EMC CCB Meeting

NAM V3.1

30 April 2014

Presented by
Eric Rogers

Presentation Outline

- Upgrade elements : what is changing and why
- Timeline of pre-implementation testing
- Parallel testing results
- A few case studies showing specific impact of changes
- Summary/implementation status

Model Changes

- Replace legacy GFDL radiation with RRTM
- Modified Gravity Wave Drag/Mountain Blocking
  - More responsive to subgrid-scale terrain variability
  - Target : Improve synoptic performance without adversely impacting 10-m wind forecasts
- New version of Betts-Miller-Janjic convection
  - Moister convective profiles, convection triggers less
  - Target : Improve QPF bias from 12-km parent, esp. in warm season
- Ferrier-Aligo microphysics
- Modified treatment of snow cover/depth
  - Use forecast rime factor in land-surface physics
  - Target : Reduce snow depth in marginal winter conditions w/complex precipitation type
- Reduce roughness length for 5 vegetation types
  - Target : Improved 10-m wind in eastern CONUS

Model changes targeting NAM nests

- **Current NAM nests configuration**
  - 4 km CONUS, 6 km Alaska, 3 km Hawaii/Puerto Rico, 1.33 km (CONUS) or 1.5 km (Alaska) fire weather nest. CONUS/AK/HI/PR nests used as input to NAM Downscaled (NDFD) grids
  - Have "reduced" convective triggering
  - All run to 60-h except 36-h for fire weather nest
- **Nests in NAM upgrade; no change in resolution**
  - All nests except Alaska will run with explicit convection
  - Measures to improve severe storm signatures:
    - Extensive modifications to microphysics (Ferrier-Aligo)
    - Reduce 2nd order diffusion in nests (improves horizontal storm structure in cases suggested by SPC)
    - Separate microphysics species advection for all nests except 6 km Alaska

Ferrier-Aligo Microphysics

- Advection of mass-weighted rime-factor (RF; i.e. “variable ice density”).
- Max N_{LI} (number concentration of large ice) a function of RF and temperature (no longer a constant).
  - “Stratiform mode” when RF<10, max N_{LI} ranges from 10-20 L^{-1}.
  - “Convective mode” when RF>=10, max N_{LI}=1 L^{-1}
  - “Hail mode” when RF>=10, mean diameters >=1mm (N_{LI}=1 L^{-1}).
- Promote more supercooled liquid water.
- Modest reduction in rimed ice fall speeds.
- Increased radar backscatter from wet, melting ice, and at T<0C when rain & ice coexist in intense updrafts.
- Combined radar return from rain and heavily rimed ice in areas of intense convection where either (a) ice is formed from freezing of rain drops or (b) rain is formed from melting of large ice.
- (Other changes related to cloud ice production not discussed here)

Analysis/NDAS Changes

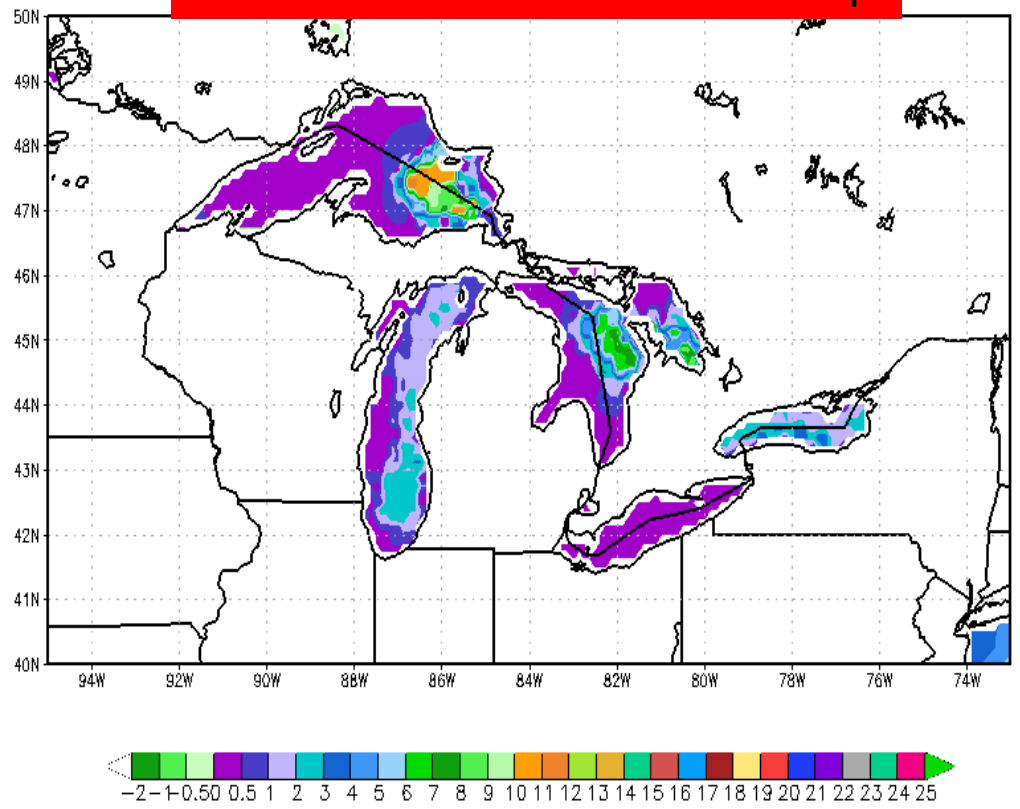
- Hybrid variational ensemble analysis with global EnKF
- New satellite bias correction scheme
- Variational Quality Control
- Raob level enhancement
- Use mesonet wind reject list from RTMA
- Use GFS ozone analysis in radiance assimilation
- Cloud analysis and diabatic digital filter initialization ~~with radar-derived temperature tendencies~~ (12 km NDAS only)
- Resume calculation of NDAS long-term precip budget adjustment (used to bias correct Stage II/IV analyses) using CCPA
- New observation types
  - GPS bending angle data replaces refractivity
  - GOES-15 radiances
  - New VAD winds (higher vertical resolution, produced at NCEP w/radial wind QC)
  - Meteosat-10 wind subtypes w/different data thinning

Other Changes

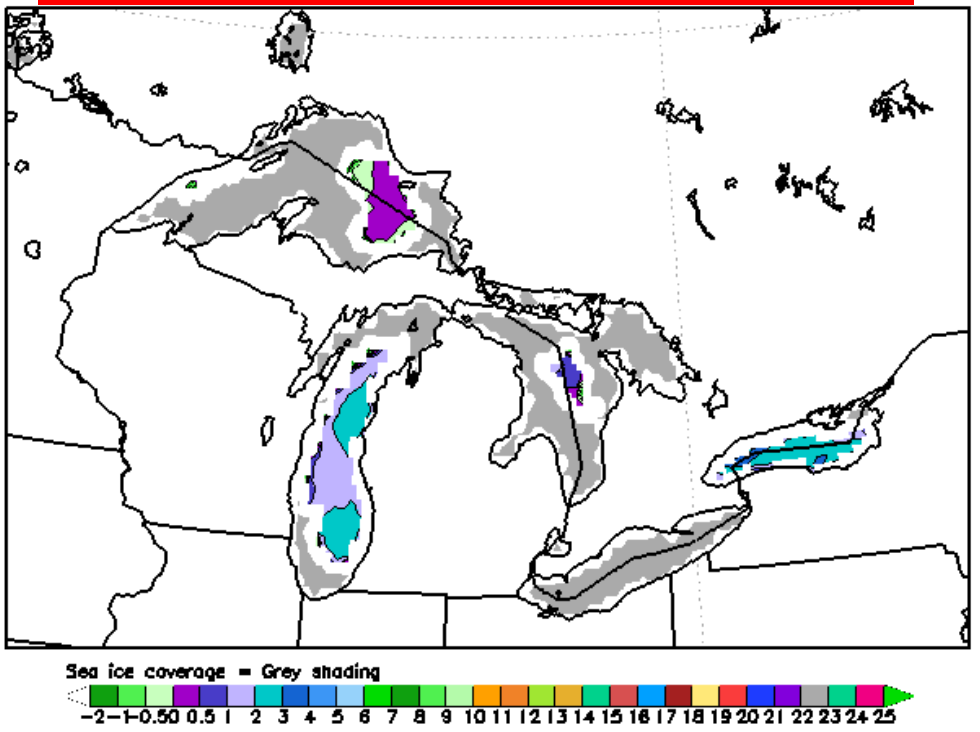
- Discontinue use of the AFWA snow depth product in the NDAS due to severe quality control problems. NDAS snow depth will continuously cycle (similar to RAP). Once per day (at start of 06z NDAS), snow will be removed at any point that is snow-free in the IMS snow cover analysis
- Discontinue use of GLERL water temperatures over the Great Lakes, use MMAB 1/12th deg RTG_SST_HR (SST used in the rest of the NAM domain)
- 28 additional BUFR sounding stations

Example of Great Lakes SST problem 30 January 2014

OPS NAM w/GLERL Lake Temp



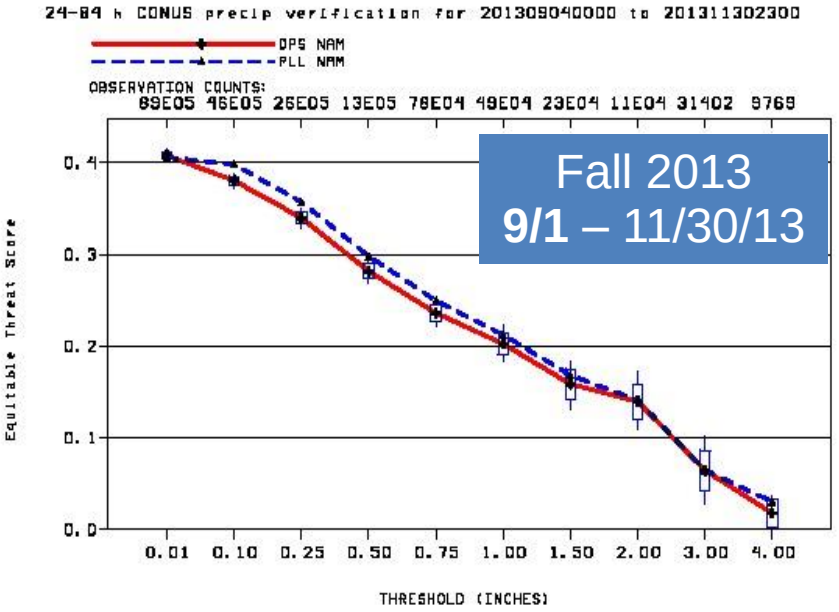
PLL NAM w/RTG_SST_HR Lake Temp



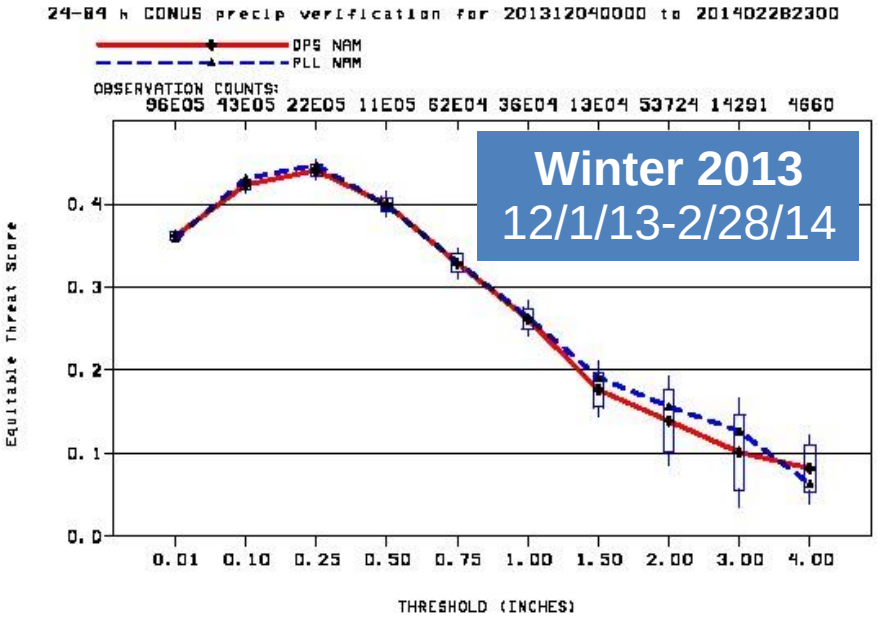
Pre-implementation testing

- **Real-time testing in two parallels has been ongoing since late 2011; dates when major components were introduced:**
  - RRTM : First version Feb 2012, development ongoing until code was frozen
  - Hybrid GSI w/global EnKF : April 2012, final GSI version Mar 2014
  - Modified BMJ : July 2012, upgraded Jan 2013
  - GWD/MB : Tuning started in 2012, major overhaul of code June/July 2013, finalized Feb 2014 (see later discussion)
  - Ferrier/Aligo microphysics : Tuning during 2013, in parallel as of Nov 2013, finalized Jan 2014
  - System frozen in early March
- **Retrospective testing**
  - July 2011 (for CMAQ, almost finished, running w/no EnKF)
  - Summer 2013 (warm season for MDL, dates T.B.D.)
  - 15 November 2013 - ? (cool season test with final version)
  - Many case studies using NAM launcher by B.Ferrier/E. Aligo (GWD tuning; DC Derecho; May 2013 Moore, OK tornado)
  - NAM launcher tests (12-km and 4 km) for all seasons tuning many aspects of RRTM, including cloud-radiation interaction (Ferrier, H-M. Lin)

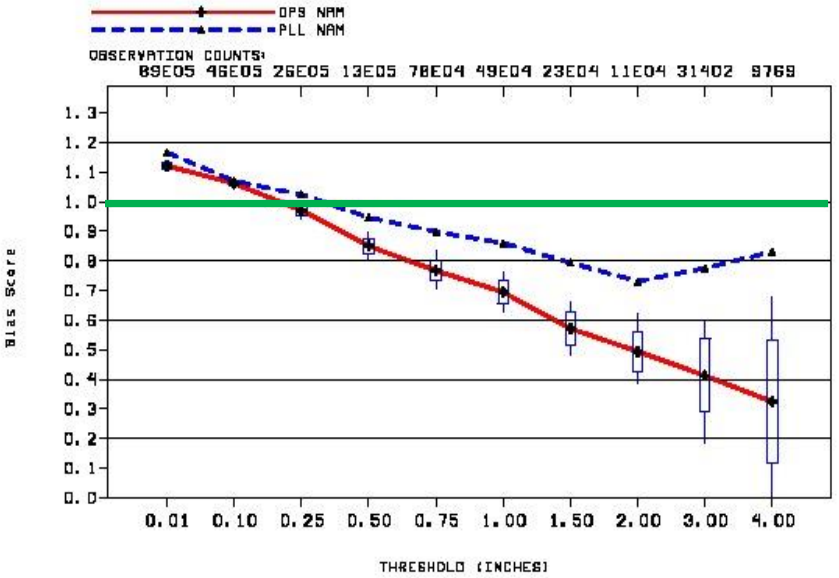
Seasonal QPF ETS (top)/Bias (bottom) : Ops (red) vs Pll (blue) NAM 12 km over CONUS

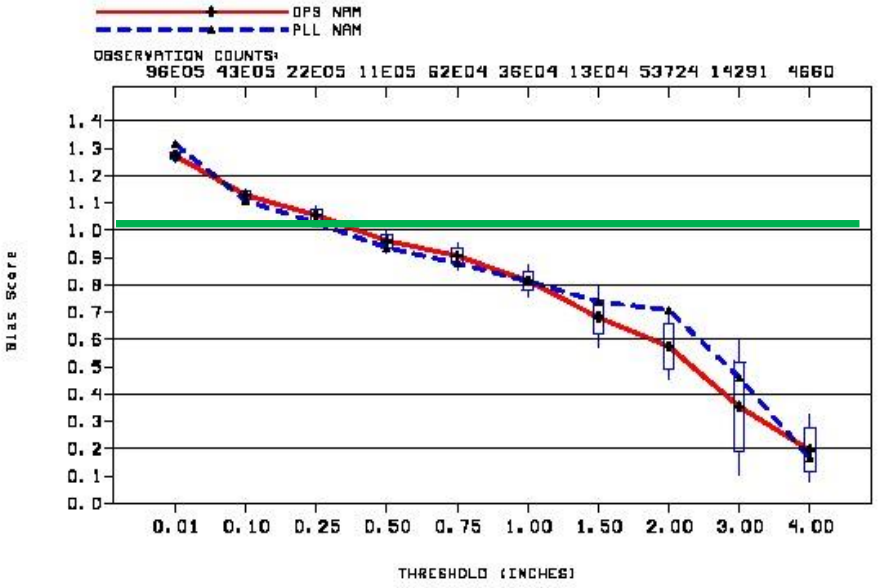


Fall 2013
9/1 – 11/30/13



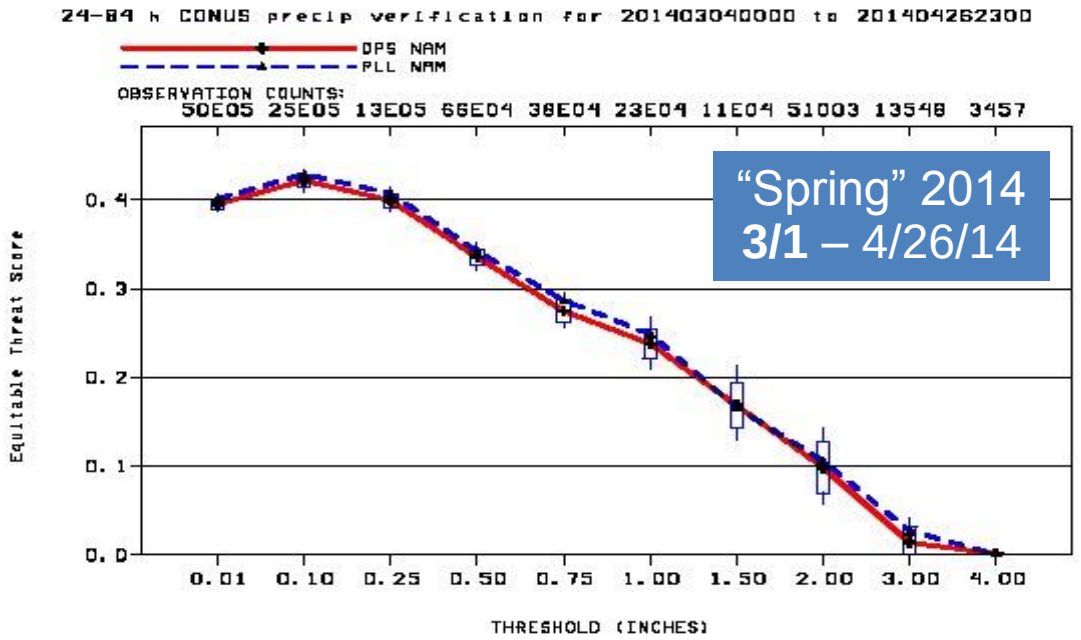
Winter 2013
12/1/13-2/28/14



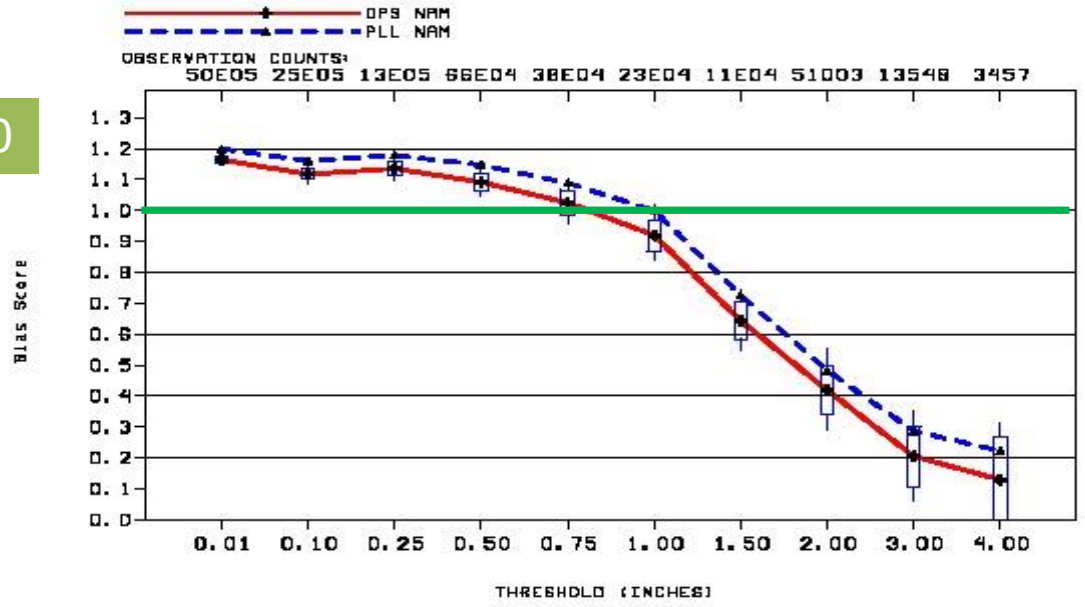


Green Line : Bias=1.0

Seasonal QPF ETS (top)/Bias (bottom) : Ops (red) vs Pll (blue) NAM 12 km over CONUS



"Spring" 2014
3/1 – 4/26/14

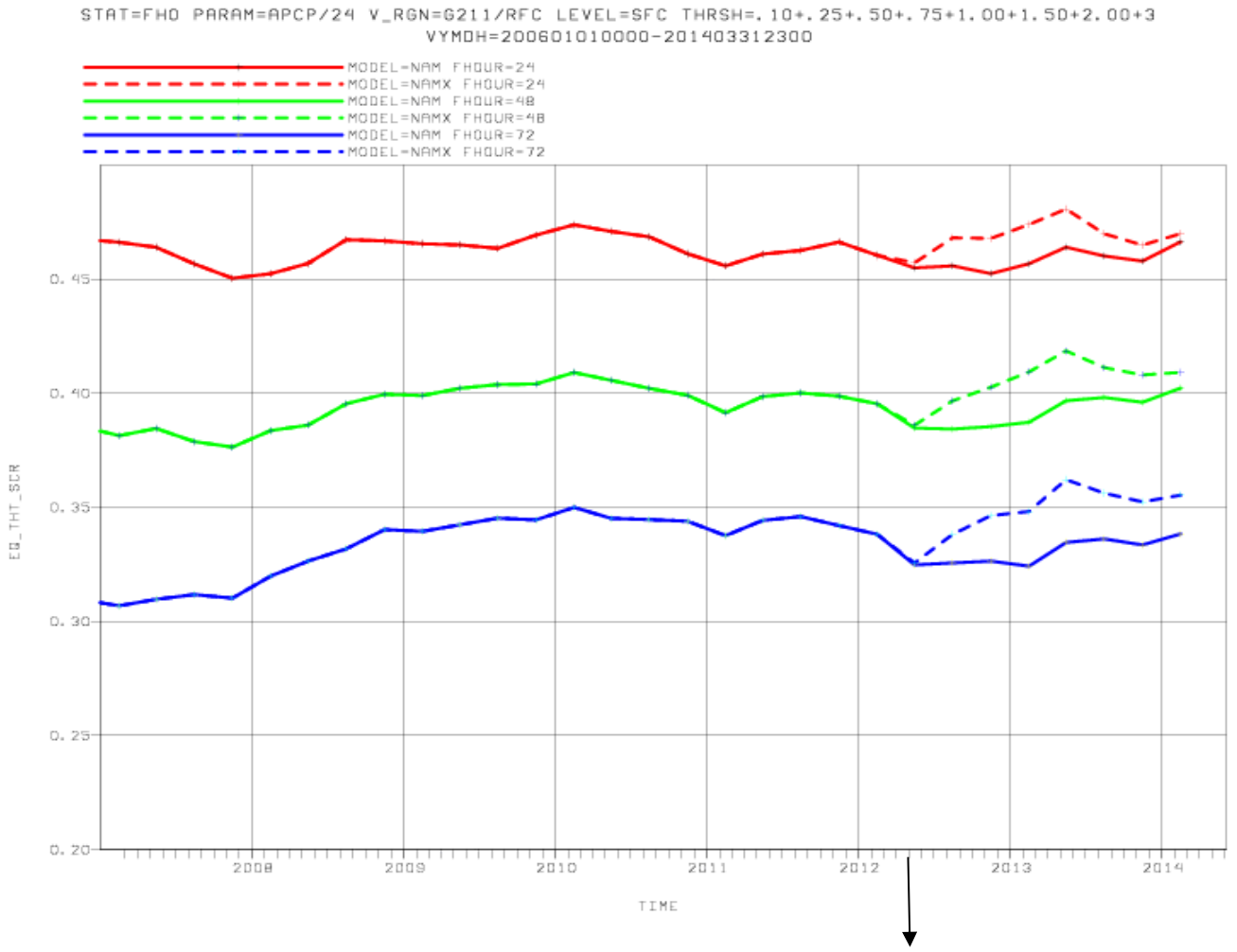


Green Line : Bias=1.0

Ops NAM, current Parallel NAM(dashed line) 24,48,72h forecasts, 2007-2014Q1

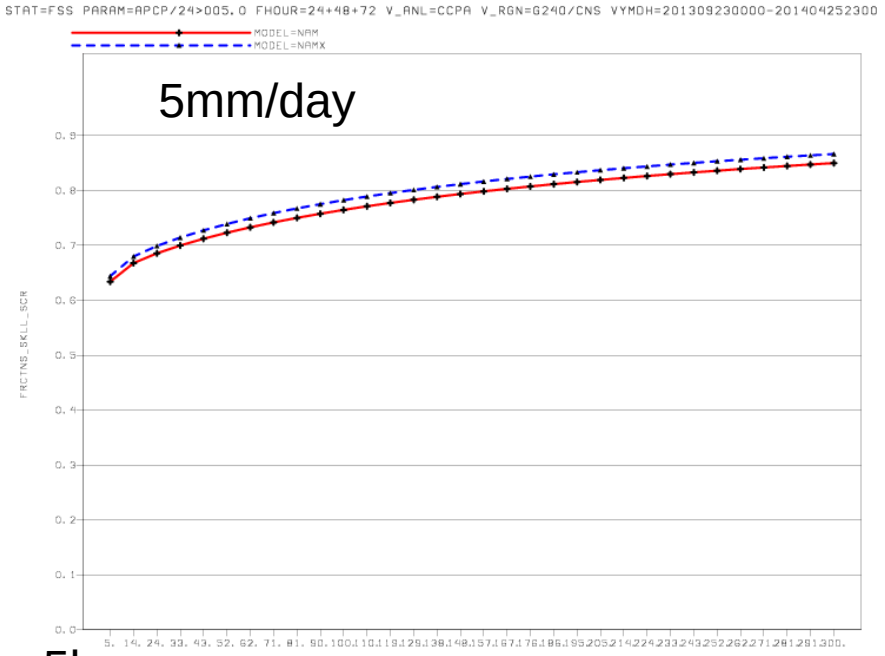
ETS at 0.25”/day

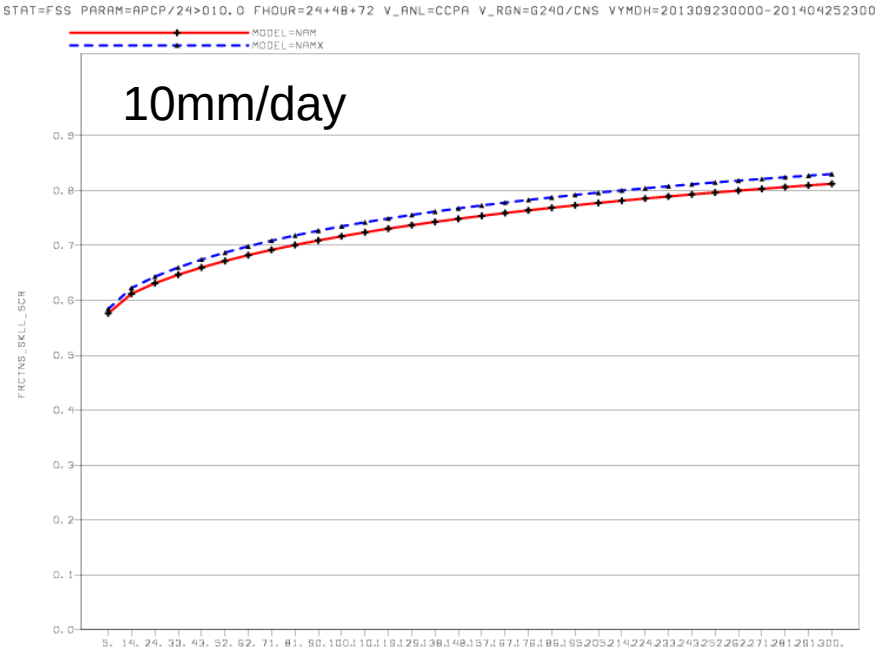
Quarterly time series, averaged over 4 quarters to remove seasonal variation



Apr 2012

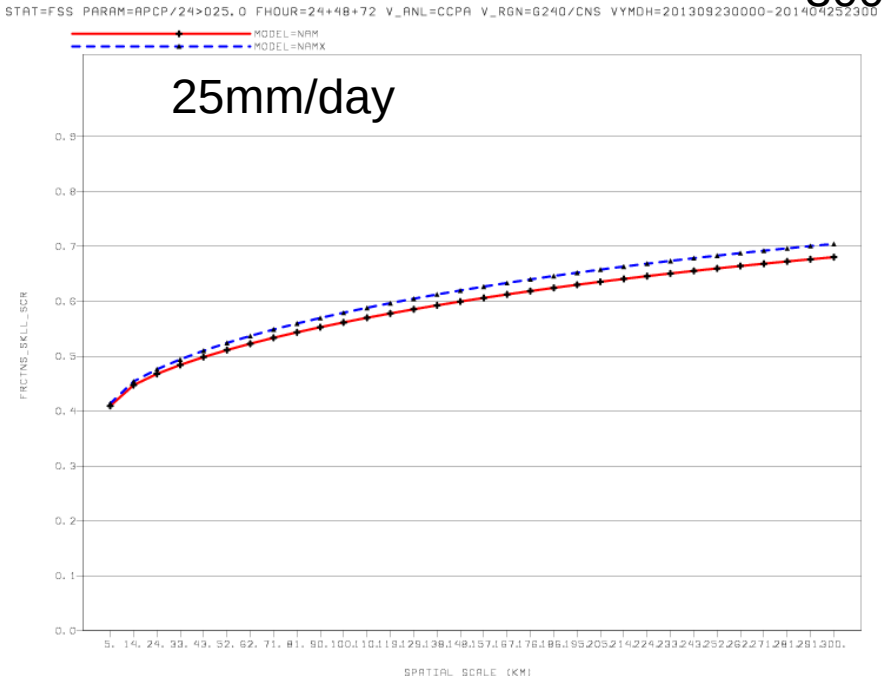
NAM, NAMX 24+48+72h FSS, 23 Sep 2013 - 25 Apr 2014

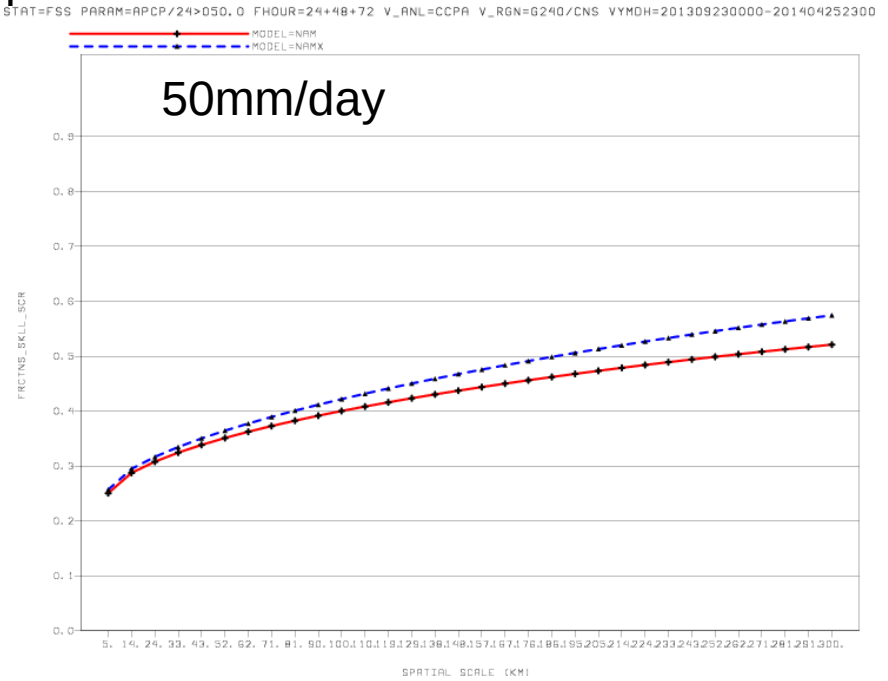




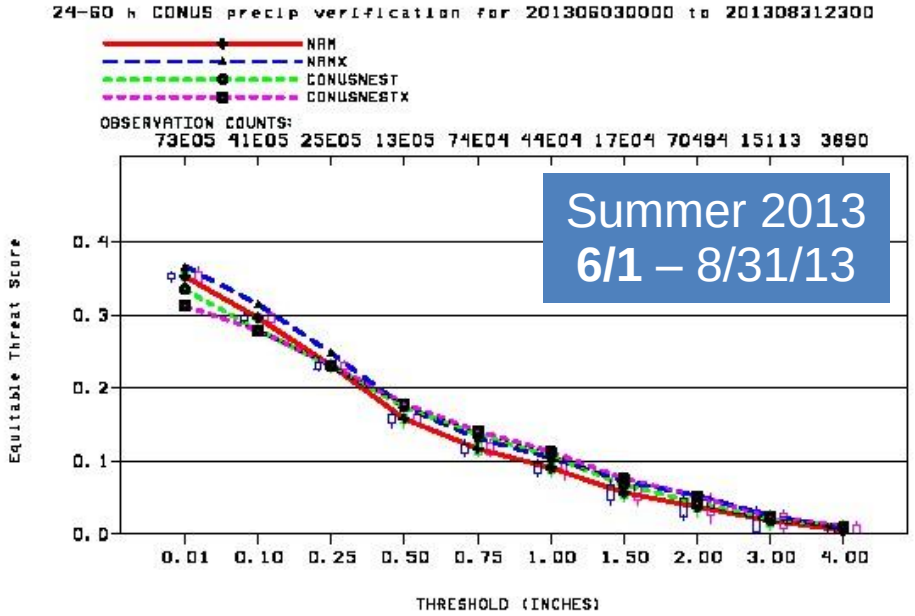
5km

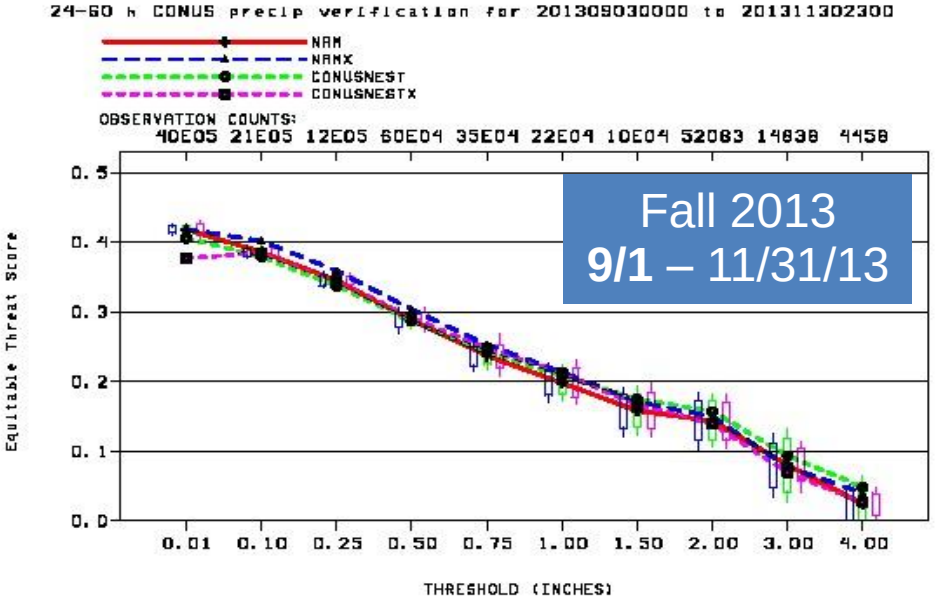
300km

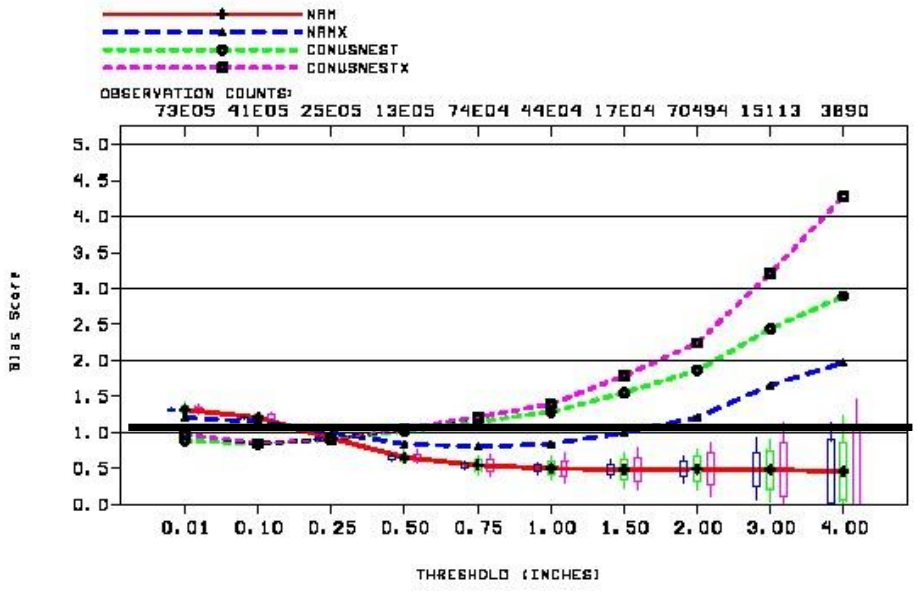


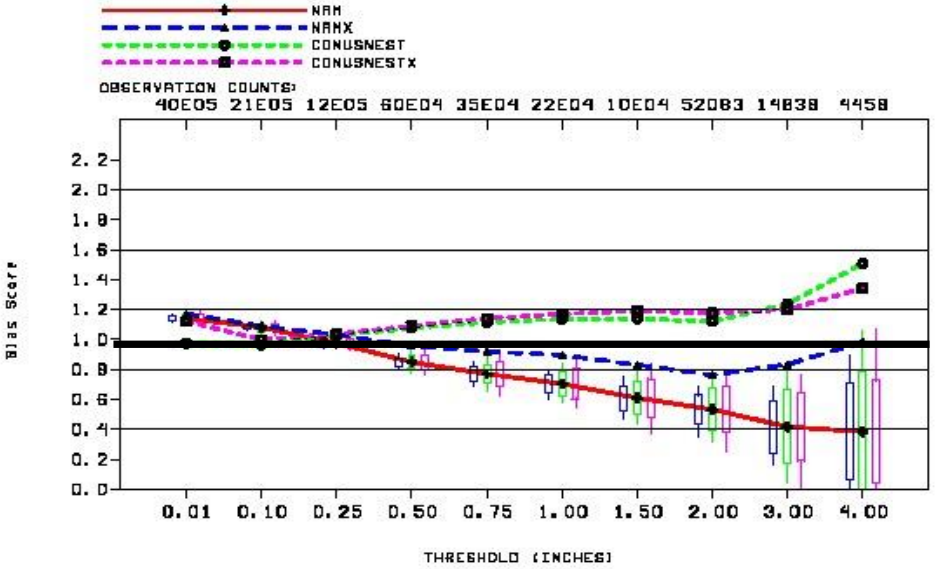


Multi-seasons of 24-60 h QPF scores for NAM ops and pll parent/nests (Pll nest ran @00z only after 9/26/13)



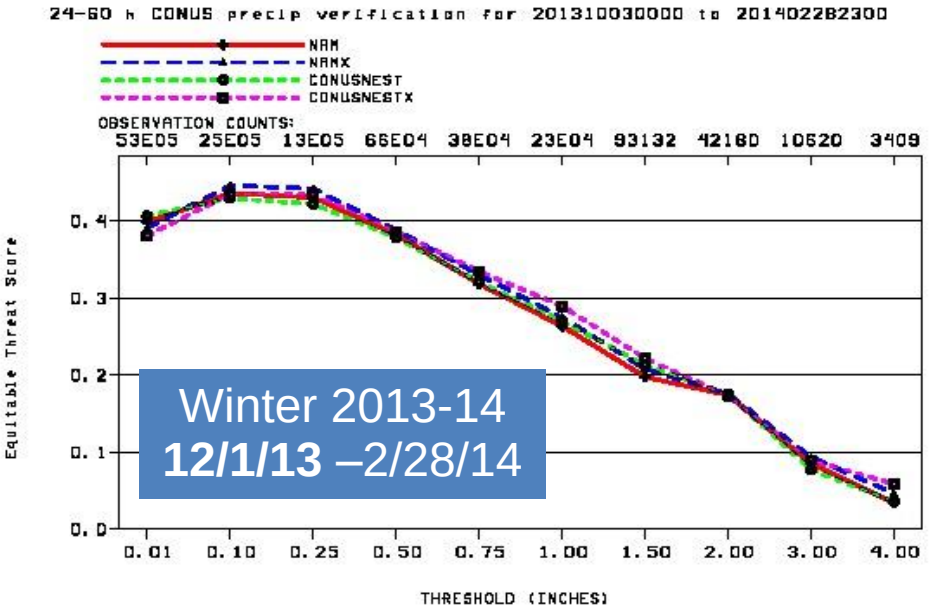


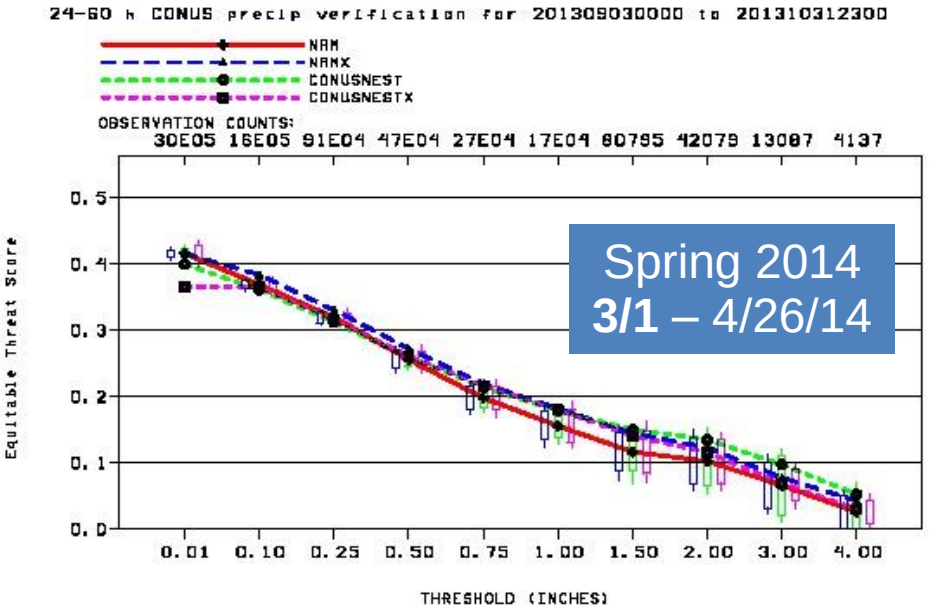


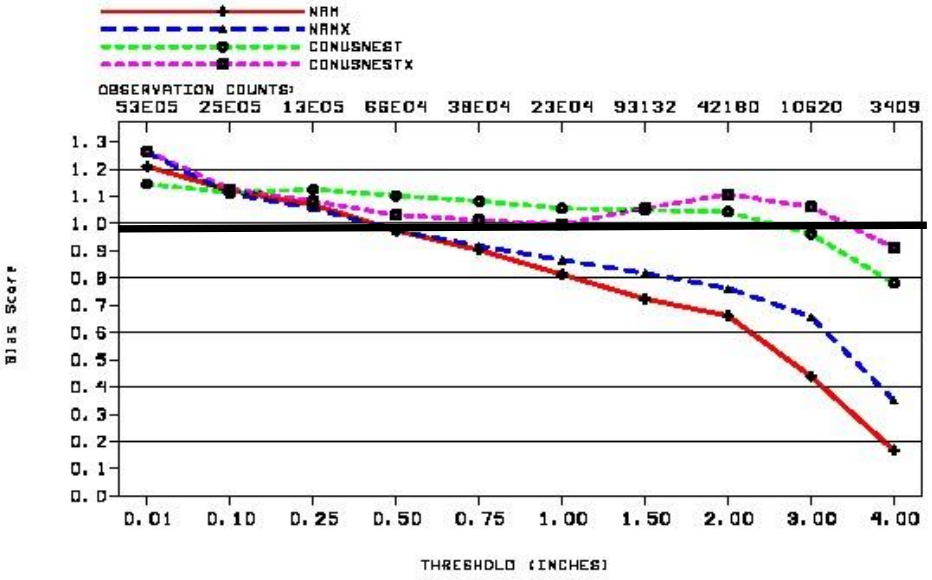


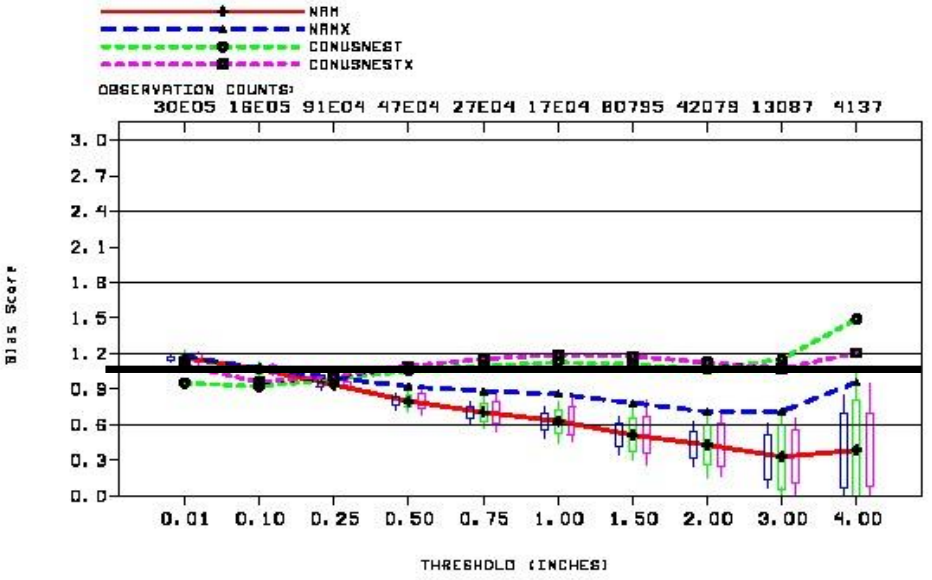
Ops NAM12=red; Pll NAM12=blue; Ops CONUS4=green; Pll CONUS4=magenta

Multi-seasons of 24-60 h QPF scores for NAM ops and pll parent/nests (00z cycle)









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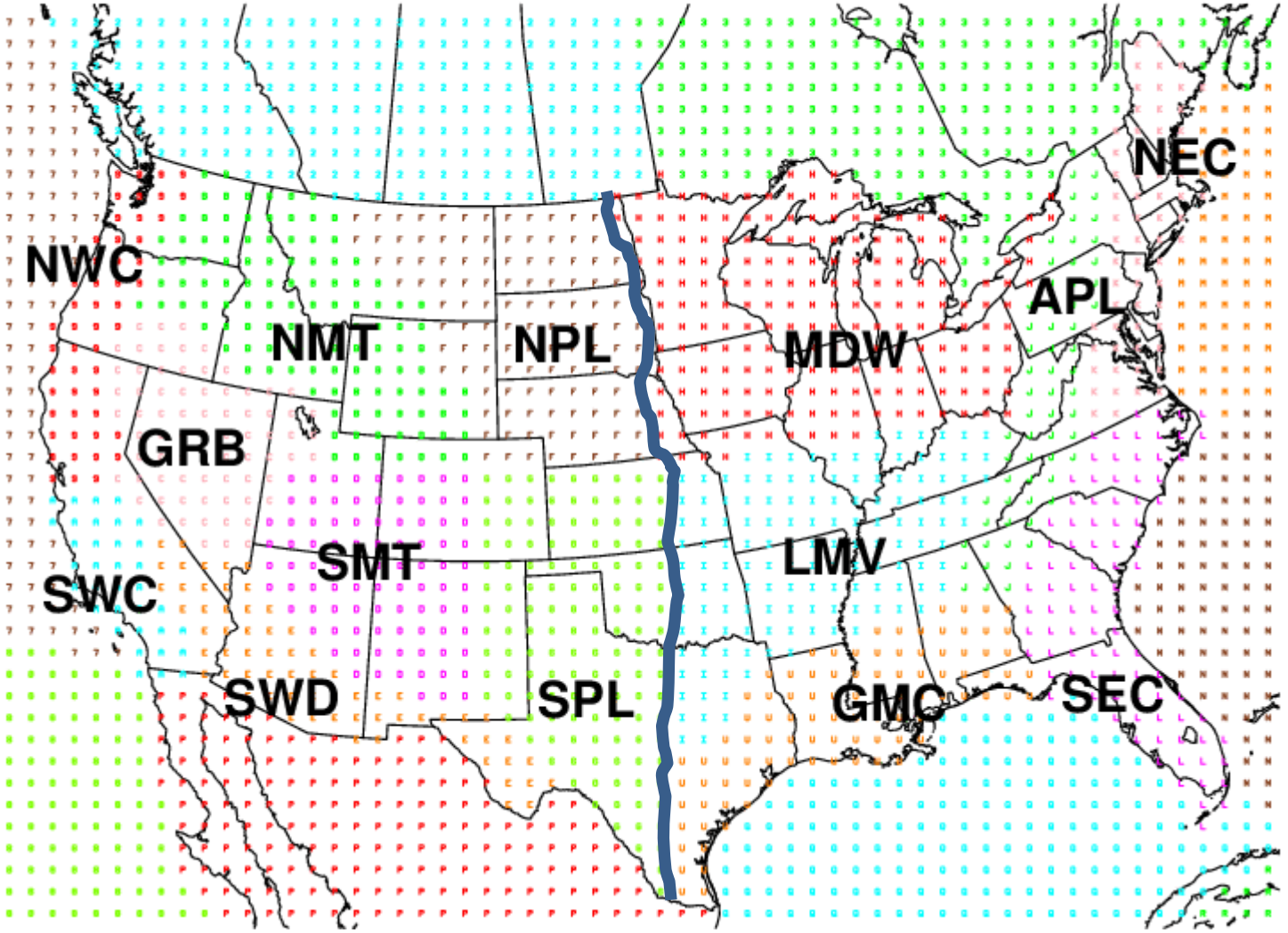
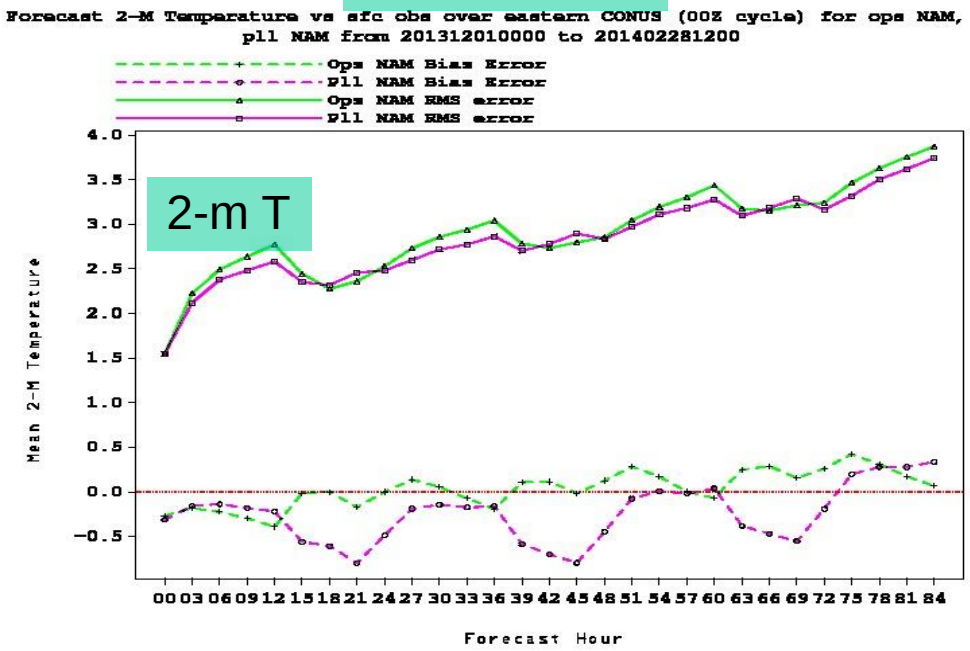
FVS Regions : Solid line is demarcation between East and West CONUS

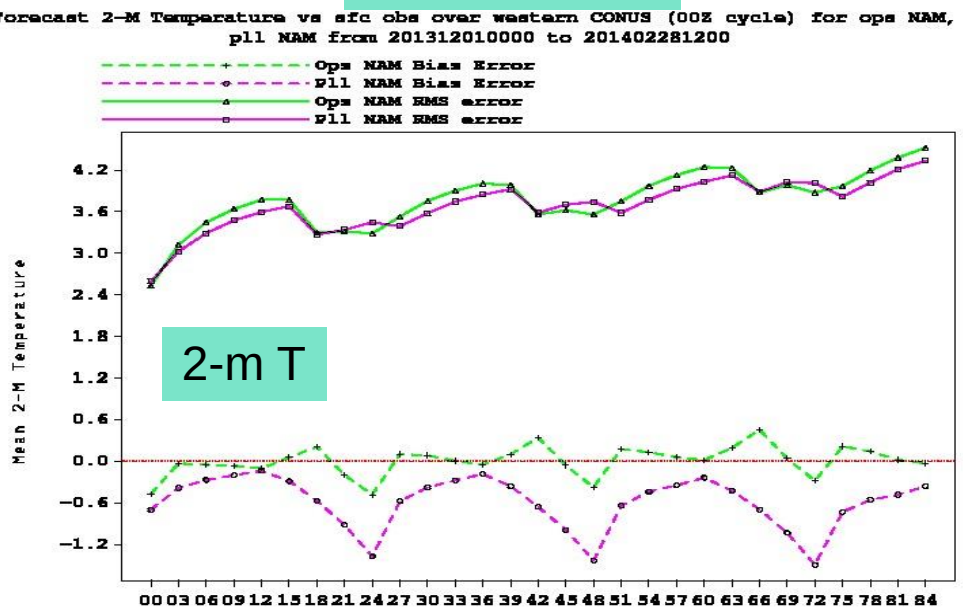


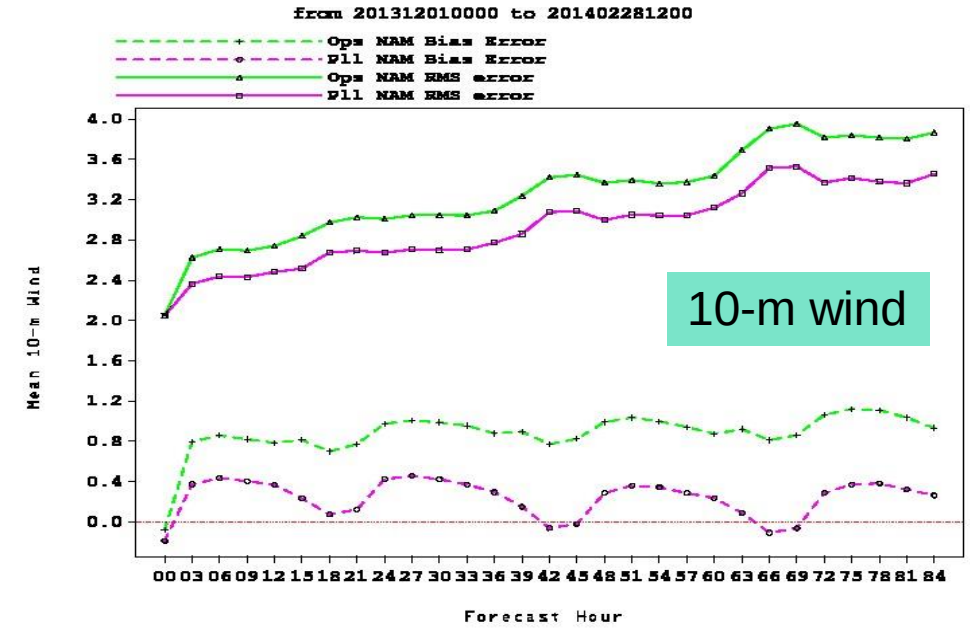
Surface fields : RMS/bias error over CONUS: 12/1/13 – 2/28/14, 00z cycles; Green=ops, Magenta=pll

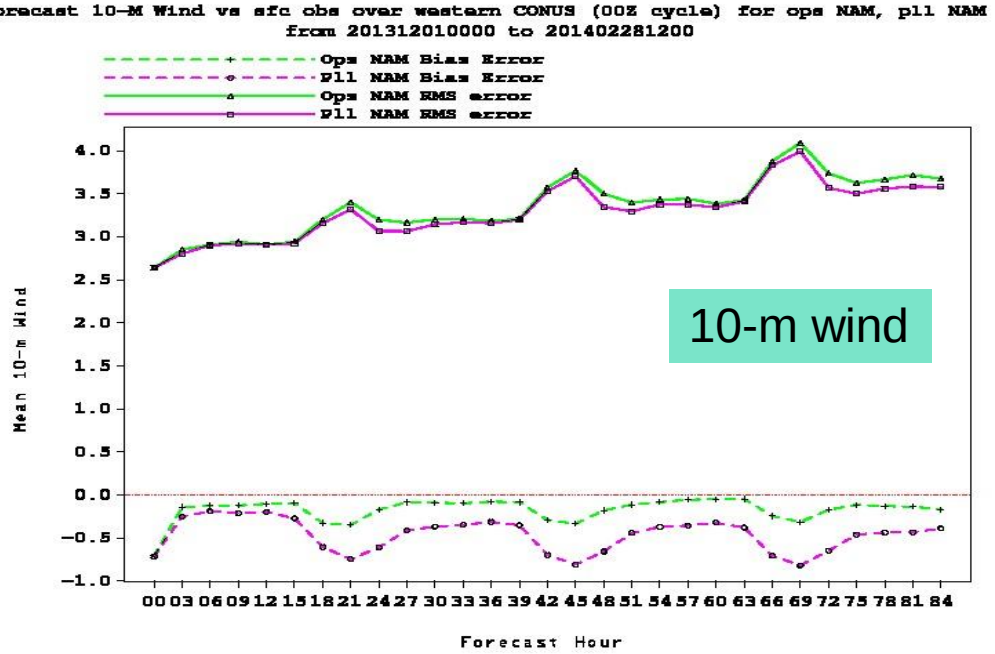
East CONUS



West CONUS

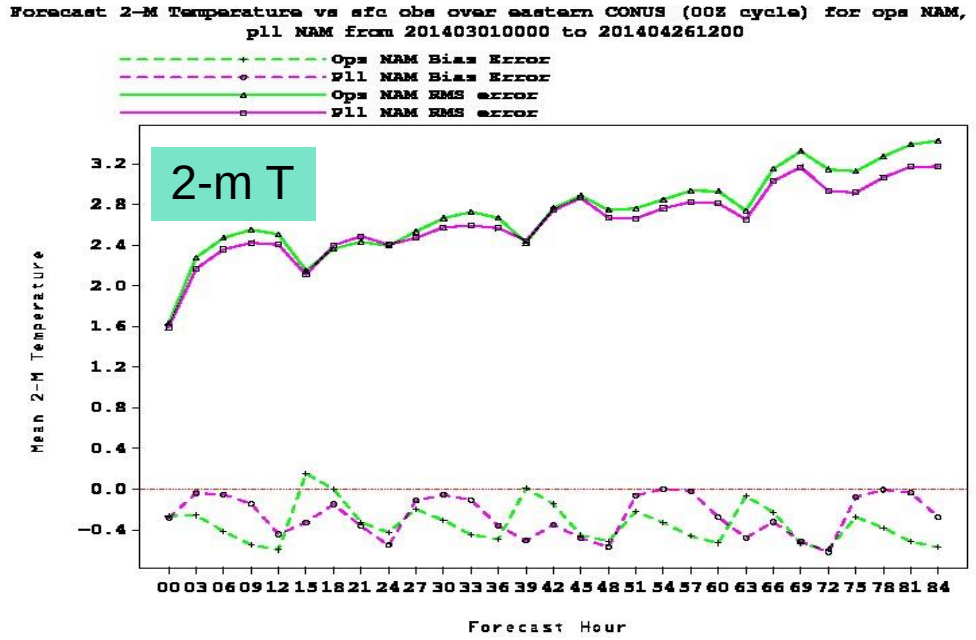




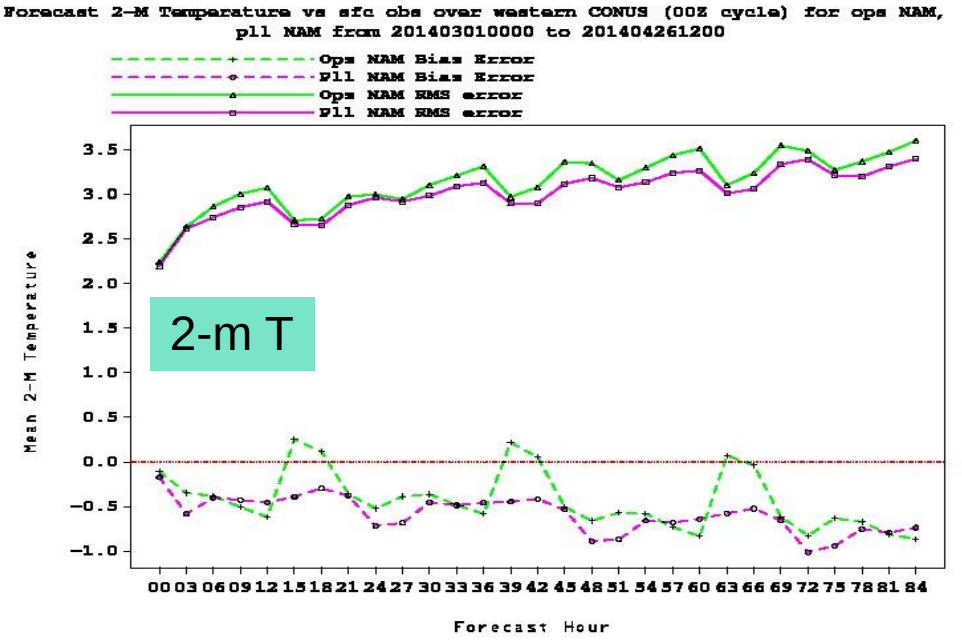


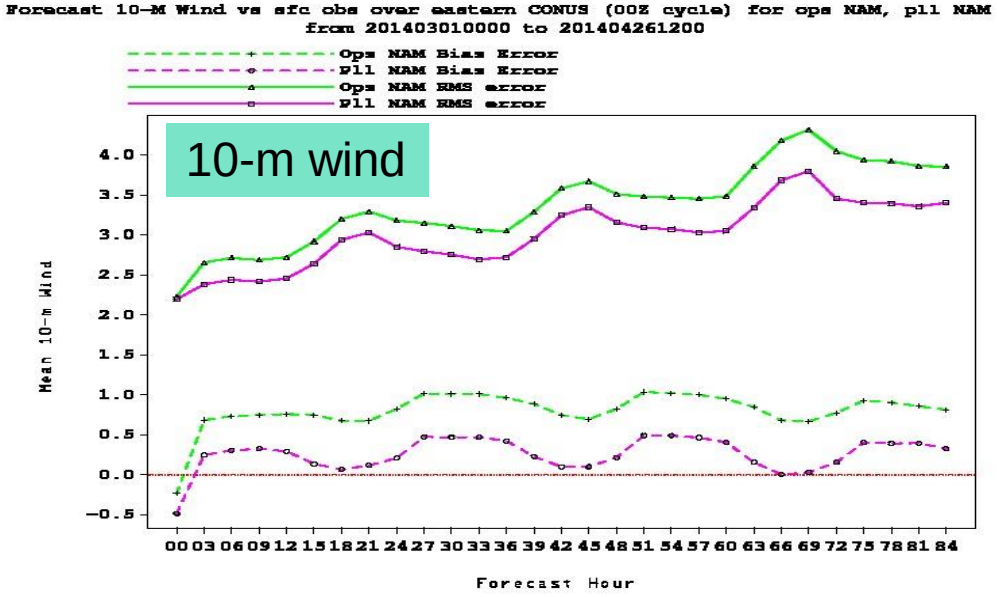
Surface fields : RMS/bias error over CONUS: 3/1/14-4/26/14, 00z cycles; Green=ops, Magenta=pll

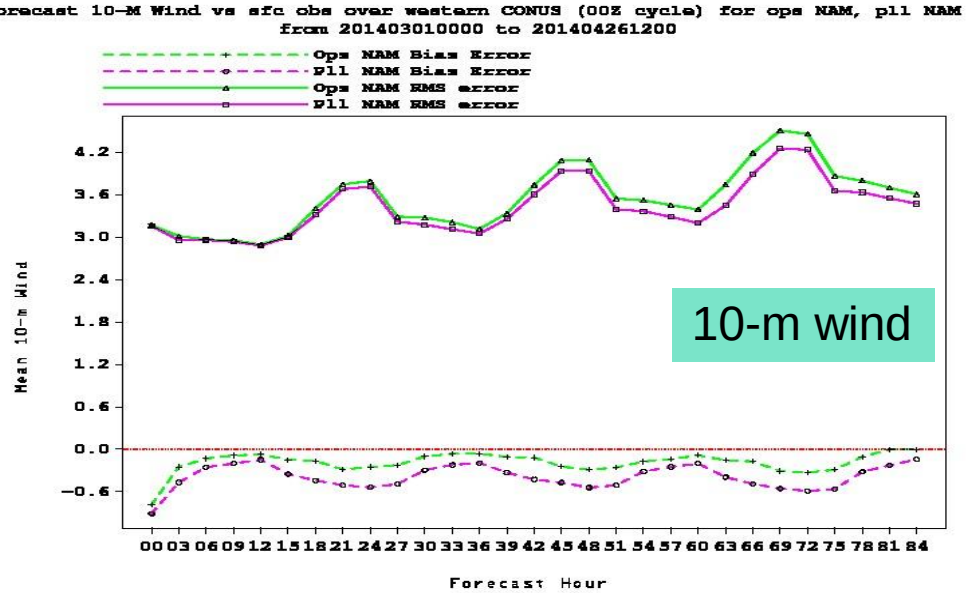
East CONUS



West CONUS

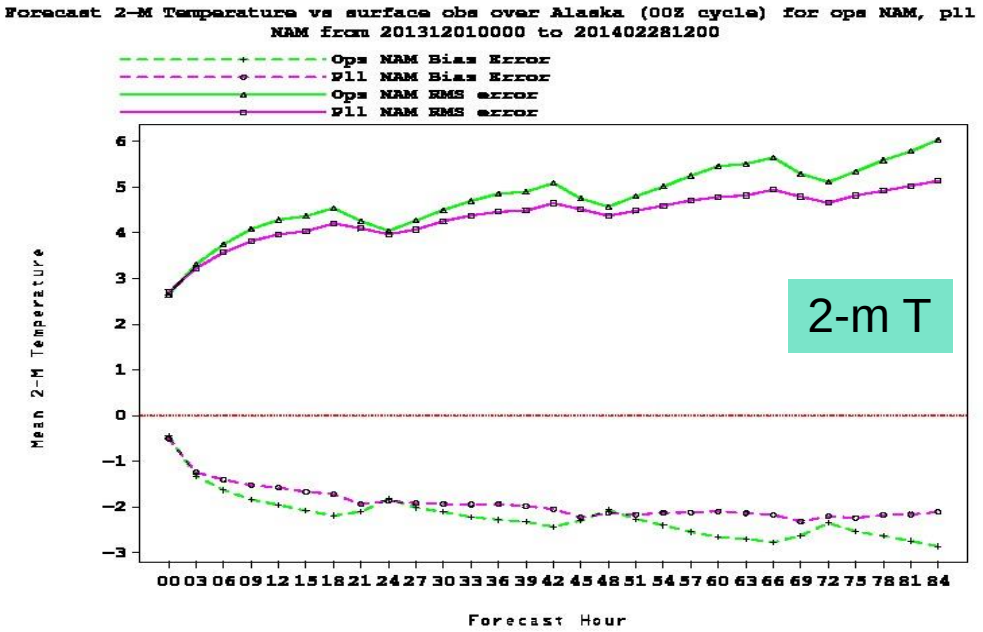


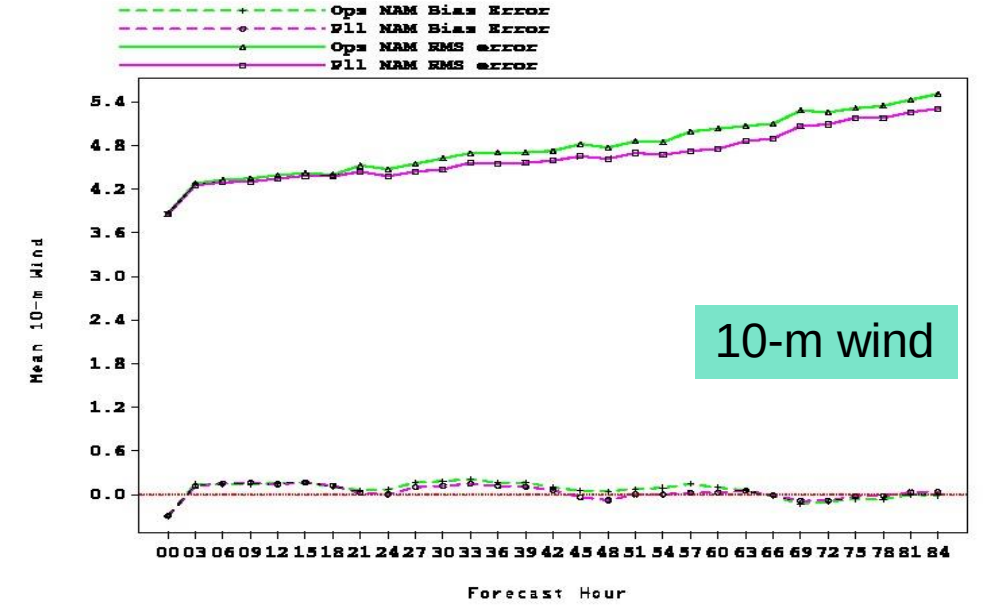




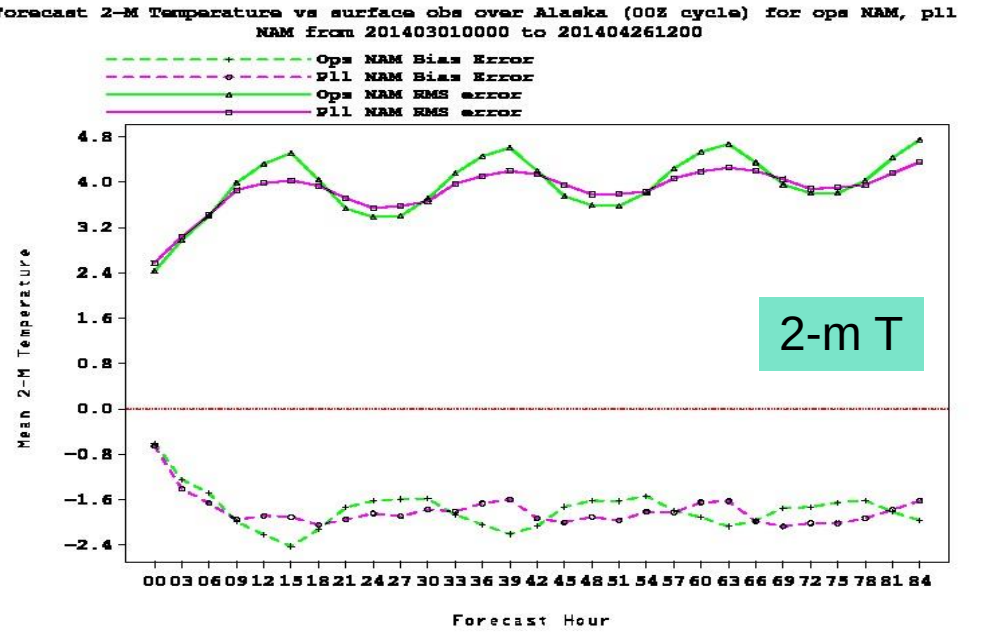
Surface fields : RMS/bias error over Alaska: All 00z cycles, Green=ops, magenta=pll

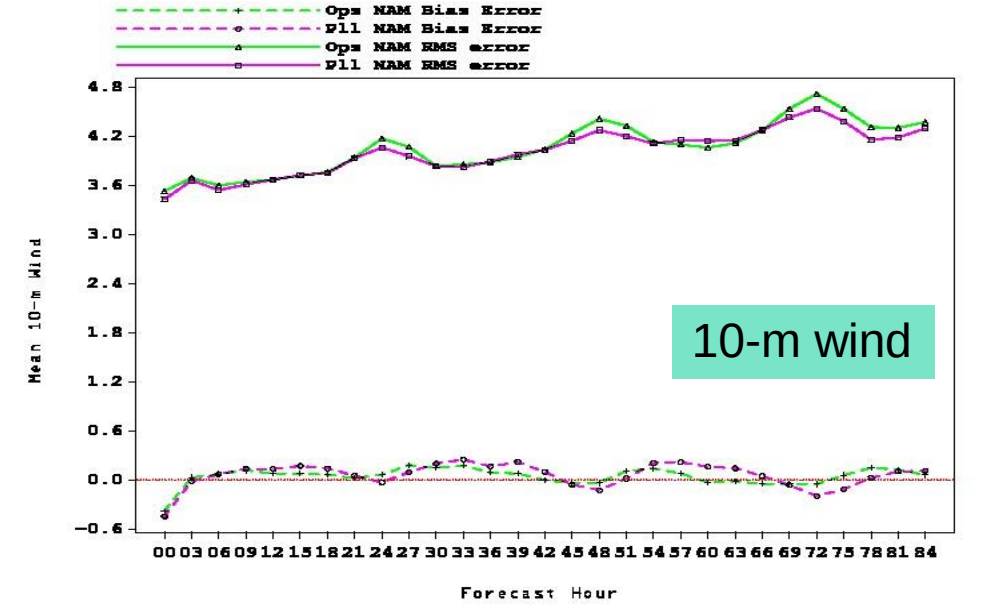
12/1/13-2/28/14



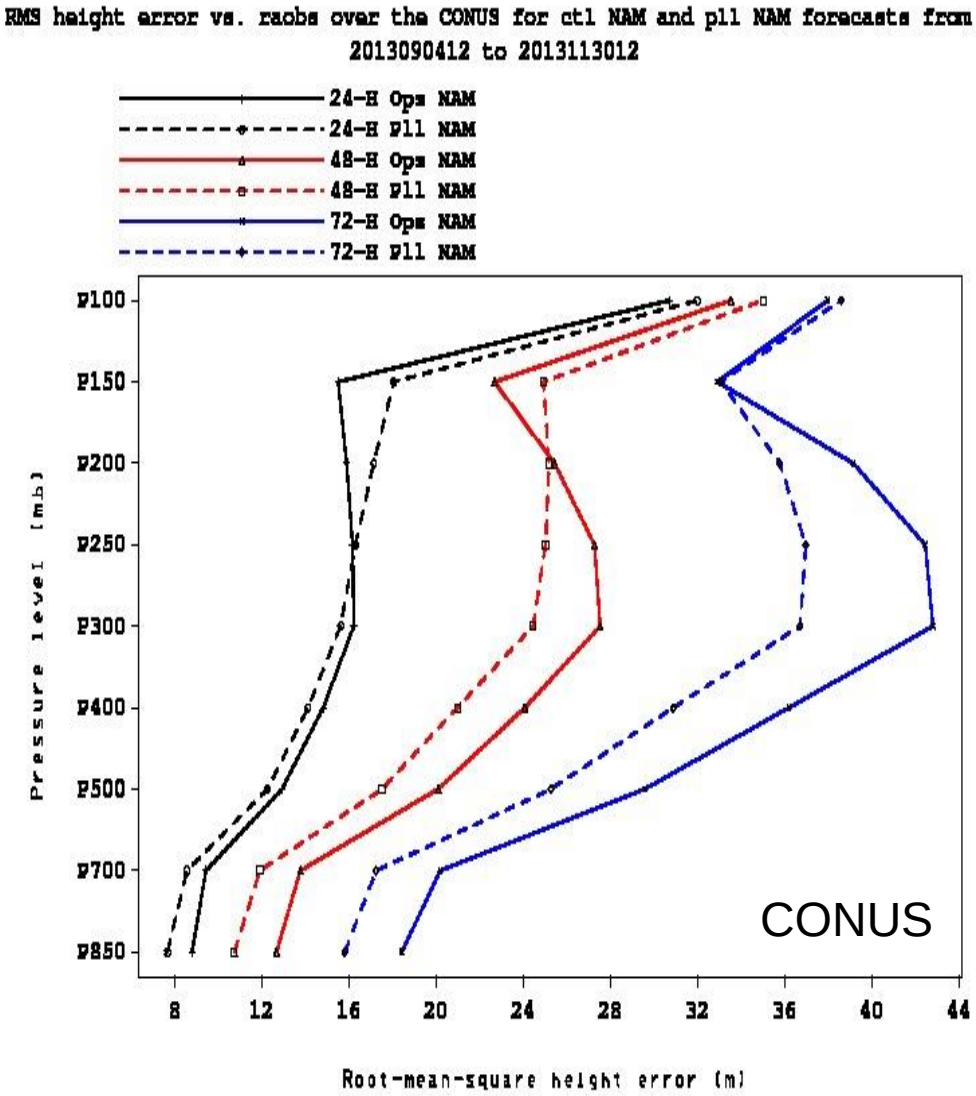


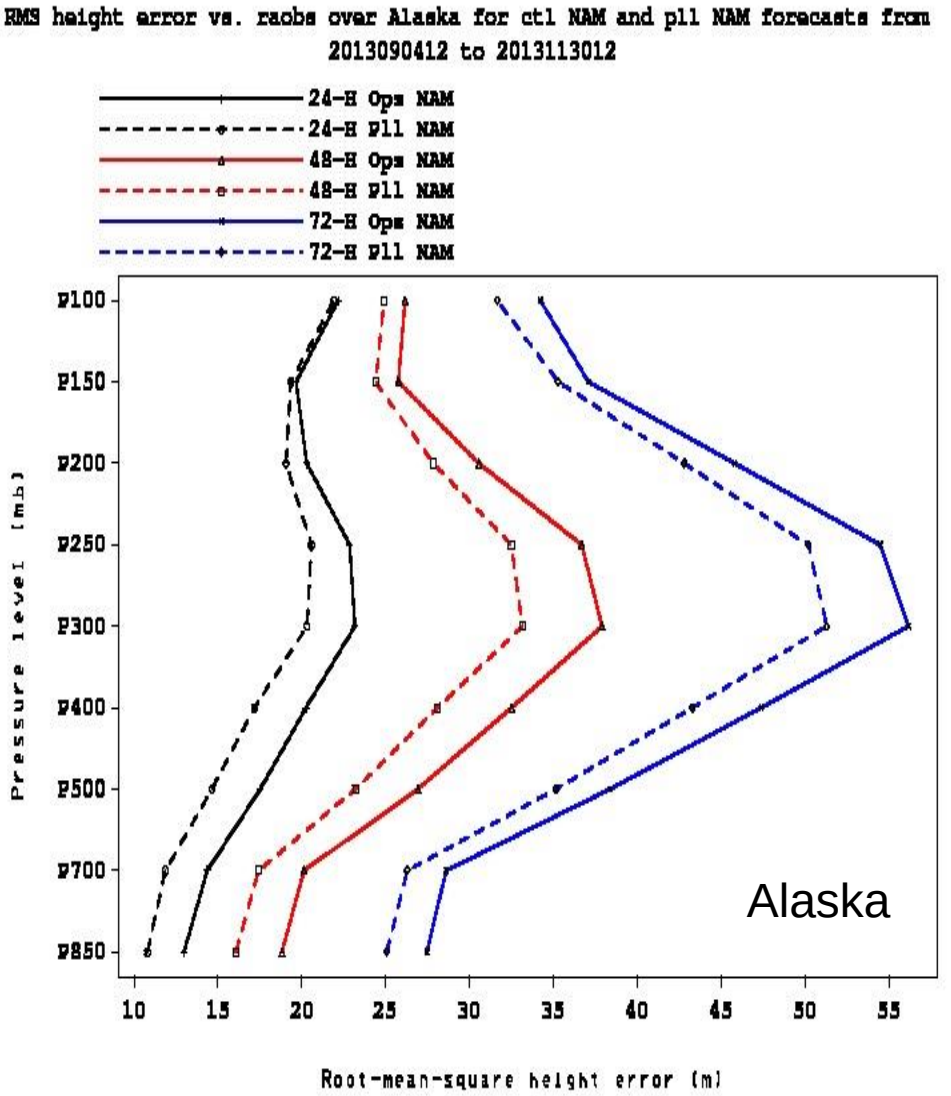
3/1/14-4/26/14





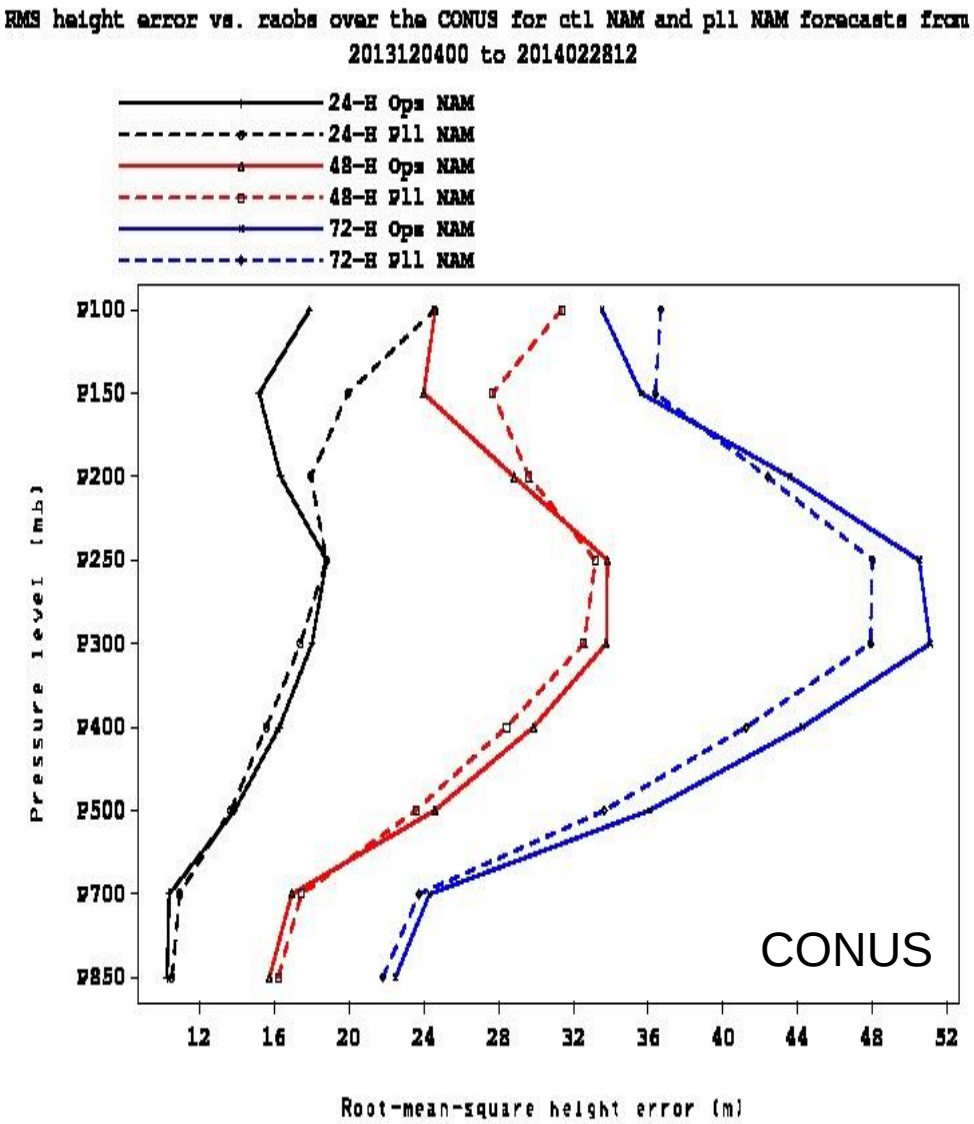
Ops NAM (solid) vs Pll NAM (dashed) : Day 1 (black), Day 2 (red), Day 3 (blue) RMS Height Error over CONUS/Alaska

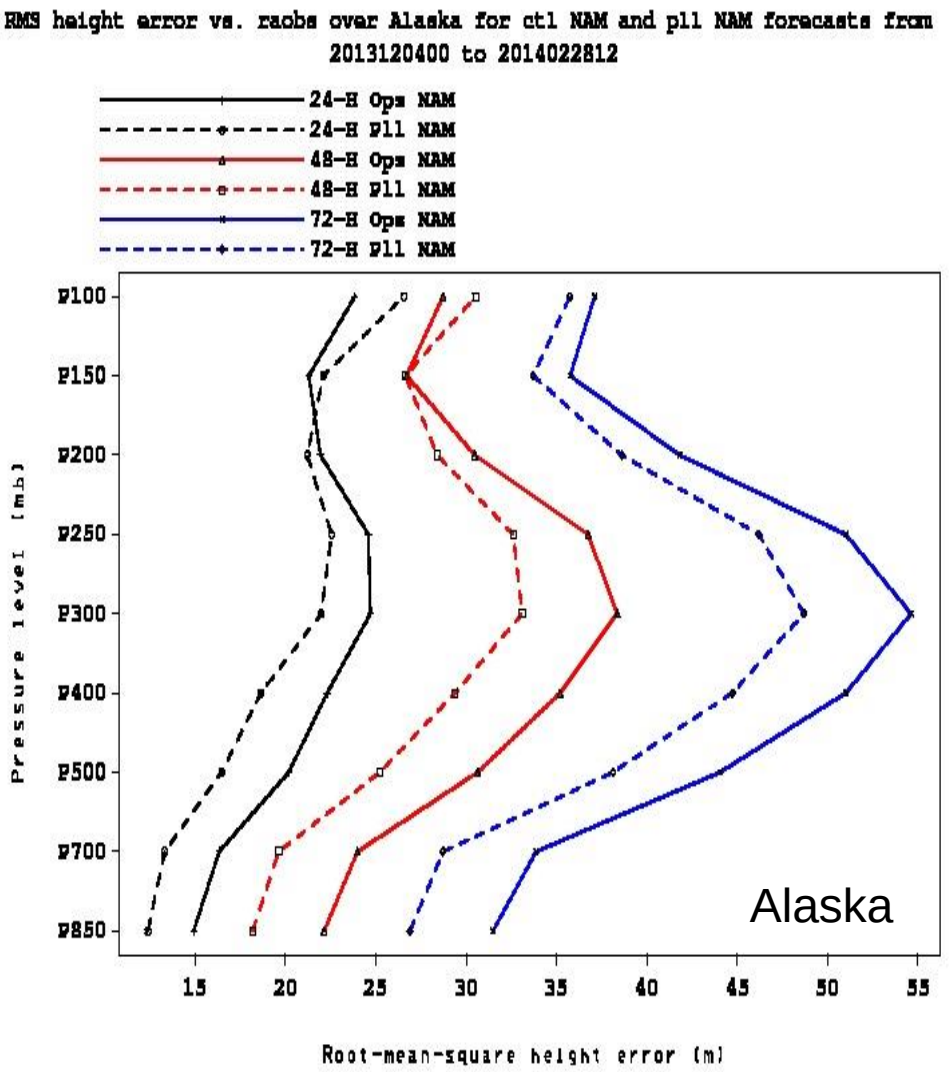




1 September – 30 November 2013

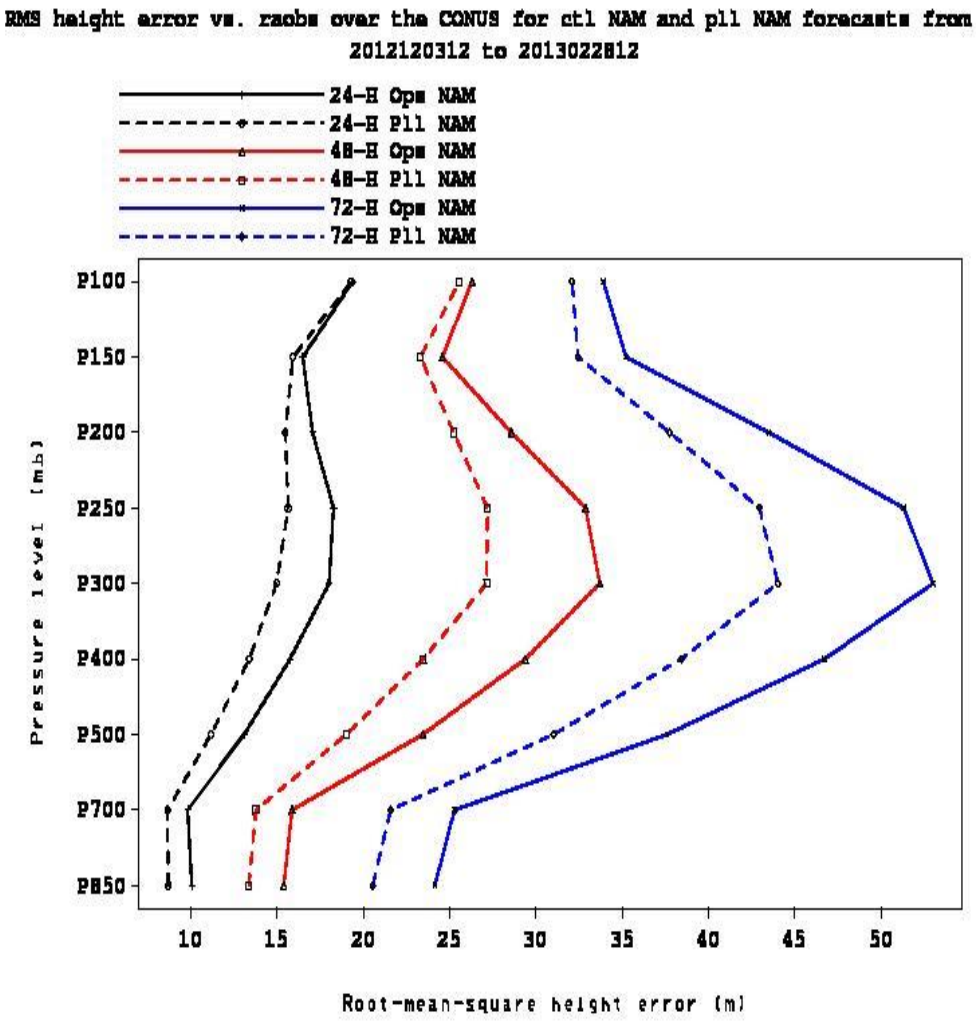
Ops NAM (solid) vs Pll NAM (dashed) : Day 1 (black), Day 2 (red), Day 3 (blue) RMS Height Error over CONUS/Alaska

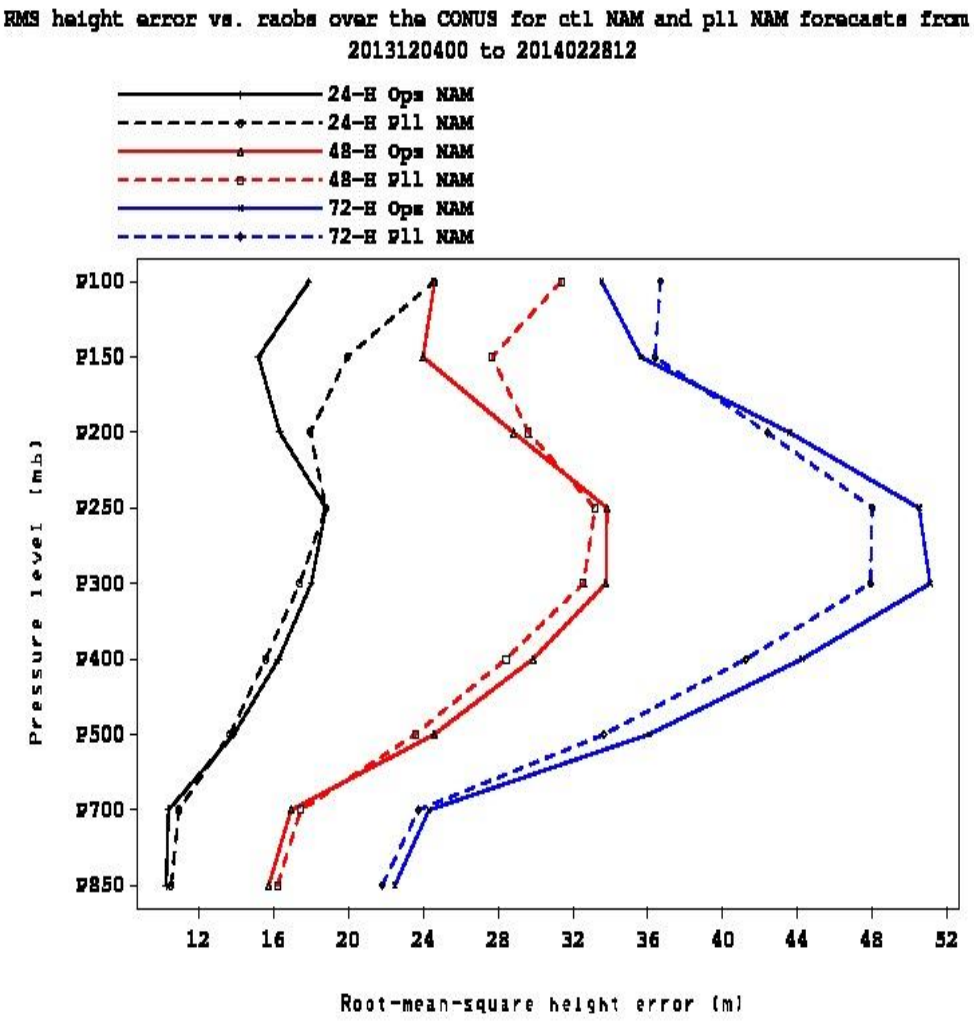




1 December 2013 – 28 February 2014

Ops NAM (solid) vs Pll NAM (dashed) : Day 1 (black), Day 2 (red), Day 3 (blue) RMS Height Error over CONUS

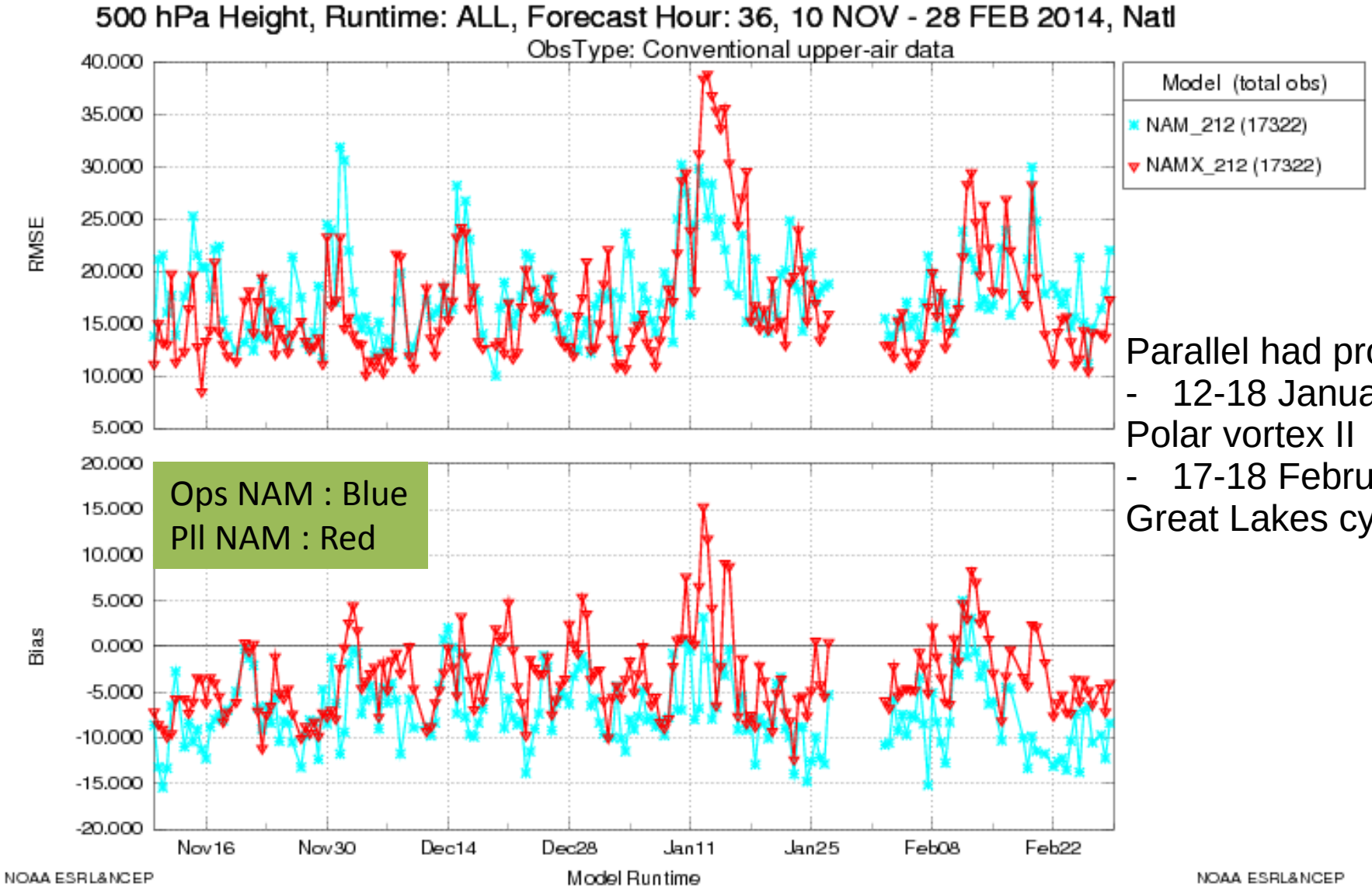




1 December 2012 – 28 February 2013

1 December 2013 – 28 February 2014

Quantitative assessment of synoptic performance : Day 1.5 500 mb height RMS error vs raobs over CONUS/Southern Canada/Mexico ; 10 Nov 13 – 28 Feb 14

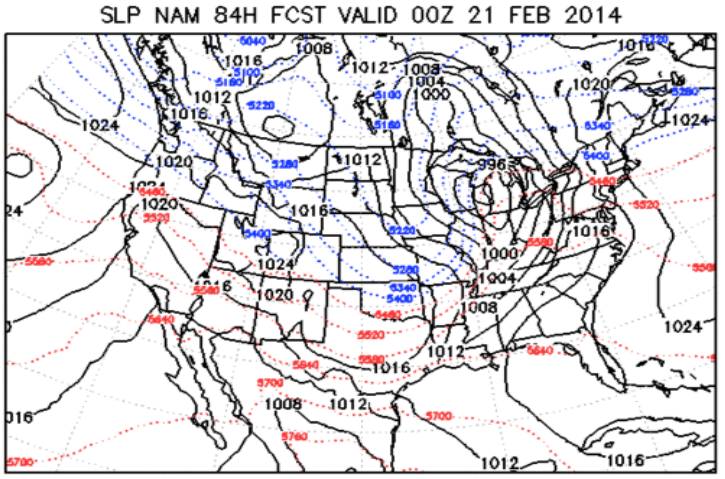


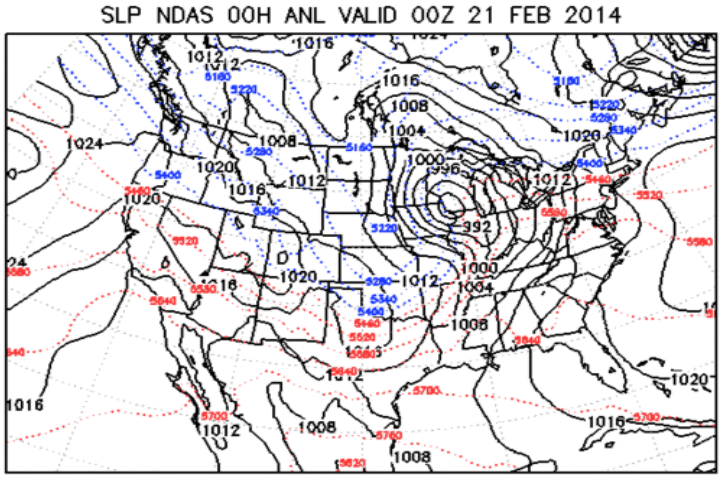
Parallel had problems
- 12-18 January for Polar vortex II
- 17-18 February Great Lakes cyclone

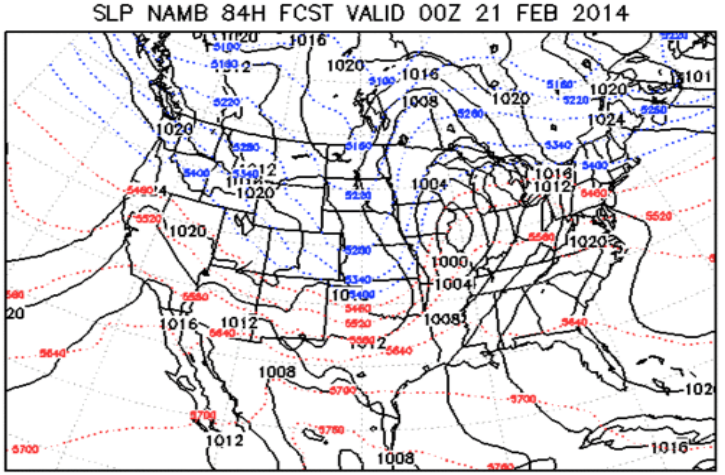
Parallel NAM had two major synoptic issues during this winter:

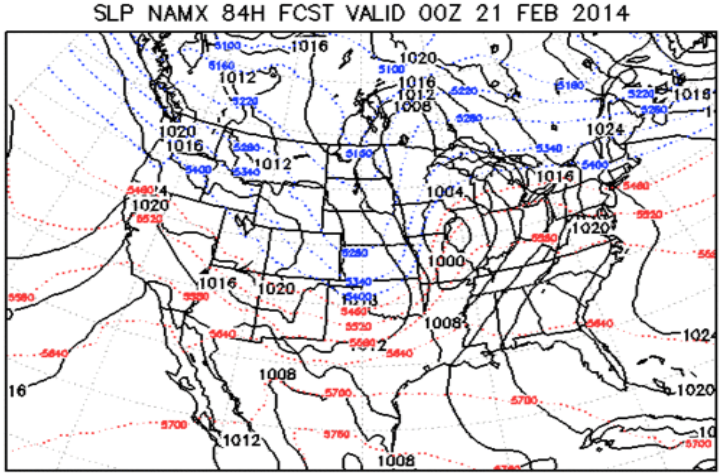
- 12-18 January : Polar Vortex II
- 17-18 February : Great Lakes cyclone
- Retrospective testing revealed that a gravity wave parameter ("cleffamp") was set too high last fall (and was functionally higher than it was during the winter of 2012-13)
- Setting this parameter back the value used in the ops NAM greatly improved the parallel for the two problem cases and had better mid-upper tropospheric skill scores in the real-time parallels

NAM 84-h SLP fcsts, NDAS analysis valid 00z 2/21

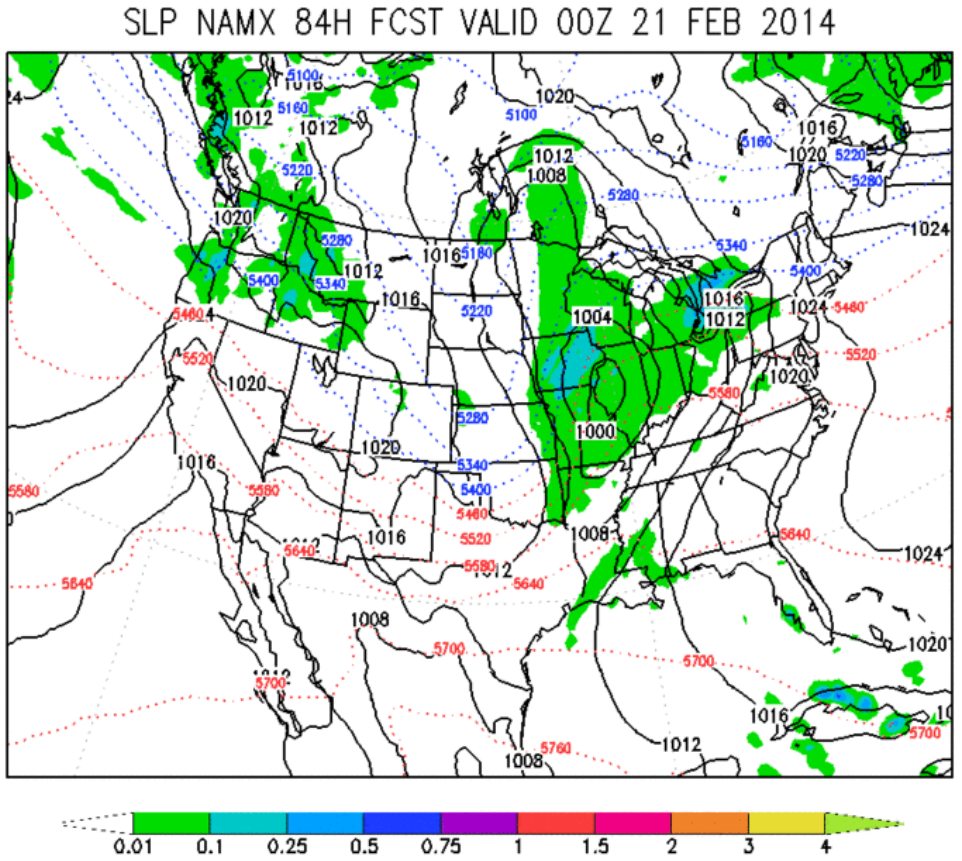


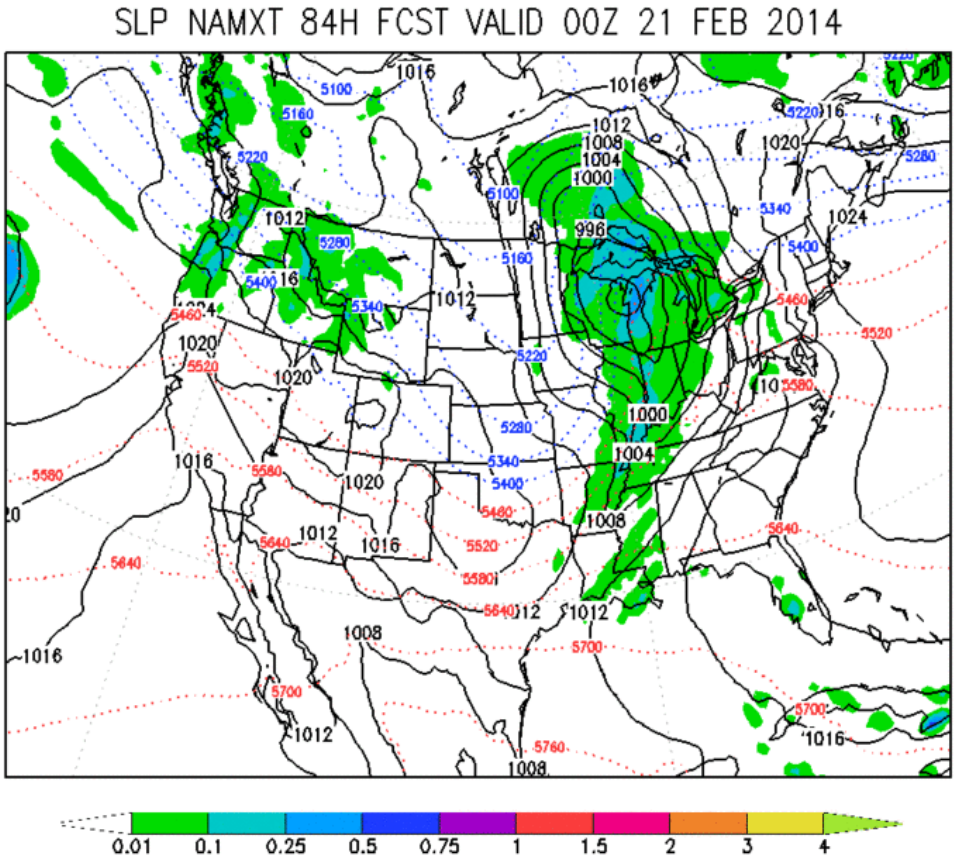




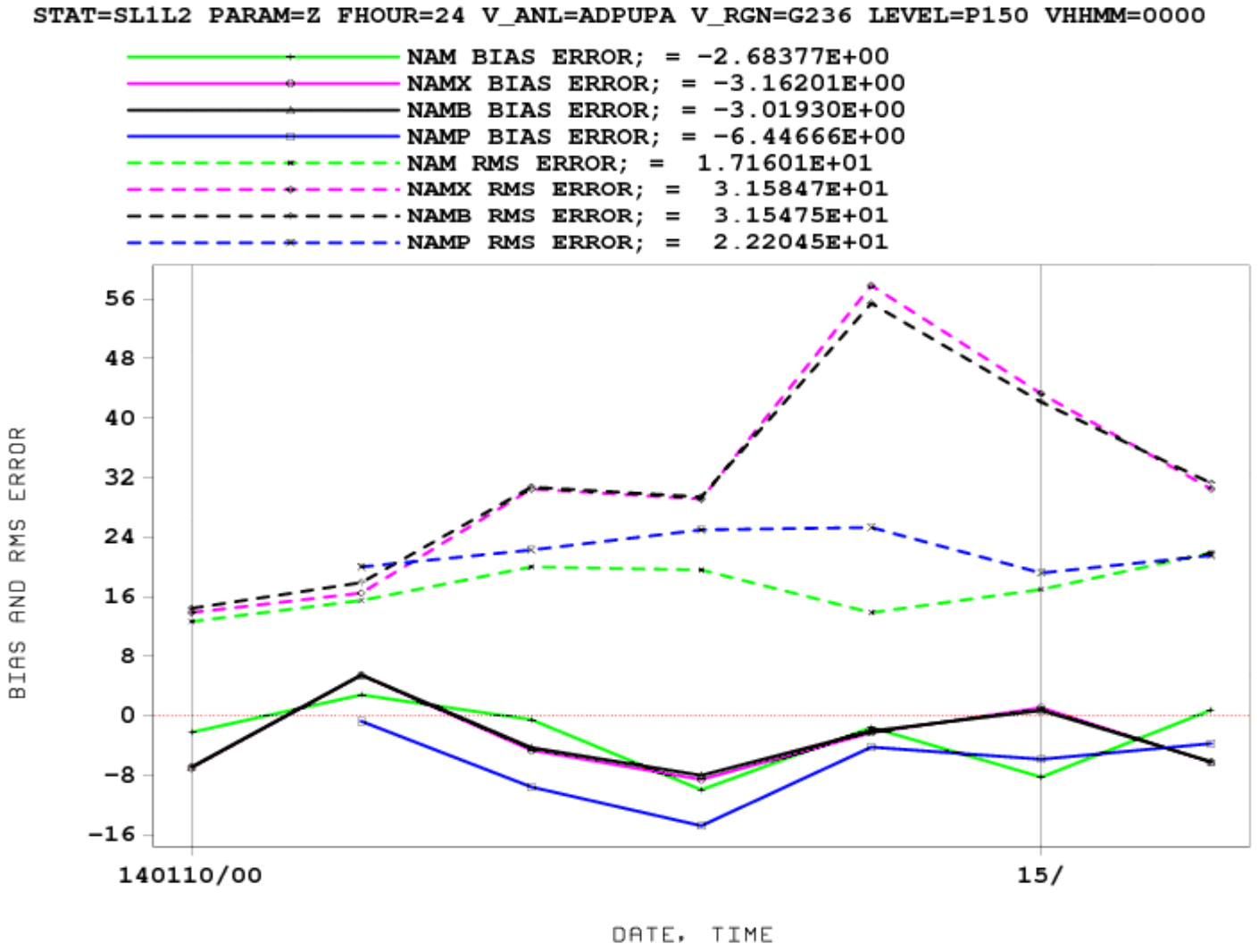


NAMX vs NAMX test with GWD change



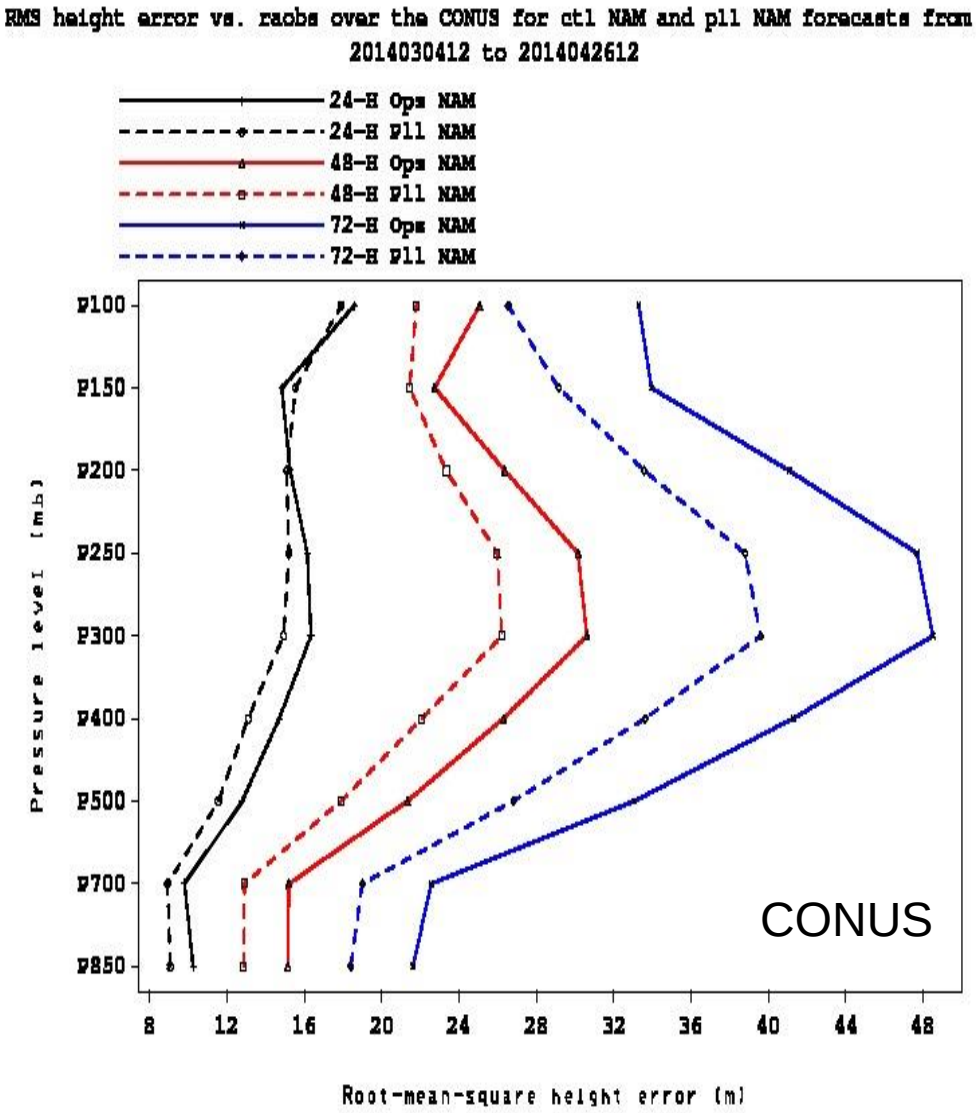


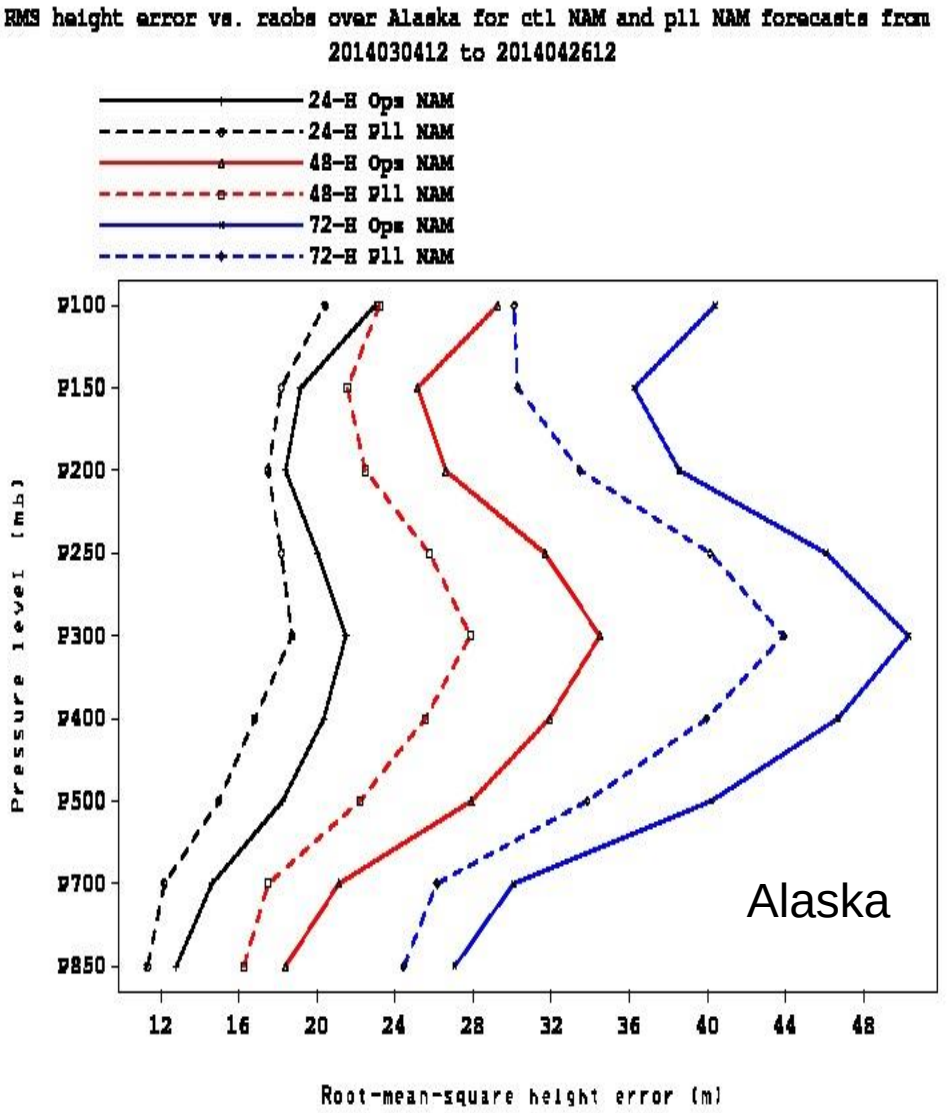
10-16 January 2014 150 mb Height RMS/bias: Parallel NAM w/GWD change (blue lines in plot)



Link to Graphics for test of GWD fix for 12z 13 January 2014

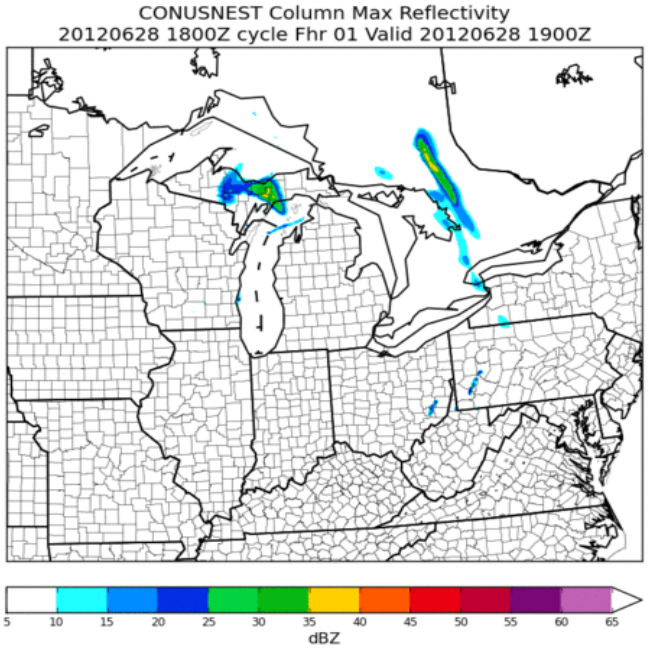
Ops NAM (solid) vs Pll NAM (dashed) : Day 1 (black), Day 2 (red), Day 3 (blue) RMS Height Error over CONUS/Alaska

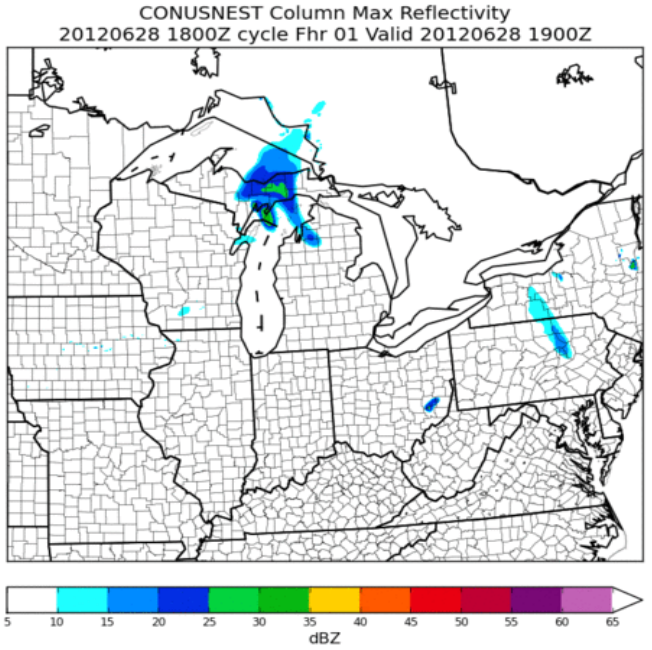


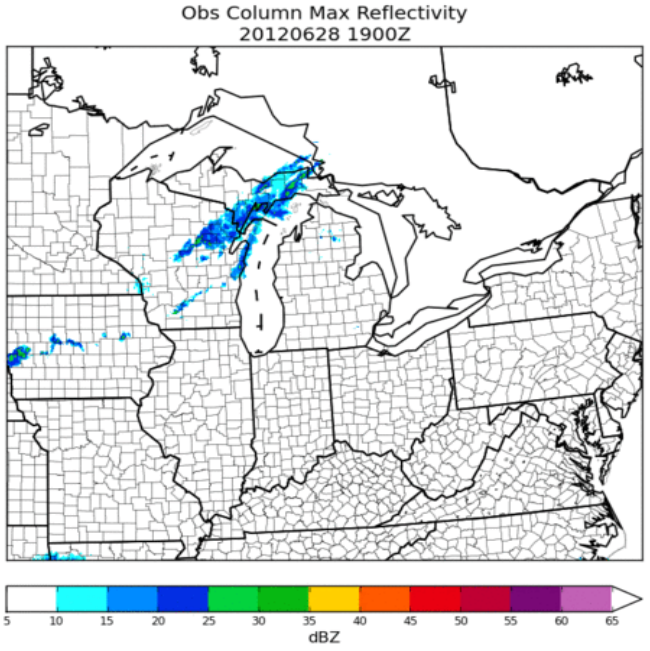


1 March 2014 – 26 April 2014

CONUS 4km rerun for DC Derecho: 18z 6/28/2012 cycle







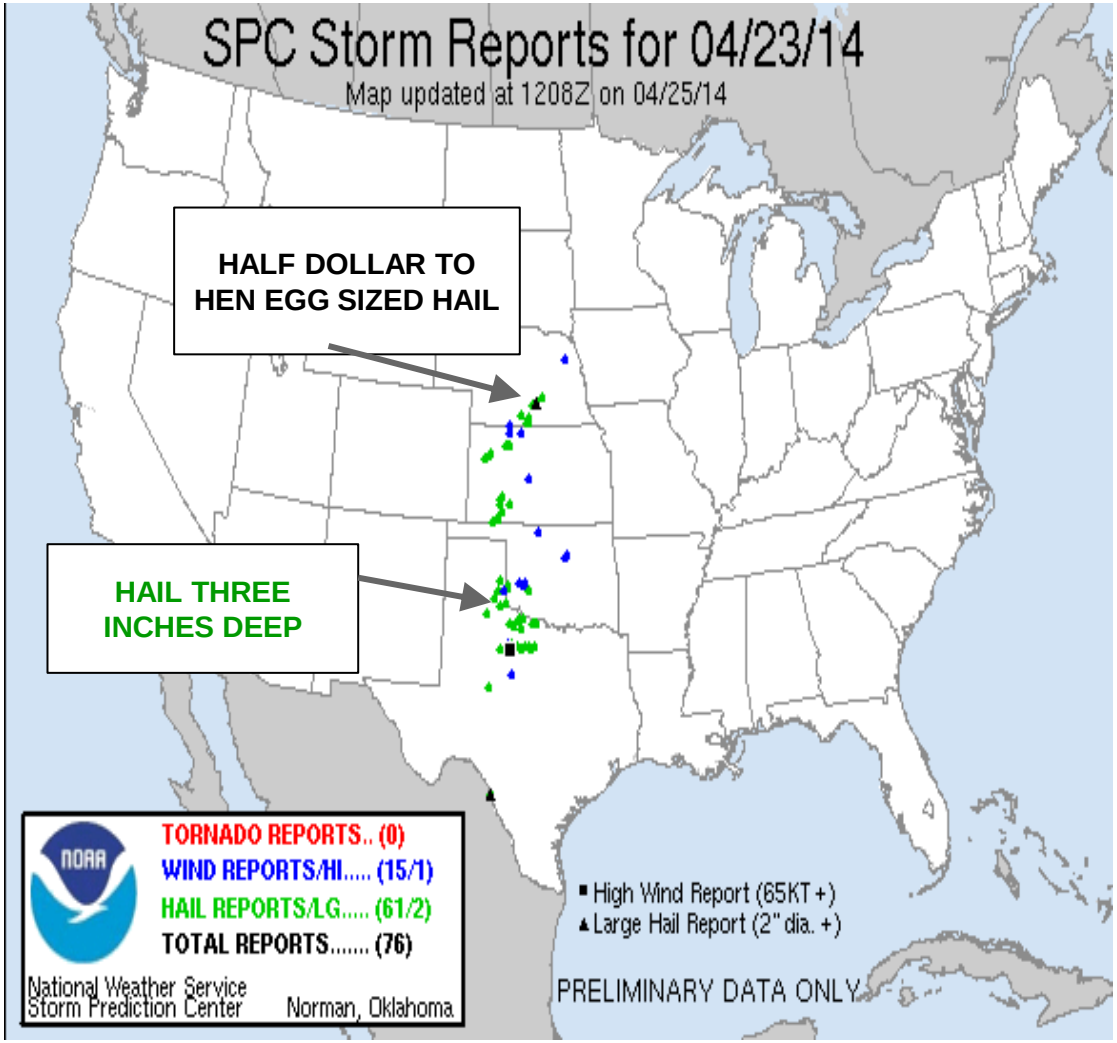
- **Top left : Parallel CONUS 4 km column max reflectivity**
- **Top right : Ops CONUS 4 km column max reflectivity**
- **Bottom left : Observed column max reflectivity**

Parallel vs Operational NAM CONUS 4 km Nest

23-24 April 2014 Severe Weather

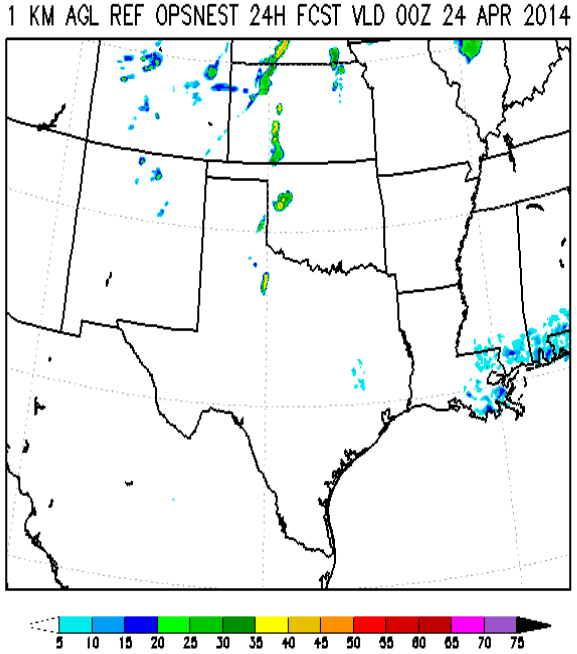
Eric Aligo and Brad Ferrier

Storm Reports

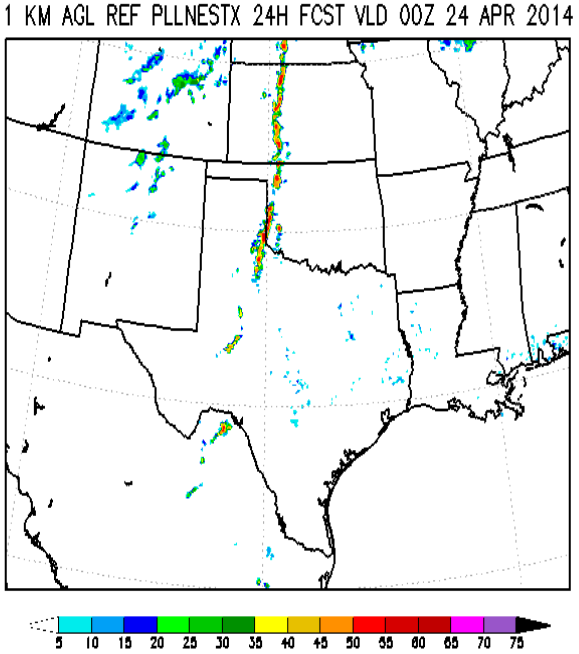


1 km AGL Reflectivity

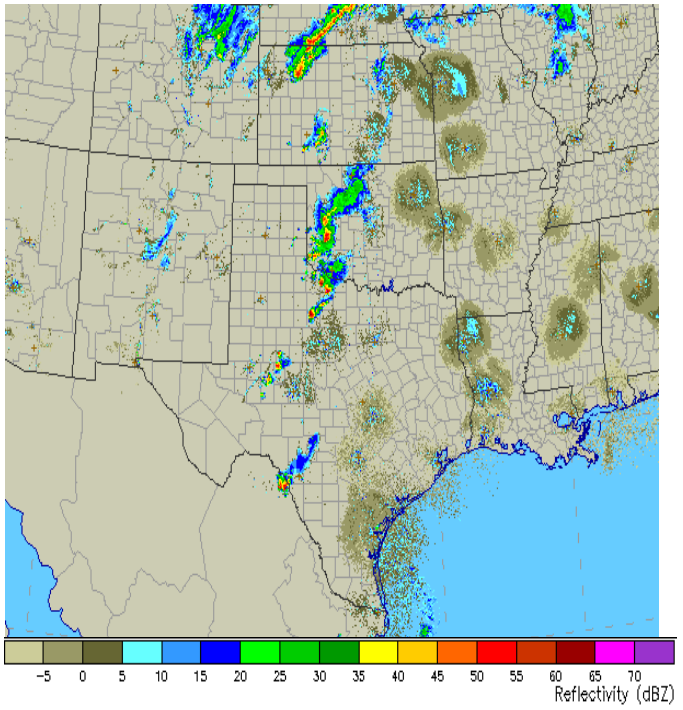
Operational Nest



Parallel Nest



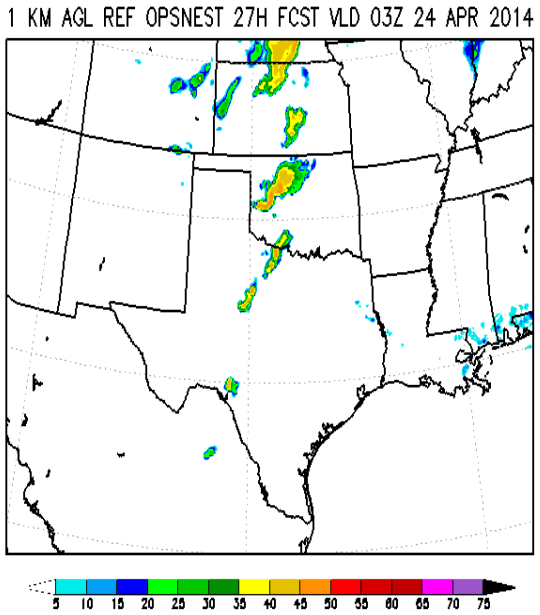
0.5 deg Reflectivity



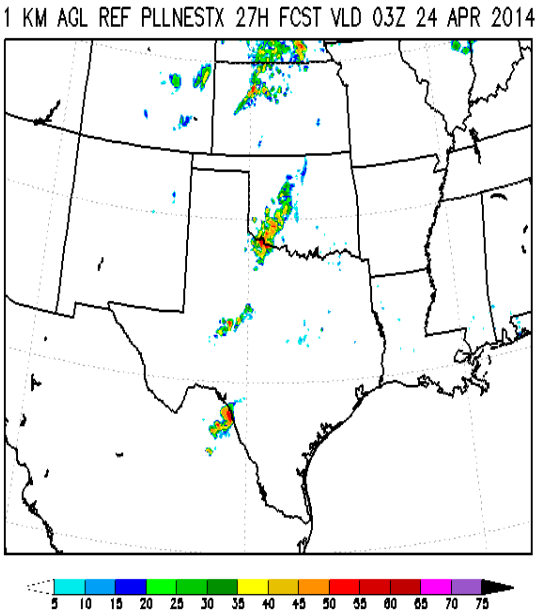
24-h (00 UTC 24 April 2014)

1 km AGL Reflectivity

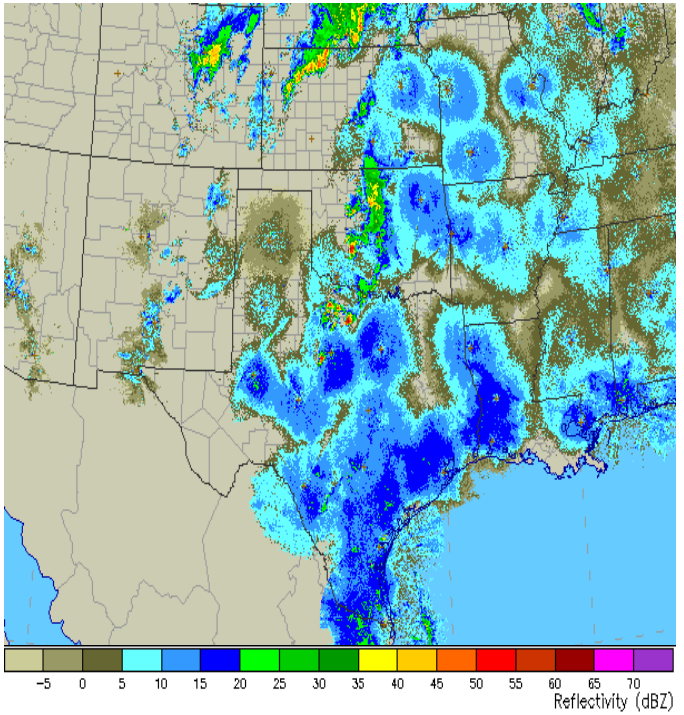
Operational Nest



Parallel Nest



0.5 deg Reflectivity

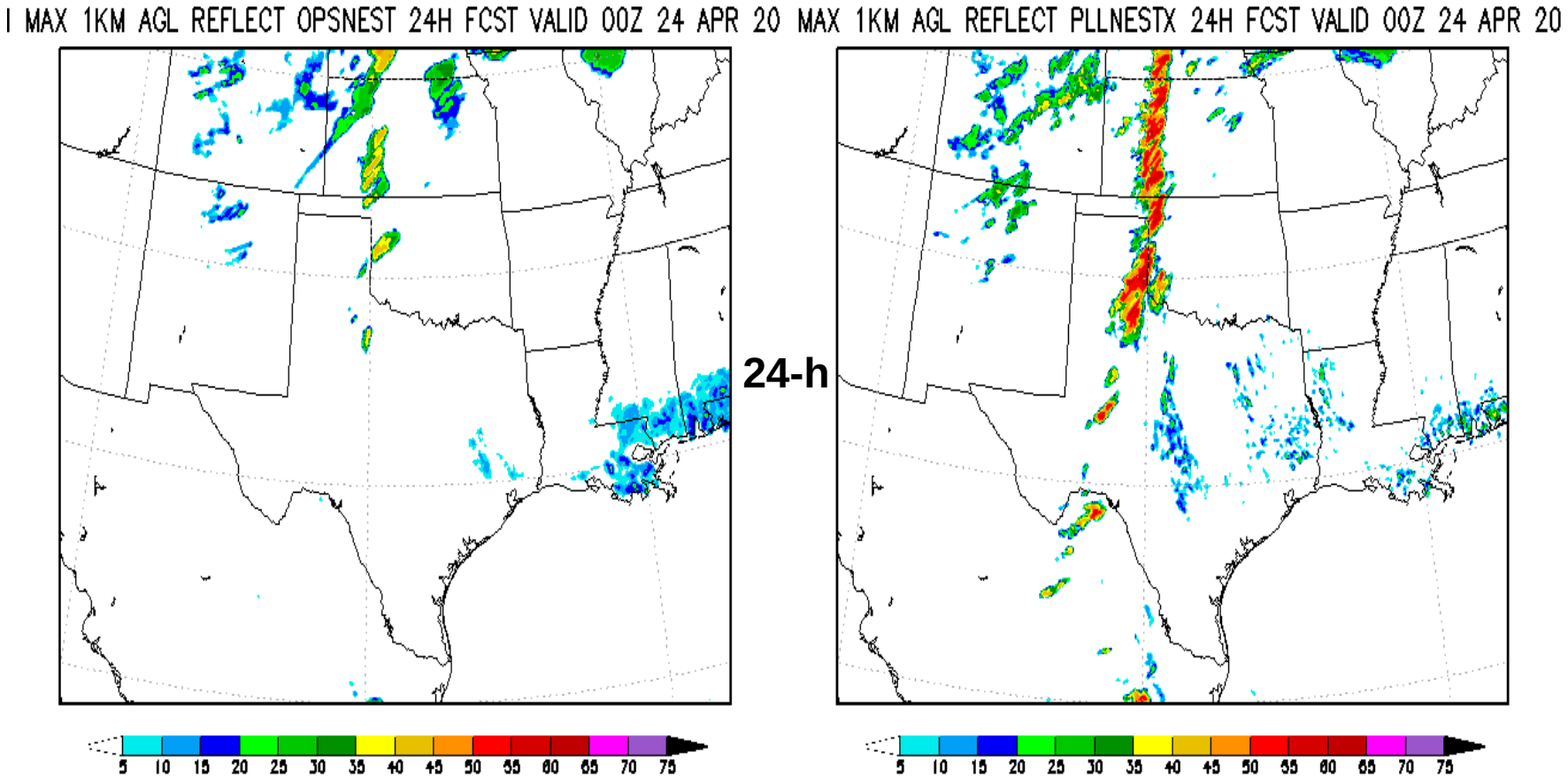


27-h (03 UTC 24 April 2014)

Max hourly 1 km AGL Reflectivity

Operational Nest

Parallel Nest



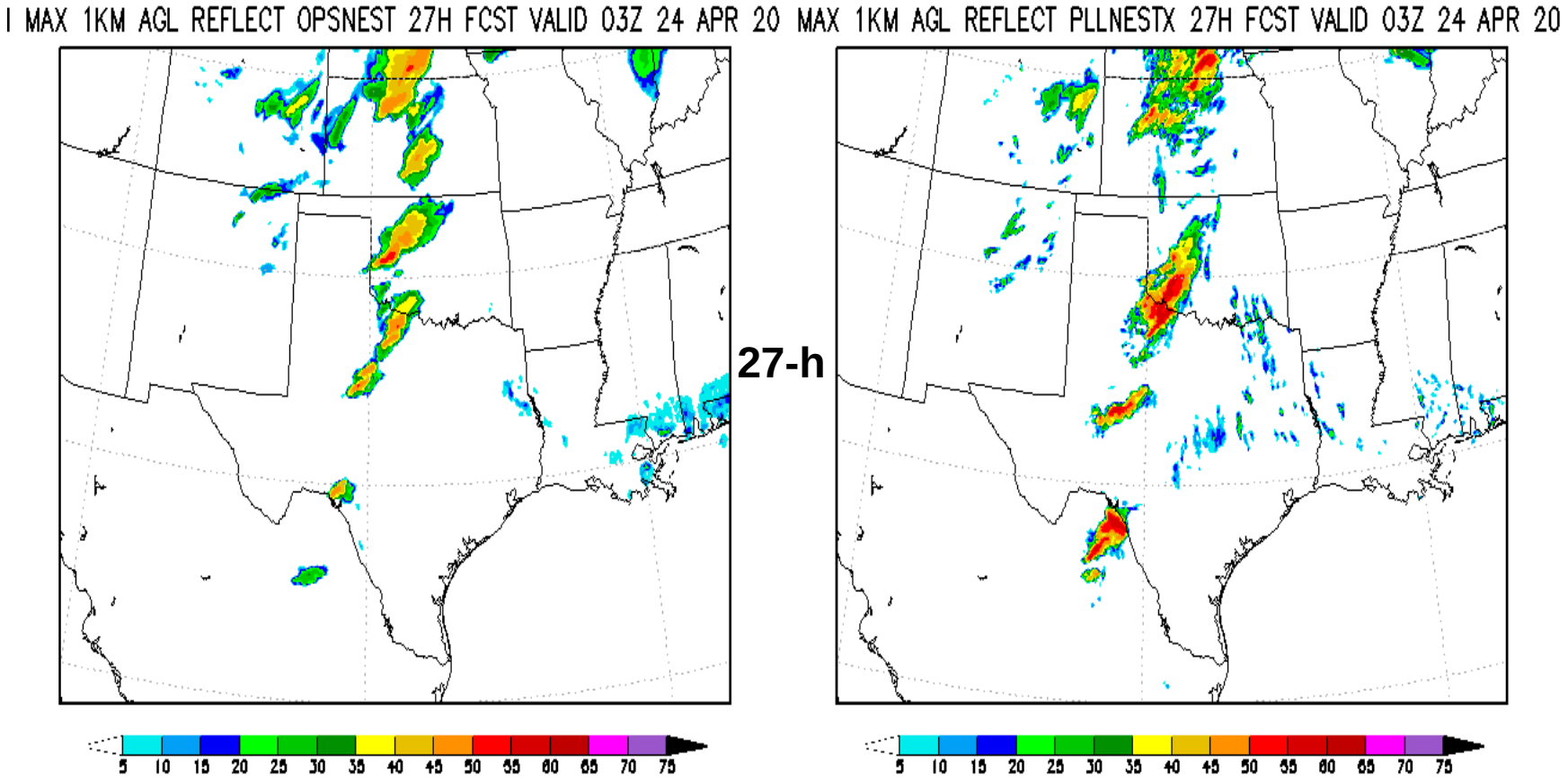
24-h

24-h (00 UTC 24 April 2014)

Max hourly 1 km AGL Reflectivity

Operational Nest

Parallel Nest

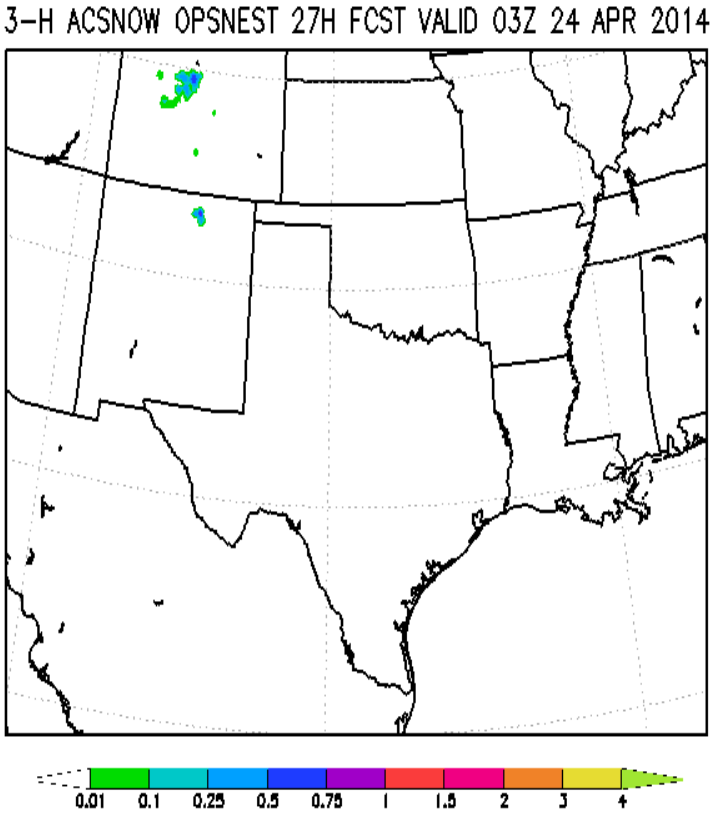


27-h

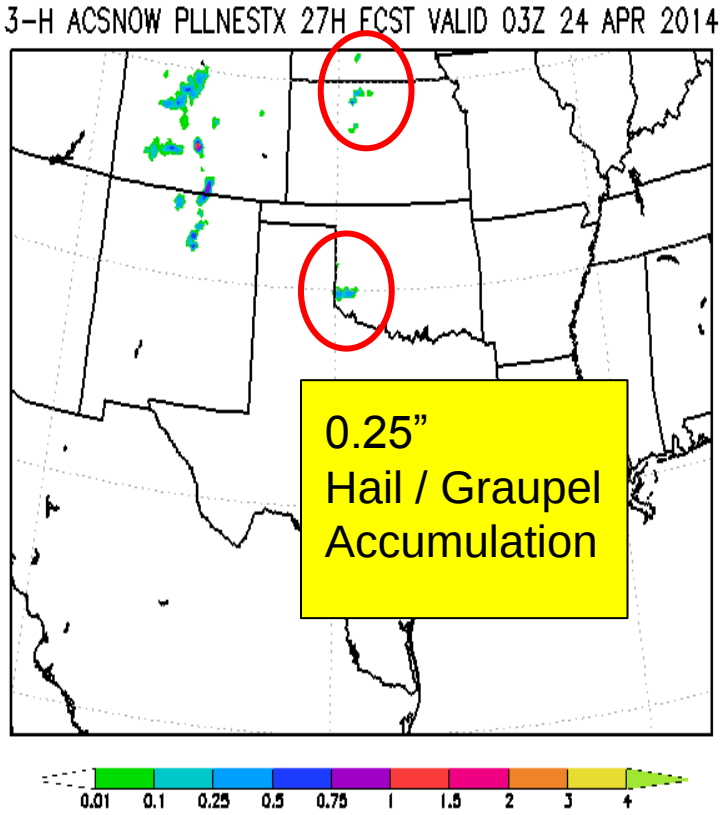
27-h (03 UTC 24 April 2014)

03-h “Snow” (Total Ice) Accumulation

Operational Nest



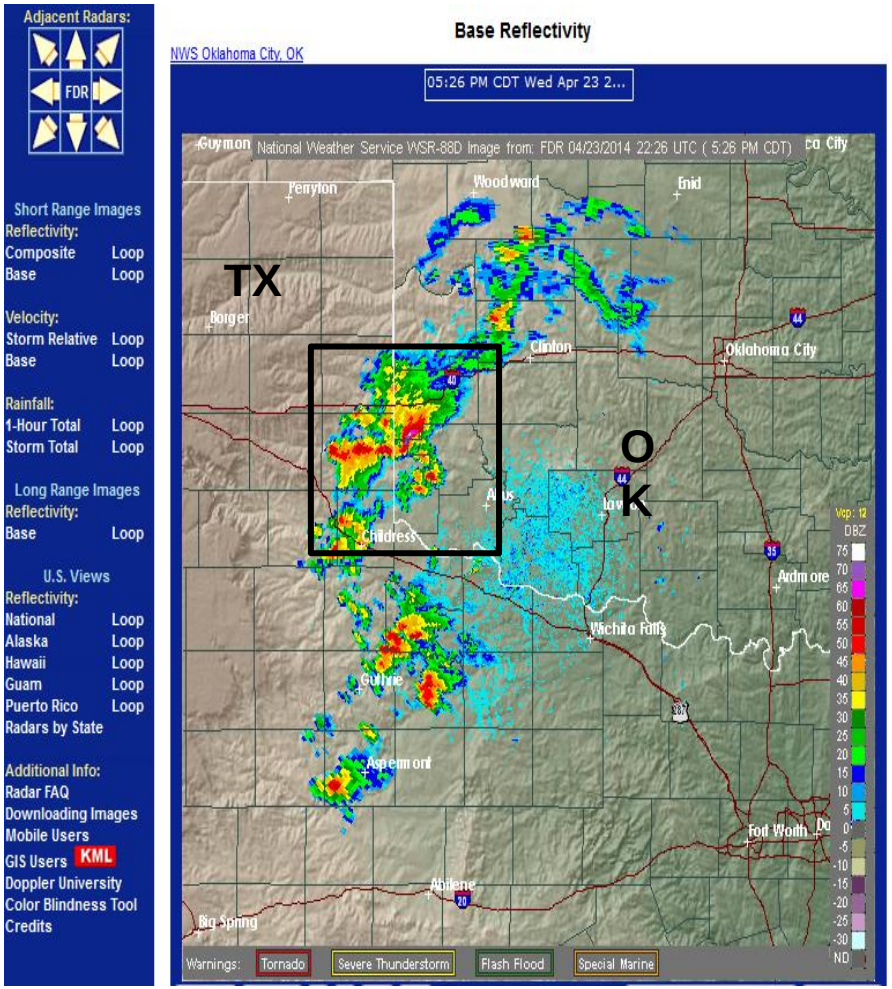
Parallel Nest



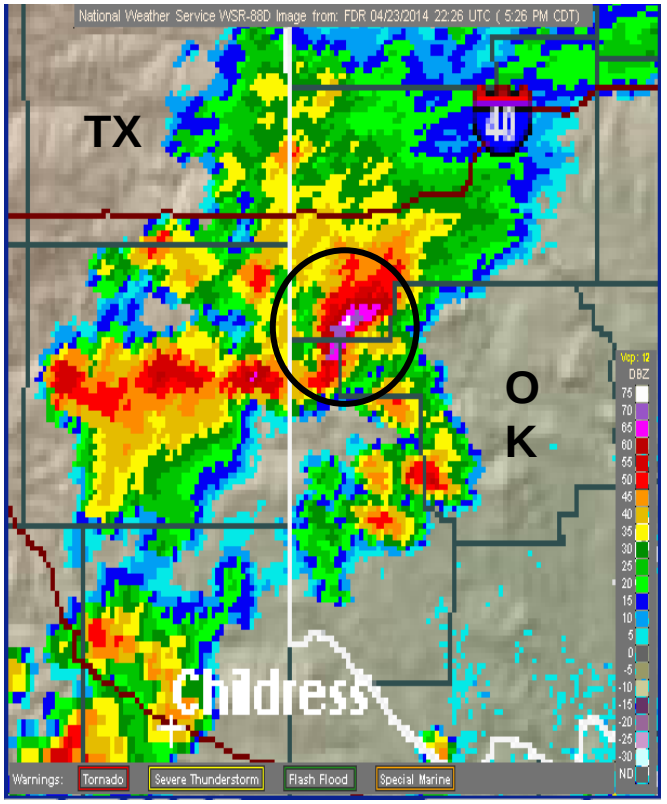
27-h (03 UTC 24 April 2014)

Base Reflectivity

22:26 UTC / 23



Zoomed In

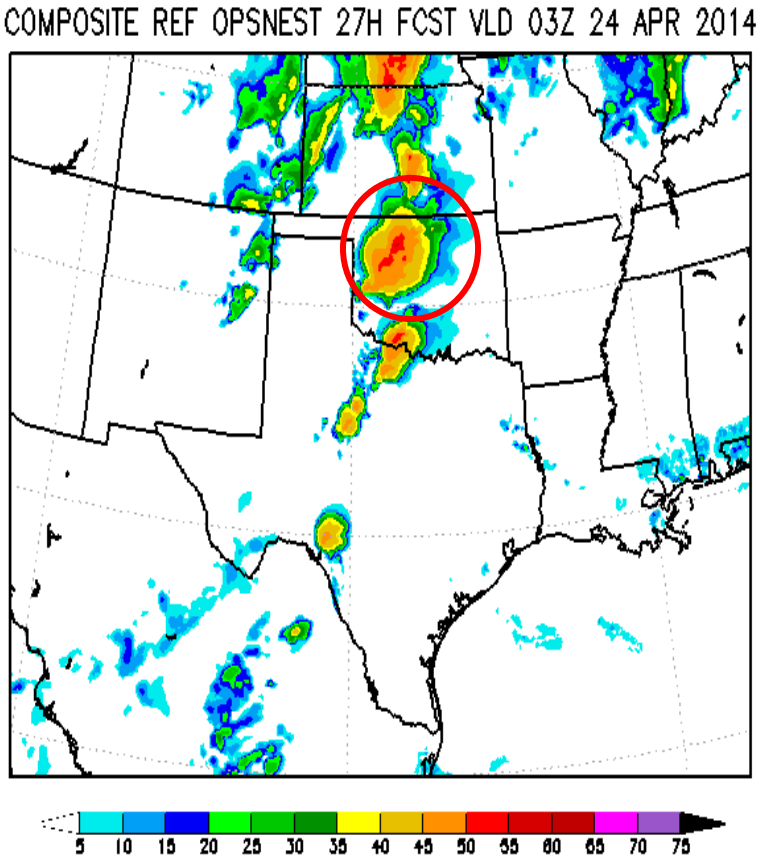


75 dBZ

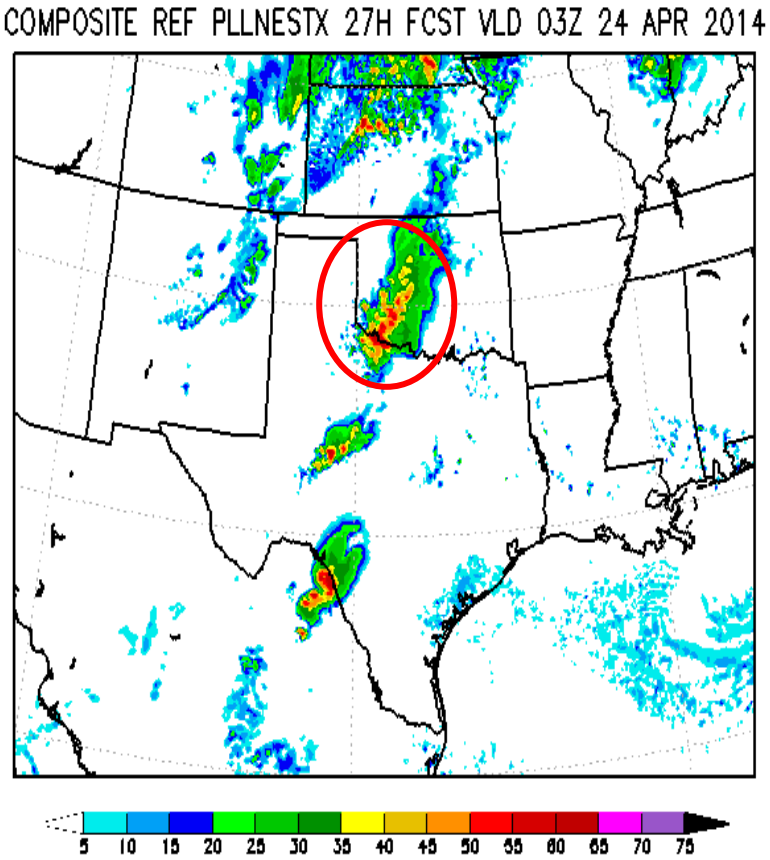
Composite Reflectivity

Remaining Slides Focus on Areas Circled

Operational Nest



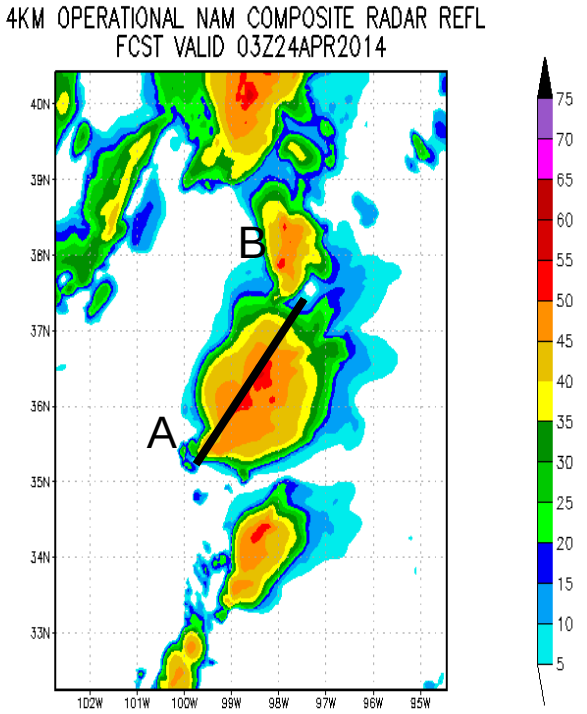
Parallel Nest



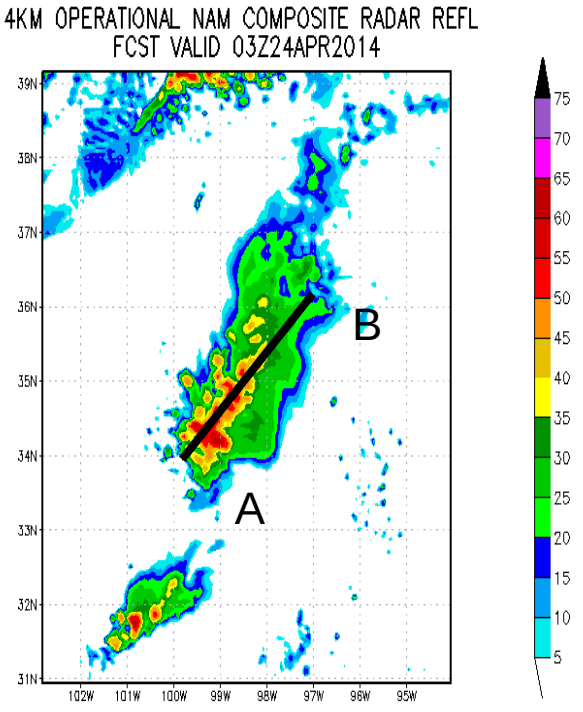
27-h (03 UTC 24 April 2014)

Composite Reflectivity

Operational Nest



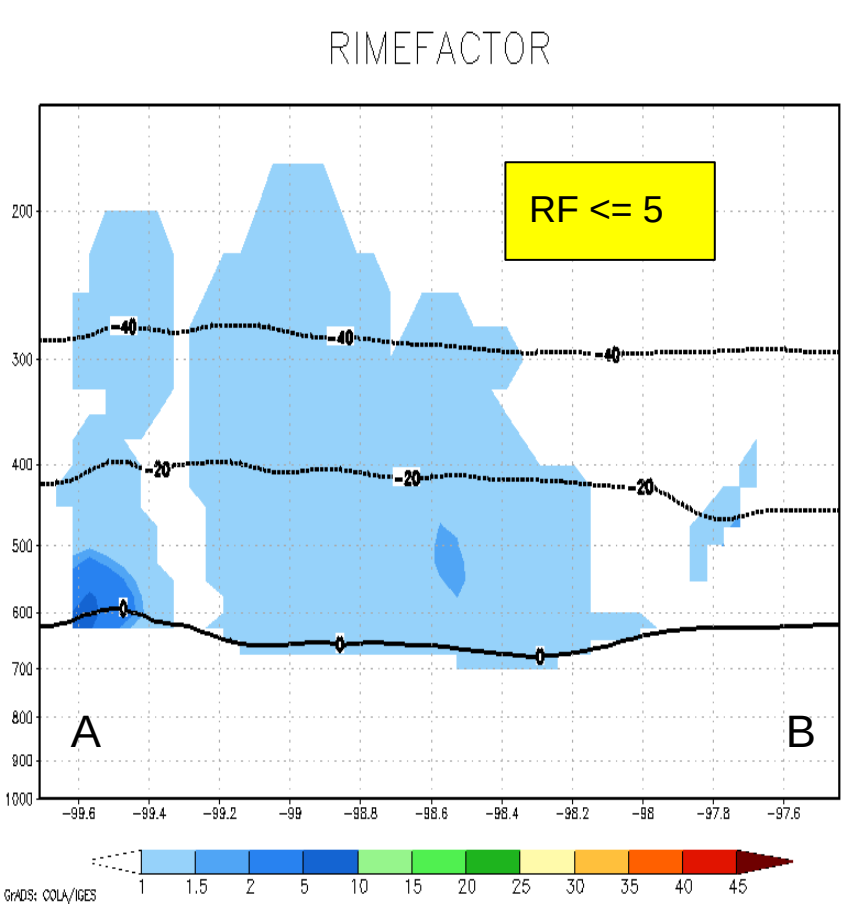
Parallel Nest



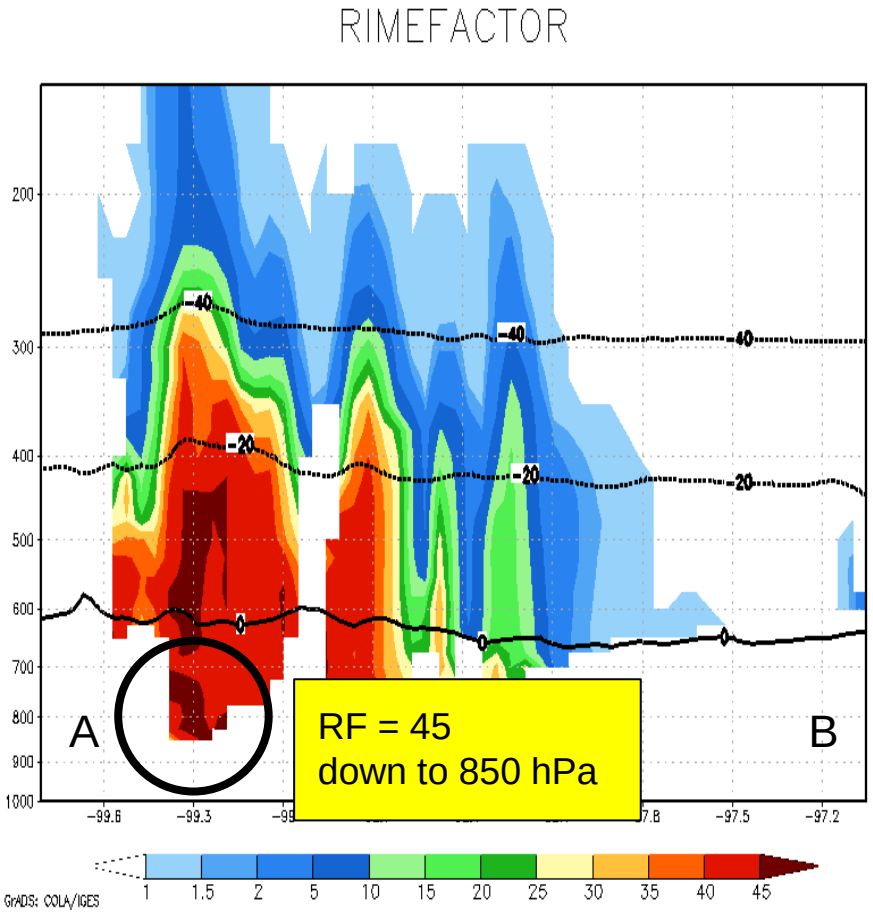
27-h (03 UTC 24 April 2014)

Rime Factor (RF)

Operational Nest



Parallel Nest



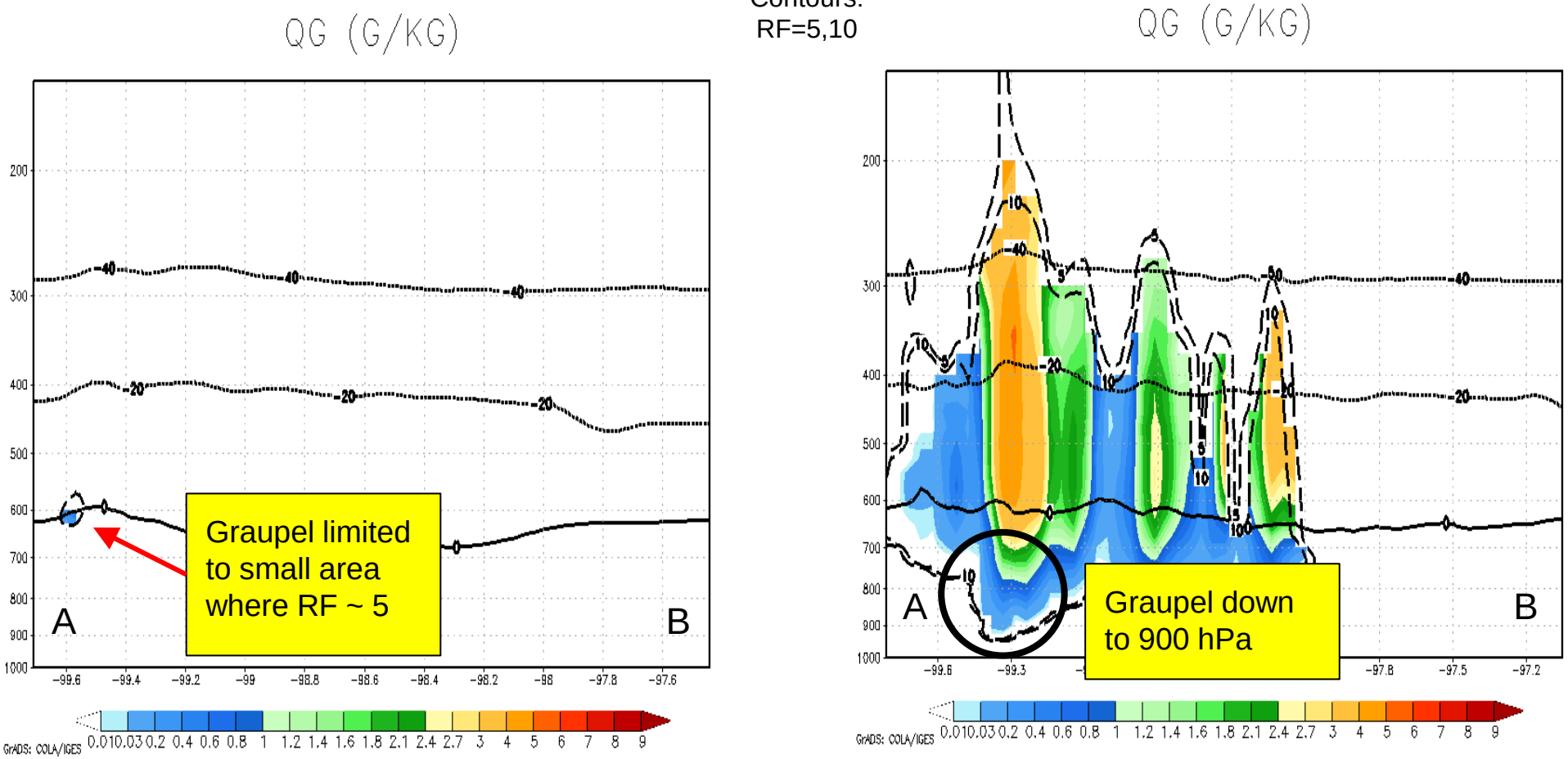
27-h (03 UTC 24 April 2014)

Graupel

Operational Nest

Dashed Contours: RF=5,10

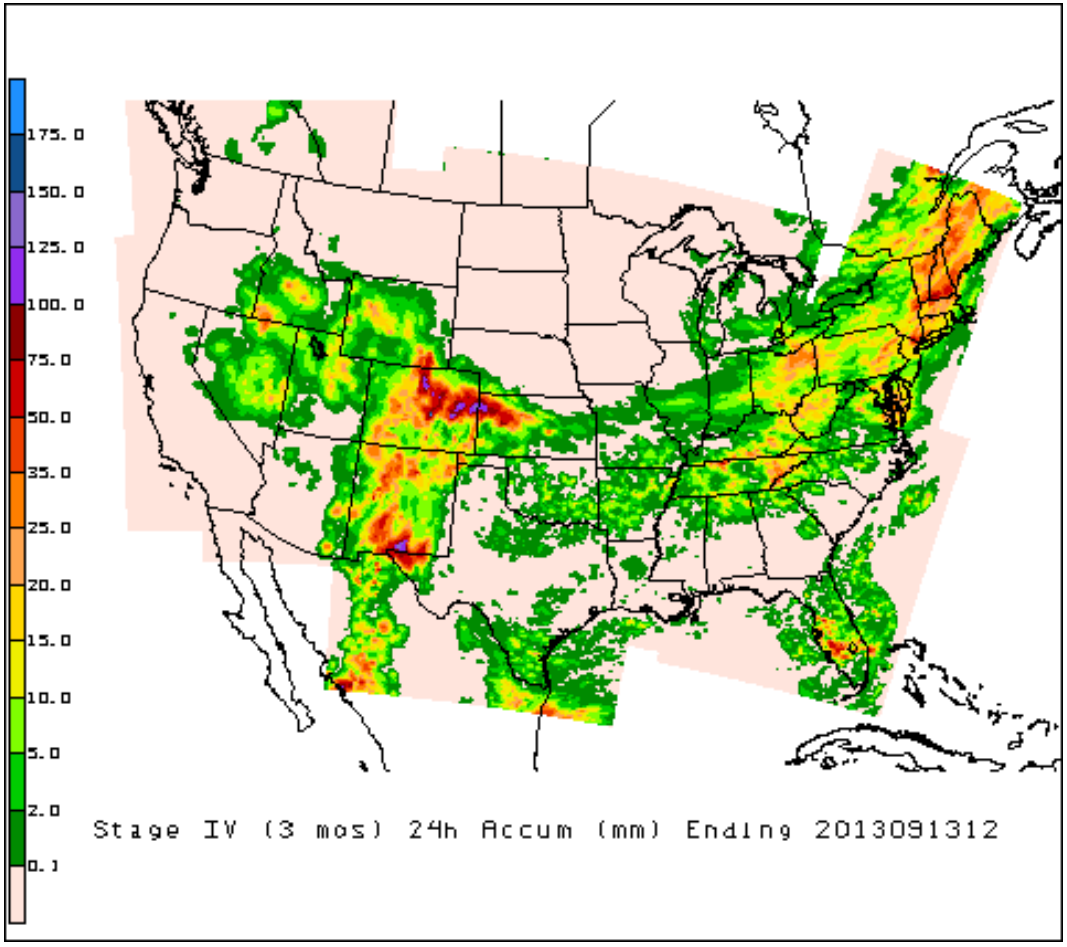
Parallel Nest

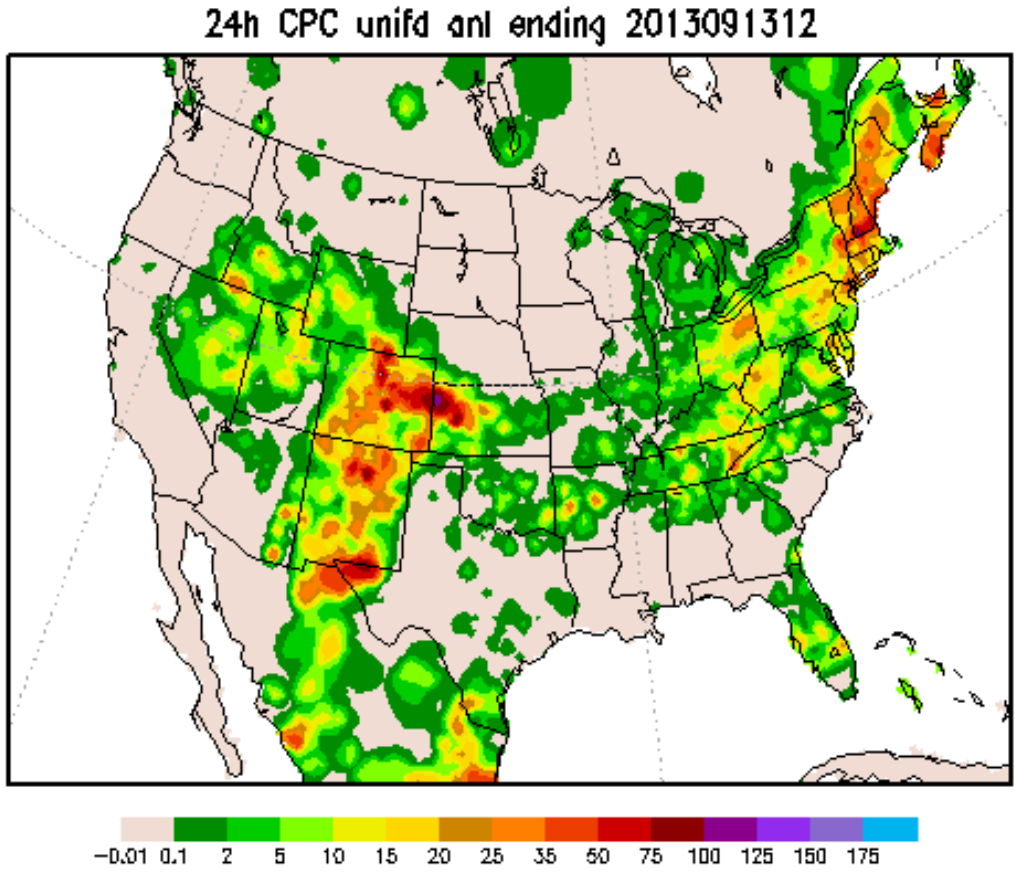


27-h (03 UTC 24 April 2014)

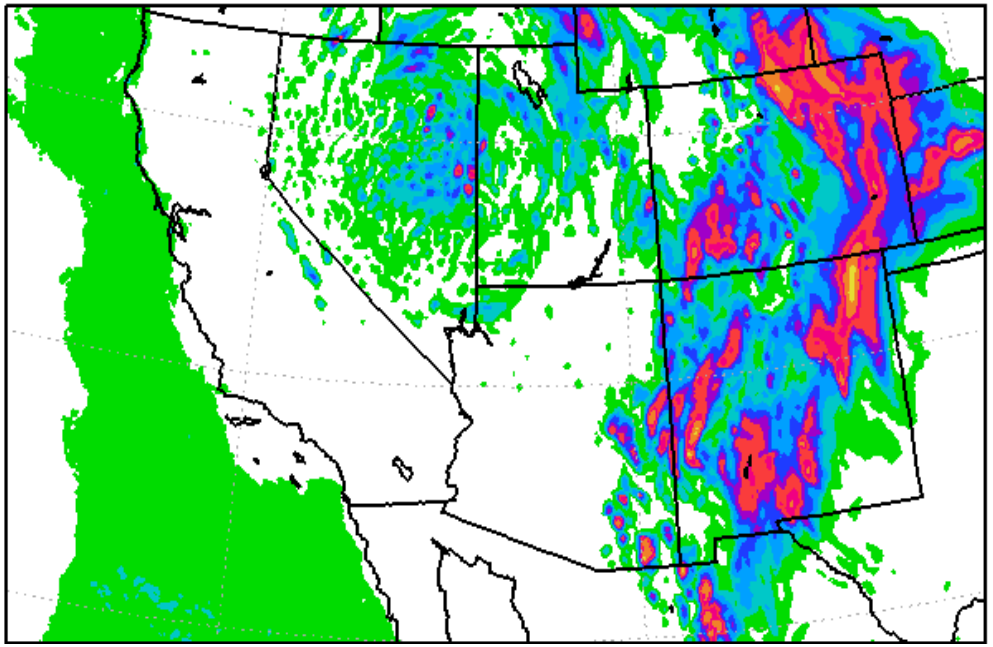
Selected Ops vs Parallel NAM 24-h QPF forecasts for Sept 2013 Colorado Floods

Stage IV (left) and CPC unified analysis (right) 24-h QPF valid 12z 9/13/2013

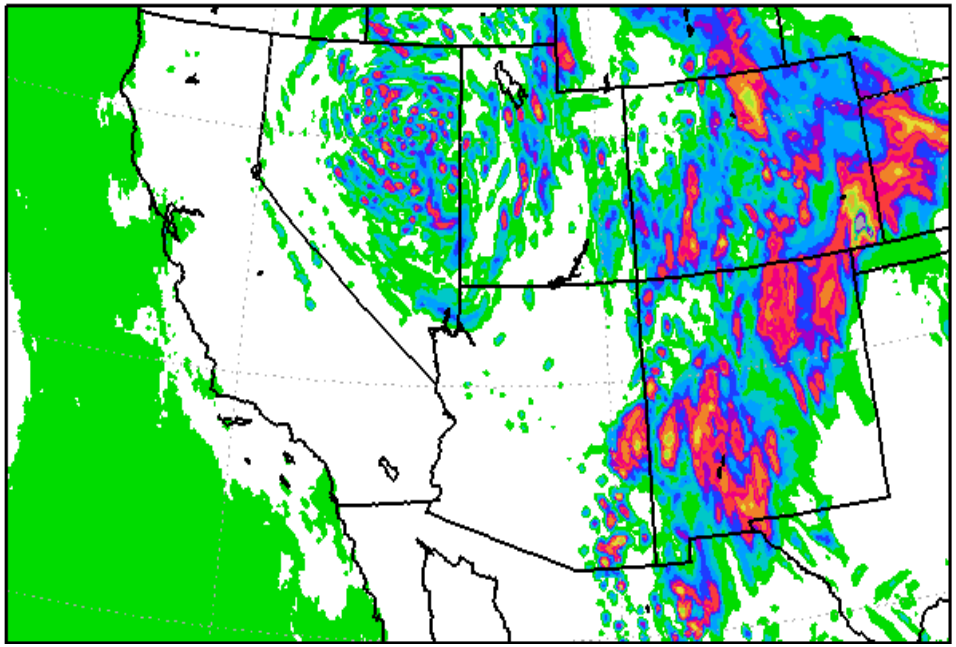




00-24 H APCP OPSNEST 24H FCST VALID 12Z 13 SEP 2013



00-24 H APCP PLLNESTX 24H FCST VALID 12Z 13 SEP 2013



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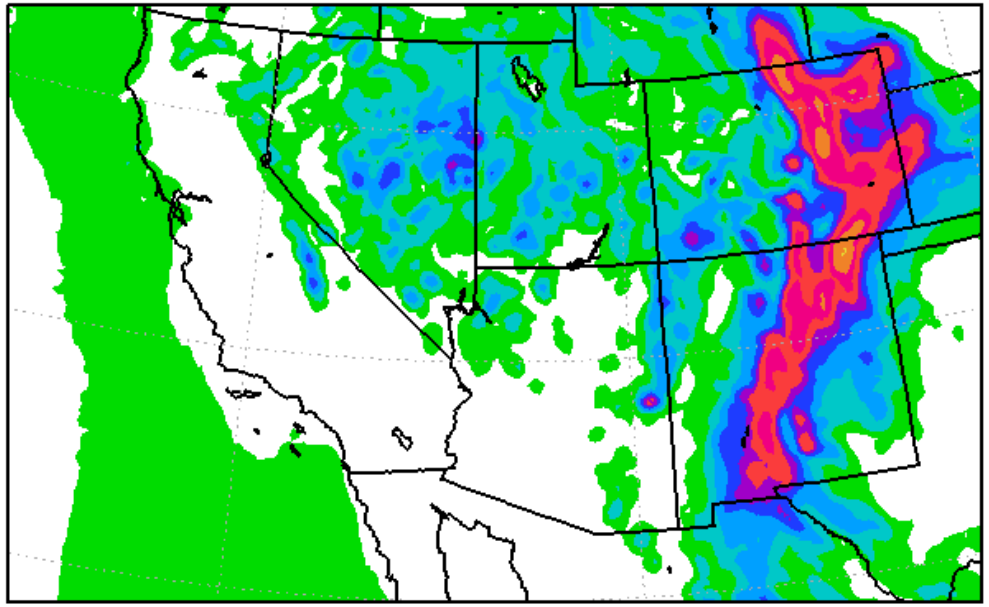

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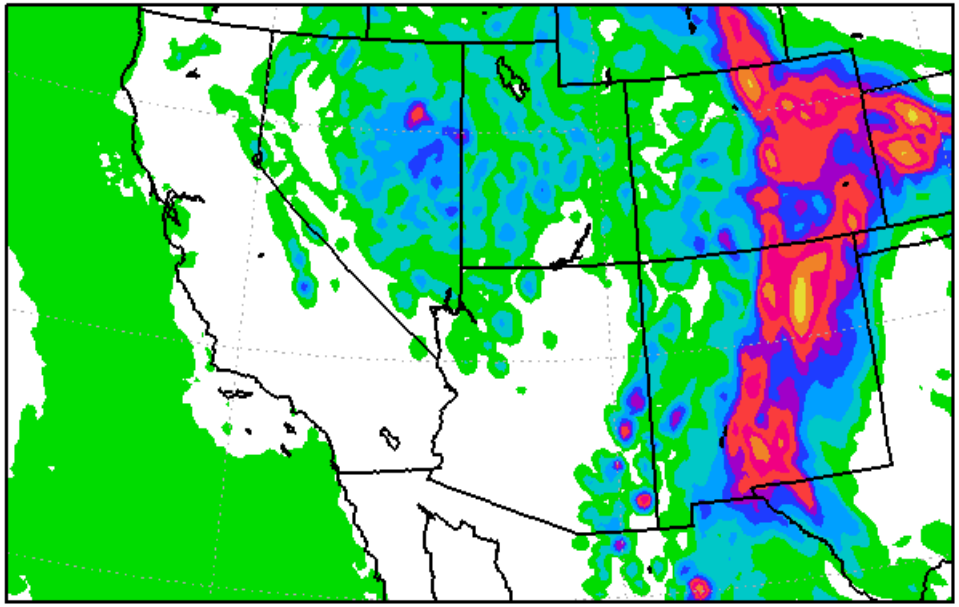
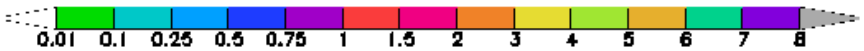
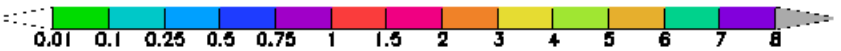
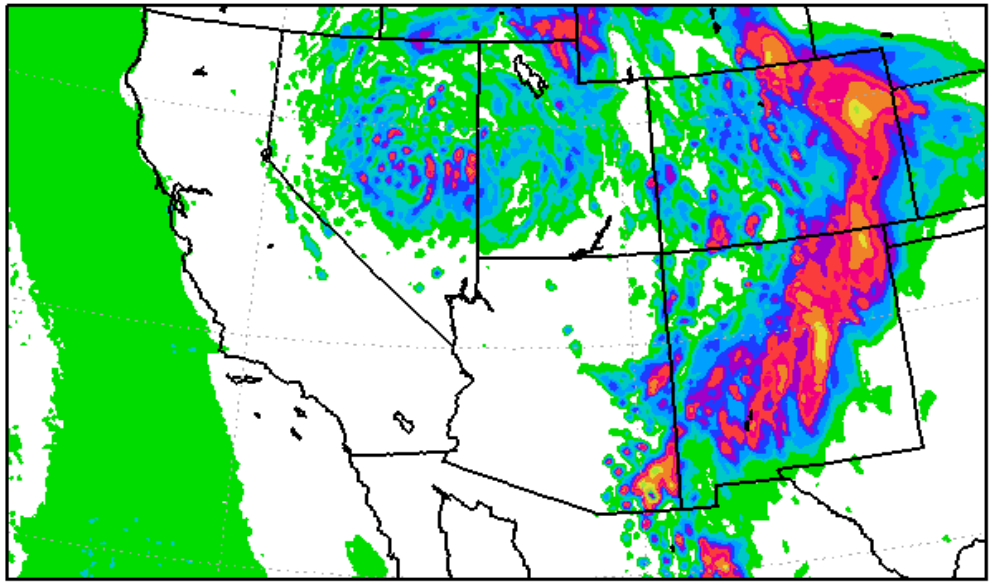


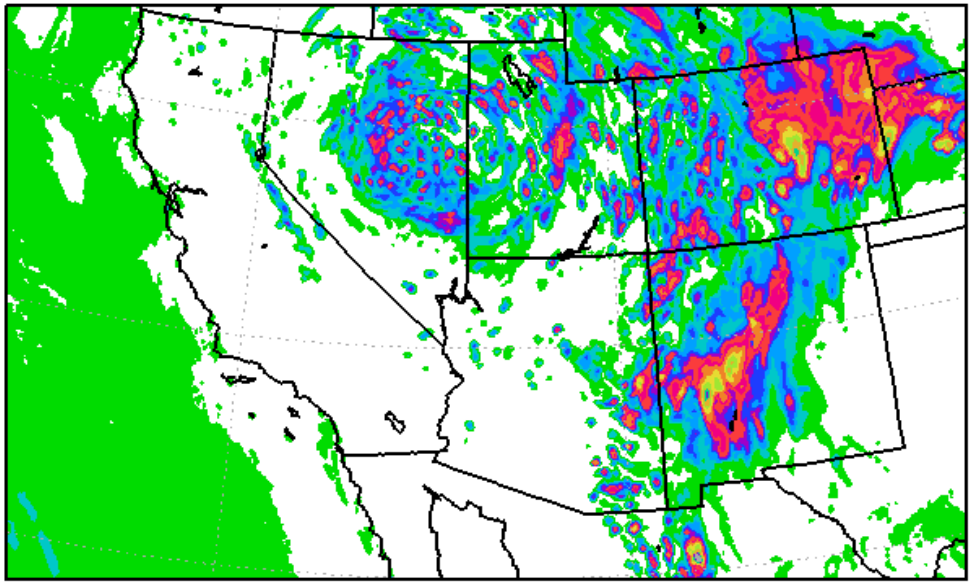




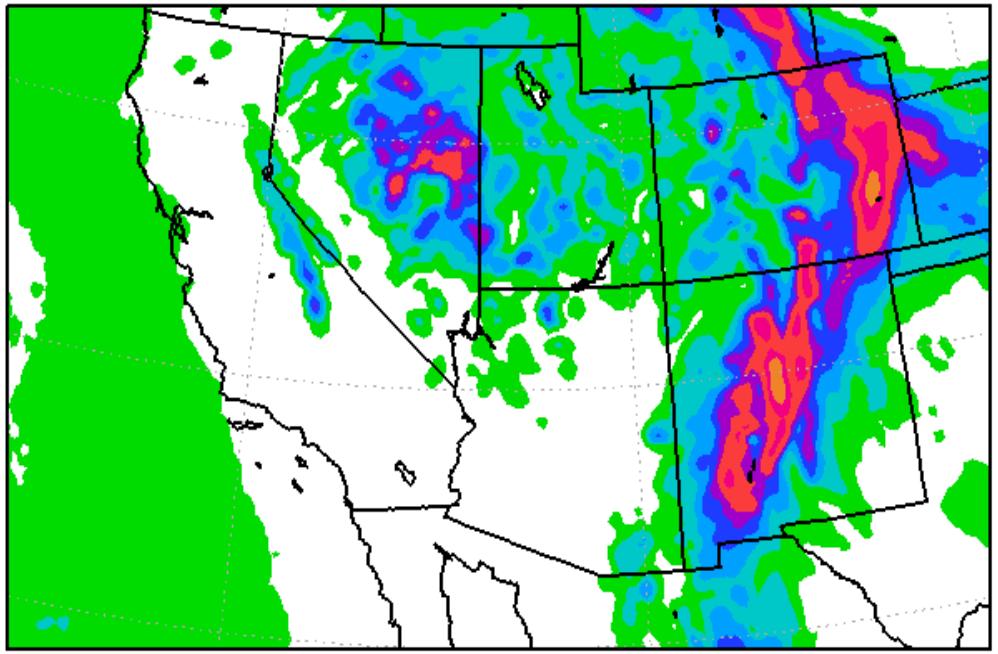
36-60 H APCP OPSNEST 60H FCST VALID 12Z 13 SEP 2013



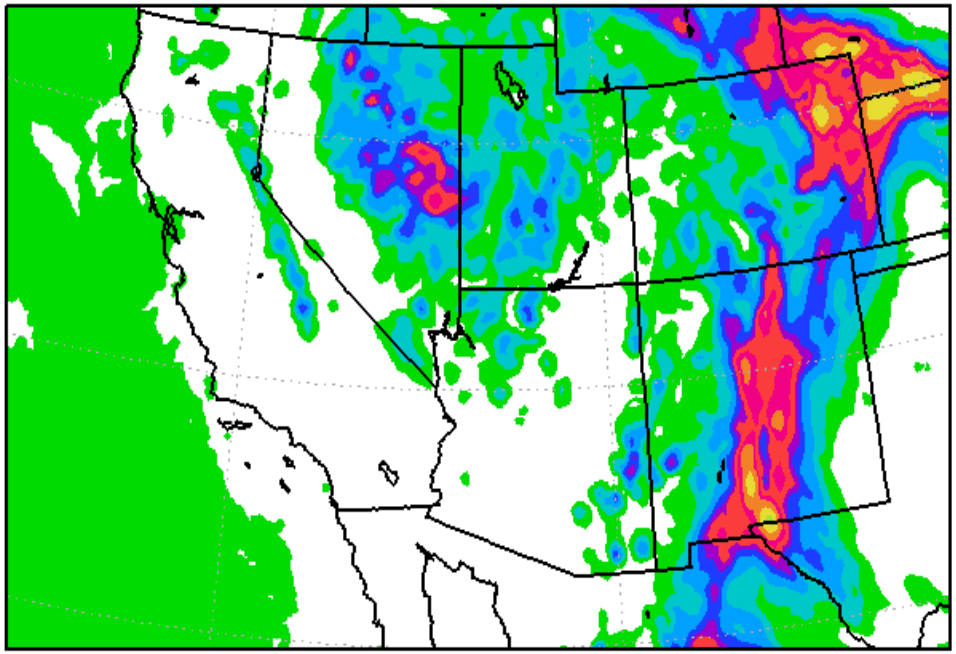
36-60 H APCP PLLNESTX 60H FCST VALID 12Z 13 SEP 2013

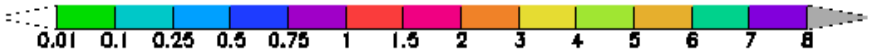


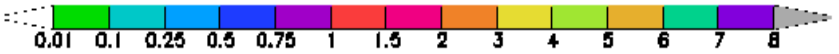
36-60 H APCP NAM 60H FCST VALID 12Z 13 SEP 2013



36-60 H APCP NAMX 60H FCST VALID 12Z 13 SEP 2013

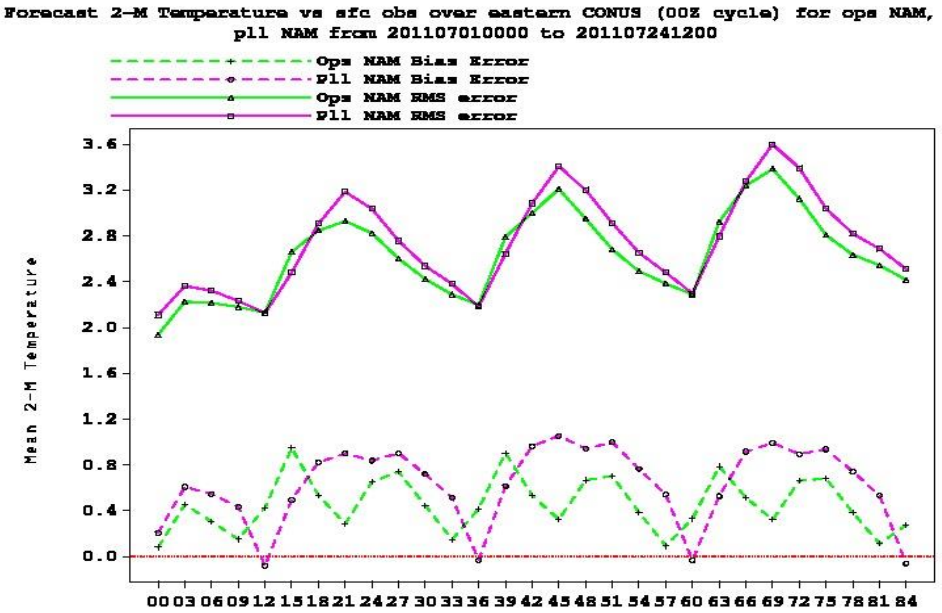




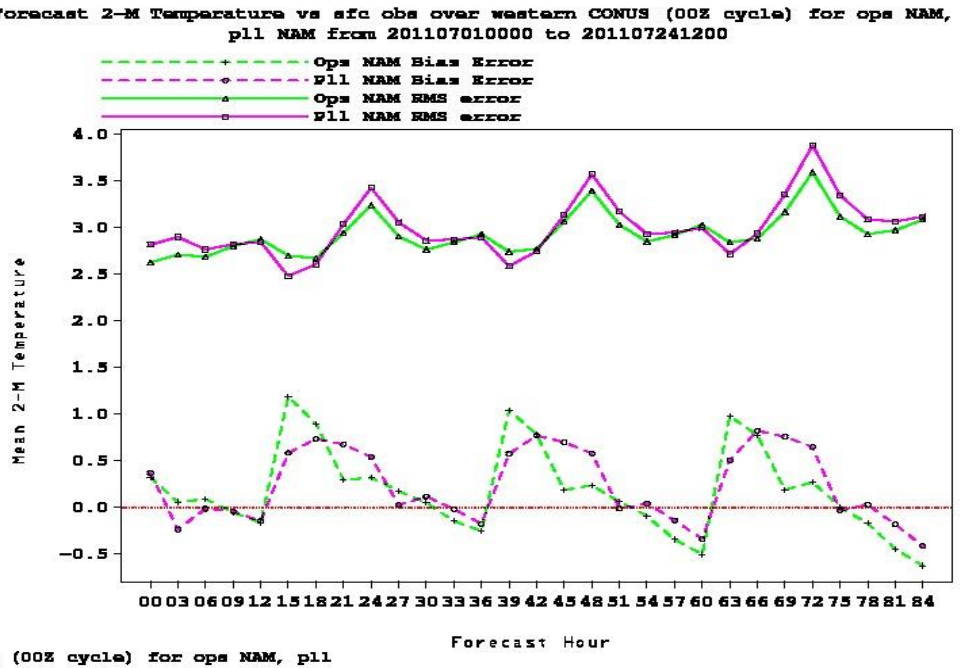


Preliminary verification stats from July 2011 retro
2-m Temp RMS/bias error, 00z cycles; Green=ops, Magenta=pll

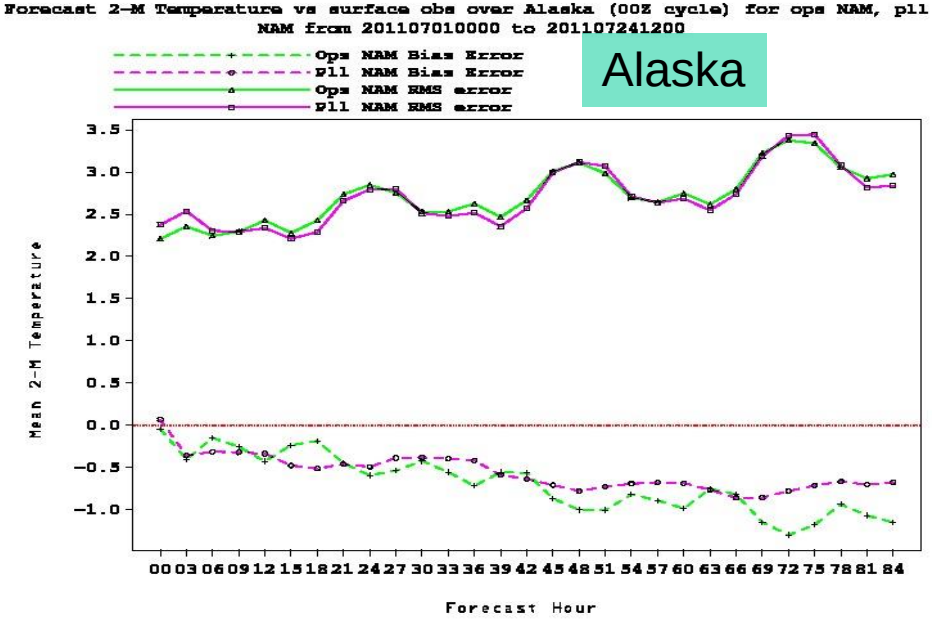
East CONUS



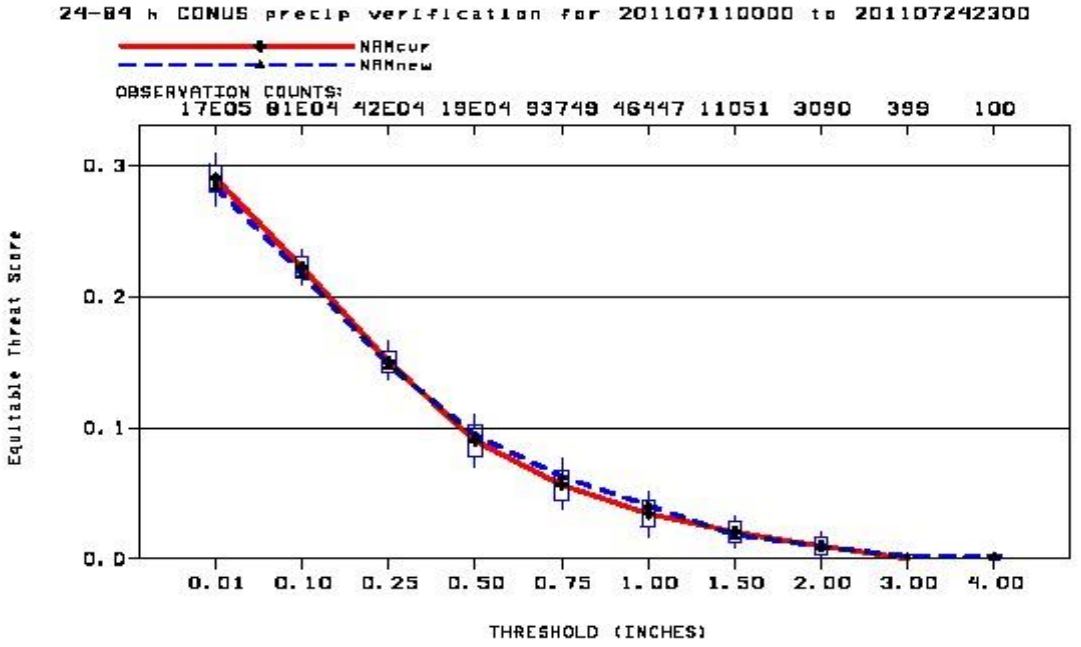
West CONUS

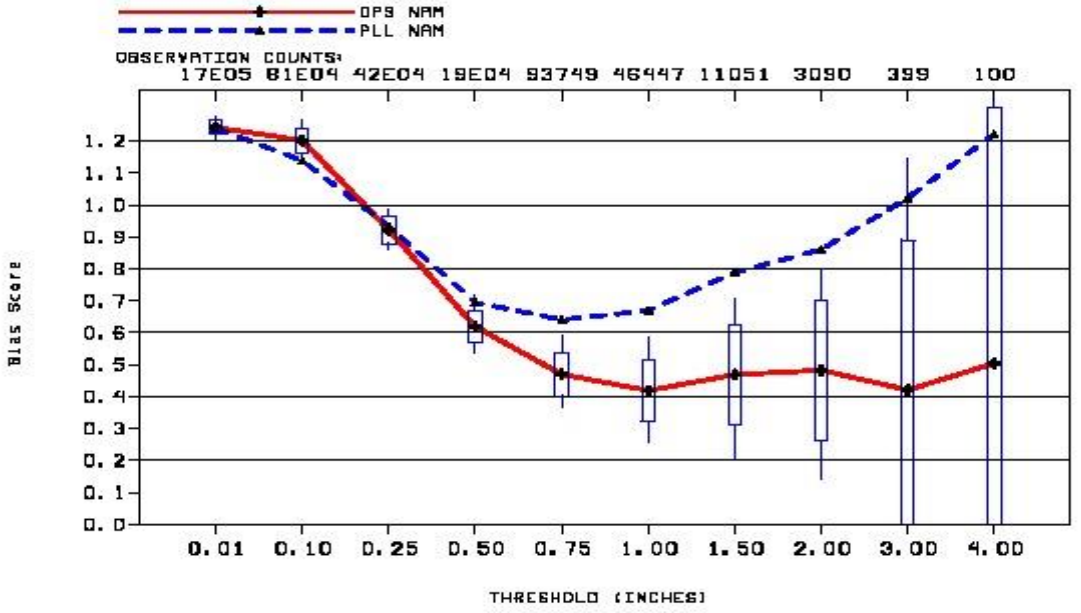


Alaska



Preliminary verification stats from July 2011 retro 24-h QPF ETS/bias error





Summary

- **NAM v3.1 addresses deficiencies in current operational NAM by**
  - **Improving large-scale synoptic performance, especially at day 2-3**
  - **Higher warm-season QPF bias in 12 km parent**
  - **Dramatically improves convective structures in the CONUS 4 km nest without degrading overall QPF skill**
    - **Important step towards ultimate goal of hourly 3-km NMMB assimilation (using radar-derived temperature tendencies) as part of high-resolution convective-scale ensemble w/HRRR (HRRRE)**
  - **By finally dropping legacy GFDL radiation for RRTM allows for better collaboration on radiation scheme enhancements with GWCMB colleagues**

Implementation Status with NCO/PMB

- **NAM/ DGEX v3.1 SVN tags/release notes delivered on 4/25**
- **Draft TIN is written and has been passed on to NCO Dataflow**
  - **Logistical issue : remove convective fields from the GRIB output from the 4 nests (CONUS, Hawaii, Puerto Rico. Firewx) which are not running convective parameterization?**