Calculation of comfortable thermal conditions for Mersin urban city planning in Turkey

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Abstract

Computer models that evaluate the formulas of these indices together with environmental factors and human characteristics have been created. Physiological equivalent temperature index and classification summer calculation model used for bioclimatic comfort calculations by obtaining monthly data of General Directorate of State Metrology Stations between 1972 and 2018 in Mersin city center. The results, comfortable monthly intervals, were determined and necessary suggestions were made for the people of Mersin city center in a month. In the calculations, the meteorological parameters such as surface-and-air temperature, wind speed, and relative humidity were taken into consideration. Monthly results show the bioclimatically comfortable area in September and May. There are conditions in Mersin that lead to comfortable perceptions in summer. During the cold period, different levels appear and warm and comfortable thermal conditions are observed. GIS analysis was used to determine the development of thermal perceptions over time. It was calculated between 1972 and 2018. According to these coefficients, there is a tendency to increase in PET values in the regions close to the water in Mersin and to decrease in Mersin, which is the station in rural areas, as a city station.

Keywords Bioclimatic comfort · Mersin · Urban city · Urban plan

Introduction

Thermal comfort indices play an important role in bioclimatology studies. These indices are based on the measurement of human reactions to meteorological parameters. Nowadays, several thermal comfort indices have been developed using various parameters. There are relatively simple and easy-to-use thermal comfort indices using a few meteorological parameters, as well as more complex indices that includes people's differences in their calculations. With the establishment of cities, energy transfer (radiation, convection, conduction), thermal conditions (specific heat, albedo), humidity conditions (evaporation, precipitation, surface flow), and air circulation systems change. These changes make the difference between cities and the natural environment. Air pollution, anthropogenic heat, impermeability of surfaces, thermal properties of materials used on surfaces, and surface geometry are also effective (Chung and Yoon 1999; Kim et al. 2016, 2017; Zeren Cetin and Sevik 2020; Cetin 2015, 2016a, b, 2019, 2020; Chung and Kim 2008, 2019; Cetin et al. 2018, 2019; Li et al. 2019; Zeren Cetin et al. 2020; Kilicoglu et al. 2020; Insaf et al. 2013; Sevik et al. 2017).

Climate is an important role for people as distribution of the earth, food and clothing choices, housing and housing structures, physiological development, and character, and plays an important role. In studies of the relationship between urban climate and bioclimatic comfort, the effect of comfort in parks, lakes or shores, street canyons, urban morphology, urban-rural comparisons, and urban modeling climate is investigated in parks to determine the importance of green spaces (Cetin et al. 2018, 2019; Insaf et al. 2013; Adiguzel et al. 2020; Kim et al. 2016, 2017; Cetin 2015, 2019, 2020; Zeren Cetin and Sevik 2020; Chung and Kim 2008, 2019; Li et al. 2019; Zeren Cetin et al. 2020).

In this research, the conditions of bioclimatic comfort of the city of Mersin were analyzed with the data obtained from the measurements made in areas with different terrain textures (high building density area, suburban rural area, city center green area, agricultural area, and city forest). It is aimed to find

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out where these comfort areas emerge in the region as well as the comfort areas experienced at different times of the year through monthly measurements in Mersin. This study aims to provide the concrete conditions of the weather conditions in which people feel comfortable and/or uncomfortable and the effects of man-made elements that change these conditions.

Materials and method

Mersin as research material is in the Mediterranean Seacoast; the southern Sea region in Turkey is with coordinates of 36° 81′ N latitude; 34° 64′ E longitude (Fig. 1). In this study, monthly relative humidity, air temperature, global solar radiation, and wind speed data of the stations reflecting different terrain textures for the period 1972–2018 were used. Each station represents a different elevation and land use areas. There are comfort value properties used to determine the spatial and temporal distribution of bioclimatic conditions. The surface area of the region of Mersin is dominated by the Mediterranean climate for the majority of the year that has cultural, recreational natural, and resources and has a high value. The climate type of the study area is defined as the Csa which is characterized by dry summers and mild, wet winters which depends on the classification of Köppen-Geiger (Ozturk et al. 2017). Mersin has its highest rainfall in winter. The coldest month is January where it reaches − 3 °C. July and August witness the highest temperature (28 °C to 29 °C). Twenty-three degrees Celsius is the annual average temperature. The more rainy regions are in the northern slopes. Bibliographic studies are showing the changes in thermal arrays over time. In this study, air temperature, which has region usage wide area in the world, PET-Physiological Equivalent Temperature index, which is one of the indices that evaluate the thermoregulators aim to providing a balance of human heat based on meteorological parameters. Hourly average PET values were calculated by using GIS software from the data obtained from the meteorological stations. GIS can calculate the average radiant temperature and thermophysiological temperature by using data (clouds cover, air temperature, wind speed, vapor pressure). The values of PET obtained from the stations were calculated by means of GIS software, elevation and land use values, and corpus classification analysis.
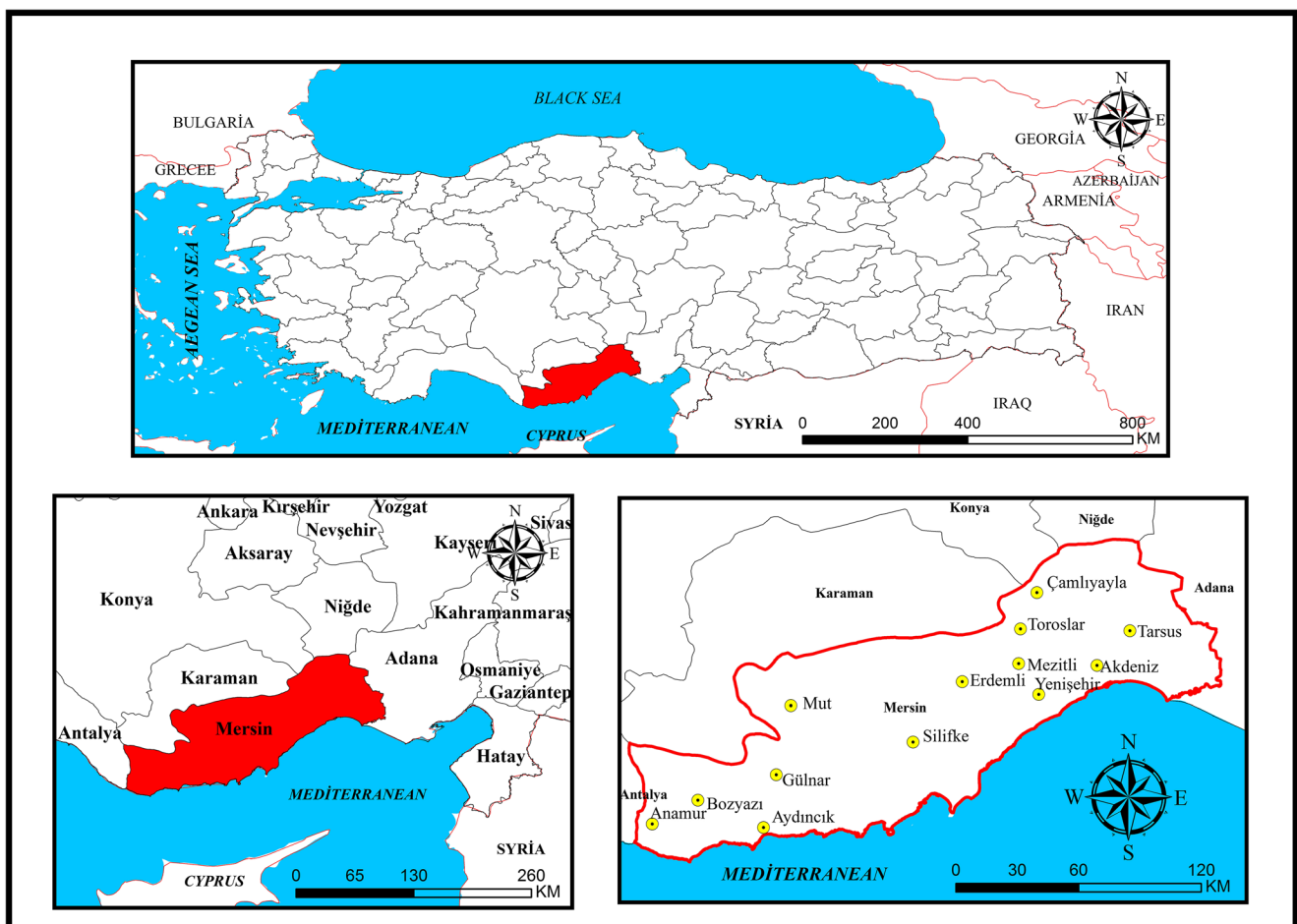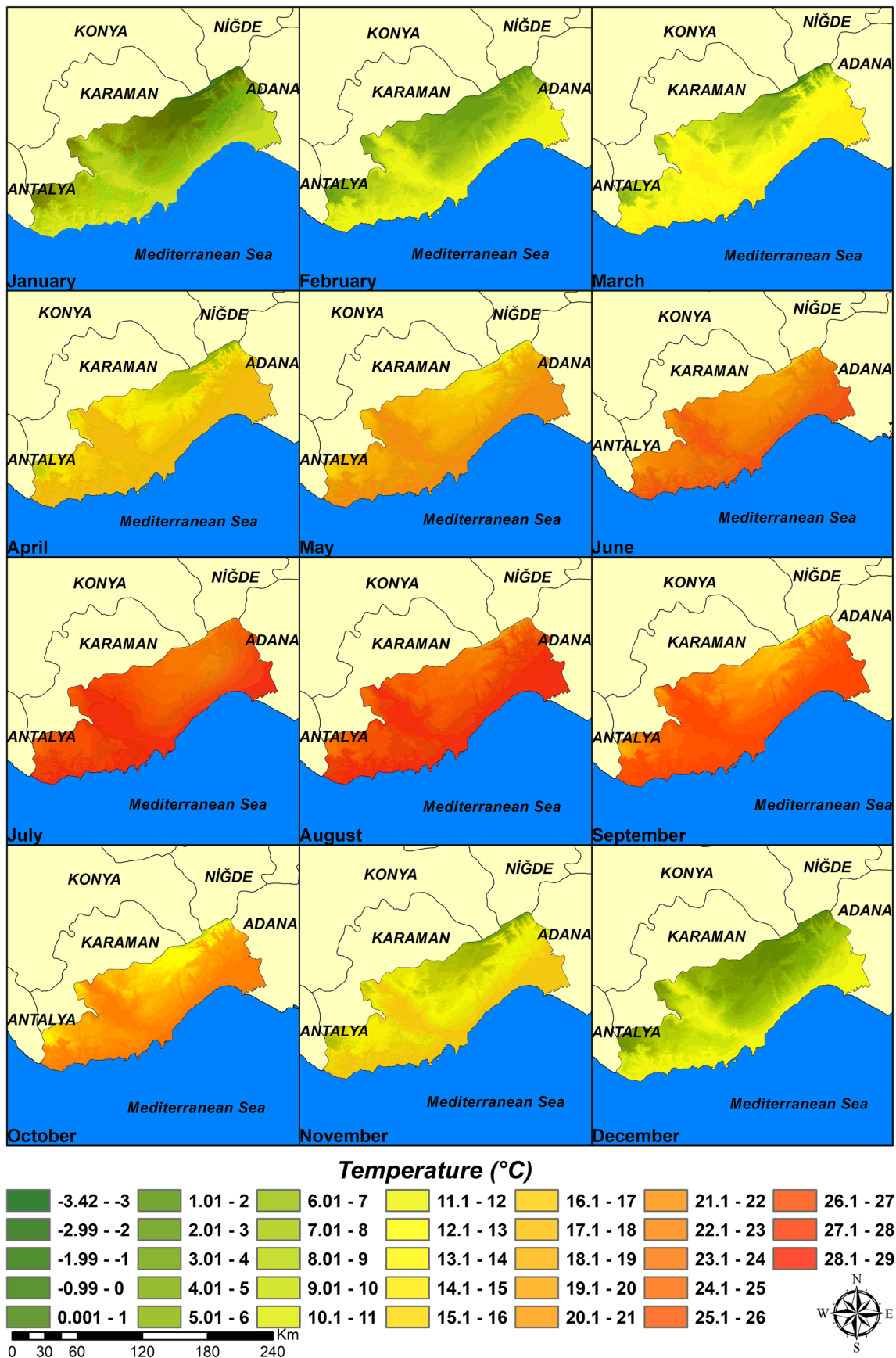

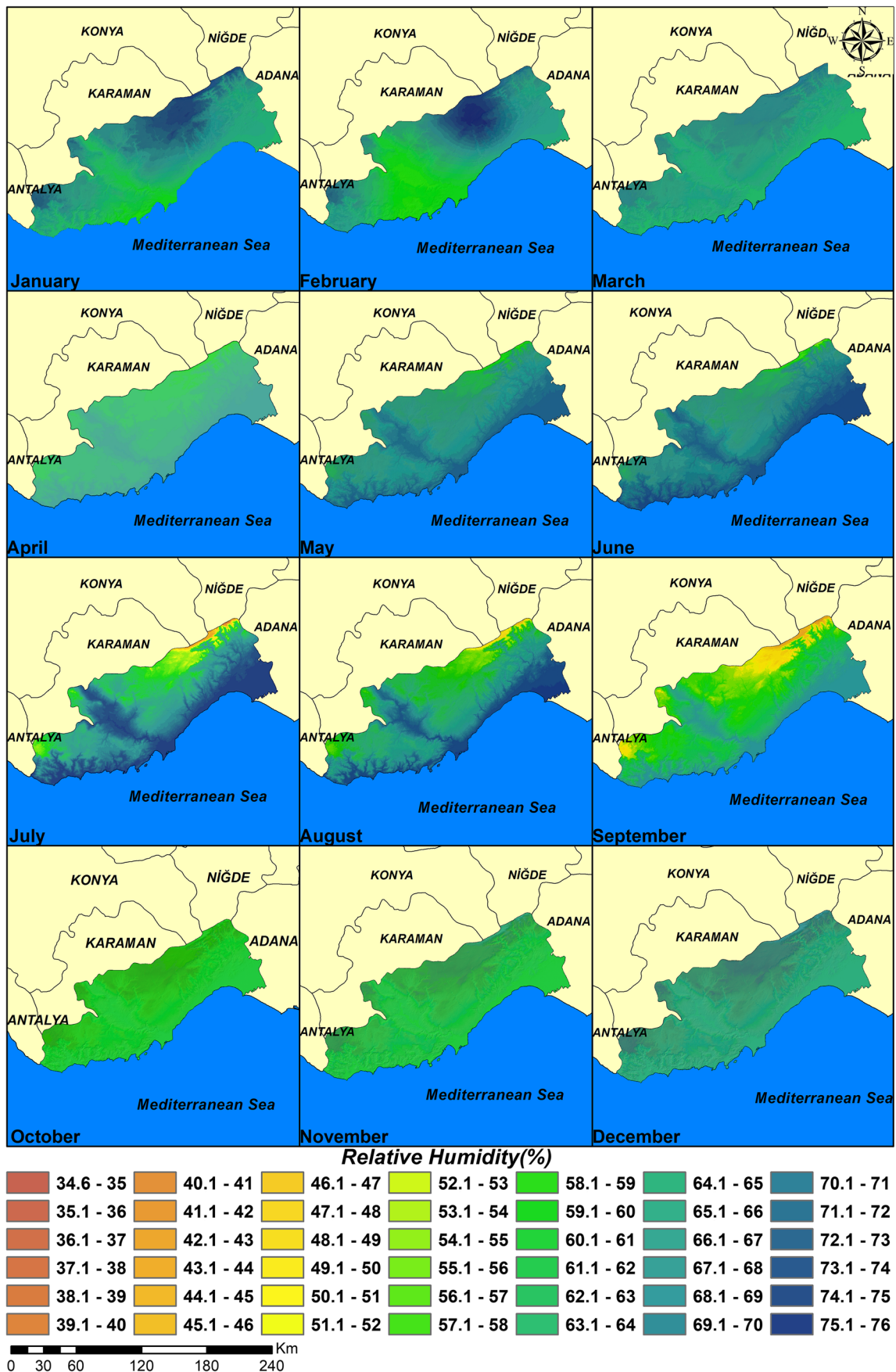**Fig. 1** The location of the study

Fig. 2 Monthly temperature results for Mersin

Fig. 3 Monthly relative humidity results for Mersin

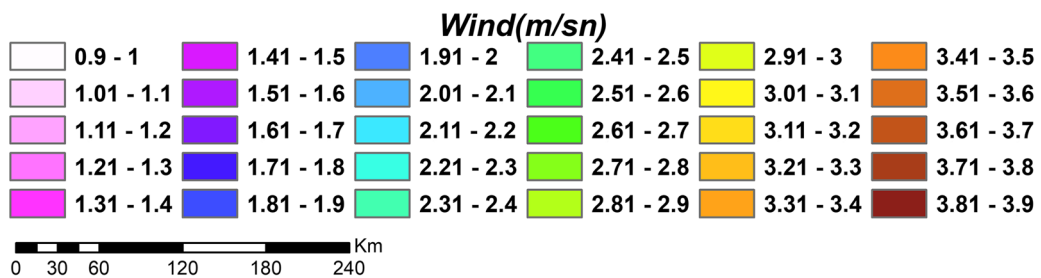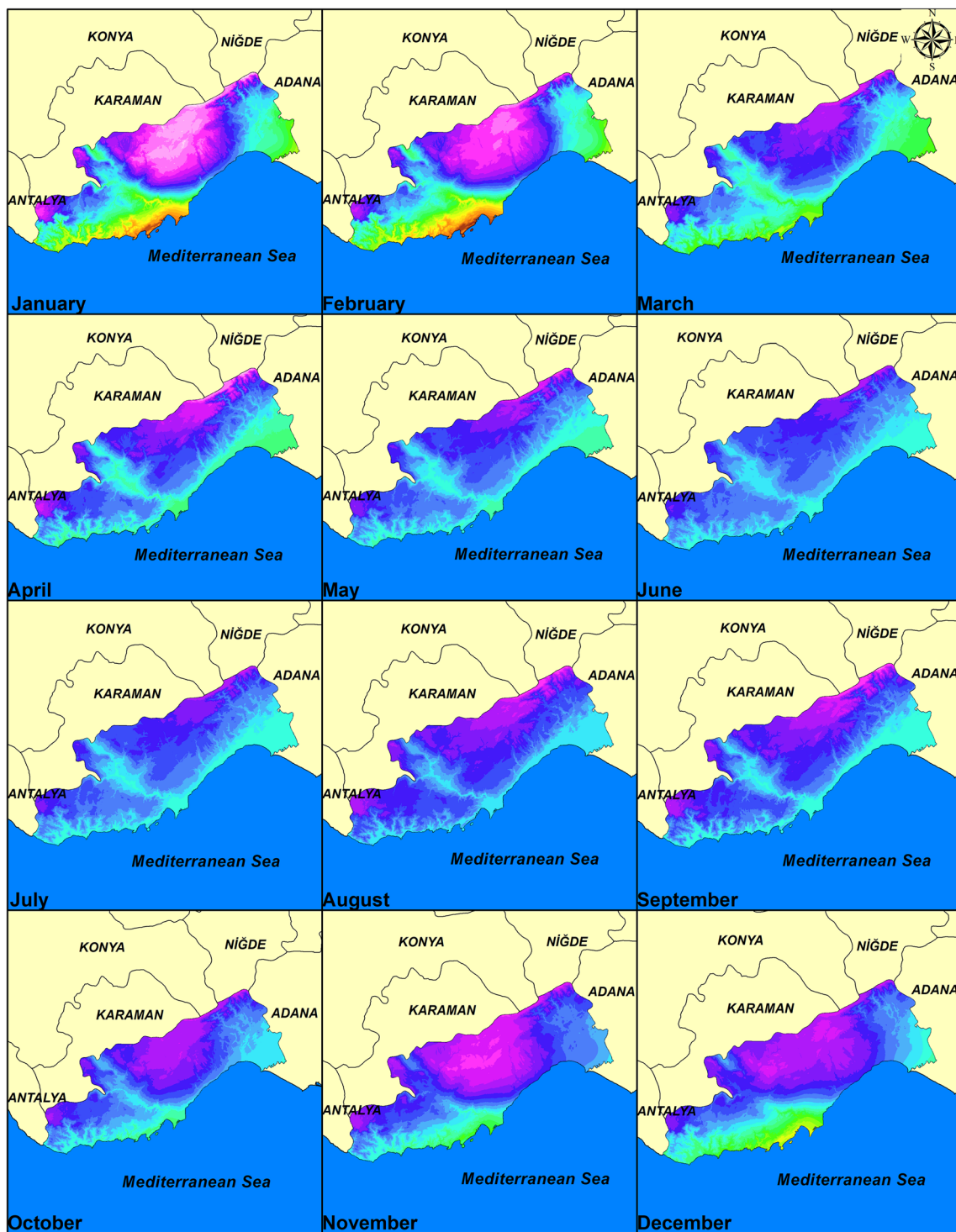Fig. 4 Monthly wind results in Mersin

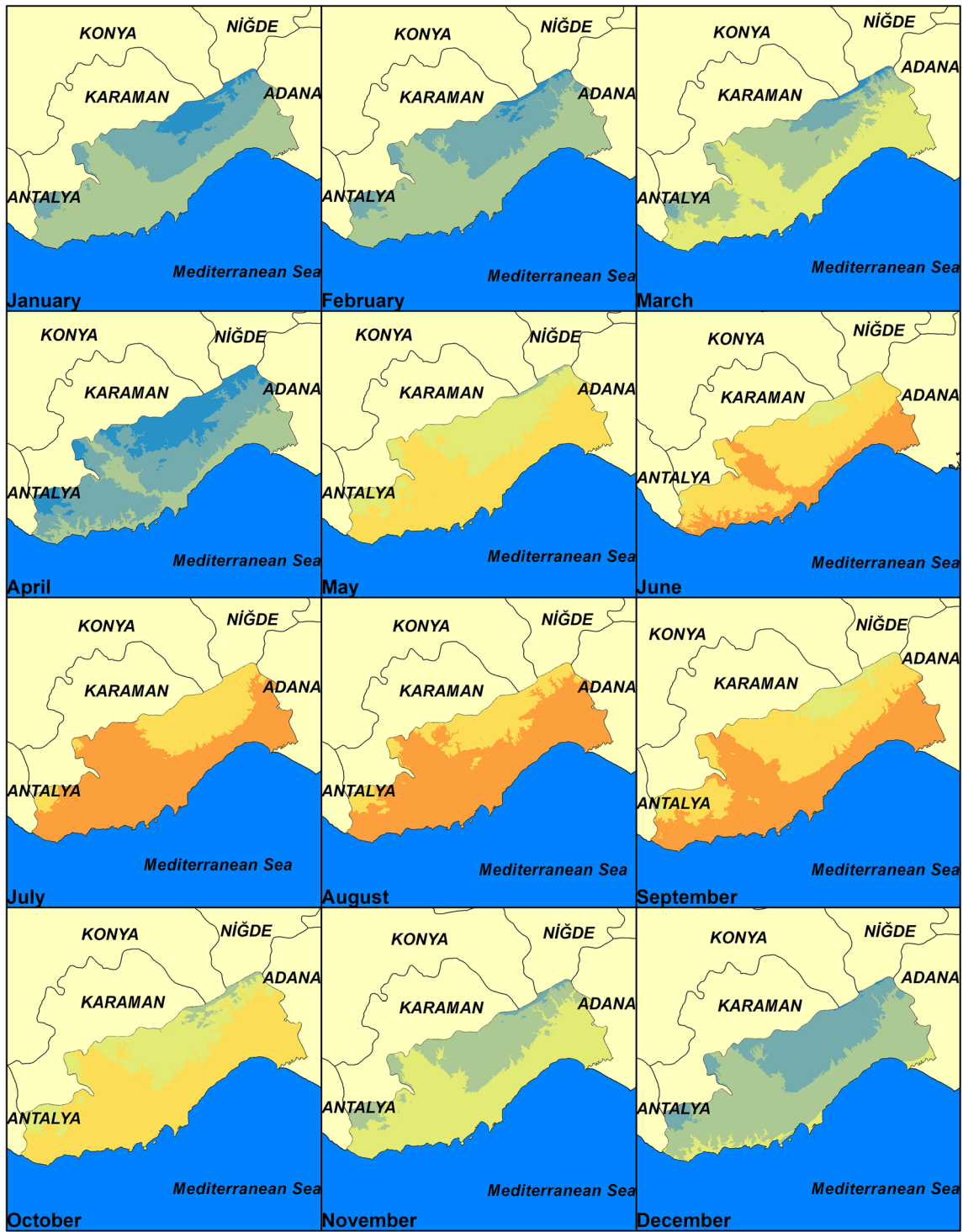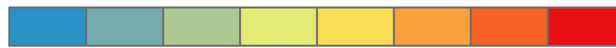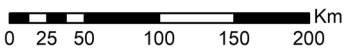**Fig. 5** Mersin bio-comfort areas

Results and discussions

In this study, maps were obtained for each month of the year according to comfort status. The 12-month classified map obtained by considering the bioclimatic comfort conditions was overlapped and an average value was obtained for each area on the map, resulting in the annual felt temperature map. The raster data for 12 months is evaluated using the "cell statistics" function in the ArcGIS program. This produces the average value for the 12-month value of each cell of each raster. The cell-based statistical function is used to calculate changes or trends between two or more raster data on the respective cells. Monthly sensed temperature values were calculated for each station using hourly sensed temperature values. The average sensed temperature values of January–December are shown in Fig. 2. The temperature map generated by the map method using these values is shown in Fig. 2. As a result of the temperature map evaluation prepared for January–December, the average difference value is observed to be 18 °C to 23 °C. Accordingly, monthly results show that the region is comfortable in September and October (Fig. 2).

Figure 3 shows that monthly relative humidity results for Mersin were determined as 51%–56%.

The wind cooling index is used for scientific advances, technology, and computer models, for accurate and useful calculations of hazards from winter wind and freezing temperatures. This index calculates the temperature sensed by the effect of wind on an adult human face with an average length of 1.52 m for the wind speed measured by an anemometer at a height of 10 m. On cold and breezy days, it calculates the heat loss from the body environment by combining it with heat transfer theory and used as a consistent standard for skin tissue resistance. The average annual wind velocity is 1.7 and 2.1 m/s for biological comfort. It was determined that the study area was north and middle (Fig. 4).

September and October are similar in terms of bioclimatic conditions. The average of September is 0.58 °C lower than the average of October. In this month, cold perceptions are represented by very cool perceptions (14.4%). The month in which comfortable conditions occupy the largest area after April is May (23%). Comfortable thermal perceptions are commonly seen in the high areas surrounding the Mersin region, on the coast. The areas with the highest FES values are the southeast lowland areas of Mersin and the coastal belt to the south and west (Fig. 5). Few hot thermal sensations covering a large part of Mersin reach 600 m in the south and 700 m in the north. The area of thermal sensations where cold stress is strengthened is limited to the high mountainous areas in the northeast. According to the averages of September, comfort values decrease by 0.39 °C in 50-m elevation and 1.80 °C in latitude increases from sea to land. The distance increases by 1.9 °C per 50 km. September and May are comfortable months in Mersin and are shown in Fig. 5.

PET values of Mersin station were compared and the effects of urbanization on physiological equivalent temperatures were determined. Many studies are investigating the effects of urbanization on climate elements (especially temperature).

Conclusions

There are different areas in the city center in terms of altitude, topography, land use, and view. During the day, the change in thermal sensing values leads to these differences. In May and September, the city of Mersin appears to cover the portion considered suitable for the bio-comfort section.

The open regions in the urban forest are distinguished from the others in terms of the conditions of bioclimatic comfort. The thermal sensing values of Mersin are higher than in the surrounding urban areas and often in areas with high building density especially in January (1–2 °C) in areas with high building density; in August, in areas with high building density − 1.5, 5 °C; and 0.5–1.5 °C in areas with open-green areas. In areas with high building density, no homogeneous distribution is observed especially during daytime. The higher PET values are seen in the region where the long-wave radiation flow is higher and the area with high roughness and surface area is higher.

The city's heat island is most powerful in November, October, and May. The weakest months are January, December, and February, where the energy is less and the city's heat island is weakened. The places with high building density in the city center appear as a comfort island between October and April and between May and September.

Compliance with ethical standards

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