

Spatiotemporal Variability of Heat Waves in Egypt : Duration , Intensity , and Frequency (1990 – 2023)

FATMA REDA AMIN ISMAIL1*, prof.Mohamed Magdy Abdelwahab2 ,Dr.Zeinab Salah1 , Dr.Moetasm El-Taweel2.

1Egyptian Meteorological Authority (EMA) , 2Astronomy, Space Sciences and Meteorology Department,

Faculty of Science , Cairo University,

*fatmareda598@gmail.com

Abstract

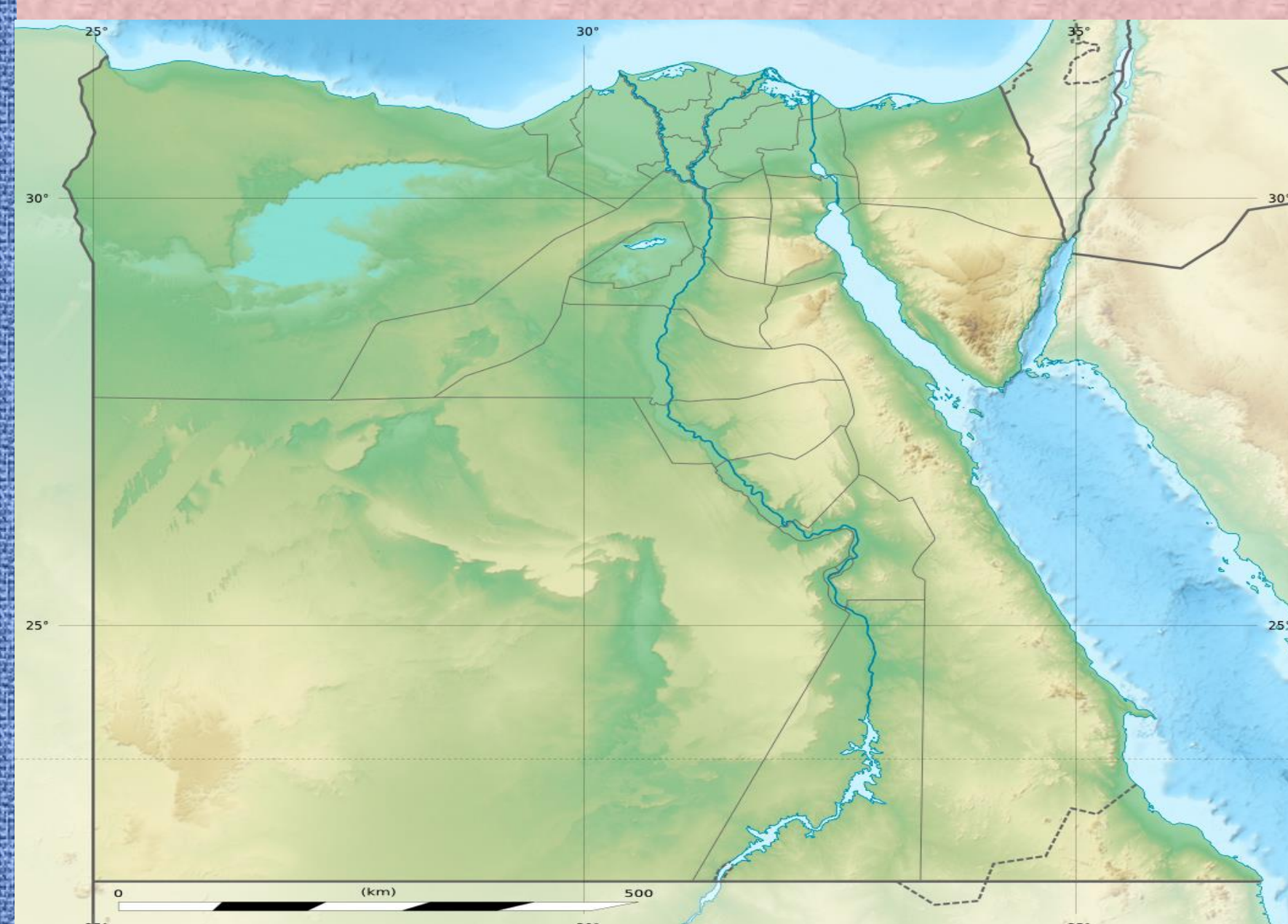
Heat waves are among the most severe extreme climate events, significantly affecting human health, agriculture, energy demand, and ecosystems. This study examines the characteristics of heat waves in Egypt using long-term daily maximum and minimum temperature data from ERA5 reanalysis for the period 1990 –2023.

Heatwave events were identified for both daytime and nighttime conditions and analyzed in terms of duration, intensity, frequency, seasonal distribution, and temporal trends.

The results reveal marked interannual and seasonal variability in heatwave characteristics across Egypt. Several years, particularly 2010, 2015, 2016, and 2021, were identified as exceptionally hot. Heatwaves occurred most frequently from late July to mid-August, while they were relatively rare during spring and autumn, confirming their strong dominance in the summer season. Despite considerable variability, the findings indicate an increasing tendency toward more frequent and intense heatwave events in recent years. These results provide valuable insights for energy management, agricultural planning, and climate adaptation strategies under ongoing climate warming.

Objectives

- Detect heatwaves over Egypt during 1990-2023.
- Detect day time heatwave and night time heatwave based on 90th percentile of Tmax & Tmin threshold.
- Detect intensity and frequency , and If Has it increased rapidly in recent years ?
- detect the common days which is repeated every year during heatwave event then analysis the reason and detect the common reason for it and also detect and study reasons of the longest heatwave in the recent year.
- Benefit in determining energy needs during the summer.
- Benefit from studying drought and determining the water requirements for agriculture.

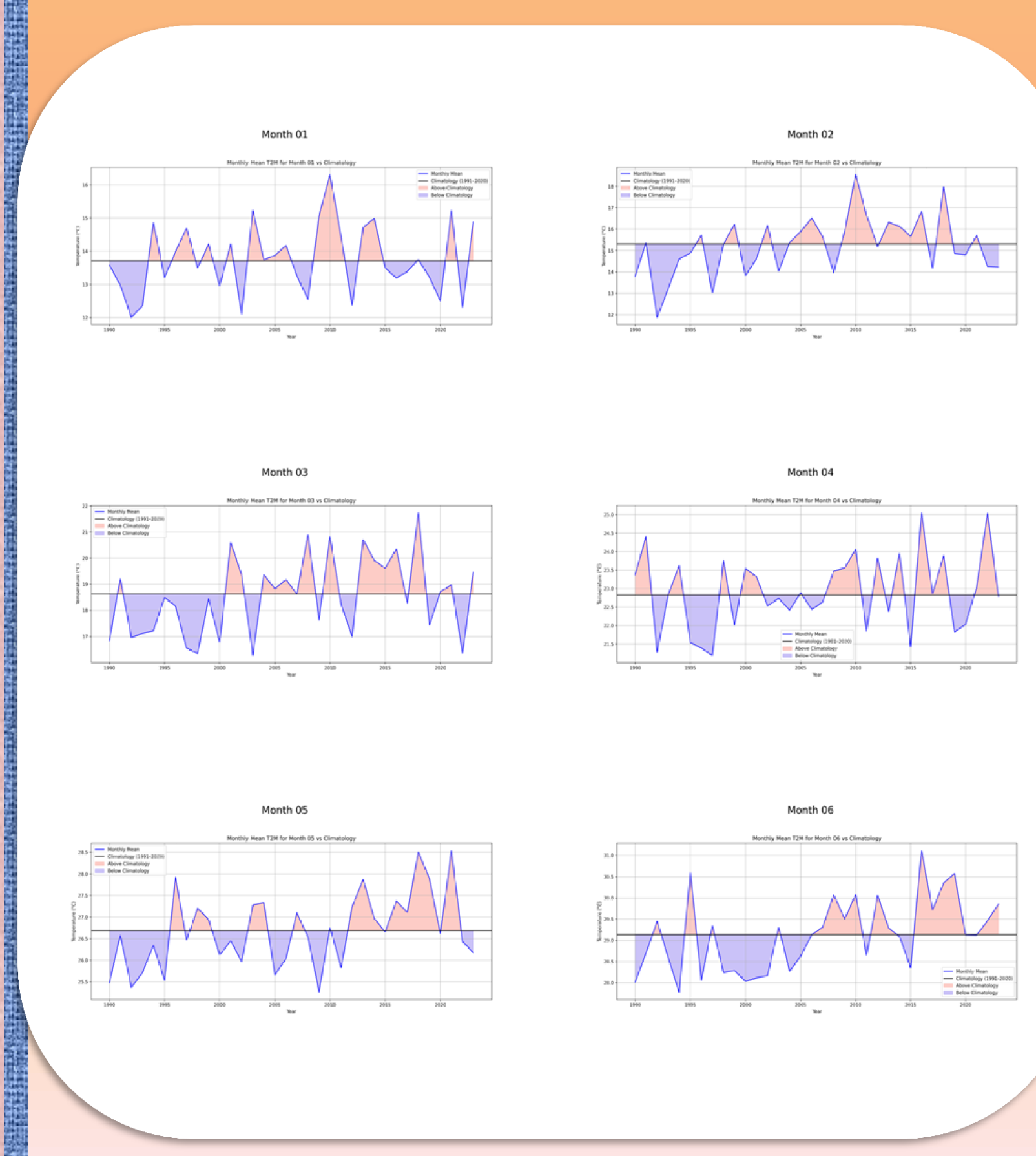


Results

- ❑ In January, 2010 recorded the highest temperature.
- ❑ In February, 2010 was the hottest year, closely followed by 2018.
- ❑ In March, the highest temperature was observed in 2018, while in April 2016 was the hottest, with 2022 slightly lower.
- ❑ In May, 2021 showed the highest temperature, with 2018 following closely.



- ❑ In June, 2016 again recorded the highest value, while in July the top was observed in 2002.
- ❑ In August, 2015 was the hottest month, while in September 2015 stood out, with 2020 slightly lower.
- ❑ In October, 2010 showed the highest temperature, while in November the maximum was observed in 2023, closely followed by 2010. Finally,
- ❑ in December, the hottest year was 1990, with 2023 slightly lower.



Introduction

Egypt's climate is dominated by hot desert conditions, with extremely high summer temperatures and large day–night variations. Heatwaves represent one of the most critical climate extremes, defined as periods of unusually high temperatures lasting at least two days relative to local climate norms.

Their frequency, duration, and intensity have major implications for health, agriculture, and energy systems. Understanding heatwave behavior in Egypt is essential due to the country's high vulnerability to extreme .

Methodology

- All datasets used in this study ERA5 reanalysis (1990 - 2023) and CMIP6 model outputs for Scenarios :-

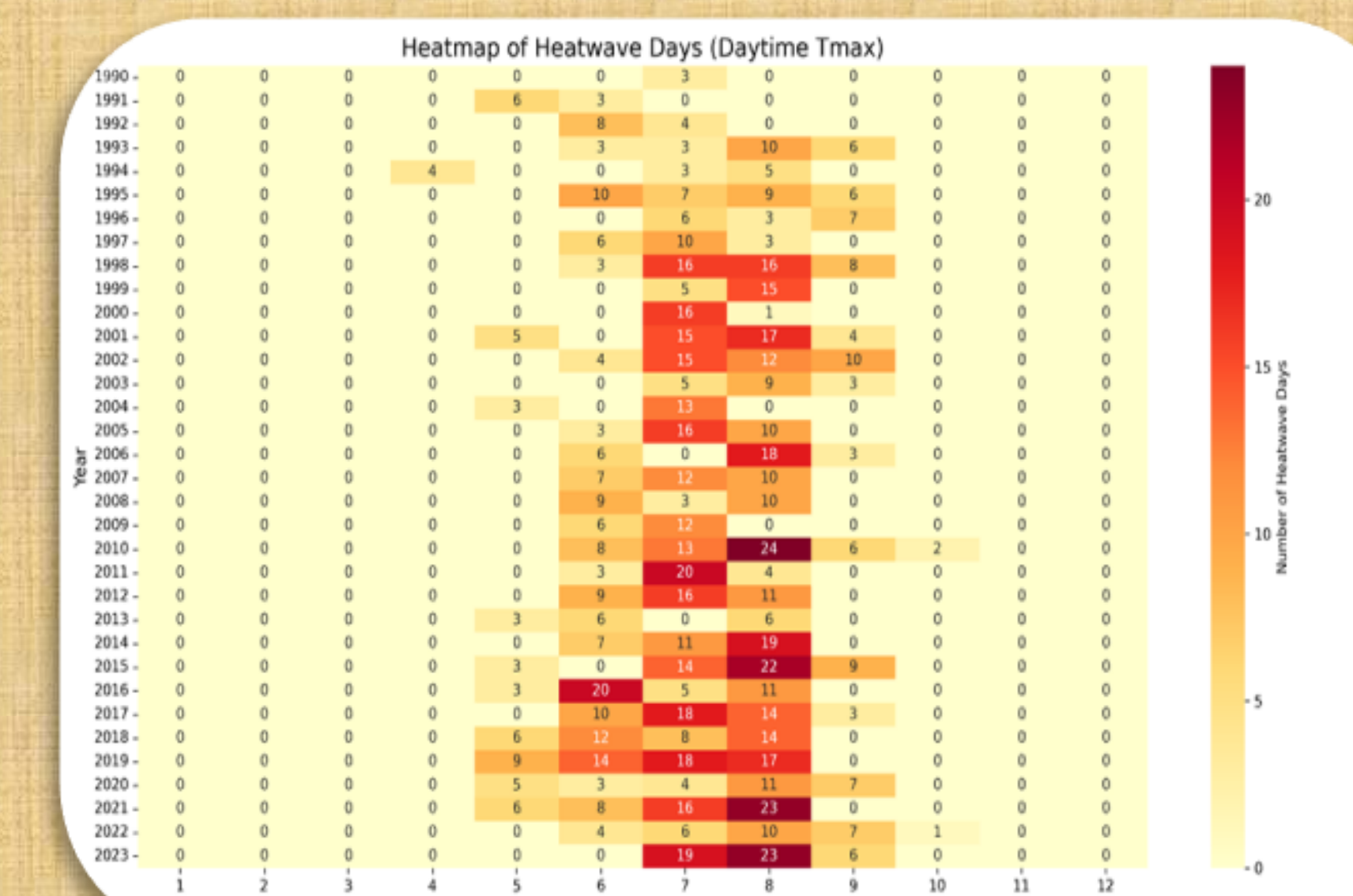
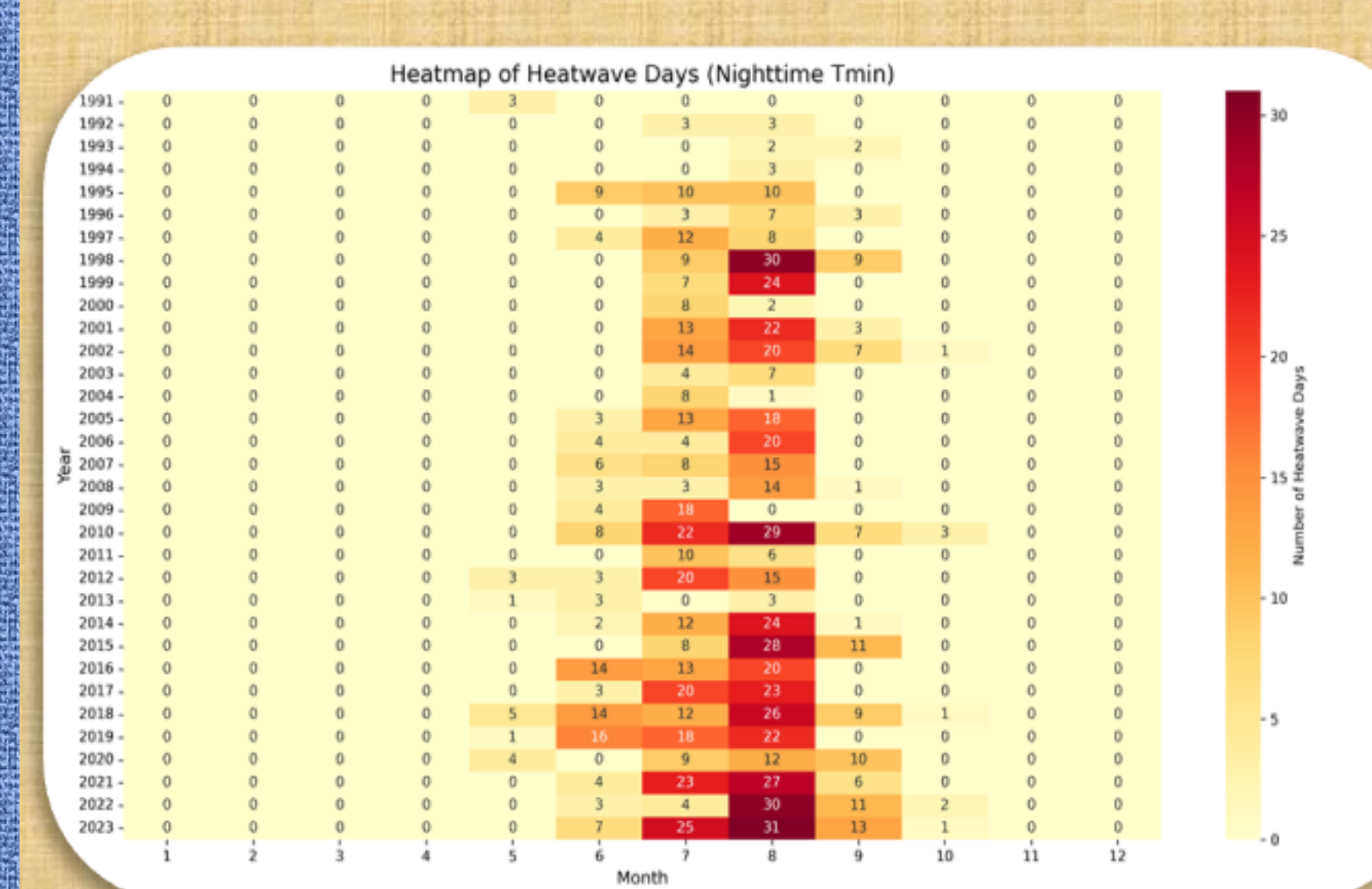
- Historical 1990 – 2014
- SSP245 2015 -2100
- SSP585 2015 – 2100

were clipped and processed over the same spatial domain, defined between latitudes 22 – 32° N and longitudes 24 – 37° E, and regrid to 0.5 then corrected CMIP6 data with ERA5 from 1990-2014 , covering the Egyptian territory to ensure spatial consistency in heatwave analysis.

Conclusion

- ❖ From heatmap, the analysis of heatwave days and the identification of common periods across years revealed that heatwaves most frequently occurred during the last week of July, the first and second weeks of August, and the last week of August. By contrast, heatwaves were less frequent during April, May, June, September, and October, highlighting a clear seasonal pattern in their occurrence.

Tmax Threshold (90th percentile) = 35.77 ~ 35.8°C
Tmin Threshold (90th percentile) = 24.8 °C



References

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- ❖ Heatwaves show a clear seasonal pattern, with peak occurrence from mid-June to late August, especially during the last week of July and early August.
- ❖ Daytime heatwaves are occasionally accompanied by nighttime events, while occurrences remain rare in spring and early autumn.

