Investigating Statistical Downscaling Methods and Applications for the NCEP/GEFS Ensemble Precipitation Forecasts

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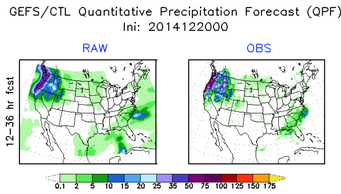
Ensemble Precipitation Forecast Calibration and Downscaling

Background – Significant discrepancies exist when coarse resolution model precipitation forecast products on standard output grids are verified against high-resolution analyses, remaining a challenge for NWP model guidance products.



(1) Model bias (over-forecast small amounts, under-forecast large amounts, inadequate spread in ensemble) => Calibration is needed
(2) Spatial distribution is too smooth, lack of intense local information associated with orographic precipitation => Downscaling is needed

Objective – To enhance the usefulness of the model products, tremendous efforts with various statistical bias correction and downscaling techniques are being made to reduce those discrepancies and recover high resolution information. In this work, based on the frequency matching method (FMM, Zhu and Luo, 2015) for bias correction and climatology downscaling technique, the one degree NCEP/GEFS ensemble precipitation forecasts are integrated with use of the Climatology-Calibrated Precipitation Analysis (CCPA, Hou et. al, 2014) to produce downscaled forecasts at 5-km NDGD grid.

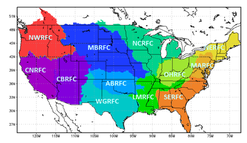
Calibration Methodology – Frequency Matching Method (FMM)

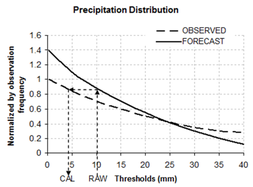
(Ref: Zhu and Luo, 2015: Weather and Forecasting)

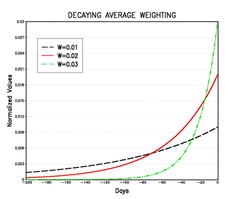
Calculate for Obs and Fcst respectively

$$\overline{CDF}_j = (1-W) * \overline{CDF}_{j-1} + W * CDF_j$$

W is weight to accumulate CDF







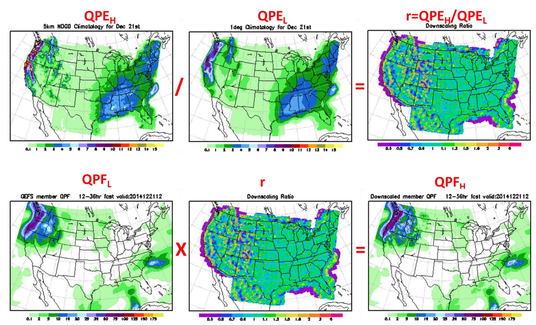
Downscaling Methodology – Climatology Downscaling

- ❑ Similar to Mountain Mapper/WPC Approach
- ❑ Similar efforts mostly made by Trevor Alcott from NOAA/NWS Western Region Headquarters
- ❑ Based on the CCPA daily climatology data
  - ➢ 1 x1 degree interpolated to 5-km NDGD grid (QPE_L)
  - ➢ 5-km NDGD grid (QPE_H)
- ❑ Determining the Downscaling Ratio (r)
  - ➢ Remap the 1x1 degree CCPA daily climatology data to the high resolution 5-km NDGD grid
  - ➢ Compute the ratio of the CCPA data on the original high resolution grid to the interpolated data. These values are the downscaling ratios
- ❑ The 1x1 degree 24-hourly QPF forecasts are spatially interpolated to 5-km resolution over CONUS
- ❑ At each grid point, multiplied by a downscaling ratio using a multiplicative downscaling ratio:

  QPF ds = QPF × r

  r = QPE_H/QPE_L
- ❑ Applied on the 5-km NDGD grid

Schematic Diagram of Downscaling Methodology



Downscaling Experiment and Verification

- ❑Tests for December 2014 thru February 2015 for raw and bias-corrected NCEP/GEFS CTL+ 20-member ensemble with and without downscaling. Verification against CCPA
- ❑Compare these three QPFs with the raw QPFs on 5-km NDGD grid:
  - ➢Downscaled only
  - ➢Bias-corrected only
  - ➢Bias-corrected and downscaled
- ❑The performance in one cold season (12/1/2014 – 2/28/2015) is investigated
- ❑Verification metrics are examined
  - ➢Continuous Ranked Probability Score (CRPS), Equitable Threat Score (ETS), Bias Score
  - ➢Brier Score, Brier Skill Score
  - ➢Reliability Diagram

Illustration of the Bias Correction and Downscaling - QPF

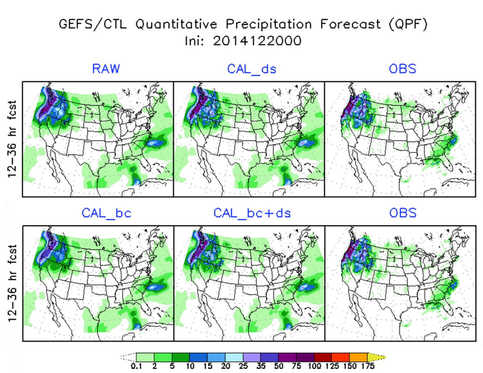
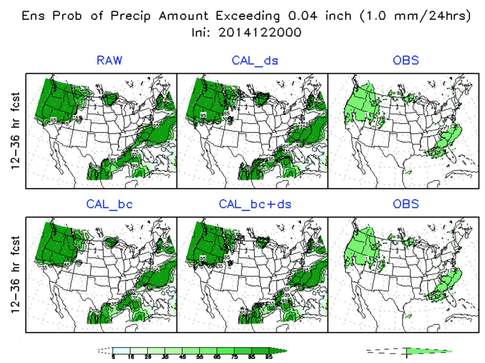


Illustration of the Bias Correction and Downscaling – PQPF



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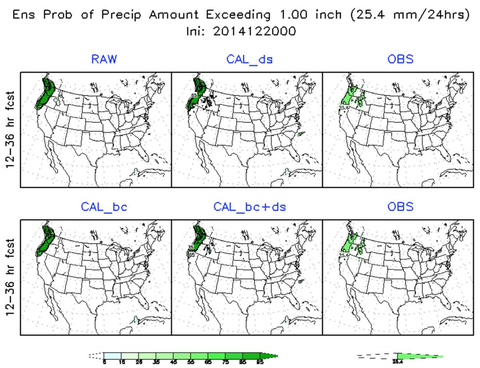
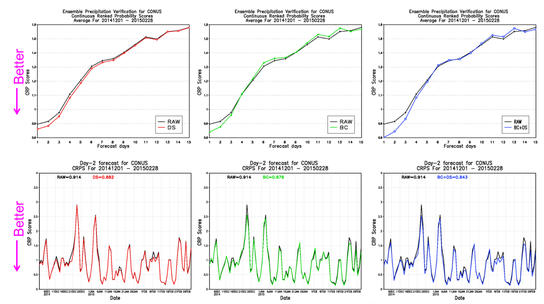
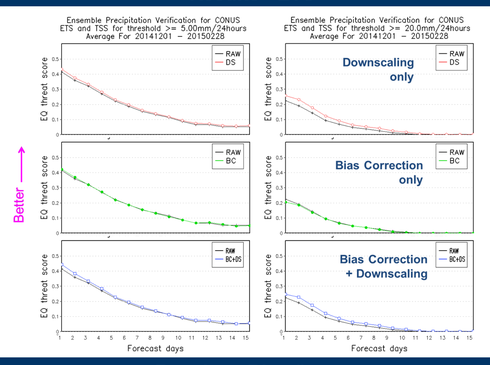


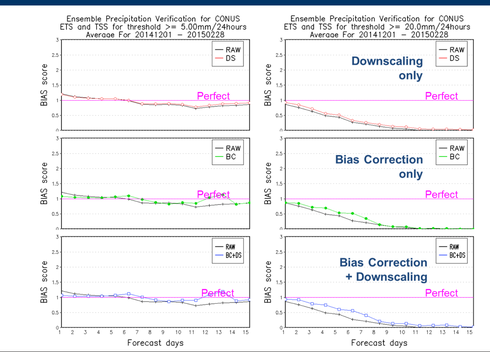
Results - CRPS



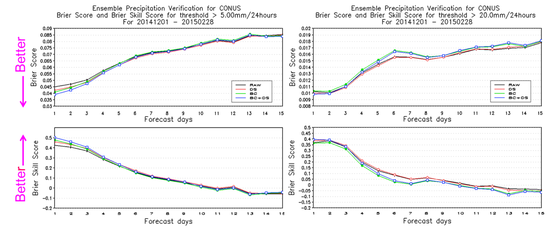
Results - ETS



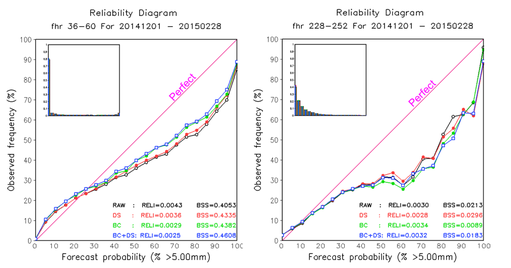
Results – Bias Score



Results – Brier Score & Brier Skill Score



Results – Reliability Diagram



Summary

- ❑ The downscaled QPFs/PQPFs tend to be able to capture some fine scale structures of observation
- ❑ Downscaled only QPFs/PQPFs outperforms Raw QPFs/PQPFs for all lead times, while the improvement is marginal for the longer leads.
- ❑ Bias-corrected only QPFs/PQPFs degrade for longer lead times is likely due in part to dominated pattern errors, and degrade for larger thresholds is likely due to limited sampling, indicates a challenge in bias-correction for long range forecasts and extreme events
- ❑ The overall skill due to calibration and downscaling is improved mainly for smaller thresholds and shorter lead times
- ❑ Use of bias-corrected and downscaled QPFs for the shorter leads and downscaled only QPFs for the afterwards could be an optimum choice of the ensemble forecast guidance products

Future Work

- ❑ Explore the impact for the warm season or longer period using the same approaches
- ❑ Integrate calibration and downscaling with use of both model climatology and observation climatology
- ❑ Other techniques (Analog) could also be applied and compared

References

- ❑ Yuejian Zhu and Yan Luo, 2015: Precipitation Calibration Based on the Frequency-Matching Method. Wea. Forecasting, 30, 1109–1124. doi: http://dx.doi.org/10.1175/WAF-D-13-00049.1
- ❑ Dingchen Hou, Mike charles, Yan Luo, Zoltan Toth, Yuejian Zhu, Roman Krzysztofowicz, Ying Lin, Pingping Xie, Dong-Jun Seo, Malaquias Pena, and Bo Cui, 2014: Climatology-Calibrated Precipitation Analysis at Fine Scales: Statistical Adjustment of Stage IV toward CPC Gauge-Based Analysis. J. Hydrometeor, 15, 2542–2557. doi: http://dx.doi.org/10.1175/JHM-D-11-0140.1