COMPARISON OF RAINFALL BIAS CORRECTION IN SUMATRA ISLAND USING THE CORDEX REGIONAL CLIMATE MODEL (RCM) OUTPUT MODEL

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ABSTRACT: Drought is a natural hazard which frequently occurs in Indonesia that impacting many sectors, particularly agriculture. In this study, rainfall is used as the main parameter to determine drought area. Currently, the use of global data is increasing in order to overcome unavailability of rainfall data. Therefore, we compare the observed rainfall data from the Climate Hazards Group InfraRed Precipitation with Station (CHIRPS) with Regional Climate Model (RCM) output from the Coordinated Regional Climate Downscaling Experiment (CORDEX) data of five models, including CSIRO MK3.6, EC -Earth, GFDL-ESM2M, IPSL-CM5A-LR, MPI-ESM-LR. However, it is still constrained due to inconsistencies (bias) to the observational data. Therefore, bias correction is needed for further use of this study. Bias correction with observational data (CHIRPS) were done using Piani method. The results showed, CSIRO MK3.6 correction value is the closest to the CHIRPS observation rainfall pattern with $r^2 = 0.38$.

1. INTRODUCTION

Drought is a natural hazard which often occurs in Indonesia that affecting the availability of groundwater reserves. It has a very wide and detrimental impact on various sectors. Therefore, it is one of the main causes of agricultural environmental and economic losses (Wilhite 1993). Drought occurs slowly and has long duration, usually it ends until the rainy season arrived. The onset and end time of drought are hardly to predict precisely unlike floods or earthquakes (Amalo et al. 2017, Vicente-Serrano et al. 2010).

Rainfall is the main parameter to determine drought. The availability of rainfall data mostly inadequate, and has been an obstacle because the distribution of rainfall measurement stations is not evenly distributed throughout Indonesia. Therefore, the use of historical climate data, particularly climate data predictions has begun to be realized as a human need. Climate model can be used as a tool to obtain that information. Climate model which is widely used to build long-term climate data is the Global Climate Model (GCM). GCM output can be more detailed by using downscaling approach.

RCM (Regional Climate Model) which is the output from GCM, has a model data named Coordinated Regional Climate Downscaling Experiment (CORDEX). It has several output models, namely, CSIRO MK3.6, EC-Earth, GFDL-ESM2M, IPSL-CM5A-LR, MPI-ESM-LR. However, it is still constrained due to inconsistencies (bias) to the observational data. Therefore, bias correction is needed for further use of this study.

2. DATA AND METHODS

2.1 Study Area

The study area is focused on Sumatra Island, which is the sixth largest island in the world and the second largest island located in Indonesia. It has an area of 473,481 km^2 (BPS, 2016). Administratively, the island of Sumatra consists of 10 provinces from the North to South, starting from the Nangroe Aceh Darussalam, North Sumatra, West Sumatra, Riau, Riau Islands, Jambi, Bengkulu, South Sumatra, Bangka-Belitung Islands, and Lampung Provinces respectively. Sumatra Island is mostly dominated by forest area. Apart from forest, gardens, fields and rice fields have now begun to dominate the Sumatran region.

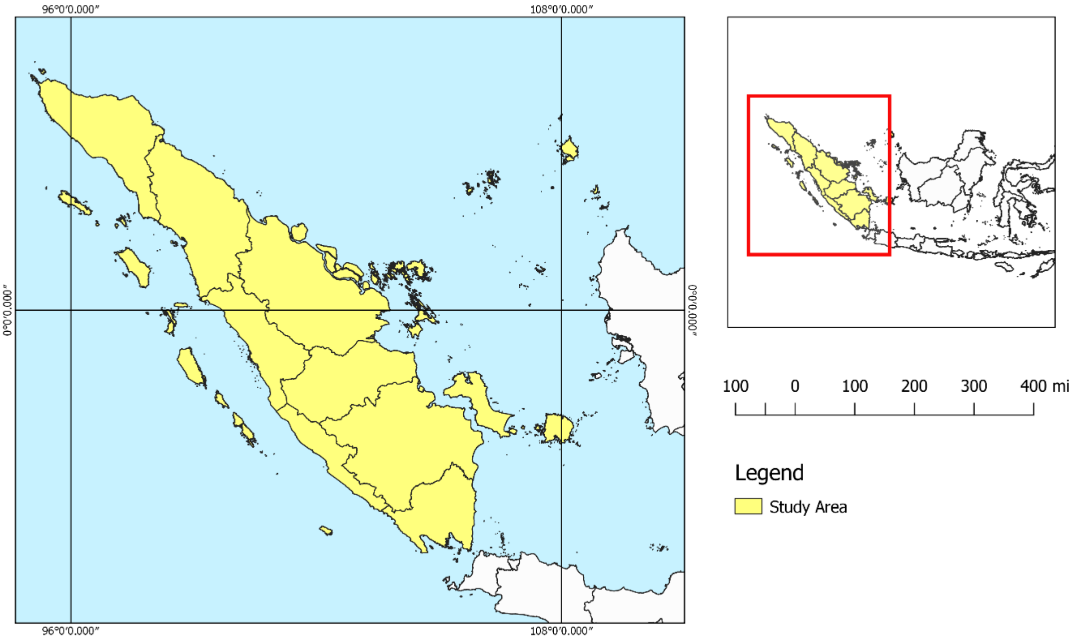


Figure 1. Study location.

2.2 Data

The data used in this research is observational rainfall data, namely CHIRPS daily rainfall 2000-2005 year (http://iridl.ldeo.columbia.edu/SOURCES/.UCSB/.CHIRPS/), and daily rainfall data for the RCM model. This study used 5 RCM models from CORDEX, namely CSIRO MK3.6, EC-Earth, GFDL-ESM2M, IPSL-CM5A-LR, MPI-ESM-LR obtained from BMKG (Meteorology, Climatology, and Geophysical Agency of Indonesia) and the LIPI (Indonesian Institutes of Sciences) Cibinong Innovation Center. Spatial resolution produced by CORDEX is 25 km x 25 km or 0.25^0 x 0.25^0.

2.3 Method

2.3.1. Bias correction of daily rainfall data from Regional Climate Model (RCM)

The RCM was re-grided with CHIRPS to simplify the bias correction process (Dasanto et al. 2014). Bias correction is needed for extreme analyzes. The first step in correcting bias with distribution mapping method (Piani et al. 2010) is to identify the type of opportunity distribution and the probability of rainfall. Generally, rainfall is considered to have a gamma probability distribution with a probability density function calculated by the equation as followed:

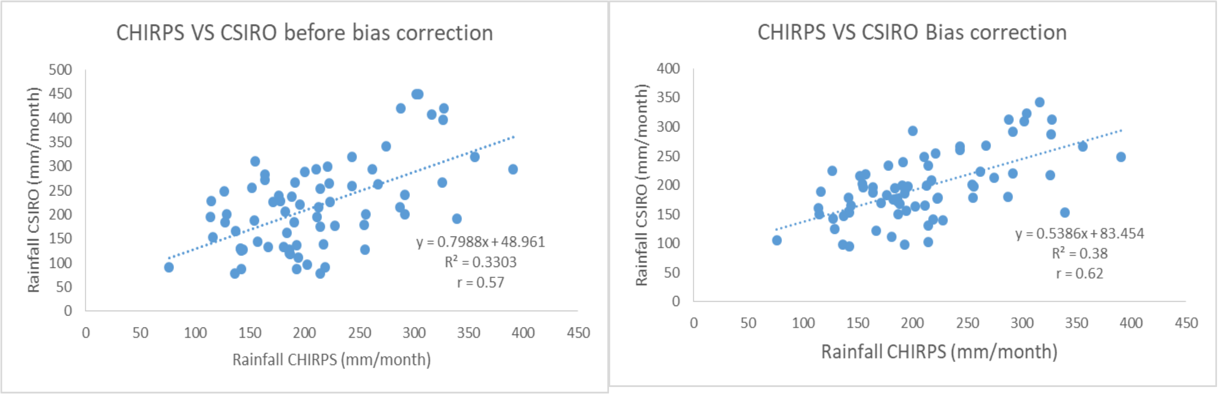
$$pdf(x) = \frac{e^{\left(-\frac{x}{b}\right)} x^{a-1}}{\Gamma(a) b^{a}}$$

The second step is to calculate the cumulative distribution of gamma by integrating the equation above. The third step is to create a gamma cumulative transfer function between station rainfall data and CHIRPS rainfall data. The transfer function used to correct CHIRPS is a polynomial regression equation that has been tested by Jadmiko et al. (2017). Polynomial regression equations are carried out every month and each grid so that in each grid there are 12 polynomial regression equations for bias correction.

3. RESULT AND DISCUSSION

Preliminary results of this study are presented in Figures 2 and 3. Figure 2 shows the comparison of rainfall from 5 RCM CORDEX models before and after bias correction. The value of the five CORDEX models after bias correction is the closest to the CHIRPS data value, which is the data used as an observation rainfall data to validate the bias correction data.

The results of this study indicate the type of rainfall in Sumatra Island, namely monsoonal and equatorial rainfall. However, most of the Sumatran region is classified as equatorial rainfall, only a part of the southern part of Sumatra whose territory is included in the monsoonal rainfall. The equatorial rainfall pattern is characterized by bimocv dial form (two rain peaks) which usually occurs around March and October or when an equinox occurs (Figure 3). Its area includes the central and northern parts of Sumatra (Hermawan, 2010).



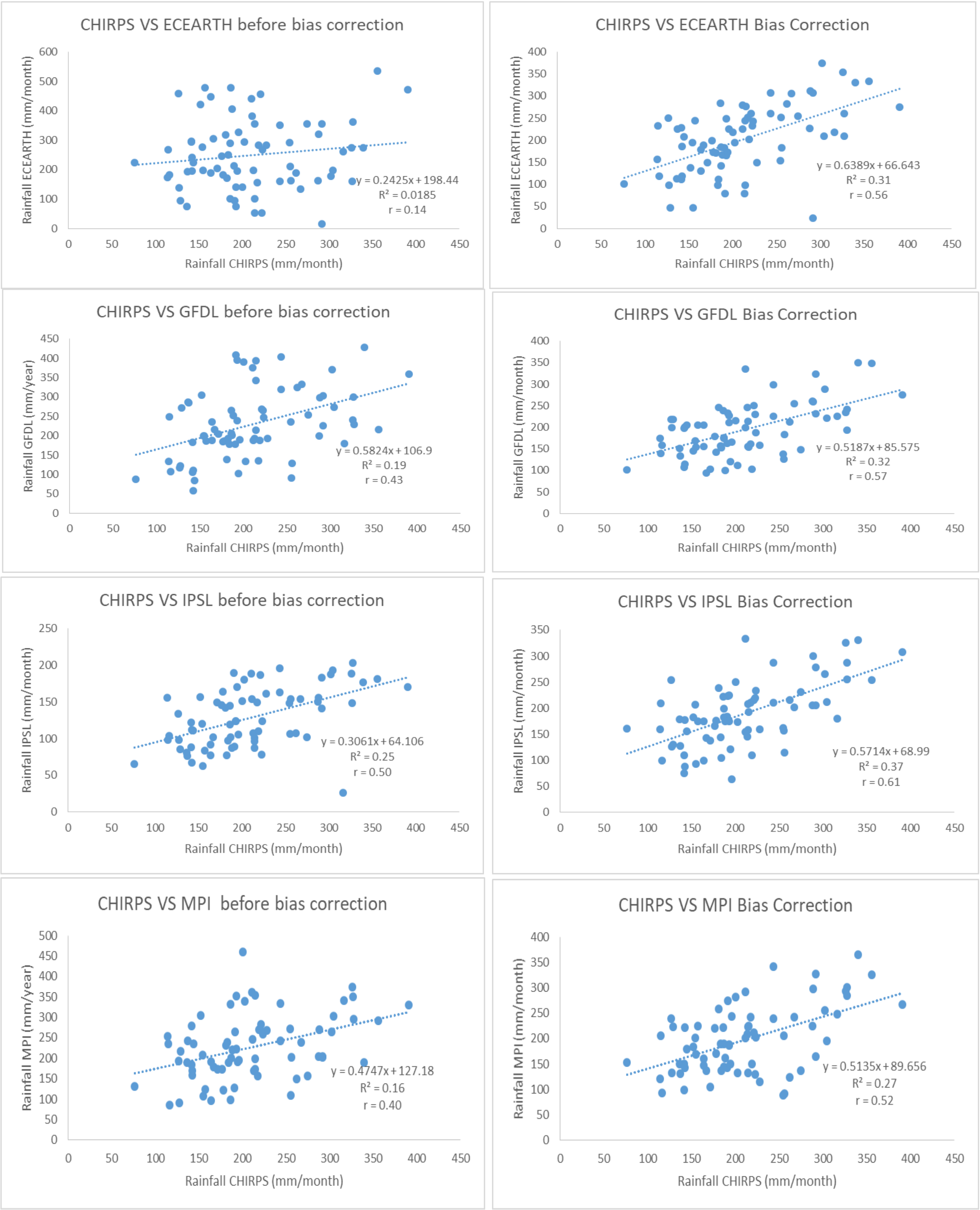


Figure 2. Comparison regression value graph between uncorrected CORDEX RCM model data (left) and bias correction (right) by comparing CHIRPS data.

The value of the 5 CORDEX models which is corrected by the distribution mapping method showed similar data distribution with observed CHIRPS data where the value tends to be evenly distributed under and above the diagonal line, with the r^2 value of CSIRO, ECEARTH, GFDL, IPSL, and MPI are 0.38, 0.32, 0.32, 0.37, and 0.0259 respectively. Therefore, the highest r^2 value which closest to the observation rainfall data, is CSIRO. The best data performance according to the corrected data sequence using the distribution mapping method are followed 1) CSIRO, 2) IPSL, 3) GFDL, 4) ECEARTH and 5) MPI.

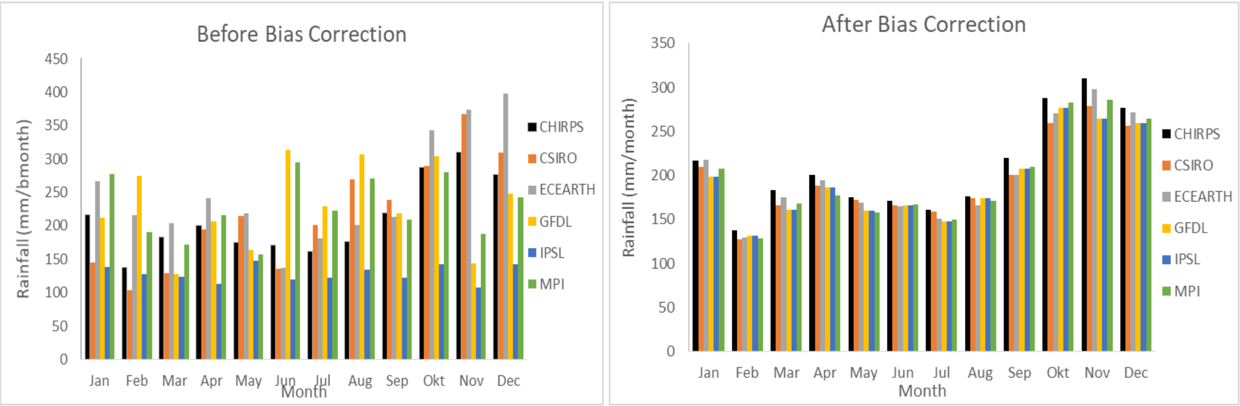
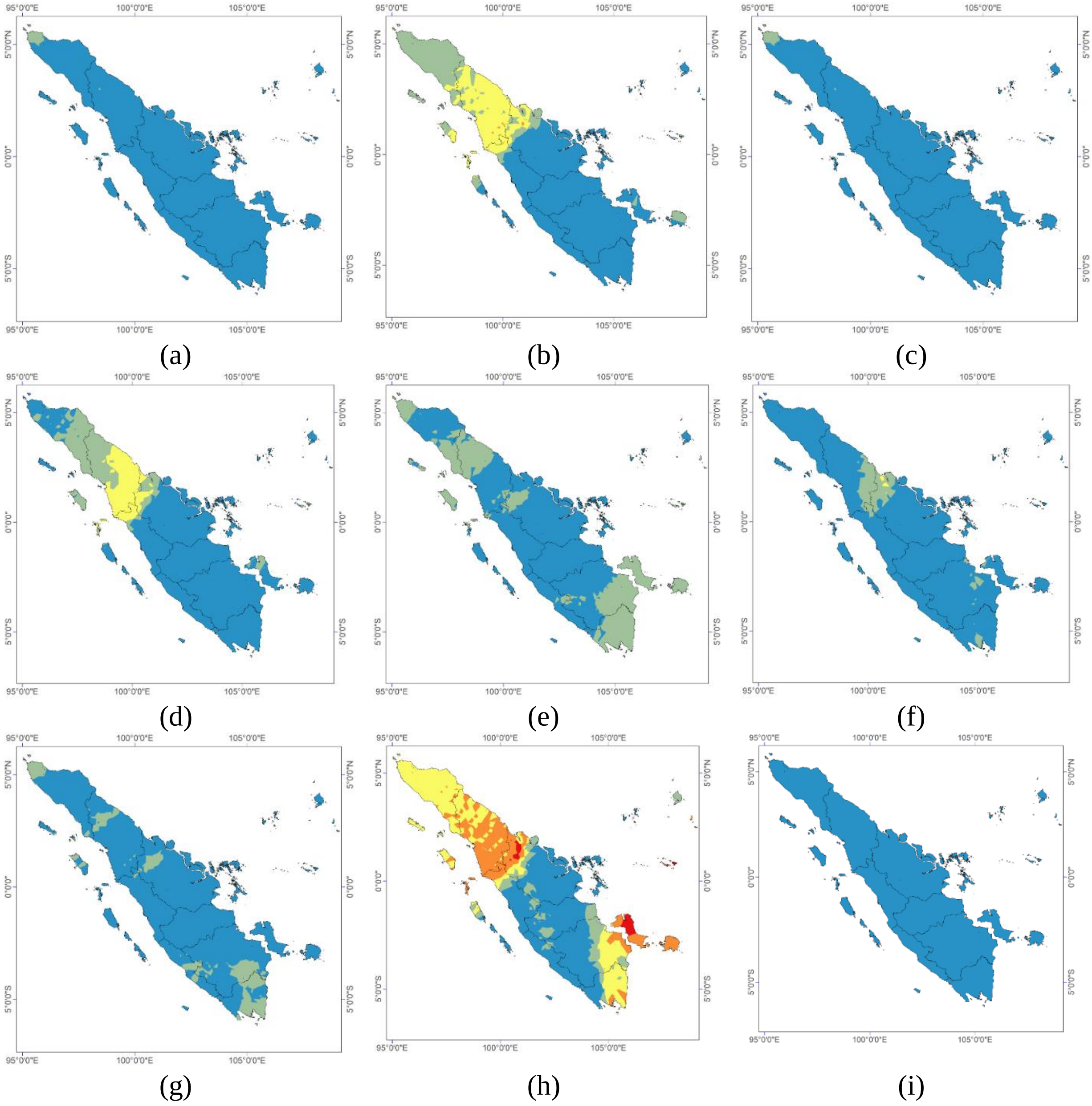


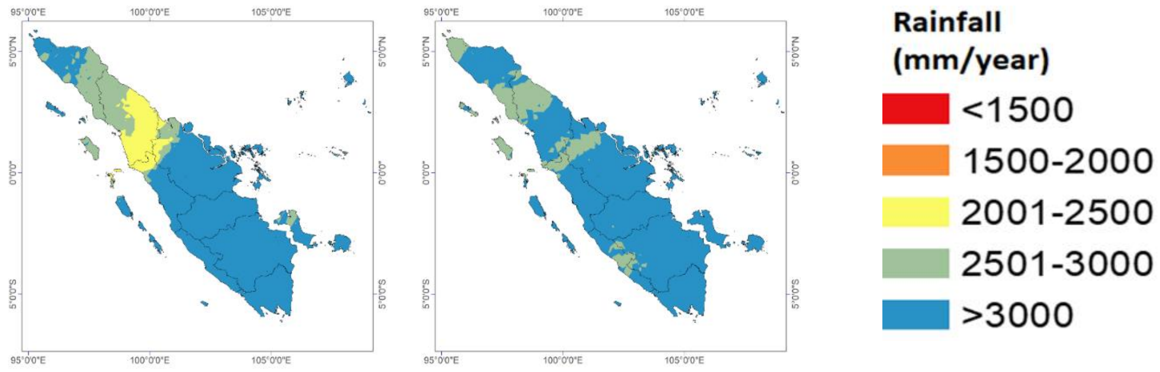
Figure 3. Comparison of rainfall values before correction (left) and after correction (right) from 5 CORDEX models that have been corrected biased with the CHIRPS data.



(a) (b) (c)

(d) (e) (f)

(g) (h) (i)



(j) (k)

Figure 4. (a) Map of annual average rainfall observations using CHIRPS data, (b) Map of CSIRO annual average rainfall before bias correction, (c) Map of CSIRO annual average rainfall after bias correction (d) Map of ECEARTH annual average rainfall before bias correction (e) Map of ECEARTH annual average rainfall after bias correction (f). Map of annual average GFDL rainfall before bias correction (g) Map of GFDL annual average rainfall after bias correction (h). IPSL annual average rainfall map before bias correction (i) IPSL annual average rainfall map after bias correction (j) Map of MPI annual average rainfall before bias correction (k) Rainfall map MPI annual average rain after bias correction.

Figure 2 shows that five CORDEX models values without bias correction showed poor accuracy, but the results after bias correction show better results, which closer to the observed rainfall value, namely CHIRPS data. Therefore, it is necessary to do bias correction in order to describe rainfall conditions, such as observation rainfall. In previous studies, CHIRPS were mostly carried out in dry areas, such as Ethiopia and Tanzania (Wu et al., 2018). The rainfall in that two regions were mostly the same in every season. Meanwhile, this research was conducted in wet tropical climate. Wet tropical climate is characterized by a clear difference in rainfall between wet and dry season. In Figures 4b, 4d, 4f, 4h, and 4j, it can be seen that CORDEX Models produce underestimated values because still has many errors. After the data is corrected (Figures 4c, 4e, 4g, 4i, and 4k), rainfall shows dominant blue color similar to the observed CHIRPS data, but some models still show underestimated rainfall values, namely the GFDL, ECEARTH and MPI models with annual rainfall values around the 2501-3000 mm/year figure range. Moreover, several models of CORDEX data which is close to the CHIRPS observation value by calculating the annual average rainfall data spatially by order are 1.) CSIRO; 2.) IPSL; 3.) GFDL; 4.) ECEARTH and 5.) MPI.

4. CONCLUSION

Based on this research, CORDEX model's data require bias correction due to inconsistencies (bias) to the observed data (CHIRPS data). Several models of CORDEX data after bias correction which is close to the CHIRPS observation value are 1.) CSIRO; 2.) IPSL; 3.) GFDL; 4.) ECEARTH and 5.) MPI. CSIRO correction value is the closest to the CHIRPS observation rainfall pattern with $r^2 = 0.38$.

5. ACKNOWLEDGMENT

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