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?

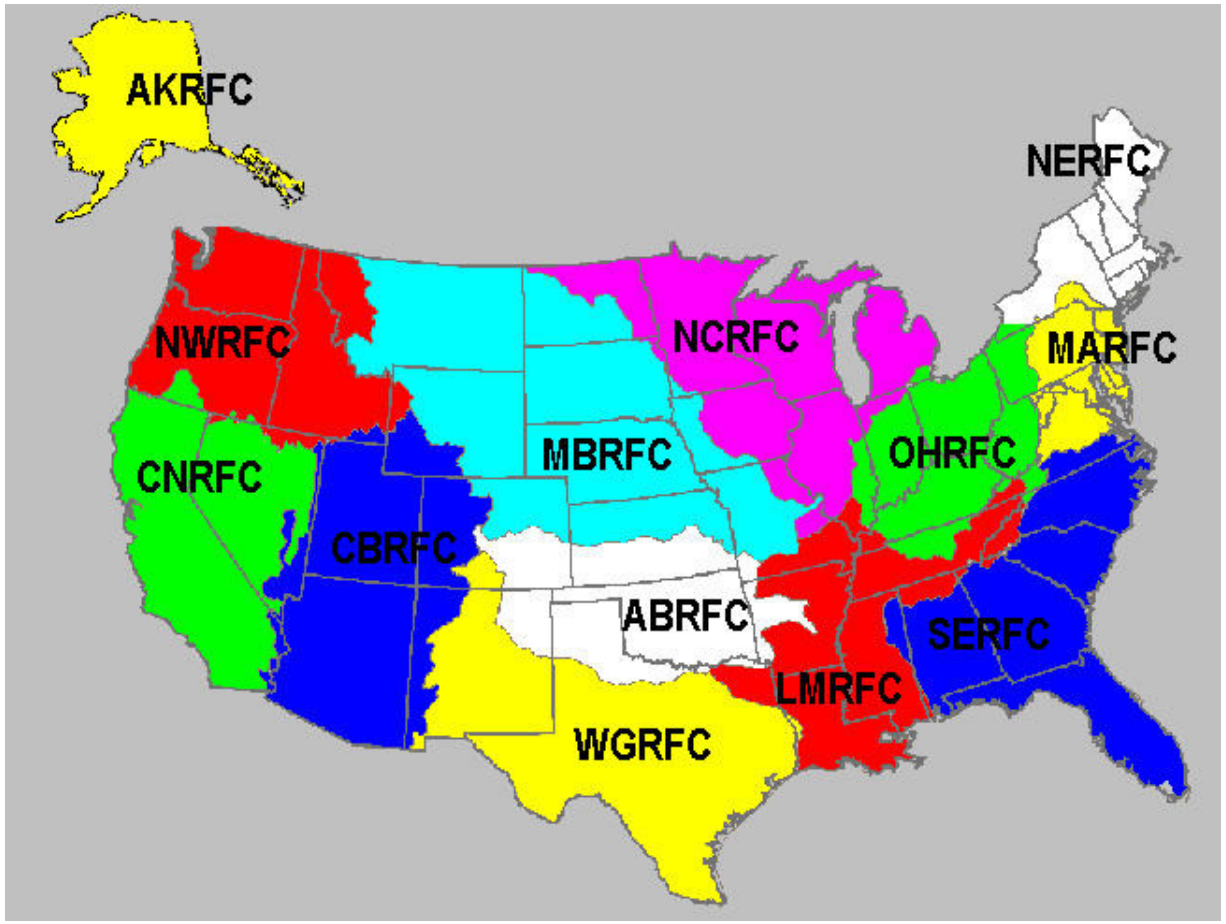
- Want an accurate, 5x5 km (NDFD), 6-hourly precip grid
  1. Downscale NAEFS precipitation forecasts to NDFD
  2. Verify NAEFS precipitation forecasts
  3. Input to Bayesian Processor of Ensemble (BPE)

- 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



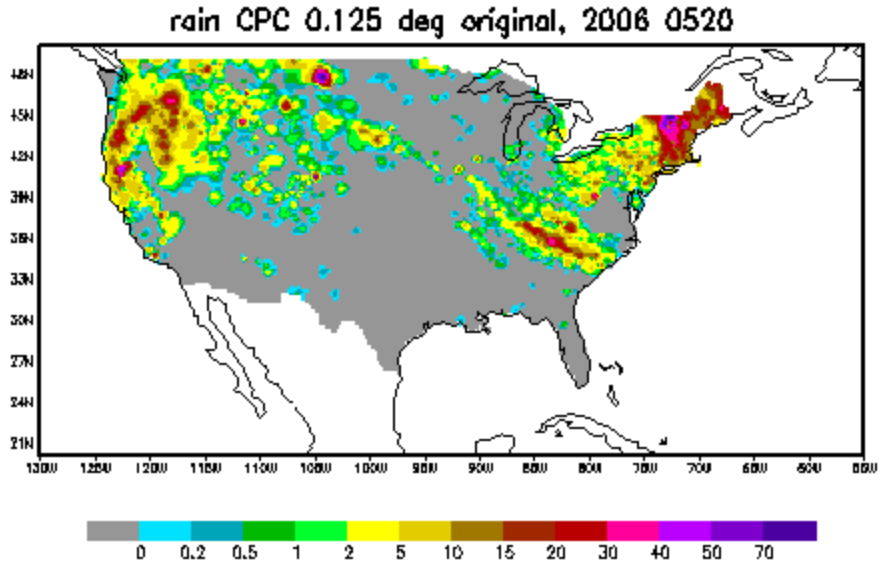
Why Calibration ?

(following Charles et. al)

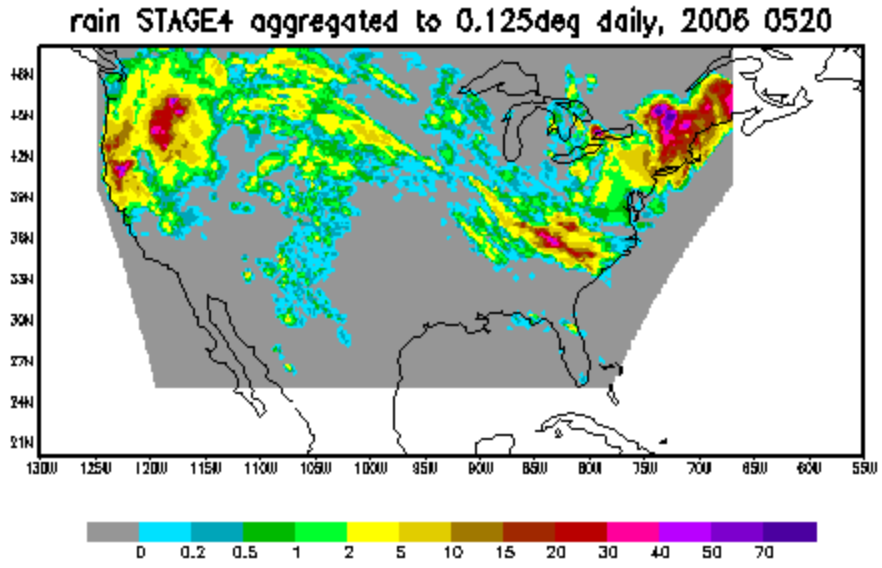
- Want an accurate, 5x5km (NDFD) 6-hourly precipitation for
  - Down scaling NAEFS precip forecast to NDFD
  - Verifying NAEFS precipitation forecast
- Stage IV, a good candidate but …
  - ✓ High resolution (close to NDFD) → better representation of fine scale temporal and spatial variability
  - Non-uniform 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)
  - ⅛° 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

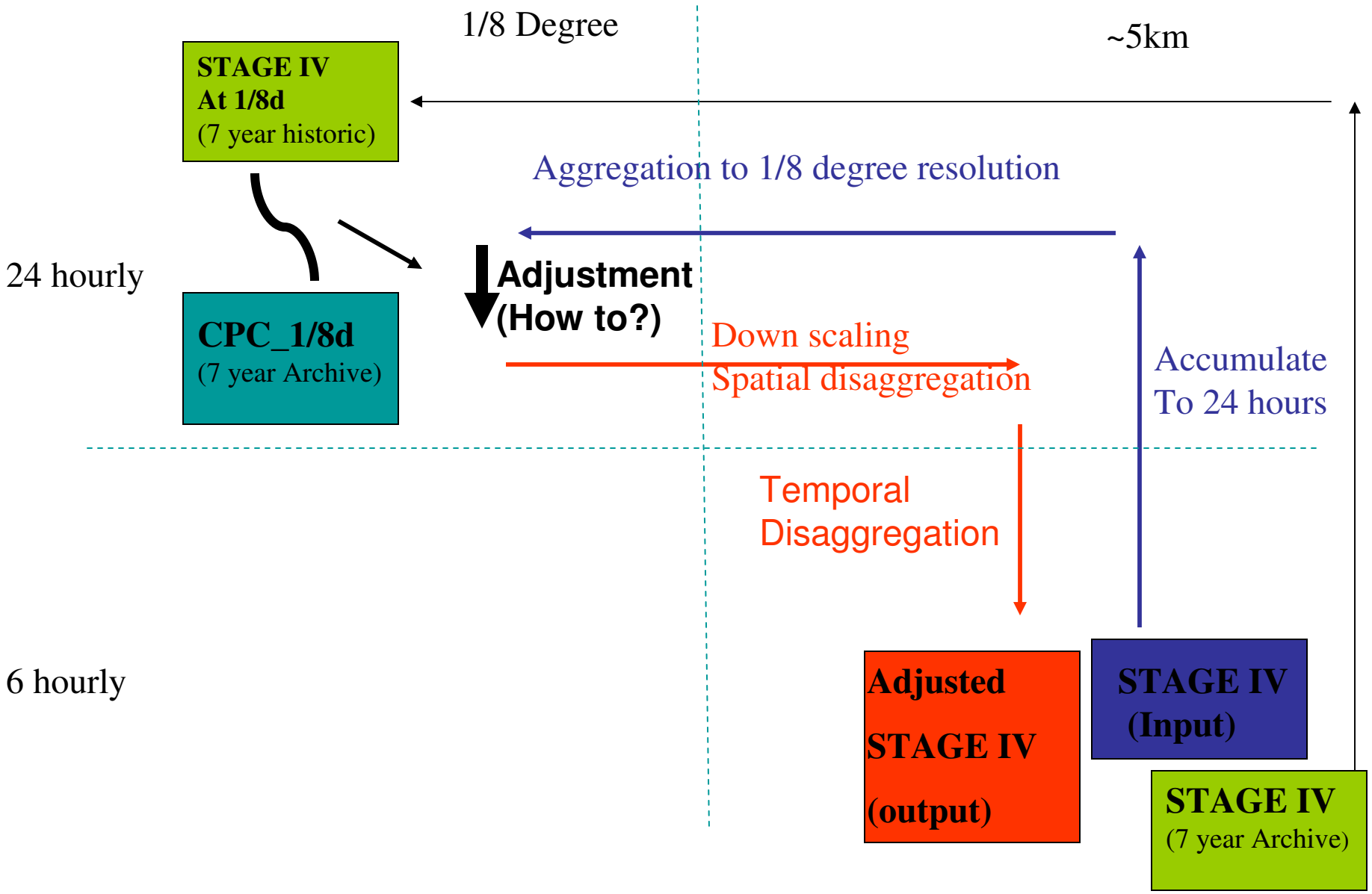


How to Calibrate

- *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
STAGE IV
At 1/8d
(7 year historic)
Aggregation to 1/8 degree resolution
24 hourly
Adjustment
(How to?)
CPC_1/8d
(7 year Archive)
Down scaling
Spatial disaggregation
Accumulate
To 24 hours
Temporal
Disaggregation
6 hourly
Adjusted
STAGE IV
(output)
STAGE IV
(Input)
STAGE IV
(7 year Archive)

Establish Statistical Relationship

1. Historical data sets

   June 1 2002 to July 31 2009 For CPC and STAGE IV

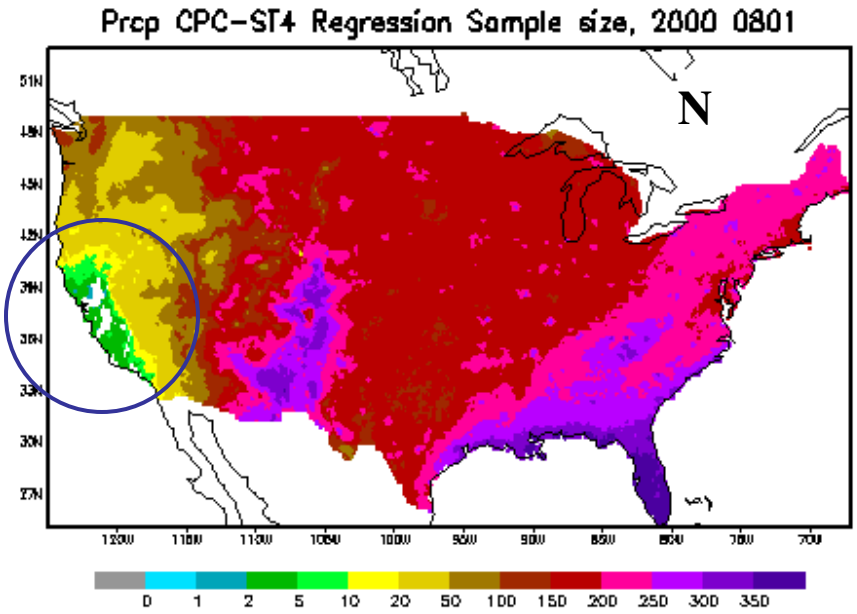
2. Match resolutions
   a. Accumulate RFC over 24 hours
   b. Interpolate to ⅛° (copygb w/ volume preservation)

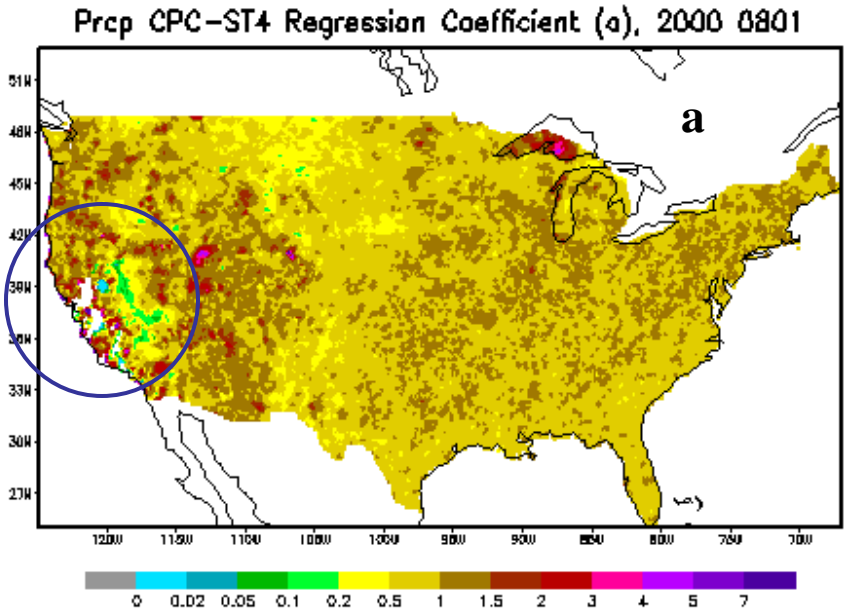
3. Collect precip samples
   a. For each day of the year and at each grid point, collect all precip within 60 day window centered around that day, over all 7 years (max ~427 data points)
   b. Use only data points with ST4 > 0

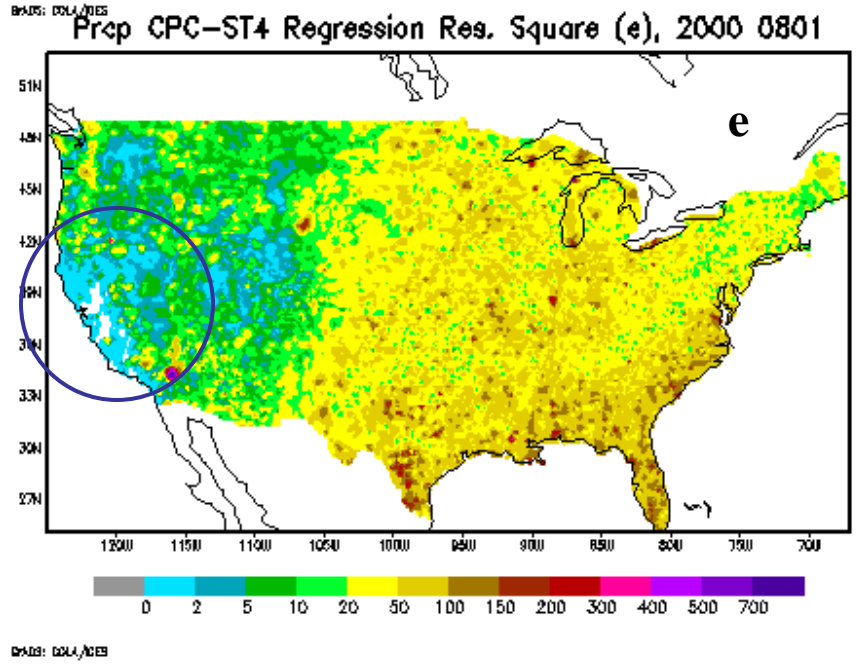
4. Linear regression
   a. CPC = a · ST4 + b

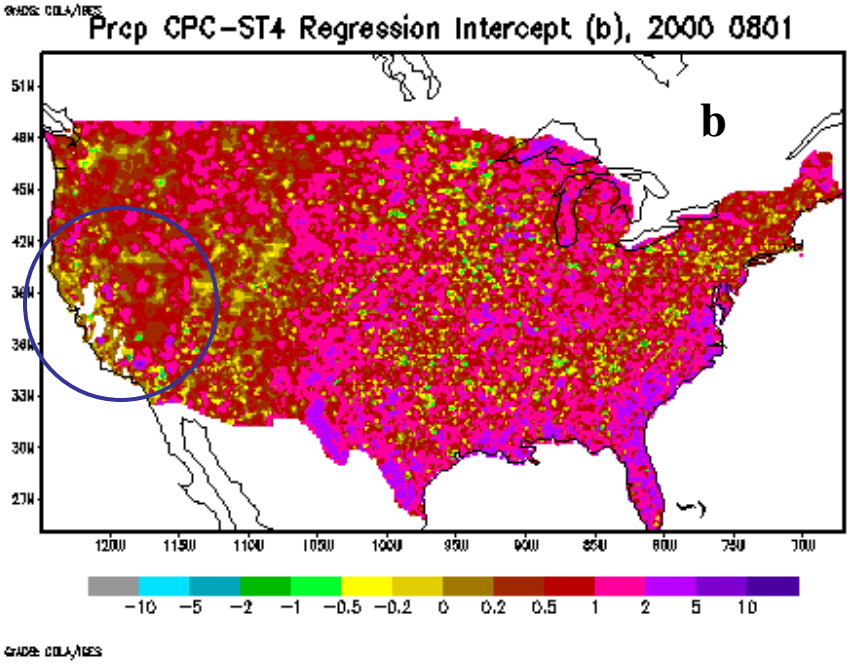
- End Result
  – Linear relationship (a & b) on ⅛° grid for each day of the year

Regression Aug. 1st (SW US, Summer Gaps, maximum 369 points)

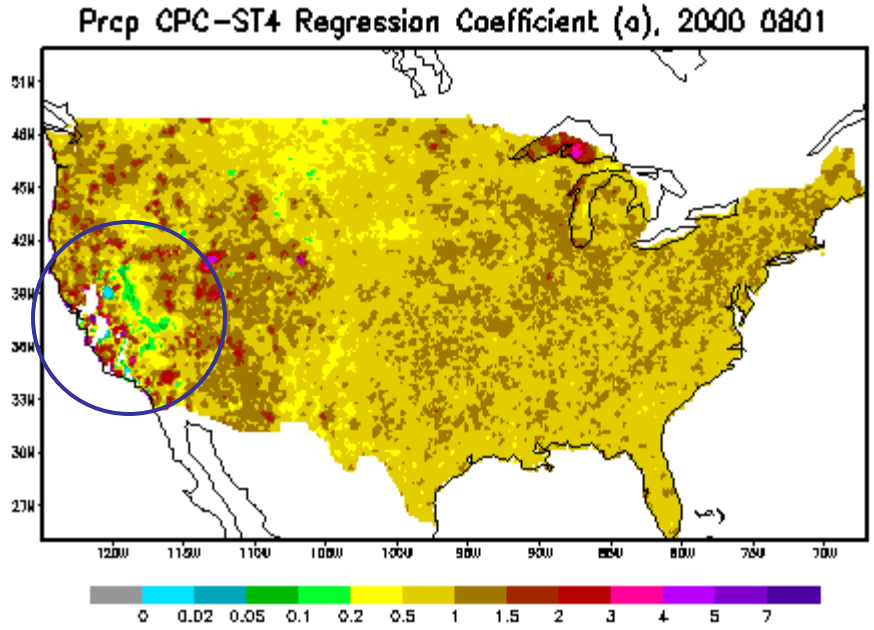


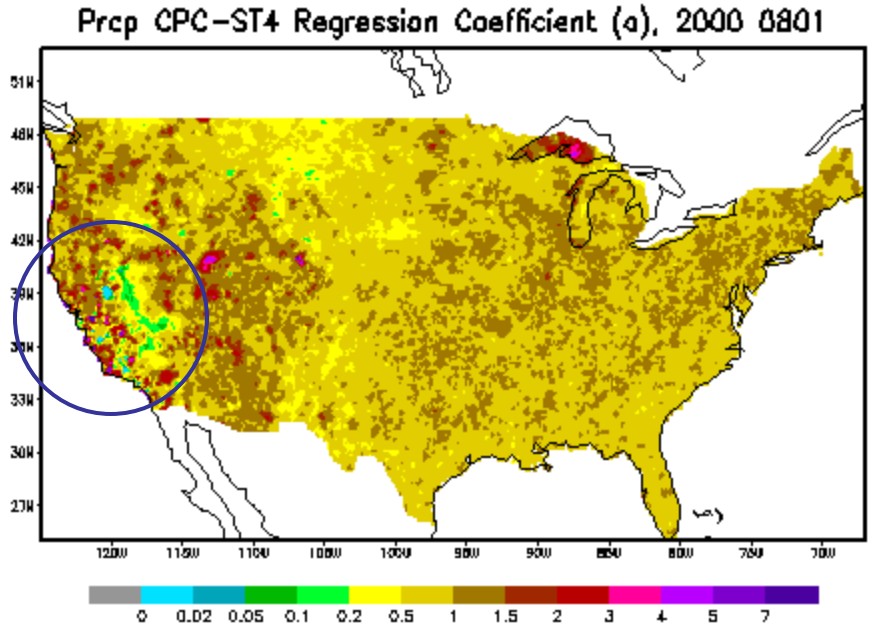


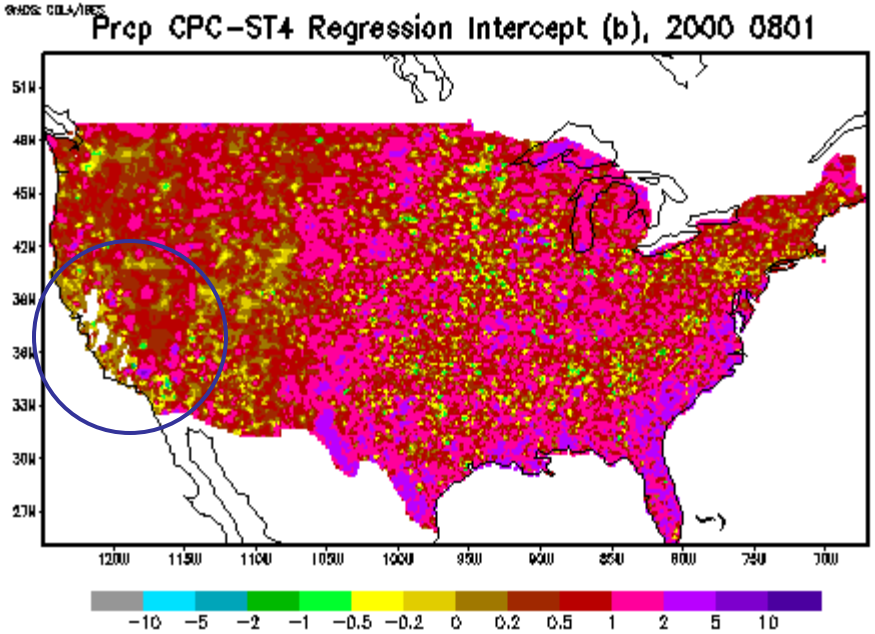


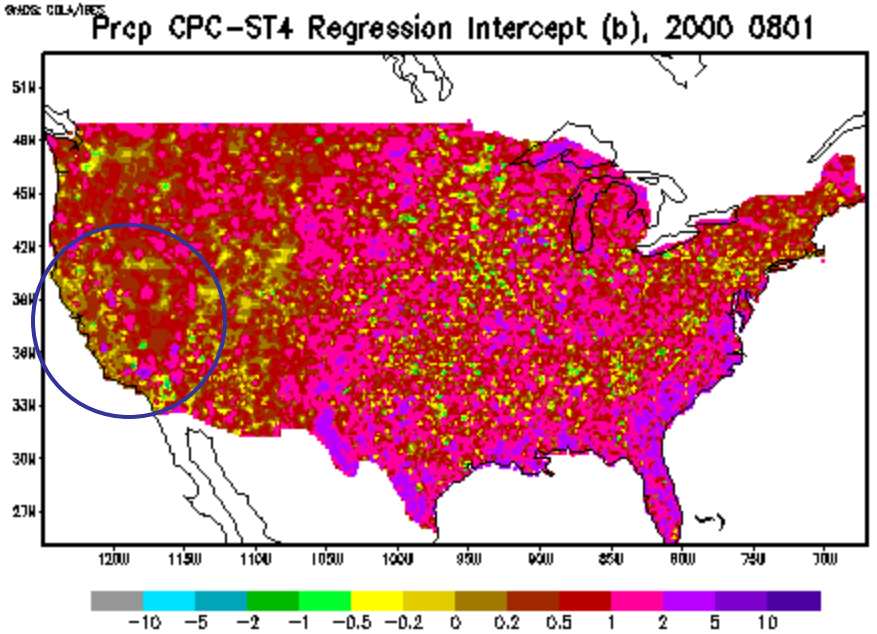


Filling the gap in Space (linear interpolation)

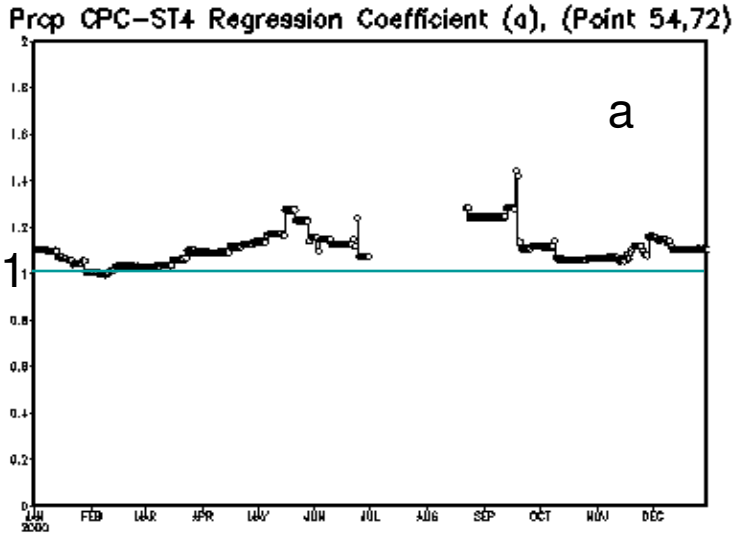


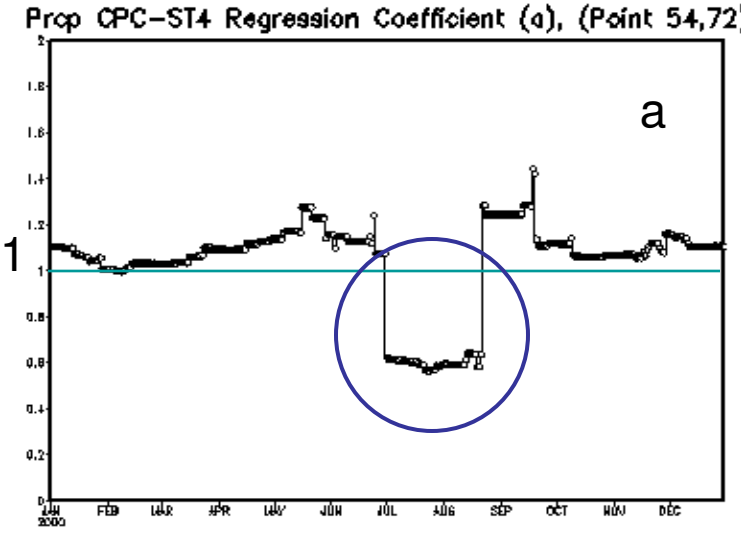


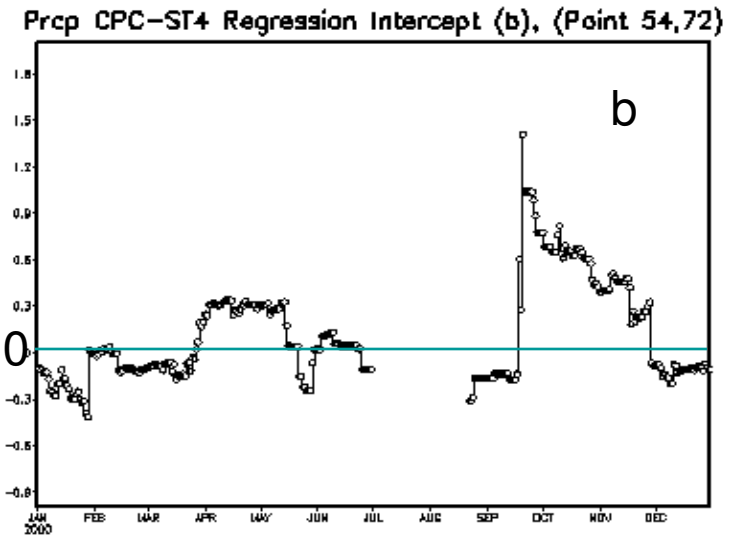


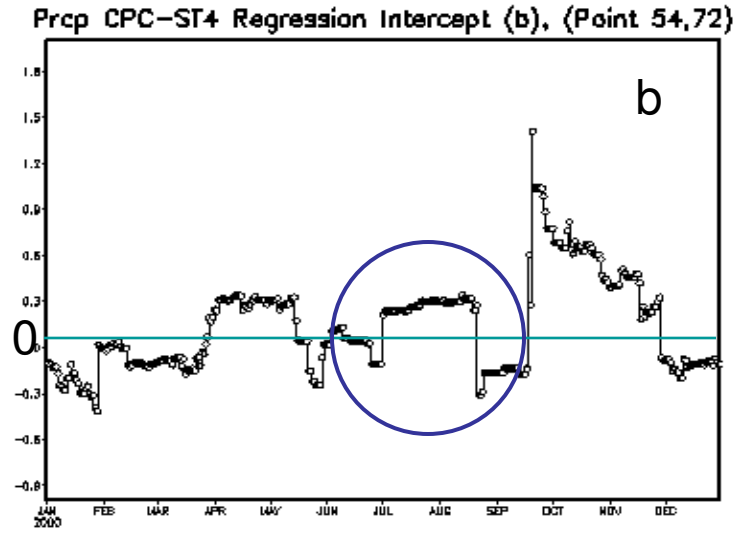


Time Series; Gap is filled by Spatial Interpolation

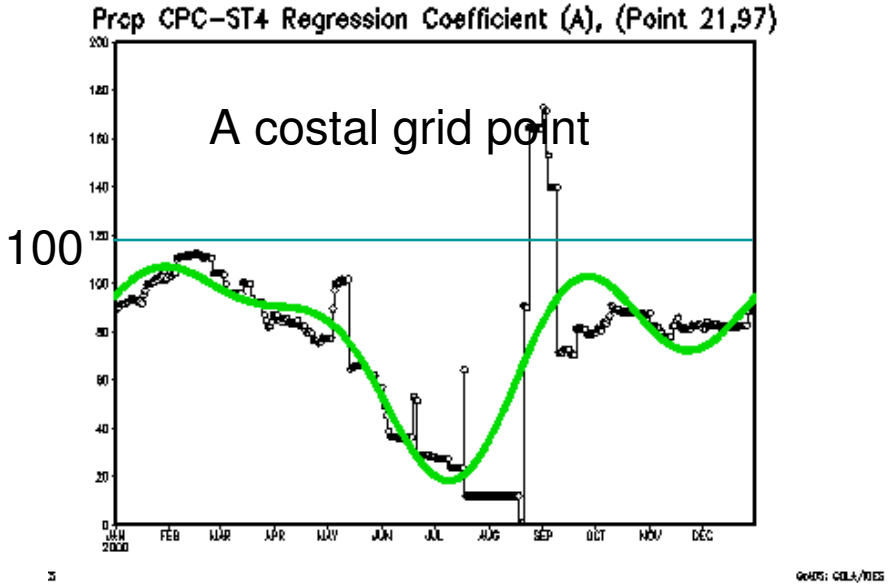


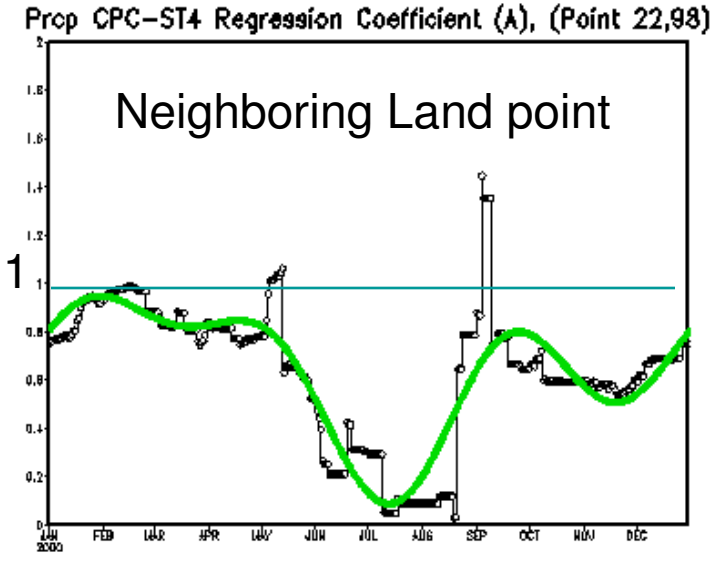


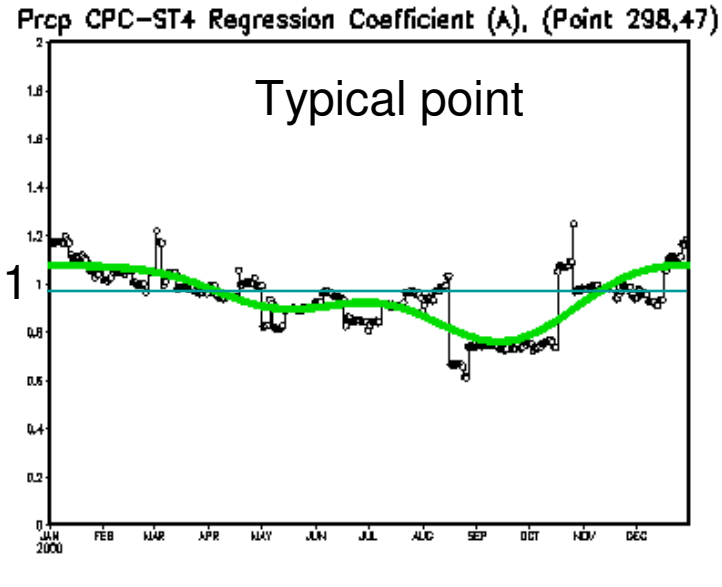


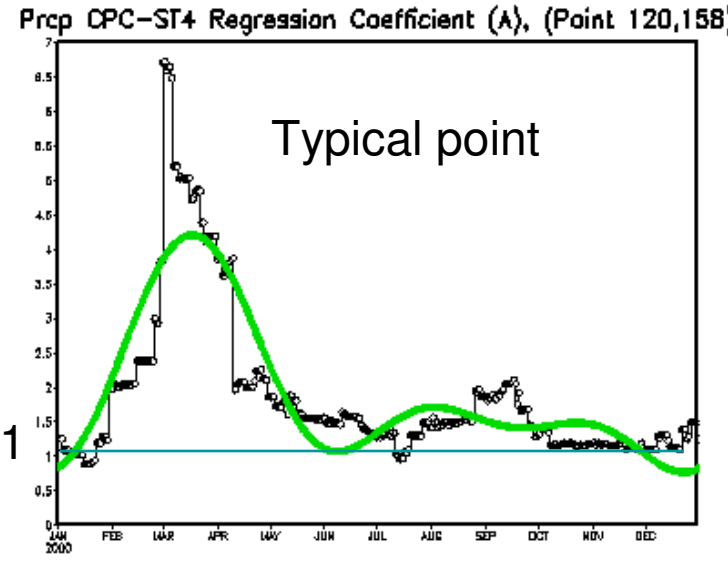


Temporal Smoothing (3 harmonics) of a

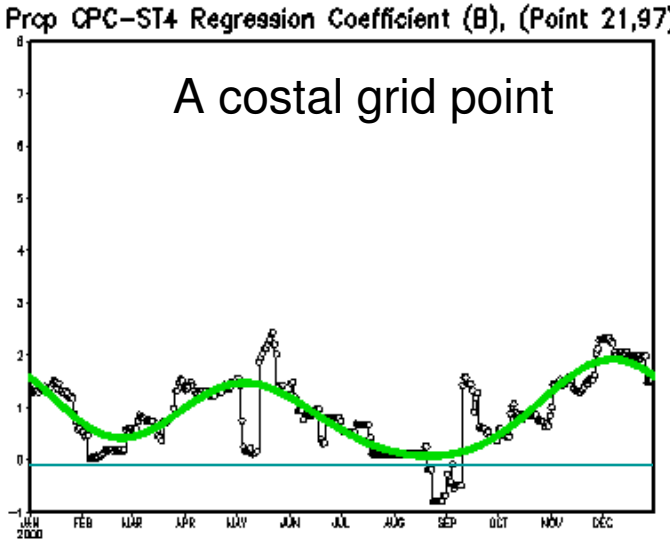


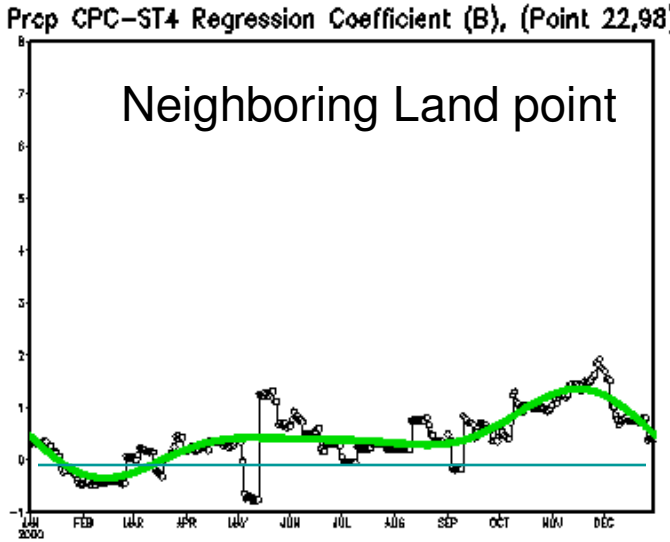


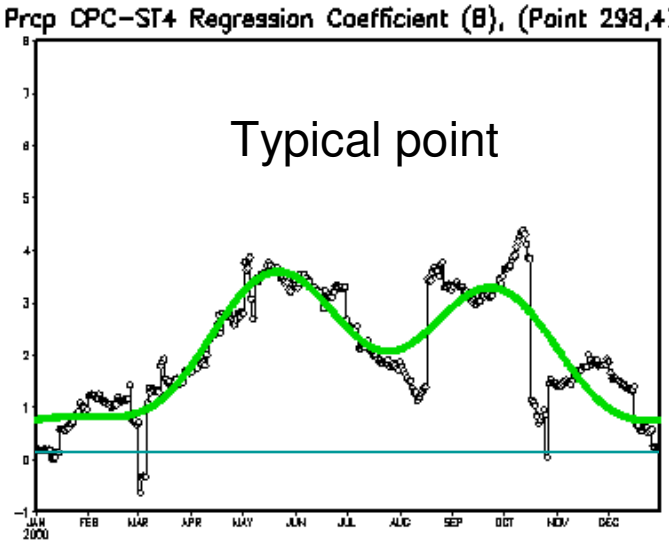


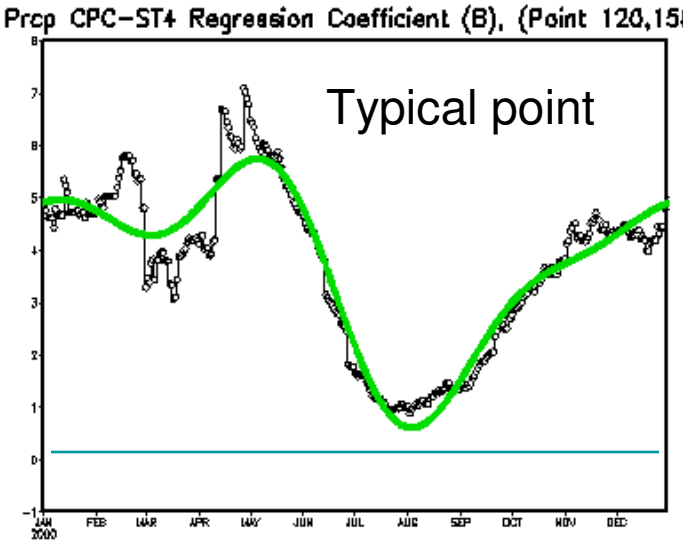


Temporal Smoothing (3 harmonics) of b

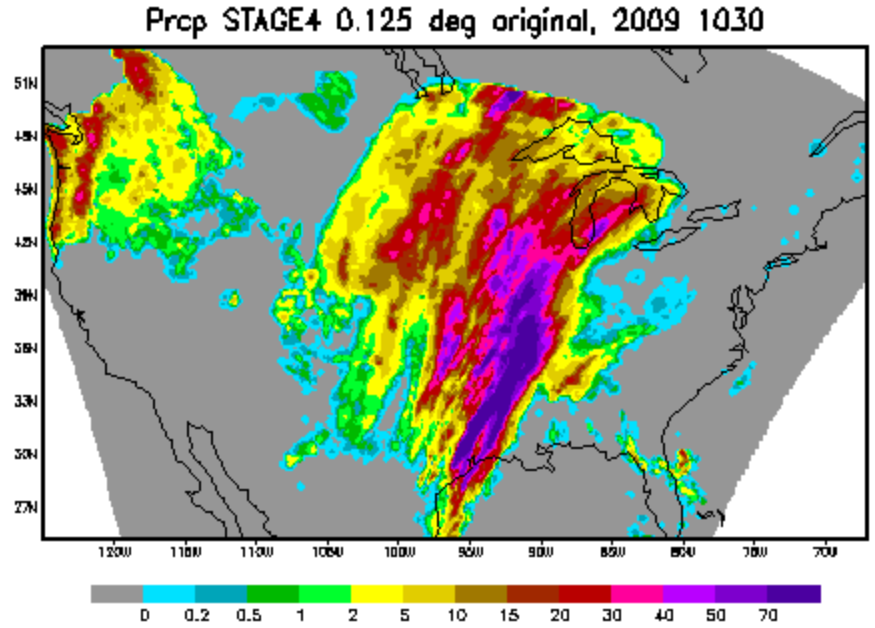


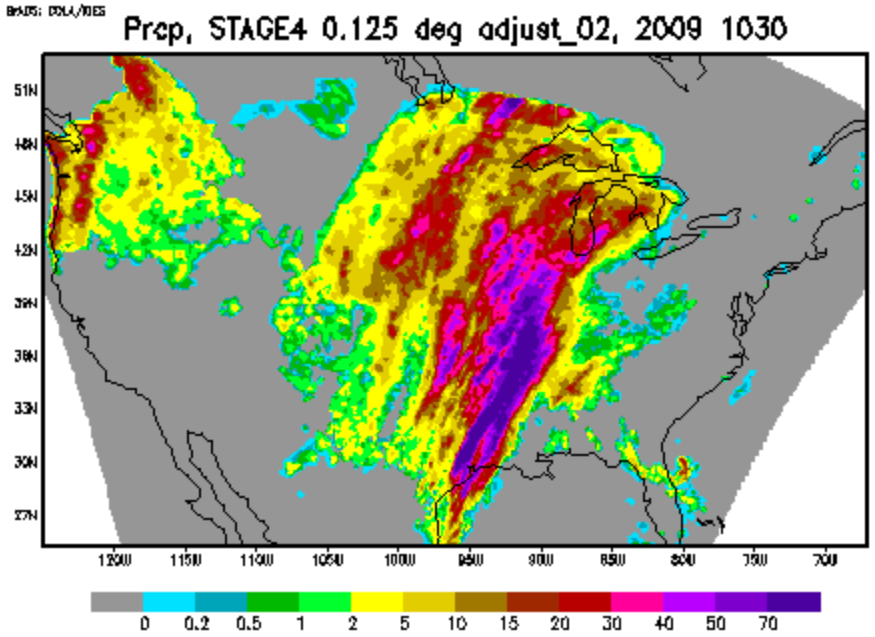






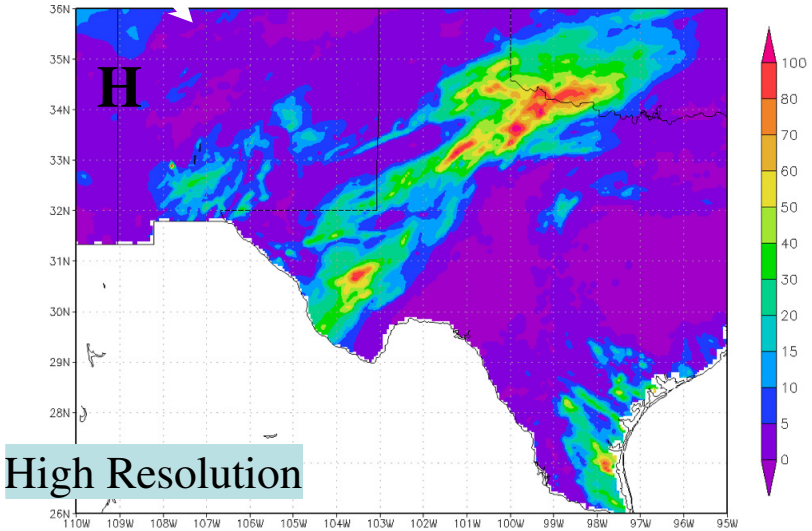
Adjustment with raw and filled a&b: $ST4^* = a \cdot ST4 + b$





Recovering Original RFC Resolutions

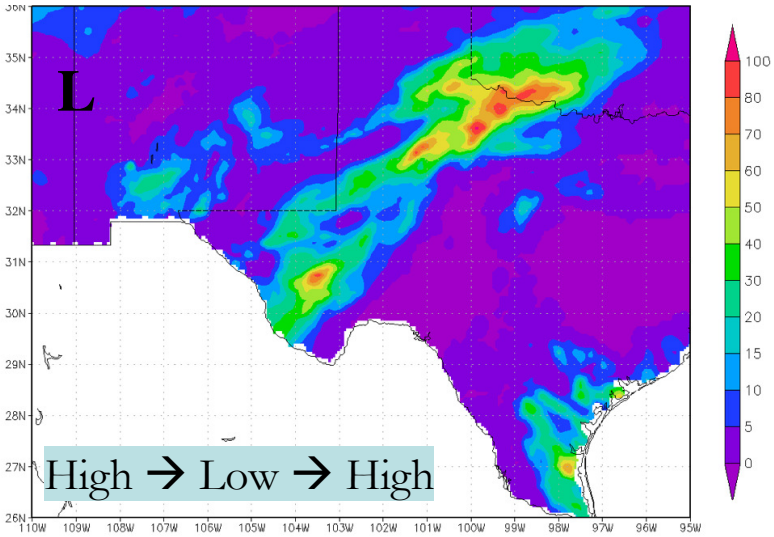
Spatial Disaggregation

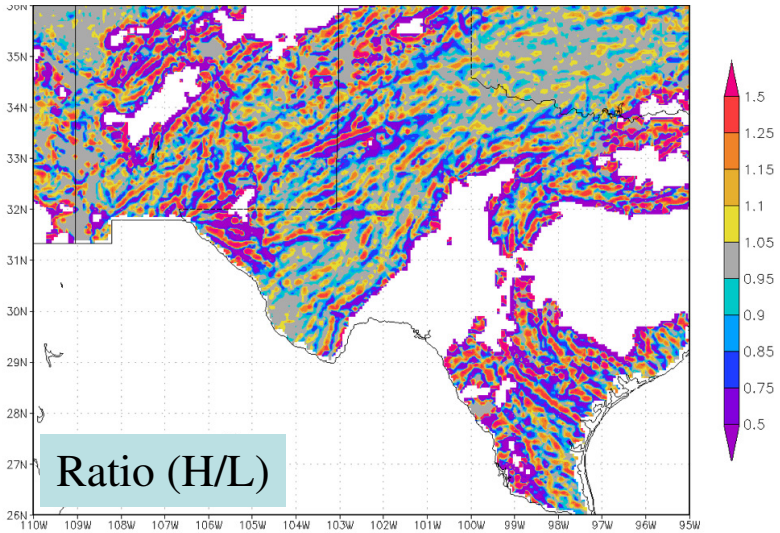


- Information is lost in ST4* (from H to L res.)
- What does lost information look like?
  - ST4,Take ratio H/L (below) from the original ST4
  - This ratio can be used to put high resolution information back into ST4*

1. Interpolate ST4* to HRAP
2. Multiply by H/L

- End with ST4* at HRAP resolution.
- Spatial information recovered from $ST4_{orig}$





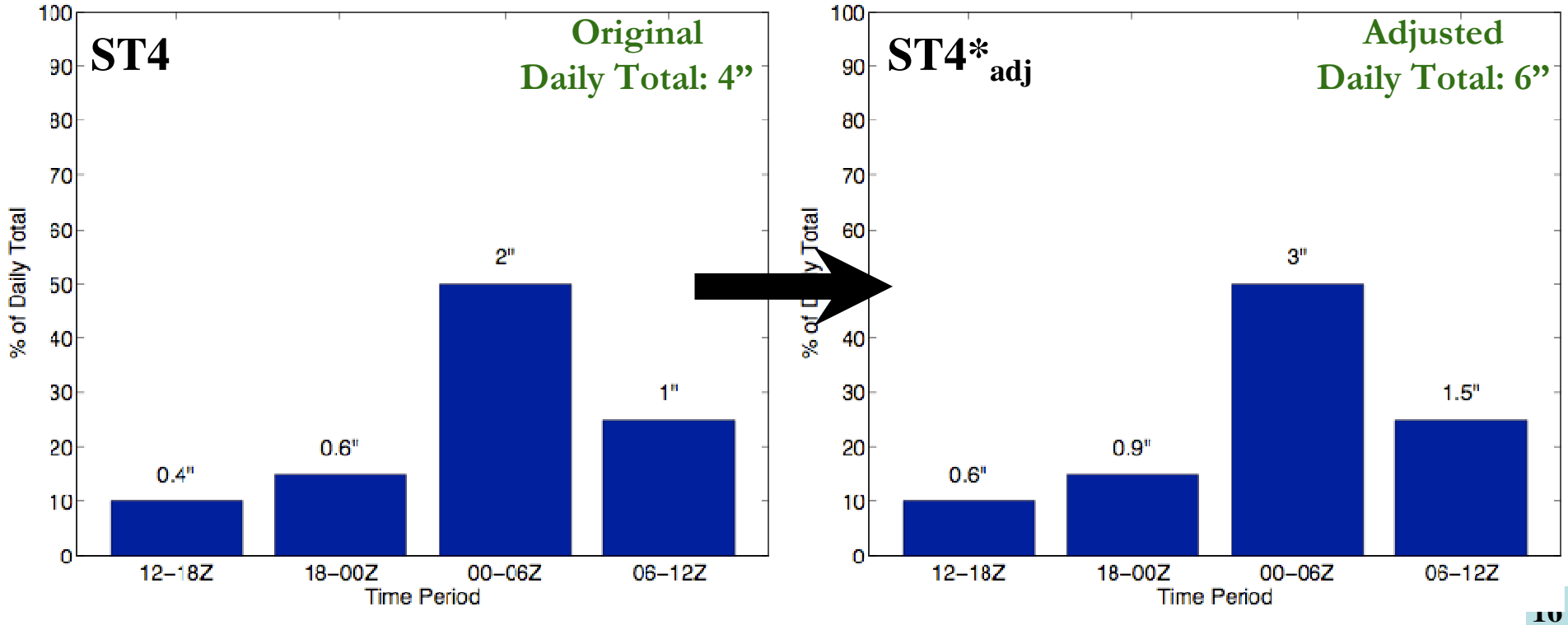
Recovering Original RFC Resolutions

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

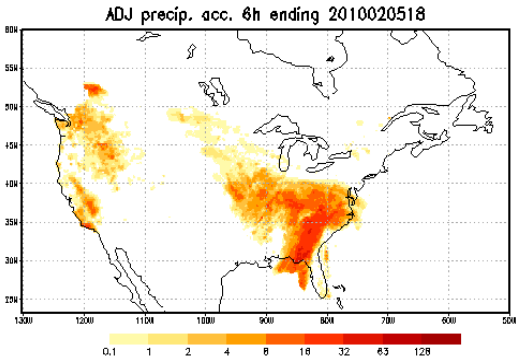


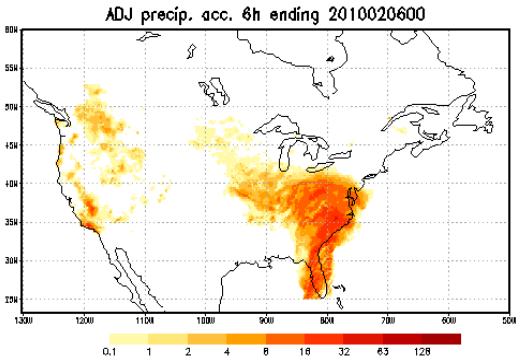
Implementation Details

- 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

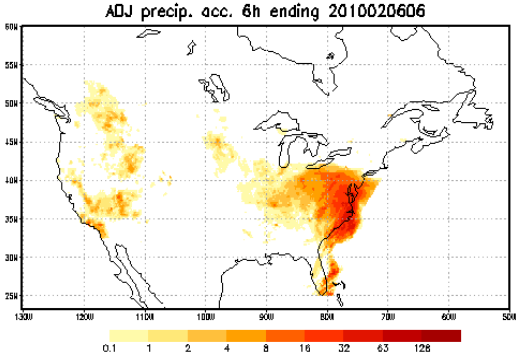
An Example
Feb. 5 2010

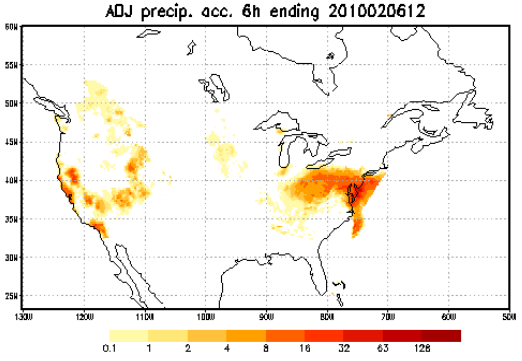
East Cost
Snowstorm 2010

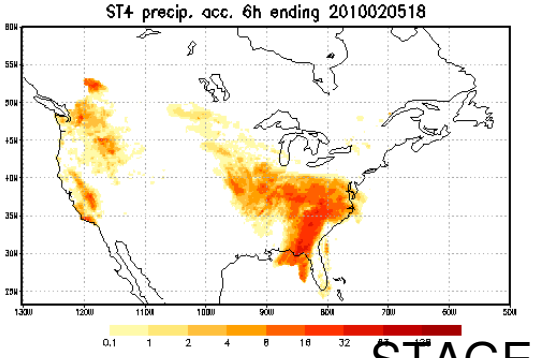


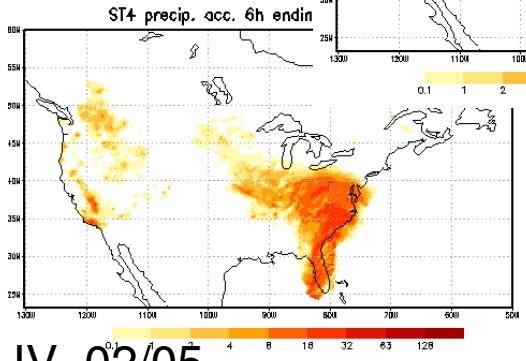


CCPA 02/05

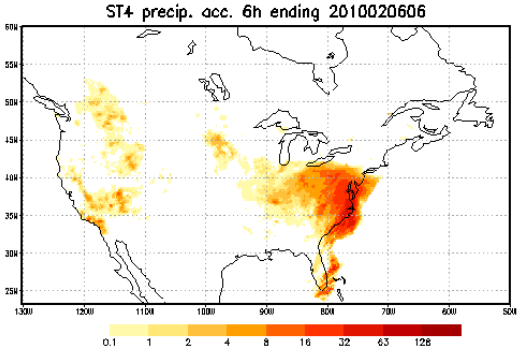


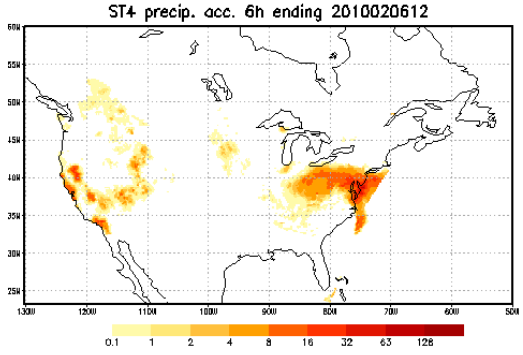




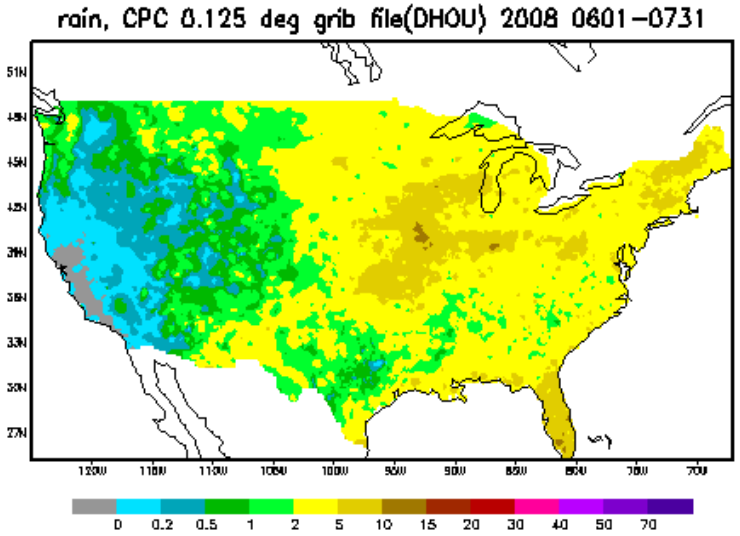


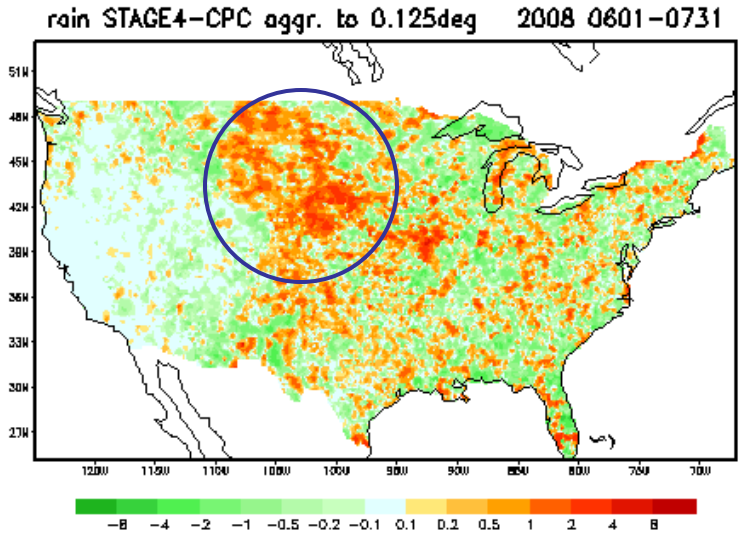
STAGE IV 02/05

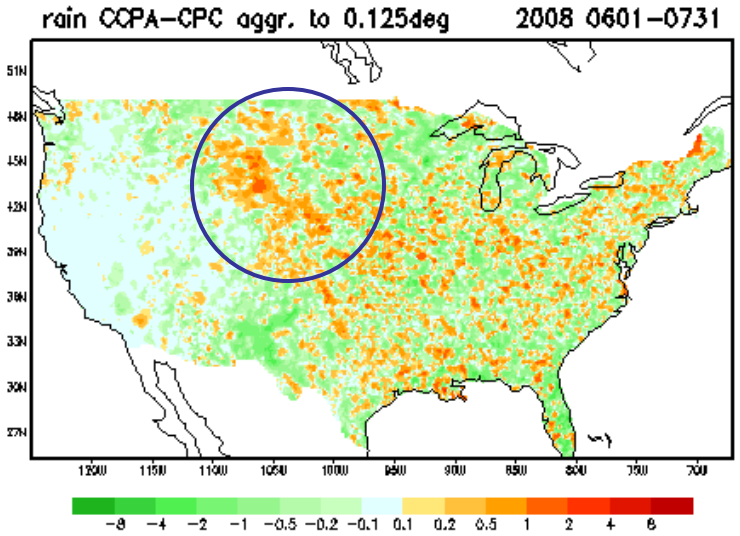




Comparison of Stage IV and CCPA Wrt. CPC



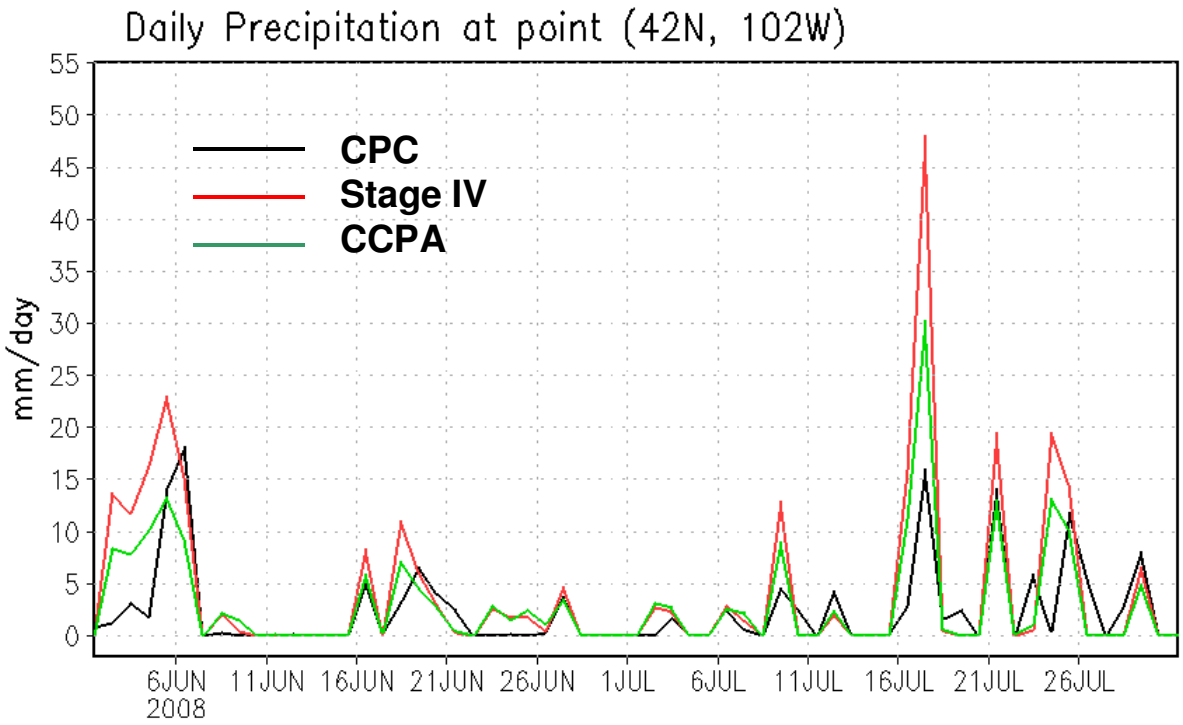




-Two Month Mean (June 1 – July 31, 2008)

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