Journal of Geography and Geology; Vol. 7, No. 1; 2015
ISSN 1916-9779 E-ISSN 1916-9787
Published by Canadian Center of Science and Education

Changes of the Rainfalls Rates in Tartous Using Gamble's Distribution

Kinana Haleme[1] & Riad Qara Fallah[2]

[1] Graduated Student (PhD), Faculty of Arts and Humanities, Tishreen University, Syria

[2] Department of Geography, Faculty of Arts and Humanities, Latakia, Syria

Correspondence: Kinana Haleme. Graduated Student (PhD), Faculty of Arts and Humanities, Tishreen University, Syria. E-mail: Halemekinana@gmail.com

Received: January 8, 2015 Accepted: January 28, 2015 Online Published: February 26, 2015

doi:10.5539/jgg.v7n1p77 URL: http://dx.doi.org/10.5539/jgg.v7n1p77

Abstract

This research aims to analyze the slope of the general line rates of the annual and quarterly rainfalls in some stations in Tartous, during the period 1970 – 2010 in order to determine the change in rates of rainfalls and the effect of this change on the vary of potential density for the occurrence of extreme rates of rains high or low according to Gamble's distribution about the values of extreme rainfall.

The results indicated the presence of a decline in the annual rates of rainfalls at all stations, between 54and 77 mm during the period of this study. Spring recorded statistically the largest important decline where the decline was (86 – 132 mm) while the winter rainfall increased between (27 – 59 mm). The share of Spring of the total annual rainfall fell around 5 – 6% against rising the rates of winter rainfall between 4 – 6%.

The probable density of the high extreme annual Rainfall increased at all stations, according to Gamble's distribution, and there was a significant increase in the likely hood of extreme low rainfall in Spring, which indicates a significant drought in this season. While the probability of Rainfalls increased more in winter so that the winter is wetter than before.

1. Introduction

Rainfalls Suffer in the Mediterranean region from irregular distribution in time and space, where 55% of the total water resources amounting concentrated, which were (600 km 3 / year) in Turkey and the countries of the north of the Mediterranean Sea.

while the countries of the southern and eastern Mediterranean suffer from a chronic shortage of water up to (100 m 3/ capita/ year), and the shortfall of some of them are up to 500 m 3/ capita/ year (Simone, 2011). The figure (1) shows the amount of decline in winter rainfalls during the period 1971 – 2010 in the Mediterranean region, compared with the period from 1902 to 2010, this is according to a study made by the National Oceanic and Atmospheric Administration (NOAA, 2011).

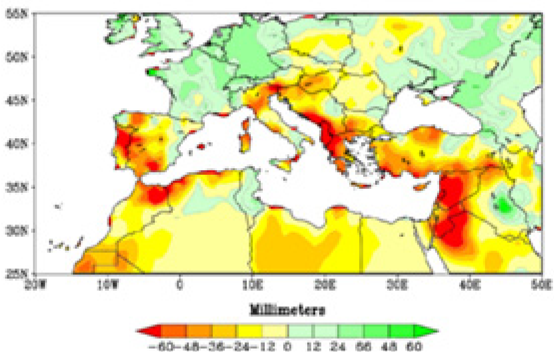


Figure 1. A map shows the change in the rate of winter rainfalls in the Mediterranean Basin during the period (1902 – 2010) (the Source is 2011 NOAA)

The report of the Arab Forum for Environment and Development (AFED, 2009) indicates that the Arab

Countries contain less than 1% of the volume of fresh water in the world, despite the fact that the area of the Arab countries is 10% of the Earth's surface where they are suffering, including Syria, from a shortage of water due to the lack of rainfall and water resources. The high average of temperatures had negative repercussions on such Countries where it was observed a decline in the rates of rainfall yearly and an occurrence of frequent and successive drought years which didn't occur in the distant past. So it was important to determine the amount of changes in the rates of rainfall and the extreme values because this important determination helps know the impact of changing rainfall on some important sectors including agriculture and securing water for irrigation and drinking.

Knowing the impact of regional climate change includes the temperature changes and the rainfall rates. It also includes changes in the likelihood of their marginal and extreme ends (Pongr'acz et al, 2009). The low levels of rains is one of the main characteristics of the extreme weather events which is associated with the increase of the drought the effects of which are considered in an area already suffered from a lack of water resources and dry summers. So that all the good readiness conditions should be taken to face the effects that may be caused by such changes. The report (2009, AFED) and report (IPCC, 2007) indicate the increasing drought due to the high temperature which will lead to the increased need for irrigation water and the agricultural periods of the crops will change.

Analyzing the general trends rates of annual and quarterly rainfall in some stations in Tartous during the period (1970 – 2010) and the divisions of time, knowing changes in the medium rates and the statistical significance of such changes, determining the seasons and periods which witnessed the biggest changes, and analyzing the changes of probable density of extreme values using Gamble's distribution of the extreme values of rainfall.

2. Method

This research relies on a rainfall database from Coastal Tartous Province represented in the monthly rainfall for three stations which are different in height during the period from 1970 to 2010 which are the stations of Tartous, Safita and Qadmous. The table shows (1) all the data relating to the stations used in this research such as coordinates, height above the sea level and the length of the time sequence related to available data for each station. While Figure 2 represents the map of the Syrian Arab Republic and the location of Tartous Province in the west and the locations of the studied stations in Province of Tartous.

Table 1. the names, locations and heights of the climatic stations used in the research

Station	Latitude	Longitude	Height/m	Type of station	Available time sequence
Tartous	35.8	34.8	5	Senub	1970-2010
Safita	36.1	34.8	370	Senub	1970-2010
Qadmous	36.1	35.0	915	Climatic	1970-2010

Source: General Directorate of Meteorology.

Figure 2. A map showing the location of Tartous in Syria and the locations of the stations studied therein

Linear regression equation of the time sequence was drawn to show the amount of change of the regression in the general line, the amount of annual and quarterly rainfall and to determine the statistical significance of each of such changes. Then divided the data by the four seasons into two time periods, the first is from 1970 to 2000 (31 years) and the second is from 2000 to 2010 (10 years), in order to determine the amount of increase in the average temperature in the first decade of the twenty-first century comparing with the last three decades in the last century which in themselves approximately constitute a climatic cycle. The reason for such choice is that 11 years from 12 years within the period (1996-2005), according to the report of the Intergovernmental Panel on the Climate Change (IPCC, 2007), was the highest in the temperatures average since the start of measurements of global temperature since 1850 and the subsequent measurements also indicated that the years of 2007 and up have been hotter and the peak was in 2010 which is the highest temperature measurements in the history of the world.

Test (T-test) was made in order to calculate the statistical significance of the different value of the rainfall average in (2001-2010), compared with the rainfall average value for the period (1970-2000) with degree of confidence of 95% (Humaydan and others, 2006) according to the following formula:

$$t = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$$

Whereas:

X_1 and X_2 are the temperature average during the two studied periods.

σ_1 and σ_2 are the standard deviation of temperature during the two studied periods.

n_1 and n_2 are the number of the years in each time period.

Gamble's distribution is used to analyze the probable density of the values of the high and low extreme rainfall so that to determine the impact of it in two ways (Fürst&Holzman, 2007). Such distribution is of great importance in the studies of climate and hydrological which focuses on the study of the impact of heavy rains on the periods of scarcity or floods (Camperling et al, 2007) and thus the amount of water can be stored in wet periods and using the same in dry periods in the irrigation of crops and different uses. It is calculated from the following formulas:

$$f(x) = e^{-e^{\frac{(x-c)}{d}}}$$

$$c = \overline{X} - 0.5772.d \qquad d = 0.7797 s_x$$

s_x is the standard deviation of the rainfall.

X is the amount of rainfall.

X is the Average of rainfall.

In this way the space below equals the distribution curve (1 or 100%) whereas the increased the arithmetic average of the rate of rainfall causes accompanied changes in its probable densities, especially the extreme ones. This is clearly shown when compared with another earlier or later time period, as (Figure A-3) explains, which represents the changes in the rates of the rainfall in a hypothetical station during two time periods where the elongation of the red curve is increased which represents the latest period of time which leads to an increase in the dispersion of rainfall and increase of its standard deviation and that means high probability of low extreme rains and which is in the figure represents 200 mm, as well as increasing the possibility of reaching the rainfall to values higher than (600 mm) which is higher than it was in the previous period in a rate that can be calculated. While model B shows the increasing of the rainfall average so that the probable high extreme rainfall increased while the low rainfall decreased. This research Will focus on the values of the upper and lower extreme rainfall that is more or less than 10% (Jungo, 2003) in the period (1970-2000) and to control the possibility of change in the most recent period (2001-2010).

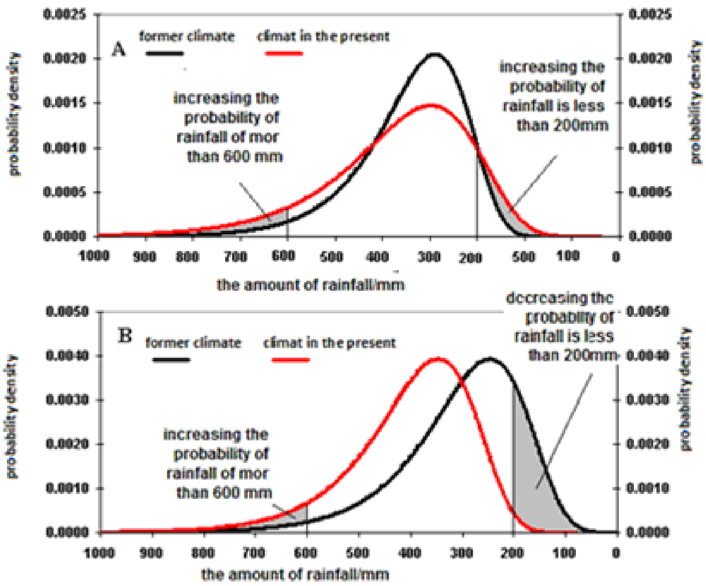
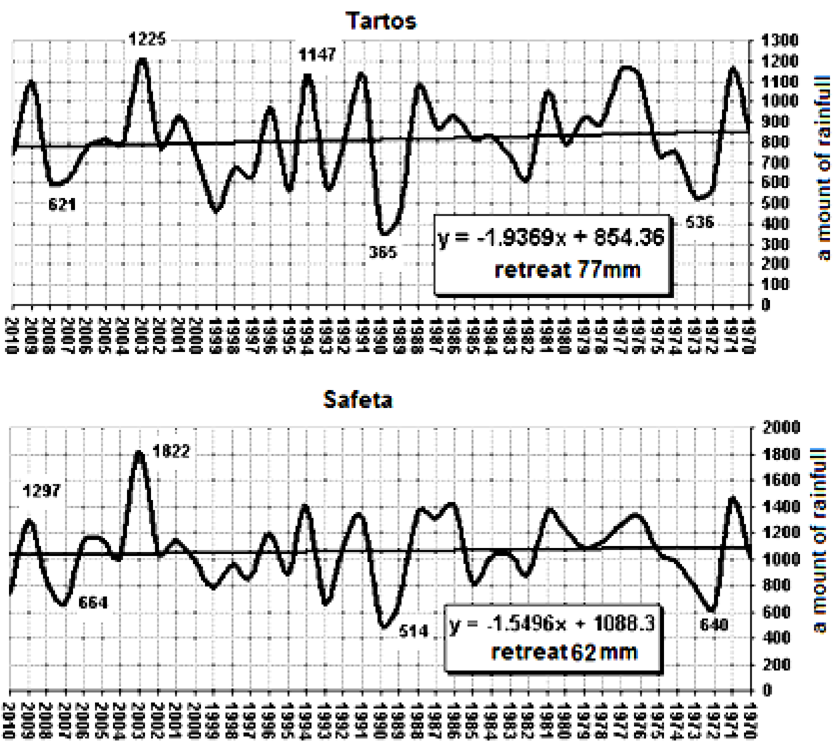


Figure 3. a form represents Gamble's distribution to compare the changes in the rainfall between the two time periods according to two different models

3. Results

The general feature of the annual amounts of rainfall in the stations in Tartous is the retreat of the decline line during the period 1970-2010. The figure (4) shows that the decline in annual rainfall amounts rates reached 77 mm in Tartous station, 62 mm in Safita and 54 mm in Qadmous station. The figure shows that 2003 was the wettest year, while1990 was the driest.



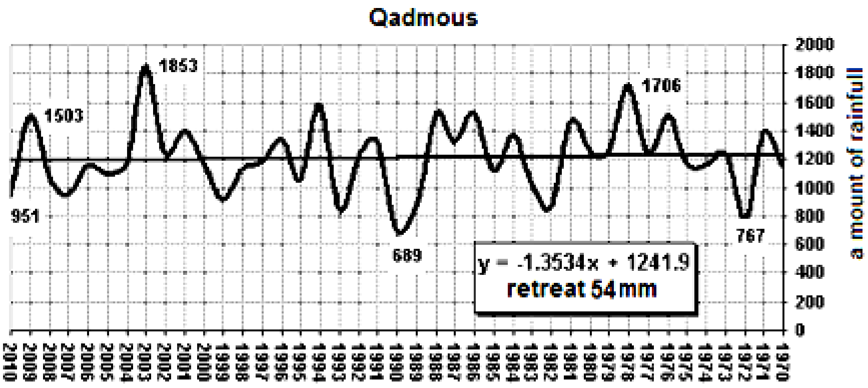


Figure 4. The general trend of medium annual rainfall amounts during the Central period (1970-2010)

Table 2 shows the absence of a significant change in the rate of annual rainfall during the period (2001-2010) compared with the period (1970-2000) where the amount of rainfall witnessed a simple increase at the studied stations which was (33-39) mm. The significant decline was prominent with statistical significance in the spring rain, the rate has reached a maximum decline in Safita station 132.2 mm (3.3 mm / year), in Qadmous 121.6 mm (3 mm/ year) and in Tartous it was 86.1 mm (2.2 / year). The rate of rainfall retreated during the spring, in the period 2001-2010, dramatically compared with the period (1970-2000) against the increase in winter rainfall during the 40 years between (27-59 mm) i.e. in the limits of (0.7 - 1.5) mm/ year and the largest increase was in Qadmous station (59 mm) then Safita (50.2 mm) and 27 mm in Tartous. According to the table we can notice the increase rainfall during winter and fall and its decline during spring and summer.

Table 2. The amount of the slope in the regression line of rainfalls average in some of the studied stations, and the statistical significance of the slope of the regression line

Station	Season	The regression line of rainfall amount1970-2010 in mm	Degree of confidence			Sig>95%
				The average of rainfall 2000-1970 mm	The average of rainfall 2010-2001 mm	The statistical significance of The average change
Tartous	Annual Rainfall	-77.5	-	805	841	-
	Winter	27.0	-	453	505	-
	Spring	-86.1	+	158	130	-
	Summer	-30.1	-	13	1	-
	Autumn	11.7	-	181	205	-
Safita	Annual Rainfall	-62.0	-	1046	1085	-
	Winter	50.2	-	562	618	-
	Spring	-132.3	+	244	195	-
	Summer	-8.5	-	10	3	+
	Autumn	28.6	-	231	269	-
Qadmous	Annual Rainfall	-54.1	-	1205	1238	-
	Winter	59.1	-	619	689	-
	Spring	-121.6	+	329	274	-
	Summer	-14.8	-	20	17	-
	Autumn	23.1	-	238	259	

Note. the differences among the averages (+) > 95% statistically significant (0) ≤ 95% is not statistically significant.

The retreat of spring rainfall and the increasing of winter rainfall cause a relative difference in separating the rainfall during the seasons, as the table 3 shows. The rainfall in spring decreased compared with the annual rainfall about 5-6% upon.

Table 3. The percent of the rainfalls during (2000- 2001) compared with (1970- 2000)

Station	Precipitation percent	Autumn	Summer	Spring	Winter
Tartus	1970-2000	22%	2%	20%	56%
	2001-2010	24%	0%	15%	60%
Safita	1970-2000	22%	1%	23%	54%
	2001-2010	25%	0%	18%	57%
Qadmous	1970-2000	21%	3%	26%	51%
	2001-2010	20%	4%	20%	57%

Gambel's distribution represent the probable values of the rainfall changes during (2001- 2010) compared with (1970- 2000). According to this table we can notice the different types of probable destiny of the rainfall in the studied stations, as stated out in Figure 5. In Tartous station the probable of high annual rainfall increased to excess 1000 mm in a simple percent of 0.26 which is labeled in red on the right of the curve. The probable of rainfalls (less than 600mm) decreased 10.2% (from 16.78% to 6.58%) which is labeled in blue on the left of the curve.

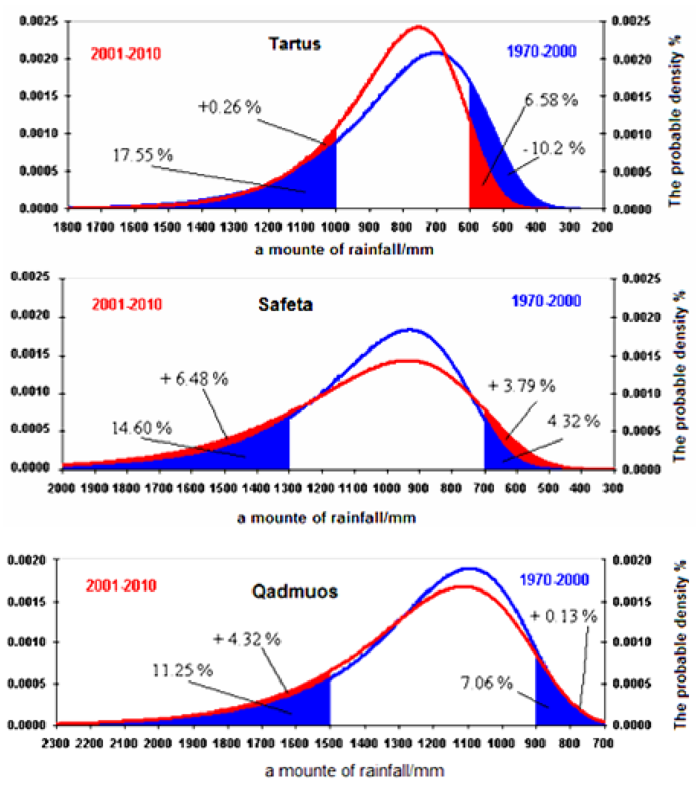


Figure 5. Probable density changes of the average annual rainfall during the period (2001-2010) compared with the period1970-2000

The situation is different for the stations of Safita and Qadmous together with an increase in the probability of high and low extreme values. In Safita the likely hood of rains less than700mm/ year mm increased by3.79% (red color on the left of the curve) and the likely hood of rain increased to become more than1300mm/ year by 6.48% (red color on the right side of the curve). The same is in Qadmous station where the grow in the likely hood of rain was less than 900mm/ year in a very simple percent of (0.13%) and the likely hood of rain increased to become more than1500mm/ year by 4.32%.

Figure 6 represents the changes of probable rainfall according to Gamble's distribution during spring and winter in the studied stations, since the focus was on these two seasons as they witnessed the most prominent changes where the spring rains decreased and winter rains increased. For the low extreme values in spring which is equal to or less than 10%, the Figure shows growing the possible rainfall by less than 75 mm in spring in Tartous by 17.8% (from 9.5% to 27.2%), in Safita the probable rainfall increased to be less than 130 mm up to 21.9% (from 10.2% to 32.1%) and in Qadmous the probable rainfall increased to be less than 200 mm up to 24.6% (from 7.1% to 31.2%). It is noted that the decline in spring rain is growing due to the height of the station. From the previous values we can conclude that the spring drought is a constant so that it becomes shorter in humidity duration and more integrated with summer.

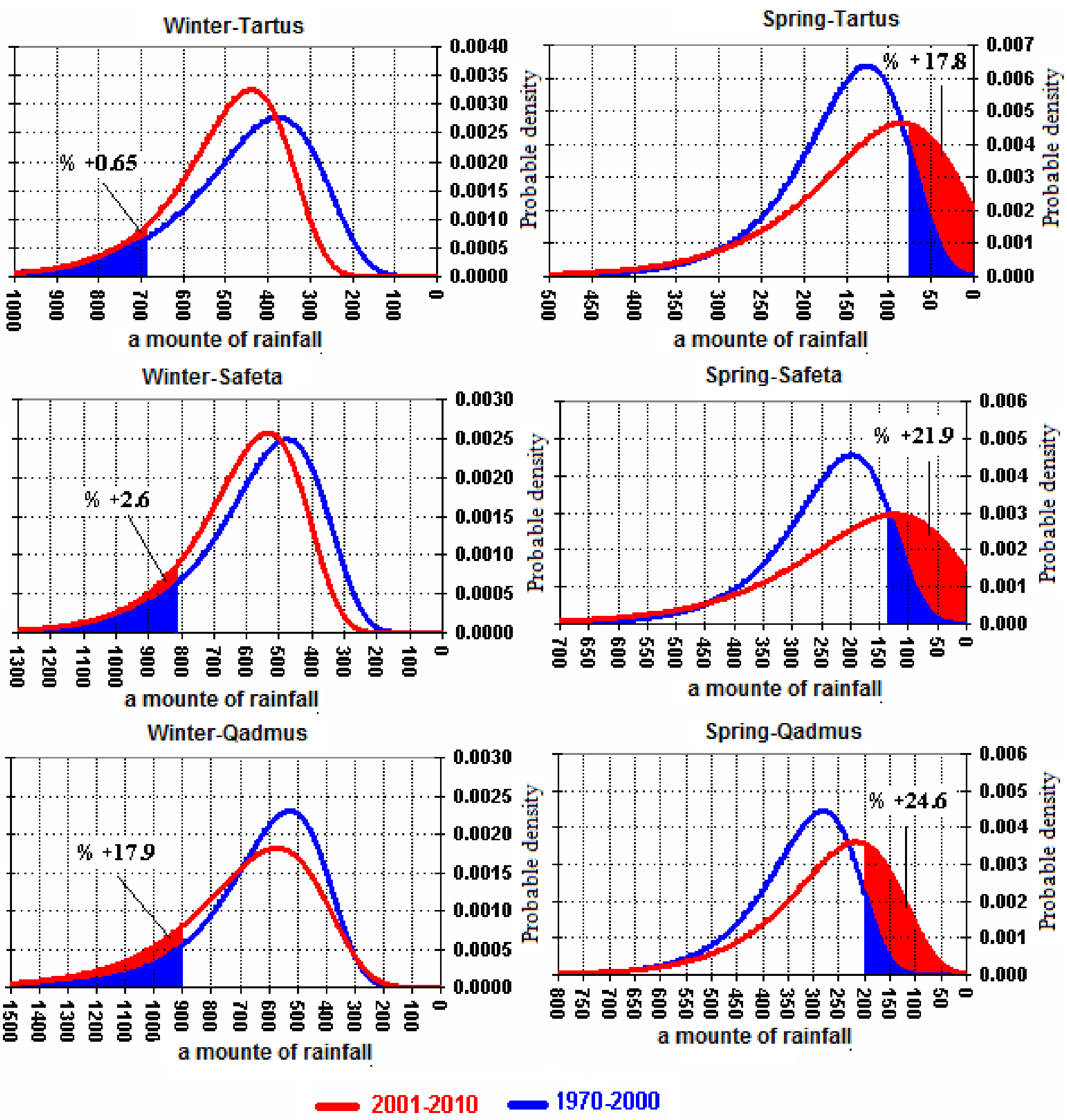


Figure 6. Probability density changes of the annual average rainfall in spring and winter during the period 2001-2010 compared with the period 1970-2000

For values of Winter upper extreme rainfall that is equal to or greater than 10%, Figure 4 shows the increase of the probability of rainfall higher than 680 mm in Tartous by 1.13% (from 10.1% to 11.2%), in Safita the probable rainfall increased more than 820 mm up to 2.6% (from 10.1% to 12.7%) and in Qadmous the probable rainfall increased over 900 mm up to 7.8% (from 10.1% to 17.9%). Here, the increase of the proportion of winter rainfall is also clearly noticed due to the height of the station. As a result, the season rains have become more concentrated in winter than ever before.

References

Camperling, C., Leroch, F., & Holzman, J. H. (2007). Wasserwirtschaft, Hydrologie und Flussgebietsmanagement, (IWHW), Institute für Wasserwirtchaft Hydroloie und konstuktiven Wasserbau, Universitat für Boenkultur Wien. Retrieved from http://iwhw.boku.ac.at/LVA816101/HydrologieFinalSkript

Humaydan. A., Makhoul, M., Jaaoni, F., Naser, A., & Ammar, A. S. (2006). Faculty of Economics, University of Damascus.

Intergovernmental Panel on the Climate Change (IPCC). change of climate and water, Working Team II, (Geneva VS 2008). Retrieved from http://www.ipcc.ch/pdf/technical-papers/ccw/climate-change-water-ar.pdf

Intergovernmental Panel on the Climate Change (IPCC). the synthesis report, (Geneva 2007, P 78). Retrieved from http://www.ipcc.ch/pdf/assessment-report/ar4. ISBN 92-9169-622-6.

NOAA. (2011). Drought in Syria manmade climate change. Retrieved from http://www.washingtonpost.com/blogs/capital-weather-gang/

P. Jungo:Temperaturextreme, OCCC. (2003). Organe consultatif sur les changements climatiques Beratendes Organ für Fragen der Klimaänderung. Bern, September. Retrieved from http://www.occc.ch/reports/Extremereignisse03/PDF

Pongr´acz, R., Bartholy, J., Gelyb´o, G., & Szab´o, P. (2009). Detected and Expected Trends of Extreme Climate Indices for the Carpathian Basin. Bioclimatology and Natural Hazards. Springer Science + Business Media B.V.2009. Retrieved from http://download.e-bookshelf.de/download/0000/0049/23/L-G-0000004923-0002333822

Qara, F. R. (2008). Auswirkung von Klimaänderungen auf hydrometeorologisch relevante Parameter. Dissertation, Agrar- und Umweltwissenschaftlichen Fakultät Universität Rostock. Germany.P1.

Report of The Arab Forum For Environment And Development (AFED 2008 & 2009). Arab Environment Climate Change: Impact of Climate Change on Arab Countries. Retrieved from http://www.afedonline.org/afedreport09/Full%20English%20Report.pdf

Copyrights