# Real-Time Mesoscale Analysis Upgrade V2.2.1 and Un-Restricted Mesoscale Analysis

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Implementation Briefing to NCEP Director 27 Jan 2014

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**RTMA: GSI-2DVar Surface Analysis on NDFD grids, Interpolated NCEP Stage-II Precip, and NESDIS GOES Sounder Effective Cloud Amount**

**CYCLES: Hourly, except 3-hourly for Guam**

**USERS:** NDFD, WFOs, Private Sector

**Upsteam Dependency:** PREPDATA, RAP, NAM, GFS, HWRF

**Downstream Dependency:** NAEFS

## Before the upgrade: six runs

1) **CONUS-5km** (v2.0.0)
2) **CONUS-2.5km** (v2.1.0)
3) **Alaska-6km** (v2.0.0)
4) **Hawaii-2.5km** (v2.0.0)
5) **Puerto Rico-2.5km** (v2.0.0)
6) **Guam-2.5km** (v2.1.0)

**Note the two versions**

**GSI-2DVar Parameters: 2-mT, 2m-SPFH, 2m-TD, 10m-Wind, and Psfc**

# CHANGES

**After the upgrade: only five runs**

1) **CONUS-2.5km** (v2.2.1)
   **CONUS-5km sampled** (v2.2.1)
2) **Alaska-3km** (v2.2.1)
   **Alaska-6km sampled** (v2.2.1)
3) **Hawaii-2.5km** (v2.2.1)
4) **Puerto Rico-2.5km** (v2.2.1)
5) **Guam-2.5km** (v2.2.1)

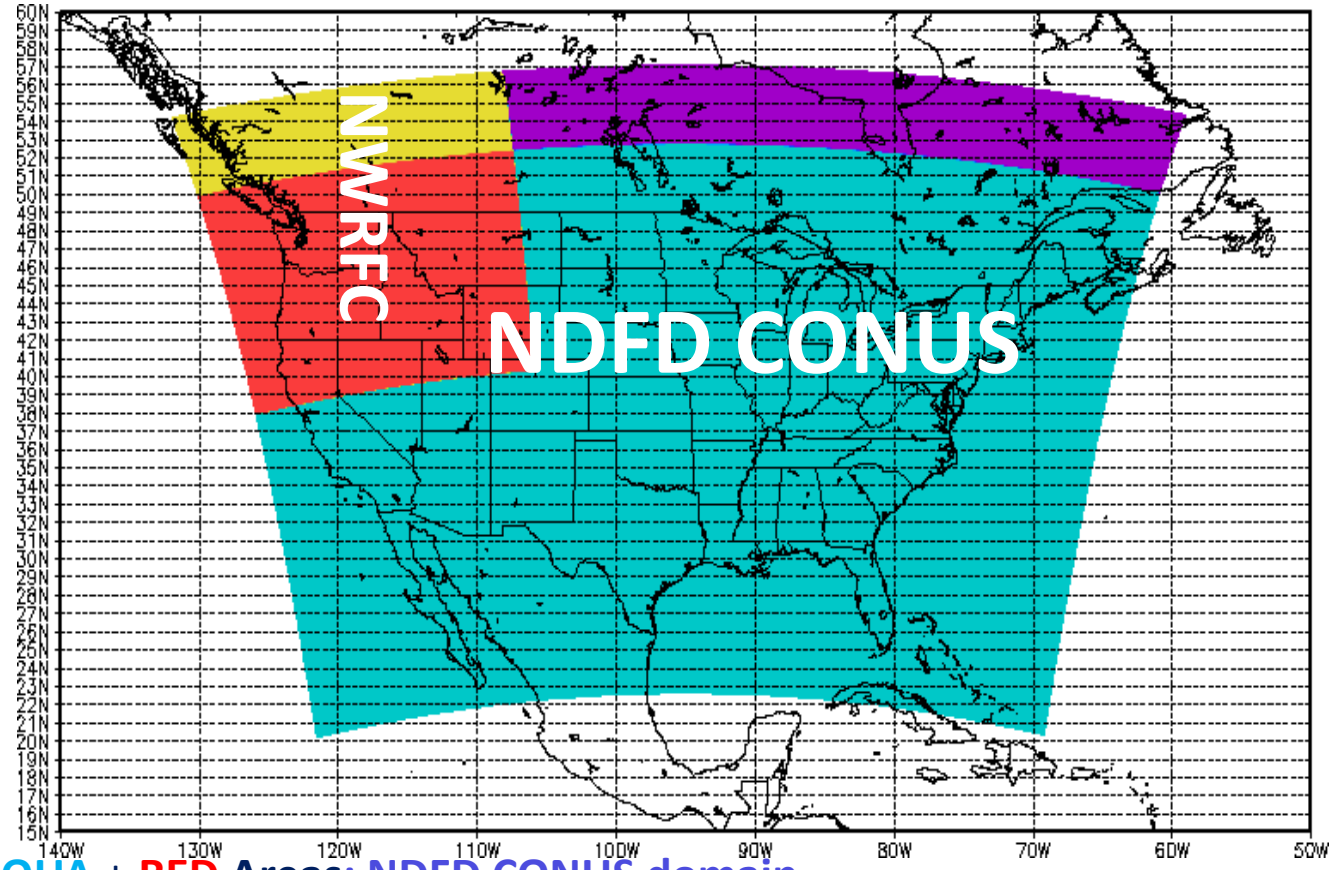
**Note: unified version**

**GSI-2DVar Parameters: 2-mT, 2m-SPFH, 2m-TD, 10m-Wind, Psfc, sfc visibility, 10m wind gust**

New NDFD parameters

# WHAT ELSE IS CHANGING

## Extend CONUS-2.5km domain to provide support for Northwest River Forecast Center (NWRFC)




**AQUA + RED Areas: NDFD CONUS domain**

**RED + YELLOW Areas: NWRFC domain produced at NCEP and shipped to WFO Seattle**

**PURPLE: Extended area currently not disseminated**

# WHAT ELSE IS CHANGING (continued 1)

- **URMA (UnRestricted Mesoscale Analysis)**
  - Identical to RTMA except with a 6 hr delay
  - Hence, *unrestricted* by real-time requirement
  - Allows use of late arriving observations
  - Generated for extended 2.5 km CONUS only
  - Includes remapped Stage IV precipitation every 6 hr (see BACKUP SLIDES)

# WHAT ELSE IS CHANGING (continued 2)

- URMA & Alaska 3km to be on AWIPS SBN
  - CONUS 5 km & Alaska 6 km will go away from ftp & NOMADS but will remain on AWIPS SBN (for now)
- 2D GSI: improve background error covariance model, bias correct 2m-T, First Guess at Appropriate Time (FGAT), include low-level sat winds, routinely compute cross-validation for CONUS 2.5 km
- First Guess: blend HWRF for tropical storm winds, blend RAP & NAMnest for Alaska 3 km
- Use diurnal reject lists for mesonet T & Td and direction-dependent accept lists for mesonet winds (see BACKUP SLIDES)

## **Expected Benefits**:

1. New services (NWRFC & AK-3km) and product stream (URMA)

2. New NDFD parameters

3. Better definition in complex terrain (AK-3km)

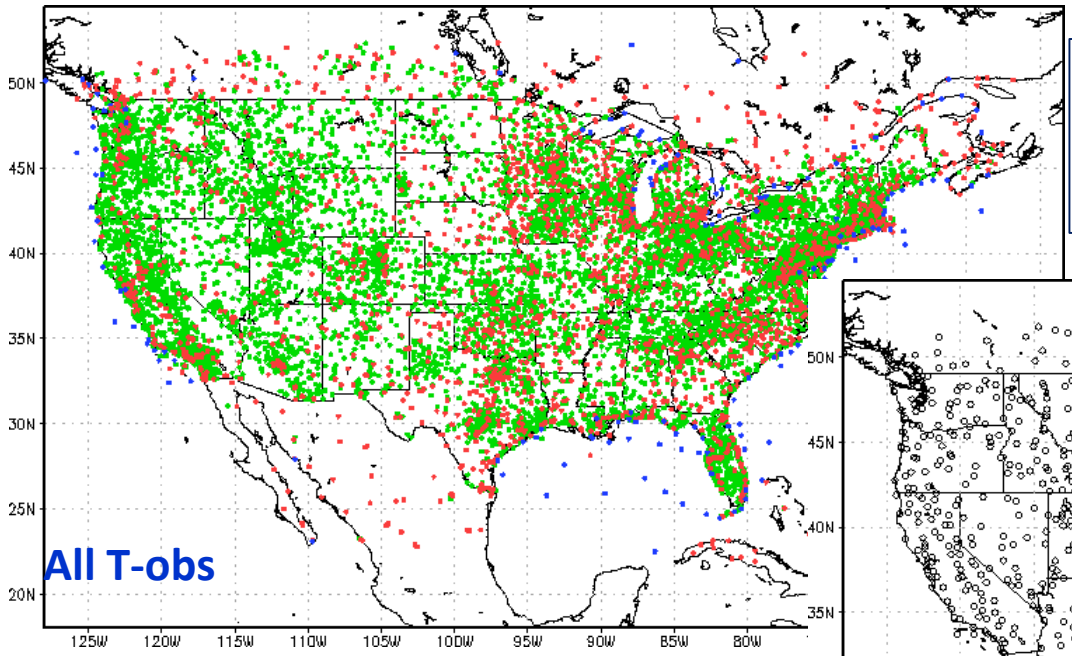
4. More uniform and consistent analyses
   a) When compared to obs
   b) From hour to hour

# CASE STUDIES

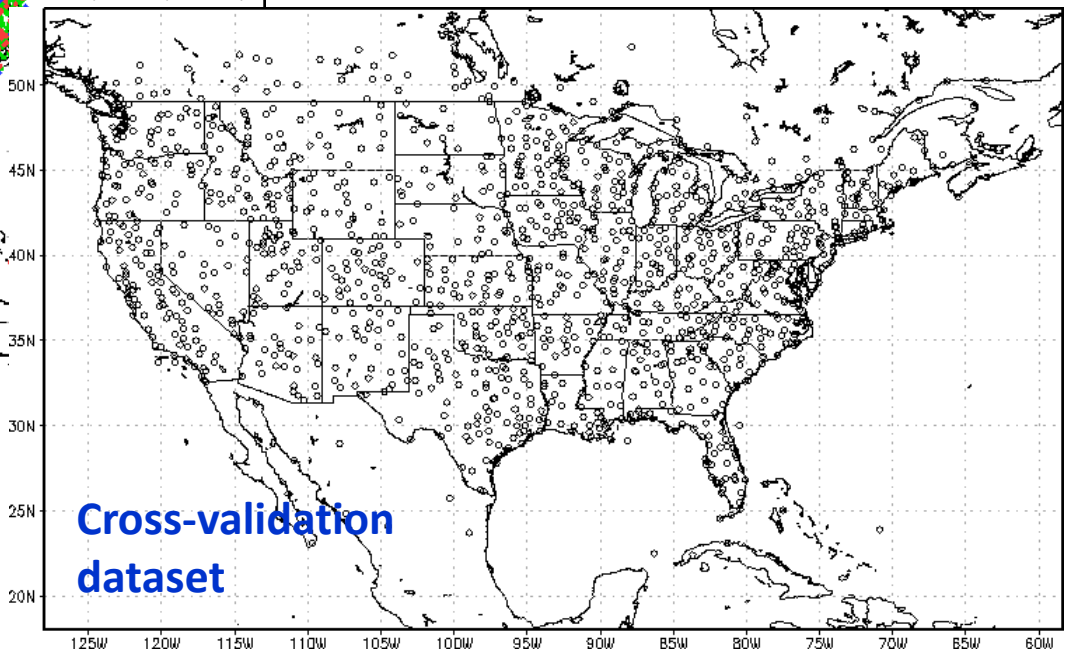
## 1) USE CROSS-VALIDATION TO DEMONSTRATE OVERALL ANALYSIS IMPROVEMENTS

## RTMA CONUS-2.5km: Upgrade vs Current

At start of each analysis , create disjoint sets of observations each containing about 10% of the data. Then, randomly withhold one set from the analysis and use for verification.



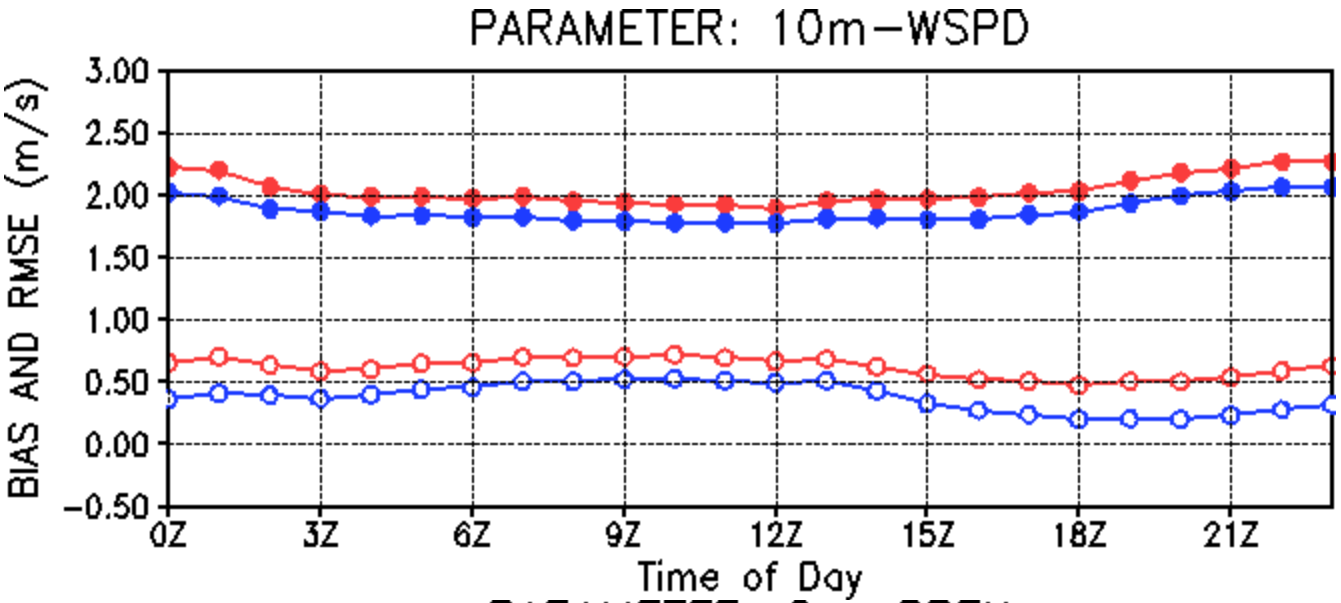

**Example: All T-obs and those for the selected cross-validation set for a given analysis time**



# Cross-validation comparisons

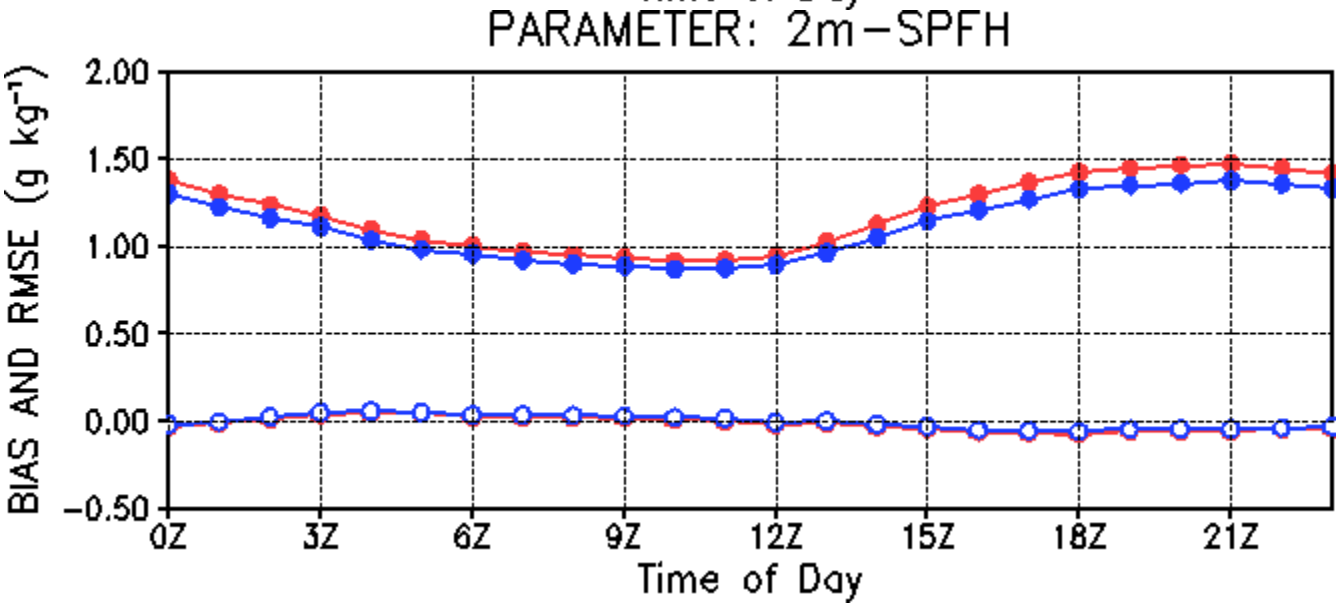
## Time and Domain Averages for Aug, Sep, & Oct 2013

**(Upgrade in BLUE & OPS in RED)**




| RMSE | BIAS |
|---|---|
| 2.03 m/s | 0.61 m/s |
| 1.87 m/s | 0.38 m/s |

A 9% improvement in the RMSE



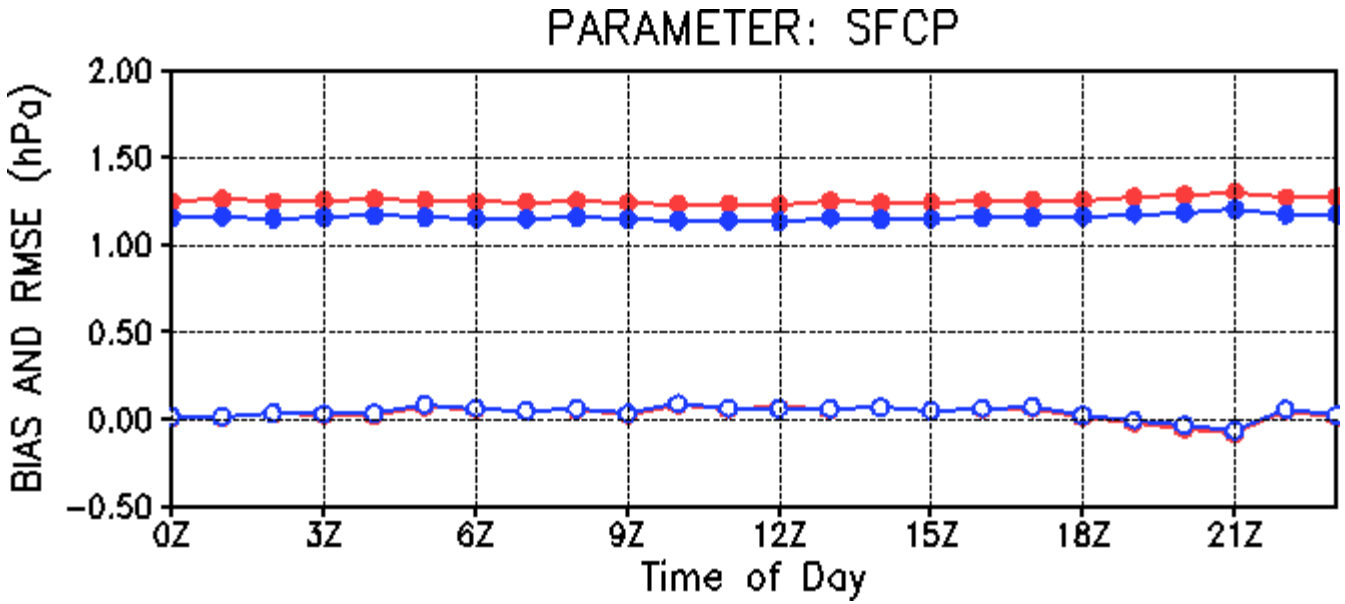

| RMSE | BIAS |
|---|---|
| 1.19 g/kg | -0.02 g/kg |
| 1.11 g/kg | -0.01 g/kg |

A 6% improvement in the RMSE

# Cross-validation comparisons

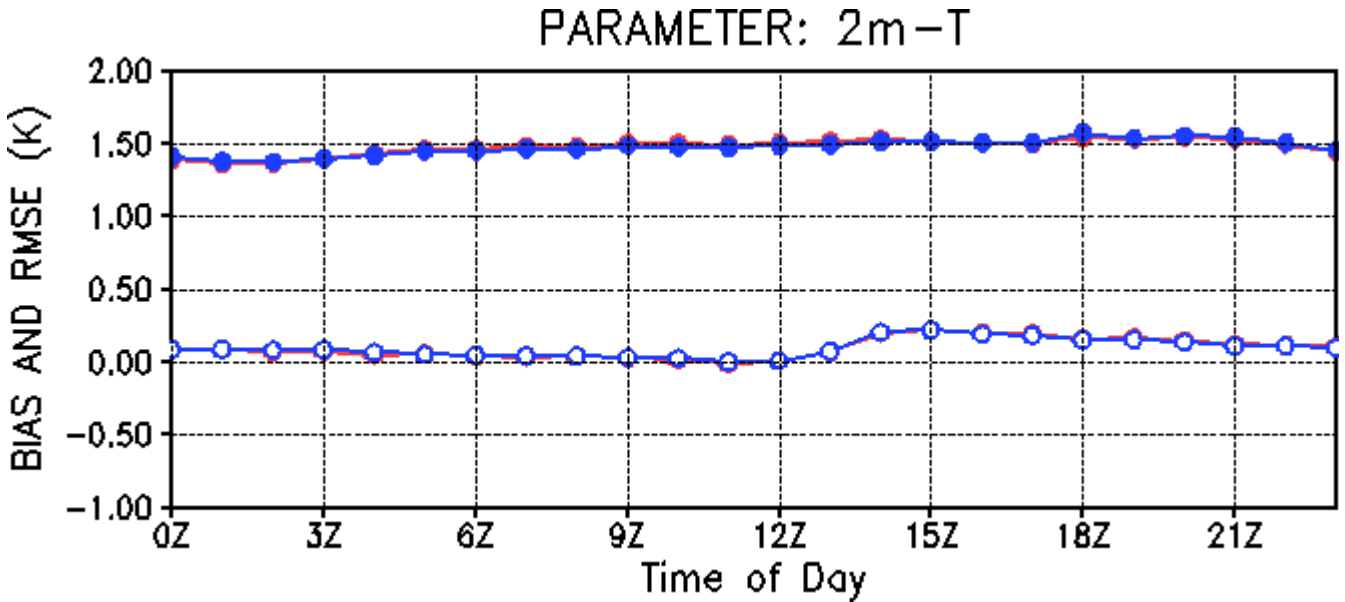
## Time and Domain Averages for Aug, Sep, & Oct 2013

**(Upgrade in BLUE & OPS in RED)**




| RMSE | BIAS |
|---|---|
| 1.25 hPa | 0.04 hPa |
| 1.16 hPa | 0.03 hPa |

**A 8% improvement in the RMSE**



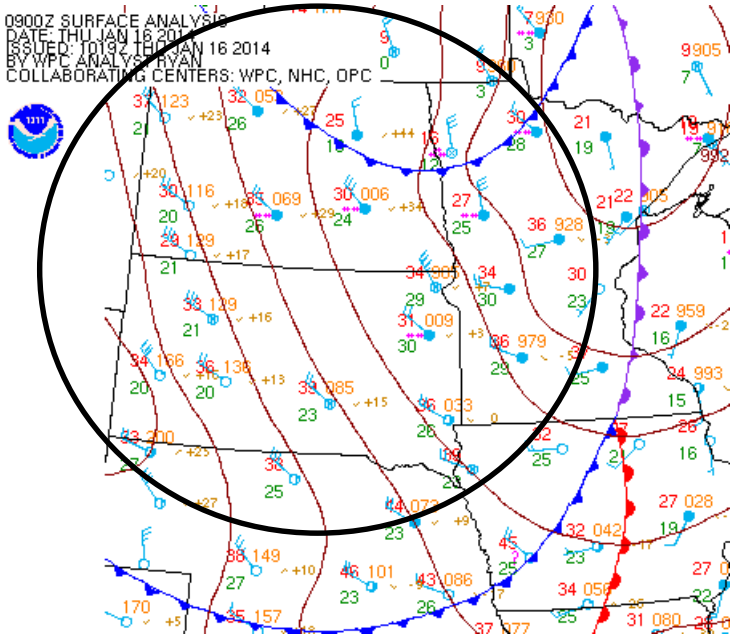

| RMSE | BIAS |
|---|---|
| 1.47 K | 0.09 K |
| 1.47 K | 0.09 K |

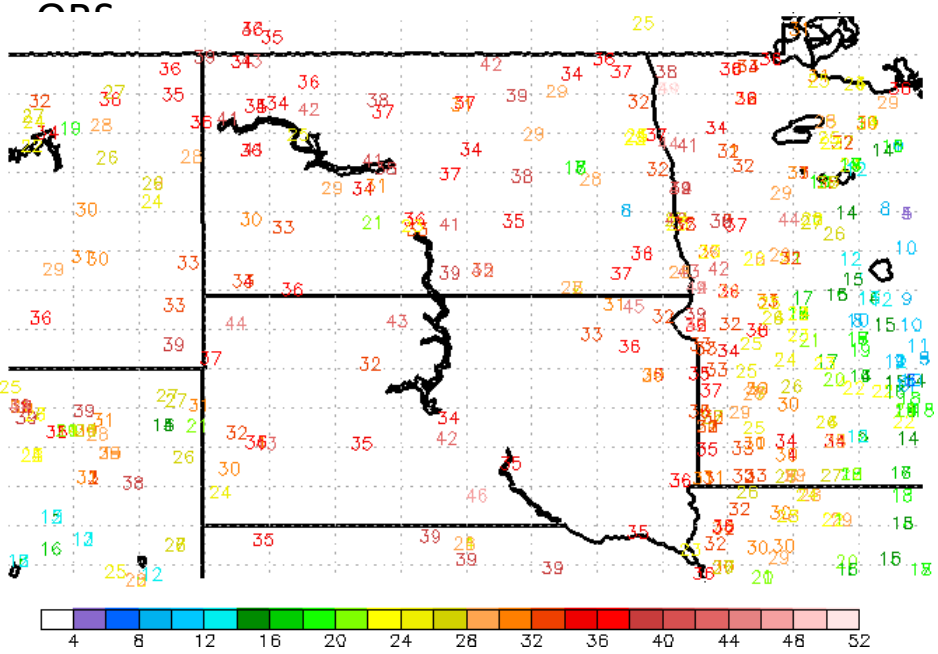
**A 6% improvement in the RMSE**

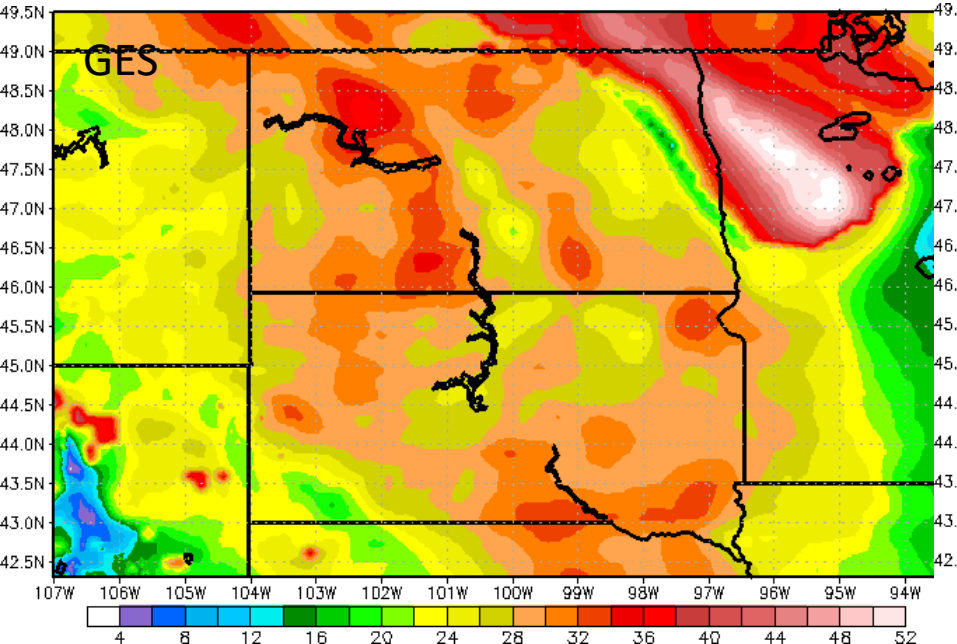
# 2) NEW PARAM: 10-m WIND GUST

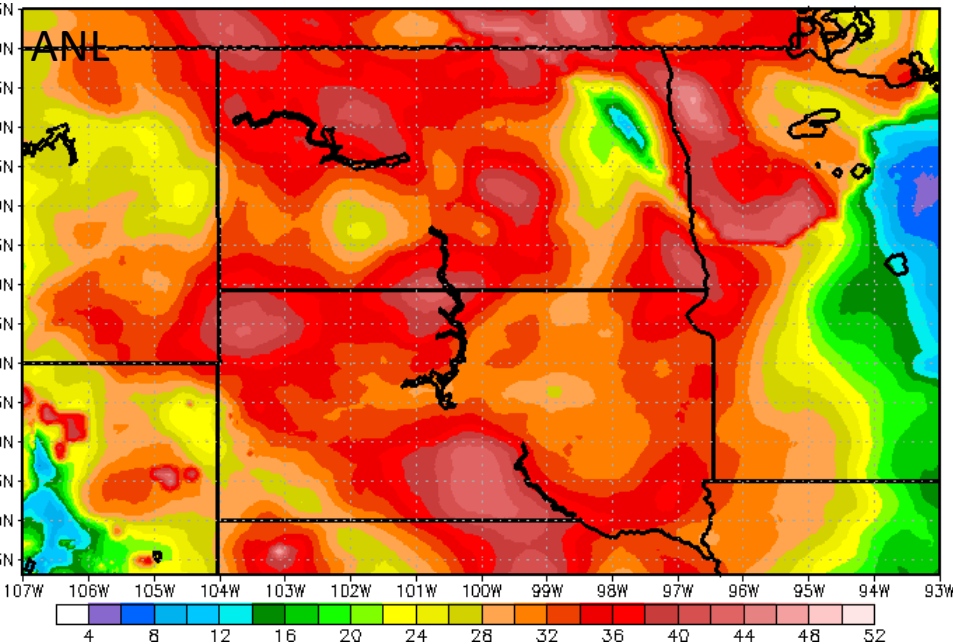
**Post-snowfall Blizzard conditions / Dakotas**

**10-m GUST (kts) 1/16/2014 10Z**



# 3) NEW PARAMETER: Visibility

# RTMA2P5 Case from South Carolina

## Synopsis

-Localized fog event along the SC Coast

-Visibilities reduced to <1/2 mile at some spots, large area <2mi

-Onset near 06Z on 10/30

-Dissipation by 14Z on 10/30

## Summary

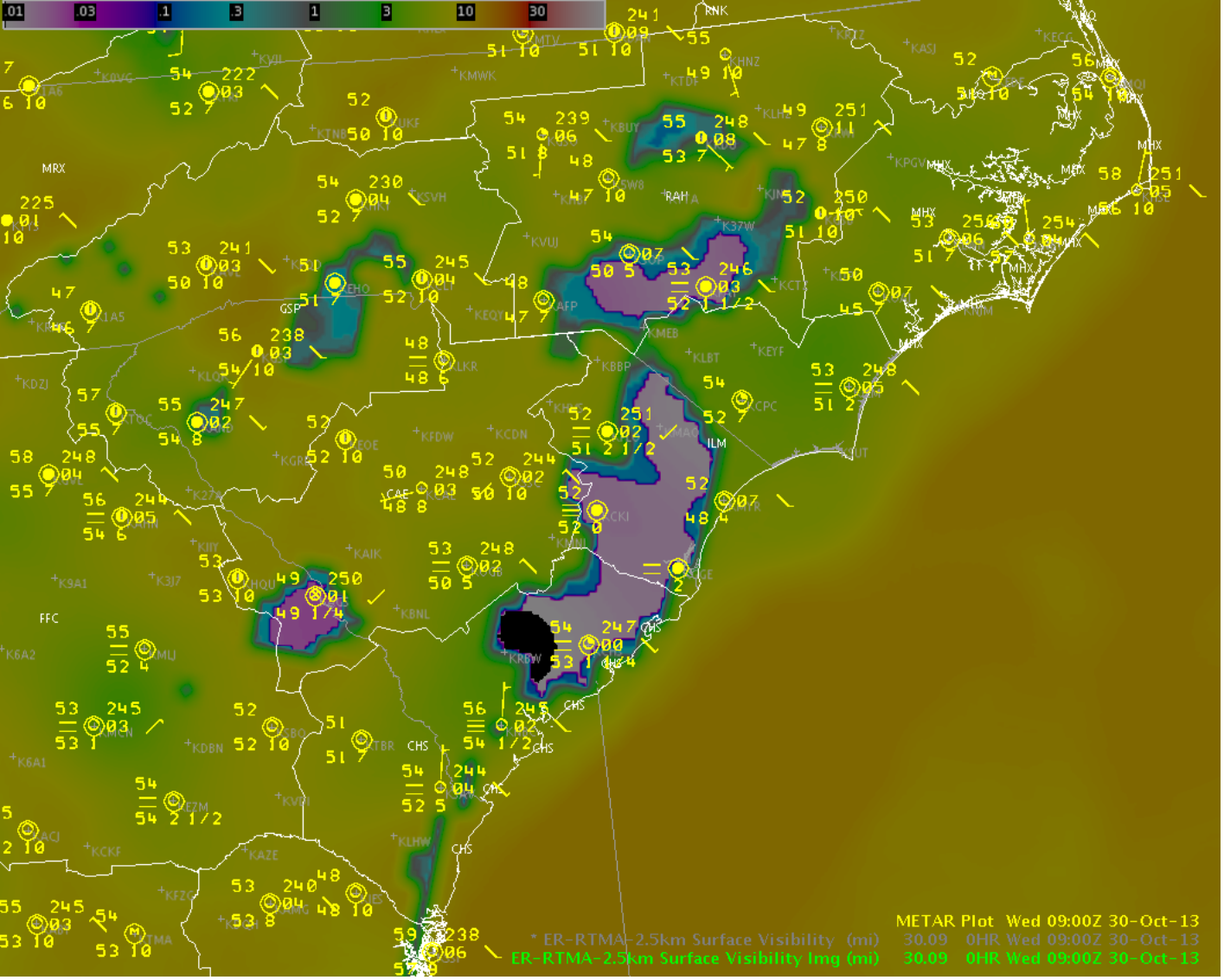
RTMA visibility performed pretty well for this southeastern fog/reduced visibility event in terms of spatial distribution and capturing of the “gradients”.

-Perhaps still too much reliance on the RAP background.

Courtesy of

Dave Radell and Brian Miretzky

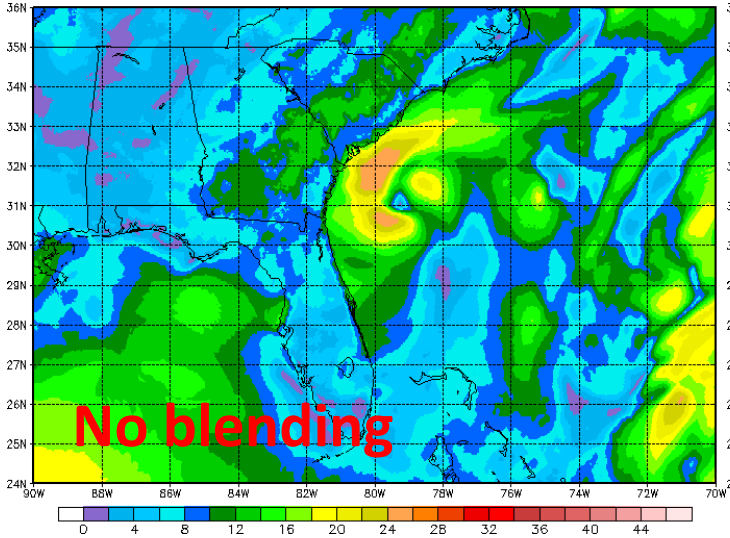
ERH/SSD

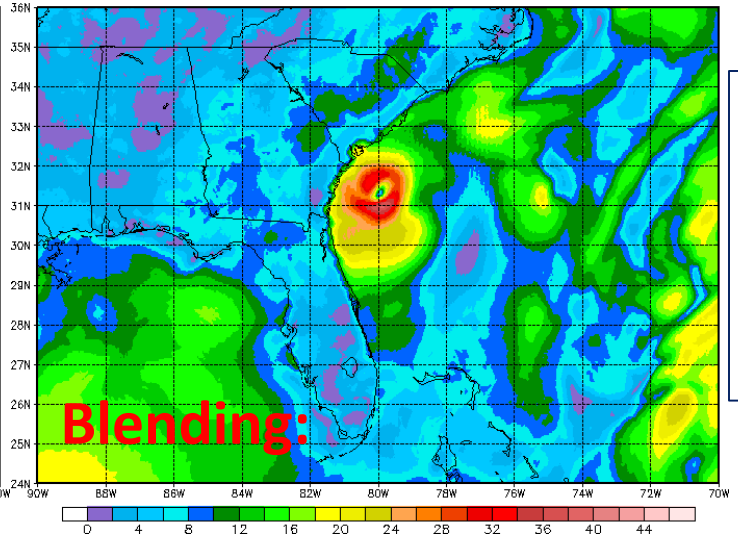



# 10/30 09Z parRTMA 2.5km Visibility (mi)

By 09Z, much of the area has <2 mile visibility from about Raleigh, NC south to Charleston, SC. RTMA picks this entire strip up pretty well.

# 4) RAP/HWRF WIND BLENDING/ RTMA2P5 10-m WSPD ANL



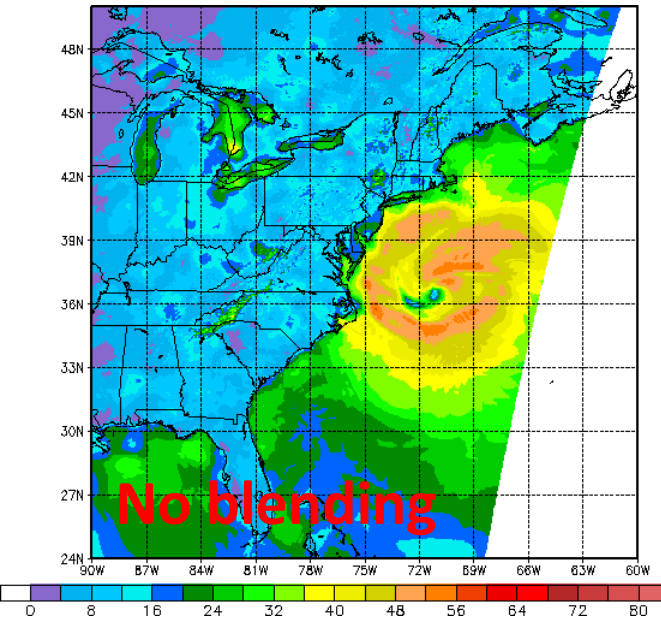

## TS BERYL

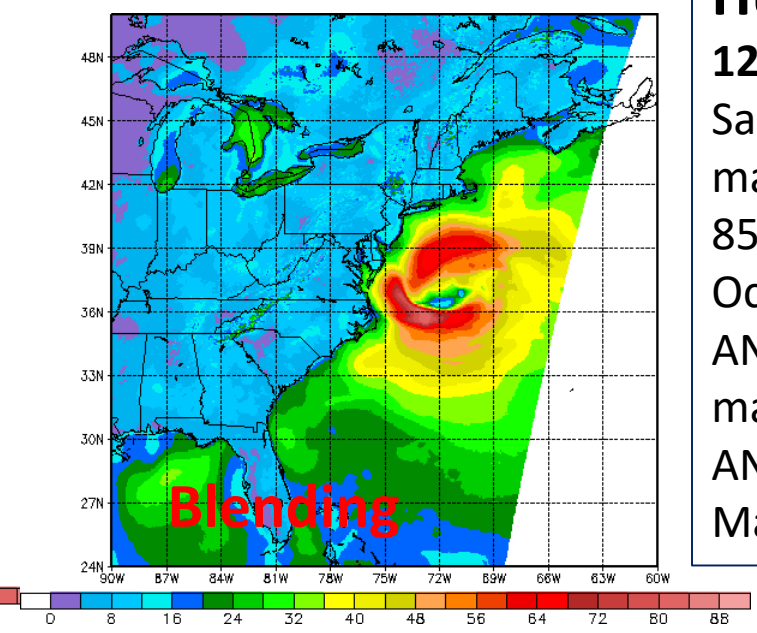
**18Z 20 May 2012**

Reported: 40+ kts

No blending : 24 kts

Blending: 40 kts




## Hurricane Sandy

**12Z 29 Oct 2012**

Sandy reached second maximum intensity with 85 kts by around 12Z on Oct 29, 2012.

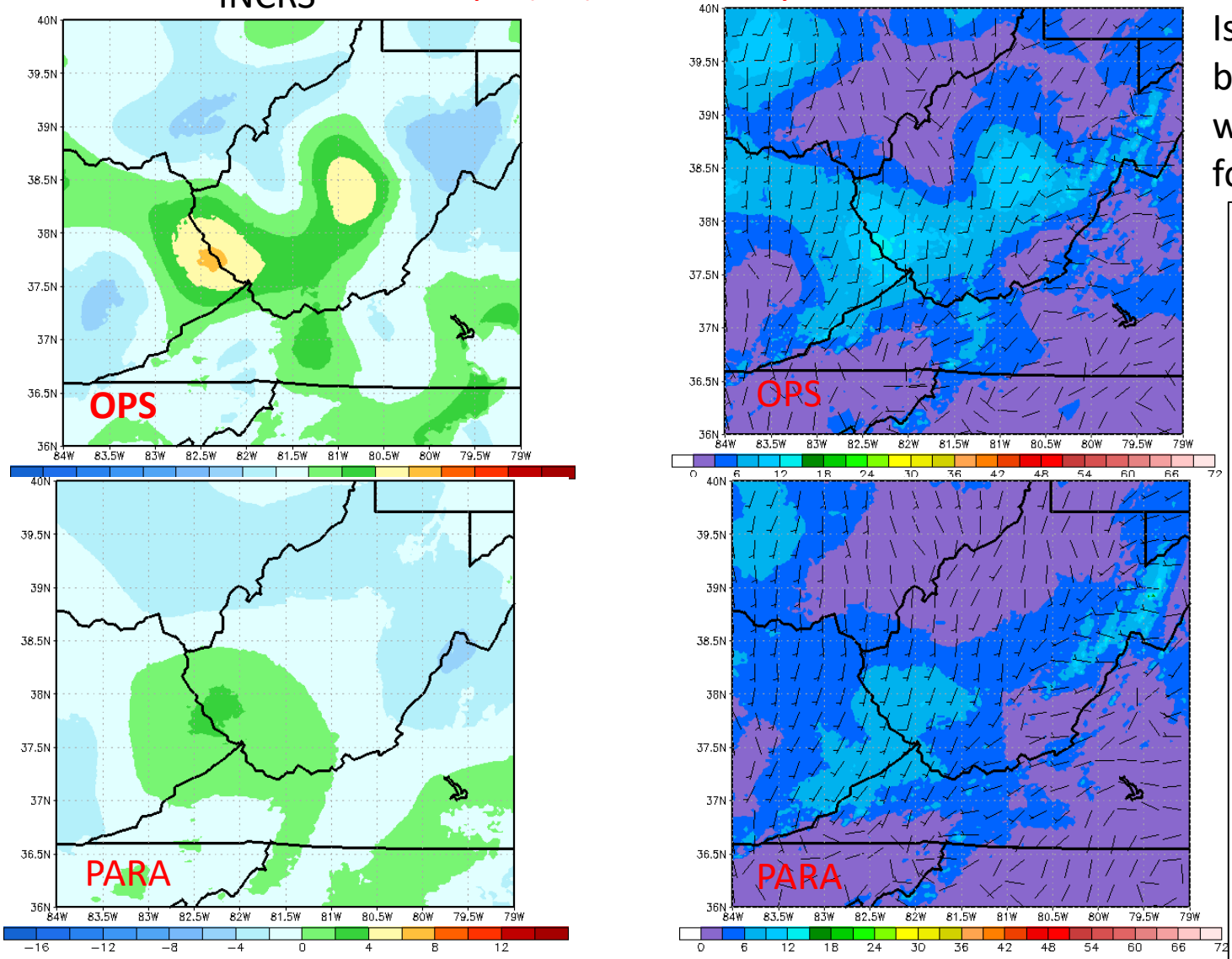
ANL without blending ➔ max around 54 kts.

ANL with blending➔ Maximum around 82 kts

# 5) PARAMETER RE-CALIBRATION IMPACT

## a) Charleston, WV reported high winds in RTMA assisted WPC Guidance

INCRS 10m wspd (kts) 13Z 14 May 2013 ANL



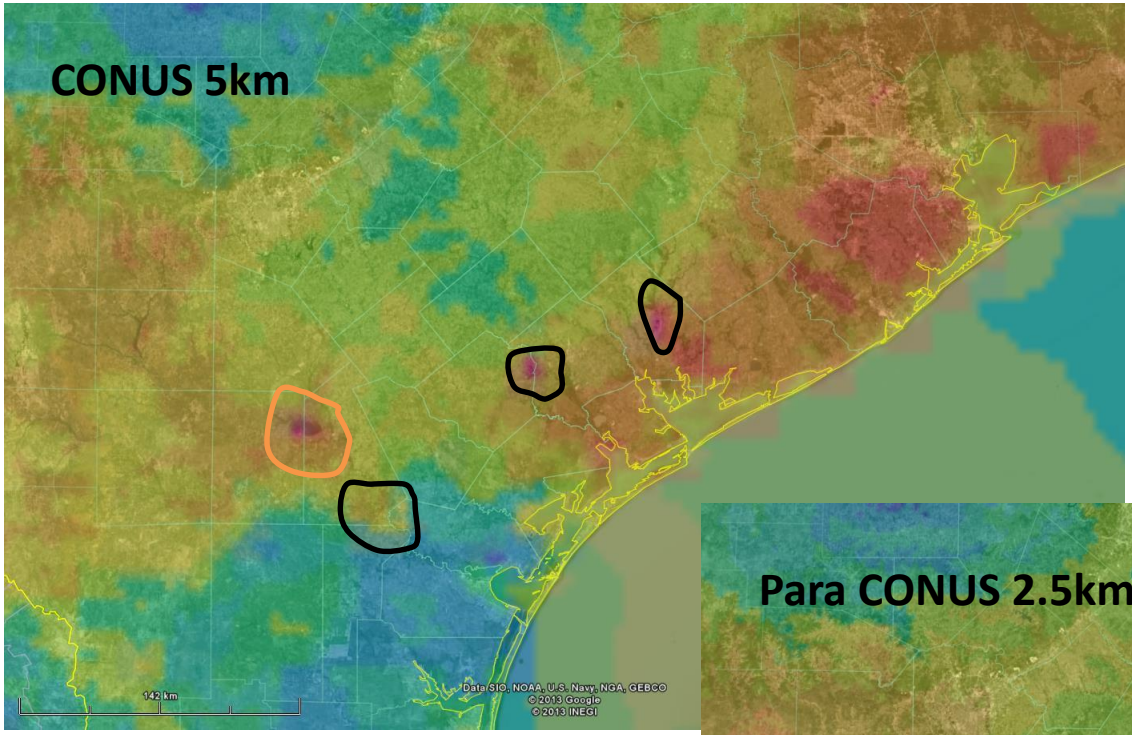

Issue was traced back to RTMA, which is used for bias correction

Operational RTMA generated spurious amplitude.

Resulted improved in new system thanks to improved parameter calibration (bckg error model)

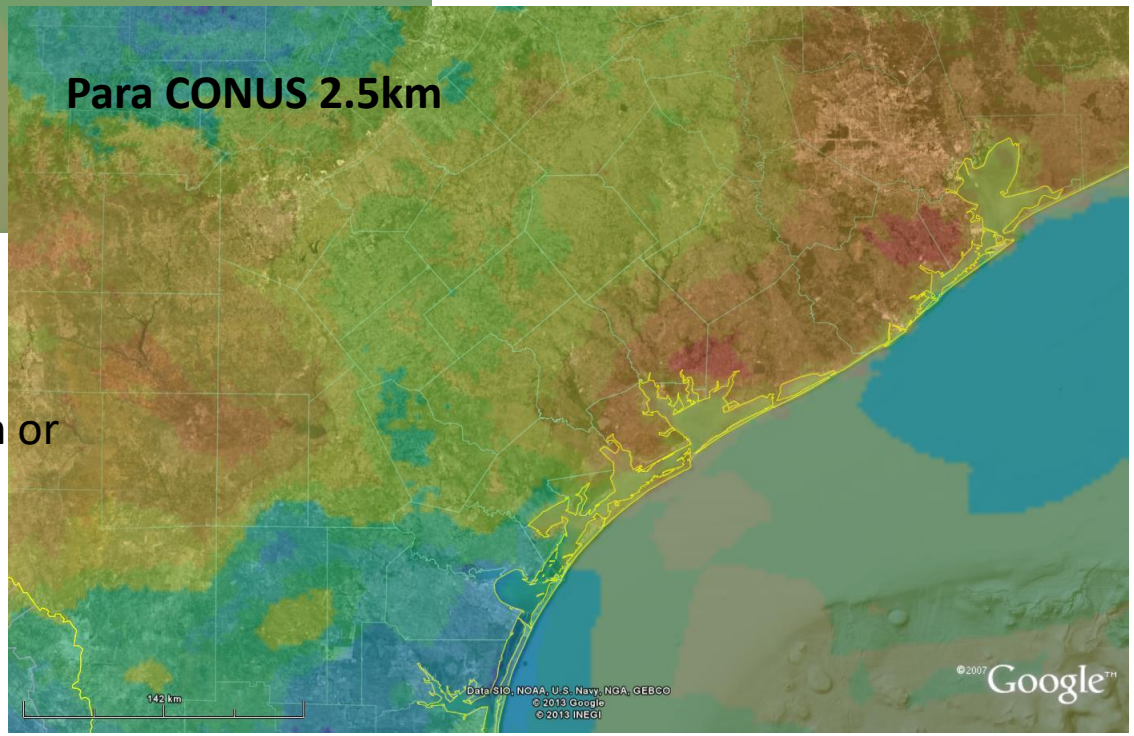
Operational Analysis generated spurious amplitudes!

# 6) BENEFITS FROM SAMPLING RTMA-2.5KM ➔ RTMA-5KM
## 2m-T Analysis / Texas




**Sent by Mike Buchanan on May 12, 2013**

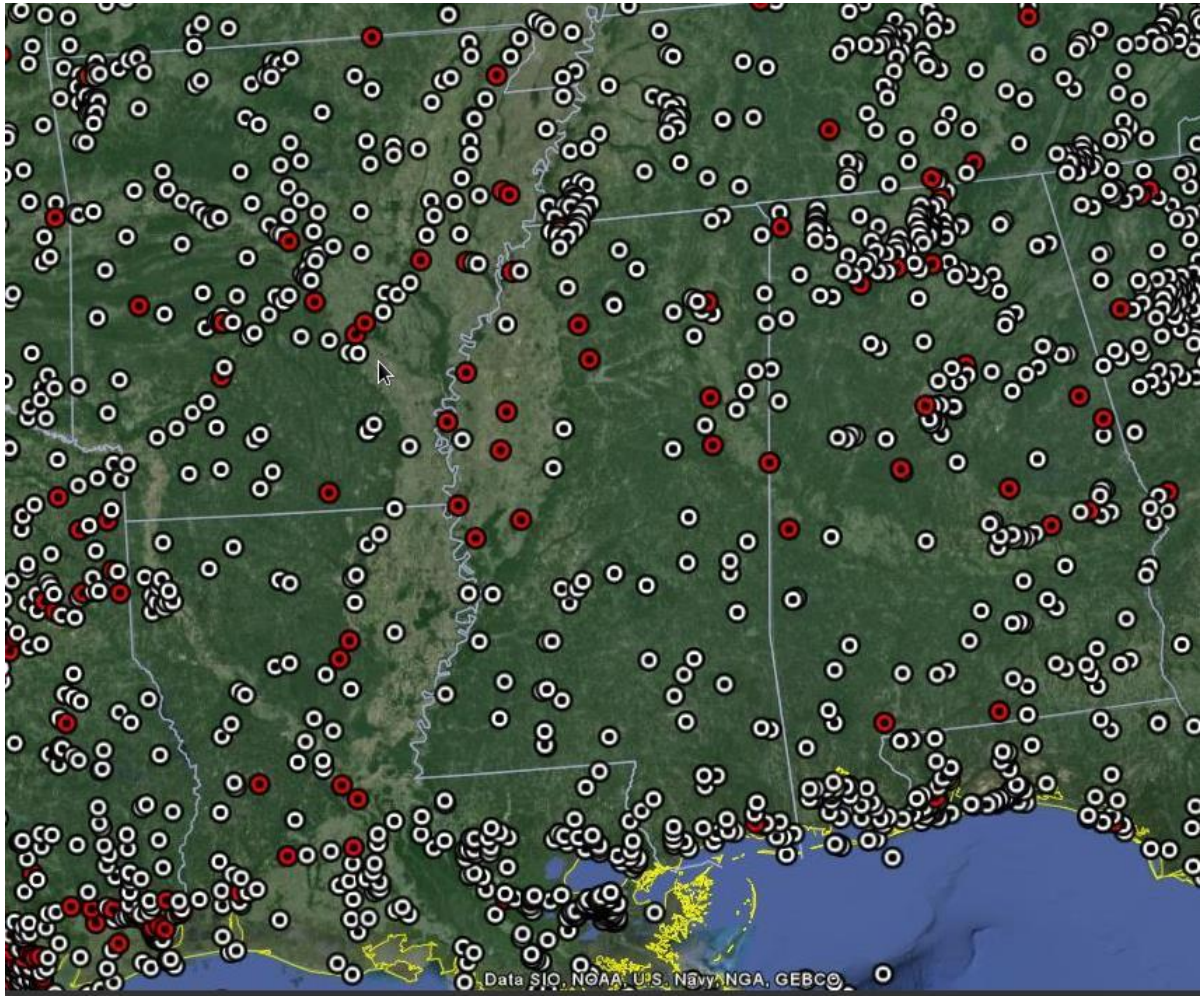
"Hot spots" noticed in RTMA temperature. Lined up with the lakes/reservoirs across the area




They are using old 5km RTMA! While present in the first guess, spots did not show in the ops 2.5km or para 2.5km thanks to improved handling of bckg error covariances!

# 7) Un-Restricted Mesoscale Analysis (URMA):

**Update RTMA Analysis on Expanded CONUS-2.5km domain 6 hours later to use more observations. More appropriate for verification.On average, using 22% (17%) more stations reporting mass obs (winds).**

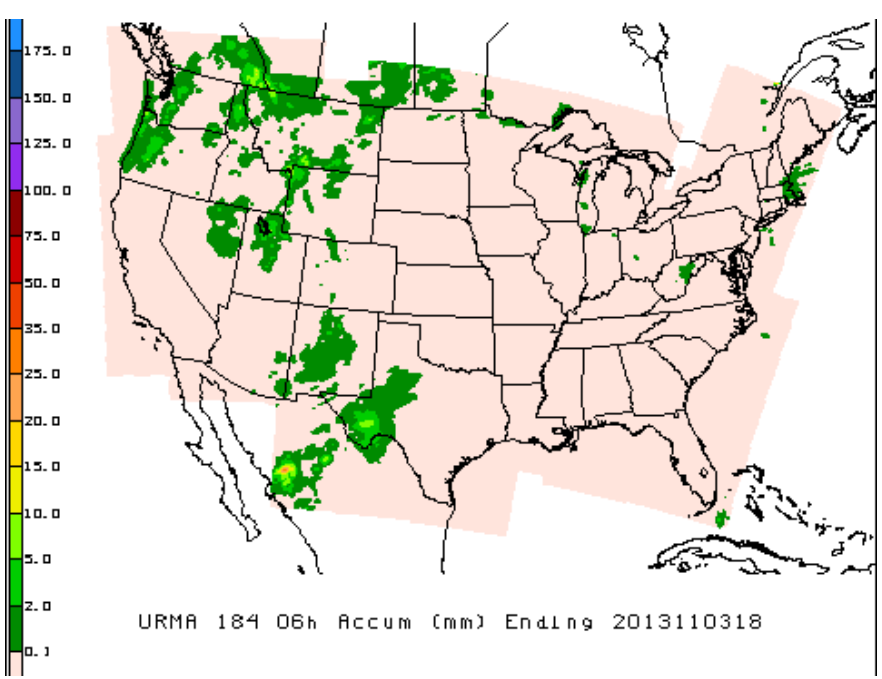


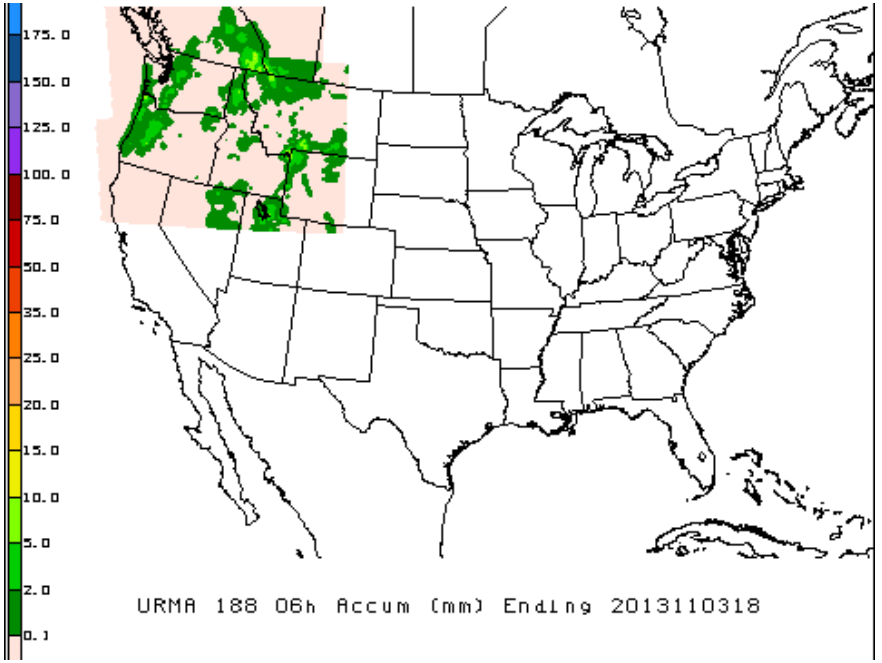

**White Dots:**
RTMA Stations

**RED DOTS:**
Additional stations used by URMA

Main benefit from URMA-2dVar is use of more obs. In future, also science benefits (better QC, split of analysis variables, more parameters)

# Precipitation URMA / REMAPPED NCEP STAGE IV PRECIP



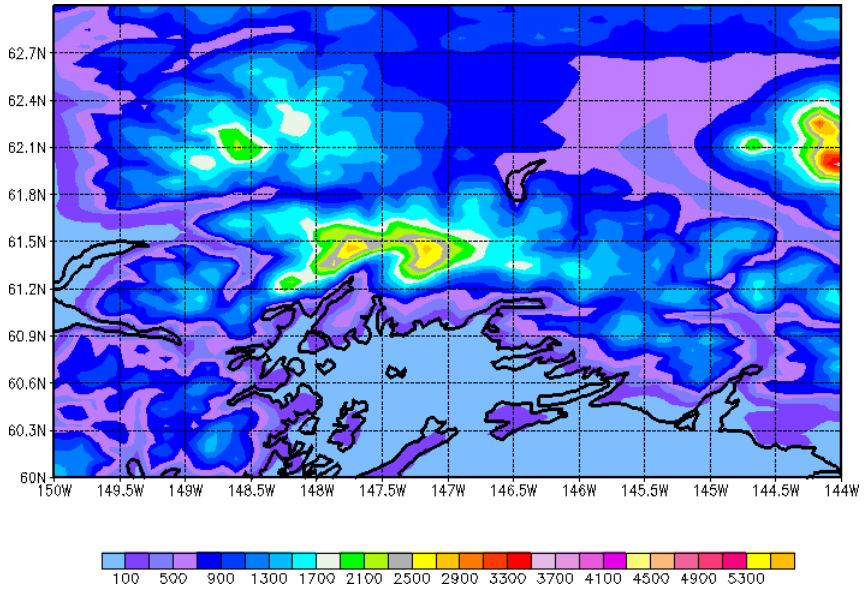

6-hourly multi-sensor precipitation estimates from the 12 ConUS River Forecast Centers (RFCs) are mosaicked into a national product (the NCEP Stage IV) and remapped to the ConUS and Northwest RTMA grids. The four 6-hourly URMA files covering a 24h period (12Z-12Z) are first available at around 13:25Z, with partial coverage. Complete ConUS coverage is usually achieved by 18:35Z. Sample precip URMA files with WMO headers: **http://www.ftp.emc.ncep.noaa.gov/mmb/precip/st4-urma/**

**Benefit: To compensate for loss of NPVU ST4 files on the SBN**

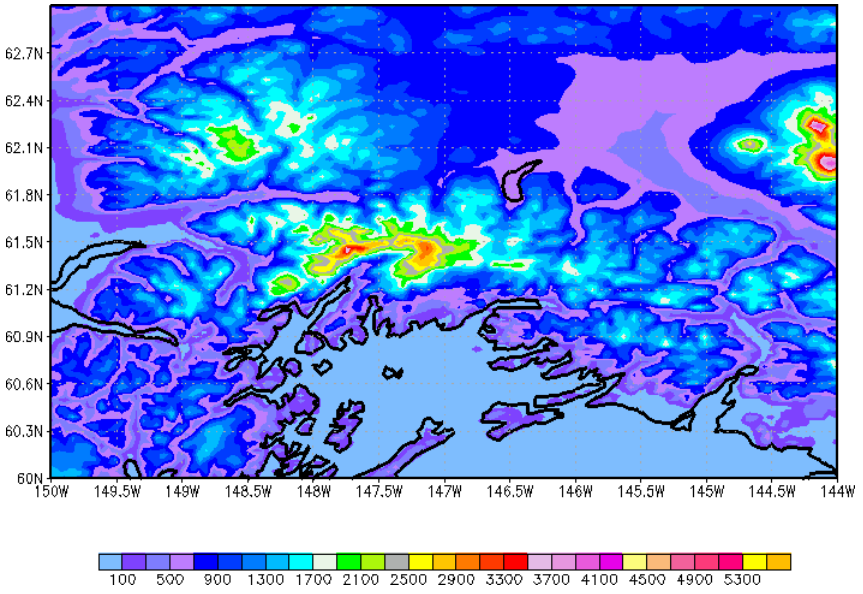
# 8) RTMA ALASKA-3km

TERRAIN (m)

**6-km Resolution**




**3-km Resolution**



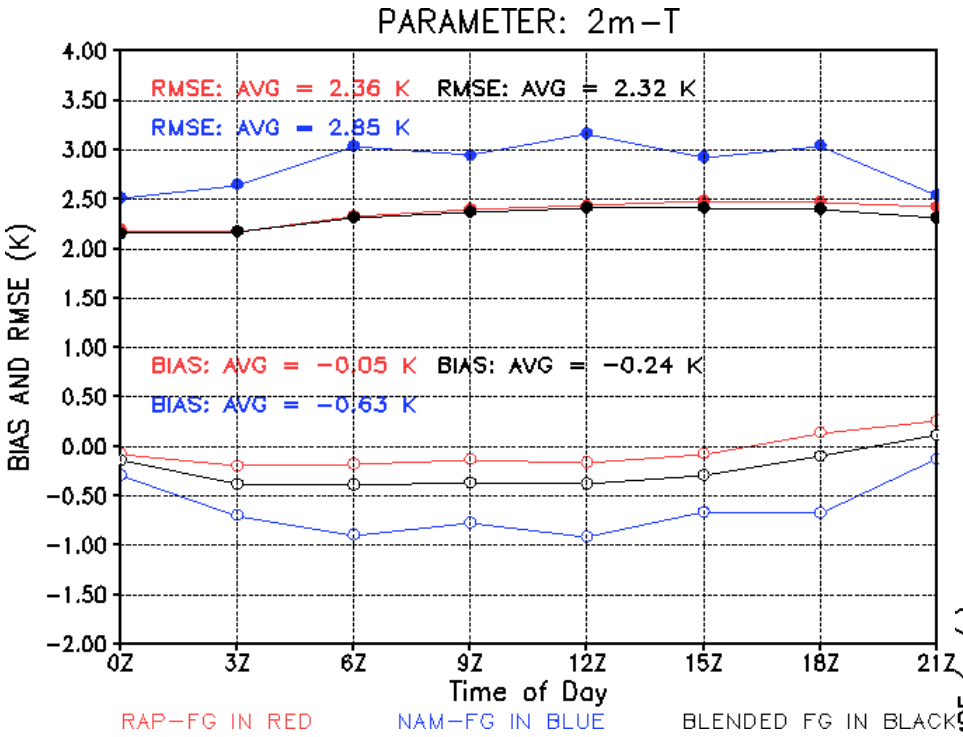

Better resolution of topography in new RTMA Alaska

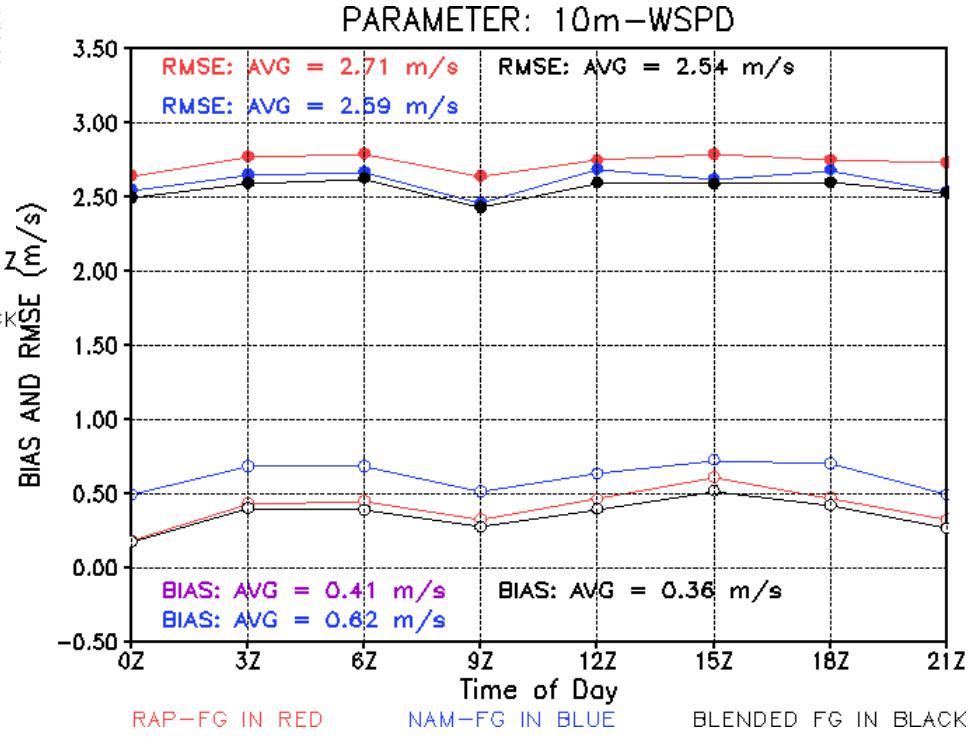
Use blended RAP/NAM Forecasts to create First Guess

Cross-validation results not very robust. Not enough obs ➔ Assess improvements on the basis of improvements to the First Guess.

# First Guess fit to the Obs

## Domain & Time average stats for 00Z Feb 2012 through 00Z 06 Mar 2012




**Similar results found for TD & Wind Gust (see Bckup Slides)**

**Compared with the single RAP or NAM first guess, blended First Guess yields reduced rms errors for all parameters!**

# OUTSTANDING ISSUES

- **RTMA not picking up cold pools and inversions well over complex terrain**
  - Two problems: background fields and ob QC

    . 13 km RAP background cannot be downscaled easily. Test HRRR & NAM nest in future

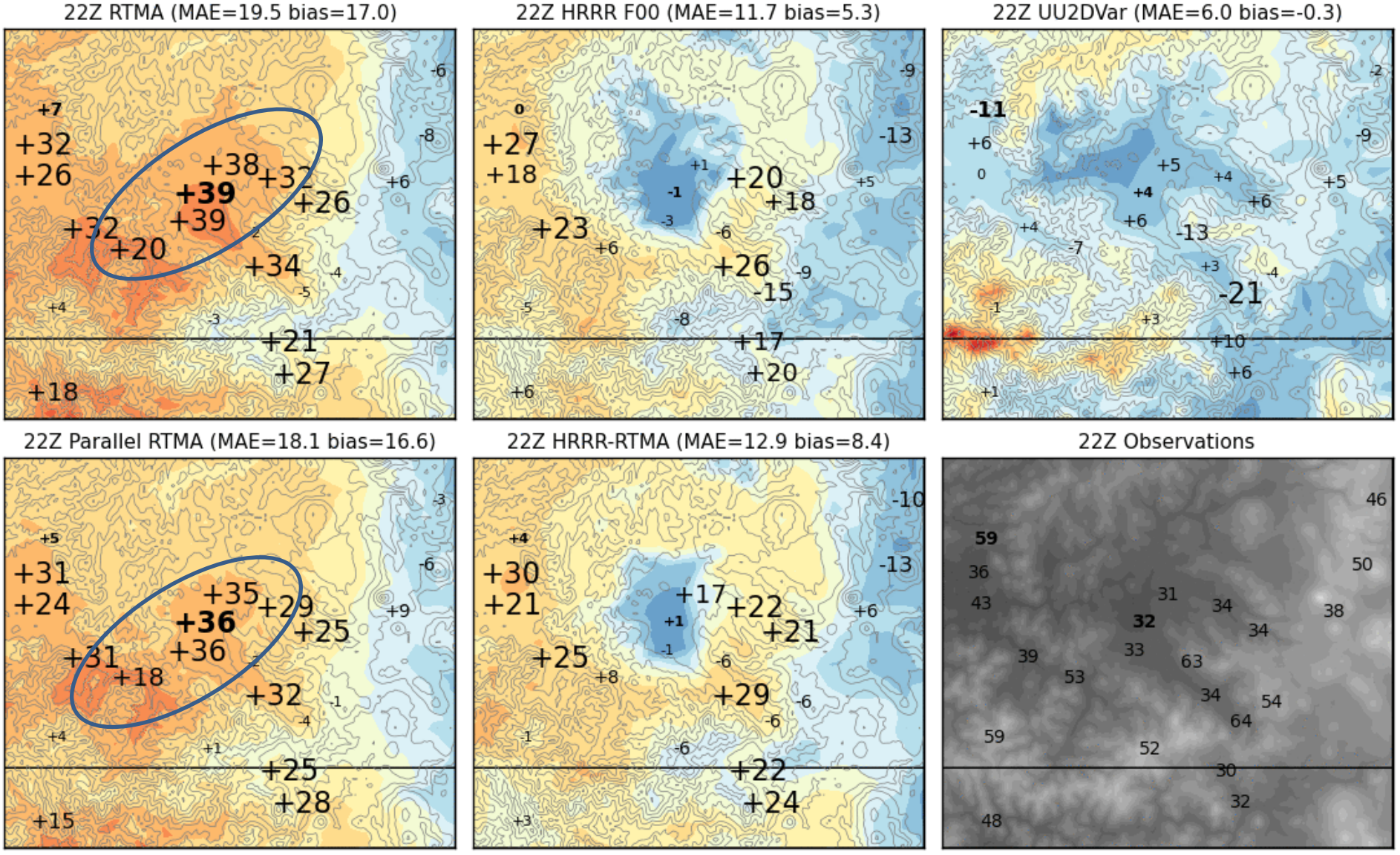
    . Some relevant obs are on obsolete WFO-provided reject list (?!) / Must either update lists frequently … or eliminate them in future

- **Analysis of snowpack still a problem. Need improved background and smart ob QC.**

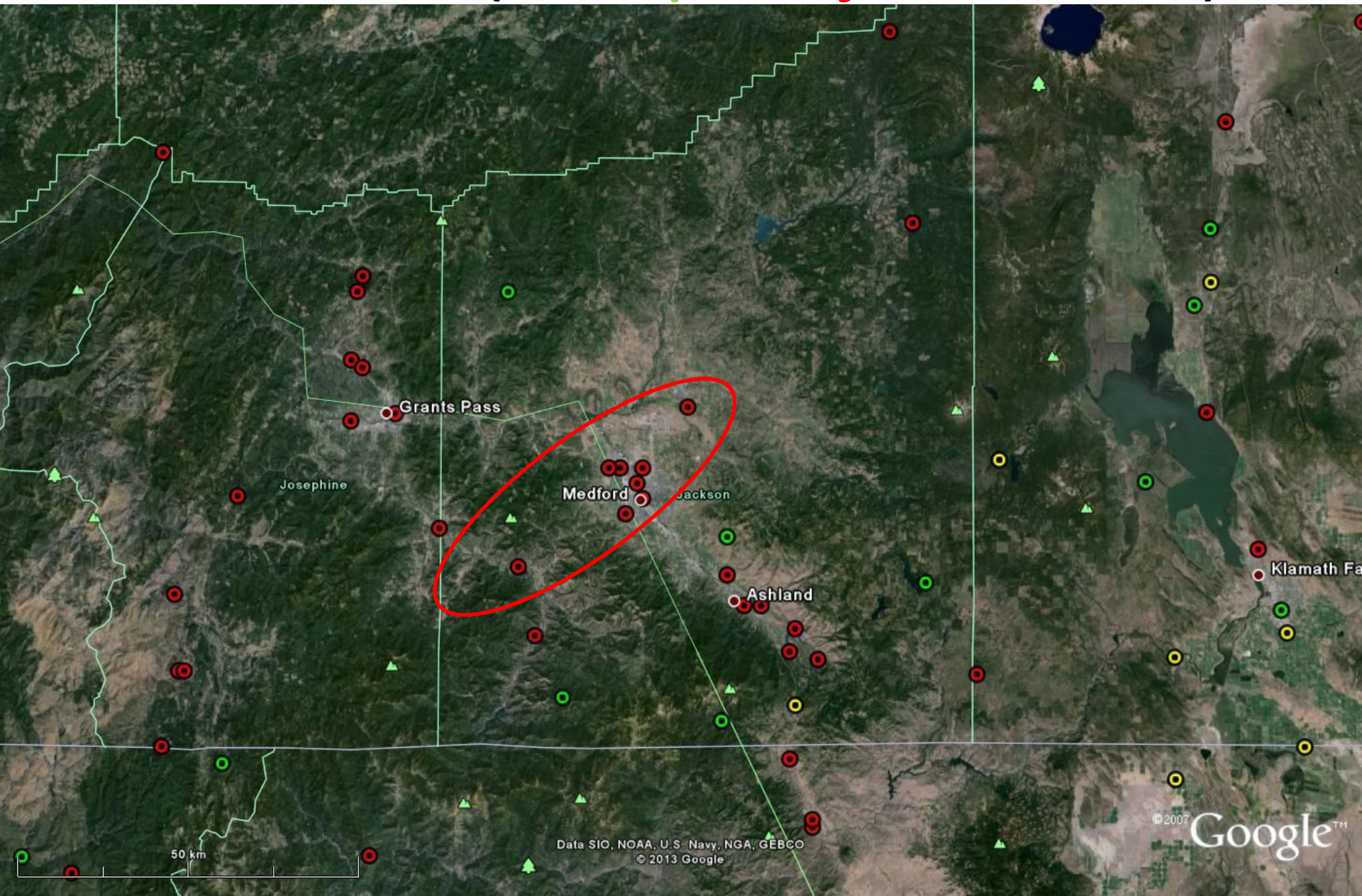
- **Along Channel Flows poorly analyzed in RTMA-Alaska / Need better wind downscaling / Currently testing CALMET downscaling**

**Evaluation from WR**
**Medford Example**

Analyses valid 22:00 UTC 01-16-2014
Temperature (F)



# RTMA QC (Accept Reject Partial)



# What happened & how can we fix it?

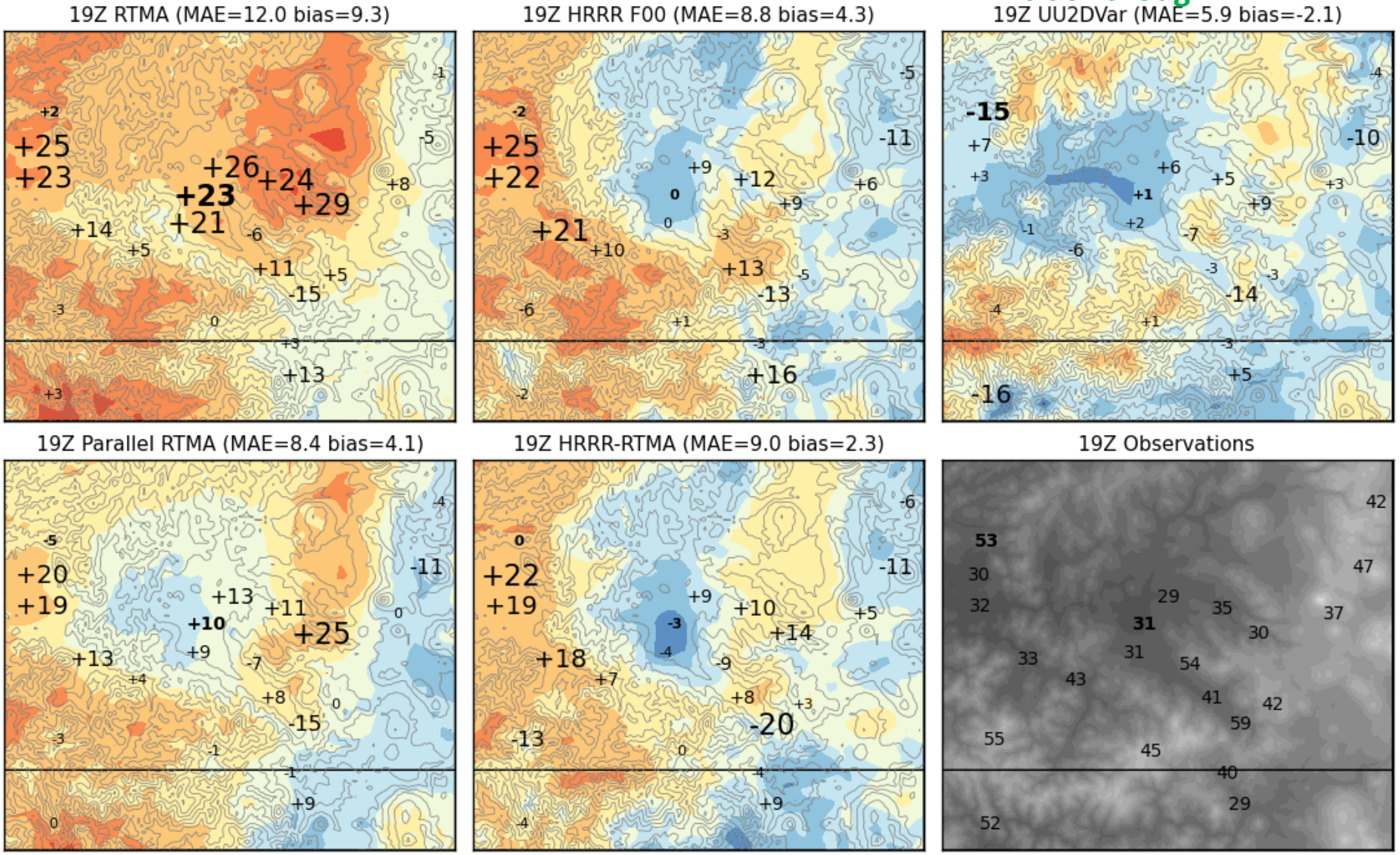
- KMFR, E1735, MDFO, C2551 all failed gross error checks
  - O-B differences on order of 20 K
  - RAP does not resolve cold pools properly
- Four other mesonets on WFO provided reject list
  - C3932, E0MED, D8000, ODT26
  - O-B differences on same order, but consistent magnitude (~ 20 K)
- Short answer: We need a better background!

Implement HRRR/NAM nest blending.

Note: Downscaled NAM nest looked better than RAP bckg for this case

Analyses valid 19:00 UTC 01-19-2014
Temperature (F)

**Upgrade is on the right track though**




**Evaluation ex. from WR. OPS analysis failed at Medford. PARA showed improvement**

# Analysis of Production Resources

## RTMA CONUS-2.5km

Compared with operational system: Increase number of processors from 16 to 48. Use minimum of 3 nodes. Run time to decrease from 16 min to 9 min

## URMA

48 processors needed. Minimum of 3 nodes. Note: Use runslot of current CONUS-5km, which uses 16 processors

## RTMA Alaska-3km

Compared with current 6km Alaska RTMA: increase number of processors from 7 to 16. Use 1 node. Run time to remain at 4 minutes. Note: To use runslot of current Alaska-6km

## Hawaii, Puerto Rico, Guam RTMAs

Increase number of processors from 5 to 7. No changes in runtime compared with current operational systems

Initial Analysis of Product Volume

| Disk Usage | Current Production | Expected New Production | Actual New Production |
|---|---|---|---|
| IBM Disk | 920 GB /day | 1860 GB /day | - |
| IBM Tape | 42 GB/day | 75 GB/day | - |
| NCEP FTP Server | 4 GB/day | 8 GB/day | - |
| NWS FTP Server | 4 GB/day | 7 GB/day | - |

Note: IBM Disk usage estimate assumes 3 day output residing in /com

# Additional Output for the package to RUNHISTORY:

- NWRFC output
- Alaska-3km output
- URMA output

This implies an additional 33GB/day added to RUNHISTORY.

**Bandwidth Requirements:** An additional 3GB/day

# Post Production and Product Generation Requirements

## OUTPUT

### NEW PRODUCTS

- ❑ GRIB2 files for NWRFC
- ❑ GRIB2 files for Alaska-3km
- ❑ GRIB2 files for URMA-2.5km

### DISSEMINATION

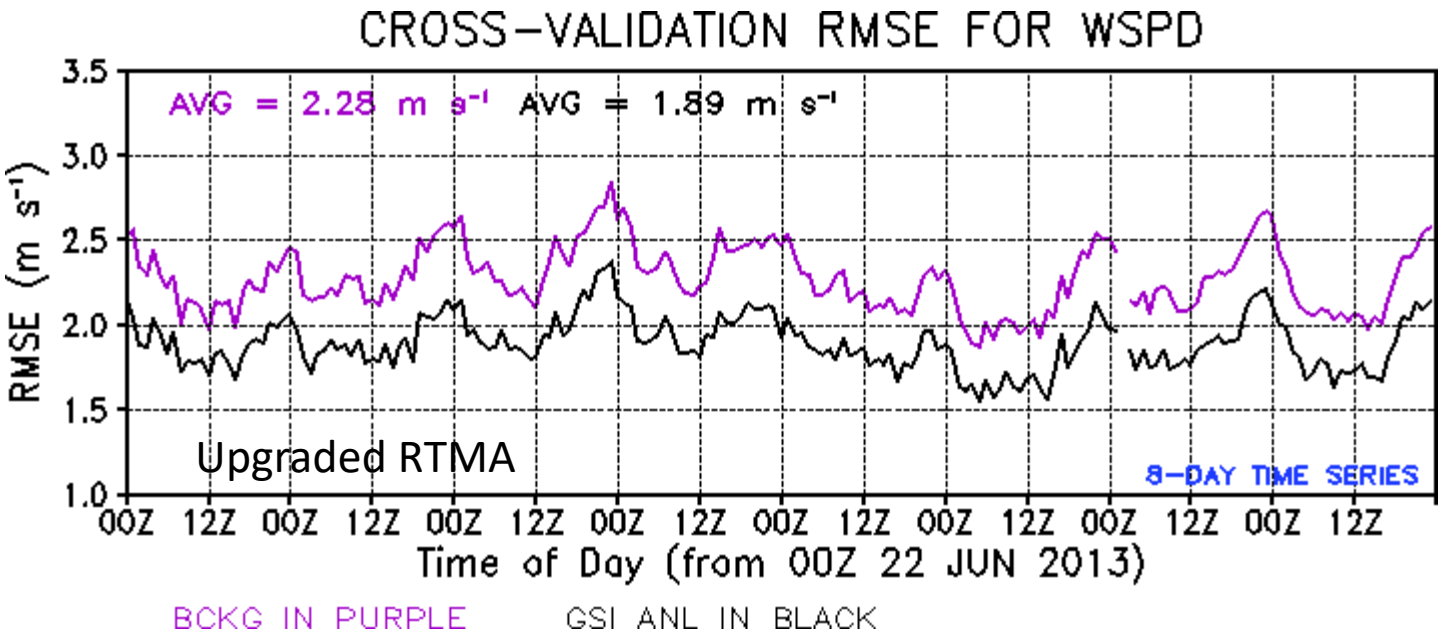
- NWRFC via NWS FTP SERVER and NOMADS only
- Alaska-3km to be on SBN, AWIPS
- URMA to be on SBN & AWIPS

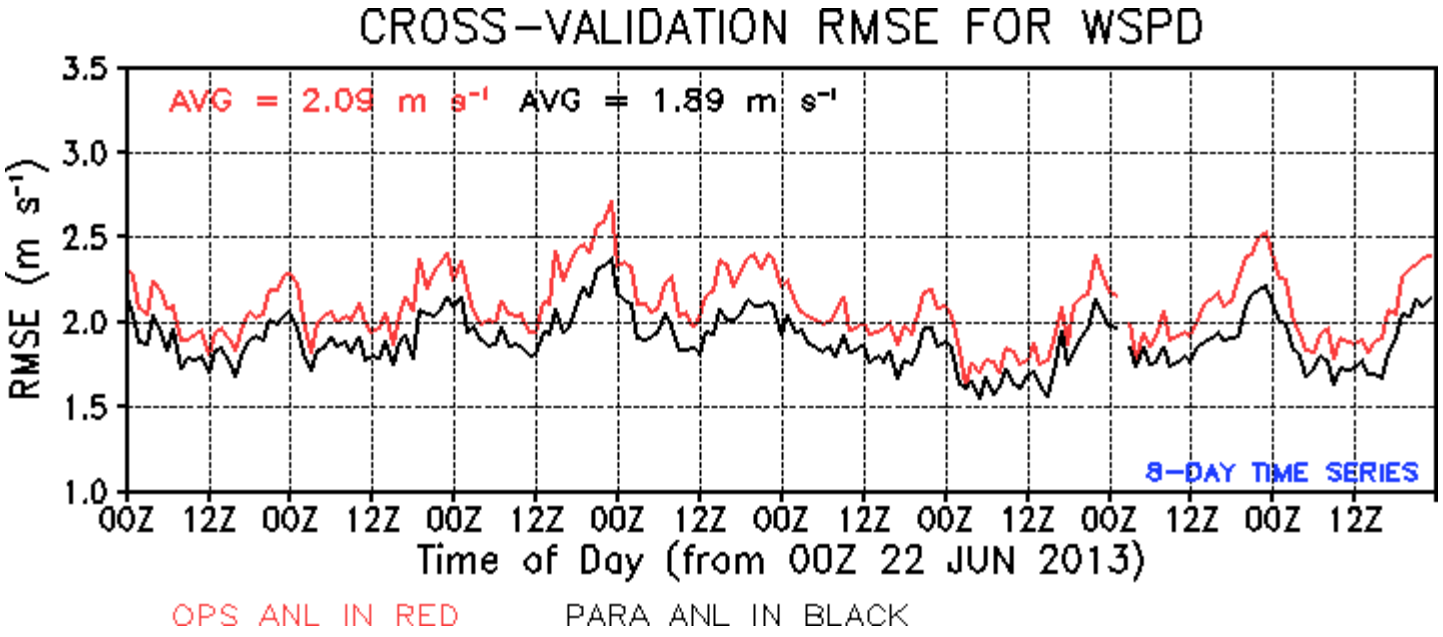
Note: CONUS-5km & Alaska-6kma to remain on AWIPS for now

# THANK YOU!

# BACKUP SLIDES

# RTMA CONUS-2.5km



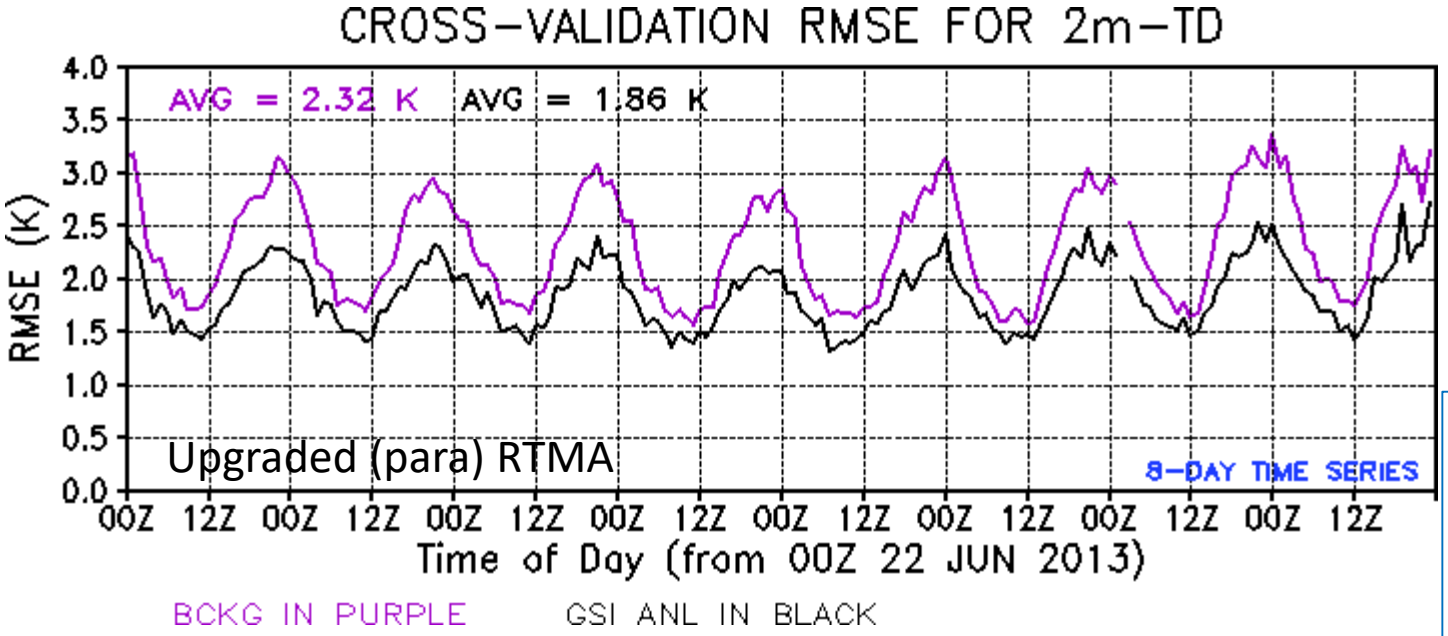

**10m-WSPD**

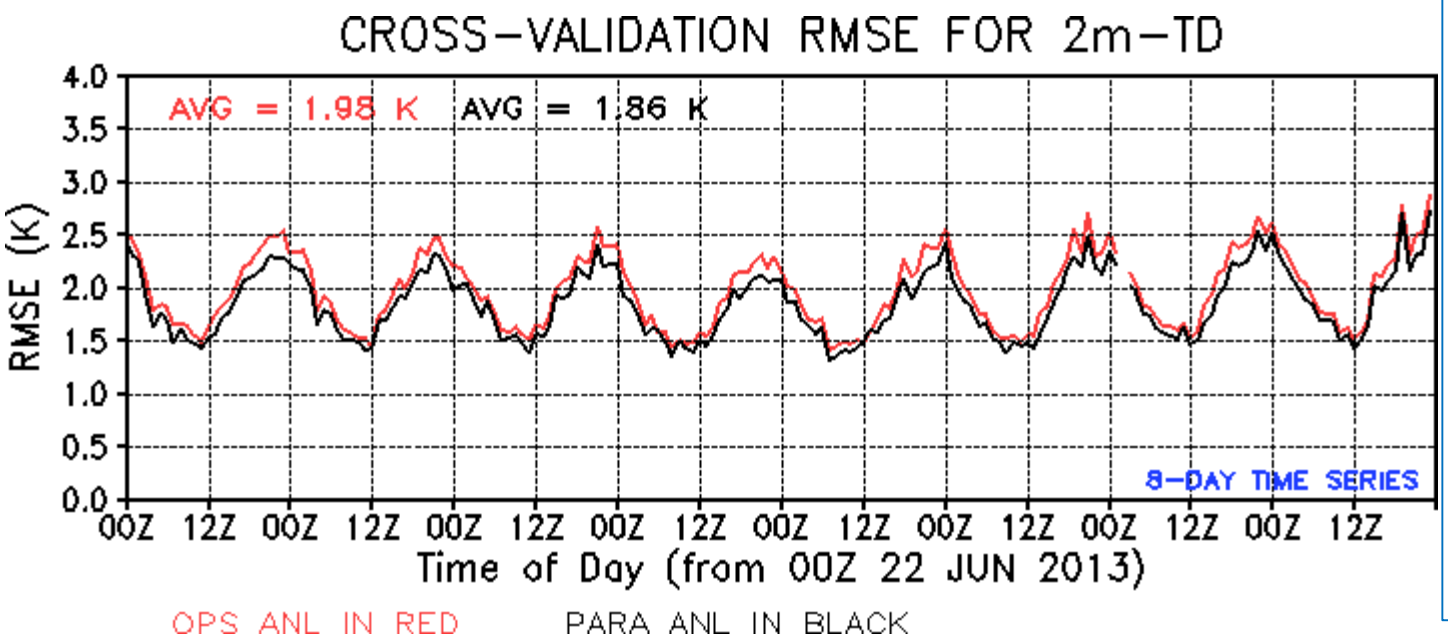
Superior CV statistics for PARA-RTMA compared with OPS. 11% improvement in 8-day stats.

Monthly Avgs: 10%

# RESULTS

**Cross-validation comparisons:**
**Ops CONUS 2.5km vs Upgraded system**



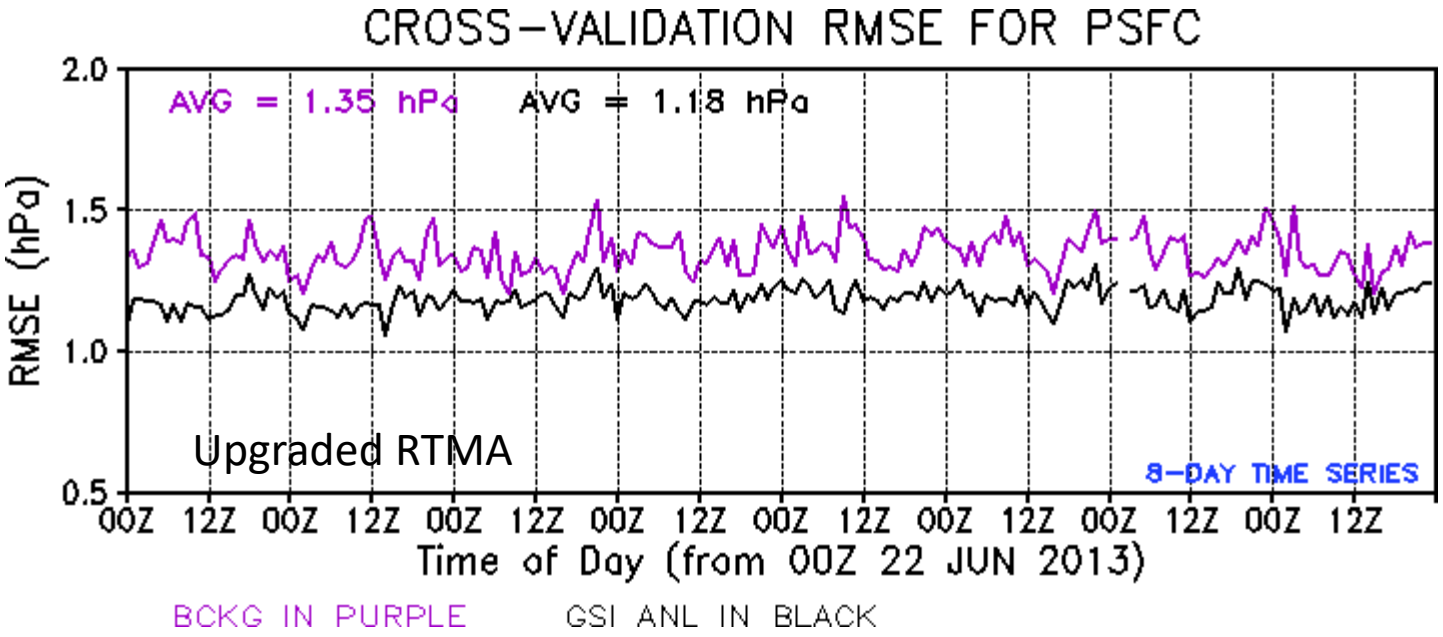



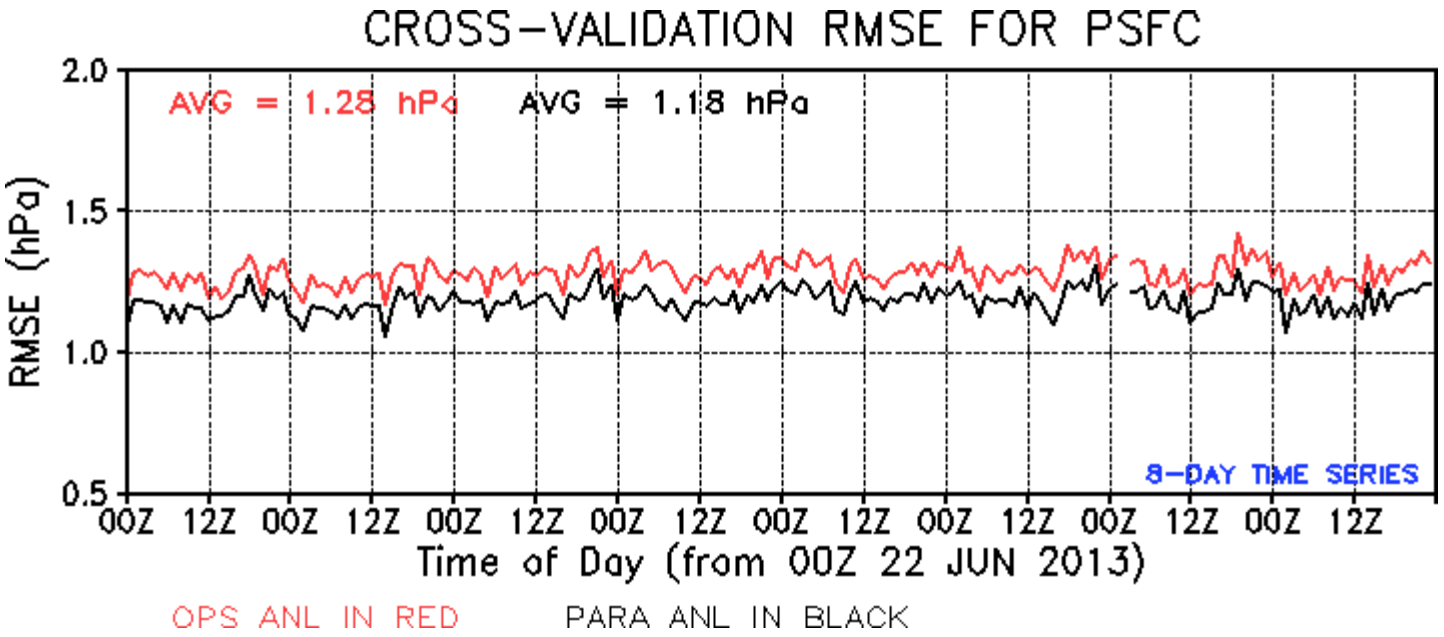

**2m-TD**

Superior CV statistics for PARA-RTMA compared with OPS. A 6% improvement in 8-day stats.

Monthly avg: 7%

# RTMA CONUS-2.5km




**PSFC**

Superior CV statistics for PARA-RTMA compared with OPS. 8.5% improvement in 8-day stats.

Monthly avg: 9%

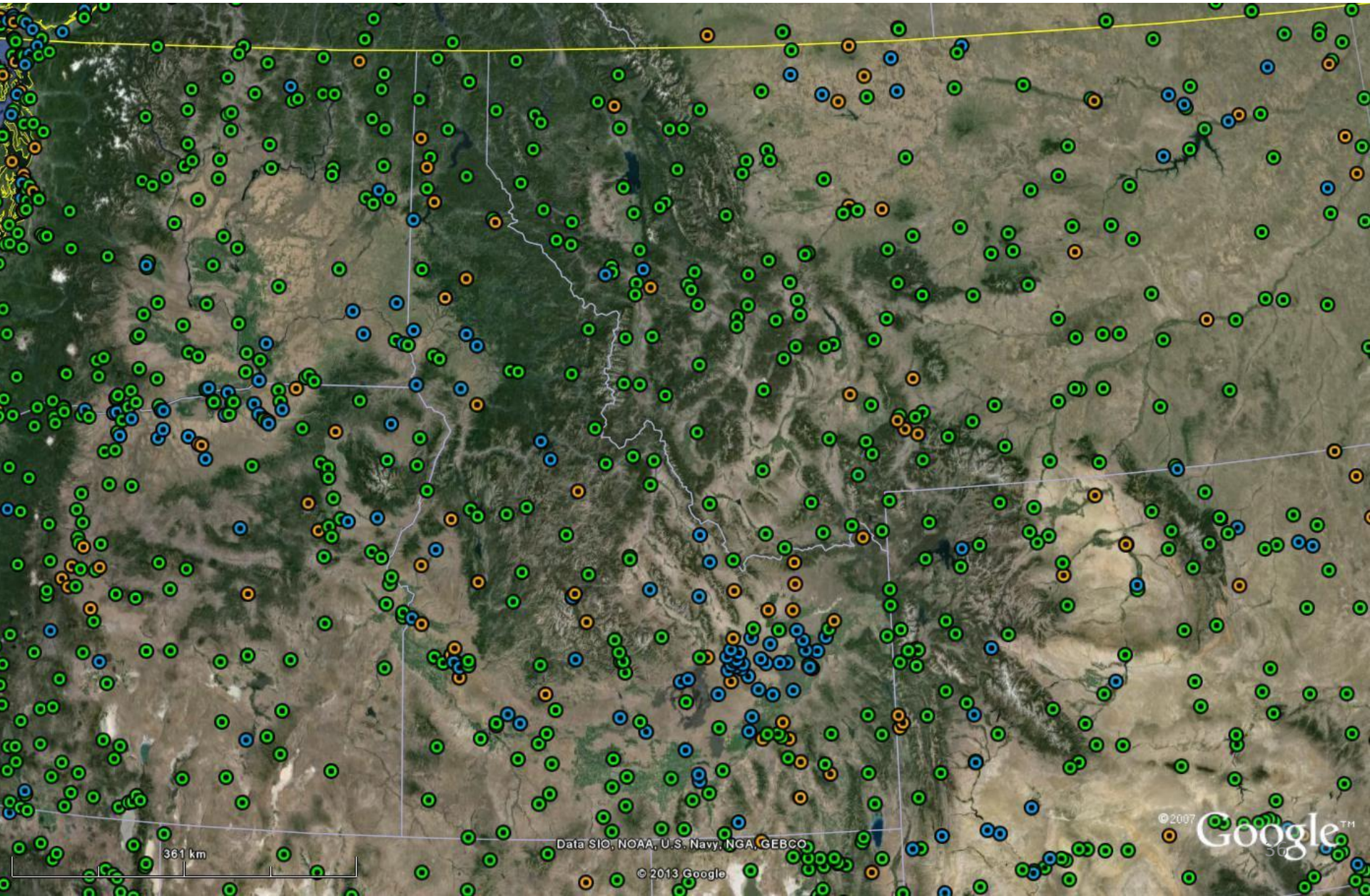
**Introduce Diurnal (Day vs night by local sun angle) reject lists for moisture and temperature observations:** Find poorly exposed stations, use only when over/under exposure does not occur or has little effect➔ Less than 1% of additional obs rejected.

## Introduce wind direction-stratified accept lists for mesonet winds + update station (static) accept list

| Domain | Wind obs available | Wind obs before | Wind obs (static) | Wind obs (static + bins) |
|---|---|---|---|---|
| CONUS | 18098 | 6625 | 7961 (20%) | 9153 (30%) |
| Alaska | 1394 | 697 | 794 (14%) | 848 (22%) |
| Hawaii | 104 | 61 | 67 | 69 |
| Puerto Rico | 60 | 25 | 29 | 34 |
| Guam | 12 | 7 | 7 | 7 |

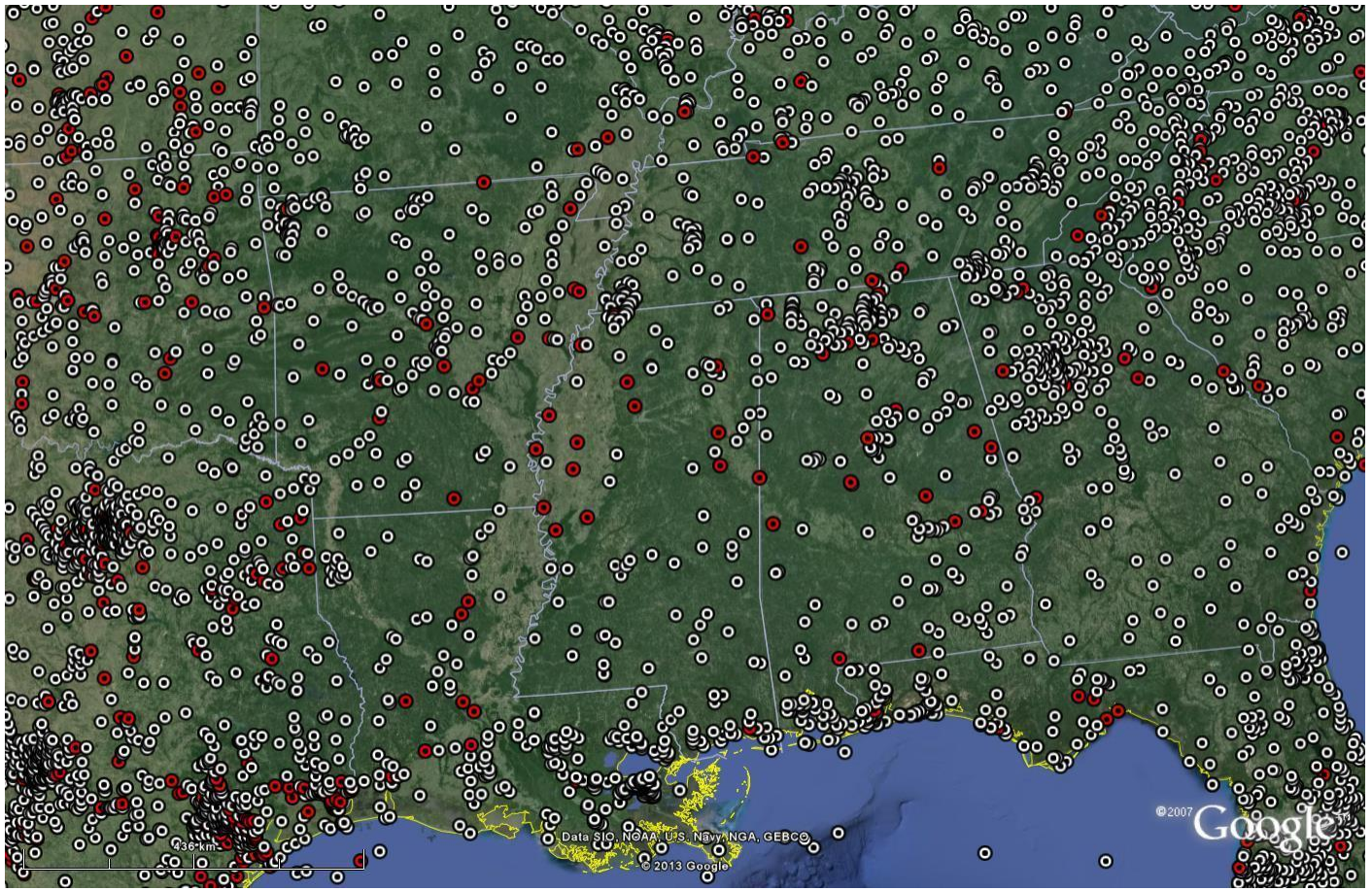
Based on production cycle: 11/04/13, 00Z

# Original Static Bins



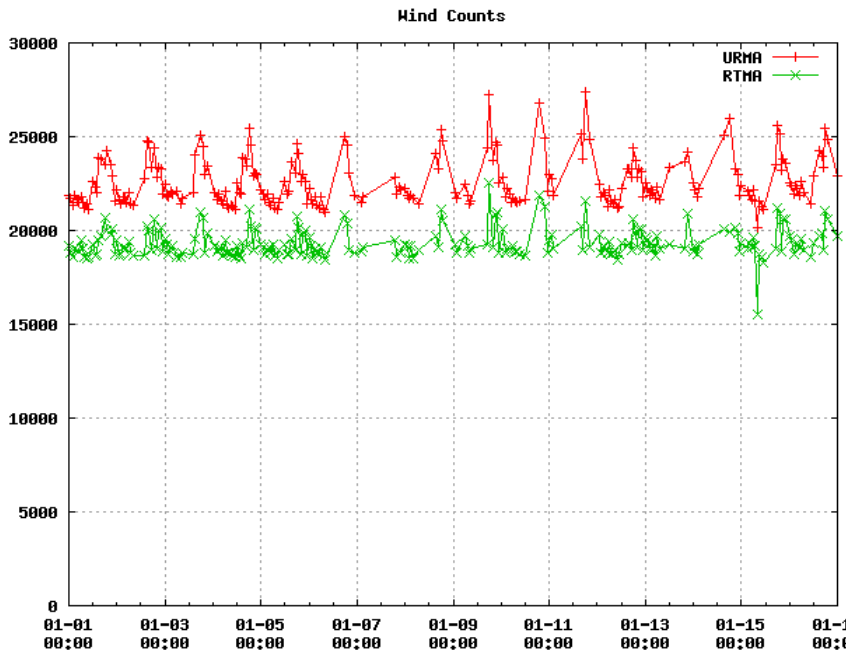
# Original Static Bins

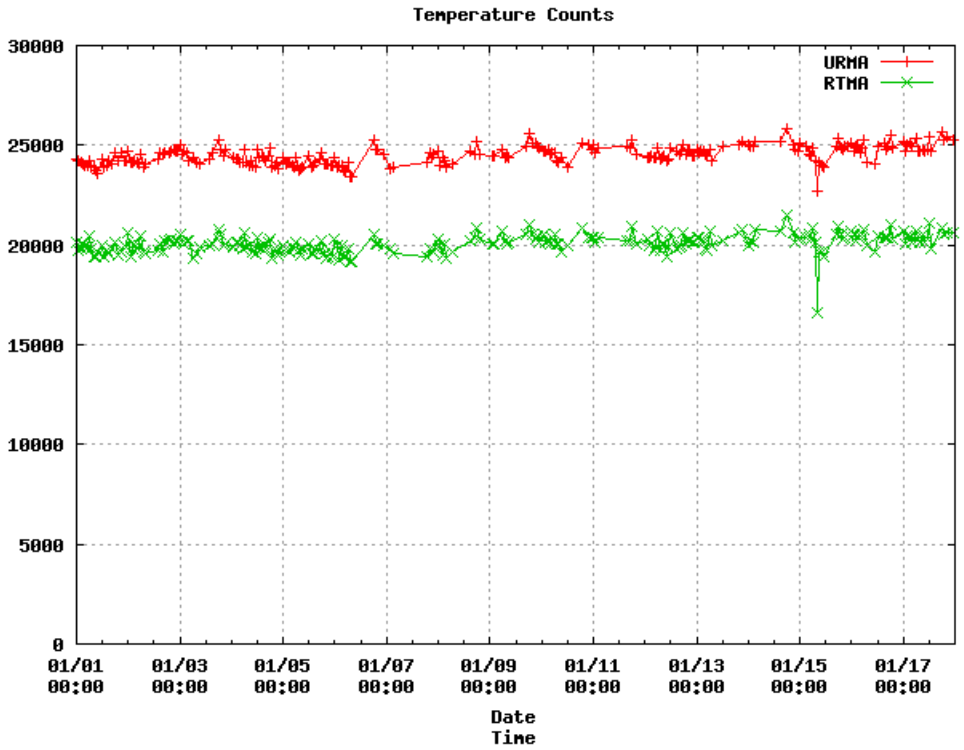
# URMA: Update of RTMA Analysis on Expanded CONUS-2.5km domain 6 hours later to use more observations. Requested by WFOs to address data latency issues. URMA more appropriate for verification



# STATION COUNTS (URMA vs RTMA)

## 1 - 17 Jan 2014



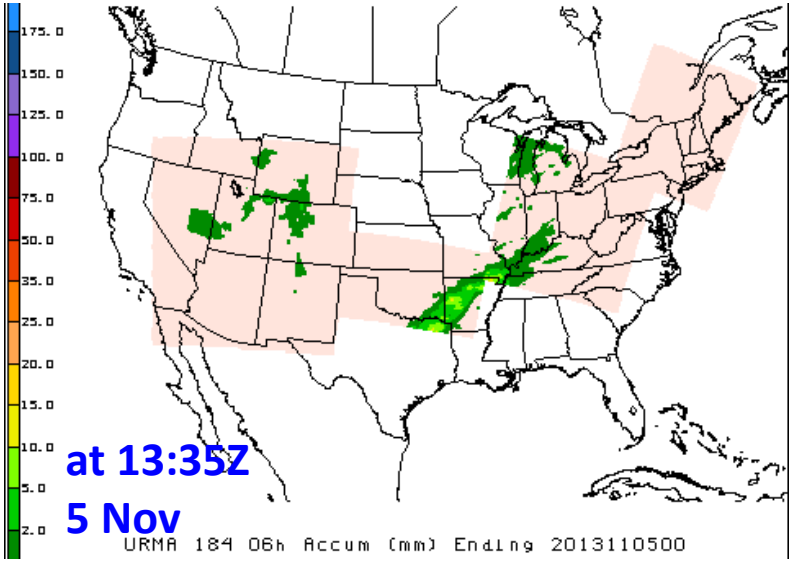



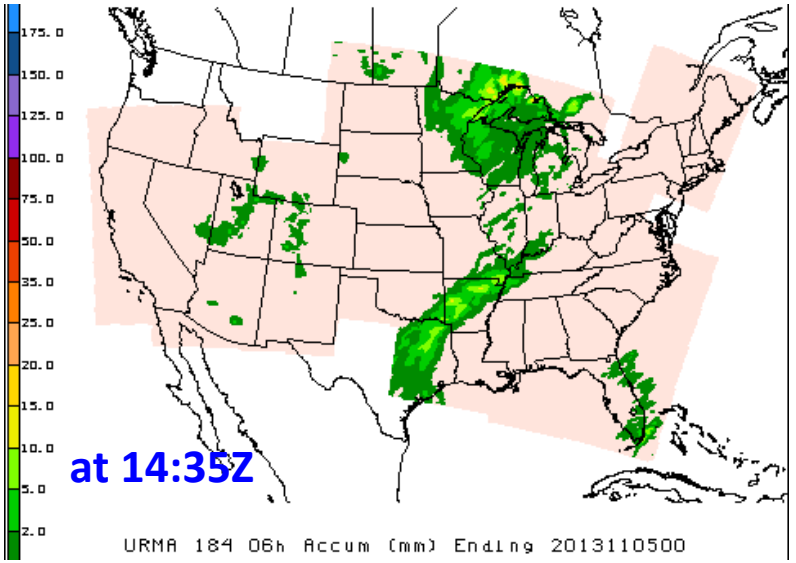

## Count averages:

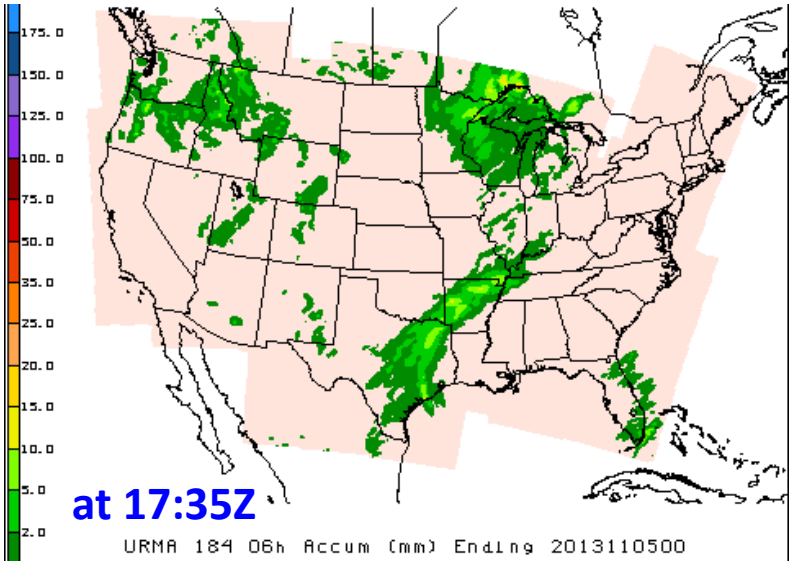
| | RTMA | URMA | % INCREASE |
|---|---|---|---|
| Temperature | 20,075 | 24,511 | 22% |
| Winds | 19,327 | 22,610 | 17% |

**URMA PRECIP IS INTERPOLATED NCEP STAGE-IV PRECIP / 6-h ACCUMULATED**

# 6h pcp accum ending 00Z 5 Nov 2013



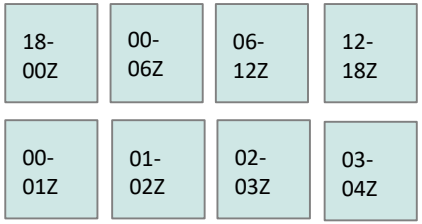




**The RFCs generally transmit their 6-hourly analysis files covering the 12Z-12Z 24h period in the several hours after 12Z. Complete ConUS coverage is usually achieved by 18:35Z. As new versions of the analysis come in, we continue to re-make the mosaicks hourly, until 23:35Z.**

# Future plans for a longer look-back period

In the current production setup, input from each RFC for each day (hourly and 6-hourly, early data and later updates) are piled up into one big file, up to 500 records for one RFC in one day. The pile is difficult to untangle, making it unfeasible to have a longer look-back period.

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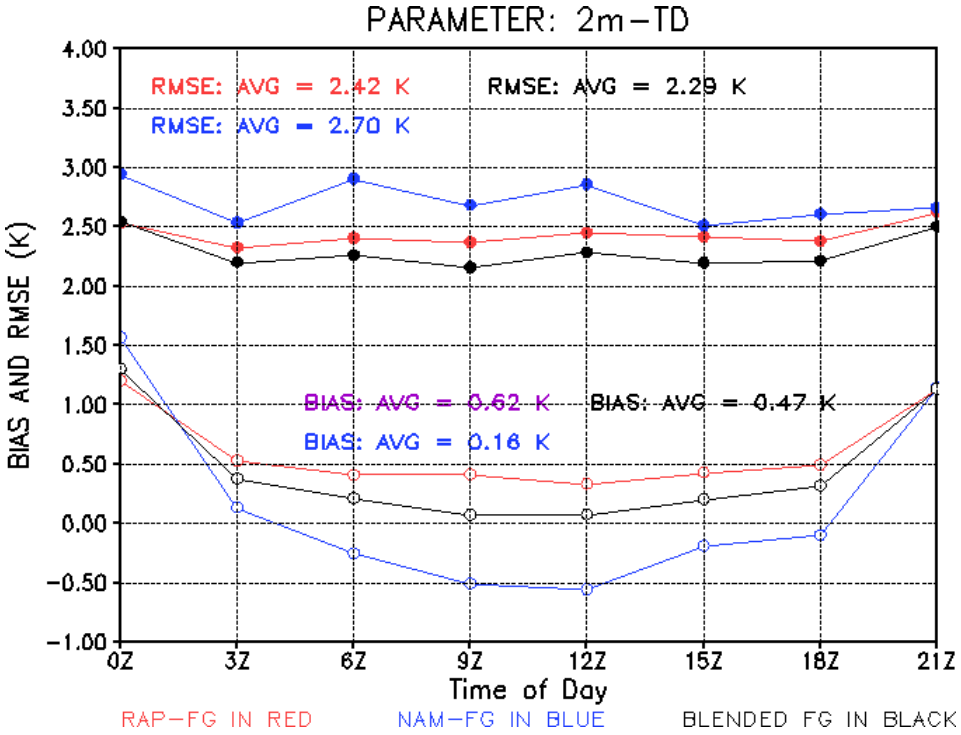
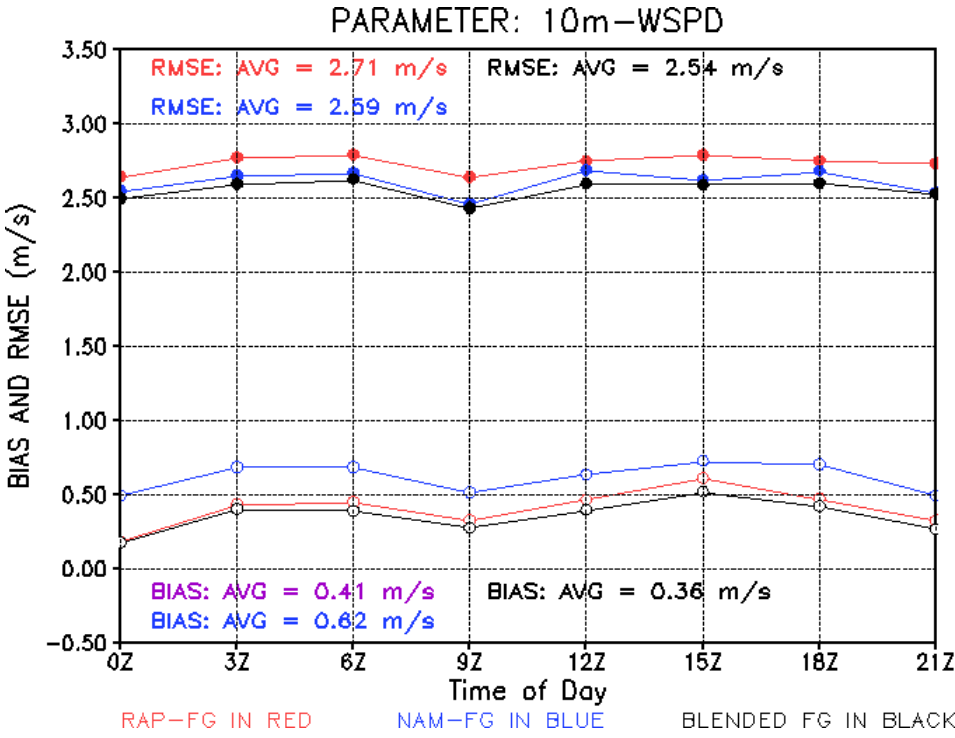
We have been working with NCO Dataflow to change this have a "horizontal" file system for incoming data, later analysis over-writes the earlier one covering the same time period. That way we can keep just 28 records (instead of ~500! 24 one-hourly records, 4 six-hourly records) for each RFC each day. Under this system, it would be easy to have a longer look-back period (5-7 days), in case one or more RFC makes a re-run when better QC'd obs becomes available.

A new input setup has just been made available (in testing stage) in /dcomdev (16 Jan 2014). Using these data, we will work on a longer look-back period for Stage IV/precip URMA for the next precipitation analysis upgrade (implementation time TBD).

# RTMA Alaska-3km First Guess fit to the Obs

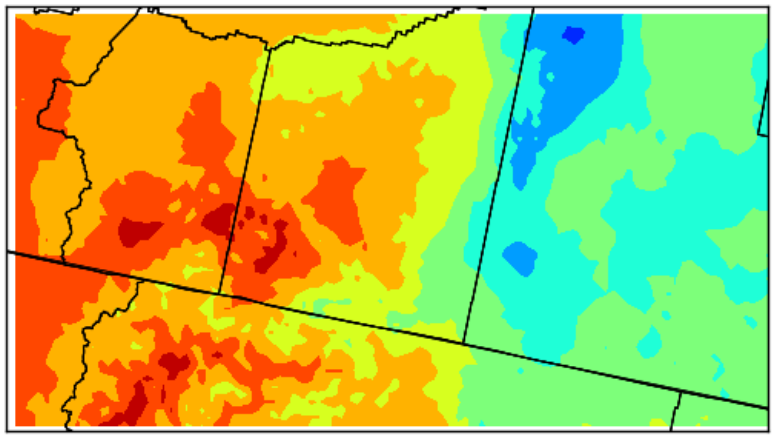
## Domain & Time average stats for
## 00Z Feb 2012 through 00Z 06 Mar 2012



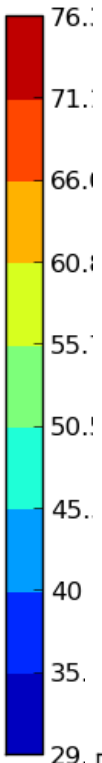




**Compared with the single RAP or NAM first guess, blended First Guess yields reduced rms errors**

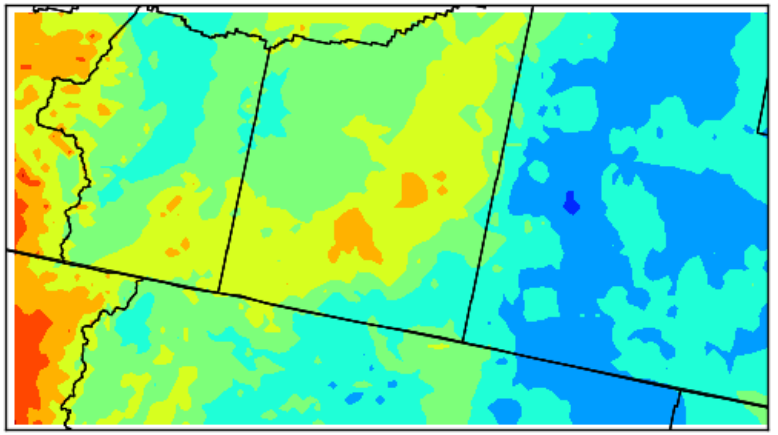
# 22 Z 16 Jan 2014 Medford /Oregon Case

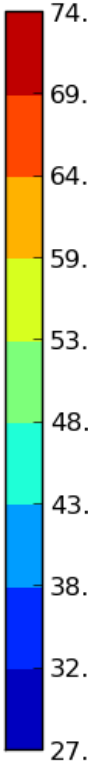


RAP-based RTMA bckg




NAM Nest would have provided a superior bckg for this case!






2.5 km downscaled NAM Nest (no surface GSI at this stage) 4 hour forecast from 18Z NAM.

# RTMA vs MatchObsALL for Missoula area 1/16/14

**1) Evaluation Slide says: Valleys of Wrn Montana were well mixed and RTMA was accurate. At KGPI: OB=43 F ANL=41.4 F ( ANL-OB=1.6F)**

We found: **para RTMA: ANL-OB=0.7 F**
**5km OPS : ANL-OB=1.4 F**
Both analyses were good at this location

## Problematic locations:

**2) Evaluation Slide says: Under stratus in Idaho Panhandle RTMA had a large error compared to METARS. At K65S: OB=32 F ANL=50.6 F (ANL-OB=18.6 F)**

We found for **para RTMA: ANL-OB=4.3 F**
**5km OPS : ANL-OB= 18.9 F** (close to WFO value)
Observations failed gross error check in 5km OPS.

**3) Evaluation Slide says: Same situation in Southern Canada. At CYXC:**
**OB=34 F ANL=47.9 F (ANL-OB=13.9 F)**
We found for **para RTMA: ANL-OB=5.8 K**
**5km OPS : ANL-OB=14.2 F** (close to WFO value)
Ob failed gross error check in 5km OPS

# RTMA vs MatchObsALL for Missoula area 1/16/14 (continued)

**4) Evaluation Slide says: Small scale cold pool in the Salmon, ID area. RTMA had a 21 degree error at KSMN: OB=28 F ANL=49.3F (ANL-OB=21.3 F)**

We found **for para RTMA: ANL-OB=17.6 F** (OB rejected! Was on global reject list)
**5km OPS : ANL-OB=20.3 F** (Close to WFO value. Ob rejected by gross-error check).

**Missoula Slides are likely to be from the old 5km-OPS. Slight chance also that they could be from the 2.5km OPS**

**Para RTMA did significantly better. KSMN should have not been on the reject list!**