

**WEATHER DEPENDENCE OF TOURIST'S SPATIAL BEHAVIOUR AND
DESTINATION CHOICES: CASE STUDY WITH PASSIVE MOBILE POSITIONING
DATA IN ESTONIA**

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ABSTRACT The aim of this paper is to study the impact of air temperature on international tourists' spatial behaviour when traveling to Estonia. Tourists' spatial behaviour depends on many factors, weather dependence is one important aspect that has been studied. This study applies passive mobile positioning; a relatively new data collecting method that has many advantages but also some disadvantages in studying tourists' spatial behaviour within a destination at a local scale. The passive mobile positioning dataset consisted of 6.1 million locations of call activities made by foreign mobile phones (roaming service) during the summer periods (June 1-August 31) of 2004 and 2005. The results of the study show that correlation between air temperature and tourists' locations is significant in 50-60% of the study area, mainly in coastal and resort areas where correlations are the strongest. In bigger cities and inland areas the activities of tourists were the least weather dependent. The study confirms the great potential of the passive positioning method for studying tourists' space-time behaviour at local destinations.

KEYWORDS: *Tourism climatology, spatial behaviour, mobile positioning, weather, destination choice.*

INTRODUCTION

Tourists' destination choices and local behaviour regularities are essential information for planning public services, businesses and tourism marketing. The space-time behaviour of a tourist depends on his/her decisions and perceptions that are affected by many external factors (natural, socio-cultural, economical etc). Studies show that weather/climate is one of the most significant factors for destination choice (e.g. Lohmann and Kaim, 1999, Hamilton and Lau, 2004). Few studies have thus far observed the weather/climate impact on tourist spatial behaviour on a micro-scale level (e.g. Perry, 1970, Kammler and Schernewski, 2004). However, on a medium scale, the impact of weather/climate on tourists' spatial behaviour has been very little studied within a destination country (e.g. Debbage, 1991). This is, in part, since tourists' spatial behaviour is often assumed to be self-evident and is often overlooked as

tourists movements have not yet been examined (Lew and McKercher, 2006, ten Hagen et al., 2006).

As a result the tourists' actual behaviour during the time between arrival and departure from a destination is known in very general terms. The main reasons for this are the lack of a suitable method and the sporadic nature of existing data on the spatial behaviour (Wermuth et al., 2003). For example, with the traditional travel-diary method tourists' actual spatial behaviour remains unclear because of spatial inaccuracy and the poor reliability of diaries, which rely on a respondent's honesty and memory (ten Hagen et al., 2006). In addition, tourists' spatial behaviour has been studied with different indirect statistics (logged data like overnight stays), but the results are given in relatively general terms. Until recently, several new data collecting methods (GPS, GSM, webcams) have been adopted into tourism studies enabling a more accurate study of tourists' space-time movements (Brown and Chalmers, 2003). This paper analyses tourists' spatial behaviour using passive mobile phone positioning. Advantages of using mobile positioning are the convenience and cost of positioning and also the possibility for indoor positioning (conversely to GPS). In addition, all data are already in a digital form. Asakura and Iryo (2007) and Ahas et al. (2007a) have successfully used mobile positioning for studying tourists.

The aim of this paper is to describe the impacts of weather on tourists' spatial behaviour within a local destination and to analyse the spatial differences in Estonia. For this paper, a local destination (Estonia) is defined as the area that could be visited in a daytrip from the place of temporary residence. This paper tries to find answers to the following questions: How weather (air temperature) affects tourist spatial movement within a local destination? Whether tourists' behaviour patterns in inland areas resemble those in coastal areas? Does weather (air temperature) affect tourist's behaviour in bigger cities?

STUDY AREA AND METHODS

The study area, Estonia, is located on the eastern coast of the Baltic Sea in Northern Europe covering around 45000 km². Estonia is located in a climate transition zone where a wet maritime climate meets a dry continental climate and, as a result, the four seasons – spring, summer, autumn, winter – are clearly distinguishable. Regional climatic differences are affected by the Baltic Sea causing temperature differences between coastal and inland areas. Summer is a period where the daily mean air temperature is over + 1 °C. The summer period lasts for three months (June-August), varying in length from 88 to 102 days. The recreation and tourism sector is an important source of income and contributes about 17 % of the gross

domestic product (GPD) for Estonia. 2/3 of international tourists come for holidays; during the summer period the percentage rises to 78 %.

Inbound tourists were studied during two summer periods from June 1 to August 31 in 2004 and 2005. In this paper the local destination is defined as the area that could be visited in a daytrip from the place of overnight stay (Lew and McKercher, 2006) and therefore a local destination could be anywhere in Estonia. For this study, the inbound tourist is defined as the foreign visitor who visited Estonia irrespective of the purpose of the visit and during that time used his/her mobile phone in the biggest mobile network provider in Estonia during the study period.

For this study the passive mobile positioning data of inbound tourists' roaming activities was analyzed. The roaming service enables the use of foreign mobile phones (non-Estonian sim-card) in the local mobile network. Roaming activity is any active use of a mobile phone: incoming/outgoing calls and SMSs and MMSs; data communication services (internet, location based services etc). Passive mobile positioning data means that the location of a call is stored automatically to the log file of a mobile operator whenever a mobile phone interacts with the mobile network. The location of every call activity is determined by the accuracy of a mobile network base station. For every base station a theoretical service area was calculated as Thiessen polygons, defining these service areas as network cells. The density of the network cells is related to the density of a settlement area, and hence, the accuracy of a passive mobile positioning is variable in space: average positioning error in rural areas is about 4.3km and in urban areas 1.7 km respectively (Ahas et al., 2007b).

The passive mobile positioning dataset, consisting over 6.1 million call activities, contains also the time and date of every call activity and country identification code where the mobile phone (sim-card) is registered. All call activities are anonymous and can not be associated with any particular person. Collecting, storing and processing of call activities are in accordance with the Directive on privacy and electronic communications of the European Parliament and of the Council (DIRECTIVE 2002/58/EC). The distribution of tourists by country of origin correlates closely with Estonian accommodation statistics (Ahas et al., 2007b). In this paper, roaming call activity is used as the location of an inbound tourist.

Daily air temperature data was obtained from 8 weather stations of the Estonian Meteorological and Hydrological Institute in Estonia. The relationship between the locations of tourists and air temperature is studied using the average for Estonia as well as data for each weather station separately. For assessing and ranking the relationships, Spearman's rank correlations were used. Correlations are studied at two levels: at the level of all of Estonia and

at the level of a mobile network cell. In bigger cities mobile network cells were aggregated into the level of a city district. Thus initially over 600 mobile network cells, 371 network cells in 2004 and 386 network cells in 2005 were analyzed.

RESULTS

The strongest correlations in the context of Estonia were found for daily mean air temperature while the correlation coefficient (ρ) was 0.48 (max 1). In the bigger cities (Tallinn and Tartu) the relationship between air temperature and tourists' locations was weak (ρ 0.16) (Fig. 1a). Excluding the data of bigger cities, the correlation coefficient (ρ) in the rest of Estonia increased up to 0.58: in 2004 $\rho=0.57$ and in 2005 $\rho=0.64$ (Fig. 1b).

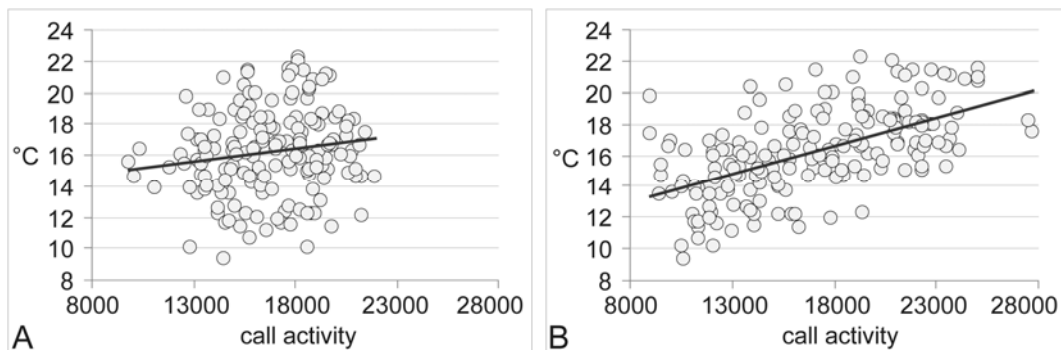


Figure 1: The relationship between tourists' locations and daily mean air temperature on a daily basis during both summer periods in bigger cities (Tallinn and Tartu together) (A) and in the rest of Estonia (B)

The relationship between tourists' locations and daily mean air temperature differs considerably between network cells in Estonia (Fig. 2). 60 % of all network cells had a statistically significant ($p < 0.1$) correlation in 2004 and 57 % in 2005. Further, 50 % in 2004 and 64 % in 2005 of network cells of all statistically significant network cells had medium correlation coefficients ($\rho > 0.3$ and < 0.7). In both summer periods, 4 % of all network cells with statistically significant relationships had a slightly negative correlation ($\rho < 0.3$). All significant correlations were linear.

Network cells with the strongest positive correlations were located in coastal areas (Fig. 2): along the Northern Estonian coast (e.g. Lahemaa NP); along the north coast of Lake Peipsi (Fig. 3b); and in Western Estonia (islands, Pärnu (Fig. 3a)). Inland relationships between tourists' locations and daily mean air temperature were not significant or the correlations were weak.

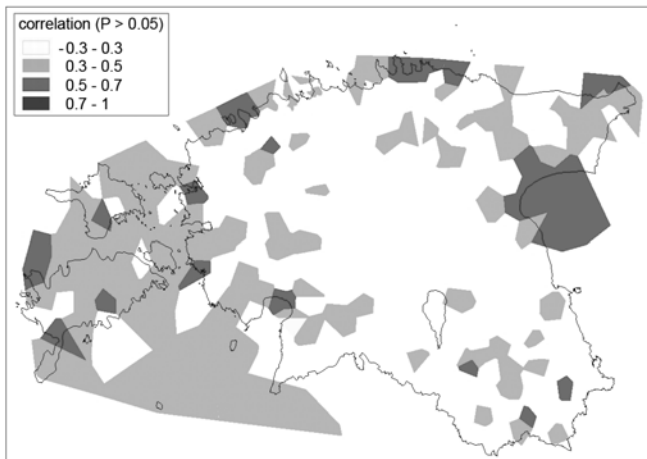


Figure 2: Correlation between tourists' locations and daily mean air temperature at the level of network cells during summer period (June-August) in 2004. Correlations are shown at significant level of $p < 0.05$

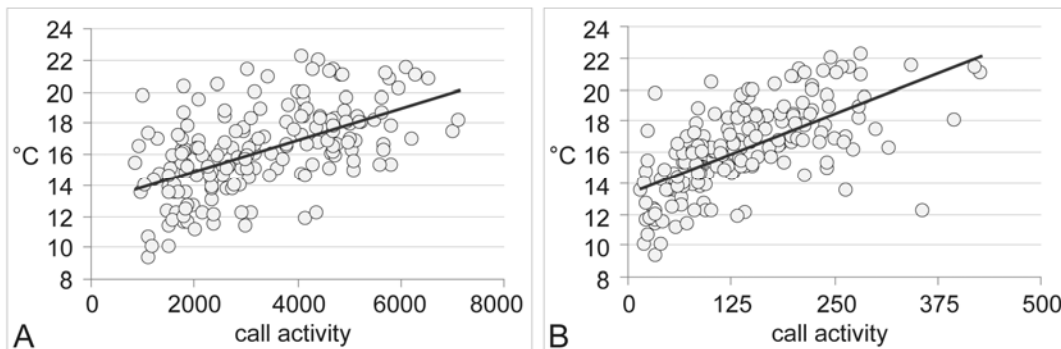


Figure 3: The relationship between tourists locations and daily mean air temperature on a daily basis during both summer periods in spa resort of Pärnu (A) and in the undeveloped beach area along the northern coast of Lake Peipsi (B)

DISCUSSION

The results of this paper clearly show that for Estonia inbound tourist locations in the summer period (June-August) is related to air temperature and that inbound tourists are dependent on warmer weather. This confirms results of previous studies that weather/climate is one of the most important reasons for visiting a destination. In addition, passive mobile positioning data enables us to analyse tourists' relationships with weather in more spatial detail. At the level of mobile network cells this study shows that tourists' weather dependency differs considerably between network cells in Estonia. The most weather dependent are holiday destinations along the coast (Fig. 2) where beach tourism dominates. The warmer the weather, the more tourists visit these seasonal holiday resorts, spas and their surroundings. This confirms the study results of Kammler and Schernevski (2004), indicating that weather (air temperature) is the main factor affecting tourists' spatial behaviour in beach and holiday resort areas. Tourists who visit inland areas with fewer tourist attractions are not affected by weather. Similarly, the

study shows that tourists do not take into account the weather when visiting bigger cities where there is diverse variety of indoor services and attractions for tourists.

The passive mobile positioning dataset containing over 6.2 million call activities was sufficient for describing tourists' spatial behaviour. Still, it is important to remember that with this data collection method the precision of tourists' spatial movements depends on the frequency of their use of mobile phones. The more call activities, the more detailed spatial movement trajectories can be studied. One must also notice that this study does not take into account inbound tourists who did not use mobile phones, but this proportion of tourists is marginal as mobile phones are becoming more and more popular. The biggest drawback of the passive mobile positioning method is the absence of social attributes of the dataset, which would enable the explanation of tourist behaviour. For example how does age affect the impact of weather to his/her spatial behaviour etc?

Mobile positioning has great potential for studying tourists' space-time behaviour at local destinations. This data collection method has advantages like convenience and cost of positioning, and all data are already in digital form and thus allows easy processing or analysis. This study observed tourists' locations on a daily basis and its relationship to weather, but the data offers much more. In future studies tourists' actual movement trajectories in space and time and their relationship to weather will be analyzed.

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