CLIMATE AND BIOCLIMATE INFORMATION FOR TOURISM – THE EXAMPLE OF EVROS PREFECTURE

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ABSTRACT There is demand for climate data and information it can provide, but in regions with a poor network of climate stations there is a shortage of appropriate quantity of climate data. A two way approach for the creation of climate information is developed here and tested on the Evros prefecture of northeastern Greece. We use the data from the collation program of the Climatic Research Unit, based on climatological observations between 1960 and 1990, to produce seasonal maps. The existing data sets provide adequate information for the production of high spatial resolution maps. The results were presented by mapping the generated parameters using digital elevation models. The available data were processed with modern geo-statistical methods. Maps for air temperature, relative humidity, sunshine duration, wind speed, precipitation and physiologically equivalent temperature have been generated. This approach generates climate and climate related information for areas with a low density of climate stations.

KEYWORDS: *Tourism, climatology, climate data, Evros*

INTRODUCTION

On the whole Greece has a low density network of climate stations. The poor spatial coverage results in a shortage of good quality climate data for applied climate rsearch in areas such as agriculture and tourism (Matzarakis, 2006) and for bioclimate applications in particular (Matzarakis et al., 1999). The aim of this study is to present a bioclimatic analysis of Evros prefecture by means of climate mapping with the aid of geo-statistical methods (between the meso and macro scale).

STUDY AREA

The study area is the Evros prefecture of northeastern Greece comprised of two national parks, the forest reserve of Dadia and the river delta of the river Evros, the island Samothraki, which also belongs to the district of Evros, is also a government controlled reserve. The climate can be described as a mix of Mediterranean and Central European climate. The national parks of Evros contain special ecosystems that are home to a number of rare animal species which are a major tourst attraction of the region.

In the west, the district of Evros adjoins the district of Rodopi, in the east it borders Turkey (East Thracia). The river Evros is the natural border to Bulgaria in the northeast and with Turkey in the east. In the south the district Evros abuts on the Aegean Sea. The district of Evros extends between 40° and 42° degrees latitude and 25° to 27° degrees longitude. In the east, the topography is dominated by rivers - predominantly by the river Evros - and areas with heights of less than 100 m. In the west the district's topography rises up to 1200 m. The island Samothraki is mountainous, with 1611 m the highest point of the island

METHODS AND DATA

The used climate data for this analysis was provided by the data collation program at the Climatic Research Unit of the University of Norwich (New et al., 1999, 2000). The method employed uses this to data to to produce high spatial (ten minute) resolution climate information for applications at the meso scale. The data required for thermal bioclimate analysis are air temperature, relative humidity, solar radiation (sunshine duration) and wind speed. These are available at monthly resolution for the climate period 1961 to 1990 for the Evros prefecture. The grid referernces of the climate data are used as the dependent variable. They are recalculated to provide a higher spatial resolution (1 km) through the use of geo-statistical methods, where the independent variables are latitude, longitude and elevation. The multiple regression using the three factors is accurate enough to contruct maps. Digital elevation data of the GLOBE data set (Hastings et al., 1999) was used.

Mean monthly data is used for the following variables: air temperature, relative humidity, wind speed, percentages of sunshine duration, monthly temperature amplitude, precipitation amount and days with precipitation a simple statistical downscaling based on latitude, longitude and elevation have been applied for the target areas.

The statistical correlation for the applied spatial resolution of approximately one kilometer show that the correlation coefficient between the climate parameters and the geographical and topographical factors depend more or less on the distribution of the land and sea masses and the size of the target area. Nevertheless, the statistical results allow the production of high resolution climate and bioclimate maps for Evros and other parts of Greece.

The calculation of PET is performed with the aid of the RayMan Model, which calculates the thermal indices mentioned above (Matzarakis et al. 2000, 2007).

Additionally, daily data of the Alexandroupolis airport station of the Hellenic National Weather Service have been analysed for tourism purposes.

RESULTS AND EXAMPLES

Seasonal air temperature, relative humidity, wind speed, percentages of sunshine duration, precipitation amount, days with precipitation and physiologically equivalent temperature have been constructed. Given that air temperature is one of the most important, meteorological/climatological variables for the description of the climate of a place or a region, this variable was given special attention. In winter the air temperature varies between -1 and 7 °C in the Evros region. The lowest temperatures, is found in winter (December until February) in the mountains and the highest temperatures are found in the regions near the sea with lower elevation. In spring (March to May) the temperature varies between 9 °C and 18 °C. The lowest temperature is measured at higher elevations on the island Samothraki and the high-lying areas of the mountains in the west of the Evros area. In summer (June to August) average temperatures are between 18 °C and 24 °C. In autumn (September to November) the temperatures lie predominantly between 9 °C and 11 °C (Fig. 1, example summer).

The seasonal duration of sunshine (hours) show the proportional value of sunshine hours in each season. Cloud cover and radiation conditions are also shown. The duration of sunshine ranges between 35 % and 60 % in winter, where the highest values are found close to the coasts and the lowest are obtained in the northern and the mountainous areas. In spring the values lie between 55 % and 75 % with the same distribution as in winter. In summer the duration of sunshine ranges between 70 % and 85 %; this is the season with the highest radiation benefit. In autumn the values ranges between 30 % and 60 % and thus show that the cloud cover has its maximum in autumn and winter (Fig. 2, for summer months).

The precipitation data is given in mm, where 1 mm corresponds to a volume of 1 l/m². Precipitation is usually high in winter and the values range between 520 mm and 800 mm. The highest values are detected at higher elevations and the lowest values in the low-lying central inland region. In spring falls approx. 80 mm of precipitation in higher elevated areas and less than 30 mm near the coast. In summer the precipitation is below 30 mm and declines gradually from north to south. In autumn the precipitation increases again and the values rise to approx. 100 mm, whereby the highest values are obtained in the mountainous areas and in the south (Fig. 3, for summer months).

Bioclimate parameters describe the influence of the thermal environment on humans (Höppe, 1999). With the bioclimate of humans and other variables, i.e. the duration of sunshine, the climate of a place or a region can be described and categorized regarding tourism and recreation. The human bioclimate here is described here through the physiologically equivalent temperature (PET), which includes the influence of air temperature, air humidity, wind velocity, radiation, clothing and activity of humans are contained (Matzarakis et al., 1999, VDI, 1998). PET of approximately 20 °C equates to thermal comfort.

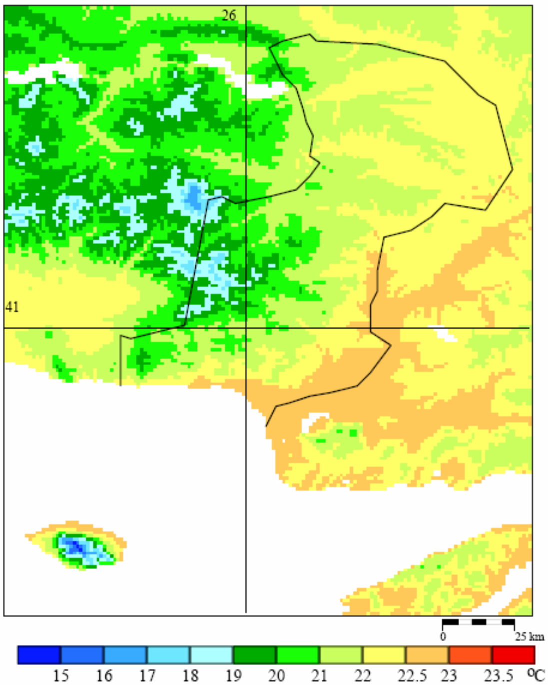

Figure 1: Summer map of air temperature (°C) for Evros

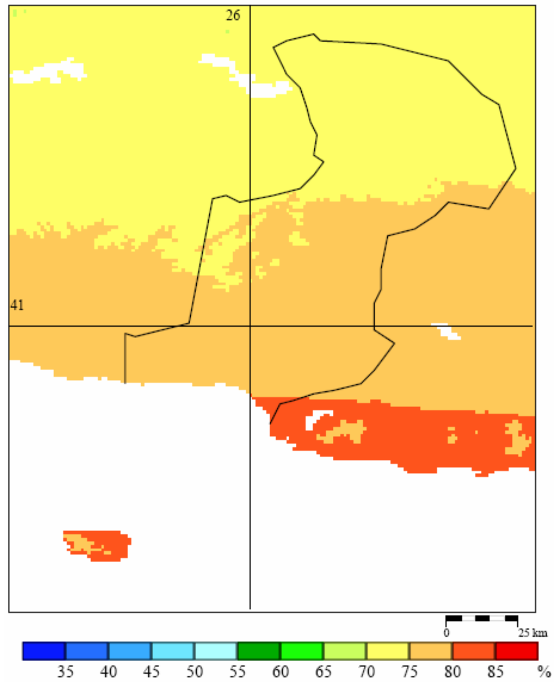

Figure 2: Summer map of sunshine duration (%) for Evros

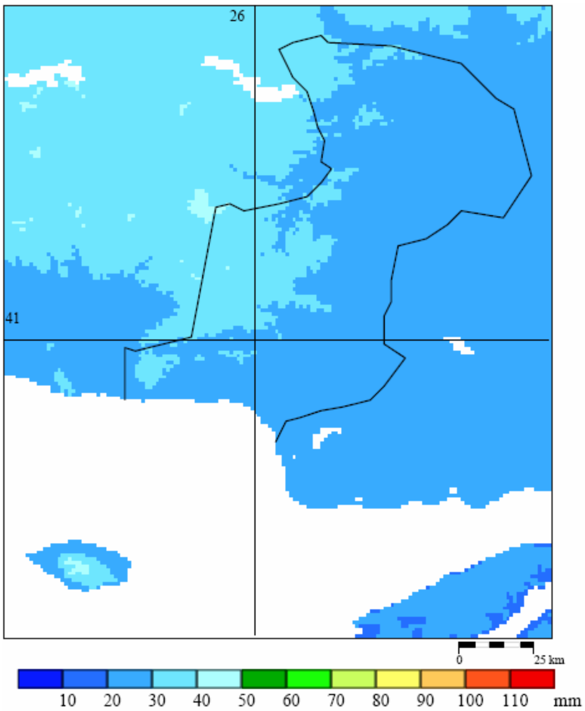

Figure 3: Summer map of precipitation (mm) for Evros

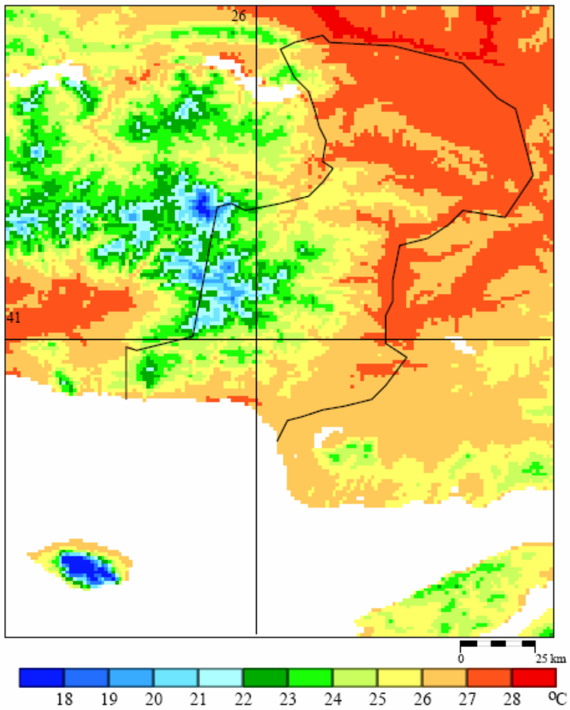

Figure 4: Summer map of physiologically equivalent temperature (°C) for Evros

Increasing values indicate heat stress and falling values cold stress. PET-conditions up to 23 °C do not mean heat stress for humans. Values over 30 °C indicate large heat load and thus affect the human health. In the Evros district the PET values vary between -3 °C and +4 °C, which indicates a cooling load for humans in winter. In spring the PET values range between 13 °C and 22 °C and conditions of thermal comfort are distributed over the whole area. The same distribution pattern exists also in autumn, although the values are lower than in spring. In summer the highest values are observed in the central parts of the region and the areas with more pleasant bioclimate are located in the coastal zone and in the mountainous areas (Fig. 4, for summer months).

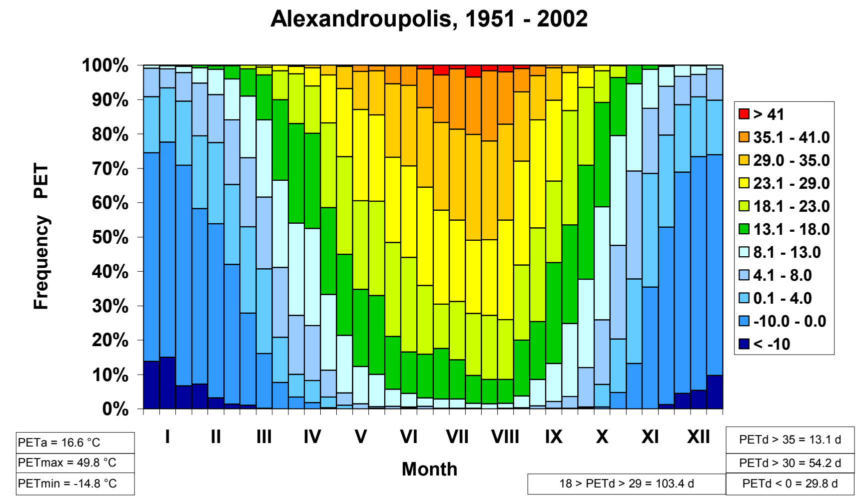

Figure 5: PET-Diagram for Alexandroupolis for the period: 1951-2001

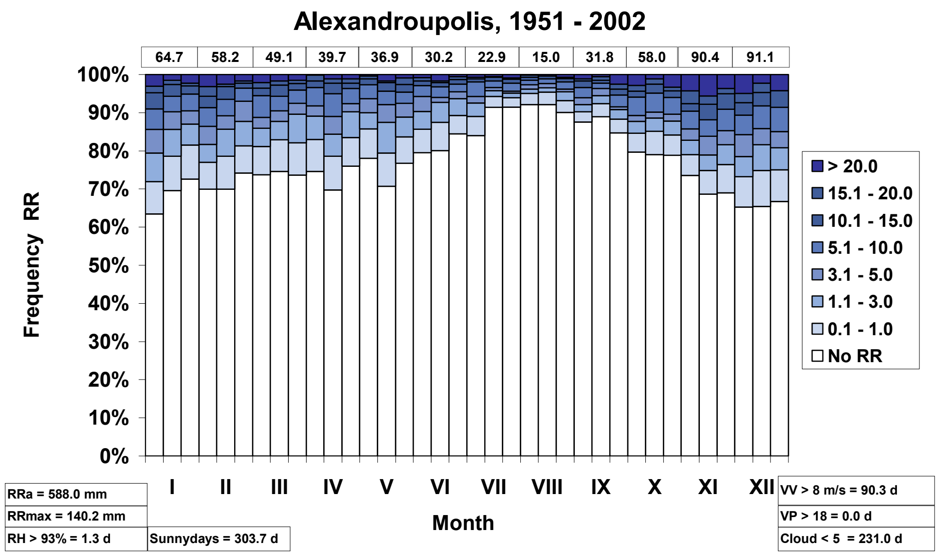

Figure 6: Precipitation diagram for Alexandroupolis for the period: 1951-2001

Based on daily information of the Alexandroupolis station of the National Hellenic Weather Service, for the period 1955 to 2003 a tourism-climate approach have been used (Matzarakis, 2007). The data have been analyzed in a human-biometeorological manner (PET-classes and frequencies) (Fig. 5) and precipitation (classes and frequencies) (Fig. 6) in ten days intervals. Additionally, based on the data a CTIS (climate tourism information scheme) has been calculated. The CTIS includes thermal, aesthetic and physical facets of climate for tourism purposes.

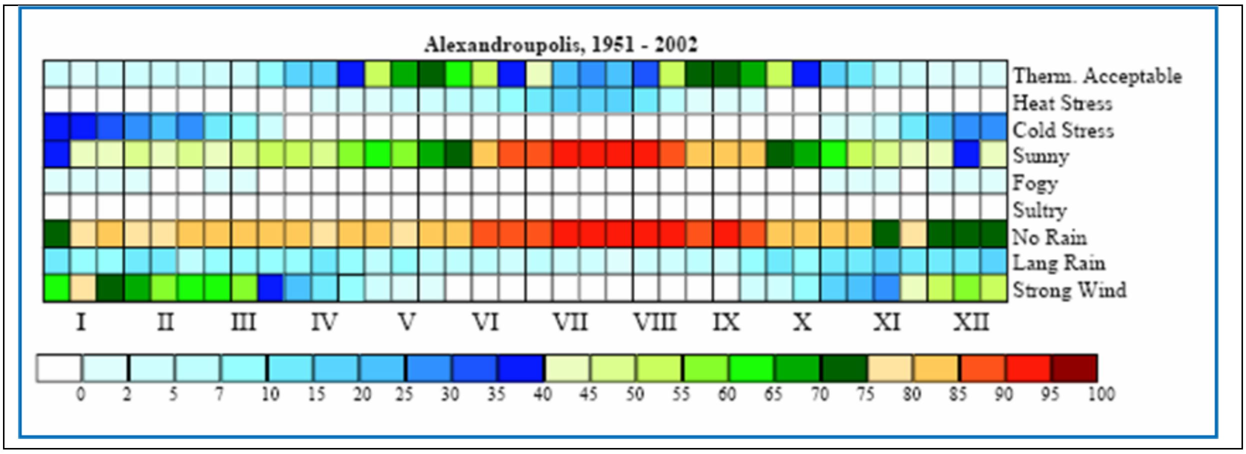

Figure 7: CTIS for Alexandroupolis for the period: 1951-2001

CONCLUSIONS

Spatial climate modelling used here is useful for generating data with higher quality spatial coverage useful in a variety of applications requiring seasonal or monthly climate data, such as agriculture, tourism, health and regional planning. Because only monthly mean data were available, only monthly and seasonal maps of simple climatological and bioclimate (physiologically equivalent temperature) maps can be constructed. Given the avialbility of daily climate data, high resolution temporal analysis can be performed and the results presented in a demanded way, a.e. CTIS.

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