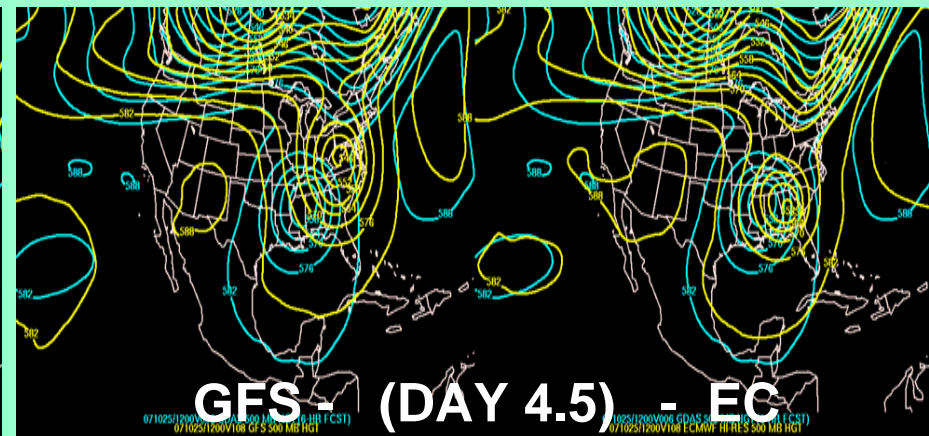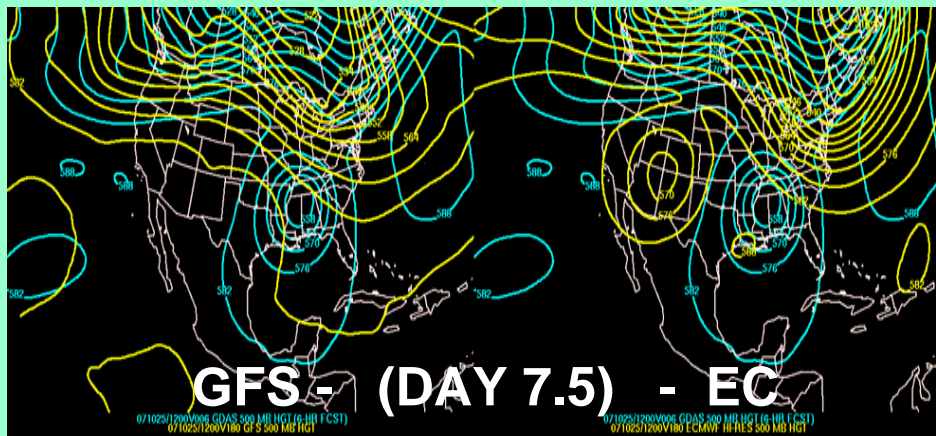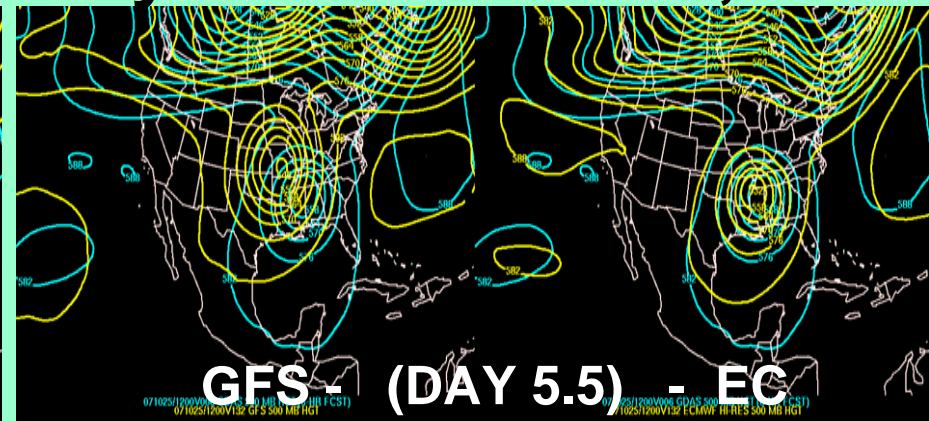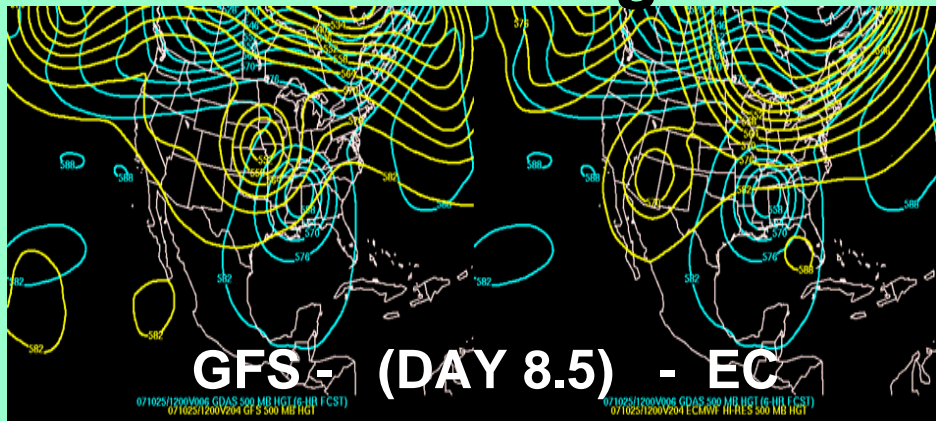
NATIONAL RESEARCH COUNCIL (NRC) REPORT
COMPLETING THE FORECAST: CHARACTERIZING AND COMMUNICATING UNCERTAINTY FOR BETTER DECISIONS USING WEATHER AND CLIMATE FORECASTS

- "NWS should take a lead role…"

- Provide ensembles at various scales and applications

- Engage and educate users, partners, social science in product development and use

  – **THORPEX**
  – **North American Ensemble Forecast System (NAEFS)**
  – **Test-beds (example: NCEP / HPC Alaskan Desk)**
  – **T-PARC (THORPEX-Pacific Asian Regional Campaign) / IPY (International Polar Year)**
    - **Tropical Cyclogenesis (Western Pacific, Aug-Sep 2008)**
    - **Extratropical Transition (Western Pacific, Aug-Sep 2008)**
    - **Winter Phase (North Pacific, Jan-Feb 2009)**

    Strong participation from Asia:
      – **Dr. L. Uccellini visited CMA in October 2007**
        » **CMA interested in possibly joining NAEFS (other centers? / logistical issues?)**
        » **TIGGE collaboration**
        » **Beijing Olympics demo project**

  – **Provide access to all forecast data / verification information**

- **"…no forecast is complete without a description of its uncertainty"**
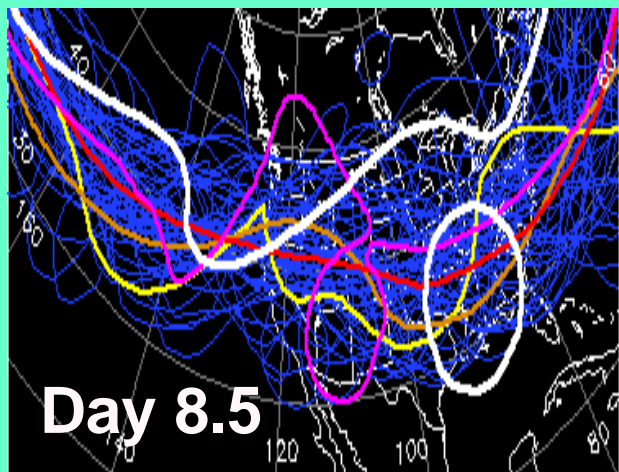
13

Challenges

- **Communication / Interaction / Cooperation:**
  - Research community, forecasters, management, public sector
  - Workshops and conferences
  - Data and guidance exchange

- **Science:**
  - New and varied model and ensemble methodologies
  - Verification (skill and continuity)

- **Resource priority:**
  - Computational costs
  - Transmission limitations
  - Data and guidance storage limitations
  - User deadlines

- **Availability:**
  - User friendly format
  - General and sophisticated user training and feedback

Poor 500 hPa height continuity all valid Oct 25, 2007

GFS - (DAY 8.5) - EC

GFS - (DAY 5.5) - EC

GFS - (DAY 7.5) - EC

GFS - (DAY 4.5) - EC

GFS - (DAY 6.5) - EC

GFS - (DAY 3.5) - EC
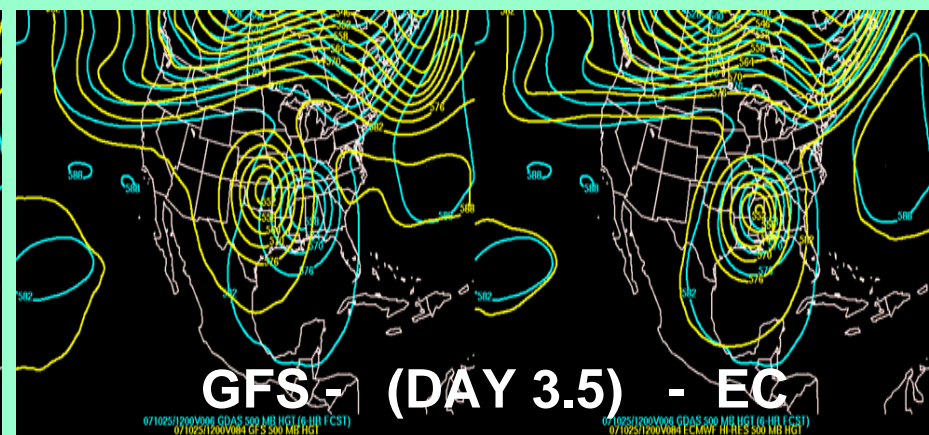
Spaghetti plots show improved 500 hPa NCEP (brown) and ECMWF (red) ensemble mean continuity all valid Oct 25, 2007 despite high solution spread

Fig. a — Centers Ensemble Forecast for 500 mb Height (5760m)
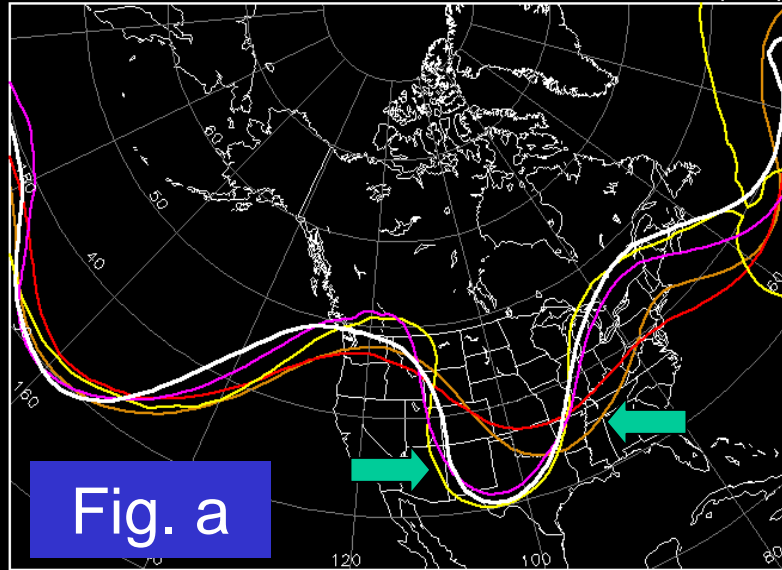itime: 2007101600   vtime: 2007102212 (156h)
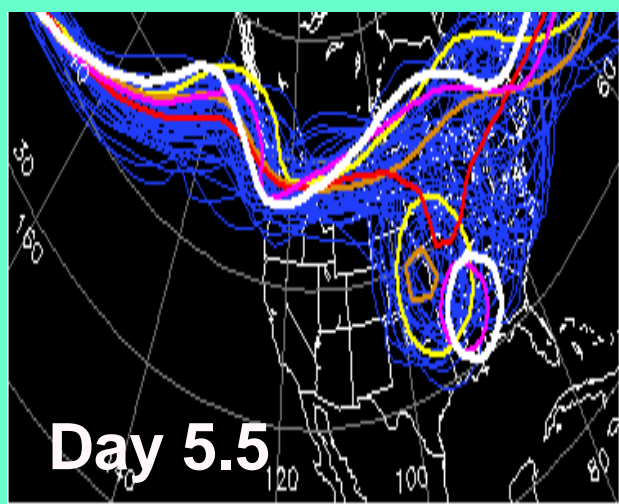
Potential errors with frequency distributions derived from a single ensemble system

Lower ensemble resolution compared to global runs can lead to increased regime dependent bias and less skill (fig. a)

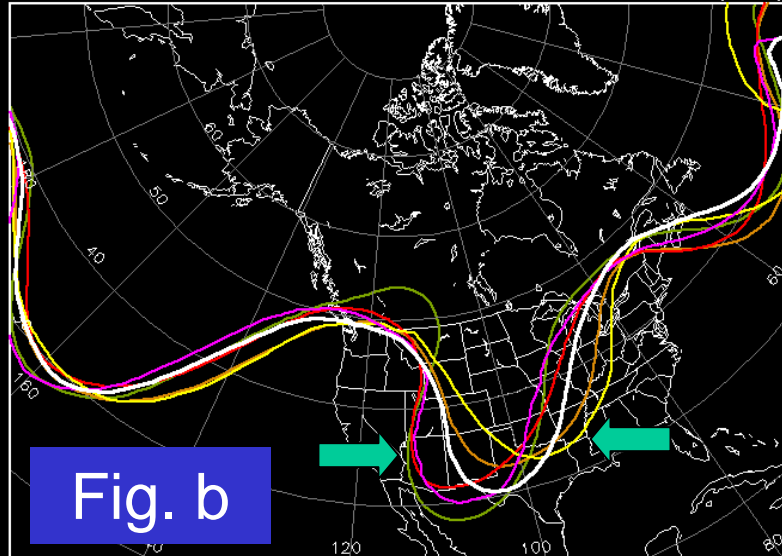Ensembles and respective global runs are often too closely correlated (figs. b, c)

* Multi-center ensemble systems may offer a more representative forecast distribution

Fig. b — Centers Ensemble Forecast for 500 mb Height (5760m)
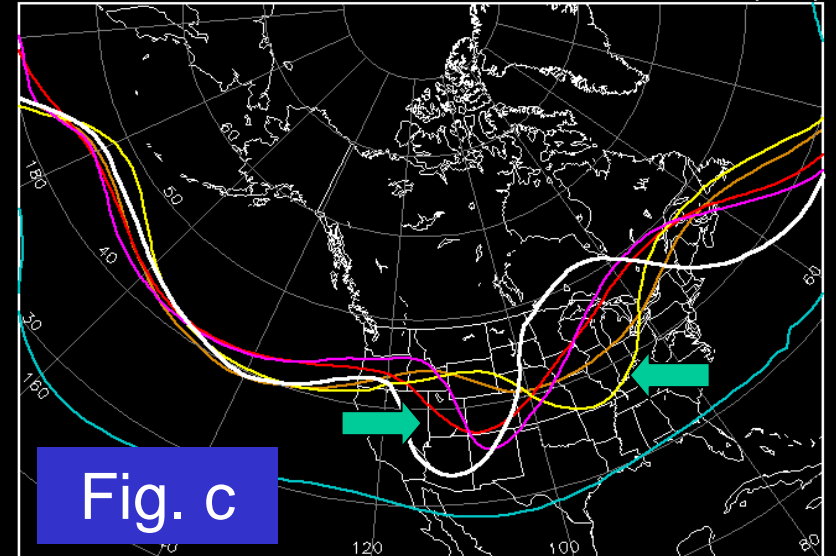itime: 2007101800   vtime: 2007102212 (108h)

Fig. c — Centers Ensemble Forecast for 500 mb Height (5760m)
itime: 2007100100   vtime: 2007100712 (156h)

NORTH AMERICAN ENSEMBLE FORECAST SYSTEM

- Operational multi-center ensemble products coordinated among National Weather Services of Canada, Mexico, US

- Combines global ensemble forecasts from Canada & USA
  - 40 members per cycle, 2 cycles per day from MSC & NWS
    - 6-hourly output frequency out to 16 days
    - 1x1 lat / lon resolution

- Generates products for
  - Intermediate users
    - E.g., weather forecasters at NCEP Service Centers (US NWS)
  - Specialized users
    - E.g., hydrologic applications in all three countries
  - End users
    - E.g., forecasts for public distribution in Canada (MSC), Mexico (NMSM), Caribbean, South America, Africa (AMMA)

- Prototype ensemble component of THORPEX Global Interactive Forecast System (GIFS)
  - Operational outlet for THORPEX research using THORPEX Interactive Grand Global Ensemble (TIGGE) archive
    - Distribution
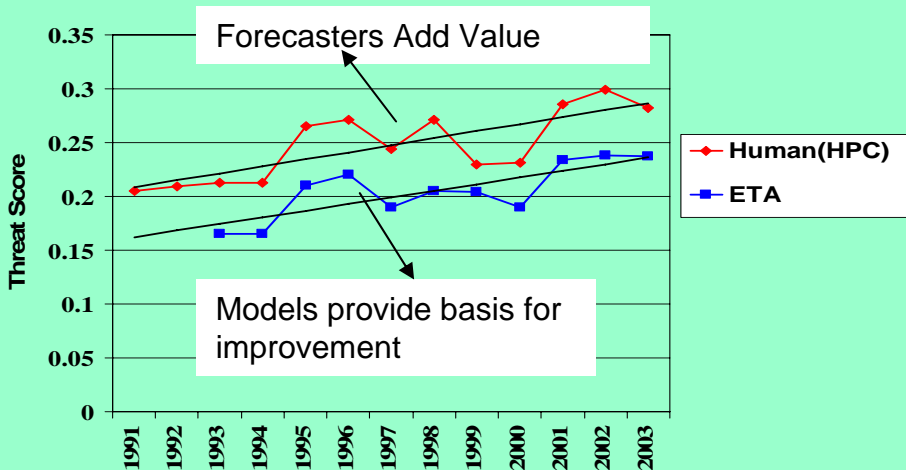   - » Ftp – *http://nomad5.ncep.noaa.gov/ncep_data/*

NOMADS
The NOAA Operational Model
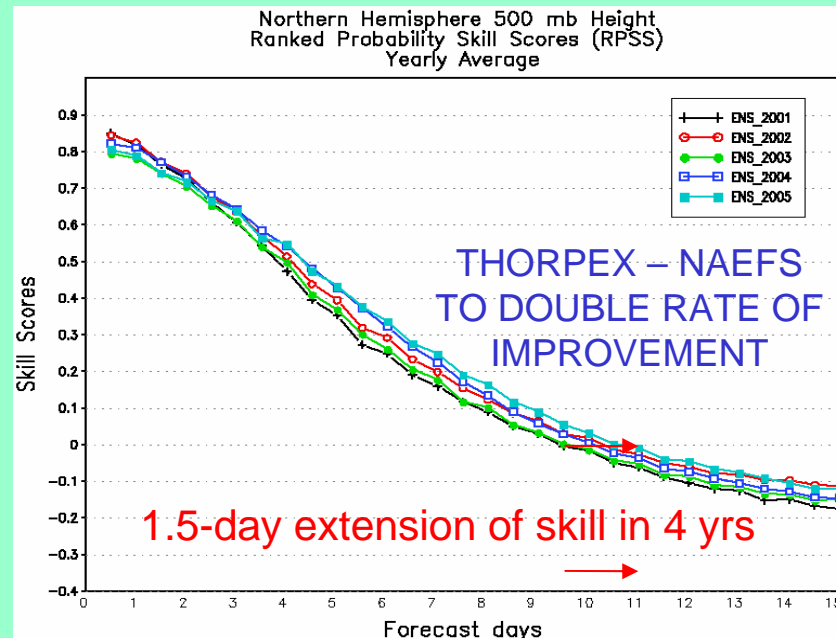Archive and Distribution System

THORPEX GOAL

- Accelerate improvements in skill & utility of high impact forecasts
    - Forecaster improvements are strongly related to advances in NWP skill and access to information
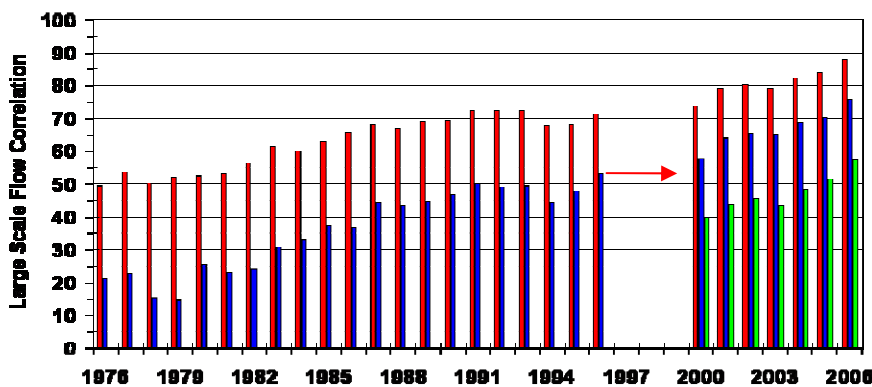
Impact of Models on Day 1 Precipitation Scores

Forecasters Add Value

Models provide basis for improvement

- Human(HPC)
- ETA

HPC Medium Range Verification
No. American MSLP Forecast Skill

**NCEP / HPC Day 7 forecast skill in 2006 equals day 5 skill in 2000 (2 day increase in 6 years)**

IMPROVEMENT IN PROBABILISTIC SKILL OVER PAST 4 YEARS

Northern Hemisphere 500 mb Height
Ranked Probability Skill Scores (RPSS)
Yearly Average

THORPEX – NAEFS TO DOUBLE RATE OF IMPROVEMENT

1.5-day extension of skill in 4 yrs

Northern Hemisphere 500 mb Height
Ranked Probability Skill Scores (RPSS)
Average For 20060425 – 20060510

Close to 2-day extension of skill with first NAEFS implementation
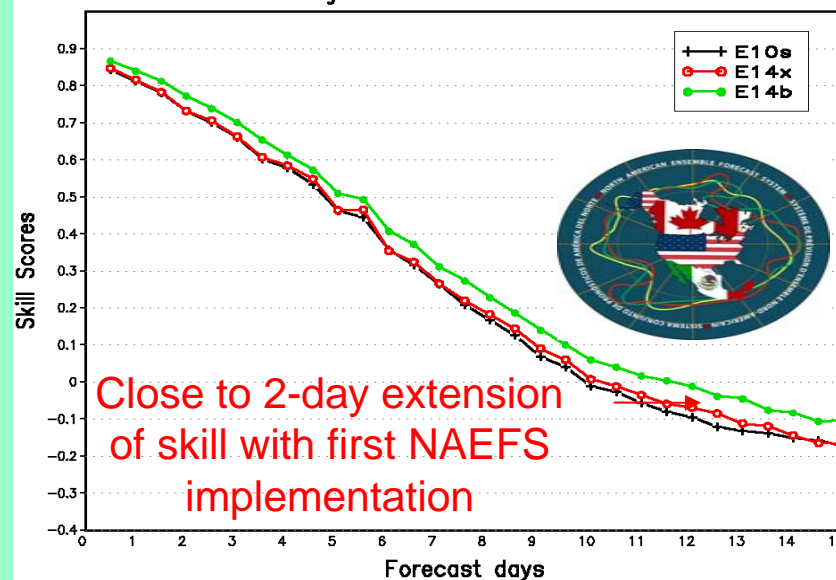
NAEFS Planned Upgrade December 4, 2007

2m Temp Bias Reduction
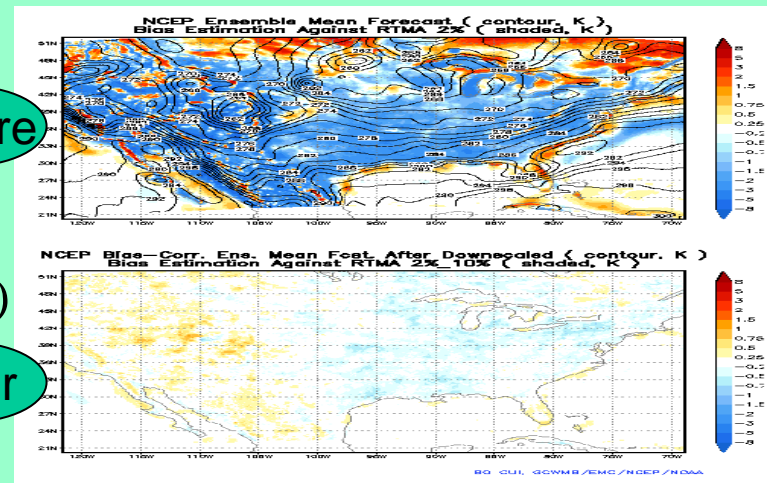
- ❑ Bias corrected GFS forecast
  - Use the same algorithm as ensemble bias correction up to 180 hours
- ❑ Combine bias corrected GFS and ensemble forecast
  - GFS has higher weights at short lead times
- ❑ NAEFS new products
  - Combine NCEP/GEFS (20m) and CMC/GEFS (20m)
  - Produce Ensemble mean, spread, mode, 10% 50% and 90% probability forecast at 1*1 degree resolution
  - Anomaly forecast from ensemble mean
- ❑ Statistical downscaling by using RTMA as reference
  - At NDGD resolution (5km), CONUS only
  - Generate mean, mode, 10%, 50% (median) and 90% probability forecasts
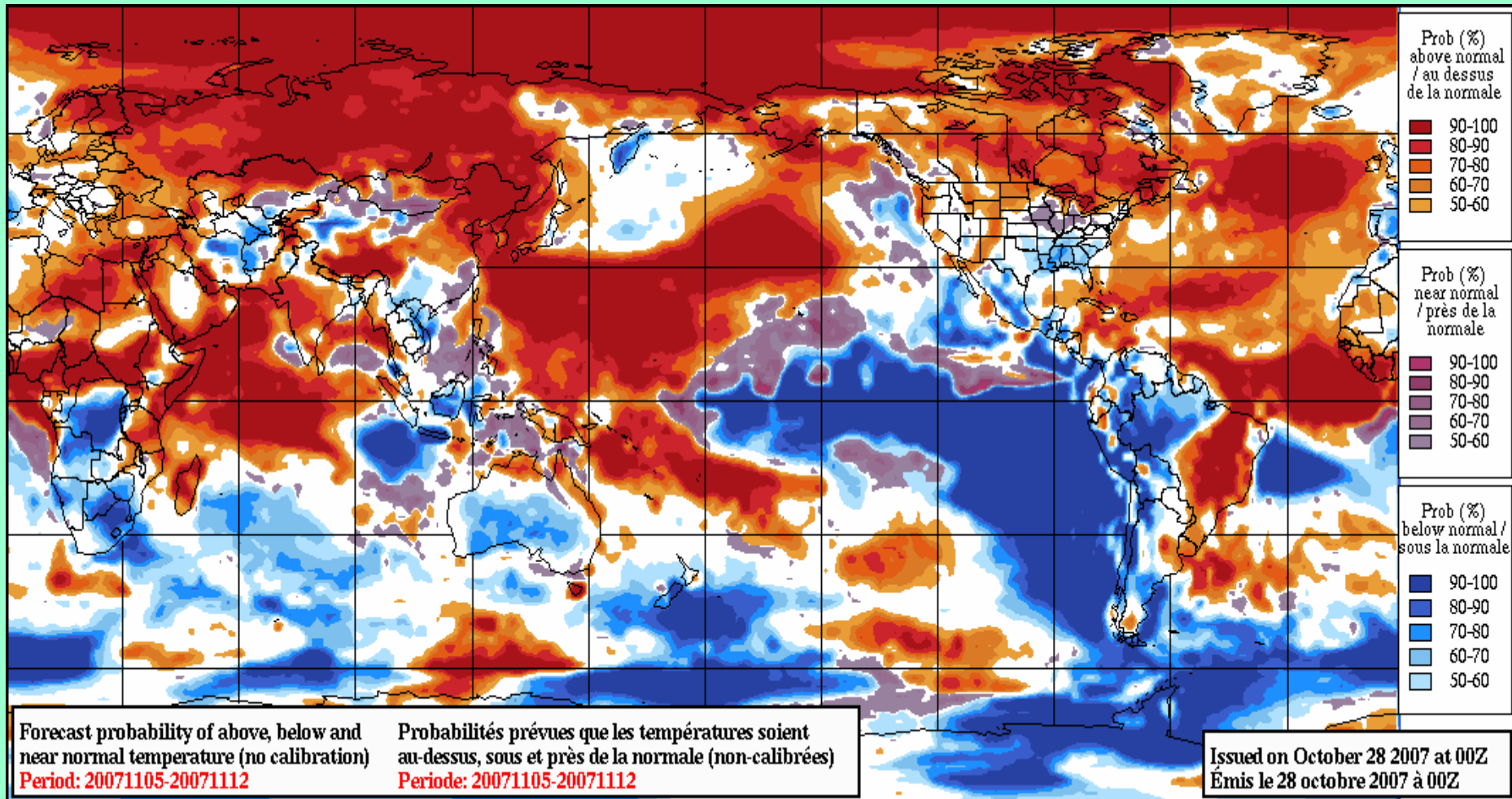 - Variables (surface pressure, 2-m temperature, and 10-meter wind)

GFS vs. Control Weighting
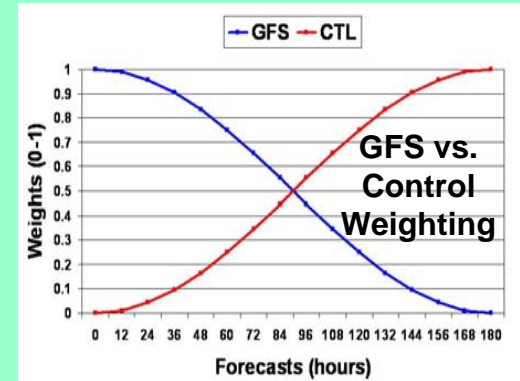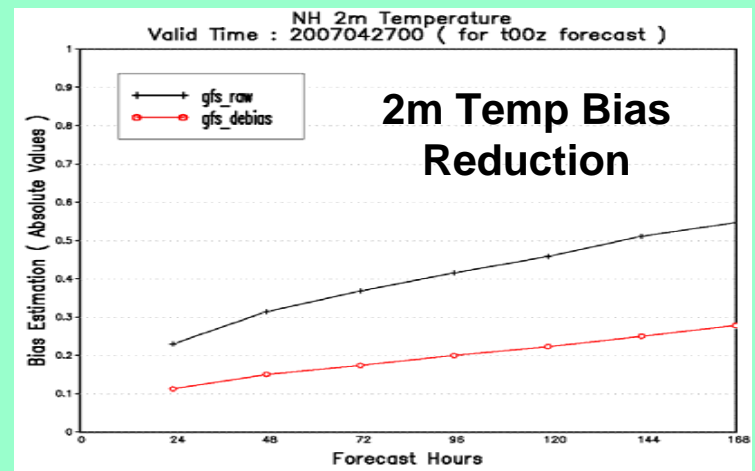
Before

After

Downscaled 2m Temp Bias Reduction

NAEFS product example: Week-2 Mean Temperature

Prob (%) above normal / au dessus de la normale
- 90-100
- 80-90
- 70-80
- 60-70
- 50-60

Prob (%) near normal / près de la normale
- 90-100
- 80-90
- 70-80
- 60-70
- 50-60

Prob (%) below normal / sous la normale
- 90-100
- 80-90
- 70-80
- 60-70
- 50-60

Forecast probability of above, below and near normal temperature (no calibration)
Period: 20071105-20071112

Probabilités prévues que les températures soient au-dessus, sous et près de la normale (non-calibrées)
Periode: 20071105-20071112

Issued on October 28 2007 at 00Z
Émis le 28 octobre 2007 à 00Z

http://meteo.ec.gc.ca/ensemble/index_naefs_e.html

SITE SPECIFIC ENSEMBLE-GRAMS (CMC)
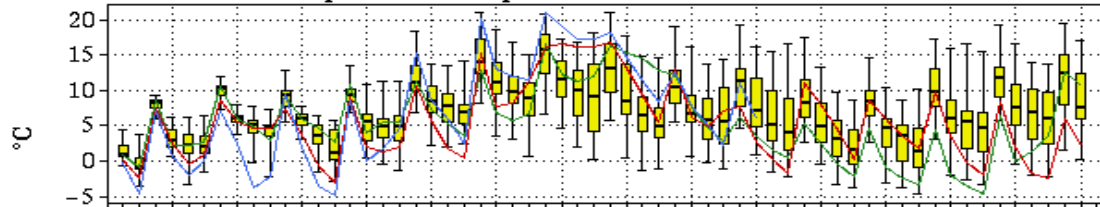
2-m Temperature
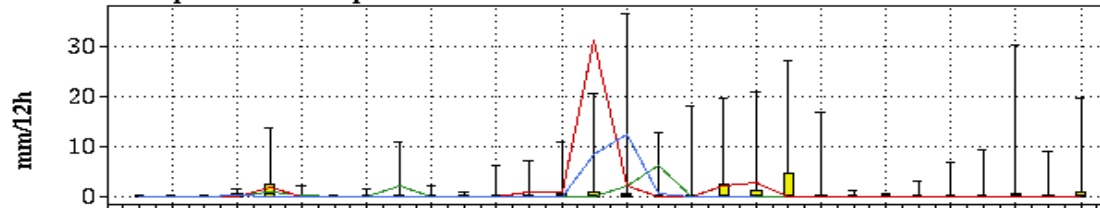
12-hr Accumulated Precipitation
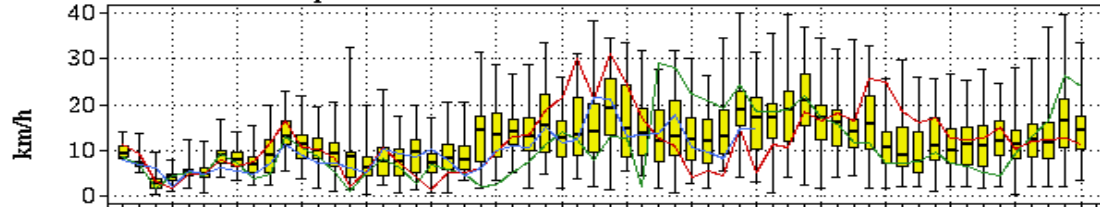
10-m Wind Speed

Total Cloud Cover
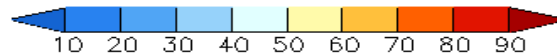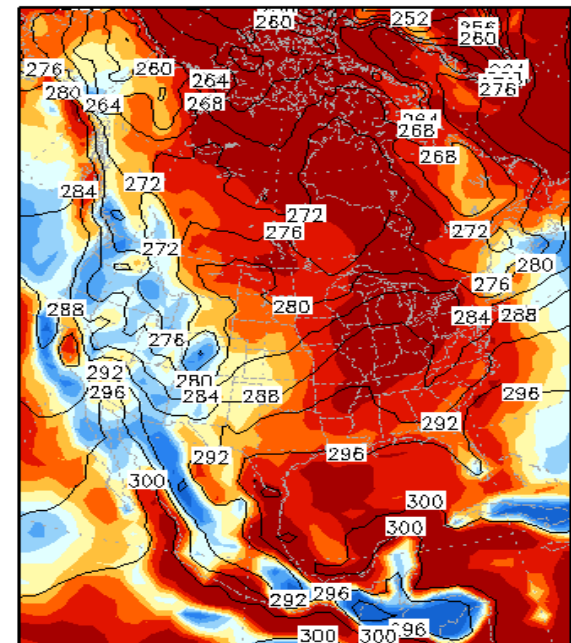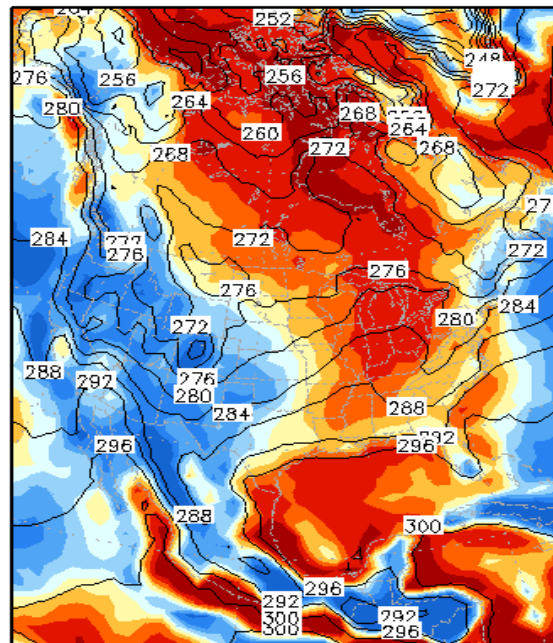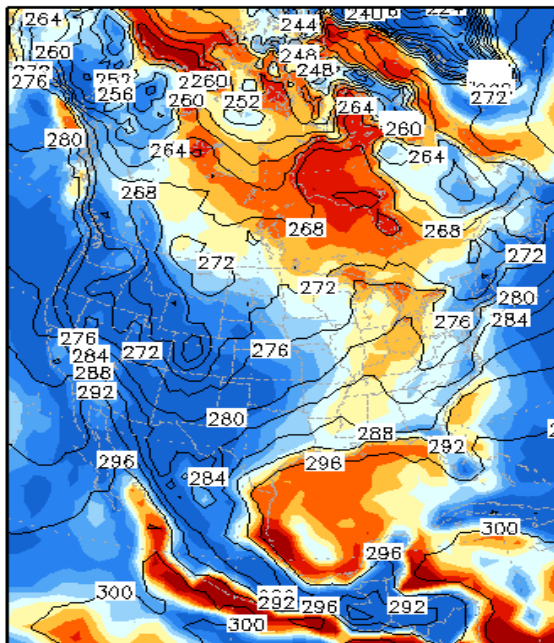
Example of probabilistic forecast in terms of climatology

Gridded GFS MOS 5–95% Temperature Probability Forecast
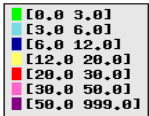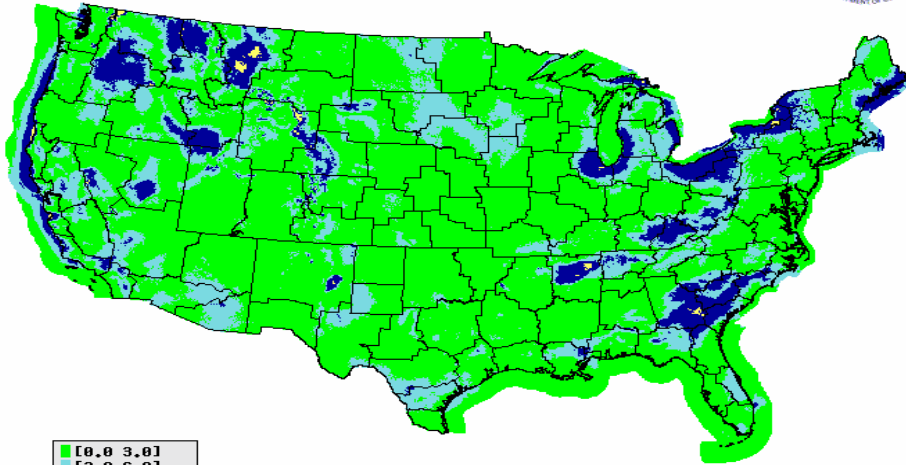
Temperature(F) mean11 50% Thu Nov 30 2006   7PM EST
(Fri Dec 01 2006 00Z)

National Digital Guidance Database
Graphic created-Sep 24   1:25PM EDT
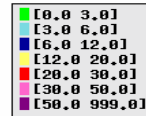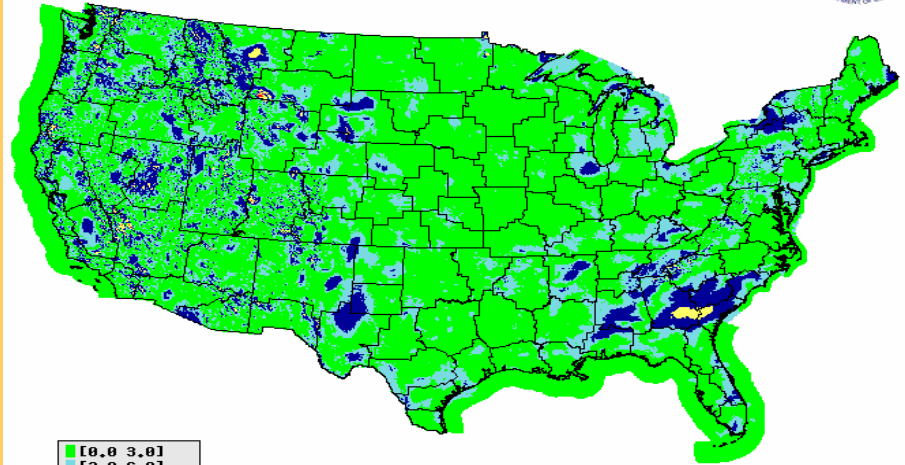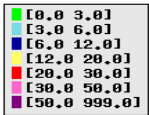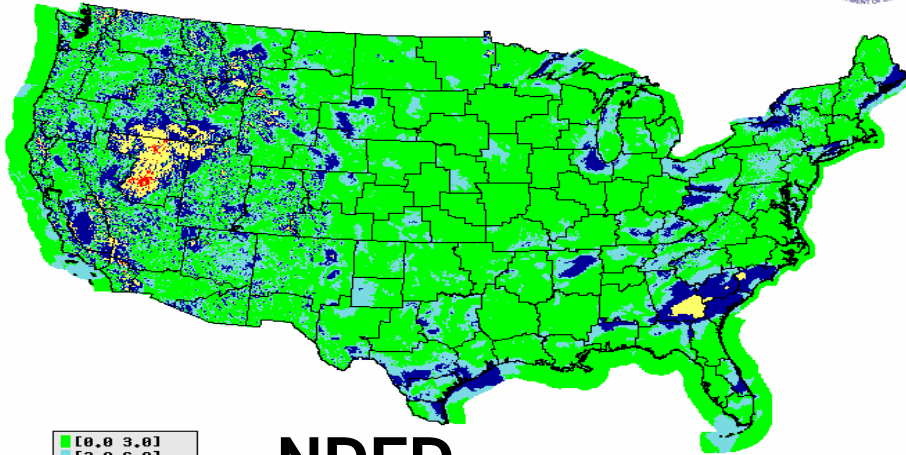
Day 1 GFS MOS…NDFD…and biased corrected/downscaled NAEFS 2-meter temperature error vs. observed (RTMA) valid June 5, 2007

Will a longer test period including the fall/winter show similar results through medium range time scales?

NCEP HPC / EMC COLLABORATION FOR A NEW ALASKAN DESK IN DEVELOPMENT

- Context
  - Alaska Desk considered experimental ground for new uncertainty products
  - After testing…consider introduction of products / procedures to other regions

- Activities
  - Jointly identify format of new products (HPC / EMC)
  - Develop ensemble-based numerical guidance for new products (EMC)
  - Operationally implement numerical guidance (EMC / NCO)
  - Develop missing tools for modification / transmission / storage of new products (HPC / EMC / NCO)
  - Experimental forecast activities (testing, feedback: HPC / Alaska Region / EMC)

- Envisaged flow of steps in operations
  - Numerical guidance generated by NCO
  - HPC modifies numerical guidance
  - HPC guidance sent to AR WFOs
  - AR modifies guidance if needed
  - Final NDFD (or NDGD) product
  - Back-propagate HPC forecaster modifications to ensemble data?

PROPOSED FORECAST FORMAT

- In addition to most likely value that is in NDFD now
  - Add two bounds corresponding to two percentile values in forecast distribution

- Specific format
  - Mid-point value
    - Use mode (not mean or median)
      - Most intuitive
      - Allows for generalization when multiple modes considered
  - Extreme bounds
    - Use 10 & 90 percentile
      - Encompasses 80% of distribution
      - More extreme values may not be statistically that reliable

- Necessary tools
  - Derive parameters from NAEFS ensemble
    - For numerical guidance
      - Bounds
      - Mode
  - Field modification – available in N-AWIPS (just like most likely)
    - Move entire distribution (i.e., bounds) if only mode modified
    - Convert three values to full pdf distribution
    - Derive additional products

EXAMPLES FROM UKMET OFFICE FOR TEMPERATURE AND PRECIP

Alaska Medium Range Desk (developments so far)

- A probability density frequency (PDF) curve will be developed from the NAEFS and bias-corrected

- From the PDF, magnitudes of the 10th and 90th percentiles will initially be calculated for:

    – Maximum Temperature
    – Minimum Temperature
    – Wind Speed and direction
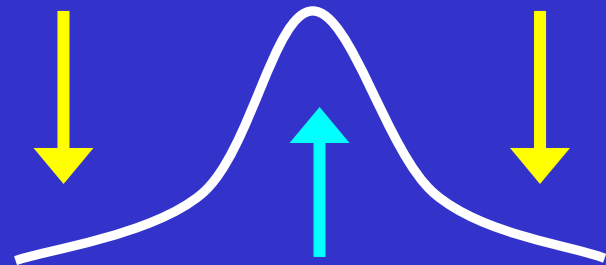
- Employing a downscaling vector, the 10th and 90th percentile values will be converted from a 1° by 1° grid to a 5 km grid.

Alaska Medium Range

- Developments thus far (cont):

  – The HPC forecast will then be compared to the mode of the PDF, and the grids will be adjusted towards the HPC forecast if there is a difference.

Disseminated NCEP PDF

NAEFS PDF

HPC Mode

NAEFS Mode

Human Influence on Forecast
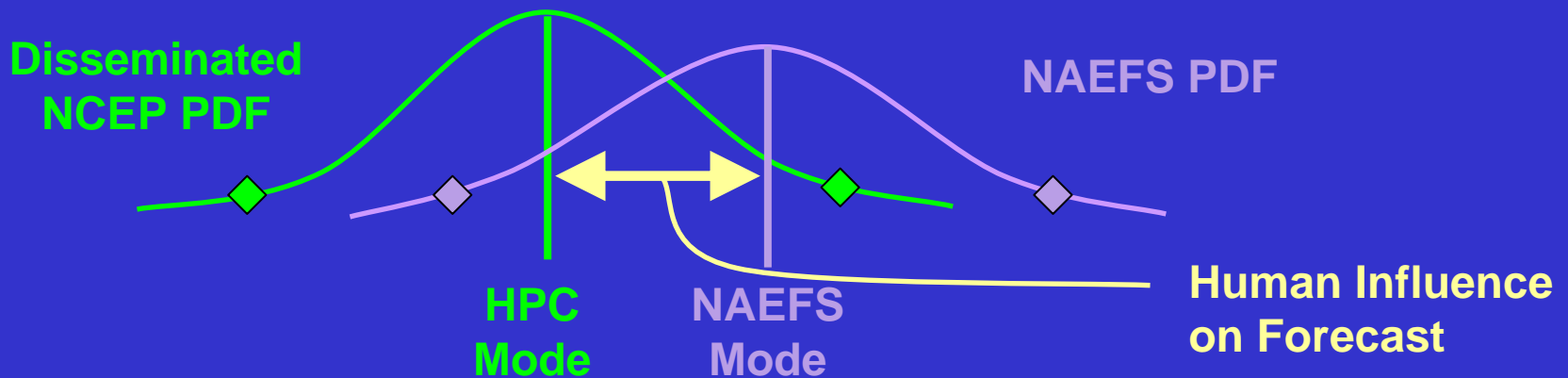
  – Alaska will be the first Region to receive medium range grids from HPC that include probabilistic bounds for meteorological variables

  – HPC hopes to use a similar method for introducing a sense of "what's meteorologically possible" into the NDFD over the lower 48 states

Alaska Medium Range

- Developments thus far (cont):

  - Additional variables are under consideration for inclusion into the HPC Alaska Medium Range grids:
    - QPF: The idea of negative precipitation would be introduced to indicate how close the model is to producing qpf, rather than the typical QPF yes or no. This will require hires gridded observationally-based analysis of precipitation.
    - Cloud Cover
    - Dewpoint
    - More?

Links with NOAA/NWS Forecast Uncertainty Service Evolution Steering Team (NFUSE) PLANS

- Current system
  - **Single value format**

- Short-term (2-3 yrs) plan – **3 values format** (pdf)
  - Provide best (bias corrected) numerical guidance in agreed upon format
  - Human forecasters modify numerical guidance using agreed upon format
  - External users provided with products in format of their choice

- Long-term (5-10 yrs) plan – **ensemble format**
  - Provide best numerical guidance in agreed upon format
  - Human forecasters modify numerical guidance using agreed upon format
    - Propagate information to modify bias corrected ensemble data
      - Modified bias corrected ensemble data is complete and final forecast dataset includes uncertainty information regarding spatial, temporal, cross-variable co-variances
      - Forecasters need ensemble access for:
        » Manipulation (added value)
        » Interpretation (user outreach)
  - External users provided with products in format of their choice