The seventh International Conference on Urban Climate,
29 June - 3 July 2009, Yokohama, Japan

AIR TEMPERATURE DISTRIBUTION IN AN URBAN PARK: DIFFERENCES BETWEEN OPEN-FIELD AND BELOW A CANOPY

Martina Petralli*, Luciano Massetti** and Simone Orlandini*

*Interdepartmental Centre of Bioclimatology, University of Florence, Florence, Italy; **Institute of Biometeorology, National Research Council, Florence, Italy

Abstract

The air temperature distribution in an urban area is very important for biometeorological studies. Many authors underline the importance of the presence of green areas for thermal wellbeing during summer and the aim of this study is to investigate the differences in apparent temperature values between a lawn and below a canopy in an urban park. The study was carried out in the greatest urban park of Florence: two meteorological stations were sited in two different areas of the park, on a grassland and on a woodland. Data were collected in August 2008, when the park is crowded and the cooling effect of green areas is stronger. Apparent temperature was compared between the two sensors, and a significant difference in maximum, minimum, and daily apparent temperature range was found. This is an important result as regard human wellbeing and the urban heat island during summer: the air temperature in an urban park is linked to the type of vegetation of the park and the human wellbeing can be significantly different in a lawn or in a forested part of the park.

Key words: Grassland, Woodland, Microclimate, Biometeorology

1. INTRODUCTION

Climatological studies has proved that cities have greater temperatures than in the past (Hasanean, 2001; Rozbicki and Golaszewski, 2003) and that are hotter than the surrounding rural areas (Oke, 1973). As a result of the Urban heat island (UHI) effect and of the consequences of heat waves on human health, people living in urban areas have an higher risk of death during Summer compared to those who live in suburban and rural areas (Conti *et al.*, 2005). Vegetated urban parks are often cooler than their surroundings (Sponken-Smith and Oke, 1999) and the magnitude and timing of the park cool island (PCI) effect varies with park type and the extent to which the park differs from its surroundings (Sponken-Smith and Oke, 1998).
The aim of this study is to investigate the human wellbeing in urban parks and to understand the better way to plan them in order to reduce negative consequences on human health and on the mitigation of the UHI effect increasing the PCI effect. The cooling effect of a park is defined by the PCI (Park Cool Island) index and it is calculated as the difference between urban and park air temperature (Spronken-Smith and Oke, 1998). But the knowledge of the intensity and distribution of park cooling does not give an immediate indication of the relationships existing between these phenomena and human comfort. Only few studies have analyzed different bioclimatic condition in urban parks applying biometeorological indexes (Bacci *et al.*, 2003; Potchter *et al.*, 2006).The city of Florence is one of the main important city of Italy for cultural tourism. In the last years, the mean age of citizen has been increasing and, as a consequence of this, the social and political interest towards elderly wellbeing too. Many authors have underlined the strong relationship between hot days and mortality (Kosatsky, 2005; Kilbourne, 1997; Conti *et al.,* 2005): the knowledge of human wellbeing in urban park can really help local administrators in planning the urban development and health care assistance in promoting elderly activities in urban green areas exploiting the benefits of more comfortable thermal conditions.

2. MATERIALS AND METHODS

The city of Florence is characterized by a great urban park named Parco delle Cascine, located near the city centre (figure 1). During Summer, many people prefer to spend their free time in urban parks because they can find better thermal conditions than in other urban areas. But inside the park the thermal comfort can be different according to the presence of arboreal plants.
Two meteorological stations were placed inside the park, one in a grassland (G) and the other in a woodland (W) near the grassland. Data were collected in August 2008 and air temperature, relative humidity and wind speed

* Martina Petralli
martina.petralli@unifi.it
Interdepartmental Centre of Bioclimatology, University of Florence,
Piazzale delle Cascine, 18 – 50144 – Florence, Italy

data were used to determine the apparent temperature (AT). The biometeorological index applied to evaluate the effect of the green area on human well-being was the Steadman Heat Index (1979a, 1979b).

Figure 1: Orthophotograph of the study area: Parco delle Cascine, Florence (Italy).

The hourly trend of AT was examined in the whole period and even in two different synoptical days: a sunny day and a cloudy day. Cloudiness was estimated using the ratio between hourly diffuse cumulated solar radiation and global cumulated solar radiation collected in a meteorological station located 4 km far away from the study area. The hourly difference of AT in the grassland and in the woodland over the study period was tested with the analysis of variance (one-way ANOVA) and the Bonferroni Test using as independent variable the hour of the day. The one sample T-test was used to evaluate if the difference between AT in Grassland and AT in Woodland was statistically different from 0. All the statistical analysis were made using SPSS for Windows version 11.5.

3. RESULTS

A first data analysis of mean monthly data showed that, even if the AT average (ATave) was similar both in the grassland and in the woodland, there were some important differences in maximum (ATmax), minimum (ATmin) and daily range (DATR) of apparent temperature (table 1).

Weather stations	ATmax °C	ATmin °C	ATave °C	DATR °C
Grassland	33.4	16.5	25.2	16.8
Woodland	31.0	19.7	25.4	11.4

Table 1: Mean monthly maximum apparent temperature (ATmax), mean monthly minimum apparent temperature (ATmin), mean monthly average apparent temperature (ATave) and mean monthly daily apparent temperature range (DATR) collected during august 2008 in the grassland and in the woodland areas of the Parco delle Cascine in Florence.

In August 2008, the mean maximum apparent temperature in the Grassland was 33.4 °C, more than 2 °C higher than in the woodland. On the contrary, the ATmin was higher in W than in G, and this reflected on the DATR, that was higher in G than in W.
The hourly trend of apparent temperature in grassland and woodland is showed in figure 2. In the morning, till 8 o'clock, the grassland was cooler than the woodland. After 9 o'clock, the apparent temperature in G rose much more than in W, and till 9 pm it remains higher in G than in W. After 9 pm, the apparent temperature in G decreases faster and stronger than in W.
The one-way ANOVA and the Bonferroni Test confirmed that there was a statistical significant difference of the hourly difference between AT in G and in W: the AT difference in each hour from 7 am to 9 pm was statistically different from each hour of the period 10 pm to 6 am (data not shown).
The one sample T-test showed that the difference between AT in G and AT in W was always statistically different from 0, except at 9 am and 9 pm.

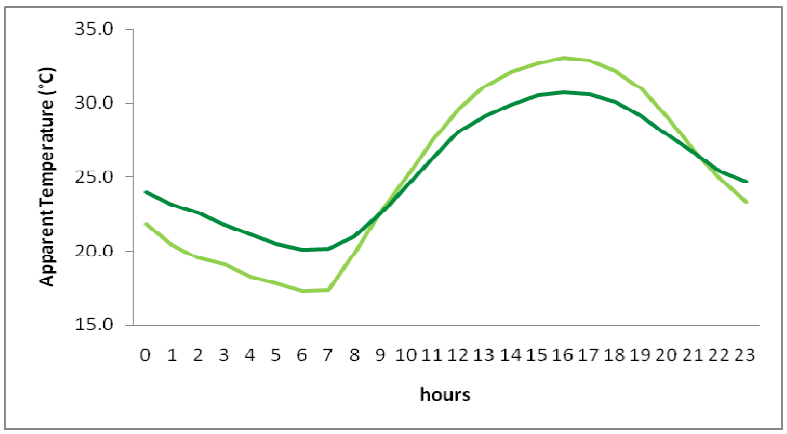

Figure 2: Hourly Apparent Temperature trend in Grassland (light green) and in woodland (green) during August 2008 in Florence.

The hourly trend of AT was also examined in two different synoptical days: a sunny day (figure 3a) and a cloudy day (figure 3b). In both cases, maximum and daily range of apparent temperature was higher in G than in W, and minimum apparent temperature was smaller in G, but the difference between the maximum values was higher in the sunny day than in the cloudy day.

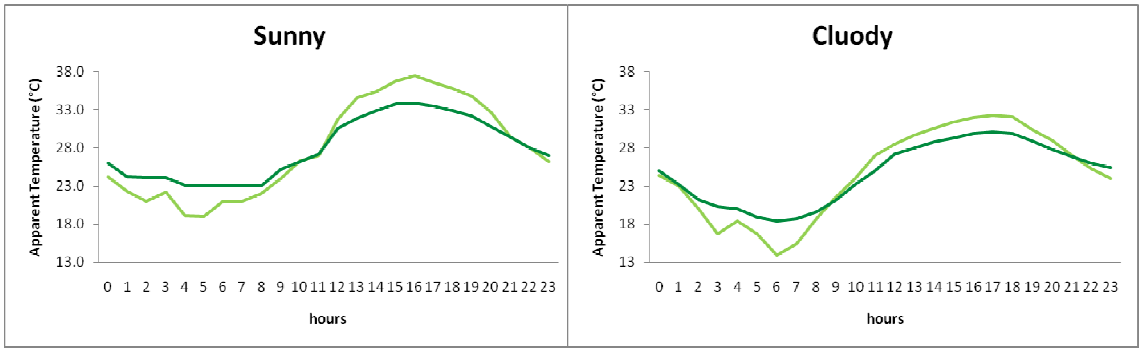

Figure 3: Hourly Apparent Temperature trend in Grassland (light green) and in Woodland (green) during a Sunny day (a) and a Cloudy day (b) in August 2008 in Florence.

4. DISCUSSION AND CONCLUSIONS

This study wants to give a contribution on the importance of green areas to improve human wellbeing within the city. In particular, the differences between apparent temperatures in a grassland or in a woodland of the major urban park of Florence were analyzed. Many authors have investigate the cooling effect of urban parks (Sponken-Smith and Oke, 1998; Sponken-Smith and Oke, 1999; Petralli *et al*., 2006a), especially during the night-time, and the importance of urban forestry in the urban microclimate (Oke, 1989), but only few authors have analyzed the differences in human wellbeing applying biometeorological indexes in different type of parks (Bacci *et a.l*, 2003; Potchter *et al*., 2006). This study underlines the differences in summer human wellbeing in an urban park between a grass area and a forested one: during the day the forested area is meanly 3 °C cooler than the grass area, but during the night the grassland is cooler than the woodland of almost the same amount. Potchter (2006) in his study on the climatic behaviour in various urban parks in Tel Aviv, explains that urban parks can not be necessarily cool islands, in contrast with the Oke theory (Oke, 1987; Sponken-Smith and Oke, 1998). Furthermore, Potchter suggest to avoid parks with grass coverage in costal Mediterranean areas. But, as the cooling effect of green areas is both during the day (in the wooded area) and during the night (in the grassland area), and as the lower temperatures during the night seems to have very important consequences in human health (Kalkstein e Davis, 1989; Petralli *et al*, 2006b), this study wants to suggest that both grassland and woodland areas of a park can have different positive effects on human wellbeing during all the hours of the day. Further study on these topics must be curried out to give some important suggestions to local administrators in

urban planning and in health care assistance to plan elderly activity in gardens to appreciate the more comfortable conditions of urban parks.

Acknowledgments

This study was supported by Tuscany Region "Servizio Sanitario Regionale" grant: MeteoSalute Project.

References

Bacci, L., Morabito, M., Raschi, A., Ugolini, F., 2003. Thermohygrometric conditions of some urban parks of Florence (Italy) and their effect on human wellbeing. *Proceedings of "Fifth International Conference on Urban Climate"*, 1-5 September Lodz, Poland.

Hasanean, H.M., 2001. Fluctuation of surface air temperature in the Eastern Mediterranean. *Theoretical and Applied Climatology* 68: 75-87

Kalkstein, L.S. and Davis, R.E., 1989. Weather and human mortality: An evaluation of demographic and interregional responses in the United States. *Ann. Assoc. Amer. Geogr*. 79: 44-64

Kilbourne, E.M., 1997. Heat waves and hot environments. In: *The Public Health Consequences of Disaster* [Noji EK (ed)]. Oxford University Press, Oxford, United Kingdom and New York, NY, USA, 51-61

Kosatsky, T., 2005. The 2003 European heat waves. *Euro Surveill*. Jul 1;10 (7)

Oke, T.R., 1973. City size and the Urban Heat Island. *Atmospheric Environment* 7: 769-779

Oke, T.R., 1987. Boundary Layer Climates, 2nd edition. Methuen. New York; 435

Oke, T.R., 1989. The micrometeorology of the Urban Forest. *Phil. Trans. Roy. Soc*. London B324, 335-349

Petralli, M., Prokopp, A. Morabito, M., Bartolini, G., Torrigiani, T., Orlandini, S., 2006a. Ruolo delle aree verdi nella mitigazione dell'isola di calore urbana: uno studio nella città di Firenze. *Italian Journal of Agrometeorology*, vol. 1; p. 51-58

Petralli, M., Morabito, M., Cecchi, L., Torrigiani, T., Bartolini, G., Orlandini, S., 2006b. Relationship between emergency calls and hot days in summer 2005 (Florence - Italy). *Proceedings of "Sixth International Conference on Urban Climate"*, 12-16 June. Goteborg (Sweden),

Potchter, O., Cohen, P., Bitan, A., 2006. Climatic behavior of various urban parks during hot and humid summer in the Mediterranean city of Tel Aviv, Israel. *Int. J. Climatolol.*, 26: 1695 - 1711

Rozbicki, T., Golaszewski, D., 2003. Analysis of local climate changes in Ursynów in the period 1960–1991 as a result of housing estate development. *In: Preprints Fifth International Conference on Urban Climate,* IAUC and WMO, Lodz, Poland, 1-5 September

Sponken-Smith, R.A. and Oke, T. R., 1998. The Thermal Regime of Urban Parks in Two Cities with Different Summer Climates. *Int. J. Remote Sensing* 19, 2084-2104

Sponken-Smith, R.A. and Oke, T. R., 1999. Scale modelling of nocturnal cooling in urban areas. *Boundary-Layer Meteorology* 93, 287-312

Steadman, R.G., 1979. The Assessment of Sultriness. Part I: A Temperature-Humidity Index Based on Human Physiology and Clothing Science. *J. Appl. Meteor.,* 18, 861-873.

Steadman, R.G., 1979. The Assessment of Sultriness. Part II: Effect of wind, extra radiation and barometric pressure on apparent temperature. *J. Appl. Meteor.,* 18, 874-885