CCPA V4.0 Upgrade

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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

• Climatolgy 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…
  – 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
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 the 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

Sample size (N) OLD (2002-2015)

Sample size (N) NEW (2002-2017)

Res, Square (e) OLD (2002-2015)

Res, Square (e) NEW (2002-2017)
Example of Regression for Aug. 1st

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

Slope (a) OLD (2002-2015)

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

Slope (a) NEW (2002-2017)

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

Intercept (b) OLD (2002-2015)

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

Intercept (b) NEW (2002-2017)
Time series of regression

Sample size (N)
OLD (02-15)
NEW (02-17)

Slope (a)

Res, Square (e)

Intercept (b)
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
Comparison against CPC analysis

a) RMSE of CCPA_PROD (mm) 07/01/15 - 06/30/17

b) RMSE Reduction by CCPA_EXPR (%) 07/01/15 - 06/30/17

\[
\text{RMSE}_{\text{prod}} - \text{RMSE}_{\text{expr}} \times 100% \\
= \frac{\text{RMSE}_{\text{prod}}}{\text{RMSE}_{\text{prod}}} \times 100%
\]

if >0 improvement
if <0 degradation
Evaluation against CPC Analysis

Precipitation Verification for CONUS
RMSE and ABSE
Average For 20020701 - 20170630

Greater than thresholds
Evaluation against observation
(RFC rain-gauge network)

Precipitation Verification for CONUS
RMSE and ABSE
Average For 20020701 - 20170630

Greater than thresholds
Evaluation against observation
(RFC rain-gauge network)
Precipitation Verification for CONUS
RMSE and ABSE
For 20170801 - 20171010

IMPROVEMENT of CCPA_EXPR over CCPA_PROD by %

\[ \text{Improvement Rate} = \frac{\text{RMSE}_{\text{prod}} - \text{RMSE}_{\text{expr}}}{\text{RMSE}_{\text{prod}}} \times 100\% \]
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 recent RTMA/URMA upgrade v2.6 (pcpanl.v3.0.0, implemented on Dec 13, 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?

Stage IV 3(01h) Accum (mm) Ending 2017082503

Stage II Multi-Sensor 3(01h) Accum (mm) Ending 2017082503

3(01h)ST4 para

3(01h)ST2

Stage II&IV Composite 03h Accum (mm) Ending 2017082503

CCPA 03h Accum (mm) Ending 2017082503

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

Sum of 6 one-hourly CCPA

6-hourly CCPA

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.
EMC real-time parallel experiments
(Started from December 21\textsuperscript{st} - Running twice per day)

CCPAv4 Products from parallel runs - [http://www.emc.ncep.noaa.gov/gmb/yluo/CCPA_para.html](http://www.emc.ncep.noaa.gov/gmb/yluo/CCPA_para.html)

CCPAv3 Products from operational runs - [http://www.emc.ncep.noaa.gov/gmb/yluo/CCPA_prod.html](http://www.emc.ncep.noaa.gov/gmb/yluo/CCPA_prod.html)
Data Locations

• **Real-time data:**
  - EMC parallel output (CCPAv4):
  - NCO operational output (CCPAv3):

• **Historical data archive:**
  - CCPAv4: WCOSS (Tide only)
    General: /ensemble/noscrub/Yan.Luo/COM_TAR
    Hourly 2.5km data: /ensemble/noscrub/Yan.Luo/CCPAv4_hourly2p5
CCPA (V4.0) Upgrade for CONUS
Project Status as of 09/06/17

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 to 1.0, 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

**Issues/Risks**

**Issues/Risks: None**

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### Scheduling

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

**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)

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**Resource estimation:** 5 nodes for 25 minutes
Acknowledgments:

• Ying Lin – EMC
• Pingping Xie – CPC
• Jeff Craven – MDL
• Eric Engle – MDL
• Phil Shafer – MDL
Background!!!
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

<table>
<thead>
<tr>
<th>Disk Usage</th>
<th>Current Production</th>
<th>Expected New Production</th>
<th>Actual New Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>IBM Disk</td>
<td>100 MB/day</td>
<td>300 MB/day</td>
<td>-</td>
</tr>
<tr>
<td>IBM Tape</td>
<td>100 MB/day</td>
<td>300 MB/day</td>
<td>-</td>
</tr>
<tr>
<td>NCEP FTP Server</td>
<td>25 MB/day</td>
<td>70 MB/day</td>
<td>-</td>
</tr>
</tbody>
</table>

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:


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