Statistical Postprocessing of Week-1 and Week-2 Precipitation Forecasts Over Taiwan

Hui-Ling Chang[1], Zoltan Toth[2], Shih-Chun Chou[1], Chih-Yung Feng[3], Han-Fang Lin[3], Pay-Liam Lin[4], Jing-Shan Hong[1], Chin-Tzu Fong[1], Chia-Ping Cheng[1]

1. Central Weather Administration, Taipei, Taiwan; 2. Global Systems Laboratory, National Oceanic and Atmospheric Administration, Boulder, Colorado, USA;
3. Manysplended Infotech Ltd, Taiwan; 4. Institute of Atmospheric Physics, National Central University, Jhongli City, Taiwan

e-mail: lingo@cwa.gov.tw (Hui-Ling Chang)

Motivation

The predictability of precipitation is hindered by finer-scale processes not captured explicitly in global numerical models, such as convective interactions, cloud microphysics, and boundary layer dynamics. However, there is growing demand across various sectors for medium- (3–10-day) and extended-range (10–30-day) quantitative precipitation forecasts (QPFs) and probabilistic QPFs (PQPFs). Therefore, the goal of this study is to predict the conditional climatology of precipitation given the forecast of the large-scale circulation conditions, which still retain predictability in the extended range.

In addition, most ensemble prediction systems are characterized by under-dispersion that limits the utility of probabilistic predictions. Here we use analog post-processing (AP; Hamill and Whitaker 2006; Hamill et al. 2015) to produce posterior ensembles with reasonable spread to effectively mitigate the problem of under-dispersion. Frequency counting and PM are then separately applied to the posterior ensemble to produce calibrated and downscaled PQPFs and bias-reduced QPFs, respectively.

Data Sources and Validation

➢ Forecast : SubX EMC-GEFS

- period: Jan 1999- Dec 2016 (reforecast, 10 members) ; Aug 2017- Sep 2020 (forecast, 20 members)
- update frequency: once per week, with forecasts initialized at 00 UTC every Wednesday.
- horizontal resolution : 1° x 1° lat/lon

➢ Observation : gridded precipitation analysis based on rain gauge data

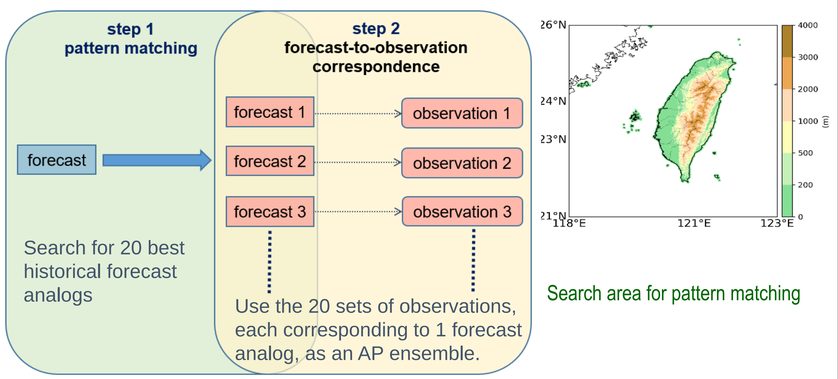
- period: Jan 1999 – Sep 2020
- horizontal resolution: 1 km x 1 km
- analysis technique: Simple Kriging method

➢ Validation period: Jan 1999 – Sep 2020

- leave-one-out cross validation

Methodology

Analog Post-processing (AP)



Search area for pattern matching

Distance-based Similarity Criterion D(t)

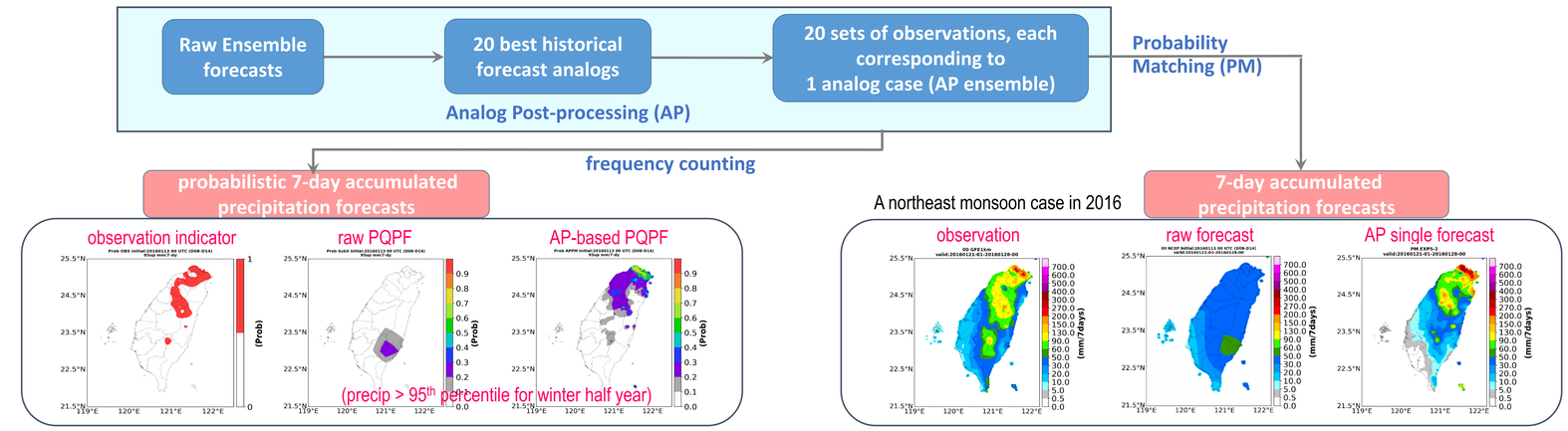
$$D(t) = \sqrt{\frac{1}{L}\sum_{l=1}^{L}(\bar{x}^{l,\mathrm{tc}} - \bar{x}^{l,t})^2 + \frac{1}{L}\sum_{l=1}^{L}(s^{l,\mathrm{tc}} - s^{l,t})^2}$$

$$\bar{x} = \frac{1}{M}\sum_{m=1}^{M} x_m \qquad s = \sqrt{\frac{1}{M-1}\sum_{m=1}^{M}(x_m - \bar{x})^2}$$

ensemble mean ensemble spread

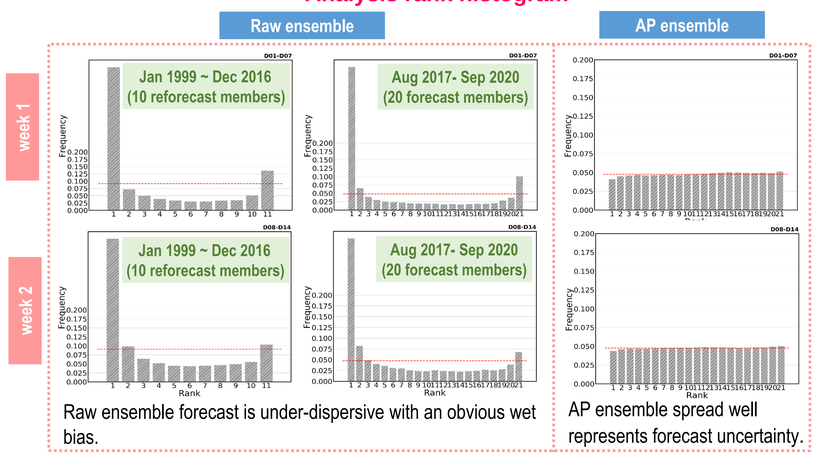
x : forecast variable (precipitation)
tc : current date
t : chosen date in the archive
L : number of grid points for pattern matching
M : number of ensemble members

Statistical post-processing procedure (SPP) for precipitation forecasts



Evaluation of ensemble distribution

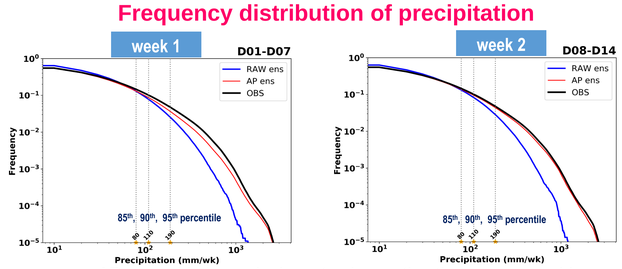
Analysis rank histogram



Raw ensemble forecast is under-dispersive with an obvious wet bias.

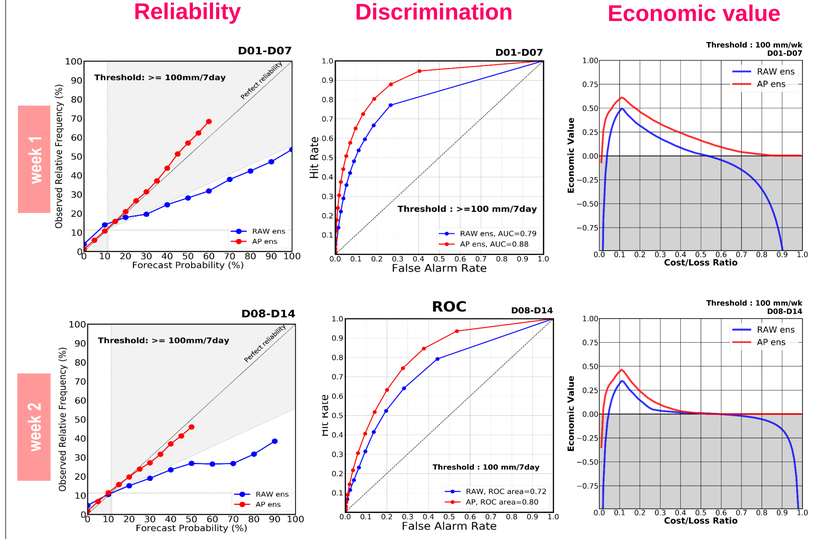
AP ensemble spread well represents forecast uncertainty.

Frequency distribution of precipitation



- AP ensemble is much closer to observation than raw ensemble.

Evaluation of PQPF (precipitation > 100 mm/wk)



- **Reliability**
  Raw forecast has obvious over-forecasting, while calibrated one has good reliability.
- **Discrimination**
  Calibrated PQPF has higher skill in discrimination than raw forecast.
- **Economic vale**
  users with a much wider spectrum of cost/loss ratio can obtain more benefit from the calibrated forecast as compared to the raw forecast. .

Conclusions

- **Ensemble distribution**
  - ✓ Raw ensemble is under-dispersive with an obvious wet bias, while AP ensemble is calibrated with most of the bias removed.
  - ✓ For frequency distribution of precipitation, AP ensemble is much closer to observation than raw ensemble.
- **AP-based probabilistic precipitation forecast, compared to raw PQPF, has**
  - ✓ better reliability and higher skill in discrimination
  - ✓ higher economic value for a much wider spectrum of cost/lost ratio

Acknowledgement and references

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Hamill, T. M., and J. S. Whitaker, 2006：Probabilistic quantitative precipitation forecasts based on reforecast analogs: Theory and application. *Mon. Wea. Rev.* , **134**, 3209–3229.

——, M. Scheuerer, and G. T. Bates, 2015：Analog probabilistic precipitation forecasts using GEFS reforecasts and climatology-calibrated precipitation analyses. *Mon. Wea. Rev.*, **143**, 3300–3309.

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