Prediction of Climate Change and Its Impact on Water Resources and Crop Yileds in Ergene River Basin

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1. Introduction

Climate change is a great and complex challenge facing human being recently. It is an issue of sustainable development as well as an environmental problem, affecting all sectors. Measures should be taken to mitigate and prevent the impact of climate change on the sectors in global and national level. To do this, climate change and its probable impacts should be properly forecasted.

The aim of this chapter is to predict the potential climate change and its effects on water resources and the yield of both wheat and sunflower, the two vital plants for the Thrace Region

2. Methods for prediction climate change and its Impact on water resources and yield

RegCM3 Regional Climate Model, reference and A2 scenario outputs were used in the estimation of climate change. The changes in temperature and precipitation were estimated for the future period of 2016-2025 (short-term), 2046-2055 (mid-term) and 2076-2085 (long-term) by comparing temperature and precipitation data measured in the study area for the period of 1970-1990 and model reference data. To model the effect of climate change on surface water resources, the SWMHMS Hydrological Model was tested with measured run off data in the study area between 1989 and 2007 and then runoff values for the future periods were simulated (Allred and Haan, 1996). In order to determine the effects of climate change yield in the region, AquaCrop Model were used. Having tested the models with the measured data of yields for 2012, the models were run for the future periods (Raes et al., 2009a; Raes et al., 2009b; Raes et al., 2009c; Raes et al., 2009d).

3. Results

3.1. Modelling Probable Climate change

RegCM3 Model was tested using the available climatic data between the years of 1970 and 1990 then it was run for the future forecasting. The measured and simulated minimum, maximum and average temperatures for the past period of 1970 -1990 were compared in **Figure 1**, **Figure 2** and **Figure 3**, respectively, whereas the simulated average temperature for the future periods of 2016-2025 (short-term), 2046-2055 (mid-term) and 2076-2085 (long-term) were presented in **Figure 4**, **Figure 5** and **Figure 6**, respectively. The changes in temperature were summarised in **Table 1**.

The measured and simulated precipitations for the past period of 1970 -1990 were compared in **Figure 7** whereas the simulated precipitations for the future periods of 2016-2025 (short-term), 2046-2055 (mid-term) and 2076-2085 (long-term) were presented in **Figure 8**, **Figure 9** and **Figure 10**, respectively. The changes in precipitations were summarised in **Table 2**.

Temperature rises of 0,12 °C, 1,43 °C, 3,05°C were forecasted for the future periods of 2016-2025, 2046-2055 and 2076-2085, respectively when compared with the data between 1970 and 1990 whereas a 9% increase during 2016-2025 and 14% and 12% decrease for the periods of 2046-2055 and 2076-2085, respectively, were predicted for precipitation.

3.2. Modelling impact of climate change on water resources

SWMHMS hydrologic model was first tested with the available measured rainfall-run off (surface water resources) data between the years of 1989 and 2007 (**Figure 11**) and then the impact of climate change on surface water resources was modelled for the future periods of 2016-2025 (**Figure 12**), 2046-2055 (**Figure 13**) and 2076-2085 (**Figure 14**). The changes in run of or surface water resources were summarised in **Table 3**.

The climate changes were estimated to increase the surface run off by %141, %3 and %59 in the future periods of 2016-2025 (short-term), 2046-2055 (mid-term) and 2076-2085 (long-term), respectively.

When the future precipitation and run-off data were evaluated together, it may be concluded that significant changes are not expected in the total precipitation but the precipitation regime is forecasted to change dramatically, large amount of rainfall is expected following long lasting drought period. This was the reason why the future run off values were simulated higher.

3.3. Modelling impact of climate change on crop yield

AquaCrop Model was first tested with the measured data of yields for 2012 (**Table 4**), then the model was run for the future periods (**Table 5 and Table 6**). Sunflower yield first increased up to 7.7% in short term and then decreased up to 23.3% and 3.1% (**Table 5**) in the mid and long term, respectively, while the wheat yield increased up to 81.4%, 60.2% and 90.2% in short, mid and long term future periods (**Table 6**), respectively, when compared to the measured data of 2012 without taking vegetation period shortage into consideration.

It may be concluded that the Thrace Region/Ergene River Basin is vital to ensure food safety of Turkey with this increase in wheat yield.

4. References

Allred B ve Haan C. T (1996). SWMHMS-Small Watershed Monthly Hydrologic Modelling System. Journal of the American Water Resources Association. 32 (3): 541-552.

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Raes D, Steduto P, Hsiao T. C ve Fereres E (2009b). Reference Manual. Chapter Two: Users Guide, FAO, Land and Water Development Division, Rome. 1-115.

Raes D, Steduto P, Hsiao T. C ve Fereres E (2009c). Reference Manual. Chapter Three: Calculation Procedures, FAO, Land and Water Development Division, Rome, 1-83.

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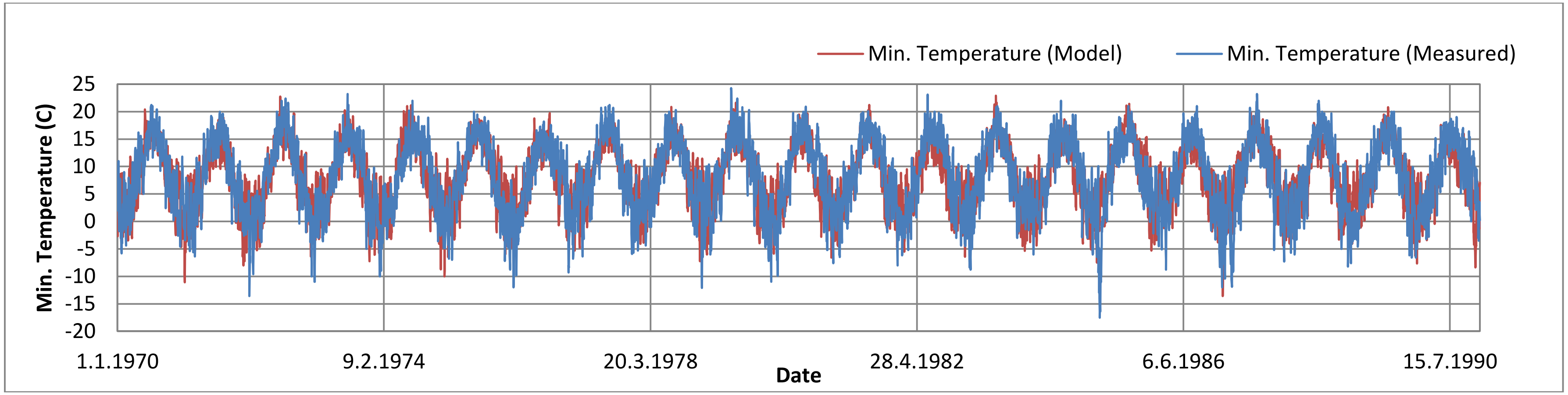

Figure 1. The measured (Corlu Meteorological Station) and simulated (RegCM3 Model) minimum temperatures for the past period of 1970 -1990.

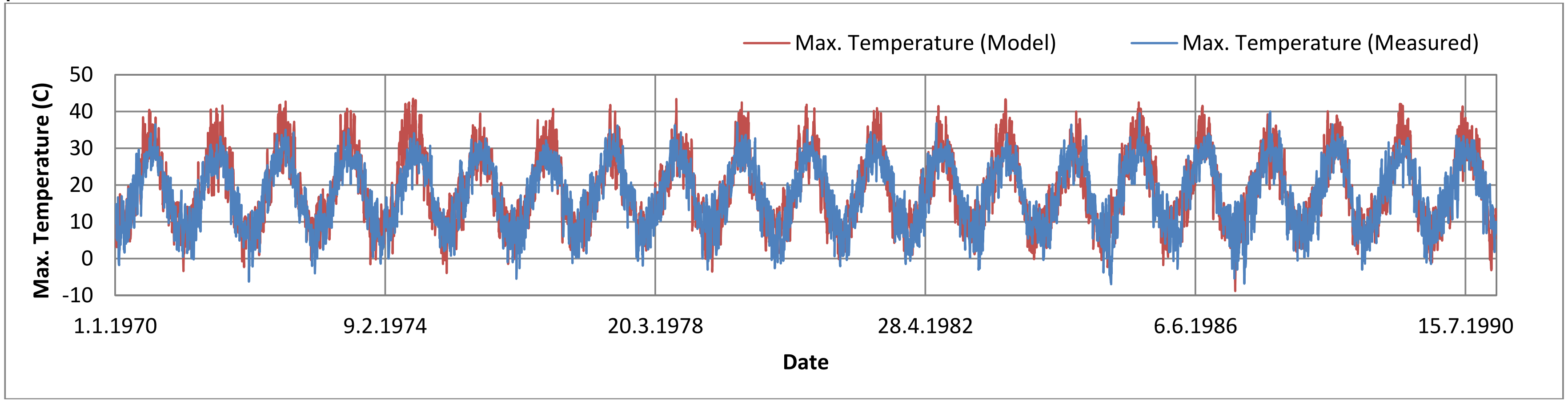

Figure 2. The measured (Corlu Meteorological Station) and simulated (RegCM3 Model) maximum temperatures for the past period of 1970 -1990.

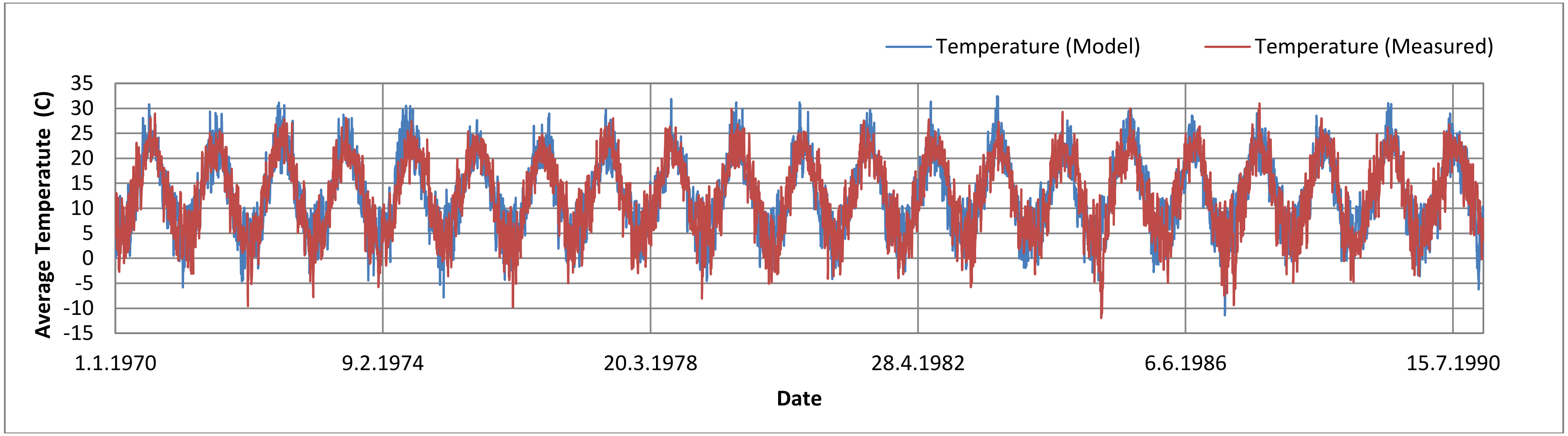

Figure 3. The measured (Corlu Meteorological Station) and simulated (RegCM3 Model) average temperatures for the past period of 1970 -1990.

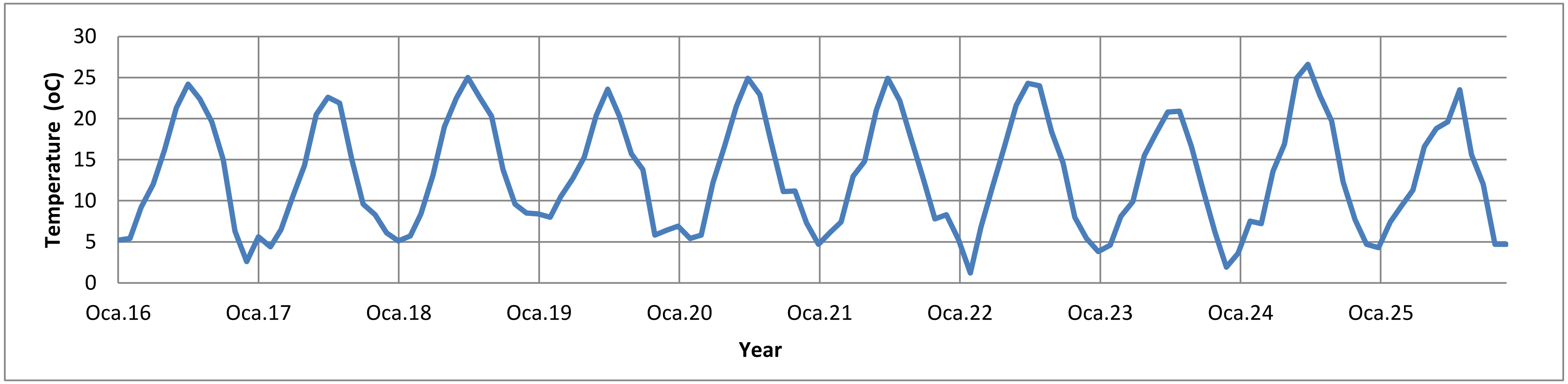

Figure 4. Simulated (RegCM3 Model) average temperatures for future short term (2016-2025) in Ergene River Basin.

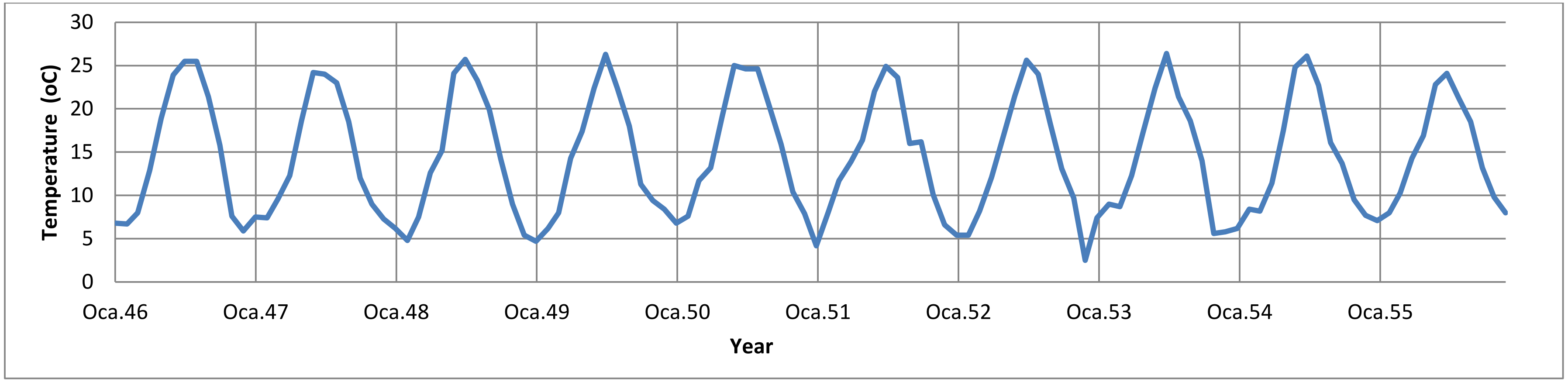

Figure 5 Simulated (RegCM3 Model) average temperatures for future mid term (2046-2055) in Ergene River Basin

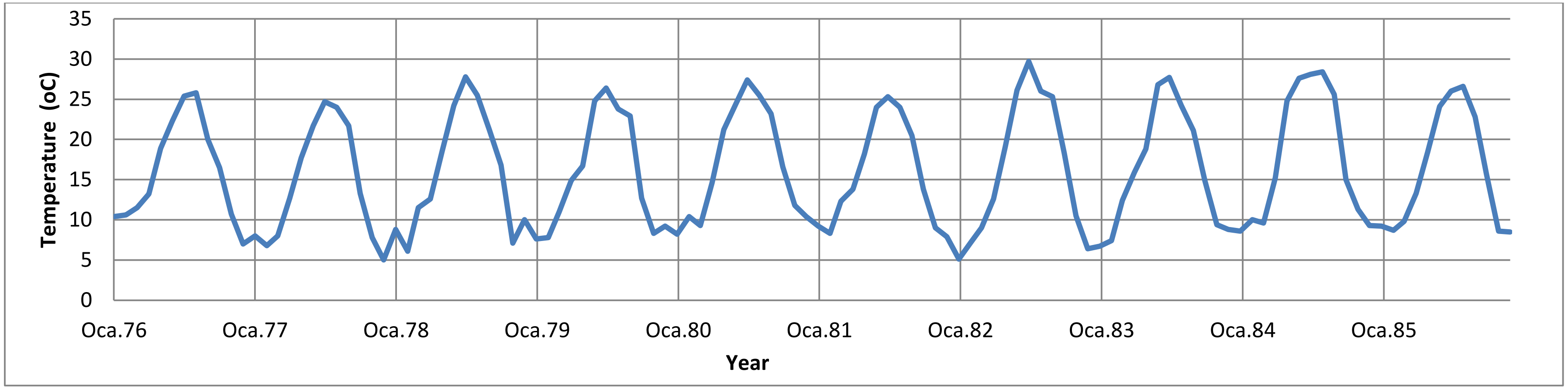

Figure 6. Simulated (RegCM3 Model) average temperatures for the future long term (2076-2085) in Ergene River Basin

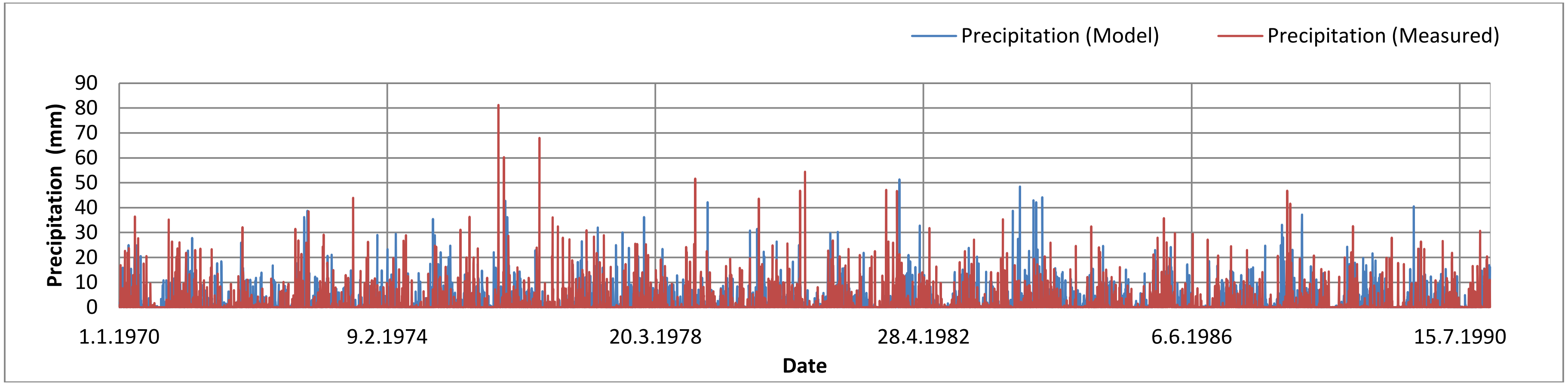

Figure 7. The measured (Corlu Meteorological Station) and simulated (RegCM3 Model) average precipitations for the past period of 1970 - 1990.

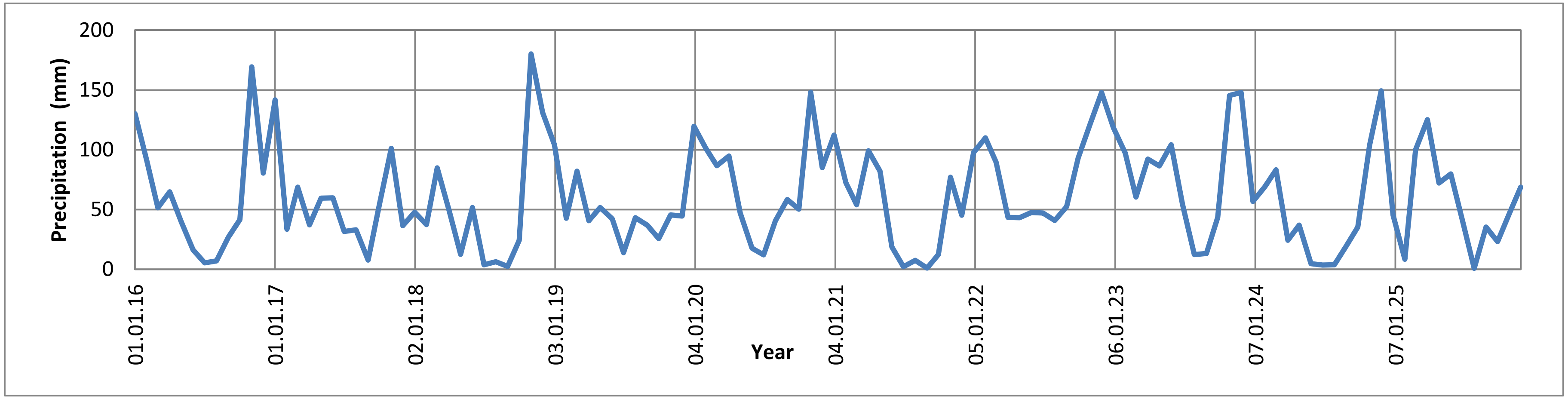

Figure 8. Simulated (RegCM3 Model) average precipitations for future short term (2016-2025) in Ergene River Basin.

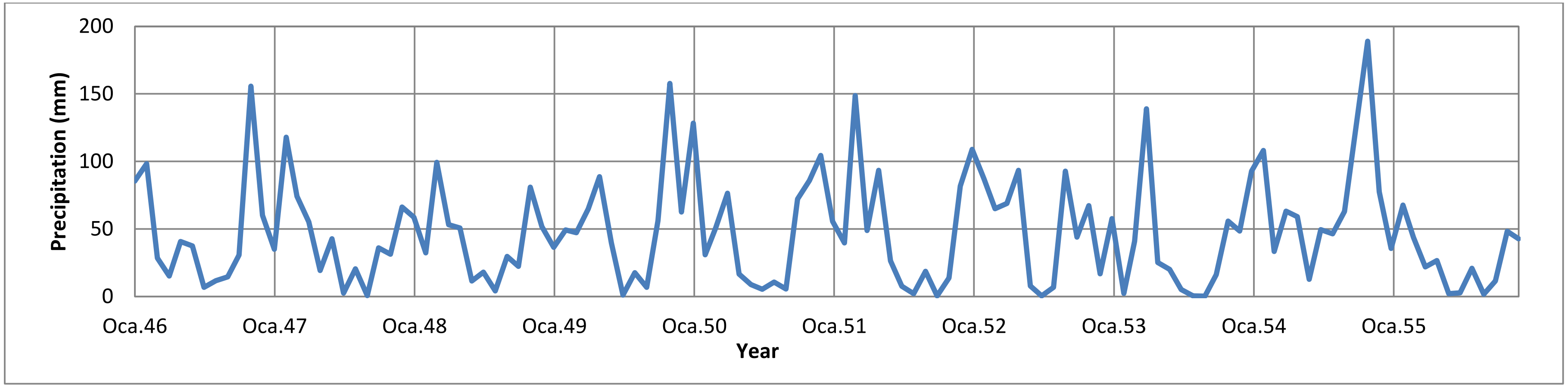

Figure 9. Simulated (RegCM3 Model) average precipitations for future mid term (2046-2055) in Ergene River Basin.

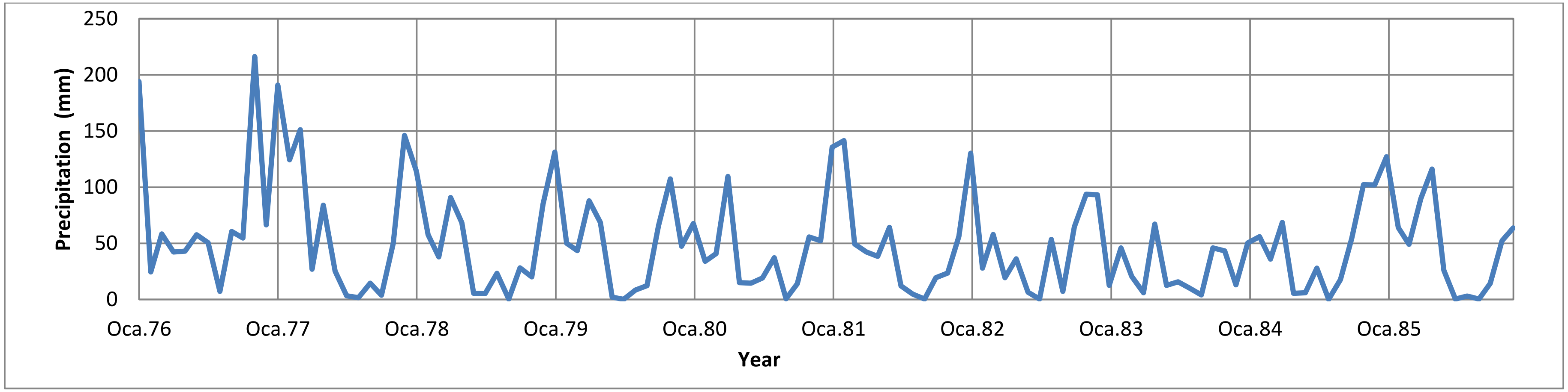

Figure 10. Simulated (RegCM3 Model) average precipitations for future long term (2076-2085) in Ergene River Basin.

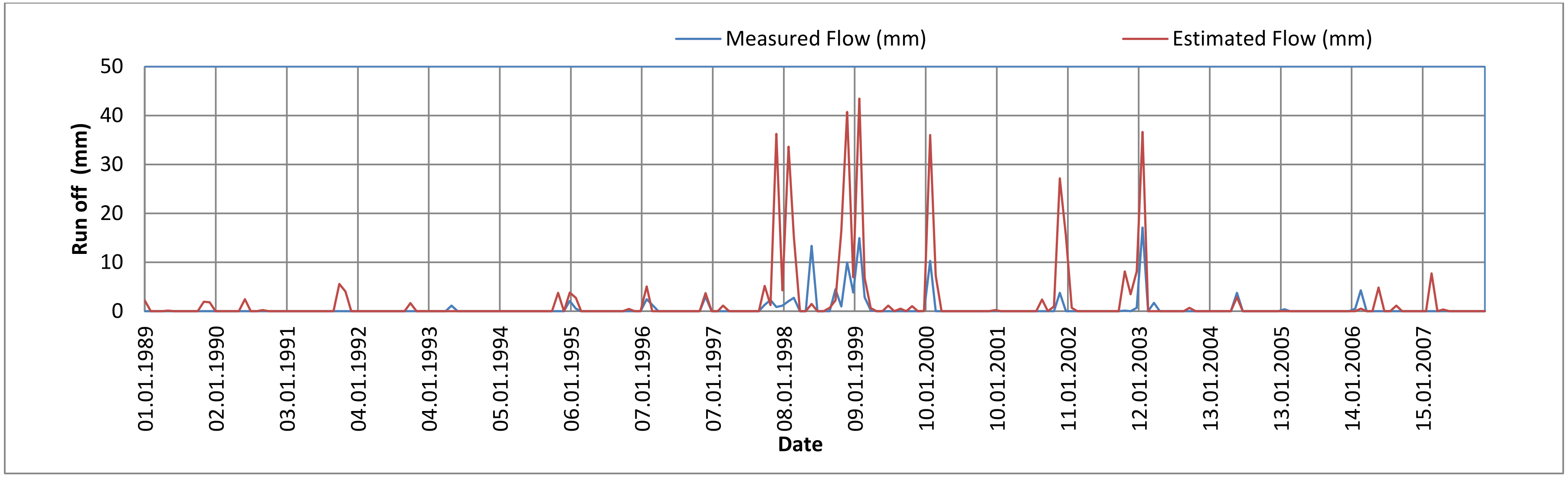

Figure 11. The measured and simulated (SWMHMS Hydrological Model) runoff values in Pinarbası sub-basin of Ergene River Basin betwen 1989 and 2007.

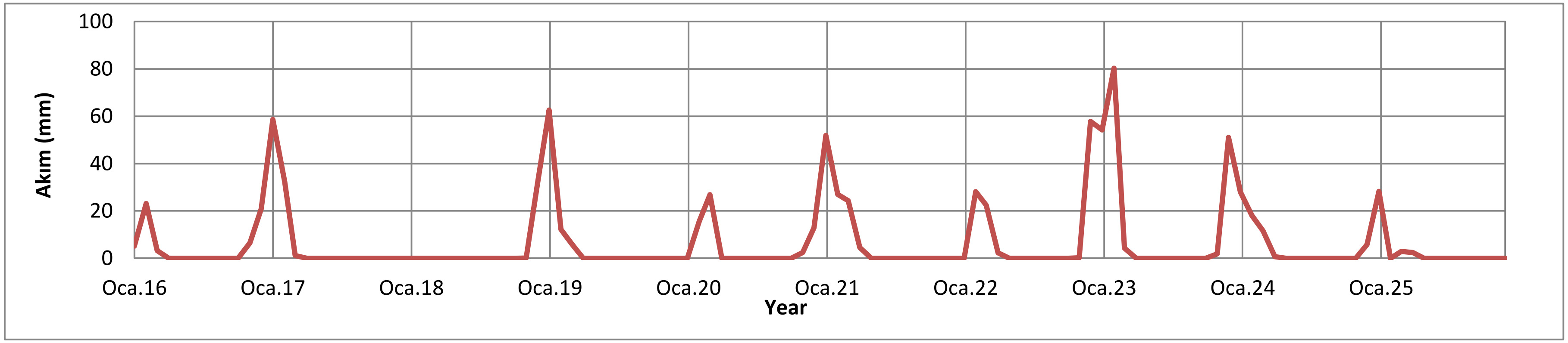

Figure 12. The simulated (SWMHMS Hydrological Model) runoff values in Pinarbası Sub-Basin of Ergene River Basin fort he future short term (1989 and 2007).

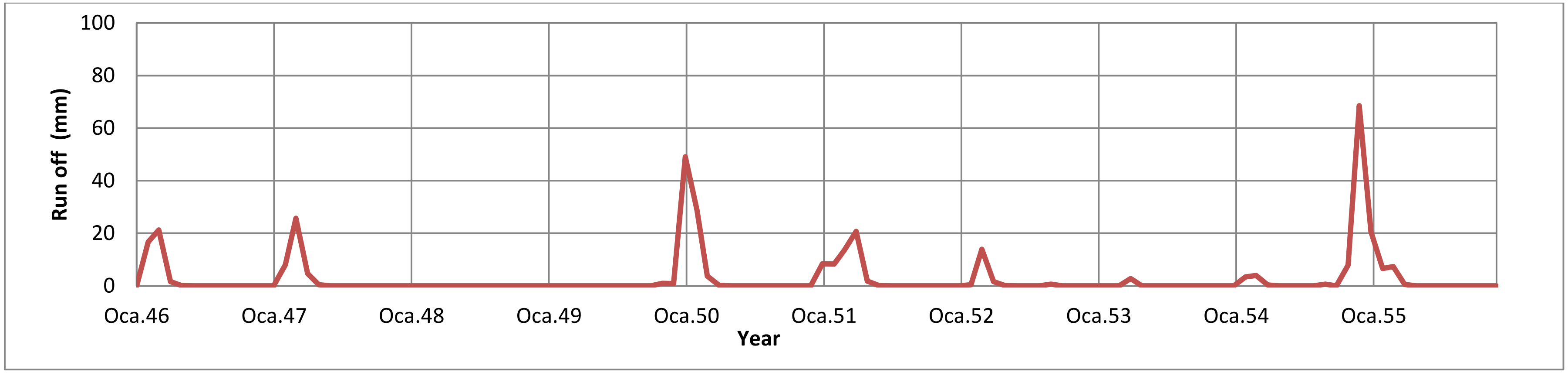

Figure 13. The simulated (SWMHMS Hydrological Model) runoff values in Pinarbası Sub-Basin of Ergene River Basin for the future mid term (2046-2055).

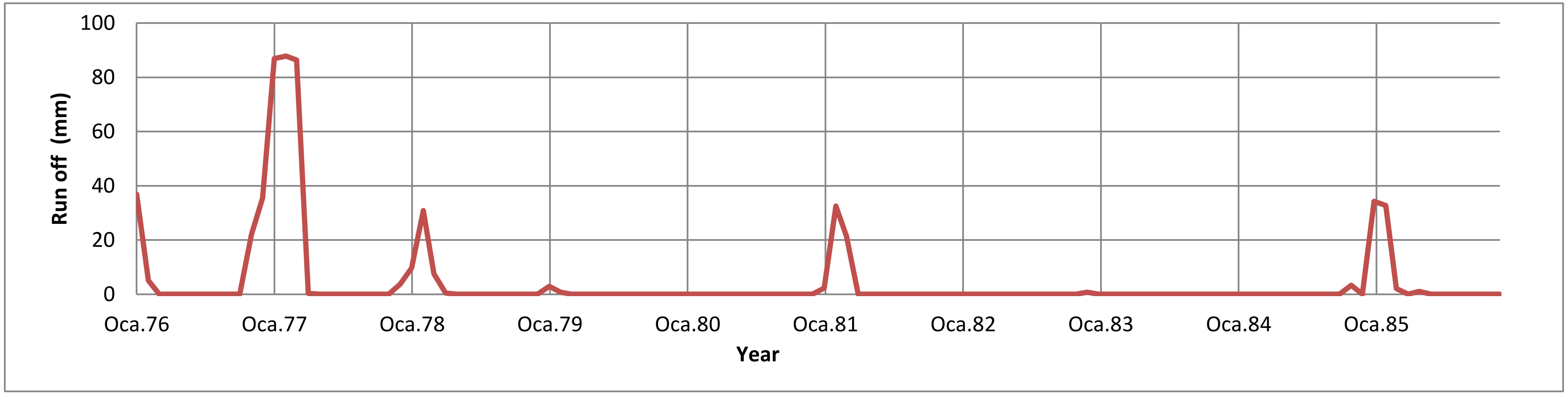

Figure 14. The simulated (SWMHMS Hydrological Model) runoff values in Pinarbası sub-basin of Ergene River Basin fort he future long term (2076-2085).

Table 1. Average temperature changes in the future periods of 2016-2025 (short-term), 2046-2055 (mid-term) and 2076-2085 (long-term) in comparison to reference period of 1970-1990.

Period	Annual average temperature (°C)	Deviation (°C)
1970-1990 (measured	12.57	
1970-1990 (simulated)	12.97	+0,4
2016-2025 (short -term)	13.09	+ 0.12
2046-2055 (mid-term)	14.40	+1.43
2076-2085 (long- term)	16.06	+3.05

Table 2. Average precipitations changes in the future periods of 2016-2025 (short-term), 2046-2055 (mid-term) and 2076-2085 (long-term) in comparison to reference period of 1970-1990.

Period	Annual average precipitation (mm/year)	Deviation (%)
1970-1990 (measured	599	
1970-1990 (simulated)	600	0,01
2016-2025 (short -term)	720	+ 20
2046-2055 (mid-term)	569	- 5,2
2076-2085 (long- term)	582	- 3

Table 3. Average runoff changes in the future periods of 2016-2025 (short-term), 2046-2055 (mid-term) and 2076-2085 (long-term) in comparison to reference period of 1989-2007.

Period	Annual average run off (mm)	Deviation (%)
1970-1990 (measured	2.80	
1970-1990 (simulated)	2.86	+2.14
2016-2025 (short -term)	6.91	+141.0
2046-2055 (mid-term)	2.96	+3.00
2076-2085 (long- term)	4.56	+59.0

Table 4. The measured and simulated (AquaCrop Model) sunflower and wheat yields in Ergene River Basin in 2012.

Crop	Location in ER Basin	Measured yield (kg/ha)	Simulated yield kg/ha)	Deviation (%)
Sunflower	Akincilar	2400	2340	-3
	Sofular	1930	1900	-1
	Cövenli	2490	2510	1
Wheat	Akincilar	5000	5020	0
	Sofular	5750	576	0
	Cövenli	6600	6630	0

Table 5. Changes in suflower yields in the future periods of 2016-2025 (short-term), 2046-2055 (mid-term) and 2076-2085 (long-term) in comparison to reference year of 2012.

Sunflower	Yield (kg/ha)				Deviation from the yieald of 2012 (%)		
	2012	2016-2025	2046-2055	2076-2085	2016-2025	2046-2055	2076-2085
Akincilar	2400	2480	2110	2410	3.3	-12.0	0.4
Sofular	1930	2080	1480	1870	7.7	-23.3	-3.1
Cövenli	2490	2510	2030	2480	0.8	-18,4	-0.4

Table 6. Changes in whet yields in the future periods of 2016-2025 (short-term), 2046-2055 (mid-term) and 2076-2085 (long-term) in comparison to reference year of 2012.

Wheat	Yield (kg/ha)				Deviation from the yieald of 2012 (%)		
	2012	2016-2025	2046-2055	2076-2085	2016-2025	2046-2055	2076-2085
Akincilar	5000	9070	801	9510	81.4	60,2	90,2
Sofular	5750	9060	808	9410	57.6	40,5	63,6
Cövenli	6600	8150	815	9330	23.5	23,5	41,3