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Assessment of Diurnal Temperature Range in Egypt

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ABSTRACT

Diurnal temperature range (DTR) is an important indicator of climate change, and its variations can have significant impacts on public health, agricultural productivity, and the carbon cycle in terrestrial ecosystems. In this study, sixteen years of maximum and minimum temperatures over 16 locations in Egypt were collected, to analyze in order to identify the variations of (DTR) in Egypt especially in the agriculture area. The differences between the study time series and normals were assessed at different levels of analysis of monthly, seasonal and annual averages. The results indicated that the DTR in Middle and Upper Egypt were the higher than Lower Egypt and the highest seasons for DTR were found during spring and summer seasons in Lower and Middle Egypt regions while in Upper Egypt region the highest DTR was found in the spring season. The comparison between DTR at the study period (2000-2015) and the normals revealed a general increase for DTR during the period from 2005 to 2012 in Lower Egypt while in Middle and Upper Egypt the increased in DTR were found during the period from 2007 to 2015. Therefore, it could be concluded that there is a general change in DTR during the studied period this returned to the change in maximum and minimum temperature.

Keywords: Diurnal temperature range, Maximum and Minimum temperature, Egypt.

I. INTRODUCTION

The diurnal temperature range (DTR) is the difference between daily maximum (Tmax) and minimum temperature (Tmin). How DTR is likely to change under current climate change projections is not clear (Eastering DR., et al. 2000). There is evidence to suggest that Tmax will increase while Tmin decreases, or that Tmax will increase at a faster pace than Tmin, in both cases increasing the DTR (Travis D. 2004). The diurnal temperature range is an important index of climate change because DTR is susceptible to a variety of environmental effects including water vapor, cloudiness, and urban influences (IPCC, 2001 and Braganza K., et al. 2004). As an identifiable characteristic of recent climate change, this trend is important in diagnosing the forcing responsible for the change, and in particular the anthropogenic component. However, the cause of the DTR trend is still poorly understood, as is its relation to anthropogenic forcing. Variations in daily temperature across an area can often be ascribed to processes in surface and atmospheric interactions related to differences in land use/land cover (LULC) throughout a region. Land surface temperature (LST) and its diurnal variation are crucial for the physical processes of land surface energy and water balance at regional and global scales (Scarino, B. et al. 2013). The diurnal cycle of LST has been used for a wide variety of applications. For example, the diurnal cycle of LST was used to analyze the urban thermal environment (Keramitsoglou I., 2013). Several recent studies based on climate model simulations suggest that DTR changes may be due to the effects of a human induced increase in atmospheric greenhouse gases (CO_2) and sulfate aerosols (Park H. S. and Joh M., 2005). In the eastern Mediterranean, Turkes et al. (1996) have shown significant decreases in the diurnal temperature range in Turkey due to significant increases in minimum temperature since 1930. Cohen and Stanhill (1996) showed a significant reduction of the DTR at three stations in the Jordan Valley, although at all stations a decrease in the maximum temperature was observed, while the minimum temperature increased at only one of the stations in the dry southern regions of the valley. A more comprehensive study of 40 meteorological stations in Israel has recently shown a slight regional decrease in the diurnal temperature range over the past 30-50 years (Ben Gai et al., 1999). Historical observations have revealed a substantial decreasing trend in globally averaged DTR for 1950-1990 (Easterling et al., 1997; Vose et al., 2005), and many climate models project further significant changes in DTR (Stone and Weaver, 2003; Lobell et al., 2007). The objective of this study is to investigate the DTR changes occurred over Egypt under current climate condition.

II. METHODS AND MATERIAL

Daily historical data of minimum and maximum air temperature for 16 locations were obtained from the climatology resource for agroclimatology data (NASA POWER), https://power.larc.nasa.gov/cgi-bin/agro.cgi?email=agroclim@larc.nasa.gov. This data was derived and validated based on recommendations from partners in the energy, architectural, and agricultural industries. The temperature parameters have been exported and analyzed from 2000 up to 2015 for the determined locations to study the change of DTR under the current climate.

The daily DTR was obtained by subtracting daily minimum temperature from the daily maximum temperature at each location to analyzed and determine the occurred changes in DTR in Egypt. The study was carried out on the Governorates around Nile valley which distributed in different geographic regions Lower, Middle, and Upper Egypt (Table 1). The studied time series from 2000-2015 were assessed at different levels of analysis of monthly, seasonal and annual averages. The mathematical annual trend of DTR was determined by curve fitting analysis of the time serious temperature data. Furthermore, the average annual DTR of 2000-2007 and 2008-2015 was calculated individually and compared together in order to find out the recent changes occurred in temperature trends.

Table (1): Coordinates of the 16 studied locations.

No.	Location	Latitude [°N]	Longitude [°E]	No.	Location	Latitude [°N]	Longitude [°E]
1	Alexandria	31.20	29.95	9	Giza	30.05	31.22
2	Behera	31.03	30.46	10	Beni Suef	29.07	29.07
3	Kafer Elshiekh	31.12	30.95	11	Fayoum	29.30	30.85
4	Dakahliya	31.20	31.40	12	Minya	27.74	30.83
5	Port Said	31.27	32.28	13	Asyut	27.20	31.17
6	Ismailia	30.60	32.28	14	Souhag	26.60	31.78
7	Suze	29.97	32.55	15	Kena	26.18	32.73
8	Monofeya	30.60	31.02	16	Aswan	23.97	32.78

III. RESULTS AND DISCUSSION

Understanding average monthly diurnal temperature range of the studied time serious (2000 -2015) for the 16 locations was the first step in carrying out this study. Fig. (1) shows the average monthly diurnal temperature range from 2000 up to 2015, at the 16 studied locations divided into three regions. Kena and Aswan locations had the highest monthly DTR trends compared to the other locations while the lowest values of monthly DTR was found in Alexandria location. Regarding the average of the 16 locations, the highest value of DTR of 13.9 was observed in May and the lowest value of DTR of 10.2 was observed in December. When the monthly averages of DTR were compared to the locations, it has been observed that the highest value of DTR was 16.7 at Aswan location it’s observed in April Month. In addition, the lowest value of DTR was 3.9 at Alexandria location it’s observed in November month.

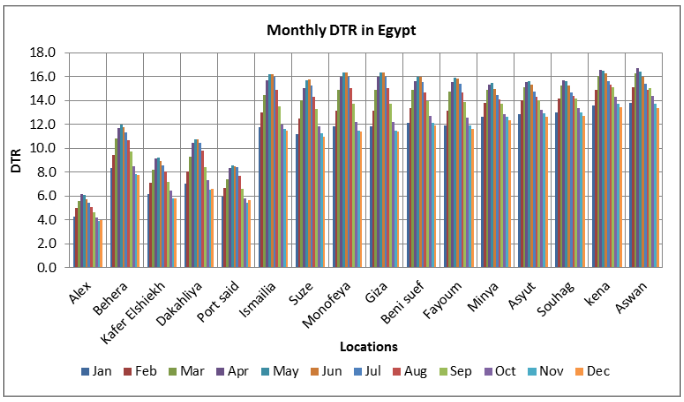

Figure 1: Average monthly diurnal temperature range from 2000 up to 2015 at the studied locations.

A. Monthly variation

Fig. (2) illustrates the monthly differences between the average historical DTR for the years from 2000 up to 2015 in three regions (Lower, Middle and Upper Egypt) and the normals. Monthly differences reflected that the highest differences were found during 2001 and 2010 in August month with value ranged from -2.41 to 3.44 in Lower Egypt and with value ranged from -2.80 to 3.16 in Middle Egypt while in Upper Egypt the highest differences were found in 2001 and 2013 in October month with value ranged from -2.41 to 2.11.

The lowest difference in Lower Egypt was found in 2007 during April and July months and in Middle Egypt the lowest difference was found during 2008 in

February month while in Upper Egypt the lowest difference was found during 2015 in October month. A general increase over the normals in Lower Egypt during 2010 in all months except January month was below the normal and in Middle Egypt the differences were above the normals during 2013 year and 2014 year except December 2013 year and May 2014 year were below the normals. All months in Upper Egypt during 2010 year and 2008 year were above the normals except January month in 2008 year was below the normals.
The differences values of all months in Lower Egypt during 2000 year were below the normal while the difference of all months during the years of 2002, 2003, 2014 and 2015 were below the normals except the months of November, January, October and September, respectively.

The values of differences were below the normals in Middle Egypt during the years from 2000 to 2003 for all months except in November during 2002 year and January during 2003 year. While the values of differences for all months in Upper Egypt were below the normals during the years from 2000 to 2002.

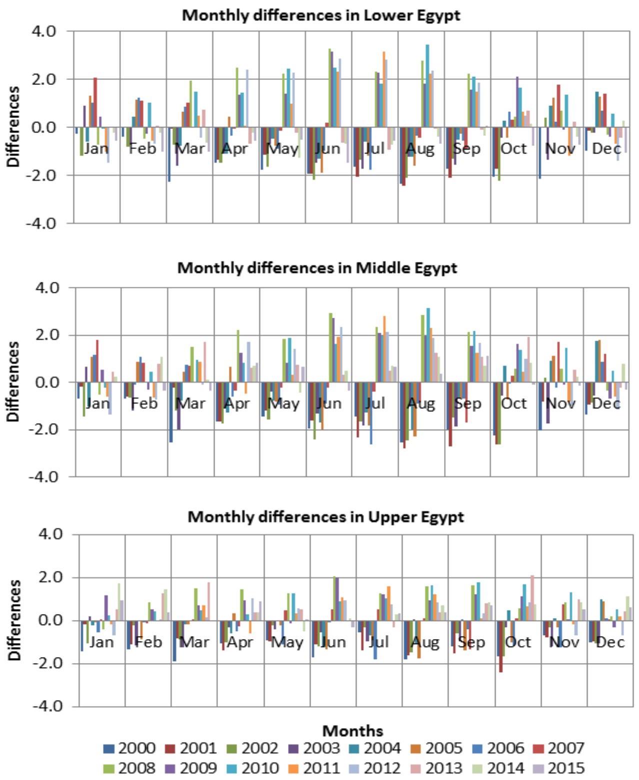

Figure 2: Differences between the monthly DTR and the normal from 2000 up to 2015 at the studied locations.

B. Seasonal variation

The average of each three months was obtained to represents different seasons like December, January, and February (DJF) represent winter season and March, April and May (MAM) represent spring season, June, July and August (JJA) represent summer season and September, October and November represent Autumn season. Fig. (3) illustrates the seasonal DTR for the years 2000-2015 in three regions (Lower, Middle and Upper Egypt).

The highest DTR were found during spring and summer seasons in Lower and Middle Egypt regions while in Upper Egypt region the highest DTR was found in spring season (MAM).

The lowest DTR in the three regions were fluctuated between winter (DJF) and Autumn (SON) seasons up to the period from 2000/2001 to 2007/2008 while at the last period from 2008/2009 to 2014/2015 the winter (DJF) season was the lowest DTR in the three regions.

Fig. (4) shows the differences between the seasonal DTR during the period 2000-2015 and the normal in three studied regions.
The results indicated that in Lower Egypt the DTR were below the normal in all seasons during the first three years from 2000/2001 to 2002/2003 and also the last two years from 2013/2014 to 2014/2015 while the DTR of All seasons were above the normal during the period 2007/2008 and 2009/2010.

The DTR in Middle and Upper Egypt were below the normal during the first four years from 2000/2001 to 2003/2004 in all seasons except the autumn (SON) season during 2003/2004 in the Middle Egypt was above the normal.

Also, the last three years were above the normal for all seasons from 2012/2013 to 2014/2015 in the two regions.
The highest difference between seasonal DTR and normal in the Lower and Middle Egypt were found in summer (JJA) season during 2000/2001 and 2007/2008 and in Upper Egypt the highest differences were found in summer (JJA) and autumn (SON) seasons.

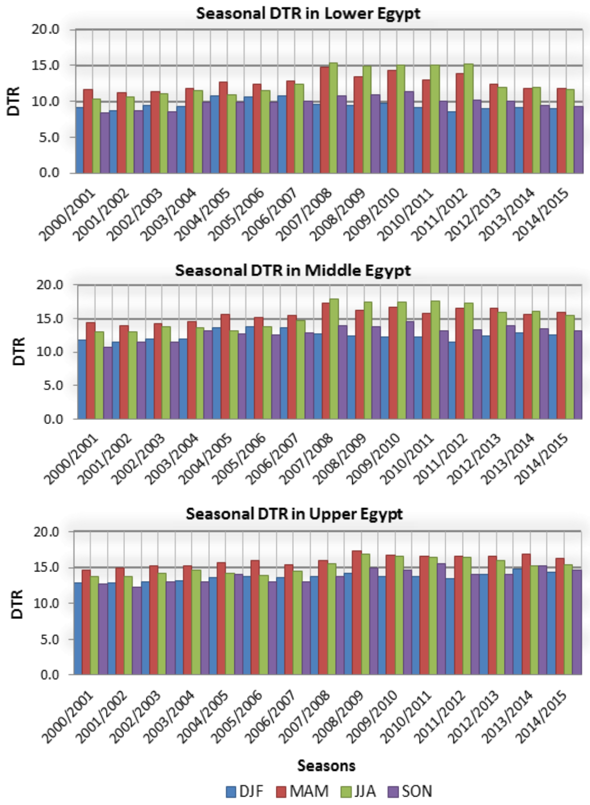

Figure 3: Seasonal DTR from 2000 up to 2015.

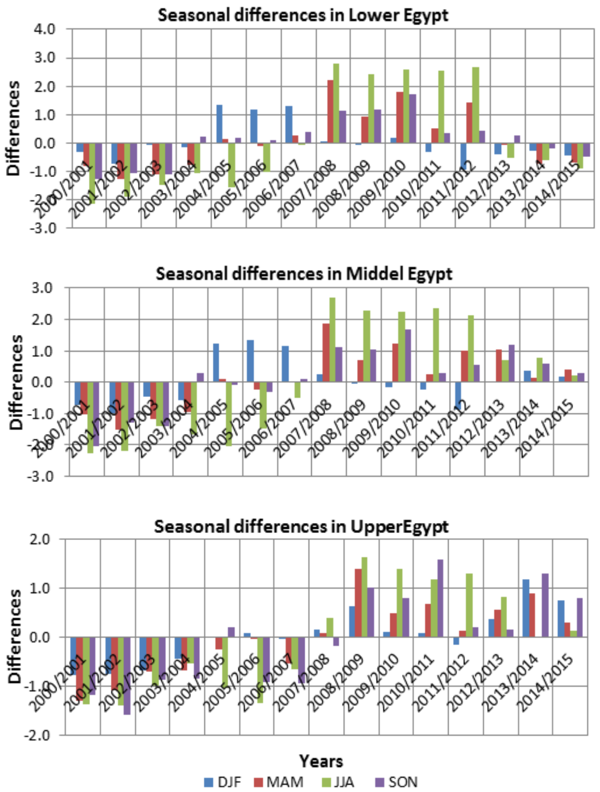

Figure 4: Differences between the seasonal DTR and the normal at the three regions.

C. Annual variation

The annual average of DTR during the period from 2000 to 2015 into three regions (Lower, Middle and Upper Egypt) as shown in figure 5 the highest annual of DTR was found in Upper Egypt while the lowest annual was found in lower Egypt. Also, the highest value of DTR found in 2008 year and 2010 year while the lowest value of DTR was found in 2000 year in the three regions. Fig. (6) illustrates the annual difference of DTR from the normal during the studied period and the results indicated that the DTR in Lower Egypt region was above the average during the period from 2005 to 2012 while in Middle and Upper Egypt the DTR were above the average during the period from 2007 to 2015. The highest difference was found in 2010 year at Lower Egypt and in Middle Egypt was found in 2008 and 2010 years while in Upper Egypt the highest difference was found in 2008 year. The comparison between DTR during two periods from 2000 to 2007 and from 2008 to 2015 as shown in figure (7) the results indicated that the DTR during the second period was the highest in comparison with the first period at Lower, Middle, and Upper Egypt. The highest DTR was found in Upper Egypt 15.3 and the Lowest DTR was found in Lower Egypt.

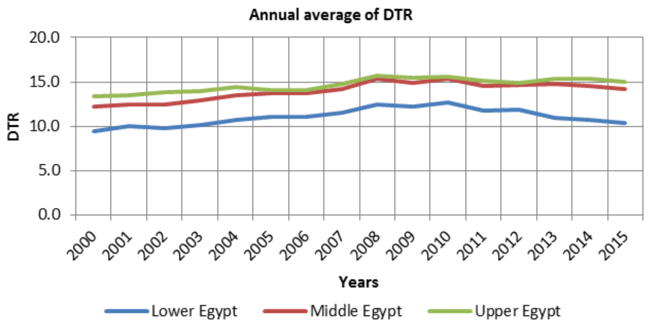

Figure 5: Annual average of DTR during the period from 2000 up to 2015 at the three regions.

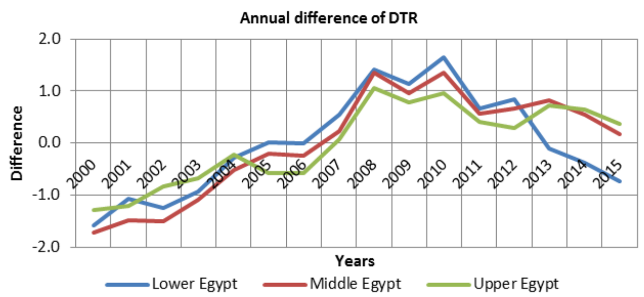

Figure 6: Annual difference of DTR from the normal at the three regions.

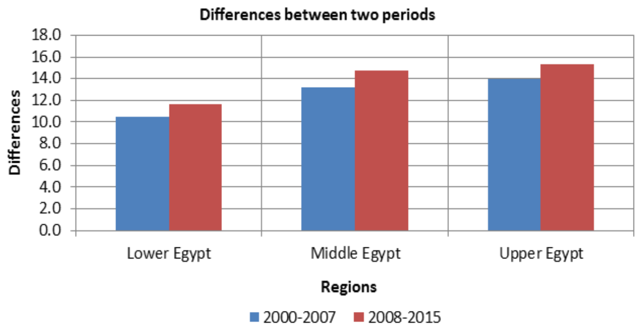

Figure 7: Differences between the averages of DTR during the two periods at the three regions.

In general, KAI WANG et al., (2011) mentioned that the DTR in the urban area continued to show a decreasing trend because of the urbanization effect, while the DTR in the rural area presented an increasing trend.

The remarkable DTR difference in the urban and rural areas showed a significant urbanization effect in the solar brightening time. KELSEY N., (2010) reported that more information on the relationships between DTR and land use/land cover (LULC type) can be gained by looking at maximum and minimum temperatures, as agricultural and urban areas should experience large differences.

The daily temperatures should also provide additional explanations for other DTR relationships.

Also, similar results obtained by Brunetti M. et al., (2011) which reported that DTR shows a positive trend, but greater in the North than in the South of Italy. There is a positive correlation between DTR and mean monthly temperature especially in spring and in summer, while there is a high significant negative correlation between DTR and monthly precipitation.

In the same line Makowski K. et al., (2008) who reported that It has been widely accepted that diurnal temperature range (DTR) decreased on a global scale during the second half of the twentieth century and in regional scale found that DTR behavior in Europe over 1950 to 2005 changed from a decrease to an increase in the 1970s in Western Europe and in the 1980s in Eastern Europe. Donglian Sun et al., (2006) reported that the DTR of grasslands is the largest followed by cropland, forests and urban areas.

Also, Chen et al. (2015) mentioned that the increasing DTR led to both advancing the mean emergence date and shortening the generation duration (hence increasing the voltinism), even as T mean was held constant.

IV. Conclusion

The comparison between diurnal temperature range in the three regions (Lower, Middle and Upper Egypt) indicated that the DTR in Middle and Upper Egypt were the higher than Lower Egypt.

The highest seasons of DTR were found during spring and summer seasons in Lower and Middle Egypt regions while in Upper Egypt region the highest DTR was found in spring season (MAM).

The comparison between DTR at the study period (2000-2015) and the normals indicated a general increase for DTR from 2005 to 2012 in Lower Egypt while in Middle and Upper Egypt the increased in DTR were from 2007 to 2015.

Rapid positive trend has been observed in the diurnal temperature range, which indicated to increasing the heat and cold waves in the recent years.

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