REVIEW OF WORLDWIDE URBAN CLIMATIC MAP STUDY AND ITS APPLICATION IN PLANNING

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Abstract: Urban Climatic Map (UCMap) is an appropriate information and evaluation tool to integrate urban climatic factors and town planning consideration. It can help urban planners, architects and governors to understand and evaluate the effect of urban climatic issues on decision-making and environment control. This paper reviews the progress of UCMap studies in the world. Firstly, the concept and structure of UCMap system are explained. Secondly, the history of UCMap as an important part of applied urban climatology is reviewed from the 1970s to nowadays. German national guideline of VDI 3787 part 1 as a milestone of the UCMap study is also reviewed. Then, two selected UCMap studies from German and Japan are compared and summarized through the case study. Finally, the paper discusses the process and consideration factors of developing UCMap and highlights future trends.

Key words: Urban Climatic Map, Urban Planning,

1. INTRODUCTION

Urban climate is one of elements of urban physical environment, which is often ignored in urban planning. To design a sustainable city, it is necessary to factor the climatic information holistically and strategically into the planning process. Since the 1970s, the concept UCMap has been generated by German researchers, which have a strong focus on applied urban climatology (Matzarakis, 2005). With the development of UCMap, it has become a worldwide research interest since the 1990s. Up to now, there are over 50 cities in Europe, South America and Asia which have already formulated their UCMaps(Fig. 1). Among them, Germany and Japan are two important leading countries in conducting urban climate analysis and application. It is important to obtain a fundamental understanding on the methodology and current trends of UCMap studies so that researchers could adopt the useful information and experience to design better urban environment, especially for the developing world.

2. THE DEVELOPMENT OF UCMAP STUDY

2.1. Concept of UCMAP

The concept of UCMap has been generated by German researchers since the 1970s (Baumüller, Hoffmann, & Reuter, 1992; Matzarakis, 2005). UCMap is an information and evaluation tool to integrate urban climatic factors and town planning considerations by presenting climatic phenomena and problems into 2-D spatial maps (VDI, 1997). Its scale varies from 1:100 000 to 1:5 000, which could be used in the spatial planning from regional to district level. In the early years, the UCMaps were drawn by hand. Since the 1990s, the UCMaps could be manipulated and created in the Geographic Information System (GIS).

UCMap consists of two individual maps, namely Urban Climatic Analysis Map (UCAn Map) and Urban Climatic Recommendation Map (UCRe Map) (Scherer, Fehrenbach, Beha, & Parlow, 1999; VDI, 1997). The UCAn Map collates meteorological data (air temperature distribution, wind direction and speed, humidity, etc.), planning, land use, topographic and vegetation information. Their inter-relationships and effects on wind and thermal environment are analyzed and evaluated spatially. Based on these investigations, the "klimatopes" of UCAn Map based on the land use information could be defined to present local climatic condition and characteristics. And the urban climatic phenomenon and problem areas could be easily found in the UCAn Map. According to the climatic understanding and evaluation acquired from the UCAn Map, similar klimatopes are grouped into bioclimatic zones. Then, the UCRe Map can be developed to give the strategic urban planning recommendations to each zone in order to improve the urban environment from the climatic point of view, which could help planners to take action more appropriately in design process. And when necessary, the noise and air pollution information also could be added into UCMap and then, the corresponding control measures can be detected and plan for.

Figure 1: Worldwide UCMap Studies
2.2. German National Guideline: VDI3787 Part 1
Since the German Federal Building Law sets the mandate to require urban development to be sustainable and respect the natural environment, more and more German cities have been formulated the UCMaps since the 1980s (Mayer, 1988). In 1997, German National Guideline VDI3787 Part1: Environmental meteorology climate and air pollution maps for cities and regions was published as the national standard by the work group of Urban Climatic Map Committee of applied climatology. It aimed to offer some expert advices on the methodology of creating UC-Map and also define the micro-climatic and meso-climatic symbols and representations used in UCAn Map and UCRe Map (Fig. 2). Because Germany leads a pioneer research of the world in UCMAP field, it becomes to be a significance reference for conducting UCMAP study and it has been used widely in the world.

3. CASE STUDIES
Since Germany and Japan lead the advanced research in the field of UCMAP study, two case studies are selected to analyze and compare the difference between German and Japanese methodology.

3.1. UCMAP Study for Kassel city, Germany
In early 1980s, local government of Kassel city decided to expand the urban area and was concerned about the environmental effects of new master plans and building developments. Due to Kassel located in a valley, decreasing the air pollution and improving human thermal comfort are the main consideration in the climatic and environmental evaluation. Thus, a first version of UCMAP for Kassel city was created by the research team led by Prof. Lutz Katzschner. Later, they made the second version in 2003.

The methodology of this UCAn Map was focused on the thermal and wind aspects based on the understanding and evaluating on the thermal radiation and surface roughness length of developments and greenery (Fig. 3s). So the topography, the percentage of vegetation coverage and land use information as influencing parameters were taken into account. They were combined and calculated in GIS platform. Then, eight classes (Klimatopes) of UCAn Map were defined to present the different urban climatic conditions according to their characteristics (Katzschner, 2006a). In the mean while, the wind patterns based on the meteorological measurement at the ground level was added into UCAn Map to present the air circulation conditions in Kassel. The major Breezeways for transferring fresh cool air and polluted air were also highlighted and separated in this map.

Based on the climatic understanding from UCAn Map, similar Klimatopes were combined together to form the climatic zones based on their homogeneous climatic characteristics and same land use. Then, the UCRe Map was developed to provide planning recommendations for each climatic zone to improve the negative climatic condition and protect the useful climatic resources (Fig. 4).
3.2. Thermal Environment Map Study for Tokyo Metropolitan, Japan

Since the mid of 1990s, Ministry of the Environment (ME) has begun to conduct the investigation project on the environmental impact of Urban Heat Island and tried to find the possible measures for improving the thermal environment. Tokyo Metropolitan’s 23 wards were chosen in this study. UCMAP as information and evaluation tool is the key interest in this project to understand the urban thermal environment. Tokyo Thermal Environment Map was generated based on the heat balance model of Tokyo’s 23 wards simulated by Urban Climate Simulation System (UCSS)(Ashie, 2008, 2009), which is composed of urban canopy model and atmospheric turbulent model. And four categories of thermal environmental load were taken into account, such as anthropogenic heat, land cover, urban morphology and building use.

At the same time, the meteorological data, remote sensing data, planning data and heat release data were input in the GIS platform and then, a simply calculation on heat balance for each mesh (500m × 500m) was conducted. Based on it, researchers could analyze the climatic problem from thermal aspect. In April 2005, Tokyo Metropolitan Government announced a “Thermal Environment Map”. According to this map, four designated areas were identified including Central Tokyo Area, Shinjuku Area, Osaki & Meguro Area, and the areas surrounding Shinagawa Station, which should be paid high attention by Tokyo Metropolitan Government. Consequently, Tokyo Metropolitan Government developed the “Guideline for Heat Island Control Measures” for all 23 wards. The control measures tried to improve the aspects of greening of the premises, rooftop greening, greening of building walls, increased reflectance of rooftops, Water-retentive pavement, reductions in waste heat from buildings and etc, based on the degree of their effectiveness.

4. DISCUSSION

1. The structure and parameters of UCMAP could be illustrated in the Figure 7.
2. The unite of each Klimatope is about 250m to 500m, so researchers do not need very precise meteorological data. However, the communication between planners and climatologists are very important in the process of generating UCMaps. For planners and architects, it is useful to know the spatial and characteristic information of urban climatic phenomena and the effective controlling and improving measures in planning language from the point of climatic view (Chandler, 1976; Eliasson, 2000). Climatologists only need to provide climatic analysis on thermal and wind environment and point out the climatic problem area and its timing range.

3. For German methodology of UCMap, all climatic data and planning information are synthesized together from the dynamic potential aspect and thermal load aspect. In the wind information layer, the prevailing wind directions, mountain and valley winds, especially Katabatic winds are taken into account. For Japanese methodology of UCMap, all climatic data and planning information are calculated and evaluated based on the heat balance model. Considering the planning use, the heat balance calculation is very simple. In the wind information layer, the land and sea breezes, mountain and valley winds, air movements from parks are taken into account.

5. The major weighting factor of defining Klimatopes in both German and Japanese methodology depends on the land use or building use information, which could be applied into low density city and highly compacted city. However, for the very high density city, this method may not be appropriated. The refinements are anticipated.

6. Since the climate change and global warming are inevitable future, the future trend of UCMap studies should focus on the bioclimatic field to understand the urban human comfort and human health condition and create the effective mitigation measures from the climatic and planning view.

5. CONCLUSION

Currently sustainable development is a hot topic for local governments and peoples. Most UCMap studies have been conducted in the developed countries and cities. There is an urgent need to carry out such UCMap studies in the developing countries and cities, which are facing the fast urbanization now. The refinements of UCMap methodology to cope with different conditions are anticipated.

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References


