Bias Correction of Satellite Climate Products: As an Option to Fill the Missing Climate Data

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1. Introduction

- Prediction of climate change impacts on several processes of the earth system needs a spatially explicit, and reliable climate datasets (Price T. *et al.*, 2000).
- However, incomplete climate dataset is the common challenge that encounters most of hydrologists, meteorologist, water engineers and climate data based researchers (Suhaila J. *et al.*, 2008).
- Together with the recent space technology improvement, satellite climate products become a widely used source of data in the climate related studies.
- Despite their role in bridging the climate data gap for researchers, they have an error which actual varies between the different products and area of study.
- In this regard, bias correction methods are considered as the ultimate alternative to reduce the bias/error between the satellite product and observed datasets.
- This study presents the performance of bias correction (Linear Scaling) method in improving the satellite climate products CHIRPS, CFSR and MERRA2 (for precipitation) and CFSR (for minimum and maximum temperature).

2. Objectives of the Study

- To evaluate the accuracy of different satellite climate products for precipitation (CHIRPS, CFSR and MERRA2) and for minimum and maximum temperature (CFSR) at the station level in the study area.
- To evaluate the effectiveness of bias correction method in improving the selected satellite climate datasets as an alternative to fill the missing climate data in the area.

3. Methodology

Linear Scaling (LS) bias correction method

$$P_{Cor,d} = P_{sat,d} * \frac{\mu(P_{obs})}{\mu(P_{sat})}$$

$$T_{cor,d} = T_{sat,d} + \mu(T_{obs}) - \mu(T_{sat})$$

Where, $P_{Cor,d}$ is the corrected precipitation at day "***d***", $P_{sat,d}$ is the satellite precipitation data at day "***d***", $\mu(P_{obs})$ and $\mu(P_{sat})$ are mean values of observed and satellite product respectively.

Performance Evaluation Techniques

$$RMSE = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(C_{sat} - C_{obs})^2}$$

$$MAE = \frac{1}{n}\sum_{i=1}^{n}|C_{sat} - C_{obs}|$$

$$PBIAS = \frac{\sum_{i=1}^{n}(C_{obs} - C_{sat})}{\sum_{i=1}^{n}(C_{obs})} * 100$$

$$MBE = \frac{\sum_{i=1}^{n} C_{obs} - C_{sat}}{n}$$

Where, **RMSE** (root mean square error), **MAE** (mean absolute error), **PBIAS** (percent bias), **MBE** (mean bias error), ***Csat*** is the satellite or bias corrected climate data, C_{obs} is the observed climate data, "***n***" is the number of time series datasets in the given parameter.

	Value range	Good result
RMSE	0 to ∞	0
MAE	0 to ∞	0
PBIAS	-∞ to +∞	0
MBE	-∞ to +∞	0

Table 1: Value range of the different evaluation techniques

4. Study Area

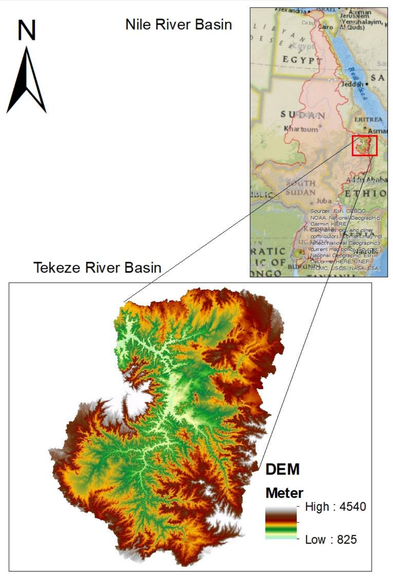

Figure 1: Map of the sturdy area

Table 2: List of stations with precipitation records and their percentage of missing data from 1986- 2016 considering minimum of 30 years data for climate change study.

Stations name	Elevation (in m a.s.l.)	Longitude	Latitude	Period of records for Precipitation	% of missing precipitation data (1986 to 2016)
Adigudom	2100	39.51	13.25	1986-2016	**19.5**
Adwa	1911	38.88	14.18	1992-2016	**22.2**
Alamata (Agr)	1589	39.71	12.42	1986-2016	**15.2**
Ambagiorgis Sch	2900	37.6	12.77	1986-2016	**9.2**
Debark	2836	37.9	13.14	1986-2016	**14.5**
Edaga Hamus	2708	39.56	14.18	1986-2016	**20.4**
Enfranz	1937	37.63	12.26	1986-2016	**11.9**
Gondar A.P.	1973	37.43	12.52	1986-2016	**5.2**
Hawzen	2242	39.43	13.97	1992-2016	**22.5**
Lalibela	2487	39.04	12.04	1989-2016	**21.4**
Maichew	2432	39.53	12.78	1992-2016	**21.7**
Maksegnit	1912	37.56	12.39	1986-2016	**3.3**
Mekele Air Port	2257	39.53	13.47	1987-2016	**13.5**
Nefas Mewcha	3098	38.47	11.73	1986-2016	**14.1**
Shire Endasilase	1897	38.29	14.1	1992-2016	**21.2**
Wukuro	1987	39.6	13.79	1992-2016	**25.3**

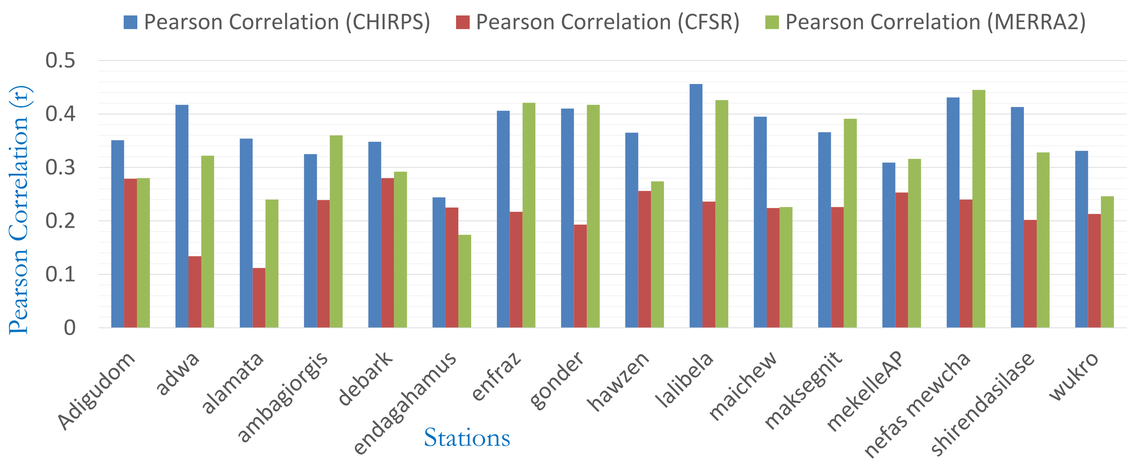

Figure 2: Correlation coefficient (r) of the satellite precipitation data (CHIRPS, CFSR and MERRA2) with observed data

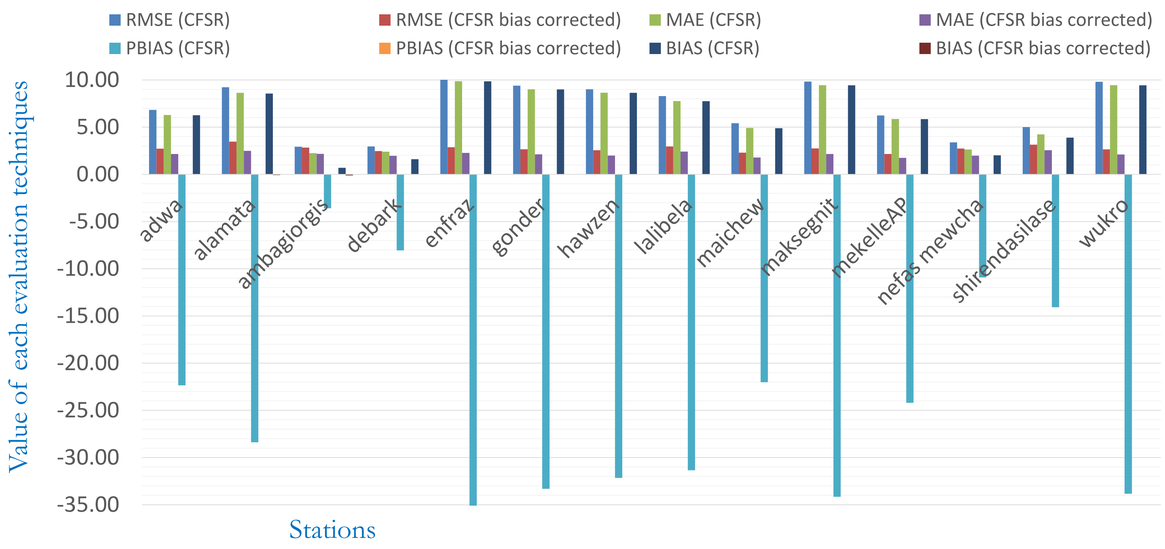

Figure 4: Comparison of the raw CFSR maximum temperature data and its bias corrected datasets using linear scaling method

5. Results and discussion

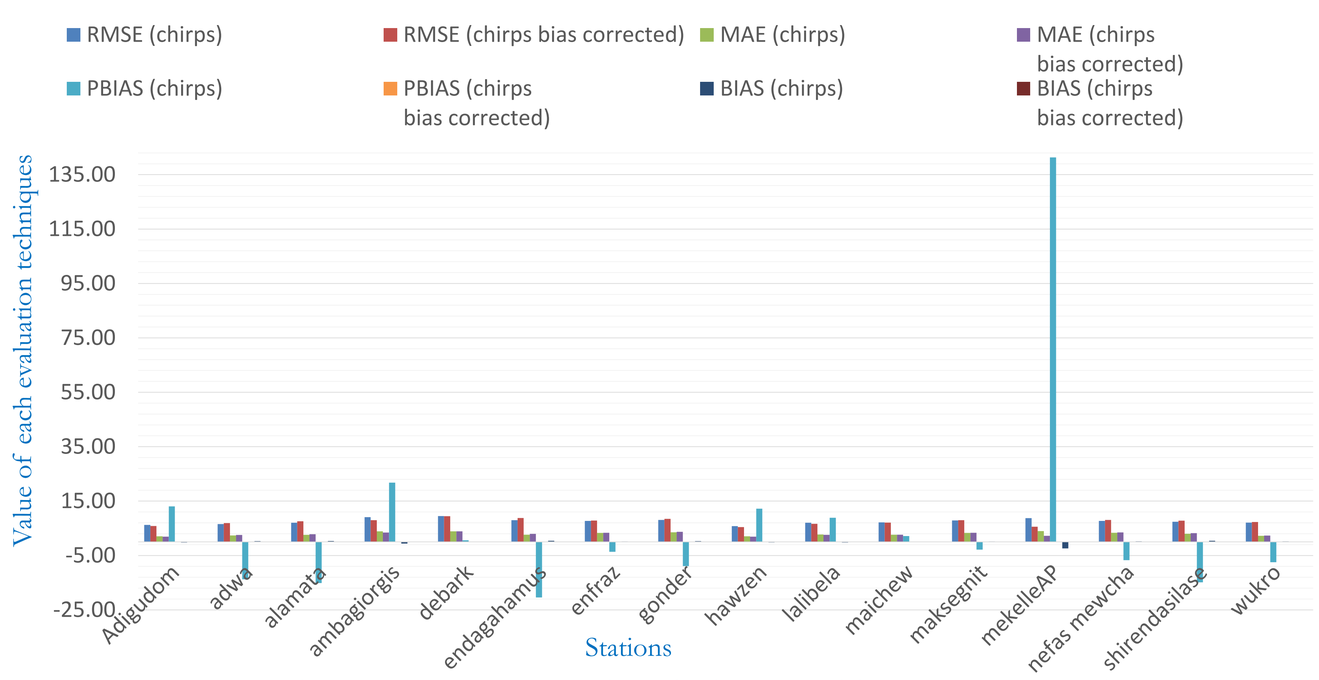

Figure 3: Comparison of the raw CHIRPS precipitation data and its bias corrected dataset using linear scaling bias correction method

6. Conclusion and Recommendation

- CHIRPS sattelite precipitation product has a relatively better correlation result and followed by MERRA2 and CFSR sattelite precipitation datasets.
- Assuming the same credit to each evaluation techniques, the bias correction method improves in the minimum and maximum temperature of raw CFSR data by **100%** while it improves the raw CHIRPS precipitation **65.6%**.
- This variation can be attributed to spatial resolution of the satellite products together with the space and time dependence of the climate parameters.
- Due to the dynamics of precipitation, it needs a special attention to fill the gap.
- Beside the effort of choosing the best satellite product, bias correction has to be considered as an option in order to improve the quality of the climate data series.

References: Price T., McKenny W., Nalder A., Hutchinson F., and Kesteven L., (2000). A comparison of two statistical methods for spatial interpolation of Canadian monthly mean climate data. *Agriculture and Forest Meteorology*, 101, 81-94.

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