TEMPERATURE AND PRECIPITATION FLUCTUATION OF MADINAH-AL-MUNAWARA, KINGDOM OF SAUDI ARABIA (1959-2011)

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ABSTRACT

This paper on temperature and precipitation fluctuation in the Royal Kingdom of Saudi Arabia (a case study of Madinah-Al-Munawara) is based on data derived from meteorological station of Madinah-Al-Munawara covering time period of fifty two years (1959-2011). This is a city in the Hejaz region of western Saudi Arabia, the capital of the Al Madinah Province. It is the second holiest city of Islam, and the burial place of the Prophet Muhammad (PBUH) and it is historically significant for being his home after the Hijrah. The city is a holly place for all Muslims and they are visited it during holly Hajj in a year and for Umrah purpose throughout the year.

The research analyzes the temperature and precipitation fluctuation of the Madinah-Al-Munawara province in terms of climate fluctuation/variation, and seasonal distribution and extreme events. The mean monthly temperature of the city recorded during 1959-2011 is 28.3 degree Celsius having mean maximum temperature of about 34.3 degree Celsius and mean minimum of 21.1 degree Celsius. The mean monthly temperature of the city shows an increase of 1.7 degree Celsius having 1.2 degree Celsius in mean monthly maximum and -1.9 degree Celsius in mean monthly minimum temperature. In general, there are ups and downs in the temperature condition. The total precipitation of the city is 36.2mm, while the sum of decrease in precipitation is -0.3millimeters but in general the trend of precipitation at Madinah-Al-Munawara shows an increasing trend throughout the period. April and November are the wettest, while June, August, September and October are the hottest months of the city. The area is characterized by two main seasons that is winter (5 months) and summer (7 months) which can further be sub-divided into four rainy seasons namely winter, sub-winter, monsoon, and post-monsoon seasons.

KEYWORDS: Climatology, Fluctuation, Seasonal fluctuation, Hajj and Umrah, Summer, Winter, Wettest, Hottest.
1. INTRODUCTION
The climate of Madinah-Al-Munawara province is marked by desert climate (36mm total precipitation) at the east and maritime climate at the west having high day time temperatures of 34°C and moderate temperatures of 21°C at night. The distribution of weather elements in Madinah-Al-Munawara generally, is due to the altitudinal and latitudinal zones of horizontal atmospheric convergence and divergence, the maritime or continental origin of prevailing air masses and the seasonal shifting of the zonal pressure and wind system (Gebeily and Rehman, 2006). The local convectional system, which results from diurnal surface heating, also causes variation in the annual distribution of the weather elements. This study deals with the complete description of weather and climate changes at Madinah-Al-Munawara and will facilitate the Muslim to visit Madinah-Al-Munawara for Umrah. (FAO (2002), IPCC (2001 and 2007), GOSA (2010), Zawad (2010), Rehman et al (2012), Shanti et al (2004), and Smith et al 2010).

Madinah-Al-Munawara has received total annual precipitation of 36.2mm (1.5inches). The area is located on the country's west side, along the Red Sea coast. The precipitation is not sufficient for the plant growth and fall in arid climate (Mazroui and Abdullah, 1998). The study area covers an area of 151,990 km² and a population of 1,512,724 per 2004 Census (Saab and Tolba, 2009). Madinah-Al-Munawara located at 39°-37’ east longitude and 24°-25° north latitude on the globe (Fig-1).

2. METHODS AND DATA:
The mean monthly and mean annual temperature, precipitation, and extreme events are examined for 52 years (1959-2012). Data of these variables have been collected from the Meteorological Department, Madinah-Al-Munawara, Saudi Arabia. The monthly and annual averages and deviation from the mean have been calculated for each element and tabulated for the analysis. The monthly and annual data have been further processed into seasonal means and deviation that led to the fluctuation of hot/dry or moderate/wet period of the observatory.

For seasonal variation the year has been divided into two main seasons that is summer and winter, so that months of the year with positive deviation from the mean are considered as summer months and otherwise winter. Based on total annual precipitation, these two main
seasons are further sub-divided into four sub-rainy seasons that is winter season (November to mid-February), post winter season (Mid-February to May), Monsoon season (June to Mid-August), and post Monsoon season (Mid-August to October). The precipitation as well as temperature shows a decrease/increase in the months of February and August, therefore these two months of the year have been divided by two and half of the month added to each season.

3. FINDINGS AND DISCUSSION:

Climate is not a static phenomena but it is changes in all aspects from place to place and from time to time. According to Berret (1963), “there are two scales of climate variation that is for short range variation, which is relatively minor in respect of temperature and precipitation and the phenomenon is called climate fluctuation. Departure from normal or mean values may simply be referred to as climate variability. The distinctions are of little importance in themselves, but they do serve to emphasize the fact that it is the nature of climate and weather to vary from one time period to another time period and the variations may be more or less extremes”. Keeping in view the above statement, a study has been devised to analyze the distribution, annual trend, and fluctuation of temperature and precipitation of Madinah-Al-Munawara.

3.1. MEAN MONTHLY TEMPERATURE:

The temperature of the study area is fairly representative of the plain strip of land at the eastern coast of Red Sea with continental plain and marine climates having hot long summers and warm short winters (Fig-2). The mean monthly temperature of the city is 28.3°C having maximum temperature of about 34.3°C and minimum of 21.1°C during the period of 1959-2011. The area has moderate temperature in winters when the mean monthly temperature drops to 21°C and hot summers when it rises up to and above 33 degree Celsius. The highest mean monthly temperature of the area is 36.1°C with a maximum of 42.2°C and minimum of 28.8°C in June and August respectively and being hottest months of the city. The lowest mean monthly temperature of 18.3°C with 23.8°C maximum and 11.8°C minimum temperature recorded in January and constitutes as a coldest month of the area. The annual march of temperature reveals that the temperature condition of the area rises up from January to August and decreases till December (Fig-2).
This variation in the annual temperature of the area is a result of annual march of the sun, angle of the sunrays, annual revolution of the earth, and the precipitation indices (Assiri and Darfaoui, 2009). The deviation of mean monthly maximum and minimum temperature reveals that it is below the mean condition from November to March and placed in winter months, whereas it is above the average line from April to October and considered as summer months of the area. This shows that there are two main seasons in the area that is summer which lasts from April to October (7 months) and winters that lasts from November to March (5 months). The extreme average maximum temperature of the city is 36.9°C recorded in 2010 with a minimum of 19.9°C recorded in 1999 having 31.1°C mean monthly temperature in 1966 during the period of 1959-2011 and being the hottest years of the area. The lowest mean monthly temperature of 26.7°C (1992) with mean monthly lowest maximum of 32.9°C (1959, 61, 82), and mean monthly minimum of 19.9°C recorded in 1992 and being coldest years of the series.

3.2. MEAN MONTHLY PRECIPITATION:

After temperature, precipitation is the most important of the climate elements. The agriculture or postural utilization of the land is the only real and lasting source of wealth, and both of these are in a large measure dependent on precipitation. The yield of crops varies with the precipitation in such a way as to leave no doubt that the precipitation has been the real determinant, and the carrying capacity of grazing land in head of stock per square kilometers emphasis the same truth. It also influences the rate of evapotranspiration from vegetation and soil, which not only, affects the production of crops but also increases the ratio of moisture in atmosphere. The size and growth of vegetation is also closely related to the amount of precipitation. Sometimes, it also plays vital role in the industrial location and disease controlling of an area.

Annual rainfall is probably the most important simple climate indicator of productivity. The total precipitation of the city is 36.2mm (1.5 inches), which is insufficient for plants growth and the city fall in arid climate. The heaviest precipitation of 11.8mm recorded in November (moistest) and lowest of 0.0mm in June and September (driest). The total precipitation of the area is 22.6mm in winters that dropped to 13.6mm in summers. The heaviest precipitation of the area ever been recorded is 193mm in 1995 and the lowest of 0.0mm recorded for 17 years during 1959-2011. In general, higher precipitation occurred in the months of April, July and November.

The average precipitation indicates that it increases with decrease in temperature from November to March, while at the rise of temperature a decrease occurs from April to October (Fig-3). In April it exceeds 6.6mm and then decreases till October and increase again onward up to November 8.8mm.
4. **SEASONAL DISTRIBUTION:**

The distinct period into which the year may be divided, in terms of duration of daylight and climate conditions, as a result of changes in duration and intensity of sunshine and rainfall is termed as season (Khan, 1993). According to Dictionary of Geography (1991), season is defined as, "Those periods of the year, which are characterized by special climate conditions, mainly caused by the inclination of the earth's Axis to the plane of the Ecliptic and the revolution of the earth about the sun". In order to study the seasonal variation of temperature and precipitation, the year has been divided into two main seasons i.e. summer and winter. The inter-relation of factors affecting climate of Madinah-Al-Munawara shows that the summer month in coastal areas may not be the summer month inland, and a summer month in plain may not be that of the mountains. Therefore, months of the year having positive deviation from the mean temperature are considered as summer months, otherwise winter (Fig-3). Generally, in Madinah-Al-Munawara, the summer lasts from April to October (7months) and winters that lasts from November to March (5moths). The annual cycle of precipitation shows two positive and two negative deviations from the mean condition. So these two main seasons of the city are further divided into four sub-rainy seasons. The winter season that lasts from November to mid-February (Moist), post winter season from Mid-February to May (Moderate), Monsoon season from June to Mid-August (Hottest), and post Monsoon season from Mid-August to October (Warmer). The characteristics of each season are as follow.

5. **ANNUAL FLUCTUATION OF TEMPERATURE AND PRECIPITATION:**

The data used are the annual averages of mean monthly temperature and precipitation from meteorological observatory of Madinah-Al-Munawara, ranging from 1959-2012. “The anomalies or trends are an upward and downward drift of central tendency such as the mean of successive values,” (UNESCO, 1984). If a trend is absent, the series of the values in time is said to be stationary. Climate is usually defined by means of thirty years average over standard periods. The variability of a climate is best explained as typical pattern of variation within such standard period. Most of these variations are quite short-term (e.g. between successive years) and periodic. Some of it, however, is truly periodic. Such variation includes daily and seasonal changes, forced by the regular behavior of the sun. Some of the variations may appear quasi-periodic, but this is usually without value for prediction, especially as regards precipitation.

5.1. **TEMPERATURE FLUCTUATION:**

The natural, physical, and socio-economical ecosystems of Madinah-Al-Munawara are not only dependent on temperature rise or fall but also on how it varies from year to year and time to time. Generally, the mean monthly, mean maximum and minimum temperature of the area show an increasing trend during 1959-2011. The temperature of the city remains low during the period where the concentration of precipitation remains high and converse condition during dry years. During 1959-1995, the trend of temperature was below the mean condition and turned to positive deviation onward till 2011. From 1961-1989, there was a rise in the temperature of the city whereas it remained low from 1990 to 1997 and rose up till 2003 and inverse till 2011 (Fig-4).
The deviation from the annual mean of temperature shows clear picture of the temperature condition in the city. The temperature of the city shows a gradual increase from 1959-1980 and negative trend from 1981-95 and remained high during 1996-2011. Consequently, there were ups and downs in the temperature condition of Madinah-Al-Munawara after each fifteen years, having periodic pattern (Fig-4). The mean monthly temperature of the city shows an increase of 1.7°C having 1.2°C in mean monthly maximum and -1.9°C in mean monthly minimum temperature during 1959-2012. The highest positive deviation of 2.6°C of mean monthly temperature is recorded in 1996, 2.2°C in mean monthly maximum temperature and 1.3°C mean monthly minimum temperature in 2010 respectively. Generally, the deviation from the mean temperature condition of the city shows an increase in mean monthly and mean monthly maximum temperature, while it indicates a decreasing trend in the mean monthly minimum temperature.

5.2. PRECIPITATION FLUCTUATION:

After temperature, precipitation is the most important weather element that maintains stability in the water resources and agriculture activities in the area. Besides, it also plays a vital role as a controlling factor of temperature. The annual trend of precipitation from 1959-2011, shows that the area remains dry during 1961-78, wet during the period of 1979-85 and reversed during 1986-89. During 1990-2011 the precipitation of the area shows an increasing trend with a dry period
during 1996 to 2003 (Fig-5). The area falls in arid climate and drought condition prevails in the city for most of the years. The longer and most severe drought of the city was observed during 1962-77 (15 years), and moderate drought in 1978-88 (10 years).

Generally, the sum of deviation from the mean condition of precipitation shows a total decrease of -0.3mm having an annual average of precipitation 0.0mm during 1959-2011. Overall, the trend of precipitation at Madinah-Al-Munawara shows an increasing trend throughout the series (Fig-5). The high positive deviation of 161mm of the city was recorded in 1995, while the lowest of-32mm observed in more than 10 years. During 1960-90, the deviation from the mean shows a negative trend and the area remained under a long drought condition. From 1991-96 the trend shows a positive deviation with heavy rain in some years and count as wet period of the Madinah-Al-Munawara. The trend in precipitation takes a negative deviation during 1997-2009 and converse onward till 2011.

6. CONCLUSIONS

- Madinah-Al-Munawara receives less than 2inches precipitation annually and fall in arid continental climate. However, the coastal region of the province characterized be land and ocean breezes and shows a maritime climates.

- The annual march of temperature reveals that the temperature condition of the area rises up from January to August and slackens till December. The mean monthly temperature of the city recorded during 1959-2011 is 28.3°C having maximum temperature of about 34.3°C and minimum of 21.1°C. The area has moderate temperature in winters when the mean monthly temperature is dropped to 21°C and hot in summers when it rises up to above 33 degree Celsius.

- The extreme average maximum temperature of the city is 36.9°C recorded in 2010 with a minimum of 19.9°C recorded in 1999 having 31.1°C mean monthly temperature in 1966 during the period of 1959-2011 and being the hottest years. The lowest mean monthly temperature of 26.7°C (1992) with mean monthly lowest maximum of 32.9°C (1959, 61, 82), and mean monthly minimum of 19.9°C recorded in 1992 and being a coldest years of the series.

- Madinah-Al-Munawara characterized by two main seasons that is summer season that lasts for seven months (April to October) and winter season for five months (November to March).The summers of the city are extremely hot, while the winters are warm. The highest mean monthly temperature of the area is 36.1°C with a maximum of 42.2°C and minimum of 28.8°C in June and August with dust storms and being hottest months of the city. The lowest mean monthly temperature of 18.3°C with 23.8°C maximum and 11.8°C minimum temperature recorded in January and constitutes as a coldest month of the area.

- The total precipitation of the city is 36.2mm (1.4inches), which is insufficient for plants growth and the city fall in arid continental climate having hot long dry summers and short warm winters. The heaviest precipitation of 11.8mm recorded in November (moistest) and lowest of 0.0mm in June and September (driest). The heaviest fall of the area ever been recorded is 193mm in 1995 and the lowest of 0.0mm recorded for 17 years during 1959-2011. In general, higher rain fall occurred in the months of April, July and November.
• The average precipitation indicates that it increases with decrease in temperature from November to March, while at the rise of temperature a decrease occurs from April to October. In April, it exceeds 6.6mm and then decreases till October and increase again onward up to November 8.8mm.

• The two main seasons of Madinah-Al-Munawara that is winter and summer is further sub-divided into four rainy seasons. These are winter season (November to mid-February), post-winter season (Mid-February to May), Monsoon season (June to Mid-August), and post Monsoon season from (Mid-August to October).

• The mean monthly temperature of the city shows an increase of 1.7°C having 1.2°C in mean monthly maximum and -1.9°C in mean monthly minimum temperature during 1959-2011. In general there are ups and downs in the temperature condition of the area after each 10 and 15 years.

• The area falls in arid climate (36.2mm total Precipitation) and drought prevails in the city for most of the years. The longer and most sever drought of the city observed during 1962-77 (15 years) and moderate drought in 1978-88 (10 years). Generally, the sum of deviation from the mean condition of precipitation shows a total decrease of -0.3mm having an annual average of precipitation 0.0mm during 1959-2011. Overall, the trend of precipitation at Madinah-Al-Munawara shows an increasing trend throughout the series and it is expected that the precipitation condition of the city will increase with passage of time.

• The heaviest precipitation of Madinah-Al-Munawara recorded in the month of April and November and constitutes wettest months of the year. The lowest precipitation of the city seems in June, August, September and October that marked it as driest months of the year having high temperature and evapotranspiration.

7. REFERENCES:

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