CCPA V4.0 Upgrade

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Presentation for EMC CCB/ODB

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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
- Climatology 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 (HRAP) 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
  - NBM projects – MDL
  - Hydrological application – NWC and RFC
- 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/ccpa.php

Highlights of CCPA Upgrade

- Update regression coefficients by extending training data sets of CPC gauge based analysis and Stage IV multi-sensor estimation
  - Current: 13 years (2002-2015)
  - Upgrade: 15 years (2002-2017)
  - Expectation: improved analysis with expanded training data sets

- Improve 3-hourly CCPA by using Stage IV hourly data in NWRFC and CNRFC areas
  - Current: using Stage II hourly in both NWRFC and CNRFC
  - Upgrade: will use Stage IV hourly only over CONUS
  - Expectation: improve 3-hourly CCPA with more accurate weights

- Introduce hourly CCPA
  - Requirement from MDL/NBM
  - Method: similar to 3 hourly CCPA
  - Expectation: improved hourly analysis to support NBM projects

Updating Regression Coefficients

1. Historical data sets
   Operational : June 1 2002 to July 31 2015 For CPC and Stage IV
   Updated: June 1 2002 to July 31 2017 (two more years of data)

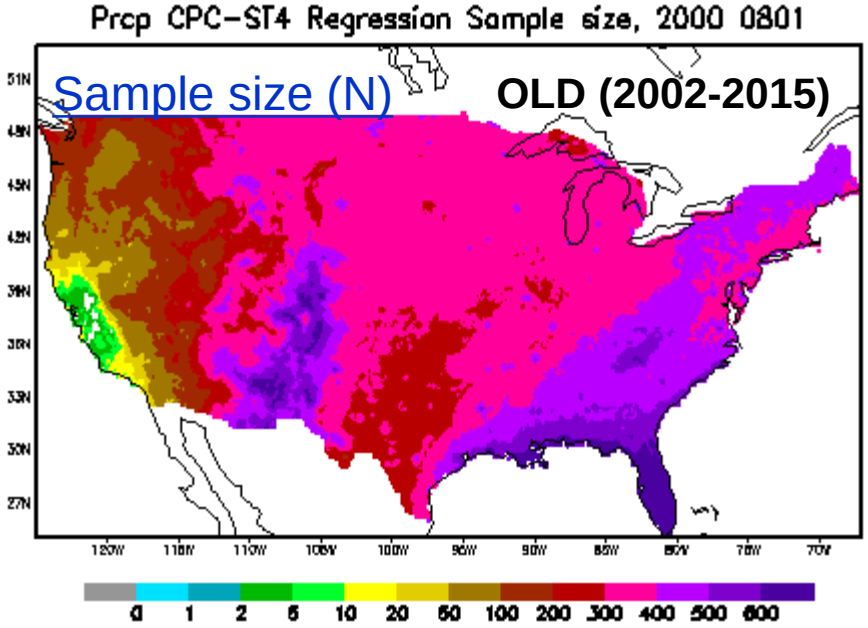
2. Match resolutions
   a. Accumulate Stage IV (hereafter ST4) over 24 hours
   b. Interpolate to ⅛° (copygb w/ volume preservation)

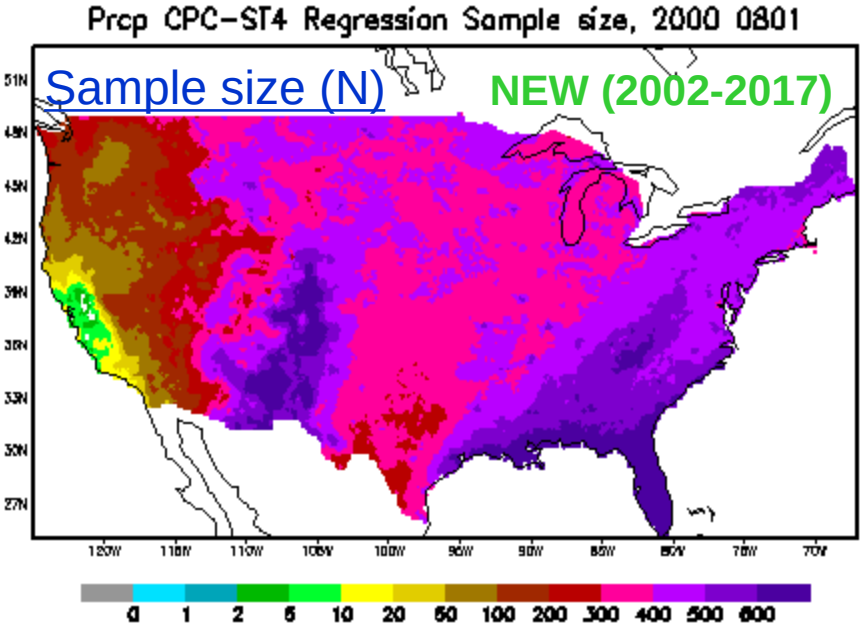
3. Collect precip samples
   a. For each day of the year and at each grid point, collect all precip within 60 day window centered around that day, over all 15 years (max ~915 data points)
   b. Use only data points with ST4 > 0

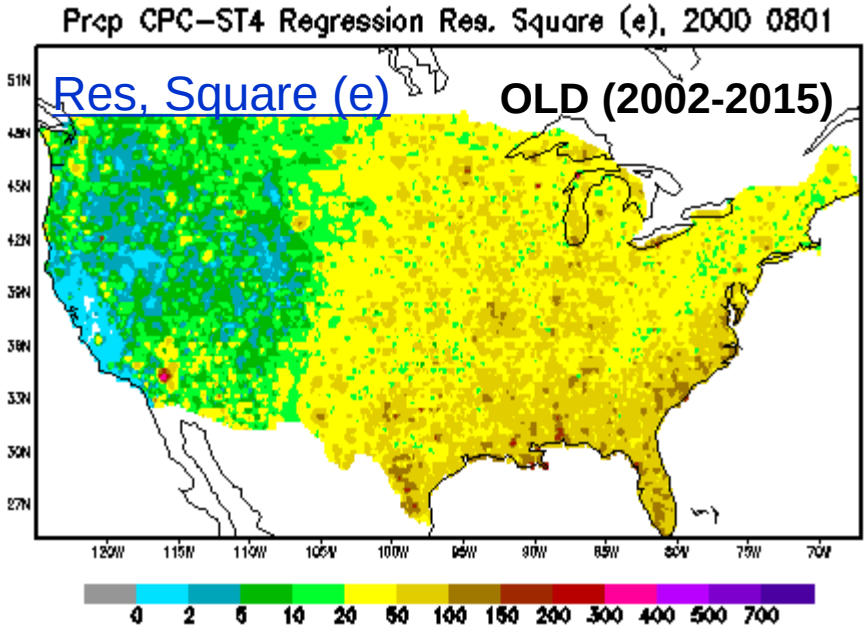
4. Linear regression
   – CPC = a·ST4 + b

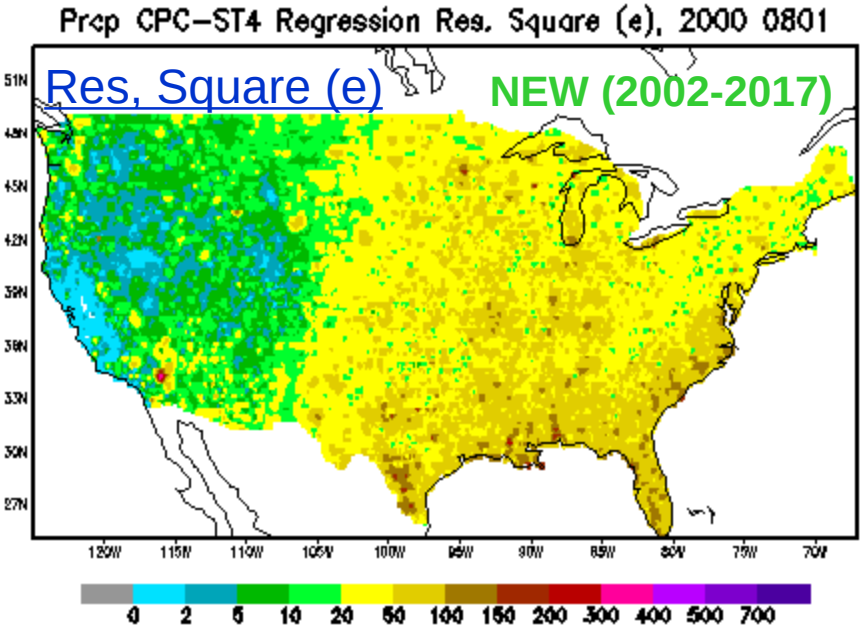
5. End Result
   – Linear relationship (a & b) on ⅛° grid for each day of the year

Example of Regression for August 1st

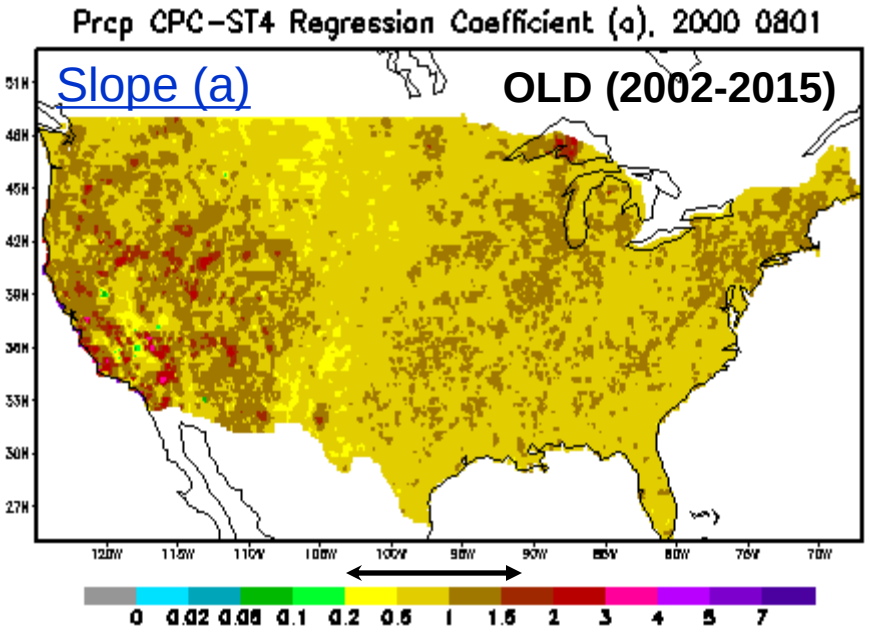


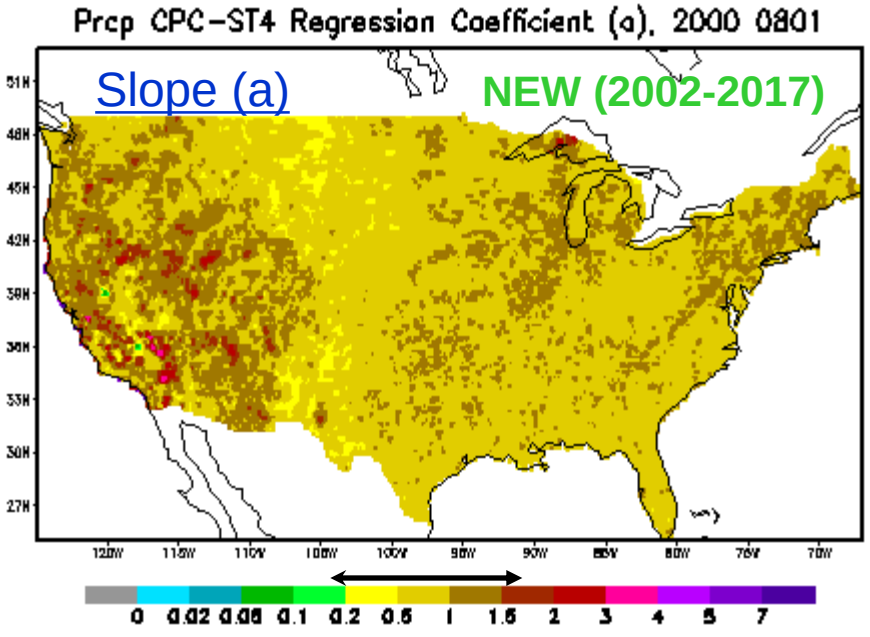


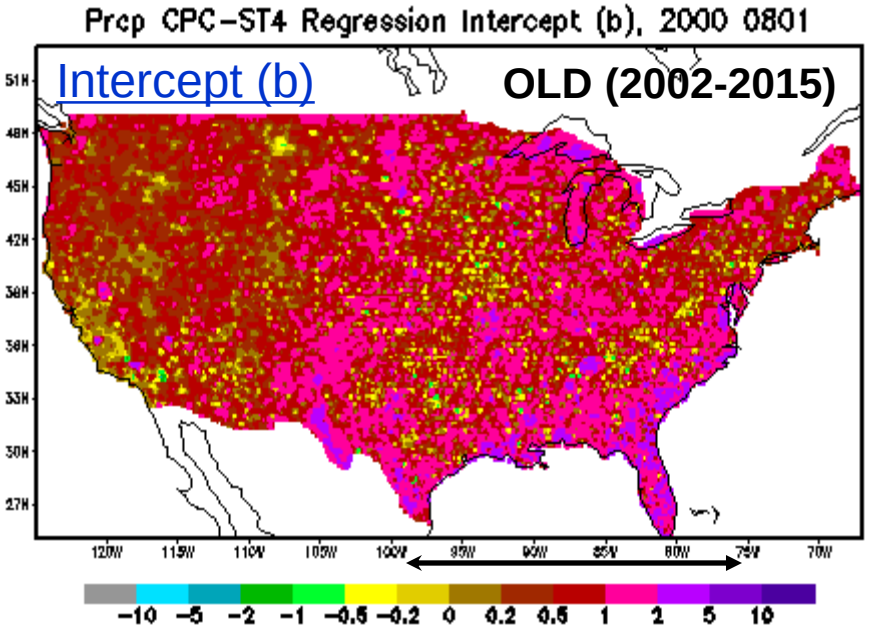


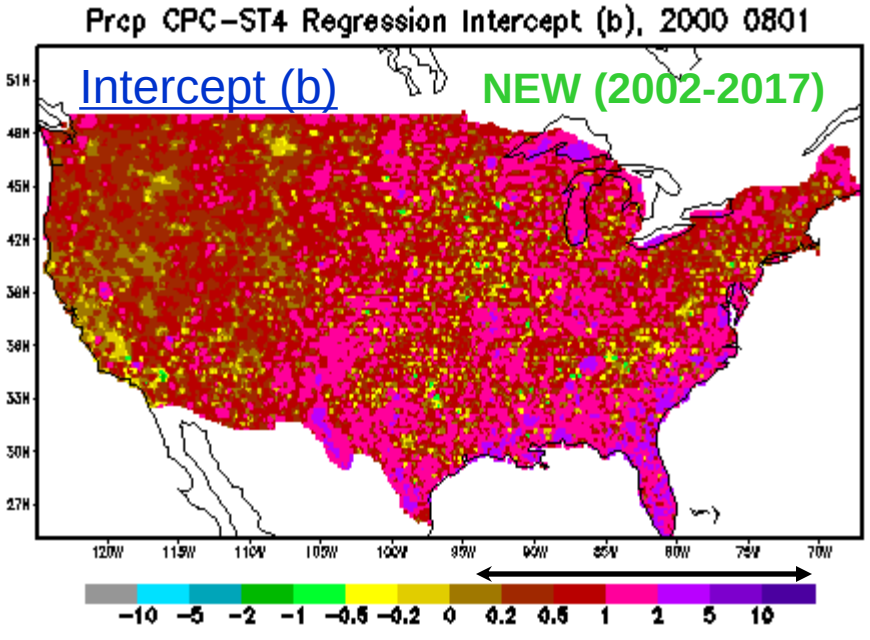


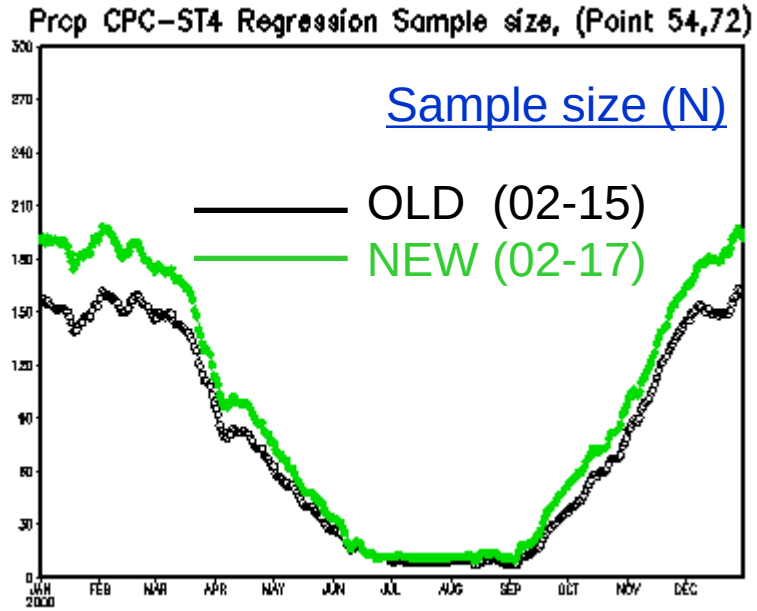
Example of Regression for Aug. 1st

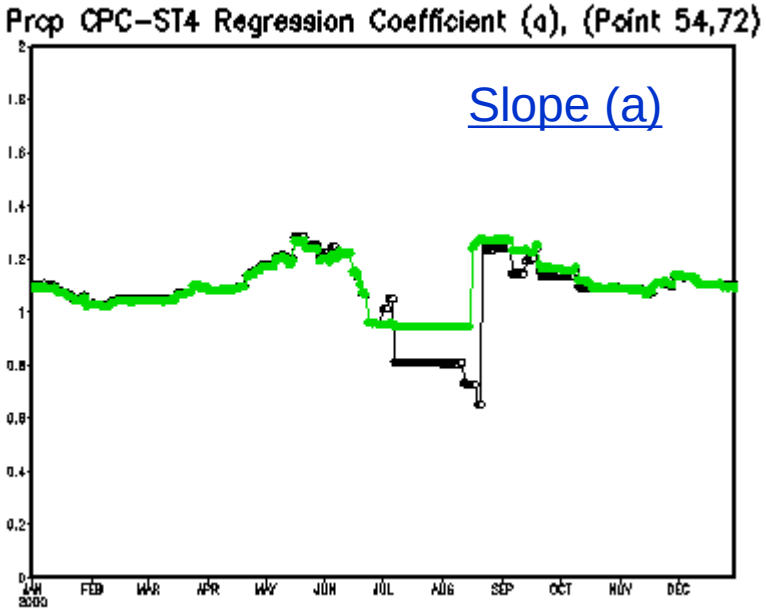




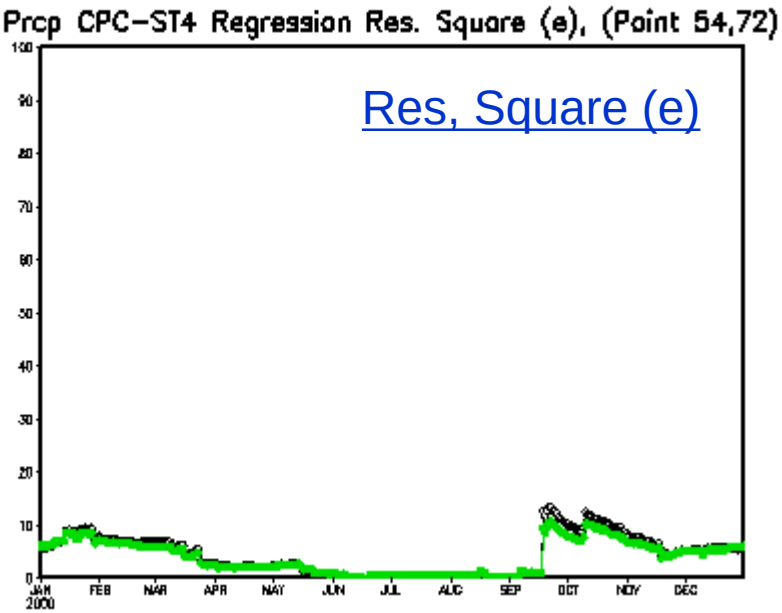


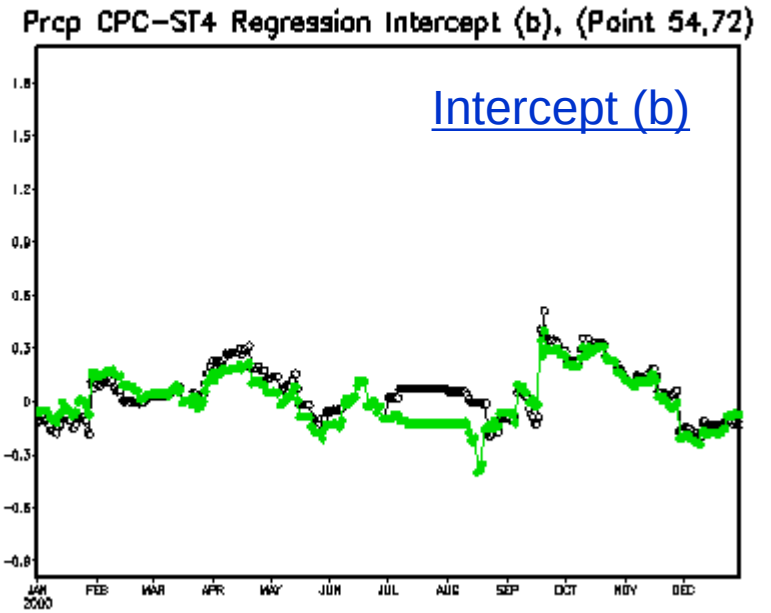


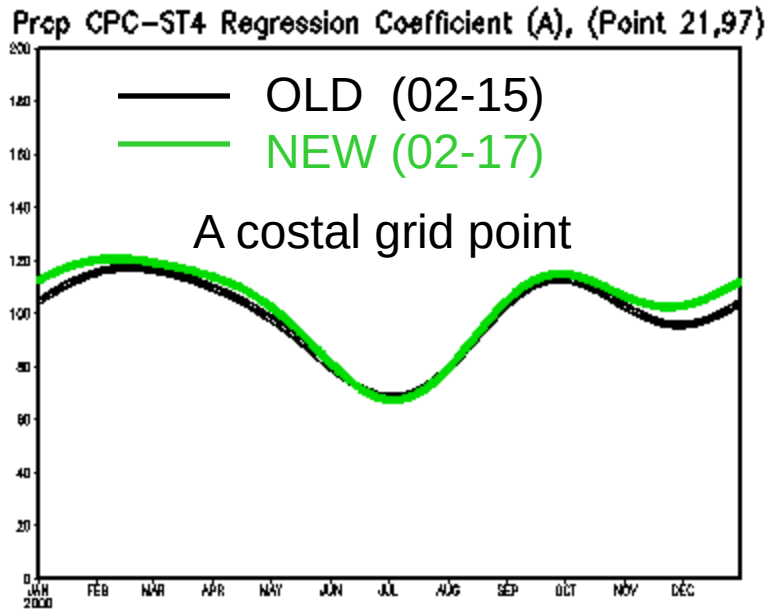


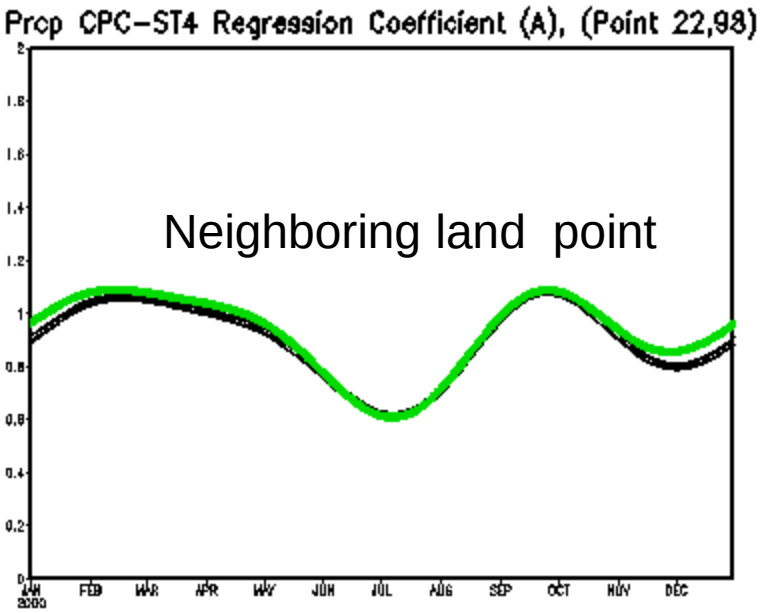


Time series of regression

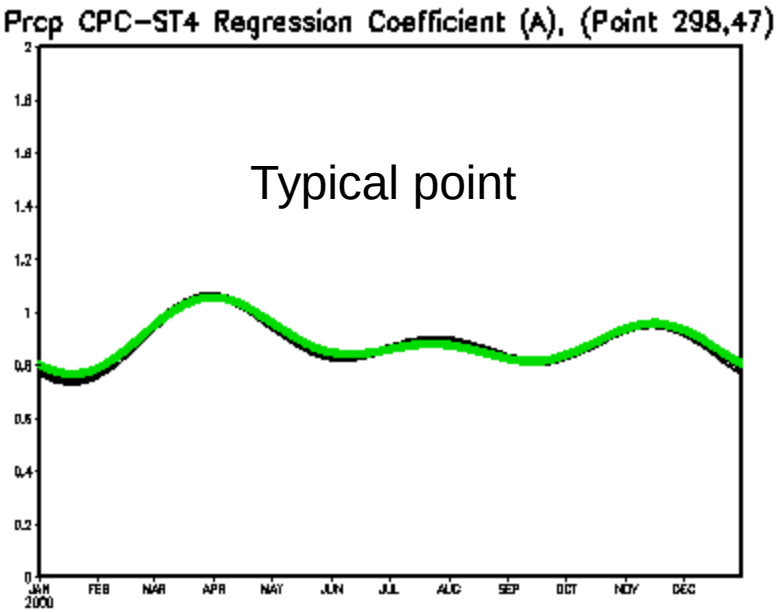


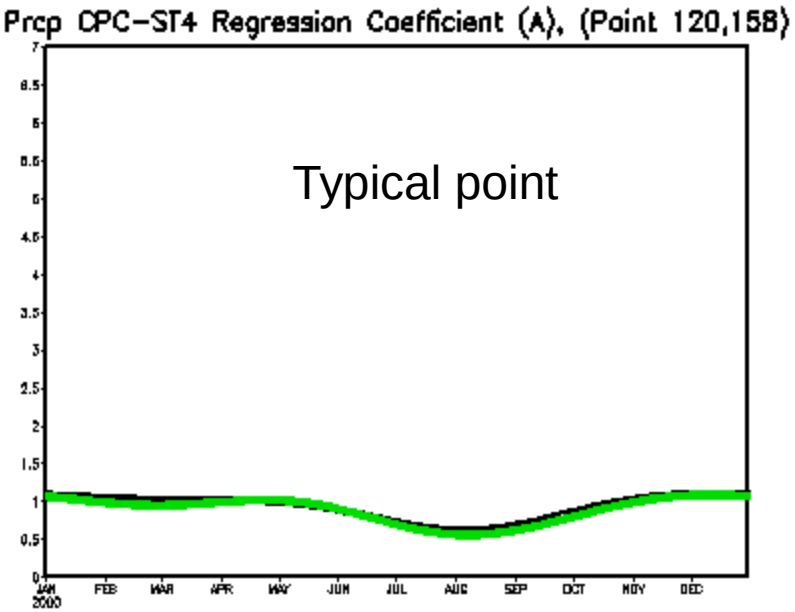


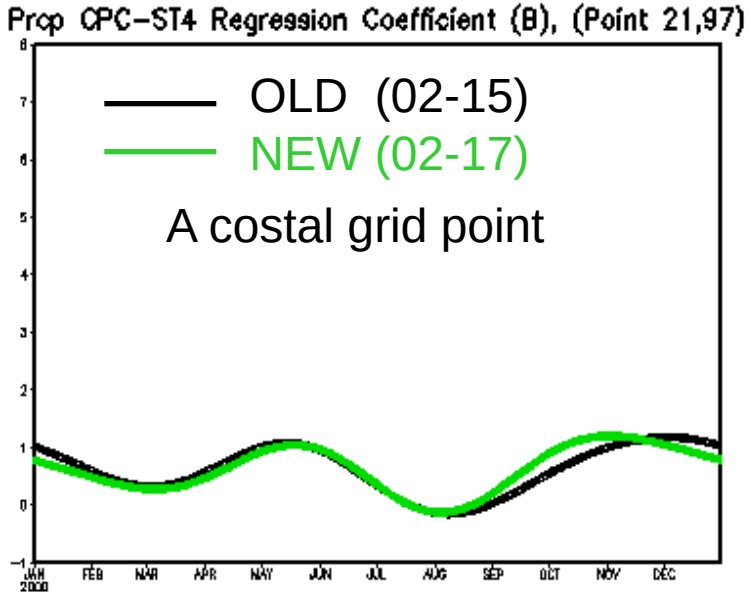


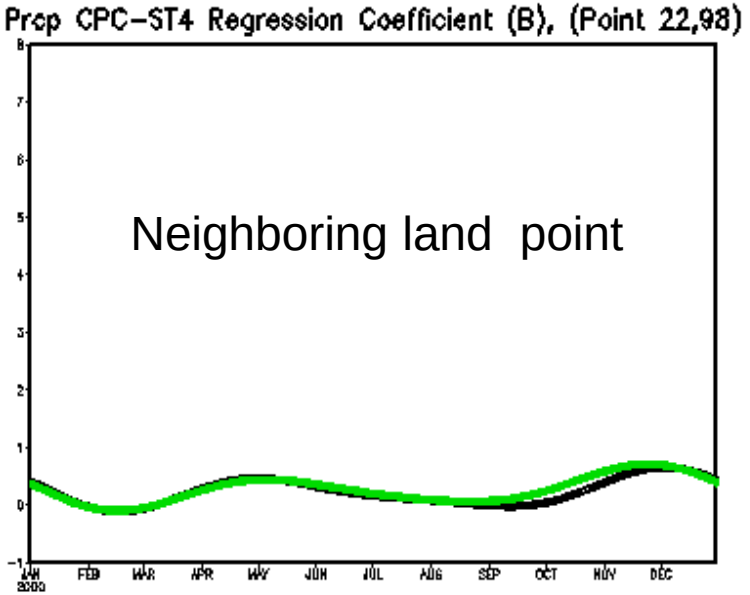


Slope (a) – smoothed

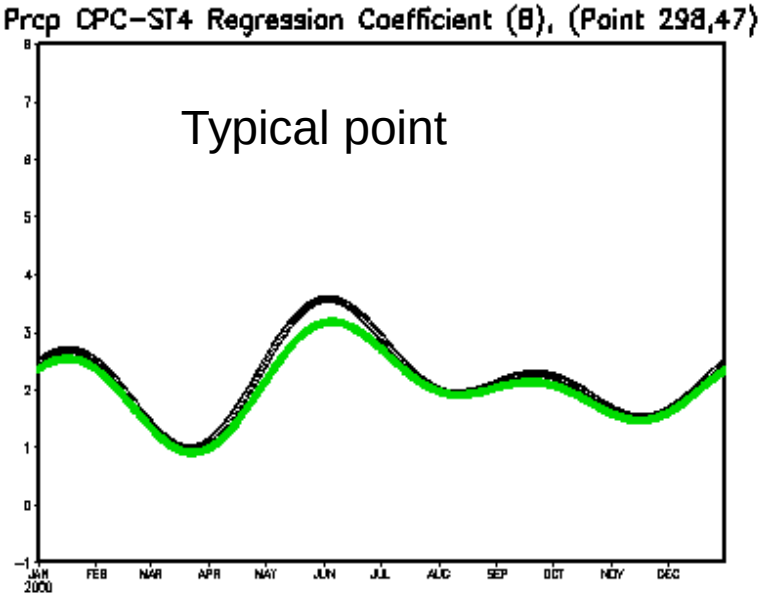


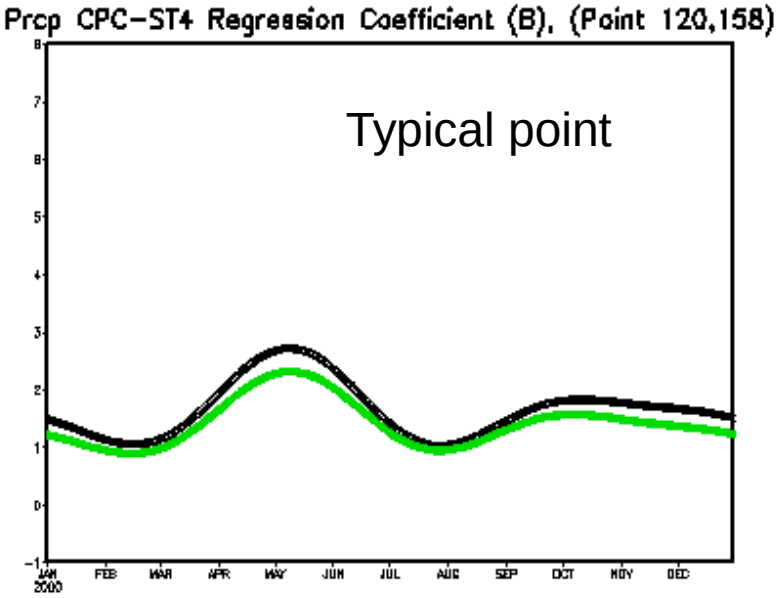




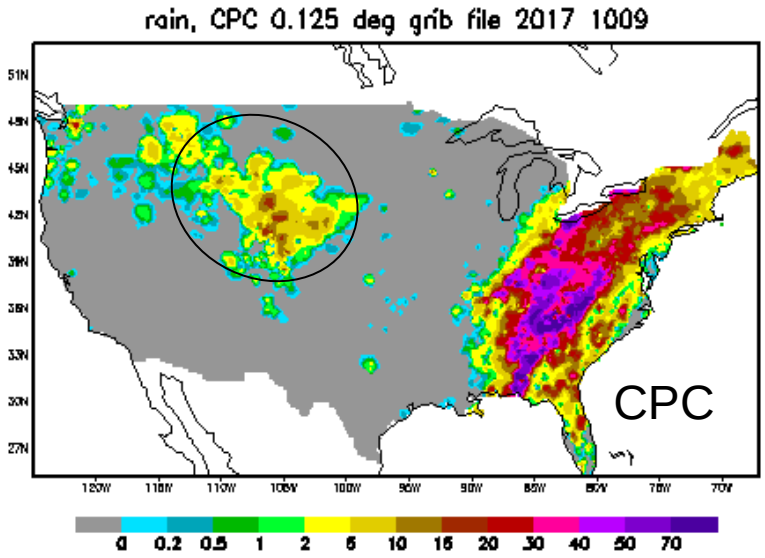


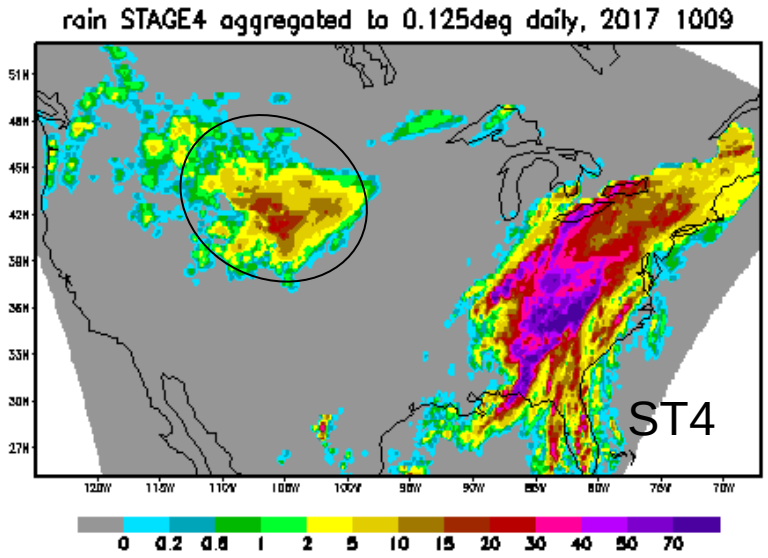
Intercept (b) – smoothed

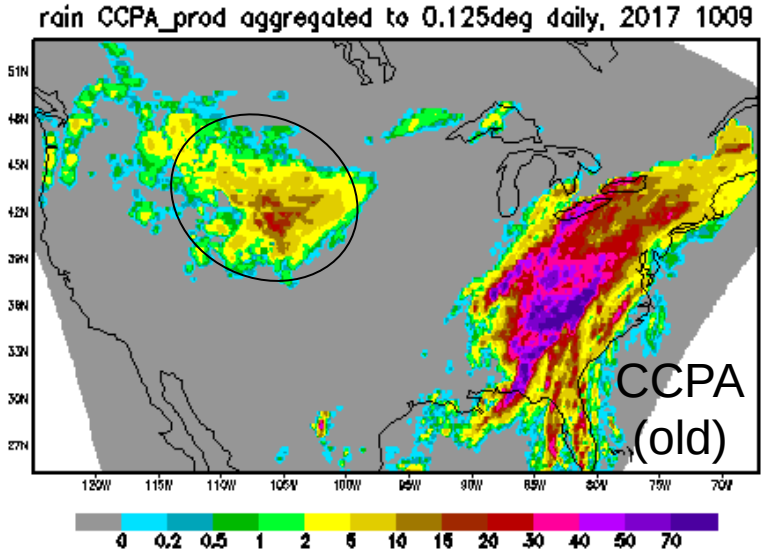


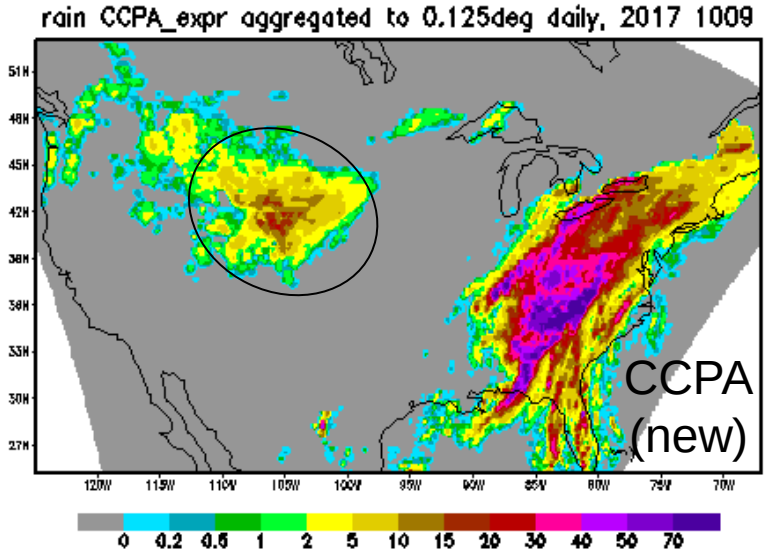


Example of analyses (24hours valid at 12Z Oct 09 2017)





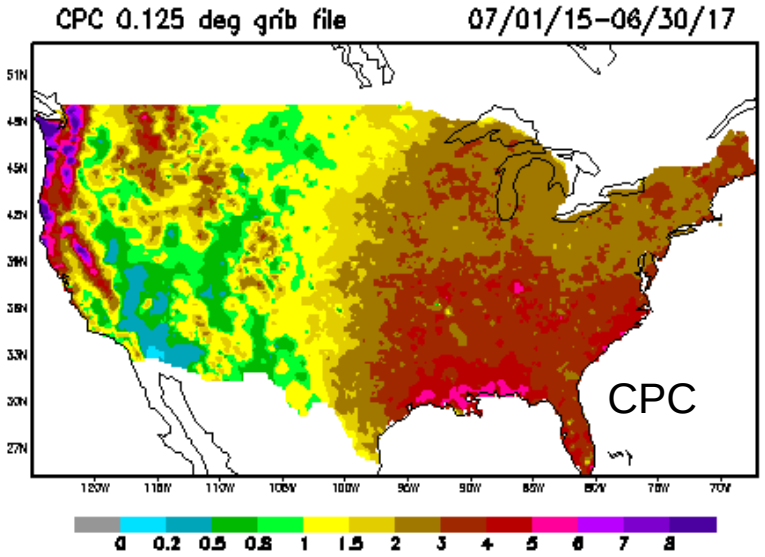


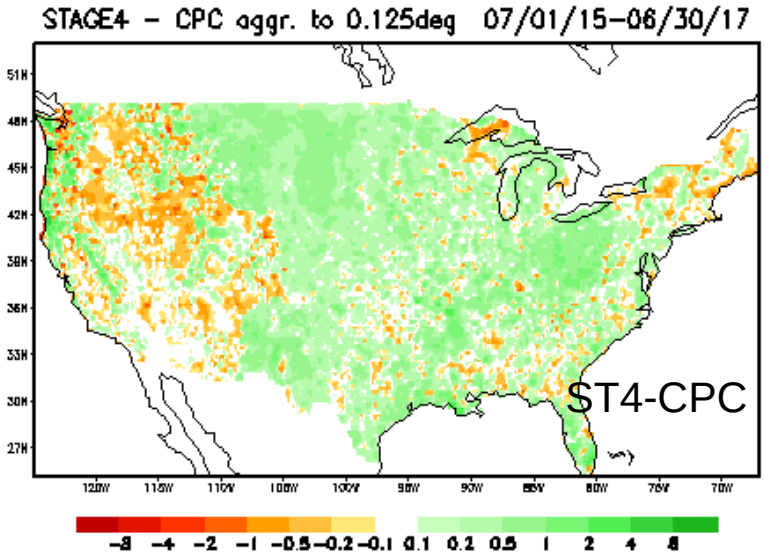


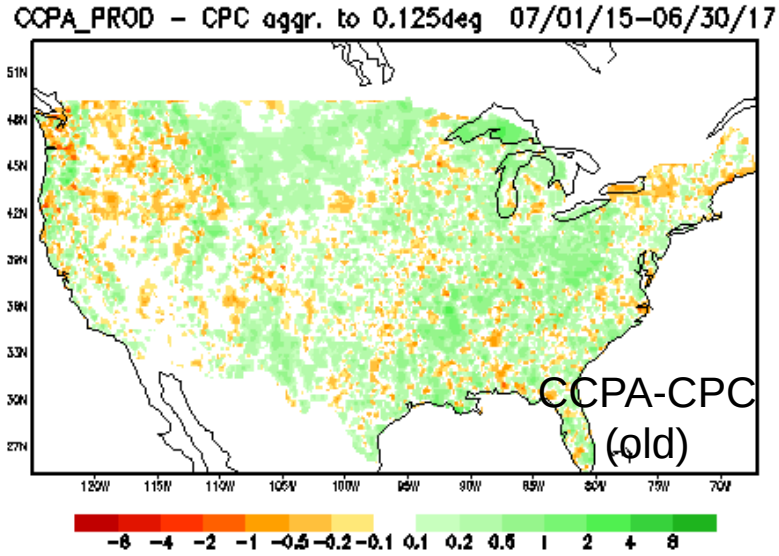
$CCPA\_old = a_{13yr} \cdot ST4 + b_{13yr}$

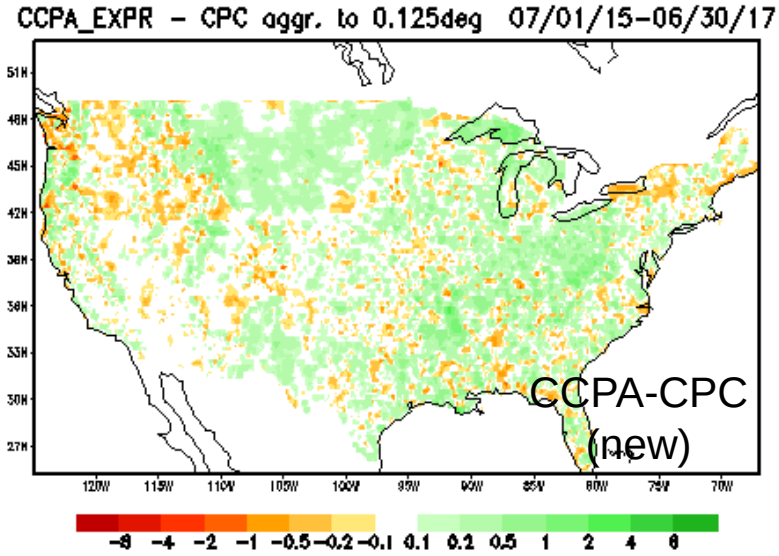
$CCPA\_new = a_{15yr} \cdot ST4 + b_{15yr}$

Comparison against CPC analysis









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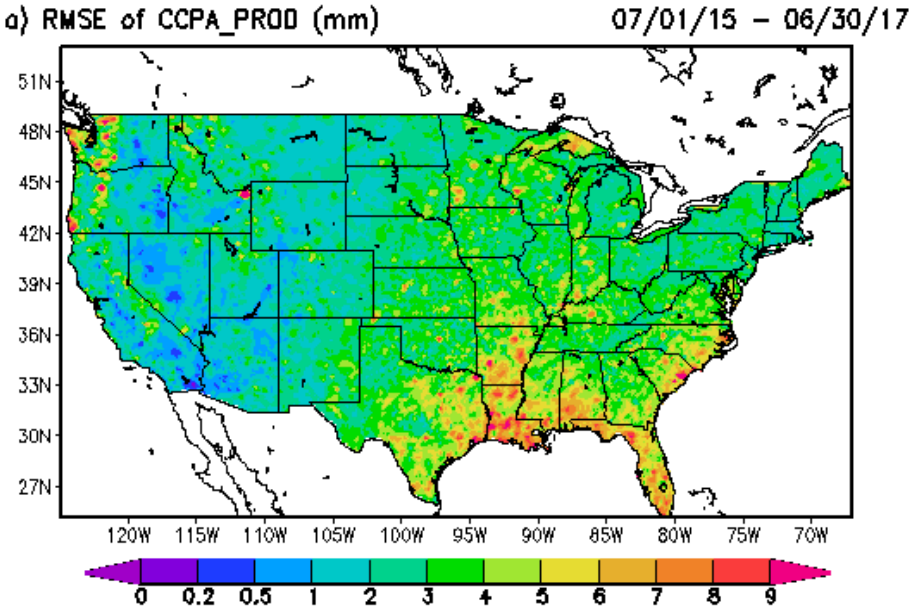
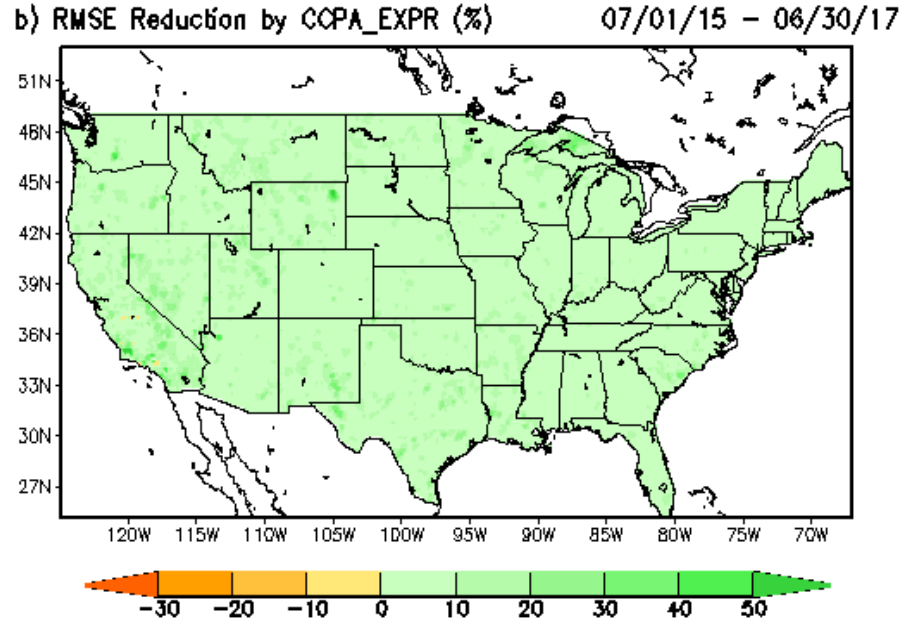
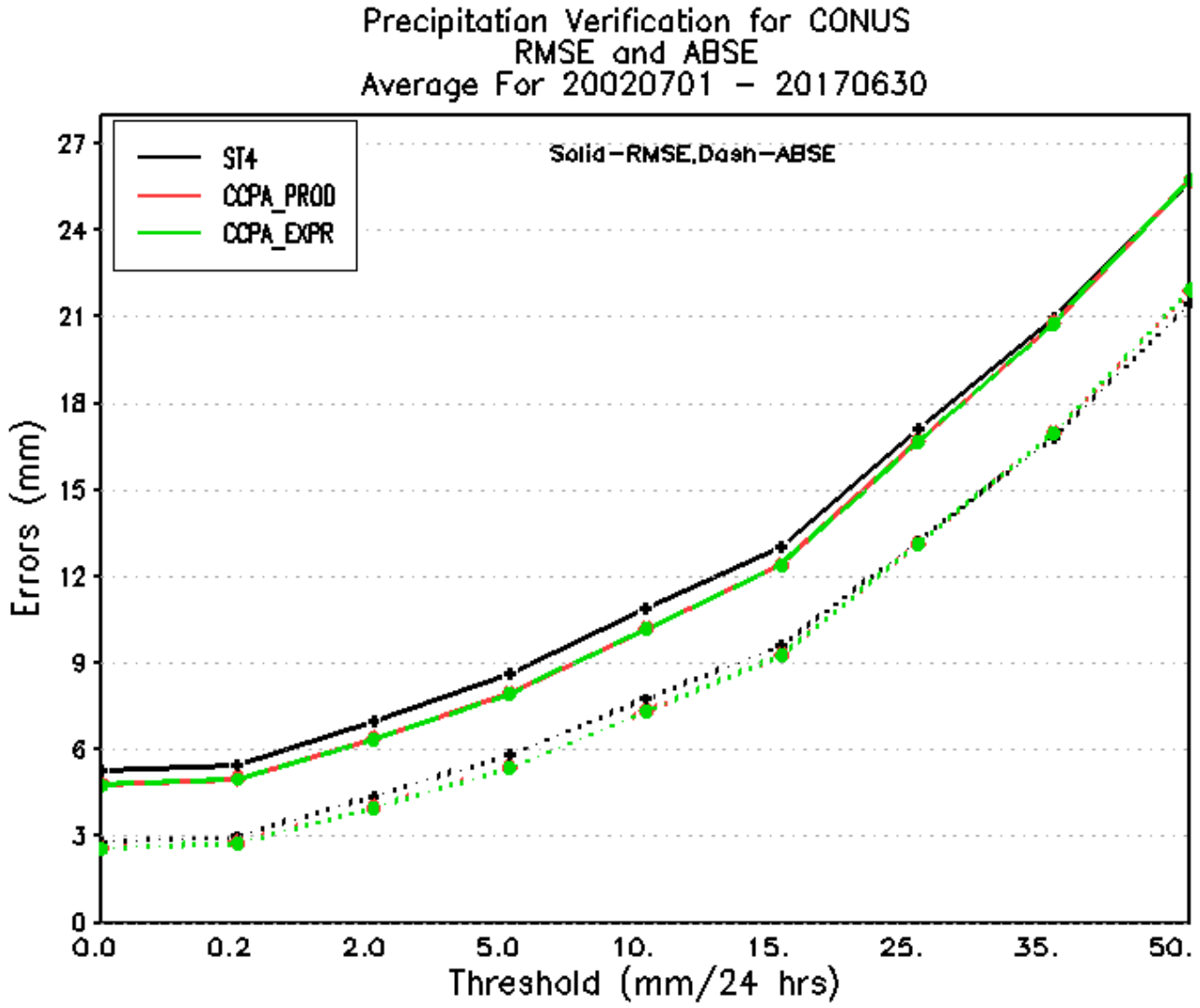




$$\frac{RMSE_{prod} - RMSE_{expr}}{RMSE_{prod}} \times 100\%$$

if >0 improvement
if <0 degradation

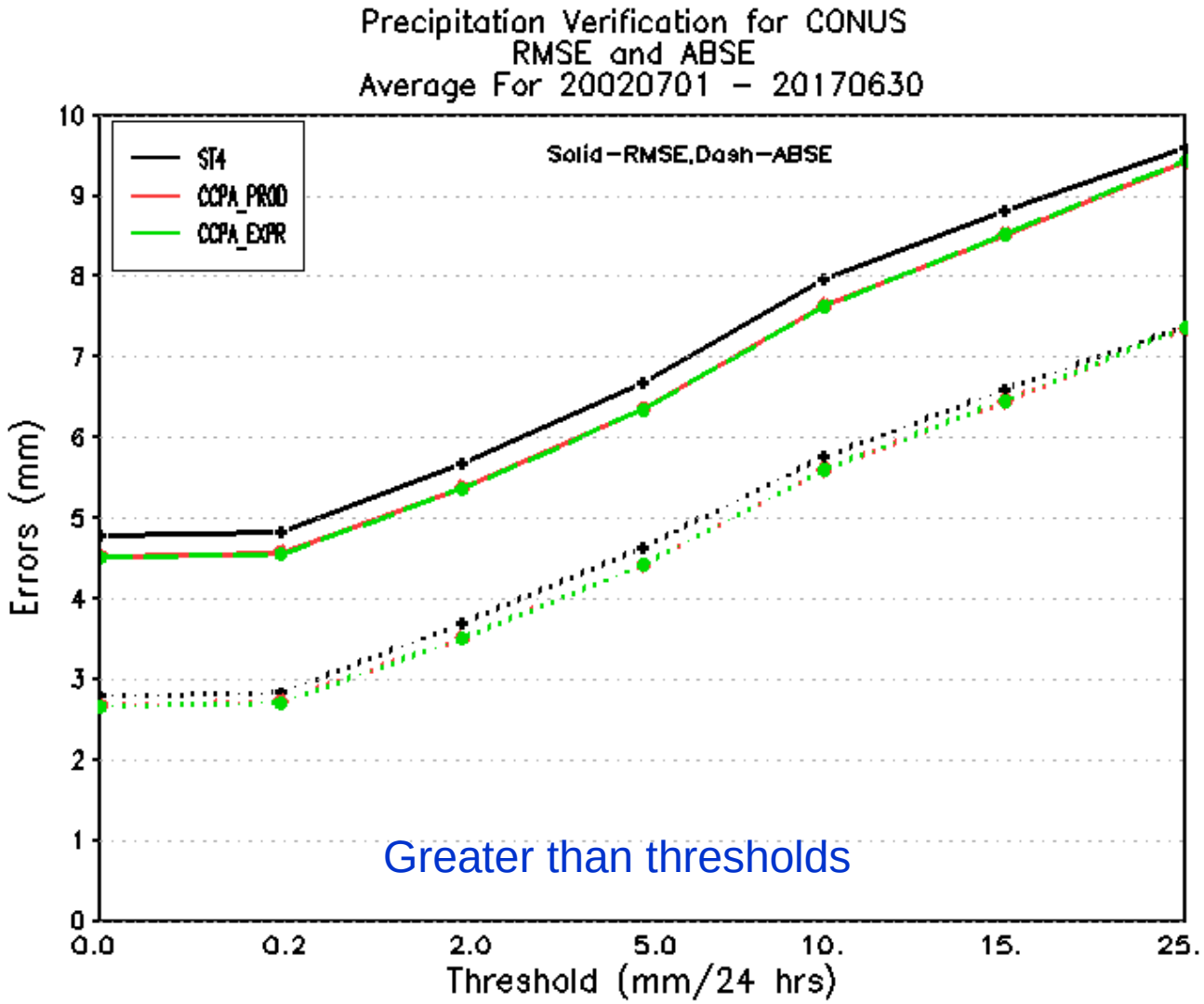
Evaluation against CPC Analysis



Greater than thresholds

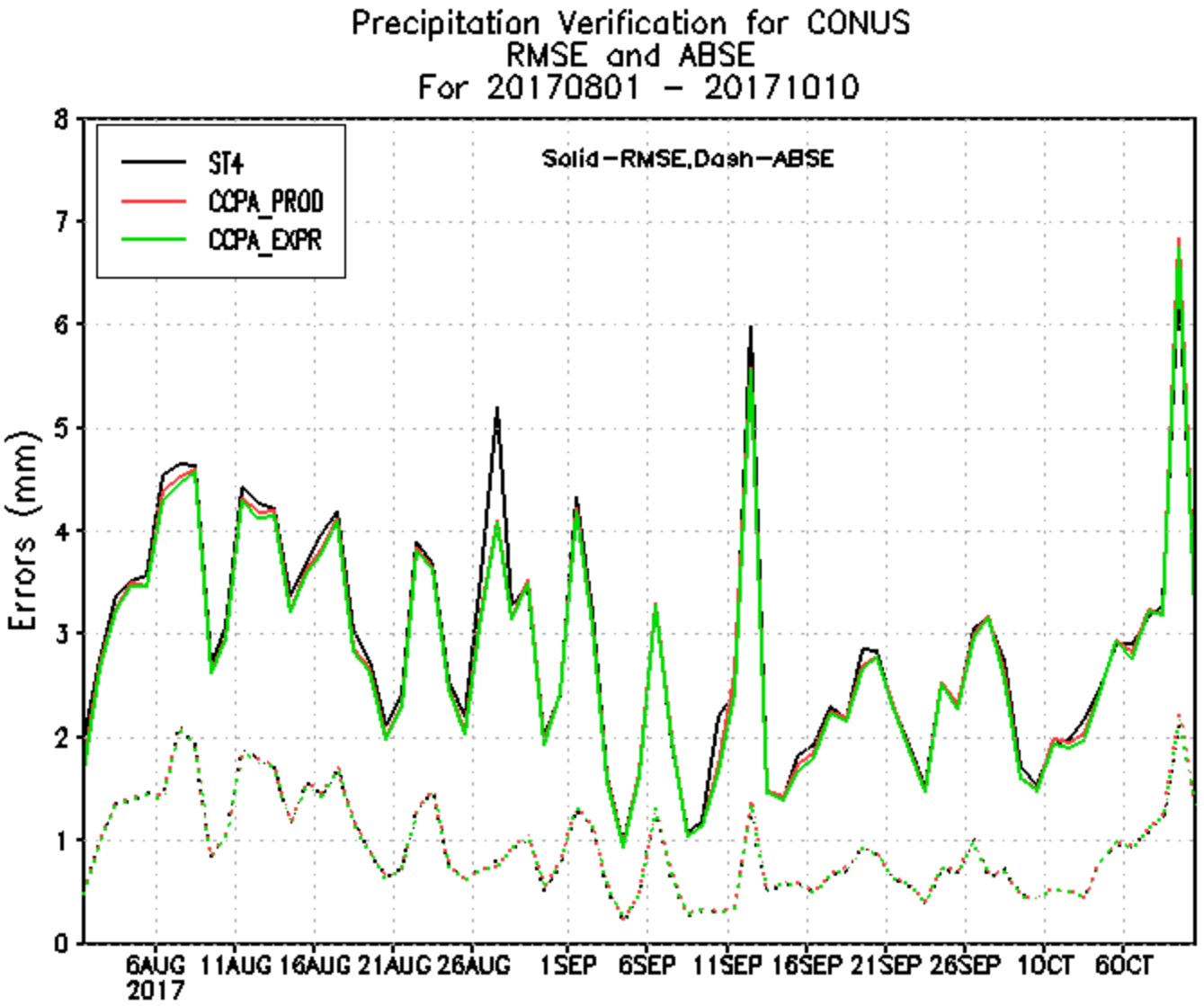
Evaluation against observation

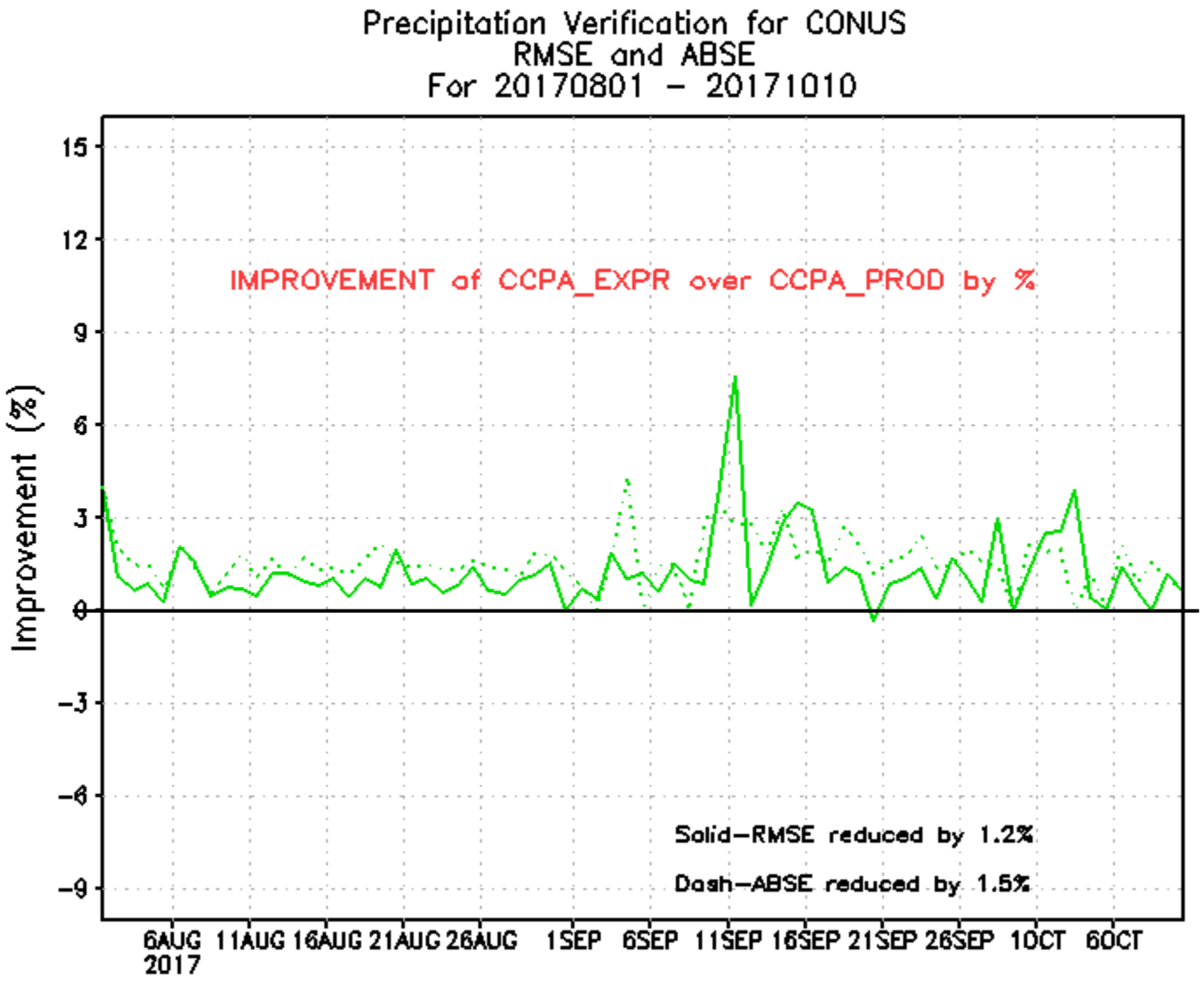
(RFC rain-gauge network)



Evaluation against observation

(RFC rain-gauge network)





$$\text{Improvement Rate} = \frac{\text{RMSE}_{\text{prod}} - \text{RMSE}_{\text{expr}}}{\text{RMSE}_{\text{prod}}} \times 100\%$$

if >0 improvement

if <0 degradation

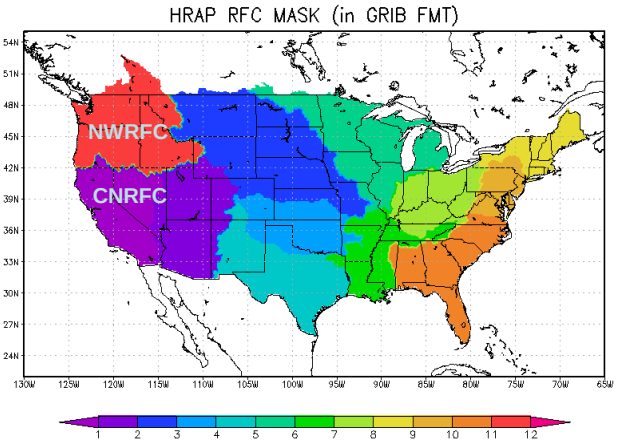
Change Specific to 3-hr CCPA

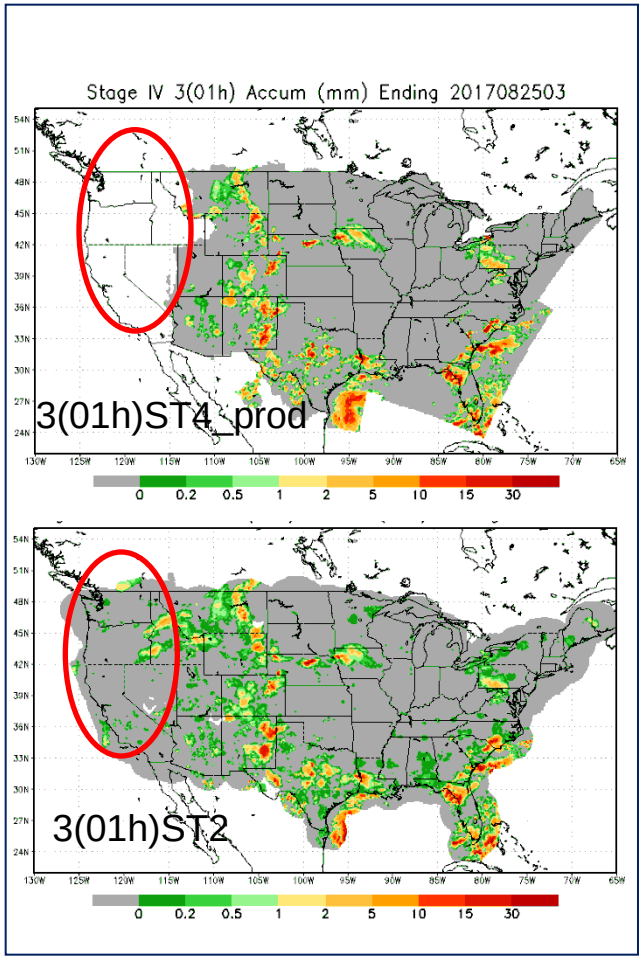
- Current CCPA production is using Stage II hourly in both NWRFC and CNRFC while use Stage IV hourly in remaining areas as weights to produce 3-hr CCPA

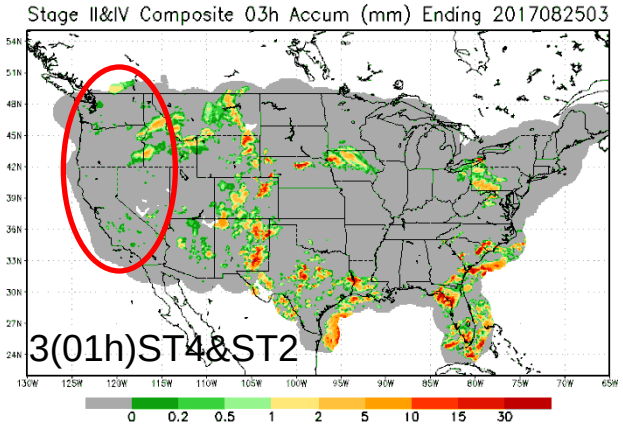
- Reason for change: Stage IV hourly in both NWRFC and CNRFC will be improve by using hourly gauge-corrected MRMS as weights to dis-aggregate the 6-hourly QPE from NWRFC and CNRFC into hourly amounts in the upcoming RTMA/URMA upgrade v2.6 (pcpanl.v3.0.0, to be implemented around Dec 2017).

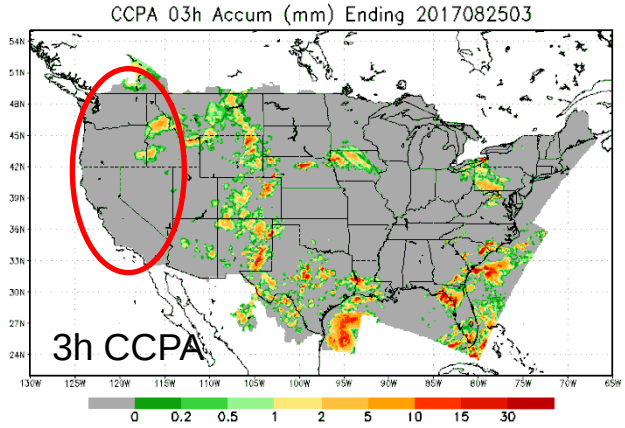
- CCPA upgrade will use Stage IV hourly only over the entire CONUS domain as weights to produce 3-hr CCPA

Why Change to 3-hr CCPA?



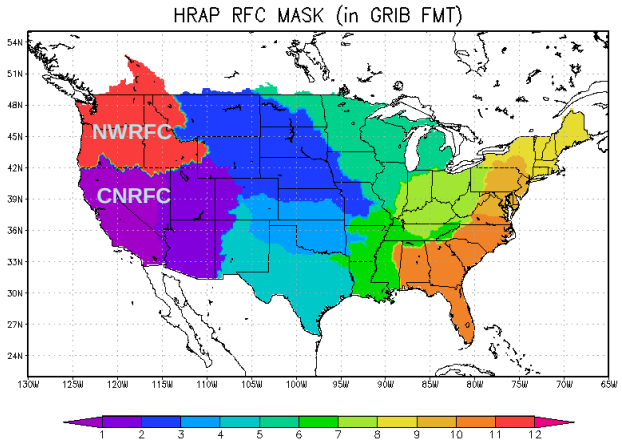


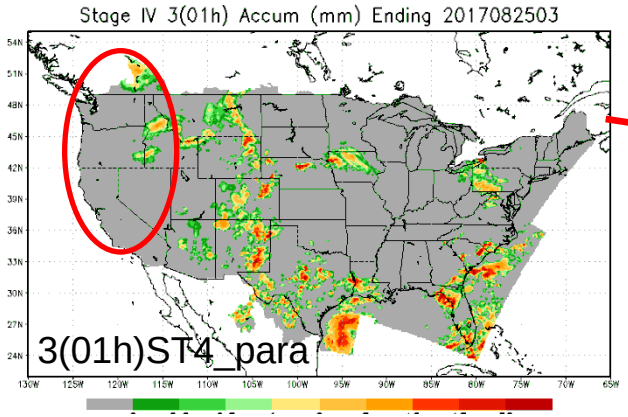


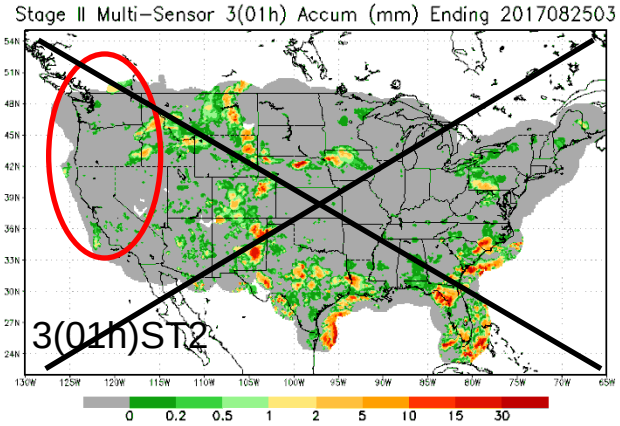


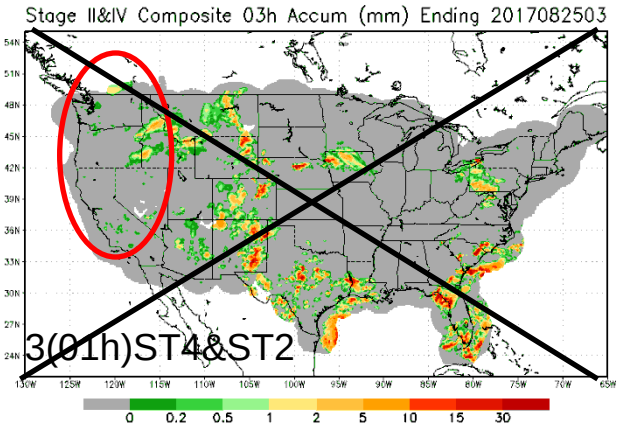
Current hourly Stage IV and 3-hr CCPA

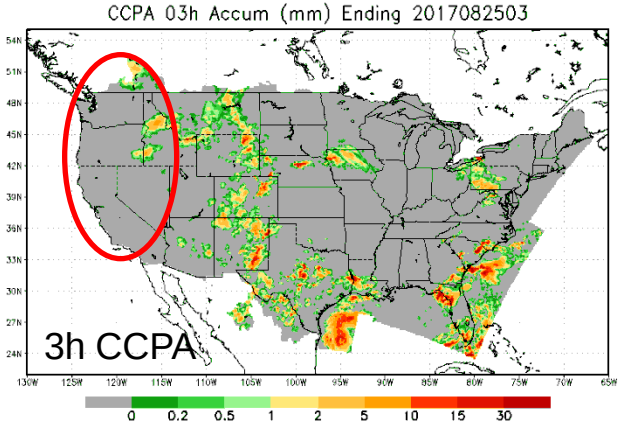
Why Change to 3-hr CCPA?











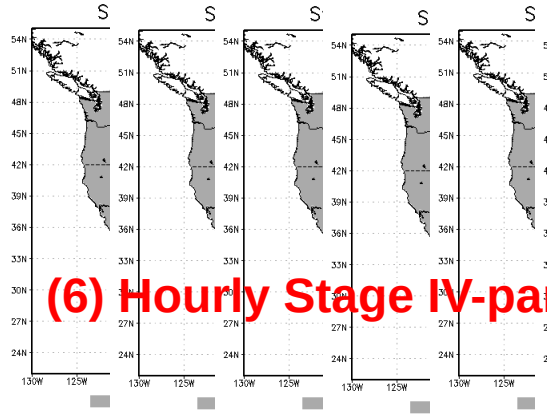
Future hourly Stage IV and 3-hr CCPA

Introduction to 1-hourly CCPA

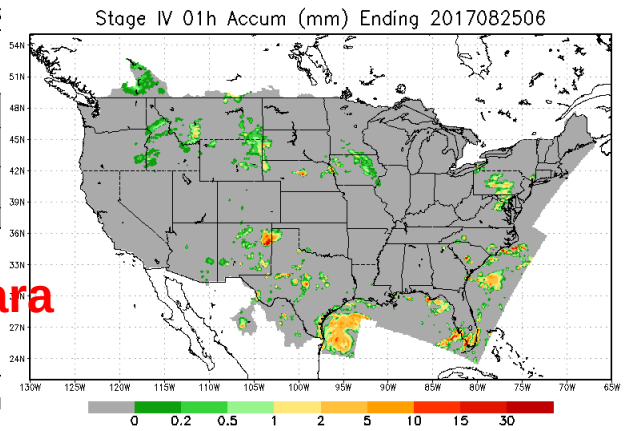
- NBM requirement for 1-hourly CCPA
- Similar approach as the one to produce 3-hourly CCPA

  Reference: 2012 AMS poster

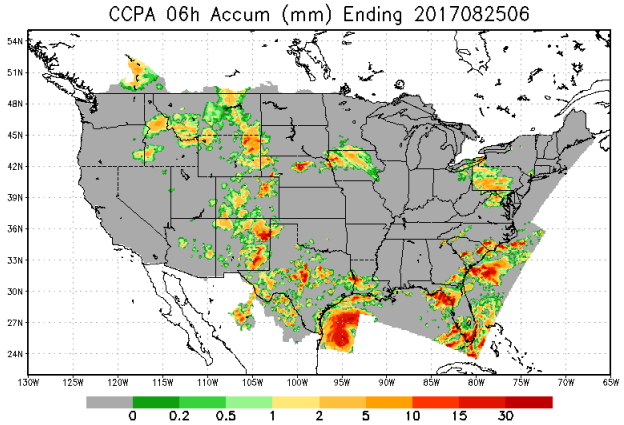
Approach



(6) Hourly Stage IV-para



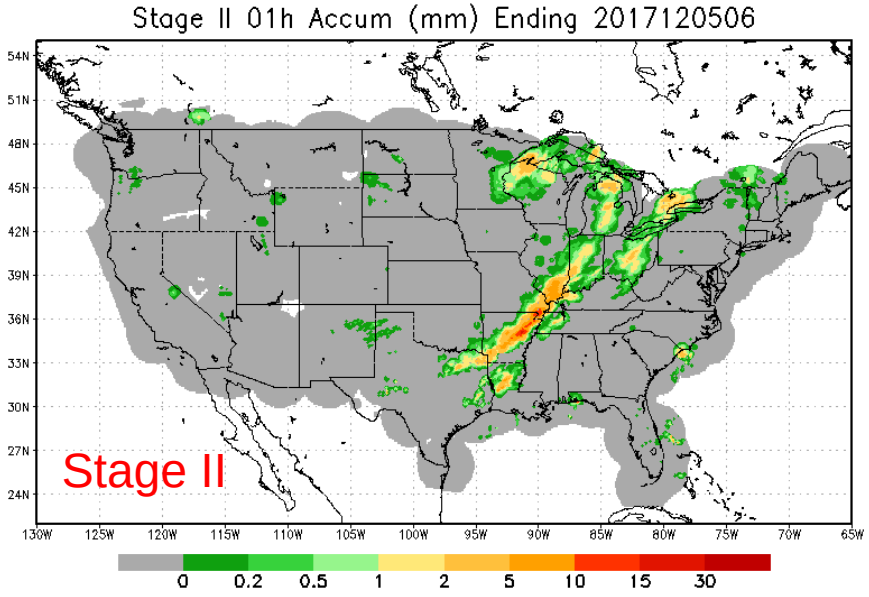
6-hourly CCPA

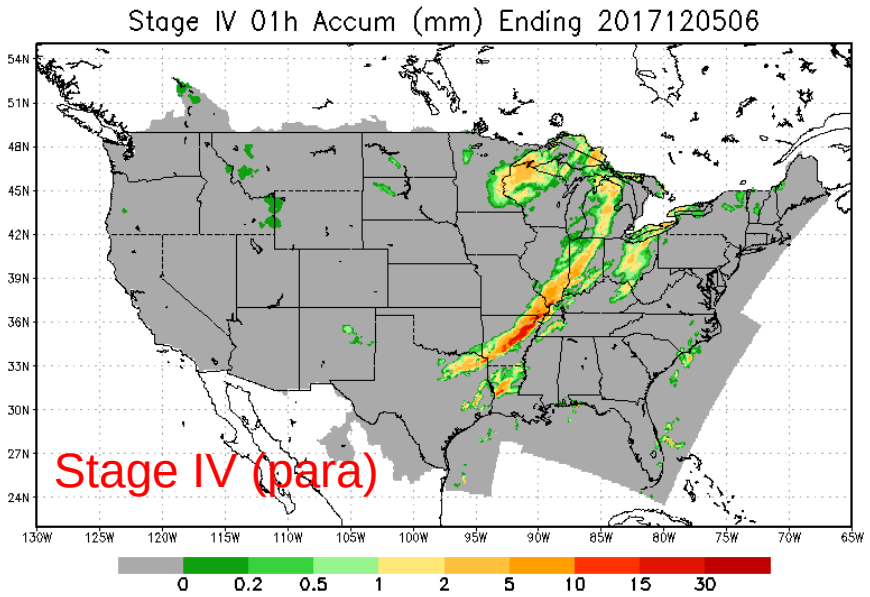


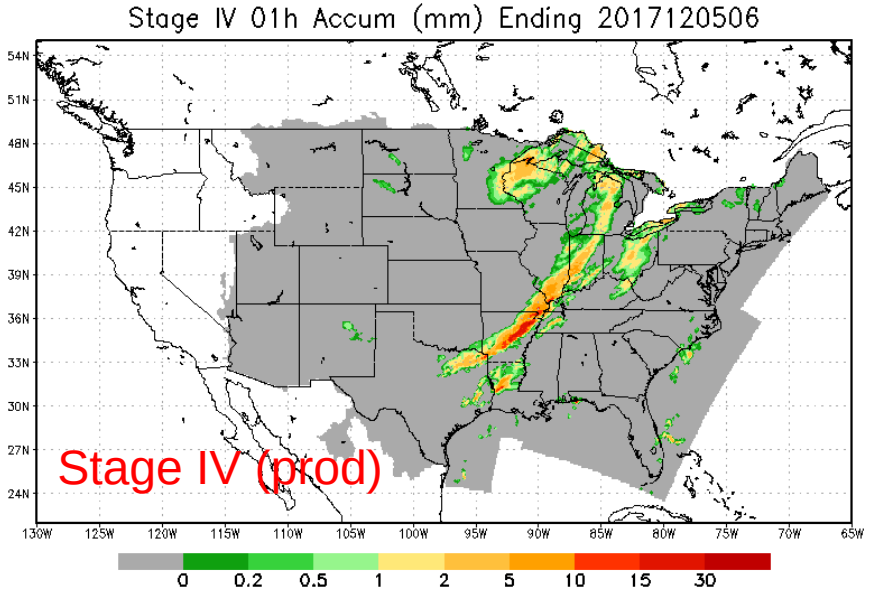
hourly CCPA

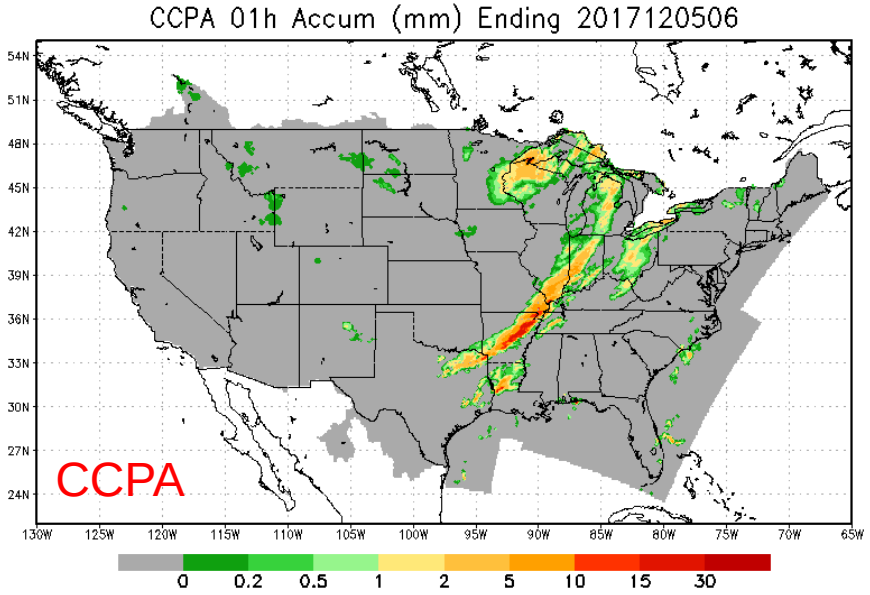
Method:
Use hourly Stage IV as weights to disaggregate 6-hourly CCPA

1h acc ending 06Z 5 Dec 2017

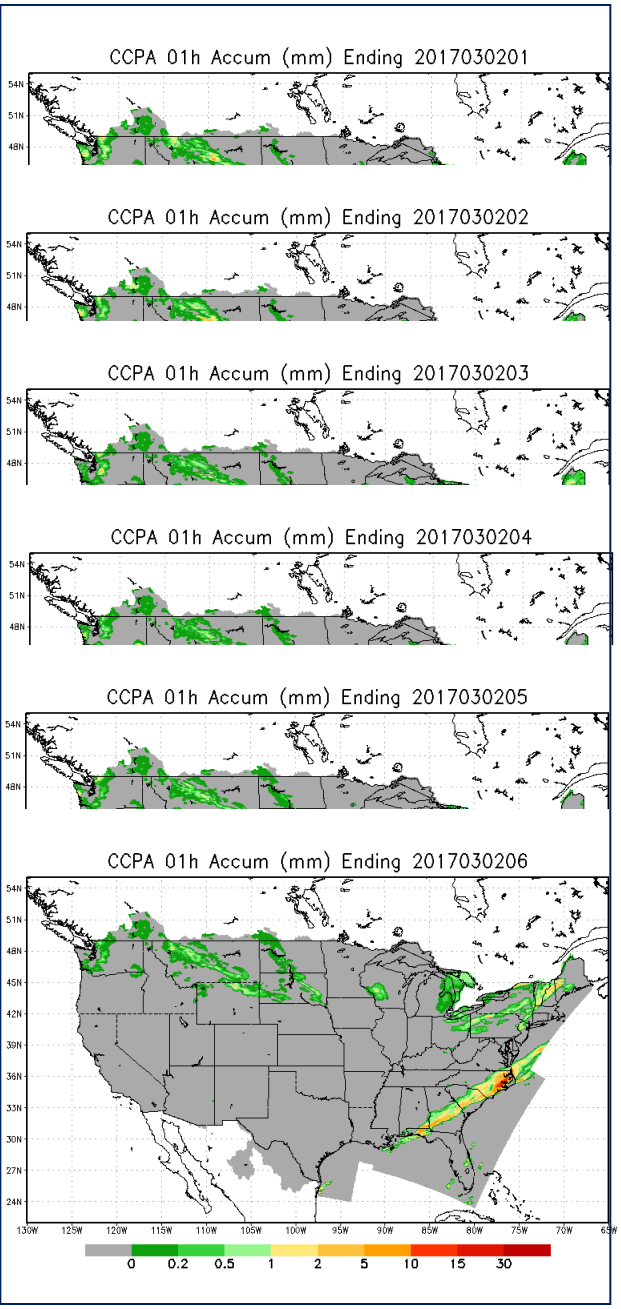








Verification of calculation



Sum of 6 one-hourly CCPA

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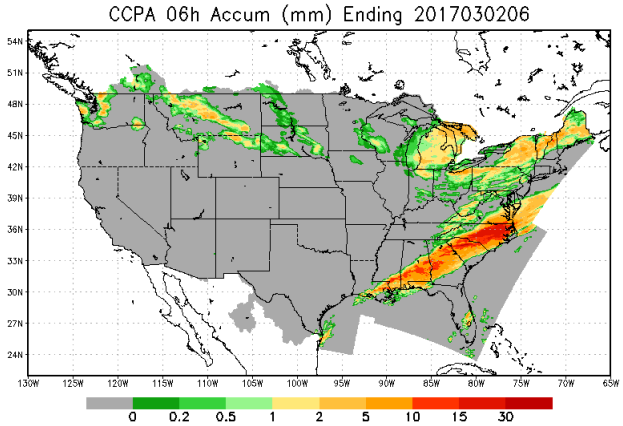

6-hourly CCPA

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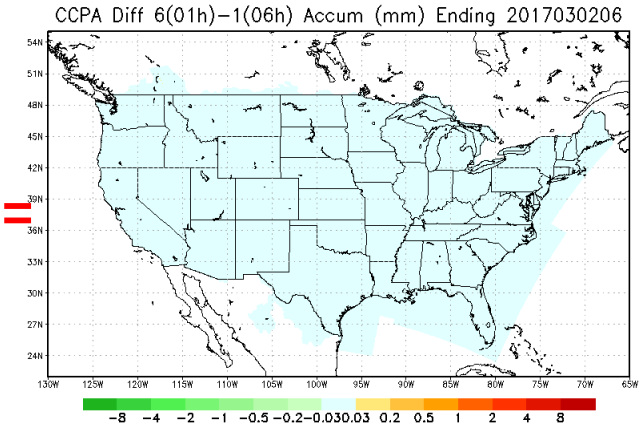

Difference

Summary

- **Updating regression coefficients with two more years of data samples**:
  - **Some slight improvements over current production can be seen in term of RMSE and MERR.**
  - **No negative impact and degradation**
- **Periodically (annually) upgrading regression coefficients with increasing sample size makes CCPA methodology robust.**
- **1 hourly CCPA is generated.**
- **The new version of 15-year CCPA historical data has been regenerated and will be available to the public.**
- **Welcome CCPA users (MDL etc.) to continuously provide comments and suggestions for the future improvements and enhancements.**

CCPA (V4.0) Upgrade for CONUS

Project Status as of 09/06/17

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Project Information and Highlights

Lead: Yuejian Zhu/Yan Luo (EMC), Steven Earle (NCO)

Scope:

- Model – Climatology-Calibrated Precipitation Analysis (CCPA) system version 4.0
- Introduce hourly precipitation analysis for extended CONUS with improving methodology to support NBM projects
- Sciences:
  - Update regression coefficients based on 15-year (vs. 13-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 to1.0, 0.5, 0.125 degree and NDGD grids (5km, 2.5km); hourly, 3hourly and 6hourly analysis

Expected Benefits:

- Improved analysis quality with extended training data

Implemented with: N/A

Dependencies: Stage II (?) and IV

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Issues/Risks

Issues/Risks: None

Resource estimation:
5 nodes for 25 minutes

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Scheduling

Milestones & Deliverables	Date	Status
Freeze system code and deliver to NCO	10/15/2017	On track
Complete full retrospective/real time runs and evaluation	11/15/2017	On track
Conduct CCB and deliver final system code to NCO	12/13/2017	On track
Deliver Technical Information Notice to NCO	12/01/2017	On track
Complete 30-day evaluation and IT testing	1/15/2018	On track
Operational Implementation	3/01/2018	On track

EMC	NCO	Red text indicates change from previous quarter

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Resources

Staff: 0.5 contractor FTEs (Yan Luo);

Funding Source: STI

Compute:

- **EMC Dev:** 5 nodes (Delta: 5 nodes);
- **Parallels:** 5 nodes (Delta: 5 nodes);
- **Ops**: 5 nodes (Delta: 5 nodes)

Archive:

- **Parallels**: 600mb/day (Delta: 300mb/day);
- **Ops**: 600mb/day (Delta:300mb/day)

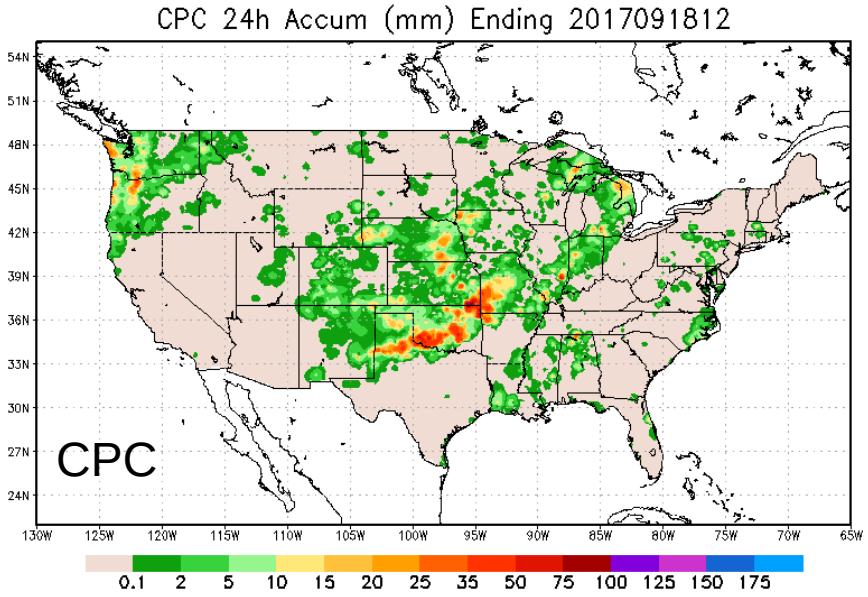
R Management Attention Required	Y Potential Management Attention Needed	G On Target

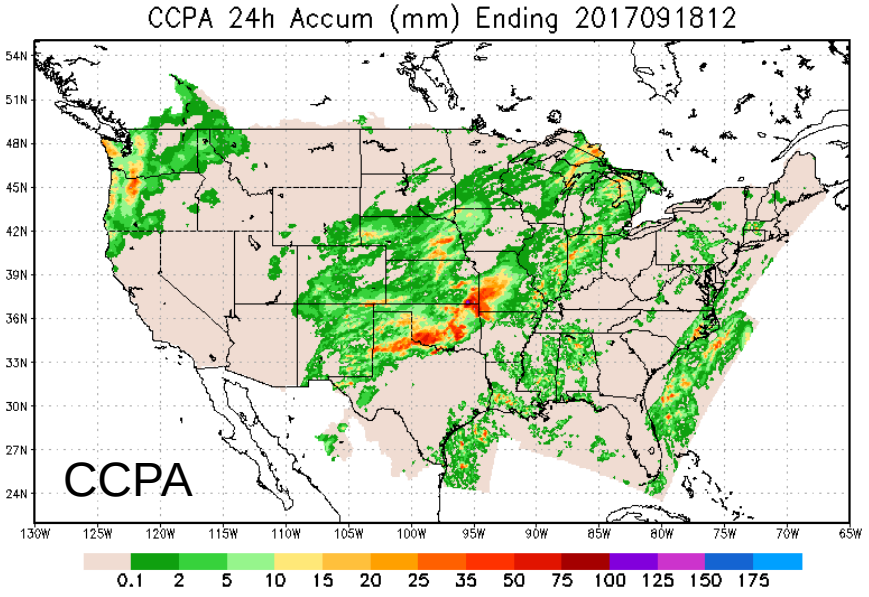
Acknowledgments:

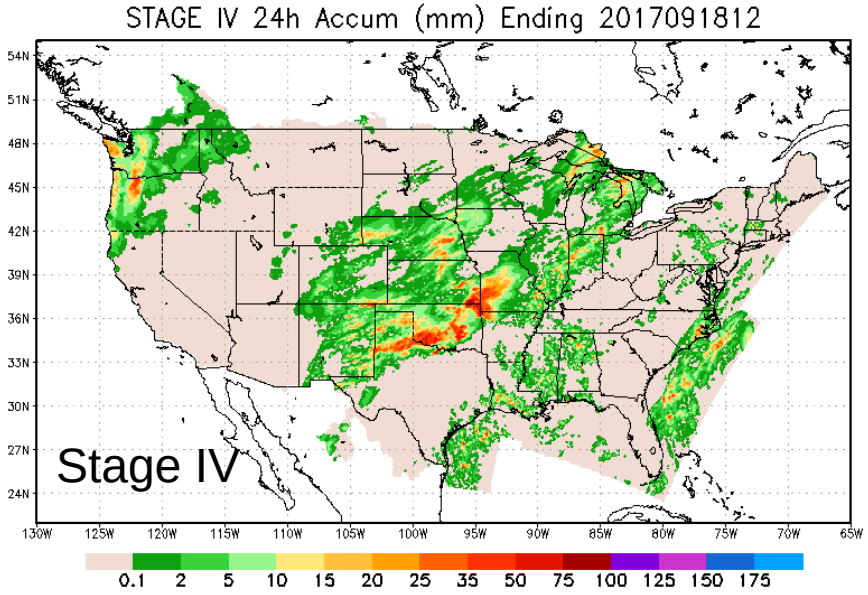
- Ying Lin – EMC
- Pingping Xie – CPC
- Jeff Craven – MDL
- Eric Engle – MDL
- Phil Shafer – MDL

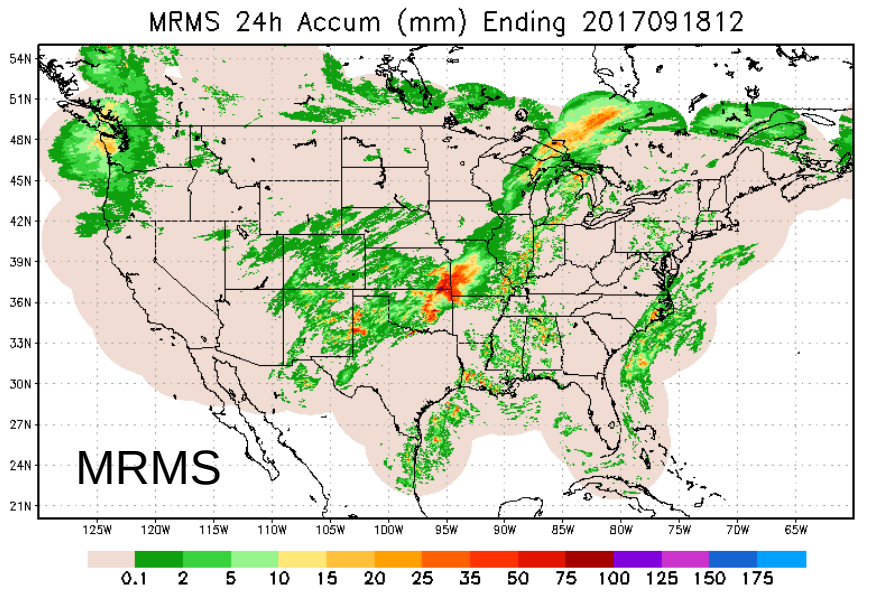
Background!!!

24h totals ending 12Z 18 Sep 2017









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 (MDL&ESRL)

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

Requested Product Volume

Disk Usage	Current Production	Expected New Production	Actual New Production
IBM Disk	100 MB/day	300 MB/day	-
IBM Tape	100 MB/day	300 MB/day	-
NCEP FTP Server	25 MB/day	70 MB/day	-

Note: IBM Disk has 15 days of output residing in /com, save the day before 8 days' output in HPSS.

Requested Production Resources

Change to use 5 nodes. Run time keeps the same as 25 minutes.

Downstream impacts, product changes

- Additional 1-hourly analysis

  e.g., ccpa.t21z.01h.0p5.conus.gb2

- Product directory structure

  /com2/ccpa/prod/ccpa.yyyymmdd/cyc

NCEP FTP/NOMADS:

ftp://ftp.ncep.noaa.gov/pub/data/nccf/com/ccpa/prod/ccpa.YYYYMMDD/HH

http://nomads.ncep.noaa.gov/pub/data/nccf/com/ccpa/prod/ccpa.YYYYMMDD/HH

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