

Expert Workshop on Developing the Capacities of
the Health Sector for Climate Change Adaptation
to Protect Health from the Climate Change Effects
on Freshwater Resources
Amman, 19-21 April 2016



Climatic Parameters Variability & Climate Change in Lebanon

Jalal HALWANI

Lebanese University, Public Health Faculty

Director of Water & Environment Science Laboratory

Head of Health & Environment Department

Tripoli, Lebanon



الجامعة اللبنانية
UNIVERSITE LIBANAISE

Short Description



To assess climatic variability and climate change in Lebanon, the climatic parameters (precipitation and minimal and maximal temperature) were studied, through registered data at Beirut International Airport, of the four principal meteorological stations in Lebanon: Tripoli, Beirut, Cedars and Rayak from 1930 to 2010 (were available).

CLIMATIC CHARACTERISTICS OF LEBANON

- Lebanon is located on the eastern coast of the Mediterranean Sea.
- The Mediterranean Climate is characterized by mild rainy winters and hot dry summers.
- A Mediterranean climate benefits from the dampening effect of the sea.
- In winter the sea temperature is higher than the air temperature, and the sea thus warms up the air masses which are then blown over the coastal regions.
- In summer the sea temperature is lower than the air temperature, and the cool breeze from the sea contributes to the reduction of the coastal temperatures.

Topographic characteristics of Lebanon

- Lebanon's topography can be divided into three features, a coastal strip, mountain ranges, and an inland plateau.
- The Western mountain range plays a key influencing role on the climatic pattern of the inland plateau.
- While the climatic pattern of the western side of the Western mountain range exhibits Maritime characteristics, the climatic pattern of the eastern side of the Western mountain range exhibits Continental characteristics.
- Continental climates are typically marked by large annual or daily temperature amplitudes, low relative humidity, and moderate to low rainfall.

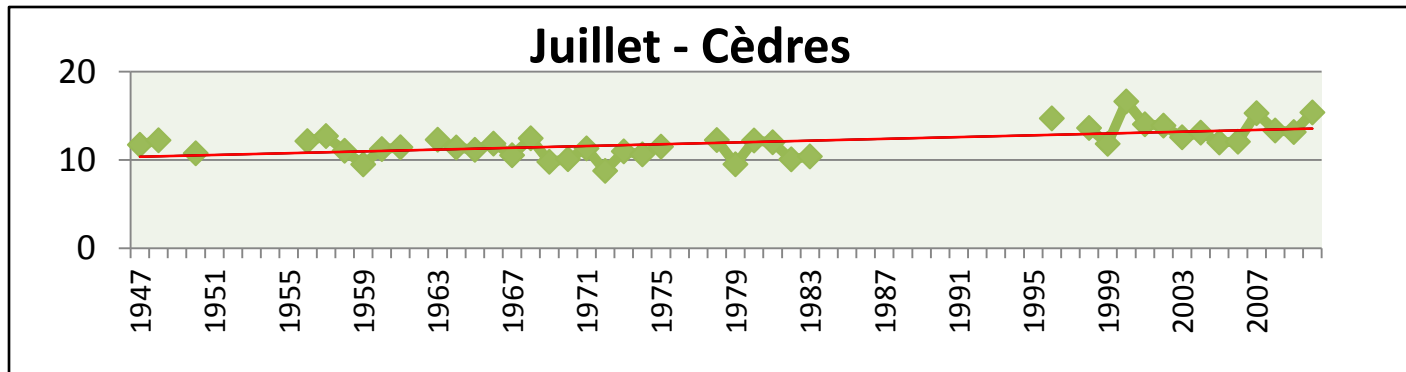
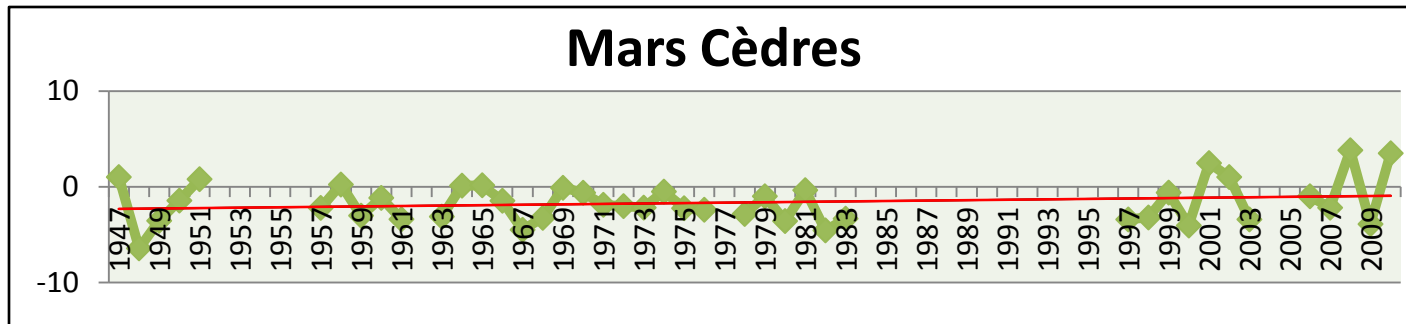
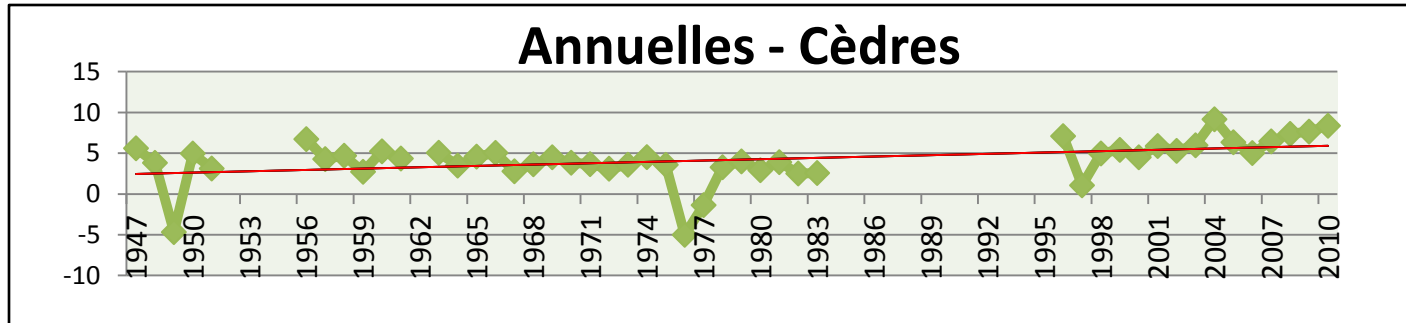


STUDY APPROACH

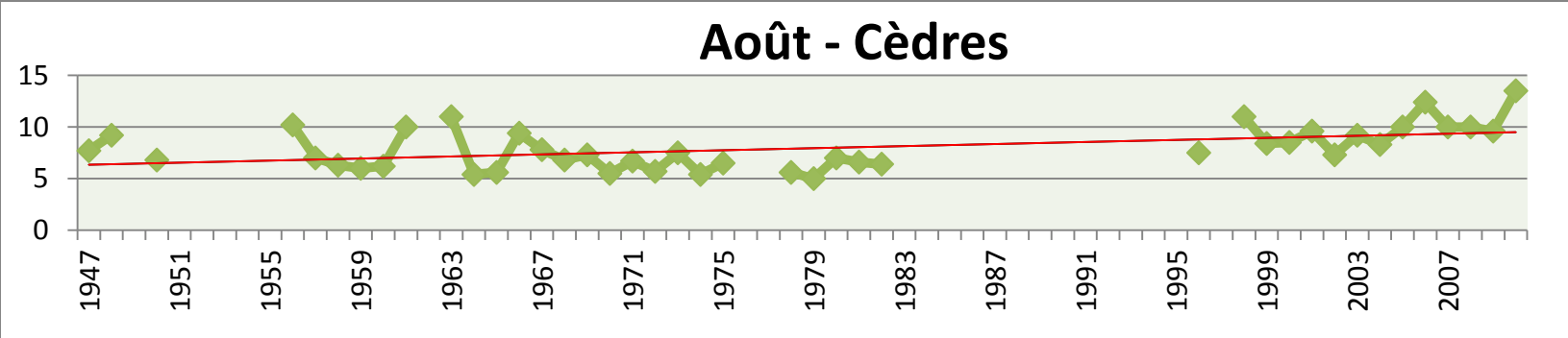
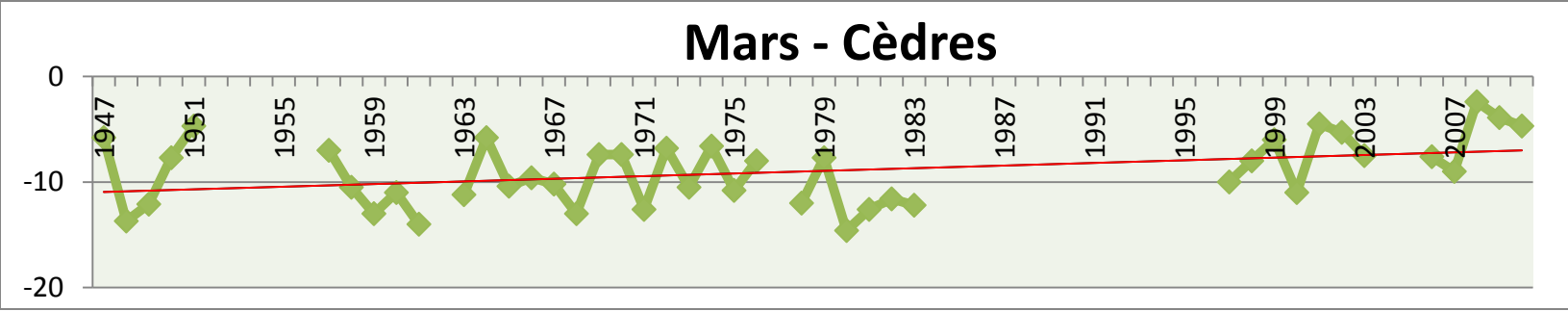
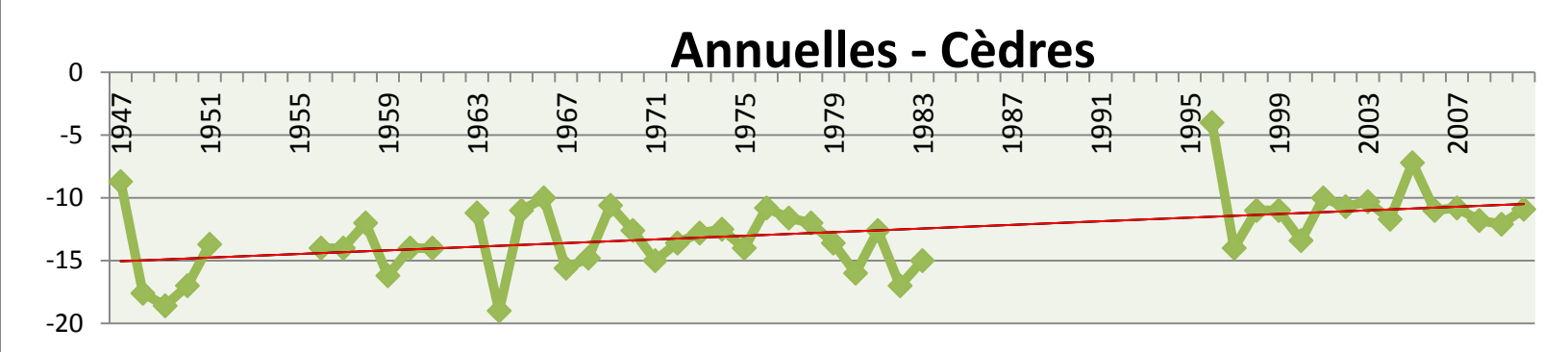
- Through statistical analysis, and based on authentic numeric records collected from the department of Meteorology at Beirut International Airport, the day-to-day minimal and maximal temperatures and rainfall records recorded in four different meteorological stations, represent the general geographical aspect of Lebanon: Beirut and Tripoli stations are coastal cities located respectively in the middle and in the North of the coast of Lebanon. Cedars is a mountainous region and Rayak is considered internal.

A- Temperatures Analysis

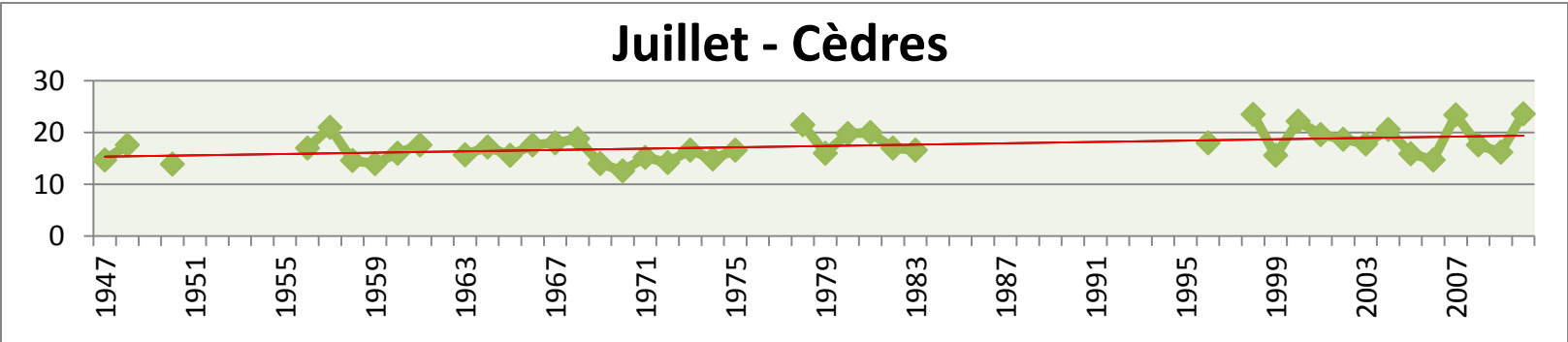
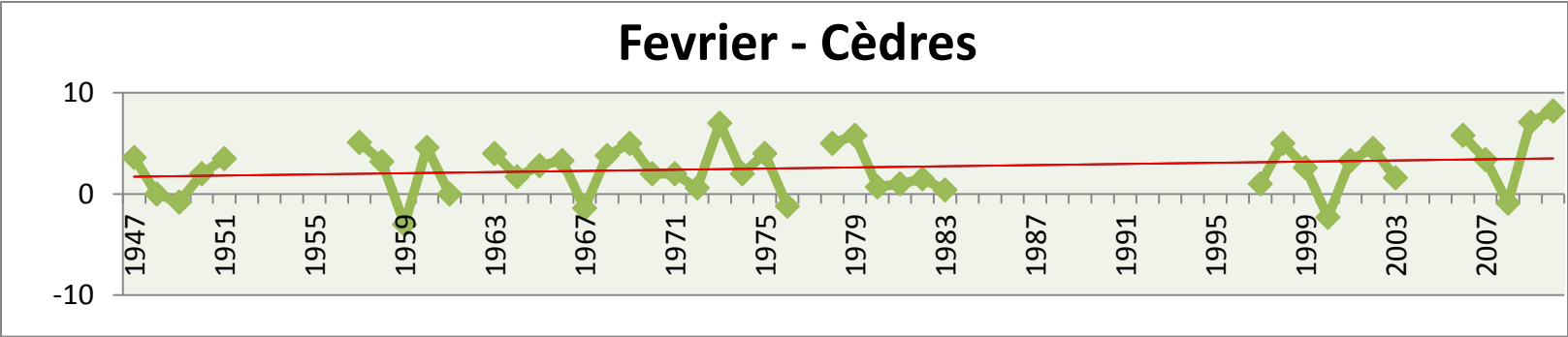
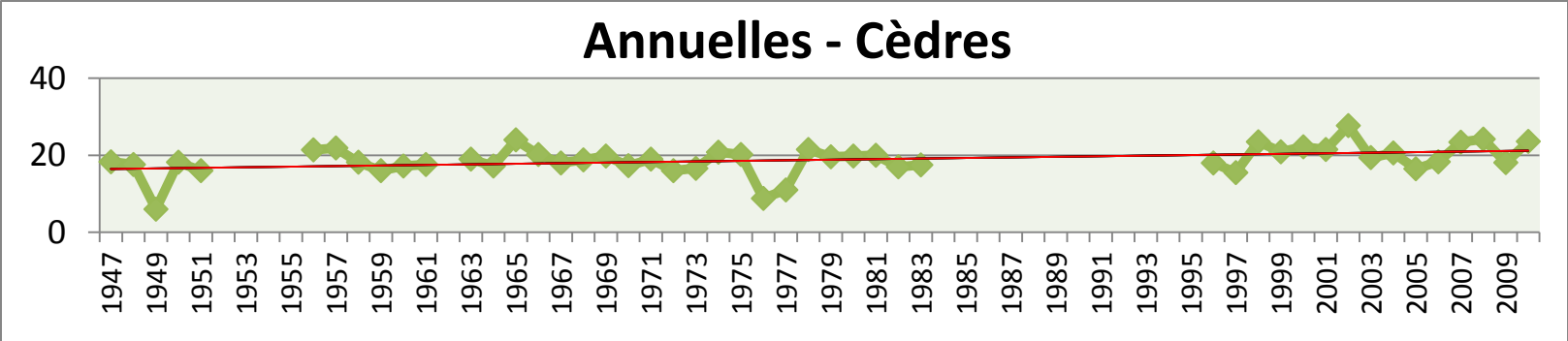
1- Average TTmin

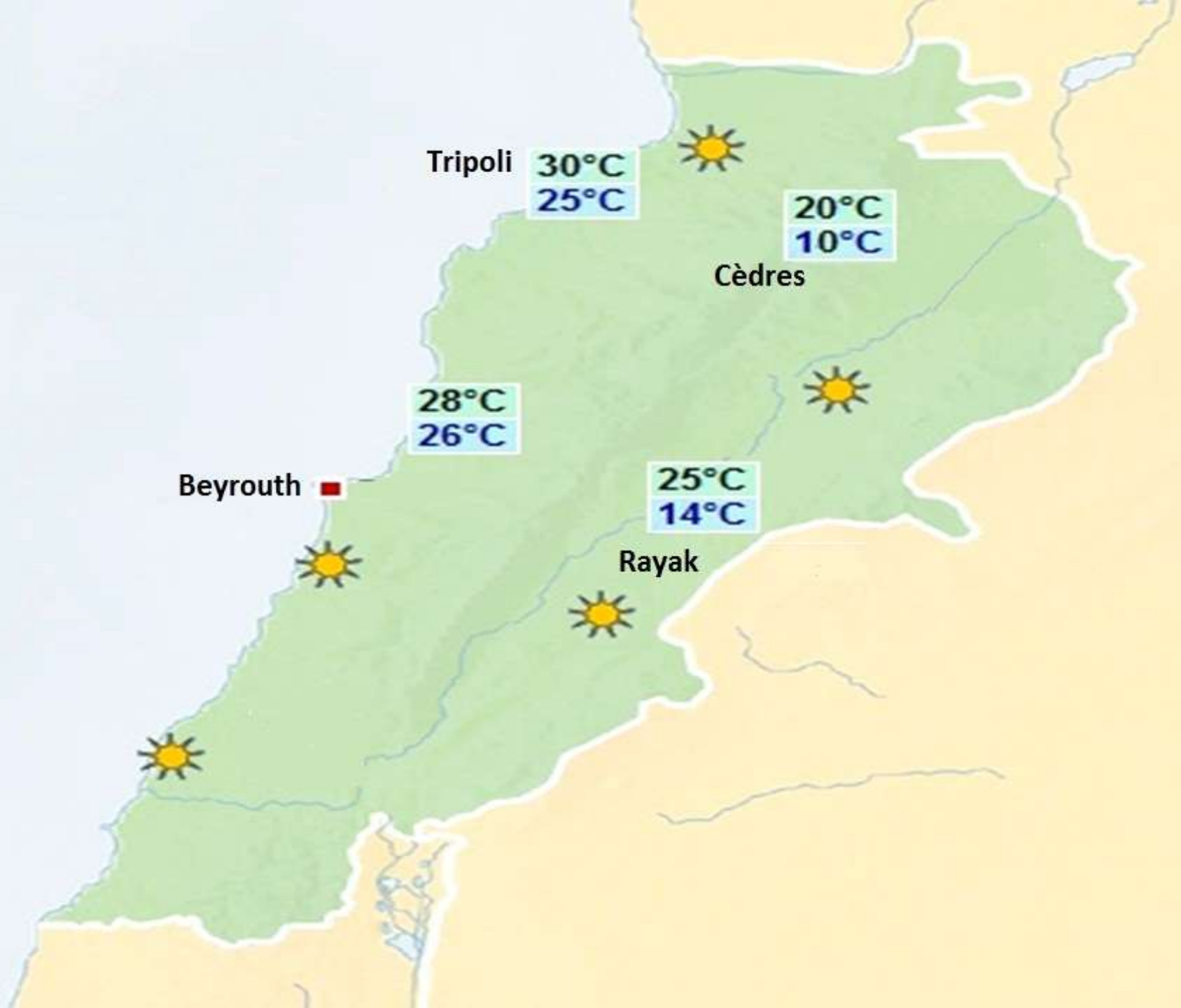


2- Min de TTmin



3- Max de T_{Tmin}





Tripoli
30°C
25°C

20°C
10°C

Cèdres

28°C
26°C

Beyrouth

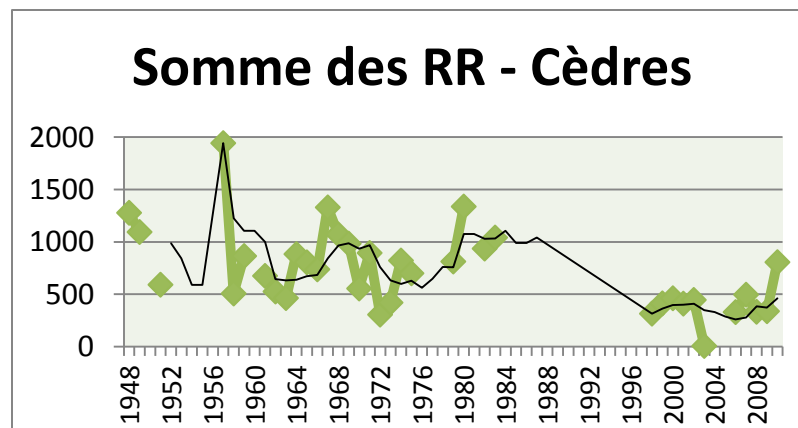
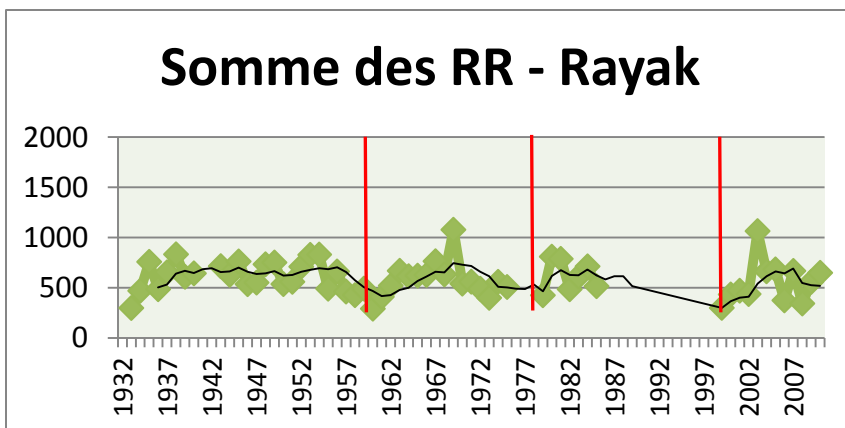
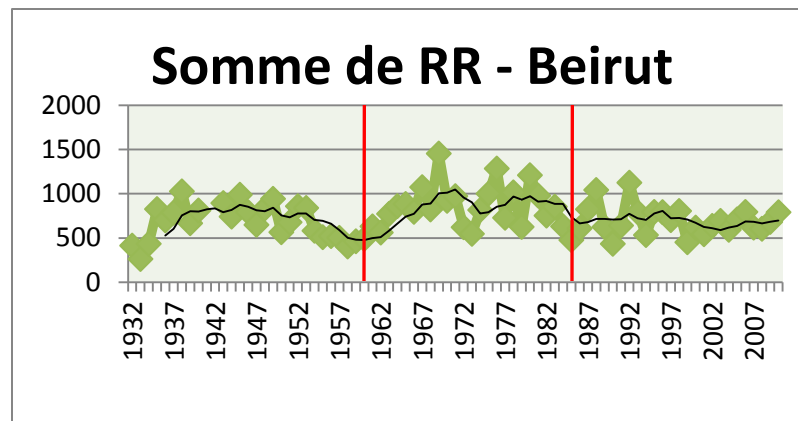
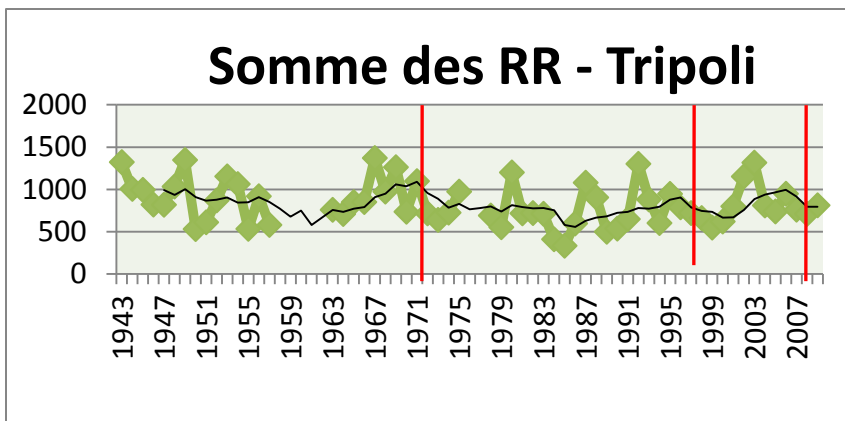
25°C
14°C

Rayak

B- RAINFALL

1- Fonction statistiques:

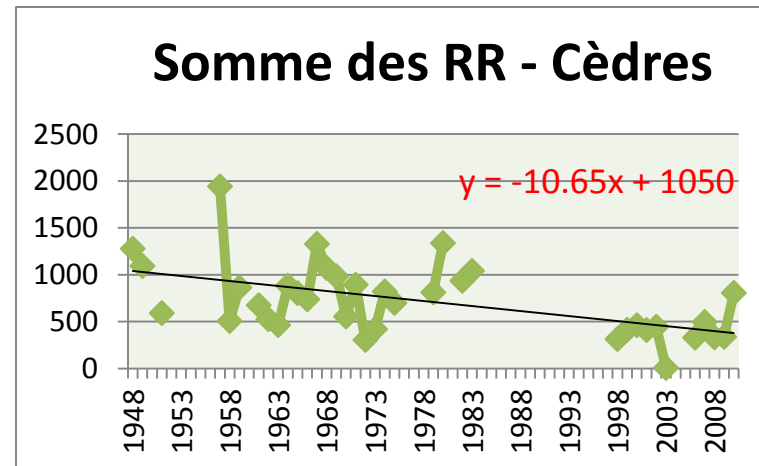
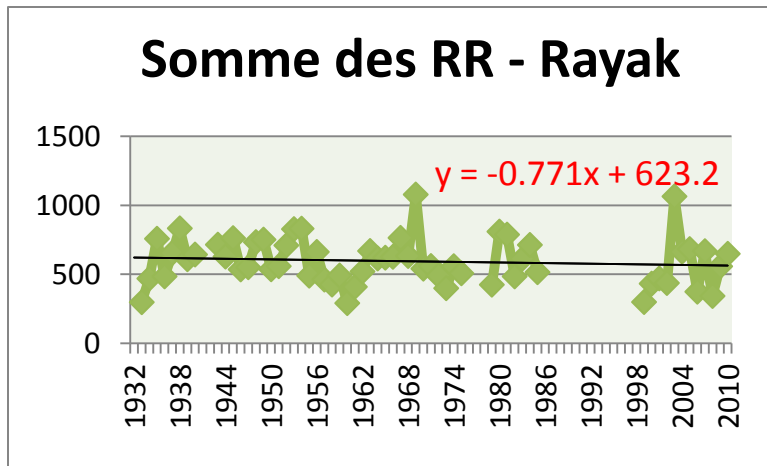
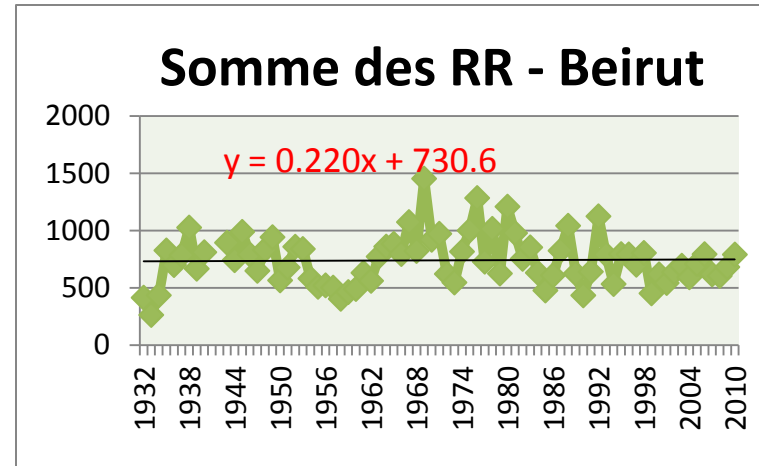
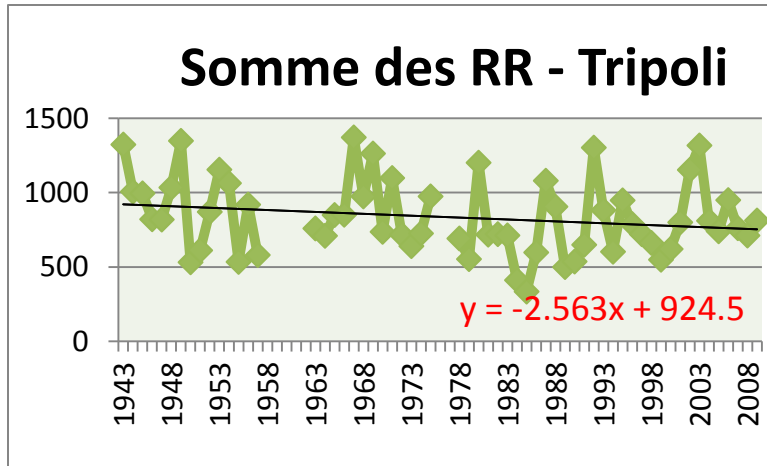
■ *Fonction "Moving Average"*



Annual distribution of Rainfall

1- Fonction statistiques:

■ *Fonction "Trendline"*



2- Percentage years RR which are lower than the average, according to periods of 10, 15,20 and 25 years:

	1930-1940	1940-1950	1950-1960	1960-1970	1970-1980	1980-1990	1990-2000	2000-2010
Tripoli	-	42.86	85.71	42.86	75.00	60	70	44.44
Beyrouth	50	66.67	80	30	30	50	60	90
Rayak	42.86	22.22	60	30	100	33.33	-	60.00
Cèdres	-	-	-	33.33	57.14	-	-	88.89

	1935-1950	1950-1965	1965-1980	1980-1995	1995-2010
Tripoli	–	60	46.15	66.67	75.00
Beyrouth	30.77	73.3	26.67	53.33	68.75
Rayak	23.08	60	58.33	–	58.33
Cèdres	–	62.5	33.33	–	90.91

	1930-1950	1950-1970	1970-1990	1990-2010
Tripoli	42.86	64.29	66.67	57.89
Beyrouth	54.55	55.00	40	75.00
Rayak	31.25	45.00	69.23	70
Cèdres	–	55.56	57.14	88.89

	1935-1960	1960-1985	1985-2010
Tripoli	–	60	69.23
Beyrouth	56.52	40	65.38
Rayak	–	–	–
Cèdres	–	–	–

Monthly distribution of Rainfall

statistical functions:

Linear Trendline:

It was noted that for months there where RR diminish or even remain constant. And likewise, increased RR appears in several months and all stations.

In the years 2007, 2008 and 2009, and only in Rayak and the Cedars, the dry months of low or RR (April © September) are a high rainfall.

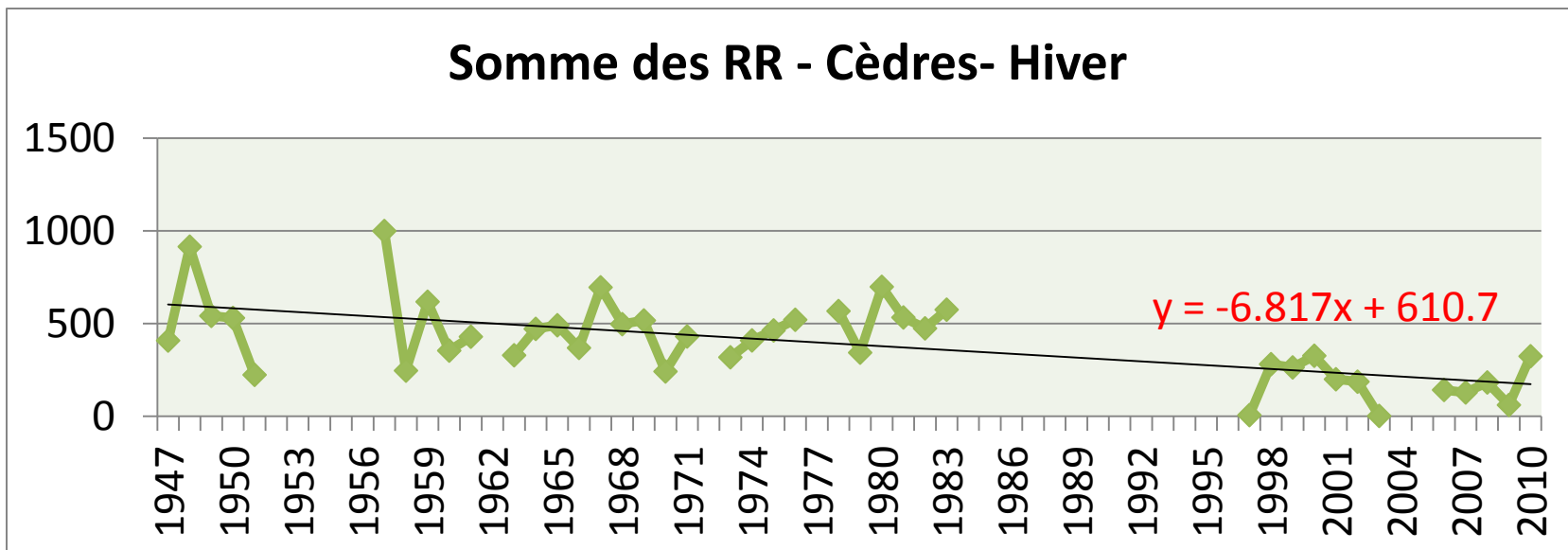
Seasonal distribution of Rainfall

1- Applying the "Linear Trendline"

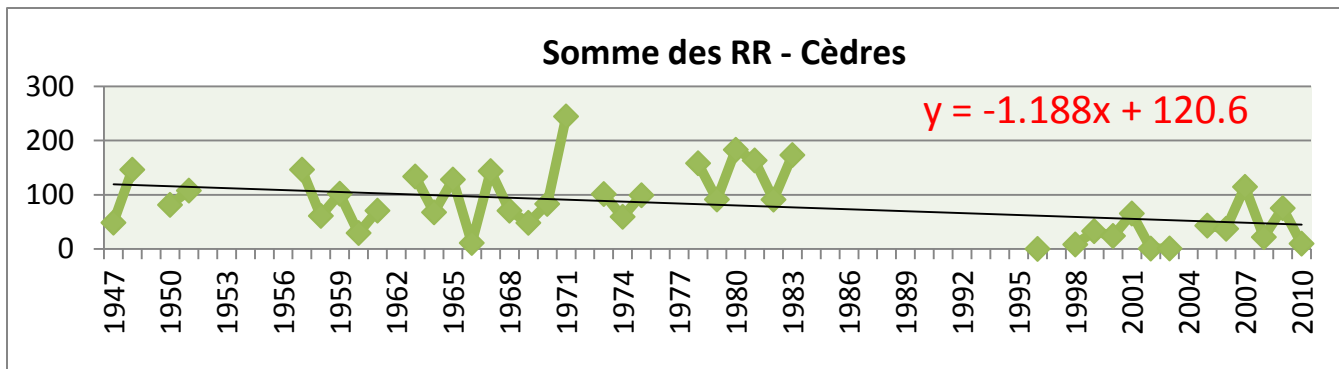
near-constant movement (slope of the equation ≈ 0) at
Tripoli, Beirut and Rayak: All stations / All seasons

Cedar

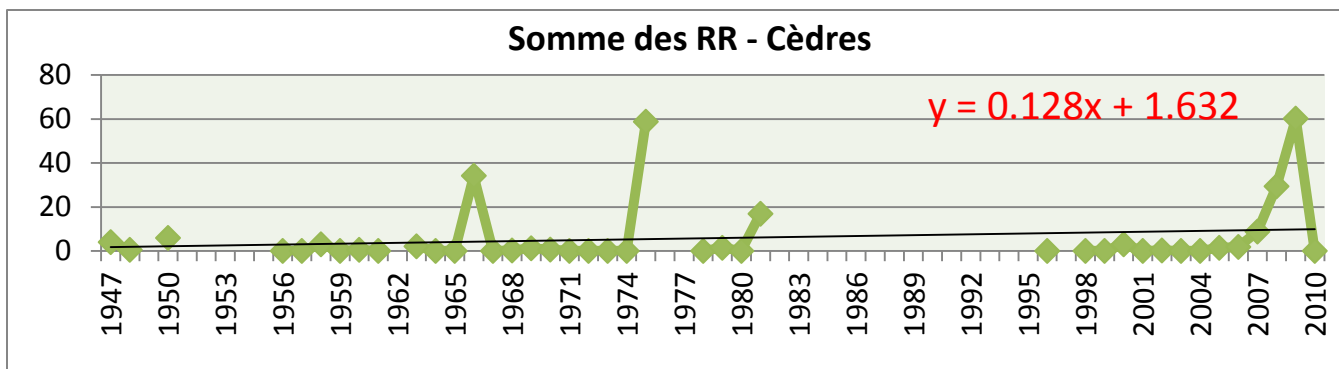
a- Winter:



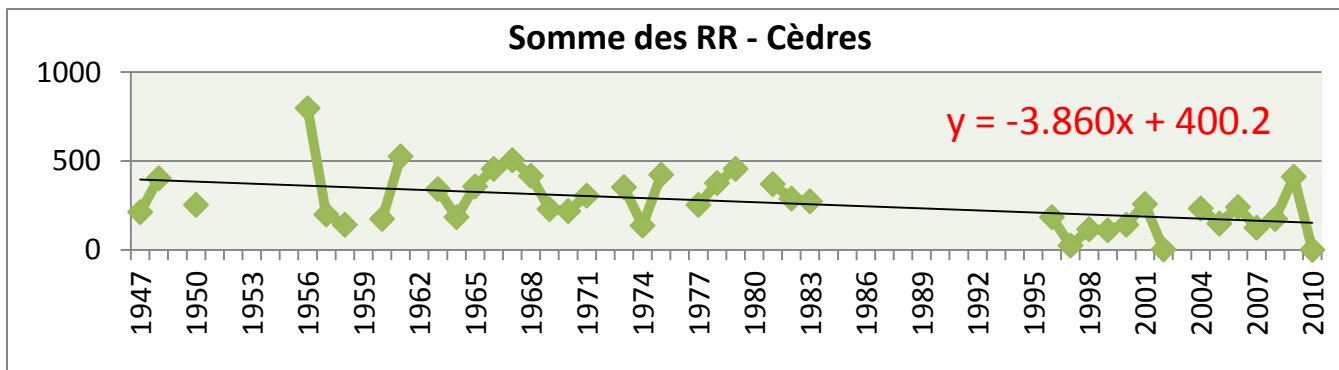
b- Printemps:



c- Eté



d- Automne



2- extreme years (Winter and Spring):

HIVER	% de la majorité des années	Intervalles	% des années extrêmes	Intervalles	Années extrêmes
Tripoli	96.88%	[100-750[	3.12%	[800-900[	1953 - 2003
Beyrouth	96.10%	[200-675 [	2.6% 3%	[150-175[[900-625[	1933 – 1958 1969
Rayak	96.88%	[150-575[	1.56% 1.56%	[600-625[[700-725[	1953 2003
Cèdres	87.8%	[100-950 [	4.88% 2.44% 4.88%	[0-50[[50-100[[900-1000[	2003-1997 2009 1948 - 1957

PRINTEMPS	% de la majorité des années	Intervalles	% des années extrêmes	Intervalles	Années extrêmes
Tripoli	98.08%	[0-200[	1.92%	[260-280[	1971
Beyrouth	94.81%	[10-190[	2.6% 1.3% 1.3%	[0-10[[260-270[[330-340[	2002-2004 1971 1976
Rayak	96.83%	[0-130[	1.59% 1.59%	[170-180[[200-210[	1971 2007
Cèdres	97.5%	[20-200[	2.5%	[240-260[	1971

2- extreme years (Summer and Fall):

ETÉ	% de la majorité des années	Intervalles	% des années extrêmes	Intervalles	Années extrêmes
Tripoli	90.08%	[0-40[	1.96%	[70-80[	2009
			1.96%	[160-170[	1966
Beyrouth	96.10%	[0-15[	1.30%	[30-35[	1959
			1.30%	[50-55[	1976
			1.30%	[65-70[	2009
Rayak	96.88%	[0-7[	3.12%	[16-18[	2007
					2009
Cèdres	95%	[0-40[	5%	[55-65[	1975-2009

AUTOMNE	% de la majorité des années	Intervalles	% des années extrêmes	Intervalles	Années extrêmes
Tripoli	94.23%	[90-600[	3.85%	[0-30[	1975 – 1977
			1.92%	[630-660[	1994
Beyrouth	93.51%	[80-440[	1.30%	[0-20[	2002
			1.30%	[60-80[	1998
			3.90%	[440-500[	1987 – 1991 - 1994
Rayak	96.88%	[30-390[	1.56%	[0-30[	1941
			1.56%	[480-510[	1968
Cèdres	90%	[100-550[	7.5%	[0-50[	2010 – 2002 - 1997
			2.5%	[750-800[	1956

Seasonal distribution of several parameters

3. Comparison between different periods of years:

In order to compare the last period to the other, a study was conducted as follows:

A calculation of the following variables was performed each season for each station:

Min and Max TT TT min and max

TT Average min and max

average general TT

RR sum



Standards values of each parameter at the 4 Seasons in Tripoli:

TRIPOLI	Max de TT max	Min de TT max	Moyenne de TT max	Max de TT min	Min de TT min	Moyenne TT min	TT moyenne	Somme de RR
Hiver	26.59	10.00	17.41	15.98	2.98	9.53	13.47	430.16
Printemps	33.65	16.94	24.31	23.29	8.74	16.34	20.32	68.09
Été	33.32	26.75	29.51	26.09	17.96	21.91	25.71	11.62
Automne	31.70	12.71	22.43	22.78	5.26	14.02	18.23	332.59

3. Comparison between different periods of years:

Then there is provided a calculation of the percentage of years having values

lower than standard:

TT: Percentage  => number of hot Years 

RR: Percentage  => number of low RR Years 

	Max TTmax	Min de TT max	Moyenne TTmax	Max TTmin	Min TTmin	Moyenne TT min	T moyenne	Somme RR
1932-1944	41.67	66.67	50.00	57.14	71.43	57.14	66.67	58.33
1945-1957	61.54	61.54	69.23	84.62	38.46	53.85	53.85	38.46
1958-1970	61.54	53.85	53.85	66.67	50.00	41.67	38.46	61.54
1971-1985	46.15	69.23	61.54	61.54	38.46	69.23	69.23	53.85
1998-2010	38.46	23.08	23.08	30.77	15.38	30.77	23.08	69.23

3. Comparison between different periods of years:
b- Spring (Beirut)

Printemps - Beyrouth	Max de TT max	Min de TT max	AVG de max	Max de TT min	Min de TT min	AVG de TT min	TT moyenne	Somme de RR
1933-1944	54.5	36.4	45.5	18.2	27.3	27.3	27.3	72.7
1945-1955	36.4	45.5	54.5	45.5	36.6	81.8	63.6	72.7
1956-1966	36.4	36.4	36.4	63.6	36.4	81.8	72.7	63.6
1967-1977	45.5	54.5	60	72.7	81.8	100	100	18.2
1978-1988	36.4	27.3	45.5	45.5	45.5	63.6	63.6	63.6
1989-1999	45.5	72.7	54.5	36.4	36.4	18.2	27.3	54.5
2000-2010	27.3	18.2	18.2	0	27.3	0	0	81.8

c- Eté (Tripoli)

Eté Tripoli	Max de TT max	Min de TT max	AVG de max	Max de TT min	Min de TT min	AVG de TT min	TT moyenne	Somme de RR
1942-1953	58.33	41.67	50.00	33.33	41.67	66.67	66.67	58.33
1954-1969	91.67	50.00	58.33	41.67	58.33	66.67	66.67	75.00
1971-1970	90.91	81.82	90.91	90.91	9.09	54.55	90.91	90.91
1985-1997	-	-	-	-	-	-	-	-
1998-2010	25.00	8.33	0.00	25.00	41.67	8.33	0.00	83.33

3. Comparison between different periods of years:

d- Fall (Beirut)

Automne Beyrouth	Max de TT max	Min de TT max	AVG de max	Max de TT min	Min de TT min	AVG de TT min	TT moyenne	Somme de RR
1933-1944	36.4	18.2	45.5	36.4	0	54.5	54.5	90.9
1945-1955	18.2	18.2	54.5	36.4	27.3	54.5	54.5	72.7
1956-1966	54.5	9.1	45.5	27.3	54.5	81.8	72.7	54.5
1967-1977	54.5	18.2	90	72.7	72.7	100	100	72.7
1978-1988	45.5	18.2	27.3	27.3	45.5	54.5	54.5	90.9
1989-1999	27.3	0	27.3	18.2	9.1	0	9.1	81.8
2000-2010	20	0	0	0	10	0	0	90

Climat Classification

Modern climate classification is based on parameters calculable climate (temperature, humidity, etc.)

⇒ Martonne index « I »

$$I = \frac{P}{T + 10}$$

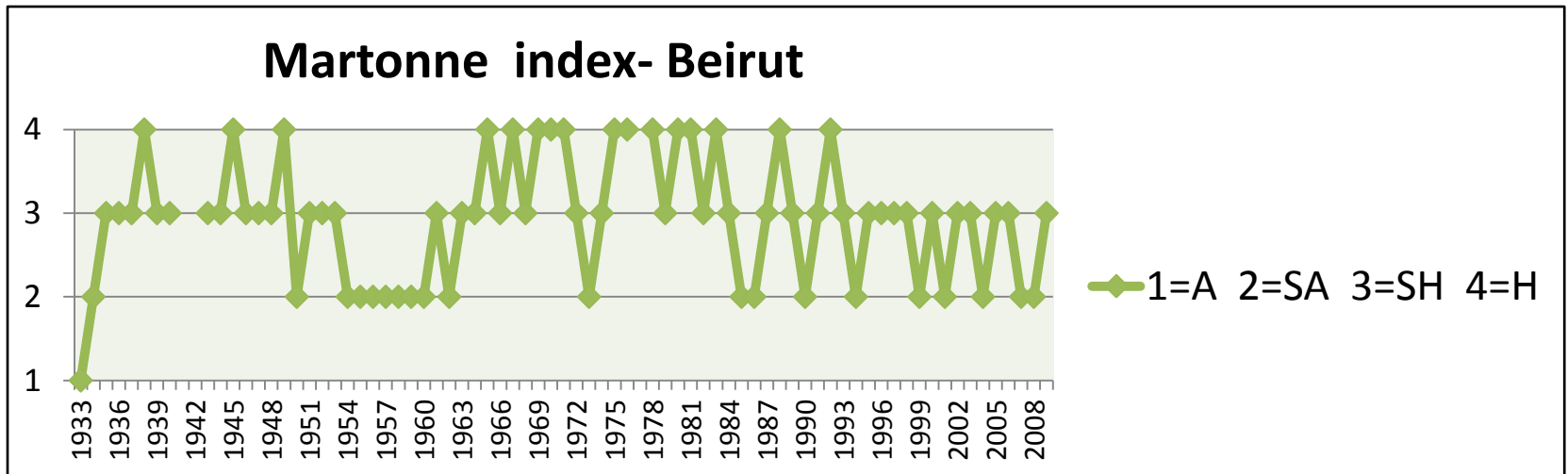
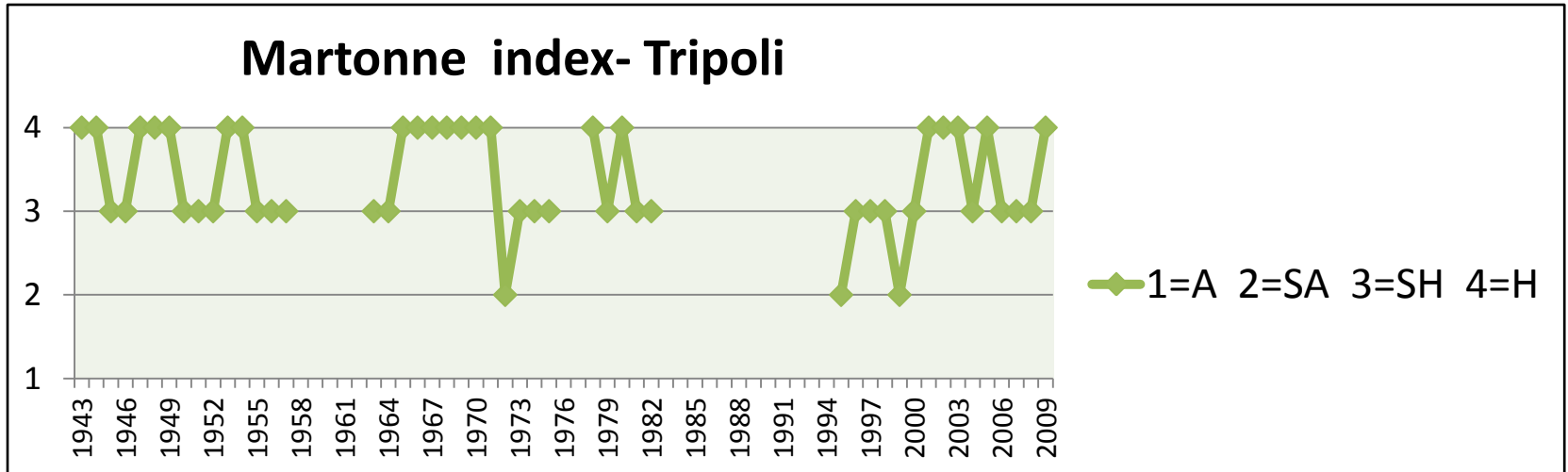
Where

P = total annual rainfall

T = Average annual temperature

I	Régions
[0 ; 5[	Hyperaride (H)
[5 ; 10[	Aride (A)
[10 ; 20[	Semi-Aride(SA)
[20 ; 30[	Semi-Humide(SH)
[30 ; 55[	Humides (H)

Climat Classification



Climate classification

% aridity over different periods

Tripoli

	A	SA	SH	H
1943-1957	0	0	53.33	46.67
1963-1982	0	5.56	44.44	50
1995-2009	0	13.33	53.33	33.33

Cedars

	A	SA	SH	H
1947-1964	0	0	33.33	66.67
1965-1974	0	0	22.22	77.78
1978-2001	0	22.22	11.11	66.67

Beirut

	A	SA	SH	H
1933-1946	8.33	8.33	66.67	16.67
1947-1958	0	50	41.67	8.33
1959-1970	0	25	41.67	33.33
1971-1983	0	8.33	33.33	58.33
1984-1995	0	33.33	50	16.67
1996-2009	0	35.71	64.29	0

Rayak

	A	SA	SH	H
1932-1944	0	25	41.67	33.33
1945-1957	0	0	84.62	15.38
1958-1970	0	23.08	46.15	30.77
1971-1985	0	15.38	69.23	15.38
1998-2010	0	46.15	38.46	15.38

RESULTS

Over the past two decades in Lebanon, there was the following:

Cedars:

The Average, Min and Max TT min and max are much higher than the average of the past years, reaching an increase of 3.9 ° C in August

The annual amount of precipitation is greatly diminished, but increased in summer and during the dry months supposed especially in 2007, 2008 and 2009.

Tripoli:

- The Average, Min and Max TT min are almost constant. But the average annual TT max increased by 1.8 ° C, and especially in July (2.5 ° C). In addition, the Min and Max TT max amounted in March, April, June, July and October.
- The annual amount of precipitation tends to decrease slightly, especially in the months of January, April and May, and the season Winter and Spring.

Rayak:

- Average annual TT min and max increased by > 1 ° C, and reaching 1.9 ° C in August The Min and Max are almost invariant, except for the months of January, February and March.
- The annual amount of precipitation tends to decrease slightly. In winter it reduces the most, but in Summer, 2 exceptional and high values were recorded (2007 and 2009).

Beirut:

- The Average Annual TR min increased by 2.3°C compared to 60 and 70, and almost 1°C from years 30, 40 and 50.
- Very high values are recorded especially in the month of summer, where the increase reached 3.9°C in August The Min and Max TT TT min and max remained almost stable and the average annual TT max. The annual amount of precipitation is constant.
- However, it increased slightly in September and October; In spring, the sum decreases, and recorded in summer high outstanding value of 65 mm in 2009.

Conclusion

- Over the two decades, the minimal and maximal temperatures in Lebanon have undergone unusual changes, which were reflected by high values of the average, the minimum and the maximum.
- we noticed that a close elevation has already been detected in the average of the minimal and maximal temperatures in all stations.
- Certainly, the elevation of the temperature and the fluctuation of the precipitation predict an anxious environmental future, where the climate is changing. Lebanon is already influenced by the global climate change particularly on water resources.



Thanks for your Attention

