Proposed NCEP SREF System Upgrade

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Thursday, July 29, 2004

where the nation's climate and weather services begin

Outline

- **Motivation for Upgrades**
- **Current System Description**
- **Proposed System**
- **Dissemination of Products**
- **System Performance**
  - ***Deterministic***
  - ***Probabilistic (non-precip and precip variables)***
  - ***Case Studies (Cold and Warm Season)***
- **Recommendations**

SREF System Goals

- **Improved Spread-Skill relationship Information**
  - ***System variance ~ System Mean Squared Error***
  - ***Less clustering around control model systems***
- **Improved or similar skill as determined from ensemble mean and probabilistic skill scores (RPSS, Sharpness of probabilistic forecast) :**
  - ***QPF***
  - ***Upper-level winds heights***
  - ***2 m Temperature, MSLP…***
- **Improved probabilistic products for NWS mission forecasts (Severe, Aviation, hydromet, ocean, tropical)**

Motivation for SREF Upgrade

- **Based on Feedback from EMC Annual Review**
  - ***NCEP Centers found Eta and RSM members clustered around parent model***
  - ***Lack of System Spread***

- **NEHRT Energy Program Participation**
  - ***Test of increased physics diversity, resolution***

Short Range Ensemble Forecast (SREF) System

Current Configuration

- **Current: 48 km**
  - **15members:**
    - **5 Eta-Betts-Miller-Janic Convection (BMJ),**
    - **5 Eta: Kain-Fritsch (KF)**
    - **5 RSM: Simple Arakawa Shubert (SAS)**

    - 1 control + 2 breeding pairs (p1,n1,p2,n2)

    - Full North American Domain

    - Eta Version: from June 2002

  - **09 and 21 Z runs to 63 hours**

    - GFS Ensemble boundary conditions

  - **Products: Standard Grib on NCEP ftp**

    - AWIPS 212 (40km) Conus Mean, spreads, probabilities

    - "Thinned" Grids for Each Member

SREF

Grib Mean/Spread Products

Grid 212: Lambert Conformal 40 km, 185x129

Mean and spread Parameters	*Units*	*Level* *(*= not in Spread files)*
2m Temperature	[K]	Sfc
10m U, Vwind	[m/s]	10 m
Total precipitation(3,6,12,24hr)	[kg/m2]	Sfc
Convective Avail. Pot. Energy	[J/kg]	
Convective inhibition (CIN)	[J/kg]	
Storm RElative Helicity (SREH)	[m2/s2]	0-3000 m
Lifted Index	[K]	0-30 mb abv grnd
Sea Level Pressure	[Pa]	Sfc
Pressure	[Pa]	1000-50 mb (every 50 mb)
*Categorical rain *	*[y/n]*	*Sfc*
*Dominant precip type (over 3hr)**	*[1-7]*	*Sfc*
*12hrly Large scale Snow Fall**	*[kg/m2]*	*Sfc*
*12hrly Snow Depth**	*[kg/m2]*	*Sfc*
12hrly Accumulated Snow Fall	[kg/m2]	Sfc
*Absolute vorticity**	*[/s]*	*1000-50 mb (every 50 mb)*
Geopotential height	[gpm]	1000-50 mb (every 50 mb
Relative humidity	[%]	1000-50 mb (every 50mb)
U, V- wind	[m/s]	1000-50 mb (every 50 mb)
Temperature	[K]	1000-50 mb (every 50 mb)
Thickness	[gpm]	1000-850, 1000-500, 850-700mb

SREF

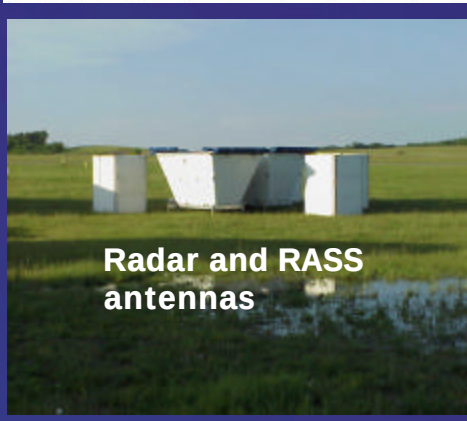
GRIB formatting fixed for these probabilistic products

Grid #212: Lambert Conformal 40 km, 185x129

Probabilistic Parameters	*Units*	*Threshold*
Convective Avail. Pot. Energy	[J/kg]	= 500, 1000, 2000, 3000, 4000
Convective Inhibition (CIN)	[J/kg]	= -50, -100, -200, -300, -400
Storm Relative Helicity (SREH)	[m2/s2]	= 100, 150, 200, 250, 300
Lifted Index	[K]	= 0, -2, -4, -6, -8
Precipitation (3, 6, 12, 24 hr)	[Inches]	= 0.1, 0.25,0.5, 1.0, 2.0
12hrly Accumulated Snow Fall	[Inches]	= 1, 2.5, 5, 10, 20
Prob precip type is rain	[%]	
Prob precip type is freezing rain	[%]	
Prob precip type is snow or sleet	[%]	

Proposed Changes

- **Increased Resolution**
  - ***48 km to 32 km horizontal resolution***
  - ***Increased to 60 levels in Eta Members***
- **Enhance SREF Physics Diversity by Running Several Members with Different Cloud Physics and Convective Parameterization Schemes**
- **Scaled Breeding System to Control Unrealistically Large Initial Condition Perturbations in cold season and increase IC perturbations in warm season**
- **Upgrade Eta members to Software Version Level Same as July 2003 Eta-12 system**
- **Upgrade RSM Members with Improved Physics and Computational Schemes**



SREF Parallel
Physics Members
Since March 3, 2004

Model	*Res (km)*	*Levels*	*Members*	*Cloud Physics*	*Convection*
RSM SAS	**32**	**28**	**Ctl,n,p**	**GFS physics**	**Simple Arak-Shubert**
RSM RAS	**32**	**28**	**n,p**	**GFS physics**	**Relaxed Arak-Shubert**
Eta-BMJ	**32**	**60**	**Ctl,n,p**	**Op Ferrier**	**Betts-Miller-Janic**
Eta-SAT	**32**	**60**	**n,p**	**Op Ferrier**	**BMJ-moist prof**
Eta-KF	**32**	**60**	**Ctl,n,p**	**Op Ferrier**	**Kain-Fritsch**
Eta-KFD	**32**	**60**	**n,p**	**Op Ferrier**	**Kain-Fritsch with enhanced detrainment**

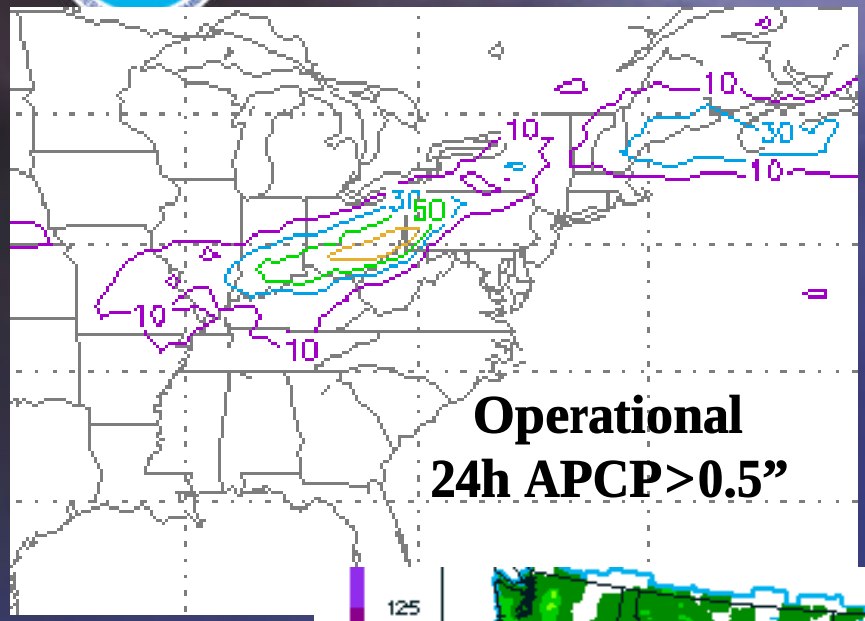
Similar to Fall-Winter 03-04 parallel system except
Removed poorest performing models (for qpf)
and
using scaled breeding

Problems with Initial Parallels

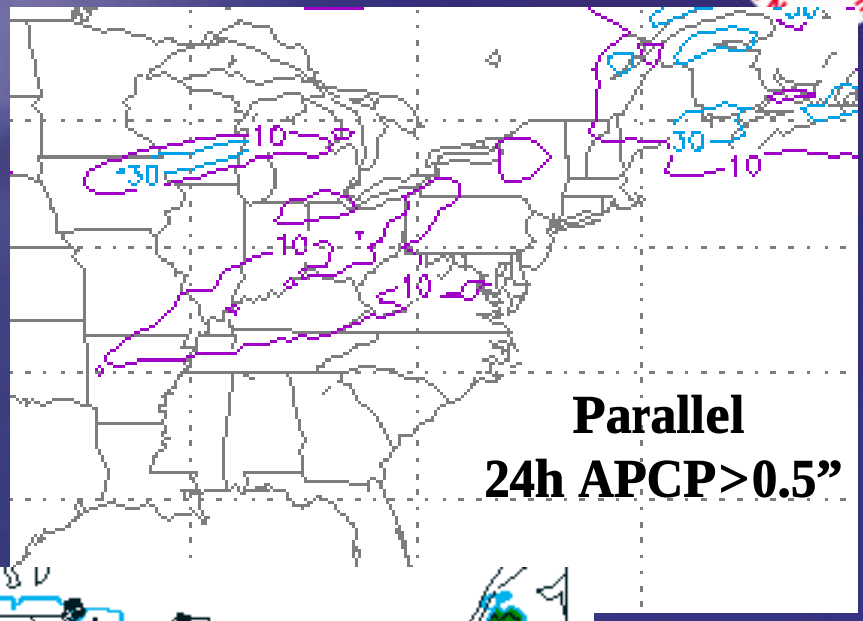
Fall-Winter 2003-2004 Experiments

- **Some members of the SREF physics diversity system performed poorly for cold season convective outbreak (January 2-4, 2004).**
- **Evaluated Jan. 2-4 and Jan. 25-27 strong storms:**
  - **Combination of Breeding & conv. Param physics members too much precip**
  - **IC breeding amplitude too high for some physics members**

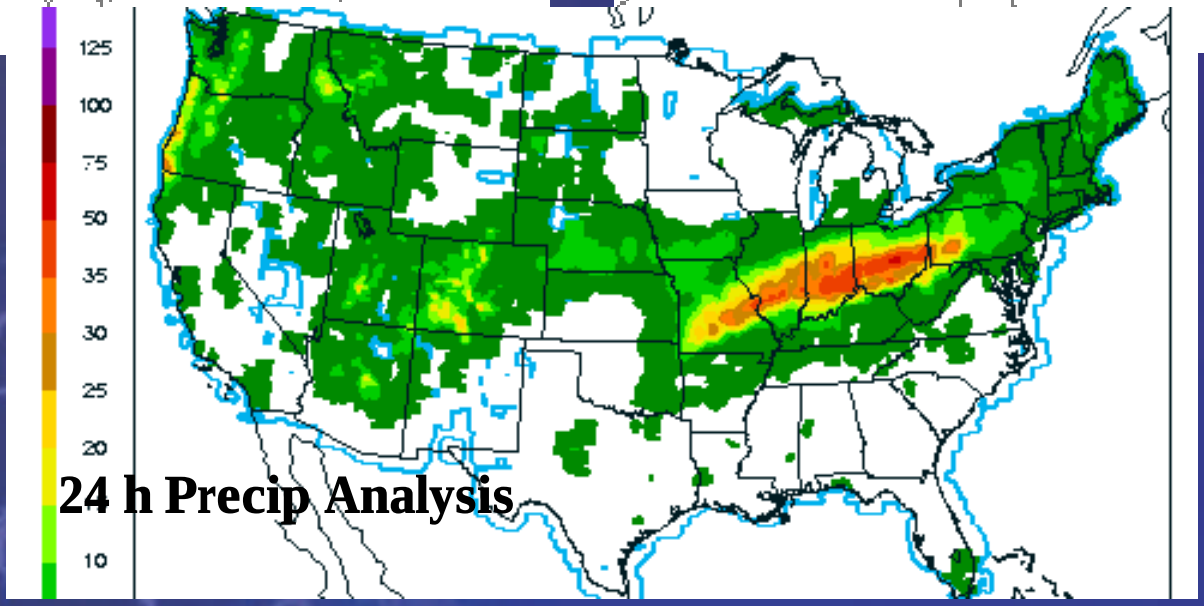
51 h SREF Probability Forecast
Verif: 12Z Jan. 4, 2004



Operational
24h APCP>0.5”



Parallel
24h APCP>0.5”



24 h Precip Analysis

Corrections to Improve Initial System Performance

- **Run reduced physics-diversity system & evaluate Modified SREF system:**
- **Develop and test scaled IC breeding code**
  - ***breeding perturbation using WRF scaled perturbation system. Used average 850 mb T standard deviation (0.5 C) to scale IC perturbations.***
  - ***IC perturbation scale = 0.5/ D***
  - ***Where $D=F_{neg}-F_{pos}$ of the 12 hour domain avg 850 mb T forecast***

Additional Corrections during Parallel Testing

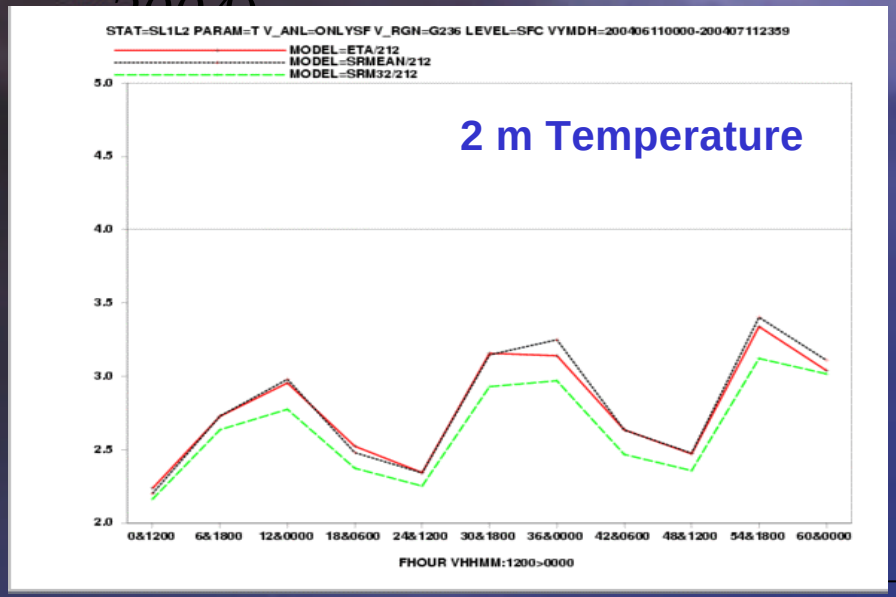
- **RSM winds corrected to true North**
- **Helicity sign error corrected**
- **Reduced saturated profiles in BMJ-SAT members**
- **Reduced detrainment in KF-DET members**

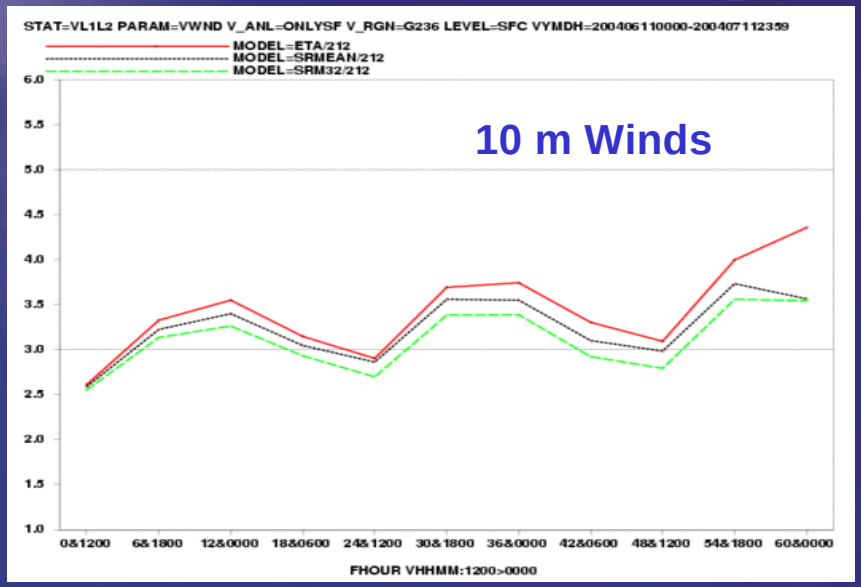
Dissemination

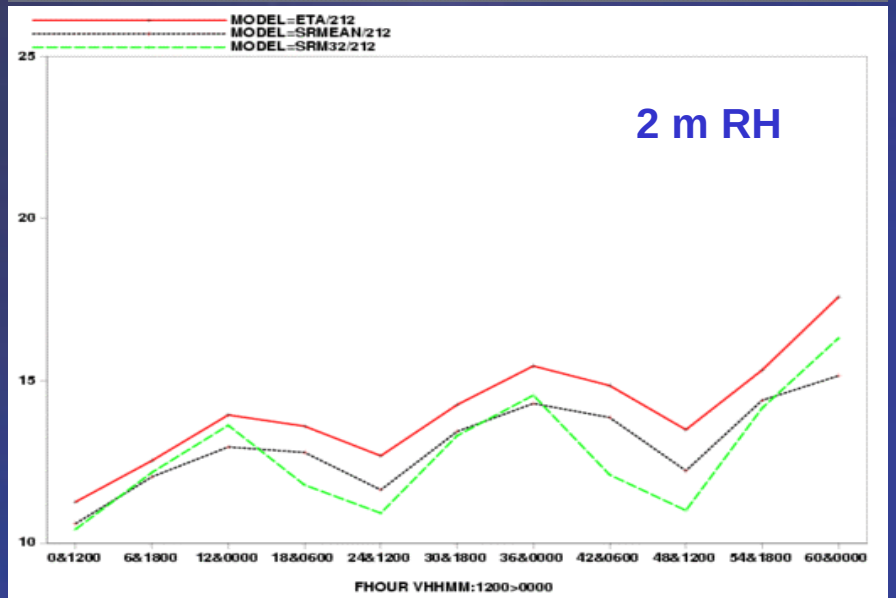
- **Mean, spread, probability files on NCO FTP**
- **EMC web graphics**
  - ***Mean, spread, probs, Individual members, profiles,***
- **SPC Convective probabilistic products**
- **Mean, spread plots are being added to NCO web page**
- **AWIPS: Scheduled for OB6 (April 2005)**

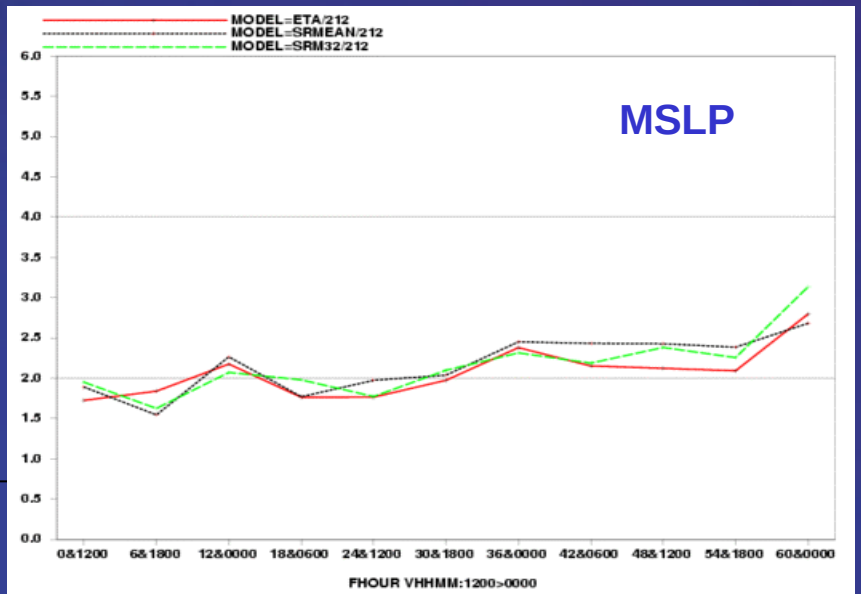
SREF Deterministic Results

Surface CONUS RMSE by Forecast hr (June 12-July 11, 2004)



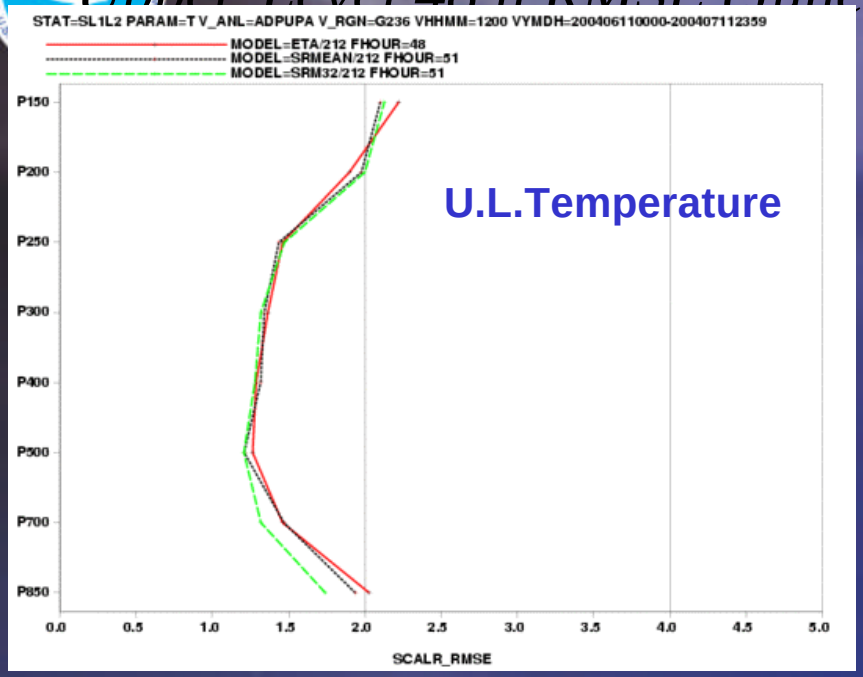


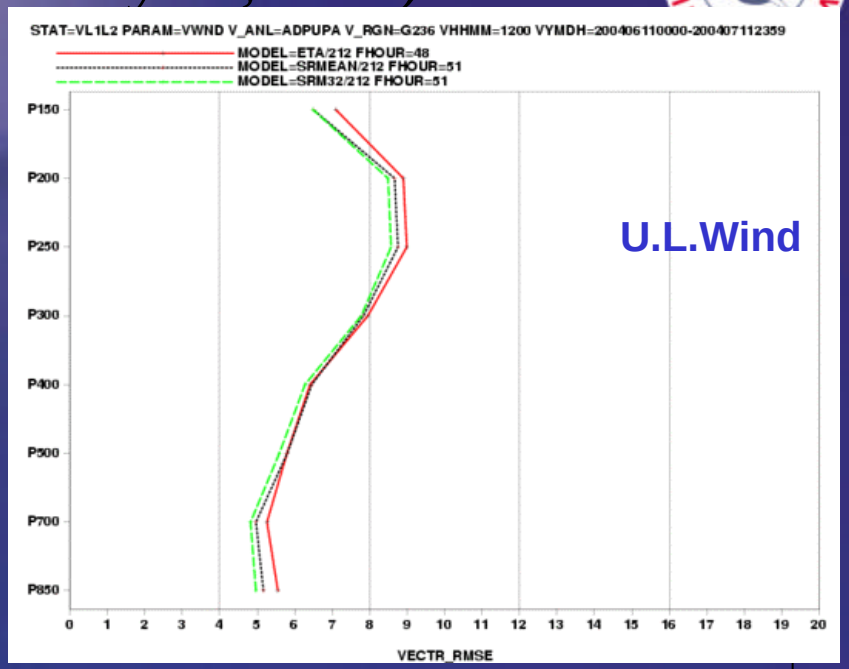


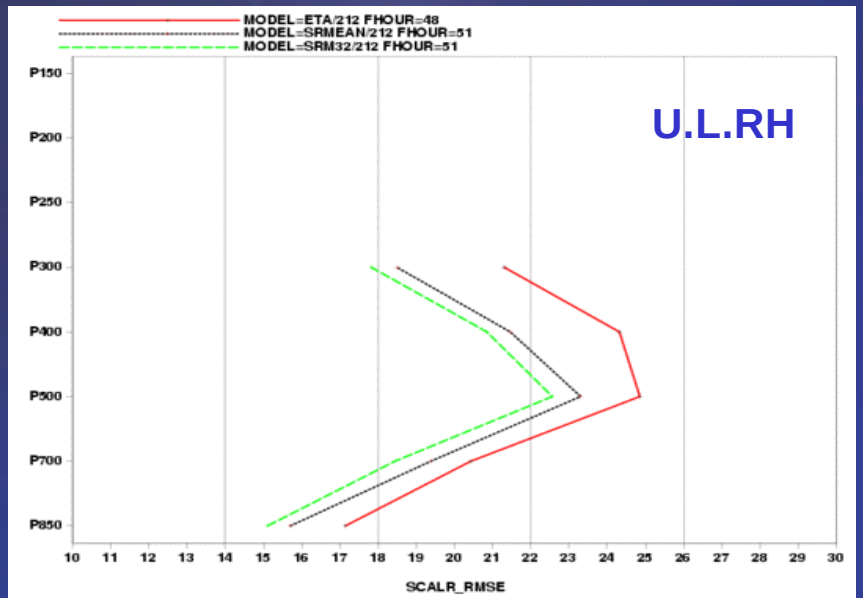


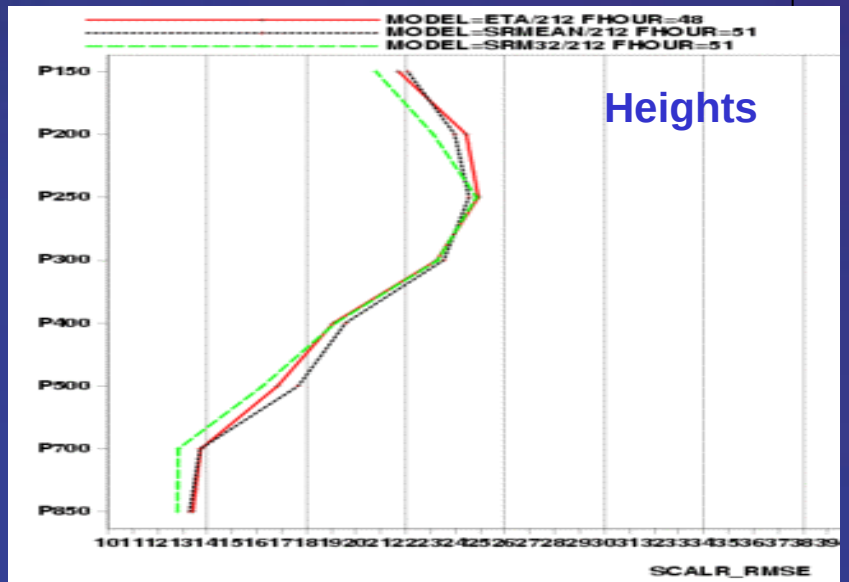
SREF Deterministic Results

Upper-Level 48 h RMSE (June 12-July 11, 2004)



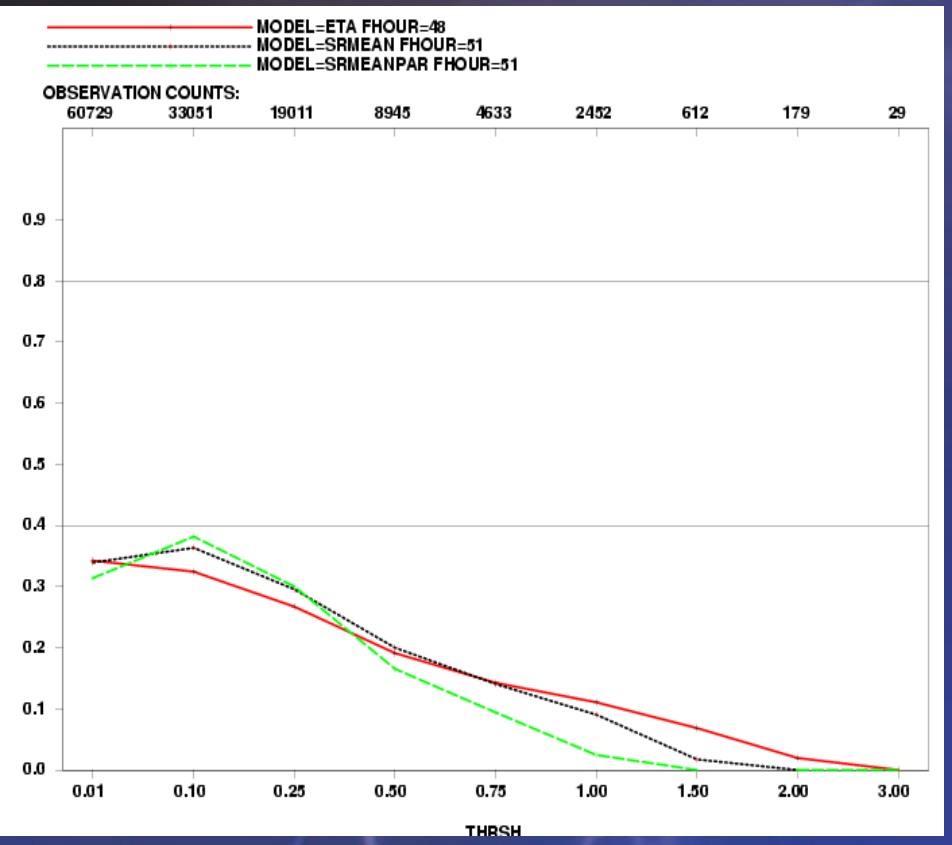




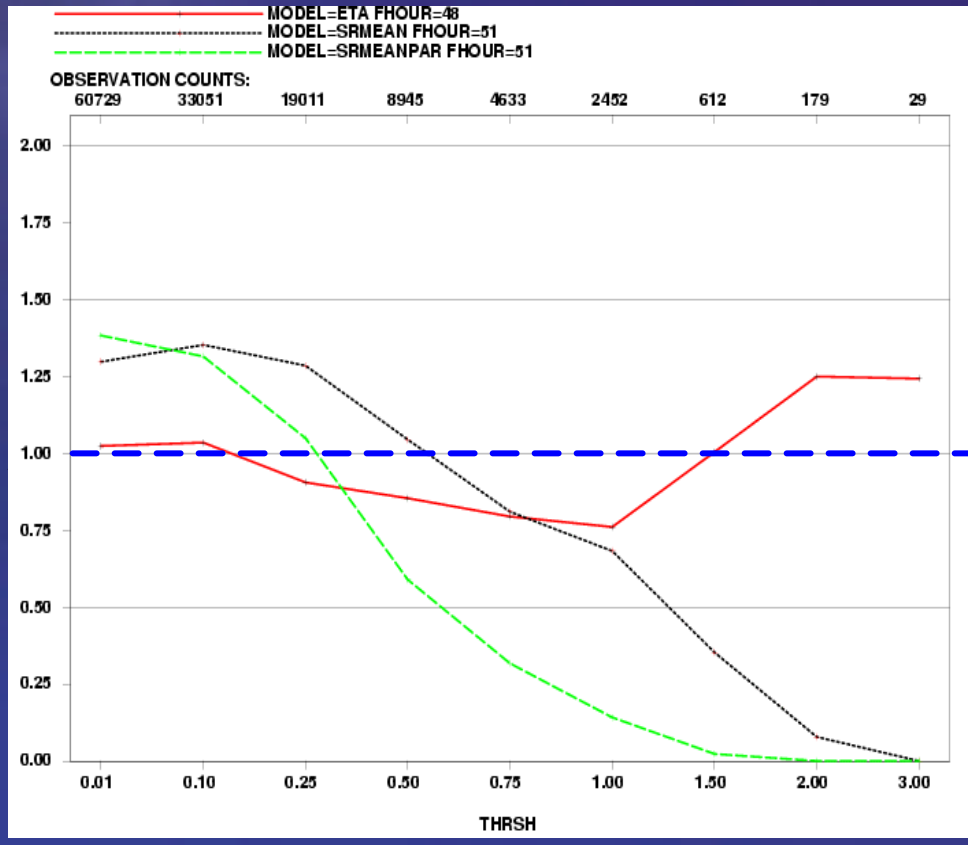


SREF Deterministic Results

48 h Precipitation Scores (June 12-July 11, 2004)



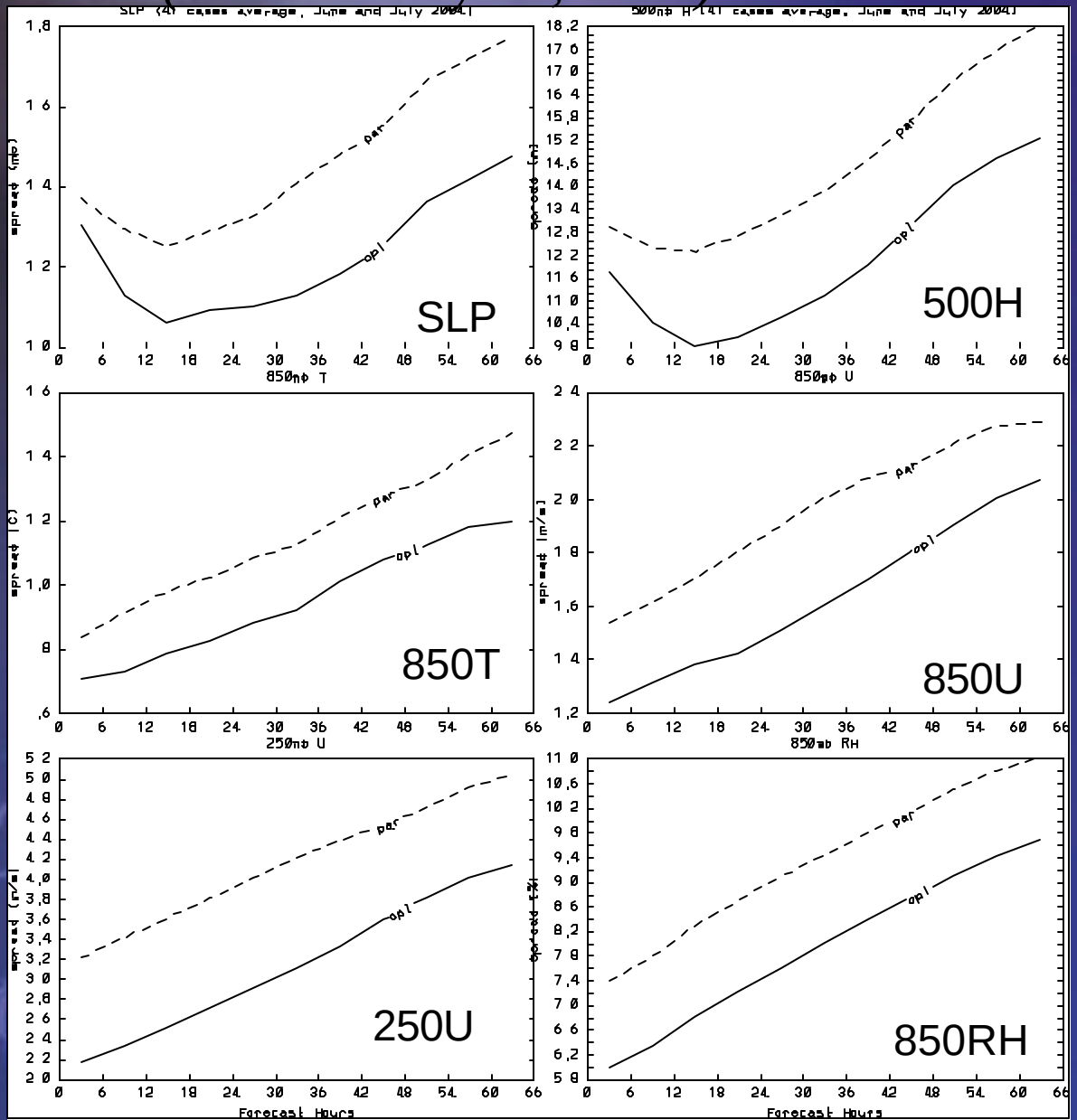
RMSE



Bias

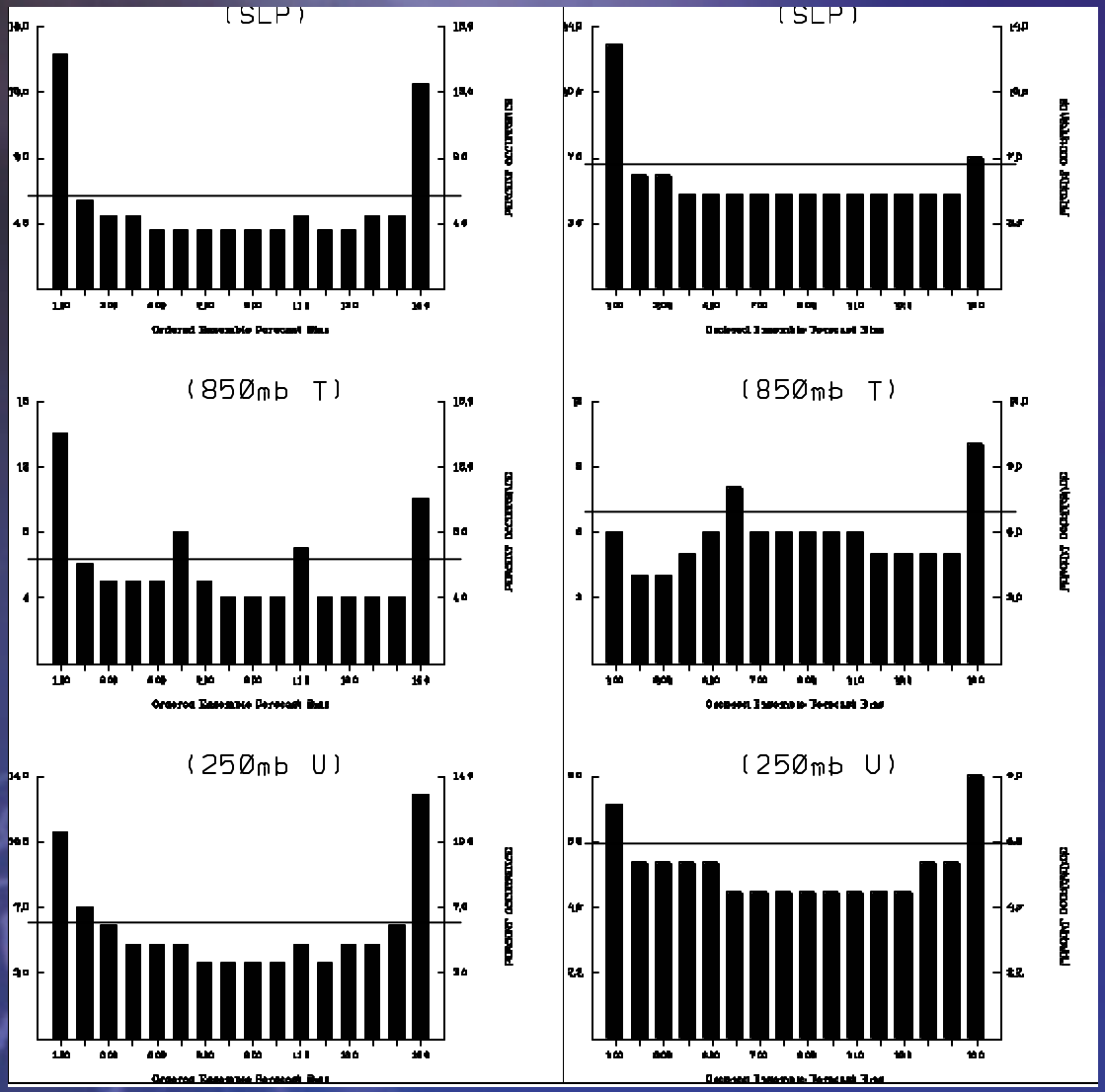
SREF Probabilistic Results

Spread Plots (June 12-July 11, 2004)



SREF Probabilistic Results

Ranked Histograms 63 h forecasts (June 12-July 11, 2004)

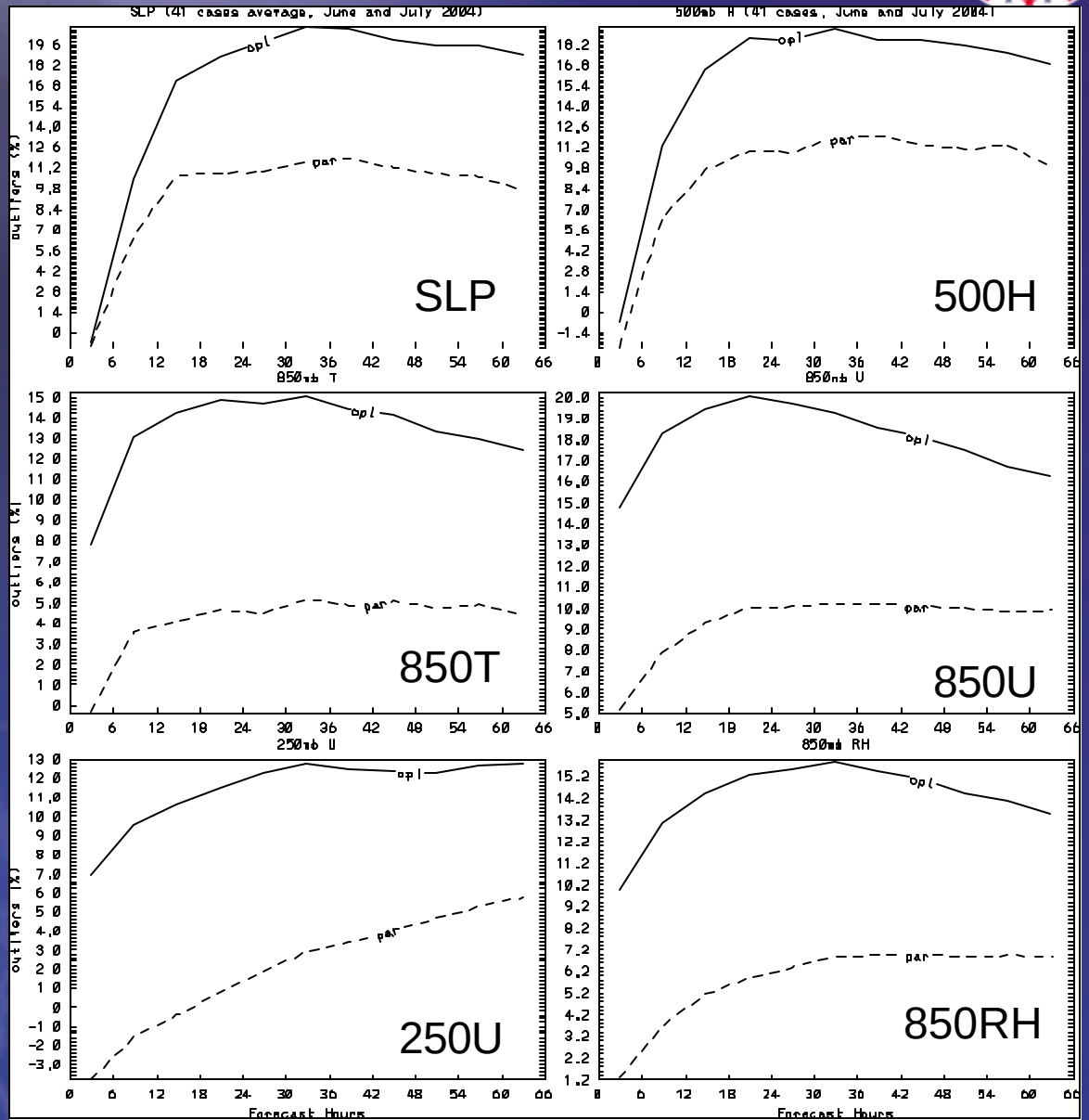


Operational **Experimental**

SREF Probabilistic Results

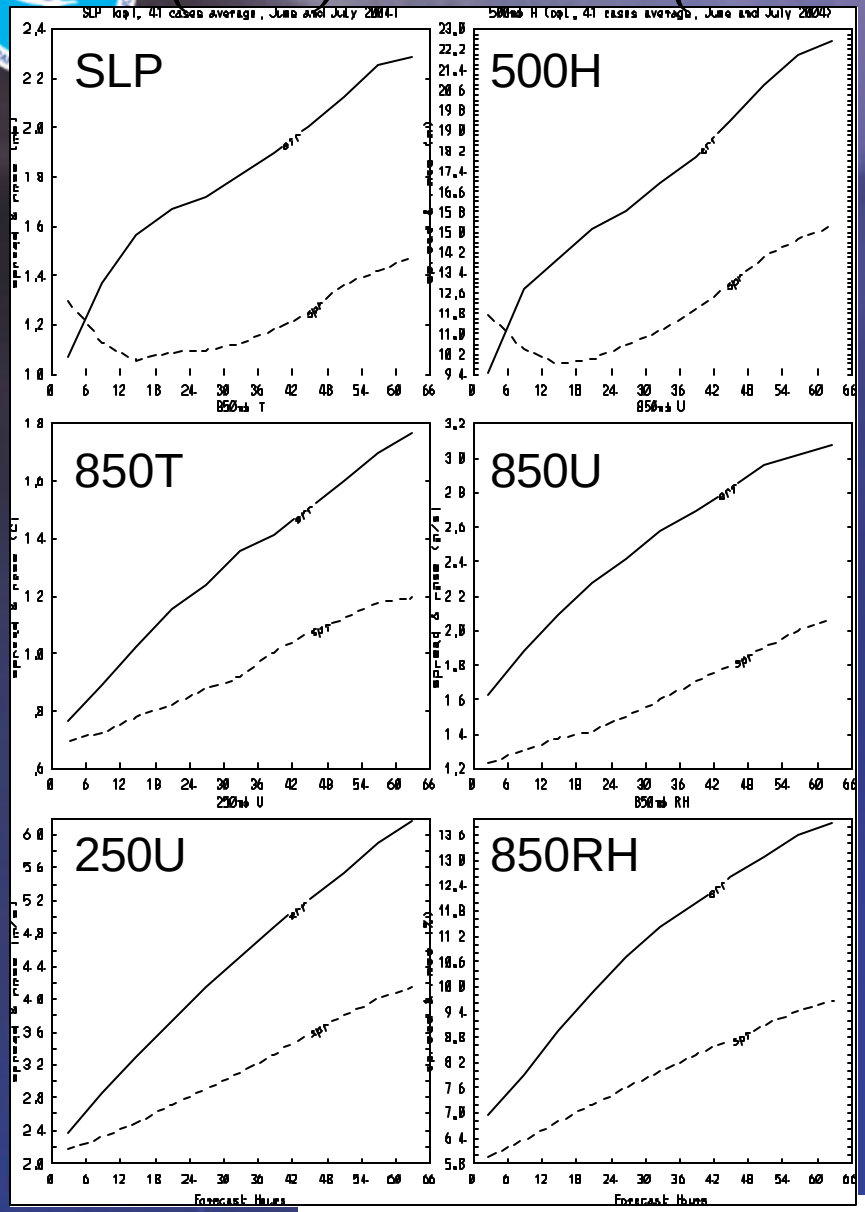
Outlier Plots (June 12-July 11, 2004)

Increased system spread for experimental physics based ensemble-→ less forecasts in outlier **bins**

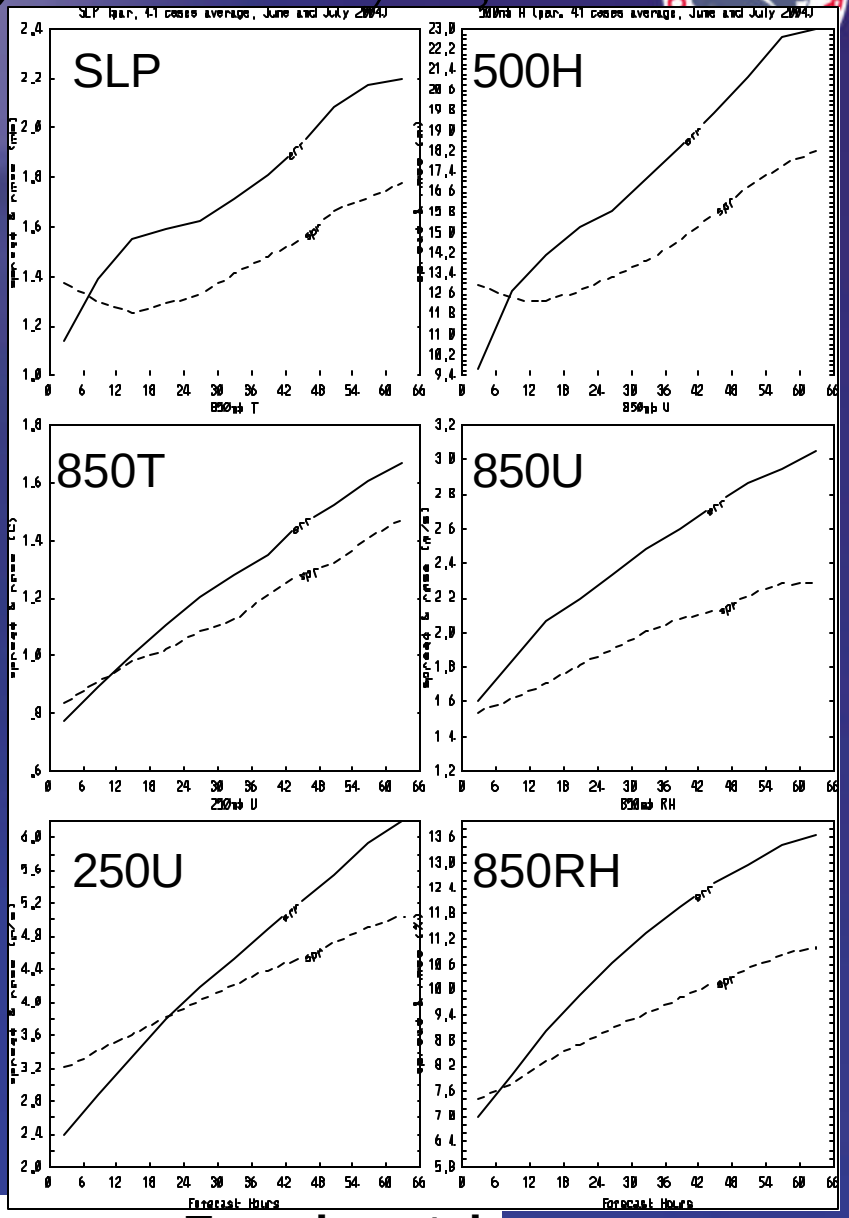


SREF Probabilistic Results

MSE(solid) vs Variance (dashed) - June 12-July 11, 2004



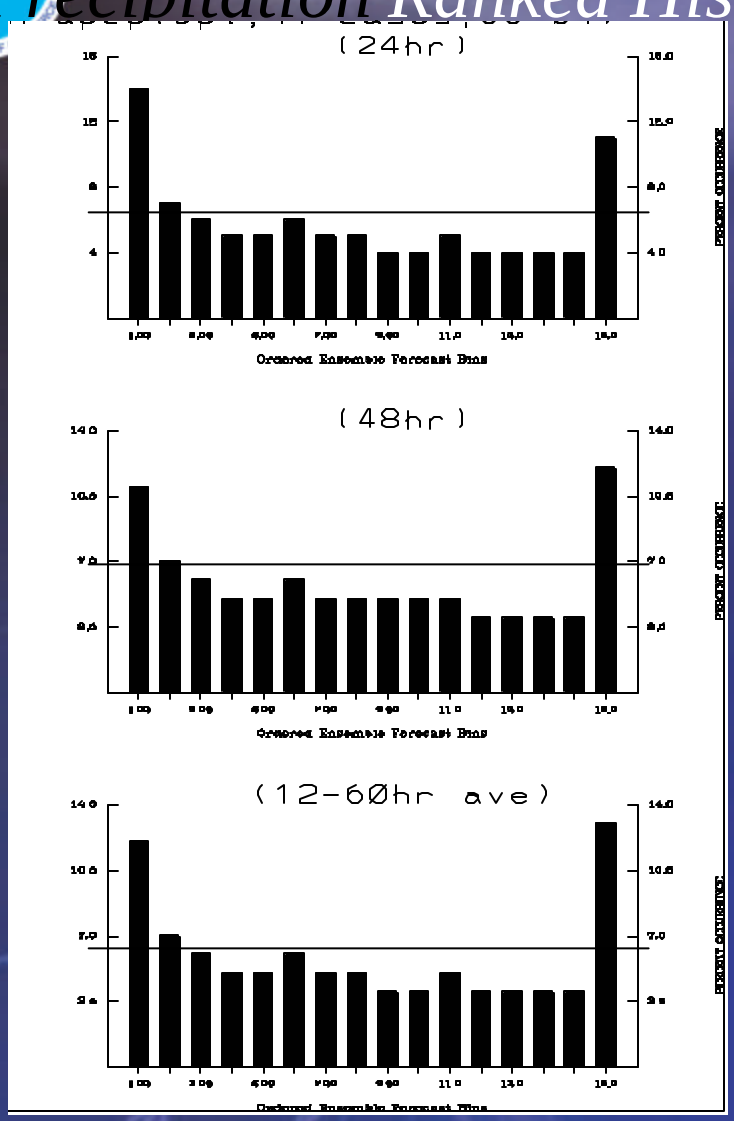
Operational

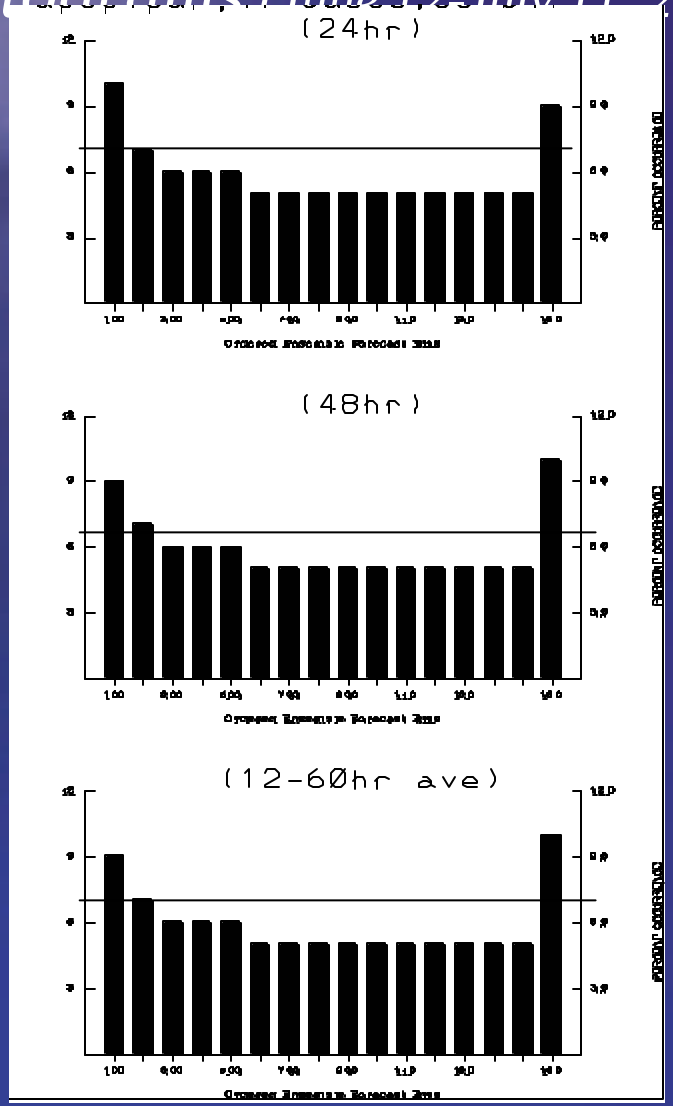


Experimental

SREF Probabilistic Results

Precipitation Ranked Histograms (June 12-July 11, 2004)

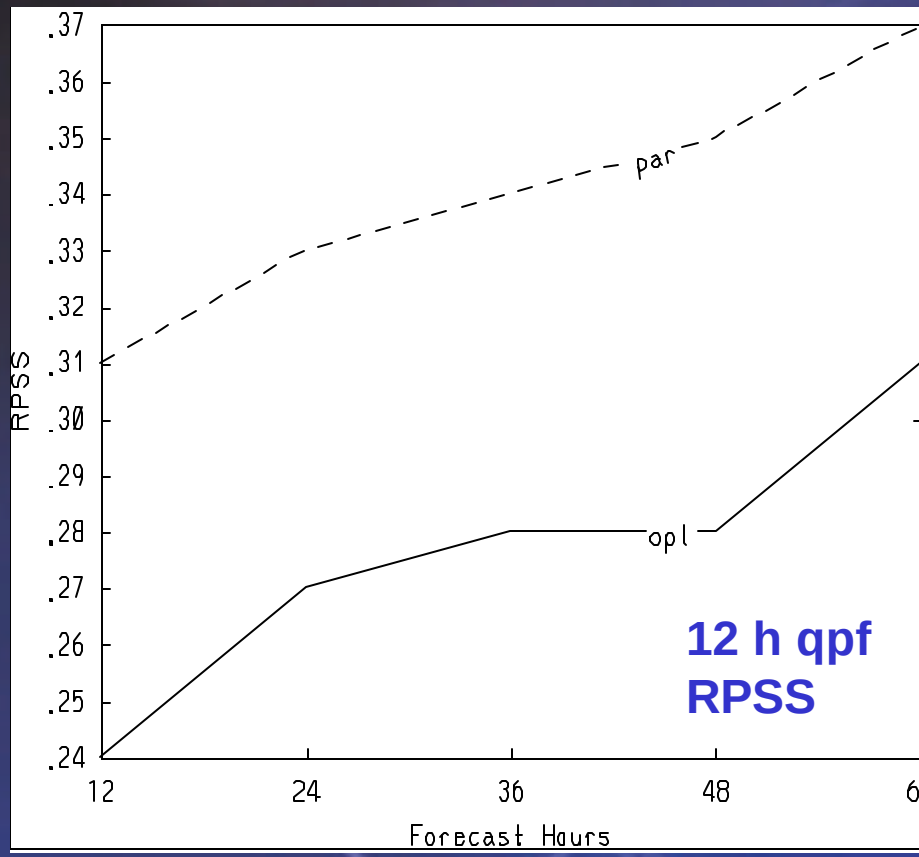


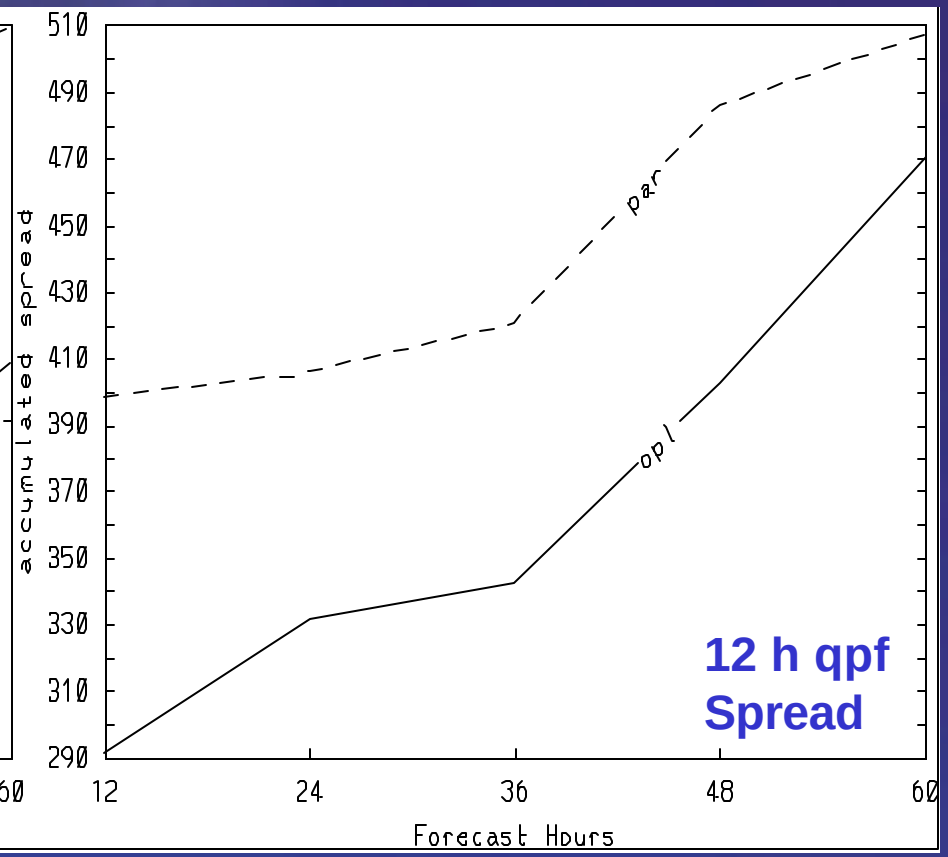


Operational **Experimental**

SREF Probabilistic Results

12h Precipitation- 0.1" threshold (June 12-July 11, 2004)

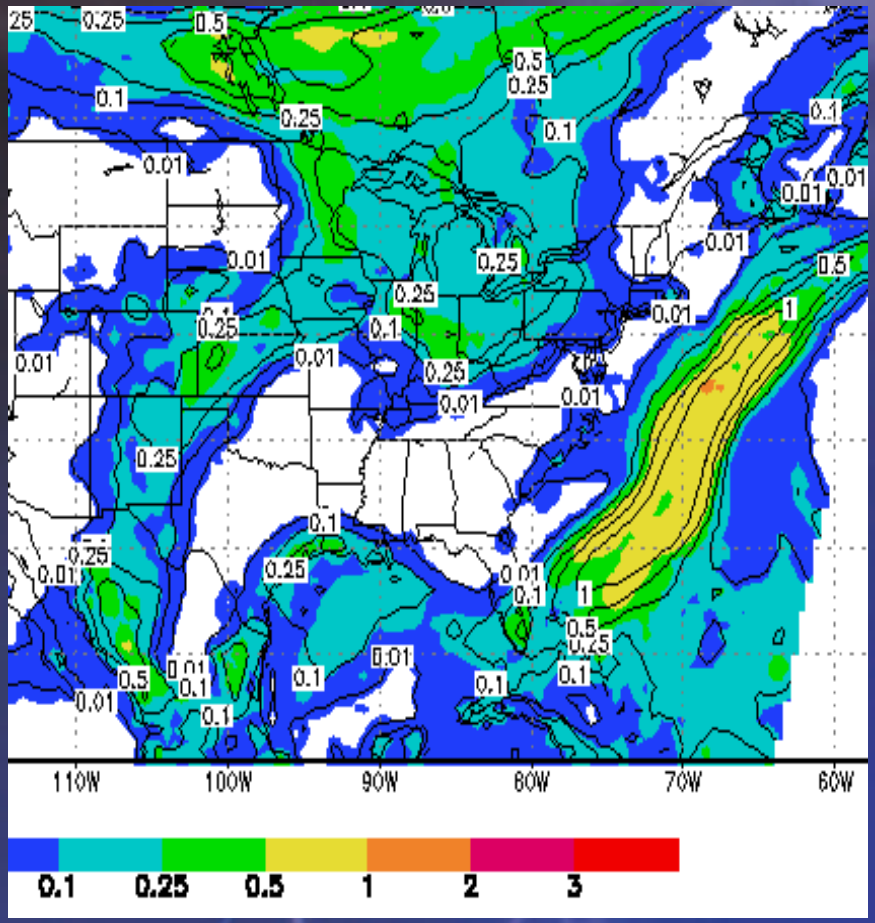




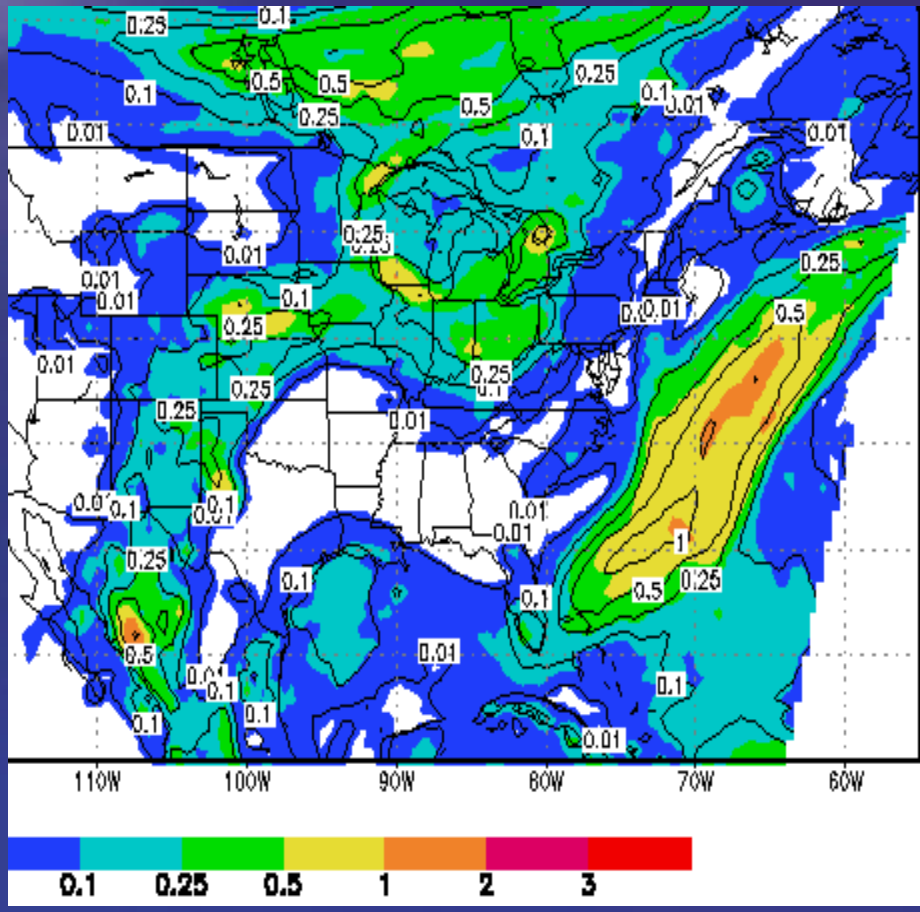
SREF Warm Season Case Study

July 22, 2004 09 Z Forecast (51h Forecast)

Operational



Experimental



Precipitation Spread (inches)

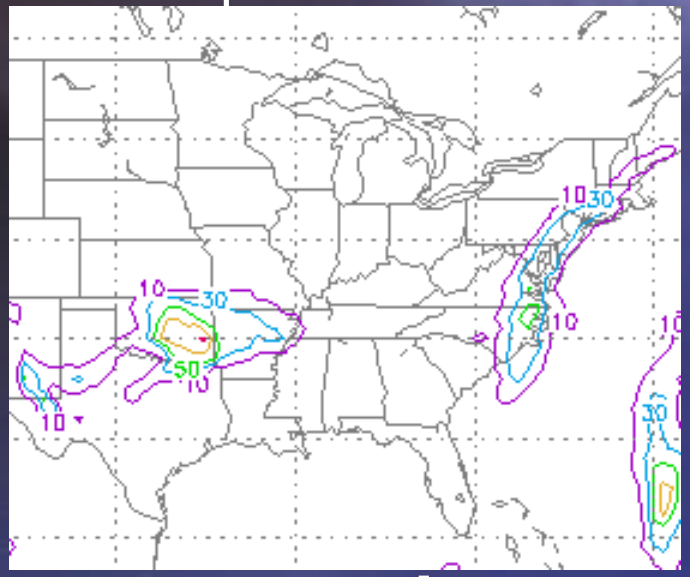
Increased spread in Enhanced physics-Diversity system

SREF Warm Season Case Study

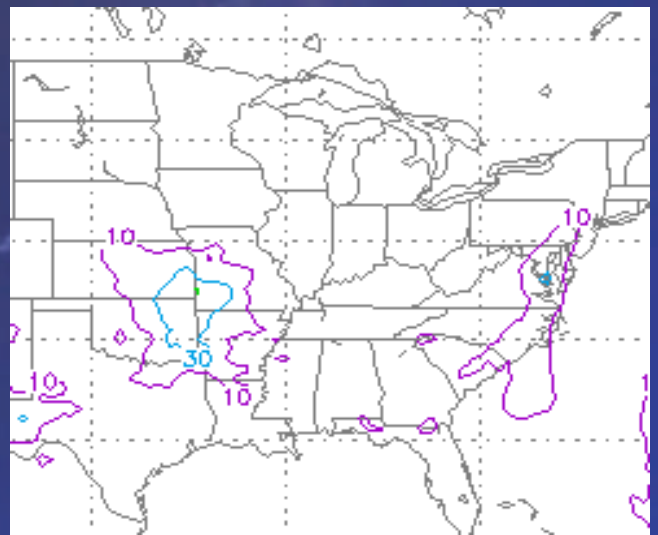
July 22, 2004 09 Z Forecast (51h Forecast)

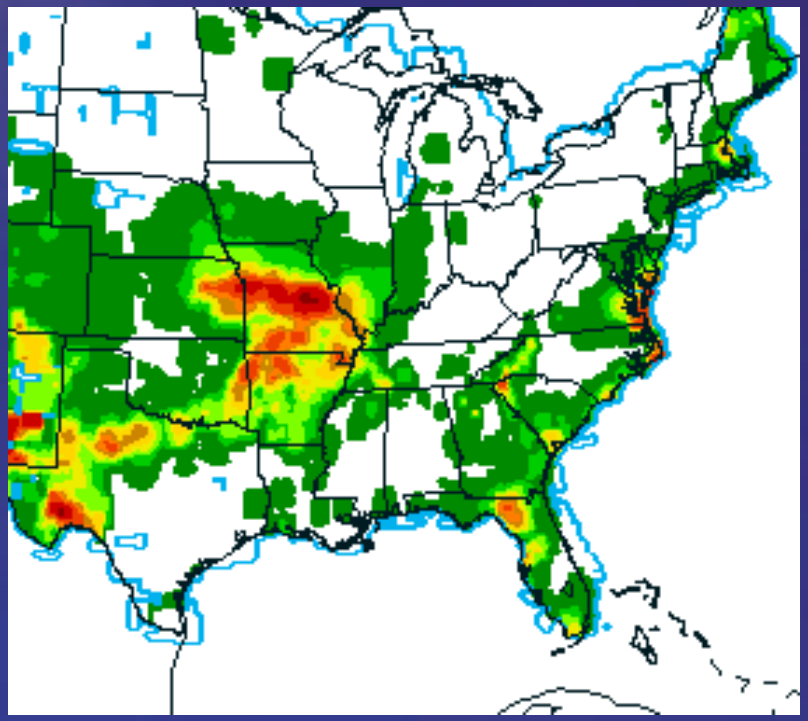
Prob. Precip>1" in 48 h

Operational



Experimental

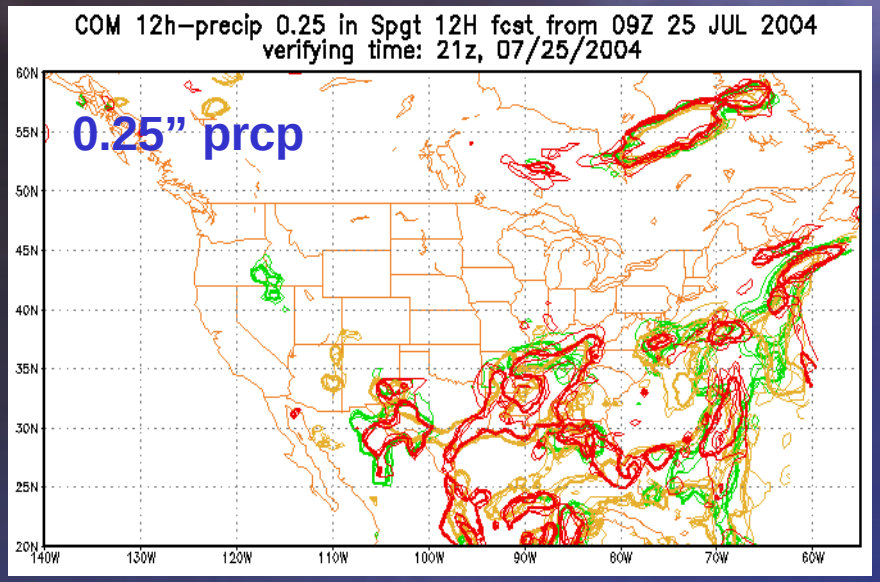


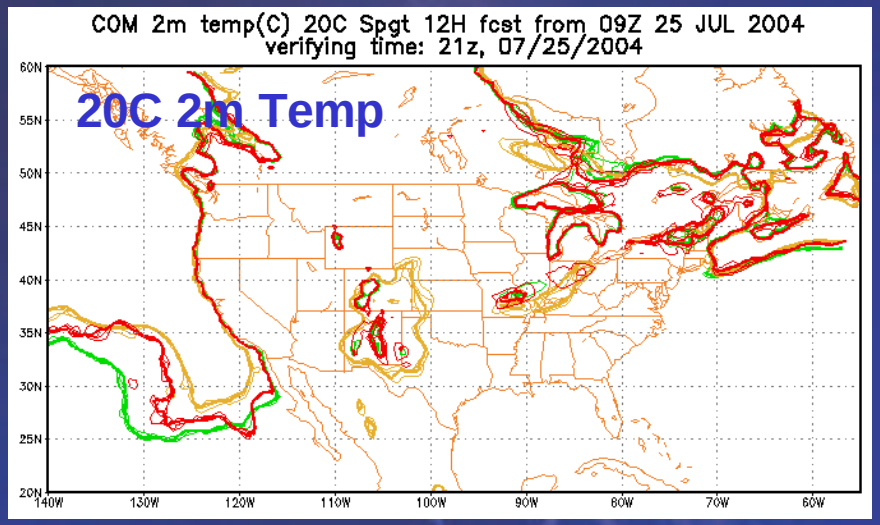


SREF Warm Season Case Study

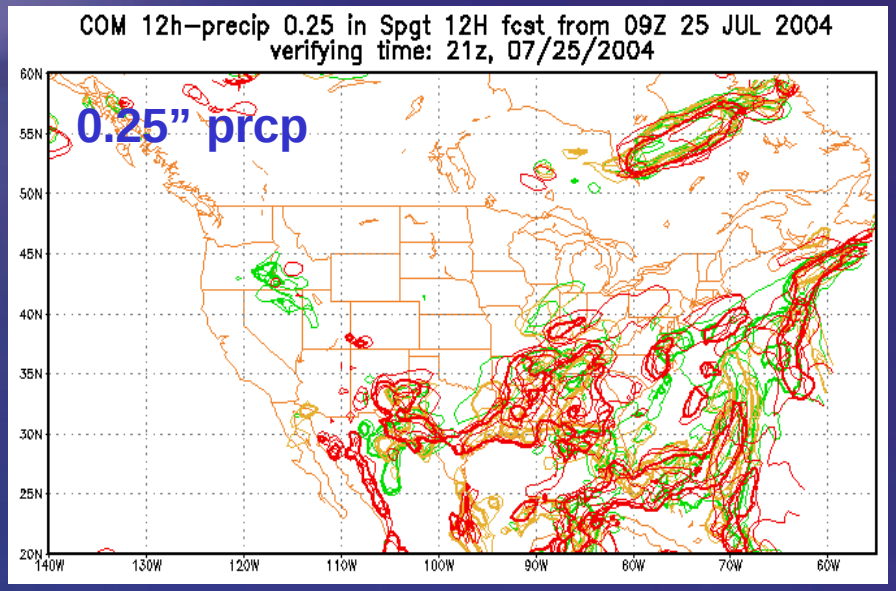
July 25, 2004 09 Z Run (12 h forecast)

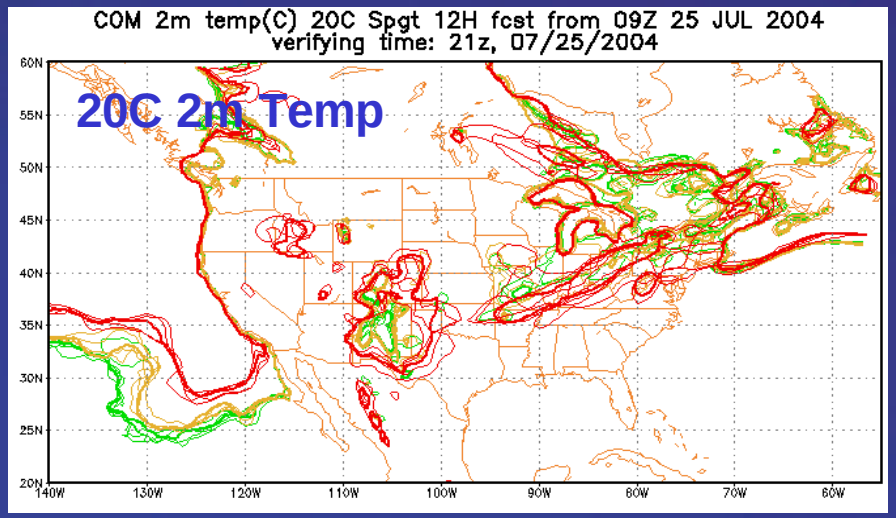
Operational





Experimental

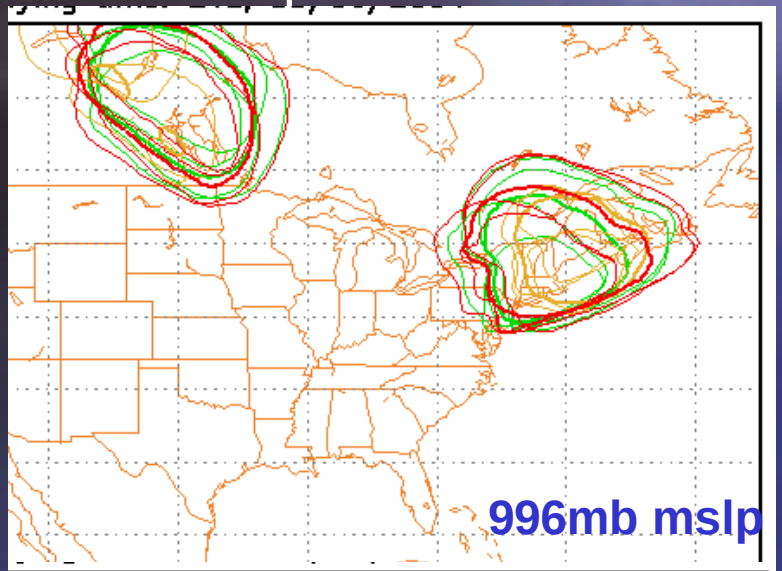


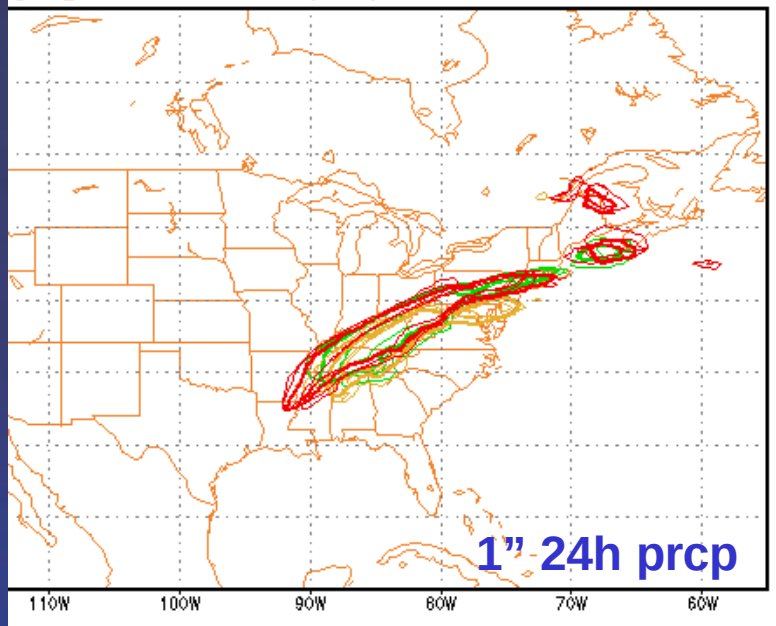


SREF Cold Season Case Study

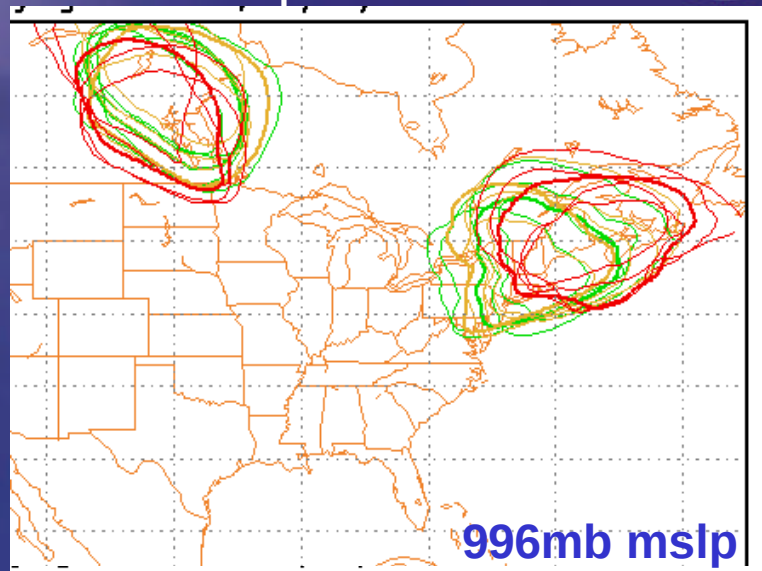
March 5, 2004 09 Z Simulation: 36h forecast

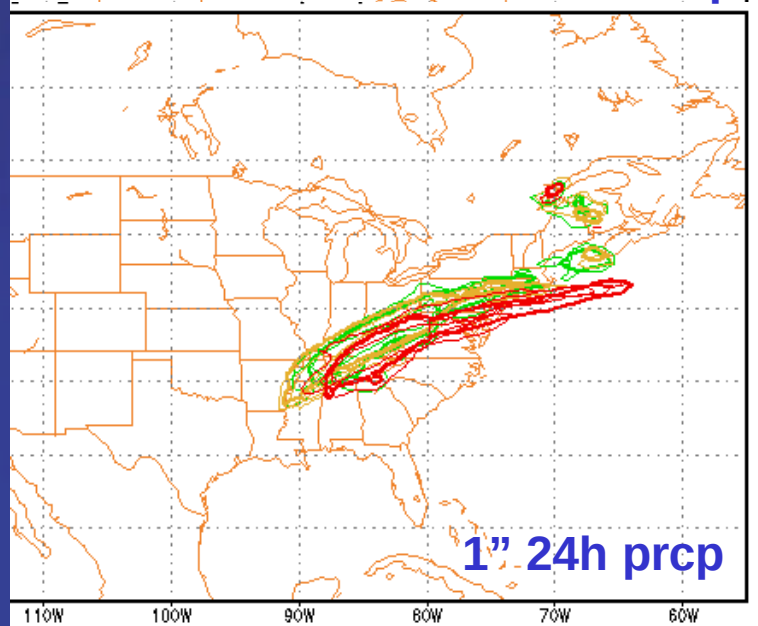
Operational





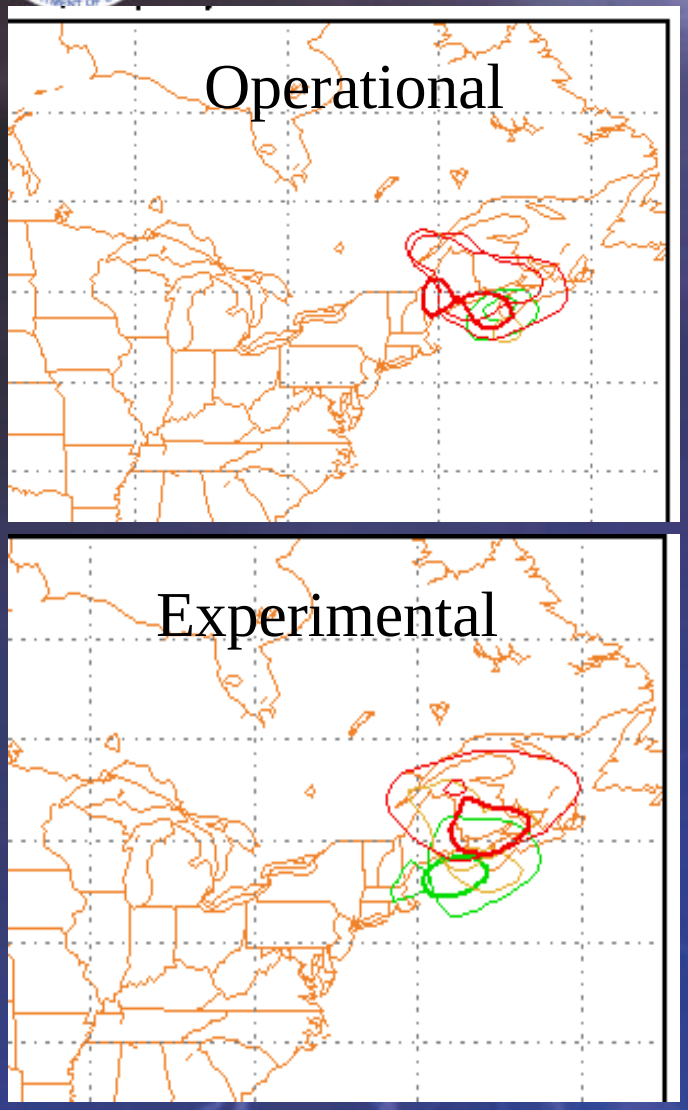
Experimental



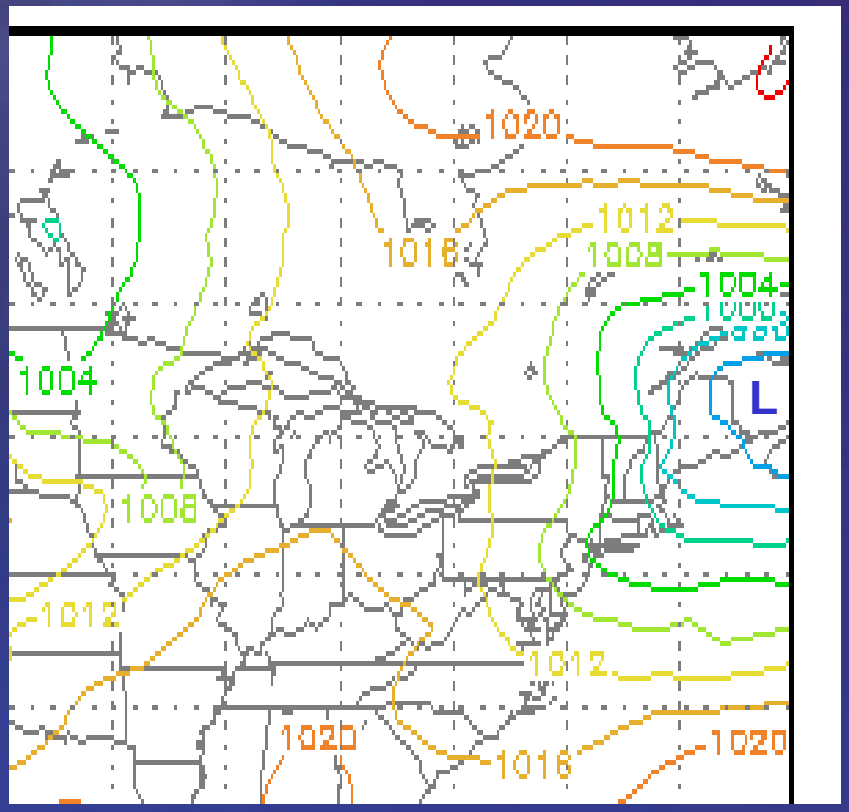


SREF Cold Season Case Study

March 5, 2004 09Z Simulation 39 h Forecast



988 mb Spaghetti Chart



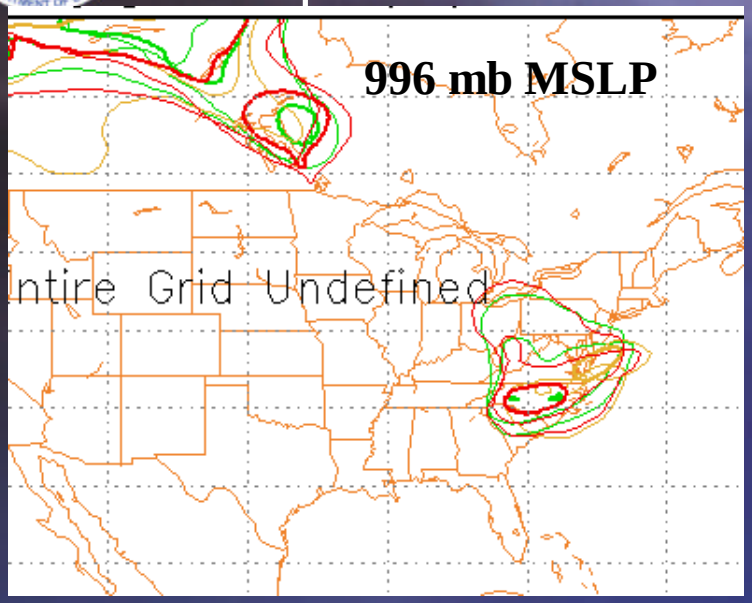
Analysis: March 7, 2004
00 UTC

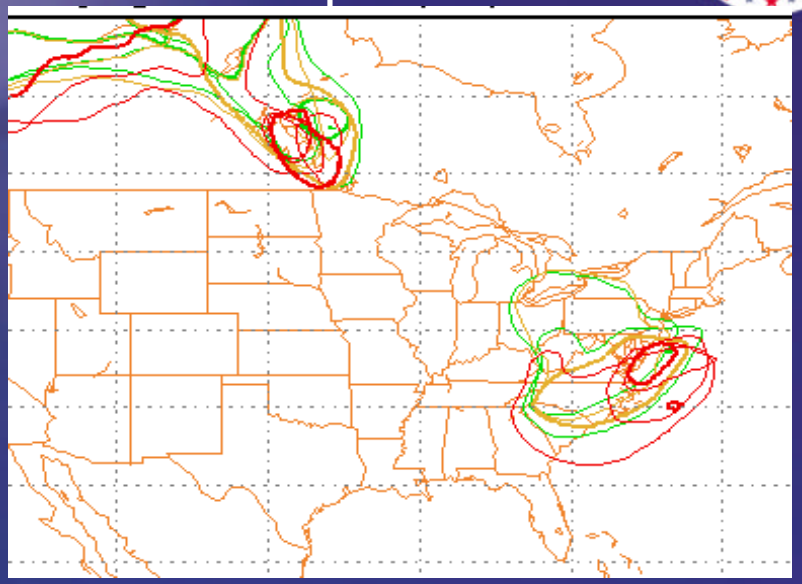
SREF Cold Season Case Study

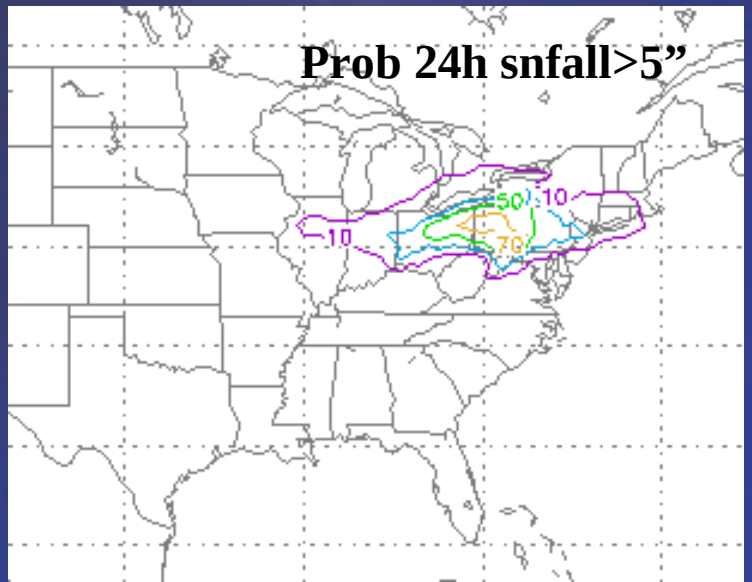
March 16, 2004 09Z Simulation (39h Forecast)

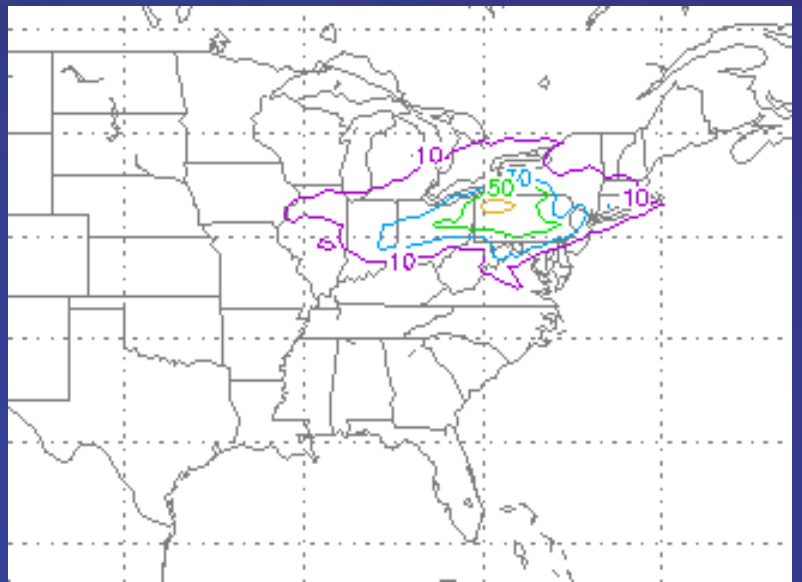
Operational

Experimental



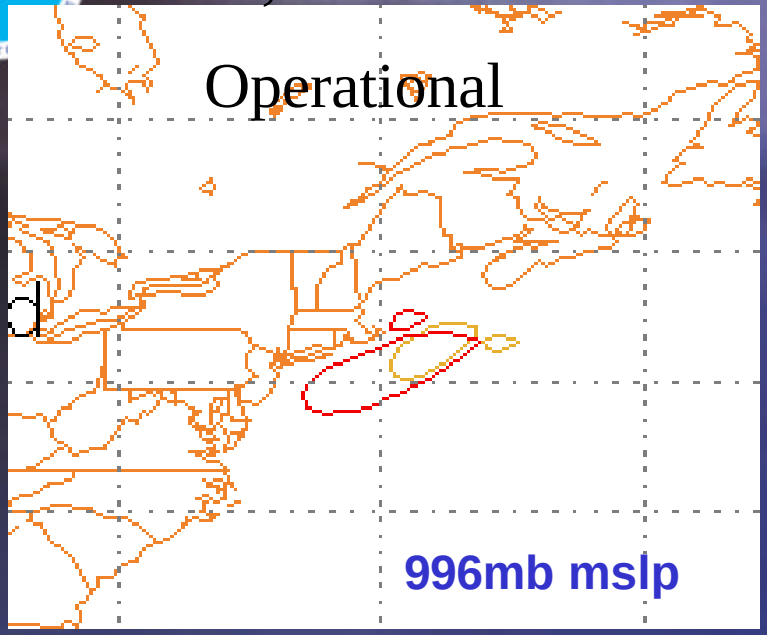


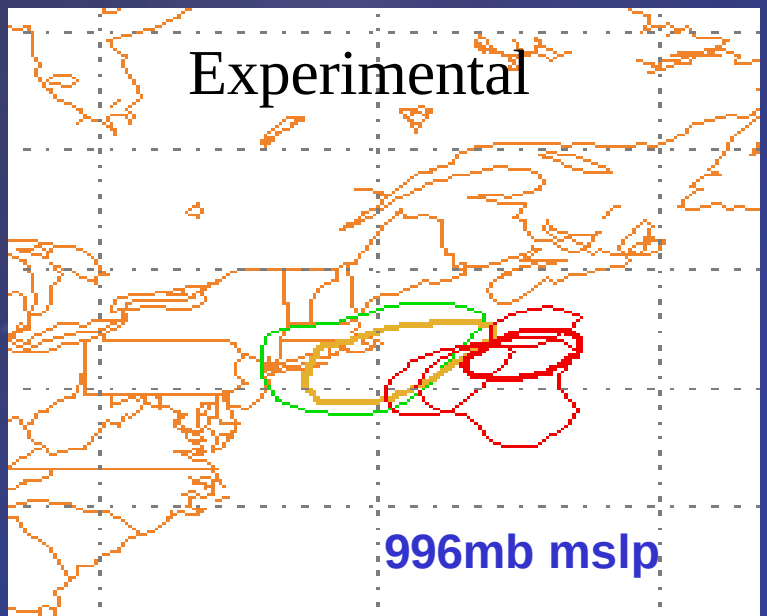


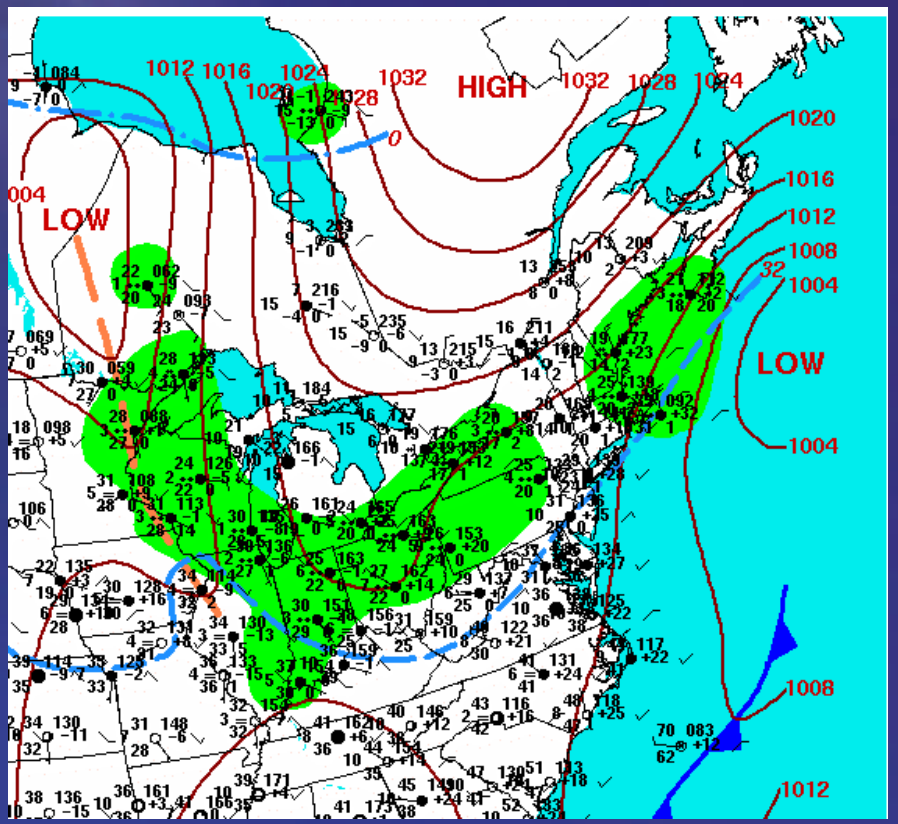


SREF Cold Season Case Study

March 16, 2004 09Z Simulation 51 h Forecast







Analysis: March 17, 2004
12 UTC

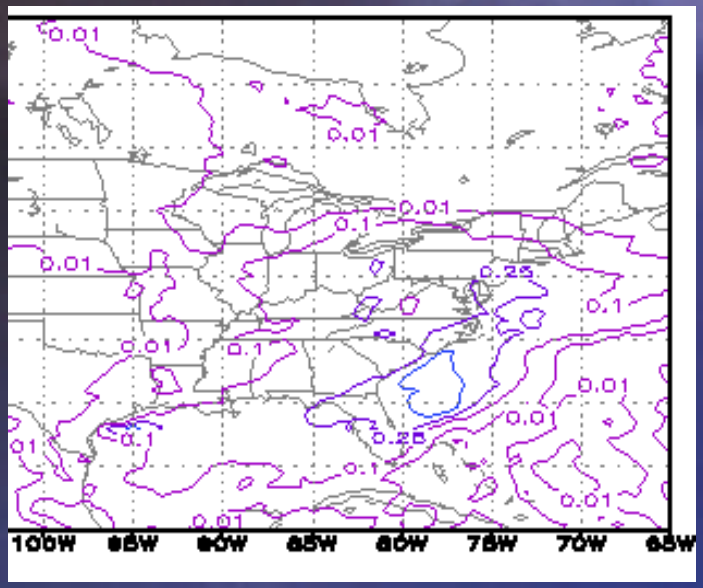
SREF Cold Season Case Study

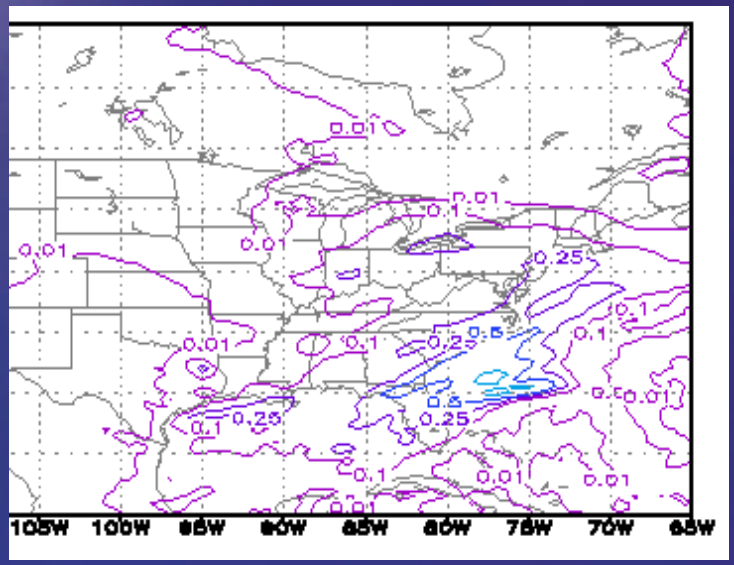
March 17, 2004 21 Z Forecast (36h Forecast)

Operational

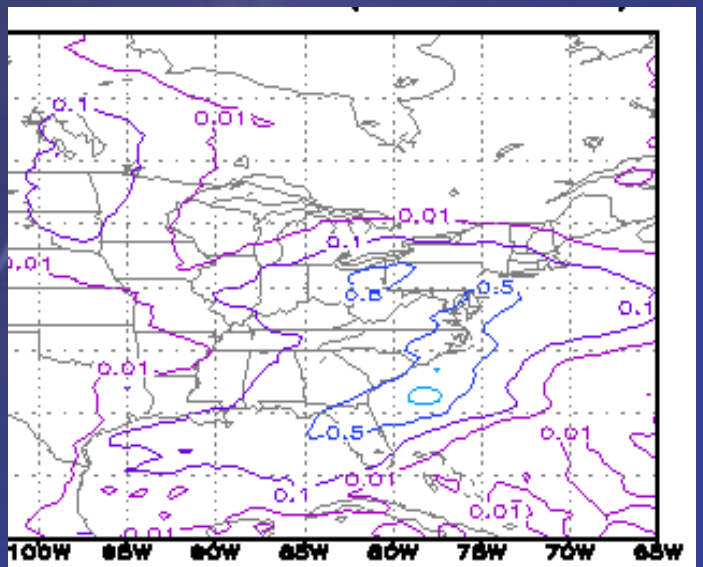
Experimental

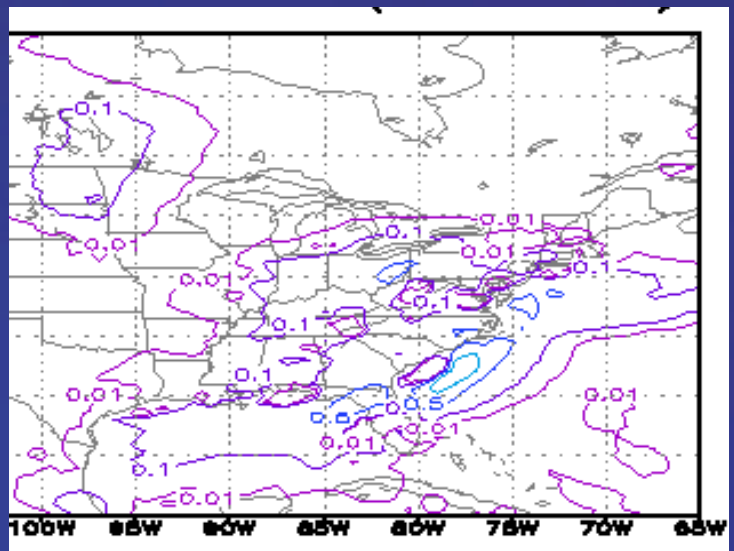
Precipitation Spread (inches)





Precipitation Error





Subjective Evaluation

- **AWC:**
  - *Performance improved, recommend implementation*
- **HPC:**
  - *Reduced clustering around parent model, increased diversity*
  - *Ensemble mean qpf is too noisy*
  - *Neutral, would have preferred more cold season cases*
- **SPC:**
  - *Improved physics diversity, reduced clustering*
  - *System spread and accuracy improvement quite impressive*
  - *Some members perform poorly for qpf*
  - *Recommend implementation*
- **TPC & OPC**
  - *SREF not used regularly*

Summary

- **Deterministic results generally positive:**
  - ***Significant reduction of lower troposphere errors***
  - ***Some degradation of mean qpf biases***

- **Increased physics diversity & resolution and scaled breeding improves system spread**
  - ***Improved Diversity***
    - **Strongest impact on sensible wx and in Warm Season**
  - ***Additional scenarios captured***
  - ***Initial Condition perturbations capture synoptic scale uncertainties well***
- **Scaled breeding controls unrealistic system spread**

Planned Upgrades

Winter 2005

- Add RSM BUFR files
- Common WRF post-processor
- Implement ensemble mean BUFR files
- 4x/day runs
- Improved and new products (Convective, Aviation, Energy)
- Alaska output (AWIPS 216)
- Grid Based Bias Correction
- Probabilistic FVS verification
- Confidence Factors (RMOP)
- 5-6 WRF members ?

BACKUPS

Developing New Tools

- **Advanced SREF Visualizations**
  - ***Used NCEP's 48-km SREF ensemble to calculate probability of occurrence for key Severe Wx parameters:***
    - **Wind Shear > 40 kts in column**
    - **CAPE > 1000 Joules/kg**
    - **Convective rain > 0.01 inch**
  - ***Multiply probabilities to form a combination probability product***

Recommendations

- **EMC Recommends Implementation of SREF-32 Upgrade Package**

- **Continue cross-center collaboration on QPF Prob. Matching techniques led by SPC**

AWIPS Dissemination

FY05 : AWIPS OB 6

- Basic mean, spread fields

FY06:

- Probabilities, higher resolution

SREF

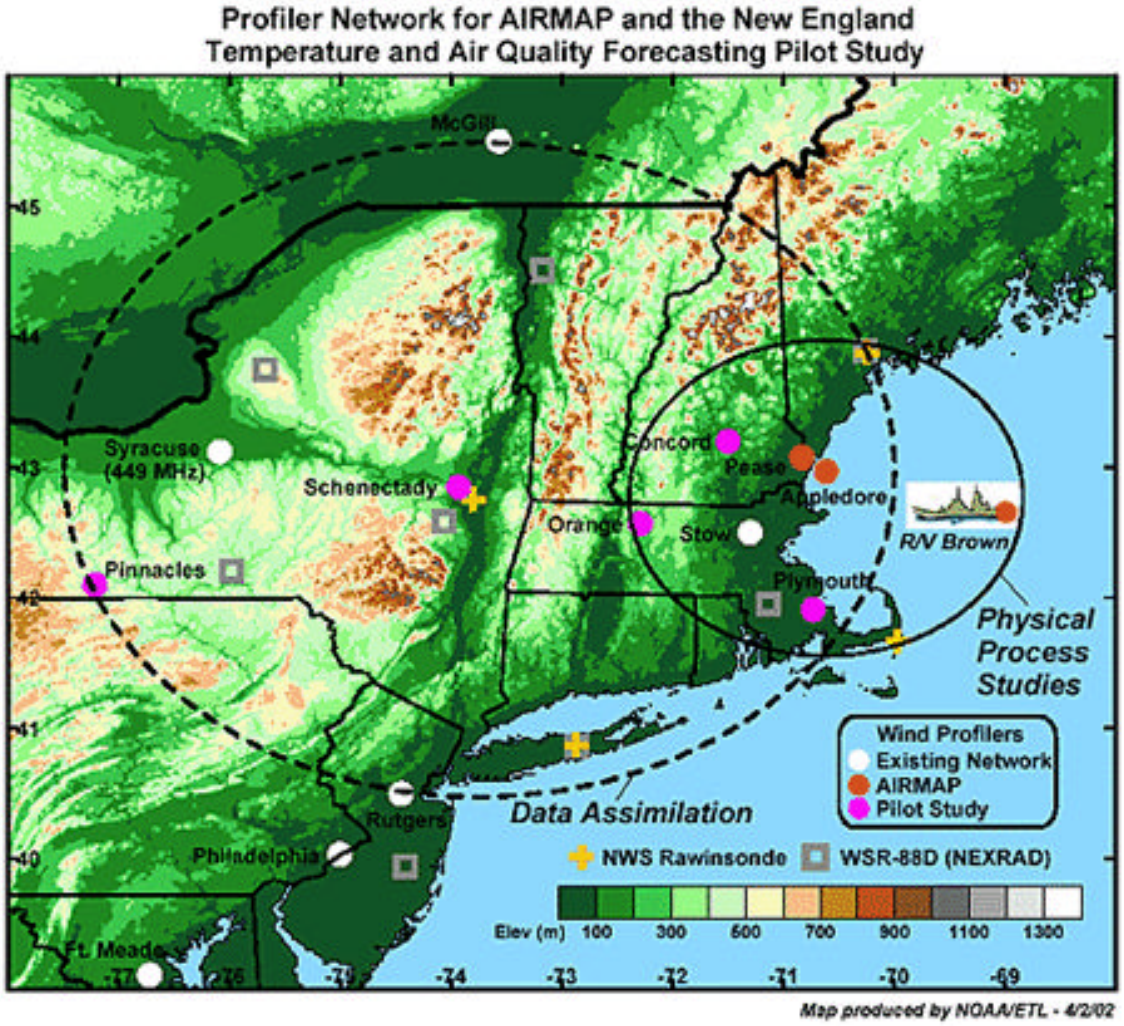
Additional Fields in individual member Post

Eta Fields	*RSM Fields*
best CAPE	best CAPE
convective cloud cover	20 new pressure levels (40 total)
non-convective cloud	dewpoint temperature all pressure levels
cloud bottom height (ceiling)	2m dewpoint temperature
cloud bottom pressure (ceiling)	storm relative helicity
cloud top height	storm motion
cloud top pressure	storm motion U component
cloud top temperature	storm motion V component
maximum wind level height	
maximum wind level pressure	
maximum wind level U component	
maximum wind level V component	
tropopause height	

HRW & NA Cycles Transition to WRF

- **FY04 : two member HRW-WRF-8**
- **FY06: North American WRF Run**
- **FY07:**
  - **Multi-member North American Run (~ 7 km)**
  - **SREF: Coarser resolution (~20 km) multi-core, physics, initialization system**

North East High Res.Temperature Program (NEHRT)



Future Implementation SREF transition to WRF

Spring 2005:

- 3 WRF-MASS-NCAR (Ctl, P, N) – replace EKF
- 2 WRF-NMM-NCAR (P,N) – replace EKF
- Confidence factors

Fall 2005:

- 2 WRF-MASS-NCEP (P,N) – replace EBMJ
- 3 WRF-NMM-NCEP (Ctl, P,N) – replace EBMJ
- Improved Post-processing/Calibration

2006…

- LSM/PBL perturbations (Zo,moisture, alb)
- GDAS-ETA/WRF members
- Advanced IC perturbations (ETKF…)

Short Range Ensemble Forecast (SREF) System

Energy Project

Domain and resolution

- *Domain is full North American continent*
- *Horizontal Resolution is 32 km*
- *Eta Vertical resolution increased to 60*
- *Forecast range was 63 hours at 6 and 18 Z*
- *Lateral boundary conditions from 6-hr old medium range ensemble system*
- *July 1-Sept. 1, 2003*