ID1: Environmental scholarship and collaborations

Exploring the changing geography of Urban Climatology: a spatial analysis of scientific production by using IAUC bibliographic data (1999-2012)

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Urban Climatology has become both an international and an interdisciplinary research field. While it is common to refer to L. Howard's pioneering work at the end of the 19th century and later to T. R. Oke in the seventieths as the origin of the field, less is known about the field's current geography (identification of places of scientific production worldwide). The field has rapidly evolved during the last decade taking advantage of the development of new numerical modeling technologies and attracting more and more scientists from different disciplines and locations all over the world.

Using the IAUC Bibliographic database, 3400 articles published between 1996 and 2013 in urban climatology, we have retrieved all the bibliographic information available in the Web of Science, and computed the authors' addresses for the whole period 1999-2012. Those addresses are referred to cities (or even smaller places) and can be used to study the field's geography and its evolution in detail. Indeed, recent advances have been made in processing bibliometric data at the local level (Eckert, Baron, Jégou, 2013, Grossetti et al. 2014). Before that, world scale spatial scientometrics' analyses were mostly limited to the country level.

Applying a spatial scientometrics' method which has just been developed in Toulouse in the frame of the Geoscience and Netscience research agendas, our aim is to localize the scientific production in urban climatology and to study its geographical evolution. Moreover, we intend to study the spatialized network of scientific collaborations in urban climatology thanks to co-authorship data. Once we have computed networks of places, we can analyze them using graph theory. Graph theory is useful to identify central places as well as clusters of cities according to the scientific interactions between places.

To summarize, our presentation will be divided in three parts. First, we will present the methodology (data retrieving, geographical coding and mapping, network analysis).

Second, we will explain our hypothesis, which can be summarized as follows:
- throughout 15 years, the research field has experienced a process of globalization, more an more places around the world having been involved. We will therefore analyse this diffusion process.

- A more detailed geography of the scientific activities must be conducted. By using titles and keywords, we will try to differentiate and explain the spatial distribution of different specialties (theory - observation - numerical modeling - urban planning). We assume that these activities display highly varying spatial patterns.

Third, we will propose and discuss our analytical results in two directions
- global geography of the field and its evolution by using a cartographical approach: how the diffusion process of urban climatology took place from 1999 onwards.
- geographical structure of the cooperation networks and its evolution

At the end, we will be able to assess general trends regarding this scientific field such as globalization, and more specific trends revealed by the analysis.

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Scientific practices within the urban climate research field: « Drastic interdisciplinary » between social and natural sciences

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Urban micro-climate is the perfect archetype of environmental concerns complexity. We propose a reflection on the scientific practices overturning when researchers invest this topic. The urban climate research field implies new compositions/relations between professional worlds: 1) between researchers and urban stakeholders 2) between researchers from different scientific traditions and disciplinary families unaccustomed to work together. In the last decade, interdisciplinary collectives of French researches developed studies on urban climate issues at different scales (city, city blocks, buildings, etc.) creating new interfaces between social sciences (sociology, anthropology, geography) and physical sciences or natural sciences (the atmospheric physics, urban engineering or building energy management). To explore the drastic interdisciplinary dynamics and reveal the mechanisms of "science in the making" (Latour, 1989), we did an investigation on the French research context on urban climate.

How those new interdisciplinary consortiums are organizing to challenge the emerging environmental concerns? To answer this central issue, our contribution is divided into three main steps.1) We first explain the scientific implications on the urban climate thematic. 2) From the feedbacks of researchers involved in this collective adventure, we identify the main issues, brakes and friction points observed in this drastic interdisciplinary meeting. 3) We finally point out the levers and facilitators to develop interdisciplinary dynamics (e.g. the overrun of mutual stereotypes, the establishment of a common language, or the proposal of innovative methodologies crossing physic phenomena and social dynamics).

Keywords: scientific practices, interdisciplinary dynamics, working methods, methodology, disciplinary identity, urban climate

ID2: Multicriteria environmental perception

Thermal notations as a design tool: evaluating the thermal comfort of pedestrians moving in spatial sequences

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Thermal perception plays a major role in the pedestrian's experience of complex urban environments, based largely in a continuous diversity of spaces, microclimates and comfort state. When moving in spatial sequences, the ability to measure thermal comfort forms a vital part of the design of comfortable urban spaces. This raises the question regarding an efficient and accurate way to evaluate thermal comfort in spatial sequences and how can this evaluation be transformed into an efficient urban design tool. Outdoor thermal comfort studies based on fieldwork tend to evaluate thermal comfort with an emphasis on the static experience of people in disconnected individual urban spaces. The impact of pedestrian movement and rapid passage from one space to the other on thermal perception, comfort and its subtle variations has not been sufficiently analysed. The author's recent work has attempted to fill this gap by developing the methodology of thermal walks. This provided an efficient tool for evaluating thermal comfort along spatial sequences through the combination of microclimatic measurements and people surveys. The present study aims to focus on the critical task of making the results of "thermal walks" accessible to architects and urban designers. This is achieved with the creation of a standard of notation that codifies a wide range of objective and subjective measurements and facilitates their interpretation and use by the non-expert.

Thermal notations are a graphic representation tool that depicts both objective and subjective data of microclimatic conditions and their effect on thermal perception along a spatial sequence of spaces. The combination of all investigated parameters is based on spatial and climatic specificity, objective and subjective descriptors and evaluation of thermal comfort. By locating the spatial sequence on a plan or a section, the notational scheme can be understood as a layer of transparency added to traditional modes of depicting urban spaces. The descriptors provide a measured value of each microclimatic parameter. At the same time, subjective descriptors record the pedestrians' perception of each objective parameter, allowing for an indication of prevailing influence between temperature, wind speed and solar radiation. Finally, this method of graphic representation provides a strong distinctive image for each thermal environment and the basis for a comparative thermal analysis between spaces. Thermal notation can be applied to the overall evaluation of a spatial sequence and the designer may use this tool to identify spaces of discomfort and propose design solutions to improve them. The present paper draws from fieldwork that took place in spring and summer 2014 in the city centre of Paris, in the context of a redevelopment project of a street sequence. This included simultaneous microclimatic monitoring and people surveys in structured thermal walks. The results are presented using the tool of thermal notations.

The evidence-based approach of the thermal notation tool shows the importance of pedestrians as generators of data in the evaluation of outdoor thermal comfort and spatial quality. Correctly interpreted, its contribution is vital and needs to be taken into account in the design of pedestrian networks identifying design improvements in spaces of movement and lingering. This opens the way towards the broad use of thermal notation and its effective integration in the design process. The thermal representation of urban space may lead to significant results about projects of pedestrianisation and spatial quality in everyday walking environments.

New qualitative methods to explore thermal perception in urban spaces

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The concept of 'outdoor thermal comfort' relies on the way people experience the thermal environment through their thermal and other sensory perceptions. So, not only the physical factors that influence direct thermal sensation, but also cues that originate from other senses (e.g. visual or haptic) play a role in thermal perception. Therefore, outdoor thermal comfort cannot be expressed with precision exclusively through the use of thermal indices based on measurements. Indicators of outdoor thermal comfort also need to take other sensory experiences and spatial information into account. Given this context, individual thermal perceptions need to be described through qualitative information as well.

Various professions that shape the environment (e.g. architects, urban designers or landscape architects) strive to design for 'outdoor thermal comfort'. And through their design interventions they can influence many factors with an impact on thermal perceptions such as microclimate, spatial configurations and ambiance of spaces. Hence, professions that shape the environment need to be provided with design guidelines that take this knowledge connecting thermal perception and design interventions into account.

Such a knowledge basis needs to be derived from monitoring human thermal perception related to the experience of the spatial environment. The methods to do so are inspired by environmental psychology methods such as interviews, 'sensewalking' and cognitive mapping techniques. These were translated into novel qualitative methods to study outdoor thermal comfort. They all rely on interviews with people in longitudinal studies, relating their thermal perception (long and short term) to spatial perceptions.

There are two distinct strands in this people-surveys approach: first, interviews can be conducted with people observing a space and assessing its thermal environment while standing, and second, 'sensewalking' interviews may be applied to collect subjective data on thermal comfort by pedestrians in movement.

The first type of surveys with people who assess their thermal perception while standing in a space can result in individual 'mental microclimate maps' that reflect the interviewee's microclimate perceptions of sub- areas. A large amount of such maps can be overlayed and be summarized into common 'mental microclimate maps'. Such common microclimate maps allow to draw generalized conclusions about the effect of spatial configurations on people's thermal perceptions. Through the interviews, additional information can be gained about the perception of building materials, colours, etc. that influence the ambiance and how this relates to thermal perceptions. Additional microclimate measurements in the spaces studied allow to make comparisons between perceptions and measured data.

The method of 'thermal walks' addresses the simultaneous monitoring of microclimatic conditions and their experience by pedestrians. This method is based on point-to-point evaluation of the thermal perception and includes the combination of measuring objective microclimatic and spatial data with subjective responses by pedestrians.

Both methodological strands involve the transfer of interview data into representations such as 'mental microclimate maps', material perception maps, 'thermal walk notations', cross- sections or other spatial representations depicting people's thermal and spatial perceptions. The measurement data help to calibrate the outcomes. Generally, the combination of both quantitative and qualitative methods has yielded reliable information describing thermal perception in relation to spatial characteristics.

Conclusions from these calibrated spatial representations can provide design guidelines that relate thermal perception and spatial design interventions. These design guidelines are useful for all professions who want to create thermally comfortable environments.

In our presentation, we will discuss a series of these new methods that have been applied in different European studies and reflect on their reliability in landscape and urban design research and the usefulness for practical applications.

Performance standard for tropical outdoors: A proposal in a time of climate change

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Unusual (>3 standard deviations above the base climate of 1951-1980) and unprecedented (>5 SD) heat extremes are expected to be the norm in much of tropical Asia and Africa in the near term even as these regions undergo transformational social and economic change. Consequently, tropical cooling load – much of which is currently latent due to low levels of economic development – is likely to be the dominant category of global energy demand. Yet, deep technological development and efficiency improvements in cooling systems are yet to be achieved. To make matters worse, cultural practices and attitudes limit adaptive possibilities to warmer temperatures even as the improving socio-economic conditions in the tropics lead to 'thermal indulgence.' One likely outcome of these developments is an unrealistic thermal comfort expectation in the tropics that is in direct conflict with the 'global good' of low/zero carbon economy. A compromise has to be reached based on societal priorities to ensure low energy expenditure without confining tropical dwellers to an inferior thermal comfort.

This paper argues that defining urban thermal comfort is critical to enhance the quality of life of tropical dwellers as their cities continue their historically unique urban trajectories. This also bodes well from an equity standpoint. However, care is needed to ensure such standards reflect the activity patterns unique to the region. Among other things, this will necessitate that the standards be coupled with non-thermal attributes of the urban commons.
Specifically, it will propose the linking of the 'in' to 'out:' it is necessary to specify not the indoor conditions to be achieved but the magnitude of change that ought to prevail between the 'in' and 'out.' It will focus on specifying standards for 'cool' urban spaces that enhance greater tolerance of warm conditions indoors. Finally, the standards need to be dynamic, responding to changes in urban microclimate as well as regional and/or global changes to climate. It will do so by proposing an 'intermediate zone of comfort' for the urban outdoors as a third category, and point to research documenting the value of individual and combined voluntary behaviours to ameliorate comfort by using local, adaptive strategies.

Such applications of adaptive strategies in the design of urban spaces will help tropical cities enhance their liveability in a time of extreme heat.

ID2 (cont): Multicriteria environmental perception

Physical load resulting from particulate matter, noise and thermal stress on inner-city public open space – An interdisciplinary analysis

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Particulate matter (PM) is an important environmental risk to health. The major proportion of world's population lives in cities, where exceedances of air quality standards occur regularly. Current research suggests that even short periods of time spent in locations with high PM concentrations, e.g. during commuting or relaxing, could have significant health impacts. However, further factors have to be taken into account when holistically investigating the physical load in urban spaces, e.g. stress resulting from noise, heat or cold. Planning and maintenance of urban areas require an integrative approach connecting methods from natural sciences, engineering and social sciences.

Field experiments were carried out at selected weekdays at 6 different locations in an inner-city public open space in the city of Aachen. The investigation site spans an area of about 0.02 km2 and is characterized by a well-attended inner city park, enclosed with buildings generally comprised of 4-5 floors. One of the most frequented roads by public transport buses and unsurfaced footpaths lead through the investigation area. Measurements have been conducted to determine air temperature, relative humidity, radiation temperature, 2-dimensional wind components, 3-dimensional solar and infrared radiation fluxes as well as mass concentration and number concentration of suspended particles with mobile sensors. Simultaneously, acoustic measurements capturing the sound pressure level at high temporal resolution and a questionnaire accounting for an overview of the perception of urban park users have been performed.

First results regarding air quality data highlight that locations in close vicinity to the main road showed lower mean PM10 concentrations (15.3 µg m-3, 14.4 µg m-3; n = 58) in comparison to several places inside the green area 150 m off the trafficked road (29.4 µg m-3, 24.9 µg m-3). In contrast, fine particle fractions were distributed differently. Nearly identical mean concentrations of PM1 were identified at all locations (6.0 µg m-3 to 6.9 µg m-3). Overall, PM concentrations followed a highly heterogeneous pattern at small scale, which leads to the assumption that unsurfaced footpaths inside the park played a significant role as a source of primary particles. As anticipated, when comparing air quality measurement data to sensation data it becomes obvious that particulate matter was not perceptible. Air quality perception seemed to be mainly driven be visible and audible occurrences or environmental circumstances. In contrast it can be stated that acoustic measurement data (i.e. psychoacoustic loudness), even as a mean value over the entire time span, compared to the results from the interview based questionnaire showed good agreement.

Further work focuses on the generation of simulation data by using numerical microclimate models (i.e. ENVI-met, Austal2000) as well as sound mapping tools. A comparison with measured data will be crucial to validate the ability of the modelling approaches for inner-city open space. Simulated data will enable a better understanding of the physical processes. It allows for a higher spatial resolution of the patterns behind physical stress factors. The approach provides an opportunity to obtain a conclusive picture regarding probable health impacts of future scenarios of re-designed open squares.

In a related paper by Maras et al. we analyze the versatile dataset from the perspective of observed and perceived thermal comfort.

Perception Studies on the Influence of Trees and Greens in Open Spaces for Environmental Quality

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Abstract- Trees within the campus have an important positive effect on people's lives. One such positive effect is the amelioration of microclimate. The aim of this research is to assess the perception of people (staff and students) on the positive effects of trees and green spaces on the microclimate of their environment and how it affects the people in return. This perception study was carried within the campus of the Federal University of Technology; Akure to determine the influence of trees, greens in opens for a quality environment, their perception about the university landscape and how landscape and weather affect people. The survey indicated that over half of the respondents strongly agree that landscape provide comfort and contributes to environmental quality, while about half agreed to the statement that the university is beautifully landscaped with adequate trees. This study helps to explain that people enjoy the comfort of trees and greens in their environment.

Key words: Landscape, microclimate, greens, comfort

Observation of urban climate variability at local scale and comparison with human perception

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Experimentally, the Urban Heat Island (UHI) is often studied at the scale of the entire city or by differentiating its effects according to homogeneous neighbourhoods. Nevertheless, the urban climate variability at very local scale may be of the same order of magnitude than at city scale. The neighbourhood is besides a quite interesting and challenging microclimate study field. The comprehension of microclimate variability and involved physical processes may open short-term perspectives regarding the local urban planning, with the double objective of improving thermal comfort while meeting as much as possible inhabitant expectations.

With this aim, an interdisciplinary field experiment associating researchers in meteorology and human and social sciences was carried out in a neighbourhood of the city of Toulouse (France). The area covered about 1 km x 0.5 km and was composed of different urban fabrics. From January to June 2014, a permanent network was setup, composed of ten weather stations recording near-surface temperature, humidity, wind speed and direction, and completed by a roof-level reference station in order to document larger scale atmospheric variables including the incoming short- and long-wave radiation. Also, three intensive observational periods were conducted in January, April and June 2014. For three successive days, every three hours, mobile measurements of temperature, humidity and wind were continuously recorded along a predefined itinerary through the neighbourhood, with a GPS recording associated. Moreover, black and grey globes were used to appreciate the "perceived" temperature. Finally, during "commented walks", the inhabitants completed a social survey (simultaneously to measurements) about their feeling perception, especially in terms of thermal comfort.

The data analysis first focuses on the objective detection of a microclimate variability at this study scale, while considering the possible seasonal influences. It also addresses the issue of climatic atmosphere or "ambiance" through the coupling of different measured meteorological parameters, and the evaluation of a perceived temperature computed using grey globes. Finally, a first cross-analysis is proposed in order to put in perspective the environmental physical parameter measurements and the results of social surveys questioning people about their perception.

Influence of urban climate on perception responses in soundwalks: case study Aachen

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This work is part of a broader study on environmental factors influencing the amount of the cost of environmental noise in urban areas. The research is integrated into a project area called Urban Future Outline (UFO) at the Human Technolgoy Centre (HumTec) at RWTH Aachen University. The aim of the here presented study is to evaluate the influence of urban climate in the perception of the environment of answers from the following aspects: visual, auditory, climatic, cultural, emotional and economic. The method selected to collect perception data is the so-called method of "soundwalks" in which a group of people express their views on urban landscapes and their perception on soundscapes with the aid of a structured questionnaire. At the same time, the sound data was monitored with the aid of Sennheiser KE-3 microphones. Climate data for the days when soundwalks occurred were obtained by fixed stations of climate monitoring at RWTH Aachen University. To check the influence of urban climate on perceptual responses obtained through soundwalks nonparametric tests are calculated as follows: Spearman correlation coefficient for quantitative and Chi2 data, along with the V Cramer coefficient for qualitative data. In the contribution to ICUC we will present results regarding the influence of actual atmospheric conditions on pedestrians' perception of other environmental factors and soundscapes for the study site of the city of Aachen.

A methodological approach to the environmental quantitative assessment of urban parks

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This study proposes an integrative methodology for the environmental assessment of urban parks. Since most of the studies that have investigated the environmental effect of urban parks have focused on only one or two nuisances (air or noise pollution or thermal discomfort), a difficulty exists in evaluating the overall influence of an urban park on environmental quality. Moreover, the small numbers of studies that have tried to suggest methodological approaches for a quantitative environmental assessment of urban green spaces have not based their assessment methods on the analysis of in-situ objective measurements of air pollution, noise and climatic nuisances and their cumulative impact at a specific location. This methodology is a quantitative environmental assessment of the three major environmental nuisances that influence overall environmental quality at specific locations.

The methodology includes five stages: (1) in-situ measurements of air pollution, noise and climatic variables; (2) data analysis and indexing by standard indices (PET, AQI and noise classification); (3) data categorizing according to a common denominator of unified criteria; (4) accumulative assessment of the examined nuisances; and (5) classification and ranking of overall Environmental Quality Level (EQL) for the specific site according to the discomfort level for humans.

This method enables the identification of the dominant nuisance in the investigated sites in various seasons and provides a useful tool for urban planners and architects in the planning process, so as to achieve an ideal environmental quality for the benefit of urban inhabitants.

A case study, which examined the environmental quality level of an urban park, an urban square and a street canyon was conducted in Tel Aviv, Israel, showed the superior environmental quality level of the urban park in comparison to other urban open spaces, in both summer and winter.

Connecting urban climate and human well-being through the measurement of individually experienced temperatures

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The heterogeneous nature of urban climates and the behaviors, movements, and preferences of the people that move throughout them create incredible diversity in experienced environmental conditions. Among the environmental factors of concern for health outcomes in urban areas is temperature, as exposure to extreme heat and cold account for the majority of weather-related deaths in developed countries. A significant portion of the heat-health research conducted to date connects temperature-related health outcomes to the outdoor characteristics of specific places in urban areas such as those measured at a nearby airport or at the location of residence of individuals who suffer illness or death during an extreme heat event. But little is known about how the outdoor characteristics of these places actually relate to the cumulative thermal experience of individuals considering their movement across urban landscapes and between indoor and outdoor settings. Here we present the results of two studies implementing a new method for examining human-environment interactions: the measurement of Individually Experienced Temperatures (IETs).

Between two measurement campaigns in the summers of 2013 and 2014, over 100 research participants were recruited to carry or wear Thermochron iButtons for a period of one week. These devices measured and recorded the air temperatures surrounding individuals as they went about their daily lives. The first measurement campaign focused on a gentrifying neighborhood in Boston, MA, USA known as the South End; the second was based in five neighborhoods with contrasting characteristics in greater Phoenix, AZ, USA. Additional study instruments included daily surveys, activity logs, exit interviews, and researcher observations.

The data collected in these studies build a more complete picture of how intra-city differences in outdoor temperatures manifest themselves into the IETs of urban residents. The Boston study found that IETs were heterogeneous within the examined neighborhood and that outdoor temperatures overestimated the majority of experienced temperatures during a heat wave. The Phoenix study also found heterogeneity in IETs but further identified significant differences in IETs between neighborhoods that differed in key elements such as racial diversity, income, age, and proximity to the urban core. Findings from daily surveys, activity logs, and exit interviews suggest that behavior (schedules, preferences, lifestyles) and access to cooling resources (air-conditioned homes and business, parks, and pools) were variable among participants. Further, individual attributes such as gender, race, socioeconomic status, age, and neighborhood tenure, also proved important in predicting heat exposure.

Individual differences are an overlooked aspect of heat exposure and should be better integrated into multi-scalar analyses. The IET approach offers an innovative means of collecting information about how individuals actually experience temperatures within cities. Together, the Boston and Phoenix IET studies combine individual, neighborhood, and city differences in heat exposure such that we can better relate urban climates to the experience of urban residents and subsequently design innovative heat-health intervention and mitigation strategies.