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Prediction of Future Temperature using Statistical Downscaling Model (SDSM) in Accessing Climate Change at Catchment Area Sungai Bekok, Batu Pahat

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Abstract: The impact of climate change in hydrologic sector worsening. The continuation of this phenomenon significantly may alter global and local climate characteristics including temperature and rainfall. The objectives of this study are to downscale the present climate variables, to downscale the future climate variables and to predict the temperature and rainfall impact of climate change on Bekok reservoir in 2021 until 2050. In this study, Statistical Downscaling Model (SDSM) has been adopted to downscale rainfall and temperature to generate future climate outputs for Bekok basin in Batu Pahat, Johor. 2 stations have been chosen as reference that provide rainfall data and 1 station for gaining temperature data. The prediction of future rainfall and temperature for the period 2030, 2040 and 2050. The results obtained from this study are acceptable because it done with calibration (2010-2015) and validation (2016-2020). Recommendation for future research are to use more rainfall stations and compare with different emissions to achieve greater reliability.

Keywords: Climate Change, Bekok, SDSM, Rainfall, Temperature

1. Introduction

Being a global phenomenon, there has been increasing interest to look at how climate change and its impact unfold regionally, including in Malaysia.[1]. Water links and maintain all ecosystems on the planet. If there was no water, there would be no life on earth. Water is indispensable for life especially to humans, but its availability at a sustainable quality and quantity is threatened by many factors such as climate change that plays a leading role. In the 21st century, climate change is considered to be one of the greatest environmental threats to the world and the changes in climate extremes are estimated to

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have greatest negative impacts on human society and the natural environment than the changes in mean climate. [2].

Bekok's river is an important river which supplies potable water to the surrounding of Batu Pahat. There are some problems regarding Bekok's river and Bekok dam. The problems are Bekok's river and Bekok dam faced flood disaster several times and contaminating with chemicals. There are also shortage of water due to Bekok dam getting insufficient water. Statistical Downscaling Model (SDSM) was chosen to be downscaled and predict for the future temperature and rainfall data in Bekok dam.

1.1 Objectives

There are three objectives that are going to be achieved. The objectives of this project are:

- To downscale the present climate variables for the Bekok basin using SDSM.
- To downscale the future climate variables for the Bekok basin using SDSM.
- To predict the temperature and rainfall impact of climate change on Bekok reservoir in 2021 until 2050.

1.2 Study area

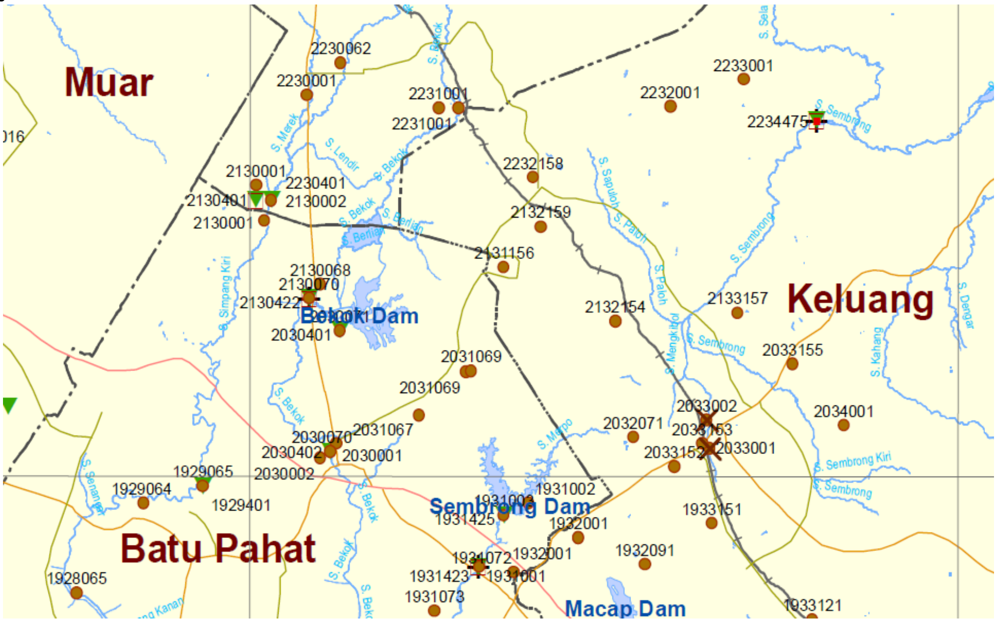

Figure 1: Location of Bekok dam and station number of rainfall stations

Bekok is stated in Batu Pahat district, Johor, Malaysia. The study area was focused at Bekok reservoir. Bekok dam is located in the mid-western part of the State of Johor. Bekok dam is located in the northeast, between 2 05 55 in latitude and 103 03 50 in longitude. Figure 1 shows location of Bekok dam and the number stations of rainfall stations surrounding of Bekok dam.

2. Materials and Methods

2.1 Rainfall data

Rainfall data from year 2010 to 2020 were collected from Department of Irrigation and Drainage (DID) as reference period of this study. 2 rainfall stations which are Ldg. Union at Yong Peng and Sg. Bekok Bt. 77 were selected as rainfall stations for this study since it was surrounding Bekok basin. Table 1 show number station, name, longitude and latitude for selected rainfall stations.

Table 1: Number station, name, longitude and latitude for rainfall stations

Number station	Name	Longitude	Latitude
2130068	Ldg. Union at Yong Peng	02 07 50	103 03 00
2130070	Sg. Bekok Bt. 77	02 07 15	103 02 30

2.2 Temperature data

Temperature data from year 2010 to 2020 were collected from Malaysian Meteorological (MMD) as reference period for this study. 1 temperature station which Batu Pahat temperature station was selected as temperature station for this study. Table 2 show name, longitude and latitude for temperature station.

Table 2: Name, longitude and latitude for temperature station.

Name	Longitude	Latitude
Batu Pahat	102 59	1 52

2.3 Statistical Downscaling Model (SDSM)

Statistical Downscaling Model (SDSM) is a multiple regression-based tool that purpose to generate future scenarios to assess the impacts of climate change. Within the taxonomy of downscaling techniques, SDSM is best described as a hybrid of the stochastic weather generator and regression based methods.[3]. The uses of stochastic weather generator and regression-based methods are to simulate local variables and atmospheric moisture predictors. Figure 2 shows steps of Statistical Downscaling Model (SDSM). SDSM model requires two types of data which local observe data (rainfall and temperature data) known as ‘Predictand’ and larger scale data different atmospheric variables known as ‘Predictors’ (NCEP reanalysis). National Centre of Environmental Prediction (NCEP) is obtained from Canadian Climate Impacts Scenario (CCIS) website for the period 1961 until 2005. NCEP contains 26 predictors. In the Statistical Downscaling Model (SDSM), there is screen variable which contains 26 predictors. 2 predictors need to choose with the consideration of minimum at P value and maximum at partial r. Then followed by calibrate model. There are also 26 predictors that can be chosen. The predictors variables that need to be chosen in calibrate model is same with the predictors variables that chosen in screen variables. After that, the step is scenario generator. Follow by model output. Last step is compared results.

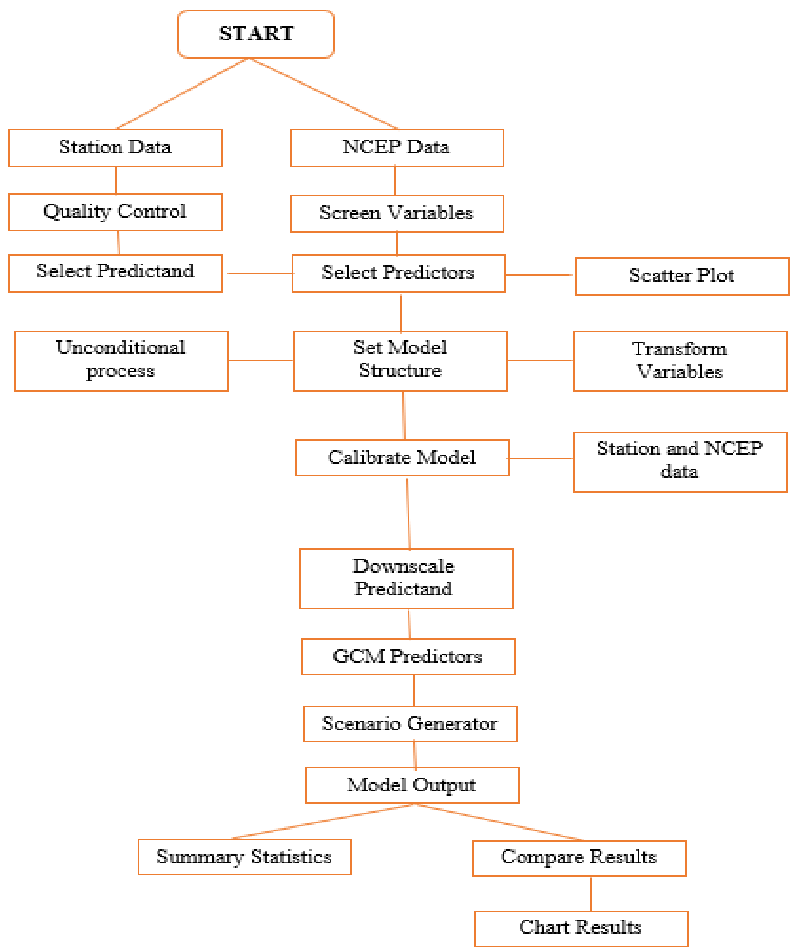

Figure 2: Steps of Statistical Downscaling Model (SDSM)

3. Results and Discussion

The SDSM is a model to generate future scenarios. SDSM requires two types of data which local observed data (rainfall and temperature data) known as 'Predictand' and larger scale data different atmospheric variables known 'Predictors' (NCEP reanalysis). The results obtained in SDSM is calibrate (2010-2015) and validate (2016-2020) to make sure the results obtained is valid. The results gained from SDSM in RCP 4.5 and RCP 8.5. There are differences between RCP 4.5 and RCP 8.5 which are RCP 4.5 is basic scenario that might happen while RCP 8.5 is describing the scarier fate and worst trend precipitation and temperature.

Table 2: Performance of calibration and validation for stations

Stations	Coefficient of Determination (R^2)	
	Calibration	Validation
Ldg. Union at Yong Peng (2130068)	0.11	0.44
Sg. Bekok Bt. 77 (2130070)	0.01	0.02
Maximum temperature at Batu Pahat	0.06	0.27
Minimum temperature at Batu Pahat	0.51	0.31

3.1 Ldg. Union at Yong Peng (2130068)

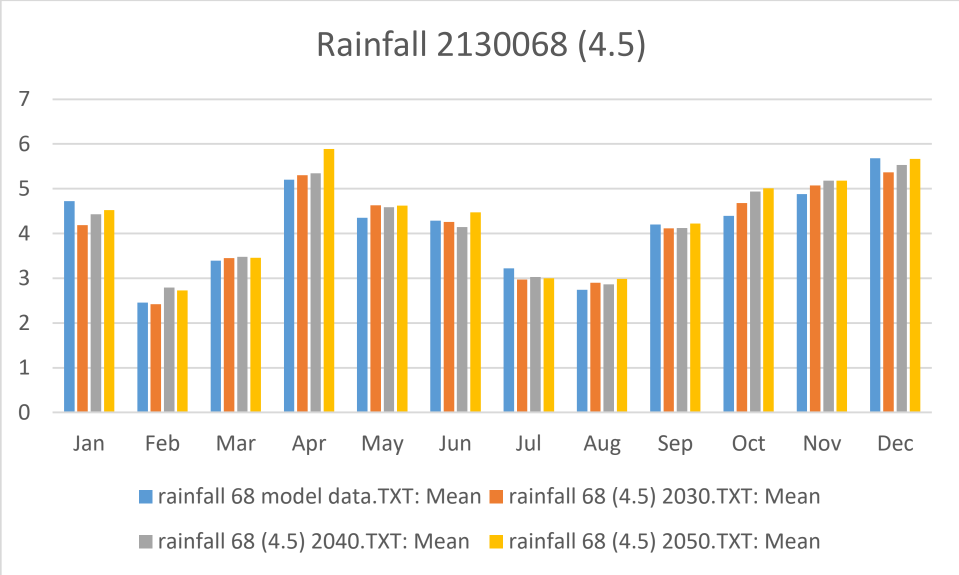

Figure 3: Rainfall data (4.5) for Ldg. Union at Yong Peng

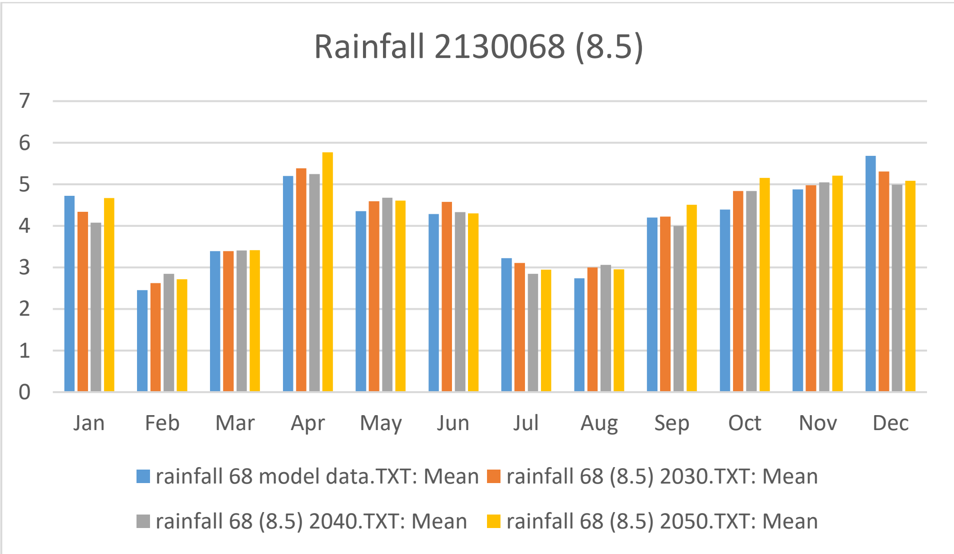

Figure 4: Rainfall data (8.5) for Ldg. Union at Yong Peng

3.2 Sg. Bekok Bt. 77 (2130070)

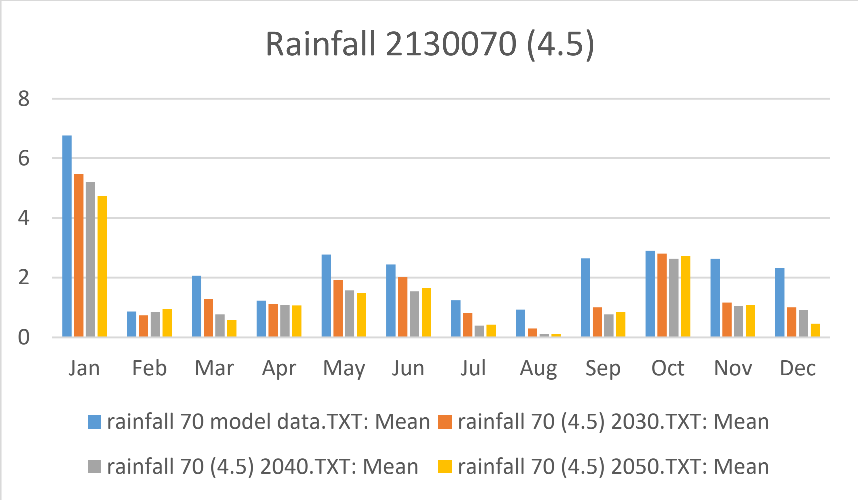

Figure 5: Rainfall data (4.5) for Sg. Bekok Bt. 77

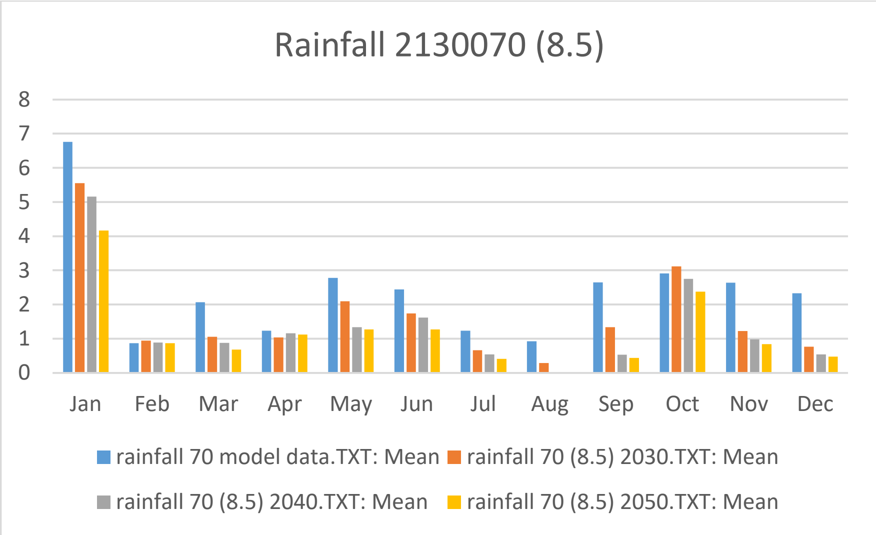

Figure 6: Rainfall data (8.5) for Sg. Bekok Bt. 77

3.3 Maximum temperature

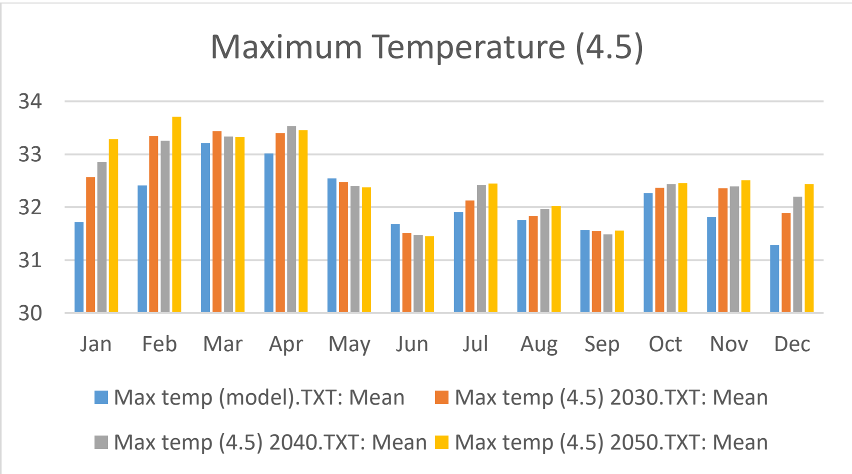

Figure 7: Maximum temperature (4.5)

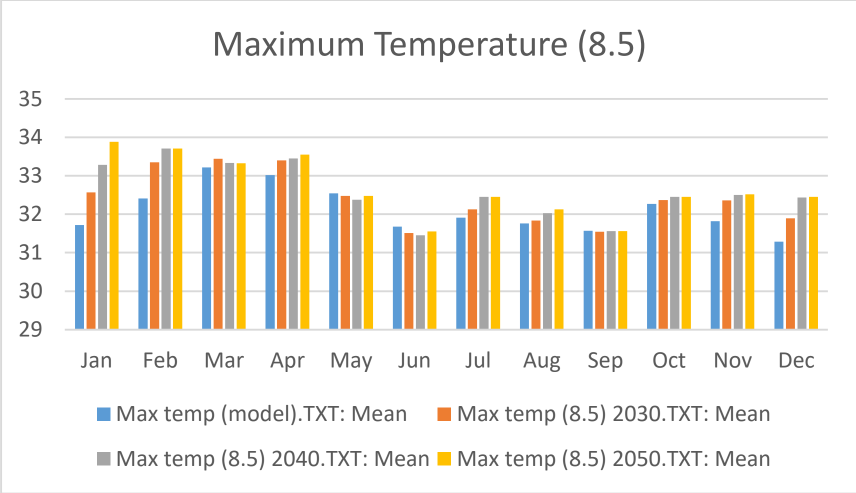

Figure 8: Maximum temperature (8.5)

3.4 Minimum temperature

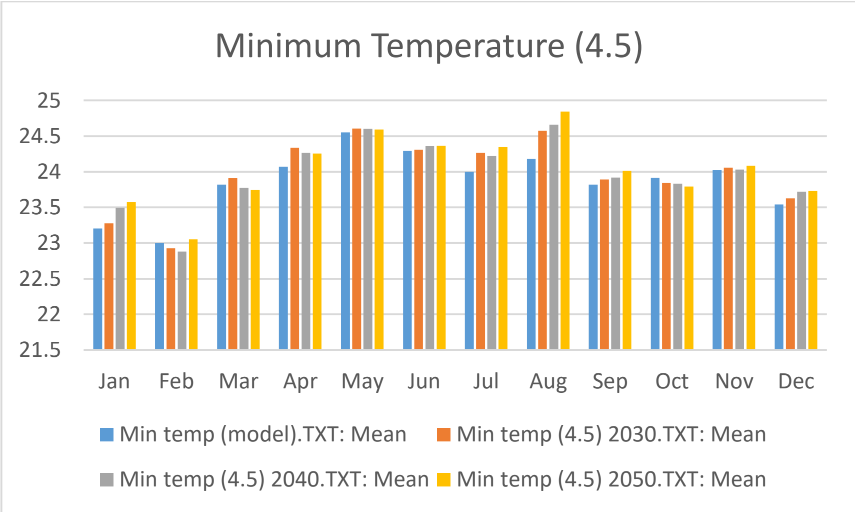

Figure 9: Minimum temperature (4.5)

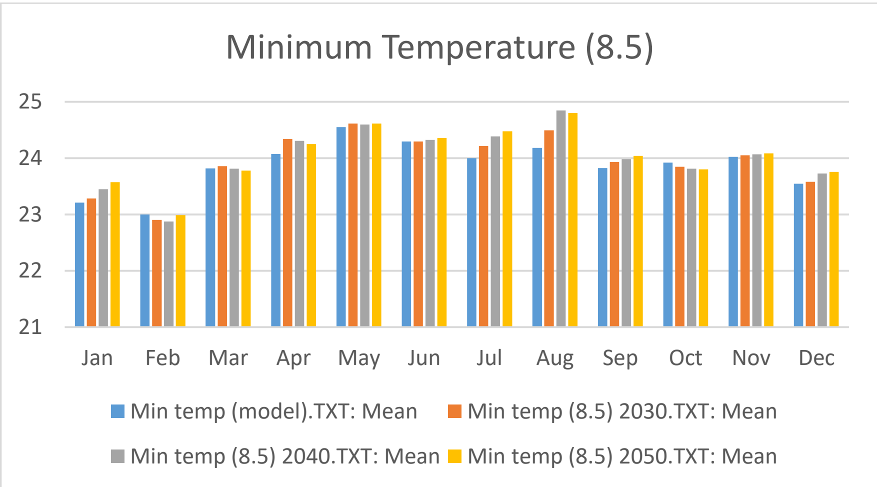

Figure 10: Minimum temperature (8.5)

3.5 Comparison with others research

There are few results and statement from other studies was used to make comparison. The purpose of comparison is to prove that the results obtained from SDSM are valid. Figure 11 shows precipitation data obtained by using Regional Climate Model (RCM). At rainfall station Ldg. Union Yong Peng for RCP4.5 in year 2030 and RCP8.5 in year 2040 shows the changes of total rainfall (%) from model data is -0.40 and -0.32. This negative sign represents that the rainfall intensity on that year is lower compare to model data. As for positive sign shows that the rainfall intensity for year increase compare to model data which at year 2040 and 2050 for RCP4.5 and year 2030 and 2050 for RCP8.5. While at rainfall station Sg. Bekok Bt. 77 shows the decreases of rainfall intensity compare to model data. As shown in figure 11 the changes of total precipitation for Batu Pahat is range 4.00 % to 6.00 %. Plus, this range is cumulative from watersheds surrounding Batu Pahat. So, the results obtained by SDSM is acceptable. Plus, the results obtained in SDSM is done with calibration (2010-2015) and validation (2016-2020). The accumulated precipitation values for 100-year return period do not always increase through the 21st century.[1]

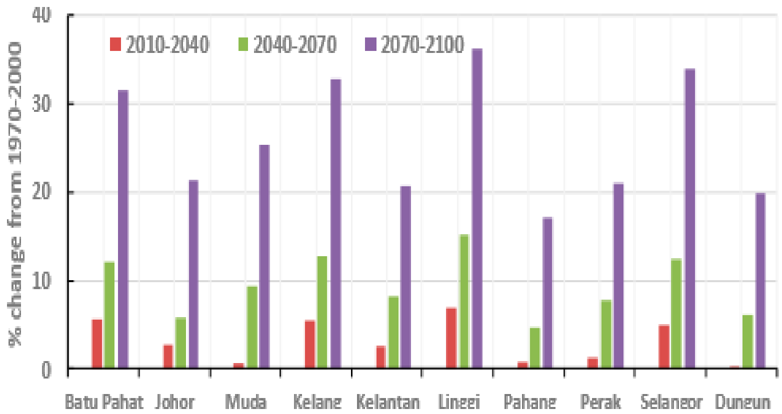

Figure 11: Precipitation data using Regional Climate Model (RCM) [4]

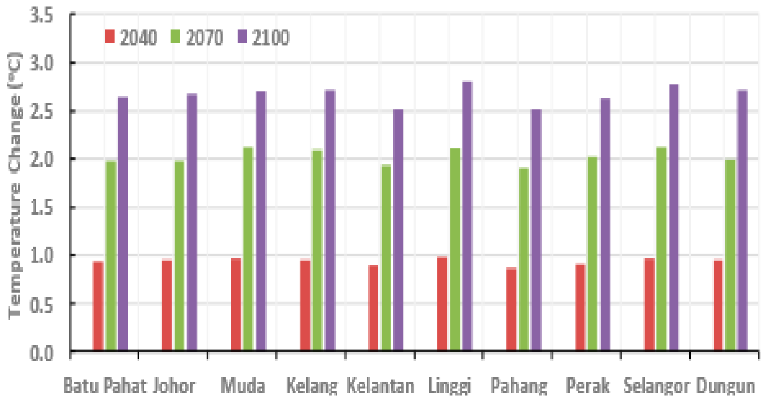

Figure 12: Temperature data using Regional Climate Model (RCM) [4]

Figure 12 shows temperature data obtained by using Regional Climate Model (RCM). For year 2050 has the higher changes of total temperature (%) which are 1.52 (RCP4.5) and 1.78 (RCP8.5) for maximum temperature while 0.69 (RCP4.5) and 0.73 (RCP8.5) for minimum temperature. The annual mean temperature increases about 1˚C over all of the selected watersheds and coastal regions from 2010 to 2040, and from 2040 to 2070.[4]. As shown in figure 12 the changes of total temperature for Batu Pahat is nearing to 1.0 ˚C. Plus this range is cumulative from watersheds surrounding Batu Pahat. So, the results obtained by SDSM is acceptable. Plus, the results obtained in SDSM is done with calibration (2010-2015) and validation (2016-2020).

4. Conclusion

In conclusion, this SDSM software can be used to obtained future rainfall and temperature data. In relation to objective 1, it can conclude by the data obtained from DID and MMD. The data gained was downscale using SDSM. Then for objective 2 can be conclude from the results of future rainfall and temperature. And for the last objective, the results indicate of future temperature and rainfall data for year 2030, 2040 and 2050. Recommendation for future research is to use more rainfall station and compare with different emissions for comparing the results obtained. This recommendation can be used to achieve greater reliability in terms of future research.

Acknowledgement

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