Pseudo-Precipitation - a Continuous Variable for the Statistical Processing of Precipitation

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Motivation

- Great challenge in bias correction of quantitative precipitation forecast (QPF) and probabilistic QPF (PQPF):

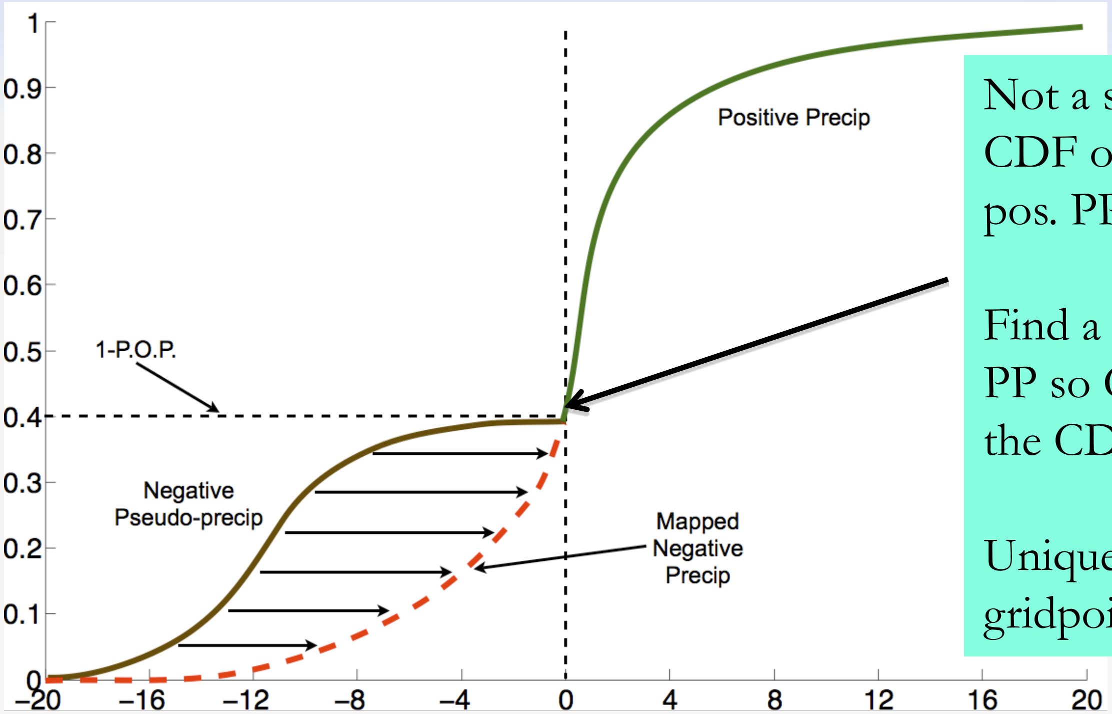
  Dry bias or there are too few members giving precipitation
- Bayesian methods for generating calibrated QPF and PQPF from ensemble forecasts require conditioning on the precipitation variable
  - Precipitation is bounded at 0
  - Discontinuous in space
- We seek to replace zeros in precipitation grid with a quantity related to dryness (the “opposite” of precipitation)
  - Negative-definite
  - Bounded at 0 on the humid end
- Ensemble pseudo-precipitation (PP) correction could provide more improvements for calibrating dry precipitation bias.

Introduction of pseudo-precipitation

Definition: positive side – precipitation (P), negative (dry) side – PP: water vapor deficit

$$PP(i,j) = P \qquad \text{if } P > 0$$

$$PP(i,j) = \frac{1}{g}\int (q_v - q_{vsat}(T))dp \qquad \text{if } P = 0$$



Not a smooth transition from CDF of neg. PP to CDF of pos. PP

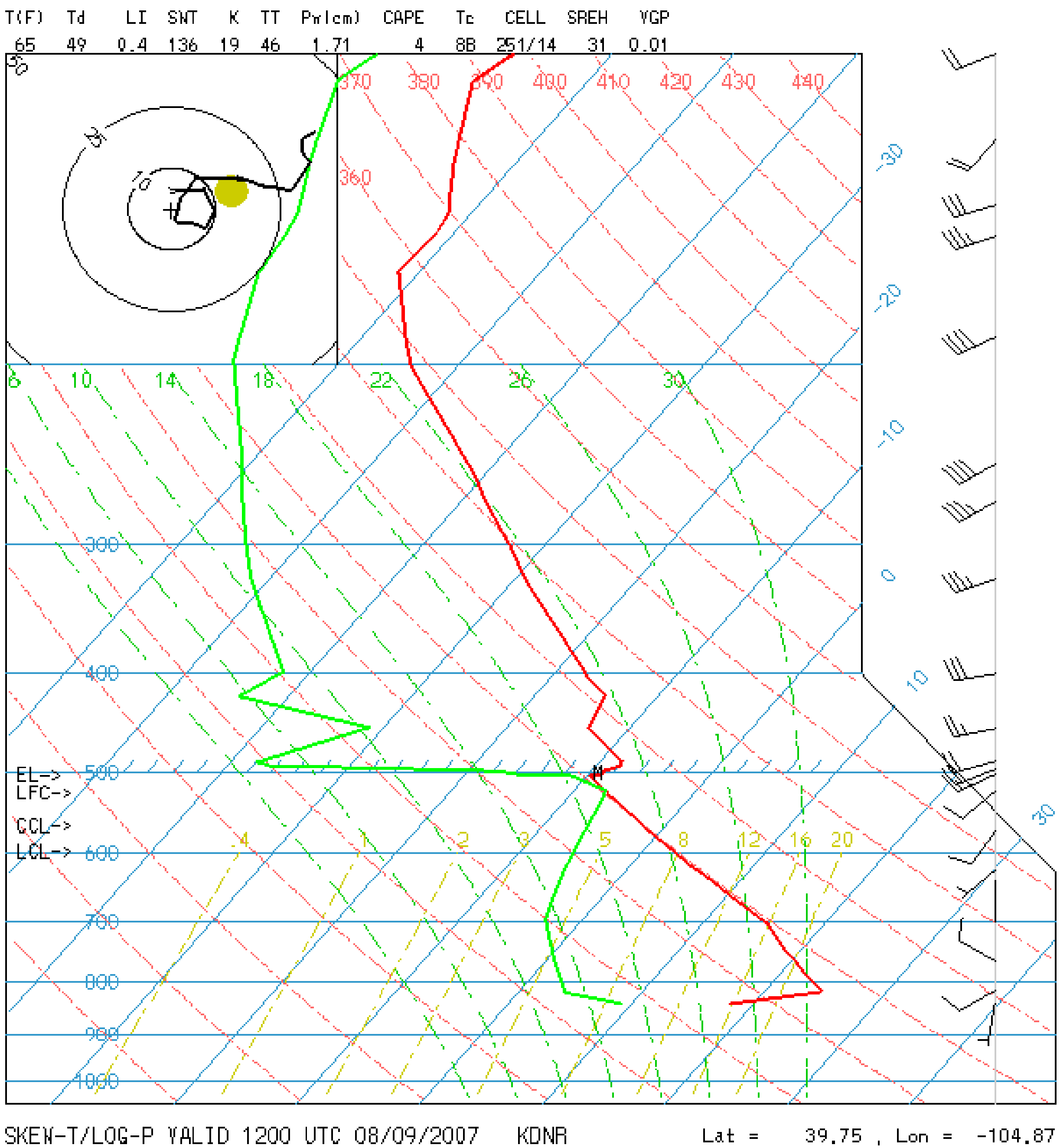
Find a function that maps neg. PP so CDF is continuation of the CDF of pos. PP

Unique function for each gridpoint/day of year

(Figure by M. Charles)

Dry side of PP

Dry side of PP is the area between the red and green traces, multiplied by -1



Two ways to calculate the dry side of PP

Method A: vertical integral

$$PP(i,j) = \frac{1}{g}\int (q_v - q_{vsat}(T))dp$$

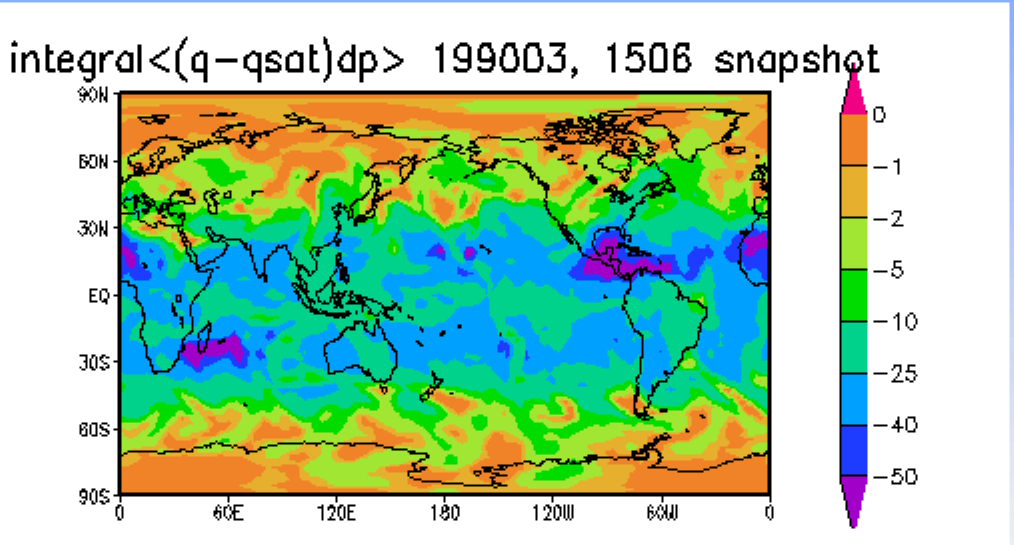
Alternative to Method A:

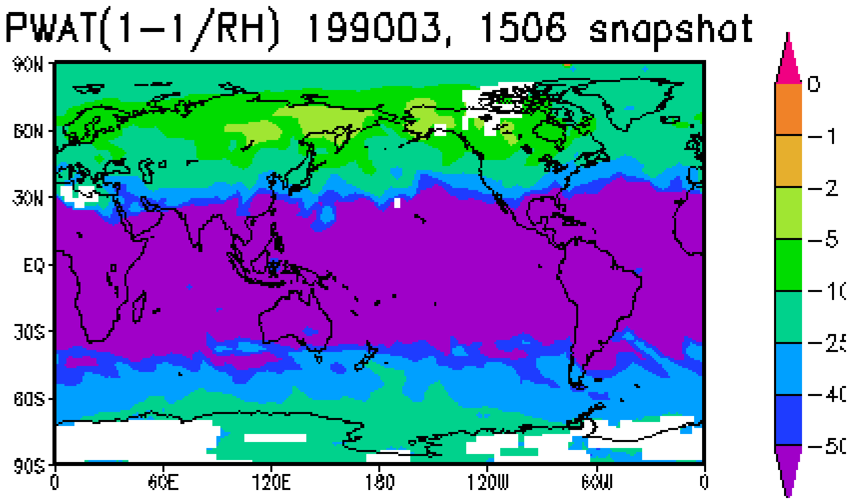
$$PP(i,j) = \frac{1}{g}\int (RH - 1)q_{vsat}(T)dp$$

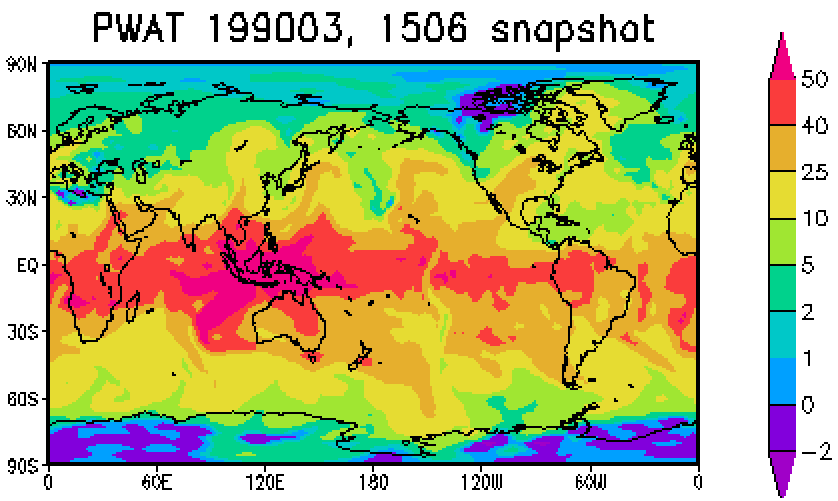
Method B: use layer-average values

$$PP(i,j) = PW\left(\frac{1}{1-\overline{\overline{RH}}}\right)$$

Snapshot of the dry side of PP

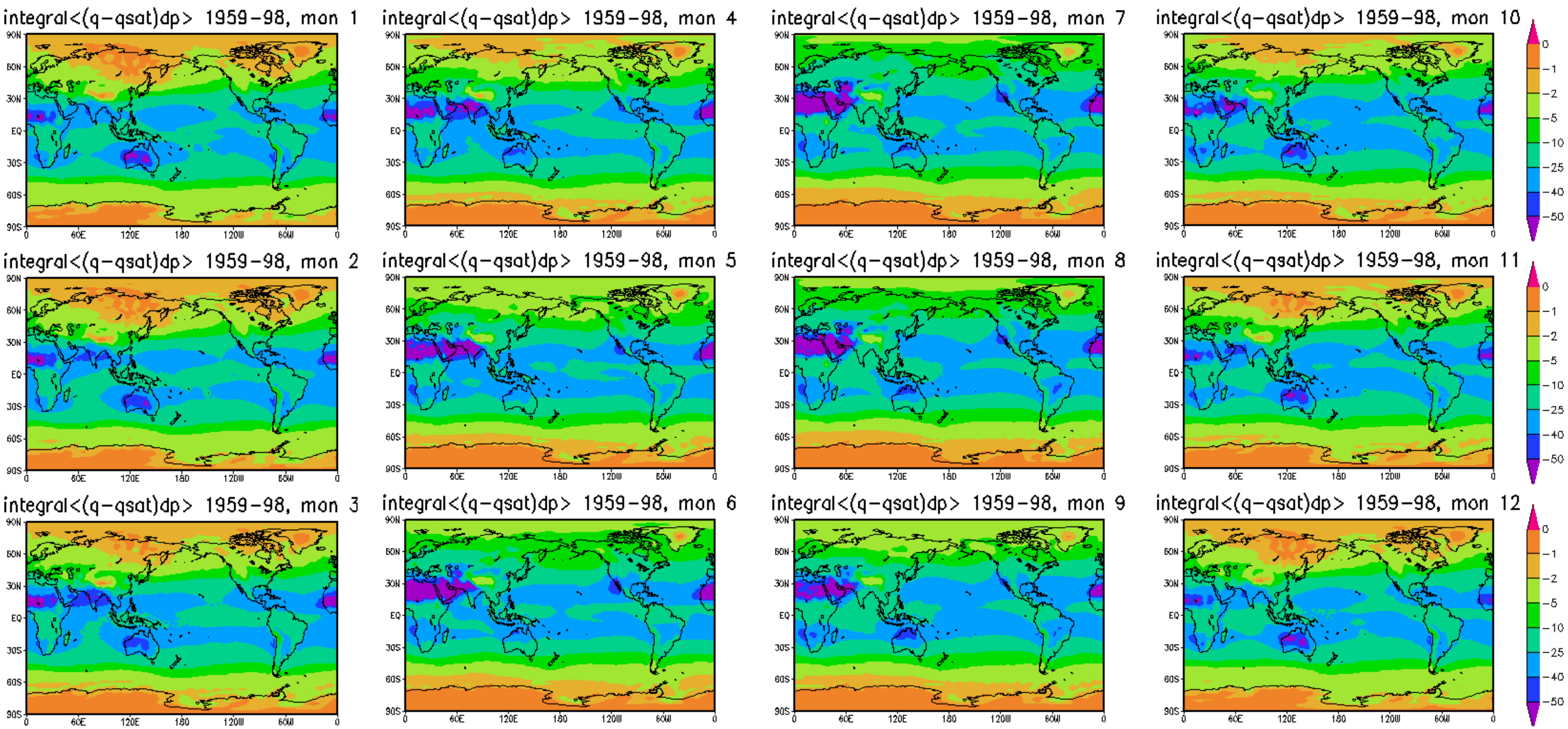






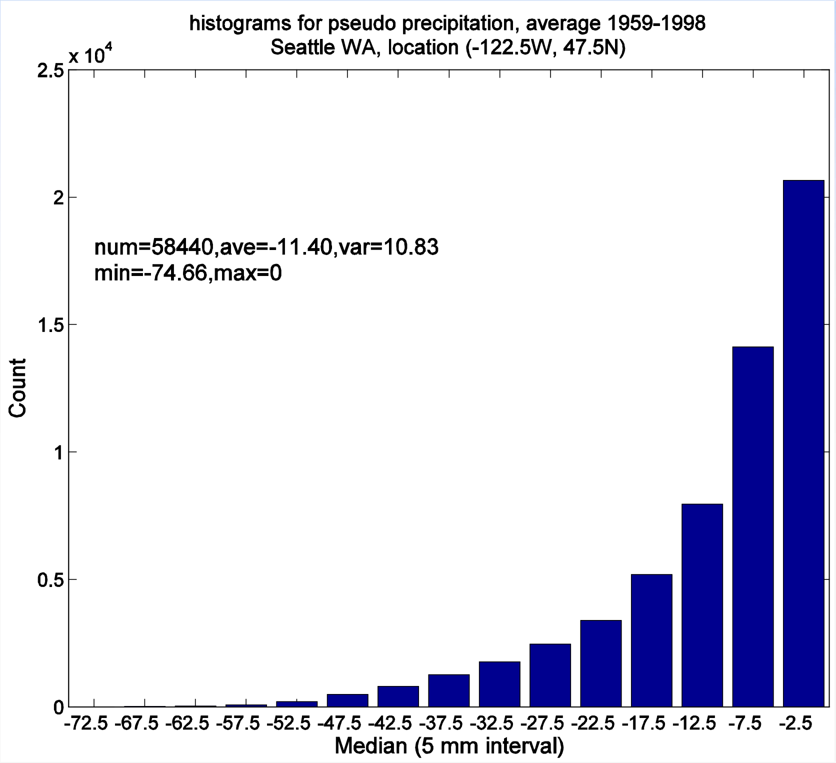
Monthly averages of the dry side of PP

4 samples per day, 112, 120 or 124 per month, each pixel is an average of 4480, 4800 or 4960 samples over 40 years

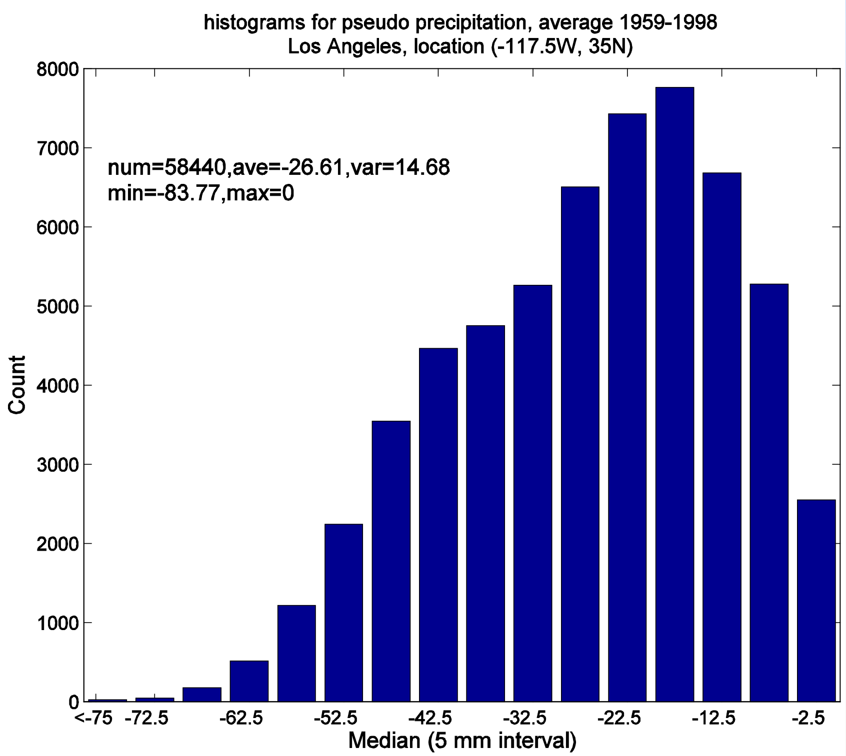


Histograms – the dry side of PP

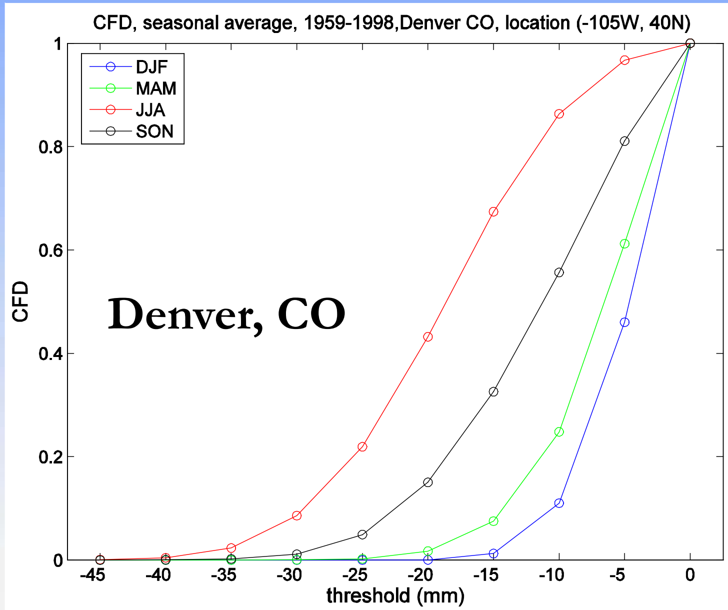
Seattle, WA

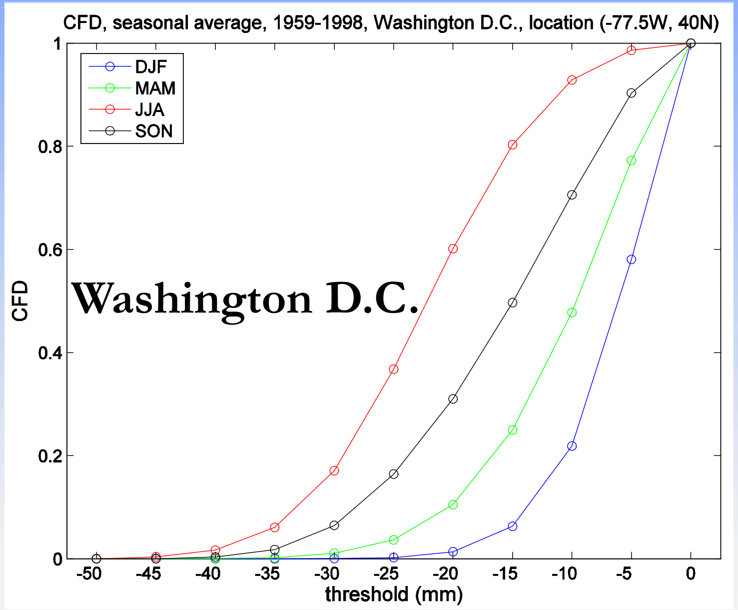


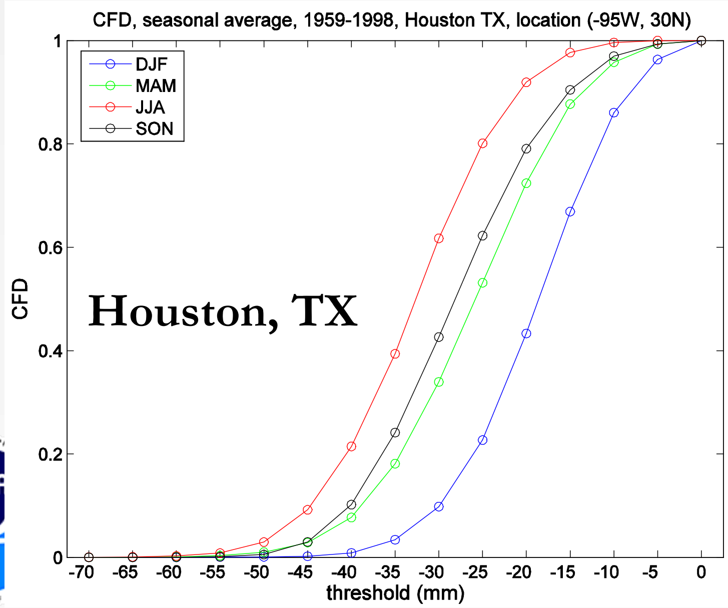
Los Angeles, CA

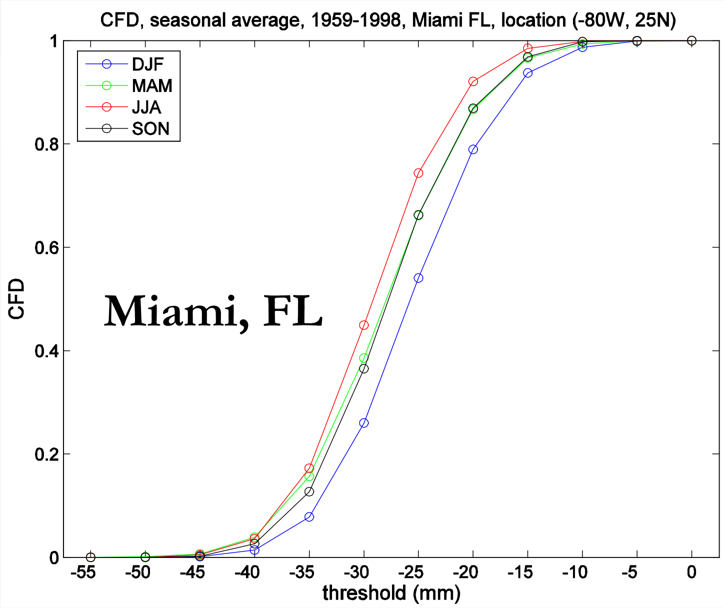


CDF of the dry side of PP, seasonal average, 4 cities

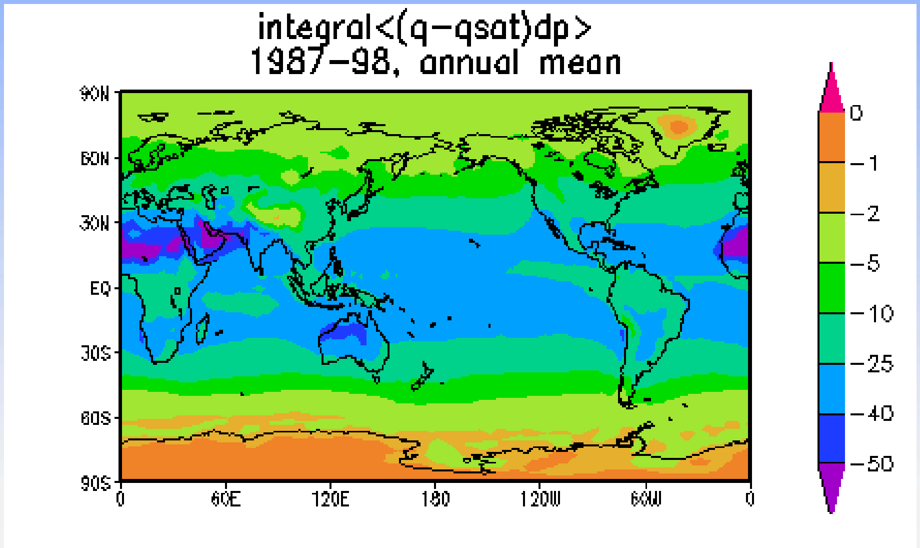




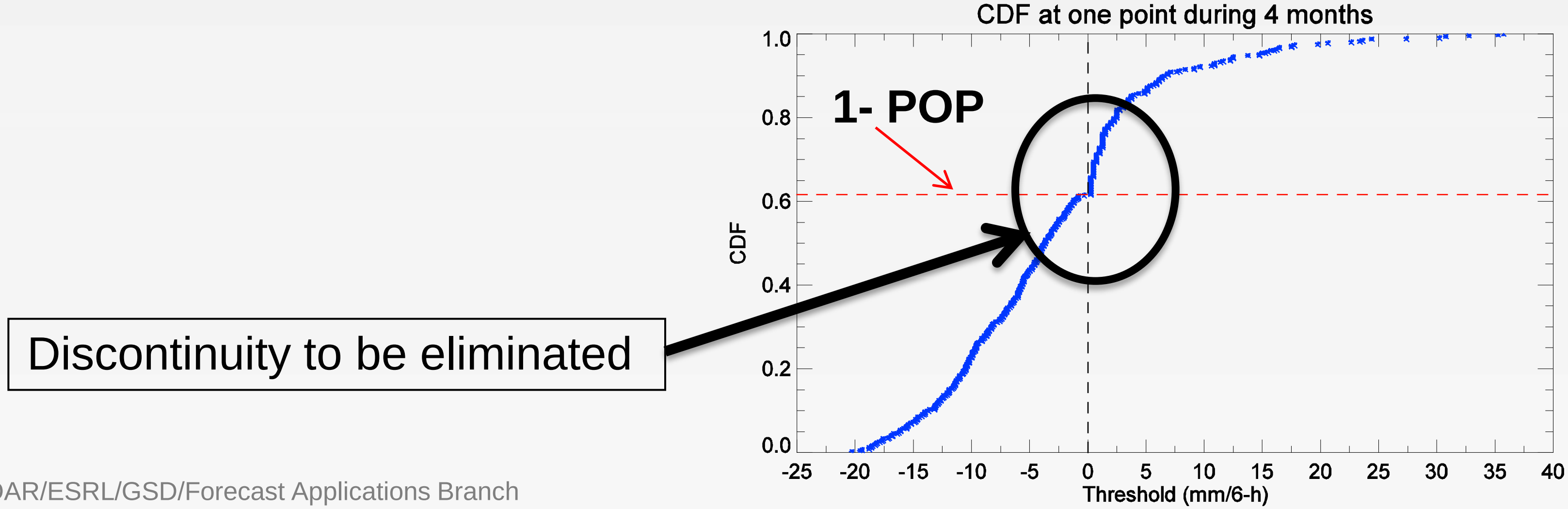




The dry side of PP and PP mapping

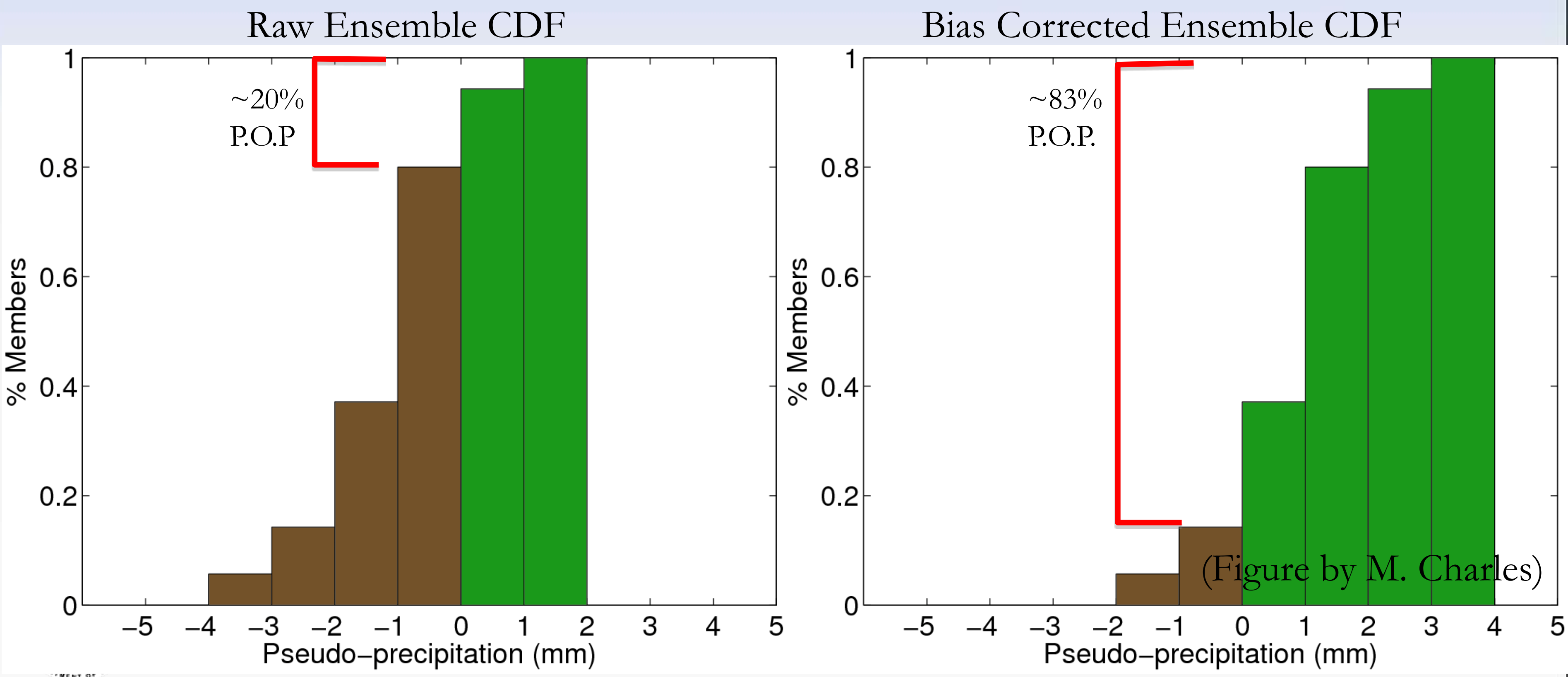


CDF of PP n using reanalysis and Stage IV data at (40 N, 121 W) for a period of 121 days (December 2005-March 2006).



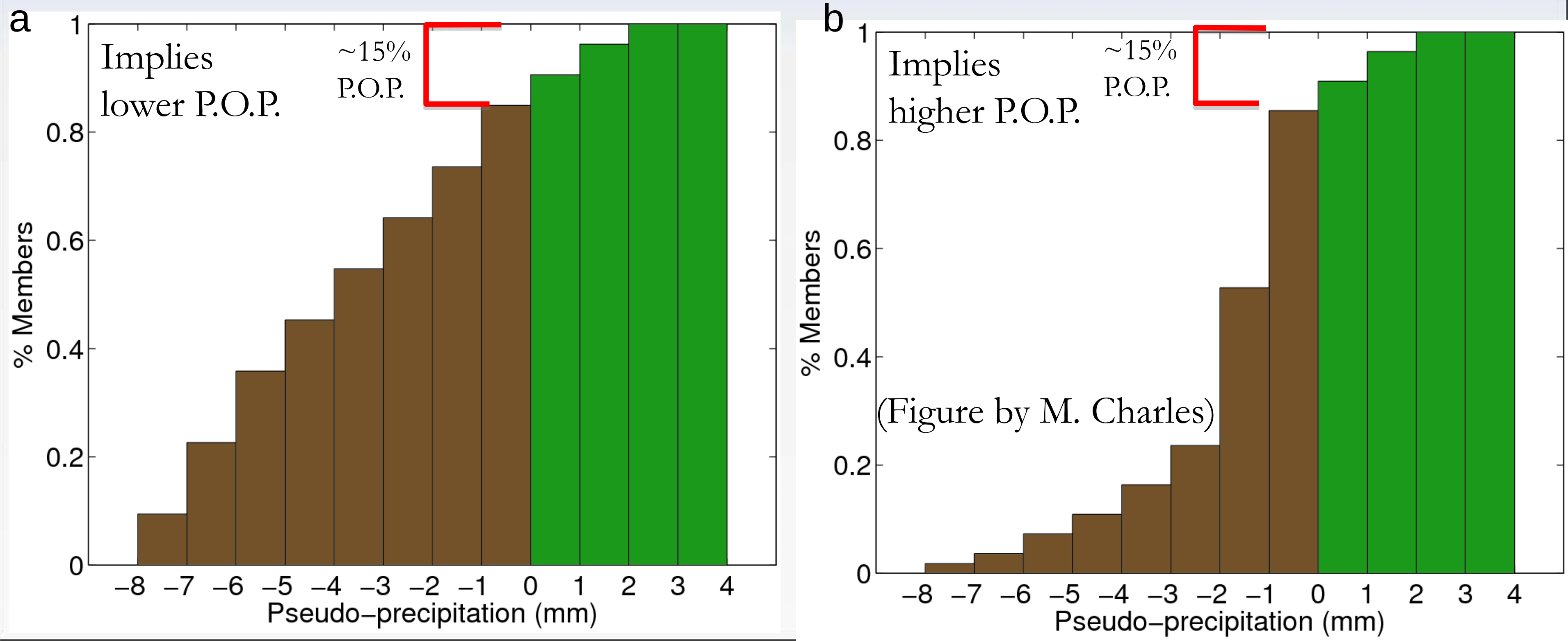
Application of PP

- With a single continuous distribution, bias correction is applied in one step
- Shift entire ensemble distribution to remove bias in PP
- For example, too few members give precipitation
- Bias correction shifts the PP distribution to the right, forcing some of those members to precipitate (removing the dry bias)



Application of PP (cont.)

- Another benefit of PP is that the distribution naturally implies P.O.P.
- If there are many members with larger negative values of PP, this implies a greater probability that the atmosphere is *not* supportive of precipitation (negative portion of PP indicates moisture deficit)
- Figure below: even though these two cases have the same % members > 0, case b has most dry members at a smaller negative value, implying higher P.O.P.



Conclusions and Future Work

- PP is a continuous variable for statistical processing of precipitation (e.g., Bayesian ensemble adjustment) and is suitable to reduce dry bias
- Mapping PP curve for long-term historical forecast data (NAEFS) to correct precipitation bias at each grid point (such as NDFD grid)
- Using the new combined CPC and Stage IV precipitation analysis (NCEP/EMC)
- Bayesian processing (e.g.,Roman Krzysztofowicz)
- Use DTC ensemble testbed data or hindcast datasets (NCEP, PSD) to test the method

Backup slides

Data in N/N Reanalysis I

- Method 1: $$PP(i, j) = \frac{1}{g}\int (q_v - q_{vsat}(T))dp + P$$

No precipitation input (*P*=0)

- RH, TMP: 1000, 925, 850, 700, 600, 500, 400, 300 mb
- RH, TMP: 30-0 mb above ground
- PRES: sfc
- RH, TMP define specific humidity (q, qsat)
- PRESsfc defines the integral layers
- Method 2: $$PP(i, j) = \frac{1}{g}\int (q_v - q_{vsat}(T))dp = PWAT(1 - \frac{1}{RH})$$

  PWAT, RH: amount for atmospheric column
- Not applicable, due to the problem in the data: RH=0 (but RH at vertical layers not equal 0), and PWAT <=0 in some grid points (?)