531: Outdoor comfort in open spaces: proposal for a quick evaluation method

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Abstract

In order to enhance quality of life in cities, comfort should be considered as an important issue when designing open spaces. Until now, only few methods addressing this issue about how people "feel" open spaces are available to architects and urban-planners, however. Thus, this study aims at developing and testing a "quick assessment" tool regarding thermal, visual and acoustic comfort in open spaces.

This method is based on results we previously obtained in the context of the EU-RUROS project (http://alpha.cres.gr/ruros). In addition to using empirical relations linking physical parameters (e.g. air temperature, wind speed, mean radiant temperature, physiological equivalent temperature) and recorded sensation votes, the method also employs the TOWNSCOPE modelling tool. "Educated guesses" are also used to simplify the analysis of certain parameters like the wind field at pedestrian level that is particularly difficult to evaluate without complex CFC approach.

For testing purposes, a newly built open space located on a university campus in Fribourg Switzerland, has been chosen as a case study site. This paper aims at showing that combining on-site meteorological measurements with results from simple modelling tools as well as with "educated guesses", the method can help both in characterising actual comfort conditions and in providing advices for potential comfort improvements.

Keywords: bioclimatic comfort, urban open spaces

1. Introduction

Even though it becomes common to study urban climate for the purpose of people's well being in outdoor spaces [1], very few simple and easy-to-use methods are yet available to architects or/and urban planners to help them taking into account the improving quality of life in cities. Though, in the actual context of climatic change and renewable energy it is of great interest to improve quality of life in city centres in order to prevent people to escape to peri-urban zones. In that sense, improving bioclimatic ambiance of urban open spaces has become a challenge for urban planner.

Few years ago, urban climatology was rarely translated into applicable planning guidelines or design tools usable by practitioners [2] even if architects and urban planners were already increasingly aware of the impacts of settlements and building design on climate (Oke, 1984) [3]. Nowadays, despite the fact that the integrated effects of meteorological variables on the human perception of the overall comfort in an open space is relatively well known [4], lots of work still need to be done to elaborate a quick assessment method regarding comfort in these spaces. Consequently, the goal of this paper is to propose a quick assessment method regarding, thermal, visual and acoustic comfort in open spaces.

2. Method

From 2001 to 2004, we took part to the RUROS project which produced a huge database of approximately 10,000 questionnaires based on interviews obtained from field surveys in 14 different sites across Europe including Fribourg (Switzerland). The findings have supported the existing relationships between microclimatic and comfort conditions, with air temperature and solar radiation strongly linked to thermal comfort as well as to the evidence linking both physically and psychologically adaptation processes that are taking place [5]. The current research is based on a similar methodology used by RUROS but the main difference aims at developing a much quicker assessment based on different existing tools combined with experience and educated guesses. This method should then be applied almost routinely.

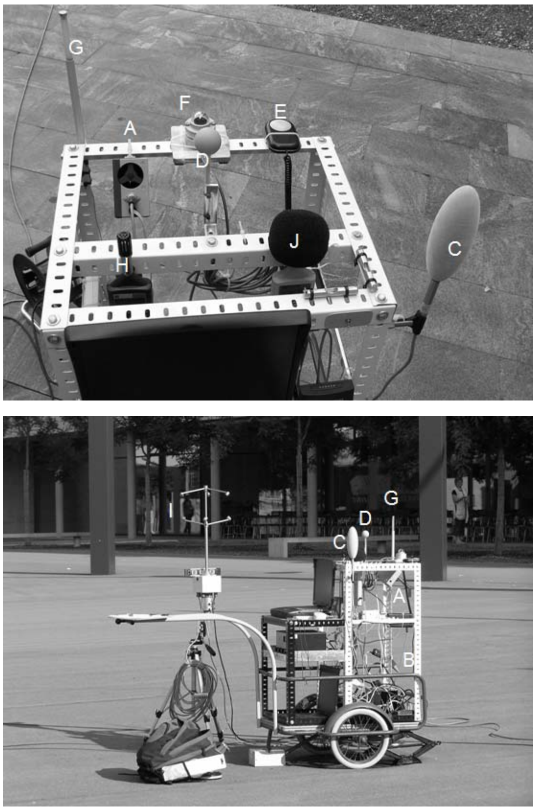
To demonstrate this, a field survey took place in June 2007 on a newly built open space “Place de Pérolles II”, located on the Fribourg University campus (Switzerland). On this place of triangular shape (156 m long X 60 m large in its larger width and 20 m in its narrower part), the ground is almost totally paved. Some black-wood and linden trees are planted in gravel corridors as shown in Fig. 1. Six measurements points have been selected all around the place according to criteria of physical aspects such as the type of soil, the presence of trees, the distance to the closest façade, and the people’s use of the area.

Figure 1. Place de Pérolles II

It is well known that people staying outside are affected by a wide range of parameters characterizing the urban micro-scale climate (e.g. wind speed, air temperature and moisture, solar radiation, air quality) as well as human physiology and psychological state of mind (e.g. human activity, clothing, age….). In that sense it was decided to locate two of the measurement points close to the two existing cafeteria terraces because of their attractiveness for people to sit outside. Some past studies have tried to apply indoor comfort criteria to the outdoor comfort evaluation but according to [4], this is not possible firstly, because under most circumstances the outdoor conditions lie outside the indoor comfort zone and secondly seasonable weather conditions may affect the physiological response to weather. The evaluation of the subjective response and behaviour is one of the main difficulties to determine criteria providing outdoor comfort.

3. Data collection

A portable micrometeorological station holding all sensors has been used to measure values of air and ground surface temperature (°C), operative temperature (°C), globe temperature (°C), relative humidity (%), horizontal illuminance (lux), cylindrical illuminance (lux), global irradiance (W m^{-2}), wind speed (m s^{-1}) and wind direction (°) as shown in Figure 2. A PC linked to the sensors recorded data automatically. Measurements were made about 1.1 m above the surface and the six measurements points were visited successively for approximately 10-minute sampling periods. According to the physical dimension of the place, a complete cycle was done in approximately 90 minutes. Data were then averaged over each period and then interpolated in space in order to derive spatial values valid at one specific time.



A-Air temperature (°C)
B- Ground temperature (°C)
C- Operative temperature (°C)
D- Globe temperature (°C)
E- Horizontal illuminance (lux)
F- Irradiance (W.m^{-2})
G—Cylindrical illuminance (lux)
H- Relative humidity (%)
I- Wind speed (m.s^{-1})
I- Wind direction (°)
J- Sound pressure level (dBA)

Figure 2. Portable micrometeorological station and sensors description

Thermographic pictures have also been taken at specific times of the day to record surfaces temperatures. In Figure 3 it is noticed that temperature difference between tree foliage and the ground directly exposed to the sun could easily reach 15 to 20°C.

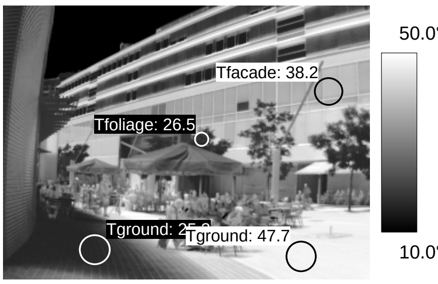


Figure 3. View of the cafeteria: thermographic picture

Finally, wind field data above the site was also measured at approximately 30 m above the ground level in order to validate our meteorological data with measurements recorded on a roof located close to our site.

4. Data analysis

To quantify comfort levels, additional parameters were also calculated in addition to the measured variables. Among them, instead of conducting interviews, empirical relations obtained from the RUROS project were used. To evaluate people's thermal sensation, the ASV (Actual Sensation Vote) model developed for Fribourg climatic conditions [6] has been applied:

$$ASV=0.068Tair\_met+0.0006Sol\_met - 0.107V\_met - 0.002RH\_met - 0.69$$

Figure 4 shows the ASV distribution for summer and winter seasons in Fribourg. In summer "cold" sensation almost never occurs but "comfortable" to "warm" sensations lasted most of the daytime when public open spaces are used. It appears that in Fribourg, independent of the season, the perception of the environment during the main hours of the day is never totally bad. Even in winter, at 2 pm, almost 25% of people would feel comfortable.

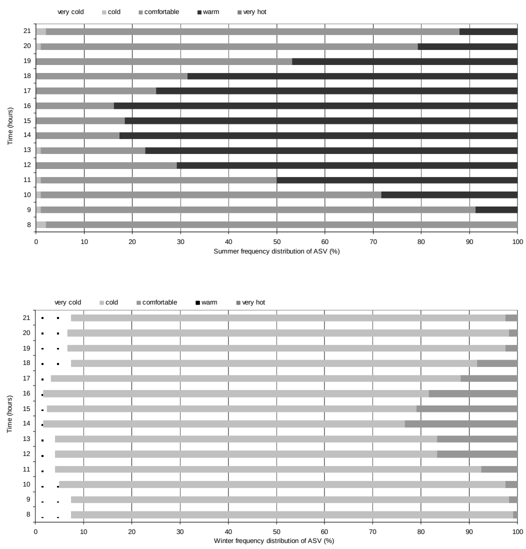


Figure 4. ASV distribution in Fribourg according to summer (up) and winter (down) time

Physiological Equivalent Temperature (PET) has also been computed as well as the ASV which, when compared to the PMV (predicted mean vote) initially developed for indoor environment, strengthens the point that a purely physiological approach is inadequate to characterize outdoor thermal environment where adaptation processes become very important [6]. PET is a thermal index derived from the human energy balance and well suited to the evaluation of outdoor thermal comfort under different climates [8]. Calculated on the basis of air temperature, wind speed, relative humidity and mean radiant temperature, the latter derived from air temperature, wind speed and globe temperature. It is expressed in the units of (°C). This makes it more easily interpretable than ASV which is a good point to keep in mind that results need to be easily understandable.

5. Simulation studies

As wind field remains difficult to represent and to analyse at such scale, a 3D model of the area has been built and installed into a wind tunnel to assess the wind field on the space according to the two main origins of the synoptic wind (i.e., NNE and SSW). Figure 5 displays the main results of wind coming from the NNE. It appears that the area located close to the measurements points situated close to the cafeteria is experiencing intense turbulent flows.

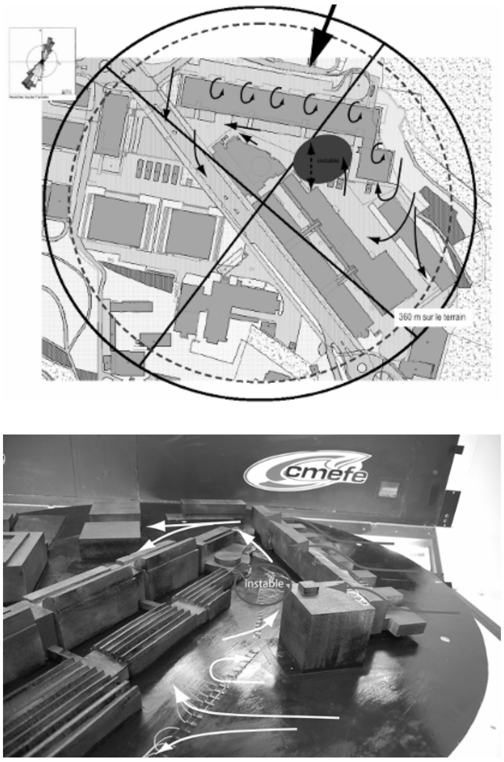


Figure 5. Wind field behaviour over the "Place de Pérolles II" for winds coming from the NNE (from CMEFE, Ecole d'ingénieurs de Genève, 2007)

Then, to address others aspects of thermal and visual comfort, existing computer tools were also applied. For instance we used TOWNSCOPE to assess solar access at the different measurement points of the place (Fig. 6) (http://www.townscope.com/).

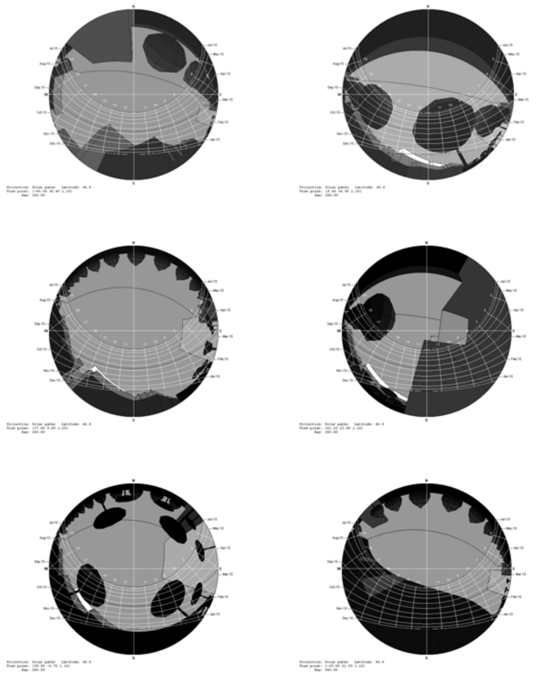


Fig 6. Sun paths and obstruction masks computed by TOWNSCOPE at the measurement points

6. Data presentation

Bearing in mind that results need to be easily understandable, it is planned to present them as coloured maps in order to make easier their reading. Fig. 7 presents the case of PET according to different times of the day.

Figure 7. PET cartography according to the time of the day

Finally, a working protocol is proposed that presents the sequence of the actions, the parameters and/or data considered as well as the objectives of the different states of the study according to the scale of interest. Some of the proposed actions are of great interest so these are strongly recommended (e.g. micro meteorological measurements). Some others are optional according to the expected degree of precision (e.g. film or take pictures of activity on the open space).

6. Conclusion

In order to propose a relatively simple, quick and easy to apply method to get a representative snapshot of comfort sensations experienced by people visiting an open space, the methodology developed is exploring many ways of approaching and analyzing different types of data, tools and statistics. Its goal aims at delivering guidelines combining results from short measurement field surveys with computer or experimental simulations using 3D models for this purpose as well as mapping.

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