Climate-tourism Analysis and Application of Tourists Flow Forecast in Taiwan

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1. Introduction

Climate significantly influences the tourist behavior and it is one of the keys for tourists when selecting the traveling location and activities (Murphy et al., 2000; de Freitas, 2003; Matzarakis et al., 2004). Facets of tourism climate can be represented by thermal, physical, and aesthetic conditions (de Freitas, 2003; de Freitas, 2005). Several studies indicate that the preference for thermal comfort during travel is very different from the thermal sensation indoors (de Freitas, 1985; Höppe and Seidl, 1991); thus, travelers' activity is also affected by climate conditions. Since the tourists come from different regions and have different perceptions for the climate, when investigating tourism climate i.e. Sun Moon Lake of Taiwan (Lin and Matzarakis, 2008) adjust the thermal sensation range for thermal comfort for western Europe and Taiwan.

However, can the tourists' thermal sensation influence the tourists flow? It is an issue for further studies. Although the past researches demonstrated the influence of climate on decision-making of tourism, there is no sufficient analysis revealing the direct correlation between the tourists flow and climate. Besides, there are no definite conclusions with respect to the climatic parameters and models for predicting the tourists flow. Thus, this research uses a tourist spot as an example to calculate and reorganize tourism climate, and applied local people's thermal comfort criteria to further recognize the thermal sensation of different periods. Finally, it analyzes the correlation between climate parameters and the tourists flow and the estimation model of the tourists flow by proper climatic factors. The results are valuable for criteria for tourists, tourism bureaus and the tourism industry.

2. Methods

2.1 THERMAL INDICES AND CLIMATE PARAMETERS

Analysis of tourism climatology is based on climate indices, such as those used in applied climatology and human-biometeorology (Matzarakis and de Freitas, 2001; Matzarakis et al., 2004). In this study, PET (physiologically equivalent temperature) values are calculated with the RayMan model (Matzarakis et al., 2007) to evaluate tourists' thermal comfort combined with thermal sensations in PET classes for Taiwan. Previous tourism related climate information is based on mean monthly conditions of air temperature and precipitation for a destination area. In order to offer more comprehensive weather information for each season, average climate parameters mentioned above are calculated for each ten-day interval of the months.

Maddison (2001) has predicted the tourists flow of Britain by PTCM (Pooled Travel Cost Model) through the number of population, GDP, length of coast, distance to London, seasonal average air temperature, precipitation. Hamilton et al. (2005b; a) further estimate the tourists flow in 207 countries by HTM model (Hamburg Tourism Model) through regional area, the number of population, annual average air temperature, the length of coast and average income. However, the uncertainty of the prediction is challenged. The model regards average temperature or precipitation as climate parameters and does not consider other critical climate parameters such as humidity, sun duration, cloud and fog and extreme climatic situations (Gössling and Hall, 2006a; b). Thus, there are some studies only estimating the tourists flow by climate parameters. Lin and Matzarakis (2008) treat precipitation, sun duration, vapor pressure and cloud as the variables and they apply PET index to reflect thermal comfort and thermal adaptation in different regions. The variables are not showed by traditional averages; instead, they were based on the monthly frequency in the specific range of the climate parameters (Lin and Matzarakis, 2008). The above estimation model of the tourists flow is upon Multiple Linear Regression (MLR). However, the explanation is limited. The reason might be in that the variables are various, complicated and non-linear and not always normal distributed.

Artificial neural networks (ANN) refer to the mathematical model imitating neural function which can solve complicated and non-linear problems. The past application in climate forecast revealed positive effects (Cavasos, 1997; Schoof and Pryor, 2001). It is also generally applied to

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the prediction of tourism demand and behavior (Tsaur et al., 2002; Balas et al., 2006; Palmer et al., 2006; Aslanargun et al., 2007). However, there are no studies which predict the tourists flow only by climate parameters by ANN model. Therefore, this research tries to conduct the analysis by ANN and construct Multilayer Perceptrons Networks (MLP) by the software STATITICA Data Mining® in order to estimate the tourists flow under different climatic conditions.

2.2 STUDY AREA AND CLIMATE DATA

This study focuses on the five national parks on the main island of Taiwan, i.e., Kenting National Park, Yushan National Park, Yangmingshan National Park, Taroko National Park and Sheipa National Park. The climate data of each Park are obtained from the nearest weather station i.e. HengChun, HuaLien JhuZihhu and YuShan weather station, respectively, owned by the Central Weather Bureau, MOTC of Taiwan.

3. Results

3.1 THERMAL COMFORT RANGE

In order to account for tourists' thermal perception under different temperatures of PET, it is necessary to define PET ranges in which tourists feel comfortable, i.e. "thermal comfort range" for PET, because people from different regions may have different thermal perception toward the same PET. Table 1 shows the PET classification for Taiwan relative to the Western/middle European scale (Matzarakis and Mayer, 1996; Lin and Matzarakis, 2008), which will be applied for further analysis in this study. The comparison of the two PET thermal scales shows that the neutral temperature scale of Taiwan is higher than that of Western/middle European. Furthermore, the PET range of Taiwan is larger than that of Western/middle European for each thermal sensation scale.

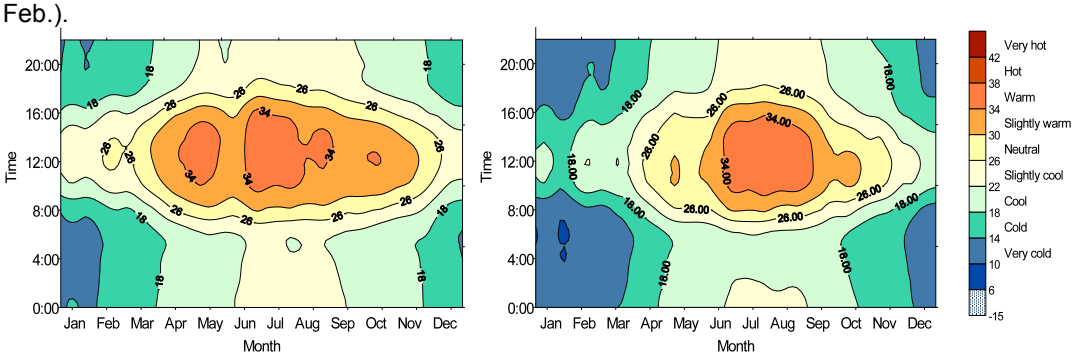
Table 1. Thermal Sensations and PET classes for Taiwan and Western/Middle European classes (Lin and Matzarakis (2008), Matzarakis and Mayer (1996))

Thermal sensation	PET range for Taiwan[a] (°C PET)	PET range for Western/middle European[b] (°C PET)
very cold	14	4
Cold	18	8
Cool	22	13
Slightly cool	26	18
Neutral	30	23
Slightly warm	34	29
Warm	38	35
Hot	42	41
Very hot		

3.2 PET ISOTHERM

Fig. 1 shows the PET isotherm of four national parks. The x-coordinate refers to month whereas y-coordinate is time. We calculate PET averages of different times in each ten days with respect to PET data in 2002-2006. For example, PET at 6:00 from Jan. 1 to 10 is upon the average of 50 climate data (5year*10days) at 6:00 from Jan. 1 to 10 in 2002-2006. Based on this principle, we calculate PET of the relative month and time and construct PET isotherm by Kriging algorithm of Surfer®.

Fig. 1 shows that among four national parks, Kenting being in tropical climate zone in the south of Taiwan reveals the most hours with over "slight warm" (PET > 30°C). During noon time from April to August, it is in "warm". On the contrary, Yushan (Jade Mt) with height of 4000 m is in the temperature from "cold" to "extremely cold" throughout the whole year (PET < 22°C). Hualien and Taroko are between the above two and have lower temperature only in winter (from Dec. to Feb.).



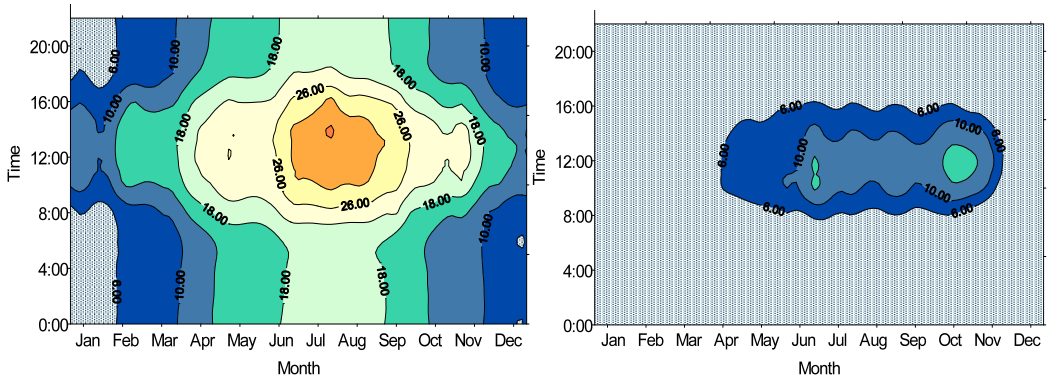


Fig. 1. PET isotherm of four national parks, from left to right, up to down are Kenting National Park, Taroko National Park, Yangmingshan National Park and Yushan National Park.

3.3. TOURISTS FLOW PREDICTION MODEL

This study tries to use the ANN method to establish the function of tourists by the climate parameters. Two ANN models, i.e. Multilayer perceptrons (MLP), and Radial Basis Functions (RBF) are applied combined with Time Serious Analysis due to the existence of time patterns in each month during the year. The dependent variables are tourists flow which is obtained by the National parks official data. Independent variable includes the different frequency of classification of each parameter, e.g. PET 18-22, 22-26, 26-30…totally 28 classifications for PET variables. In addition to PET, vapour pressure, sun duration hours, wind speed and precipitation are included in the function with different range, totally 105 climate variables are added in the ANN model.

Fig. 2 displays the procedure of time serious analysis in Kenting National Park. The first 12 cases, i.e. January to December of 2002 are training cases for later 48 cases from Jan 2003 to Dec 2006. The pattern of predict tourists flow fit well with observed tourists flow pattern. The correlation of predict/observed tourists flow of best-fit ANN model are shown in Fig 2, with coefficient R^2 =0.77, revealing that almost 70% of the tourists flow can be explained by the climate parameters coupled with time reason.

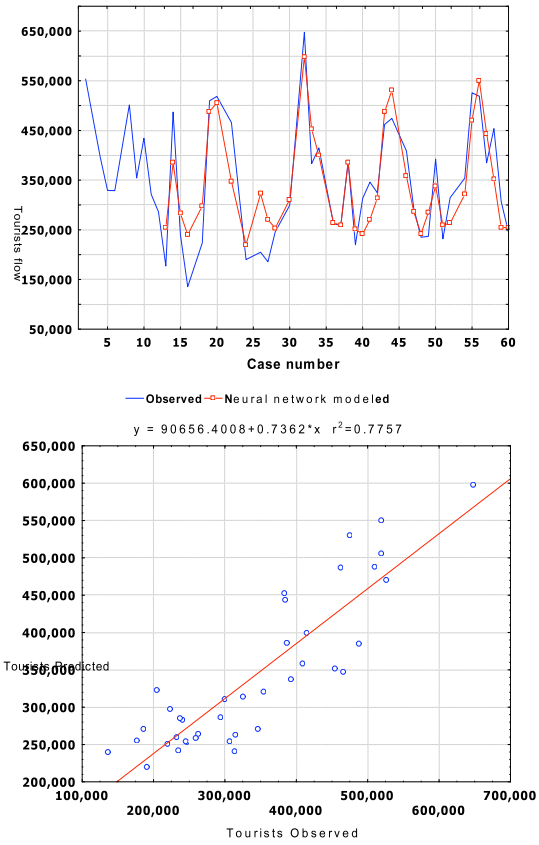


Fig. 2. Time serious analysis (above) and the correlation of predict/observed tourist flow of best-fit ANN model (below)

4. Discussion

In the field of tourism climate, when the subjects are related to the tourists' thermal sensation, we must have the criteria of the specific tourists' thermal acceptable range as shown in Table 1. Thus, we can demonstrate the specific tourists' thermal sensation toward local climate. For instance, fig. 2 shows the distribution of annual thermal sensation upon the thermal comfort criterion of the tourists in Taiwan. When the tourists from Western/middle Europe visit Taiwan, they should follow the distribution upon the criterion of the tourists in Western/middle Europe (see Table 1). A PET value of 18°C is cool for the Taiwanese; however, for tourists from Western/middle Europe it is neutral. Fig. 2 demonstrates useful information and allows the tourists to find thermal comfort distribution in different months and times. For example, it is neutral during the daytime in Hualien in April and cool in the morning; in Yangmingshan, it is cooler in winter and warmer at noon in July. We can certainly produce annual thermal sensation distribution for tourists from Western/middle Europe to meet their needs.

Different from the past studies which predicted the tourists flow by average temperature and rainfall, the prediction of this research is based on the frequency of the climate parameters in the specific range in every month. In the past, we have also predicted the tourists flow by Multiple

Linear Regression (MLR) with respect to the same cases and variables and the determination factor R^2 was 0.3-0.4. The analytical result of this research by ANN and time sequence demonstrates that the explanation degree (R^2=0.78) is better than that with MLR, showing that the method is feasible for predicting the tourists flow.

In fact, the prediction on the tourists flow still includes varied uncertain factors. The tourism characteristics of different nations and spots are extremely different. Besides the climate, there are also the factors of economy, politics and unexpected events. Thus, this research does not intend to construct the prediction model involving population, square, society and economy which can be applied to different countries and regions; instead, we treat one spot as the target and simply explore the influence of the climatic factor on the tourists flow. Although the prediction model of the spot cannot be applied to other spots, we can predict the influence of the climatic factor on the certain spot in details.

5. Conclusion

This research uses four national parks in Taiwan as examples and treats thermal comfort of local people in Taiwan as the criteria to draw PET isotherm of different periods during 2002-2006 so that the tourists can find thermal comfort distribution of different months and periods. Besides, we try to analyze the influence of climate parameters on the tourists flow by ANN and time sequence. The prediction effect is better than traditional MLR models and it is more significant. Through the research findings, we can not only allow the tourists have better and reliable information about thermal comfort all periods in the year, but also predict the influences of climate change in the future.

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