Biometeorology for Tourism/Recreation in Japan: A Review

Toshiaki ICHINOSE[1*], Olaf MATUSCHEK[2], Yuanshu JING[3]

[1]*National Institute for Environmental Studies / Nagoya University, Japan*
16-2 Onogawa, Tsukuba-shi, Ibaraki 305-8506, Japan
[2]*University of Freiburg, Freiburg, Germany*
[3]*Nanjing University of Information Science and Technology, Nanjing, China*
**e-mail: toshiaki@nies.go.jp*

Abstract

Major European studies on biometeorology for tourism/recreation have been conducted from the viewpoint of human health, while most Japanese studies in this field have focused on the environmental impact on human behaviors as influenced by the weather. Research on biometeorology for tourism/recreation has not been popular in Japan, whose peoples have a higher acclimation potential than European peoples. However, study in this discipline has progressed in China similarly to popular studies in Europe, although the climatological background and acclimation potential of the peoples of China are partially similar to those of Japan.

Key words: acclimation, biometeorology, China, Japan, recreation, tourism

1. Introduction

Scott *et al.* (2004) and Matzarakis (2006) are highly regarded studies with tremendous relevant information on achievements in biometeorology for tourism/recreation worldwide. Weather and climate influence the environmental resources that are the foundation for tourism/recreation, the length and quality of tourism and recreation seasons, the health of tourists and even the quality of tourists' experiences (Scott *et al.*, 2004). Weather and/or climate information is of interest to tourists and the tourist industry, especially before and during the vacation period. This idea seems to be one of the bases of European biometeorology for tourism/recreation and it supports the idea that human biometeorology can offer and supply relevant information about weather/climate conditions, UV-radiation, air pollution and bioclimatic conditions. This climate-related information can be used by the tourist industry in the planning of tourism facilities and tourism areas (Matzarakis, 2006). Actually, numerous studies on climate-comfort indices or climate-tourism indices show a need for a suitable metric for "favorable climate" from the tourists' view. Technical work needs to be translated into simple language for use by tourism planners, tour operators in the tourist sector generally and the public. Summaries and short explanations of different kinds of indices are available. Yoshino and Miyashita (2007) reviewed achievements in biometeorology in Japan. However most of the related studies in Japan have been on the medical aspects of weather-health forecasting and there is quite a stock of achievements in that aspect. The authors, therefore, reviewed achievements in biometeorology for tourism/recreation in Japan, comparing them with others from around the world.

2. Studies on Biometeorology for Tourism/Recreation in Japan

A series of studies by Aoki stands out among the not so rich stock of research on biometeorology for tourism/recreation in Japan and it characterizes Japanese research in this discipline.

Aoki and Aoki (1974) studied seasonal fluctuation in park-use. The object of this study was to research fluctuations in the number of people who visit and use parks. Fluctuation in use is a very important phenomenon and a clear understanding of the rules governing that fluctuation would make it possible to estimate the number of people visiting parks by referring to records of research over several days and to establish research methods regarding park-use. In this research, the authors drafted and considered a "User Prediction Equation" based upon factors related to clear given systematic fluctuations in use. The subjects of the study were six parks in Tokyo. The number of users was calculated based upon the number of people who paid fees to enter parks requiring entrance fees. The authors established a Prediction Equation by means of "Quantification Theory," taking weather and seasons as factors in fluctuations.

Aoki and Fujinuma (1996) studied the effects of

weather conditions and seasonal attractions on parking demand at the Oku-Nikko area of central Japan. It is to be expected that natural factors of weather conditions and seasonal attractions would effect the visitors' behavior at National Parks. To clarify the effects of these factors in fluctuations in the use of parking lots, Hayashi analyzed the numbers of automobiles by Quantification Theory (I) using the factors of months and weather conditions at Yudaki Fall in Nikko National Park. Three important results were obtained as follows.

1) Increases in automobiles were observed in August and October, contributing to an increase equal to half the range in seasonal fluctuation.
2) The contribution of temperature, isolation duration and precipitation were statistically demonstrated.
3) The fluctuations in the parking of automobiles were explained by weather conditions and scenic autumn leaves.

Fujinuma and Aoki (1998) showed some effects of weather on daily use of ski areas. Fluctuations in daily use of natural parks provides an important planning factor for the management of natural scenic areas; *e.g*., congestion at the site, damage to the natural resources, amounts of garbage to be treated and needs for parking lots. To clarify the effect of weather conditions, the authors analyzed fluctuations in the number of skiers and the use of parking lots at the Yumoto ski area in Nikko National Park, central Japan. These were examined using a multiple regression equation with the factors of year, month and weather conditions; *e.g*., snow depth, temperature, humidity, rainfall, sunshine, etc., observed at the Oku-Nikko Field Monitoring Station of the National Institute for Environmental Studies. Three important results were obtained as follows.

1) The snow depth was significantly correlated to increases in skiers and the use of parking lots. The results suggest that greater snow depth allowed better skiing and thereby induced visitation.
2) The highest temperature of the day was correlated with increased use of parking lots. Higher humidity was correlated with a decrease in skiers and the use of parking lots. This suggests that the effects of weather conditions on fluctuations in use were proven by the statistical test.
3) January and February had increases in skiers and the use of parking lots. Moreover, a larger increase was observed in the number of skiers. This suggests that skiers at the time of the seasonal peak using public transportation to visit.

Tamura and Aoki (2005) aimed to determine the factors which account for fluctuations in the number of visitors and also the effects of decentralization of visitors in the Oze area of Nikko National Park. After clarifying fluctuations in the number of visitors to the Oze area over fifteen years, a multiple regression equation was used to examine fluctuations in the number of visitors in terms of social factors, natural factors and traffic control factors in the Oze area of Gunma Prefecture over three years. The analysis showed that decentralization of visitors on weekdays had a clear effect on all areas of Oze, and there was an obvious dispersion of visitors away from crowed entrance spots in the part of Oze located in Fukushima Prefecture. The flowering period of the giant skunk cabbage brought an increase in the number of visitors to Hatomachitohge. The analysis further showed that controlling the number of private cars and sightseeing buses had some effect on decentralizing visitors in areas in Gunma Prefecture.

Aoki and Aikoh (2008) compared outdoor activities between Austria and Japan. In order to clarify the differences in outdoor activities between Austria and Japan, a cooperative research project was conducted by BOKU (University of Natural Resources and Applied Life Sciences, in Vienna) and NIES (National Institute for Environmental Studies, in Tsukuba). The Austrian side researched visitor numbers and the sense of congestion at eight parks in Vienna. The Japanese side enlisted nine universities to take data on park visitors for comparison of their outdoor activities with those of park visitors in Vienna. The Japanese side obtained comparable data to that of Austria and both sides are now analyzing the results, testing the data obtained and conducting further investigations for validation. Their results show different outdoor activities and different modes of activities. Similar effects of climatic conditions on visitor numbers were found. There were difficulties, however, in comparing the different activities and levels of crowdedness.

Table 1 Words associated with each season (Aoki & Aikoh, 2008).

	Hokkaido	Japan	Vienna
Spring	flowers (84)	flowers (94)	flowers (63)
	thaw (34)	entrance/graduation (22)	sun/light (31)
	entrance/graduation (23)	greenery* (19)	greenery* (24)
Summer	sea/swimming in the ocean (47)	hot (46)	hot (53)
	hot (33)	sea/swimming in the ocean (34)	swimming/bathing (32)
	greenery* (17)	insects (24)	sun/light (39)
Autumn	autumn colors (55)	autumn colors (58)	autumn colors (52)
	fruits (17)	fruits (17)	fallen leaves (31)
	fallen leaves (17)	fallen leaves (17)	fog (19)
Winter	snow (74)	snow (50)	snow (73)
	cold (33)	cold (38)	cold (52)
	skiing/snowboading (24)	skiing/snowboading (13)	skiing/snowboading (16)

*include some plants

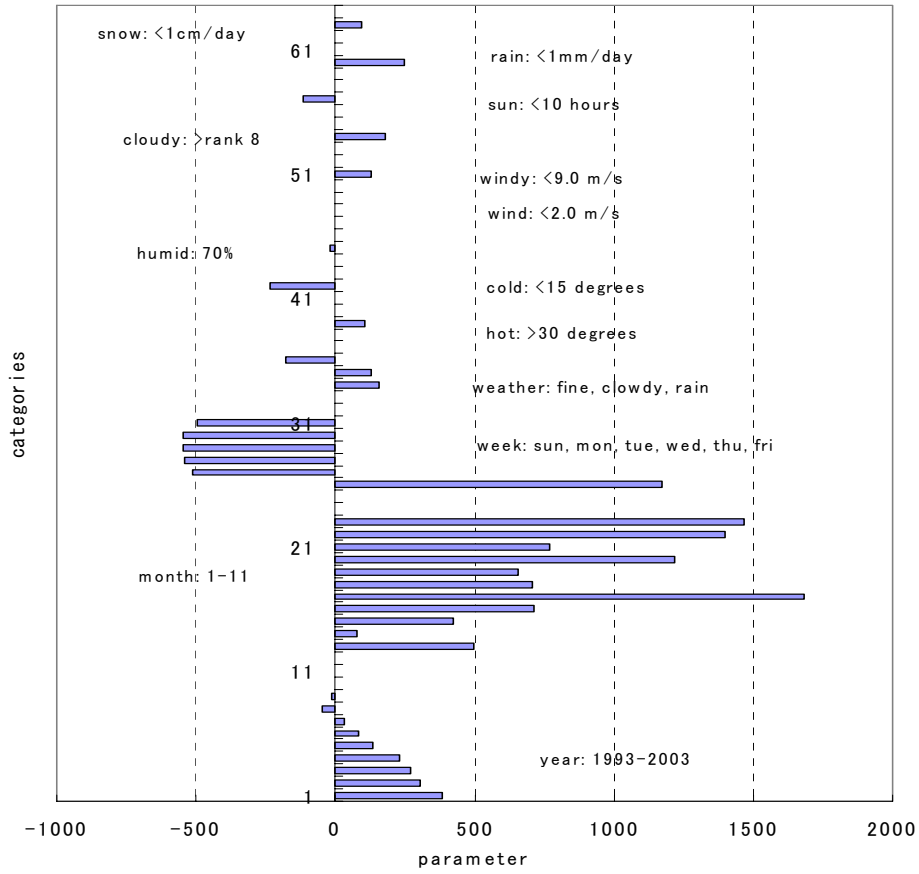

Fig. 1 Example of data on the daily number of visitors analyzed by Quantification Theory I at Mt. Tsukuba (Aoki & Aikoh, 2008).

Tokiwa (2007) discussed life-weather merchandising, including demand for tourism/recreation. Retailers in Japan are nowadays planning, selling, ordering and stocking according to daily weather forecasts, taking into consideration the relationship between weather and customers' needs. Many retailers have succeeded at reducing losses and increasing their profit ratios. "Life-weather Merchandising (LMD)" is an application of biometeorological knowledge and social engineering techniques to retail marketing. In order to develop further solutions to the problems involved, this paper reviews the present status of the science, based mainly on the observed facts in Japan. Previously there has been a lot of research on changes in health conditions due to changes in weather, but there are few examples of research referring to food preference changes or changes corresponding to seasonal and daily fluctuations in details of units of nutrients. Further development is needed urgently.

Fukushima *et al.* (2003) indicated influences of air temperature changes on ski activities as representative of leisure industries. This paper was cited in the IPCC report. Merchandizing in conjunction with tourism/recreation in the future will have to consider ongoing climate change. Key ecosystems offering winter sports and beach holiday facilities will be directly threatened by global warming and sea level rise (Smith, 1990). In addition, tourists have the greatest capacity to adapt to the impacts of climate change, with relative freedom to avoid destinations impacted by climate change or shifting the time of their travel to avoid unfavorable climate conditions. As such, the response of tourists to the complexity of destination impacts will reshape demand patterns and play a pivotal role in the eventual impacts of climate change on the tourism industry (UNWTO, 2007). Understanding and anticipating the potential geographic and seasonal shifts in tourist demand will remain critical areas of research in the future. The tourist industry should be more aware of these sensitivities and be planning now for climate change.

3. Comparison with Case Studies in China

One of the reasons the study of biometeorology for tourism/recreation is not popular in Japan might be the fact that peoples in Eastern Asia have a higher acclimation potential than European peoples. This means Eastern Asian peoples have a stronger resistance to thermal stress than European peoples. They are, therefore, not as nervous about this matter and it reduces the emphasis on this discipline there. With this in mind, how is study progressing in this discipline in China whose climatological background is partially common with that of Japan?

In recent years, many Chinese scholars have been working in the tourism sector and studying tourism cli-

mate comfort from different views and in different regions. Tourism and biometeorology evaluation methods, temporal and spatial distribution of tourism climate comfort and the impact of factors are main research areas.

Quantification of indices on humans and infrastructure was gradually established to develop research on tourism climate comfort. In the early stage, Qian and Ye (1996) presented a mathematical model for evaluating comfort of weather for tourists in Sichuan Province by using the factors of air temperature, sunshine, rainfall, number of misty days, wind speed, humidity and pollutant concentrations. Quantitative indices were introduced, which made the weather in different seasons and spots quantitatively comparable. This is helpful in planning and practicing tourist services.

The appropriate season on islands in Zhejiang Province was also studied by means of the human climate index, wind index and comfort index, respectively (Chen *et al*., 2006). Necessary revisions were made to the comfort index according to the features of island tourism. The revised comfort index, which combines seven meteorological factors, such as air pressure, sunshine, precipitation, temperature, humidity, wind and visibility, can evaluate synthetically the reaction of human bodies to weather. It can be used to appraise more completely the economic development value of a scenic spot and the length of the appropriate season for tourism.

Han *et al*. (2007) discussed thermal comfort inside residences of three cities in the hot-humid climate of central southern China. Field sampling took place in the summers of 2003 and 2004 by obtaining 110 responses to a survey questionnaire and measuring environmental comfort variables in three rooms in each of 26 residences. The average clothing insulation for seated subjects was 0.54 clo with 0.15 clo of chairs. Only 48.2% of the measured variables were within the ASHRAE Standard 55-1992 summer comfort zone, but approximately 87.3% of the occupants perceived their thermal conditions acceptable, for subjects adapt to prevailing conditions. The operative temperature denoting the thermal environment accepted by 90% of occupants was 22.0-25.9. In the ASHRAE seven-point sensation scale, the thermal neutral temperature occurred at 28.6. The preferred temperature, *i.e*., the mean temperature requested by respondents, was 22.8.

Some integral assessments of weather and climate were also performed in recent years in different provinces. Duo *et al*. (2008) analyzed favorable and unfavorable climatic conditions for ice and snow tourism in the winter tourism season in Heilongjiang Province from 1960 to 1990 using cluster analysis methods, and established a climate information system and Climate-Tourism-Information-Scheme (CTIS) for different tourist areas in Heilongjiang Province.

Guo *et al*. (2008) elucidated the features of tourism climate resources in Sichuan Province. The climate comfort degree was calculated by using climate data of 158 stations in Sichuan Province from 1971 to 2000, based on the suitable months and the length of time of tourism. The tourism climate resources in the province are divided into three tourism districts: a summer resort tourism district (District I), a winter resort tourism district (District II) and a warm spring and autumn district (District III). Districts I and III can be divided into three sub-districts each. The Sichuan Basin was shown to be suitable for tourism in spring and autumn, the West Sichuan Plateau, for summer resorts; and the southern Sichuan mountains, for winter resorts and sunshine tours.

Tan *et al*. (2006) sought out factors that influenced the mortality of populations due to heat waves in Shanghai in summer (15 June-15 September). Daily data on mortality from all causes, meteorological and air pollution in Shanghai in 1998 and 2003 were collected. Multivariate analysis was employed to investigate the relationship between mortality and heat wave intensity, duration and timing within the summer season and air pollution concentrations. The heat wave in 1998 was more severe and caused a higher mortality than that in 2003. In the 1998 heat wave, the duration and timing within the summer season were significantly associated with the daily number of deaths, while in 2003, in addition to the above two factors the daily maximum temperature also played an important role. Air pollution levels increased slightly during the heat wave and some factors such as the number of air conditioners and the amounts of living space and urban greenbelt areas could be used to explain the distinctive difference in heat related mortality between 1998 and 2003. High temperature was the crucial factor in the high mortality of the population due to the heat waves in Shanghai in the summers (15 June-15 September) of 1998 and 2003. Using air conditioners and enlarging living spaces help to decrease the mortality.

Shao and Liang (2004) discussed the features of tourism climate in Henan Province, and ascertained suitable seasons for tourism in different regions by quantitative analysis of average climatic comfort indices from January to December within 30 years in 130 counties and cities. They were the first to put forward optimal tourism times. They divided Henan Province into six districts: the Xichuan ecological zone, Luoyang peony ecological zone, Middle-Hehan ecological zone, summer vacation ecological zone, Yellow River ecological zone and Southern-Henan ecological zone.

Li *et al*. (2006) analyzed meteorological statistical data spanning many years in Xinjiang, including the wind effect index and the warm and humid indices of tourism. They studied the travel climate resources of the key tourist cities in Xinjiang using quantitative analysis, obtaining the suitable seasons for travel in each city. These cities can be divided among five travel climate types: grassland, basin, desert, lowland and valley.

4. Conclusions

Major European studies on biometeorology for tourism/recreation have been conducted from the viewpoint of human health (Scott *et al.*, 2004; Matzarakis, 2006), while most Japanese studies in this field have focused on the environmental impact on human behaviors as influenced by the weather. Research on biometeorology for tourism/recreation has not been popular in Japan, whose peoples have a higher acclimation potential than European peoples. However, study in this discipline has progressed in China similarly to popular studies in Europe, although the climatological background and acclimation potential of the peoples of China are partially similar to those of Japan.

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References

Aoki, K. and Y. Aoki (1974) A study on the fluctuation of park-use –Three categories in the year round-use classified by seasons–. *Journal of the Japanese Institute of Landscape Architects*, 38 (2): 12-17. (in Japanese with English Summary)

Aoki, Y. and T. Aikoh (2008) Comparison of outdoor activities between Austria and Japan. *Journal of Environmental Information Science*, 36 (5): 109-118.

Aoki, Y. and Y. Fujinuma (1996) Effects of weather conditions and seasonal attractions to parking demand at Oku-Nikko area. *Papers on Environmental Information Science*, 25 (2): 69-72. (in Japanese with English Abstract)

Chen, S., G. Fan and L. Guo (2006) Climate suitability of tourism in Zhejiang islands. *Chinese Meteorology Science & Technology*, 6: 719-723. (in Chinese with English Abstract)

Duo, X., G. Liang, J. Xu and J. Zhu (2008) Ice and snow tourism in Heilongjiang Province of the climatic conditions. *Journal of Heilongjiang Meteorology in China*, 25: 28-30. (in Chinese with English Abstract)

Fujinuma, Y. and Y. Aoki (1998) Effects of weather and day of the week on daily use of Yumoto ski site at Oku-Nikko area. *J. JILA*, 62: 181-183. (in Japanese with English Summary)

Fukushima, T., M. Kureha, N. Ozaki, Y. Fukimori and H. Harasawa (2003) Influences of air temperature change on leisure industries: Case study on ski activities. *Mitigation and Adaptation Strategies for Climate Change*, 7: 173-189.

Guo, J., Y. Jiang, Y. Hu and M. Sun (2008) Climatic analysis and division of tourism resources in Sichuan Province. *Resources and Environment in the Yangtze Basin*, 17: 390-395. (in Chinese with English Abstract)

Han, J., G. Zhang, Q. Zhang, J. Zhang, Liu, L. Tian, C. Zheng, J. Hao, J. Lin, Y. Liu and D.J. Moschandreas (2007) Field study on occupants' thermal comfort and residential thermal environment in a hot-humid climate of China. *Building and Environment*, 42: 4043-4050.

Li, X., X. Li, K. Abudu, Q. Miao and X. Qi (2006) The appraisal and classification of the tour climate resource of the traveling cities in Xinjiang. *Journal of Arid Land Resources and Environment in China*, 20 (3): 128-131. (in Chinese with English Abstract)

Matzarakis, A. (2006) Weather- and climate-related information for tourism. *Tourism and Hospitality Planning & Development*, 3: 99-115.

Qian, M and M. Ye (1996) A method for evaluating tourism comfort in Sichuan Province. *Journal of Chengdu Institute of Meteorology in China*, 38 (3): 128-135. (in Chinese with English Abstract)

Scott, D., B. Jones and G. McBoyle (2004) *Climate, tourism and recreation: A bibliography*, University of Waterloo, Waterloo.

Shao, X. and L. Liang (2004) Climatic analysis and division of tourism in Henan province. *Journal of Xinyang Normal University in China*, 17: 72-77. (in Chinese with English Abstract)

Smith, K. (1990) Tourism and climate change. *Land Use Policy*, 7: 176-180.

Tamura, Y. and Y. Aoki (2005) An analysis of the fluctuation in the number of visitors in the Oze area of Nikko National Park. *LRJ*, 68: 723-726. (in Japanese with English Abstract)

Tan, J., G. Song and Y. Zheng (2006) Heat waves and related mortality in Shanghai in 1998 and 2003. *Chinese Journal of Environment and Health*, 6: 21-24. (in Chinese with English Abstract)

Tokiwa, K. (2007) Life-weather merchandising. *Global Environmental Research*, 11 (1): 79-82.

UNWTO (2007) Davos Declaration "Climate Change and Tourism: Responding to Global Challenges. Summary" Second International Conference on Climate Change and Tourism, Davos

Yoshino, M. and R. Miyashita (2007) Studies on bioclimate and weather-health forecasting in Japan. *Global Environmental Research*, 11: 23-31.

Toshiaki ICHINOSE

Toshiaki ICHINOSE is an Executive Senior Research Scientist at the National Institute for Environmental Studies (NIES), Japan, and a Professor at the Graduate School of Environmental Studies, Nagoya University. With an academic background in Geography and Civil Engineering, he is interested in various aspects of Urban Environment Systems, ranging from urban climatology, energy systems and GIS to their application in urban planning. In particular, he has performed many relevant field surveys in China and other Asian countries. He has authored many related publications including *Counteracting Urban Heat Islands in Japan* (Elsevier "Urban Energy Transition," 2008). He has served as a board member of the International Association for Urban Climate (IAUC) and a member of the WMO Expert Team on Training on Urban Climatology. His main on-going research topic is *Strategic Urban Planning and Assessment of Low-Carbon Cities*.

Olaf MATUSCHEK

Olaf MATUSCHEK is working on a Master's of Science degree at the University of Freiburg in Germany. His major is Geography, and his minor subjects are Meteorology and Computer Science. At the Meteorological Institute of the University of Freiburg he works as an assistant on the project KUNTIKUM (Climate Trends and Sustainable Development of Tourism in Coastal and Low Mountain Range Regions). At KUNTIKUM, researchers work jointly together with tourism-oriented politicians and representatives of the tourist industry. At the moment, Olaf Matuschek is writing his Master's thesis on the subject "Climate in Northern China at the Maunder Minimum, 1680-1700, reconstructed from Jesuit travel journals."

One major focus of Olaf Matuschek's research has been East Asia, especially Japan. He thinks that through insight into both European and East Asian cultural worlds and understanding of these regions' different patterns of solving problems, a deeper understanding of many pressing questions can be accomplished. Olaf Matuschek is actively participating in deepening international relationships.

Yuanshu JING

Yuanshu JING is a Professor at the College of Applied Meteorology at the Nanjing University of Information Science and Technology. He has served as a board member of the Commission for Agricultural Meteorology, Chinese Meteorological Society, since 2003, becoming a board member of the Commission for Forest Meteorology, Chinese Society of Forestry, in June 2005. He is interested in various aspects of urban ecology, ranging from the effects of climate on man, use of bioclimatic charts and the relation of climatic elements to comfort. He has published many papers including *The Features of Effective Temperature for Human Beings in the Nanjing Area* (Chinese Information on Science & Technology, Beijing, 2008) and *Factors Related to Urban Heat Islands* (Chinese Information on Science & Technology, Beijing, 2006). He is devoting himself to getting a wider range of academic background and experience for analyzing the detailed characteristics of urban heat islands and performing numerical simulation of the most rapidly growing cities.

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