Use of Outdoor Spaces and Microclimate in a Mediterranean Urban Area

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Abstract

This paper presents some of the findings of the European project, RUROS, concentrating on the effect of microclimatic conditions on the use of open spaces in an urban Mediterranean environment. The findings confirm that there is a strong relationship between microclimatic conditions and use of open spaces. Regarding the users of open spaces, a sensitivity to the summer heat was apparent for the age category >65. The spatial distribution of the interviewees demonstrates that in summer, visitors prefer to sit in shaded areas, whereas in autumn and winter sunlit areas are more popular. Observations of the use of space revealed that air temperature and solar radiation were found to be the most dominant parameters in relation to the use of space, with wind speed and relative humidity having a weak effect. In general, people prefer shaded areas at higher air temperatures. However, as high air temperature is a factor contributing to discomfort, overall presence is reduced when air temperature rises significantly. The preference of sun, differs from season to season, depending on the activities taking place in the areas (either designated or not). The diurnal pattern of the use of space also reveals a strong dependency on meteorological parameters. Regarding the time of maximum attendance, this is found in the evening during summer, while there is a transition of the time of maximum attendance towards noon as the season progresses from summer to winter. Daytime attendance figures of autumn and winter are 300-400% higher than in the summer. The need open spaces cover and the social ties provided may also be traced by analyzing the social composition of the interviewees and the reasons bringing them in the space.

Keywords: use of outdoor spaces, microclimate, social ties, urban design

1. Introduction

The rapidly increasing concentration of people in urban areas along with the focus to improve quality of life, and revitalise city centres, has led to increased attention to the quality of open urban spaces. In this framework it has been realised that simple allowance of open space given to the city does not ensure social cohesion. In New York, in 1972, developers were given incentive bonuses for providing plazas; for each square foot of open space they would give to the public, they would gain 10 ft^2 of extra floor space above the normally permitted [1]. As a result plazas surrounding expensive developments rapidly increased, but in their vast majority remained empty of people apart form the occasional passer-by, eventually enhancing isolation and social exclusion. On the other hand, there is the San Francisco experience, where public interest in the quality of open spaces has led to different referendums for protection of sunlight access in parks and protection from the winds from new developments [2].

It has become apparent that the environmental conditions imposed on people using open spaces, may improve or ruin their experience of them. Thus by integrating social and environmental objectives, it will be possible to increase use of outdoor space and revitalise cities, strengthening social interaction between citizens, by allowing for such interaction to take place.

Scandinavia has been strongly advocating the importance of the physical environment and microclimate in particular, at the use of urban spaces. With their harsh climate, especially during winter, they have identified the seasonal use of cities and are keen to extend their “outdoor season”, having acknowledged how social interaction is facilitated or retarded by the prevailing climatic conditions. Jan Gehl, from Denmark, is one of the pioneers to define the goodness of a

Doi: 10.1016/j.buildenv.2006.09.008

place, in terms of the protection it offers from negative aspects of climate and exposure to the positive ones [3]. Similarly, Swedish Ralph Erskine, defines the social space as the place for spontaneous activities to take place mentioning the strong influence of climate to it 4], whereas Finnish Reima Pietilä speaks of architecture and climate as being a dynamic couple [5].

There is, however, a significant lack of information on the way microclimatic issues affect the use of open spaces, along with subjective data for evaluation of comfort conditions in outdoor spaces, which in effect will assist the design and planning of such spaces. Recent research in the UK [6] has shown that responses to the microclimate may be unconscious, but they often result in a different use of open space under different climatic conditions. In a different climatic context, in Canada, the more extreme microclimatic conditions caused by tall buildings in business districts has been studied in relation to human activities and behaviour, in one of the first studies to understand the way people respond to microclimatic conditions [7].

In this framework, a large-scale project was organised, with the aim of examining and evaluating a wide range of comfort conditions across Europe. Project RUROS (Rediscovering the Urban Realm and Open Spaces) included extensive field surveys to understand and evaluate comfort conditions across Europe, encompassing the wide climatic variation, urban morphology, cultural background and plethora of personal differences, characterizing the users of open spaces. The evaluation and assessment of comfort conditions, based on a database of approximately 10,000 questionnaire guided interviews has been described elsewhere [8] and confirmed a strong relationship between microclimatic and comfort conditions, with air temperature and solar radiation being important determinants of comfort.

This paper goes further, examining on the way the microclimatic conditions affect the use of urban open spaces in a Mediterranean climate, concentrating on the surveys carried out in Athens, Greece.

2. Research framework

Two case studies of different nature were examined in each of the cities participating in the project, used as the medium for examining comfort conditions outdoors. In Athens, the case study areas selected were at the municipality of Alimos, at the south of the city, and include a variation of typologies, functions, types and activities characteristic of the municipality.

The field surveys involved detailed microclimatic monitoring with the use of a portable mini-weather station, with sensors conforming to ISO 7726 [9], while people were studied in their natural environment through structured interviews and observations, to evaluate the comfort conditions they experience and their perception of the environment. Detailed information on the environmental monitoring and the questionnaires used for the survey are described in [8]. Beyond the questionnaire guided interviews, the use of space was studied, by counting the number of people at different spaces in the area, both in terms of activities carried out, as well as in terms of patterns of use of areas found in the sun or shade. Special care was taken to select the interviewees in a manner representative of the different age groups present in and the patterns of use of the different areas.

The field surveys began in July 2001 and were completed in March 2002, covering the four seasons; summer, autumn, winter and spring. Each site was monitored for a full week each time, to get the weekly pattern of use. The time period that the surveys were carried out varied according to the season, also aiming to obtain the daily, as well as the seasonal, pattern of use. The daytime span was roughly separated in four periods, morning (10:00 – 11:59), midday (12:00 – 14:59), afternoon (15:00 – 17:59) and evening period (18:00 – 20:59). Their duration also varied according to the season, i.e. in summer surveys were running until 20:59, whereas in autumn, the surveys were running until 17:00, for security reasons as it was getting dark earlier.

This paper concentrates on issues related to the use of space, as opposed to people's evaluation of the comfort conditions, which have been described in [8]. People were studied in their natural environment, while issues affecting the use of space (patterns of use, groups of people using the space, preferences within the area, etc.) were also investigated.

2.1 Case studies description

The two sites considered in this study, namely Karaiskaki square (approximately 80x100 m^2) and the Seashore of Alimos (approximately 200x100 m^2) are of contrasting character.

Karaiskaki is a neighbourhood square of approximately 80x100 m^2, encompassing a range of activities. It has a playground for children, a small open-air theatre, a basket-ball field and a coffee-shop, acting as a focal point for the square (Fig. 1). Sitting places are provided with benches at the eastern side of the playground, along the corridors and the small area covered in grass, as well as actual seats outside the coffee-shop. It has to be pointed out that the actual coffee-shop building has a small footprint, while sitting spreads outside. There are no fixed boundaries between the area the coffee-shop covers and the rest of the square, thus it is easy for people to sit in the outside tables and watch their children playing in the playground or cycling along the corridors.

The area is mostly covered with hard materials, such as stone and partly soft, with grass. There are mature trees shading part of the grass-covered area and some of the benches, while awnings and a tree shade the area extending outside the coffee-shop.

Fig. 1: Karaiskaki square - plan view and different areas in the square

The Seashore area is part of the coastline of Alimos, an important area for greater Athens. At approximately 200x100 m^2 it includes areas for promenading, swimming and relaxation, along with a big playground (Fig. 2) and two coffee-shops. The latter are not included in the analysis, due to their fixed boundaries and borders, which separate them from the main open area. Due to its location and nature, the area also attracts visitors from neighboring municipalities and central Athens, who wish to visit the sea-side not only for swimming, but also for promenades.

At the northern boundaries, the area experiences heavy vehicular traffic, from the main traffic-carrying avenue along the coast of Athens and the new light-railway service. The playground has a lot of vegetation, both in terms of grass and mature trees. A long corridor directs people to the sea-front, and another long corridor running parallel to the coastline. Both of these corridors are characterized by large heat capacity materials, i.e. stone, and absence of shading. Furthermore, as both corridors are unprotected and located in an environment very similar to the open field, they are exposed to the winds from almost any direction.

Fig. 2: The Seashore site - plan view and different areas in the square

3. Data analysis

Extensive statistical treatment of the data collected was carried out. A brief discussion is initially presented focusing on the characteristics of the population using these spaces. Since collecting personal data on every people present was not feasible, the people that participated in the surveys, i.e. interviewed, were used as a representative sample to provide an understanding of the overall population.

Use of space is initially examined in relation to the different groups of people found in the areas, on an annual, as well as seasonal basis. The social aspect is also investigated, concentrating on population characteristics and the reasons bringing people to the space.

The microclimatic parameters recorded in the space are also presented along with the meteorological data used for investigating correlations with the use of space. Finally, the diurnal pattern of use of space is investigated for the different sites, focusing on the relationship with the local meteorological conditions.

3.1 Population statistics and use of space

Overall, 1503 interviews were carried out in Athens, 418 in summer (July-August), 360 in autumn (November), 418 in winter (February) and 307 in spring (April-May). The population demographics were investigated in terms of age groups and gender. In total, eight different age groups were identified; <12, 12-17, 18-24, 25-34, 35-44, 45-54, 55-64, >65 and the analysis demonstrated some interesting findings for the use of the different case study sites.

The population frequenting both sites presents a fairly uniform age distribution for most of the year (Fig. 3). Ages between 25 and 44 years account for almost 50% of the interviews followed by the >65 category that accounts for 15% for all seasons at the Seashore and Karaiskaki in spring. In summer, the age category 25-34 presents the highest frequency for both sites. During autumn and winter in Karaiskaki, the age category >65 presents increased presence with 25-30% of the interviews while during the summer elderly people seem to avoid the square.

This demonstrates one of the many roles of open spaces in cities, which is to offer opportunities for meeting people and socializing, an aspect of creating strong communities. This is particularly evident in the elderly group of the population, frequently pensioners, for which meeting with other

people in their neighbourhood is part of their daily routine. The sensitivity of this group of the population (>65) to the summer heat was also evident, when their presence was not as strong.

Regarding gender, there is 60:40 ratio in favour of females over males.

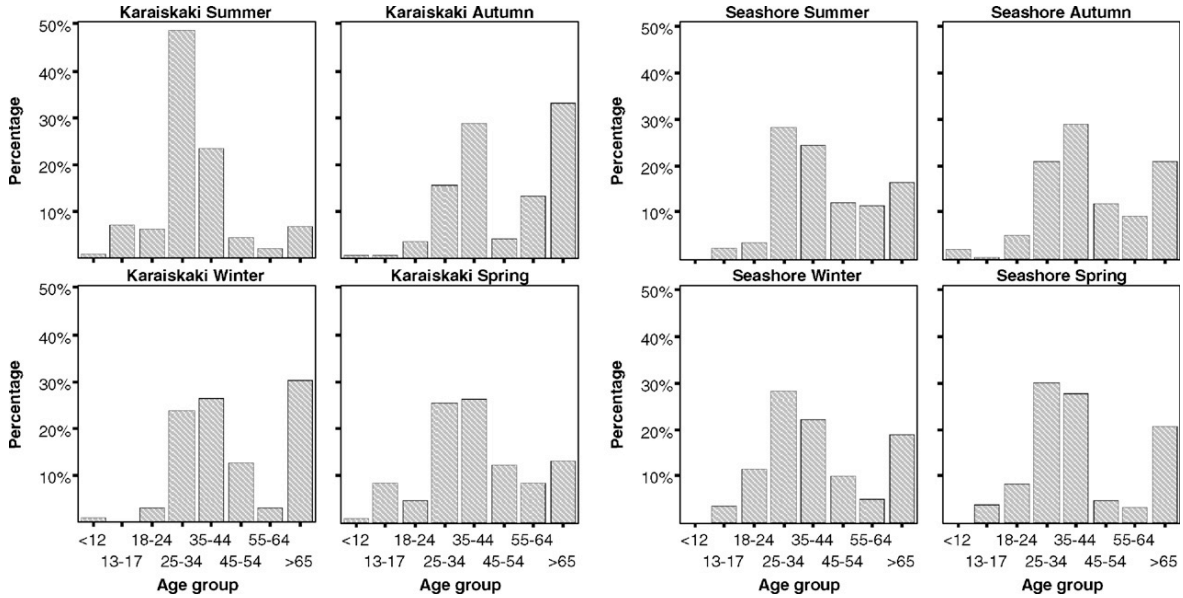

Figure 3: Demographics of the interviewees for the different sites and seasons.

The spatial distribution of the interviewees provides insight on the use of space as well as activities taking place at the different times of year. A brief analysis of that is presented below, where different colours represent the frequency of use of the various areas (Figs. 4 and 5).

In summary, at Karaiskaki (Fig. 4), the longest number of people is located in the coffee-shop, particularly close to the playground so that parents can watch their children playing. Another popular sitting place is inside the playground directly involved with the children playing. These are the most popular locations for all seasons, whereas the rest of the users are spread evenly at the rest of the areas, wherever benches are available.

Examining use seasonally, it becomes apparent that during the summer visitors prefer to sit in shaded areas, whereas in autumn and winter sunlit areas become more popular (Fig. 4). Similarly, areas such as the small theatre are not used much in the summer due to the resulting uncomfortable thermal environment, a combination of the absence of any shading and large heat capacity materials. In the summer, its use is limited in the evening, along with the small basket-ball court, where children from the neighbourhood gather to play.

At the Seashore, a very important feature of the site is, of course, the sea. This is the main reason that the benches by the sea and the kiosk are very popular locations. Activities taking place in the area, also strongly affect the use of the space, and as such the playground provides a very popular location for children and the adults accompanying them (Fig. 5).

From the seasonal analysis, it is apparent that the seaside is always very popular, but particularly during cooler seasons, the benches which are not shaded get busy. In the warmer seasons, however, the shaded kiosk gets very busy along with the playground, where there is ample shade from the trees (Fig. 5).

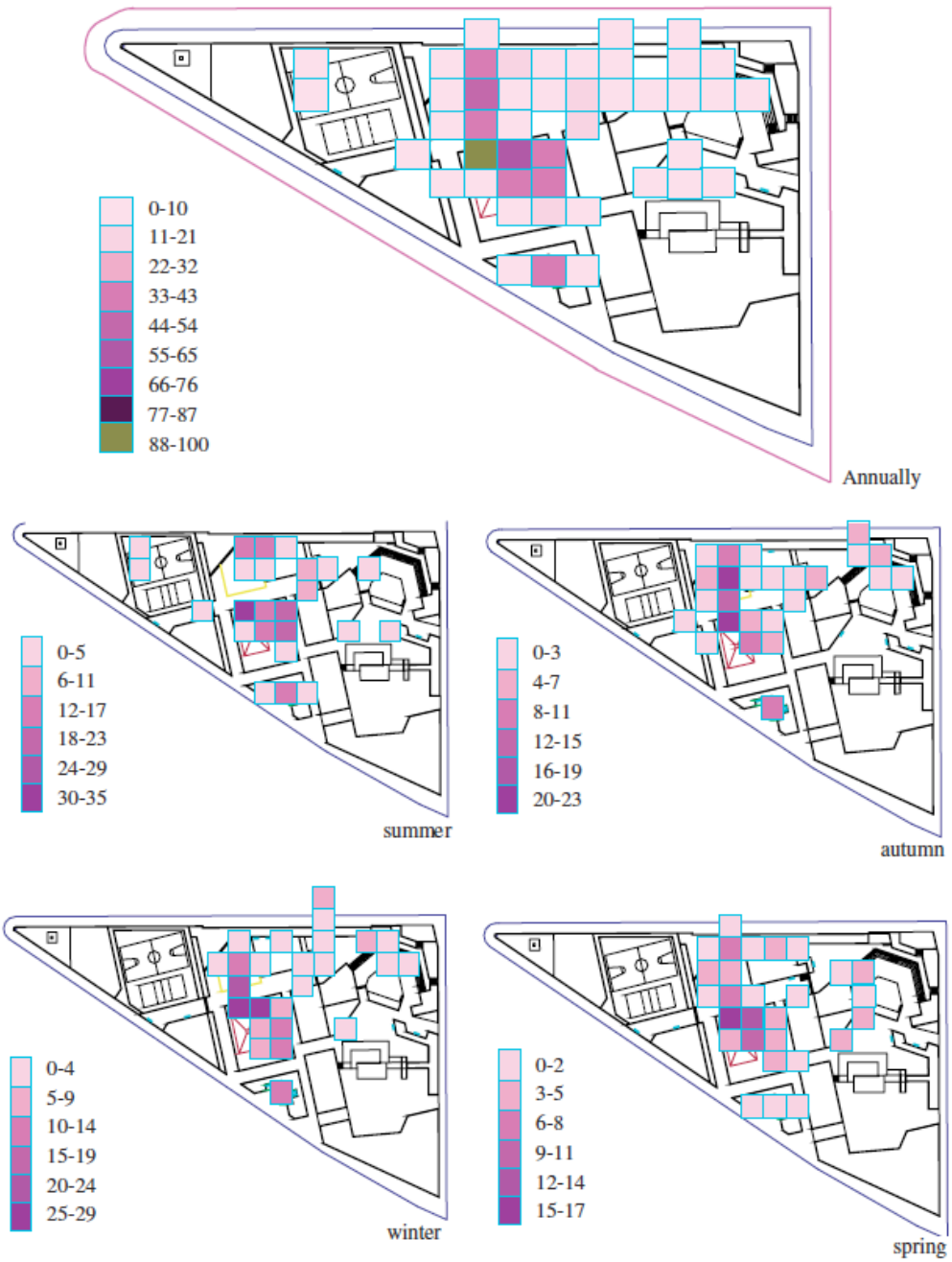

Fig. 4: Average number of interviewees present at Karaiskaki, annually (top), summer (middle left), autumn (middle right), winter (bottom left), spring (bottom right) [10].

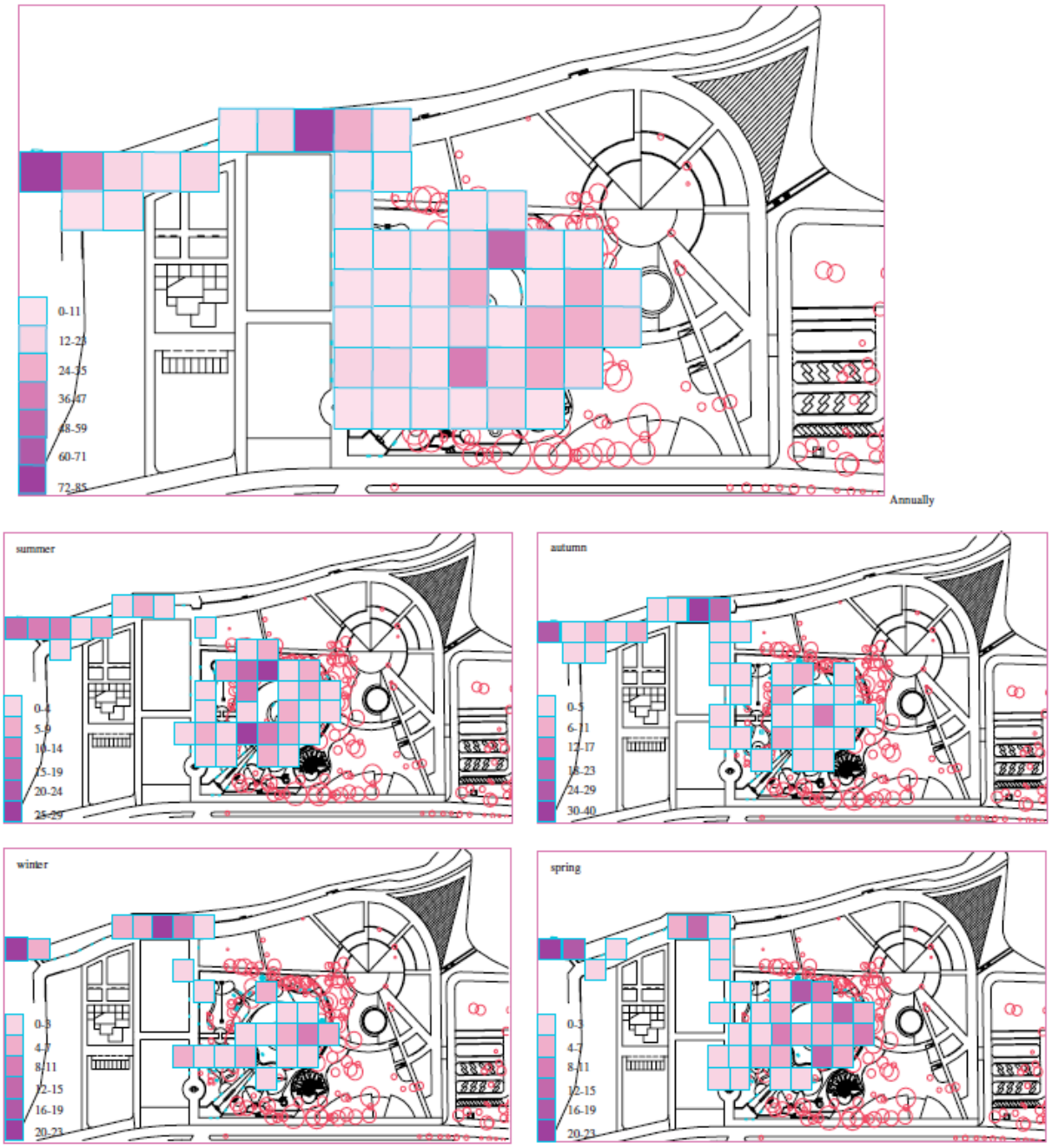

Fig. 5: Average number of interviewees present at Seashore, annually (top), summer (middle left), autumn (middle right), winter (bottom left), spring (bottom right) [10].

Analysing the related social aspects of the questionnaire, interesting issues arose. As far as the reasons bringing people in the area, 45% of the interviewees reported that the main reason was for the children to play, and this applied to both sites. Food/ coffee consumption is also a main attraction, as in Karaiskaki, 20% of the interviewees report that as the main reason for being in the area. This is in compliance with previous studies in open spaces, which have pointed out the attraction of outdoor cafés and restaurants [1]. 32% of the people have reported being there to relax, considering the outdoor environment with the natural setting as relaxing.

In terms of where the people are coming from, before arriving at the open space, a staggering 72%, i.e. 1037 interviewees reported that they arrived there straight form home. This is an important finding, as people viewed the open space as their actual destination, demonstrating the importance of open spaces in the urban fabric for every day life, covering basic human needs. Only 11% arrived in the space returning from carrying out various duties.

The nature of Karaiskaki as an important place for the neighbourhood also becomes apparent examining the users in the area and the respective frequency of use. 77% of the interviewees were local inhabitants, which compares to a 38% in the Seashore. Thus a visit to the square for the children to play is part of the daily routine for 26% of the interviewees. Whether locals or visiting the area from further afar, regular users of both areas (i.e. daily or weekly use, normally at week-ends), accounts for 60% of the frequency of use, with very few incidental users.

Another interesting point is that 55% of the population interviewed was professionals, with only 20% pensioners. Once again the importance of Karaiskaki for the neighbourhood is emphasised, where although the percentage of professionals is constant for both areas, pensioners account for 24% as opposed to 17% in the Seashore. In fact as it was commented, the benches in the square was a frequent meeting place, for people to sit in order to exchange news, read their newspaper, or watch incidental activity, people passing by, children playing, couples having coffee, etc.

Concerning the great number of professionals found in the open spaces, it may be tempting to attribute this to the Mediterranean way of life, or the hot weather. However, carrying out a similar comparison for all the sites that were employed in the RUROS surveys across Europe (which also included the cities of Thessaloniki (GR), Milan (I), Fribourg (CH), Cambridge (UK), Sheffield (UK) and Kassel (D)), similar percentages are found. More specifically, 46% of the participants in the surveys (from nearly 10,000 interviews) are professionals, while pensioners accounted for only 15%; other main categories included pupils at 27% and housewives at 7%.

3.2 Microclimatic data

A summary of the microclimatic information for the different interview periods is presented in Table 1. The measurements vary widely, not only due to the daily fluctuation, but also due to different microclimate even in the same space, e.g. measurements in shade under a tree, or in the sun. Due to the nature of the study with the portable mini-met station, the measurements obtained are very dependent on the local microclimate experienced by the people interviewed. In order to study the actual use of space, including all the people present in the area, as opposed to only those that participated in the interviews, climatic data obtained from the local meteorological station are used instead. The reason is that these are independent of the local microclimate and thus more representative of the average conditions in the open space overall.

Table 1: Summary of microclimatic variables for the surveys in Athens, for the different seasons

	Tair, °C				Tglobe, °C				Ws, m.s^{-1}				RH, %			
	sum	*aut*	*win*	*spr*	*sum*	*aut*	*win*	*spr*	*sum*	*aut*	*win*	*spr*	*sum*	*aut*	*win*	*spr*
mean	30.1	18.8	14.4	21.9	31.1	21.6	20.4	25.4	1.0	0.7	0.7	1.1	46.6	62.4	51.7	48.5
max.	35.5	23.3	19.2	27.7	41.0	30.3	27.4	34.6	4.5	3.4	3.3	4.0	76.6	84.2	80.4	70.4
min.	26.6	10.7	12.1	16.5	22.1	11.2	12.4	16.9	0.1	0.0	0.0	0.1	23.5	36.6	26.3	21.0
st.dev.	1.9	2.9	1.2	2.9	2.5	3.5	2.2	3.4	0.6	0.6	0.6	0.7	13.7	9.8	9.7	13.2

Generally, the microclimatic data recorded at the interview periods are in accordance to the data recorded at the meteorological station for all seasons, with small differences attributed to the effect of the urban fabric. Large differences are expected in wind speeds due to the fact that at the different sites wind speed was measured at less than 1m high, whereas at the meteorological station the respective height is 10m, unobstructed by buildings and vegetation.

Thus, wind speed from the meteorological station is transposed from the z_1=10m height, down to z_2=0.75m, corresponding to the average height of measurements during the surveys according to:

$$Ws_{Z2}=Ws_{Z1}*(z_2/z_1)^{0.25} \quad [11]$$

The relationship between the data measured on site and those of the meteorological station is shown in Figure 6.

Regarding the solar radiation information obtained from the station, horizontal illuminance measured in klux is used for the comparison. Although these are different parameters, they are nevertheless strongly related, as horizontal illuminance is a specially treated fraction of the global solar radiation [11].

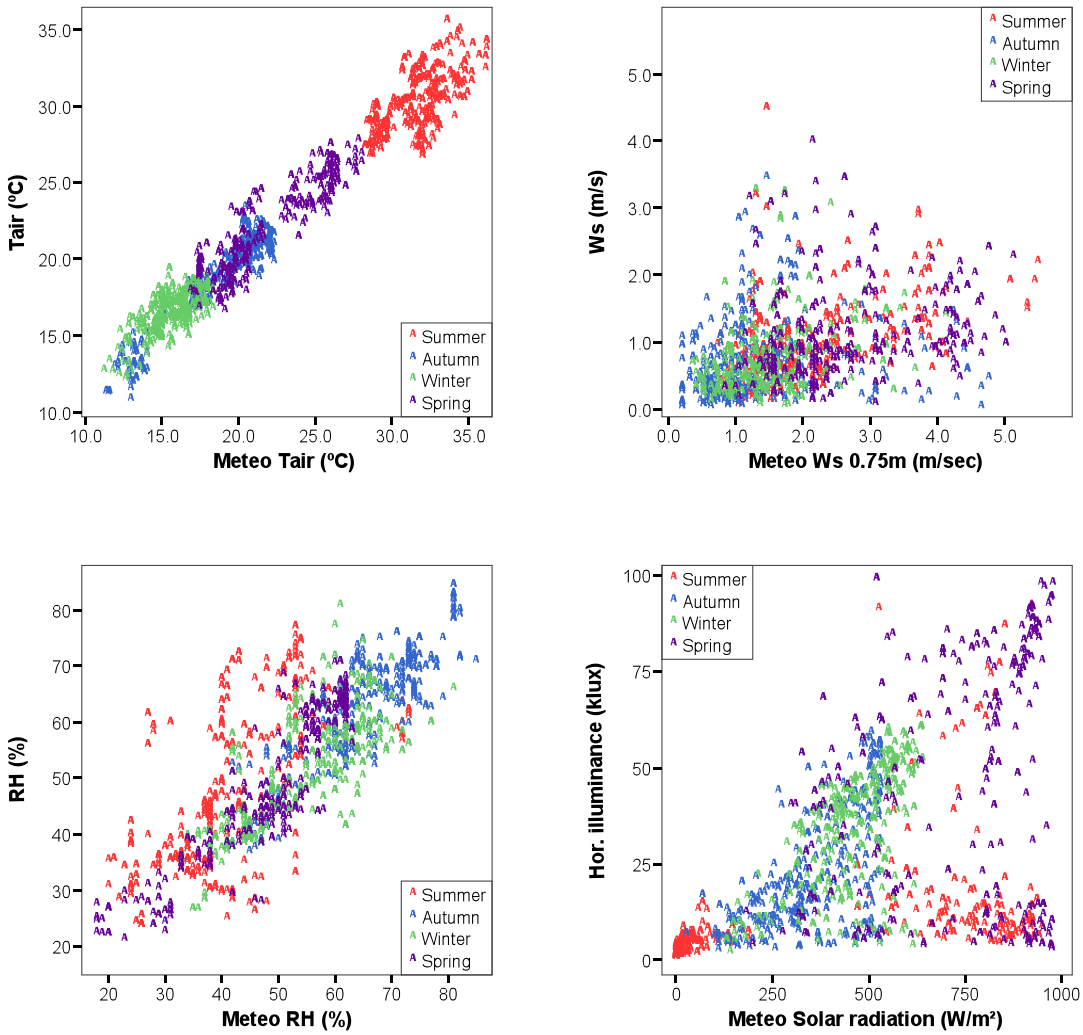

Figure 6: Relationship of the microclimatic data measured on site during the surveys with those of the meteorological station.

3.3 Correlations between meteorological parameters and use of space

Observations of the overall use of space, involved counts of the number of people present at the different areas, throughout the day, for three seasons, summer, autumn and winter. An attempt is made to correlate the use of space with meteorological conditions.

Analysis is carried out for the two sites separately, as well as in a combined dataset. Different areas within the sites are identified, in terms of activities, as well as in terms of whether the space is in sun or shade.

Air temperature and solar radiation are the most dominant parameters in relation to the use of space as respective correlations with wind speed and relative humidity are very weak.

Examining all the dataset together, correlation between presence in the sun and air temperature is -0.23 (Pearson correlation coefficient, $p<0.01$), demonstrating that as air temperature increases the number of people found in the sun is reduced.

This is particularly the case in Karaiskaki, where presence was examined in the playground and the benches all exposed in the sun, as well as the coffee-shop which is shaded. When sun or shade preference is examined, the correlation coefficients are -0.29 and 0.24 (all at $p<0.01$) respectively, demonstrating that people prefer shaded areas at higher air temperatures. Examining the

identified areas in terms of function and microclimate also provides interesting results, where although correlations are weak, they nevertheless reveal tendencies.

Thus the correlation coefficient between air temperature and presence is -0.12 for the playground and -0.03 for the benches -both in the sun- while for the shaded area of the coffee-shop it is 0.01. These figures imply a tendency for shaded areas being preferable when air temperatures rises. However, as high air temperature is a factor contributing to discomfort, overall as air temperature rises significantly, presence is reduced (r = -0.09).

The conflicting nature of response for the different seasons is, at least partly, responsible for the low correlations, i.e. in the cooler season it is expected that presence in the sun will be higher than in shade, whereas the reverse is to be expected in the hot season. Thus the specific relationship is not straightforward and cannot be fully described through simple correlations.

Another interesting feature of the use of space arises when examining the Seashore data in more detail. Overall presence appears to decrease with increasing air temperature and solar radiation (r = -0.05 and -0.20 respectively), however, presence in the sun appears to increase both with air temperature and solar radiation (r = 0.19 and 0.16 respectively). At first glance this seems illogical, but the use of the Seashore has to be examined beyond its formally designated use. The actual use of the Seashore site includes people using the area for swimming, preferring the more informal rock-formations, whilst sitting on the benches (Fig. 7), from the nearby organised swimming beach. The number of people going swimming peaks as air temperature rises, particularly in sunny days, which explains the above mentioned, seemingly contrasting behaviour.

The various tendencies are better illustrated, by considering the regression analyses of presence over the meteorological parameters, on a seasonal basis, and furthermore for each site or identified area separately. Once again correlations are low, yet certain patterns are distinguishable.

The presence of people in the sun, for the two sites is rather different for both seasons (Fig. 7). In the summer, as has already been explained before, presence decreases in Karaiskaki, but is slightly increasing at the Seashore, which in effect includes the people going there for a swim. On the other hand in winter, presence in the sun increases in both sites, yet the increase is much larger for the Karaiskaki, since at the Seashore the areas exposed to the sun are predominantly the benches at the sea-front, which are also exposed to the wind, thus becoming unfavorable in terms of comfort.

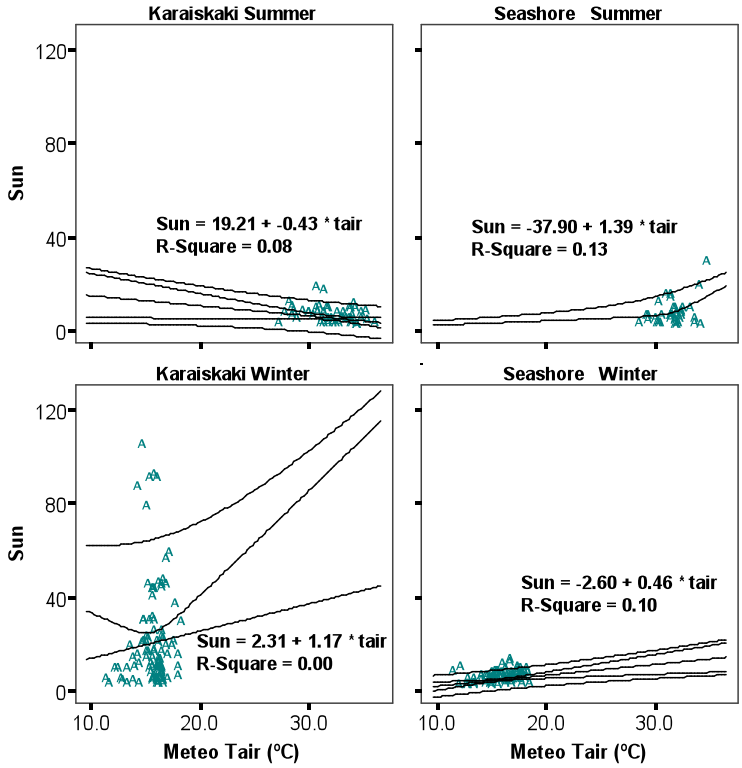

Fig. 7: Presence of people in sunlit areas as a function of air temperature measured at the meteorological station, for the two sites, for summer and winter.

The seasonal variation in the coffee-shop of Karaiskaki is also interesting. When absolute numbers are examined (Fig. 8i), it is apparent that when air temperature rises, presence drops in the summer and increases in winter (with awnings drawn back to allow for sun access). However, when presence is examined in terms of the percentage of people found in the coffee-shop with respect to the overall number of people present in the square at the specific time (Fig. 8ii), the situation is reversed for the summer. Although, overall, increasing air temperatures is a reason for staying away from the square and hence the coffee-shop, the effective microclimate of the coffee-shop with shading available and the trees next to it render it a more popular area compared to the rest of the square.

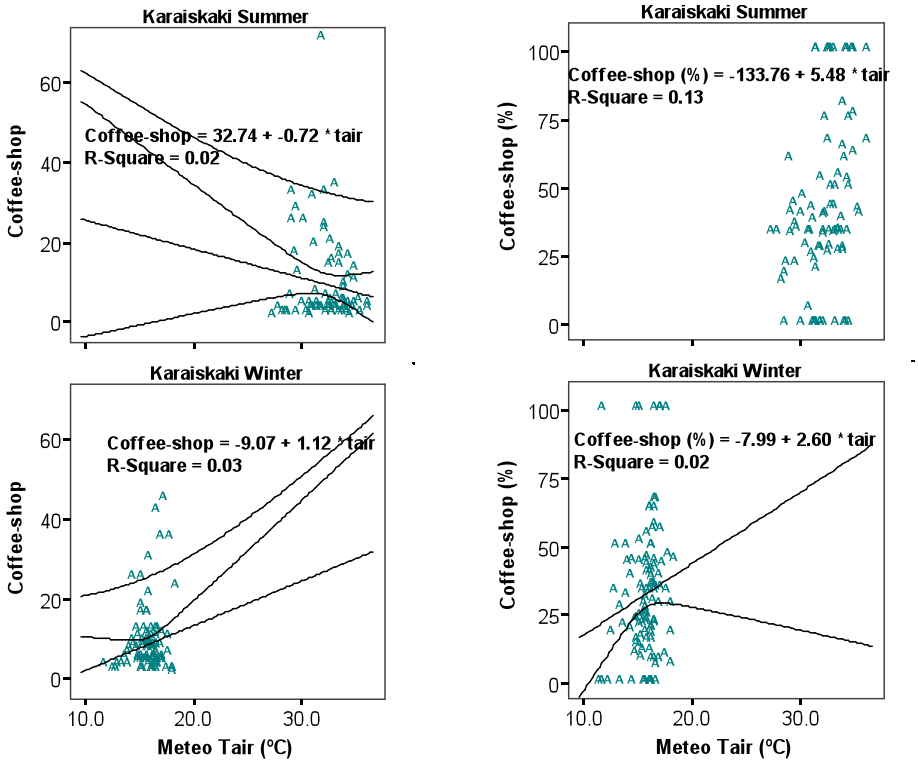

Fig. 8: Presence of people at the coffee-shop in Karaiskaki as a function of air temperature measured at the meteorological station, for summer and winter: (i) absolute numbers (left), (ii) percentage of overall presence in the square at the time (right).

Examining the two sites as wholes (i.e. shaded and sunlit areas together), as expected, presence decreases in summer, more intensely for the Seashore, while in winter, it increases in Karaiskaki and decreases for the Seashore (Fig. 9). The latter could be attributed to the fact that the playground is shaded and thus less desirable at lower air temperatures than the sunny playground at Karaiskaki, as well as the fact that higher temperatures during winter, in Athens, are mostly associated with southern winds, hence anyone sitting on the benches along the Seashore is directly exposed to the humid wind blowing directly from the sea.

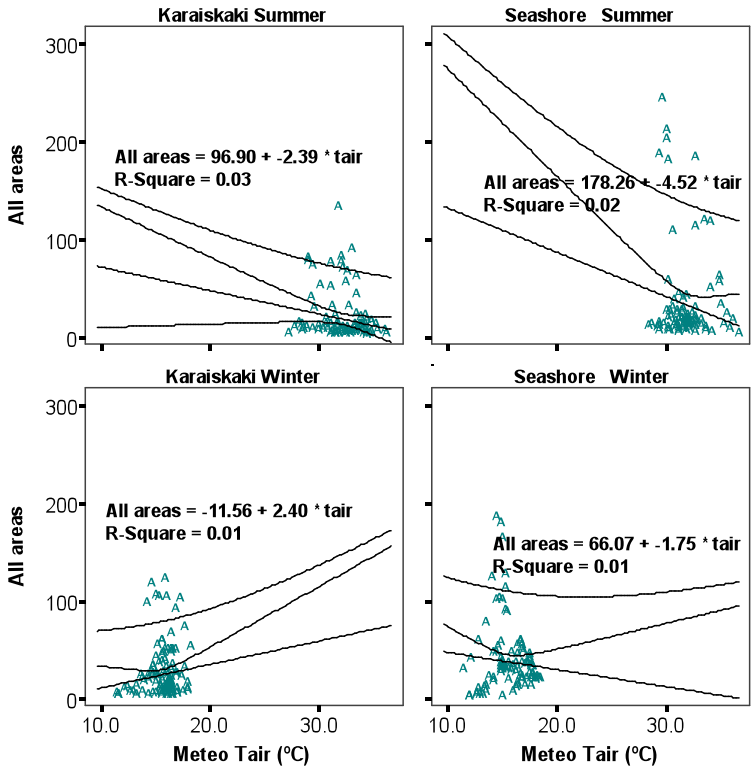

Fig. 9: Presence of people as a function of air temperature measured at the meteorological station for the two sites, in summer and winter.

When considering climatic parameters, air temperature, although very significant, on its own cannot fully explain the patterns observed in the preferred use of space. Wind speed and solar radiation can also prove significant parameters.

Wind speed appears to be a contributing factor to the decreasing presence of people, irrespective of season (Fig. 10). The influence of wind, during summer, is weaker for Karaiskaki compared to the Seashore, since the later is much more exposed as a site, while in the former, the coffee-shop with the extended parasols provides better wind protection. Conversely during winter people frequenting Karaiskaki are more strongly affected by wind.

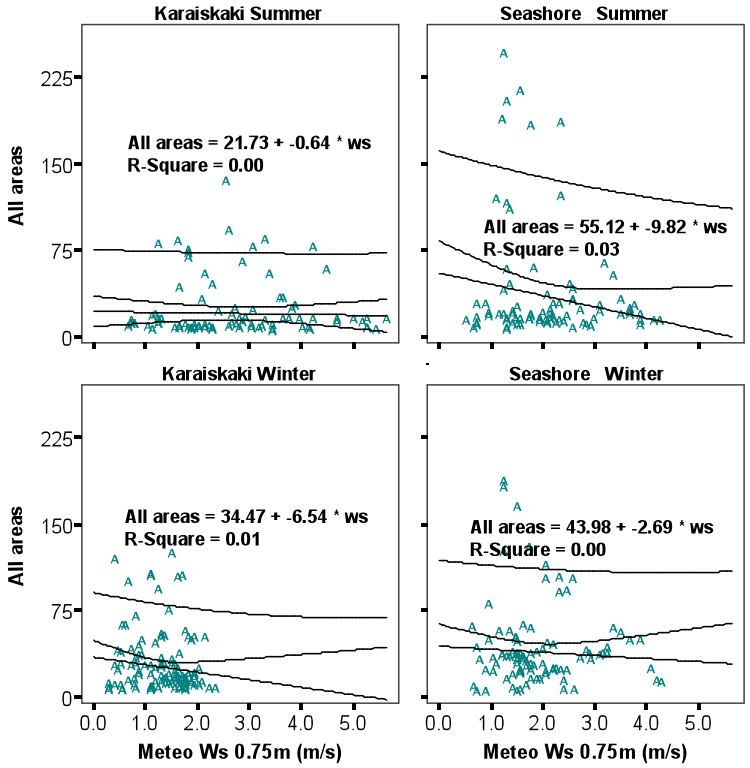

Fig. 10: Presence of people as a function of wind speed (at 0.75 m) for the two sites, in summer and winter.

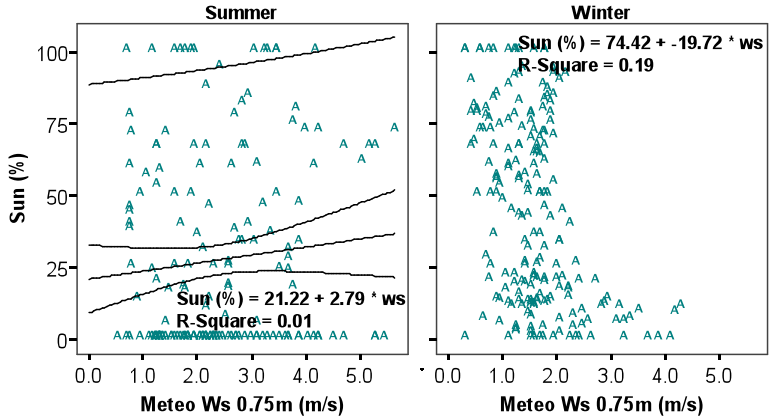

Fig. 11: Percentage of overall presence of people in the sun for both sites as a function of wind speed, for summer and winter.

When analysis concentrates on people sitting in the sun, wind appears to have a positive effect in the summer – when it is most welcome particularly by those sitting directly in the sun. The effect is negative in winter, reducing presence significantly since a sunlit position is, usually, also exposed to wind (Fig. 11).

Finally, examining solar radiation, on a site level (Fig. 12), presence decreases with increasing solar radiation in summer, while it increases in winter, when exposure to the sun is welcome. Presence in the Seashore during winter seems to be practically independent of solar radiation and

this is due to the exposed nature of the site to the wind and the large area of the site being in shade, as already described earlier on.

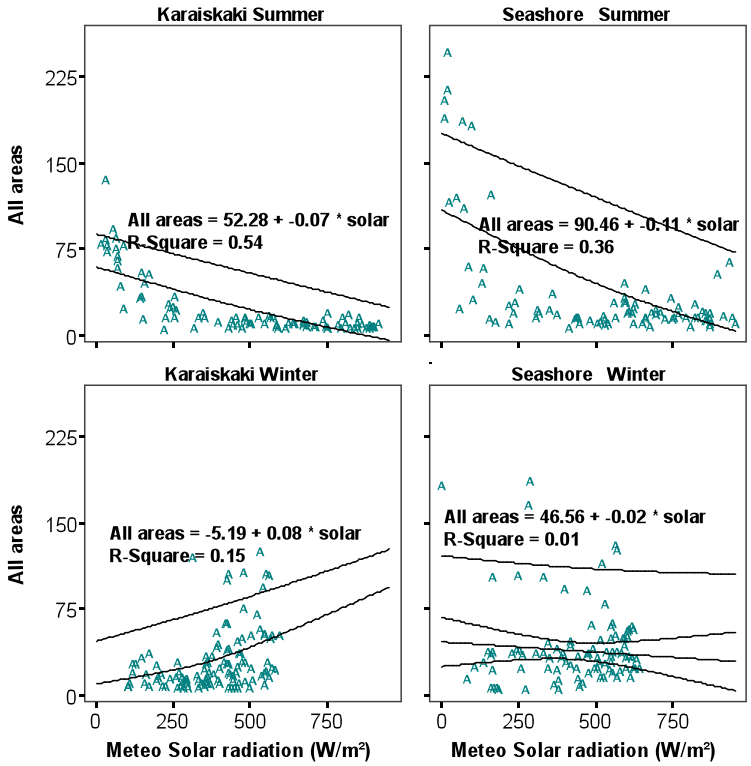

Fig. 12: Presence of people as a function of solar radiation for the two sites, in summer and winter.

In this analysis, another factor that has to be examined is the effect of time of the day and adaptation processes. Any temperature occurrence has to be compared to the range of temperatures occurring throughout the day, as well as previous days, which means that different conditions will be evaluated very differently at different times of the day, month or year. This issue is further discussed in Section 3.4.

3.4 Diurnal pattern of the use of space

Having examined the use of space as a function of different meteorological parameters, our attention focuses on the daily use of the space and the effect microclimate has on the diurnal pattern.

In a study of outdoor thermal comfort conditions in Cambridge in 1997, it was demonstrated how in the UK climate, people enjoy feeling warm and thus the maximum attendance of people outside was at higher air temperatures [6]. Furthermore, the authors speculated that in warmer climates, the situation could be reversed and more people would be expected outdoors when temperatures would be lower than average. It is thus interesting to examine the daily pattern of use for a typical hot day in Greece. A hot, working, day at Karaiskaki, in summer 2001 is selected, to emphasise the dynamic relation of the use of space and air temperature in the area.

Generally, during working days, the morning use of space is lower than the evening, and is mostly restricted to mothers with small children, elderly people, etc. However, even with this reduced attendance, it is apparent that in the morning, when air temperature has not risen yet, the use of space is higher than at midday, reducing as the air temperature rises (Fig. 13). The use of the space is increasing again, in the evening, as the temperature drops, and becomes particularly high after 20:00 hours, when the open spaces are considered by the residents in the neighbourhood, a much cooler place to escape to from the hot indoor environment.

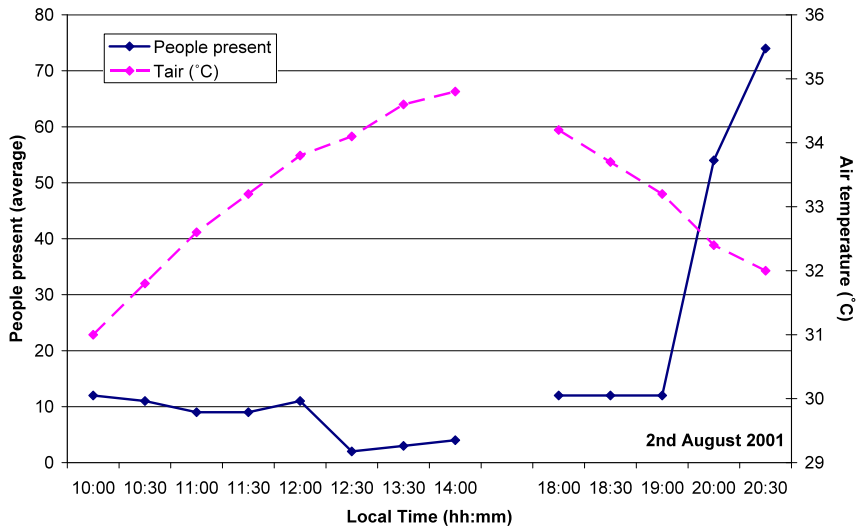

Figure 13: Daily course of air temperature and the mean number of people at Karaiskaki, on 2nd August, 2001.

This snapshot of the use of space in a typical hot summer day appears to follow a course inverse of the fluctuation of air temperature in the diurnal pattern. It is also worth pointing out the effect of psychological adaptation and particularly past experience and expectations in this framework, which has been extensively analysed in [13, 14] and in the context of the current field surveys in [8]. The range of 30-32 ˚C air temperature would normally be regarded as a deterrent for any outdoor activities. When the previous days, however, have been characterised by high air temperatures, people have been used to it, they expect it to be hot in the specific climatic context, are aware of what actions to take to improve their comfort state, and thus are not particularly bothered by it. This explains why air temperature of 30˚C is regarded as relatively cool in a day when maximum air temperature reached 35 ˚C, with outdoor activity, as evident from the increased presence of people in the square, reaching high levels.

Beyond the correlation on a daily basis, it is also interesting to examine the mean diurnal pattern of use of space on a seasonal basis for both sites. Most of this information is presented in two different ways, in absolute numbers of people found in a specific area, as well as in percentage of people, as distributed in the different areas of the site. This is done for two reasons. The different size and nature of the two sites mean that they have the potential to attract different numbers of people. Karaiskaki is smaller in size and of neighbourhood character, thus attracting primarily residents in the area, while the Seashore attracts people from municipalities outside Alimos, who come to the area to be near the sea. The second reason for presenting percentages is that the success of different areas within a site, in conjunction with the relevant microclimatic conditions, can be judged by examining the relative presence of people in those areas.

The seasonal variation of the mean diurnal distribution of the number of people in Karaiskaki confirms that there is a relationship between the amount of people present and the local meteorological conditions. At this stage it has to be borne in mind that during summer, observations along with measurements stopped at 14:00 and began again at 18:00 till 20:30. The reason was for the people carrying out the surveys to avoid the afternoon heat, when normally air temperatures peaked, as well as rest before returning to the square for the evening. In the other seasons, the surveys continued throughout the day, until 17:00 when it would start getting dark.

In summer (Fig. 14), presence is rather stable in the morning period, at relatively low numbers, decreasing after midday. In early evening, presence increases significantly as it is getting dark and air temperature is dropping.

In autumn (Fig. 14), the highest occurrence of people is normally in the mid-morning period, coinciding with the period small children would be taken to the playground and elderly people meeting up to exchange news, read their papers, etc., while it reduces as the day moves towards

the afternoon. It is interesting, however, that throughout the day, absolute numbers in autumn are higher than in the summer for most of the day. This can only be attributed to climatic parameters (Table 1), as other factors are the same.

In winter (Fig. 14), presence is low at the beginning of the day, increasing rapidly to reach maximum levels at midday, and then decreasing rapidly again to more stable figures in the afternoon. The rapidly increasing presence in the morning period is probably due to air temperatures being low at the start of the day, warming up significantly till midday, which then also coincides with people having their lunch-break, outdoors. With a mean air temperature of 14.4 ˚C and a maximum of 19.2 ˚C (Table 1), outdoor activities are well supported, with minimum personal adjustments.

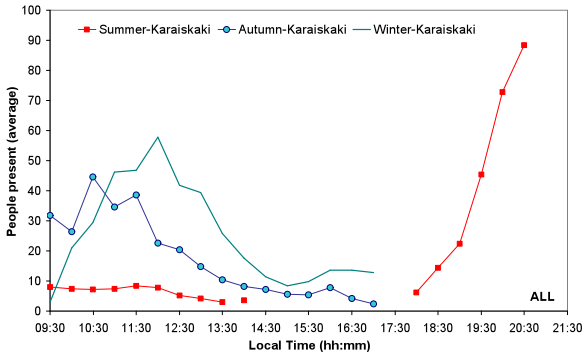

Figure 14: Seasonal variation of the mean diurnal distribution of the number of people in Karaiskaki.

Examining separately different sub-areas within the square, the situation is similar to the overall pattern described. In winter notably, approximately half the population of the square is in the playground (Fig. 15). In fact the playground, as has been repeatedly mentioned, is a major attraction for the area throughout the year. Even at the low presence numbers of the summer, bringing children to play appears to be the predominant reason, accounting for 60% of the people in the square at mid-morning. The lowest relative frequency in the playground is during summer evening, accounting only for 25-30% of the population found in the square. At that time, as explained in relation to Figure 13, under lower air temperatures, neighbours view the open space as a way to escape from the heat of the indoor environment.

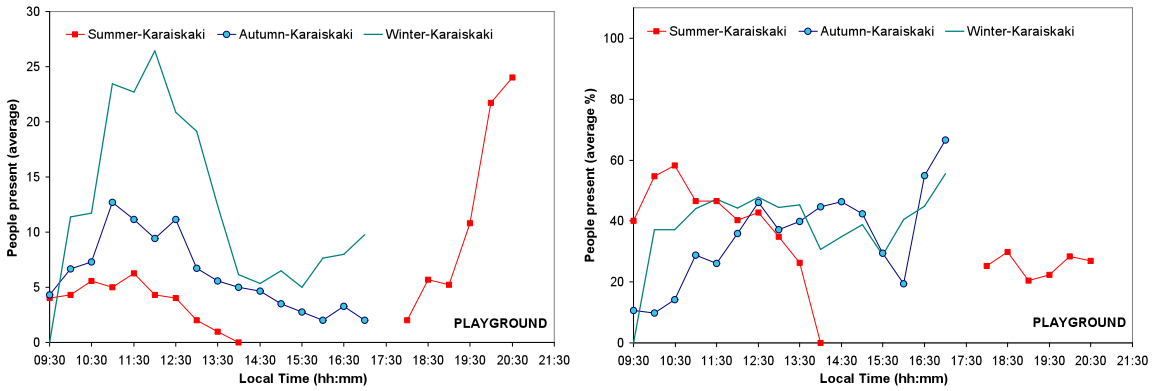

Figure 15: Seasonal variation of the mean diurnal distribution of the number of people in the playground of Karaiskaki (left) and corresponding percentages of the overall presence in the site (right).

The coffee-shop is the main shaded area of the square (Fig. 16) and as such attracts a large number of the people found in the area in the summer, where, at midday, even though at low numbers, all found in the square are in the shade of the coffee-shop. In autumn and winter, presence fluctuates at around 20%-40% of the square population.

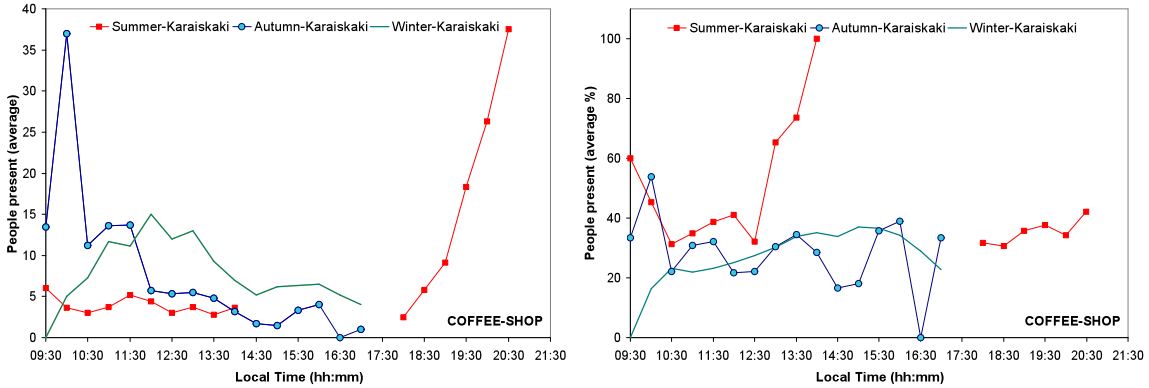

Figure 16: Seasonal variation of the mean diurnal distribution of the number of people in the coffee-shop of Karaiskaki (left) and corresponding percentages of the overall presence in the site (right).

The benches are predominantly exposed to the sun and as such attract few people during the day in the summer, but this increases to 40% in the summer evening. In autumn and winter, use of the benches is more stable, and following the seasonal pattern, highest figures, about 30%-40%, are found in the morning in autumn and midday in winter (Fig. 17).

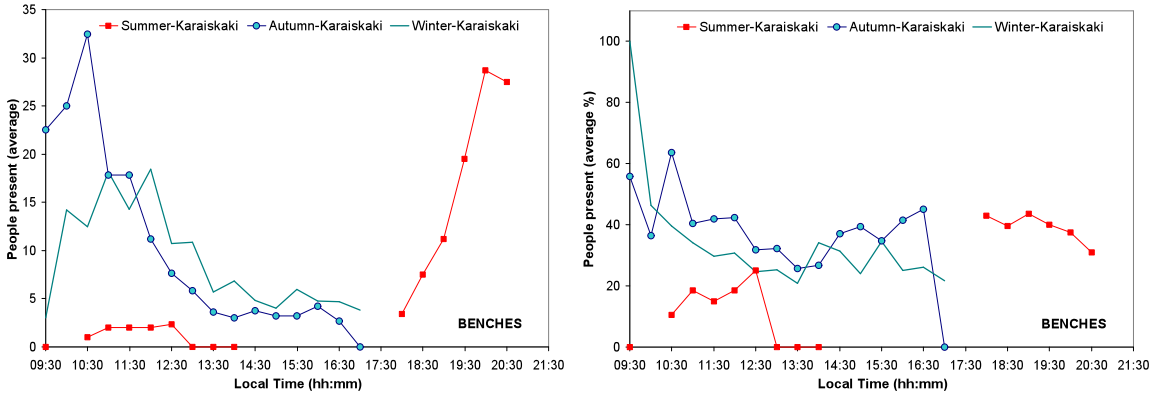

Figure 17: Seasonal variation of the mean diurnal distribution of the number of people at the benches of Karaiskaki (left) and corresponding percentages of the overall presence in the site (right).

Finally, looking at all the spaces exposed in the sun together (i.e. also including the basket-ball court and the open air theatre), presence in terms of absolute numbers exhibits an expected variation, with much higher values during autumn and winter as compared to the summer, and a transition of the time of maximum attendance towards noon as the season progresses from summer to winter (Fig. 18). During summer 50-60% of the people are in the sun, predominantly in the playground, while in winter and autumn the percentage of people sitting in the sun is greater.

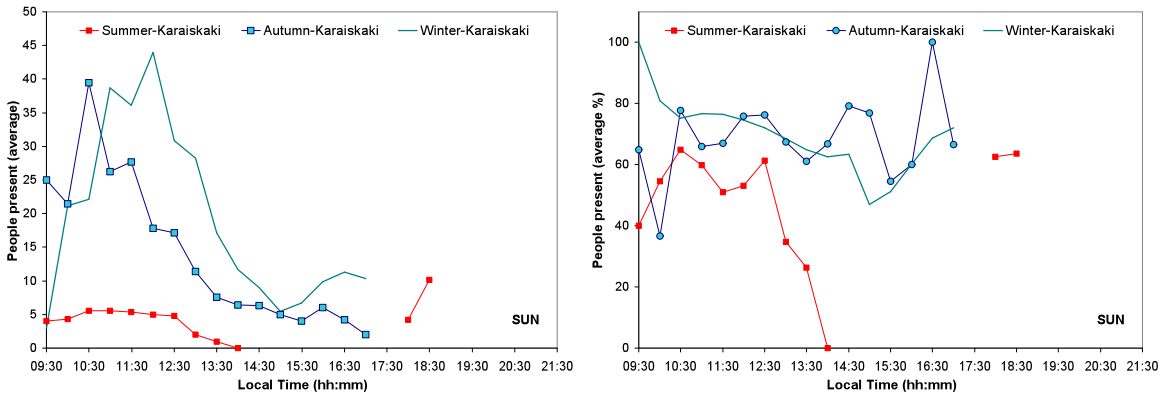

Figure 18: Seasonal variation of the mean diurnal distribution of the number of people sitting in the sun, in Karaiskaki (left) and corresponding percentages of the overall presence in the site (right).

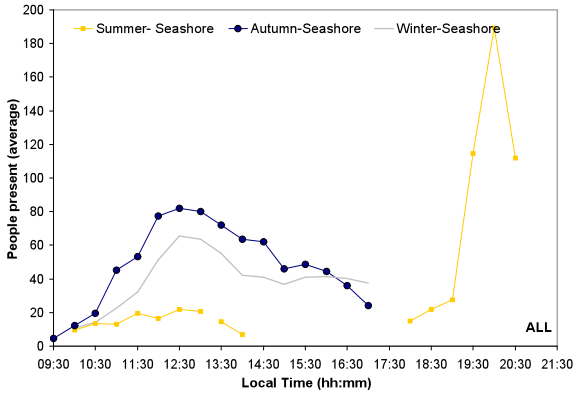

Figure 19: Seasonal variation of the mean diurnal distribution of the number of people at the Seashore.

The seasonal variation of the mean distribution of the number of people at the Seashore also demonstrates strong dependency on the prevailing meteorological conditions. In summer (Fig. 19), presence is relatively stable in the morning period, at comparatively low numbers, once again decreasing after midday. Similarly to Karaiskaki, in early evening presence increases significantly, a result of the decreasing air temperature and absence of intense solar radiation. The highest occurrence of people coincides for autumn and winter (Fig. 19), at midday. As in Karaiskaki absolute numbers of autumn and winter are 300-400% higher than in the summer during daytime.

The playground is the main attraction of the site at all seasons, receiving approximately 80% of the population most of the time (Fig. 20), the rest found mostly at the benches by the Seashore. The exception is the summer daytime period, where the playground receives about 50-60% of the visitors with the benches receiving a large amount of the rest of the users, (Fig. 21), due to the people going there for swimming. Given the size of the area, the benches receive a low number of people in the other seasons, predominantly due to the fact that being next to the Seashore, they are exposed to the wind and increased humidity.

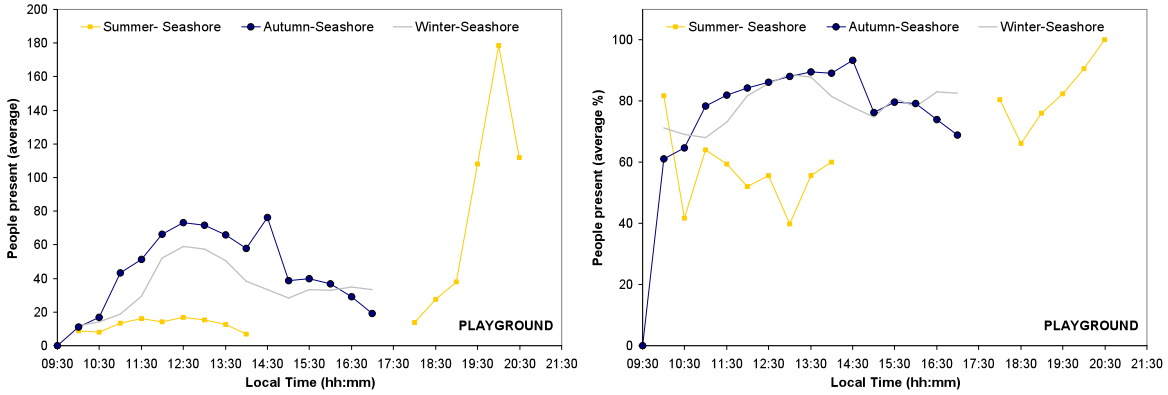

Figure 20: Seasonal variation of the mean diurnal distribution of the number of people in the playground of the Seashore (left) and corresponding percentages variation of the overall presence in the site (right).

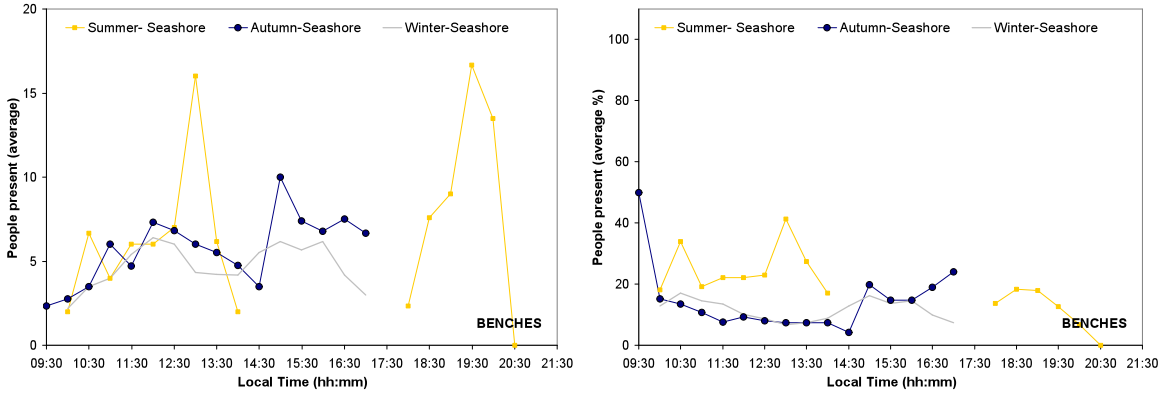

Figure 21: Seasonal variation of the mean diurnal distribution of the number of people at the benches of the Seashore (left) and corresponding percentages of the overall presence in the site (right).

4. Conclusions

The work described in this paper presented some of the findings of the European project, RUROS, discussing the effect of microclimatic conditions on the use of open spaces within an urban environment, in the Mediterranean climatic context. Observations of the use of two different open spaces in the greater city of Athens, along with environmental monitoring and questionnaire guided interviews with the users of these spaces, provided the basis for analysis. The two sites are of very different character, Karaiskaki is a neighbourhood square, whereas the Seashore is an important site at the coastline, also attracting visitors from other municipalities.

The findings presented confirm that there is a strong relationship between microclimatic conditions and the use of open spaces, while there is also a difference in people's sensitivity to them. From the 1503 interviews that were carried out, an increased sensitivity to the summer heat was apparent for the age category >65. This category accounted for about 15% of the people interviewed for all seasons at the Seashore as well as in Karaiskaki during spring. In autumn and winter in Karaiskaki, the >65 age category had an increased presence at 25-30%, while during the summer elderly people seemed to avoid the square, accounting for less than 5% of the interviewees.

The spatial distribution of the interviewees demonstrates that although designated activities (e.g. playground, coffee-shop) are important for the use of space, the latter is greatly affected by the respective microclimatic conditions at different times of the year. Thus in summer, visitors prefer to sit in shaded areas, whereas in autumn and winter sunlit areas are more popular.

Observations of the use of space through counts of the number of people present at the different areas, throughout the day, for summer, autumn and winter provided some interesting results. Air temperature and solar radiation were found to be the most coherent dominant parameters in relation to the use of space, as respective year-round correlations with wind speed and relative humidity are very weak.

In general, people prefer shaded areas at higher air temperatures. Examining the identified areas in terms of function and microclimate correlations reveal tendencies, for shaded areas being preferable, when air temperature rises. However, as high air temperature is a factor contributing to discomfort, overall presence is reduced as air temperature rises significantly.

Regression analysis of presence over the meteorological parameters also reveals distinguishable tendencies. The presence of people in the sun, for the two sites is rather different for different seasons. In the summer, presence decreases in Karaiskaki, but is slightly increasing at the Seashore, which in effect includes the people going there for a swim. In winter, presence in the sun increases in both sites, yet the increase is much larger for Karaiskaki, since at the Seashore the areas exposed to the sun are predominantly the benches at the sea-front, which are also exposed to the wind, thus becoming unfavorable in terms of thermal comfort. Wind appears to have a positive effect in the summer – when it is most welcome, particularly by those sitting directly in the sun, and negative effect in winter, reducing presence significantly.

The diurnal pattern of the use of space also reveals a strong dependency on meteorological parameters. In summer, presence is rather stable in the morning period, at relatively low numbers,

thereon following a curve inverse to that of air temperature. The increase around sunset becomes quite sharp apparently because residents consider the open space of the square, a much cooler place to escape to from the hot indoor environment. The effect of psychological adaptation also becomes apparent, where recent experience of the thermal environment imply that people are used to the hot conditions and they have similar expectations in the specific climatic context.

In autumn, the highest occurrence of people is in the mid-morning period, coinciding with the period small children would be taken to the playground and elderly people meeting up to exchange news, etc., while it reduces as the day moves towards the afternoon. In winter, presence is low at the beginning of the day, when air temperature is still low, increasing rapidly to reach maximum levels at midday and then decreasing rapidly again to more stable figures in the afternoon.

Regarding the time of maximum attendance, this is found in the evening in the summer, with a transition of the time of maximum attendance towards noon being noticeable as the season progresses from summer to winter. For both sites, attendance figures of autumn and winter are 3-4 times greater than in the summer during daytime.

Returning to the social aspect of open spaces in the urban environment and the needs they cover, their importance has been repeatedly mentioned for strengthening social interaction and improving quality of life in neighbourhoods [15, 16]. In working-class areas, particularly, they are extensively used both for socialising with neighbours and for taking the children out to play [17, 18].

This aspect has also been revealed in the current study since, irrespective of age-group.45% of the participants in the surveys mentioned that bringing the children to play was the reason for being in the area. This is even more evident in relation to the regular users of the space, as 77% of the interviewees in Karaiskaki were local inhabitants. In fact, the square plays an important role in family life, as a visit to the square for the children to play was reported as part of the daily routine for 26% of the interviewees. Furthermore, 24% of the participants, who were pensioners, welcomed the opportunity to meet up with neighbours, exchange news, or read their newspaper on a regular basis. Regular users of both areas accounted for 60% of the frequency of use (i.e. 902 of the people interviewed) while 55% of the population interviewed in Athens were professionals, a figure comparable to the interviews carried out in other cities (46%), in the framework of the RUROS project.

This demonstrates a healthy composition of different groups of people in the area, who in turn, indirectly can safeguard social cohesion and quality of life in their neighbourhood. Appropriate microclimatic treatment of different spaces, offering the environmental diversity required at different seasons, with appropriate solar exposure or shading and wind protection or exposure can encourage people's sense of place and community, ensuring use of open spaces is feasible throughout the year.

Acknowledgements

Project "RUROS: Rediscovering the Urban Realm and Open Spaces" (Contract No. EVK4-CT2000-00032) was funded by the EU 5th Framework Programme, Key Action 4 "City of Tomorrow and Cultural Heritage" from the programme "Energy, Environment and Sustainable Development".

Special thanks are due to the individuals who carried out the field surveys in Athens.

Ms Maria Kikira from the Centre for Renewable Energy Sources in Athens for the production of Figures 4 and 5 for the Final Report of the RUROS project and for redrawing detailed aspects of the maps for Figures 1 and 2.

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