environmental sciences proceedings

MDPI

Proceeding Paper

Trends of Extreme Events in Precipitation and Temperature during the1986-2015 Period at Cairo, Egypt†

Eman Gaber *

Egypt Metrology Authority
* Correspondence: eman.hamza69@yahoo.com

† Presented at The 6th International Electronic Conference on Atmospheric Sciences, 15-30 October 2023.

Abstract: Daily temperature and precipitation were analyzed for Cairo (Latitude 30.18° S, Longitude: 31.2° E in Egypt. The study objective was to evaluate the climate indices for extreme weather conditions on temperature and precipitation from 1986 to 2015. Quality and homogeneity of the time series data were checked using ClimPACT2 software package was used to compute the indices. Annual maximum temperature were statistically significant with a negative linear trend (R2=0.0043). Additionally, results showed a amplitude heat wave Decrease in absolute indices .The maximum warmest daily temperature (TXx) index showed a predominant decrease in the monthly and annual maximum value of daily maximum temperature at Cairo. The minimum warmest daily temperature (TXn) showed a similar trend for the annual value. The Daily Temperature Range (DTR) significantly decreased annually resulting in a linear slope of 0.0478.Results also showed that the daily mean temperature (TMm) and mean daily maximum temperature (TXm) had increased from 1986 - 2015.

Keywords: ClimPACT2; climate indices; climate change; climate extremes

Citation: To be added by editorial staff during production.

Academic Editor: Firstname Lastname

Published: date

1. Introduction

Extreme events demonstrate long-term climate change and variability, for example droughts and heat waves, and are also of great importance for societal, environmental and economic impacts in most regions of the world [1]. Any change in the intensity of extreme climate events will have a profound impact on nature and society [2-4] so analysis of extreme events is needed. This requires monitoring, detecting, and basing extreme climate changes on daily time series data [3].

A Climate change affects precipitation around the world as reflected in mean precipitation as shown in the IPCC AR4 (2007) variability estimates [5,6].

Egypt's climate has a historical record of drought and floods [7]. The Expert Group on Climate Risk and Sector-Specific Indicators (ET CRSCI) created a program called ClimPACT to calculate climate indicators [9] in an easy way.

ClimPACT2 is a program that uses the R language to calculate special climate indicators and provides useful indicators for application in the sectors of health, agriculture, food security, water resources and hydrology. ClimPACT2 is based on calculations in the RClimDEX program developed by the World Meteorological Organization's Commission on Climatology (CCl)/World Climate Research Programme.

The development and analysis of these ClimPACT2 sector-specific indicators have contributed significantly to climate change discussions in IPCC assessment reports [1].

2. Materials and Methods

2.1. Study Area and Data

Cairo is the capital of the Arab Republic of Egypt. Its climate is semi-desert, its winters are very mild, and its summers are hot and sunny. The study was used on weather data in Cairo Governorate (latitude: 30.18 degrees south, longitude: 31.2 degrees east in Egypt).

Cairo Meteorological Station is located in northern Egypt, as shown in the picture.

Figure 1. Location of Cairo.

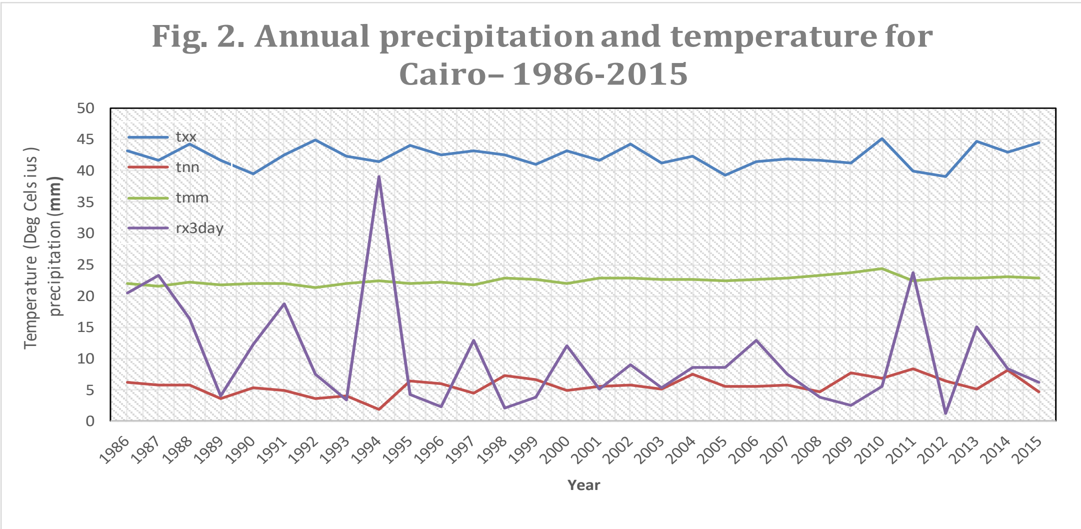


Figure 2. shows temperatures and rainfall in Cairo during the period - 1986-2015.

The year in the Arab Republic of Egypt is divided into four seasons. The hot season consists of three months (June, July, and August). It is the summer season, starting from mid-May to mid-September. It is hot and sunny. Heat waves are very frequent in the months of May and June. The weather gradually stabilizes, and air humidity rises with the rise in temperature, which increases our feeling of heat even more, reaching its peak in August due to pollution.

The winter rainy season starts from December to February and is very mild, similar to the spring season, and high temperatures usually reach about 20 degrees Celsius (68 degrees Fahrenheit). Due to cold air masses coming from Eastern Europe, some days can be cold. Somewhat, with temperatures high around 5°C (41°F) and lows around 10/13°C (50/55°F) and snow extremely rare. It is said that in February 1950, snow fell in the Nile Delta region. On 13 December 2013, Cairo was bleached by a type of snow-like precipitation, called downy hail, with a minimum temperature of 5 °C (41 °F) and a maximum of 8 °C (46.5 °F).

The spring season is from March to May. Spring, from March to mid-May, is pleasantly sunny and warm, but there may be some hot days when the Khamsin River is blowing. In March, it is still a little cold at night, especially in the first half of the month.

And the autumn or dry season (September to November) from mid-September to November, the weather is hot but without extremes, although it is possible that some hot days may occur in early October, when the fifty winds blow, then the weather gradually becomes more moderate, and it becomes Pleasantly warm in November.

Historical climate data (1986–2015) of daily precipitation and minimum and maximum air temperature were obtained from the Egyptian Meteorological Authority (EMA) and are shown in Figure 2

2.2. Climate Indices

The relevant expert group analyzed sector-specific climate indices (ET-SCI) related to daily temperature and precipitation characteristics. A full descriptive list of indicators is provided in [1,9]. ET-SCI indices of extreme temperature and precipitation have been used to explain many questions regarding aspects of the climate system that affect many human and natural systems, especially extreme events. Temperature indices describe cold and warm extremes while precipitation indices describe wet extremes. The studied indicators were divided into 5 categories as adapted from [12] and [13] and are presented in Tables 1 and 2.

2.2.1. Absolute Indices

Absolute indices are defined as the maximum or minimum value of weather parameters during a season or year. Examples of absolute temperature indices include the maximum warmest daily temperature (TXx), the minimum coldest daily temperature (TNn), the maximum daily minimum temperature (TNx), and the minimum maximum daily temperature (TXn).

Absolute precipitation indices are the maximum 1-day precipitation (RX1day) and the maximum 5-day precipitation (RX5day). Maximum precipitation regimes are defined as the monthly maximum 1-day precipitation amount (Rx1day) and the monthly maximum consecutive 5-day precipitation amount (Rx5day) [14].

Table 1. extreme temperature indices.

indices	Definition	units	Time scale	Sectors
TXx	Warmest daily TX	°C	Mon/Ann	AFS
TNn	Coldest daily TN	°C	Mon/Ann	AFS
DTR	Mean difference between daily TX and daily TN	°C	Mon/Ann	
TNx	Warmest daily TN	°C	Mon/Ann	
TXn	Coldest daily TX	°C	Mon/Ann	
TMm	Mean daily mean temperature	°C	Mon/Ann	
TXm	Mean daily maximum temperature	°C	Mon/Ann	
TNm	Mean daily minimum temperature	°C	Mon/Ann	

Table 2. extreme precipitation indices.

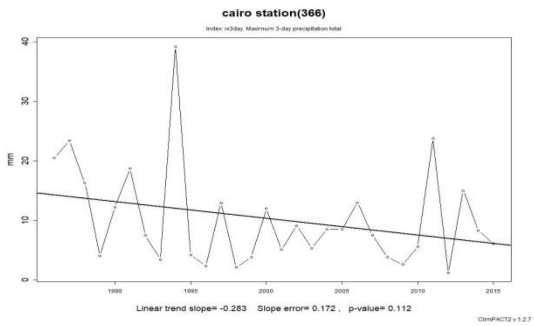
indices	Definition	units	Time scale	Sectors
R10mm	Number of days when PR >= 10 mm	days	Mon/Ann	
Rx1day	Maximum 1-day PR total	mm	Mon/Ann	
Rx3day	Maximum 3-day PR total	mm	Mon/Ann	
CWD	Maximum annual number of consecutive wet days (when PR >= 1.0 mm)	days	Ann	
CDD	Maximum No. of consecutive dry days (when PR < 1.0 mm)	days	Mon/Ann	H, AFS, WRH

2.3. Analysis and Calculation of Climate Indicators

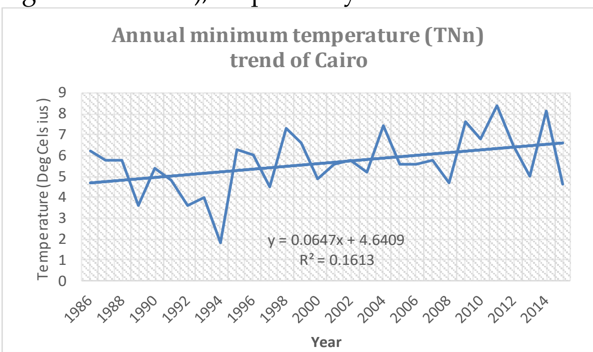
ClimPACT2 was used to calculate the climate indices presented in Tables 1 and 2, respectively[9,10]. Time series of daily maximum temperature (TX), daily minimum temperature (TN) and daily precipitation (PR) were used as inputs into ClimPACT2. The diurnal temperature range (DTR) was calculated as the difference between the maximum and minimum temperature during a 24-h period [15].

3. Results and Discussion

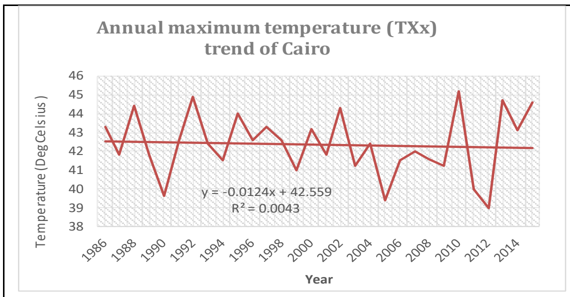
Figure 2 Shows annual time series and trends in precipitation and temperature. We find that the relative changes in the total percentage of the maximum 3-day period ranged from 15 mm to 40 mm of rain, but during the first years it ranged between 5 mm and 20 mm in the period from 1986 to 1993, then it increased sharply in 1994 until it reached 40 mm before Gradually decreasing again, the p-value of precipitation (lateral p-value = 0.112, Sen slope = -0.283) and correspondingly, the minimum temperature fluctuated between T1 and T2 2°C and 8.5°C as in Figure 3 . (Side p-value = 0.007, S-slope = 0.008).) statistically (see Fig. 3a and b). The maximum temperature showed a weak trend between the T1 and T3 values of 39°C and 45°C, which is statistically significant (p-value = 0.729, Sen slope = -0.012), and the average temperature anomaly also shows a more stable trend at 22°C. Although it increased in 2010 and reached 24, which is statistically significant (p-value = 0, slope S). = 0.054) (Figure 3C and D), respectively.



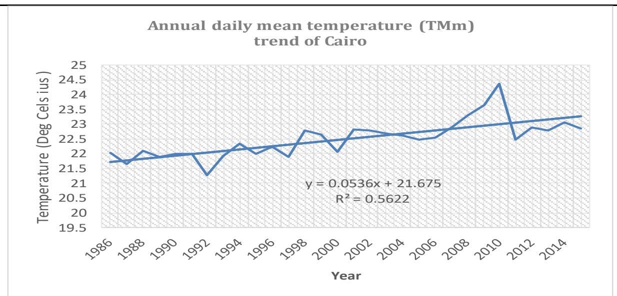
(**a**) Annual Maximum 3-day PR total Trend Cairo



(**b**) Annual minimum temperature trend Cairo



(**c**) Annual maximum temperature trend Cairo



(**d**) Annual Mean daily mean temperature trend Cairo

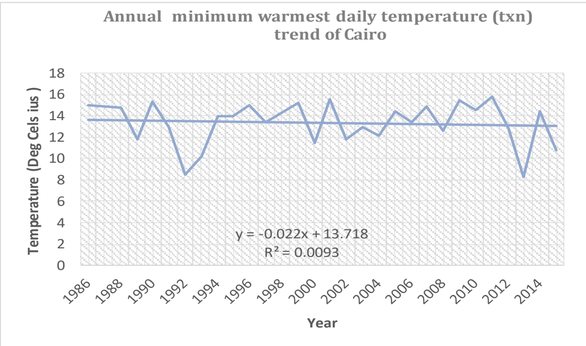
Figure 3. Annual precipitation and temperature for Cairo – 1986-2015.

Table 3 shows the warmest daily maximum temperature index (TXx) showed a prevailing steady state in the annual maximum value of daily maximum temperature in Cairo. The warmest daily minimum temperature (TXn) showed a similar trend as the annual value. The warmest daily TN increased significantly at P_Value = 0.008 and the coldest day TX had significantly decreased at P_Value 0.612 during the period 1986–2015. This study reported that recent climate change trends show that extreme heat is becoming more common, while extreme cold is becoming more common. And the average annual difference between daily TX and TN (DTR) decreased significantly at slope = -0.048. This indicates that the monthly average difference between the maximum and minimum temperature has decreased in Cairo. But the mean daily temperature (TMm) and mean maximum daily temperature (TXm) have increased from 1986-2015. And RX1day and RX3day had a non-significant negative trend at p = 0.112 in Figure 5.

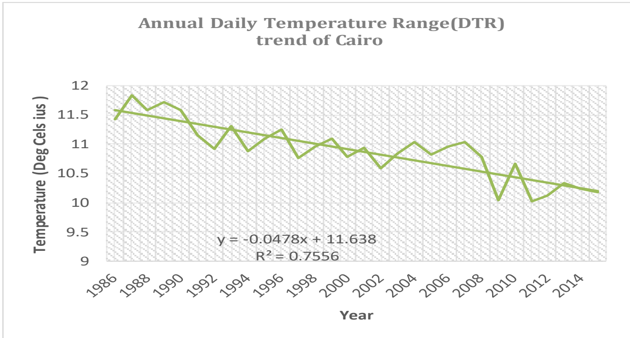
Table 3. This is a table Description Linear trend statistics for Cairo.

Index	Frequency	StartYear	EndYear	Slope	STD_of_Slope	P_Value
txx	ANN	1	12	-0.012	0.036	0.729
tnn	ANN	1	12	0.065	0.028	0.028
tnx	ANN	1	12	0.091	0.032	0.008
txn	ANN	1	12	-0.022	0.043	0.612
dtr	ANN	1	12	-0.048	0.005	0
tmm	ANN	1	12	0.054	0.009	0
txm	ANN	1	12	0.03	0.01	0.005
tnm	ANN	1	12	0.077	0.009	0

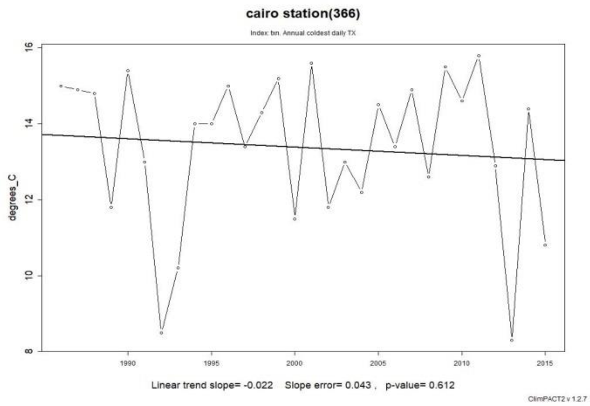
Index	Frequency	StartYear	EndYear	Slope	STD_of_Slope	P_Value
cdd	ANN	1	12	1.81	2.098	0.396
cwd	ANN	1	12	-0.033	0.016	0.053
r10mm	ANN	1	12	-0.022	0.01	0.032
rx1day	ANN	1	12	-0.18	0.132	0.184
rx3day	ANN	1	12	-0.283	0.172	0.112



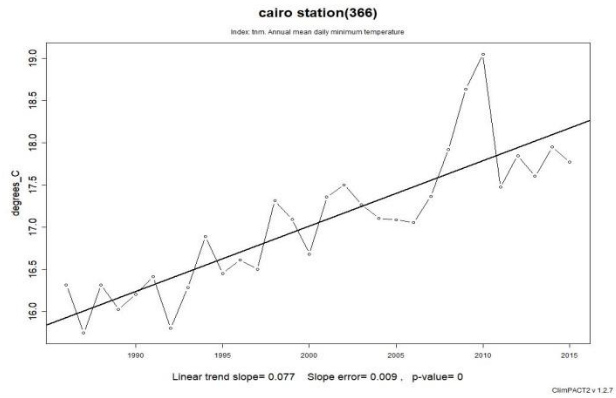
(**a**) Annual minimum warmest daily temperature trend Cairo



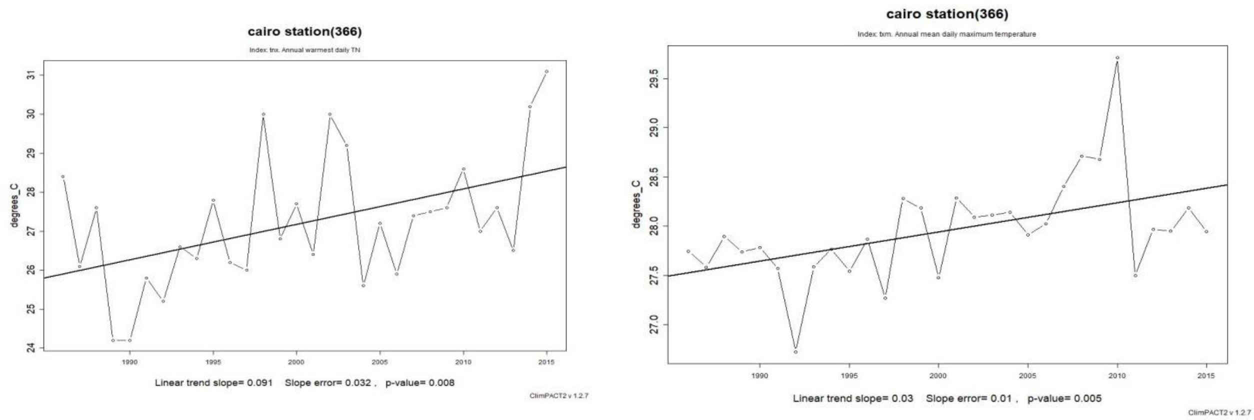
(**b**) Annual daily temperature range (DTR) trend Cairo



(c) Annual coldest daily TX

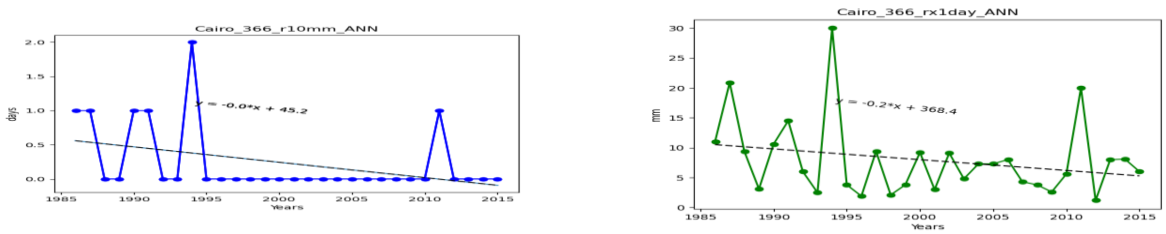


(d) Annual mean daily minimum temperature

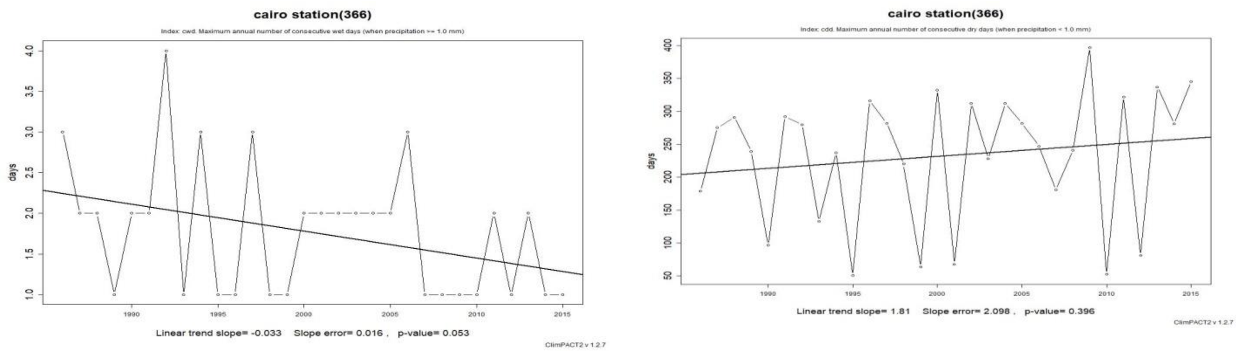


(e) Annual warmest daily TN (f) Annual mean daily maximum temperature

Figure 4. Annual temperature for Cairo – 1986-2015.



(**a**) Number of days when PR >= 10 mm (**b**) Maximum 1-day PR total



(c) Maximum annual number of consecutive wet days (when PR >= 1.0 mm) (d) Maximum No. of consecutive dry days (when PR < 1.0 mm)

Figure 5. Annual preciptation for Cairo – 1986-2015.

4. Conclusion

Climatic indices over Cairo provide valuable information contained in daily time series data based on daily minimum and maximum temperatures and precipitation time series from 1986 to 2015. Indices of extreme climate events are widely used in some disciplines and have become an important influencing parameter in climate change impact assessment studies.

The warmest daily maximum temperature index (TXx) showed a prevailing steady state in the annual maximum value of daily maximum temperature in Cairo. The warmest daily minimum temperature (TXn) showed a similar trend to the annual value and the warmest daily TN increased significantly at P_Value = 0.008 The coldest TX day decreased significantly at P_Value 0.612 during the period 1986–2015. This study stated that recent climate change trends show that extreme heat is becoming more common, while extreme cold is becoming more common.

Climate indices calculated based on temperature and precipitation can also be used as a means of reporting the impact of climate change on agricultural production systems and hydrological risks such as exposure time, threshold levels of event intensity.

References

1. Alexander LV. Global observed long-term changes in temperature and precipitation extremes: A review of progress and limitations in IPCC assessments and beyond. Weather Clim. Extrem.2016;11:4–16
2. Karl TR, Nicholls N, Ghazi A, Clivar/GCOS/WMO workshop on indices and indicators for climate extremes workshop summary. Clim. Change. 1999;42(1):3–7.
3. Peterson TC, Folland CC, Gruza G, Hogg W, Mokssit A, Plummer N. Report on the activities of the working group on climate change detection and related rapporteurs 1998–2001. Rep. WCDMP-47, WMO-TD 1071. 2001;143.
4. Peterson TC, Folland CC, Gruza G, Hogg W, Mokssit A, Plummer N. Report on the activities of the working group on climate change detection and related rapporteurs 1998–2001.Rep WCDMP-47, WMO-TD 1071. 2001;143.
5. Osman Y, Al-Ansari N, Abdellatif M Aljawad SB, Knutsson S. Expected future precipitation in central iraq using LARS- WG Stochastic Weather Generator. Engineering. 2014;3:948–959.
6. Hashmi MZ, Shamseldin AY, Melville BW. Downscaling of future rainfall extreme based approach. 18th World IMACS Congr. MODSIM09 Int. Congr. Model. Simul. Model. Simul. Soc. Aust. New Zeal. Int. Assoc. Math. Comput. Simul. 2009;3928–3934.
7. Baldi, M.; Amin, D.; Al Zayed, I.S.; Dalu, G.A. Extreme rainfall events in the Sinai Peninsula. In Proceedings of the EGU General Assembly Conference Abstracts 2017, Vienna, Austria, 23–28 April 2017; Volume 19, p. 13971.
8. Al Zayed, I.S.; Ribbe, L.; Al Salhi, A. Water harvesting and flashflood mitigation-wadi watier case study (South Sinai, Egypt). Int. J. Water Resour. Arid Environ. 2013, 2, 102–109.
9. Alexander L, Yang H, Perkins S. ClimPACT. Indices and software. A document prepared on behalf of The commission for climatology (CCl) expert team on climate risk and sector-Specific Climate Indices (ET CRSCI); 2013.
10. Alexander L, Herold N. Clim PACT2. Indices and software. A document prepared on behalf of the commission for climatology (CCl) Expert Team on SectorSpecific Climate Indices (ET-SCI); 2016. 11.
11. Huang J, Zhang J, Zhang Z, Sun S, Yao J. Simulation of extreme precipitation indices in the Yangtze River basin by using statistical downscaling method (SDSM). Theor. Appl. Climatol. 2011;1–19. 12.
12. Alexander LV, Zhang X, Peterson TC, Caesar J, Gleason B,. Tank Haylock AMGKM, Collins D, Trewin B, Rahimzadeh F, Tagipour A, Kumar KR, Revadekar J, Griffiths G, Vincent L, Stephenson DB, Burn J, Aguilar E, Brunet M, Taylor M, New M, Zhai P, Rusticucci M, VazquezAguirre JL, Global observed changes in daily climate extremes of temperature and precipitation. J. Geophys. Res. Atmos. 2006;111(5):1–22.
13. Fonseca D, Carvalho MJ, Marta-Almeida M, Melo-Gon P?? Alves, Rocha A. Recent trends of extreme temperature indices for the Iberian Peninsula. Phys. Chem. Earth. vol. 2016;94:66–76.
14. Zhang Q, Xiao M, Singh VP, Chen YD, Max-stable based evaluation of impacts of climate indices on extreme precipitation processes across the Poyang Lake basin, China. Glob. Planet. Change. 2014;122:271–281.
15. IPCC, Annex 11: Glossary of terms. Cambridge University Press, Cambridge, UK, and New York, NY, USA; 2012.