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

Huiling Yuan¹, ², Paul Schultz¹, Zoltan Toth¹, Mike Charles³, Yuejian Zhu³, and Bo Cui³

1. NOAA/ESRL/GSD
2. CIRES, University of Colorado, Boulder
3. NOAA/NCEP

Contributors/collaborators:
NCEP/EMC: Dingchen Hou, Malaquias Pena
University of Virginia: Roman Krzysztofowicz
ESRL/GSD: Isidora Jankov
ESRL/PSD: Tom Hamill
NOAA/OHD: DJ Seo, John Schaake

http://esrl.noaa.gov/gsd/fab
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

\[
PP(i, j) = P \quad \text{if } P > 0
\]

\[
PP(i, j) = \frac{1}{g} \int (q_v - q_{sat}(T))dp \quad \text{if } P = 0
\]

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 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

\[
PP(i, j) = PW \left( \frac{1}{1 - RH} \right)
\]
Snapshot of the dry side of PP

integral\(\langle q - q_{sat}\rangle dp\) 199003, 1506 snapshot

PWAT(1-1/RH) 199003, 1506 snapshot

PWAT 199003, 1506 snapshot
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

Denver, CO

Washington D.C.

Houston, TX

Miami, FL
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).

Discontinuity to be eliminated
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)

(Figure by M. Charles)
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
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 \((q, q_{sat})\)
  - PRESsfc defines the integral layers

- **Method 2:**
  \[ PP(i, j) = \frac{1}{g} \int (q_v - q_{vsat}(T)) dp = PWAT \left(1 - \frac{1}{RH}\right) \]
  \(PWAT, RH\): 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 (?)