

# February 2012 Upgrade of the NCEP Global Ensemble Forecast System (NAEFS)

Yuejian Zhu

EMC ensemble team

February 8 2012

# Contribution

- Main contributors
  - Dingchen Hou (task lead)
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  - Mozheng Wei
  - Jessie Ma
  - Bo Cui
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  - Shrinivas Moorthi
  - Julia Zhu
- Acknowledgements
  - Weiyu Yang
  - Malaquias Pena
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  - Yucheng Song
  - Jun Du
  - Luke Lin
  - Rebecca Cosgrove
  - Chris Caruso Magee

[http://wwwt.emc.ncep.noaa.gov/gmb/yzhu/html/imp/201109\\_imp.html](http://wwwt.emc.ncep.noaa.gov/gmb/yzhu/html/imp/201109_imp.html)<sub>2</sub>

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- Proposal Changes
  - GFS model
  - Configurations
  - Adjust initialization (ETR) and stochastic perturbations (STTP)
- Results from retrospective runs
- Results from real time runs
- Summary for user evaluations

# Proposal Changes

- Model and initialization
  - Using GFS V9.01 (current operational GFS) instead of GFS V8.00
  - Improved Ensemble Transform with Rescaling (ETR) initialization
  - Improved Stochastic Total Tendency Perturbation (STTP)
- Configurations
  - T254 (55km) horizontal resolution for 0-192 hours (from T190 – 70km)
  - T190 (70km horizontal resolution for 192-384 hours (same as current opr)
  - L42 vertical levels for 0-384 hours (from L28)
- Add Sunshine duration for TIGGE data exchange
- Part of products will be delayed by approximately 20 minutes
  - Due to limit CCS resources
  - 40-42 nodes for 70 minutes (start +4:35 end: +5:45)
- Unchanged:
  - 20+1 members per cycle, 4 cycles per day
  - pgrb file output at 1\*1 degree every 6 hours
  - GEFS and NAEFS post process output data format
- What do we expect from this implementation?
  - Improve general probabilistic forecast skill overall
  - Significant improvement of tropical storm tracks (especially for Atlantic basin)

# GSI/GFS Bug Fix (May 2011 - V9.01)

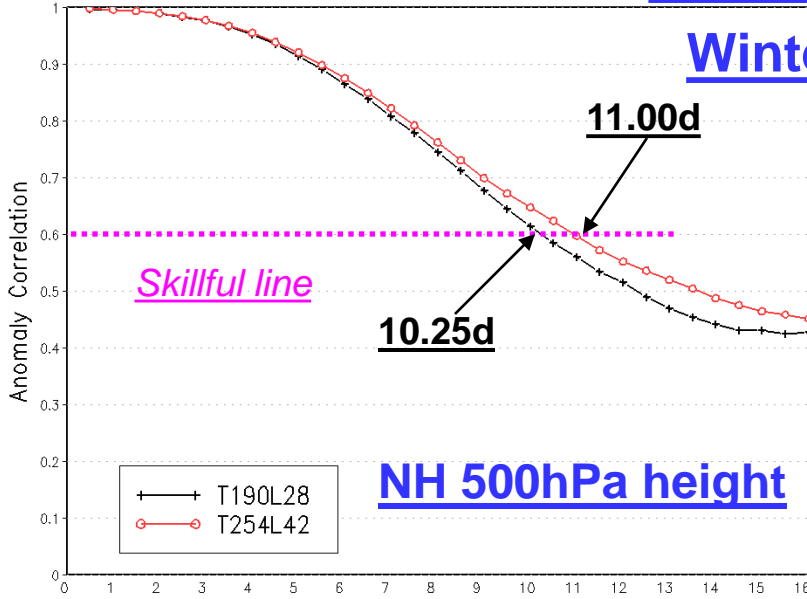
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- Analysis Changes
  - Improved OMI QC
  - Removal of redundant SBUV/2 total ozone
  - Retune SBUV/2 ozone ob errors
  - Relax AMSU-A Channel 5 QC
  - New version of CRTM 2.0.2
  - Inclusion of Field of View Size/Shape/Power for Radiative transfer
  - Remove down weighting of collocated radiances
  - Limit moisture  $\geq 1.e-10$  in each outer iteration and at end of analysis
  - Inclusion of uniform (higher resolution) thinning for satellite radiances
  - Improve location of Buoys in vertical (move from 20 to 10m)
  - Improved GSI code with optimization and additional options
  - Recomputed background errors
  - Inclusion of SBUV from NOAA-19
  - Ambiguous vector quality control for ASCAT (type 290) data
- Model Changes
  - New Thermal Roughness Length – Reduce low level warm bias over land
  - Set minimum moisture Value in Stratosphere to  $1.0E-7$  – Reduce strato. cooling
  - Reduce background diffusion in the Stratosphere – Reduce strato. neg wind<sup>5</sup> bias

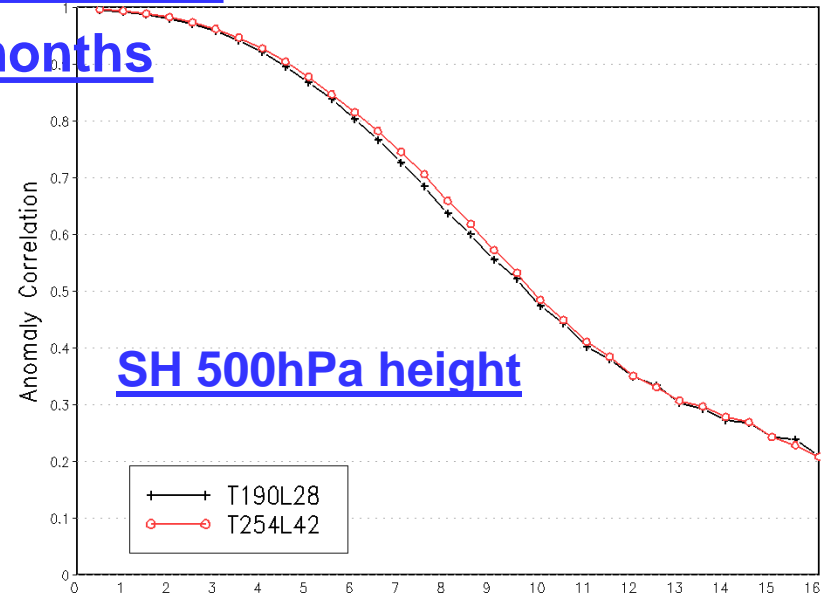
Northern Hemisphere 500hPa Height  
Ensemble Mean Anomaly Correlation  
Average For 20091202 – 20100201

# Anomaly Correlation

Southern Hemisphere 500hPa Height  
Ensemble Mean Anomaly Correlation  
Average For 20091202 – 20100201



## Winter 2 months

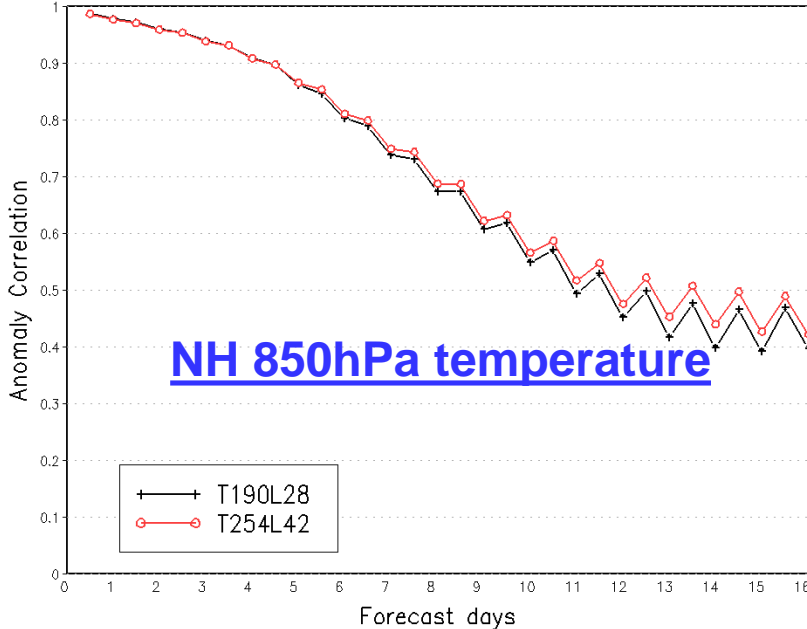


## SH 500hPa height

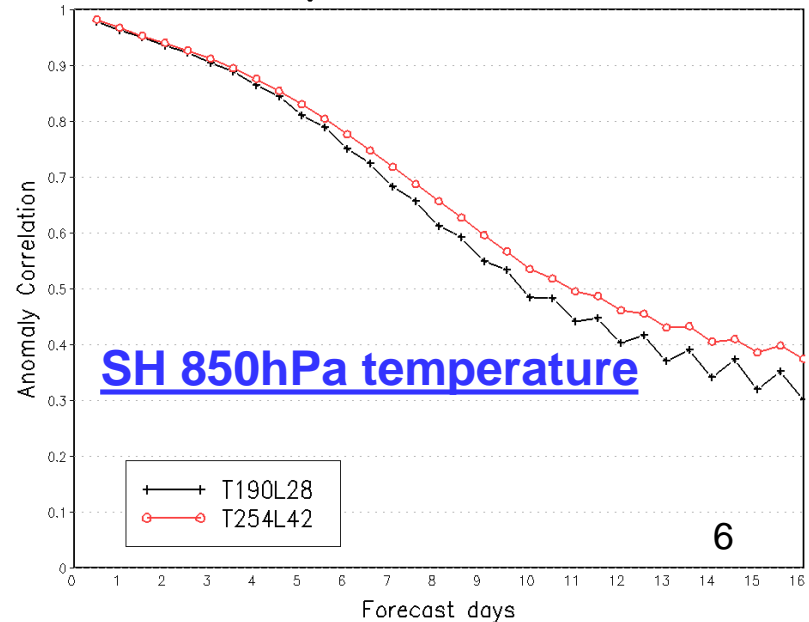
Northern Hemisphere 850hPa Temp.  
Ensemble Mean Anomaly Correlation  
Average For 20091202 – 20100201

# GFS V8.0 .vs V9.0

Southern Hemisphere 850hPa Temp.  
Ensemble Mean Anomaly Correlation  
Average For 20091202 – 20100201



## NH 850hPa temperature



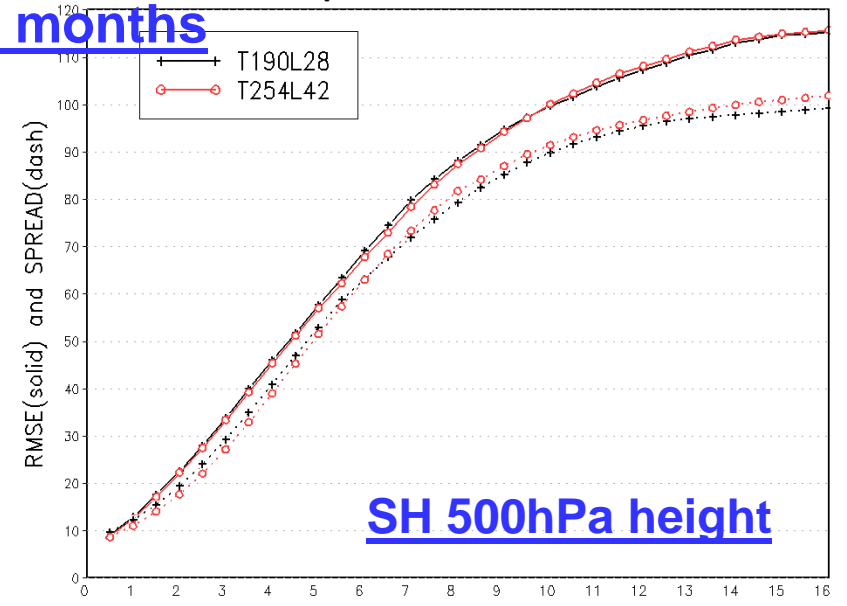
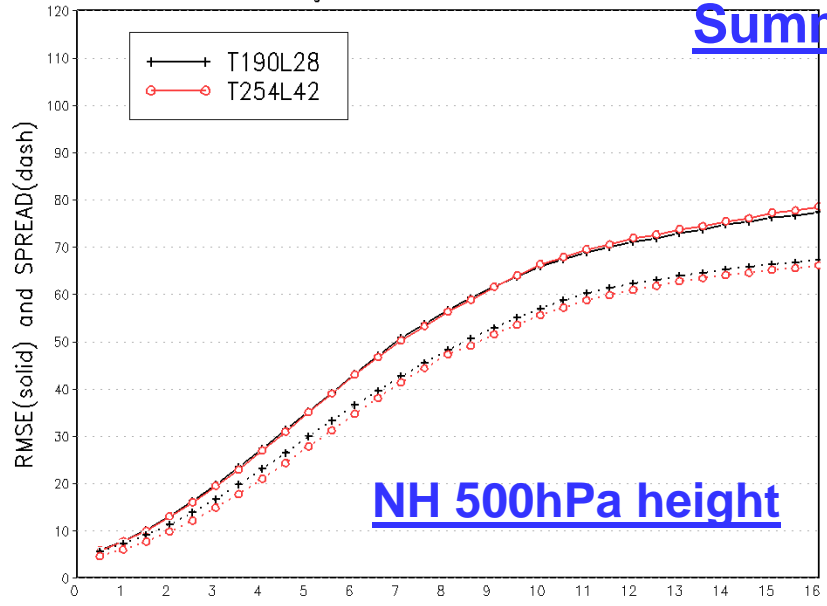
## SH 850hPa temperature

Northern Hemisphere 500hPa Height  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20100802 - 20100930

# RMS Error & Spread

Southern Hemisphere 500hPa Height  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20100802 - 20100930

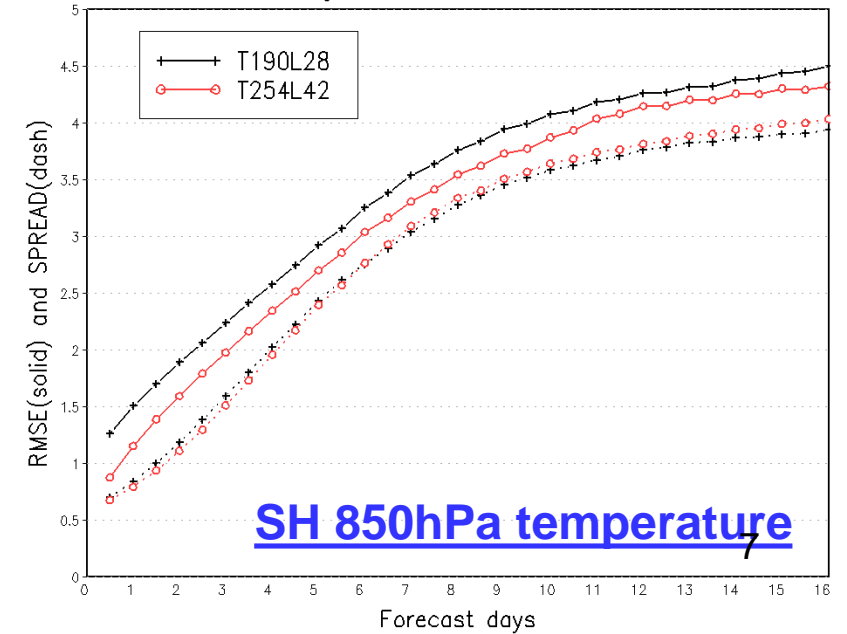
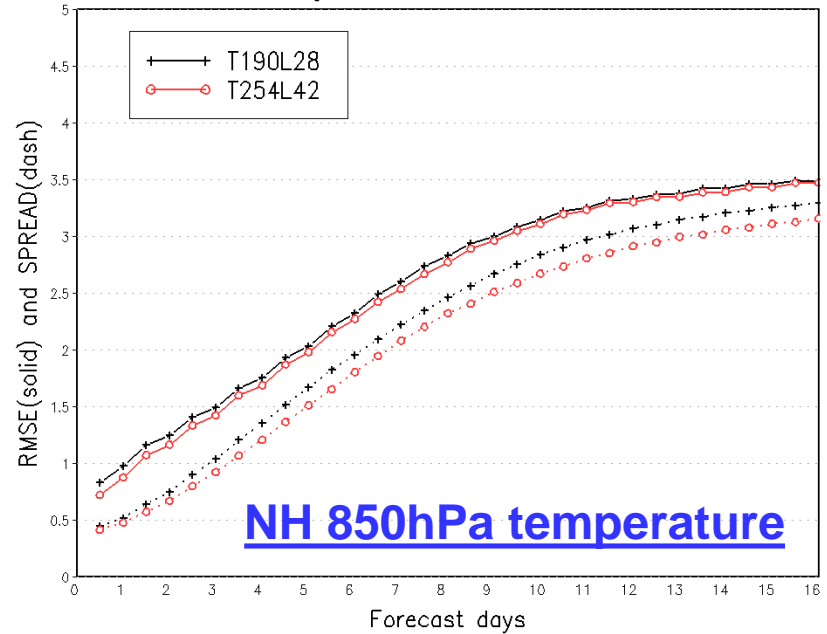
## Summer 2 months



Northern Hemisphere 850hPa Temp.  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20100802 - 20100930

## GFS V8.0 vs V9.0

Southern Hemisphere 850hPa Temp.  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20100802 - 20100930

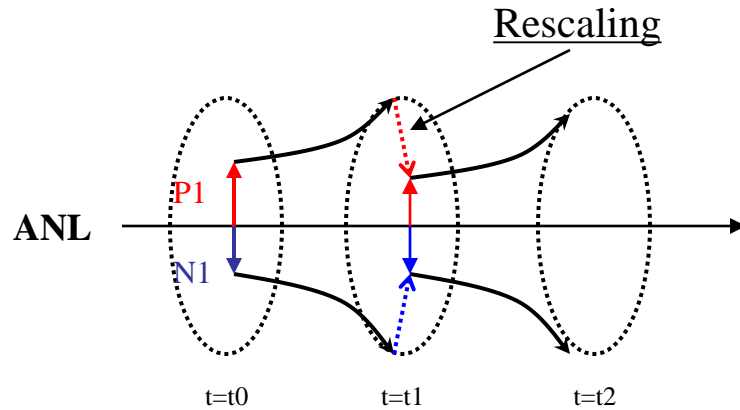


# Proposal Changes

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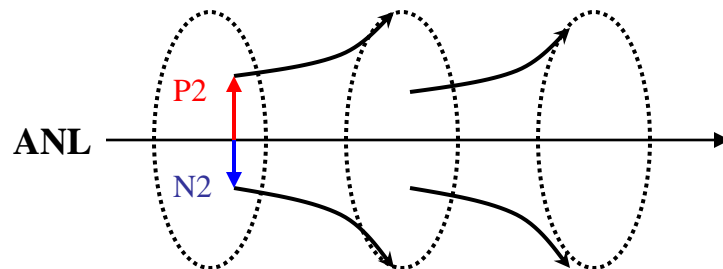
# Bred Vector (Introduced 1990's)



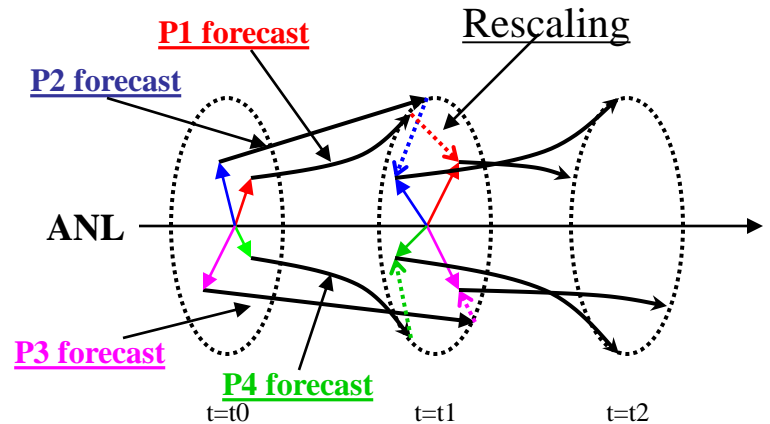
**P#**, **N#** are the pairs of positive and negative

**P1** and **P2** are independent vectors

Simple scaling down (no direction change)



# Ensemble Transform with Rescaling (Current Operation)



**P1**, **P2**, **P3**, **P4** are orthogonal vectors

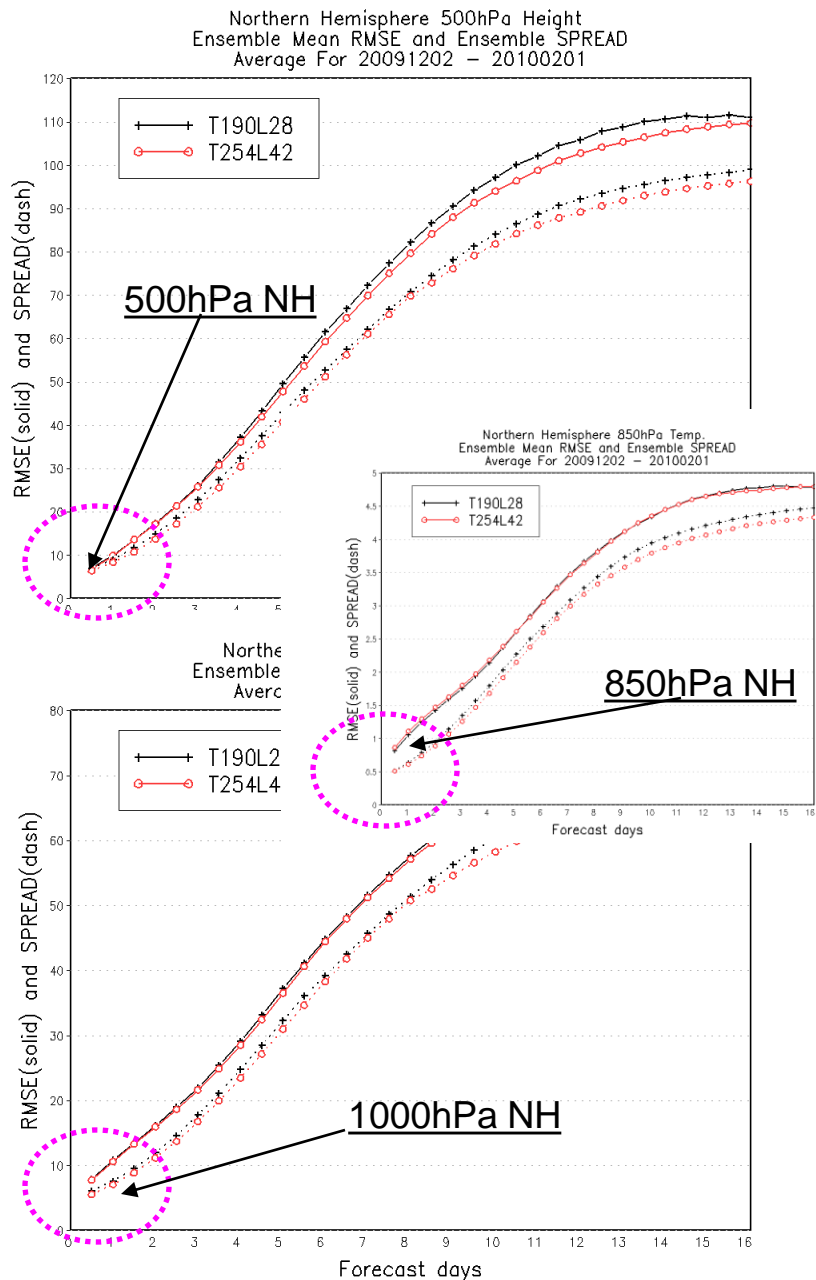
No pairs any more

To centralize all perturbed vectors (sum of all vectors are equal to zero)

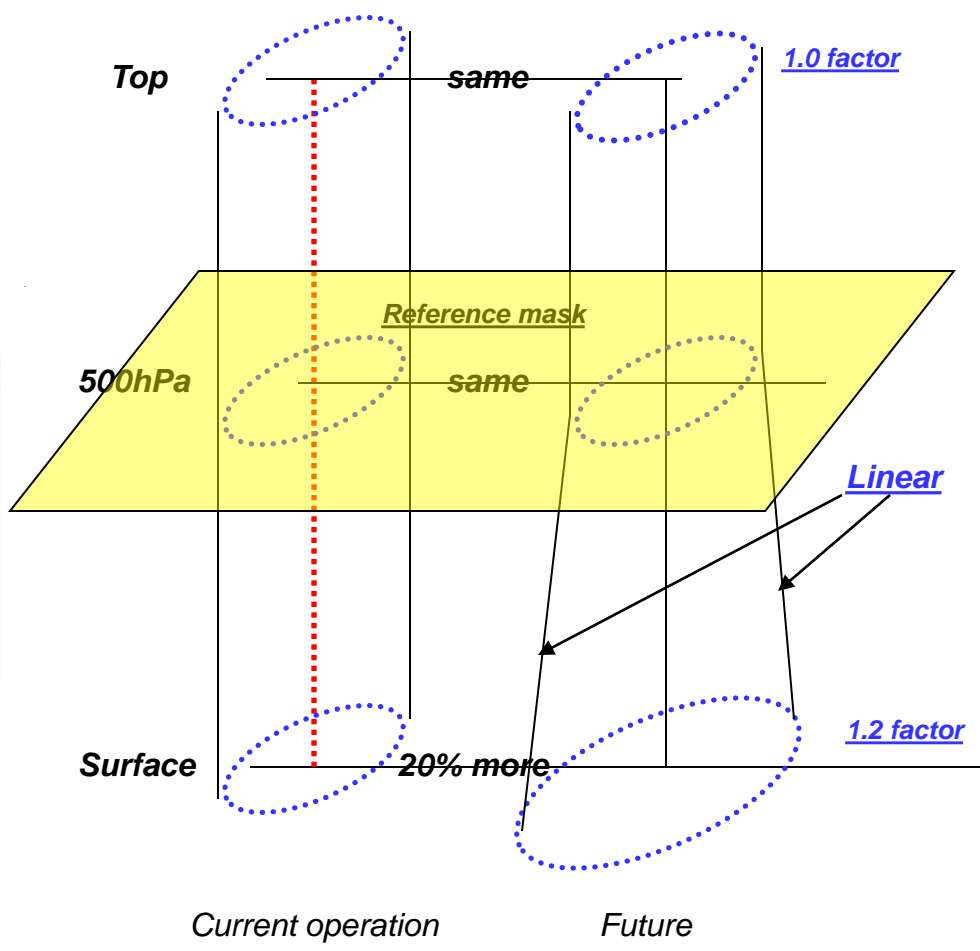
Scaling down by applying mask (2D mask is generated based on mid-of-troposphere near 500hPa as a reference)

The direction of vectors will be tuned by ETR.

# How do we tune ETR initial perturbations ?



## Rescaling mask and factors



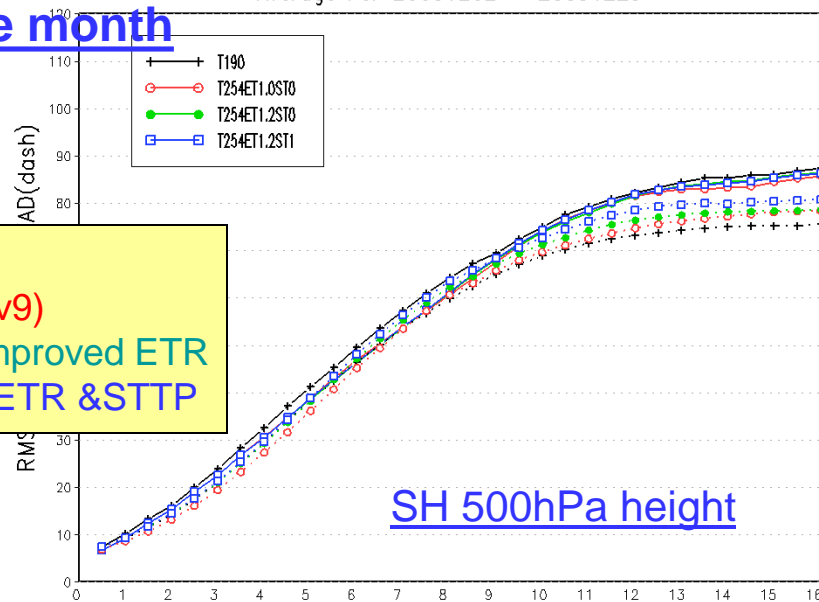
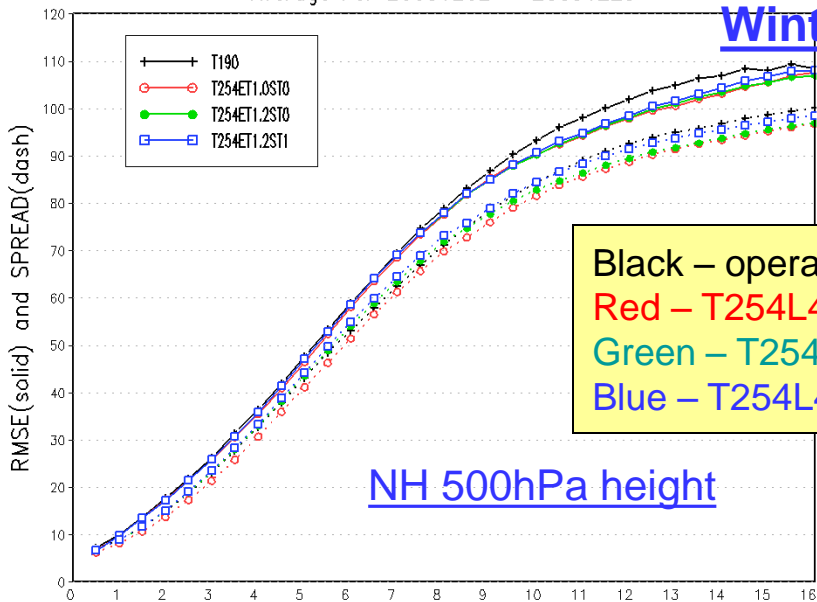
## Schematic of tuning initial perturbations

Northern Hemisphere 500hPa Height  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20091202 - 20091229

# RMS & Spread

Southern Hemisphere 500hPa Height  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20091202 - 20091229

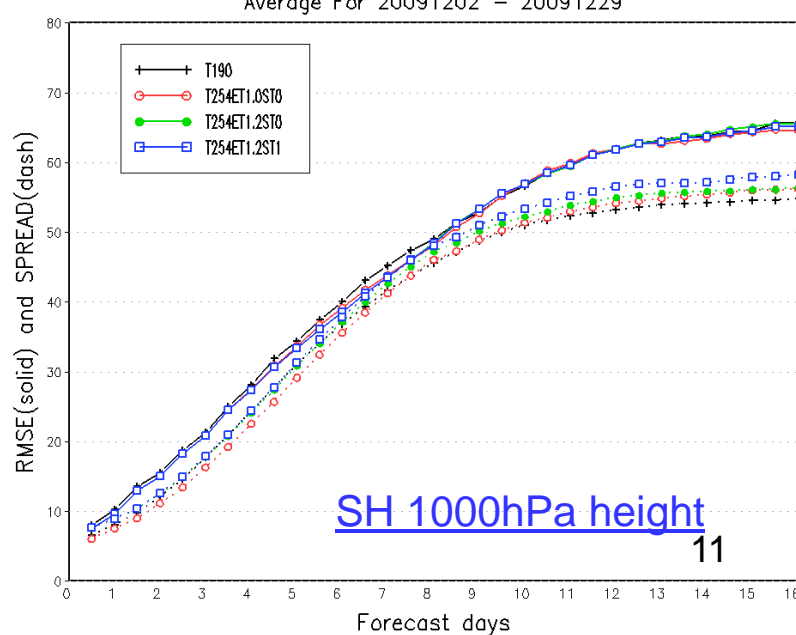
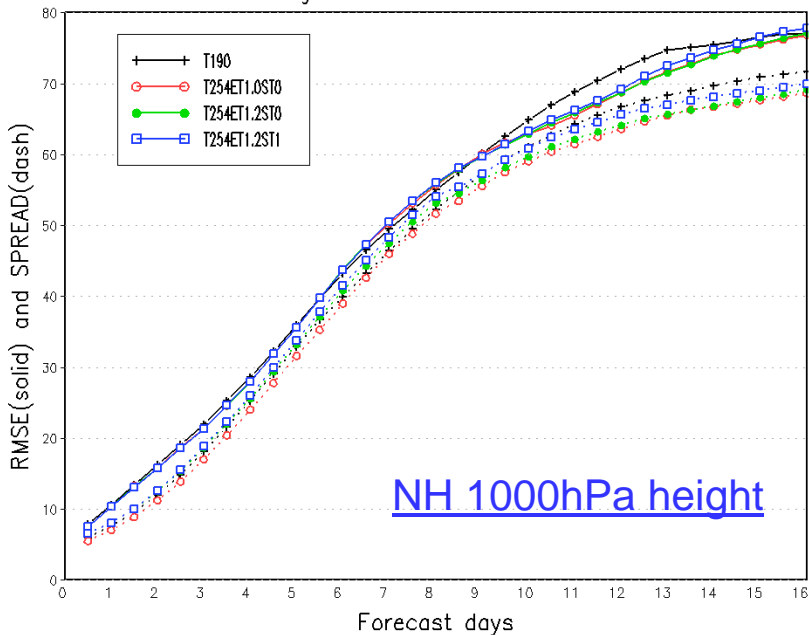
## Winter one month



Northern Hemisphere 1000hPa Height  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20091202 - 20091229

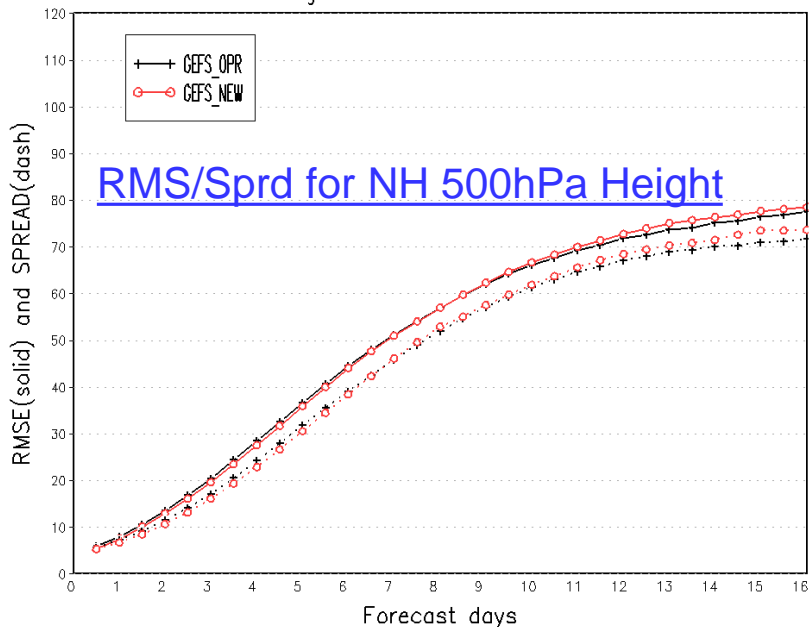
# GFS V8.0 .vs V9.0

Southern Hemisphere 1000hPa Height  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20091202 - 20091229

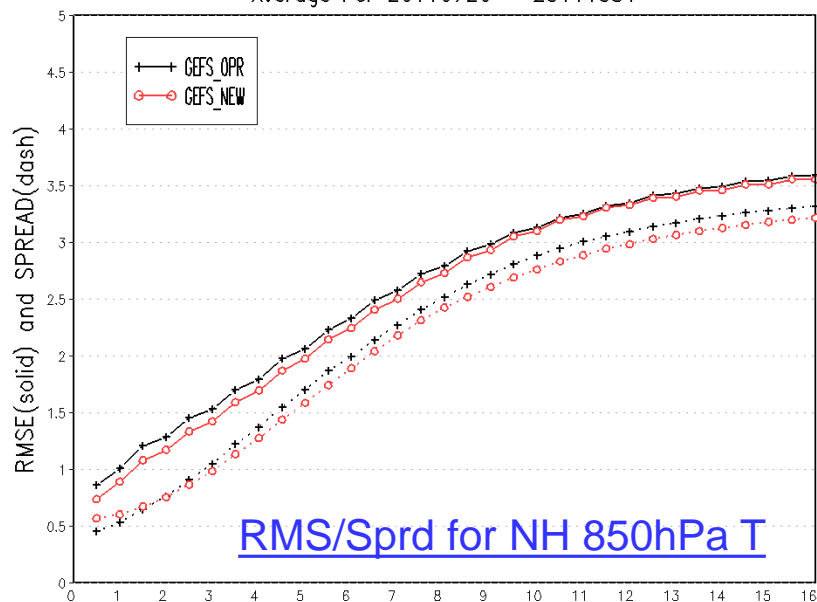


# Results from Retrospective Runs

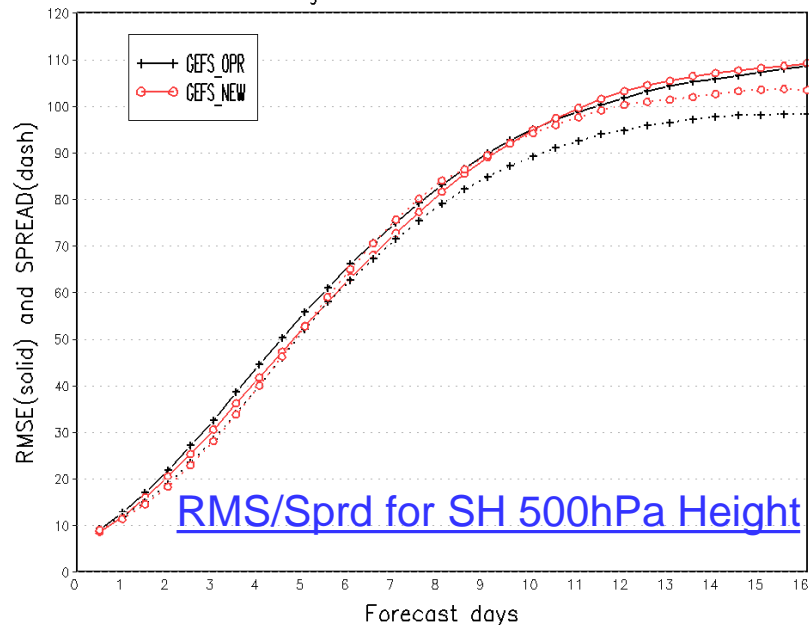
Northern Hemisphere 500hPa Height  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20110720 - 20111031



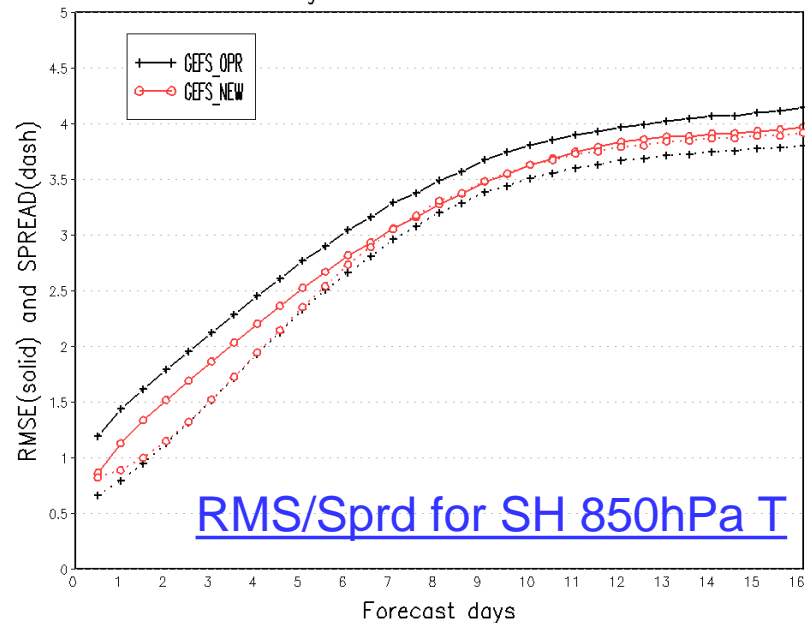
Northern Hemisphere 850hPa Temp.  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20110720 - 20111031



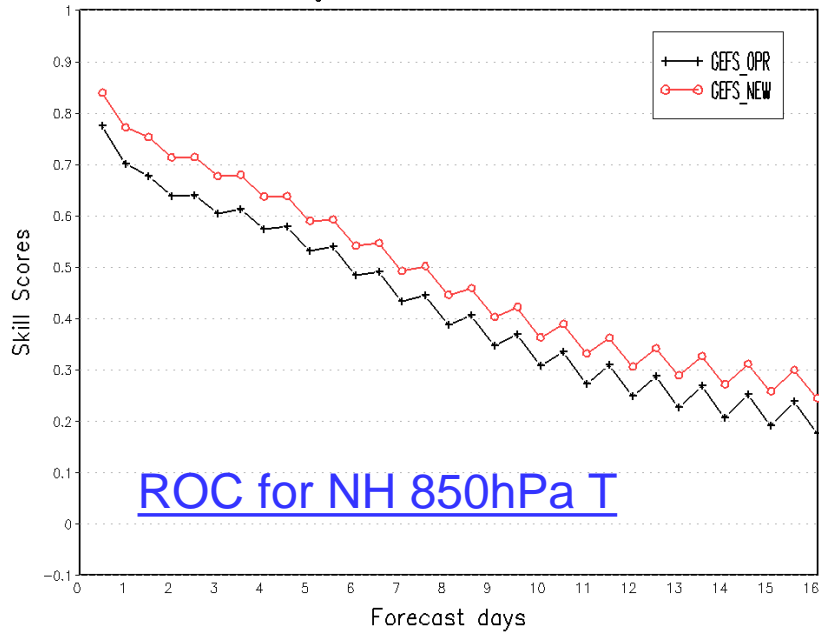
Southern Hemisphere 500hPa Height  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20110720 - 20111031



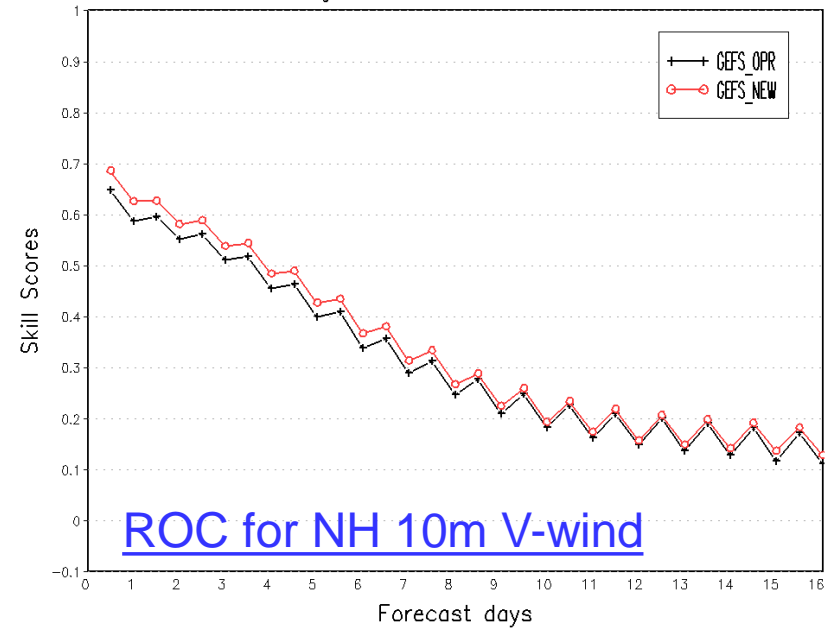
Southern Hemisphere 850hPa Temp.  
Ensemble Mean RMSE and Ensemble SPREAD  
Average For 20110720 - 20111031



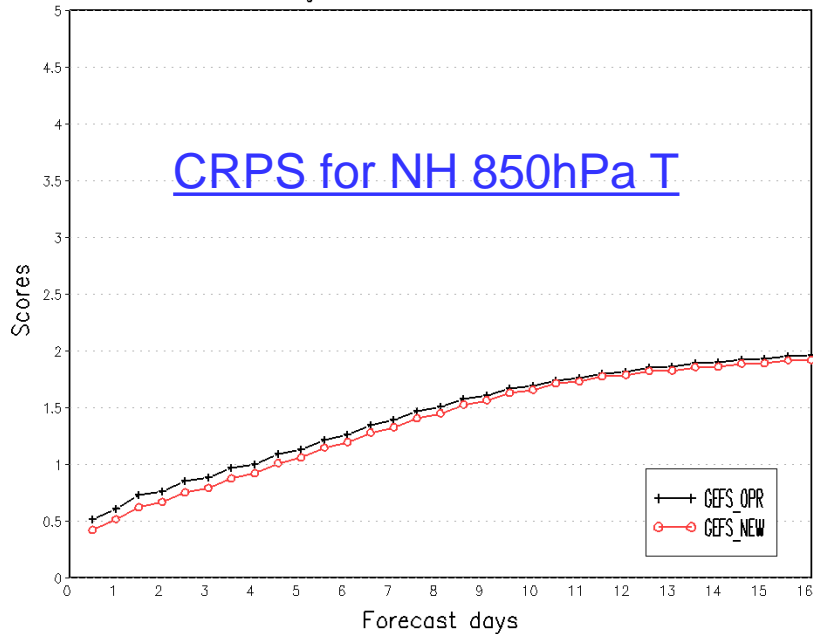
Northern Hemisphere 850hPa Temp.  
 ROC area (0-1)  
 Average For 20110720 - 20111031



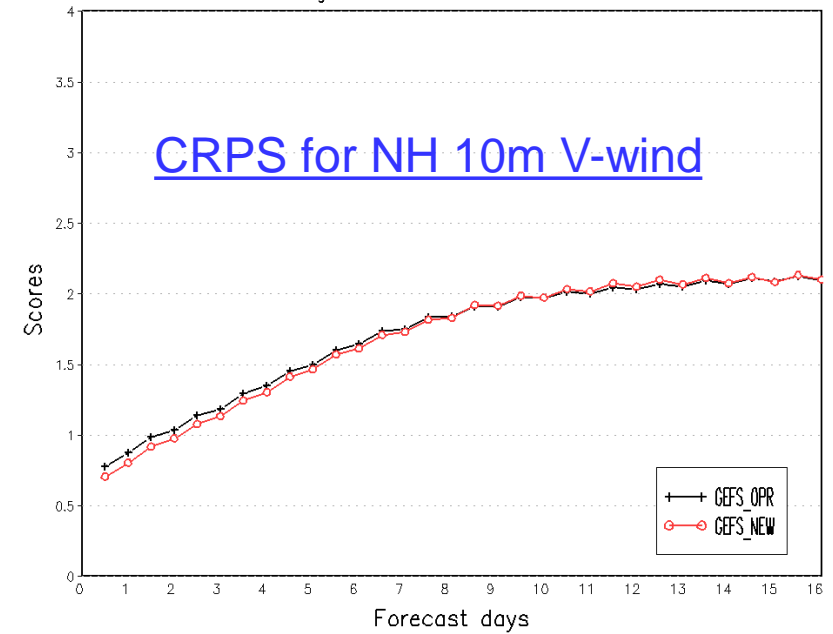
Northern Hemisphere 10 Meter V Wind  
 ROC area (0-1)  
 Average For 20110720 - 20111031



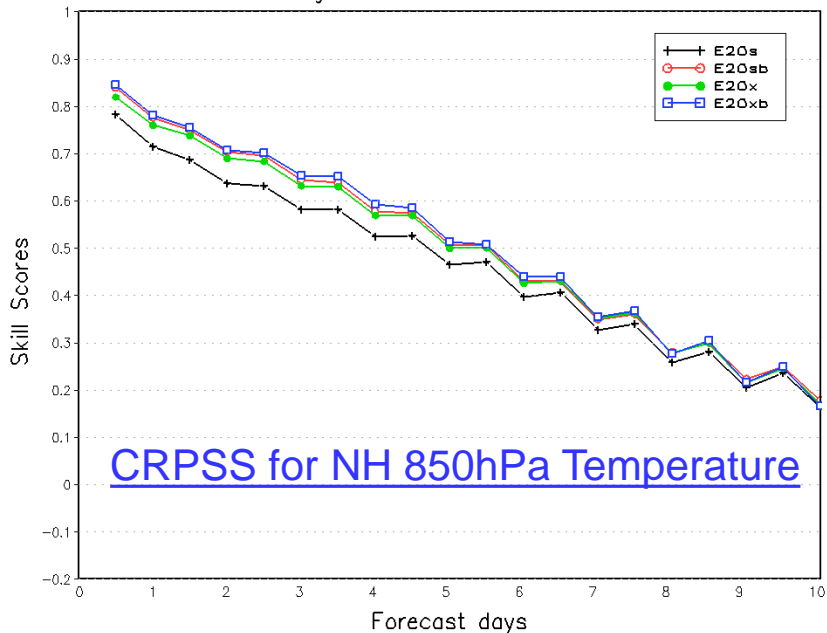
Northern Hemisphere 850hPa Temp.  
 Continuous Ranked Probability Scores  
 Average For 20110720 - 20111031



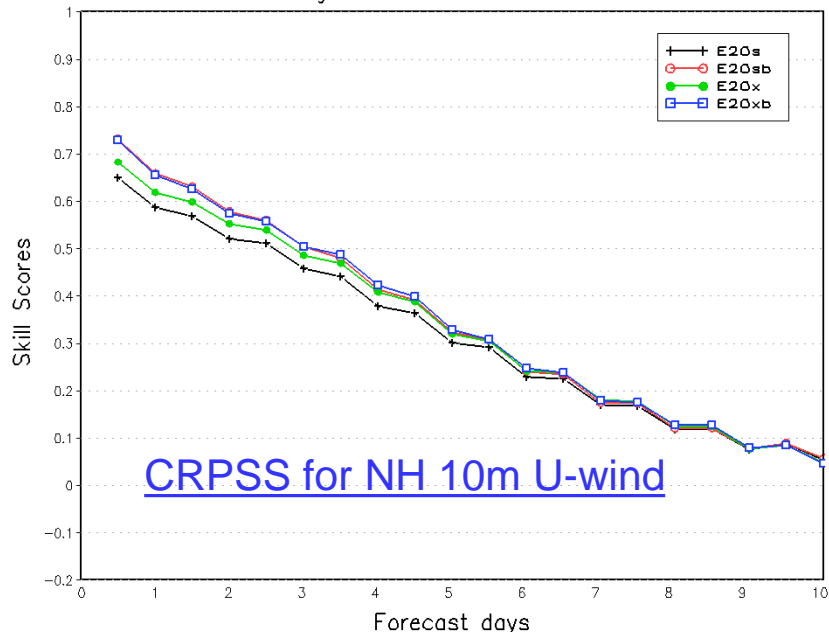
Northern Hemisphere 10 Meter V Wind  
 Continuous Ranked Probability Scores  
 Average For 20110720 - 20111031



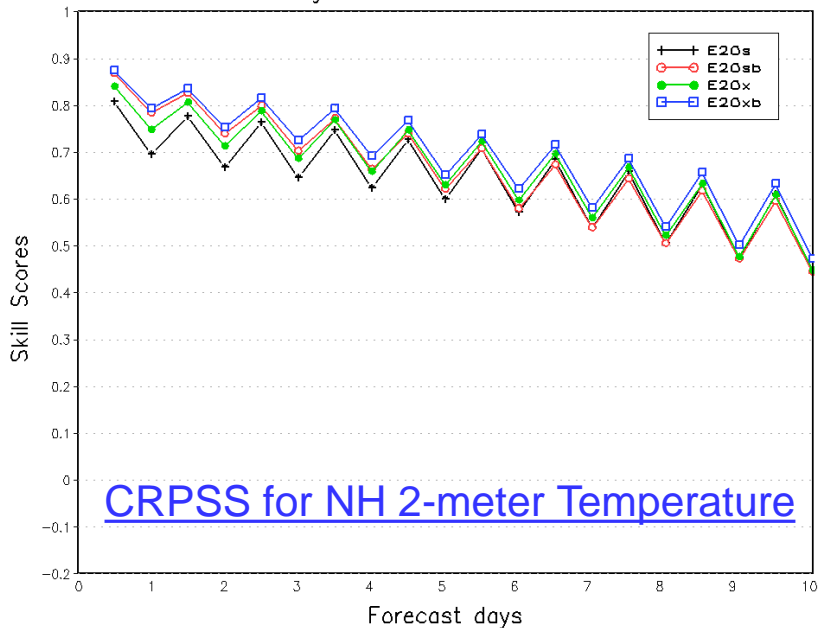
Northern Hemisphere 850hPa Temp.  
 Continuous Ranked Probability Skill Scores  
 Average For 20111001 - 20111031



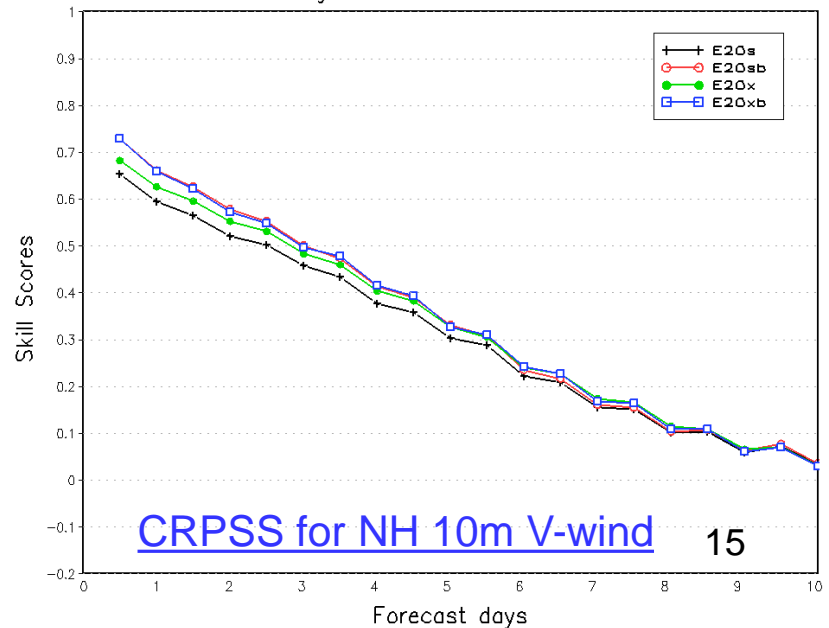
Northern Hemisphere 10 Meter U(wind)  
 Continuous Ranked Probability Skill Scores  
 Average For 20111001 - 20111031

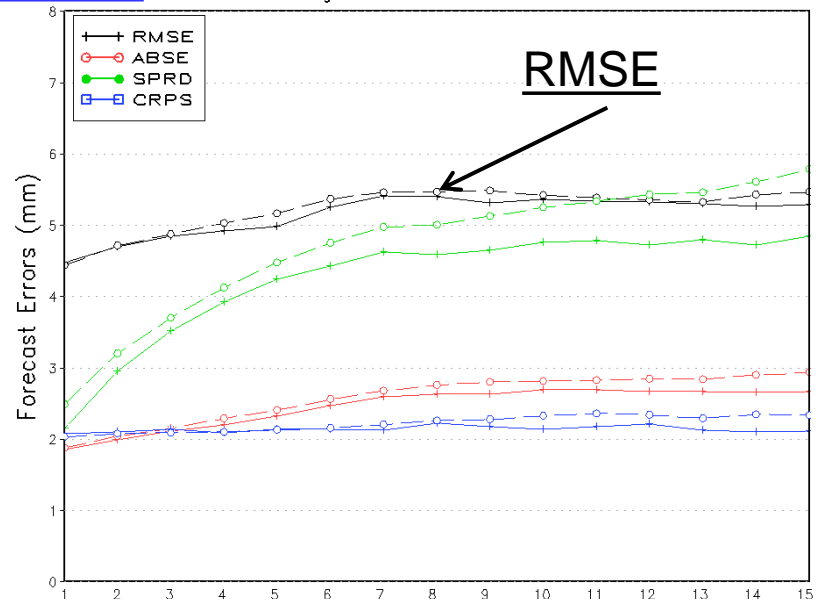
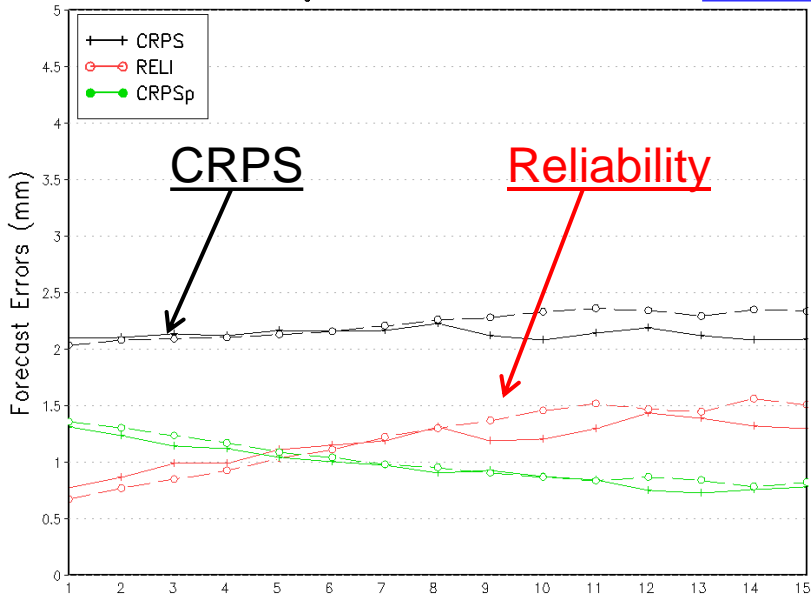


Continuous Ranked Probability Skill Scores  
 Average For 20111001 - 20111031

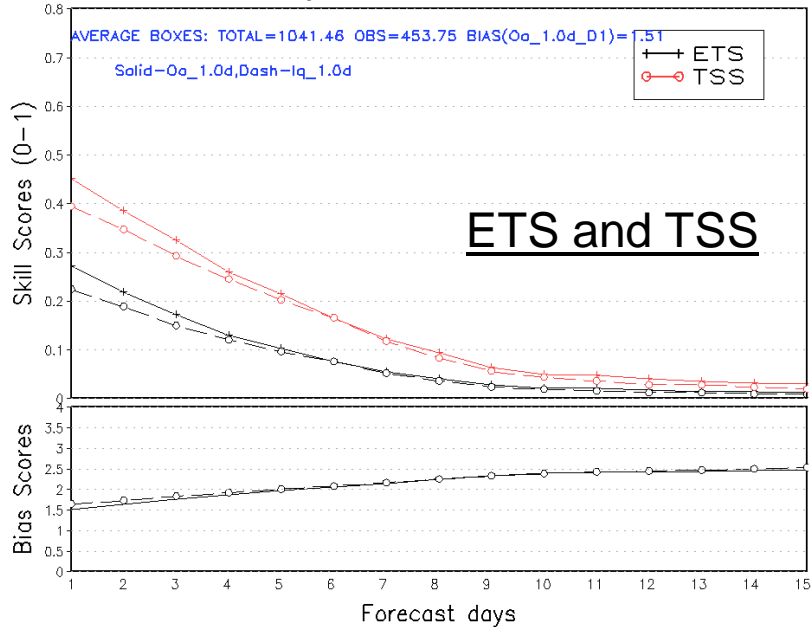


Northern Hemisphere 10 Meter V(wind)  
 Continuous Ranked Probability Skill Scores  
 Average For 20111001 - 20111031

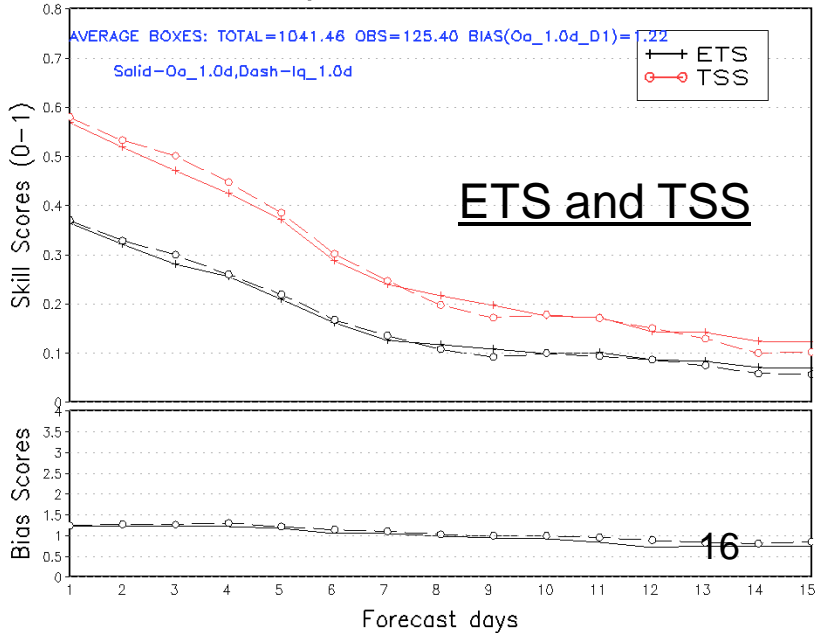




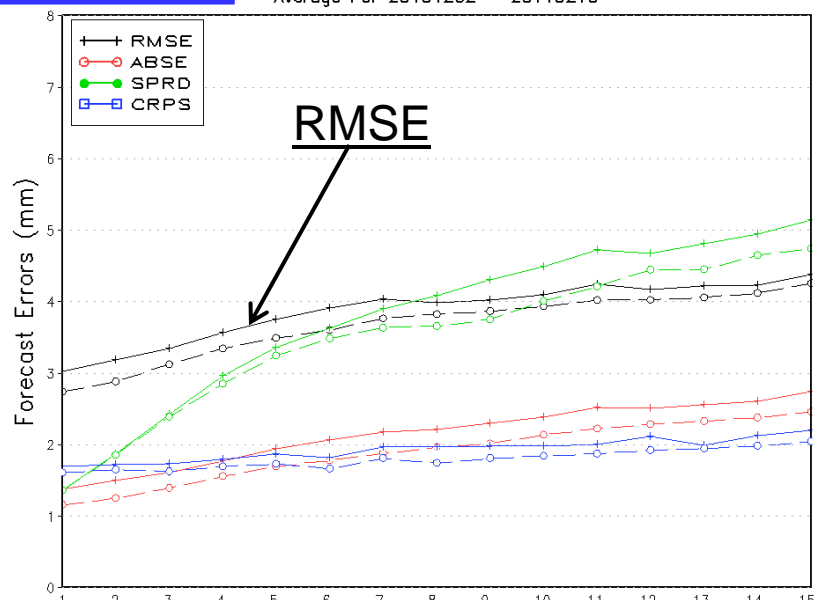
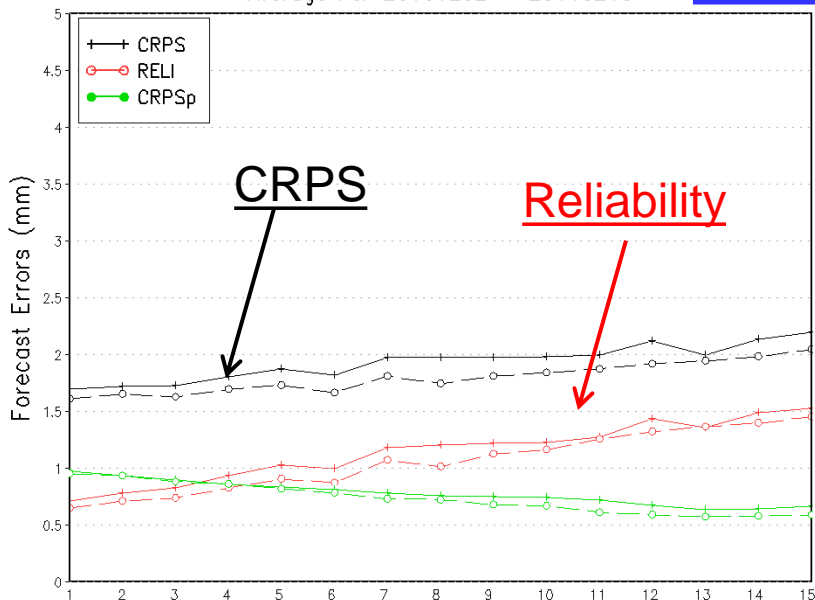
Ensemble Precipitation Verification  
ETS and TSS for threshold  $\geq 0.01\text{mm}/24\text{hours}$   
Average For 20100802 - 20100930



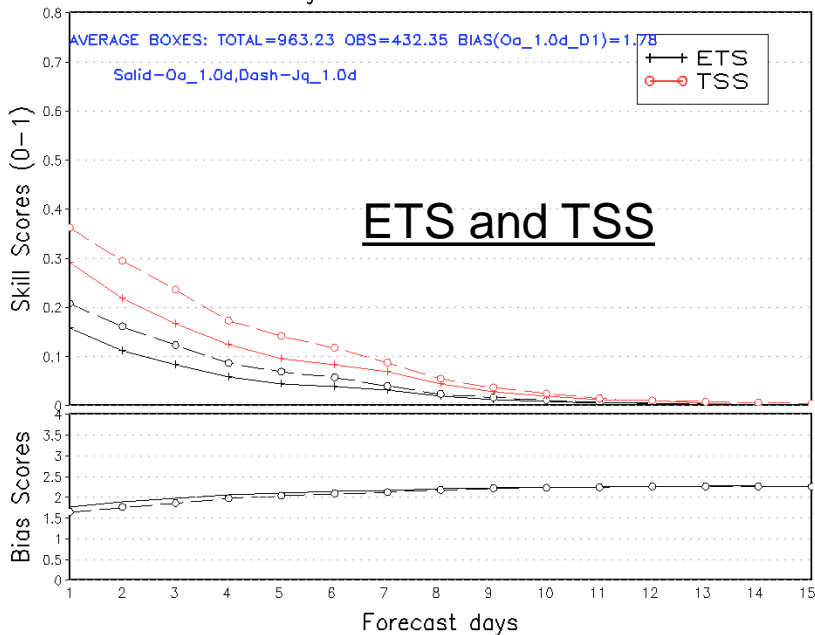
Ensemble Precipitation Verification  
ETS and TSS for threshold  $\geq 5.00\text{mm}/24\text{hours}$   
Average For 20100802 - 20100930



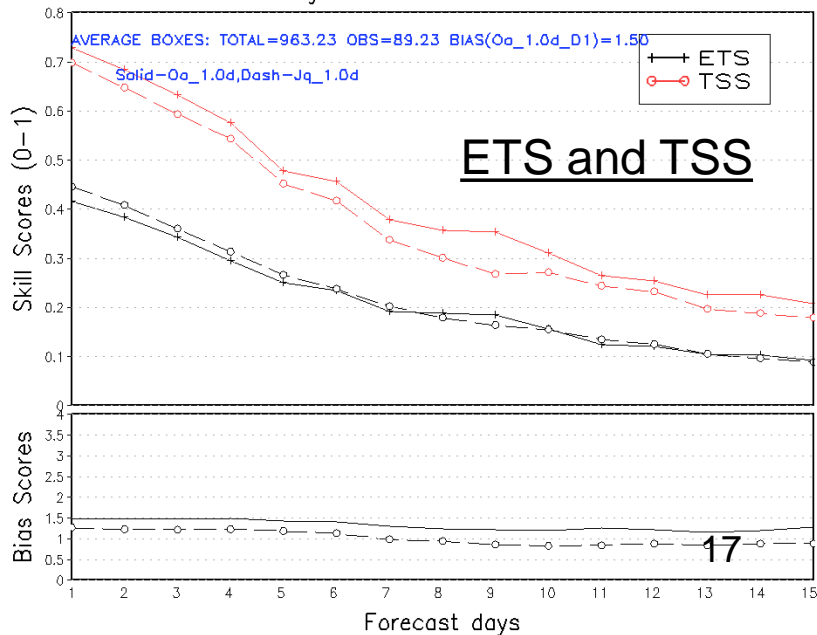




Ensemble Precipitation Verification  
 ETS and TSS for threshold  $\geq 0.01\text{mm}/24\text{hours}$   
 Average For 20101202 - 20110210



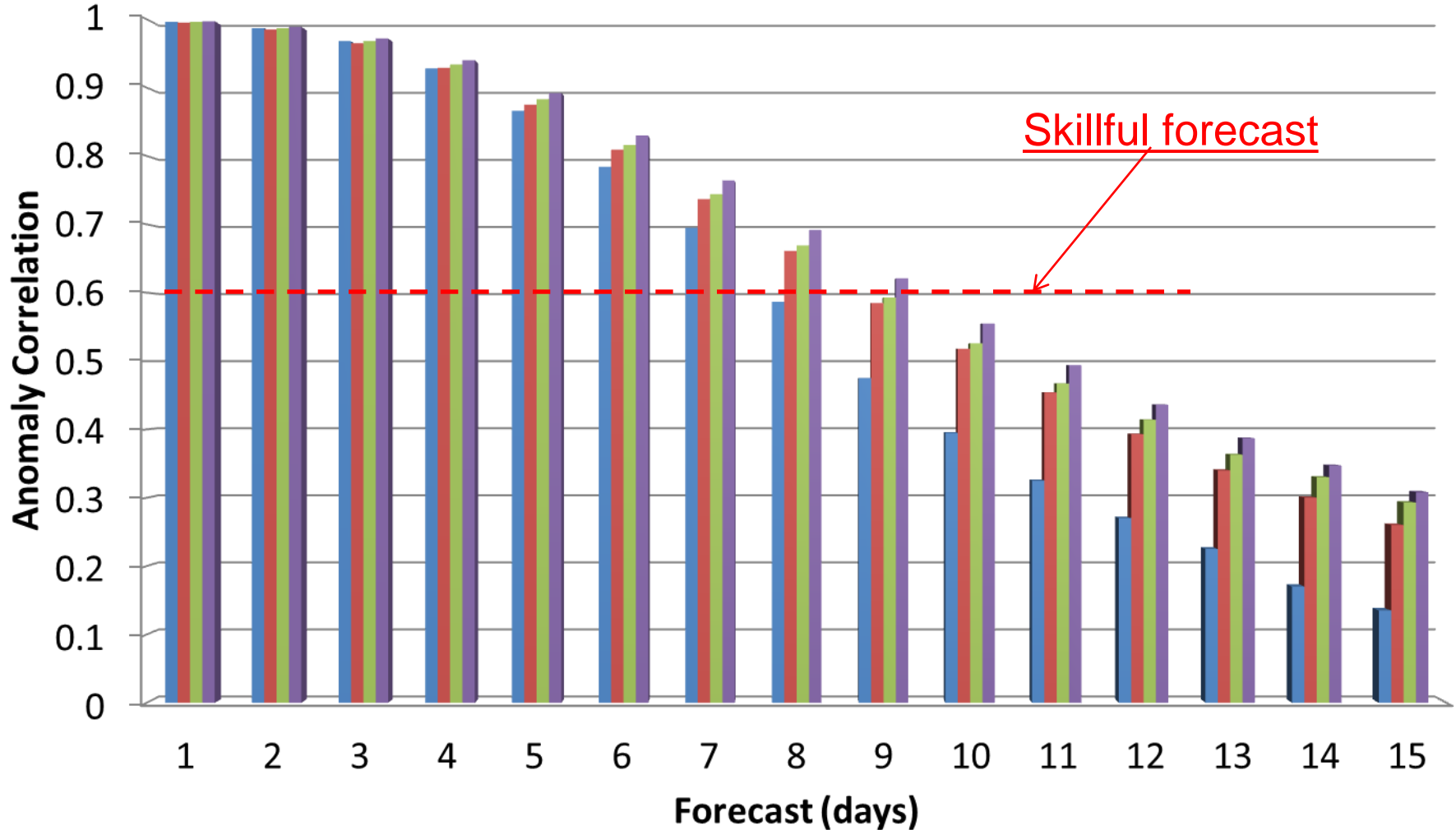
Ensemble Precipitation Verification  
 ETS and TSS for threshold  $\geq 5.00\text{mm}/24\text{hours}$   
 Average For 20101202 - 20110210



# NH Anomaly Correlation for 500hPa Height

Period: September 1st – November 30th 2011

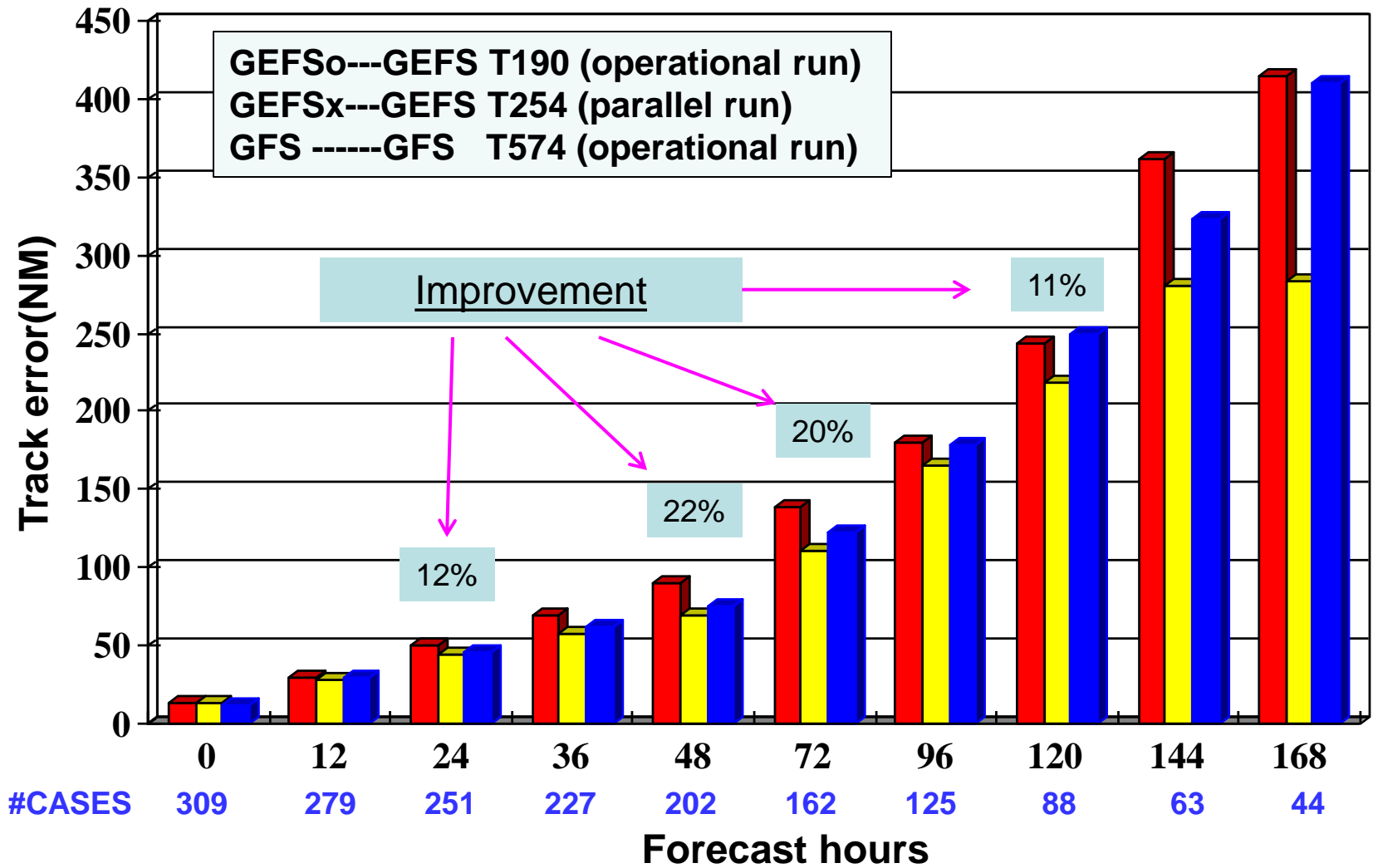
■ GFS ■ GEFS ■ GEFSx ■ NAEFS



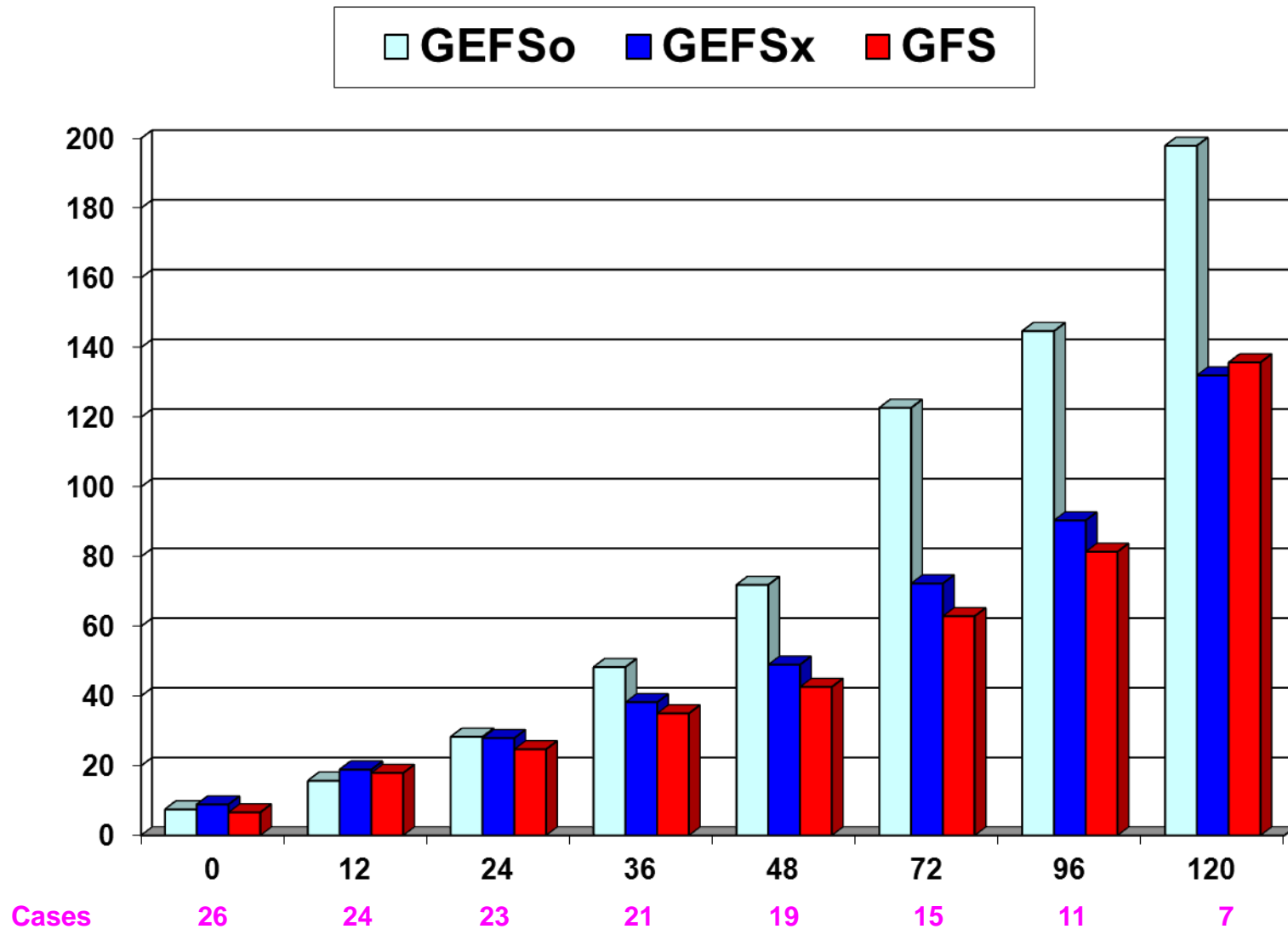
# Atlantic, AL01~19 (06/01~12/31/2011)

■ **GEFS<sub>o</sub>**
■ **GEFS<sub>x</sub>**
■ **GFS**

GEFS<sub>x</sub> runs once per day before Oct.

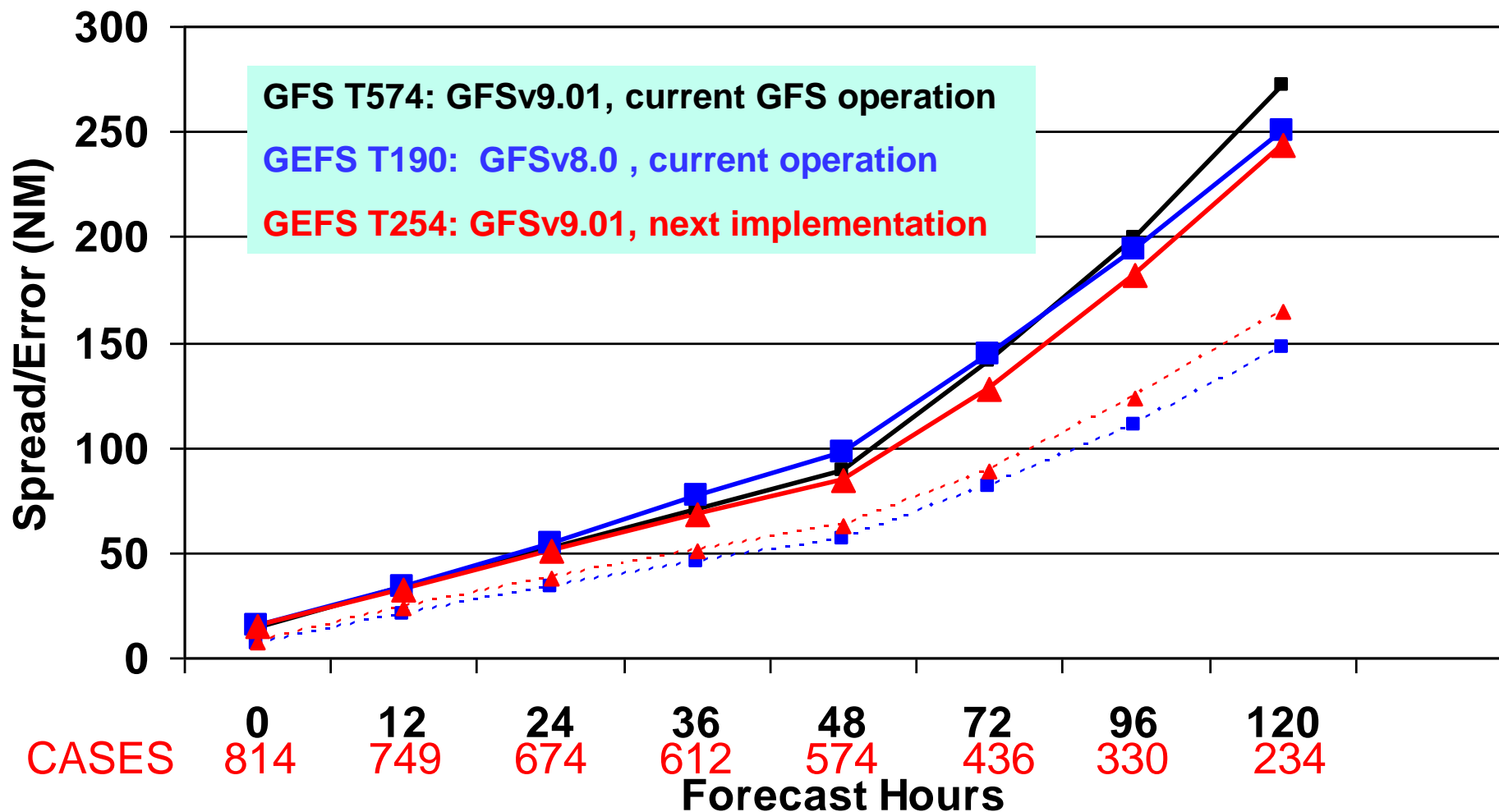
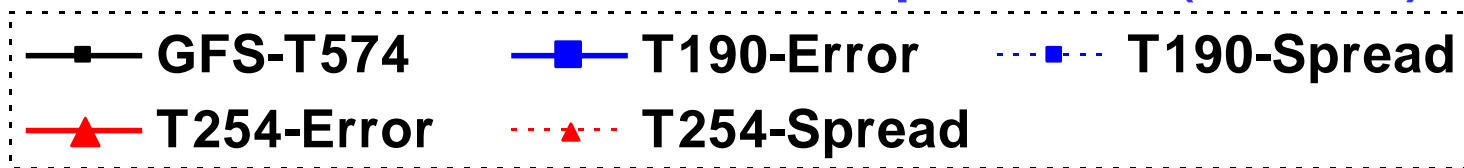


# Track forecast error for Hurricane Irene (2011)



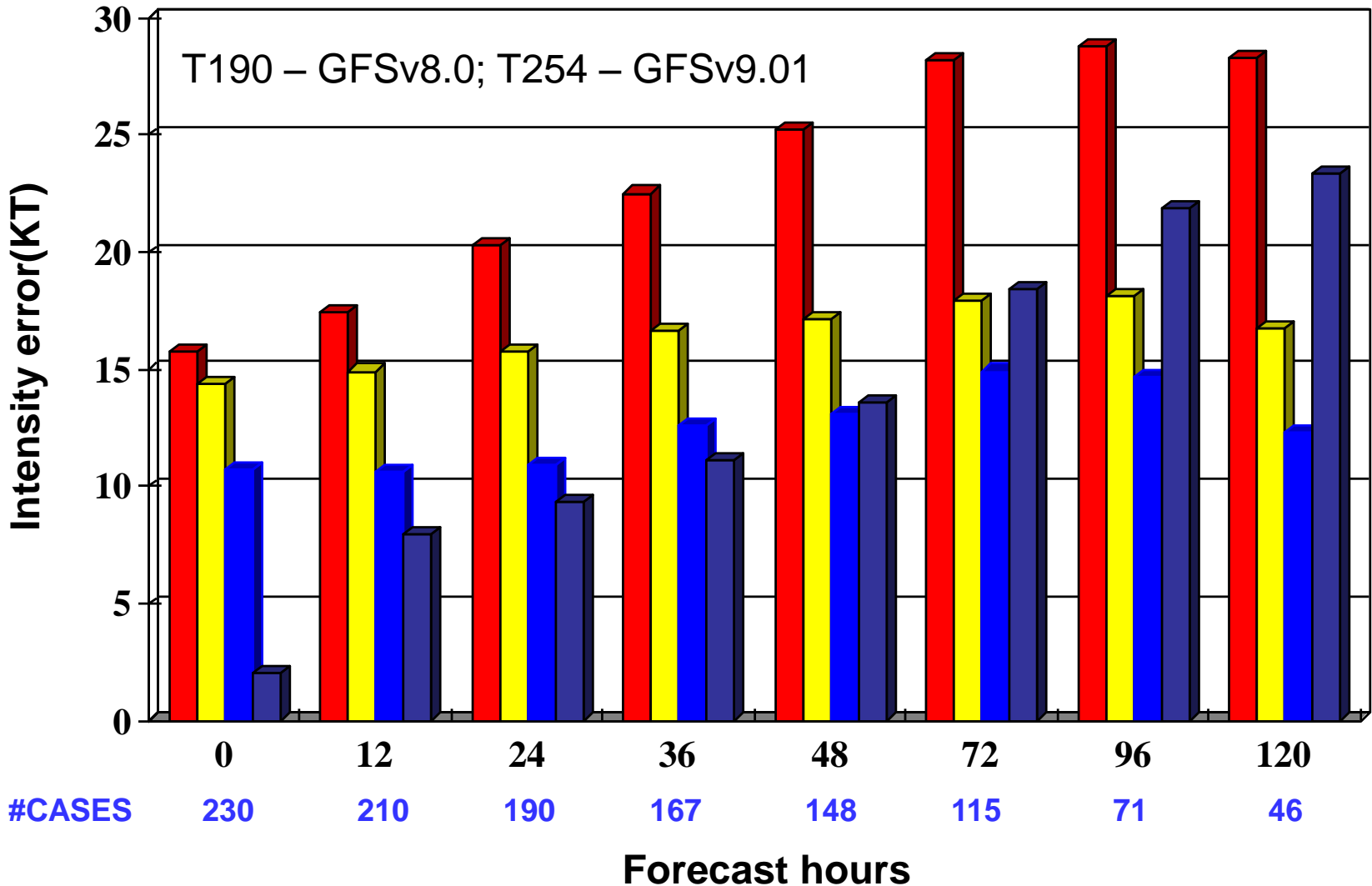
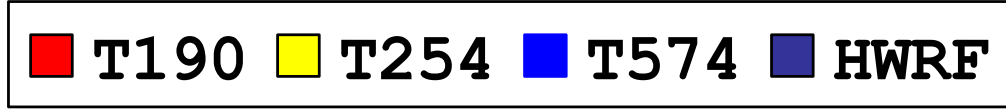
Period: 08/20 – 08/27/2011

# TS track mean error .vs spread (2011)



Tropical Storm Tracks (June – Dec. 2011, for AL, EP and WP)

# 2011 Atlantic, AL01~17, (06/01~09/30/2011)



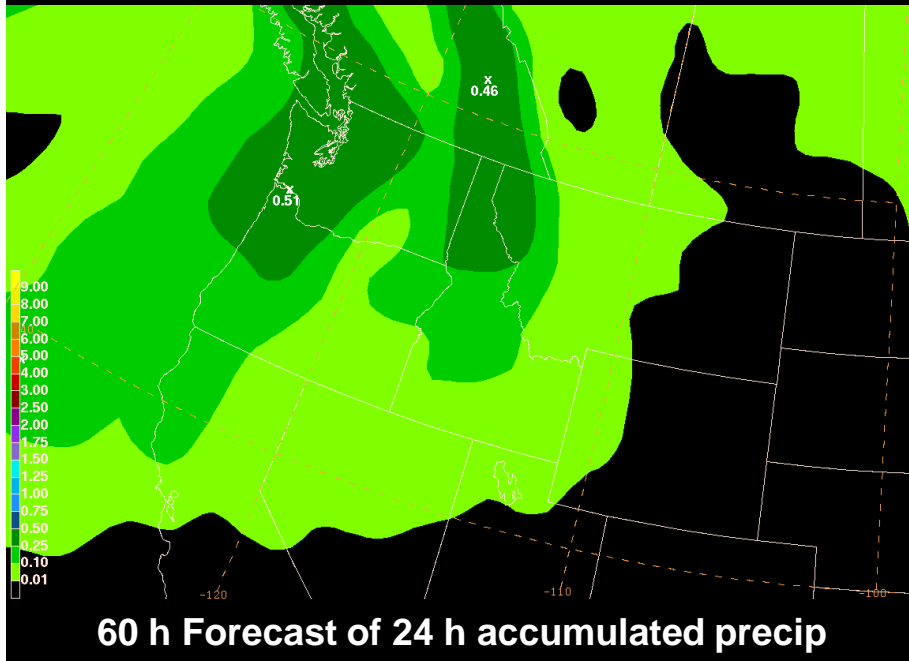
# Results from Real Time Runs

Since December 21 2011

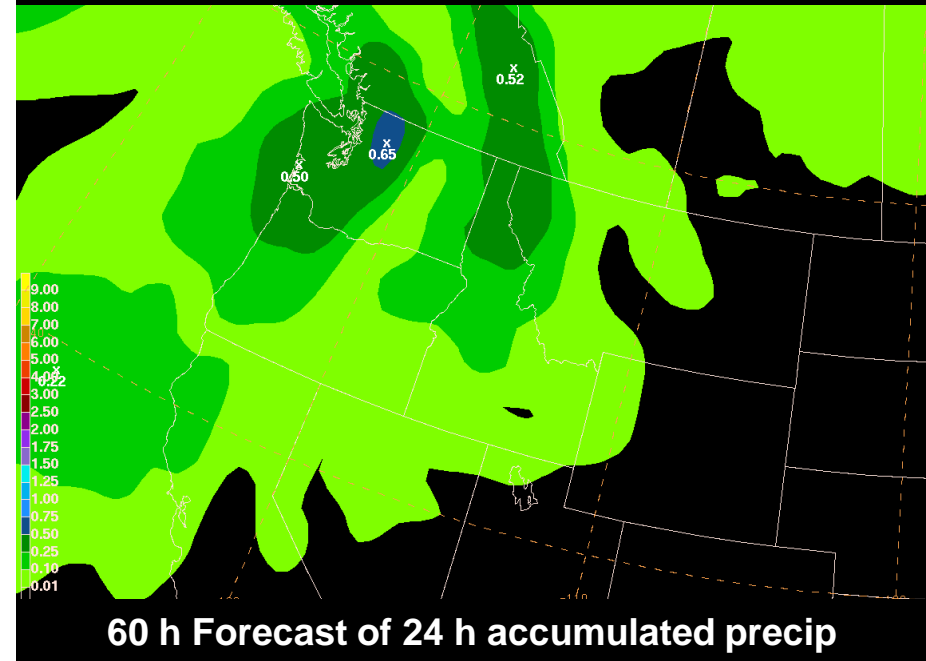
# QPF (plot provided by HPC, David Novak)

## Similar observation by Richard Grumm

Operational



Parallel



- Better in areas of complex terrain
- Otherwise similar skill and bias as the current GEFS

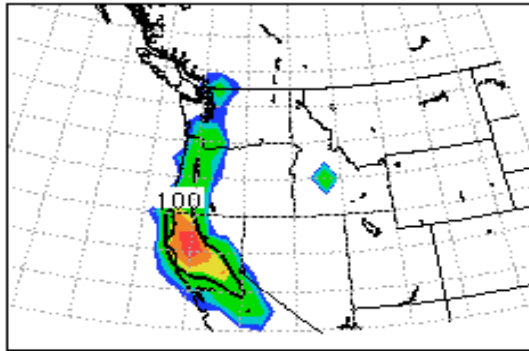


# Evaluation from WFO forecaster

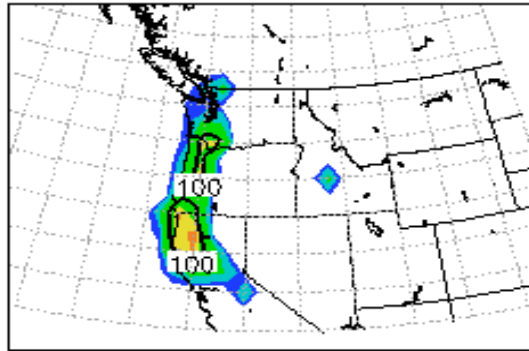
## - Richard Grumm

- Several good cases this winter
  - West Coast Rain and Snow
  - Western US-Plains warm episode
  - January Warm Episode
- GEFSPARA seems to perform well
  - May have sharper forecasts with cold/warm surges and precipitable water surges
  - Western QPF shows sharper terrain features.
- These are based on case comparisons not statistical

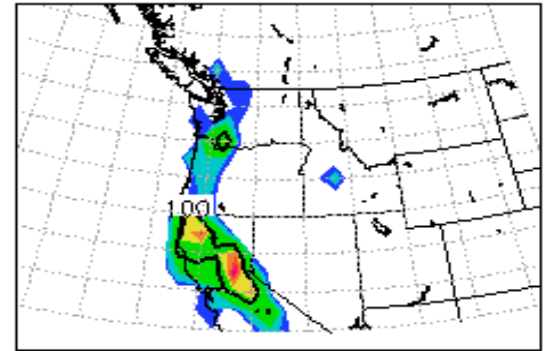
a.00Z16JAN2012 GEFS Prob:100mm apcpcf  
VT: 12Z19JAN2012 to 12Z22JAN2012 Sun



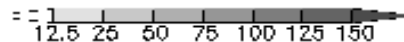
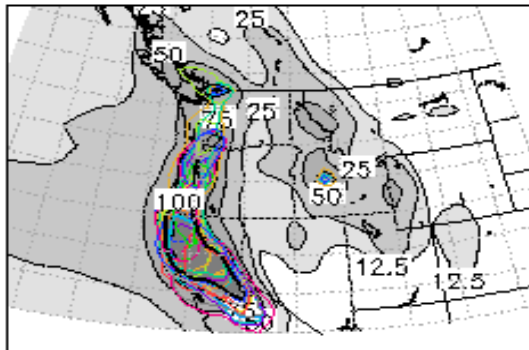
b.12Z16JAN2012 GEFS Prob:100mm apcpcf  
VT: 12Z19JAN2012 to 12Z22JAN2012 Sun



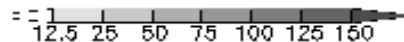
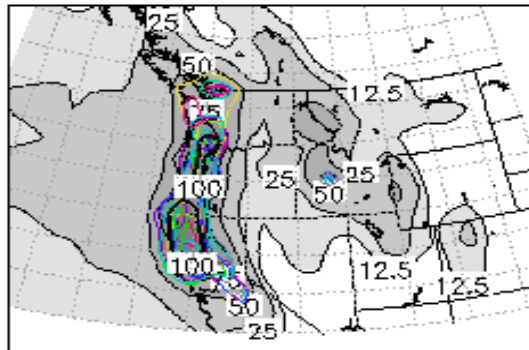
c.00Z16JAN2012 GEFSPARA Prob:100mm apcpcf  
VT: 12Z19JAN2012 to 12Z22JAN2012 Sun



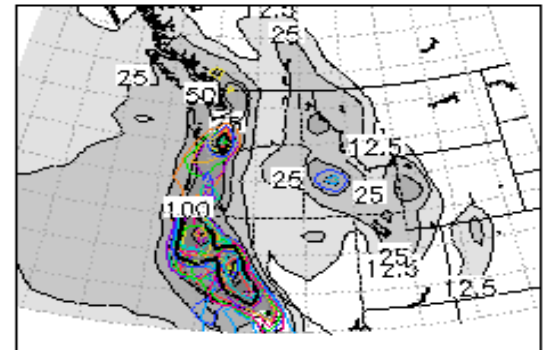
d.00Z16JAN2012 GEFS QPF & 100mm 72-h  
Valid 12Z19JAN2012 to 12Z22JAN2012 Sun



e.12Z16JAN2012 GEFS QPF & 100mm 72-h  
Valid 12Z19JAN2012 to 12Z22JAN2012 Sun



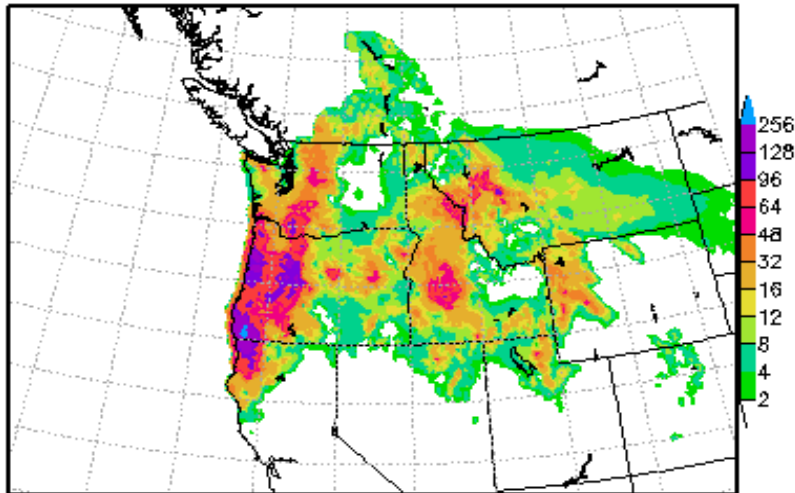
f.00Z16JAN2012 GEFSPARA QPF & 100mm 72-h  
Valid 12Z19JAN2012 to 12Z22JAN2012 Sun



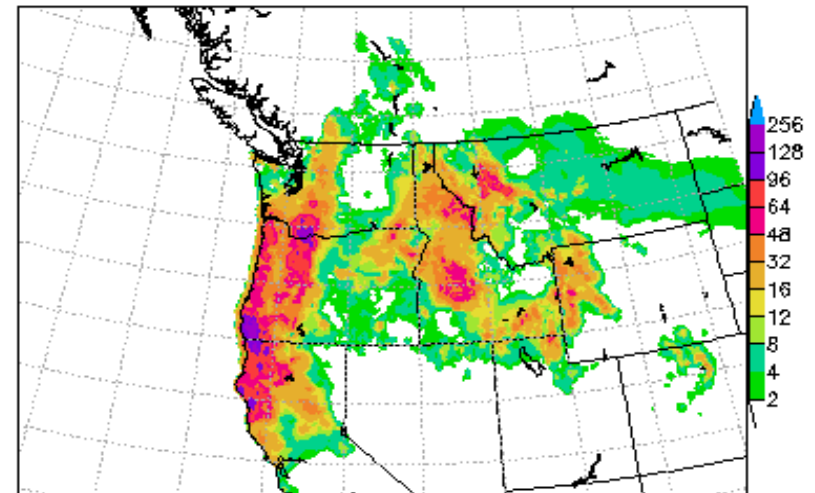
a & d) NCEP 75km GEFS initialized at 0000 UTC 16 January 2012, b & e) NCEP 75km GEFS initialized at 1200 UTC 16 January 2012, and c & f) NCEP 55km parallel GEFS initialized at 0000 UTC 16 January 2012. Percentages as per the color key in the upper panels. Shaded QPF is in the color bar.

Courtesy of Richard Grumm

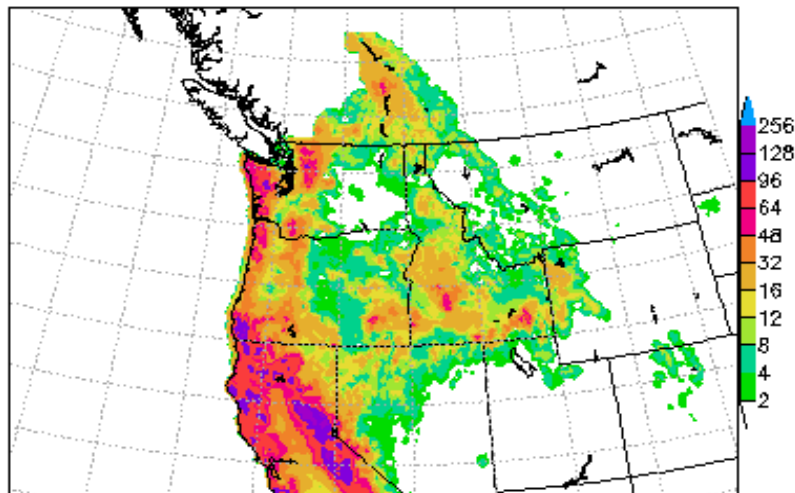
a. Accumulated liquid equivalent precipitation (mm)  
valid 12Z18.JAN2012 12Z19.JAN2012



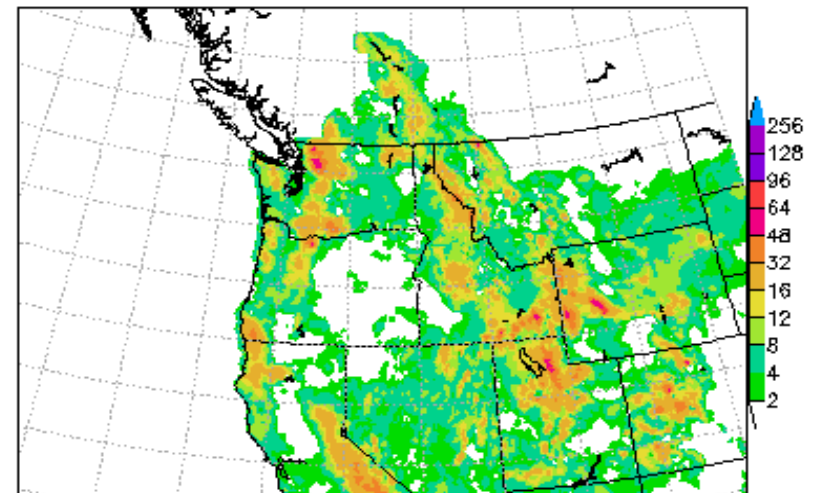
b. Accumulated liquid equivalent precipitation (mm)  
valid 12Z19.JAN2012 12Z20.JAN2012



c. Accumulated liquid equivalent precipitation (mm)  
valid 12Z20.JAN2012 12Z21.JAN2012



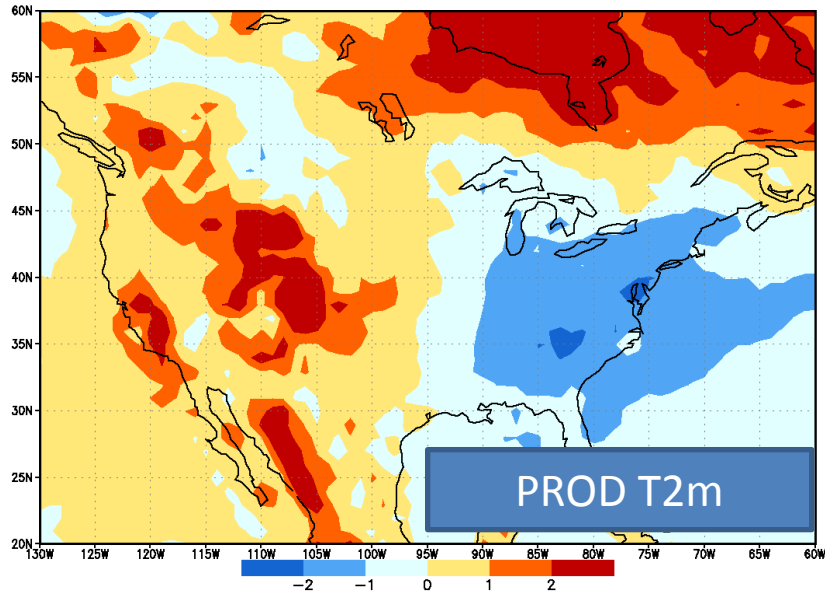
d. Accumulated liquid equivalent precipitation (mm)  
valid 12Z21.JAN2012 12Z22.JAN2012



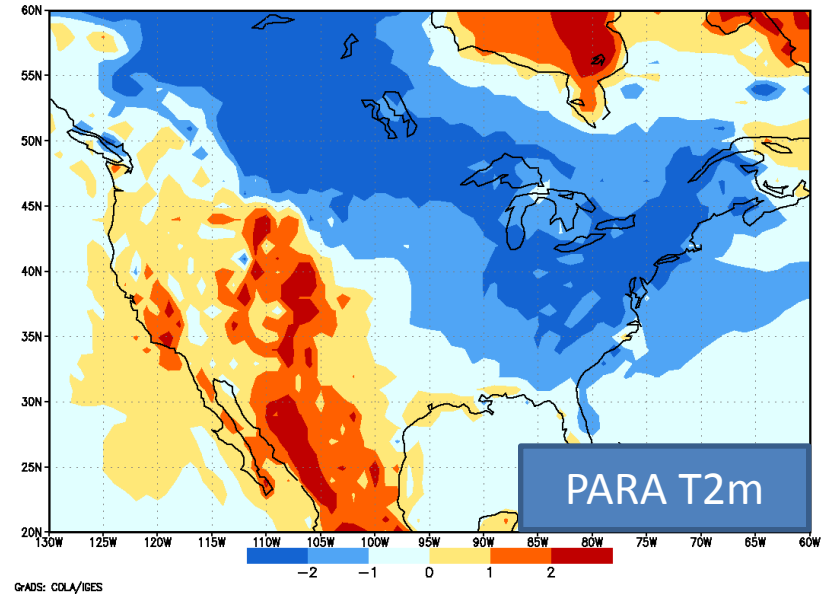
Stage-IV 24 hour accumulated precipitation for the 4 periods ending at a) 1200 UTC 19 January 2012, b) 1200 UTC 20 January 2012, c) 1200 UTC 21 January 2012, and d) 1200 UTC 22 January 2012.

# Cold bias for east of US in winter 2 months

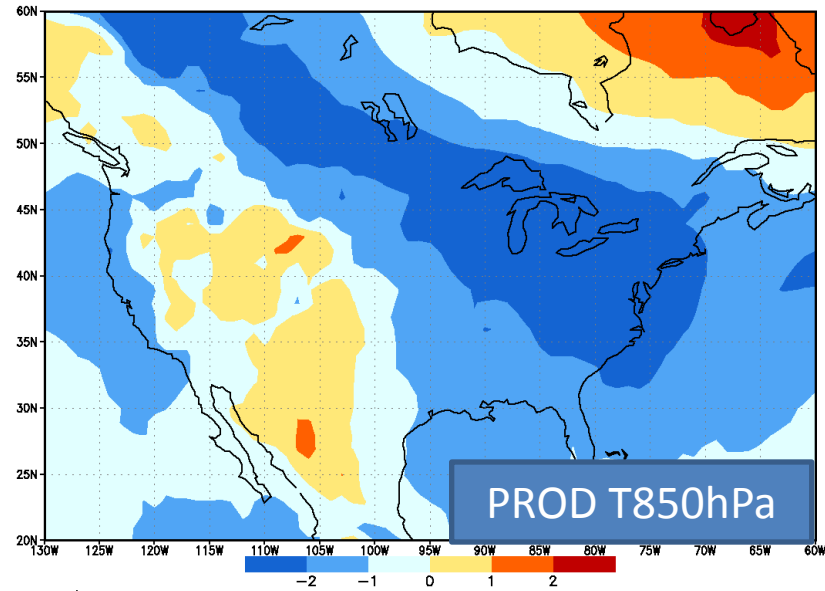
Accumulated forecast errors (bias) for surface temperature (PROD)  
Initial:2012012000 and forecast: 312 hours



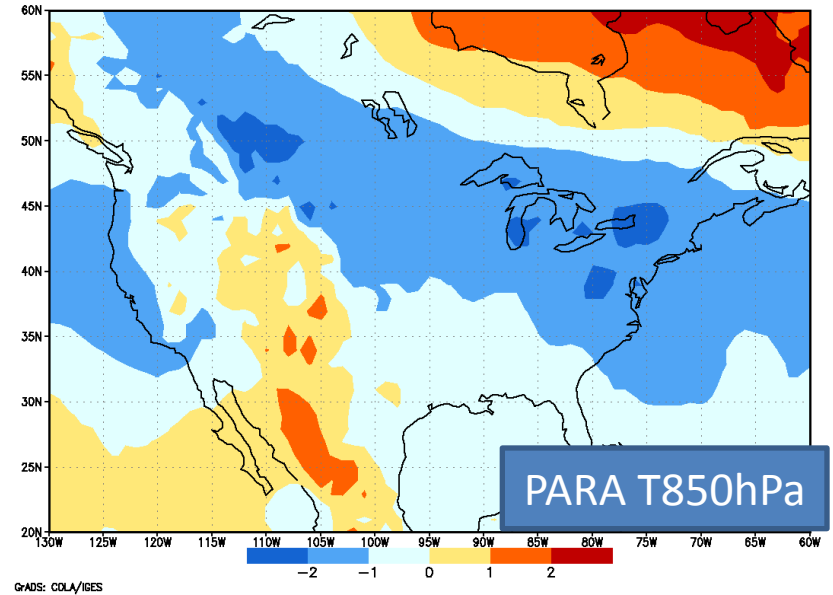
Accumulated forecast errors (bias) for surface temperature (PARA)  
Initial:2012012000 and forecast: 312 hours



Accumulated forecast errors (bias) for 850hPa temperature (PROD)  
Initial:2012012000 and forecast: 312 hours



Accumulated forecast errors (bias) for 850hPa temperature (PARA)  
Initial:2012012000 and forecast: 312 hours



# Summary for User Evaluations

- HPC
  - Recommend for implementation
- OPC
  - Endorse this implementation
- NHC
  - Endorse this implementation
- CPC
  - Recommend for implementation
- First energy – Peter Manousos
  - Recommend for implementation
- WFO – State College – Richard Grumm
  - Recommend for implementation