A High Resolution Precipitation Dataset over CONUS: Climatology-Calibrated Precipitation Analysis (CCPA)

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Acknowledgements

Steve Lord, EMC/NCEP/NWS/NOAA
Letitia Soulliard, HPC/NCEP/NWS/NOAA

5th NAEFS Workshop, Juitepec, Mexico, 17-19 May 2010
Why do we need another dataset?

- **Want an accurate, 5x5 km (NDFD), 6-hourly precip grid**
  1. Downscale NAEFS precipitation forecasts to NDFD
  2. Verify NAEFS precipitation forecasts
  3. Input to Bayesian Processor of Ensemble (BPE)

- **What do we Have?**
  - Stage IV
  - CPC

- **Note:** This effort has limitations, as it was developed to simply combine existing datasets. Much more work will be needed for a more comprehensive approach, but this is out of the scope of this work
What is Stage IV

- National Stage IV QPE product
  - Mosaicked from Individual RFC's Multi-sensor Precipitation Analyses (RMPAs)
  - Available within 1h of receiving any new hourly/6-hourly data from one or more RFCs.
  - 12 RFCs over CONUS
  - Some manual QC at RFCs
  - 4km HRAP grid
Why Calibration?
(following Charles et. al)

• Want an accurate, 5x5km (NDFD) 6-hourly precipitation for
  – Down scaling NAEFS precip forecast to NDFD
  – Verifying NAEFS precipitation forecast

• Stage IV, a good candidate but …
  ✓ High resolution (close to NDFD) → better representation of fine scale temporal and spatial variability
    Non-uniform QC (different RFCs have different methods)
    Each RFC may make their own adjustments before mosaicking

• CPC Unified Precipitation Analysis
  – Back to 2000 (eventually back to 1979, then 1948)
  – $\frac{1}{8}^\circ$ spatial resolution
  – Daily
  – Global land
  ✓ More confidence in long term statistics of CPC dataset
    a. Uniform QC across entire domain
    b. Gauge-based
    Too low resolution for downscaling
Comparison of CPC and Stage IV

CPC: CONUS LAND ONLY

Stage IV: Geometric Boundary
How to Calibrate

• *Solution*: adjust Stage IV grids so their climatology is consistent with the CPC dataset
  ✓ Have the reliability of the CPC dataset, with the high spatial and temporal resolution of the RFC dataset

• *Note*: This effort has limitations, as it was developed to simply combine existing datasets. Much more work will be needed for a more comprehensive approach, but this is out of the scope of this work
Flow Chart

1/8 Degree ~5km

Aggregation to 1/8 degree resolution

STAGE IV (Input)

Adjusted STAGE IV (output)

Temporal Disaggregation

STAGE IV At 1/8d (7 year historic)

CPC_1/8d (7 year Archive)

Adjustment (How to?)

Down scaling Spatial disaggregation

Accumulate To 24 hours

24 hourly

6 hourly
Establish Statistical Relationship

1. Historical data sets
   June 1 2002 to July 31 2009 For CPC and STAGE IV

2. Match resolutions
   a. Accumulate RFC 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 7 years (max
      ~427 data points)
   b. Use only data points with ST4 > 0

4. Linear regression
   a. CPC = a \cdot ST4 + b

• End Result
  – Linear relationship (a & b) on ⅛° grid for each day of the year
Regression Aug. 1st (SW US, Summer Gaps, maximum 369 points)
Filling the gap in Space (linear interpolation)
Time Series; Gap is filled by Spatial Interpolation
Temporal Smoothing (3 harmonics) of a

A coastal grid point

Typical point

Typical point

Neighboring Land point
Temporal Smoothing (3 harmonics) of b

A costal grid point

Neighboring Land point

Typical point

Typical point
Adjustment with raw and filled a & b: $ST4^* = a \cdot ST4 + b$
Recovering Original RFC Resolutions

Spatial Disaggregation

- Information is lost in ST4* (from H to L res.)
- What does lost information look like?
  - ST4, Take ratio H/L (below) from the original ST4
  - This ratio can be used to put high resolution information back into ST4*

1. Interpolate ST4* to HRAP
2. Multiply by H/L
- End with ST4* at HRAP resolution.
- Spatial information recovered from ST4 orig
Recovering Original RFC Resolutions

Temporal Disaggregation

1. Determine percentage of daily total precipitation in each 6-hour period in original ST4

2. Divide 24 hour ST4* into four 6-hour precip amounts using the percentages from original ST4

Percent of daily total in each 6-hourly period

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Original ST4</th>
<th>ST4* adj</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-18Z</td>
<td>0.4&quot;</td>
<td>0.6&quot;</td>
</tr>
<tr>
<td>18-00Z</td>
<td>0.6&quot;</td>
<td>0.9&quot;</td>
</tr>
<tr>
<td>00-06Z</td>
<td>2&quot;</td>
<td>1&quot;</td>
</tr>
<tr>
<td>06-12Z</td>
<td>1&quot;</td>
<td>1.5&quot;</td>
</tr>
</tbody>
</table>

Original Daily Total: 4"

Adjusted Daily Total: 6"
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
An Example
Feb. 5 2010

East Cost
Snowstorm 2010
Comparison of Stage IV and CCPA Wrt. CPC

Two Month Mean (June 1 – July 31, 2008)

For Stage IV and CCPA
- Aggregated from HRAP to 0.125 deg
- Aggregated from 6-hourly to daily
Comparison of time series of CPC, Stage IV and CCPA

- Example: A Point (42N, 102W) near Ashby, NE
- Selected from 0.125 deg datasets for June 1 – July 31 2008
Concluding Remarks

- A new dataset of precipitation analysis, over CONUS at 6h, 4km resolution
- Statistical adjustment of Stage IV data with same resolution toward CPC analysis
- A combination of the Stage IV and CPC Unified Precipitation Analysis
- Simple linear regression at 0.125 degree and 24h accumulation
- Spatial interpolation and temporal smoothing to regression coefficients
- Keep the fine scale structures of Stage IV
- Closer to CPC Unified Precipitation Analysis, in the sense of climatology
- Provide a proxy of truth for precipitation forecast calibration and downscaling

What is next?

- Operational implementation at NCEP, planned for 2010
  - Generate the historical data set of CCPA for 2002-2010
  - Real time generation of CCPA after STAGE IV, once per day
- Periodic (annual) upgrading regression coefficients with increasing sample size
  - Updating coefficients a and b for real time CCPA
  - Re-generate the CCPA historical data set
- Improving the methodology