

CCPA Upgrade (v.3)

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**Environmental Modeling Center
9th October 2015**

Climatology Calibrated Precipitation Analysis

- Motivation and background - (QPF and PQPF calibration in NCEP)
 - Implemented on 2004 (HPC, CPC endorsed)
 - Bias corrected GFS/GEFS forecasts
 - At 2.5 degree resolution, every 24 hours, using Gauge (12UTC-12UTC)
 - Using decay average (or Kalman Filter) method for sampling
 - Using frequency match algorithm for CDF of OBS/FCST
- Climatological Calibrated Precipitation Analysis (CCPA)
 - Use CPC unified analysis at 1/8 degree, daily, global land - reliability
 - Use RFC/QPE (stage IV) 5km resolution, 6-h(CONUS) – resolution
 - Use regression method to generate a and b from above two datasets
 - Produce CCPA analysis ($CCPA = a * QPE_{rfc} + b$)
 - Resolution is 5km (NDGD) grid (and subsets) for CONUS for current production
 - Update frequently by apply longer stage IV to produce better regression coefficients
- Important Applications
 - Improving QPF/PQPF bias correction – GEFS, NAEFS, SREF and etc...
 - Statistical downscaling QPF/PQPF forecast for GEFS, NAEFS, SREF and etc...
 - WPC daily precipitation analysis products – CCPA web products (2012)
 - Daily precipitation verifications (WPC and EMC meg briefing)
 - NAM's precipitation analysis
 - Hydrological application – NWC and RFC
 - Research Communities
- Reference
 - Publication: <http://journals.ametsoc.org/doi/abs/10.1175/JHM-D-11-0140.1>
 - Web display (EMC): <http://www.emc.ncep.noaa.gov/gmb/yluo/CCPA.html>

Highlights of CCPA Upgrade

- Update regression coefficients by extending training data sets of CPC gauge based analysis and STAGE IV multi-sensor estimation
 - Current: 7 years (2002-2009)
 - Upgrade: 13 years (2002-2015)
 - Expectation: Improved analysis with expanded training data sets
- Make change to 3-hr CCPA due to poor data quality of Stage IV hourly data in CNRFC area
 - Current: using Stage II hourly in NWRFC only
 - Upgrade: will use Stage II hourly in both NWRFC and CNRFC
 - Expectation: Improve 3-hr CCPA with more accurate weights
- Make change to CCPA rerun schedule
 - Current: rerun at 1 day only after ending of the accumulation time
 - Upgrade: rerun at 1/3/5/7days
 - Expectation: Improved analysis with more accurate Stage IV inputs

Updating Regression Coefficients

1. Historical data sets

Operational : June 1 2002 to July 31 2009 For CPC and STAGE IV
Updated: June 1 2002 to July 31 2015 (six more years of data)

2. Match resolutions

- a. Accumulate RFC over 24 hours
- b. Interpolate to $\frac{1}{8}^\circ$ (copygb w/ volume preservation)

3. Collect precip samples

- a. For each day of the year and at each grid point, collect all precip within 60 day window centered around that day, over all 13 years (max ~793 data points)
- b. Use only data points with ST4 > 0

4. Linear regression

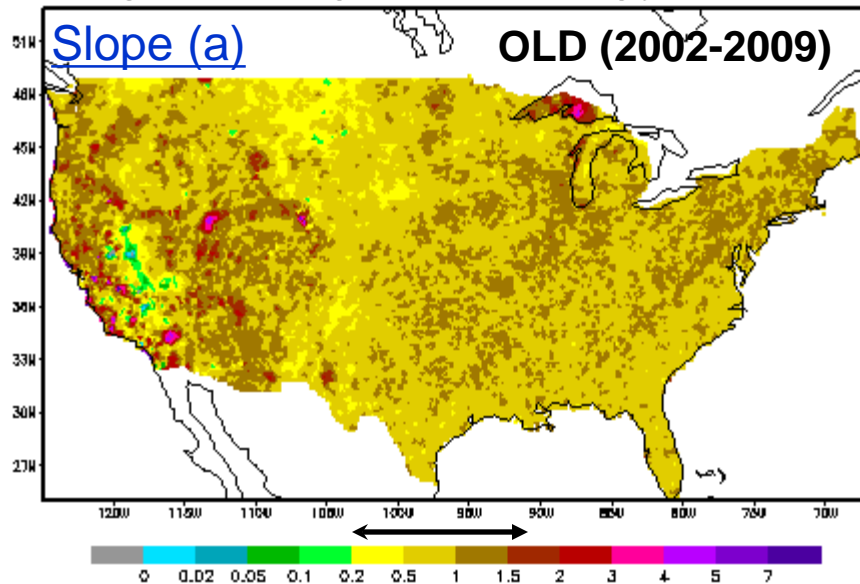
- $\text{CPC} = a \cdot \text{ST4} + b$

5. End Result

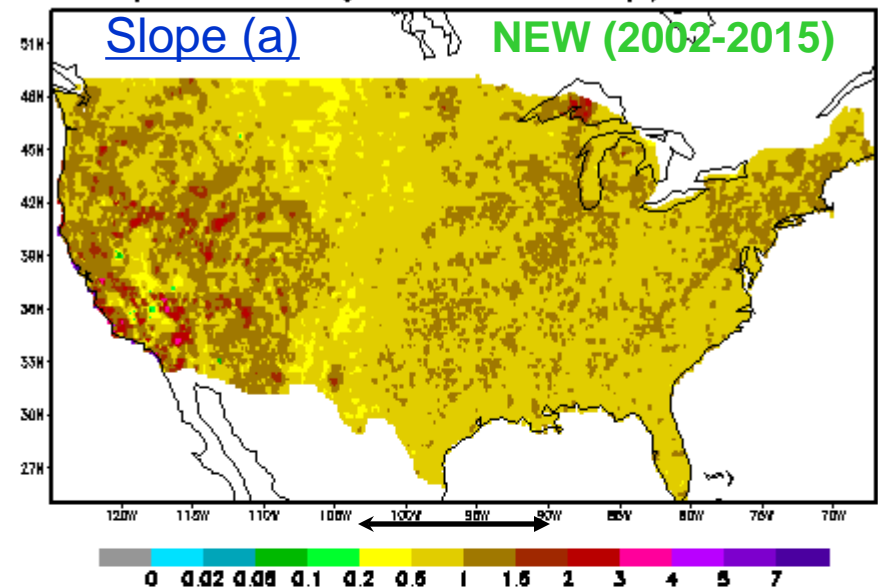
- Linear relationship (a & b) on $\frac{1}{8}^\circ$ grid for each day of the year

Example of Regression for Aug. 1st

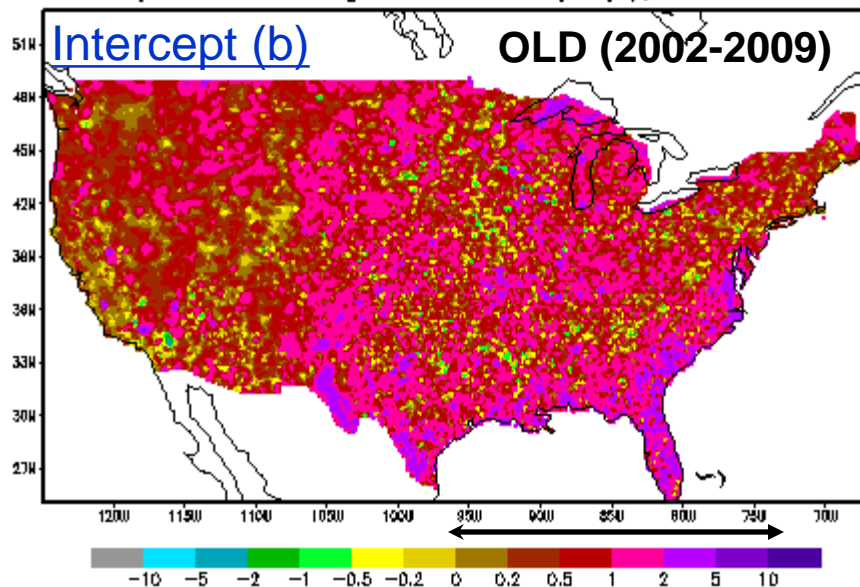
Prcp CPC-ST4 Regression Coefficient (a), 2000 0801



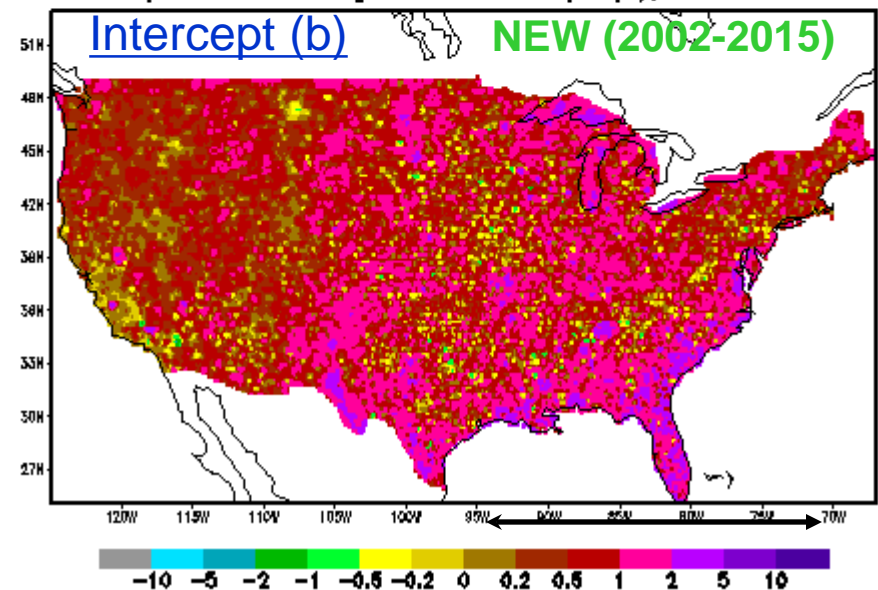
Prcp CPC-ST4 Regression Coefficient (a), 2000 0801



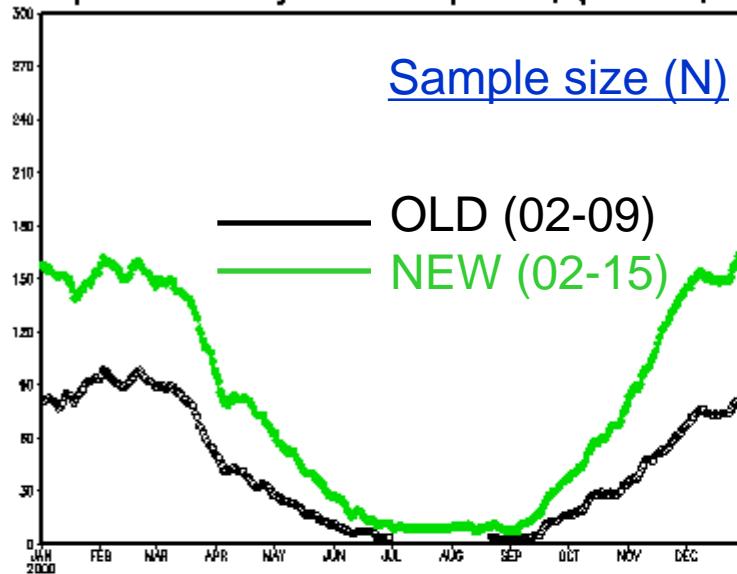
Prcp CPC-ST4 Regression Intercept (b), 2000 0801



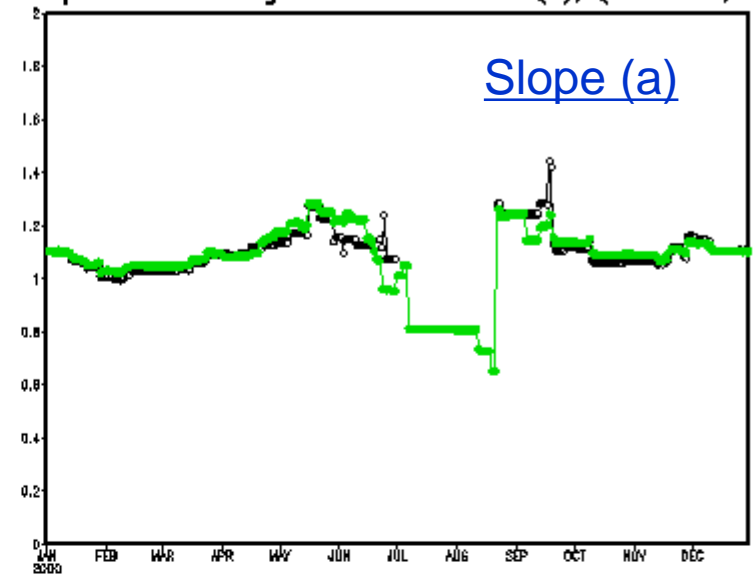
Prcp CPC-ST4 Regression Intercept (b), 2000 0801



Prop CPC-ST4 Regression Sample size, (Point 54,72)

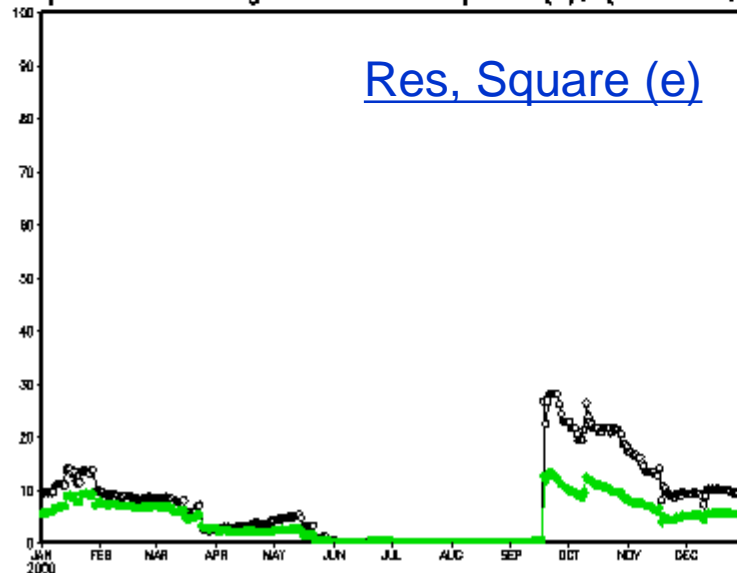


Prop CPC-ST4 Regression Coefficient (a), (Point 54,72)

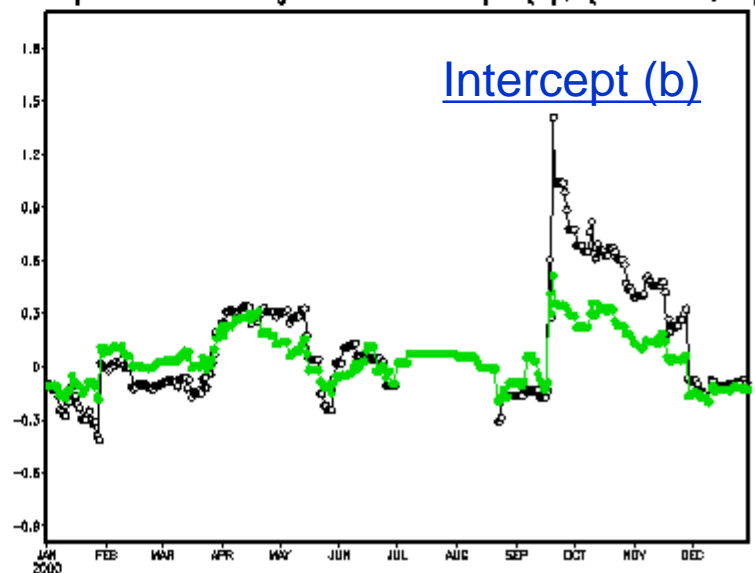


Time series of regression

Prop CPC-ST4 Regression Res. Square (e), (Point 54,72)

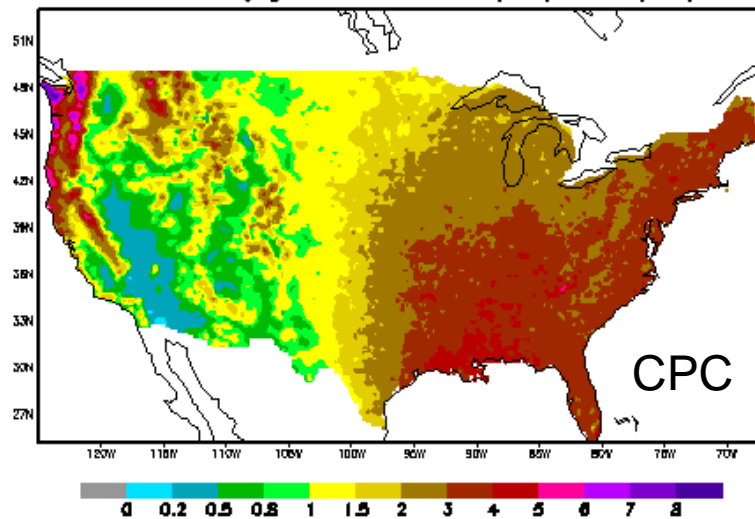


Prop CPC-ST4 Regression Intercept (b), (Point 54,72)

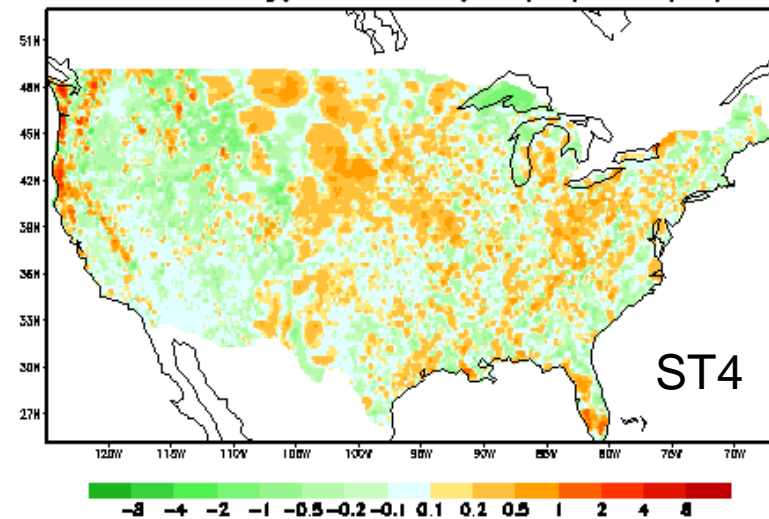


Comparison against CPC analysis

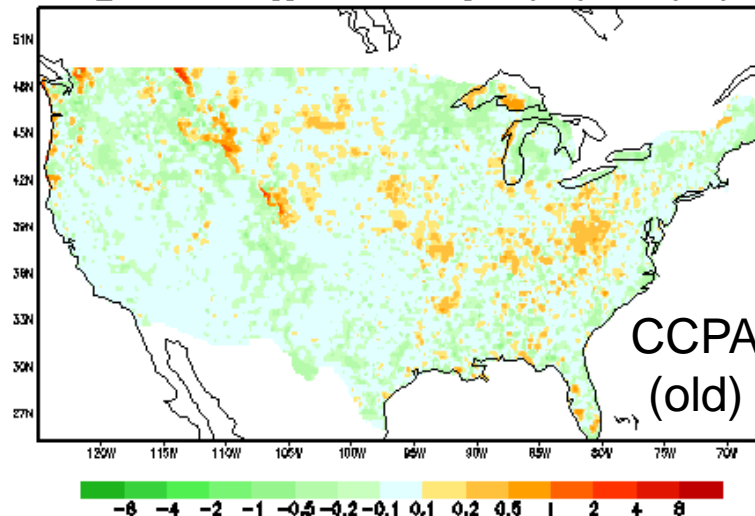
CPC 0.125 deg grb file 07/01/02-06/30/15



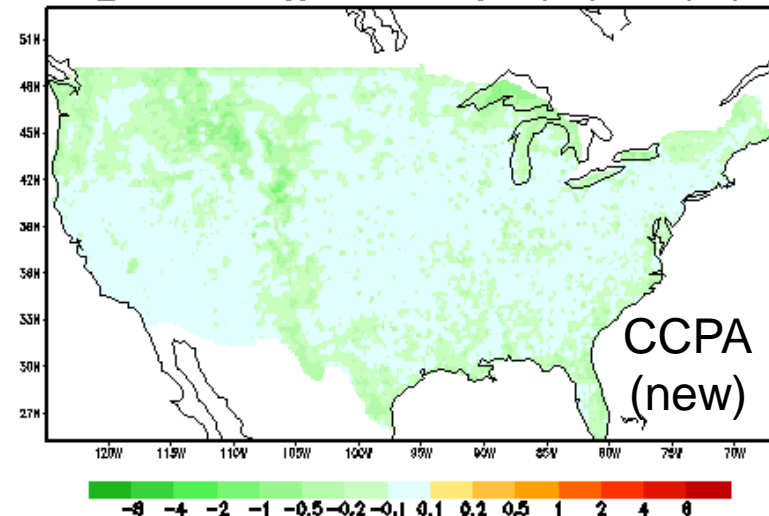
STAGE4 - CPC aggr. to 0.125deg 07/01/02-06/30/15



CCPA_old - CPC aggr. to 0.125deg 07/01/02-06/30/15

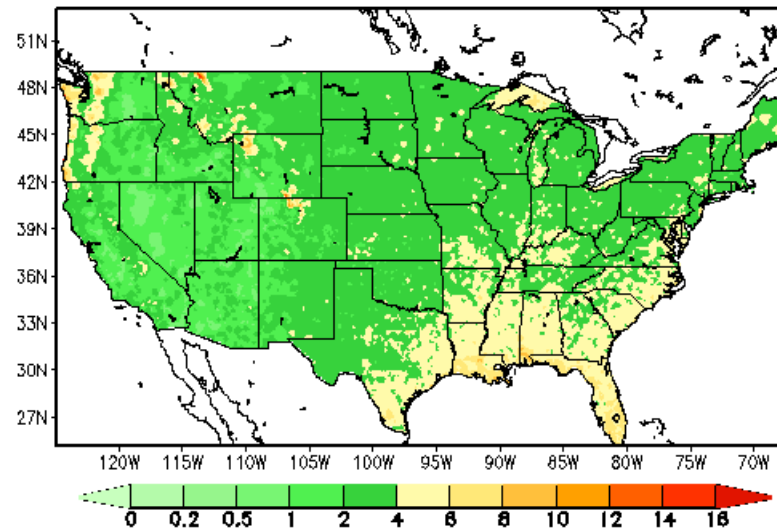


CCPA_new - CPC aggr. to 0.125deg 07/01/02-06/30/15

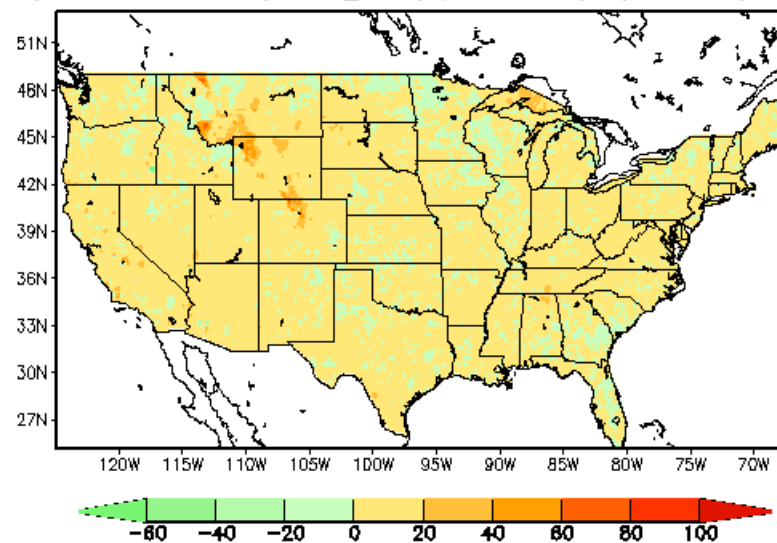


Comparison against CPC analysis

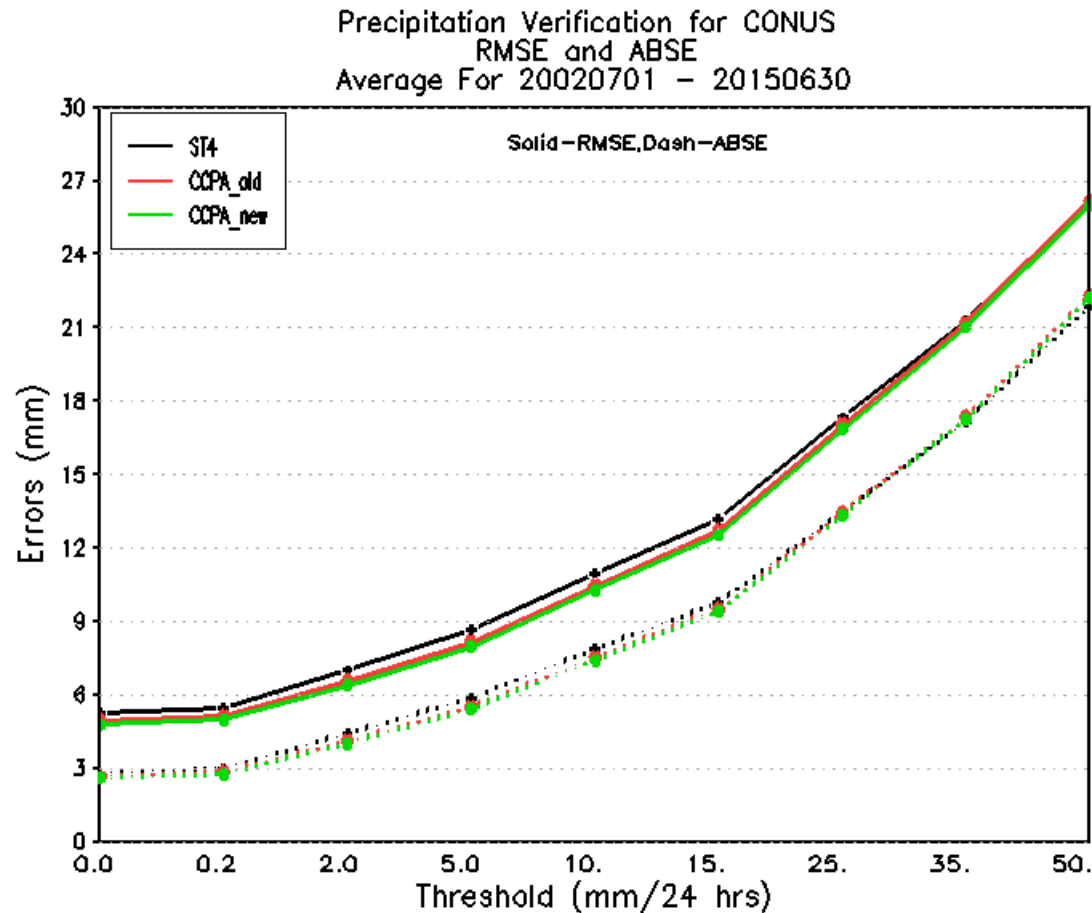
a) RMSE of CCPA_old (mm) 07/01/02 - 06/30/15



b) RMSE Reduction by CCPA_new (%) 07/01/02 - 06/30/15



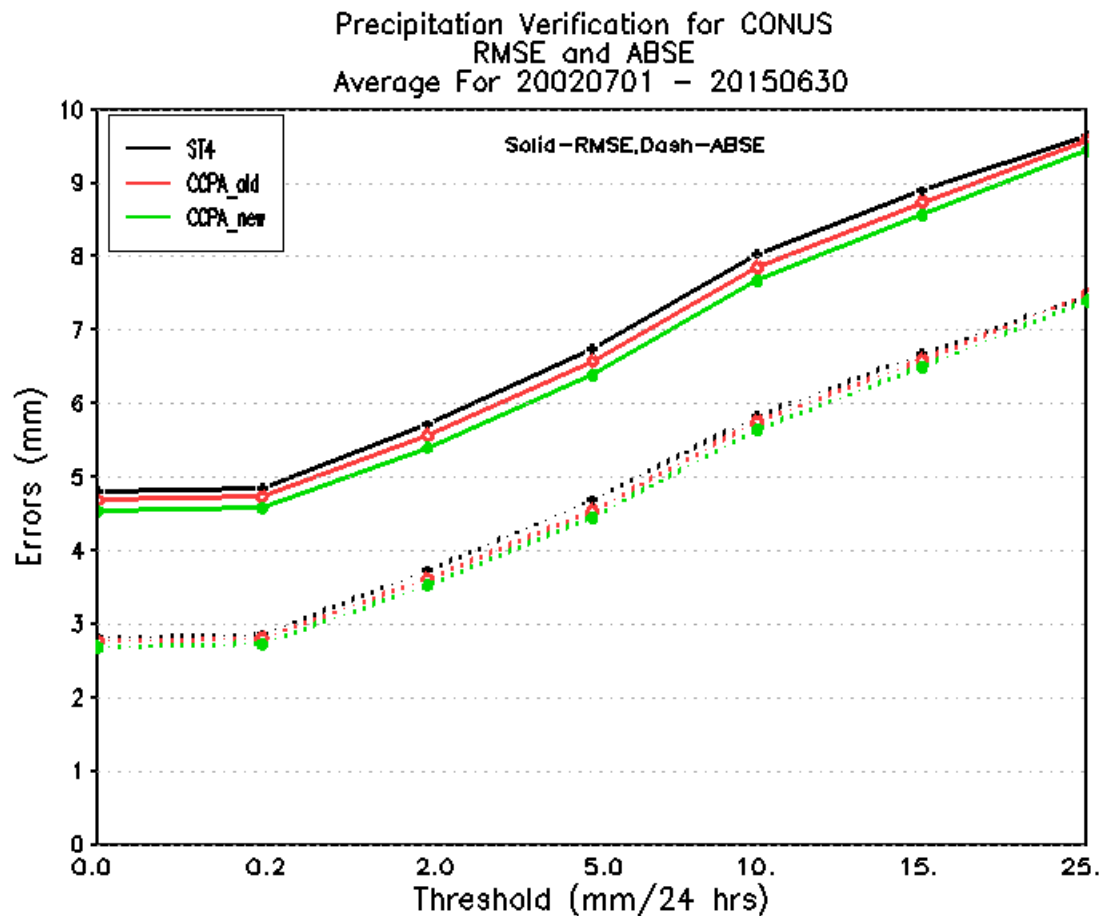
Evaluation against CPC Analysis



Greater than thresholds

Evaluation against observation

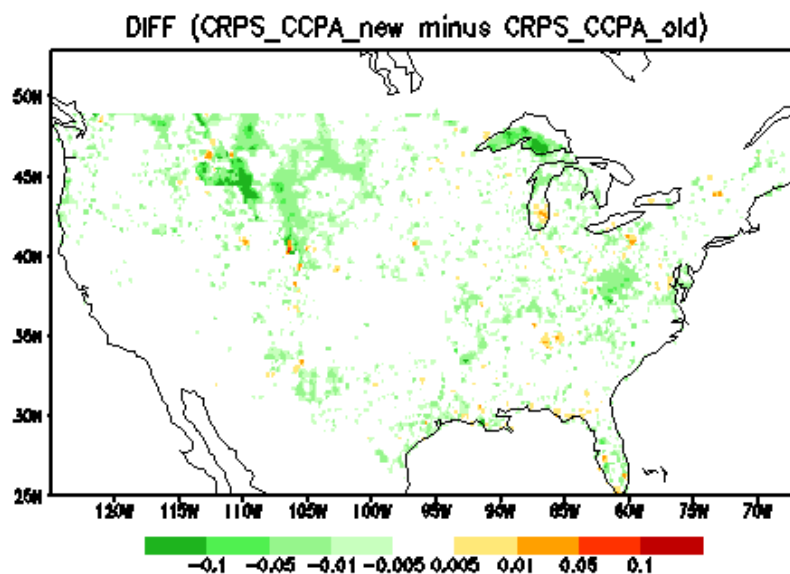
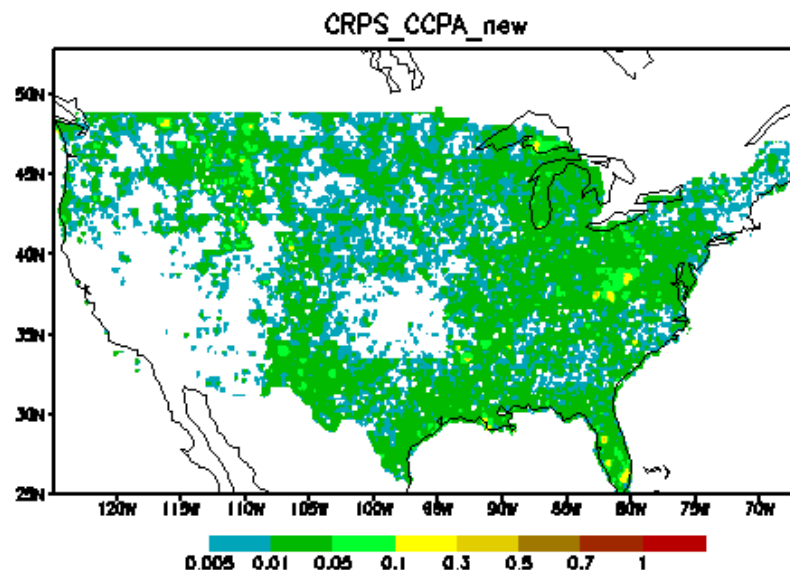
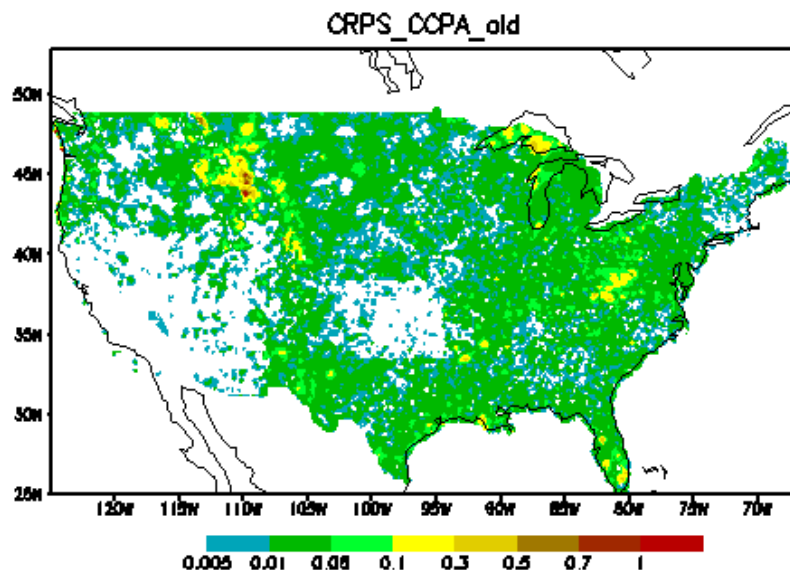
(RFC rain-gauge network)



Greater than thresholds

Comparison of CCPA production (old) and parallel (new) - CRPS

$$\text{CRPS} = \sum_{i=1}^{n_{\text{point}}} \sum_{j=1}^{n_{\text{thres}}} \left[\frac{1}{n_{\text{day}}} \sum_{k=1}^{n_{\text{day}}} \text{Count}_{\text{ccpa}}(i, j, k) - \frac{1}{n_{\text{day}}} \sum_{k=1}^{n_{\text{day}}} \text{Count}_{\text{cpc}}(i, j, k) \right]^2$$



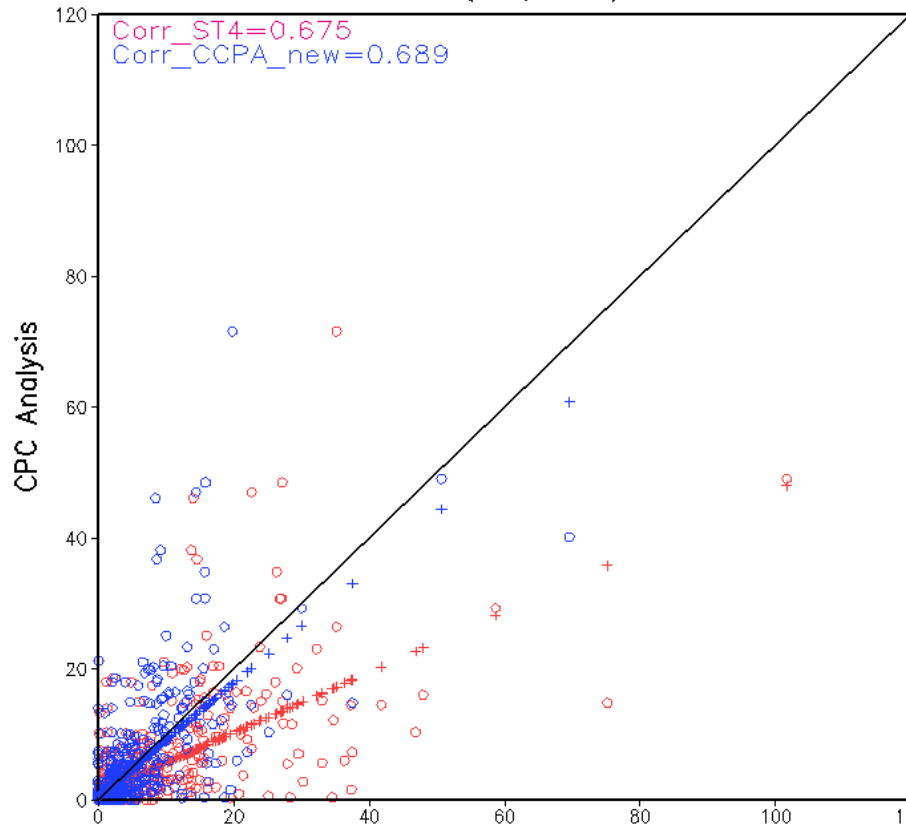
Against CPC analysis

Period: 7/1/2014 – 6/30/2015

Negative (green) is better

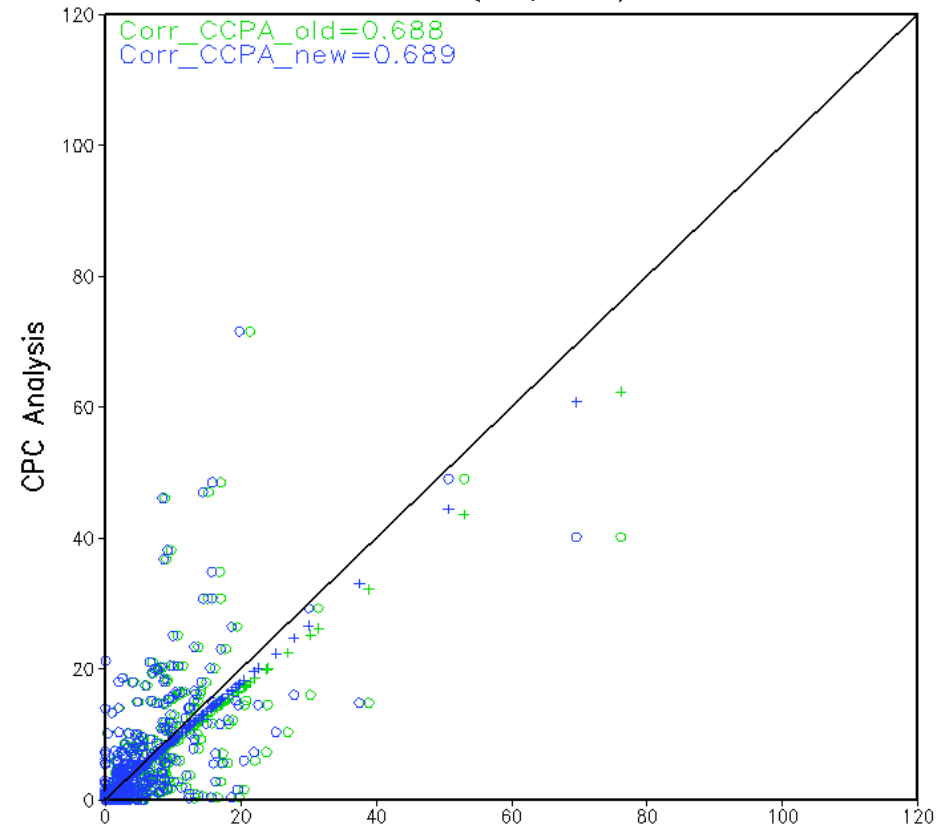
Example of one scatter plot for one grid point

Point (42N, 102W)



ST4 & CCPA Analysis

Point (42N, 102W)



CCPA Analysis

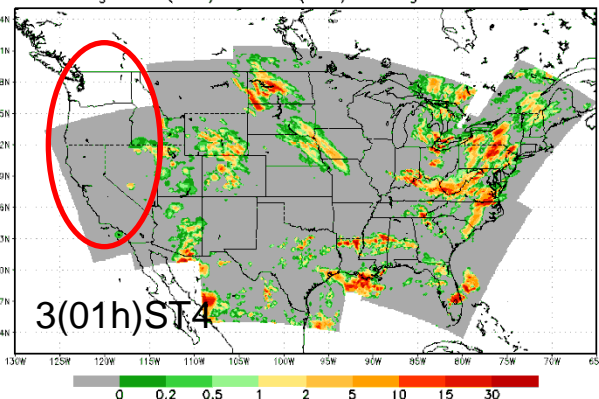
- All data pairs are sampled at point (42N,102W) for 61 days centered around July 1st for 14 years (2002-2015).
- Sample size : 14 years x 61 days (6/1-7/1-7/30) = 854
- The fitting line which is the closer to the diagonal line is the better:
 - CCPA_new is slightly better than CCPA_old
 - Both CCPA_new & CCPA_old are better than ST4

Change Specific to 3-hr CCPA

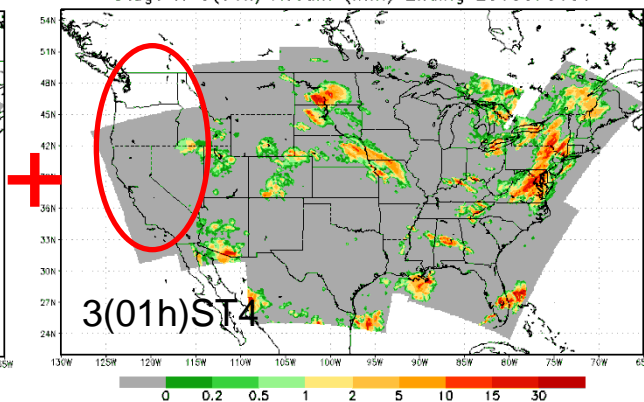
- Stage IV hourly has no data record in NWRFC and has not good data record in CNRFC as well
- Current CCPA production is using Stage II hourly in NWRFC only and Stage IV hourly in remaining areas as weights to update 3-hr CCPA
- CCPA upgrade will use Stage II hourly in both NWRFC and CNRFC while use Stage IV hourly in remaining areas as weights to update 3-hr CCPA

Why Change to 3-hr CCPA?

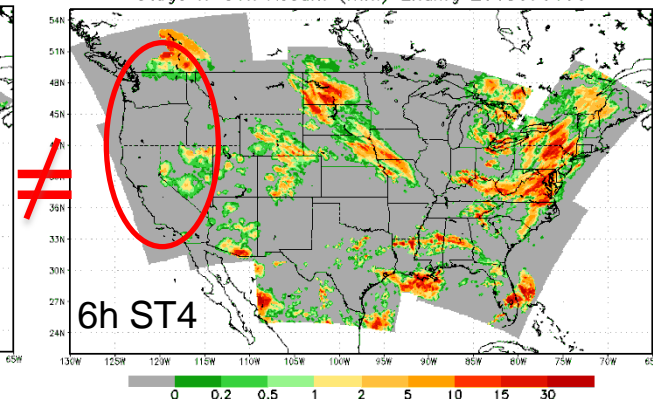
Stage IV 3(01h) Accum (mm) Ending 2015070103



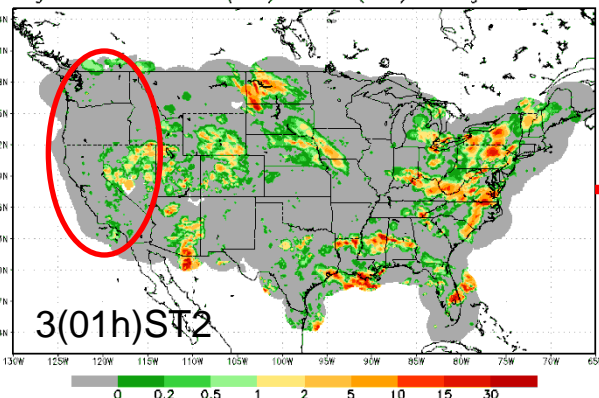
Stage IV 3(01h) Accum (mm) Ending 2015070106



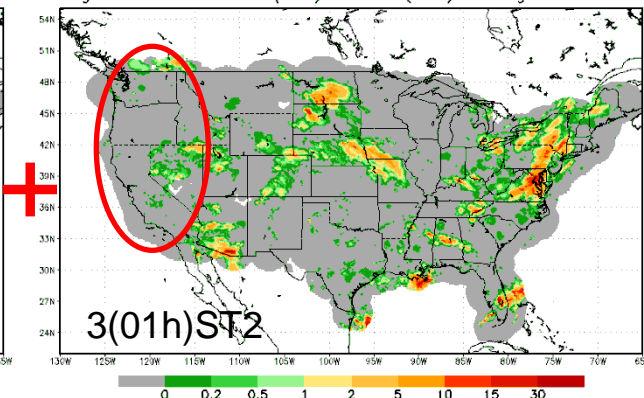
Stage IV 06h Accum (mm) Ending 2015070106



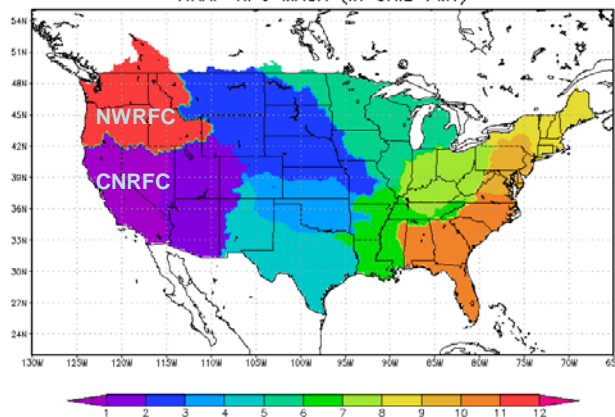
Stage II Multi-Sensor 3(01h) Accum (mm) Ending 2015070103



Stage II Multi-Sensor 3(01h) Accum (mm) Ending 2015070106



HRAP RFC MASK (in GRIB FMT)

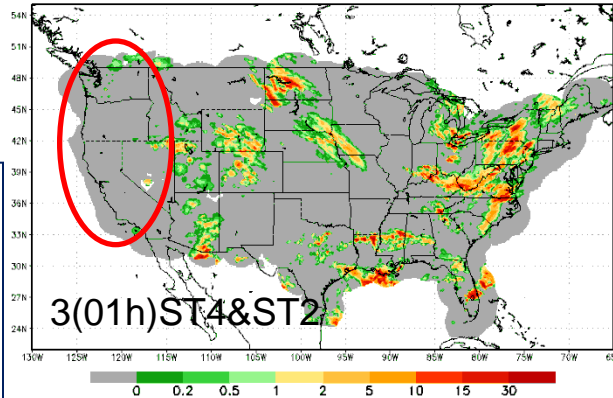


Stage IV hourly has data issue in CNRFC, similar to the issue in NWRFC: not much data report; not so realistic as Stage II hourly

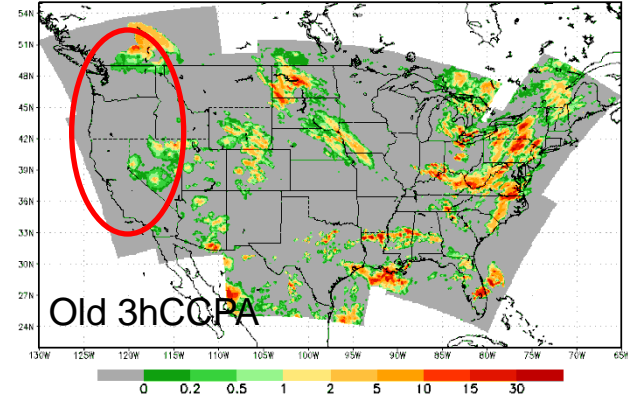
Before
Problem over CNRFC



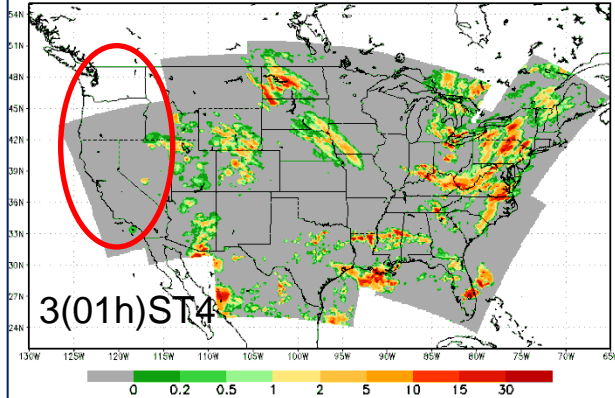
Stage II&IV Composite 03h Accum (mm) Ending 2015070103



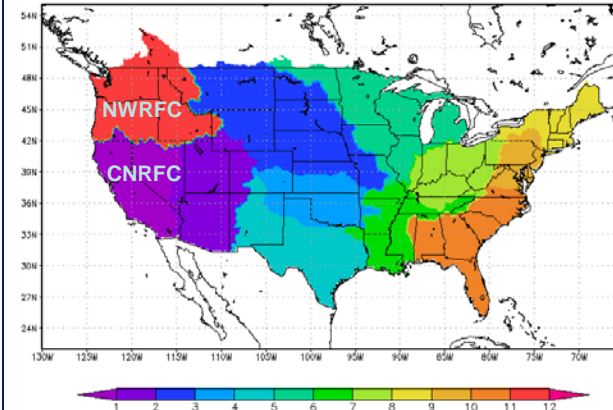
CCPA 03h Accum (mm) Ending 2015070103



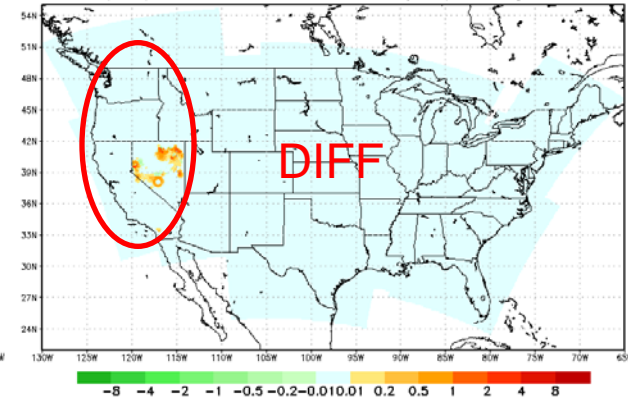
Stage IV 3(01h) Accum (mm) Ending 2015070103



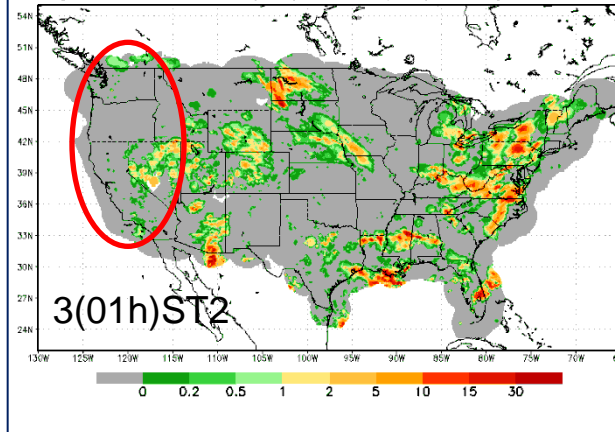
HRAP RFC MASK (in GRIB FMT)



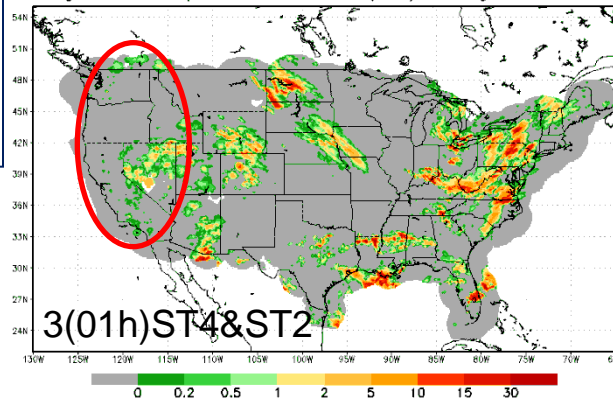
CCPA 1st(03h) Diff After-Before Accum (mm) Ending 2015070103



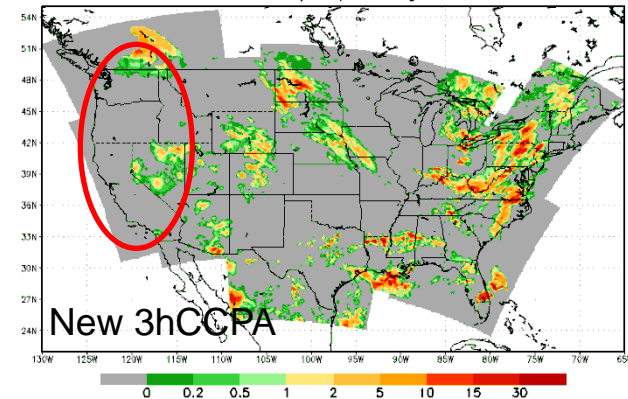
Stage II Multi-Sensor 3(01h) Accum (mm) Ending 2015070103



Stage II&IV Composite 03h Accum (mm) Ending 2015070103



CCPA 03h Accum (mm) Ending 2015070103



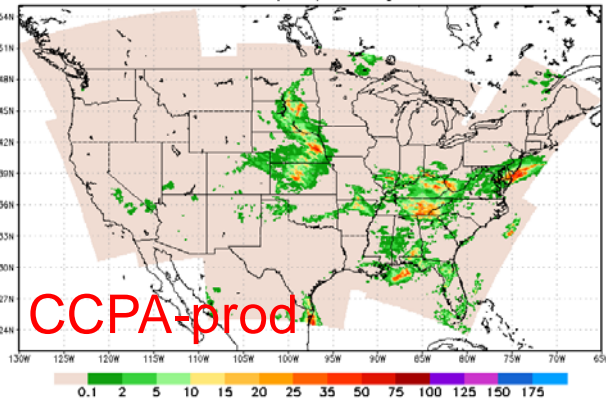
After
Better splitting weights



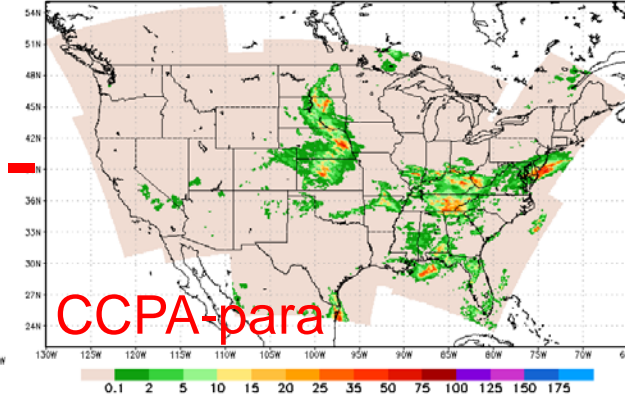
Example Impact of Change in Rerun Schedule

(06h accum ending 18Z 20150702)

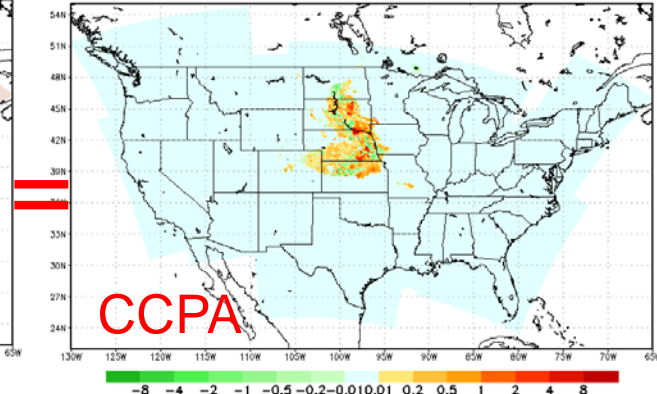
CCPA 06h Accum (mm) Ending 2015070218



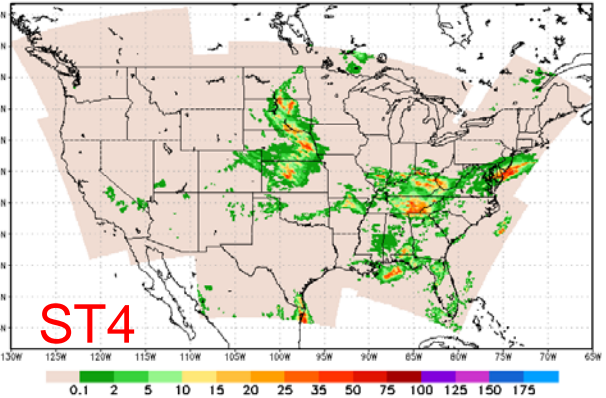
CCPA 06h Accum (mm) Ending 2015070218



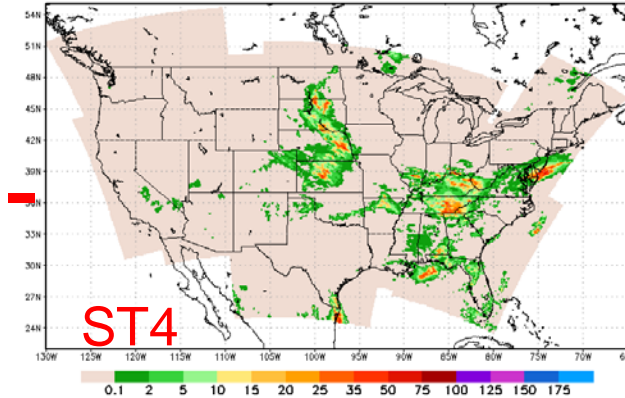
CCPA 06h Diff Accum (mm) Ending 2015070218



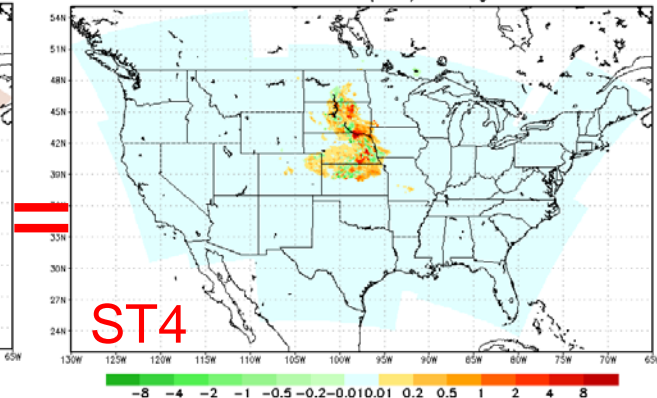
STAGE IV 06h Accum (mm) Ending 2015070218



STAGE IV 06h Accum (mm) Ending 2015070218



STAGE IV 06h Diff Accum (mm) Ending 2015070218



Look-back period
up to 2days

Look-back period
up to 7days - final

DIFF

Upstream Dependencies

- Stage II & Stage IV (Ying Lin)

Downstream Dependencies

- SREF (Jun Du) – 3hrly CCPA
- NAM (Eric Rogers)
- ConUS QPF verification package (Ying Lin)
- National Blender Project (ESRL&MDL, will be implemented in the near future)

Other Applications

- WPC daily precipitation analysis products (CCPA web products)
- Daily precipitation verifications (WPC and EMC meg briefing)
- Hydrological application – NWC and RFC
- Research Communities

Summary

- **Updating regression coefficients:**
 - Some slight improvements of CCPA can be seen in term of RMSE, MERR and CRPS.
 - No negative impact and degradation were found when regression coefficients are updated and applied to generate new version of CCPA.
- **Periodic (annual) upgrading regression coefficients with increasing sample size makes CCPA methodology robust.**
- **Per user request the new version of CCPA historical data has been regenerated and will be available to the public.**

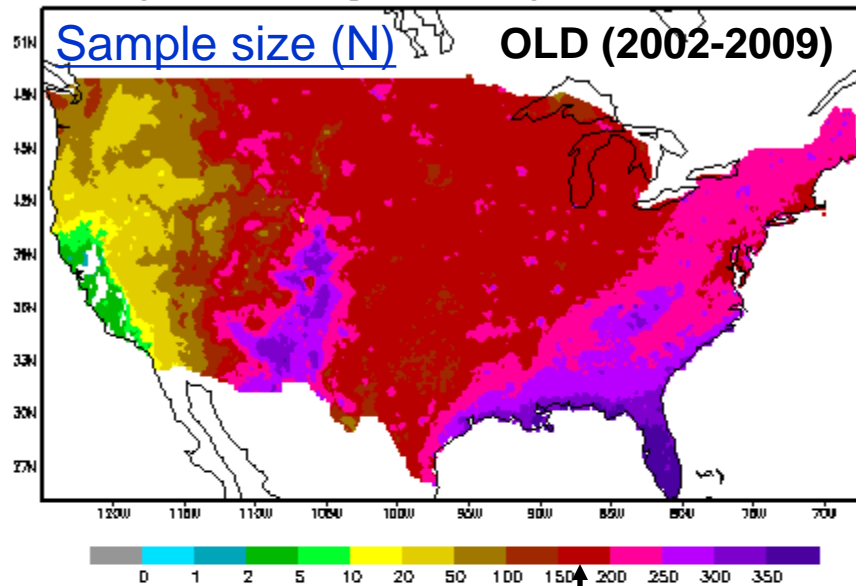
Acknowledgments:

- Ying Li – EMC
- Pingping Xie - CPC

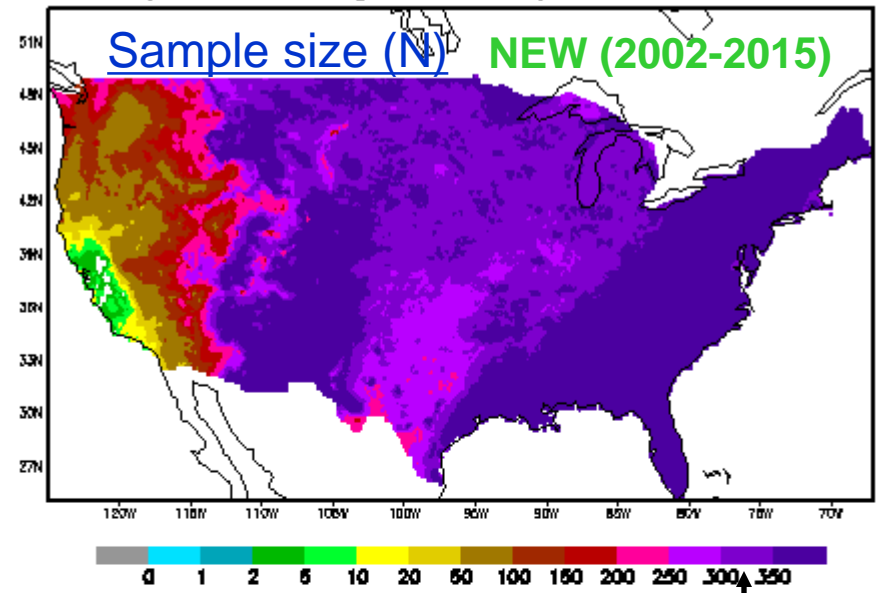
Background!!!

Example of Regression for August 1st

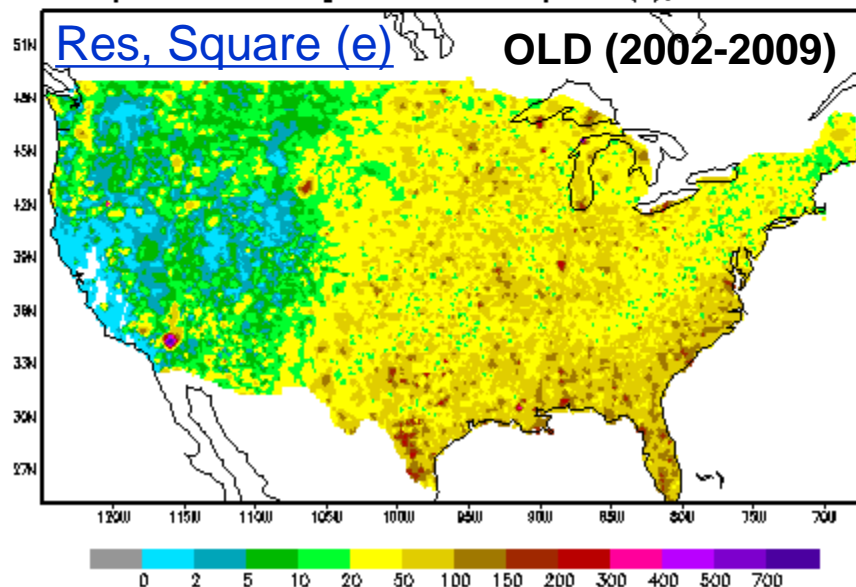
Prcp CPC-ST4 Regression Sample size, 2000 0801



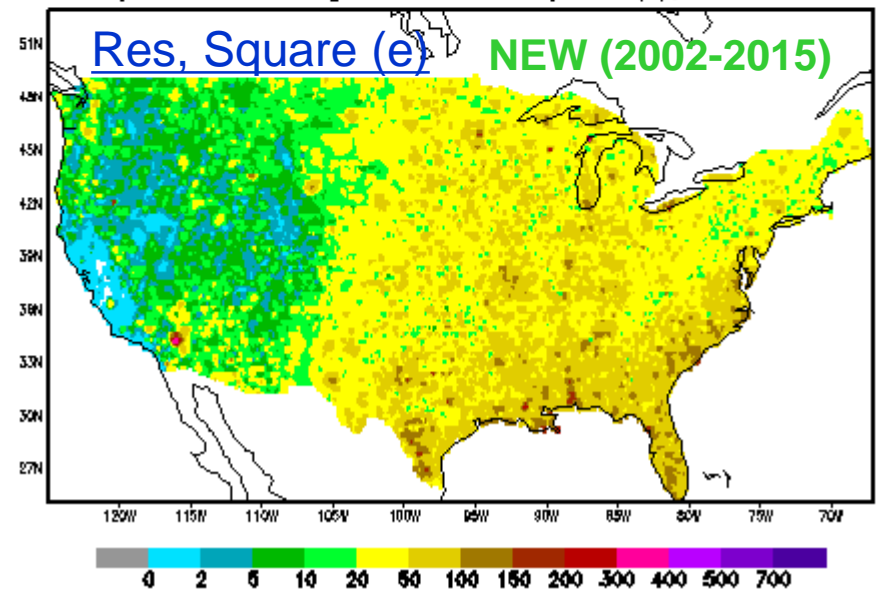
Prcp CPC-ST4 Regression Sample size, 2000 0801



Prcp CPC-ST4 Regression Res. Square (e), 2000 0801

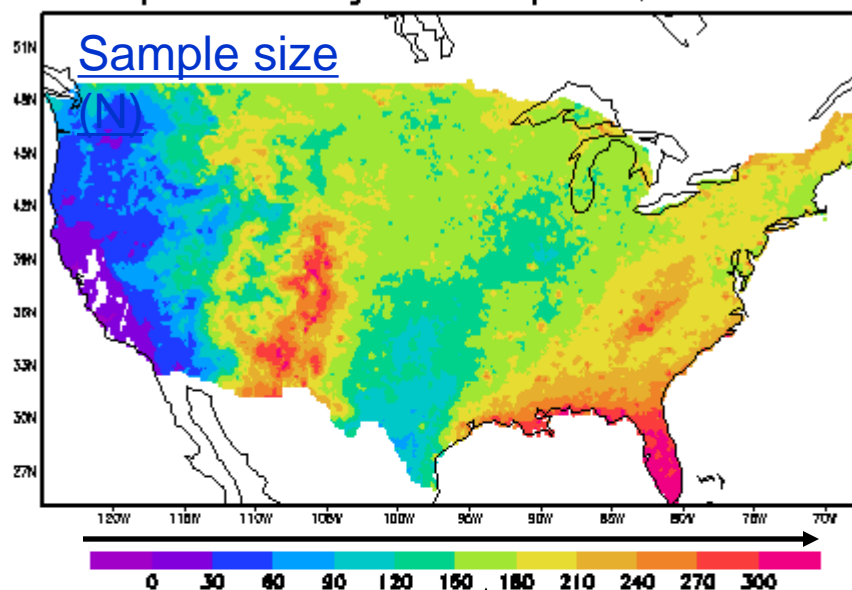


Prcp CPC-ST4 Regression Res. Square (e), 2000 0801

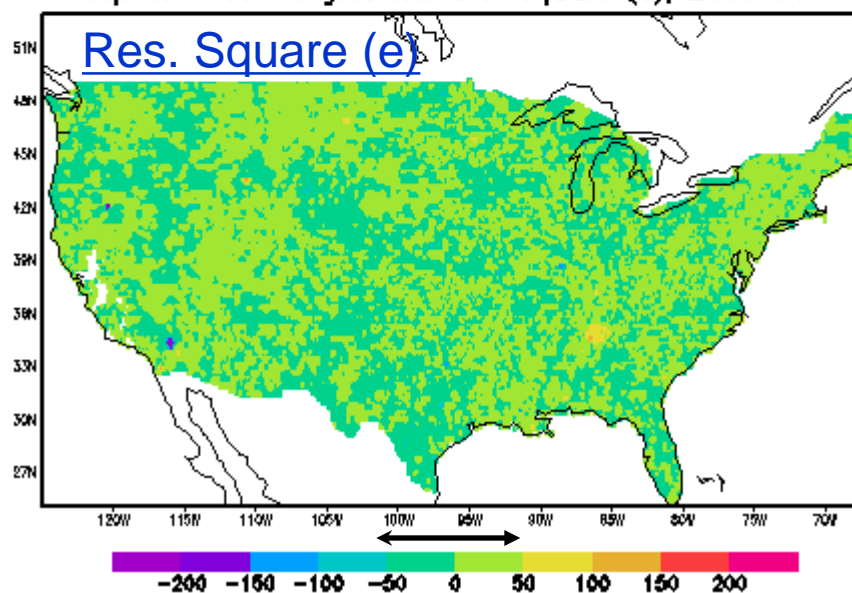


Regression for Aug. 1st – Difference (NEW-OLD)

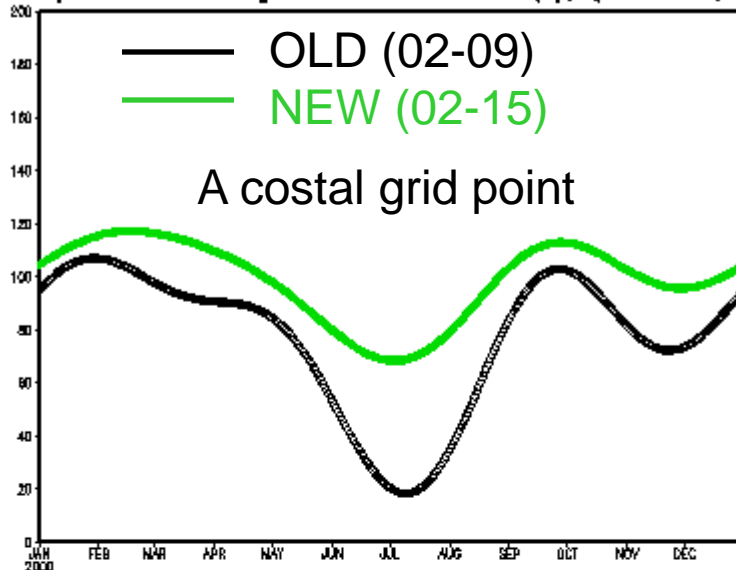
Prcp CPC-ST4 Regression Sample size, 2000 0801



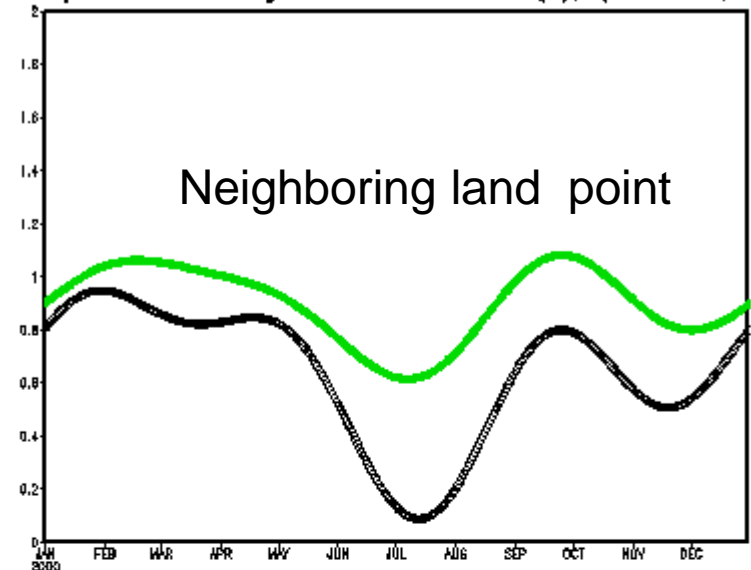
Prcp CPC-ST4 Regression Res. Square (e), 2000 0801



Prop CPC-ST4 Regression Coefficient (A), (Point 21,97)

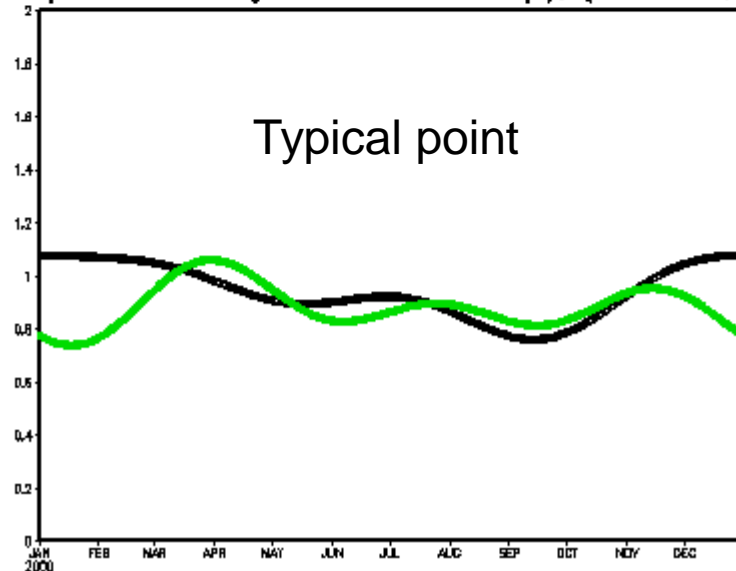


Prop CPC-ST4 Regression Coefficient (A), (Point 22,98)

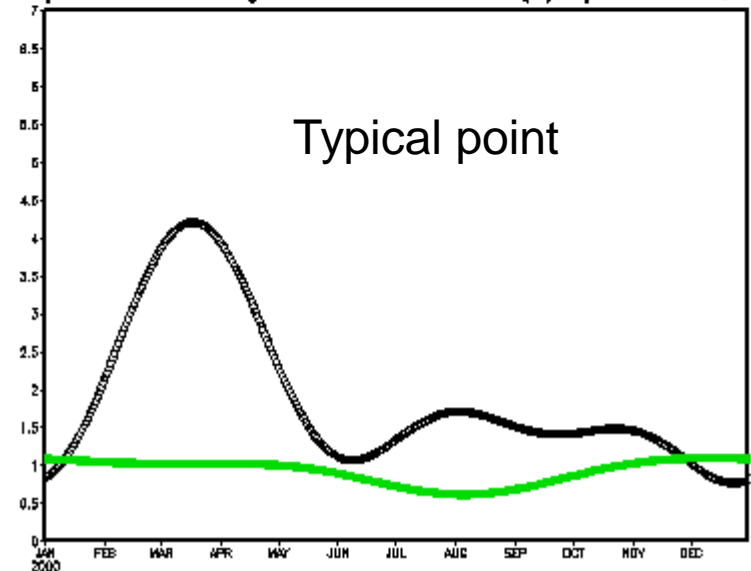


Slope (a) – smoothed

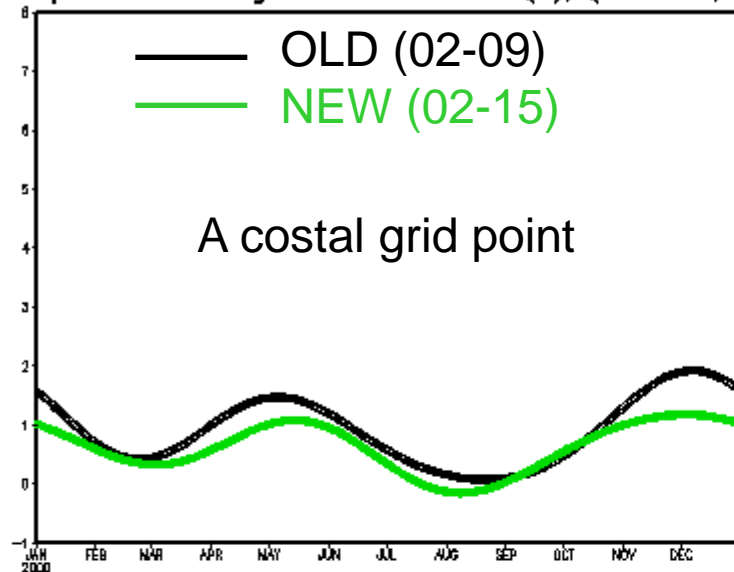
Prop CPC-ST4 Regression Coefficient (A), (Point 298,47)



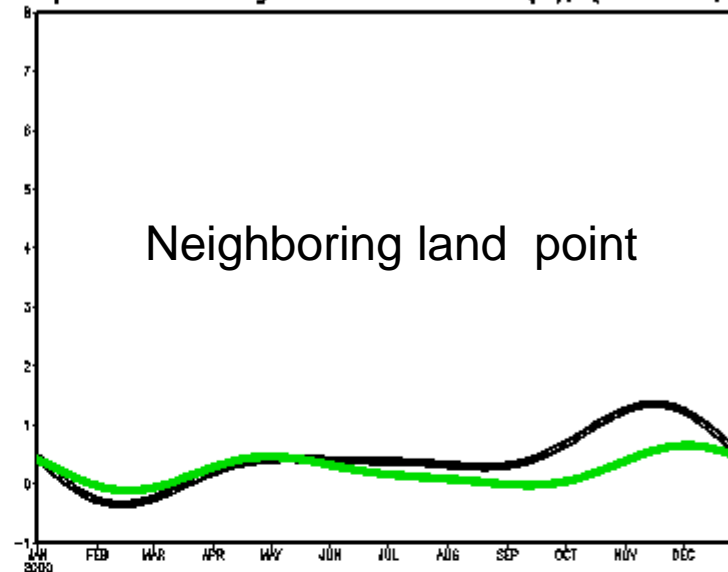
Prop CPC-ST4 Regression Coefficient (A), (Point 120,158)



Prp CPC-ST4 Regression Coefficient (B), (Point 21,97)

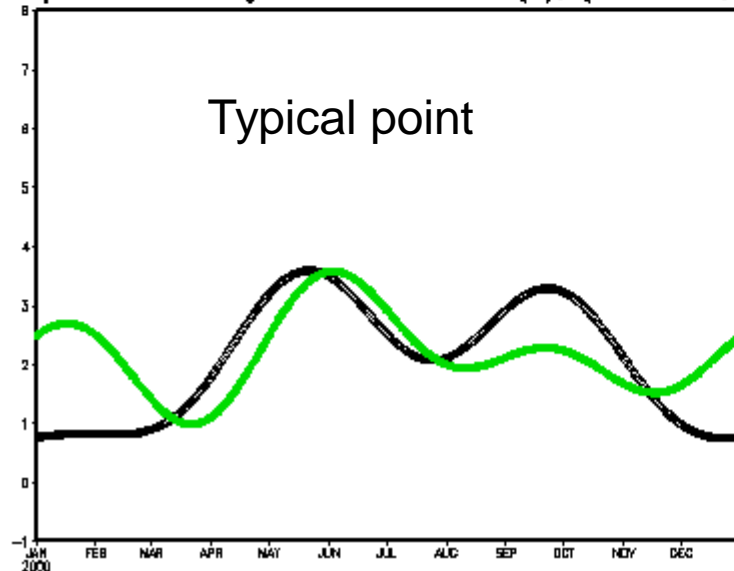


Prp CPC-ST4 Regression Coefficient (B), (Point 22,98)

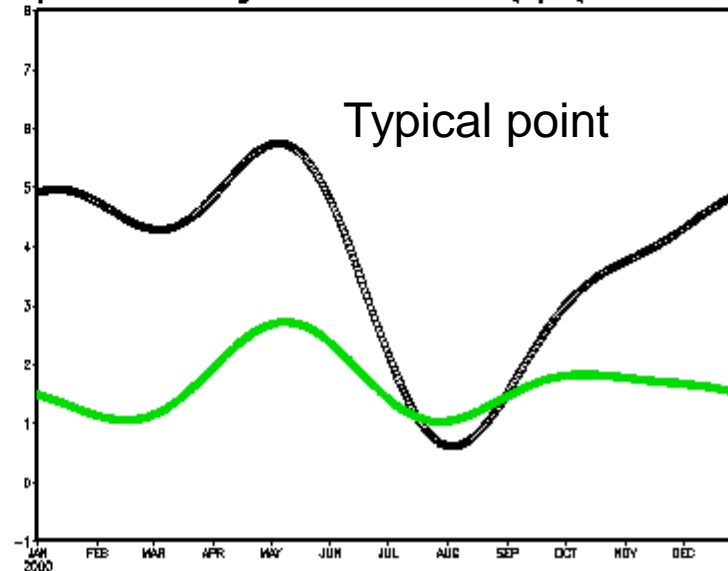


Intercept (b) – smoothed

Prp CPC-ST4 Regression Coefficient (B), (Point 298,47)

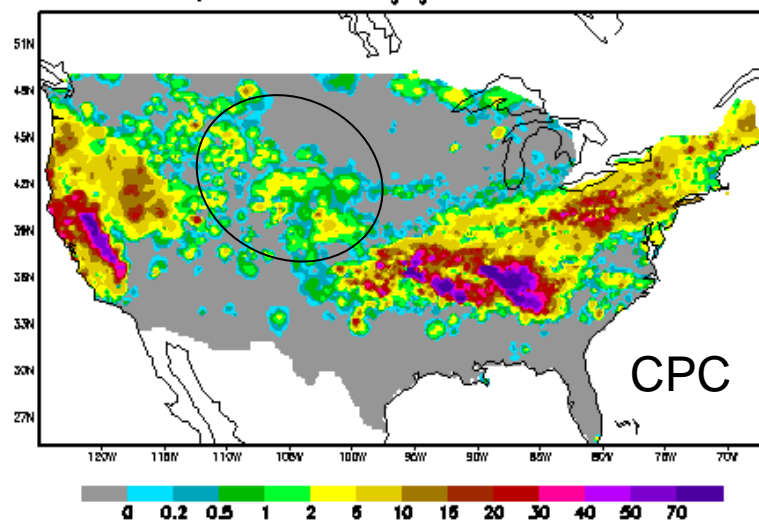


Prp CPC-ST4 Regression Coefficient (B), (Point 120,158)

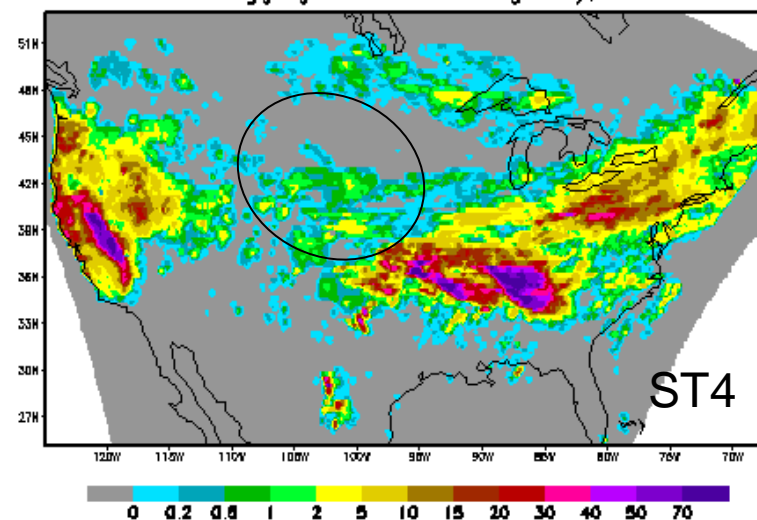


Example of analyses (24hours valid at 12Z May 02 2009)

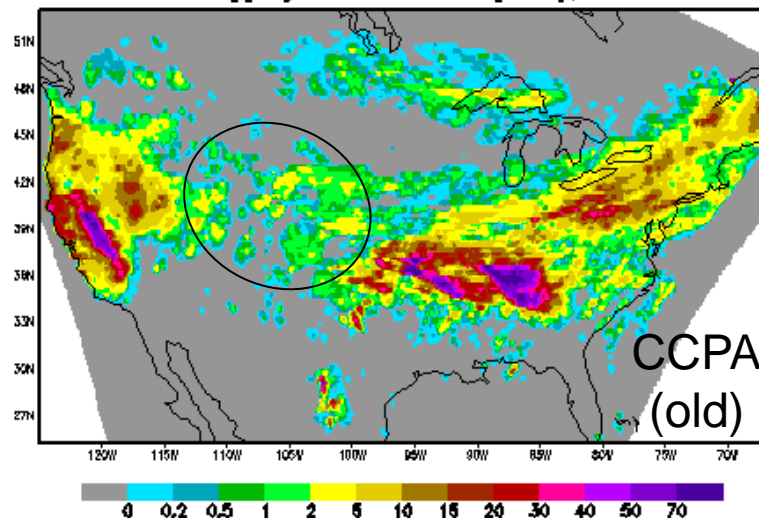
rain, CPC 0.125 deg grib file 2009 0502



rain STAGE4 aggregated to 0.125deg daily, 2009 0502

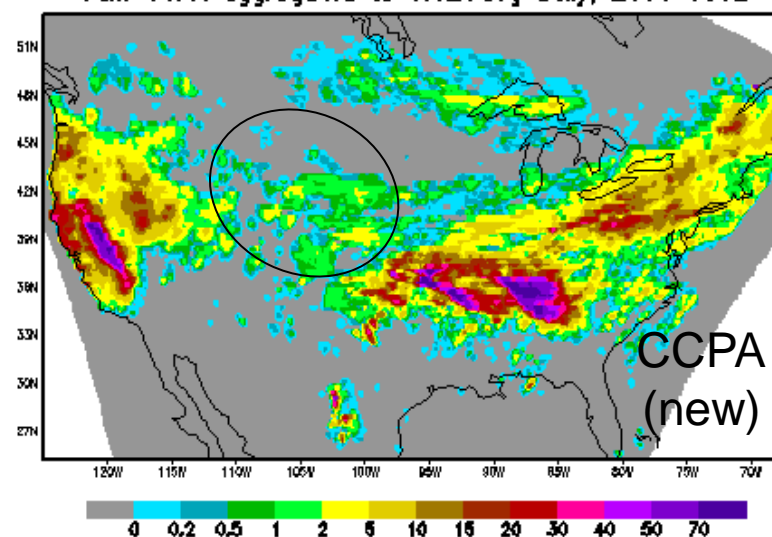


rain CCPA aggregated to 0.125deg daily, 2009 0502



$$\text{CCPA}_{\text{old}} = a_{7\text{yr}} \cdot \text{ST4} + b_{7\text{yr}}$$

rain CCPA aggregated to 0.125deg daily, 2009 0502



$$\text{CCPA}_{\text{new}} = a_{13\text{yr}} \cdot \text{ST4} + b_{13\text{yr}}$$



CCPA (V3.0.0) Upgrade for CONUS

Project Status as of 03/06/15



Project Information and Highlights

Lead: Yuejian Zhu, Yan Luo EMC, Becky Cosgrove, NCO

Scope:

- Model – Climatology-Calibrated Precipitation Analysis (CCPA) system version 3.0.0
- Sciences:
 - Update regression coefficients based on 12-year (vs. 7-year) of training data sets of CPC gauge based analysis and STAGE IV multi-sensor estimation
 - Statistically adjust STAGE IV towards CPC analysis
 - Linear regression is applied at 0.125 degree resolution and 24h accumulation
- Output
 - Converted back to HRAP grid and 6 hour accumulation
 - Interpolated to 1.0, 0.5, 0.125 degree and NDGD grids (5km, 2.5km)

Expected Benefits:

- Improved analysis quality with extended training data



Issues/Risks

Issues:

Risks:

Mitigation:

Resource estimation:
1 node for 25 minutes



Scheduling

Milestone (NCEP)	Date	Status
Initial coordination with SPA team	05/01/2015	
EMC testing complete/ EMC CCB approval	06/15/2015	
Initial Code Delivery to NCO	06/19/2015 → 7/01/15	
Technical Information Notice Issued	07/01/2015	
SPA begins prep work for 30 day test	06/22/2015 → 7/06	
30-day evaluation begins	07/20/2015 → 8/03	
30-day evaluation Ends	08/18/2015 → 9/01	
Management Briefing	09/04/2015 → 9/11	
Operational Implementation	09/08/2015 → 9/15	



Finances

Associated Costs:

Funding Sources: EMC Base: T2O 3 Man-months; NCO Base: 0.2 man-months for implementation, 0.2 man-month annually for maintenance



Management Attention Required



Potential Management Attention Needed



On Target

Requested Product Volume

Disk Usage	Current Production	Expected New Production	Actual New Production
IBM Disk	52 MB/day	104 MB/day	-
IBM Tape	52 MB/day	104 MB/day	-
NCEP FTP Server	12 MB/day	21 MB/day	-

Note: IBM Disk has 20 days of output residing in /com, save the day before 8 days' output in HPSS.

Requested Production Resources

Continue to use 1 node. Run time to increase from 10 to 20-25 minutes.

Downstream impacts, product changes

- Additional 2.5 km NDGD grid product
- Product directory structure change

current: /com/gens/prod/gefs.yyyymmdd/cyc/ccpa

new: /com/ccpa/prod/ccpa.yyyymmdd/cyc

NCEP NOMADS:

[http://nomads.ncep.noaa.gov/pub/data/nccf/com/ccpa/prod/ccpa.YYY
YMMDD/HH](http://nomads.ncep.noaa.gov/pub/data/nccf/com/ccpa/prod/ccpa.YYY
YMMDD/HH)

- File name change by following NCO filename conventions

e.g.,

ccpa_conus_0.5d_t21z_03h_gb2 → ccpa.t21z.03h.0p5.conus.gb2

Implementation Details

- Rules
 - Only Non-Zero Stage IV is adjusted
 - Zero values remains zero
 - Adjustment is applied over CONUS LAND only
- Leap Year
 - 366 day convention is adapted in regression calculations
 - Feb 29 has its own regression coefficients a and b
- Spatial Continuity
 - US Boundaries
 - Land/Ocean Boundary
 - Zero/Non-Zero Boundary
- Rare cases of abnormal regression coefficients
 - Temporal smoothing of a and b reduces abnormal values
 - Discard the regression coefficients a and b, if too large
 - Set an upper limit to the adjusted St4 value