Rainfall data Similarity Assessment of the Coordinated Regional Downscaling Experiments South East Asia Models to Observation in the Bintan Island.

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Abstract. Present planning for sustainable water resources management should consider climate variability changes to minimize the risks of future water-related problems and hazards. Nowadays, CORDEX SEA provides the historical and future projections climatic data derived from downscale several global climate models for Southeast Asian countries. The study intended to select the most appropriate CORDEX SEA model in projecting future rainfall over Bintan Island. The assessment of the trend and variable variation of the CORDEX-SEA models (CNRM, CSIRO, EC-EARTH, MPI, and its ENSEMBLE) to observation was carried out using statistical tests before similarity ranking. The trend similarity was confirmed using the Mann Kendall and Sen's slope tests methods, while variable variations similarity was confirmed with the Spearman Correlation test and classed by Percent Bias (PBias). The similarities of models to observation were ranked after the least deviation of the statistical parameters. The assessment designates the MPI is the most appropriate among CORDEX-SEA models for Bintan Island. Monthly and annual rainfall trend and variability of the CORDEX SEA models in the historical, actual and foreseen future periods over Bintan Island were compared.

1. Introduction
IPCC reports the global increase of surface temperature about 0.74°C between 1906 and 2005 accompanied by changes in rainfall patterns and weather intensities and extremes [1]. Rainfall of some regions shows a decreasing tendency [2] [3] while in the others tends to increase[4] or uncertain [5] even different tendency were found in an adjacent region [3]. In the early 21st century, the air temperature of southeast Asia warm pools will increase by 2 – 5°C, and the rainfall change response varies among regions [6]. In the tropics, rainfall directly affects water availability, especially for small islands such as Bintan. Small islands are vulnerable to water scarcity due to the limited catchment that restraints the resident time of surface water, aquifer dimension, and the surrounding saline seawater. Therefore, climate change menaces small islands through various sea-level rise, increasing storm events’ intensity and prolonging drought [7]. Rainfall mitigation plays an essential role in management planning to maintain the small islands’ water resources sustainability in a changing climate.

For the resources management planning in the current circumstances, rainfall data use should include the prediction of the undergoing change and the state of rainfall in the future to achieve more
measurable mitigation and adaptation. The intergovernmental Coordinated Regional Downscaling Experiments (CORDEX), including southeast Asian Countries (CORDEX-SEA), provides the results of downscaled data models from several Global Circulation Model (GCMs) using Regional Climate Model Reg.CM4.3 [8]. The CORDEX-SEA downscaled data offers a spatial resolution of 25km × 25km for historical periods (1981-2005) and projections (2006 to 2100). On the other hand, each climate model derives different results that create uncertainty to establish the most appropriate predictor for future circumstances. The evaluation of CORDEX models performance reveals the differences between the projected results[9] in both spatial and temporal variability. Every model has its conformity with observational data that change from one area to another [10]. The multi-model ENSEMBLE data formulated as the arithmetic mean of all models time-series data usually used as a compromise to elucidate the uncertainty of future projection. The downscaled CORDEX-SEA model results [9] show that in the Southeast Asia Warm pool, the wet (dry) region will become wetter (drier) in future projections. In many parts of Indonesia, the periods of consecutive days of no rain will prolong even in rainfall regions amount no change [11]. In Vietnam, every model has its expanse of reliable and malicious accordance with observational data, and the CSIRO model exhibits the best result for rainfall data [8]. In Indonesia, CORDEX-SEA evaluations show the MPI model well reproduce the spatial distribution of rainfall overland but overestimated over the ocean [12]. HadGEM2–AO results show that, although the uncertainty due to the various parameterization of variables, areas around the equator will have a higher drought severity change in the future compared to the other expance [13].

The study objective was to assess which model among the CORDEX-SEA downscale results presented the best observation data in Bintan Island, so its future projection can be perceived as the most suitable to be applied in estimating future rainfall. This study evaluates the data of the CORDEX-SEA downscaled models (CSIRO, EC-EARTH, CNRM, MPI, and its ENSEMBLE) provided by the Meteorology, Climate, and Geophysics Agency of the Government of Indonesia (BMKG). The assumption taken for this study is that the most appropriate rainfall time series model for future estimator is the most similar to observation data as posing the least deviations in trend and rainfall height variability.

2. Material and Methods

2.1. Research site

Bintan Island is located south of the edge of the Malacca peninsula, at 0° 40' - 1° 15' N and 104° 00' - 104° 53' E, at the junction between the Malacca Strait, the Java Sea, and the South China Sea, covering an area of approximately 1,319.51 km2. The largest landform occurs as the gently sloping area occupies the island’s western and central parts while undulating to a hilly area in the north and east of the island. The island's peak elevates 350m above sea level, situated at the southern tip of the island. About half of the island constituted old volcano-sedimentary formations in tuffaceous sandstone, about 40% granite intrusions, and 10% of recent alluvial [14]. The climate exists a maritime equator type with an annual rainfall average of around 3900 mm evenly distributed throughout the year. The rainiest months fall in April-May and December-January, while the months of the least rain found in February-March and August-September. Monsoonal oscillations influence annual rainfall, while ENSO and IOD influence inter-annual variation [15].

2.2. Data

Data used in this study consisted of monthly and annual rainfall data of observations from 1981 to 2018 at the Kijang Weather Station (104.525°E; 0.925°S) and The downscaled CORDEX-SEA historical data (1981-2004) and near-future projection (2006-2045) of RCP 4.5 and RCP 8.5 for four different models (CNRM, CSIRO, EC-EARTH, and MPI) obtained from the Indonesian Agency of Meteorology Climatology and Geophysics (BMKG). Every downscale model and station observation of the historical period have bias-corrected using the Quantile method [16] to obtain the resulting
comparison between bias-corrected and raw data of each downscale model. The arithmetic mean ENSEMBLE of both unprocessed and corrected data has been involved in the trend and rainfall variation similarity test.

2.3. Methods

Trend similarity examined utilizing Mann-Kendall (MK) and Sen's Slope, whereas the similarity of rainfall height variation assessed using Spearman Correlation test and Percent Bias (PBias) determination. The couple tests of MK [17] [18] and Sen's slope (Ss) usually used to verify the trend of time series data. The MK test carried out through the determination of the MK $S$ Statistics, variance $V(S)$, and the $Z_{mk}$ statistical standard test (the MK coefficient). $Z_{mk} = 0$ indicates no trend in the data series; positive $Z_{mk}$ indicates an upward trend and a negative $Z_{mk}$ value indicates a downward trend. For a sample size greater than 30, the Hypothesis was tested by comparing $Z_{mk}$ against $z_{crit}$ determined according to the normal distribution curve at the 95% confidence level ($\alpha=0.5$) where the smallest limit is at $z_{crit} = -1.96$ and the largest limit at $z_{crit} = 1.96$. The decision is: Reject H0 and Accept H1 if $-z_{count} < -1.96$ and $z_{count} > +1.96$. Conversely, accept H0 and Reject H1 if $-z_{count} > -1.96$ and $z_{count} < +1.96$. The Ss method used in cases where the trend can be assumed to be linear. Ss determines the median of all slopes.

![Figure 1](image1.png)

**Figure 1.** Location of the study area: Bintan island.

Spearman's rho ($\rho$) test performed to verify the presence and strength of the correlation between two different datasets of the same series of observations [19]. Spearman Correlation is unaffected by the distribution of the population. The test assumes the data are independent and identically distributed. The hypothesis is $H_0$: $\rho = 0$, there is no relationship and $H_1$: $\rho \neq 0$; there is a relationship. Because the present study's data series contains the same sizeable numbers, a correction factor that considers tied values (t and T) must be applied [20] [21]. The Spearman correlation coefficient values range from 1 when data pairs are positively correlated to -1 when data pairs are negatively correlated, and $rs = 0$ indicate no correlation. As for the MK test, the decision resolved by comparing the calculated $z$ to $z$
criteria. The decision is: Reject H0 and accept H1 if $-z_{count} < -1.96$ and $z_{count} > 1.96$ and conversely. Higher $r$s and $z$ indicate the stronger correlation between the tested pairs and the higher significance levels.

Bias is a crucial method for analysing the deviation between simulation result and observation data [22]. The biases between each model of CORDEX-SEA and observation data inspect the differences indices among time series data. PBias indicates the average variation of the data, whether smaller or larger than their counterparts. PBias values range from $-\infty$ and $+\infty$, and the smaller is the PBias, the higher is the similarity. The goodness fit between data pairs could be classified according to PBias value [23] as very good ($PBias < \pm10$), good ($\pm10 < PBias < \pm15$), satisfactory ($\pm15 < PBias < \pm25$), and unsatisfactory ($PBias > \pm25$).

We rank the similarity using the procedure comprises of two steps scoring. The first step involves the significance scoring of statistical test results (i.e. $Z_{mk}$ and $z$). The factor of 1 or -1 given to a significant test result and a factor of 0 to an insignificant. The multiplier factor of 1 also given to statistical parameters that are not coupled by a confidence test. The second step completes ordering the similarities by regarding the disparity value of the same statistical parameter between models and observation data. The smallest difference value model is placed in the first rank and set in the largest (5), sequence number while the model with the most considerable difference value is placed in the last rank and set in the smallest(1) sequence number. The factor and sequence number multiplication produce a score. The Sum of all of the parameter scores generates the total score for each model. We consider the model retaining the largest total score is the most similar model to the observation.

3. Result and Discussion

3.1 Historical data trend similarity.
Two-tailed MK test results only two data represent a significant trend (Table 1): observation data of the Kijang station showing an increasing trend and the EC-EARTH model showing a decreasing trend. The others have the $Z_{mk}$ values between 1.96 and -1.96 indicates insignificantly inclined data series. The Kijang station data produce positive $S$, and $Z_{mk} = 1.96$ mean an adequately significant upward trend. In contrast, most models (CNRM, EC-EARTH, MPI, and ENSEMBLE), except CSIRO, show a negative $S$ and $Z_{mk}$ signify a downward trend. Although the positive $S$ value makes CSIRO the closest model to the observation data, its low $Z_{mk}$ value categorized as posing no trend.

Table 1. The statistical trends parameters values of the Kijang observation station and the CORDEX-SEA models of the historical period.

|        | station | CNRM | CSIRO | EC-EARTH | MPI | ENSEMBLE |
|--------|---------|------|-------|----------|-----|----------|
| Mann-Kendall |        |      |       |          |     |          |
| a. Uncorrected |        |      |       |          |     |          |
| $S$    | 3411    | -655 | 2004  | -4722    | -2101| -2505    |
| $Z_{mk}$ | 1.96$^{*)}$ | -0.38 | 1.15  | -2.72$^{*)}$ | -1.21| -1.44    |
| Interpretation Sign | Increasing | No Trend | No Trend | Decreasing | No Trend | No Trend |
| b. Bias corrected |        |      |       |          |     |          |
| $S$    | 3411    | 216  | 3221  | -4941    | -2795| -2459    |
| $Z_{mk}$ | 1.96$^{*)}$ | 0.124 | 1.855 | -2.85$^{*)}$ | -1.609| -1.42    |
| Interpretation Sign | Increasing | No Trend | No Trend | Decreasing | No Trend | No Trend |
| Sen’s slope |        |      |       |          |     |          |
| a. Uncorrected | 19.0 | -1.5 | 1.5  | -16.5    | -8.8 | -6.3     |
| b. Bias Corrected | - | 1.0  | 14.6 | -28.6    | -15.7| -9.9     |

$^{*)}$ Significant at $Z_{criteria}$ 0.05 = ± 1.96

Bias correction improves the trend similarity of CNRM, CSIRO, and ENSEMBLE models to observation indicated by reducing $S$ values disparity and alters EC-EARTH and MPI models. $Z_{mk}$
values increase for CNRM, CSIRO, and ENSEMBLE and reduce for EC-EARTH and MPI. Except for CNRM that changes negative to positive signs of S and Zmk, Bias correction modifies only slight trends (S) and significance level (Zmk) of trends. A large number of variable pairs ensure the obtained Ss parameter (B) value situated between the upper and lower limits of the two-tailed 95% confidence level. The Ss test results for each time-series (table 1) show that the Kijang station data has a strong positive trend (B = 19). The only model data series that shows a positive trend is CSIRO, even though with a weak increasing tendency (B = 1.5) and is classified as having no trend, while the other models show a weak to strong negative trend. Ss value of every CORDEX model change by Bias correction is similar to that of the MK test: increase for CNRM, CSIRO, and ENSEMBLE and decrease for EC-EARTH and MPI. Bias Correction shifts as well the negative to the positive sign of the CNRM model slope.

3.2 Historical rainfall variation similarity

The result Spearman correlation tests (table 3) shows the weak correlations of all corrected and uncorrected CORDEX-SEA models to observation data as indicated by low (<0.5) rs values. Except for the data of Bias corrected CNRM, all z values of model data were more than 1.96 that the decision should reject H0 and accept H1, which means positive correlations exist between the pairs of tested data-series.

Table 2. Spearman correlation parameters and PBias values between CORDEX-SEA models and Kijang Observation Station time series of the historical period.

|                  | CNRM | CSIRO | EC-EARTH | MPI       | ENSEMBLE |
|------------------|------|-------|----------|-----------|----------|
| **Spearman Correlation** |      |       |          |           |          |
| Uncorrected      | 0.12 | 0.29  | 0.16     | 0.22      | 0.31     |
|                  | 2.11" | 5.06" | 2.75"    | 3.82"     | 5.36"    |
| Bias corrected   | 0.07 | 0.23  | 0.16     | 0.24      | 0.23     |
|                  | 1.14 | 3.97" | 2.72"    | 4.21"     | 4.02"    |
| **PBias**        |      |       |          |           |          |
| Uncorrected      | 59.70 | 62.23 | 40.93    | 35.62     | 49.32    |
| Bias Corrected   | 23.06 | 26.37 | 21.21    | 16.33     | 21.10    |

*Significant at $Z_{criteria}$ 0.05 = ± 1.96

ENSEMBLE shows the highest correlation to observation as well as the highest confidence level. Bias Correction alters the correlation and confidence level of most models, except for MPI. Bias correction improves both correlation and significance level of MPI data that encompasses the most significant correlation with observation data overtaking the ENSEMBLE correlations and significance whose uncorrected data resembled the most. PBias values (Table 2) for all models and its ENSEMBLE decrease to about a half after correction. All the uncorrected data having unsatisfactory class PBias value. After correction, all CORDEX-SEA data having satisfactory PBias values, except CSIRO that still unsatisfactory. The smallest PBias value of models and observation data obtained for the MPI data series. After correction, MPI retain the lowest PBias value, indicating the least biased to the observation data among CORDEX SEA models.

3.3 Historical data similarity ranking
Bias correction improves the rank sequence by placing MPI and ENSEMBLE in the different positions, while in the uncorrected models, they were placed at the same rank. Bias correction changes the model's rank position tested by Spearman Correlation and PBIAS but does not by MK and Sen's slope tests. Bias Correction does not modify the sequence but improves PBias value and categorizes better into satisfactory class. This result agrees with the previous studies that suggested performing bias correction of the models to observation before projection utilization since bias correction does not alter the original distribution time [24]. Spearman correlation tests show uncorrected ENSEMBLE is the most similar to the observation in rainfall variation followed by uncorrected CSIRO and corrected MPI. Meanwhile, uncorrected ENSEMBLE and CSIRO exhibit large PBias that are categorized as unsatisfactory. The above values suggest pointing the corrected MPI model as the most appropriate to be used as a future predictor. The minimum bias is essential for the predictor model since significant differences between the projection model to observation will deteriorate the signal's reliability for the future magnitude of climate change[25].

Table 3 shows the ranking of the model similarity to observation. For the case of Bintan Island, EC-EARTH is the only model having a significant Zmk value, although with an opposite sign to observation. Meanwhile, CSIRO is the only model with a positive sign of S. It means a similar trend direction with observation, but in insignificant Zmk value by putting the data series into no trend category. Most of MK and Ss test parameters of the other CORDEX-SEA models offer zero multiplier factors since the MK test produces an insignificant confidence level of trend, lead to unusable MK and Ss test results.

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Table 3. The ranking score of the similarity between CORDEX-SEA models to Observational data of Kijang Station of the historical period.

|                | CNRM | CSIRO | EC-EARTH | MPI  | ENSEMBLE |
|----------------|------|-------|----------|------|----------|
|                | F<sup>a</sup> | R<sup>b</sup> | S<sup>c</sup> | F | R | S | F | R | S | F | R | S | F | R | S | F | R | S | F | R | S | F | R | S |
| a. Uncorrected |      |       |          |     |   |  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
| Mann - Kendall | 0 | 4 | 0 | 5 | 0 | -1 | 1 | -1 | 0 | 2 | 0 | 0 | 3 | 0 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Sens Slope     | 0 | 4 | 0 | 5 | 0 | -1 | 1 | -1 | 0 | 2 | 0 | 0 | 3 | 0 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Spearman       | 1 | 1 | 1 | 1 | 4 | -1 | 2 | -2 | 1 | 3 | 3 | 1 | 5 | 5 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| PBias          | 1 | 2 | 1 | 1 | 1 | 1 | 3 | 3 | 1 | 5 | 5 | 1 | 4 | 4 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| TS<sup>d</sup> |     |     |     |     | 3 |     |     | 5 |     |     |     | 1 | 8 | 9 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| b. Bias Corrected |      |       |          |     |   |  |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |   |     |     |     |
| Mann - Kendall | 0 | 4 | 0 | 5 | 0 | -1 | 1 | -1 | 0 | 2 | 0 | 1 | 3 | 0 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Sens Slope     | 0 | 4 | 0 | 5 | 0 | -1 | 1 | -1 | 0 | 2 | 0 | 0 | 3 | 0 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| Spearman       | 1 | 1 | 1 | 1 | 3 | 3 | 1 | 2 | 1 | 5 | 5 | 1 | 4 | 4 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| PBias          | 1 | 2 | 1 | 1 | 1 | 1 | 4 | 4 | 1 | 5 | 5 | 1 | 3 | 3 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| TS<sup>d</sup> |     |     |     |     | 3 |     |     | 4 |     |     |     | 4 | 10 | 7 |     |     |     |     |     |     |     |     |     |     |     |     |     |     |

The total score order (Table 3) shows the Bias Corrected MPI is the most similar to observation. This study revealed a better similarity model(s) than arithmetic means ENSEMBLE of models to the observation. In the present study, trend similarity ranking placed the ENSEMBLE in the 3rd and the variable variation ranking indicated by PBIas, apart from Spearman tests that put the ENSEMBLE at the second rank. This evidence is noteworthy, mentioning that actual presumption put the ENSEMBLE model as the most acceptable alternative to be used in predicting future circumstances and makes the
majority of CORDEX data employment for future estimation using projection of multi-model ensemble data [24] [26].

3.4. Similarities in the historical and actual periods.
Statistical similarity indices of historical data have been compared to actual data to verify the similarity consistency in historic and post-historic data. The actual or post-historic data consist of the station observation data of 2006 to 2017 and bias-uncorrected data of RCP 45 models of a similar period. Table 4, 5, and 6 present the results of the similarity test for post-history data.

Table 4. The statistical trends parameters values of the Kijang observation station and the CORDEX-SEA models of the actual period.

| station CNRM | CSIRO | EC-EARTH | MPI | ENSEMBLE |
|-------------|--------|----------|-----|----------|
| Mann-Kendall |
| S           | -754   | -217     | -95 | -251     | 49       | -271 |
| Zmk         | -1.30  | -0.37    | -0.16 | -0.43   | 0.08     | -0.47 |
| Interpretation | No Trend | No Trend | No Trend | No Trend | No Trend |
| Sen’s slope  | -20    | -1.37    | -0.5  | -3.5     | 0.6      | -2.5   |

*) Significant at $Z_{criteria} 0.05 = \pm 1.96$

MK test on station observation data (table 4) shows the decreasing monthly rainfall trend during the post-historic period opposite the historic period trend significantly increased. Although $Z_{mk}$ value shows an insignificant level, the Sen’s slope value of the observed rainfall indicating the steepest decrease comparing to all models. The ENSEMBLE trend is the most similar to the observation, and MPI is the most different among the models. Spearman correlation tests for the actual period show EC-Earth is the most similar monthly rainfall variation among models to observation. The most similar model is attributed to MPI, while EC-earth only placed at the fourth similar in the historical period. ENSEMBLE is the worst correlated in the actual period, which was the most in the historical period. The P-bias measure shows EC-earth as the most similar in monthly rainfall variation to observation, and CNRM is the least similar. MPI model that was the most similar in the historical period placed at the second similar in post-historic. Tests show the similarity ranks rainfall depth variation during the actual period differ critically to the historic period.

Table 5. Spearman correlation parameters and PBias values between CORDEX-SEA models and Kijang Observation Station time series in the actual period..

| Spearman Correlation | Uncorrected | CNRM | CSIRO | EC-EARTH | MPI | ENSEMBLE |
|----------------------|-------------|------|-------|----------|-----|----------|
| $rs=                  | 0.06        | 0.19 | 0.35  | 0.34     | 0.05|
| $z=                  | 0.67        | 2.3  | 4.18  | 4.12     | 0.7 |
| PBias                | Uncorrected | 65.06| 53.23 | 45.35    | 48.04| 52.92    |

*) Significant at $Z_{criteria} 0.05 = \pm 1.96$
MPI, which was the most similar to the observation in the historical period, shifts to the second similar in post-historic (Table 6). The first similarity is replaced by EC-earth, which was the least similar in the historical periods. The above results show the similarity inconsistency of both trend and rainfall height variation among models and observation in a different period. Seemingly, no particular model has a permanent similarity level to the observation data in all periods or all localities in both trend and variability. ENSEMBLE data does not represent the best of both trend and rainfall height variation. Since the ENSEMBLE represents all models’ average, there will be a weakening of rainfall height fluctuation. ENSEMBLE is useful to predict the future trend but not rainfall height variation. In predicting the extreme climate events, the ENSEMBLE would be particularly weak.

Table 6. The ranking score of the similarity between CORDEX-SEA models to observation in the actual period.

|               | CNRM | CSIRO | EC-EARTH | MPI | ENSEMBLE |
|---------------|------|-------|----------|-----|----------|
| Mann - Kendall| F a) R b) S c) | F R S | F R S | F R S | F R S |
| Sens Slope    | 0 0 0 | 0 2 0 | 0 4 0 | 0 1 0 | 0 5 0 |
| Spearman      | 0 2 0 | 1 3 3 | 1 5 5 | 1 4 4 | 0 1 0 |
| $PBias$       | 1 1 1 | 1 2 2 | 1 5 5 | 1 4 4 | 0 3 3 |
| TS d)         | 1 5 5 | 10 10 | 8 3 3 | 3 3 3 |

a) = Multiplication Factor; b) = Ranking Number; c) = Score Number; d) = Total Score

3.5. Model Projection of the foreseen (2021-2045) period.
The time series curve of observation data of historical and actual periods (1981 -2019) and ENSEMBLE of CORDEX model data of historical, actual and foreseen projection (2020-2045) periods on figure 6 illustrates the future annual rainfall prediction of Bintan Island. We use RCP 45 and RCP 85 scenarios for the prediction of actual and projection.

Figure 2. Time series of the observation vs corrected historical ENSEMBLE and projection ENSEMBLE models in the different periods.
There is no significant divergence between rainfall height and trend of RCP 45 and RCP 85 Scenarios models in both actual and projection periods. However, the annual rainfall of both scenarios fluctuates individually. The ensembles of model data (figure 2) predict the foreseen future's annual rainfall (between 2021 and 2045) climate will be drier than historical and actual periods. The bias correction method does not show significant performance on the rainfall simulation results in the actual and projected periods than on the historical rainfall result. The simulation results generally underestimate the results of observations, and the results of observations in the actual (post-historical) period have a smaller average value with a downward trend.

Figure 3 shows the monthly rainfall statistics of historical observation and both scenario of foreseen projection periods. Monthly variation models present that in average the rainfall of majority of months in the projected years will be less than that in the historical years, except in the wettest month (November) when the average of projected rainfall is more than historical rainfall. The result warns that both drought and flood risks might increase in the foreseen future. Drought risk by the rainfall diminution in the majority of months, and flood risks by rainfall amount rise in the rainy season's peak.

4. Conclusion.
1. Among the CORDEX-SEA models, MPI is the most similar to the observation data over Bintan Island in the historical period. However, no particular model shows a permanent similarity to the observation data in all historical, actual and future projection periods.
2. The rainfall average of most months in the projected years will be less than in the historical years, except in the wettest month (November) when the average of projected rainfall is more.

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