Climate change impacts on bioclimatic conditions in the Eastern Mediterranean

Panagiotis T. Nastos[1], Iliana D. Polychroni[1], John Kapsomenakis[1], Stavros Solomos[2], and Christos S. Zerefos[1,2]

[1]Laboratory of Climatology and Atmospheric Environment, Department of Geology and Geoenvironment, National and Kapoditrian University of Athens
[2]Research Center for Climatology and Atmospheric Physics, Academy of Athens

Background:

- ✓ More than 50% of the world's population (IPCC, 2013) and almost 75% of Europeans (Eurostat, 2016) live in urban areas.

- ✓ It is estimated that in the cities of southern Europe, due to climate change, there will be a greater increase in the number of hot days (Guerreiro, 2018).

- ✓ However, the increase in maximum temperature during heat waves is expected to be greater in Central European cities.

- ✓ These future climate forecasts are very likely to shape and influence the criteria for choosing a place as a touristic destination.

The objective of this study is:

- to highlight the bioclimatic conditions anticipated to prevail in the eastern Mediterranean, studying five touristic destinations; namely, Heraklion, Crete Island (Greece), Antalya (Turkey), Limassol (Cyprus), Valletta (Malta) and Cairo (Egypt).

- Although the Mediterranean is considered as a hot spot for climate change, the specific climatological properties of individual sites are expected to vary significantly with obvious implications for the touristic activites.

Data and methodology used in this study:

✓ To assess the biometeorological conditions over the study area, the human thermal index Physiologically Equivalent Temperature (PET) was estimated by using the RayMan energy model.

✓ PET is based on the human energy balance model MEMI (Munich Energy Balance Model for Individuals)

✓ PET is defined as the air temperature at which the energy balance for the assumed indoor conditions is balanced by the same mean skin temperature and sweat rate as calculated for the actual outdoor conditions.

Data and methodology used in this study:
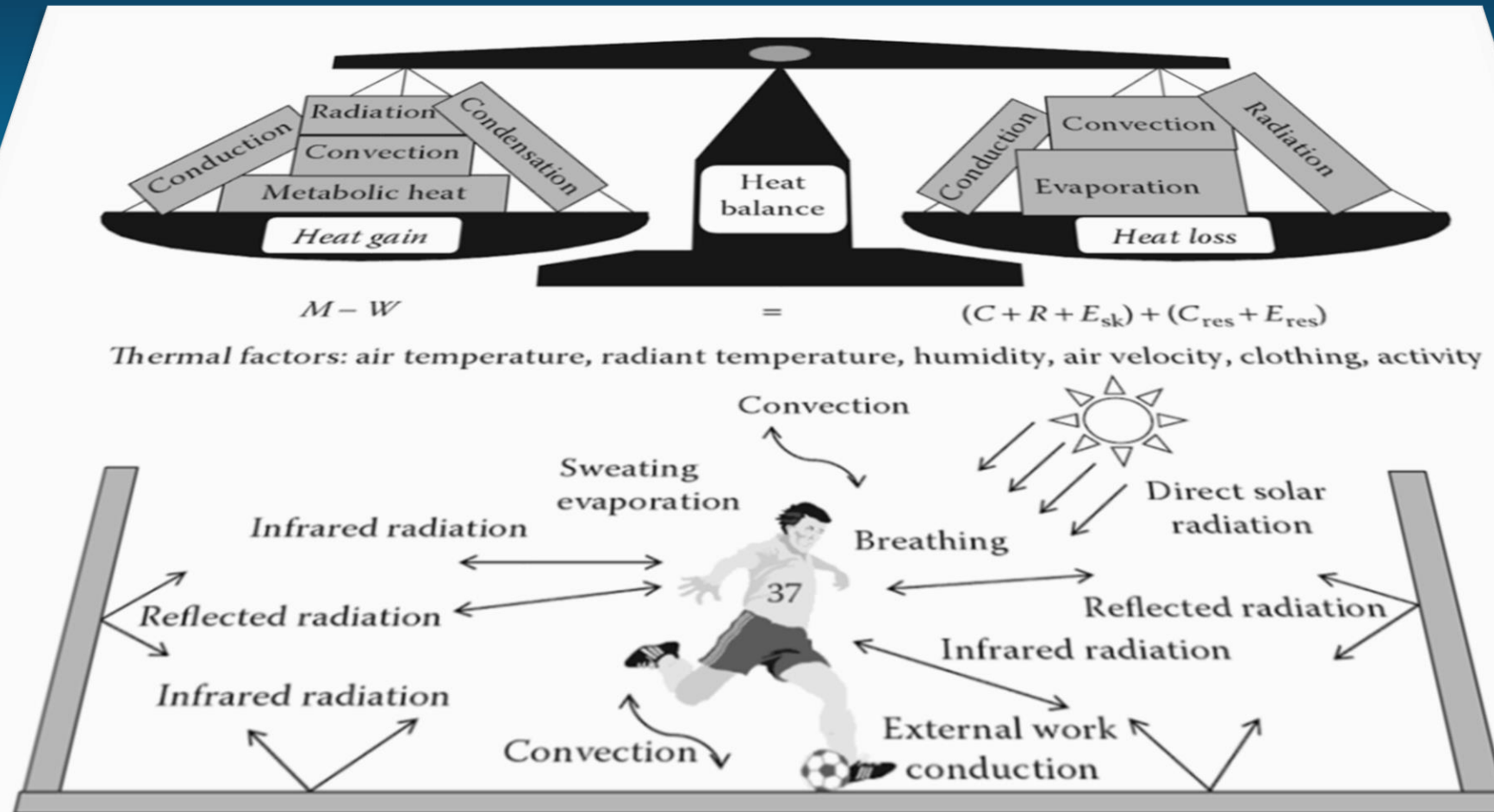
Illustration of the fundamental energy balance equation

Data and methodology used in this study:

PET (ºC)	Thermal Perception	Physiological stress level
<4	Very Cold	Extreme Cold Stress
4-8	Cold	Strong Cold Stress
8-13	Cool	Moderate Cold Stress
13-18	Slightly Cool	Slight Cold Stress
18-23	Comfortable	No Thermal Stress
23-29	Slightly Warm	Slight Heat Stress
29-35	Warm	Moderate Heat Stress
35-41	Hot	Strong Heat Stress
>41	Very Hot	Extreme Heat Stress

Threshold values of PET for different grades of thermal sensation and physiological stress on human beings (during standard conditions (according to Matzarakis and Mayer, 1996)

Data and methodology used in this study:

- ✓ Air temperature, humidity, wind speed and global solar radiation (estimated at 1.1m where is the gravity center of the human body and builds the reference level for human biometeorological studies) are the parameters needed for the assessment of PET

- ✓ The meteorological datasets concern 3-hour data from the SMHI RCA4 regional climate model (Rossby Center, Swedish Meteorological and Hydrological Institute, Norrkoping Sweden, spatial analysis 11 km), for the historical period 1971-2000 (reference period), as well as for the periods 2021-2050 and 2071-2100 under the two Representative Concentration Pathways, RCP4.5 (intermediate) and RCP8.5 (extreme).
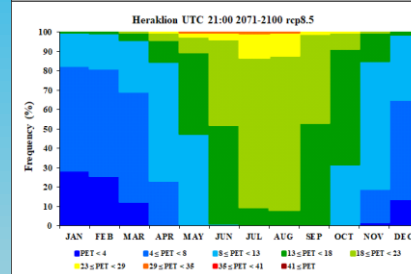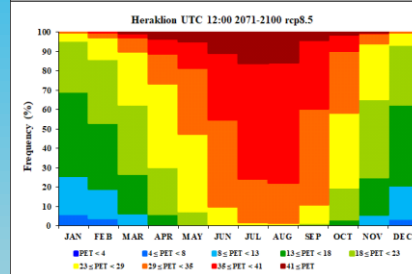
Results:

Freqency (%) of PET classes for the Heraklion, Crete Island (Greece)

A: diagrams for the reference period 1971-2000 for the hours 12:00 and 21:00

B: diagrams for the period 2021-2050 for the RCP 4.5 and RCP8.5 for the hours 12:00 and 21:00

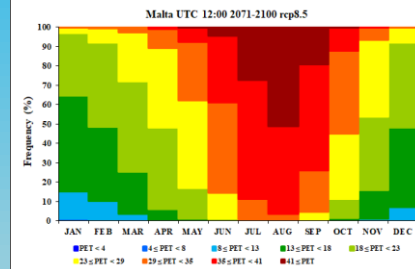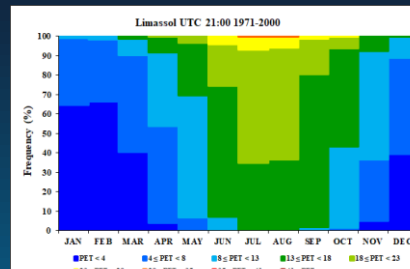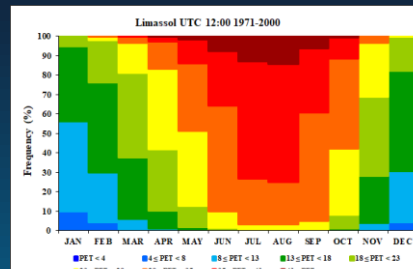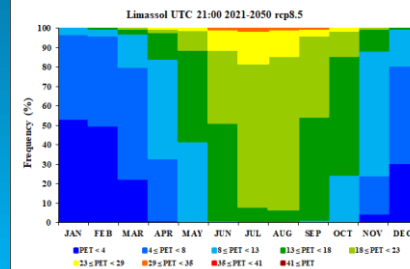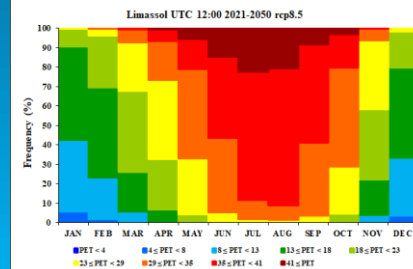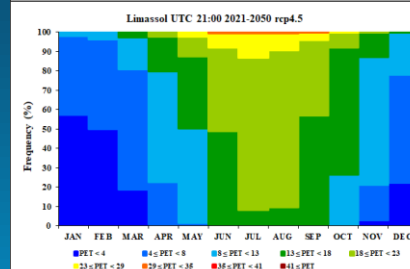C: diagrams for the period 2071-2100 for the RCP 4.5 and RCP8.5 for the hours 12:00 and 21:00.
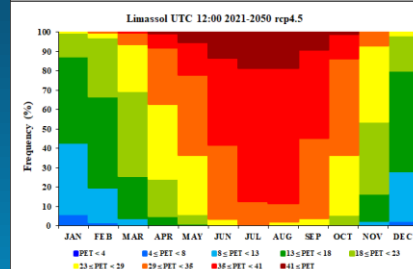
Results:
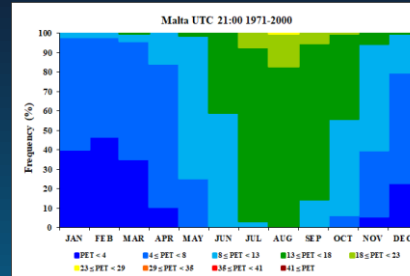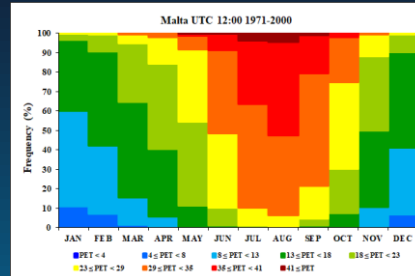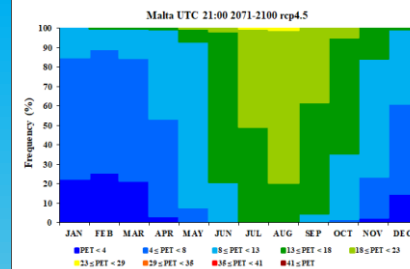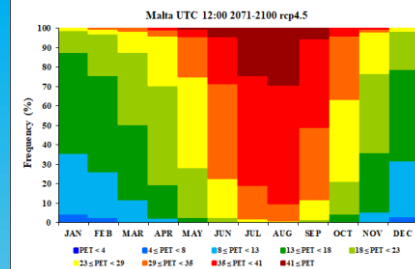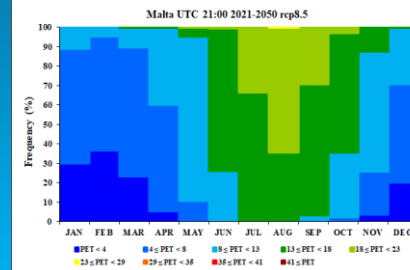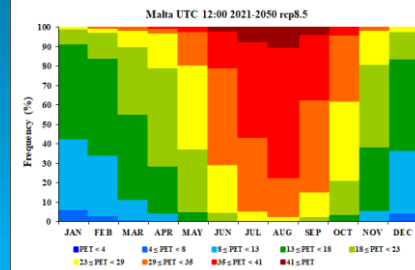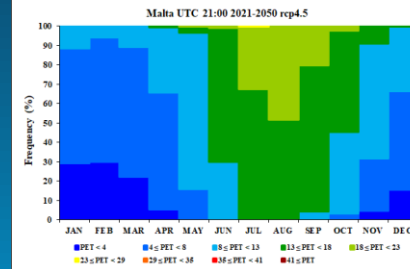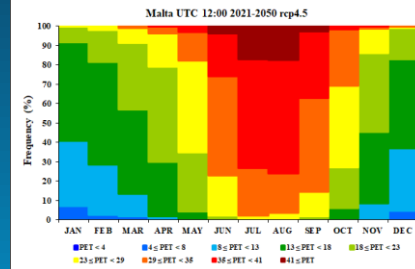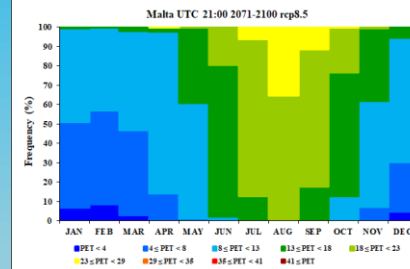
Frequency (%) of PET classes for the Valletta (Malta)

A: diagrams for the reference period 1971-2000 for the hours 12:00 and 21:00

B: diagrams for the period 2021-2050 for the RCP 4.5 and RCP8.5 for the hours 12:00 and 21:00

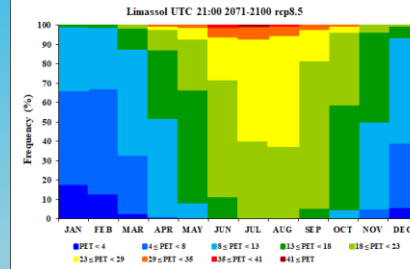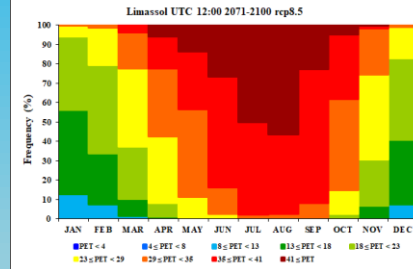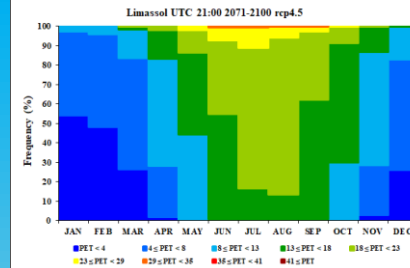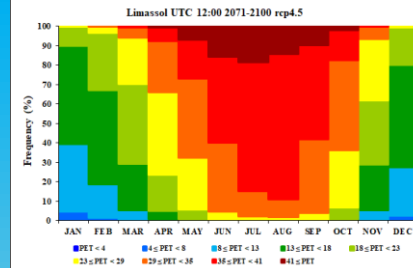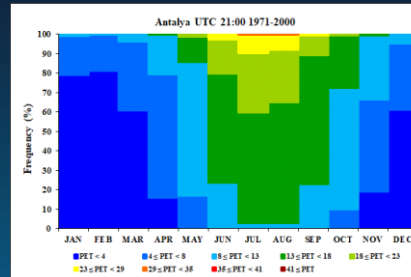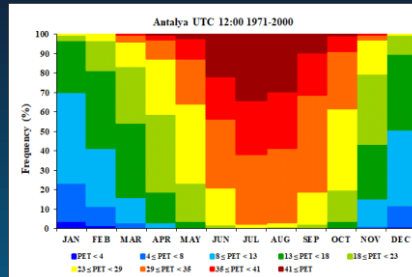C: diagrams for the period 2071-2100 for the RCP 4.5 and RCP8.5 for the hours 12:00 and 21:00.

Results:

Frequency (%) of PET classes for the Limassol (Cyprus)

A: diagrams for the reference period 1971-2000 for the hours 12:00 and 21:00

B: diagrams for the period 2021-2050 for the RCP 4.5 and RCP8.5 for the hours 12:00 and 21:00

C: diagrams for the period 2071-2100 for the RCP 4.5 and RCP8.5 for the hours 12:00 and 21:00.
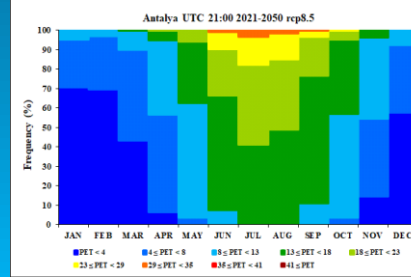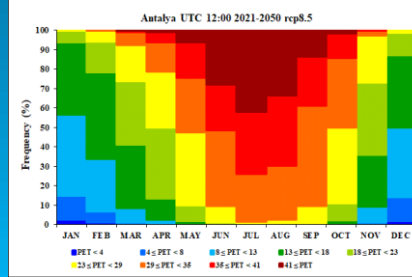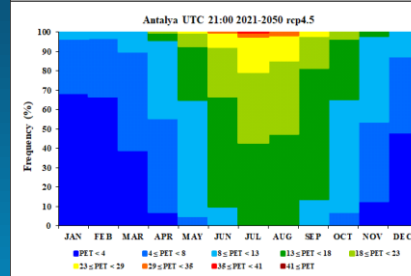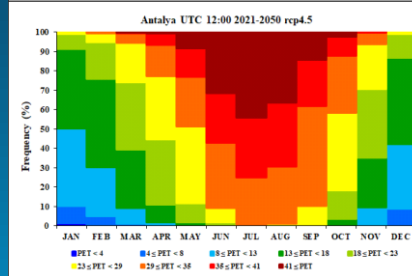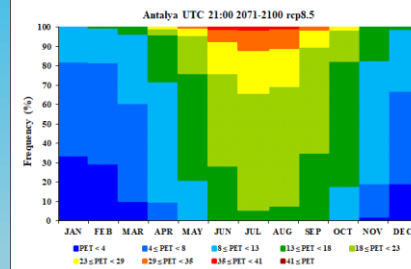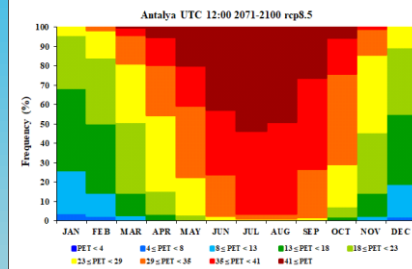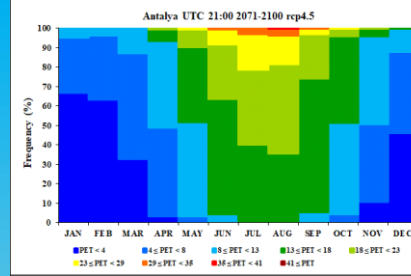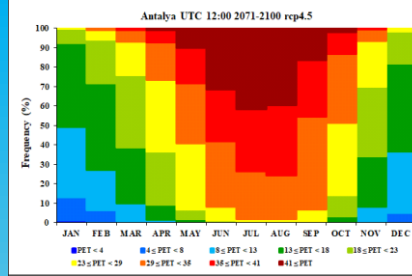
Results:

Frequency (%) of PET classes for the Antalya (Turkey**)**

A: diagrams for the reference period 1971-2000 for the hours 12:00 and 21:00

B: diagrams for the period 2021-2050 for the RCP 4.5 and RCP8.5 for the hours 12:00 and 21:00

C: diagrams for the period 2071-2100 for the RCP 4.5 and RCP8.5 for the hours 12:00 and 21:00.

Results:

Frequency (%) of PET classes for the Cairo (Egypt)

A: diagrams for the reference period 1971-2000 for the hours 12:00 and 21:00
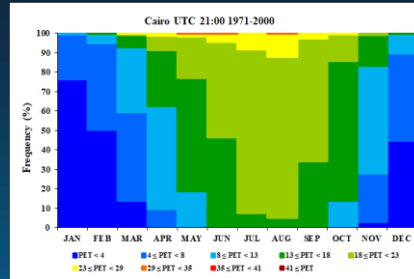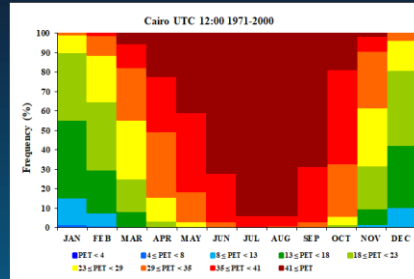
B: diagrams for the period 2021-2050 for the RCP 4.5 and RCP8.5 for the hours 12:00 and 21:00

C: diagrams for the period 2071-2100 for the RCP 4.5 and RCP8.5 for the hours 12:00 and 21:00.
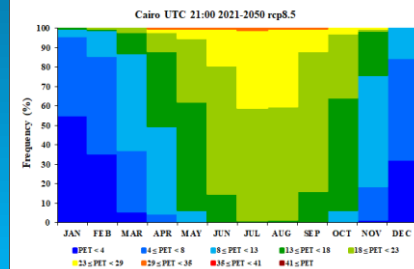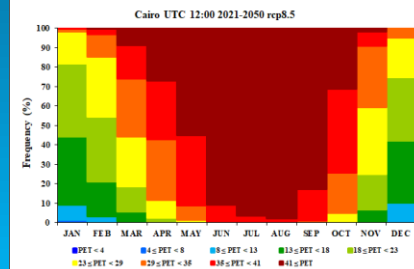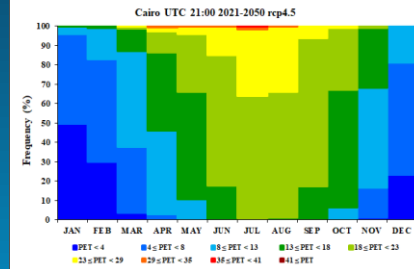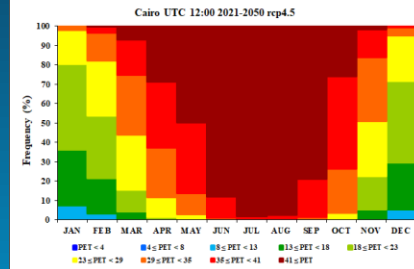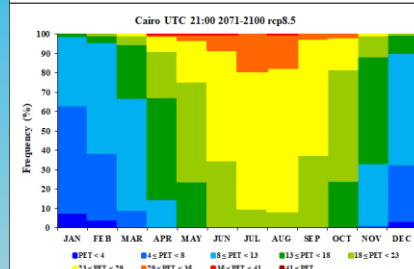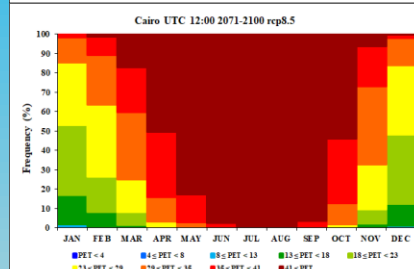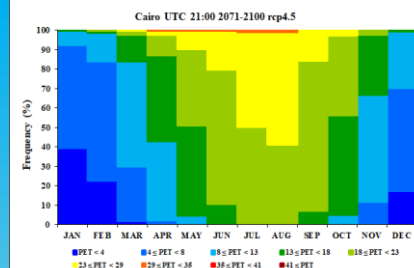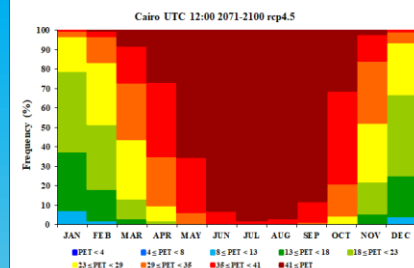
Conclusions:

- ✓ The biometeorological analysis reveal the PET classes (%) at the five touristic destinations for the midday and the evening for the historical period (1971-2000), the near future (2021-2050) and the far future (2071-2100) under the RCP4.5 and RCP8.5.

- ✓ As far as the historical period is concerned, the findings of the analysis showed that Heraklion, Crete Island, appears the most favorable bioclimatic conditions at midday (UTC 12:00), followed by Limassol and Malta, while Cairo and Antalya show high frequency and duration of strong/extreme heat stress within the year. Regarding evening hours (UTC 21:00) during summertime, there is a slight cold stress/thermal comfort in Heraklion and Malta, followed by Limassol, Antalya and Cairo with worse bioclimatic conditions.

Conclusions:

✓ Based on climate model simulations for 2021-2050 (near future) and 2071-2100 (far future) under RCP4.5 and RCP8.5, for midday (UTC 12:00), Heraklion, Crete Island depicts the best bioclimatic conditions, which can be attributed to the increased frequency and intensity of the Etesians winds, blowing during the summer period of the year contributing to the mitigation of the strong/extreme heat stress.

✓ The frequency and the duration of thermal comfort in the evening (UTC 21:00) is expected to increase for both RCPs. Malta shows similar bioclimatic behavior to Heraklion during evening hours, followed by Limassol, Antalya and Cairo, where the light/moderate heat stress occurs with increasing frequency and seasonality.

Conclusions:

✓ The results of the bioclimatic analysis offer an important decision tool for the management/dissemination of climate information for tourism purposes. In addition, the methodology used, based on bioclimatic (PET) diagrams, can provide detailed information in order to assess and quantify the climate change impacts on the tourism potential in the eastern Mediterranean.

Ευχαριστώ πολύ για την προσοχή σας

Thank you for your attention