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HiResWindow Upgrade
Implementation Decision Brief
17 March 2011

Geoff DiMego for Matt Pyle, Brad Ferrier &
Staff of Mesoscale Modeling Branch

Where the Nation's climate and weather services begin

Topics

- Summary slide with links to data & displays
- Code upgrades & microphysics change
- Domain changes Guam & Puerto Rico
- Product generation updates
- Statistical at al. results
- Summary & plans for 2012

March 2011 Upgrade of HiResWindow

- Upgrade NMM & ARW to WRF v3.2 with *improved passive advection* in both cores
- Add Guam runs
- Add product generation: High Resolution Ensemble Forecast (HREF), BUFR, and SPC hourly max, fire wx and 80m agl fields.

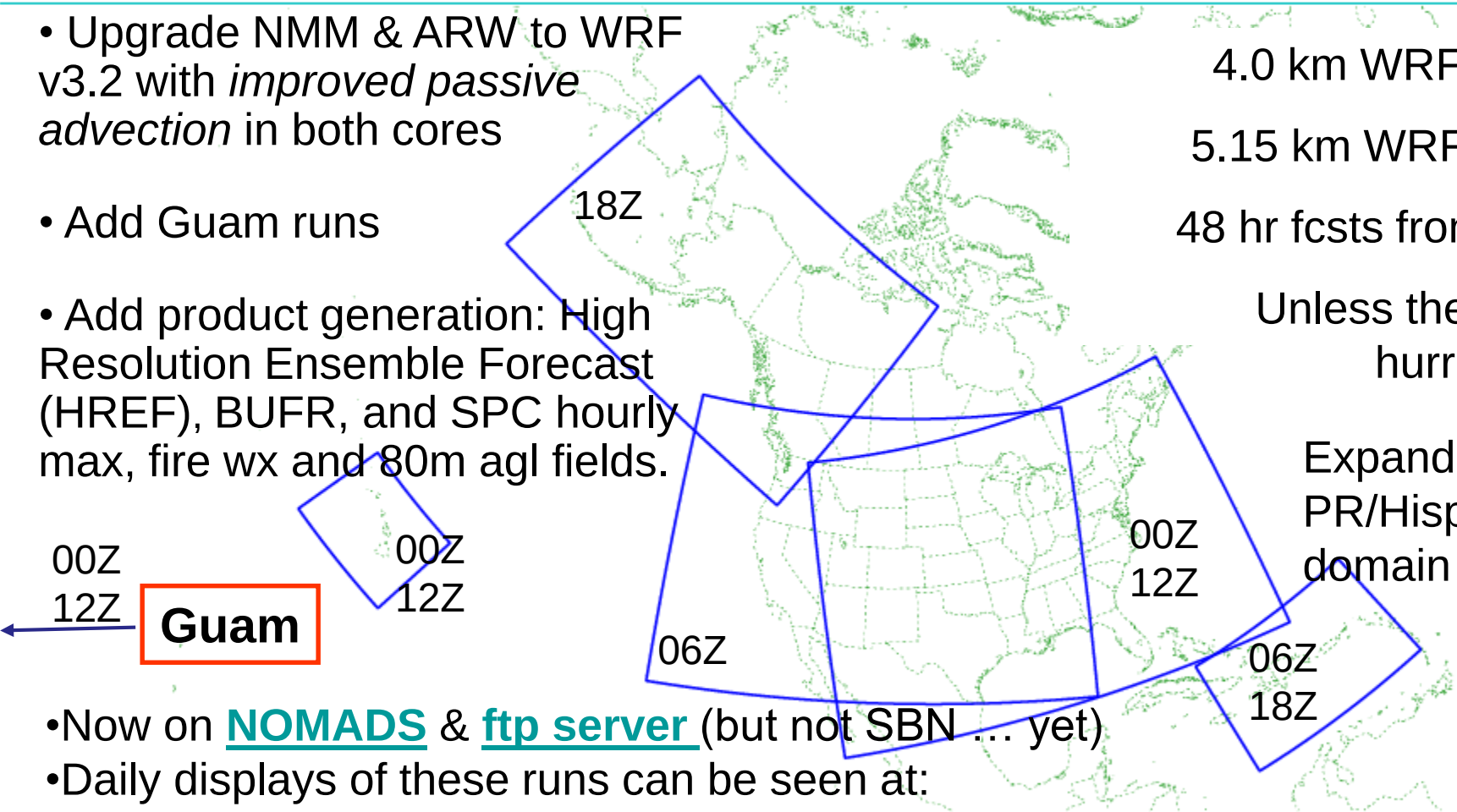
4.0 km WRF-NMM

5.15 km WRF-ARW

48 hr fcsts from both

Unless there are hurricanes

Expanded PR/Hispaniola domain

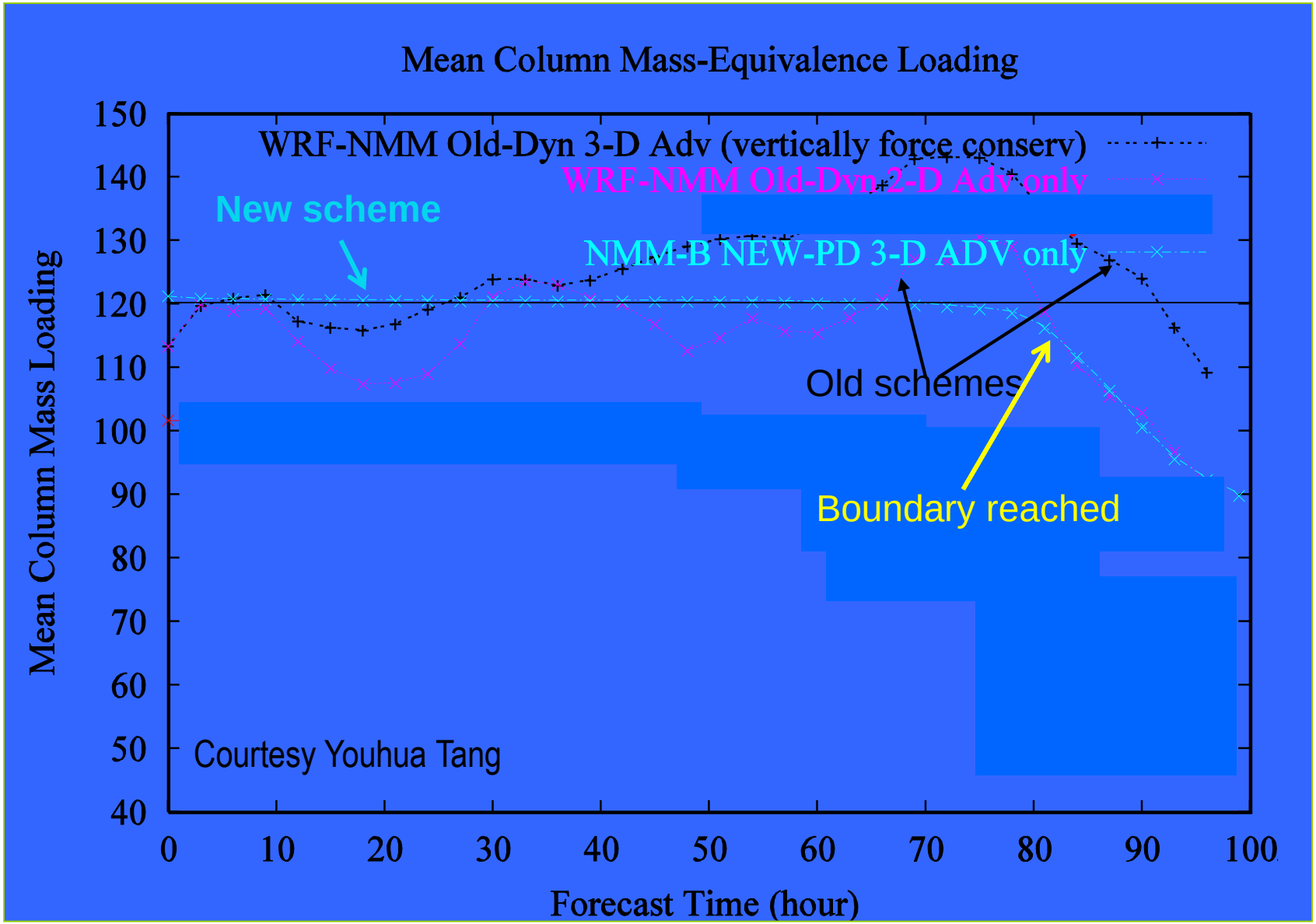


- Now on **NOMADS** & **ftp server** (but not SBN … yet)
- Daily displays of these runs can be seen at:
  http://www.nco.ncep.noaa.gov/pmb/nwprod/analysis/ and
  http://www.emc.ncep.noaa.gov/mmb/mmbpll/nestpage/
- Matt Pyle's full CONUS NMM runs [/00 or /12] for SPC can be seen at **http://www.emc.ncep.noaa.gov/mmb/mpyle/cent4km/conus/**

HiResW Upgrade Elements - 1

- Update/upgrade codes from WRF Version 2.2 (circa April 2007) to WRF Version 3.2 (circa April 2010)
  - With both cores (NMM and ARW) will now use better conserving schemes for advecting passive variables
    - TKE [turbulent kinetic energy]
    - Water vapor
    - Cloud condensate
    - Hydrometeors

Conservation Properties of NMM Passive Advection Schemes



Details of NCEP HiResWindow Runs

No Changes with This Upgrade

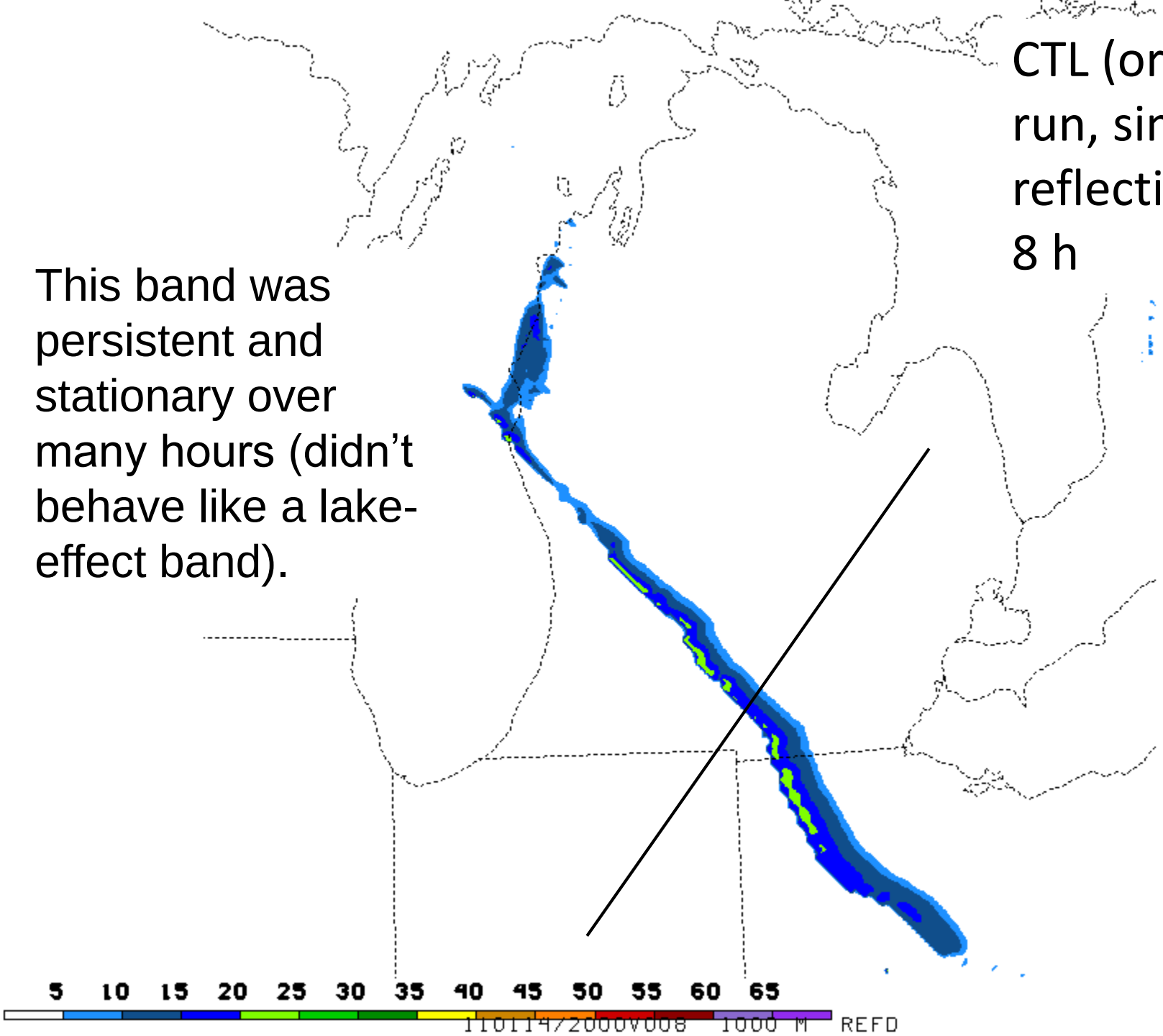
	WRF-NMM	WRF-ARW
Horizontal grid spacing (km)	4.0	5.15
Vertical levels	35 sigma-pressure hybrid	35 sigma
PBL/turbulence	MYJ	YSU
Microphysics	Ferrier	WSM3
Land-Surface	NOAH	NOAH
Radiation (SW/LW)	GFDL/GFDL	Dudhia/RRTM
Parameterized Convection	None	None

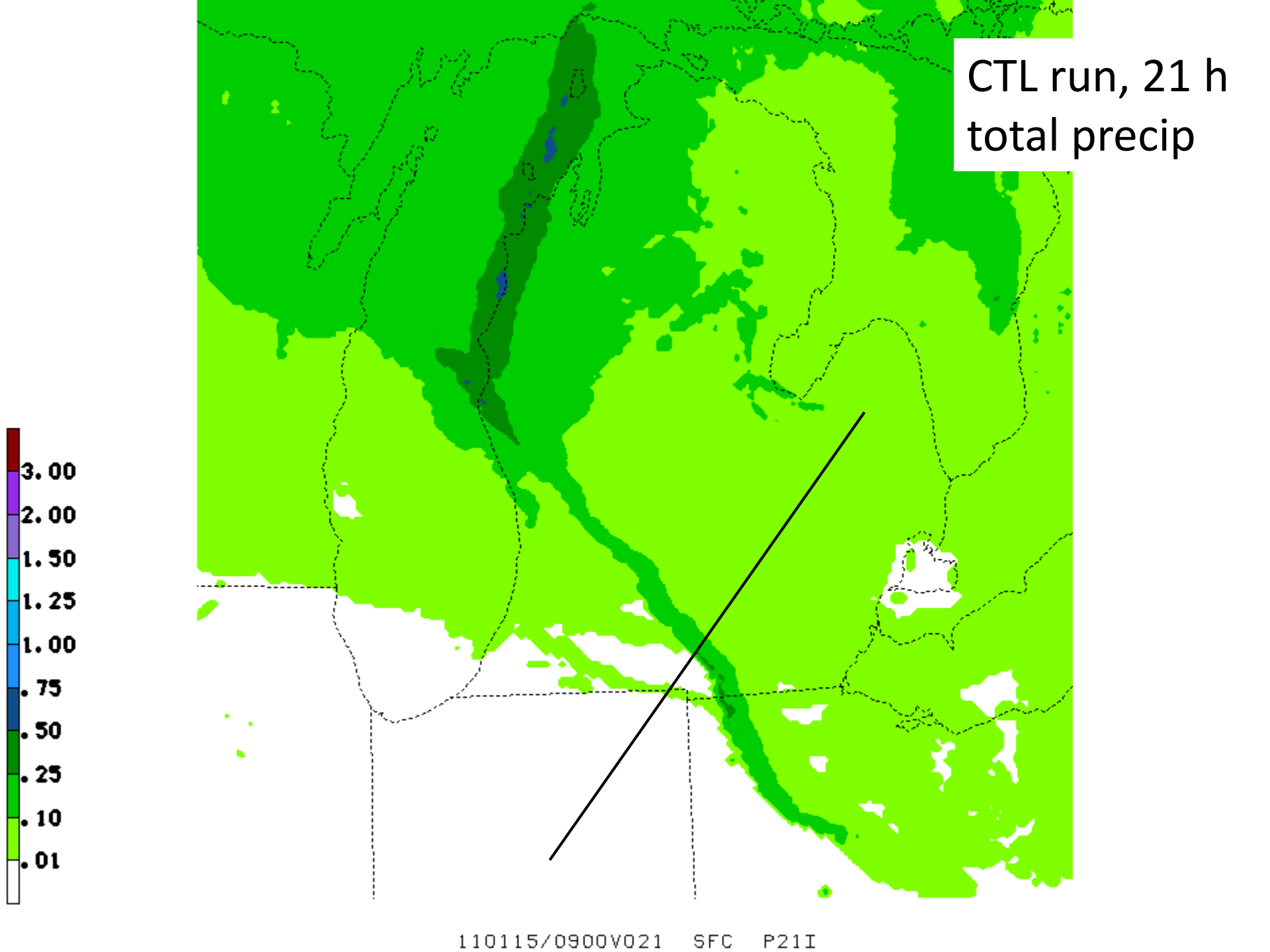
HiResW Upgrade Elements - 2

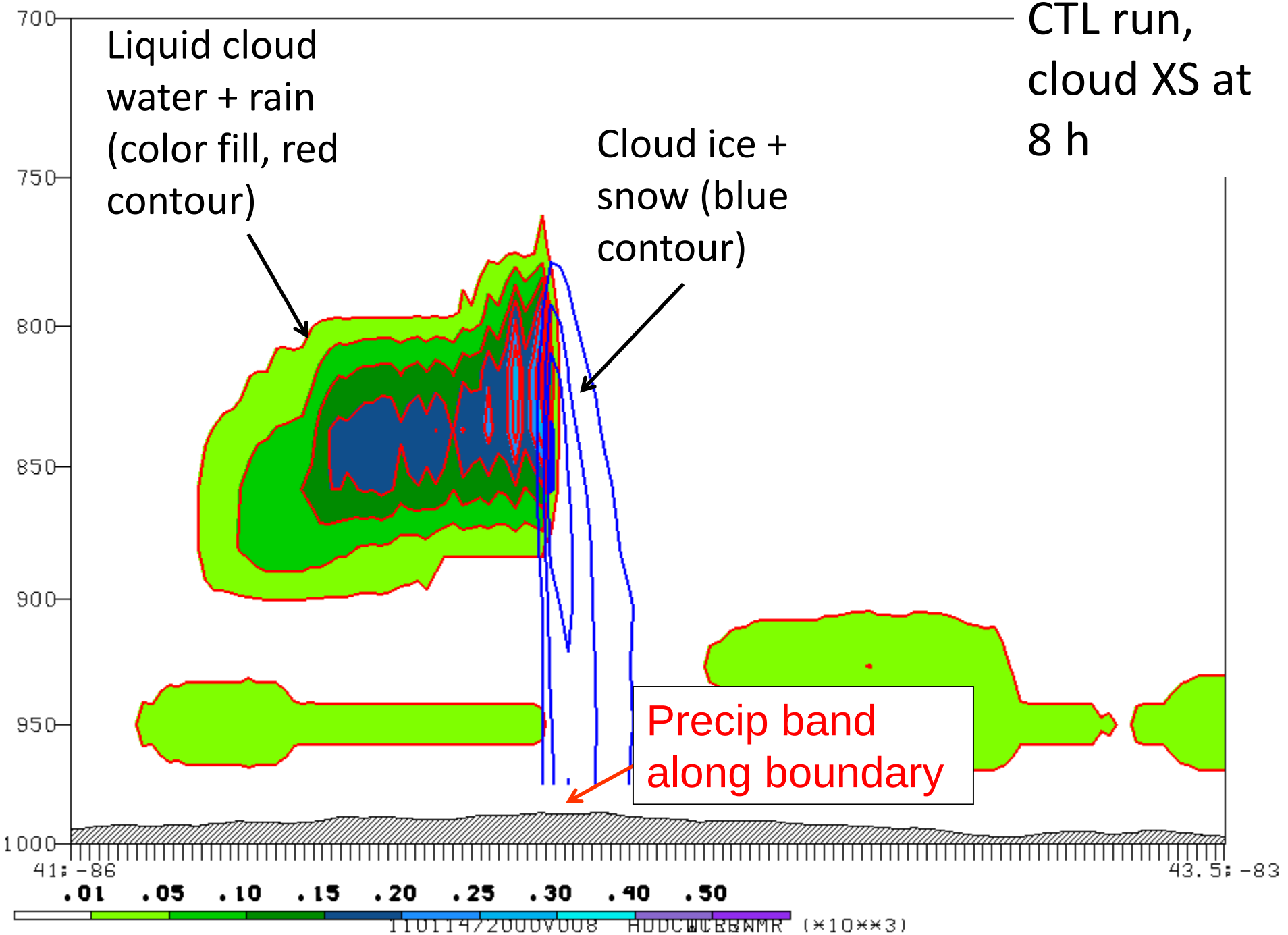
- Microphysics code change - background
  - Received an inquiry from HPC about a persistent (and bogus) precipitation band they observed in the HiResW during their winter experiment,
  - The band was evident in **both** the production and parallel WRF-NMM runs (though muted in the parallel).

CTL (orig para) run, simulated reflectivity at 8 h

This band was persistent and stationary over many hours (didn't behave like a lake-effect band).




CTL run, 21 h
total precip
3.00
2.00
1.50
1.25
1.00
.75
.50
.25
.10
.01
110115/0900V021 SFC P21I

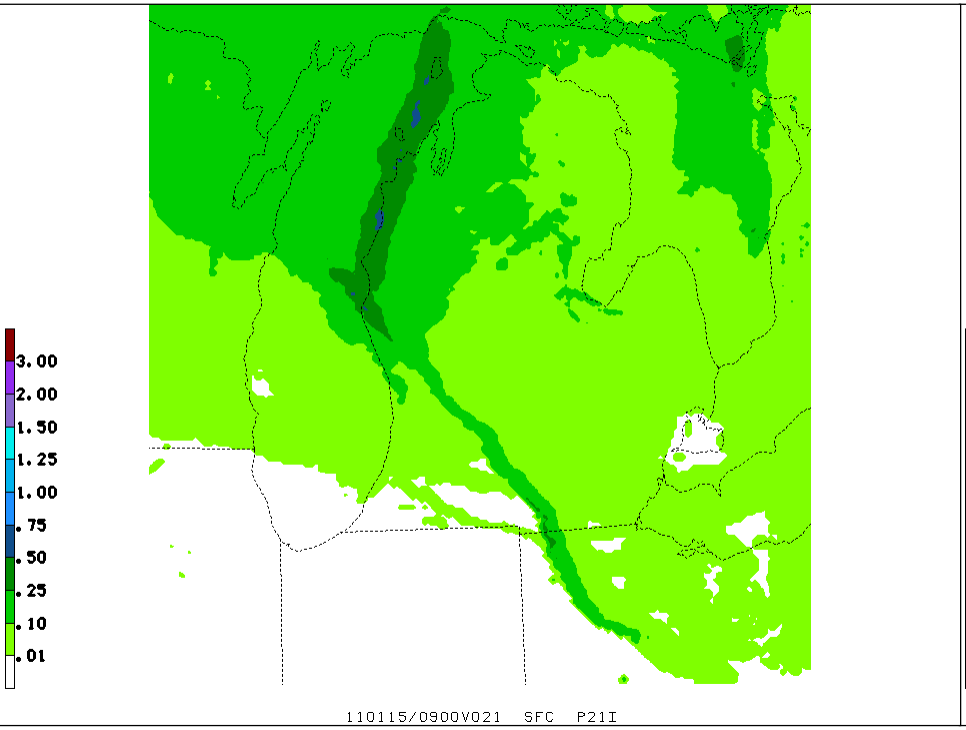

CTL run, cloud XS at 8 h
Liquid cloud water + rain (color fill, red contour)
Cloud ice + snow (blue contour)
Precip band along boundary
700
750
800
850
900
950
1000
41: -86
43.5: -83
.01 .05 .10 .15 .20 .25 .30 .40 .50
(*10**3)

Microphysics Code Change

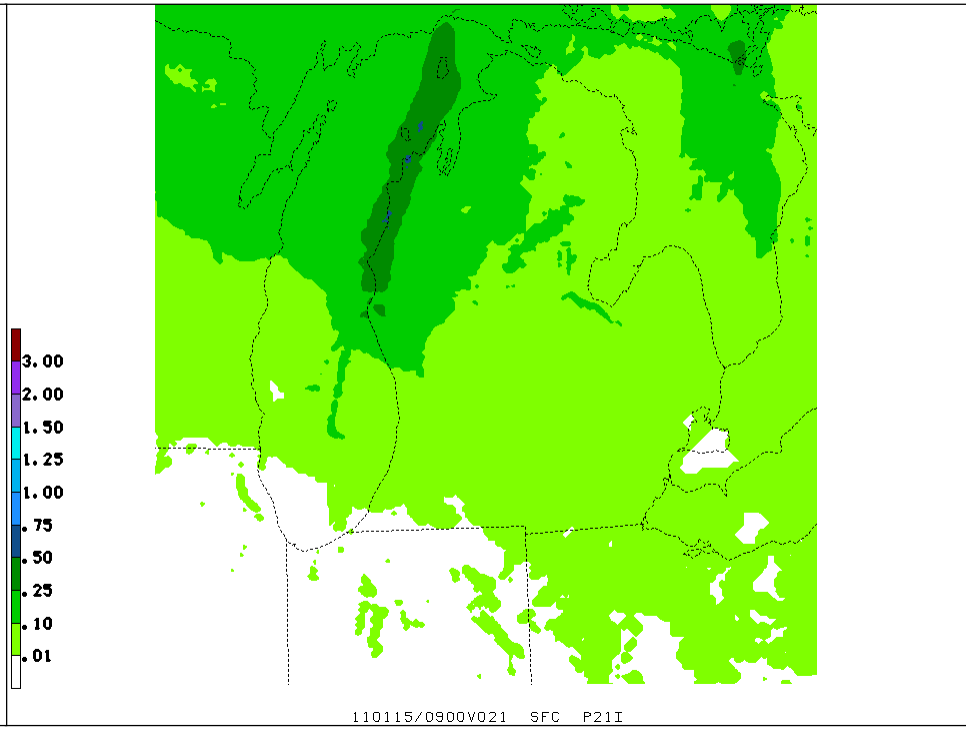
- Quick insight from Brad Ferrier led to a test modification of the cloud microphysics allowing ice nucleation to begin at warmer temperatures:

  T_ice_init changed from -15 C to -5 C

- This change worked perfectly, eliminating the specific pathology, and having very small forecast impact over several other test cases.



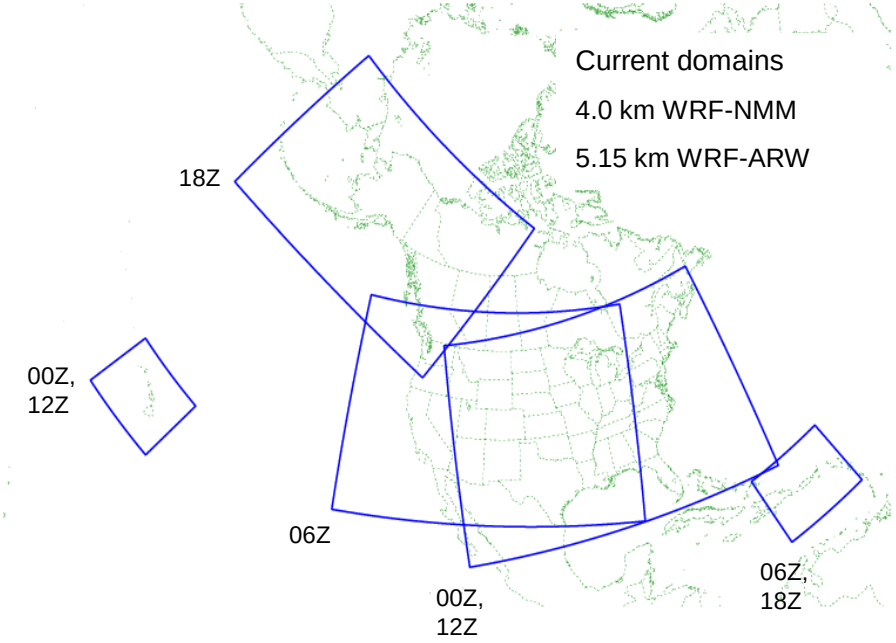
CTL run, 21 h total precip

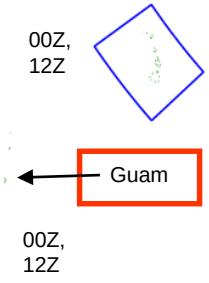


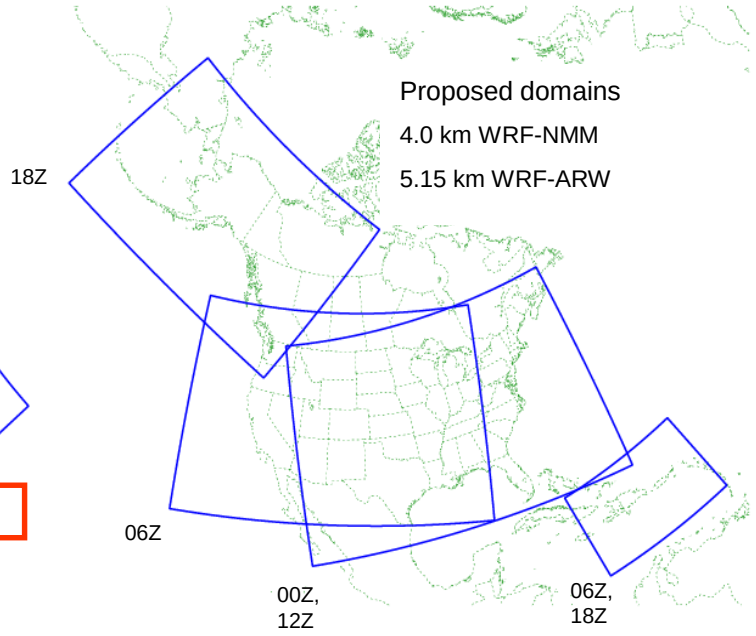
EXP run, 21 h total precip

HiResW Upgrade Elements - 3

- Domain Changes
  - Add Guam runs at 00z & 12z as 6th domain covered by the HiResW
    - By agreement with PR
      - Can drop RSM run for Hawaii
      - Guam runs not subject to preemption by hurricane runs
    - Superior first guess for Guam RTMA (will replace downscaled GFS).
  - Expand Puerto Rico nest domain to cover Hispaniola for Haiti earthquake recovery support.

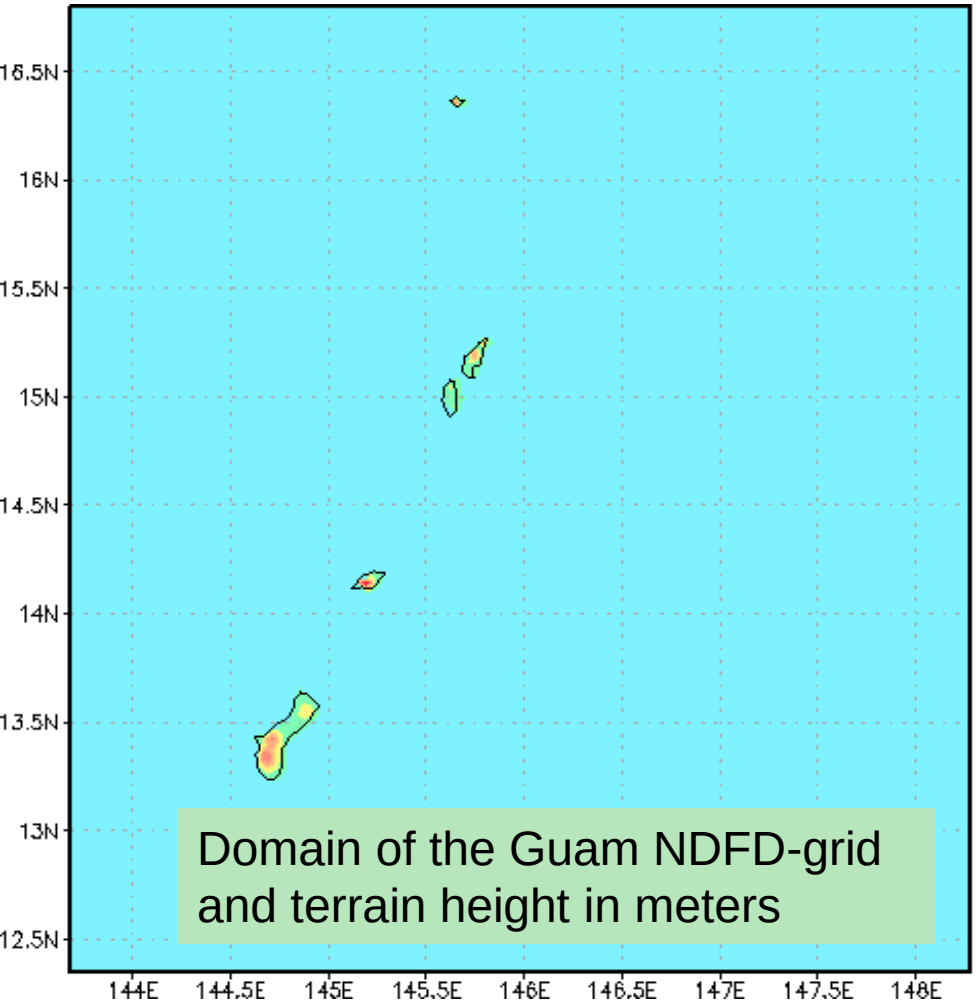


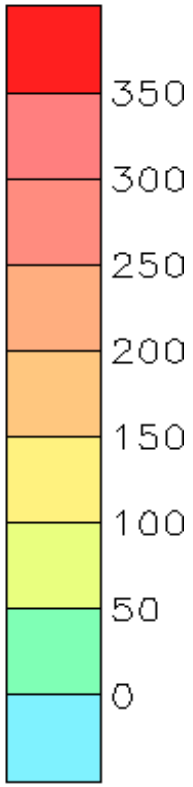




GUAM-RTMA

New System Implemented 28 Sept 2010





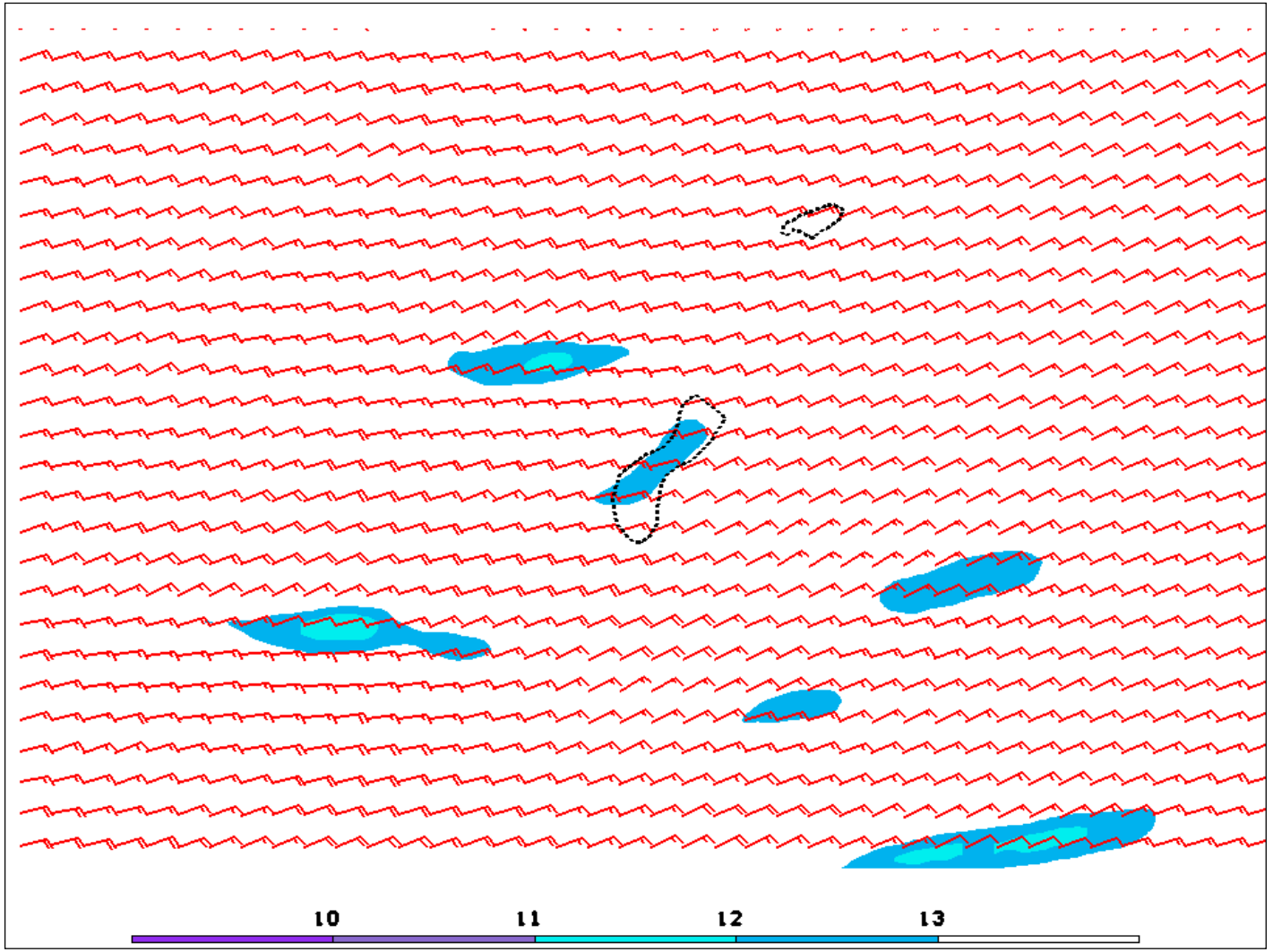
Description

- Mercator grid
- 2.5 km resolution
- 193 x 193 grid points
- Use Unified RTMA code
- Use GFS forecasts downscaled to 2.5km as First Guess
- Use Terrain following background-error covariances
- Analyze 2m-T, 2m- q , 10m-u,10m - v, and psfc
- Compute analysis uncertainty

- **ISSUE: Downscaled GFS has no diurnal cycle**
- **HiResWindow Guam forecast will be superior**

10 m winds, NMM HiresW, 20110310/12Z cycle

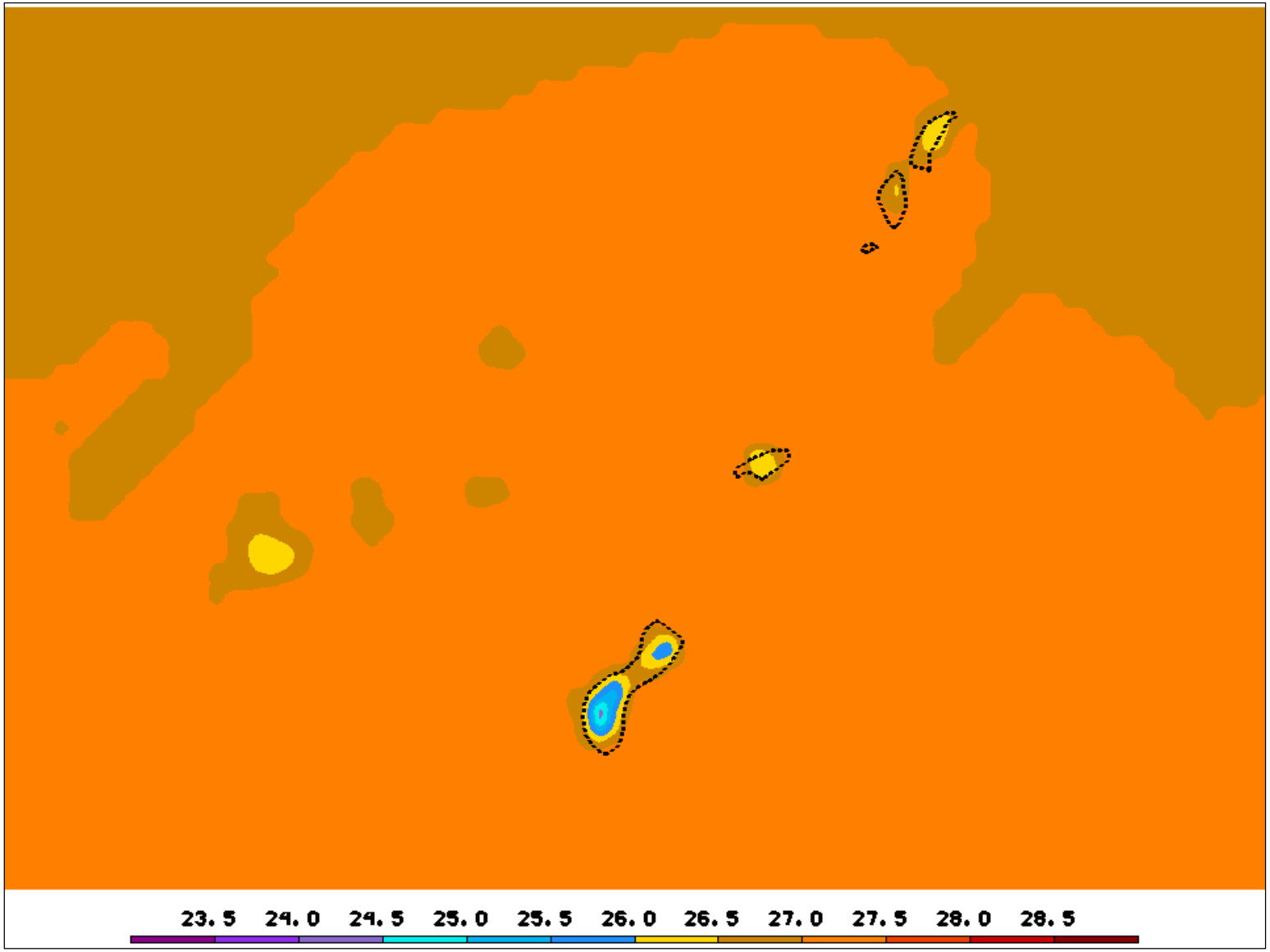
f24- f34 (12Z to 22Z - overnight)



Weaker winds shaded

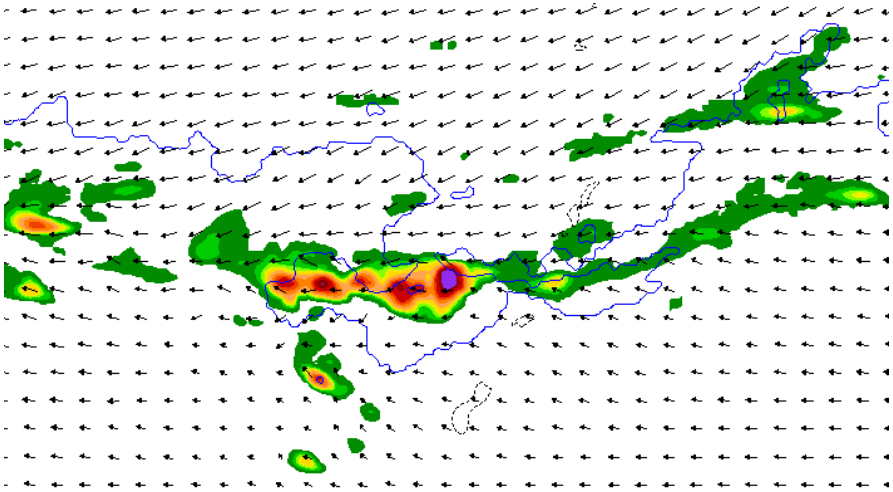
2 m T, NMM HiresW, 20110310/12Z cycle

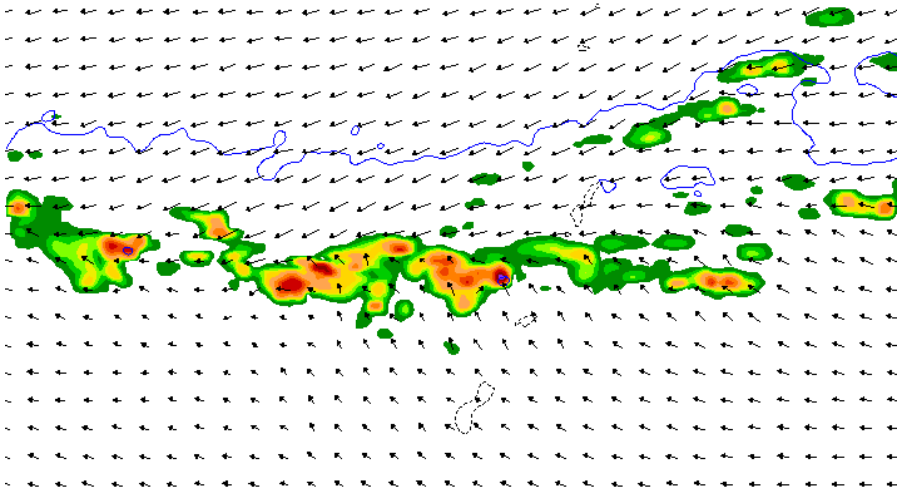
F09 (21Z - morning)



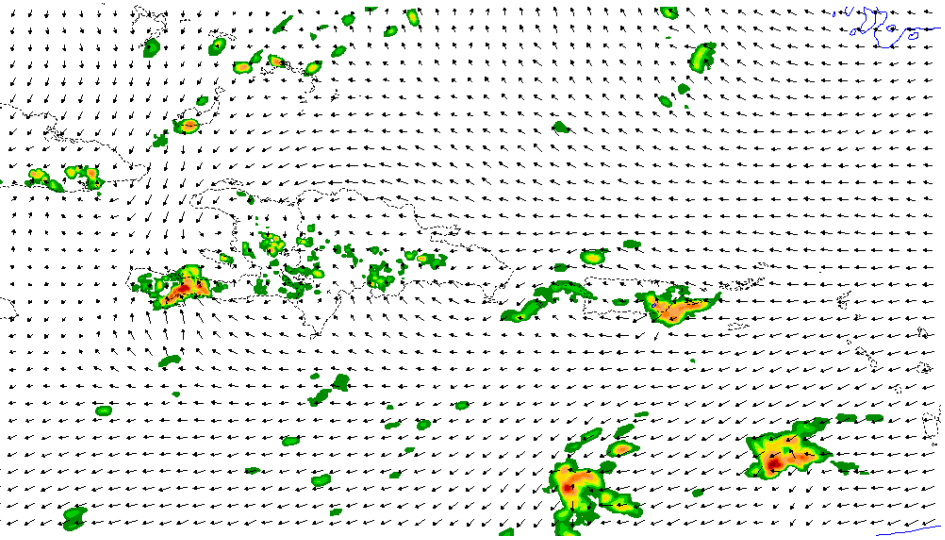
Sample 1 hr Precip Forecasts at 18 hr

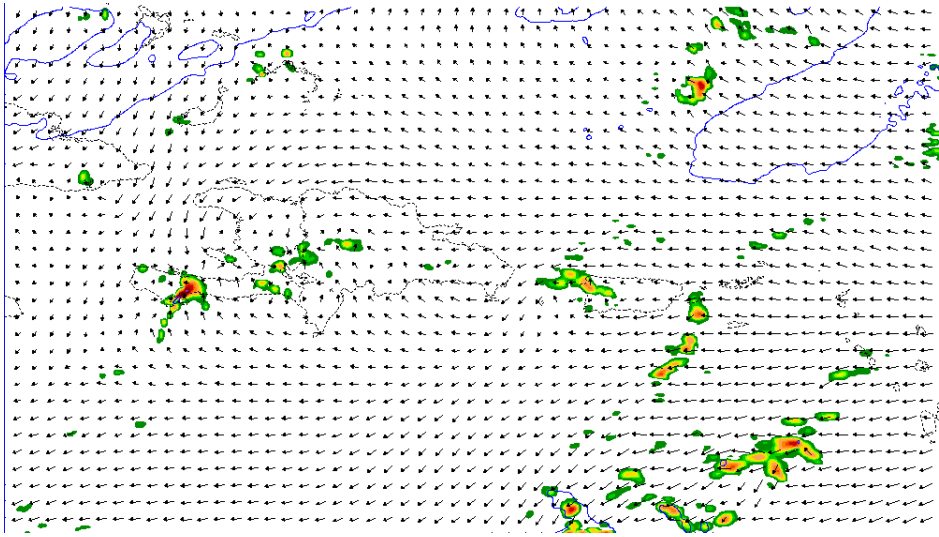
NMM Guam from 8 Feb 00z ARW Guam





NMM Puerto Rico from 2 Mar 06z ARW Puerto Rico



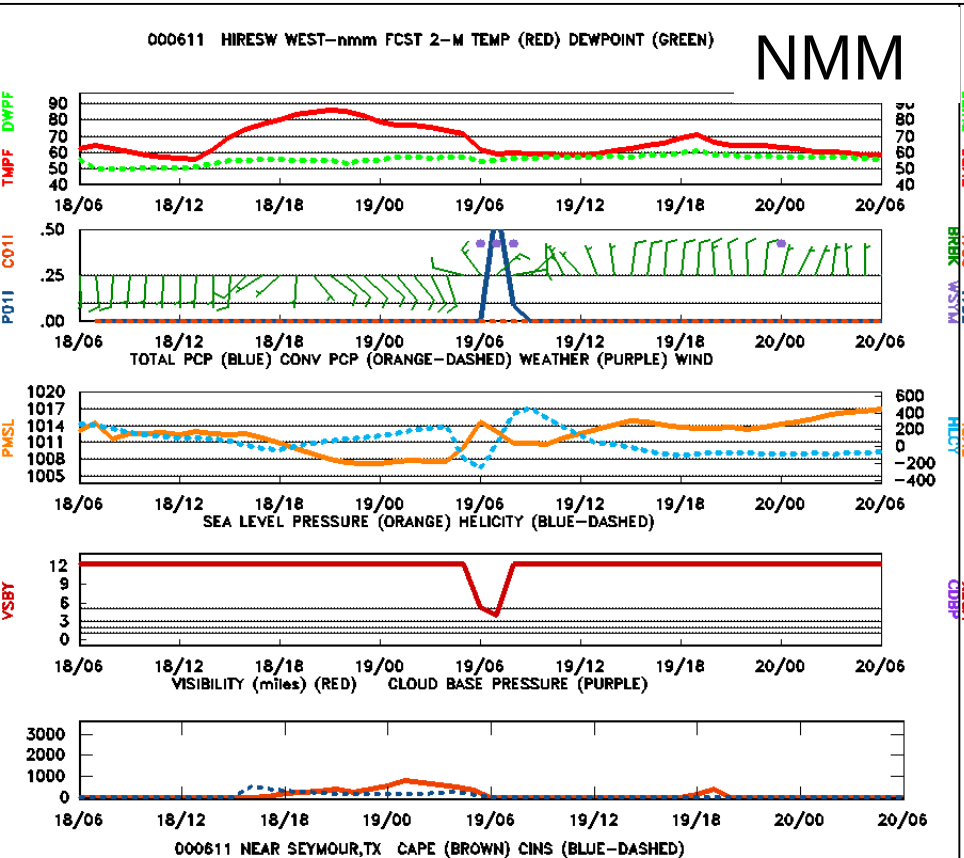


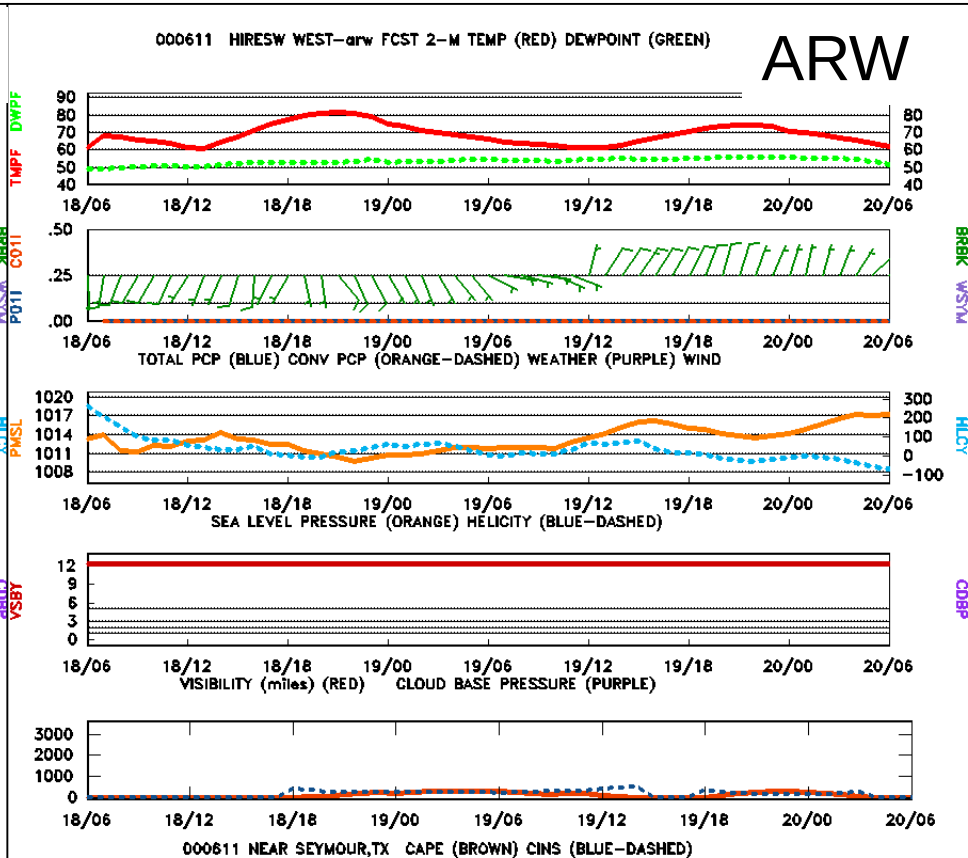
HiResW Upgrade Elements - 4

- Add / enhance product generation:
  - Add generation of BUFR output (hourly point forecast soundings) for both cores and SPC, fire wx and 80m agl fields.
  - Produce High Resolution Ensemble Forecast (HREF) products (Du 2004).
  - Add simulated radar echo top and hourly maxima of select severe weather forecasting fields for SPC
  - Add PBL height and other fields for Fire Weather support
  - Add 80m agl (above ground level) temp, wind, moisture and pressure for wind energy sector.

BUFR output

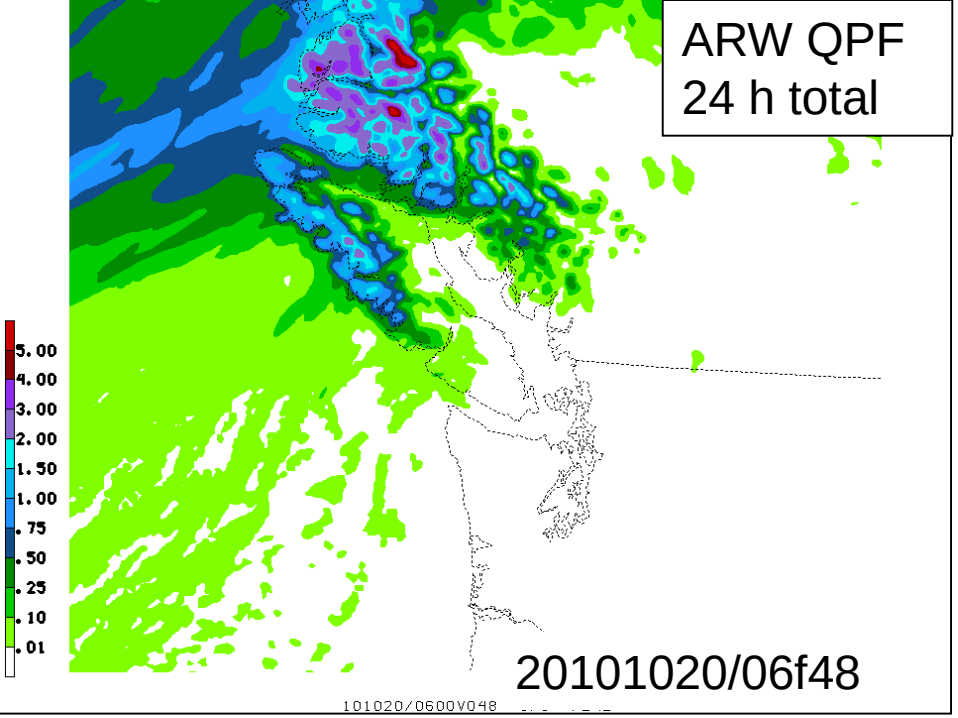
- Hourly BUFR output from the HiResW was dropped when switching from non-WRF NMM to the WRF-based dual NMM & ARW system back in 2005.
- With this upgrade package, it FINALLY will be restored.

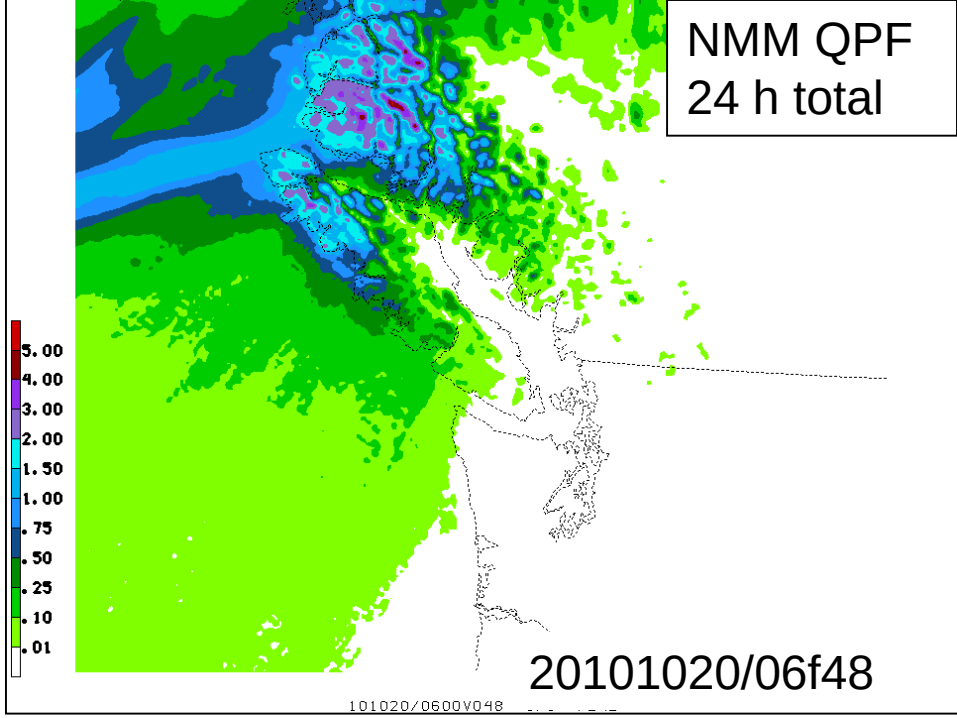


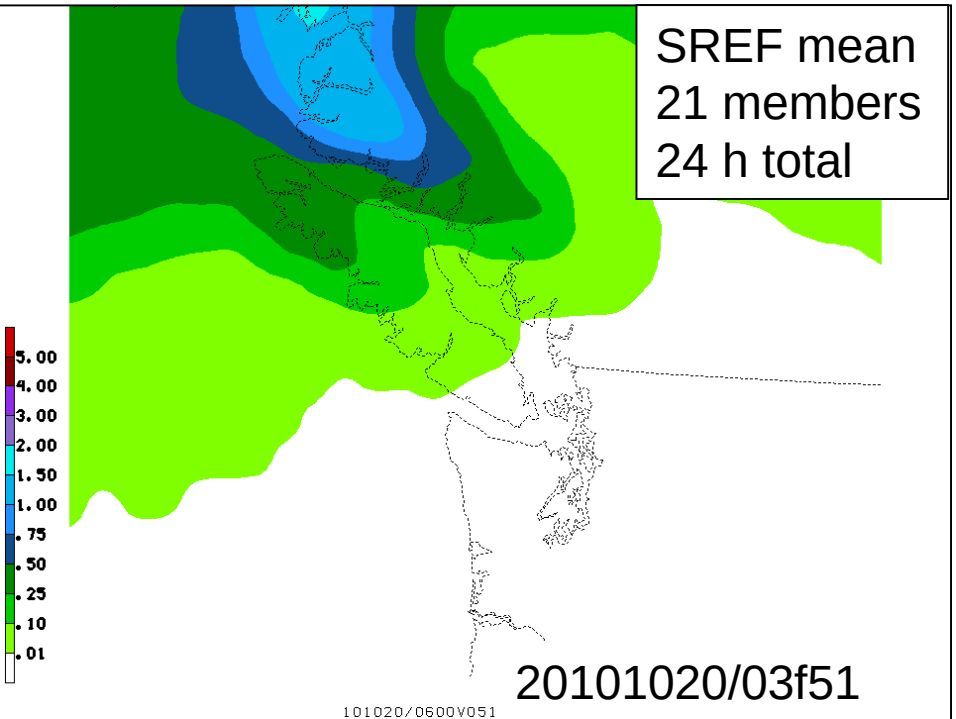


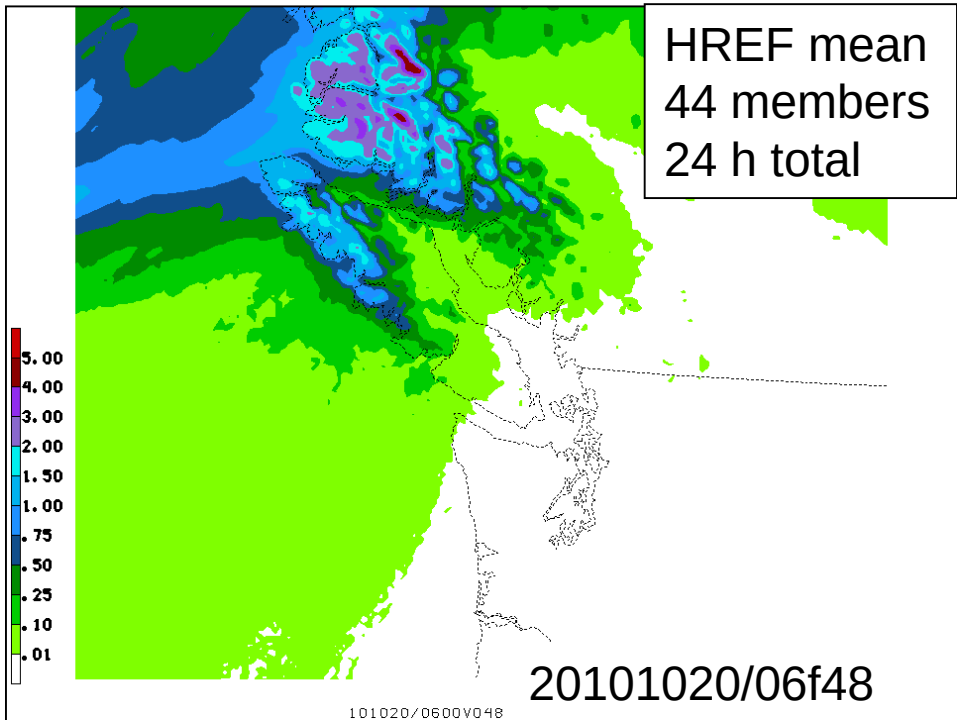
HREF Ensemble Guidance (aka Hybrid)

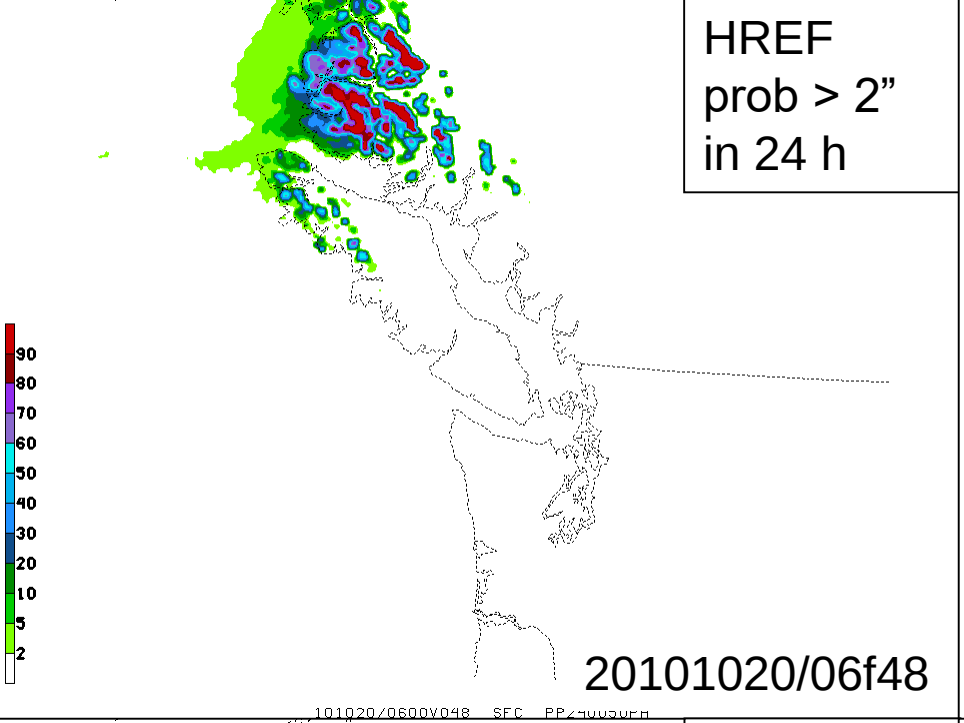
- 21 SREF members are interpolated to the HiResW output domains (excluding Guam).
- The SREF perturbations are combined with the two HiResW (NMM and ARW) deterministic runs to produce a 44-member “ensemble”.
- Provides higher-resolution probabilistic and ensemble-mean guidance at minimal computational expense.
- Motivated by the Hanson Dam issue in Washington.

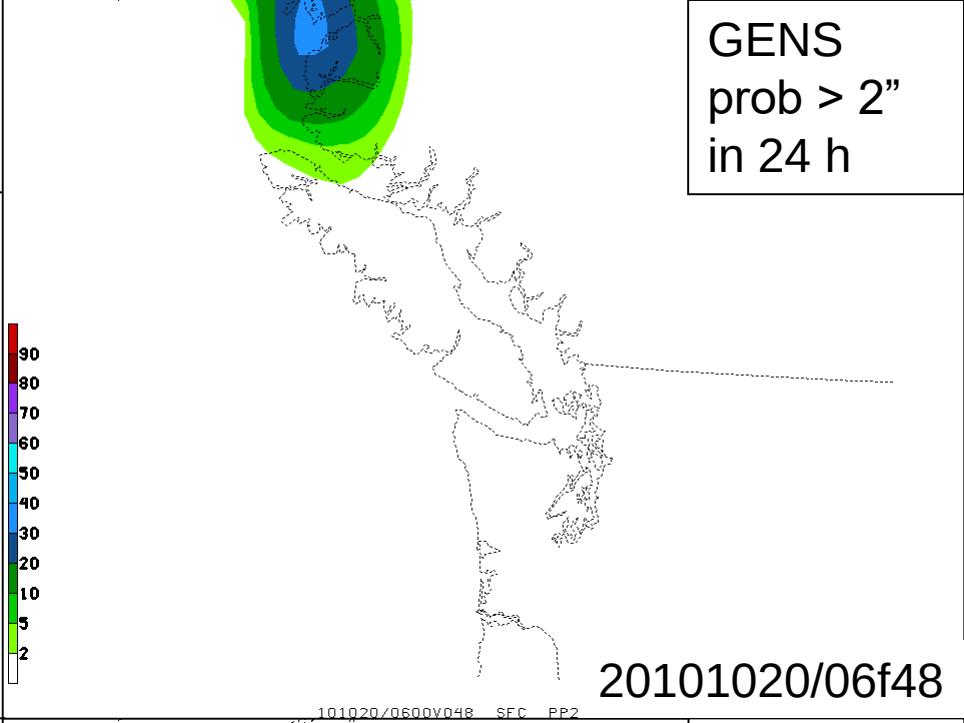

ARW QPF
24 h total
5.00
4.00
3.00
2.00
1.50
1.00
.75
.50
.25
.10
.01
20101020/06f48
101020/0600V048

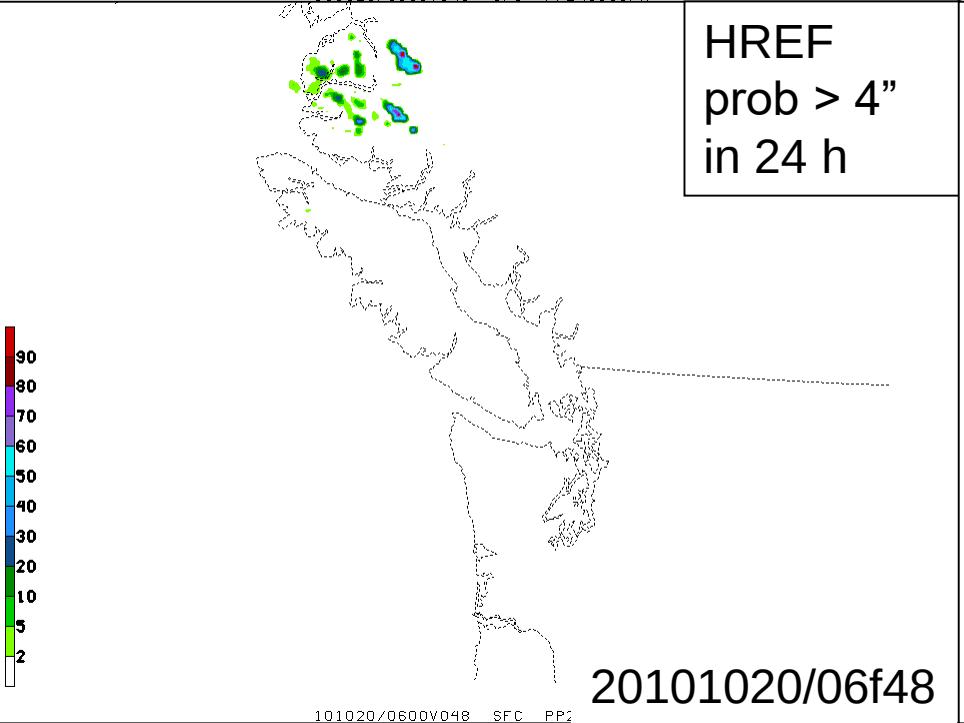

NMM QPF
24 h total
5.00
4.00
3.00
2.00
1.50
1.00
.75
.50
.25
.10
.01
20101020/06f48
101020/0600V048

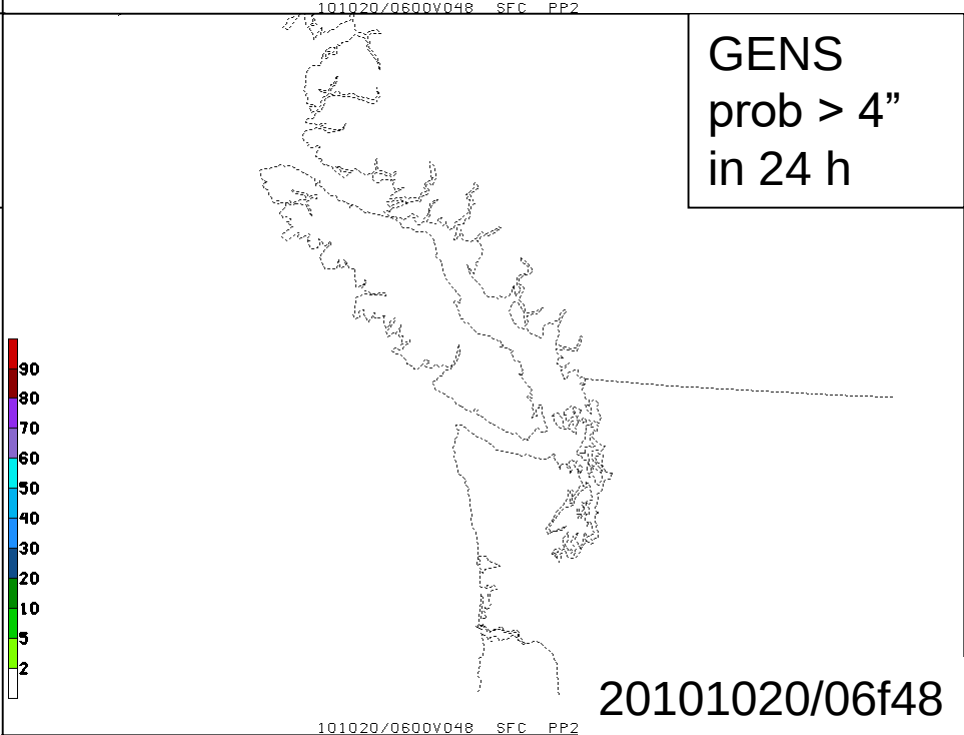

SREF mean
21 members
24 h total
5.00
4.00
3.00
2.00
1.50
1.00
.75
.50
.25
.10
.01
20101020/03f51
101020/0600V051


HREF mean
44 members
24 h total
5.00
4.00
3.00
2.00
1.50
1.00
.75
.50
.25
.10
.01
20101020/06f48
101020/0600V048

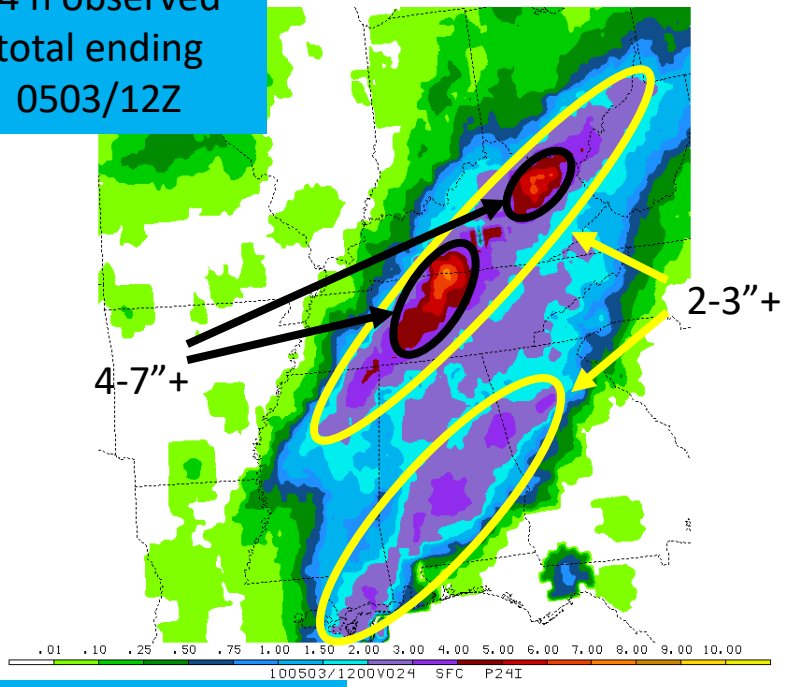

HREF
prob > 2”
in 24 h
90
80
70
60
50
40
30
20
10
5
2
20101020/06f48


GENS
prob > 2”
in 24 h
90
80
70
60
50
40
30
20
10
5
2
20101020/06f48

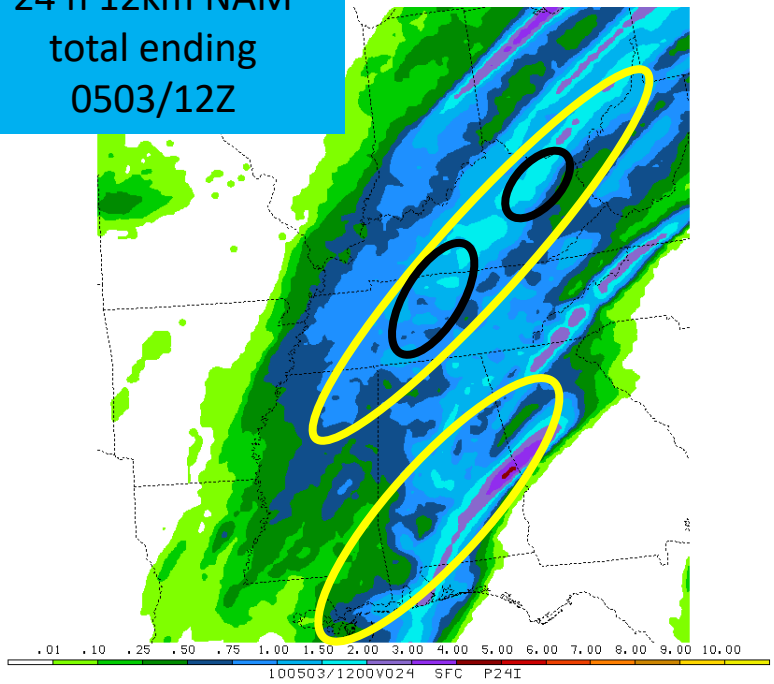

HREF
prob > 4”
in 24 h
90
80
70
60
50
40
30
20
10
5
2
20101020/06f48


GENS
prob > 4”
in 24 h
90
80
70
60
50
40
30
20
10
5
2
20101020/06f48

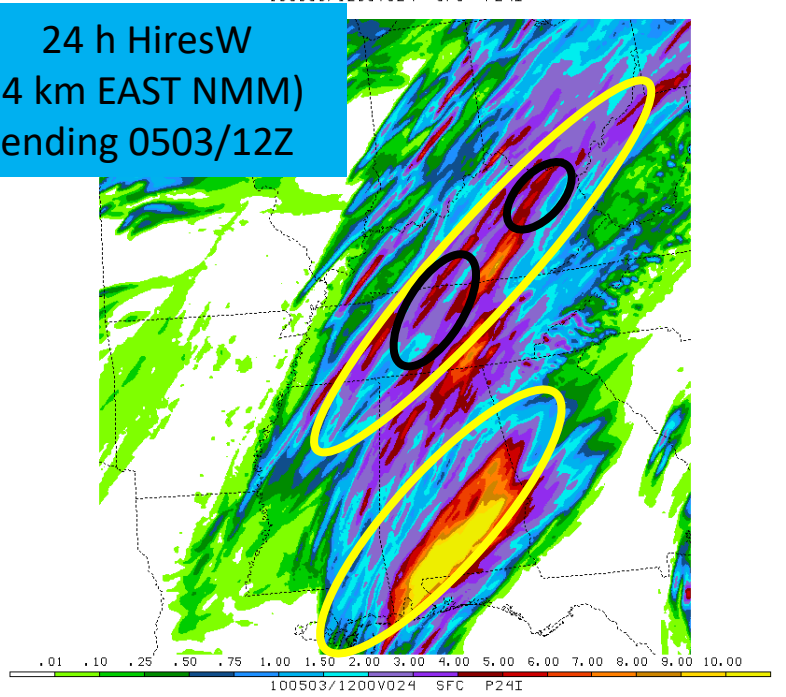
24 h observed
total ending
0503/12Z



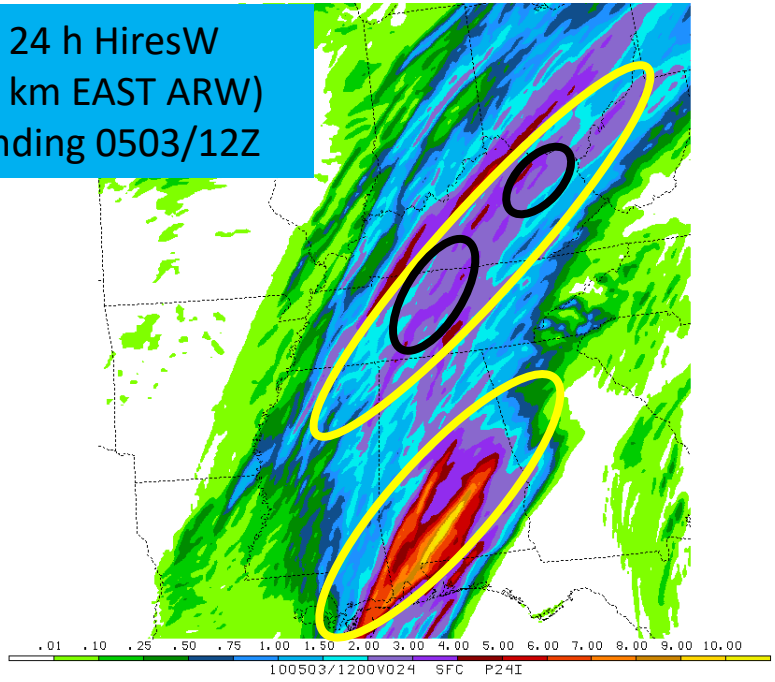
24 h 12km NAM
total ending
0503/12Z



24 h HiresW
(4 km EAST NMM)
ending 0503/12Z

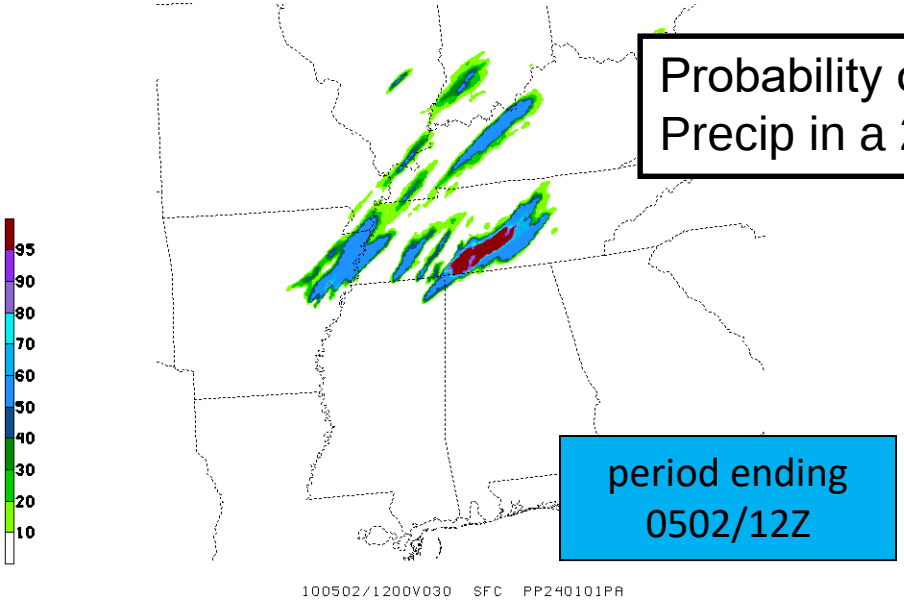


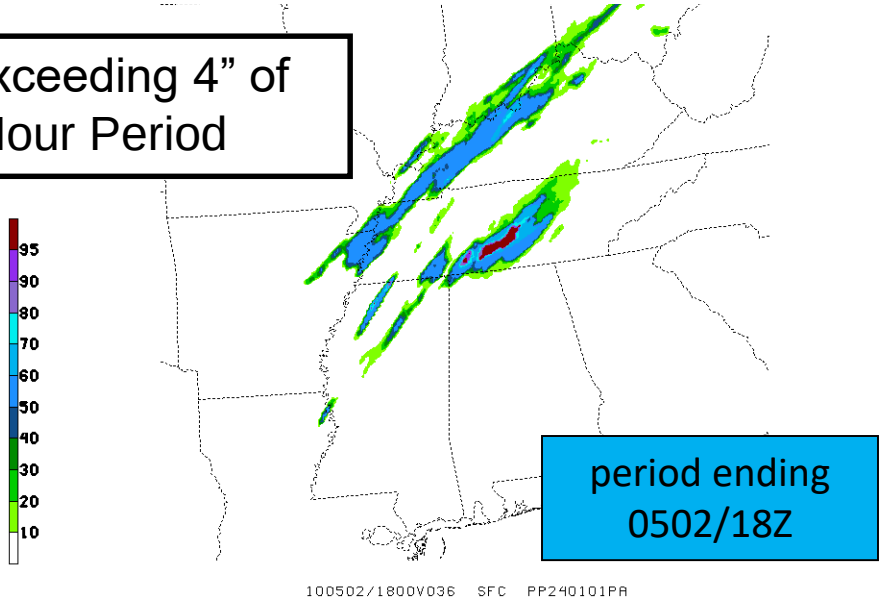
24 h HiresW
(5 km EAST ARW)
ending 0503/12Z

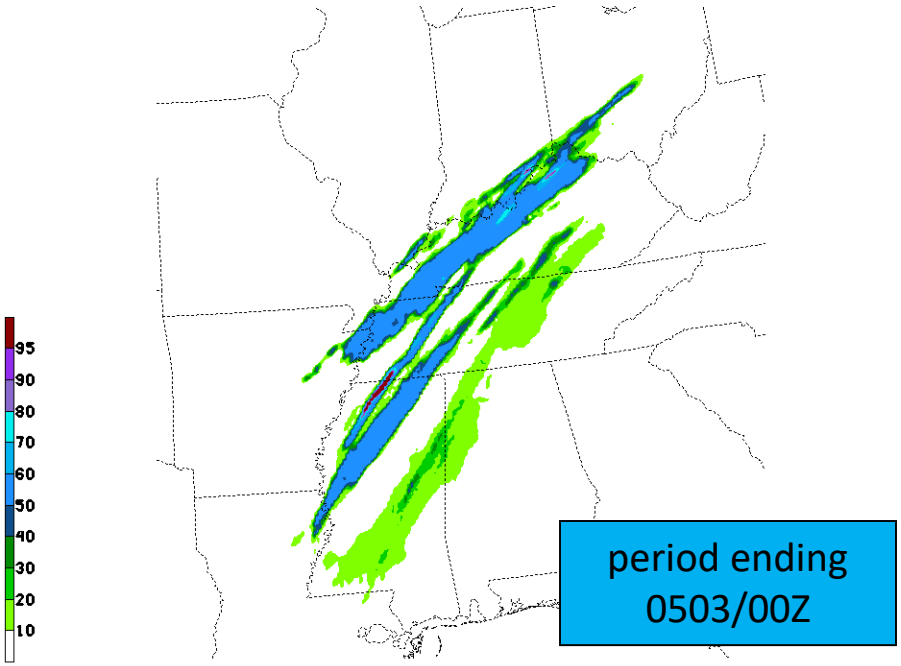


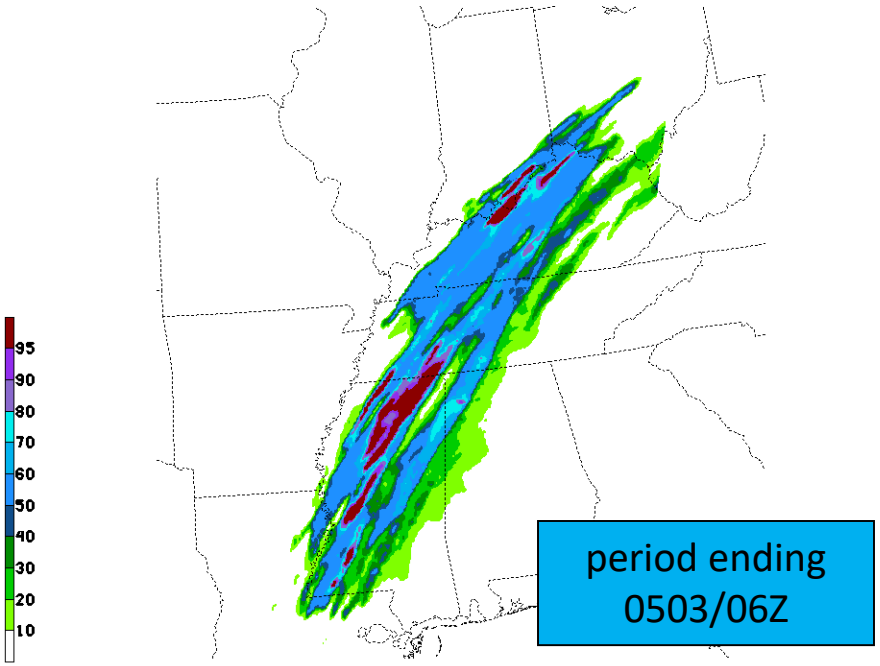
Experimental High Resolution Ensemble Forecast

Probability of Exceeding 4” of Precip in a 24 Hour Period









New HiResEnsFcst (HREF) Output Fields from HiResW – 1

Ensemble Mean & Spread (standard deviation) fields:

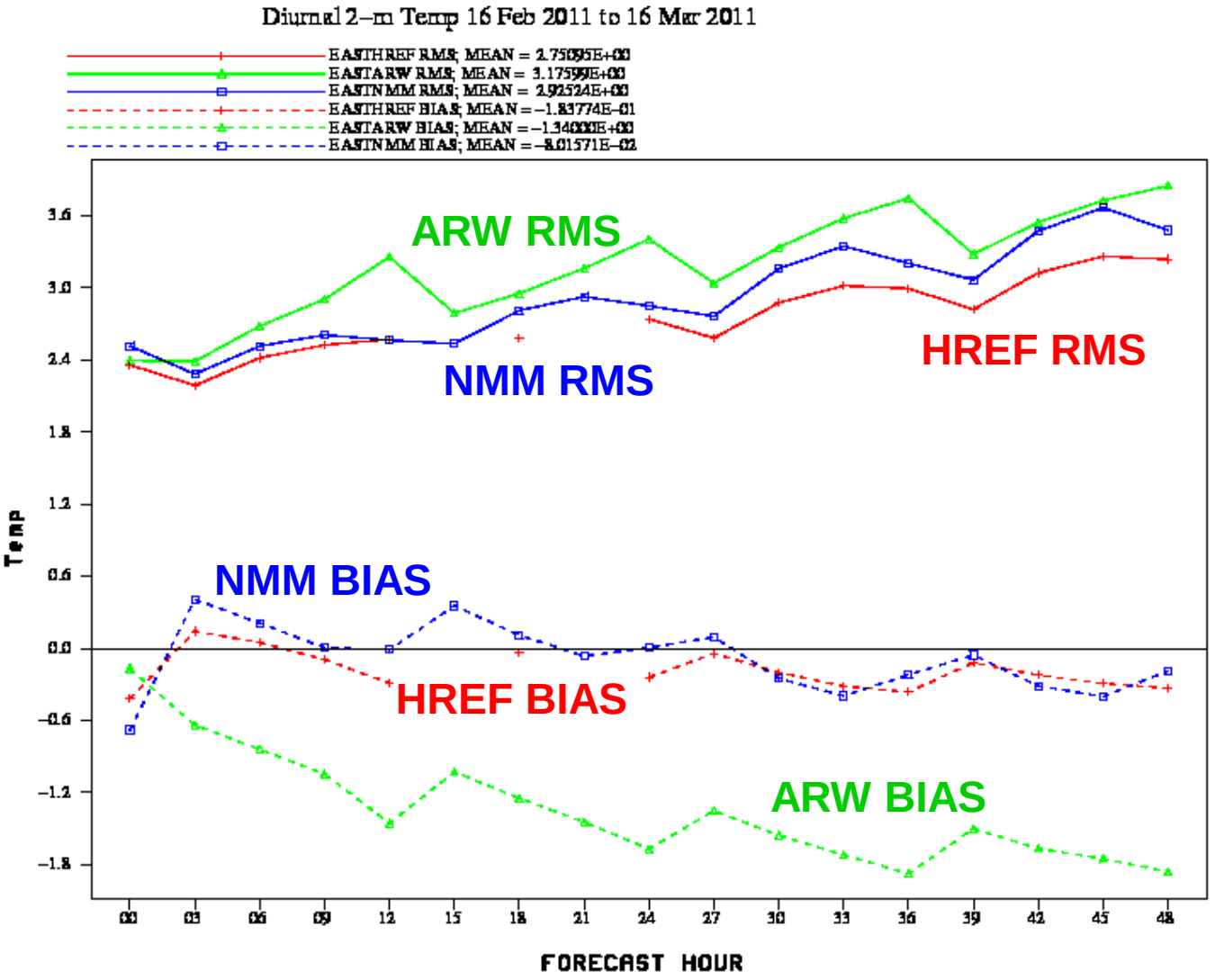
- UGRD 10 m above ground
- VGRD 10 m above ground
- UGRD 850 mb
- VGRD 850 mb
- UGRD 250 mb
- VGRD 250 mb
- PRMSL mean sea level
- HGT 500 mb
- RH 850 mb
- RH 2 m above ground
- TMP 850 mb
- TMP 500 mb
- TMP 250 mb
- TMP 2 m above ground
- CAPE surface
- CIN surface
- WIND SPD 10 m above ground
- WIND SPD 850 mb
- WIND SPD 250 mb
- APCP (3 h, 6 h, 12 h, and 24 h accumulations as available for a given forecast range)

New HiResEnsFcst (HREF) Output Fields from HiResW – 2

Ensemble Probability fields:

- TMP 2 m agl prob < 273
- TMP 2 m agl prob > 298.8
- TMP 850 mb prob < 273
- CAPE surface prob > 500
- CAPE surface prob > 1000
- CAPE surface prob > 2000
- CAPE surface prob > 3000
- CAPE surface prob > 4000
- CIN surface prob < -50
- CIN surface prob < -100
- CIN surface prob < -200
- CIN surface prob < -300
- CIN surface prob < -400
- WIND SPD 10 m agl prob > 12.89
- WIND SPD 10 m agl prob > 17.5
- WIND SPD 10 m agl prob > 25.78
- Accumulated Precip probabilities at these thresholds (.01" to 6“ equivalents) for 3 h, 6 h, 12 h, and 24 h (as available at a given forecast range):
  - APCP prob > 0.25 mm
  - APCP prob > 1.27 mm
  - APCP prob > 2.54 mm
  - APCP prob > 6.35 mm
  - APCP prob > 12.7 mm
  - APCP prob > 25.4 mm
  - APCP prob > 38.1 mm
  - APCP prob > 50.8 mm
  - APCP prob > 101.6 mm
  - APCP prob > 152.4 mm

HREF Mean, ARW & NMM
2m Temperature vs Surface Obs

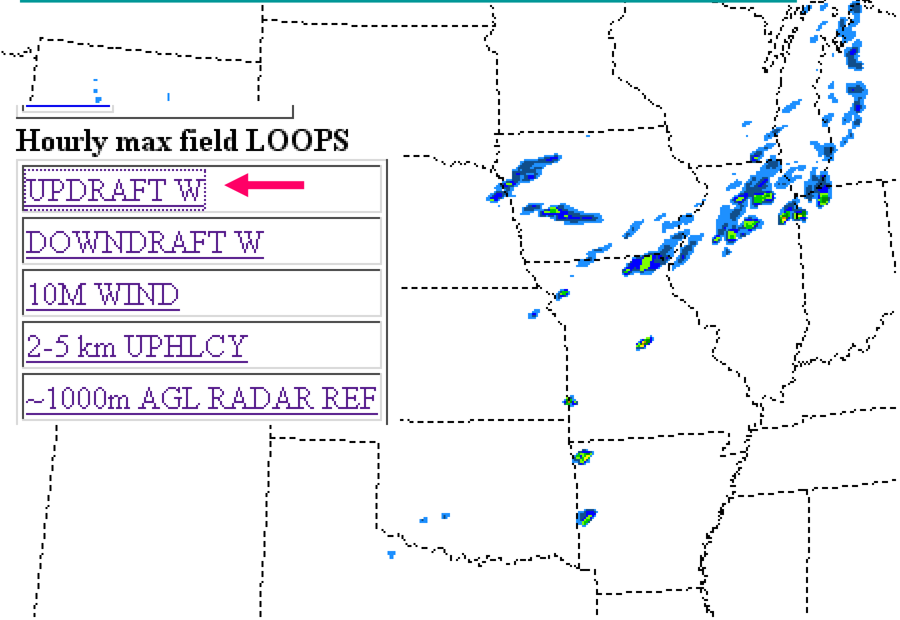


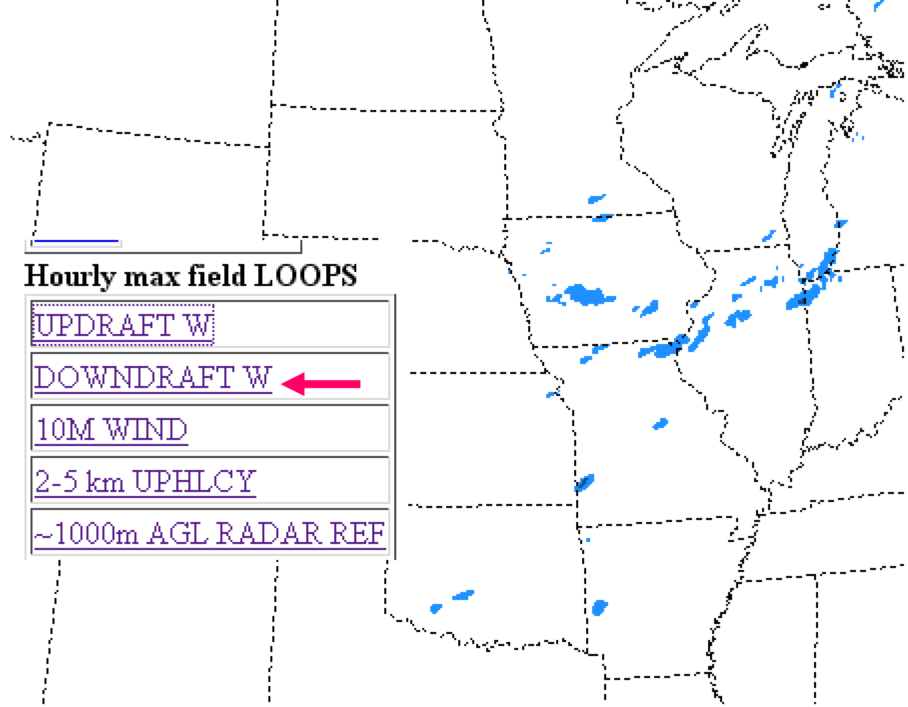
HREF has Lowest RMS & Good BIAS

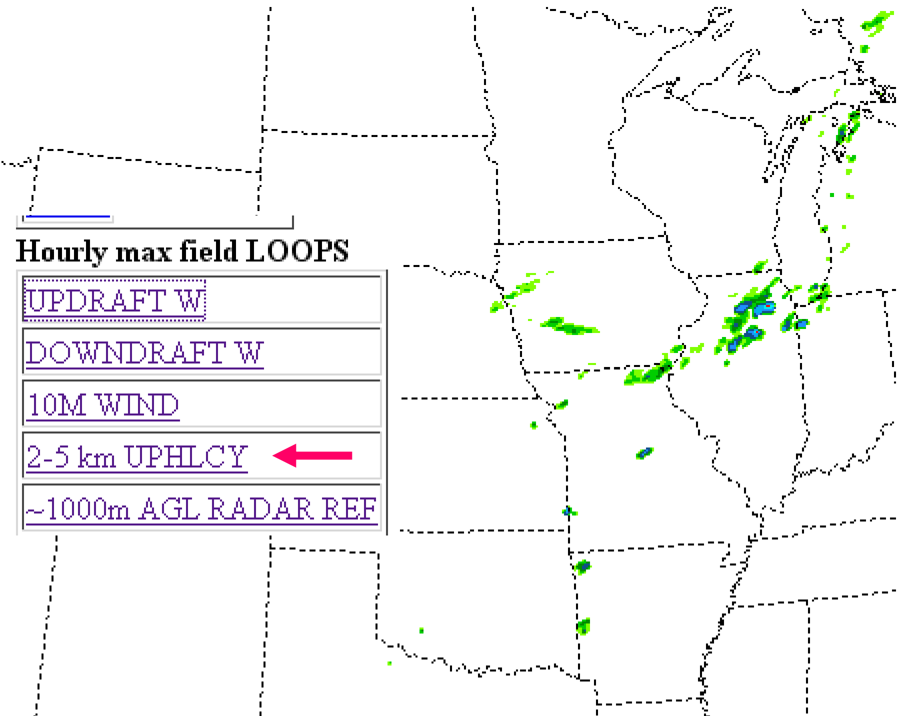
New Output Fields from HiResW

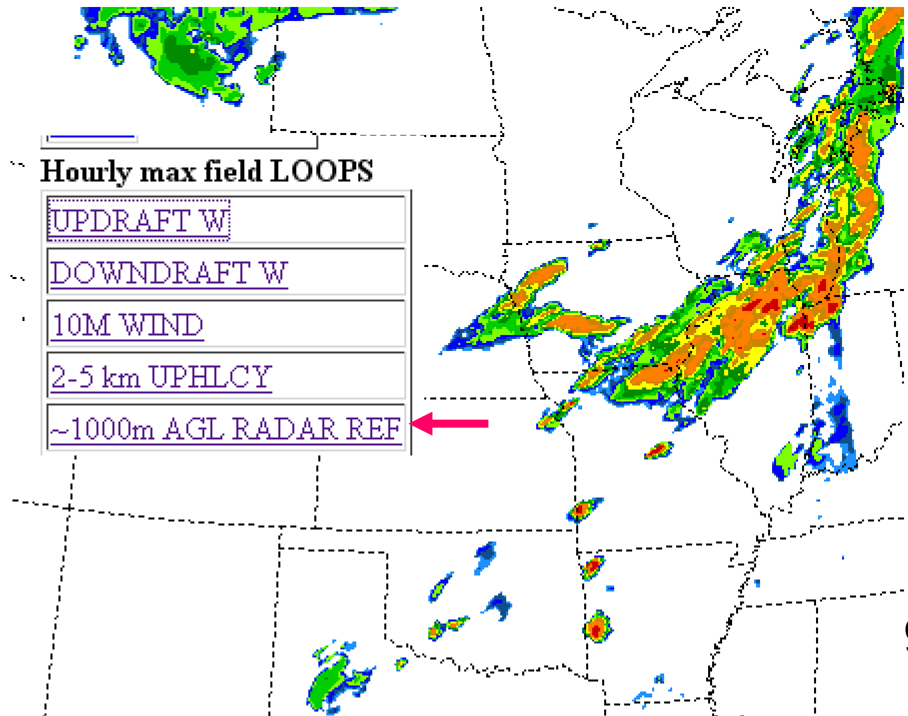
- Hourly maxima (saved in the model) provide insight into time period between output times for rapidly evolving fields, and first four of these are relatively new SPC favorites:
  - 1000 m reflectivity
  - updraft velocity below 400mb
  - downdraft velocity below 400mb
  - updraft helicity over 2-5 km AGL layer
  - 10 m wind speed
  - 2 m temperature
  - 2 m RH
- Hourly minima of:
  - 2 m temperature
  - 2 m RH
- 80 m AGL U + V wind
- 80 m AGL temperature
- 80 m AGL spec humidity
- 80 m AGL pressure
- Radar echo top height (18 dBZ level)
- Richardson Number based PBL height
- Transport Wind
- Ventilation Rate

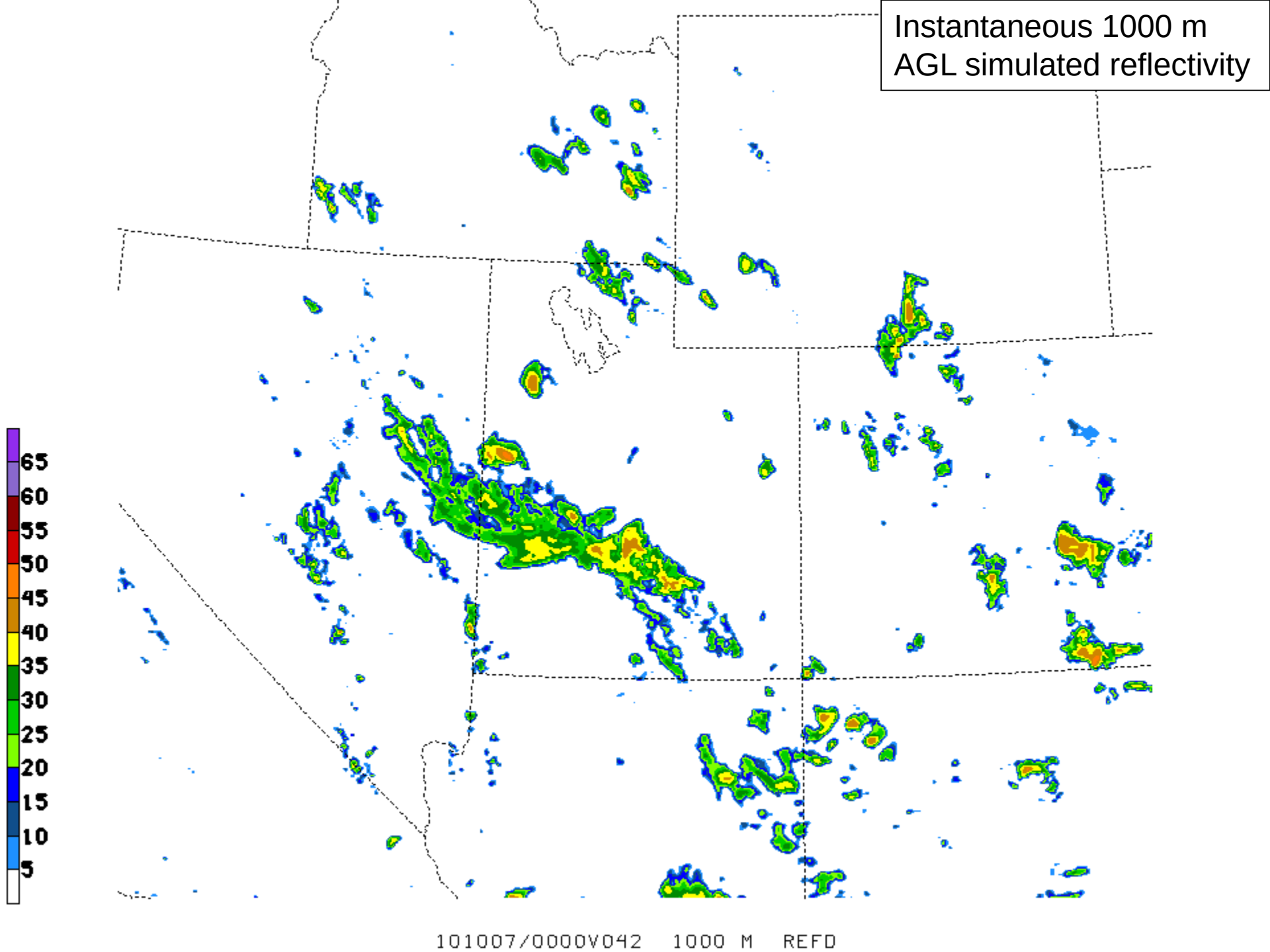
Matt Pyle Webpage

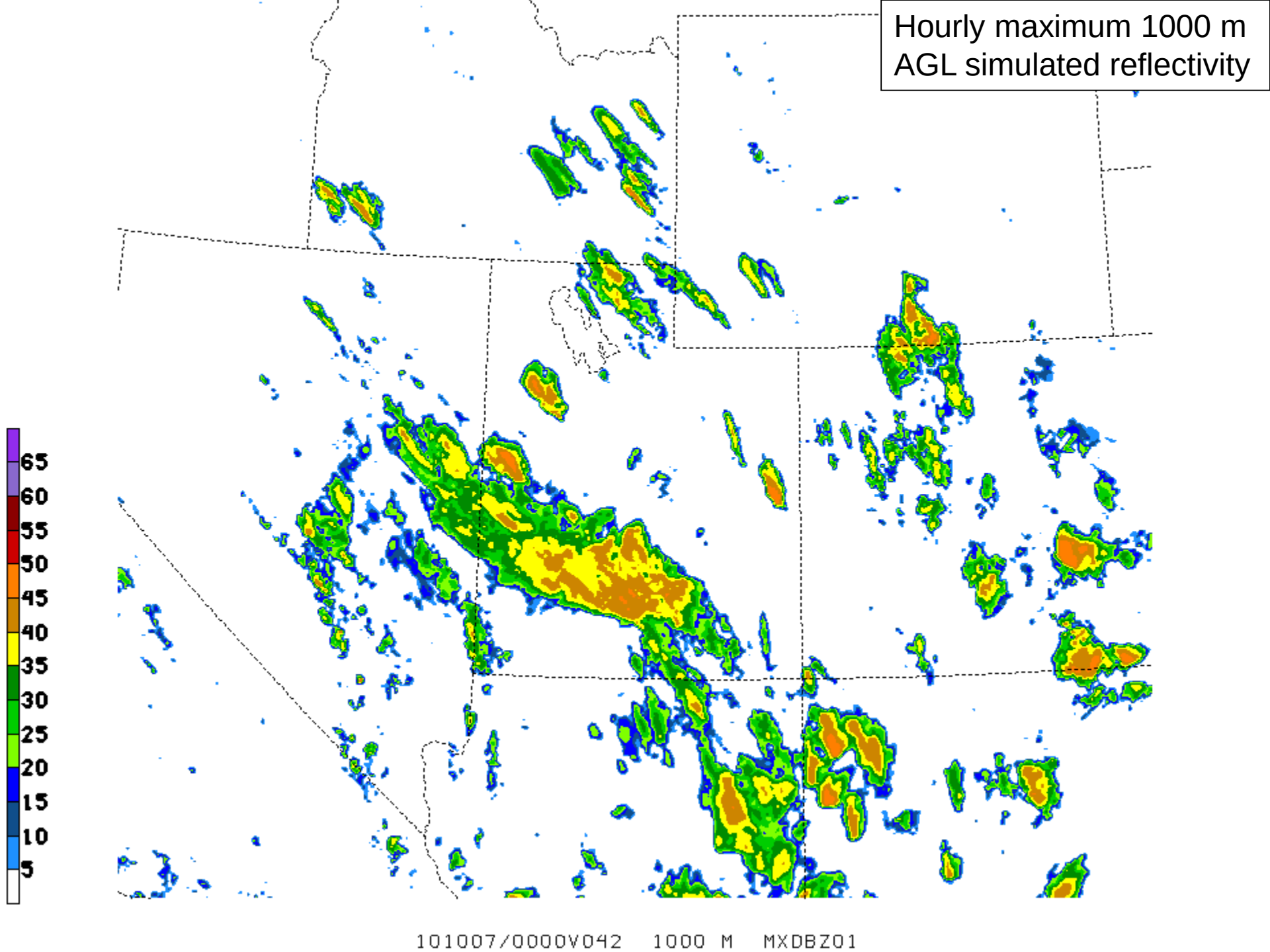




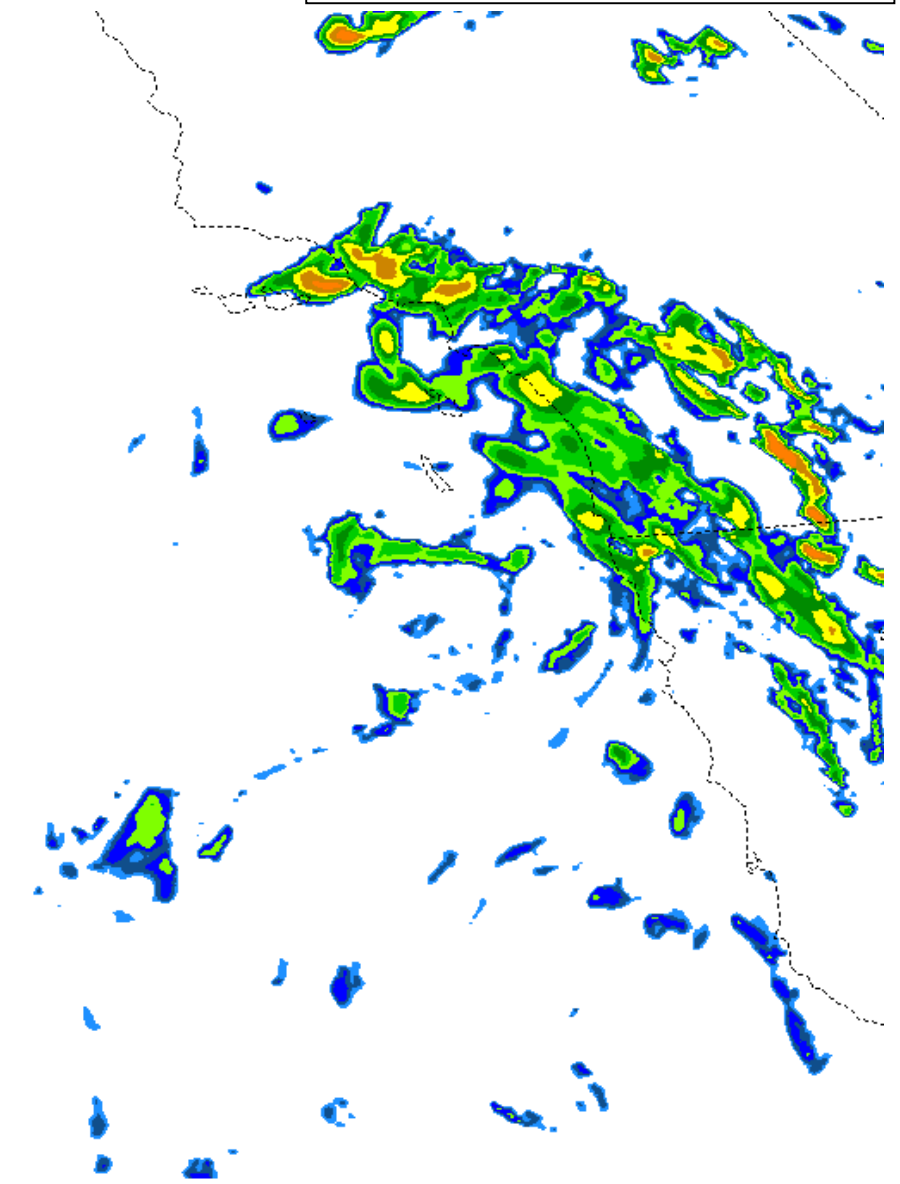




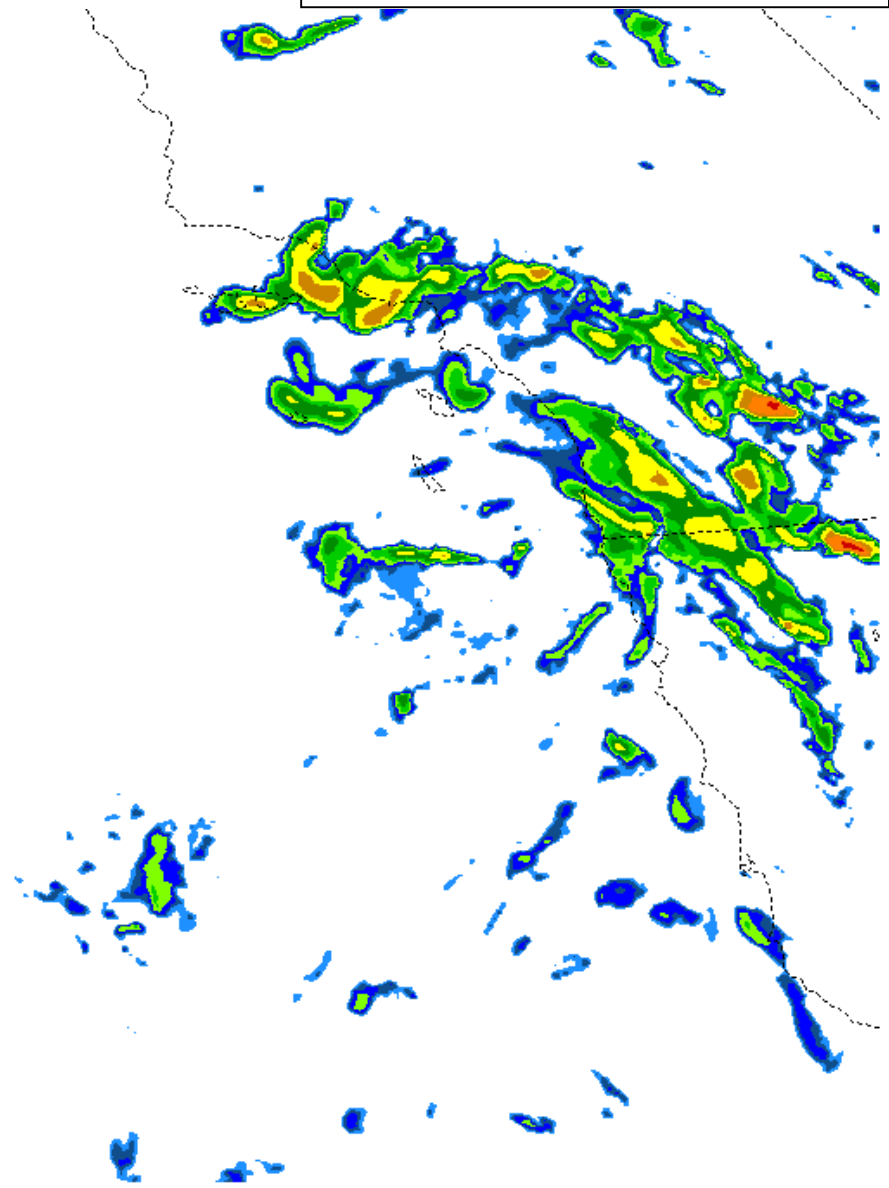

Instantaneous 1000 m
AGL simulated reflectivity
65
60
55
50
45
40
35
30
25
20
15
10
5
101007/0000V042 1000 M REFD

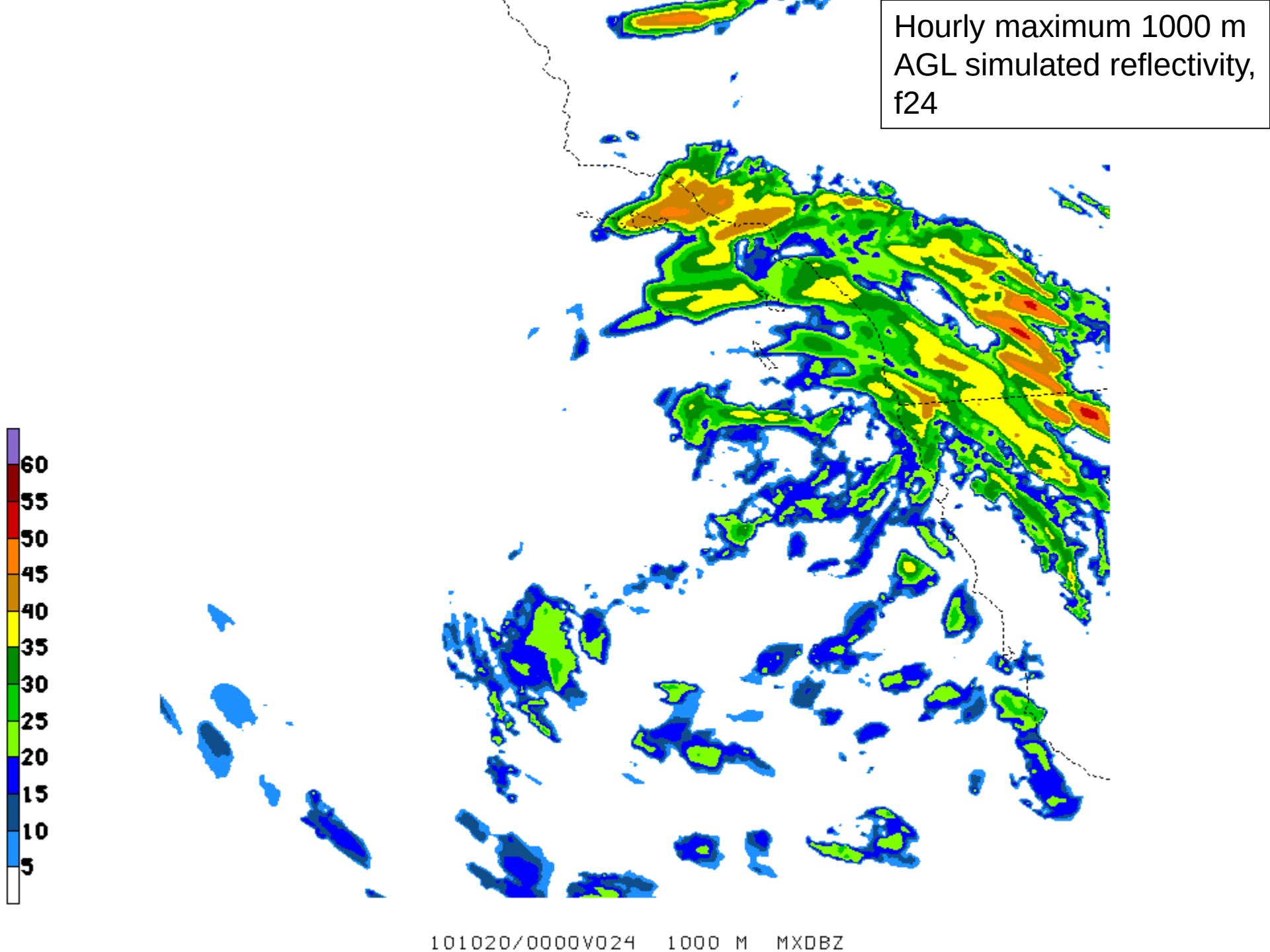

Hourly maximum 1000 m
AGL simulated reflectivity
65
60
55
50
45
40
35
30
25
20
15
10
5
101007/0000V042 1000 M MXDBZ01

Instantaneous 1000 m AGL simulated reflectivity, f23



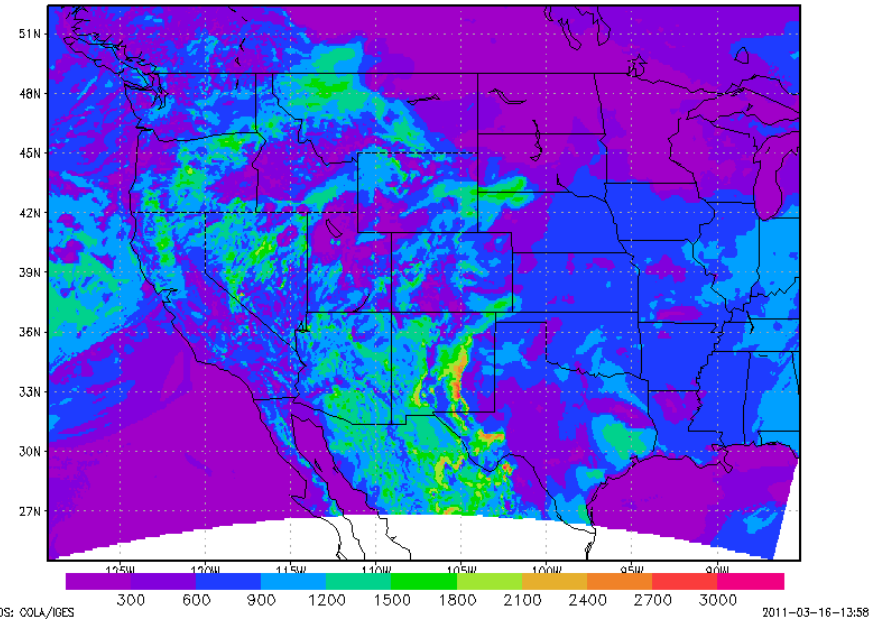
Instantaneous 1000 m AGL simulated reflectivity, f24



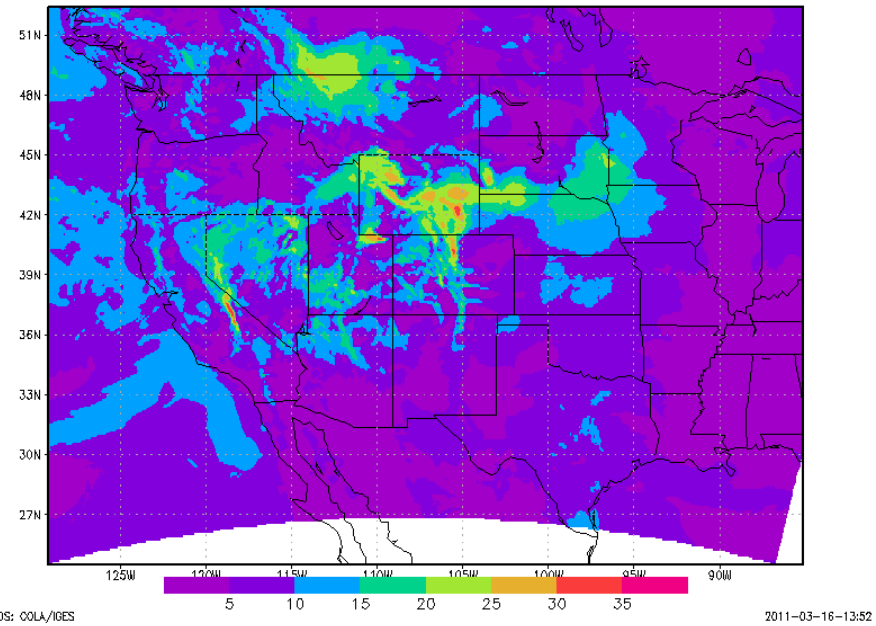

Hourly maximum 1000 m AGL simulated reflectivity, f24
60
55
50
45
40
35
30
25
20
15
10
5
101020/0000V024 1000 M MXDBZ

Sample Fire Wx Fields

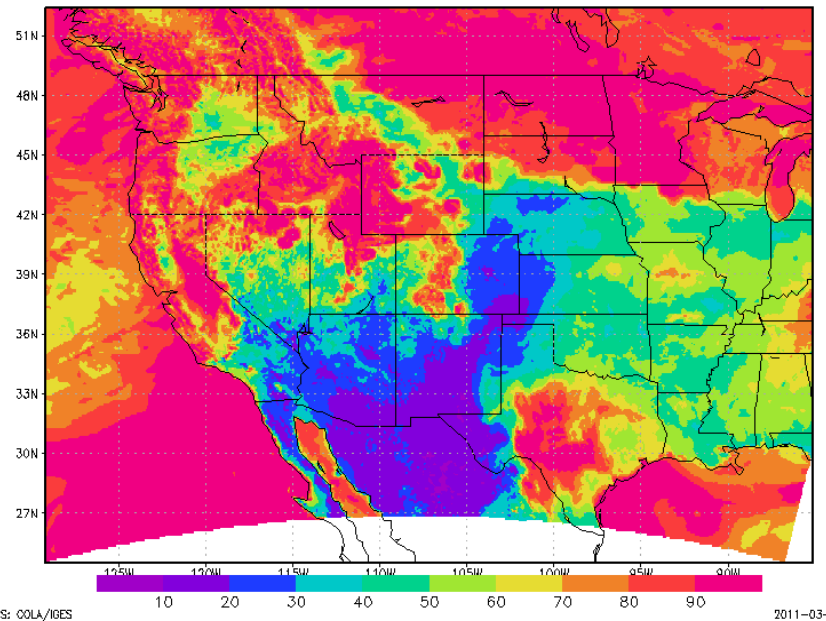
PBL H forecast from HIRES NMM run vt 2011031606F12



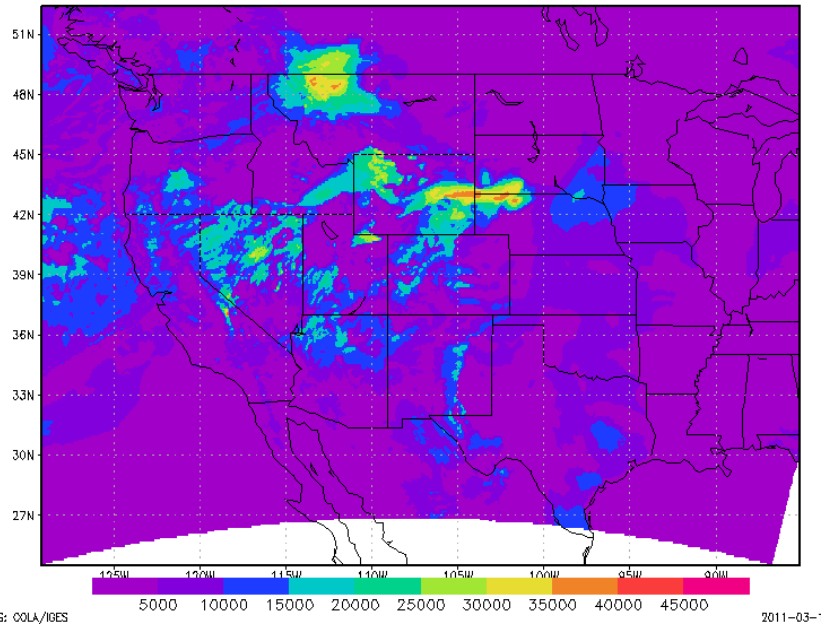
Transport wind speed forecast from HIRESNMM run vt 20110316



Min 2m RH orecast from HIRES NMM run vt 2011031606F12



Ventilation rate forecast from HIRES NMM run vt 2011031606F12



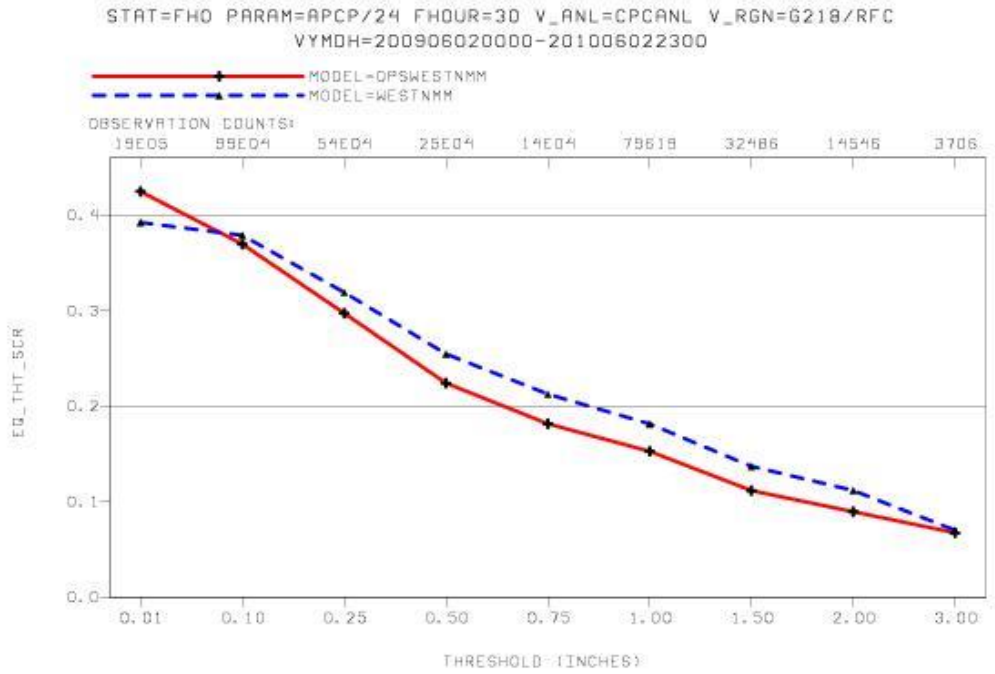
HiResW Upgrade Testing

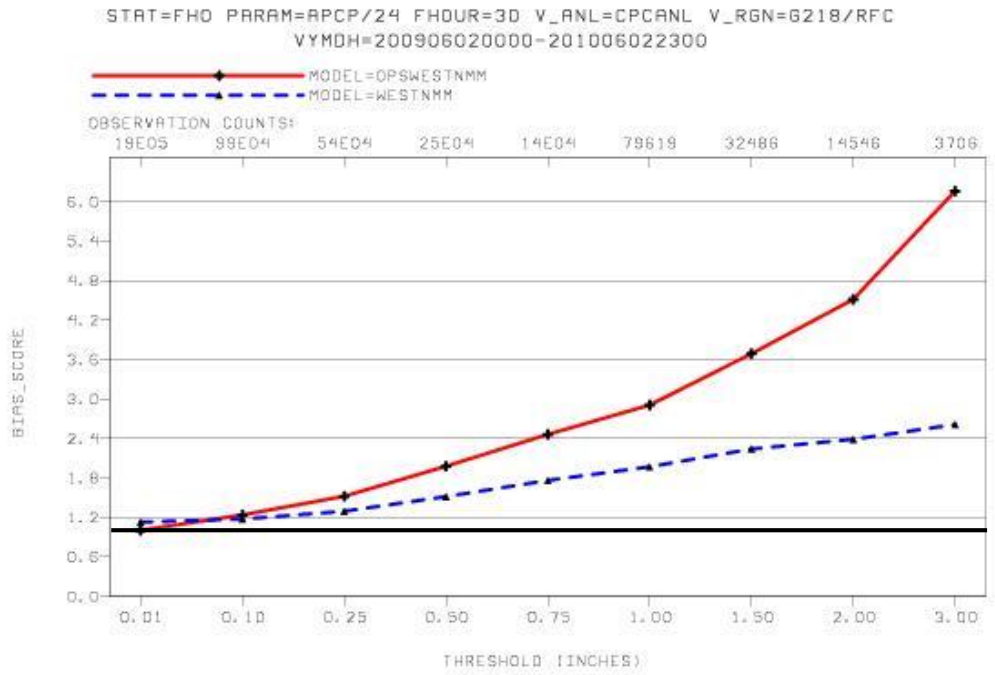
- Thus far have run the updated code for three separate periods, totaling about 115 days:
  - June 2009 (warm season)
  - a ~40 day period in Dec 2009 - Jan 2010 (cold season)
  - a transition period from mid-April to early June 2010 (spring)

HiResW testing precipitation results

- The most dramatic improvement in the test results is a reduction of the high precipitation bias in the current HiResW (esp. for heavier thresholds).
- NMM shows a net ETS improvement (except at .01”/24 h) mostly due to improvements in the warm season. Bias much improved.
- ARW changes have a fairly neutral impact on ETS all seasons, but bias made nearly perfect.

ALL tests
WESTNMM
30 h fore



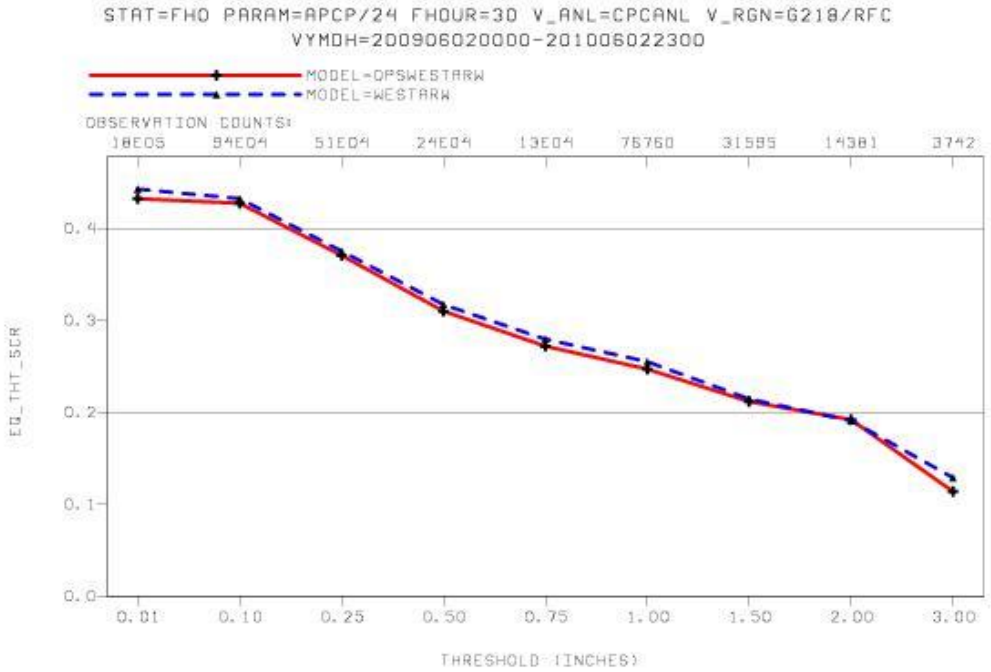


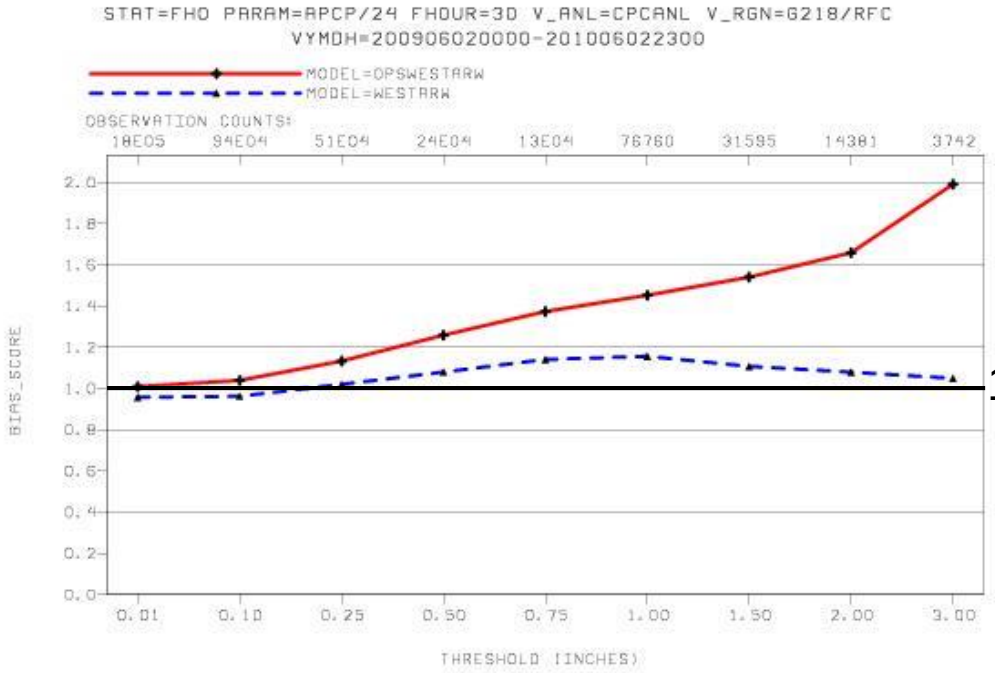
nwprod

nwtest

1.0

ALL tests
WESTARW
30 h fore



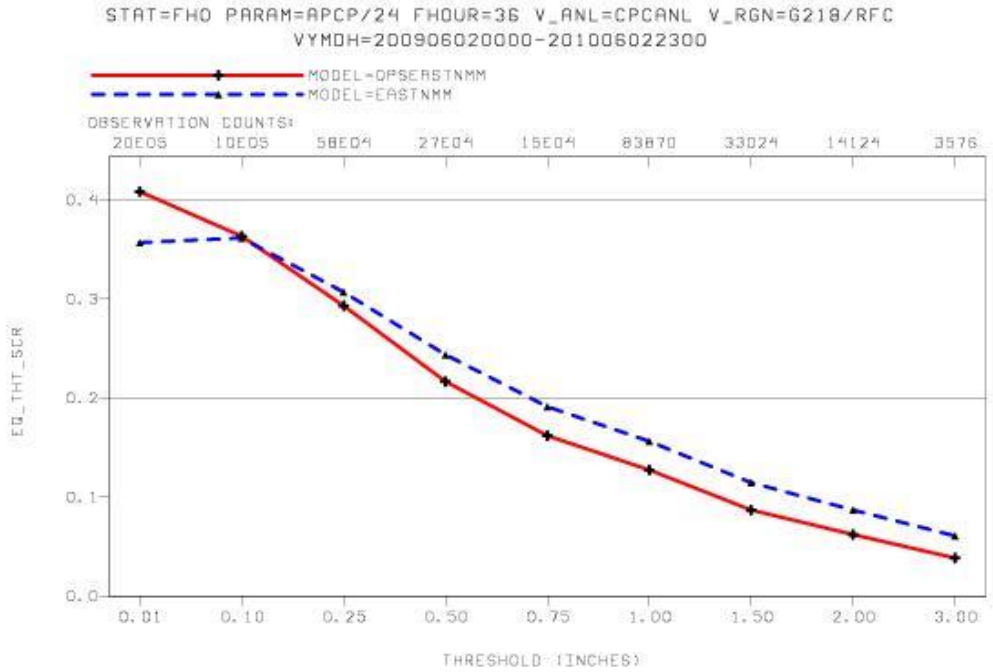


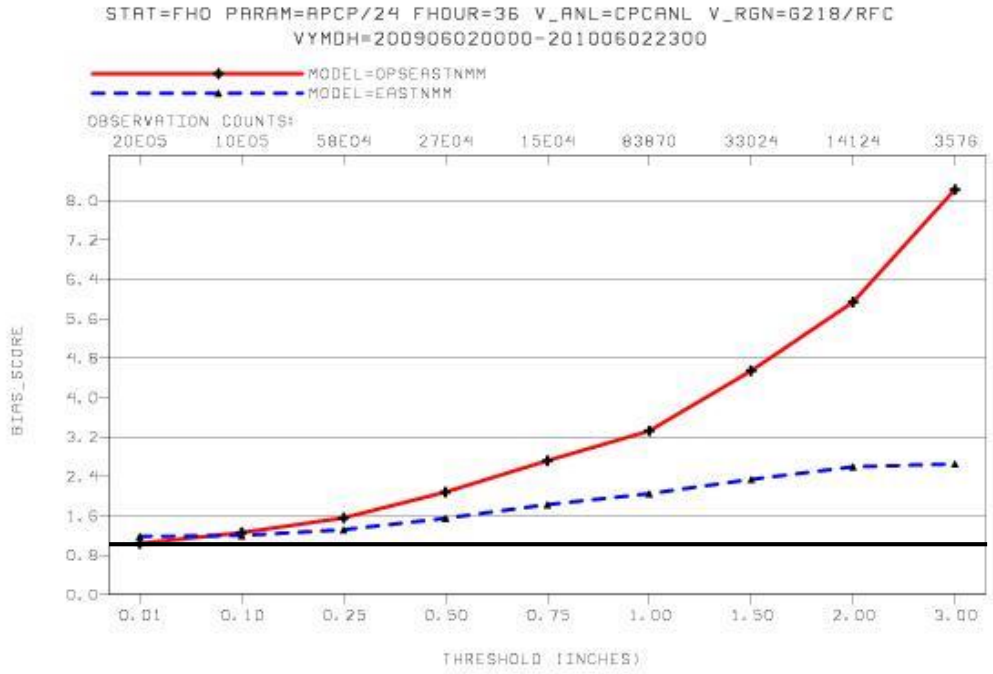
1.0

nwprod

nwtest

ALL tests
EASTNMM
36 h fore



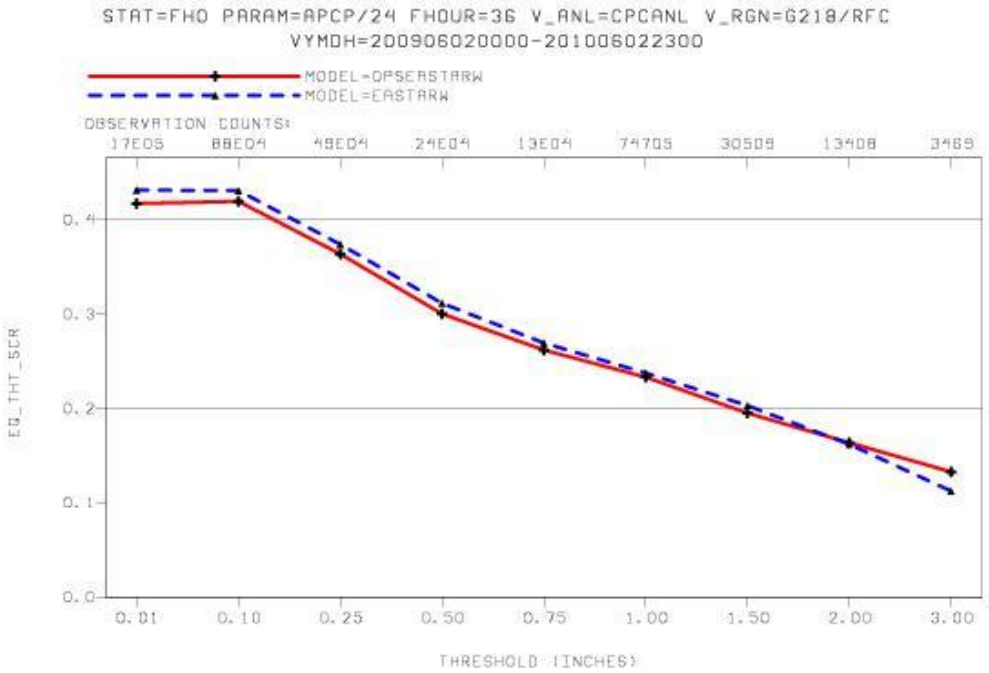


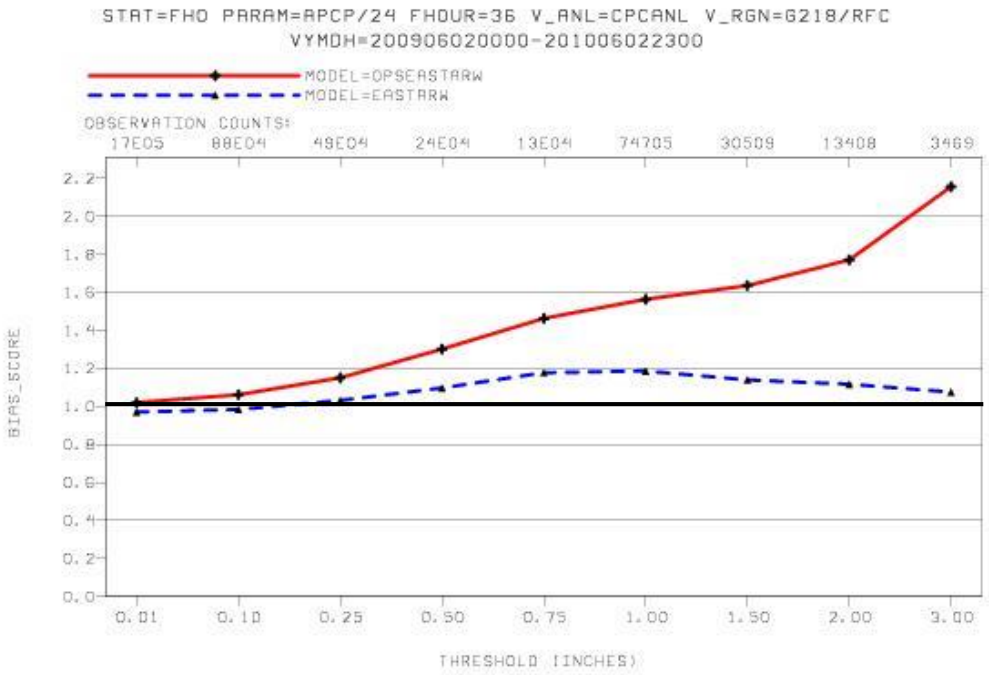
1.0

nwprod

nwtest

ALL tests
EASTARW
36 h fore

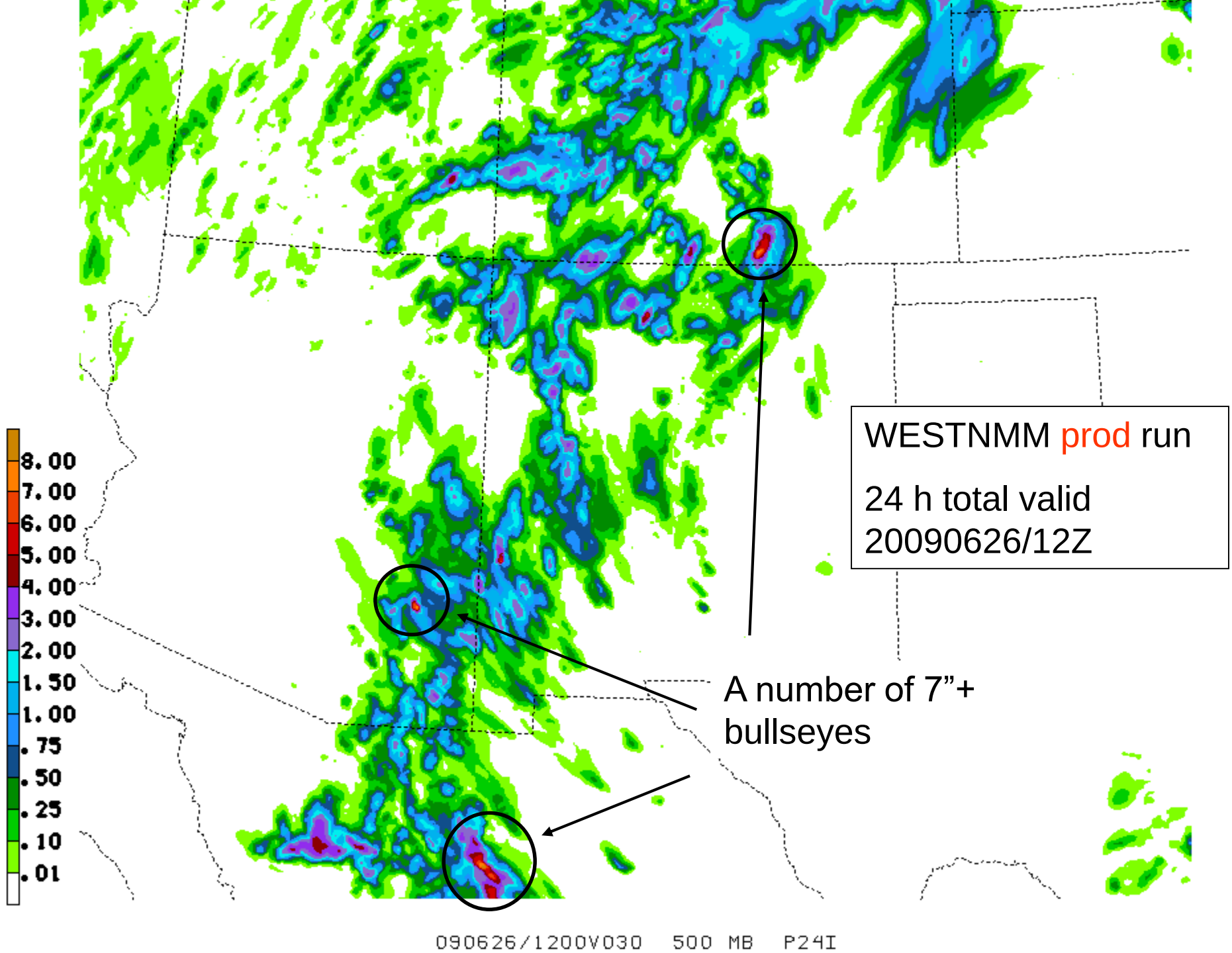


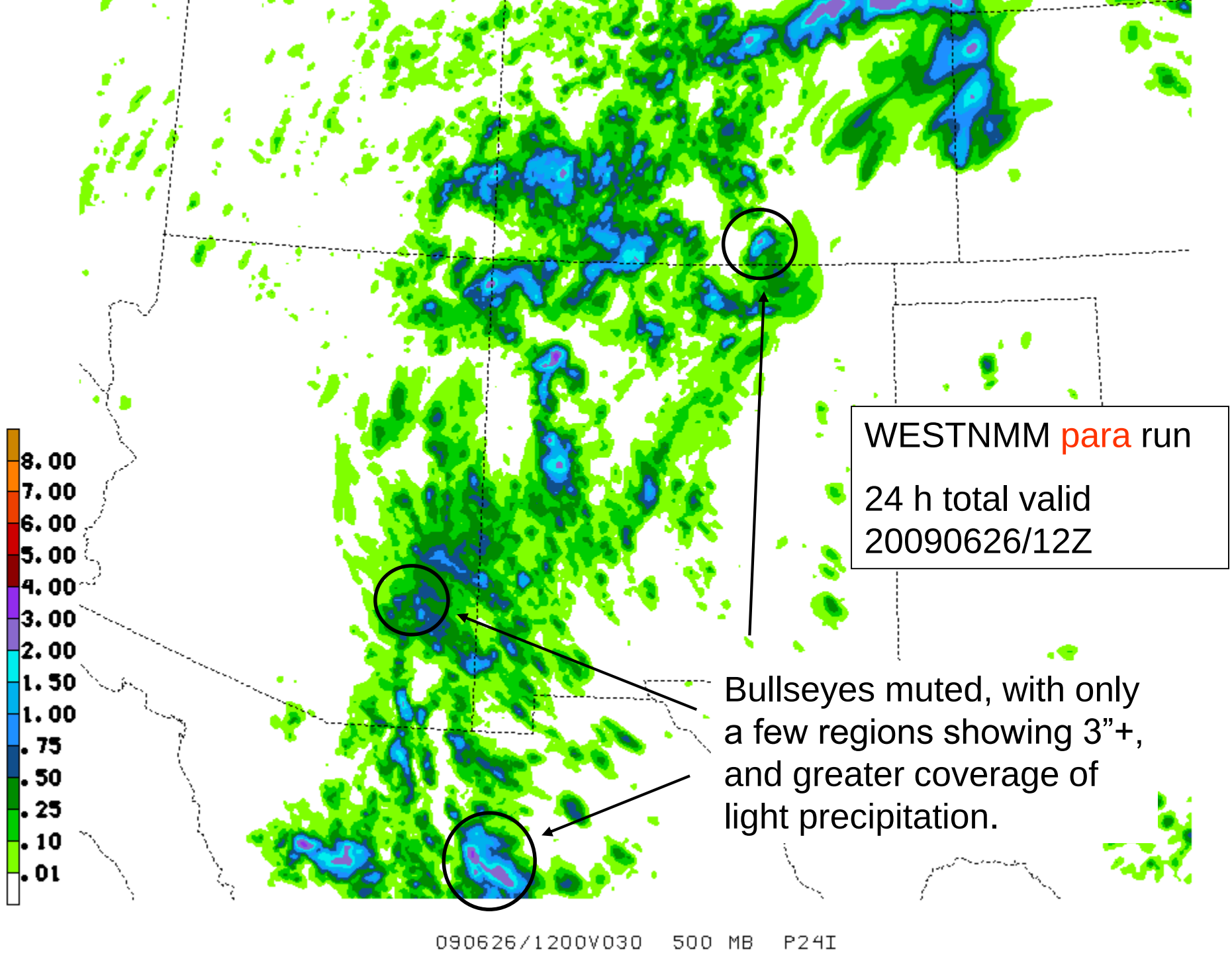


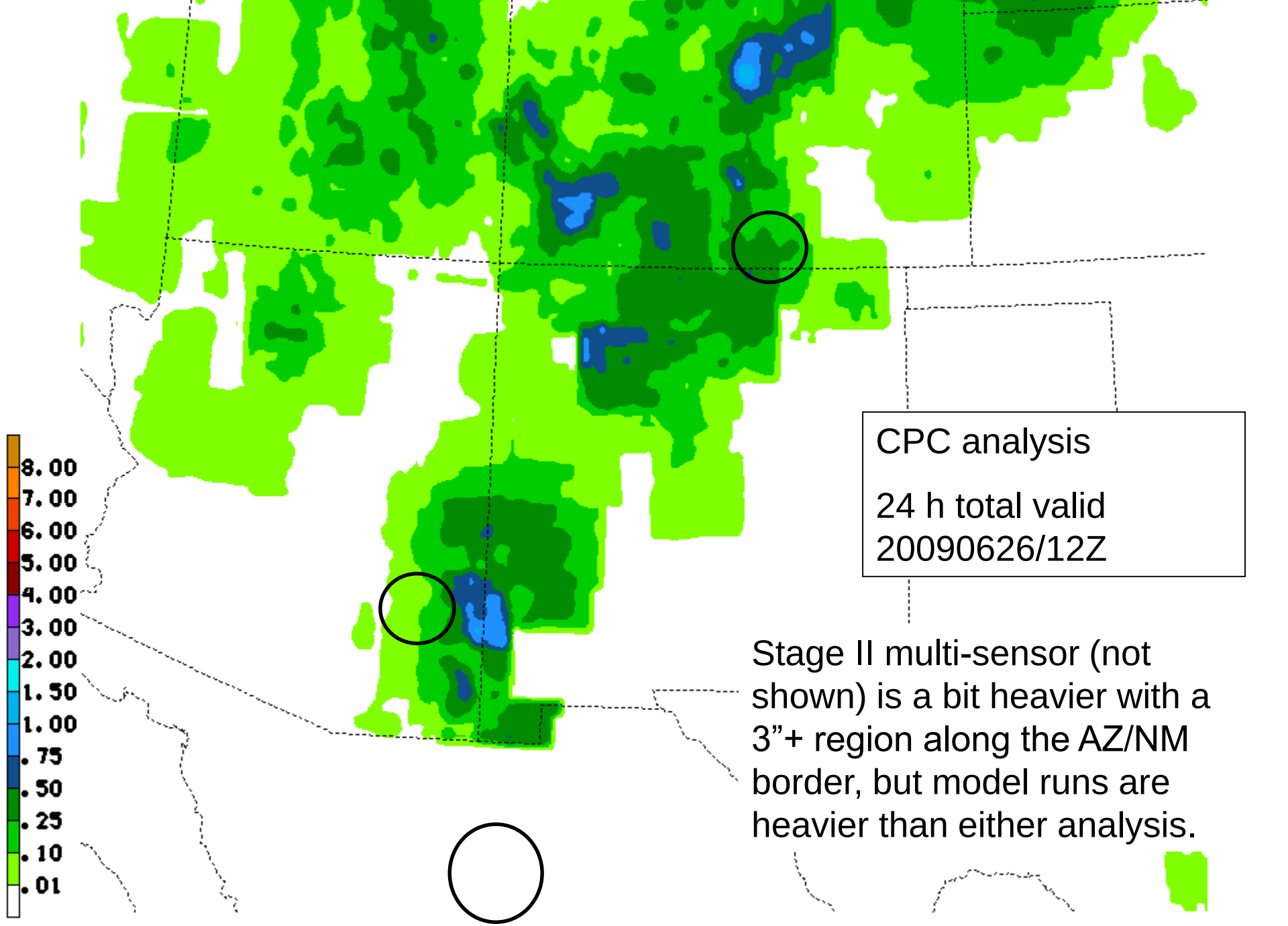
1.0

nwprod

nwtest


8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.50
1.00
.75
.50
.25
.10
.01
WESTNMM prod run
24 h total valid
20090626/12Z
A number of 7”+
bullseyes
090626/1200V030 500 MB P24I


8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.50
1.00
.75
.50
.25
.10
.01
WESTNMM para run
24 h total valid
20090626/12Z
Bullseyes muted, with only a few regions showing 3"+, and greater coverage of light precipitation.
090626/1200V030 500 MB P24I


8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.50
1.00
.75
.50
.25
.10
.01
CPC analysis
24 h total valid
20090626/12Z
Stage II multi-sensor (not shown) is a bit heavier with a 3”+ region along the AZ/NM border, but model runs are heavier than either analysis.
090626/1200V024 500 MB P24I

HiResW Testing Upper-Air Results

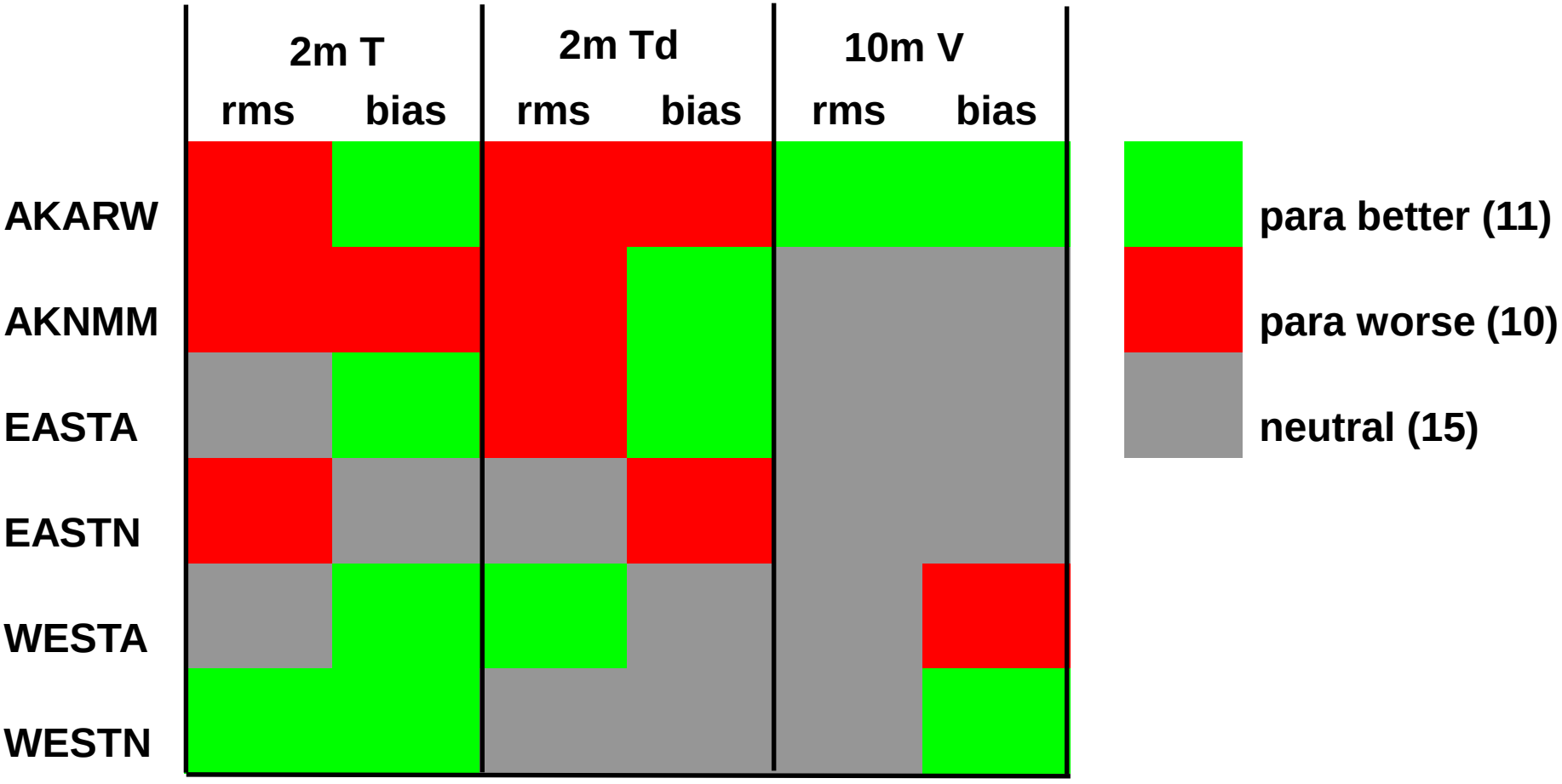
- NMM shows big improvement in warm season CONUS, little impact in cold season. Overall (all cases) neutral to positive, except for AK.
- ARW shows big improvement in cold season, smaller improvement in warm season. Overall a positive impact.
- The following plots cover all test periods.

HiResW Testing Surface Results

- In an overall sense, a decidedly mixed bag. More improvements to bias than to RMS.
- 2 m T signals clearest: In winter/spring, para ARW warmer than prod ARW, while para NMM is cooler than prod NMM at night. Most pronounced AK/West.
- 2 m Td is least improved (most degraded) surface field.
- 10 m V generally shows the smallest impact from the upgrade.

Subjective Summary Surface Statistics

combined June 2009, 20091213-20100123 (winter), 20100415-20100602 (spring)



Summary

- Updated model codes significantly improve upon the well-known HiResW high bias in precipitation.

- Other verifications also show some improvement:
  - upper air significantly improved for ARW, slightly better for NMM.
  - surface biases generally better, but seasonal challenges remain.

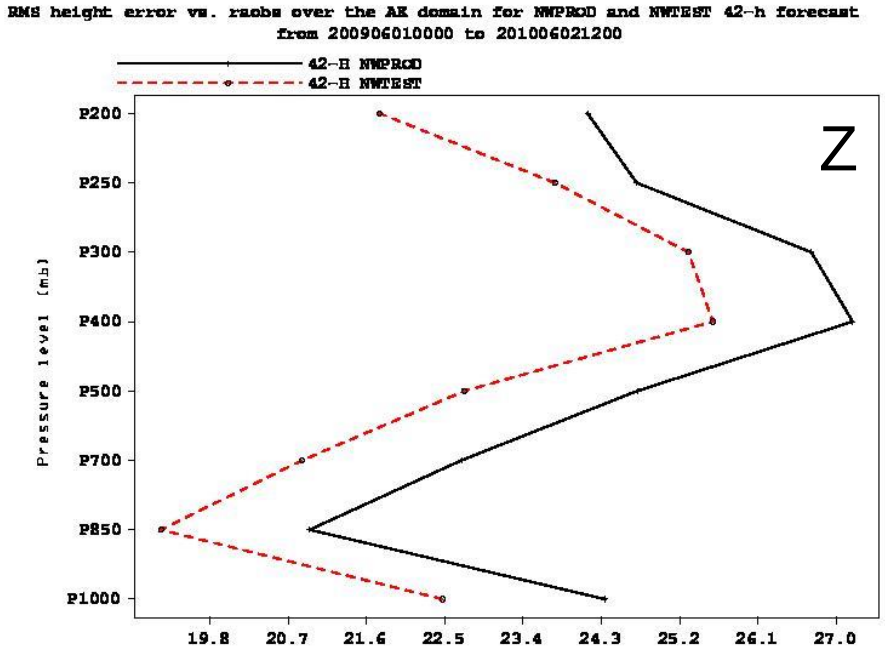
- Provides new runs, new fields and new forms of guidance requested by and/or promised to the field:
  - high-resolution guidance for Guam [and Haiti]
  - hourly BUFR output
  - high-resolution probabilistic guidance for flood forecasting
  - new fields beneficial for severe weather and air quality forecasts
  - new fields beneficial for fire weather and wind energy forecasts

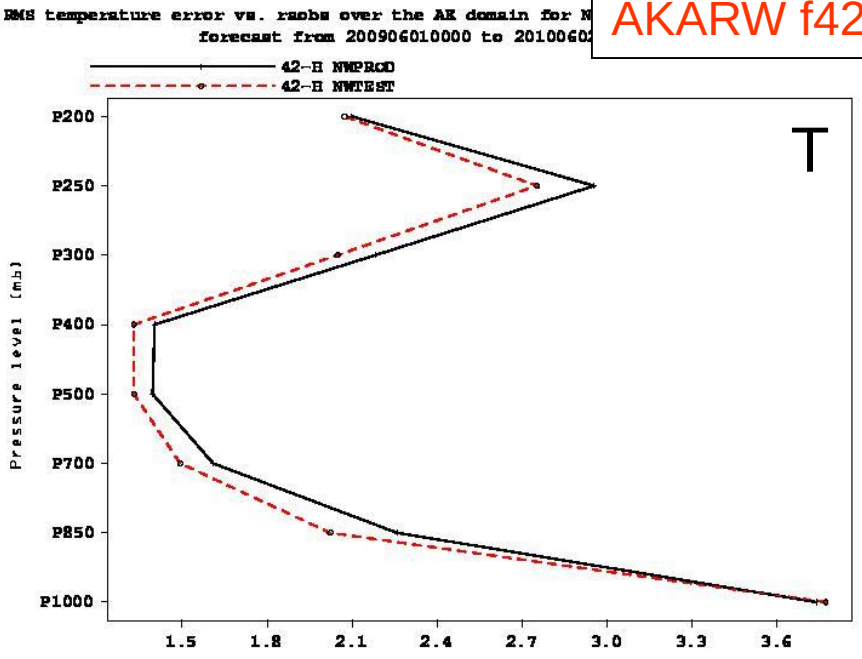
Plans For 2012 HiResWindow

- Use Guam forecast as first guess for RTMA
- Upgrade ARW to Version 3.3
- Replace NMM with NMMB
- Some or all of the following:
  - Increase resolution to ~2 km
  - Expand to full CONUS – new schedule:
    - CONUS, Hawaii & Guam at 00z and 12z
    - Alaska, Puerto Rico-Hispaniola at 06z an 18z
  - Improve Initialization of HiResWindow runs
    - GSI using all available data & mini-NDAS
    - GSI adapted specially for Level II 88D winds
    - Digital filter with Level II 88D reflectivity (ala RUC/RR)
  - Start generating HRRRE-TL [Time Lagged]

Bonus / Background Materials

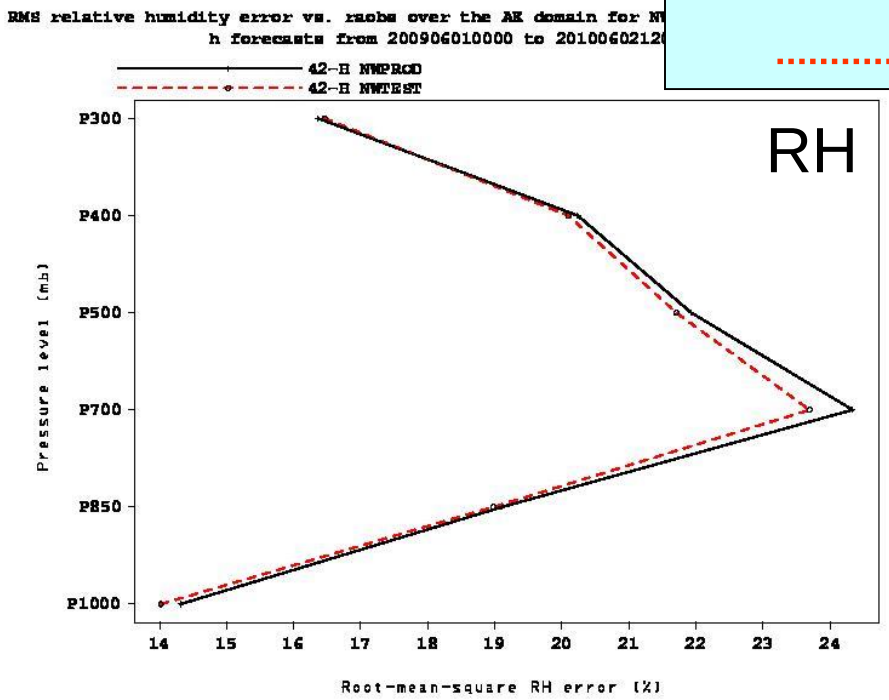
AKARW f42

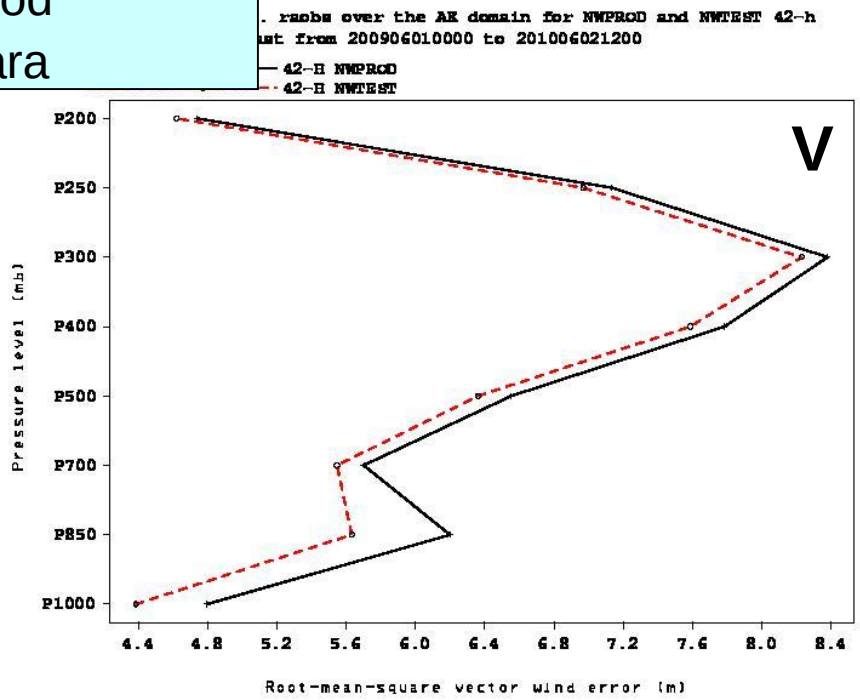


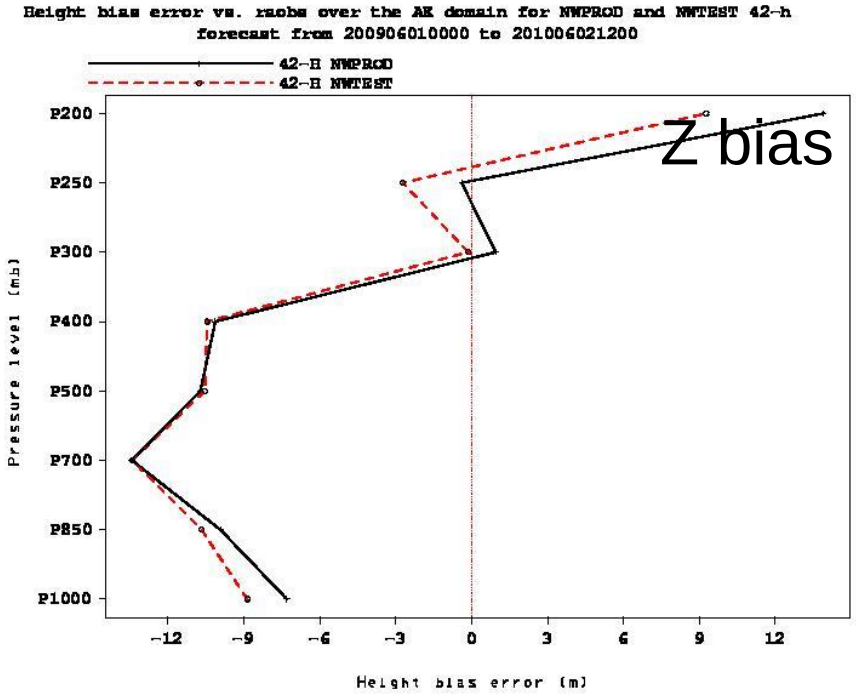


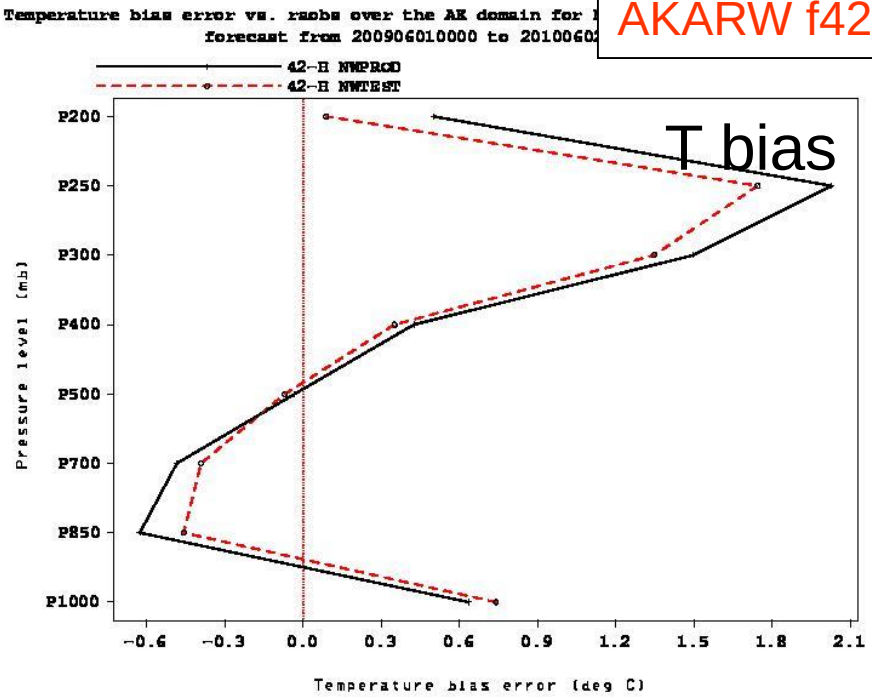
prod

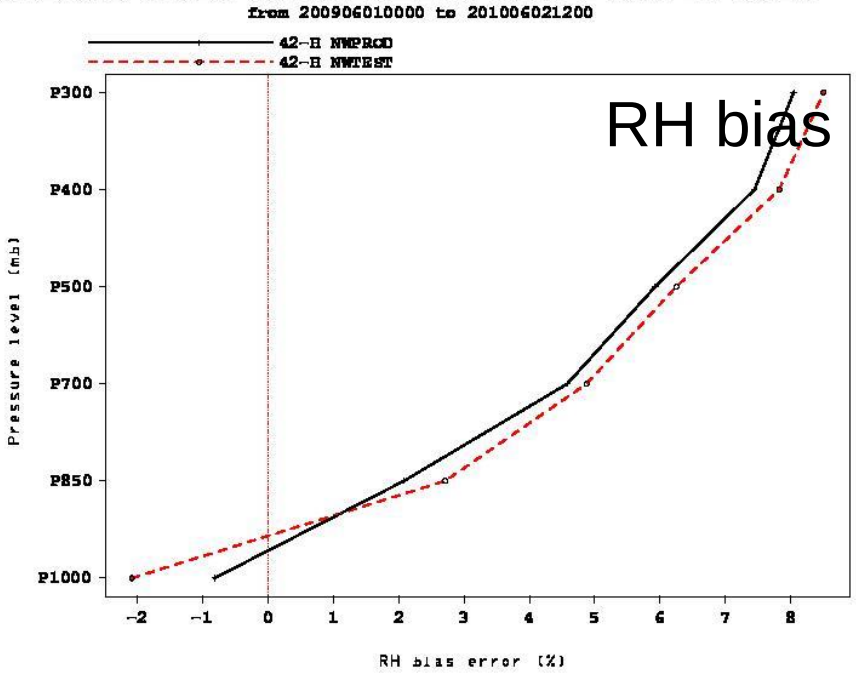
para



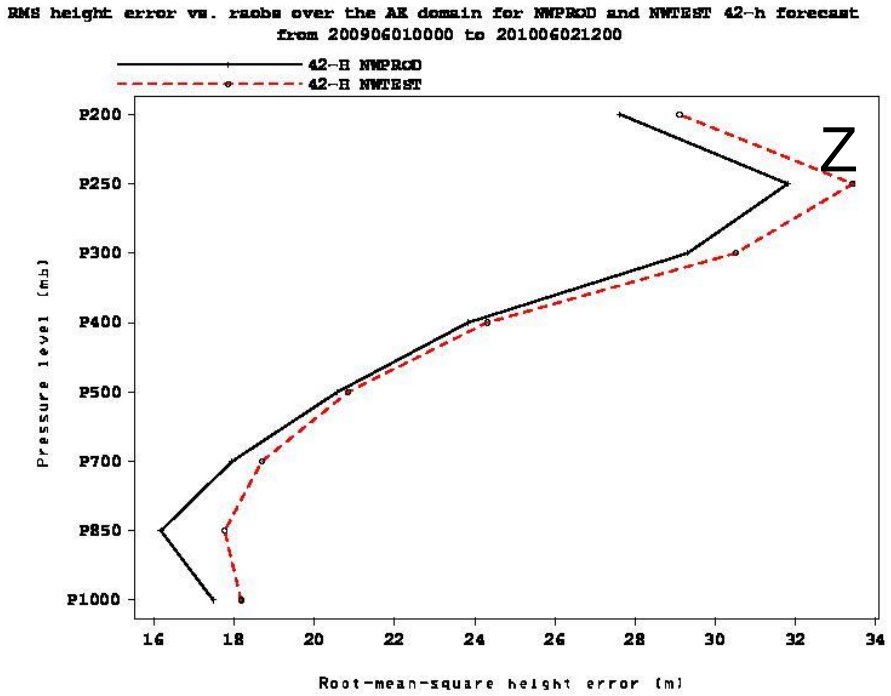


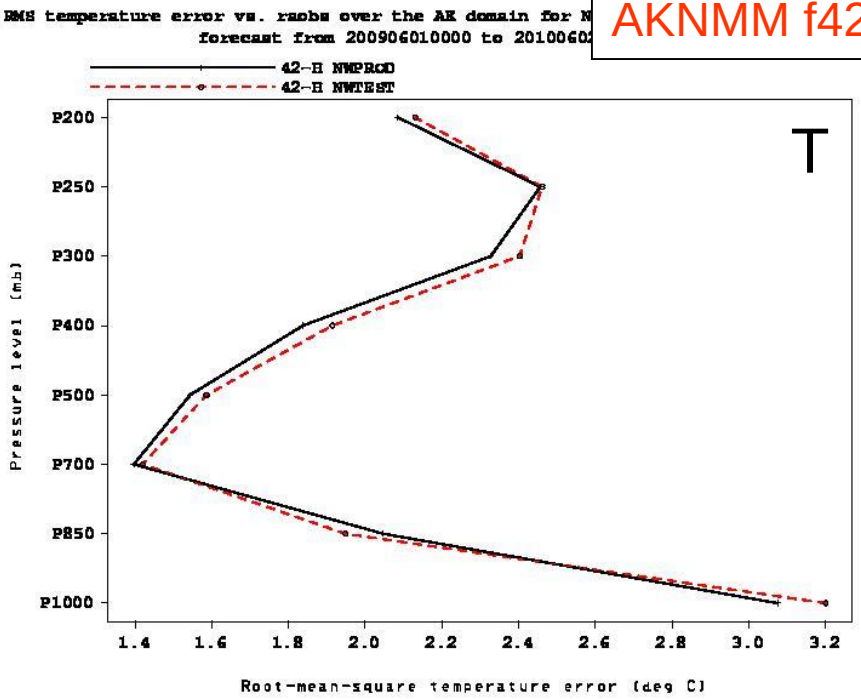

Height bias error vs. raobs over the AK domain for NWPROD and NWTEST 42-h
forecast from 200906010000 to 201006021200
42-H NWPROD
42-H NWTEST
Z bias
P200
P250
P300
P400
P500
P700
P850
P1000
Pressure level (mb)
-12
-9
-6
-3
0
3
6
9
12
Height bias error (m)

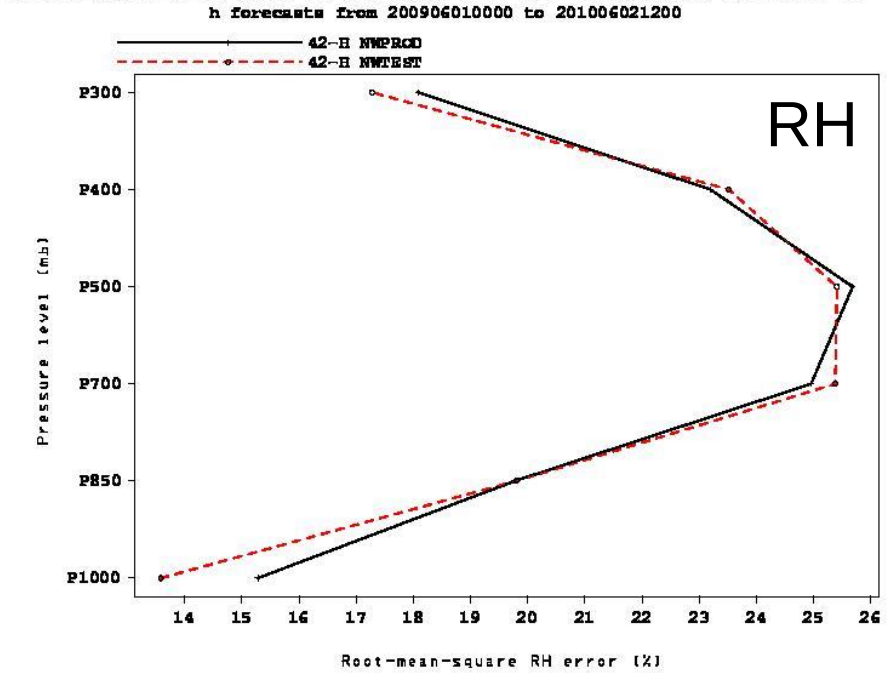

Temperature bias error vs. raobs over the AK domain for
forecast from 200906010000 to 20100602
42-H NWPROD
42-H NWTEST
T bias
P200
P250
P300
P400
P500
P700
P850
P1000
Pressure level (mb)
-0.6
-0.3
0.0
0.3
0.6
0.9
1.2
1.5
1.8
2.1
Temperature bias error (deg C)

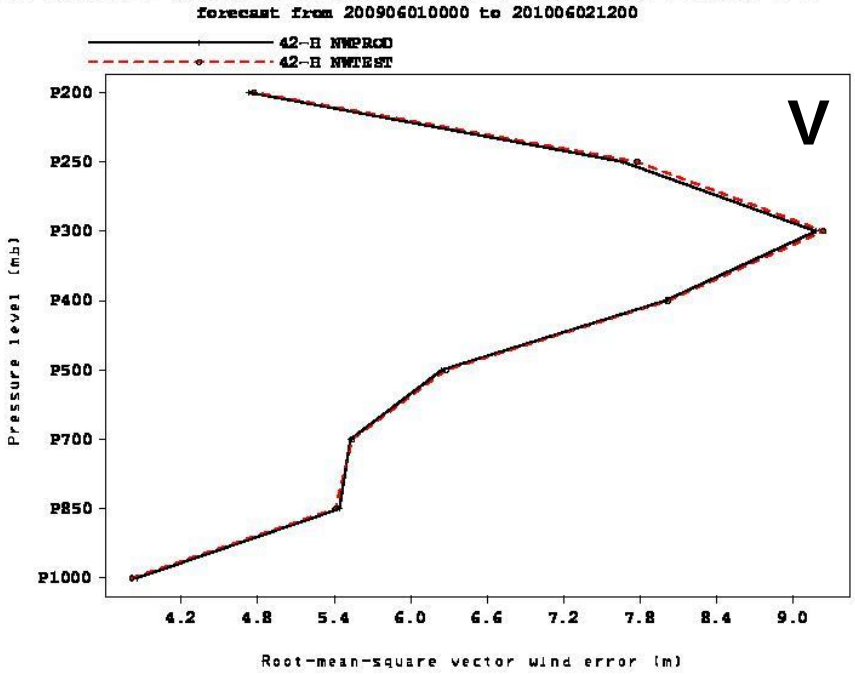

from 200906010000 to 201006021200
42-H NWPROD
42-H NWTEST
RH bias
P300
P400
P500
P700
P850
P1000
Pressure level (mb)
-2
-1
0
1
2
3
4
5
6
7
8
RH bias error (%)

AKNMM f42

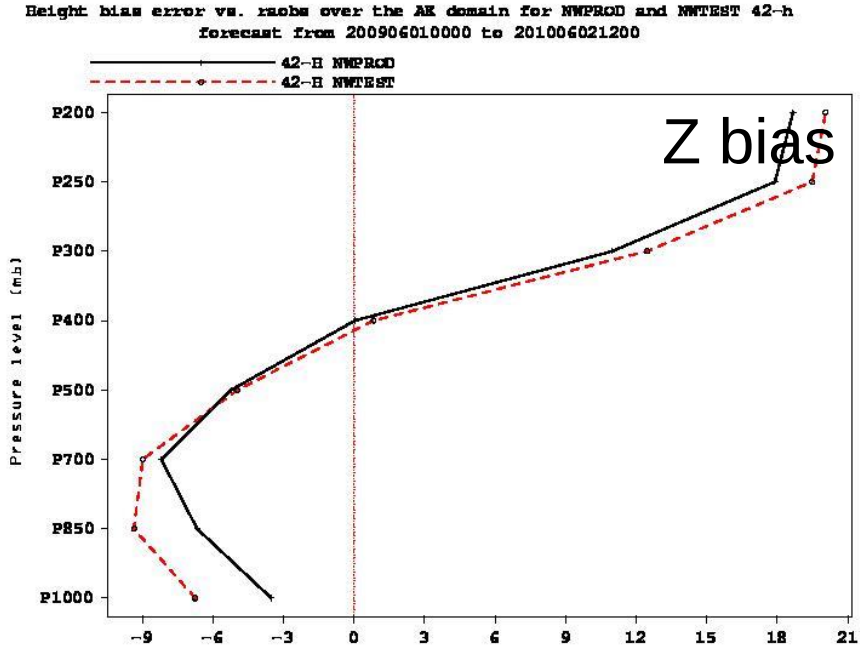

RMS height error vs. raobs over the AK domain for NWPROD and NWTEST 42-h forecast
from 200906010000 to 201006021200
42-H NWPROD
42-H NWTEST
Z
Pressure level (mb)
P200
P250
P300
P400
P500
P700
P850
P1000
16
18
20
22
24
26
28
30
32
34
Root-mean-square height error (m)

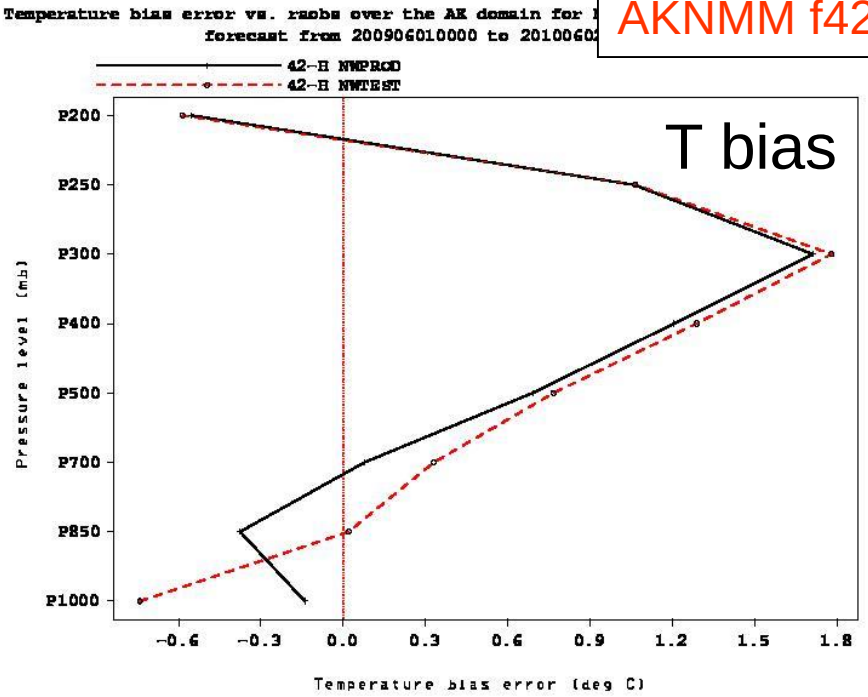

RMS temperature error vs. raobs over the AK domain for N
forecast from 200906010000 to 20100602
42-H NWPROD
42-H NWTEST
T
Pressure level (mb)
P200
P250
P300
P400
P500
P700
P850
P1000
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
Root-mean-square temperature error (deg C)

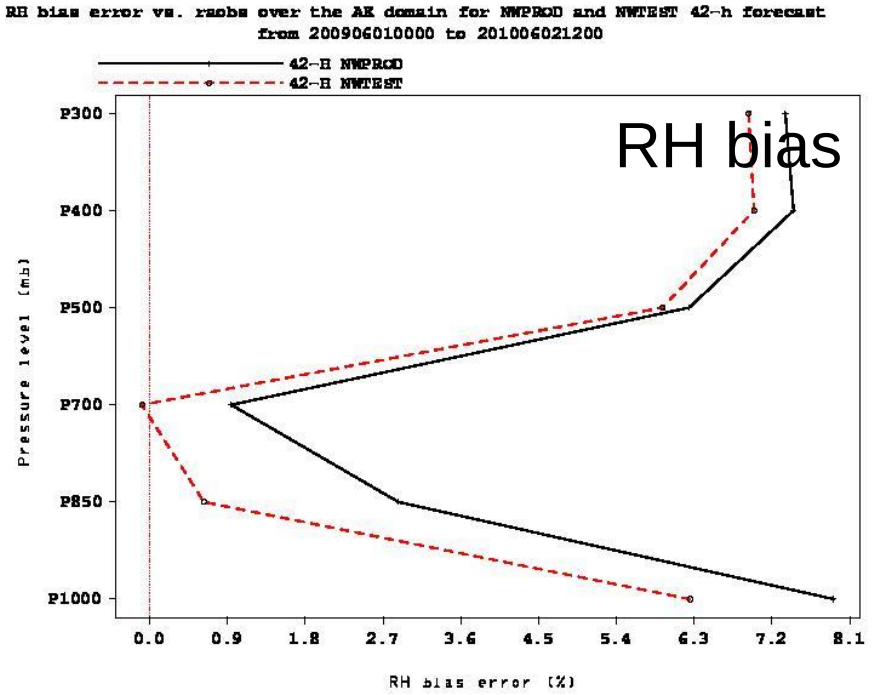

h forecasts from 200906010000 to 201006021200
42-H NWPROD
42-H NWTEST
RH
Pressure level (mb)
P300
P400
P500
P700
P850
P1000
14
15
16
17
18
19
20
21
22
23
24
25
26
Root-mean-square RH error (%)


forecast from 200906010000 to 201006021200
42-H NWPROD
42-H NWTEST
V
Pressure level (mb)
P200
P250
P300
P400
P500
P700
P850
P1000
4.2
4.8
5.4
6.0
6.6
7.2
7.8
8.4
9.0
Root-mean-square vector wind error (m)

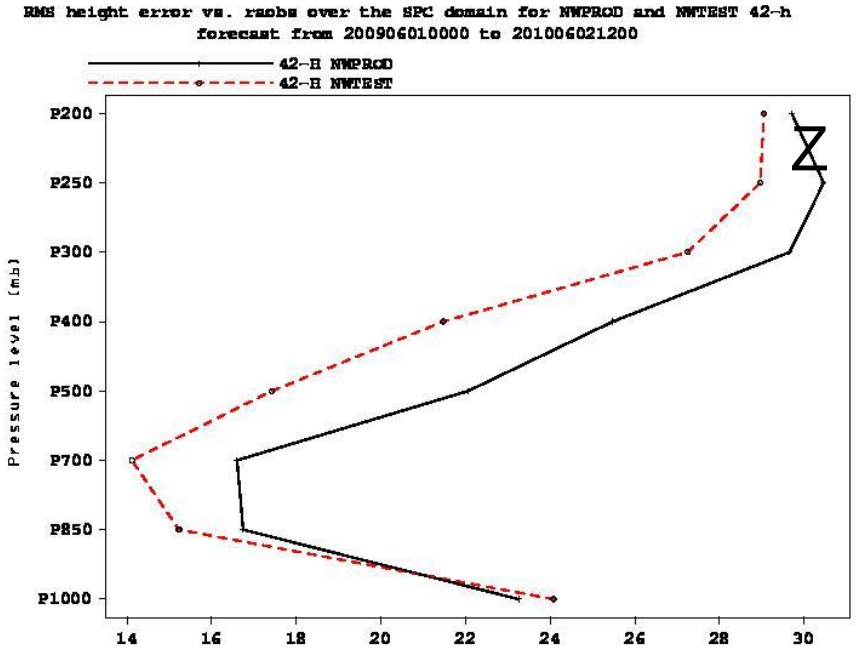
AKNMM f42

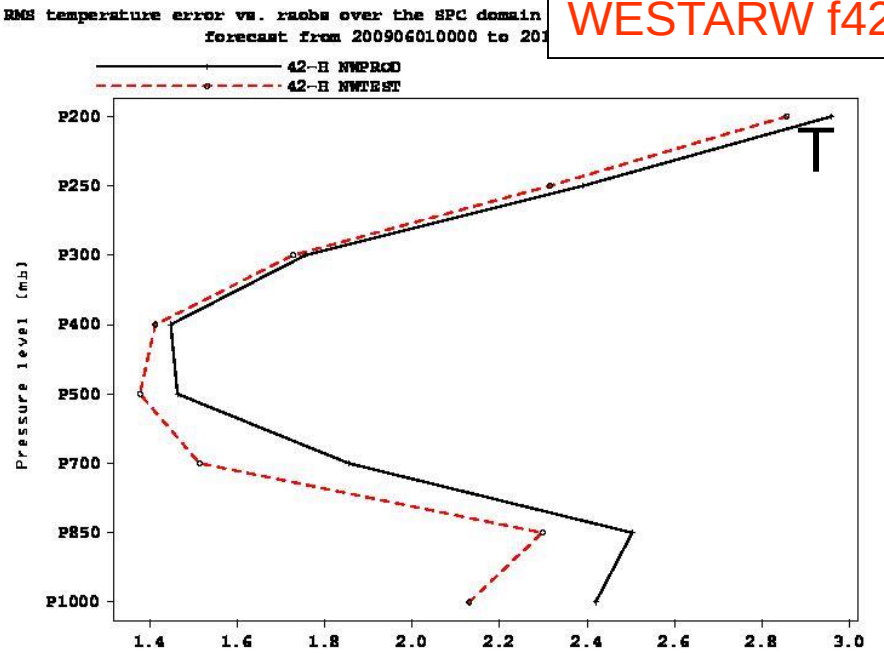

Height bias error vs. raobs over the AK domain for NWPROD and NWTEST 42-h forecast from 200906010000 to 201006021200
42-H NWPROD
42-H NWTEST
Z bias
Pressure level (mb)
P200
P250
P300
P400
P500
P700
P850
P1000
-9
-6
-3
0
3
6
9
12
15
18
21

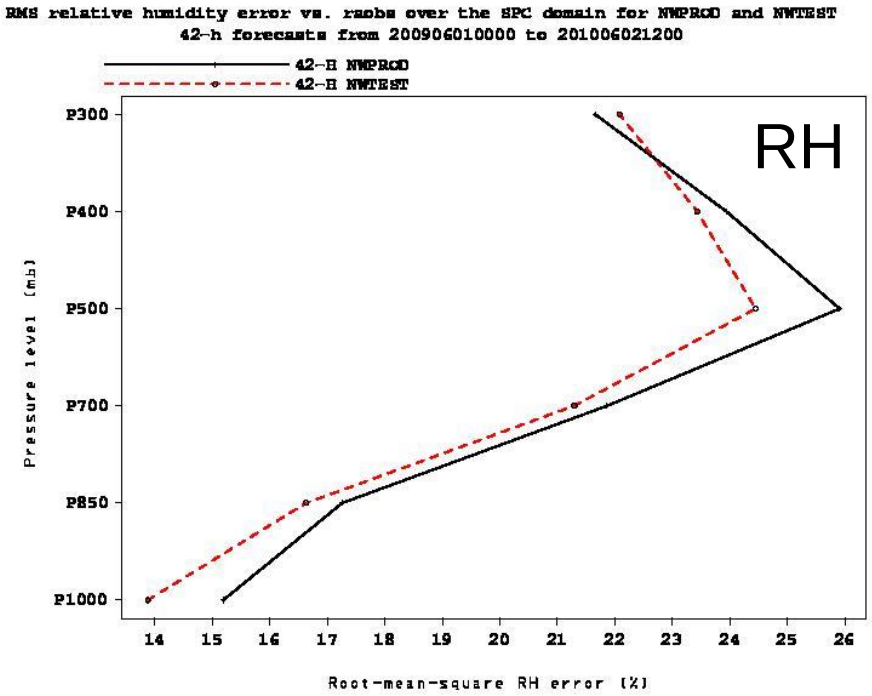

Temperature bias error vs. raobs over the AK domain for
forecast from 200906010000 to 20100602
42-H NWPROD
42-H NWTEST
T bias
Pressure level (mb)
P200
P250
P300
P400
P500
P700
P850
P1000
-0.6
-0.3
0.0
0.3
0.6
0.9
1.2
1.5
1.8
Temperature bias error (deg C)

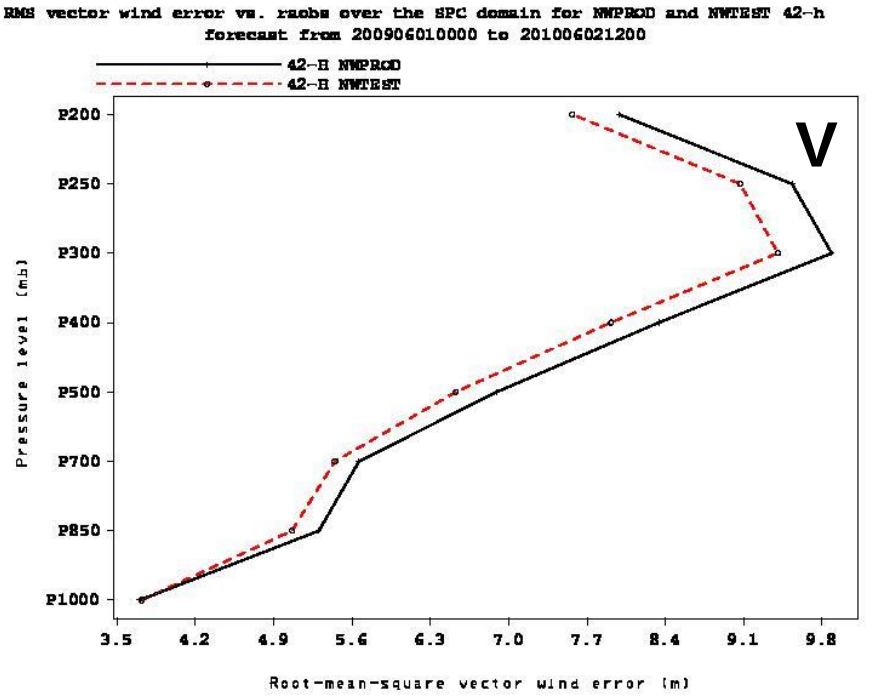

RH bias error vs. raobs over the AK domain for NWPROD and NWTEST 42-h forecast from 200906010000 to 201006021200
42-H NWPROD
42-H NWTEST
RH bias
Pressure level (mb)
P300
P400
P500
P700
P850
P1000
0.0
0.9
1.8
2.7
3.6
4.5
5.4
6.3
7.2
8.1
RH bias error (%)

WESTARW f42

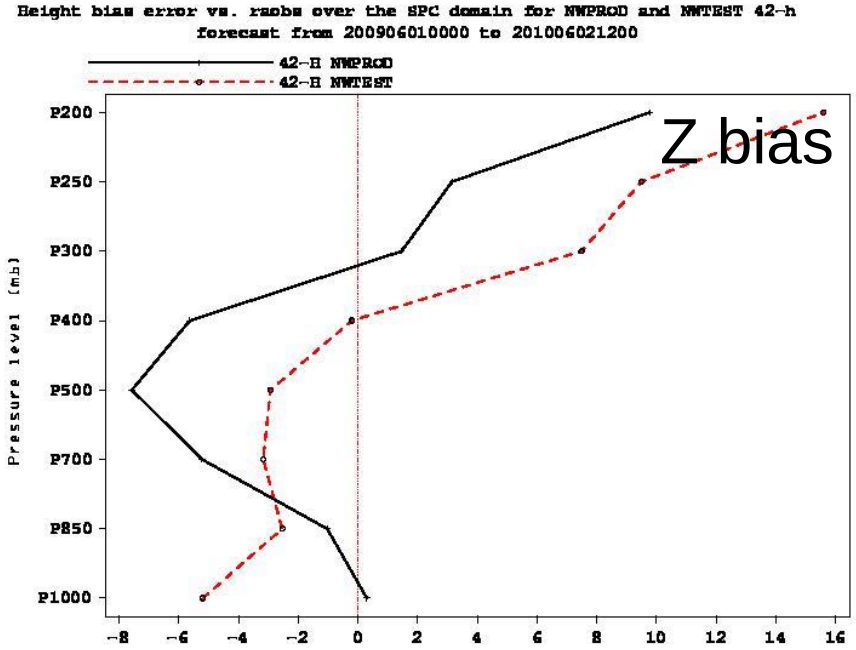

RMS height error vs. raobs over the SPC domain for NWPROD and NWTEST 42-h forecast from 200906010000 to 201006021200
42-H NWPROD
42-H NWTEST
Z
Pressure level (mb)
P200
P250
P300
P400
P500
P700
P850
P1000
14
16
18
20
22
24
26
28
30

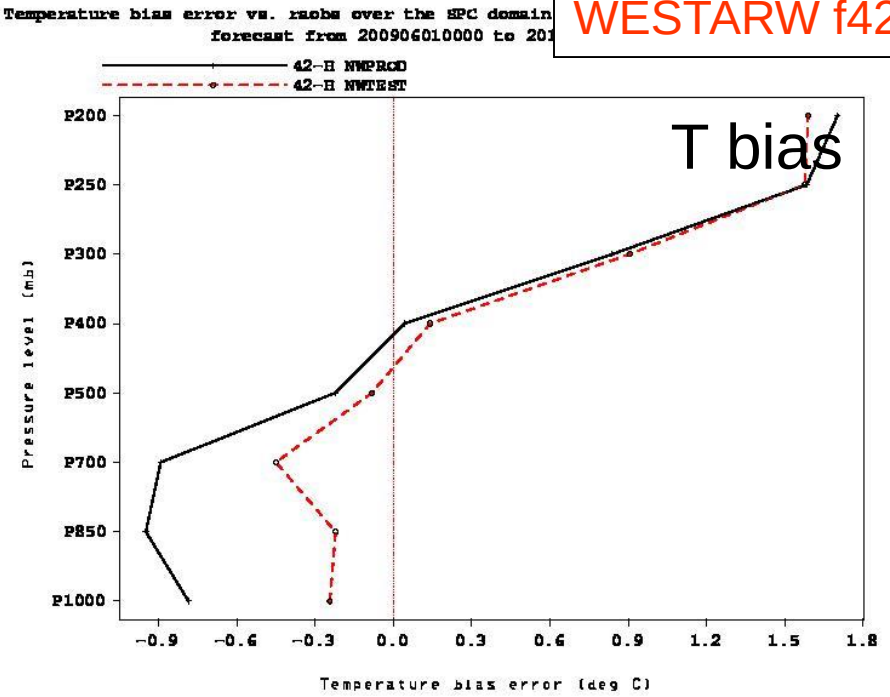

RMS temperature error vs. raobs over the SPC domain
forecast from 200906010000 to 201
42-H NWPROD
42-H NWTEST
T
Pressure level (mb)
P200
P250
P300
P400
P500
P700
P850
P1000
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0

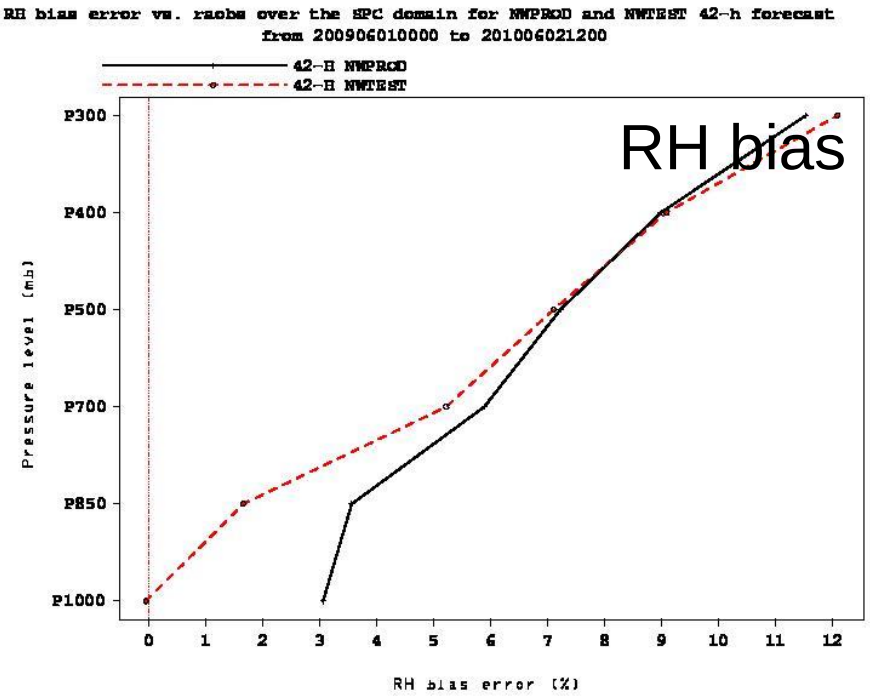

RMS relative humidity error vs. raobs over the SPC domain for NWPROD and NWTEST
42-h forecasts from 200906010000 to 201006021200
42-H NWPROD
42-H NWTEST
RH
Pressure level (mb)
P300
P400
P500
P700
P850
P1000
14
15
16
17
18
19
20
21
22
23
24
25
26
Root-mean-square RH error (%)


RMS vector wind error vs. raobs over the SPC domain for NWPROD and NWTEST 42-h
forecast from 200906010000 to 201006021200
42-H NWPROD
42-H NWTEST
V
Pressure level (mb)
P200
P250
P300
P400
P500
P700
P850
P1000
3.5
4.2
4.9
5.6
6.3
7.0
7.7
8.4
9.1
9.8
Root-mean-square vector wind error (m)

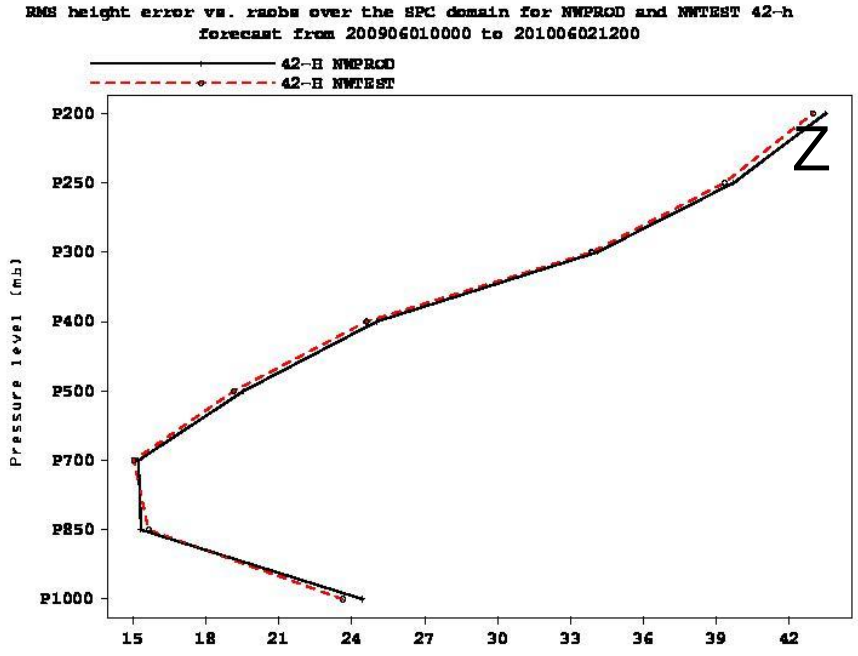
WESTARW f42

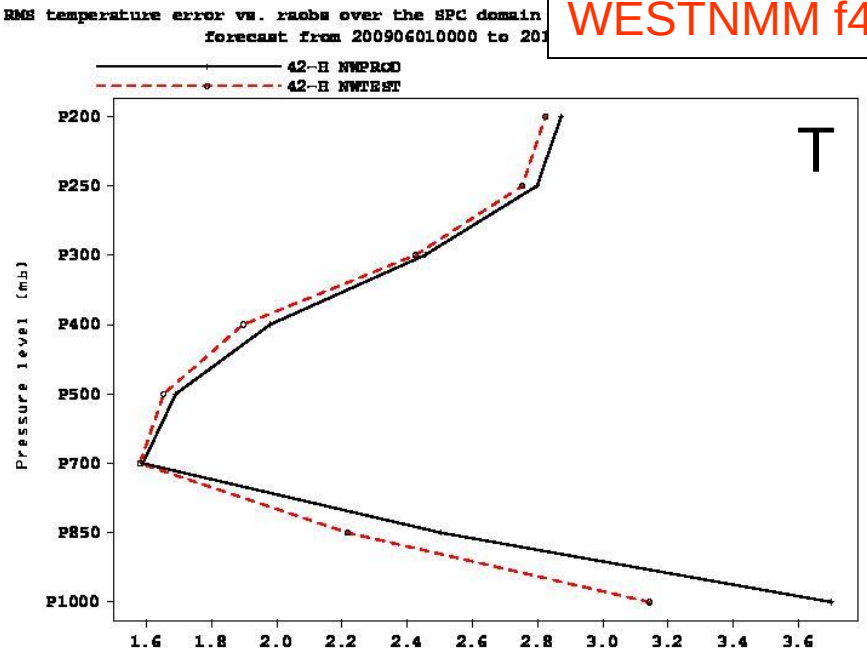

Height bias error vs. raobs over the SPC domain for NWPROD and NWTEST 42-h forecast from 200906010000 to 201006021200
42-H NWPROD
42-H NWTEST
Z bias
Pressure level (mb)
P200
P250
P300
P400
P500
P700
P850
P1000
-8
-6
-4
-2
0
2
4
6
8
10
12
14
16

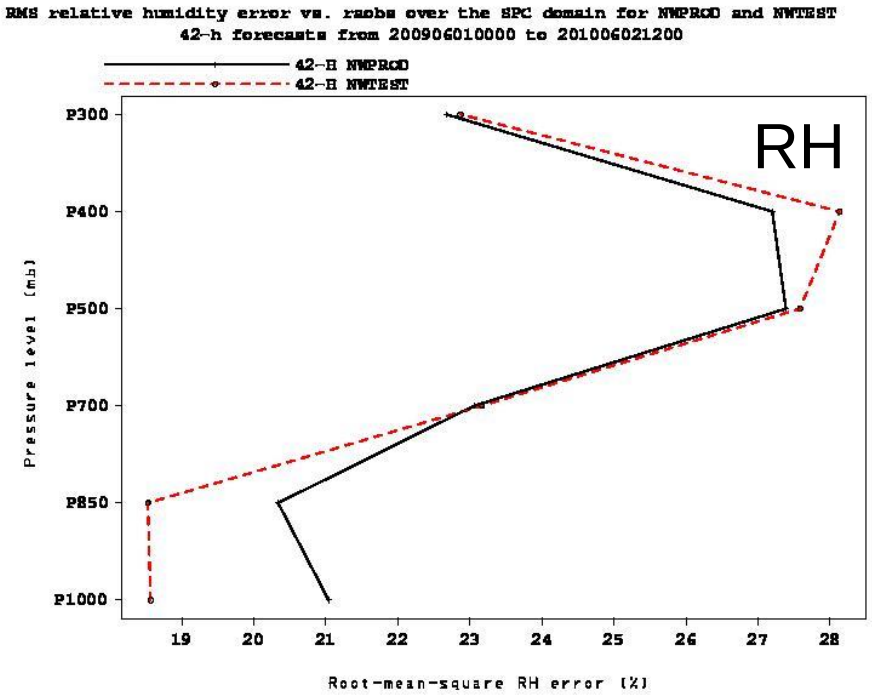

Temperature bias error vs. raobs over the SPC domain
forecast from 200906010000 to 201
42-H NWPROD
42-H NWTEST
T bias
Pressure level (mb)
P200
P250
P300
P400
P500
P700
P850
P1000
-0.9
-0.6
-0.3
0.0
0.3
0.6
0.9
1.2
1.5
1.8
Temperature bias error (deg C)

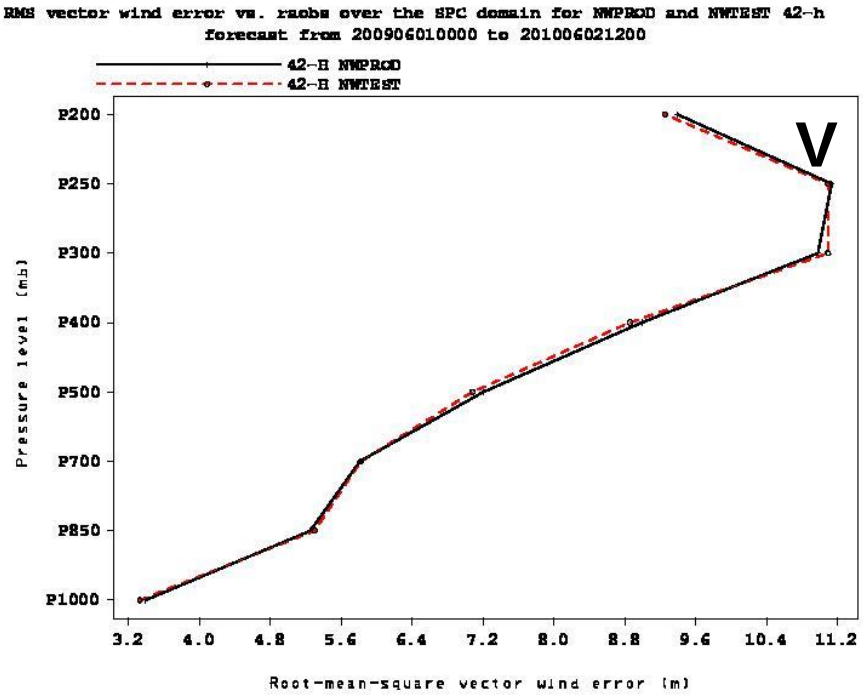

RH bias error vs. raobs over the SPC domain for NWPROD and NWTEST 42-h forecast from 200906010000 to 201006021200
42-H NWPROD
42-H NWTEST
RH bias
Pressure level (mb)
P300
P400
P500
P700
P850
P1000
0
1
2
3
4
5
6
7
8
9
10
11
12
RH bias error (%)

WESTNMM f42

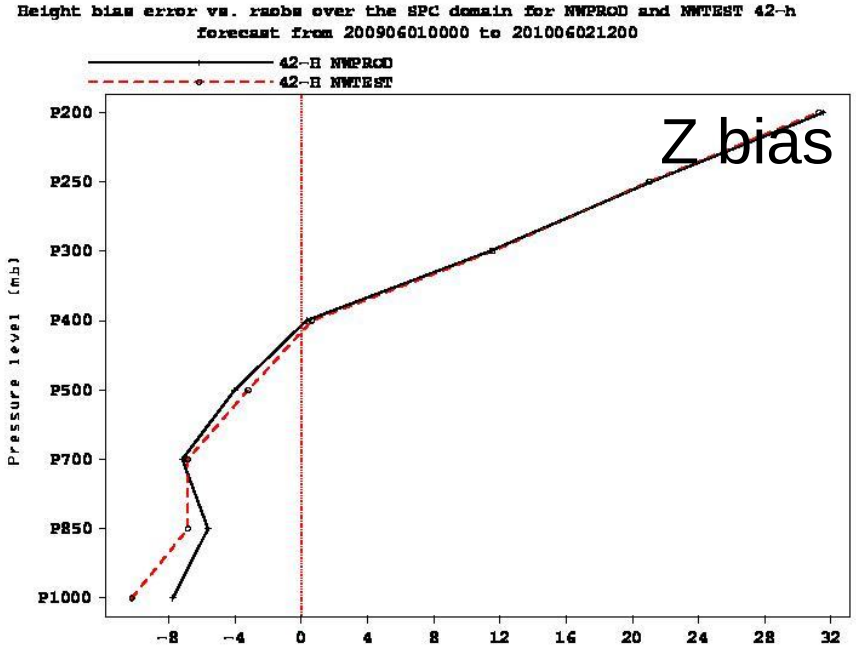

RMS height error vs. raobs over the SPC domain for NWPROD and NWTEST 42-h forecast from 200906010000 to 201006021200
42-H NWPROD
42-H NWTEST
Z
Pressure level (mb)
P200
P250
P300
P400
P500
P700
P850
P1000
15
18
21
24
27
30
33
36
39
42

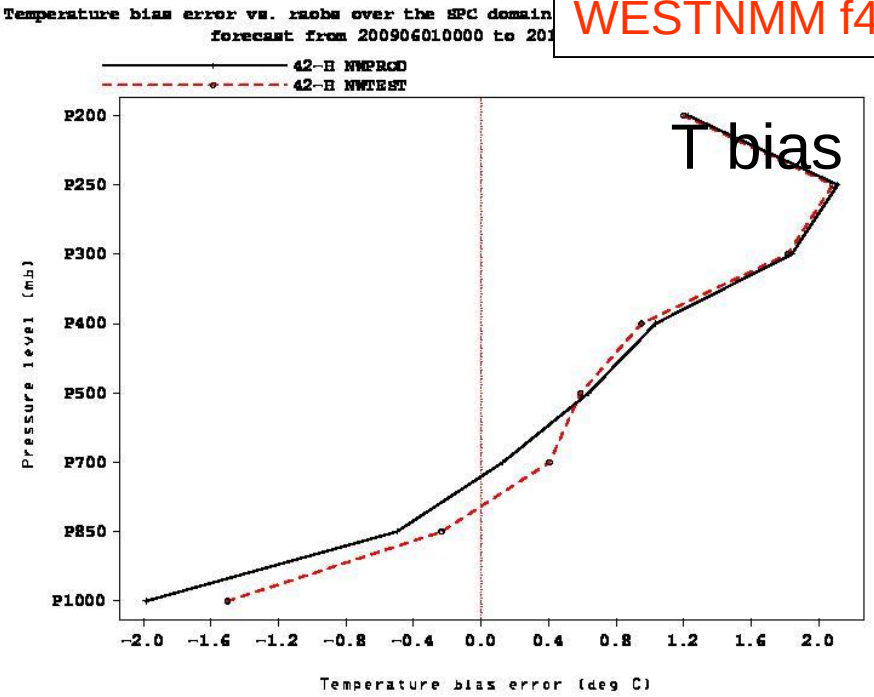

RMS temperature error vs. raobs over the SPC domain forecast from 200906010000 to 201
42-H NWPROD
42-H NWTEST
T
Pressure level (mb)
P200
P250
P300
P400
P500
P700
P850
P1000
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4
3.6

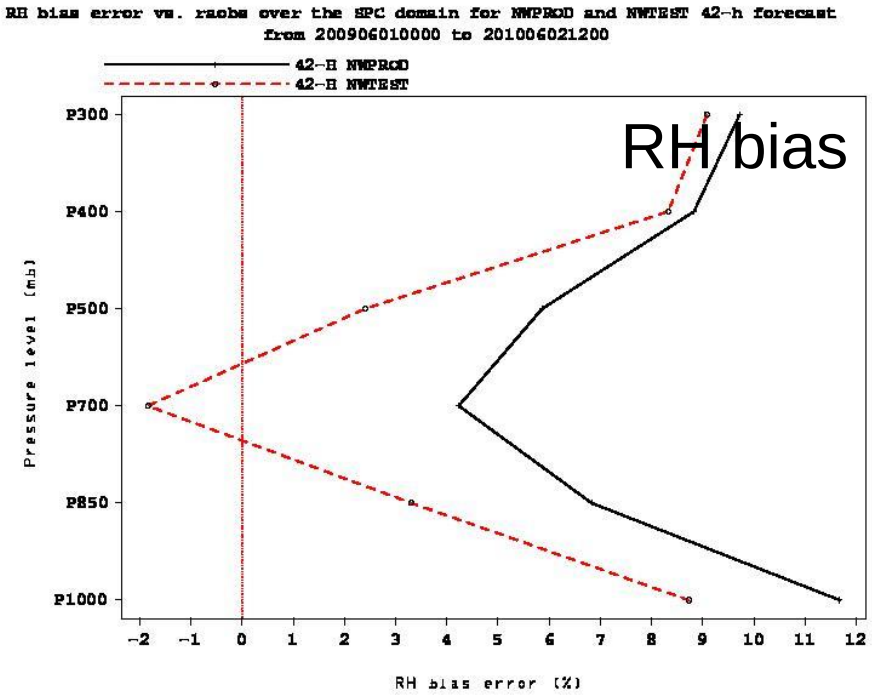

RMS relative humidity error vs. raobs over the SPC domain for NWPROD and NWTEST 42-h forecasts from 200906010000 to 201006021200
42-H NWPROD
42-H NWTEST
RH
Pressure level (mb)
P300
P400
P500
P700
P850
P1000
19
20
21
22
23
24
25
26
27
28
Root-mean-square RH error (%)


RMS vector wind error vs. raobs over the SPC domain for NWPROD and NWTEST 42-h forecast from 200906010000 to 201006021200
42-H NWPROD
42-H NWTEST
V
Pressure level (mb)
P200
P250
P300
P400
P500
P700
P850
P1000
3.2
4.0
4.8
5.6
6.4
7.2
8.0
8.8
9.6
10.4
11.2
Root-mean-square vector wind error (m)

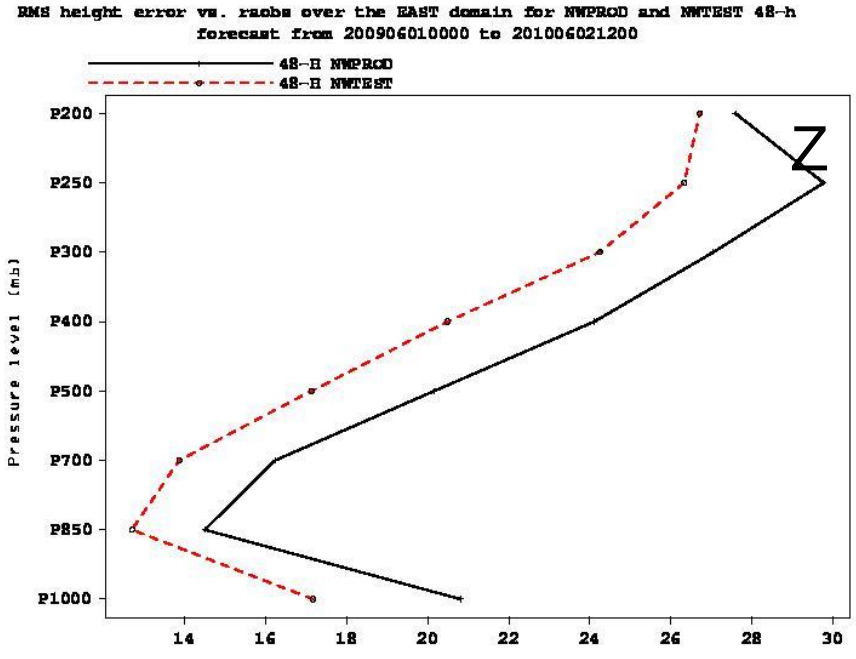
WESTNMM f42

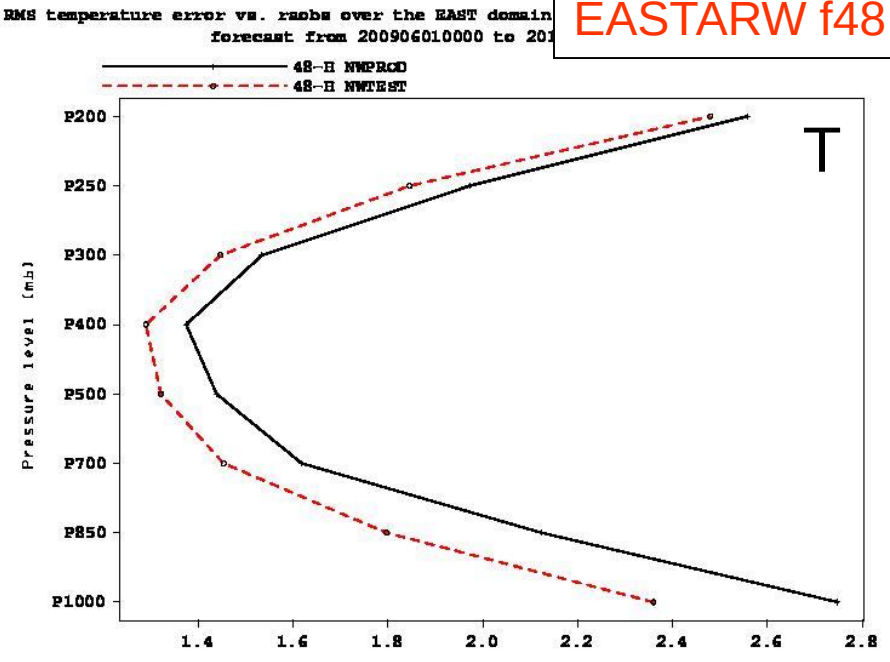

Height bias error vs. raobs over the SPC domain for NWPROD and NWTEST 42-h forecast from 200906010000 to 201006021200
42-H NWPROD
42-H NWTEST
Z bias
Pressure level (mb)
P200
P250
P300
P400
P500
P700
P850
P1000
-8
-4
0
4
8
12
16
20
24
28
32

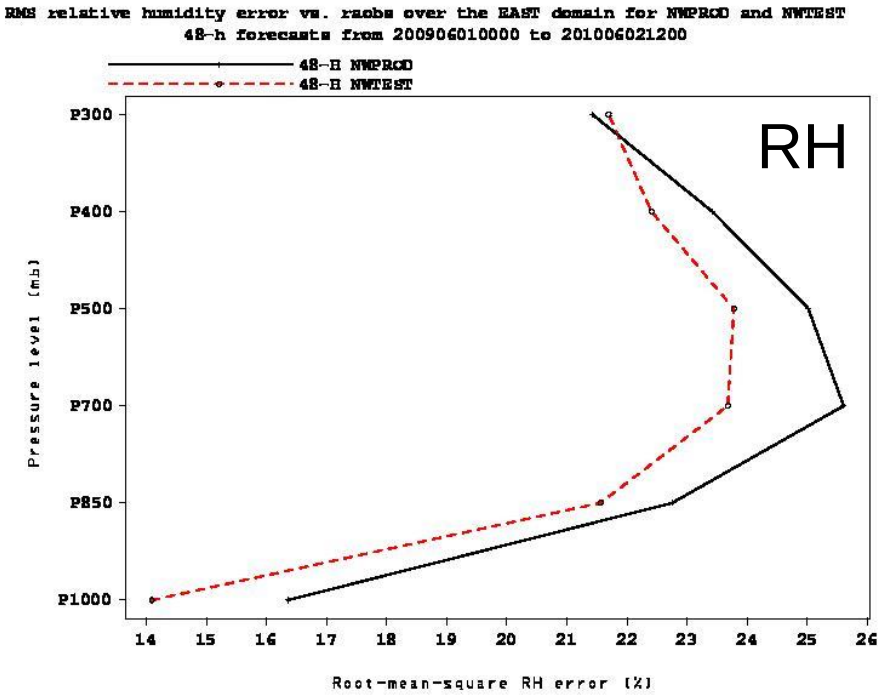

Temperature bias error vs. raobs over the SPC domain
forecast from 200906010000 to 201
42-H NWPROD
42-H NWTEST
T bias
Pressure level (mb)
P200
P250
P300
P400
P500
P700
P850
P1000
-2.0
-1.6
-1.2
-0.8
-0.4
0.0
0.4
0.8
1.2
1.6
2.0
Temperature bias error (deg C)

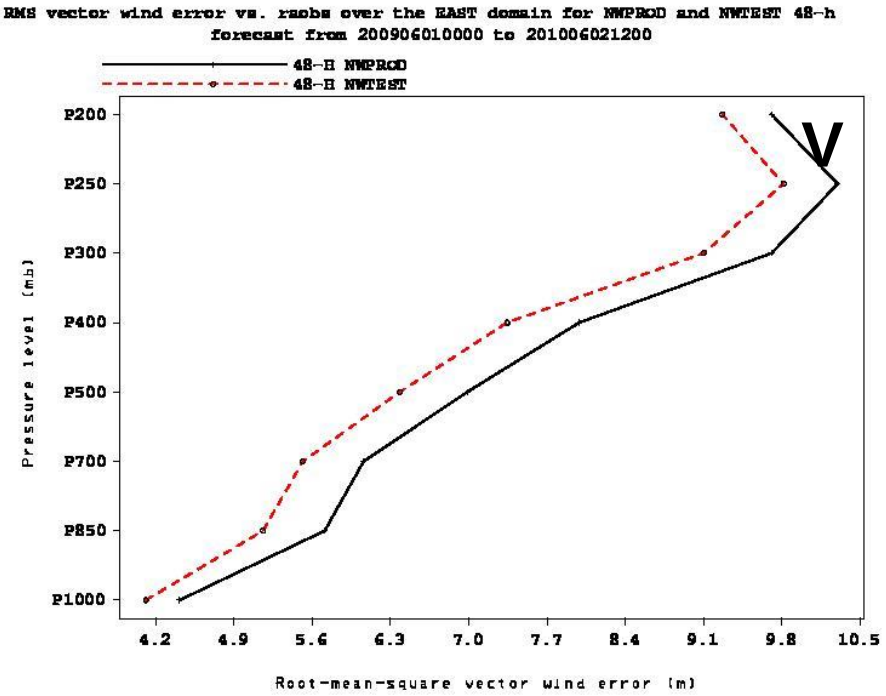

RH bias error vs. raobs over the SPC domain for NWPROD and NWTEST 42-h forecast from 200906010000 to 201006021200
42-H NWPROD
42-H NWTEST
RH bias
Pressure level (mb)
P300
P400
P500
P700
P850
P1000
-2
-1
0
1
2
3
4
5
6
7
8
9
10
11
12
RH bias error (%)

EASTARW f48

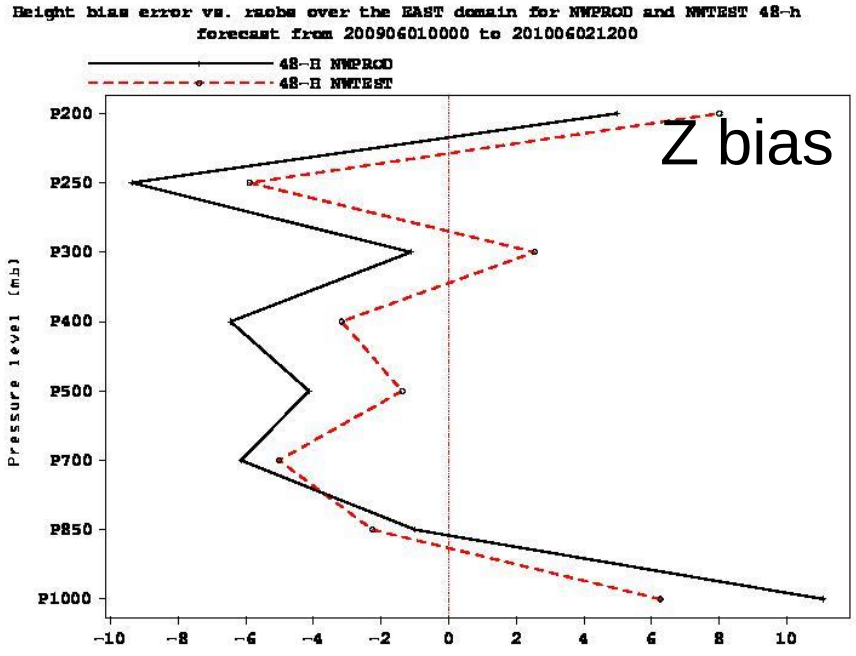

RMS height error vs. raobs over the EAST domain for NWPROD and NWTEST 48-h forecast from 200906010000 to 201006021200
48-H NWPROD
48-H NWTEST
Z
Pressure level (mb)
P200
P250
P300
P400
P500
P700
P850
P1000
14
16
18
20
22
24
26
28
30

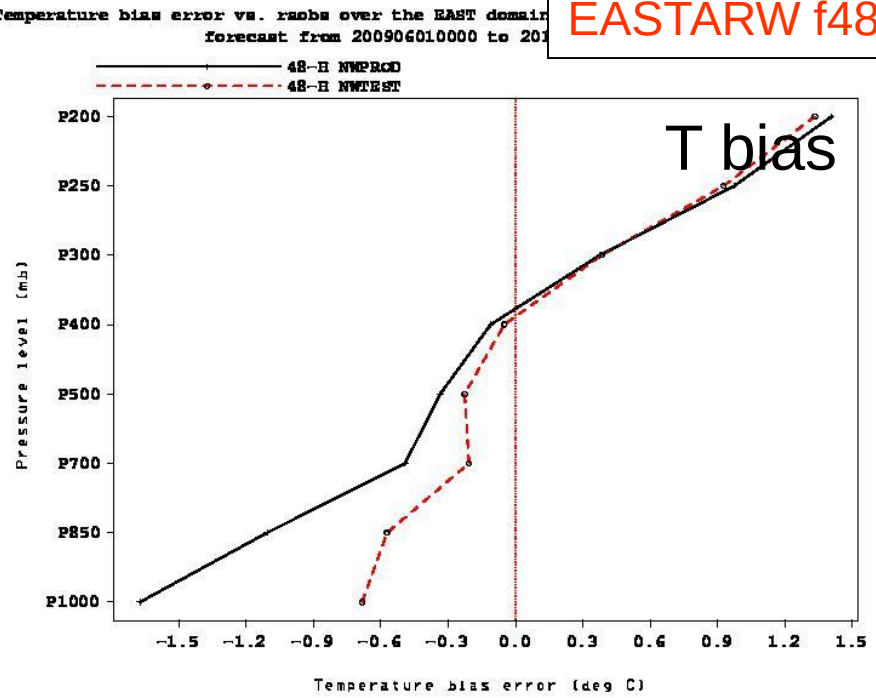

RMS temperature error vs. raobs over the EAST domain
forecast from 200906010000 to 201
48-H NWPROD
48-H NWTEST
T
Pressure level (mb)
P200
P250
P300
P400
P500
P700
P850
P1000
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8

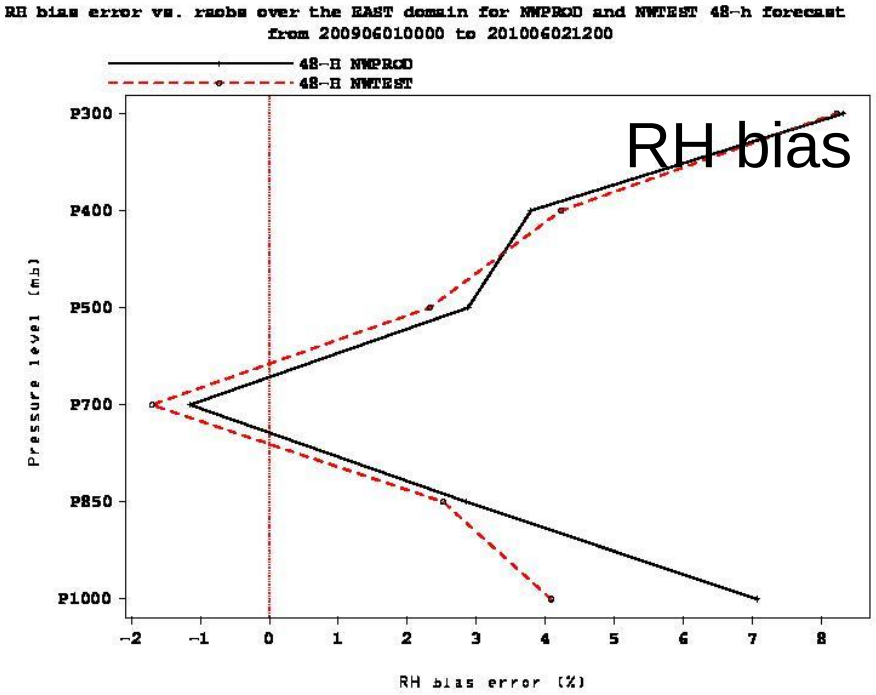

RMS relative humidity error vs. raobs over the EAST domain for NWPROD and NWTEST
48-h forecasts from 200906010000 to 201006021200
48-H NWPROD
48-H NWTEST
RH
Pressure level (mb)
P300
P400
P500
P700
P850
P1000
14
15
16
17
18
19
20
21
22
23
24
25
26
Root-mean-square RH error (%)


RMS vector wind error vs. raobs over the EAST domain for NWPROD and NWTEST 48-h
forecast from 200906010000 to 201006021200
48-H NWPROD
48-H NWTEST
V
Pressure level (mb)
P200
P250
P300
P400
P500
P700
P850
P1000
4.2
4.9
5.6
6.3
7.0
7.7
8.4
9.1
9.8
10.5
Root-mean-square vector wind error (m)

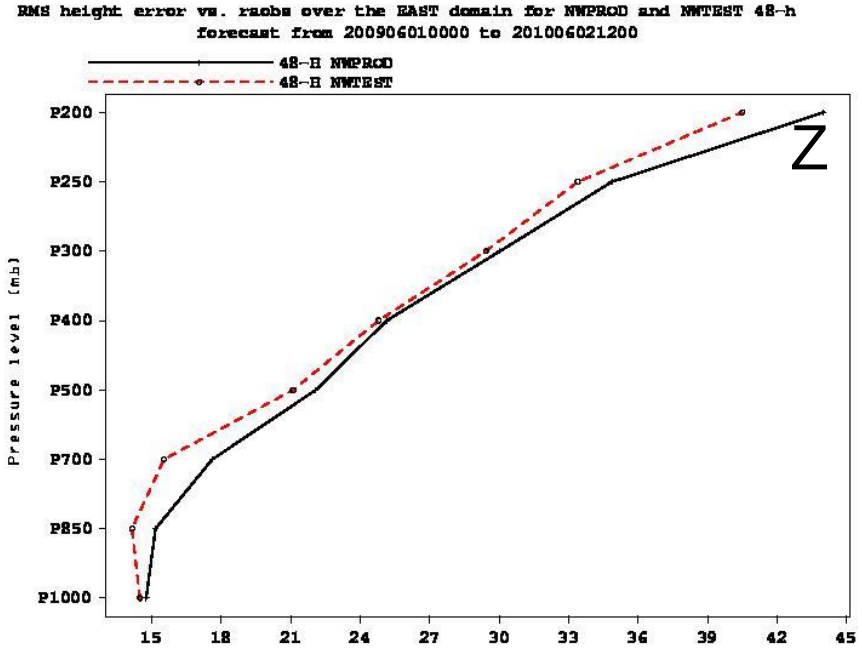
EASTARW f48

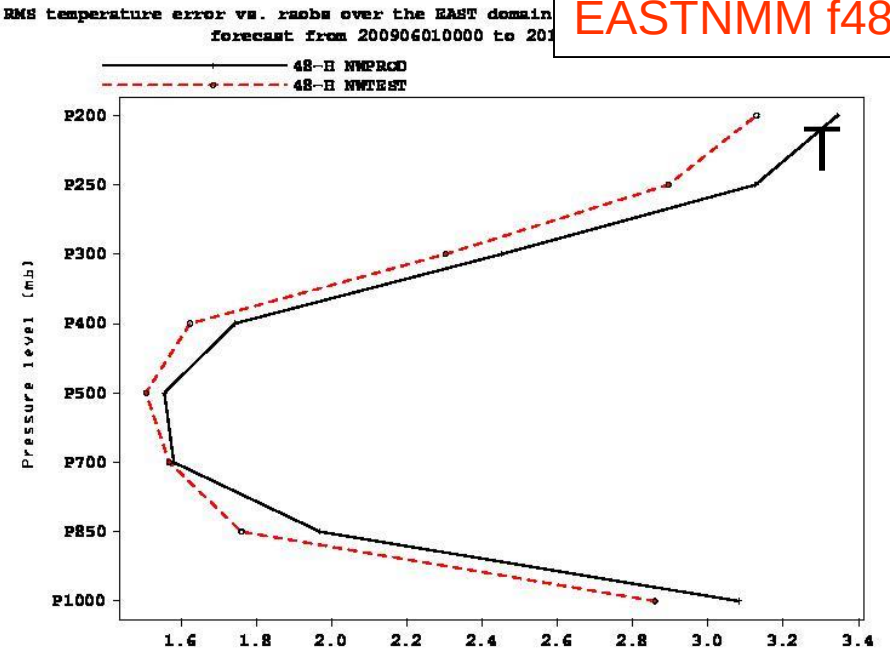

Height bias error vs. raobs over the EAST domain for NWPROD and NWTEST 48-h forecast from 200906010000 to 201006021200
48-H NWPROD
48-H NWTEST
Z bias
Pressure level (mb)
P200
P250
P300
P400
P500
P700
P850
P1000
-10
-8
-6
-4
-2
0
2
4
6
8
10

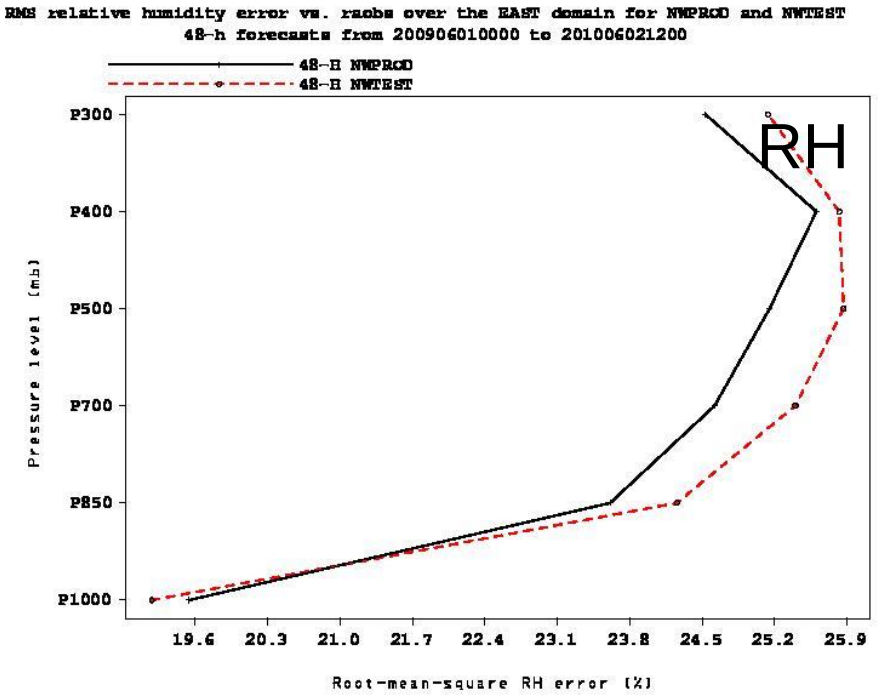

Temperature bias error vs. raobs over the EAST domain
forecast from 200906010000 to 201
48-H NWPROD
48-H NWTEST
T bias
Pressure level (mb)
P200
P250
P300
P400
P500
P700
P850
P1000
-1.5
-1.2
-0.9
-0.6
-0.3
0.0
0.3
0.6
0.9
1.2
1.5
Temperature bias error (deg C)

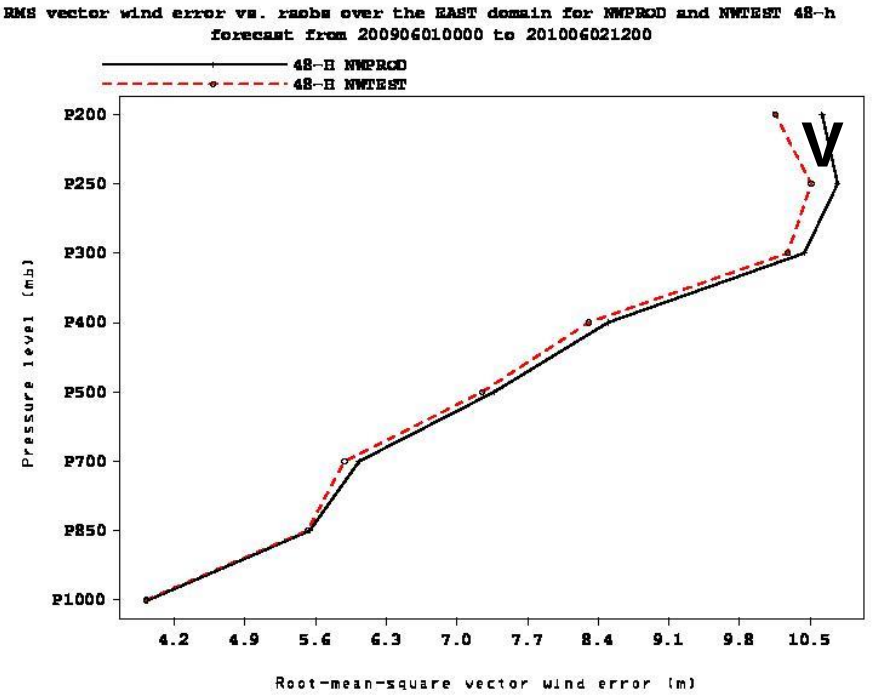

RH bias error vs. raobs over the EAST domain for NWPROD and NWTEST 48-h forecast from 200906010000 to 201006021200
48-H NWPROD
48-H NWTEST
RH bias
Pressure level (mb)
P300
P400
P500
P700
P850
P1000
-2
-1
0
1
2
3
4
5
6
7
8
RH bias error (%)

EASTNMM f48

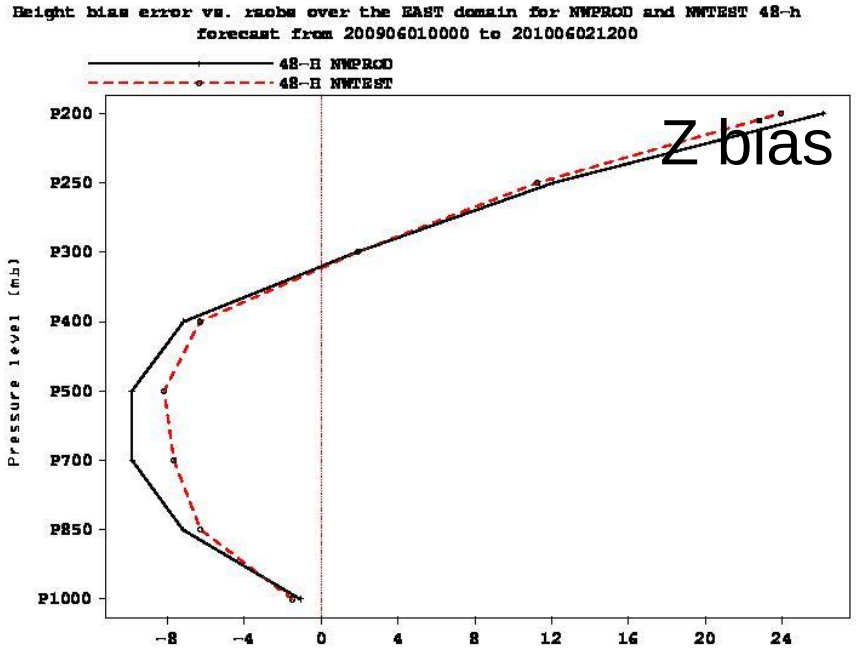

RMS height error vs. raobs over the EAST domain for NWPROD and NWTEST 48-h forecast from 200906010000 to 201006021200
48-H NWPROD
48-H NWTEST
Z
Pressure level (mb)
P200
P250
P300
P400
P500
P700
P850
P1000
15
18
21
24
27
30
33
36
39
42
45

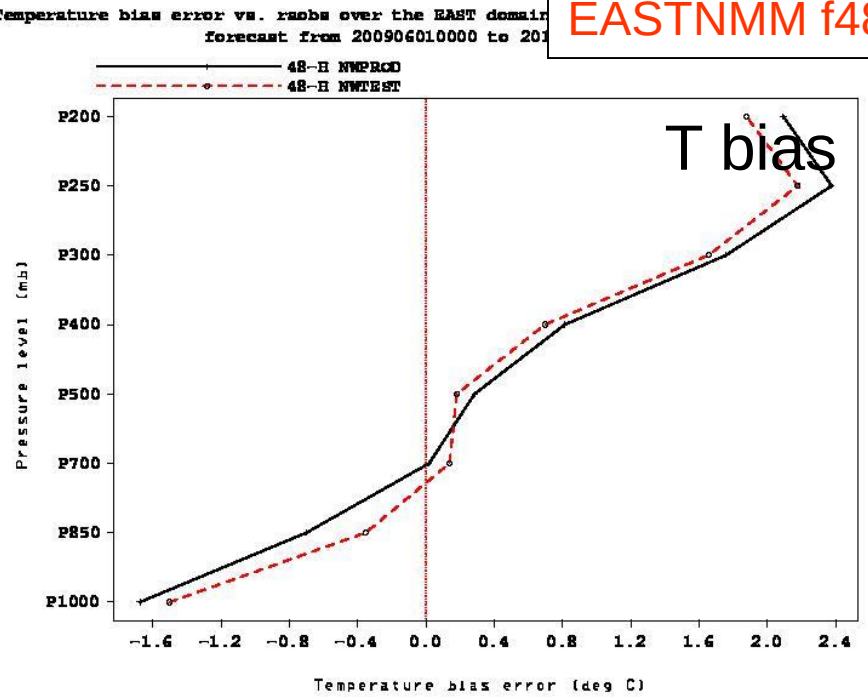

RMS temperature error vs. raobs over the EAST domain
forecast from 200906010000 to 201
48-H NWPROD
48-H NWTEST
T
Pressure level (mb)
P200
P250
P300
P400
P500
P700
P850
P1000
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4

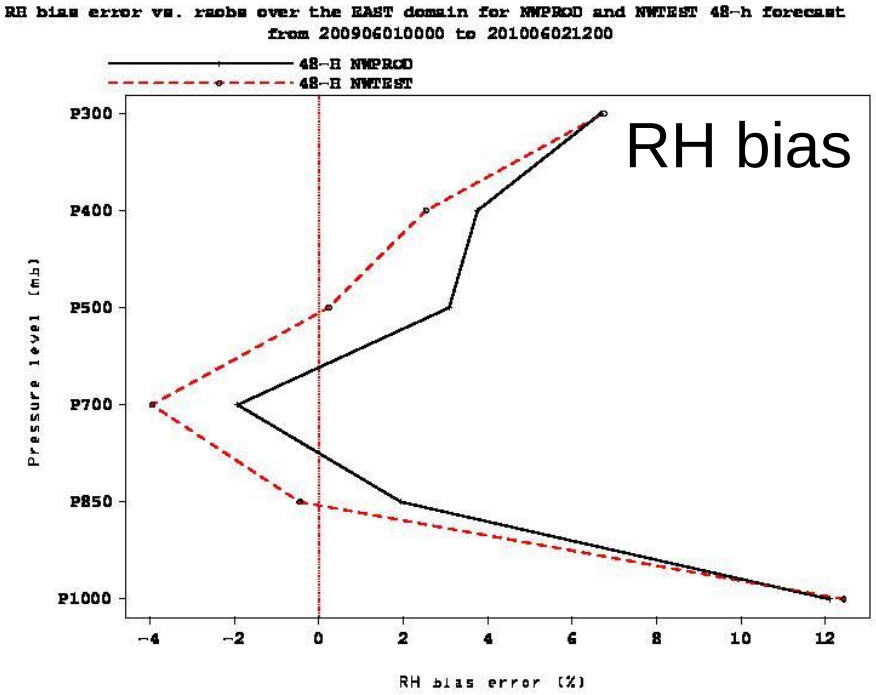

RMS relative humidity error vs. raobs over the EAST domain for NWPROD and NWTEST
48-h forecasts from 200906010000 to 201006021200
48-H NWPROD
48-H NWTEST
RH
Pressure level (mb)
P300
P400
P500
P700
P850
P1000
19.6
20.3
21.0
21.7
22.4
23.1
23.8
24.5
25.2
25.9
Root-mean-square RH error (%)

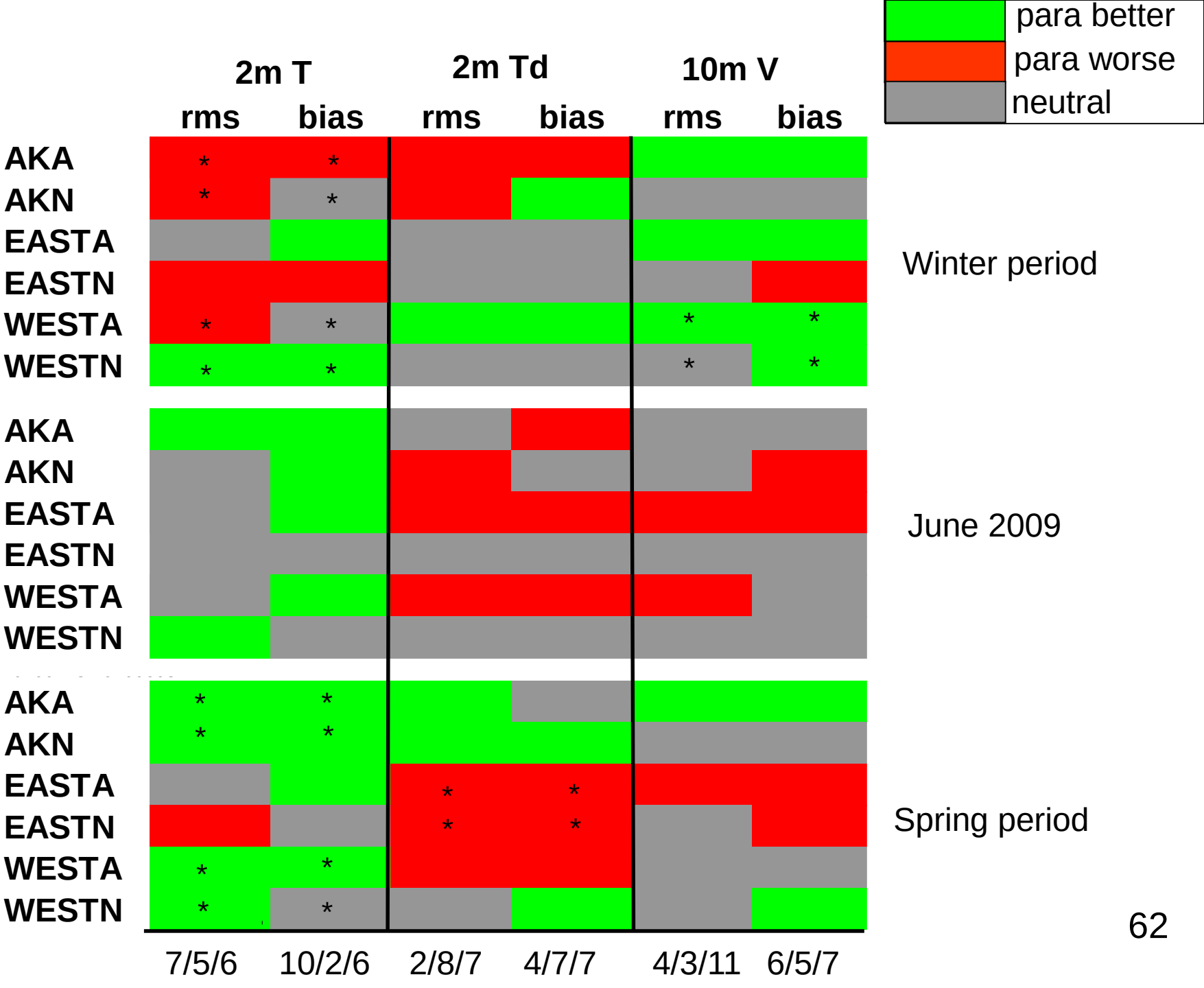

RMS vector wind error vs. raobs over the EAST domain for NWPROD and NWTEST 48-h
forecast from 200906010000 to 201006021200
48-H NWPROD
48-H NWTEST
V
Pressure level (mb)
P200
P250
P300
P400
P500
P700
P850
P1000
4.2
4.9
5.6
6.3
7.0
7.7
8.4
9.1
9.8
10.5
Root-mean-square vector wind error (m)

EASTNMM f48


Height bias error vs. raobs over the EAST domain for NWPROD and NWTEST 48-h forecast from 200906010000 to 201006021200
48-H NWPROD
48-H NWTEST
Z bias
Pressure level (mb)
P200
P250
P300
P400
P500
P700
P850
P1000
-8
-4
0
4
8
12
16
20
24


Temperature bias error vs. raobs over the EAST domain
forecast from 200906010000 to 201
48-H NWPROD
48-H NWTEST
T bias
Pressure level (mb)
P200
P250
P300
P400
P500
P700
P850
P1000
-1.6
-1.2
-0.8
-0.4
0.0
0.4
0.8
1.2
1.6
2.0
2.4
Temperature bias error (deg C)

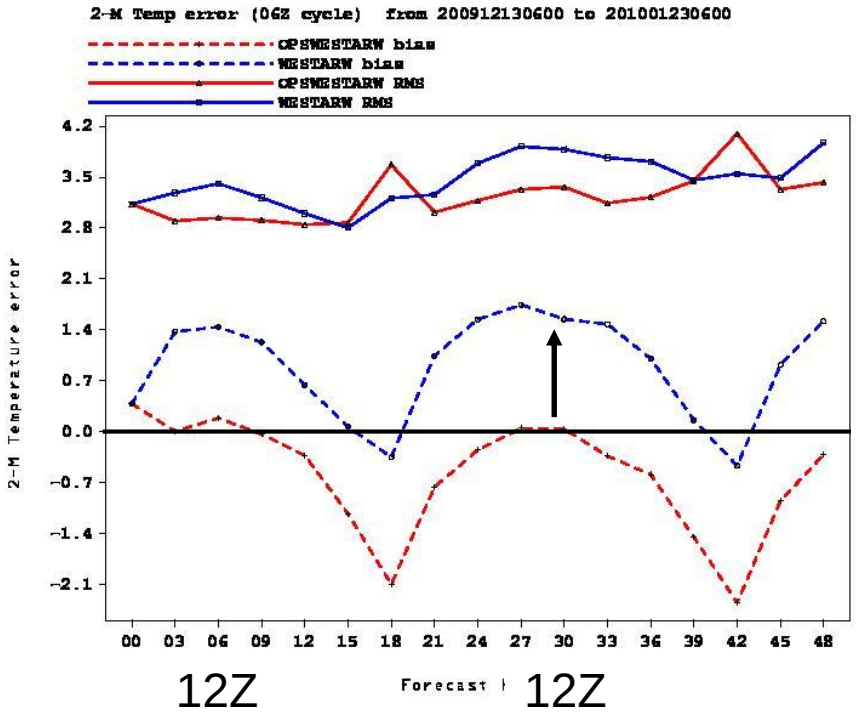

RH bias error vs. raobs over the EAST domain for NWPROD and NWTEST 48-h forecast from 200906010000 to 201006021200
48-H NWPROD
48-H NWTEST
RH bias
Pressure level (mb)
P300
P400
P500
P700
P850
P1000
-4
-2
0
2
4
6
8
10
12
RH bias error (%)


para better
para worse
neutral
2m T
2m Td
10m V
rms
bias
rms
bias
rms
bias
AKA
AKN
EASTA
EASTN
WESTA
WESTN
Winter period
AKA
AKN
EASTA
EASTN
WESTA
WESTN
June 2009
AKA
AKN
EASTA
EASTN
WESTA
WESTN
Spring period
7/5/6
10/2/6
2/8/7
4/7/7
4/3/11
6/5/7

WEST diurnal 2m T
20091213 - 20100123

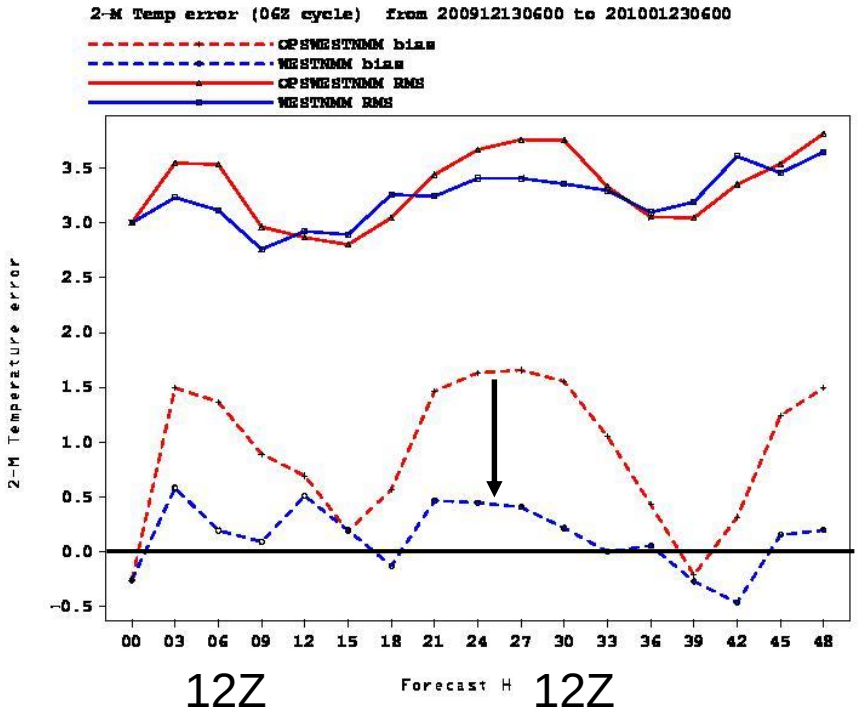
RED = ops run

BLUE = para run



12Z 12Z

ARW



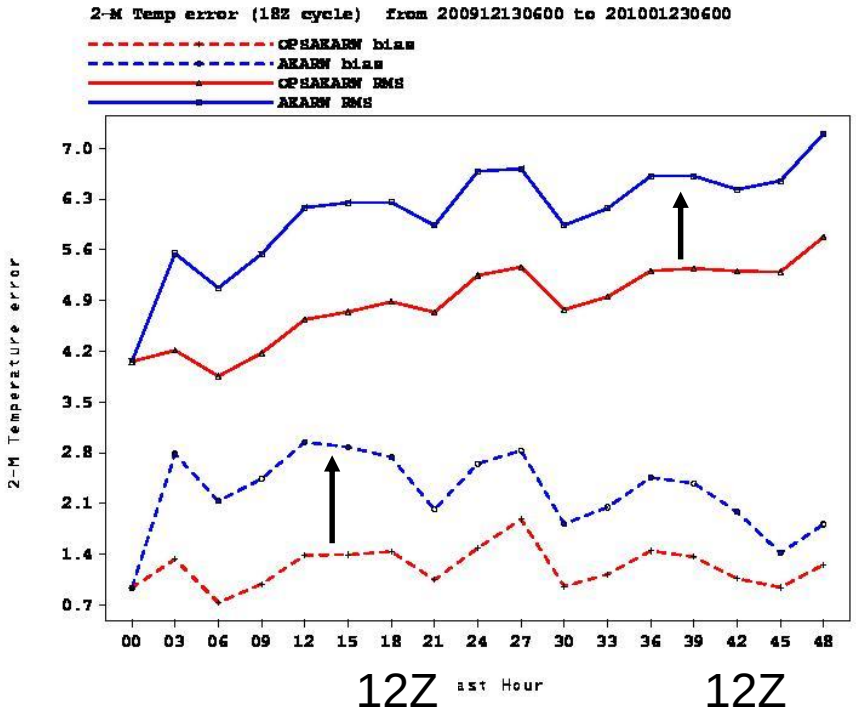
12Z 12Z

NMM

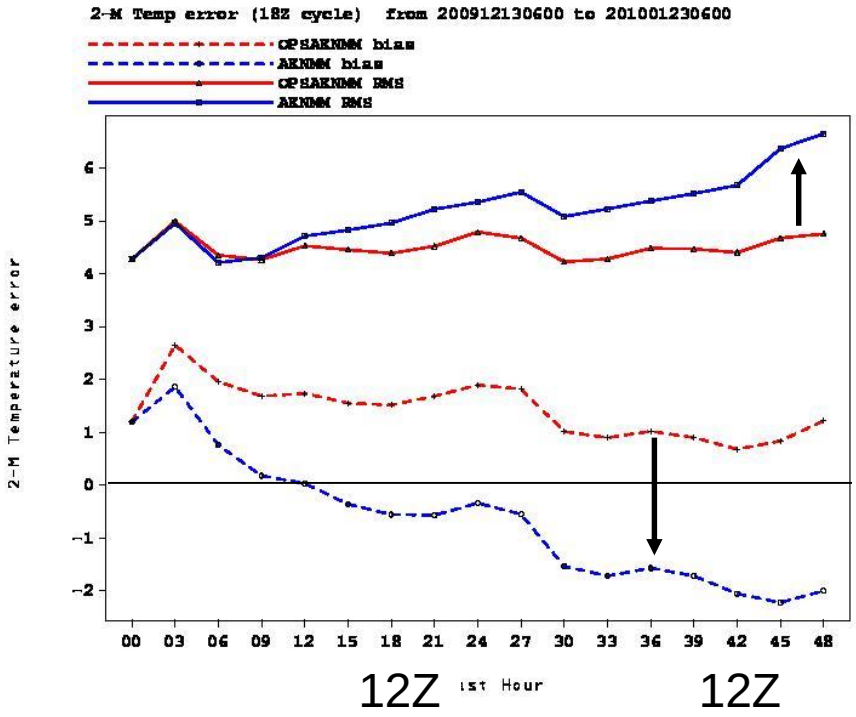
AK diurnal 2m T
20091213-20100123

RED = ops run

BLUE = para run



ARW

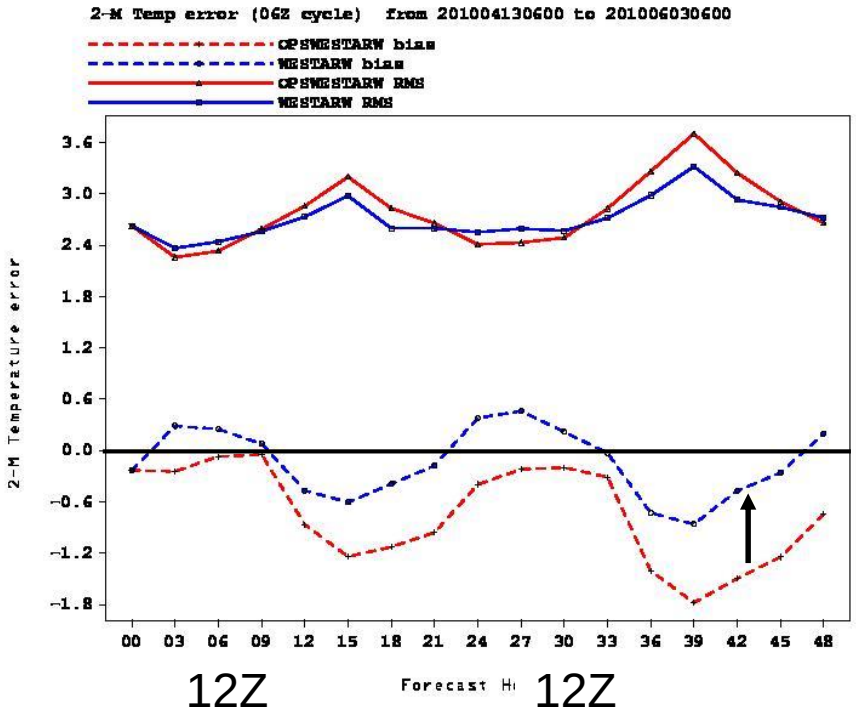


NMM

WEST diurnal 2m T
Spring 2010

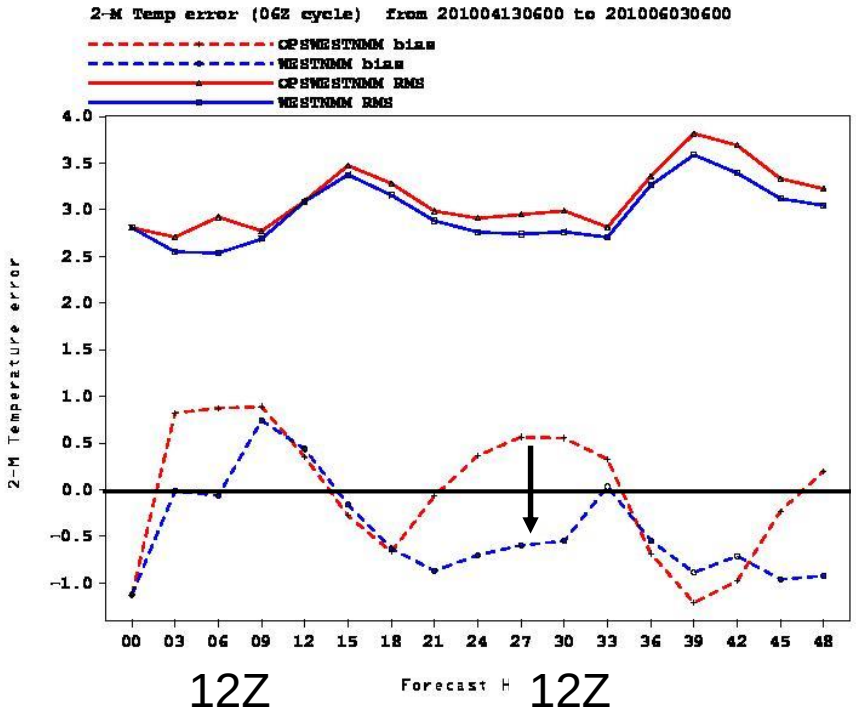
RED = ops run

BLUE = para run



12Z 12Z

ARW



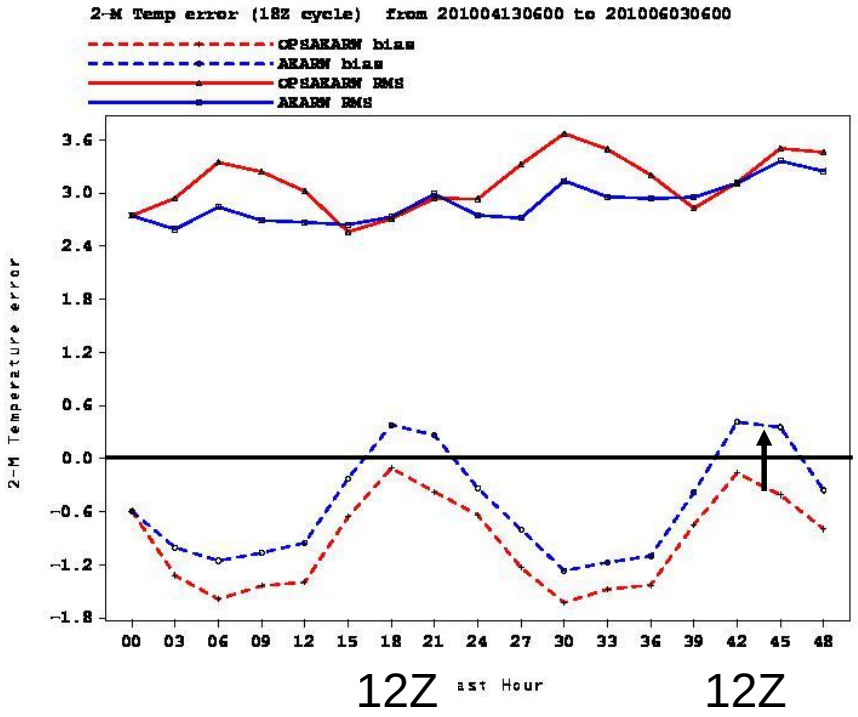
12Z 12Z

NMM

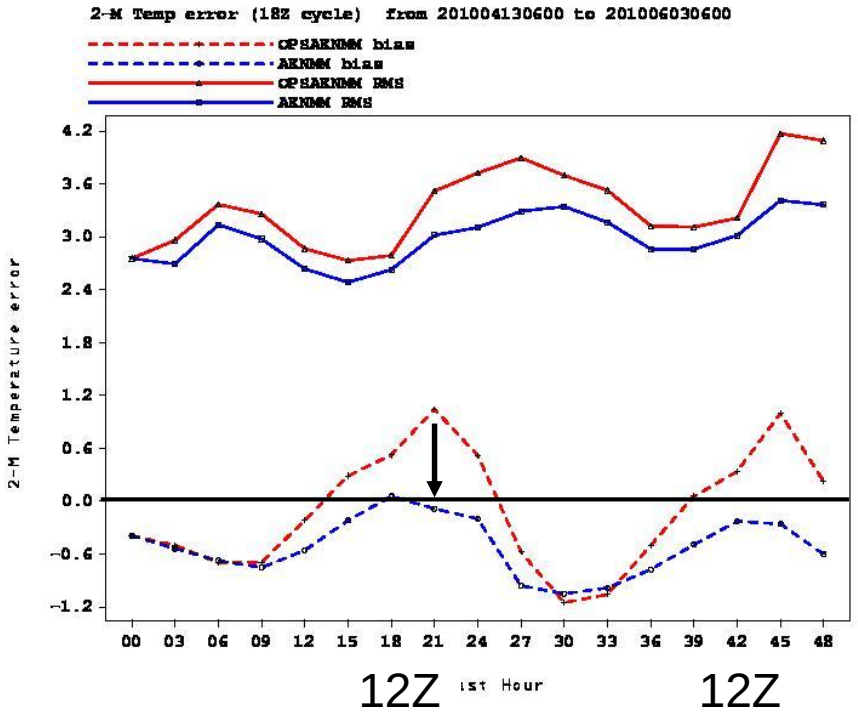
AK diurnal 2m T
Spring 2010

RED = ops run

BLUE = para run



ARW

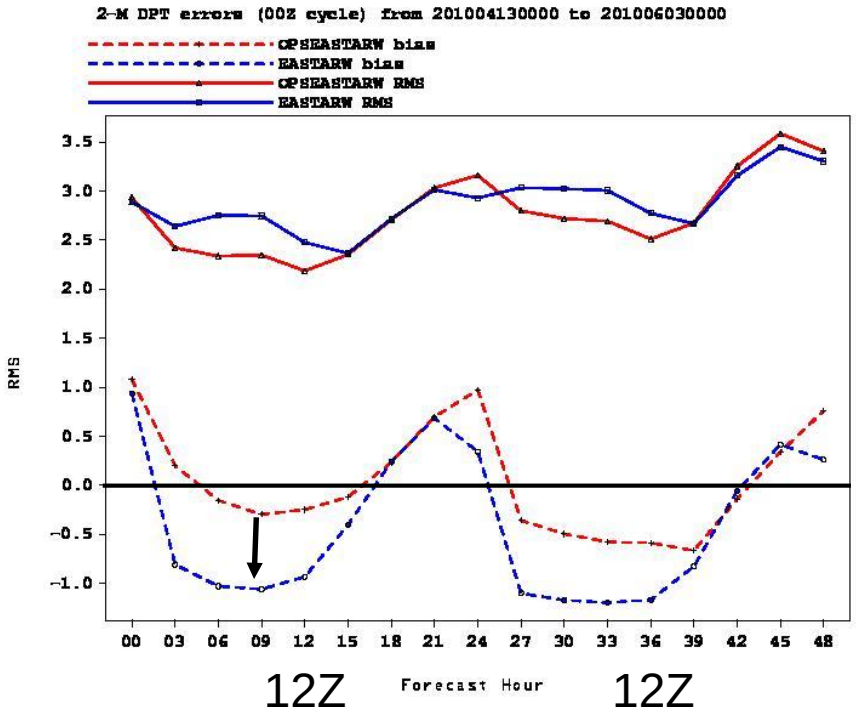


NMM

EAST diurnal 2m Td
Spring 2010

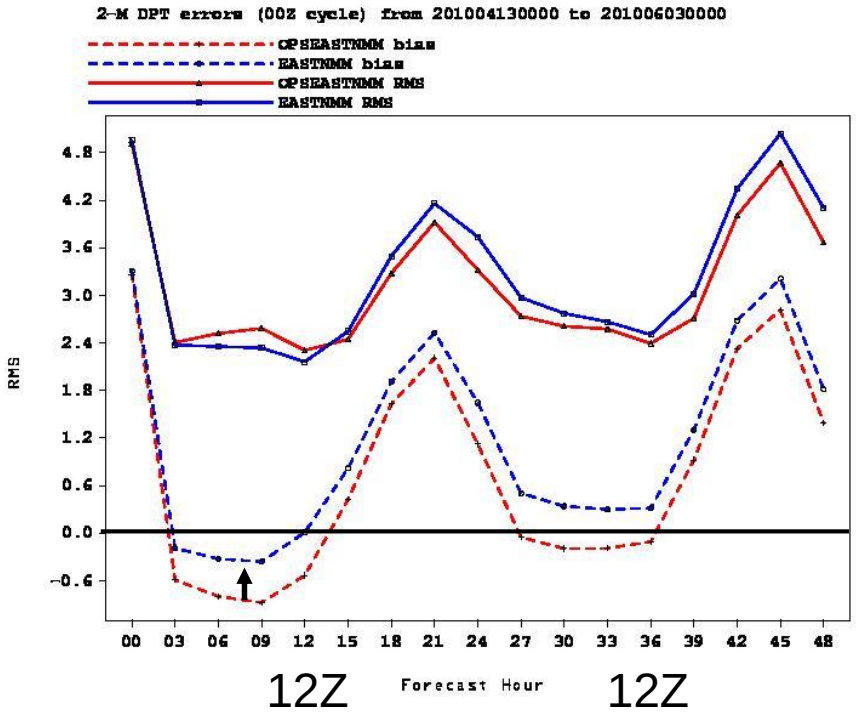
RED = ops run

BLUE = para run



12Z 12Z

ARW



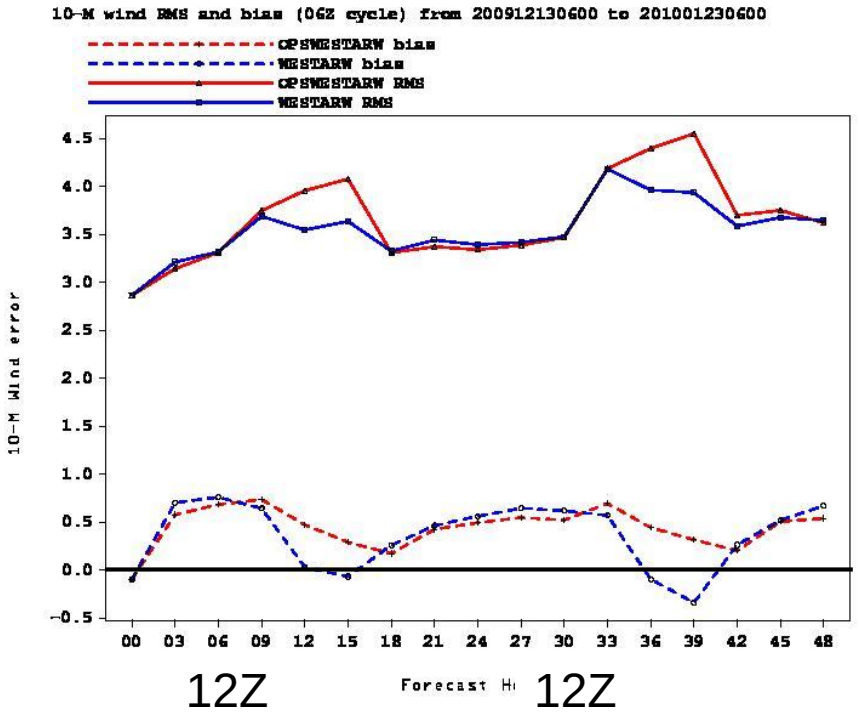
12Z 12Z

NMM

WEST diurnal 10 m **V**
20091213 - 20100123

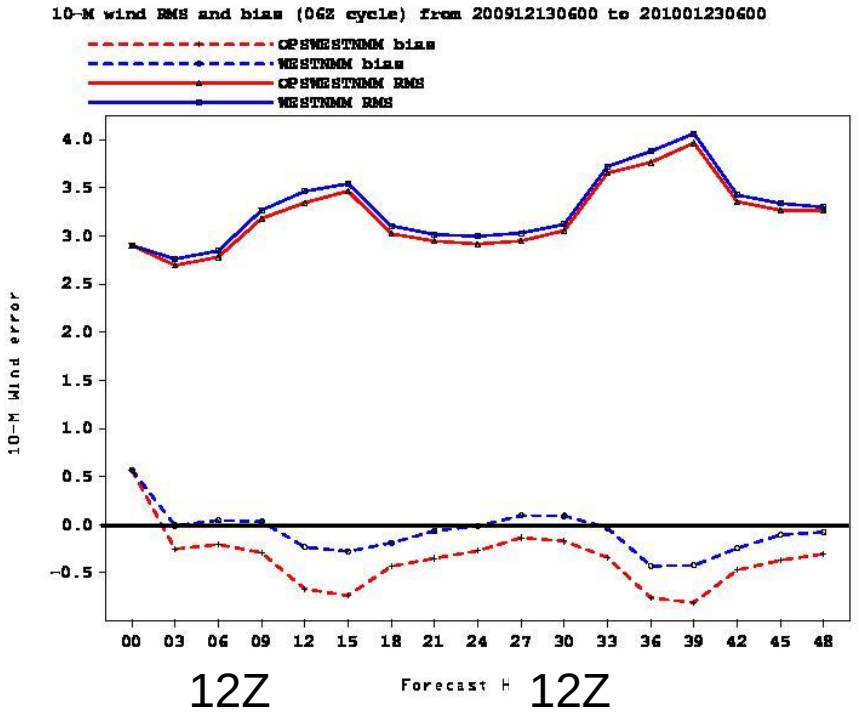
RED = ops run

BLUE = para run



12Z 12Z

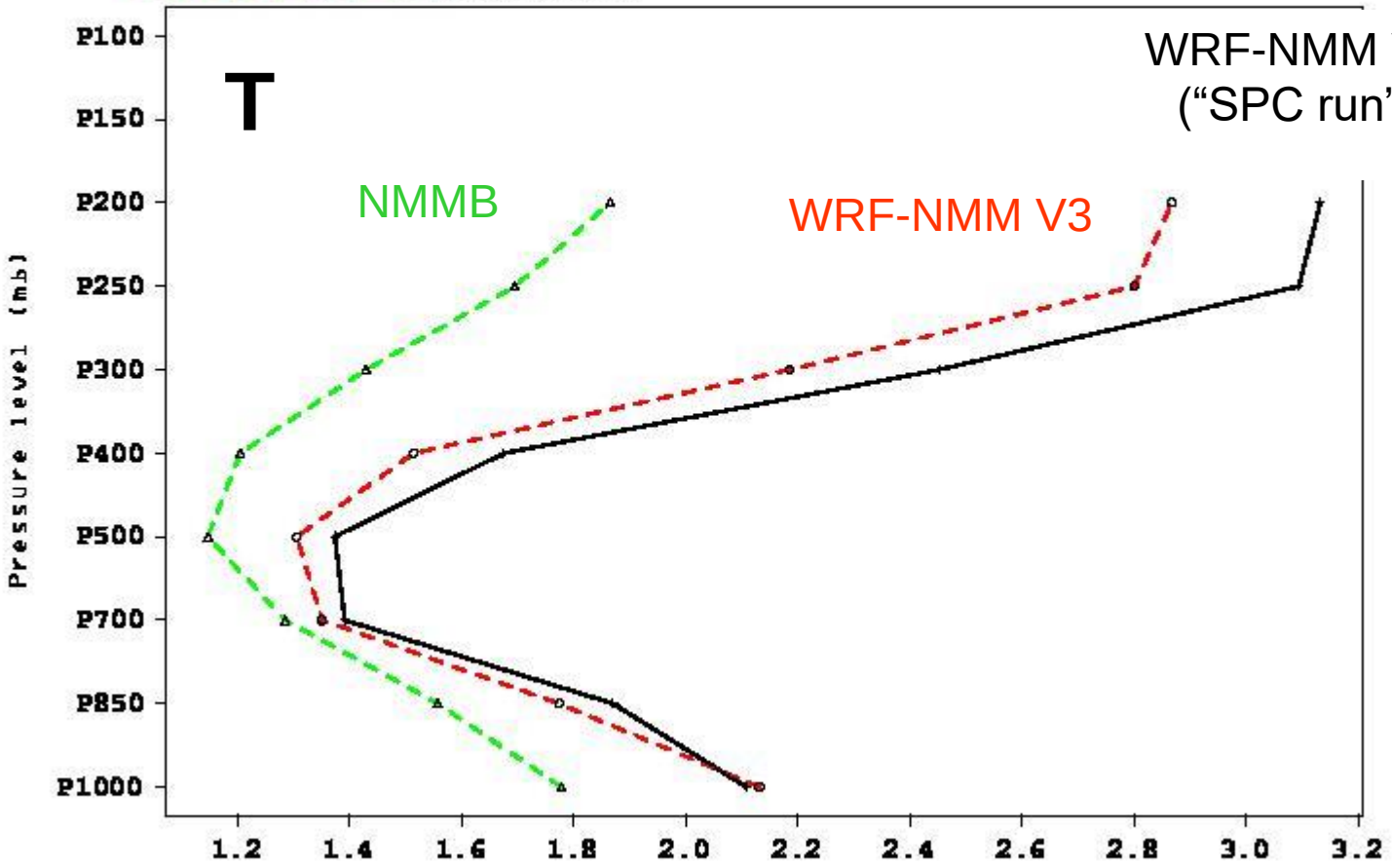
ARW



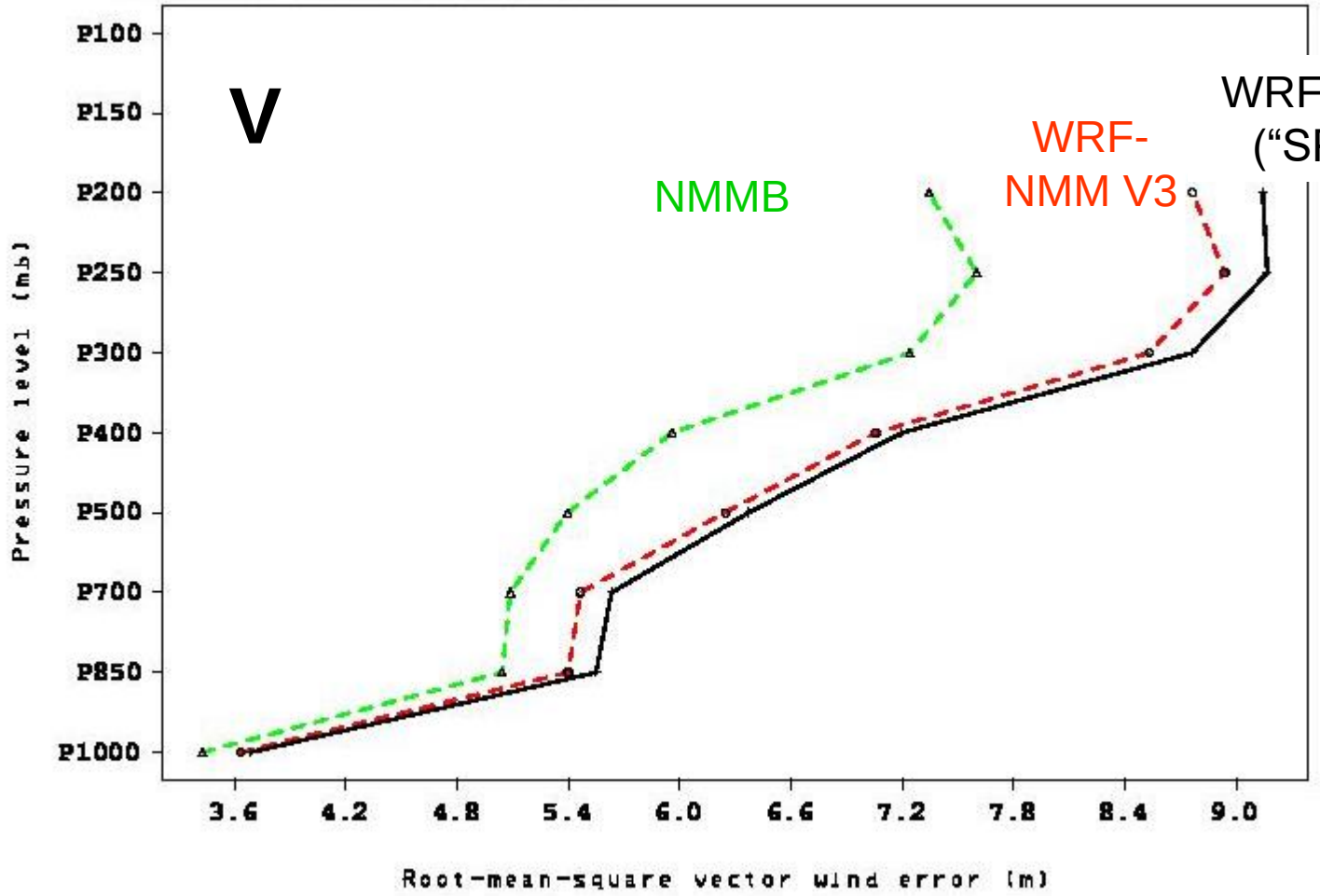
12Z 12Z

NMM

Development CONUS 4 km runs 04/03-09/27: 36 h forecast T rms



Development CONUS 4 km runs 04/03-09/15: 36 h forecast V rms



High Resolution Rapid Refresh Ensemble (HRRRE) Time-Lagged [TL] System

- **Example: Ensemble member combination for 06Z cycle run**

4 NAM-nest cycles, weighted 0.7, 0.5, 0.3, 0.1, respectively

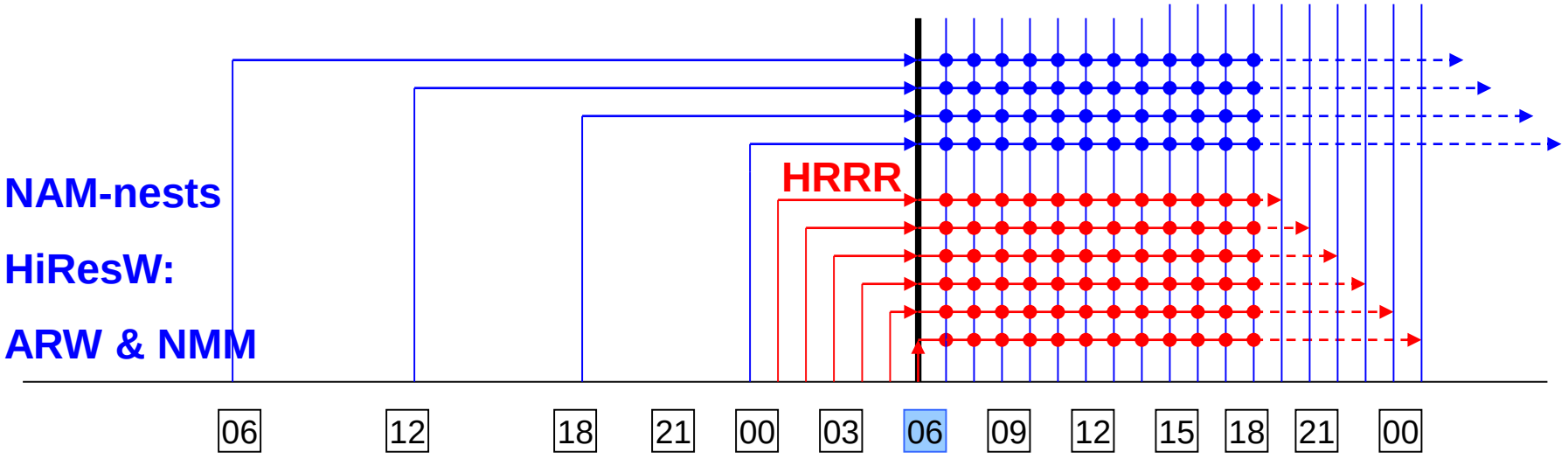
4 HRW-ARW cycles, weighted 0.7, 0.5, 0.3, 0.1, respectively

4 HRW-NMM cycles, weighted 0.7, 0.5, 0.3, 0.1, respectively

4 Pyle-SPC cycles, weighted 0.7, 0.5, 0.3, 0.1, respectively

6 HRRR cycles, weighted 1.0, 0.9, 0.8, 0.7, 0.6, 0.5, respectively

Forecast range could be extended beyond 12 hr without HRRR



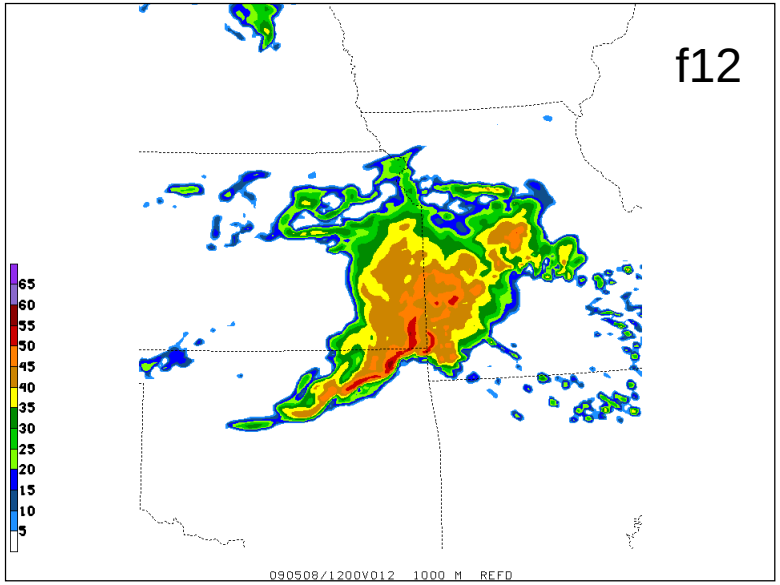
Like VSREF soon-to-be-known-as the NARRE-TL for Time Lagged NARRE

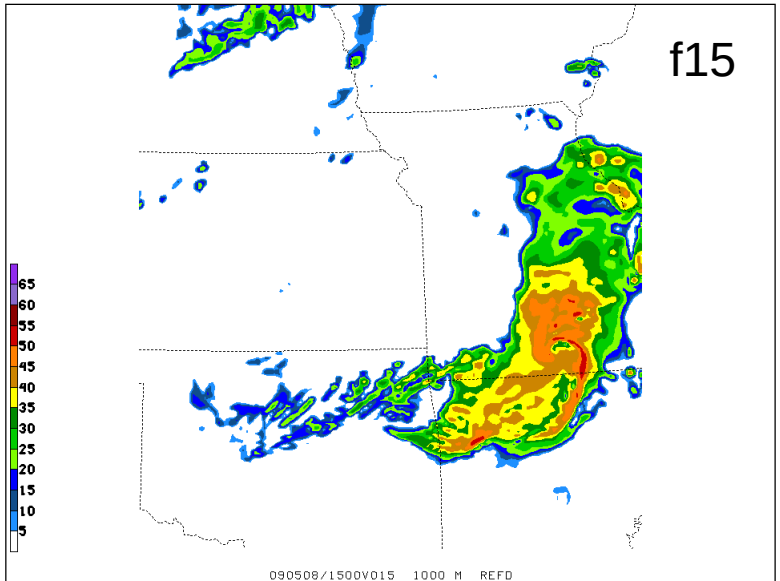
Charter Test Plan Case reruns

- Alaskan operational failure cases rerun:
  - 20090115/18Z
  - 20091112/18Z
  - no issues
- 20090508 bow echo case - details changed, but retain bowing convective system in parallel.
- 20091007 precipitation case - little apparent improvement in skill (but smaller false alarm over OK for NMM).

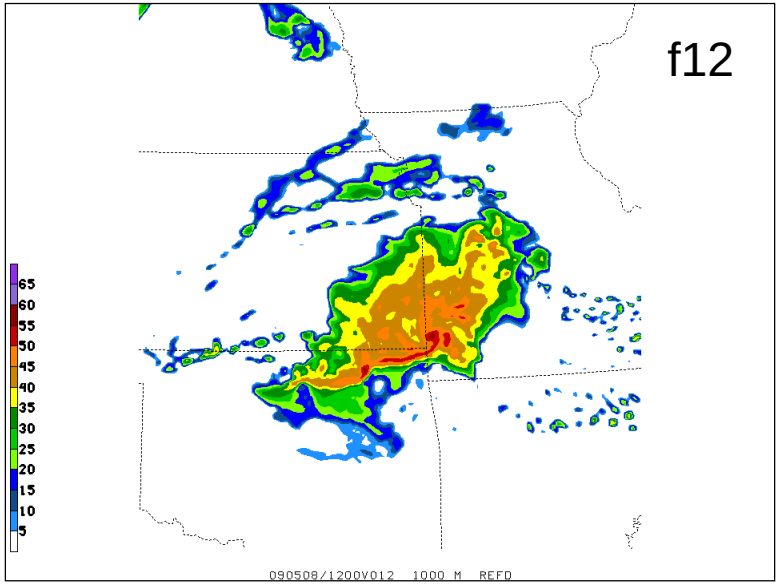
20090508/00Z case

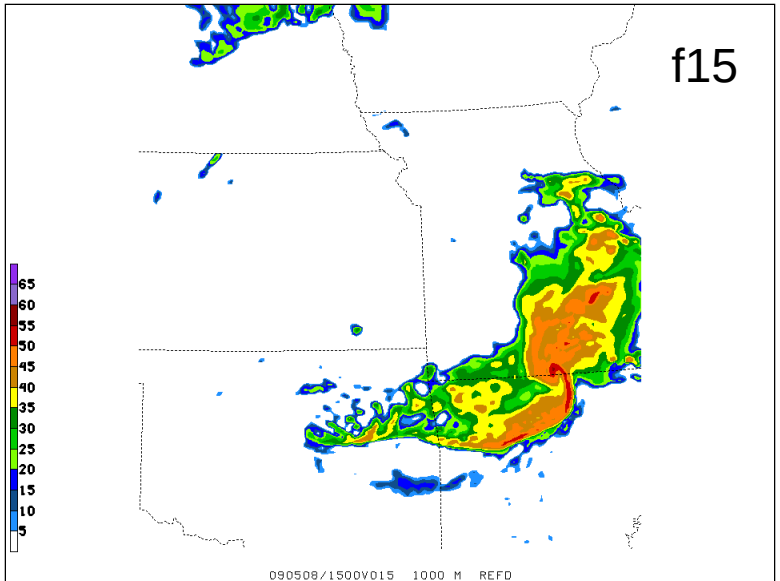
Prod ARW





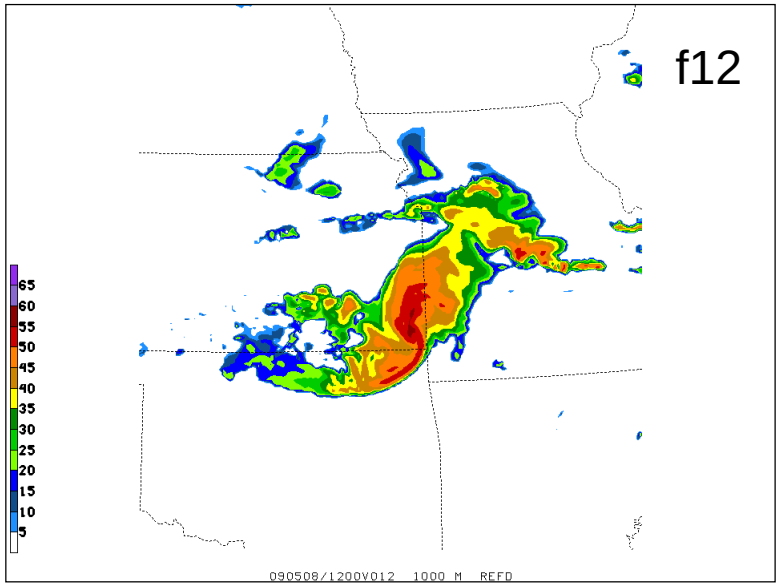
Para ARW

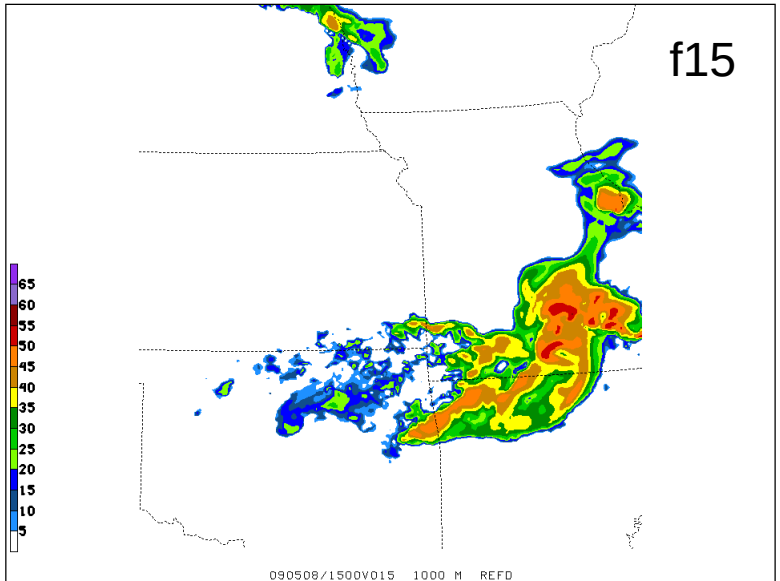




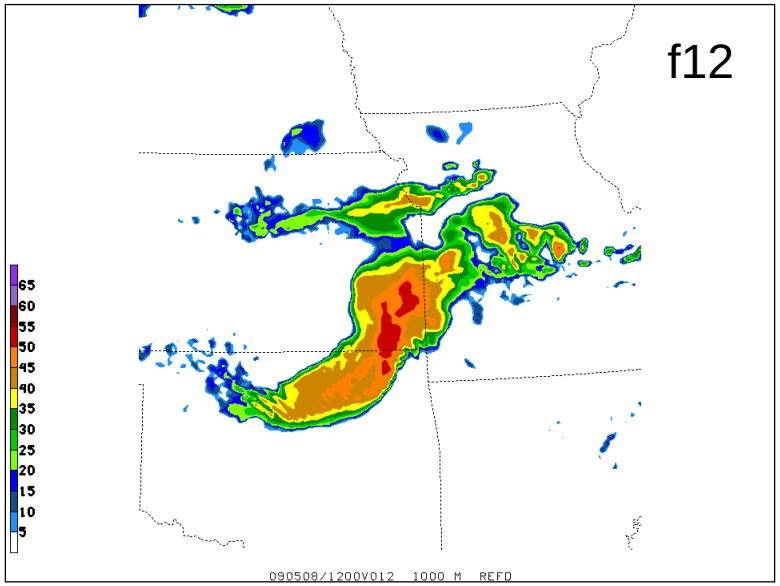
20090508/00Z case

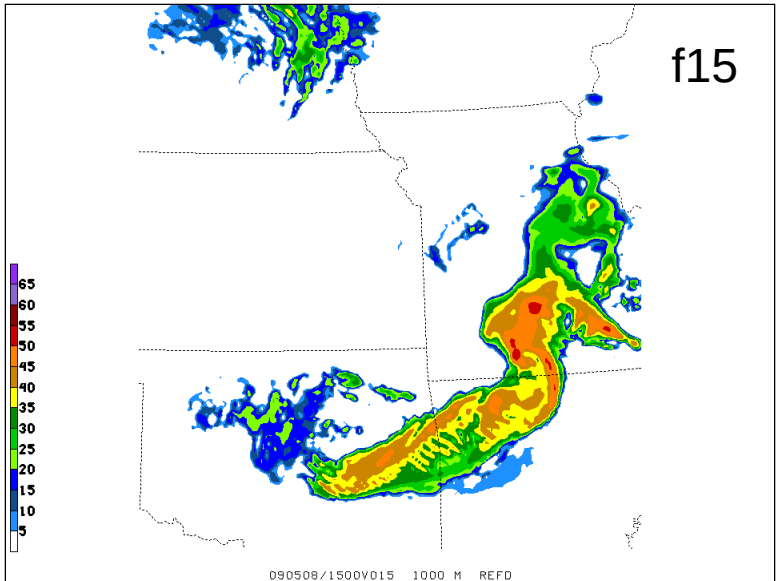
Prod NMM





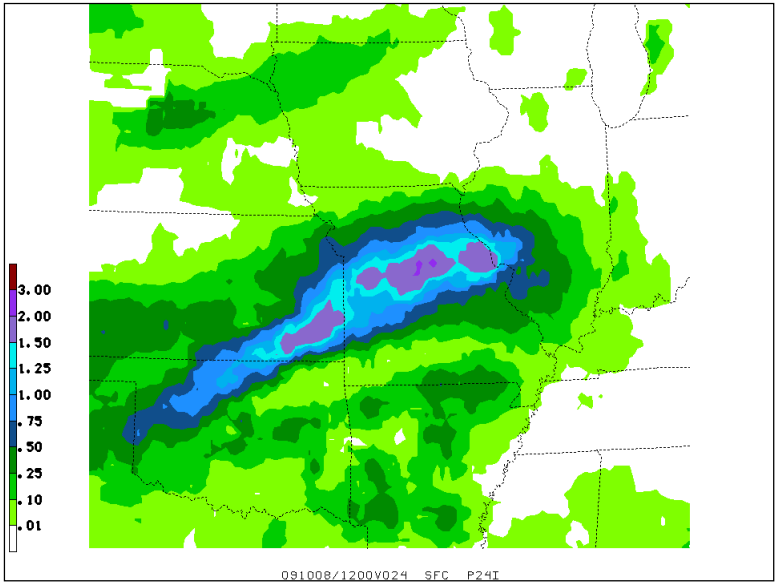
Para NMM

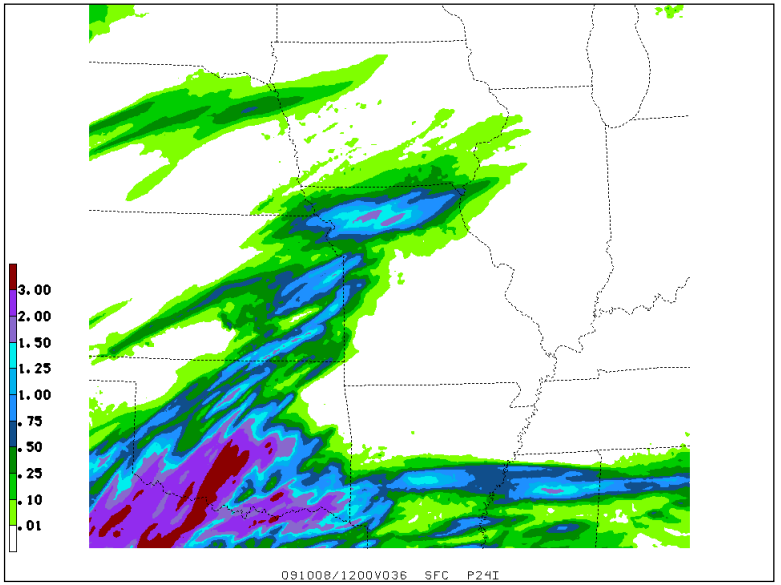




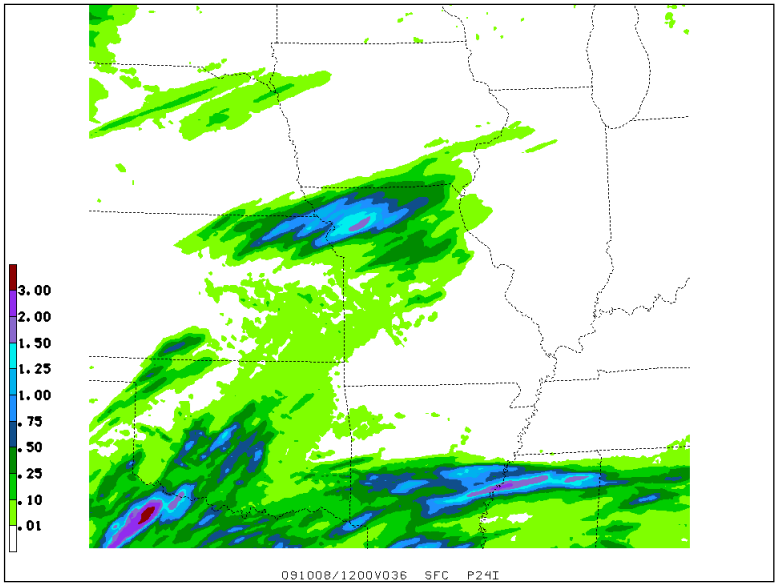
24 h precipitation valid 20091008/12Z

CPC verif





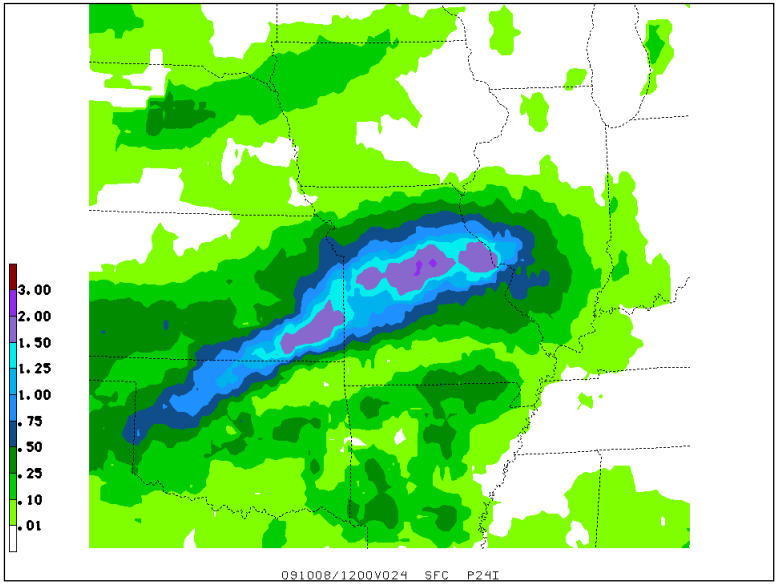
Ops NMM

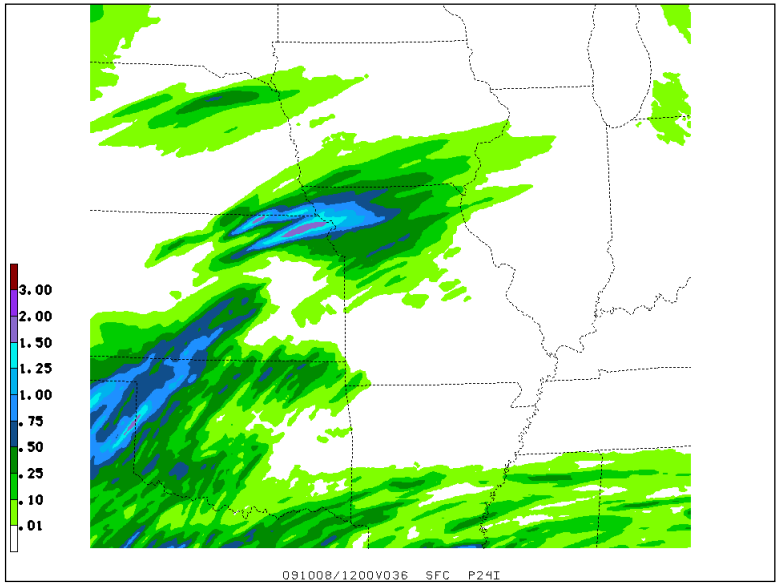


Para NMM

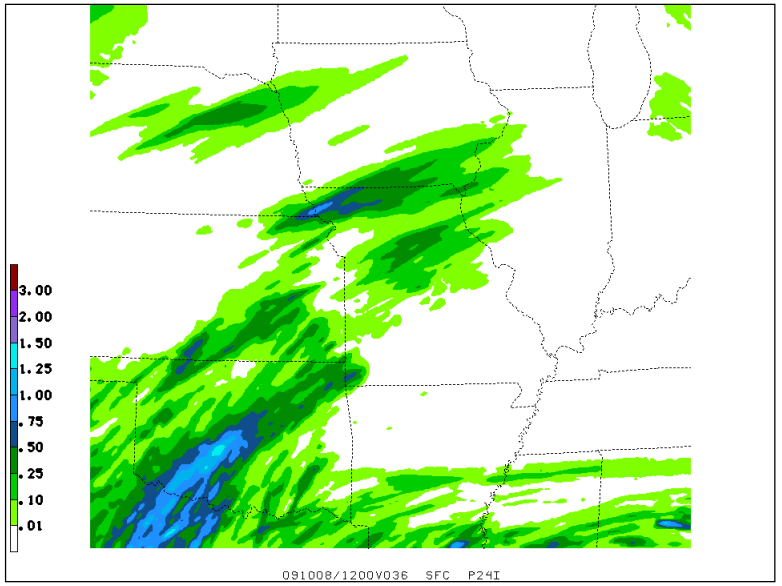
24 h precipitation valid 20091008/12Z

CPC verif





Ops ARW



Para ARW