Comparison and potential of bias correction methods for skewed variables

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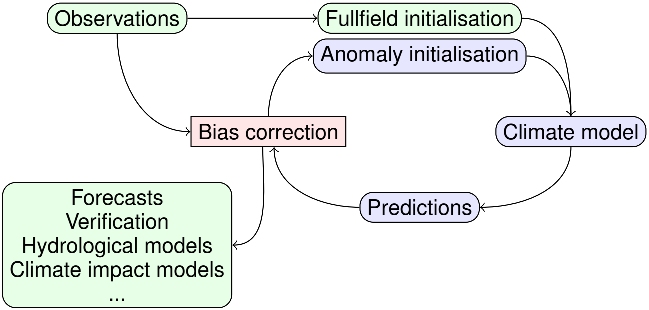
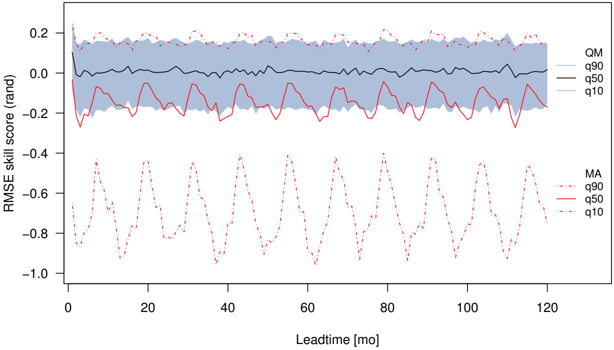
Introduction



- Are improvements possible, in comparison to the actual standard ?
- Main interest is on bias correction for skewed variables
- Comparison of different correction strategies
- Impact on prediction scores

Motivation



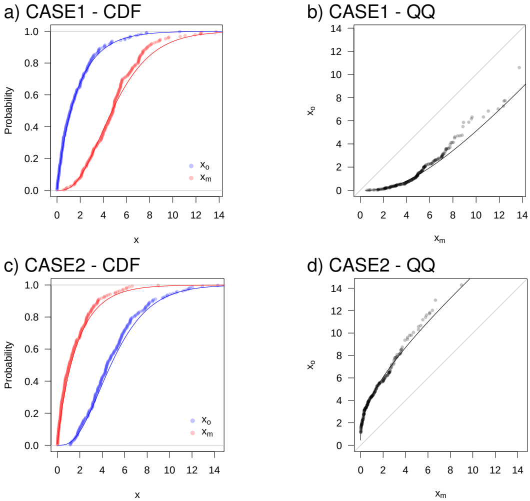
- Bias correction (BC) methods accounting for higher order moments lead to an RMSE skill-score increase of 0.2 on average in comparison to the standard Method (”anomalies”)

Test cases

- Simulation study to quantify the performance of BC methods
- x_o ("observervations") and x_m ("model predictions") Gamma distributed

$\mu_o < \mu_m$ and $\sigma_o^2 < \sigma_m^2$

$\mu_o > \mu_m$ and $\sigma_o^2 > \sigma_m^2$



Methods overview

1. Additive or multiplicative constant

$$x_{m,bc} = x_m - \overline{x_m} + \overline{x_o} \qquad \textbf{(ADD)}$$

$$x_{m,bc} = (\overline{x_o}/\overline{x_m})x_m \qquad \text{(MUL)}$$

$$x_{m,bc} = (x_m - \overline{x_m})\frac{\sigma(x_o)}{\sigma(x_m)} + \overline{x_o} \qquad \text{(NORM)}$$

2. Transfer functions from QQ-relation

$$x_{m,bc} = \alpha + \beta x_m \qquad \textbf{(LIN)}$$

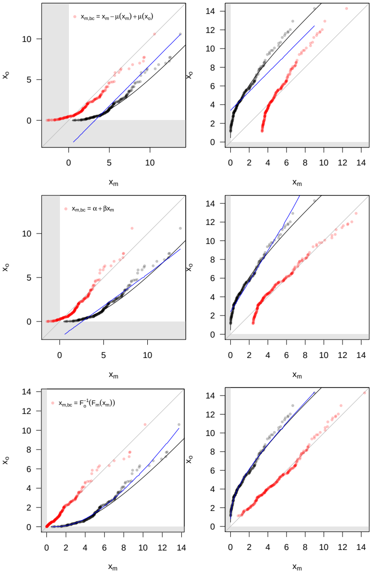
$$x_{m,bc} = \alpha x_m^{\beta} \qquad \text{(POW)}$$

$$x_{m,bc} = (\alpha + \beta x_m)(1 - \exp(-(x_m)/\gamma)) \qquad \text{(EXP)}$$

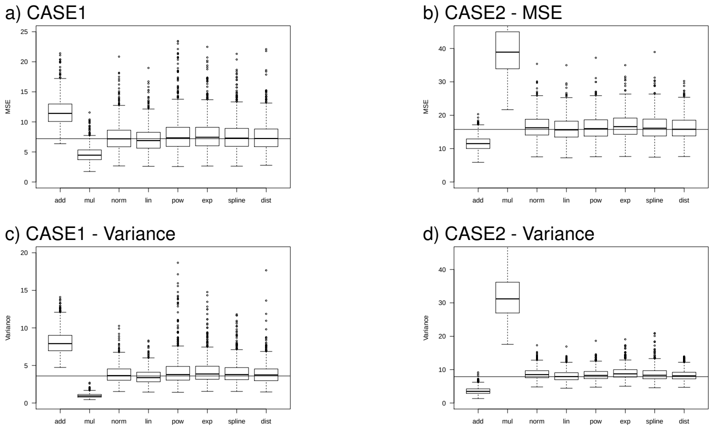
Smoothing spline (SPLINE)

3. Probability distributions

$$x_{m,bc} = F_o^{-1}\left[F_m(x_m)\right] \qquad \textbf{(DIST)}$$



Mean squared error (MSE)

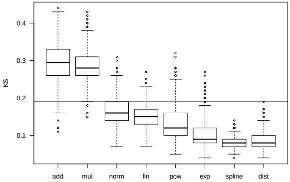


- Uncorrected x_m: $\text{MSE}_m \approx 23.38$
- MSE of ADD is too high (low) for CASE1 (CASE2)
- Similar MSE from NORM to DIST

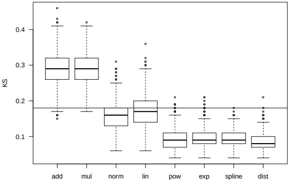
Distributional properties of bias corrected values ($x_{m,BC}$)

- Kolmogorov-Smirnov distance

a) CASE1 - KS

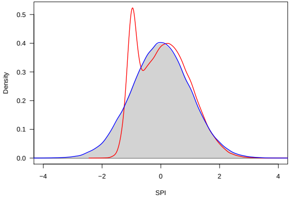


a) CASE2 - KS

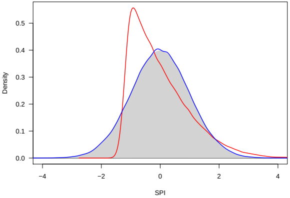


- Standardized Precipitation Index (SPI); LIN (red), DIST (blue)

a) CASE1 - SPI



b) CASE2 - SPI

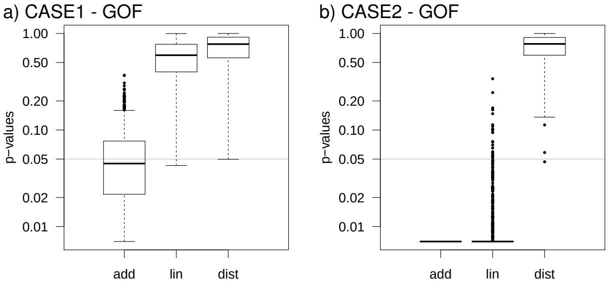


$\Rightarrow$ MSE is insensitive to the distributional shape

- Note: Most published comparison studies use MSE (or MAE)

Reliability - ensemble consistency

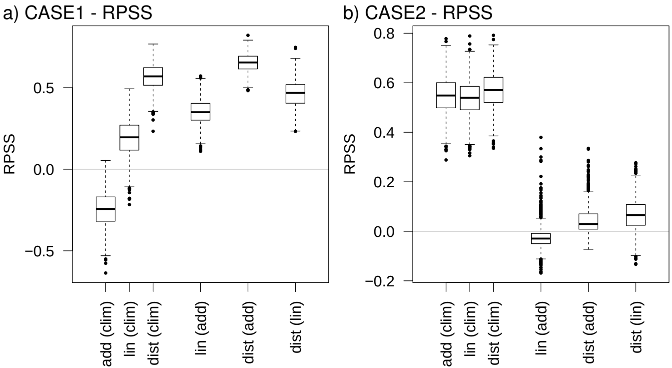
- Uniformity of ranks, deviations indicate:
  bias, overconfidence and underconfidence
- Discrete goodness of fit test (GOF), Anderson-Darling statistic
- Correlated Gamma ditributed x_o and x_m ($\rho = 0.8$)



$\Rightarrow$ BC methods improve the reliability of ensembles

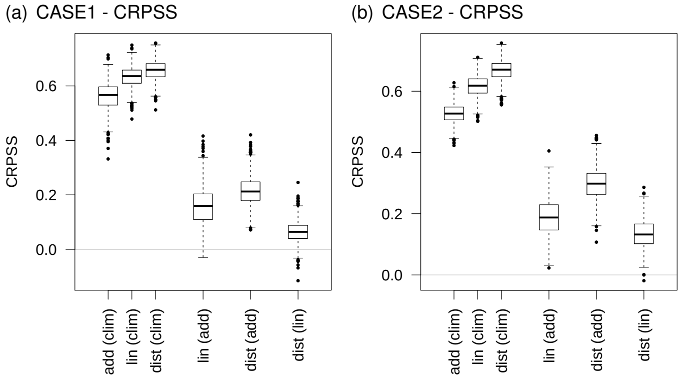
Rank probability skill score (RPSS)

- RPSS for 3 classes: no precipitation, below and above the median



⇒ BC methods improve the accurateness of probability forecasts for multiple categories

Continuous rank probability skill score (CRPSS)



⇒ BC methods improve the difference between the predicted and observed distribution function

Summary

- Differences between bias correction methods can not be addressed with the MSE
- BC methods accounting for higher order moments improve probabilistic predictions and result in better calibrated ensembles