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METEOROLOGICAL CONDITIONS AND THE RATE OF EVAPORATION OVER EGYPT

By

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ABSTRACT

Egypt extends across some 10 degrees of Latitudes (22°-32° N) and 9 degrees of Longitudes (25° -34° E). In the present paper the meteorological conditions and rate of evaporation, for at least one-sunspot activity cycle, over different regions of Egypt were studied. The air mass is cool in Winter, while it is warm Summer. Lower air temperature is in Delta, while higher value is over Red Sea coast and West Desert. The pressure oscillation over Egypt has very small amplitude. It is relative low in Summer and high in Winter. It is high in north decreases southward. The wind field varies from place to another, and also with time. The northerly currents are strong affect, especially on Mediterranean Sea coast. The southerly currents are high affect on the most areas, except northern region. In late Spring and Summer the winds reach their main peaks, while the low winds are in Winter except northern region. The lower wind speeds are at Delta and West Desert, while its higher speeds are in Red Sea coast. The higher air humidity is in Winter, while its lower value is in Spring. Relative humidity is high in northern region and Delta while it is low in West Desert and south extreme of Wadi El-Nile. The rate of evaporation is low in Winter, while it is high in Summer. The lower rate of evaporation is in Delta, while its higher values are in Red Sea coast. The value of mean annual evaporation over Egypt is relatively agreement with evaporation estimations of Ocean Atlas.

INTRODUCTION

Egypt (fig., 1) occupies the northeastern corner of Africa (Mediterranean Sea in the north, Red Sea in east and desert in south and west), with an area of about one million km^2, 3% of the total area of Africa (Zahran and Mashaly, 2000). It located between Latitudes (22°-32° N) and Longitudes (25° -34° E). Egypt may be categorized into five major zones, Mediterranean Sea coast (Northern region), Red Sea coast (Eastern region), Delta, Wadi El-Nile, and West Desert (Williams, 1984, and Zahran & Mashaly,

2000). Egypt contains, in addition to the Mediterranean -and Red Seas, water basins as River Nile and some Lakes; Maryut, Idku, Burullus, Manzalah and Bardawil (known as the northern Egyptian Lakes), Qarun & Wadi El-Rayan (in Fayoum Depression), and Nasser Lake in the extreme south.

Much literatures (Mehanna, 1976; Maiyza, 1988; Maiyza et al, 1988; El-Bakry, 1993; Said, 1993; Abd Ellah, 1995, 1999 and 2003; Eissa and Hamada, 2000; El-Asrag et al, 2000, Zahran and Mashaly, 2000 & Eissa and Elhelow, 2003), has reported on the concept of climate and evaporation in one year calendar. The aim of the present paper is to throw light on the meteorological conditions and estimate the rate of evaporation, for at least one-sunspot activity cycle (11 years), over different regions of Egypt in order to overcome the inter-annual variability.

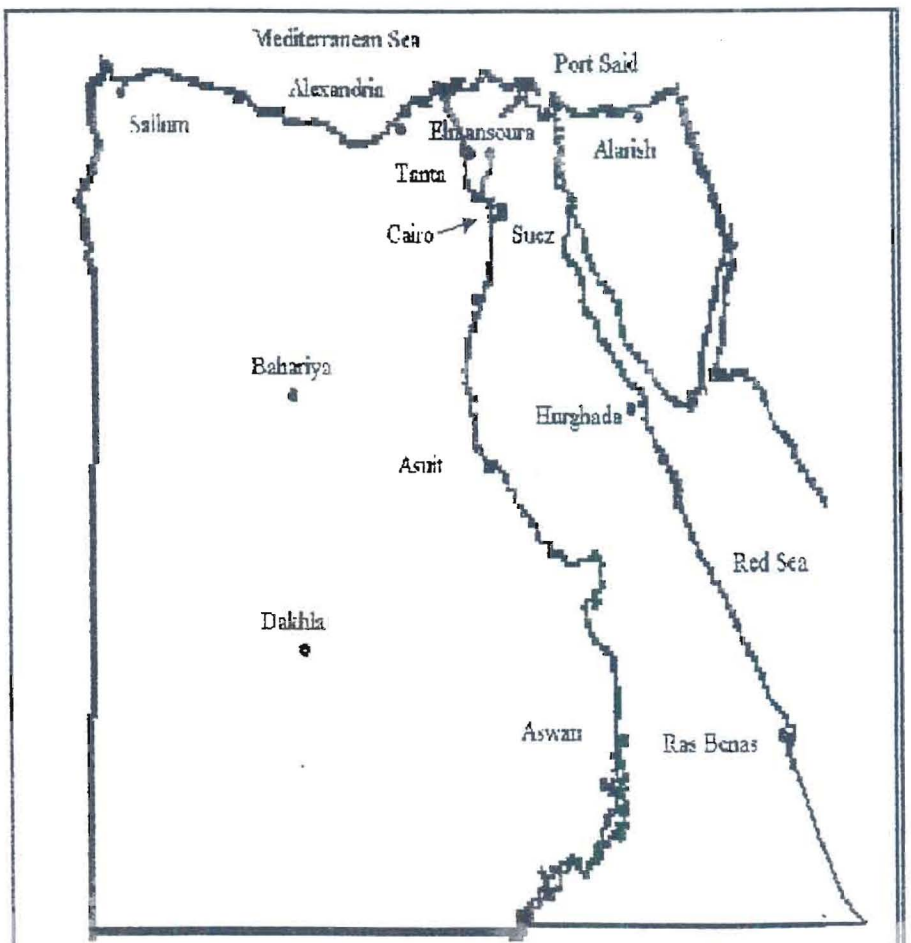


Figure (1) Weather Stations location in Egypt

DATA AND METHODOLOGY

During last 40 year Egyptian Meteorological Authority (EMA) created large group of classical and modern weather stations to cover Egypt. The present study is based on available data (fourteen EMA weather stations), average at least of 15 year. Sallum, Alexandria, Port Said and Alarish represented Northern region (Mediterranean Sea coast). Suez, Hurghada and Ras Benas represented Eastern region (Red Sea coast). Tanta and Elmansoura represented Delta. Cairo, Asuit and Aswan represented Wadi El-Nile. Dakhla and Baharia represented West Desert. The recording parameters are; Air temperature, Air pressure, Wind speed and direction, and Relative humidity.

Evaporation equation was developed by: Sverdrup (1937), Millar (1937), Narris (1948), Suttan (1940), Marciano and Harbock (1954) and Meshal and Morcos (1984). In the present study the rate of evaporation of Egypt was estimated using the formula:

$E = AU (e_o - e_a)$

Where

E: the rate of evaporation (in cm/day)

A: the evaporation coefficient, factor depend on the elements of weather.

In Egypt it ranges between 10.5 $x10^{-3}$ and 12.0 $x10^{-3}$, with average of 11.0 $x10^{-3}$ (Roden, 1959 and Abd Ellah, 2003).

U: the wind velocity (in m/s)

e_o: the saturation vapor pressure (in mb)

e_a: the vapor pressure at high a (in mb)

RESULTS

Air temperature (figs.2) over the coast of the Mediterranean Sea was (13.5-27.3°C) and Red Sea coast (14.7-32.1 °C). Above Delta, air temperature was (11.9-26.2 °C), Wadi El-Nile (13.2-33.5 °C) and West Desert (12-30.9 °C).

Egypt profiles of pressure are presented in figure (3). Over Mediterranean Sea coast, the air pressure was (1007.5-1017.9mb) and Red Sea coast (1003.7-1018.5mb). Above Delta air pressure was (1008.4-1019.9mb), Wadi El-Nile (1005-1018.4mb) and West Desert (1007.7- 1019.1mb).

Over Egypt the prevailing wind varied from place to another (tab., 1). Its direction was; over Mediterranean Sea coast (N, NNW, WNW, SSE), Red Sea coast (N, NNW, WNW), Delta (N, NNW, NNE, WNW), Wadi El-Nile (NNE, ENE, N, NNW, WNW, W) and West Desert (N, NNE, WNW, NNW). The wind speed (figs. 4) over Mediterranean Sea coast was (0.92-5.65m/s) and Red Sea coast (2.95-7.15m/s). Above Delta wind speed was (1.9- 3.55 m/s), Wadi El-Nile (3.05-4.65m/s) and West Desert (1.7-2.46m/s).

The relative humidity (figs., 5) over Mediterranean Sea coast was (54-75 %) and Red Sea coast (28-59%). Above Delta the relative humidity was (53-74%), Wadi El-Nile (13-61%) and West Desert (19-51%).

The rate of evaporation (figs., 6) over Mediterranean Sea coast was (0.92-4.49 mm/day) and Red Sea coast (1.82-18.87mm/day). Above Delta the rate of evaporation was (0.83-3.90mm/day), Wadi El-Nile (1.99-16.46mm/day) and West Desert (1.25-9.09mm/day).

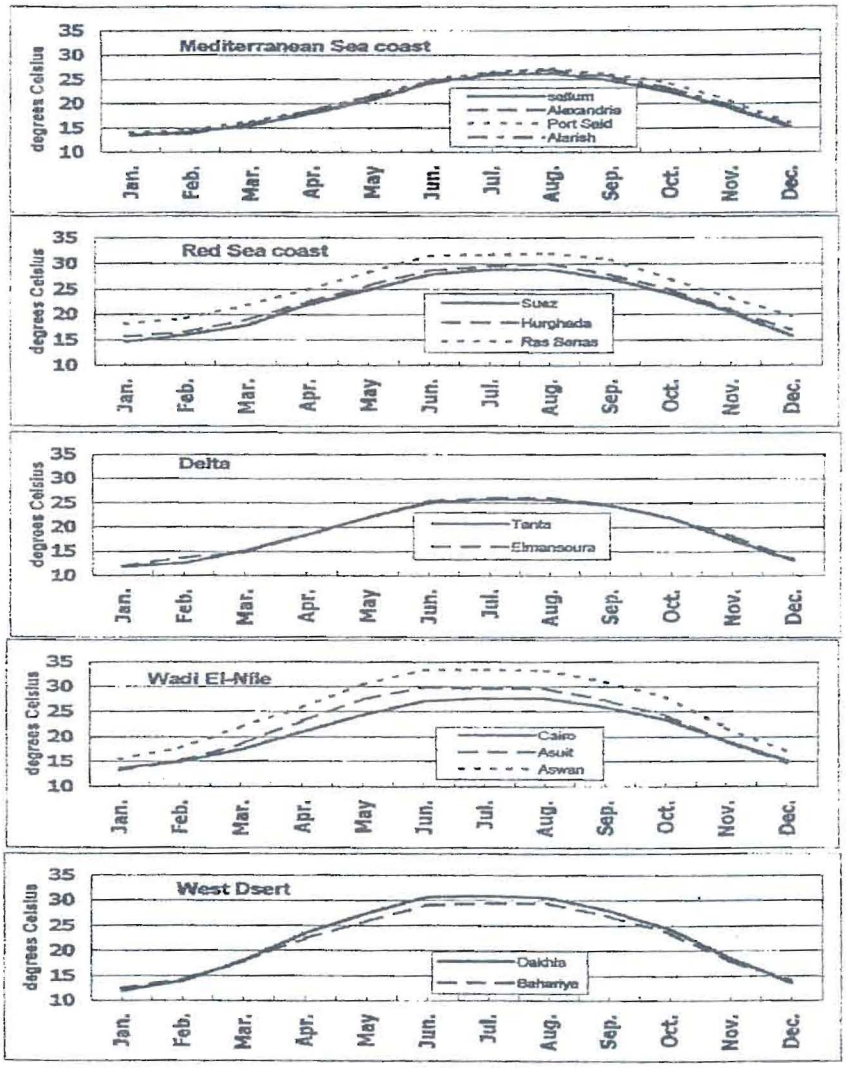
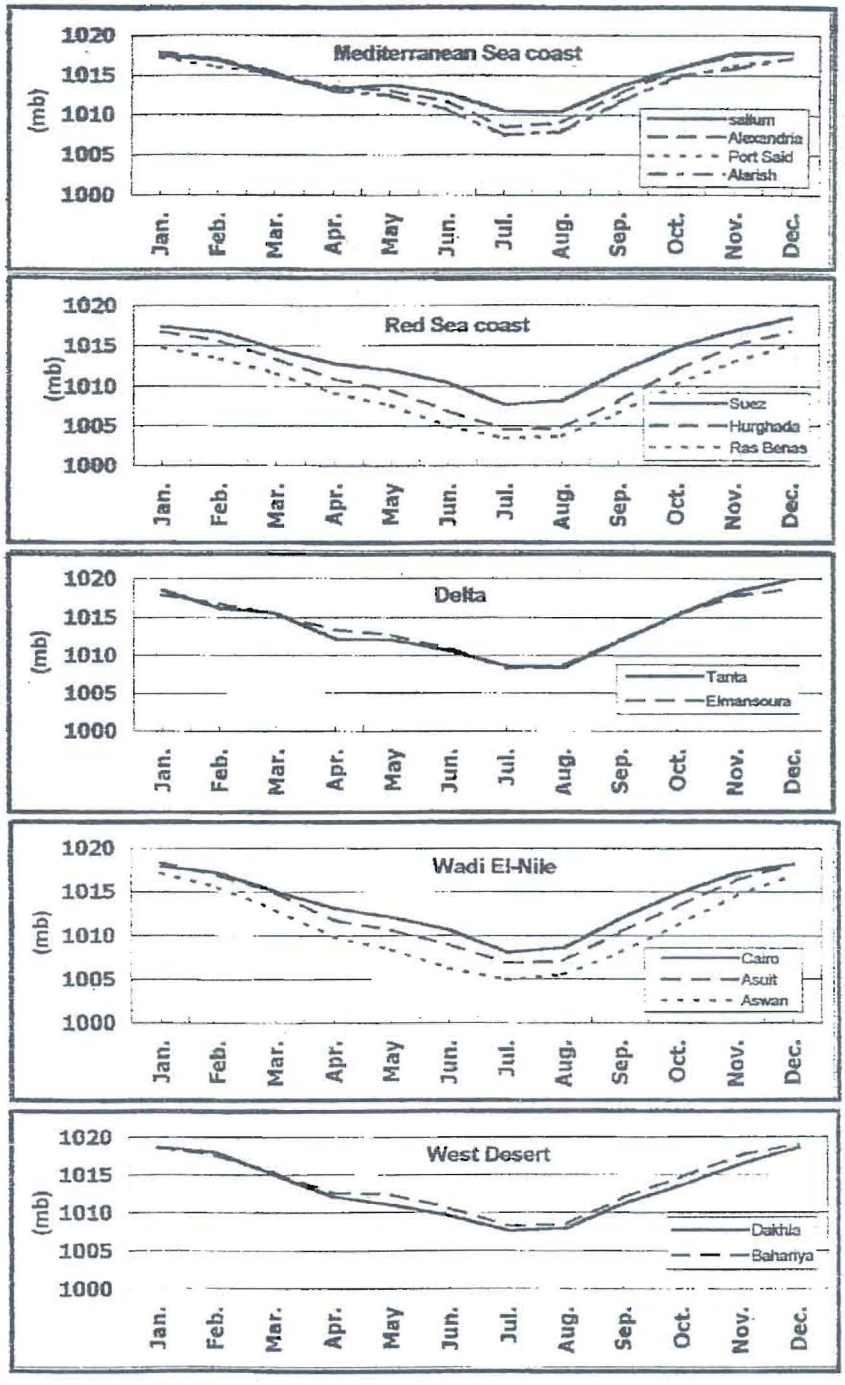


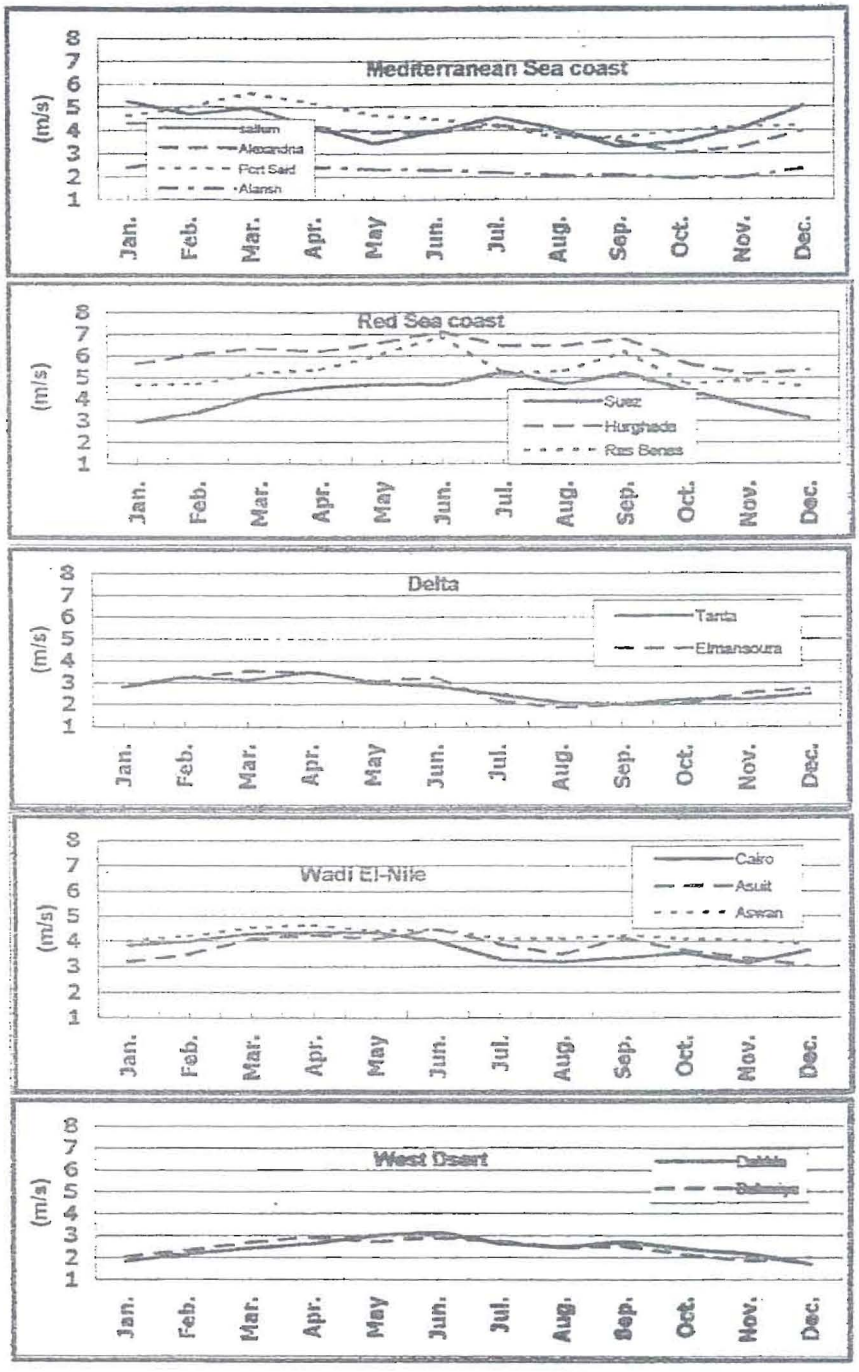
Fig.(2): Air temperature at different regions of Egypt



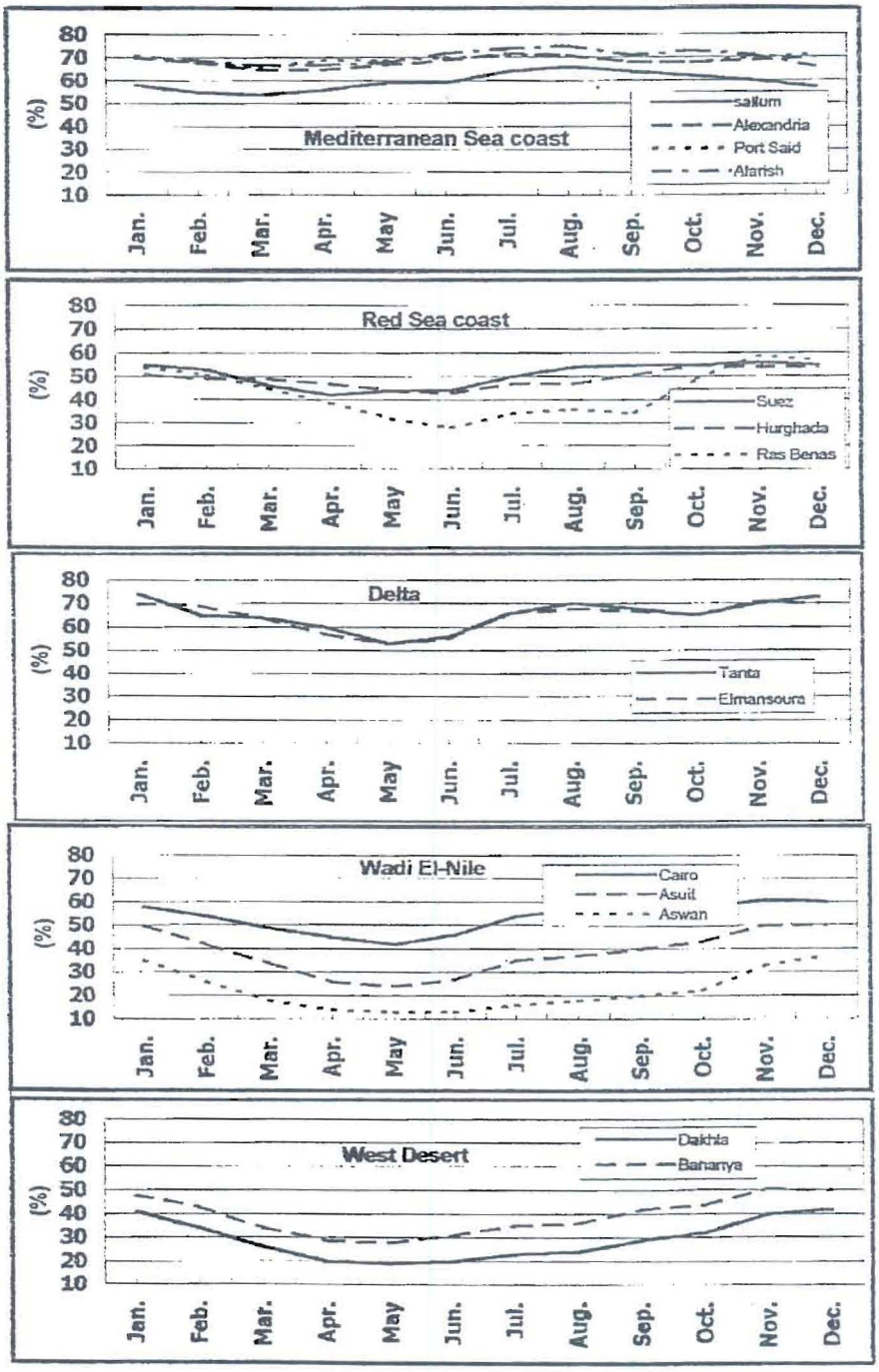
Figures (3): Air pressure at different regions of Egypt

Table (1): Wind direction at different regions of Egypt

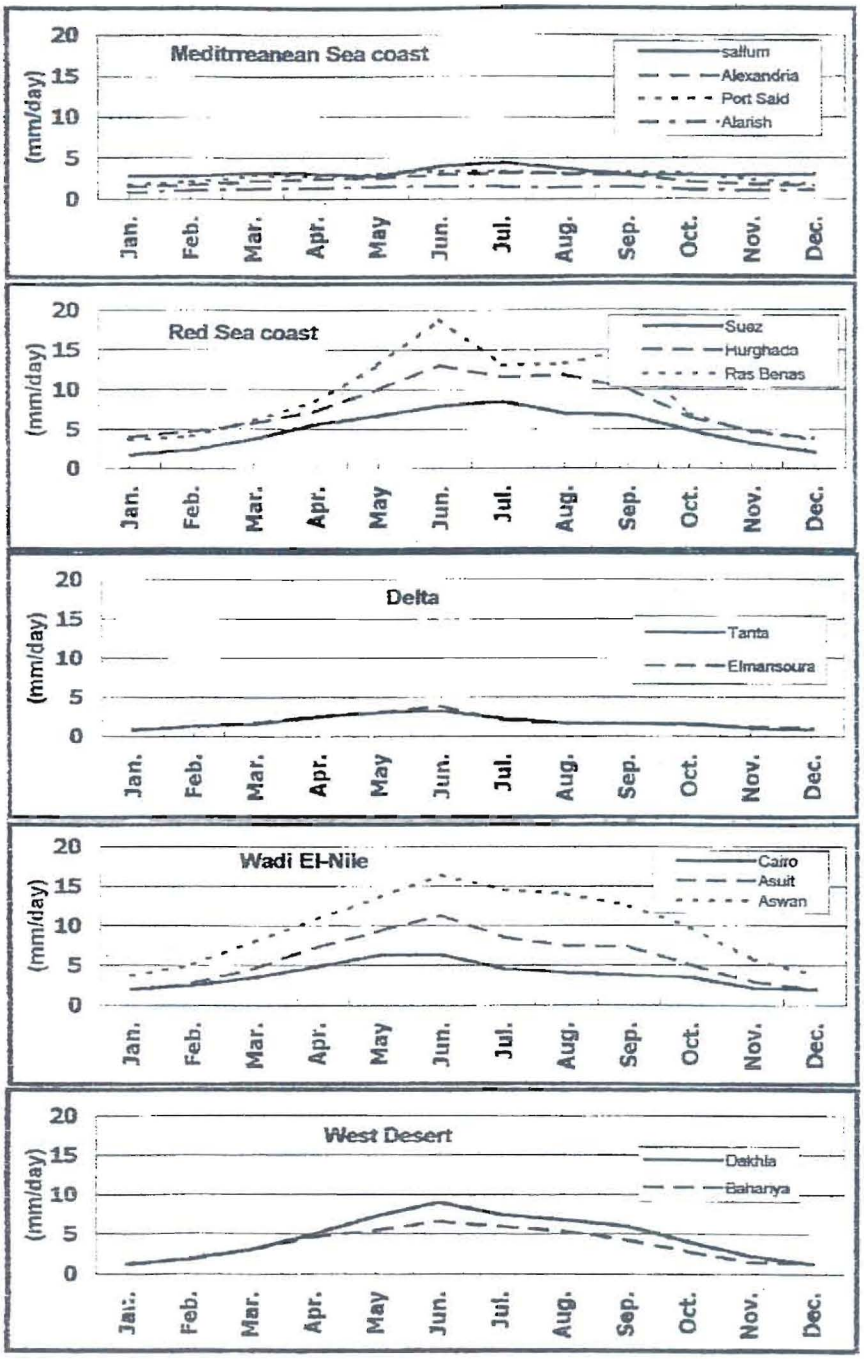
		Jan.	*Feb.*	*Mar.*	*Apr.*	*May*	*Jun.*	*Jul.*	*Aug.*	*Sep.*	*Oct.*	*Nov.*	*Dec.*
	Sallum	WSW, W, WNW	W, WNW, NNW	W, WNW, NNW	ENE, E, WNW, NNW	NNE, ENE, E, WNW, NNW	NNE, WNW, NNW	NNE, WNW, NNW	NNE, ENE, NNW	NNE, ENE, NNW	NNE, ENE, WNW	W, WNW, NNW	WSW, W, WNW
	Alexandria	SSW, WSW, NNW	WNW, NNW	WNW, NNW	N, NNE, WNW, NNW	N, NNE, WNW, NNW	N, WNW, NNW	N, WNW, NNW	N, WNW, NNW	N, WNW, NNW	N, NNE, NNW	N, NNE, NNW	SSW, WSW, NNW
Medit. Sea Coast	*Port Said*	SSW, WSW, W	WSW, W	WSW, WNW	N, NNW	N, NNE	N, NNW	N, NNW	N, NNW	N, NNW	N, NNW	N, NNE	SSW, WSW, NNW
	Alarish	SSE, WSW	SSE, WSW	NNE, SSE, WSW, WNW	N, NNE, SSE, WNW, NNW	N, NNE, SSE, NNW	N, WNW, NNW	N, WSW, WNW, NNW	N, SSW, WNW, NNW	N, NNW	N, NNE, NNW	N, NNE, SSE	SSE, SSW, WSW
	Suez	N, WNW, NNW	N, WNW, NNW	N, NNW	N, NNW	N, NNW	N, NNW	N, NNW	N, NNW	N, NNW	N, NNW	N, WNW, NNW	N, WNW, NNW
Red Sea Coast	*Hurghada*	N, W, WNW, NNW	N, WNW, NNW	N, WNW, NNW	N, WNW, NNW	N, WNW, NNW	N, WNW, NNW	N, WNW, NNW	N, WNW, NNW	N, WNW, NNW	N, WNW, NNW	N, W, WNW, NNW	N, W, WNW, NNW
	Ras Benas	N, WNW, NNW,	N, NNW	N, NNW	N, NNW	N, NNW	N, NNW	N, NNW	N, NNW	N, NNE, NNW	N, NNW	N, NNW	N, WNW, NNW
Delta	*Tanta*	WSW, W	WSW, W	NNE, W, WNW, NNW	N, NNE, ENE, NNW	N, NNE, WNW, NNW	N, WNW, NNW	N, WNW, NNW	N, WNW, NNW	N, NNW	N, NNE, NNW	N, WNW, NNW	WSW
	Elmansoura	SSW, WSW, W	SSW, WSW, W	NNE, WSW, W, WNW	NNE, ENE, WNW, NNW	N, NNE, WNW, NNW	N, NNE, WNW, NNW	WNW, NNW	WNW, NNW	N, WNW, NNW	N, NNE, WNW, NNW	N, NNE, WNW, NNW	SSW, WSW, W
	Cairo	S, SSW	ENE, SSW, WSW	NNE, ENE, WNW	NNE, ENE, NNW	N, NNE, ENE, NNW	N, NNE, NNW	N, NNE, WNW, NNW	N, NNE, WNW, NNW	N, NNE, NNW	NNE, ENE	NNE, ENE	S, SSW
Wadi El-Nile	*Asuit*	W, WNW	W, WNW	W, WNW	W, WNW, NNW	WNW, NNW	WNW, NNW	WNW, NNW	W,WNW, NNW	WNW, NNW	W, WNW, NNW	W,WNW	W, WNW
	Aswan	N, NNE, NNW	N, NNE, NNW	N, NNE, NNW	N, NNE, NNW	N, NNW	N, WNW, NNW	N, WNW, NNW	N, NNW	N, NNE, NNW	N, NNE, NNW	N, NNE, NNW	N, NNE, NNW
West Desert	*Dakhla*	W, WNW, NNW	W, WNW, NNW	WNW, NNW	N, WNW, NNW	N, WNW, NNW	N, NNE, WNW, NNW	N, W, WNW, NNW	N, W, WNW, NNW	N, WNW, NNW	N, W, WNW, NNW	N, W, WNW, NNW	W, WNW, NNW
	Baharlya	W	W	N, NNE	N, NNE	N, NNE	N, NNE	N, NNE, NNW	N, NNE, NNW	N, NNE	N, NNE	N, NNE	N, W



Figures (4): Wind speed at different regions of Egypt



Figures (5): Relative humidity at different regions of Egypt



Figures (6): Rate of evaporation at different regions of Egypt

DISCUSSION

Above Egypt (as Northern Hemisphere) the lower air temperature is in Winter, while the higher air temperature is in Summer (Maiyza, 1988; Maiyza et al, 1988 and El-Bakry, 1993 and Abd Ellah, 1999). Lower air temperature is in Delta (agricultural land), while higher value is over Red Sea coast and West Desert (dry land) (Dawood, 2000 and Zahran and Mashaly, 2000). Over Mediterranean Sea coast air temperature does not vary appreciably from place to another, its values rang in the tenth portions of degrees Celsius. This result occurs in Delta and West Desert. Above Red Sea coast and Wadi El-Nile air temperature increased southward (with low latitudes). Addition to prevailing atmospheric currents, the variation of air temperature over Egypt depend on physico- geographic (desert, cultivated land and coast) and location (latitude) (El-shahawy, 1975; Mehanna, 1976; Abd Ellah, 1995 and Abd Ellah, 1999).

The pressure over different regions of Egypt has very small amplitude; the values amount to tenth fractions of a millibar. Air pressure is relative low in Summer (hot season) and relative high in Winter (cool season) (El-shahawy, 1975; Mehanna, 1976 and Abd Ellah, 1999). Above Egypt air pressure is high in northern region (Mediterranean Sea coast), while it is low in southern region. Over Mediterranean Sea coast air pressure has the same trend, with very small variations in the values. This result found in Delta and West Desert. The air pressure over Red Sea coast and Wadi El-Nile decreases southward (Egypt land descend to north). The air pressure over Egypt is inverse proportional with air temperature and altitude (El-shahawy, 1975; Tarakanov, 1982, El-Bakry, 1993 and Abd Ellah, 1999).

In Egypt the wind fields varies from place to another, and also with time. Over Northern region the prevailing winds has the same trend (N, NNE, ENE, NNW, WNW), except Alarish also WSW, SSW, SSE winds are effect. Over different places the wind direction of; Eastern region (N, NNW, WNW, W), Delta (W, WSW, SSW in Winter, N, NNE, NNW, WNW in the rest year) and West Desert (N, NNW, NNE, WNW, W) does not vary appreciably from place to another. In Wadi El-Nile the prevailing wind changed from place to another. Where it is N, NNE, NNW, ENE in Cairo and Aswan, while it is W, WNW, NNW in Asuit. The velocities of wind in different regions of Egypt differ from each other. In late Spring and Summer the winds reach their main peaks, while the low winds are in Winter except northern region (El-Asrag et al, 2000). The regions of low wind speeds coincide at Delta and West Desert, while the high is in Red Sea coast (Elliott et al, 1987). Over Mediterranean Sea coast the wind speed is low in late Summer and Autumn and high in Winter and early Spring. This seasonally evaluation is obviously related to the cyclonic activity variations (Bethoux, 1994). The significant variations in wind in Winter may be related to the deepness and the tracks of the depressions passing over the area. On the other meaning, in the cool season when large number of depressions pass over the Eastern Mediterranean Sea, the low frequency oscillations contain most of the wind (El-Gindy and Hamed, 1986). The horizontal differ in wind at northern region is due to the

irregular of Egyptian Sea coast (El-Gindy and Hamed, 1986 and El-Asrag et al, 2000). Over eastern region it is low in Winter and high in end of Spring and Summer. In Delta, Wadi El-Nile and West Desert the speed of the wind is low in Winter & Autumn and high in Spring (El-Asrage et al, 2000). In general the prevailing wind plays very important role in the weather conditions (Liston and Pielke, 2000). On the geographical northerly currents (atmospheric depressions) prevailing in Winter, and southerly (atmospheric height) in Summer (Mortensen and Said, 1996). The northerly winds (cool and wet) are strong affect on Mediterranean Sea coast, while it is weak affect on the rest Egypt. The southerly winds (hot and dry) are low affect in the north, while it is strong in the rest Egypt (El-Asrag et al, 2000).

The air masses over Egypt loaded high quantity of water vapor (high humidity, wet air masses) during mid of Winter, while it has low vapor (low humidity, dray air masses) in spring (Awwad, 2000). Relative humidity is high in northern region and Delta while it is low in West Desert and south extreme of Wadi El-Nile . This is mainly due to the air masses over Mediterranean Sea coast is greatly damp (northerly winds above Mediterranean basin) than that over rest of Egypt (dray winds). Relative humidity in Mediterranean Sea coast increases eastward related to prevailing wind (low speed) (Littmann, 2000 and Hasanean, 2001). Above Red Sea coast, Wadi El-Nile and West Desert the humidity increases northward, while in Delta it has the same trend.

Egypt can be divided into two main climatic provinces (Zahran and Mashaly, 2000); arid province (Latitudes 32°-30 ° N) and hyper (extreme) arid province (Latitudes 30 ° - 22 ° N). On the other side, the weather characteristics over Sea coast differ significantly than that in its open water (Measha1 et al, 1983 and Maiyza and Beltagy, 1987).

Over different regions of Egypt the rate of evaporation is low in Winter, while it is high in Summer (Hamad, 1970; Measha1 and Morcos, 1984; El-Bakry, 1993 and Abd Ellah, 1999) . The low evaporation is in Delta, while the high is in Red Sea coast. In general the lower evaporation due to low wind speed and wet air mass, while the higher value is associated with peak wind and its dry direction (Maiyza, 1988 and Abd Ellah, 1999). Above Mediterranean Sea coast the rate of evaporation decreases eastward, while in Delta its value is close to each other. Above Red Sea coast, Wadi El-Nile and West Desert the rate of evaporation increases southward.

The mean annual evaporation rate over Mediterranean Sea coast is 2.47 mm/day. The present value is absolute lower than that the previous studies for Mediterranean Sea basin (open water); 4.28 mm/day (Bunker, 1972), 4.47 mm/day (Bethoux, 1979 and Bethoux & Gentili, 1994), 4.19 mm/day (Maiyza and Beltagy, 1987) and 4.21 mm/day (Said, 1993). The low rate of evaporation in Mediterranean Sea coast than that in Mediterranean Sea basin, may be, due to effect of northerly wet winds. These winds which pass over Mediterranean Sea basin lead to increase wet air mass and decreases its temperature over Northern Coast.

Over Red Sea coast, the mean annual of evaporation is 7.40 mm/day. This value is absolute highest estimations of rate of evaporation over Red Sea. Where the previous literatures has reported on the evaporation variability were; 6.39 mm/day (Yegorov, 1950), 5.67 mm/day (Privett, 1959), 5.86 mm/day (Morcos, 1970), 4.0 mm/day (Behairy et al, 1981) and 3.56 mm/day (Maiyza, 1988). The high in the difference between evaporation values from coast and open water of Red Sea can be explained by examining all the parameters of the equation that influence evaporation. North northwest, West northwest and westerly dry winds, may be, the reason.

The mean annual of evaporation over Delta is 1.86 mm/day, Wadi El-Nile; 6.56 mm/day and West Desert; 4.15 mm/day. In general the absolute peak of annual mean potential evaporation was At Aswan (9.89 mm/day). This result agree the previous estimations of evaporation, with change in amplitude, by Mehanna, 1976 (10.42 mm/day), El-Bakry, 1993 (7.02 mm/day). At Lake Qarun and Wadi El-Rayan Lakes (100 km southwest of Cairo), the evaporation rate rounded about 4.72 mm/day (Abd Ellah, 1999).

The correlation coefficients, between rate of evaporation and air temperature ($r = +0.95773$) and for the wind speed ($r = +0.65932$), are positive value. It has negative value with atmospheric pressure ($r = -0.88759$) and humidity ($r = -0.76029$). In general the mean annual evaporation over Egypt is about 4.55 mm/day. This result is agreement with evaporation estimations of Ocean Atlas (Behairy et al, 1981). Where, using data of climate Atlas, the evaporation value between 30° -8° N is 5.2 mm/day and between 40° -30° N it is 3.3 mm/day (Meshal et al, 1983).

CONCLUSION

Above Egypt the air mass is cool in Winter, while it is warm Summer. Lower air temperature is in Delta, while higher value is over Red Sea coast and West. The air temperature at different places in Mediterranean Sea coast has the nearly values. This result occurs in Delta and West Desert. Above Red Sea coast and Wadi El-Nile air temperature increased southward. The pressure over different regions of Egypt has very small amplitude. Its value is relative -low in Summer and high in Winter. Air pressure in northern region is higher than that in southern region of Egypt. The air pressure over Egypt is inverse proportional with air temperature and altitude. over Egypt the wind field varies from place to another, and also with time. The northerly winds are strong affect on Mediterranean Sea coast, while it is weak affect on the rest Egypt. The southerly winds are low affect in the north, while it is strong in the rest Egypt. Meanwhile the velocities of wind in different regions of Egypt differ from each other. In late Spring and Summer the winds reach their main peaks, while the low winds are in Winter except northern region. The lower wind speeds are at Delta and West Desert, while its higher speeds are in Red Sea coast. The prevailing wind plays very important role in the weather conditions of Egypt. The higher humidity is in Winter, while its lower value is in spring. Relative humidity is high in northern region and Delta while it

is low in West Desert and south extreme of Wadi El-Nile. Relative humidity increases eastward in Mediterranean Sea coast. Above Eastern region, Wadi El-Nile and West Desert it increases northward, while in Delta it has the same trend. The weather characteristics over Sea coast differ significantly than that in its open water. The rate of evaporation is low in Winter, while it is high in Summer. The lower rate of evaporation is in Delta, while its higher values are in Red Sea coast. The rate of evaporation in Mediterranean Sea coast is lower than that the previous studies for its basin, while in Red Sea coast it is high comparing with values over its basin. The correlation coefficients, between rate of evaporation -and air temperature and for the wind speed are positive value, while its value is negative for air pressure and for humidity. The value of mean annual evaporation over Egypt is relatively agreement with evaporation estimations of Ocean Atlas.

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