Urban Climate News

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From the IAUC President

Welcome to another exciting issue of *Urban Climate News*, the quarterly newsletter of IAUC.

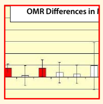
The **In the News** section features a survey and summary of news reports on urban air quality strategies implemented in Beijing for the summer Olympic games, compiled by Winston Chow. You can also read about yet another accolade our past president, Tim Oke, has recently received, this time from the Governor General of Canada.

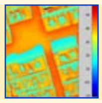
Kevin Gallo's discussion on the influence of urban areas on large scale temperature trends is the topic of the **Feature** article. This is the second in a series, following Eugenia Kalnay's article in Issue 27. We would like to encourage responses and generate an ongoing forum to continue this discussion. So please contact newsletter editor David Pearlmutter at davidp@bgu.ac.il if you would like to contribute an article or opinion piece.

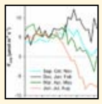
The two **Urban Project** reports in this edition discuss climate change induced heat stress in Swedish cities and the role of trees in reducing pollution in Beijing, respectively. The latter article complements the survey on urban air quality strategies during the Olympic games. I am also very pleased to note another addition to our growing list of **Country Reports**, this time on the large body of research available from Germany, adding to an earlier report published in Issue 11 (June 2005). I would like to take this opportunity to encourage those of you from countries that have not appeared yet to consider submitting a summary of urban climate research.

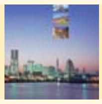
The first **Call for Papers for ICUC-7** next summer in Yokohama, Japan has recently been distributed and is included in this newsletter on p. 23. I strongly urge all IAUC members to give this conference your full support and submit an abstract at http://www.ide.titech.ac.jp/~icuc7 (deadline is **15 December**, 2008).

Inside the Fall issue...









Finally, I would like to draw your attention to the call for nominations for the 2008 Luke Howard Award. The full announcement is included in the **IAUC Board** section on p. 28. The deadline for submission of nomination packages is **1 November** 2008.

Matthias Roth

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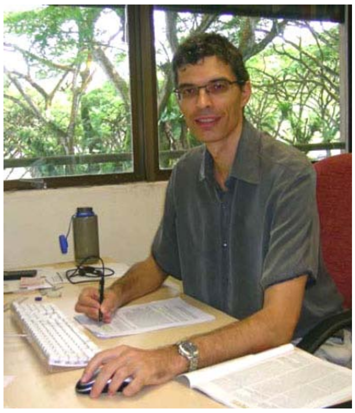

Beijing Olympics – an experiment in controlling urban air pollution?

A special news review by **Winston T.L. Chow**, School of Geographical Sciences, Arizona State University

August , 2008

The recently concluded Beijing Olympics were proclaimed by Jacques Rogge, head of the International Olympic Committee (IOC), as being "truly exceptional.[1]" For sixteen days, we were treated to a spectacular sporting festival graced with memorable performances by athletes like Michael Phelps and Usain Bolt. Despite the organizational success, a notable concern before the Games began was Beijing's air quality. The Chinese capital has been afflicted with periodic episodes of urban smog that distorts the city skyline (see Figure). Several factors contribute to cause this air pollution, such as:

The view outside the BBC Beijing office (from left to right): Aug. 5, 10, 15, 20 and 25, 2008[19]

• The rapid urban-industrial development of the region since the 1980s has been coupled with increasing rates of car ownership in the city itself.

• Beijing's metropolitan area is bounded by the Yanshan mountains to the north and west, which inhibits pollution venting, especially on days with stagnant winds.

• Frequent dust and sandstorms that originate from the city's outskirts.

These pollution levels are not trivial; Beijing's urban atmosphere had higher mean concentrations of total suspended particulates (TSP), SO2 and PM10 than Mexico City, Mumbai and Bangkok in 2000[2].

The high air pollution levels were a concern amongst athletes, especially those competing in endurance events. Current men's marathon world record holder, Haile Gebrselassie, pulled out of the event as early as March 2008, stating that "…the pollution in China is a threat to my health and it would be difficult for me to run 42 km in my current condition (Gebrselassie is an asthmatic)[3]." Cognizant of this problem, the organizers of the Beijing Olympics embarked on an ambitious blueprint to combat the pollution in time for the start of the Games. These measures appeared to be successful, with mainly clear skies seen throughout the event. This surprised athletes like Gebrselassie, who regretted his decision not to compete in the marathon[4].

But several questions related to urban climate remain: What were these measures? How much of the clear skies were due to these controls, vs. regional weather patterns? And will these measures last after August 2008?

Measures to control pollution

A suite of air pollution controls were effected in Beijing since 1998[5], but after being awarded the right to host the Olympics in 2001, the organizers and the city's government implemented several additional measures, such as closing 70% of its local solid mines[6], retiring 13,000 taxis that exceed new emission standards[7], and improving monitoring of exhaust from 200 heavy industrial plants, coupled with fines or closure if new emission standards were exceeded[8]. Consequently, air quality did improve with reports of the number of "blue sky" days (i.e. days where PM_{10} levels are less than 100 μg/m3) rising from 100 to 246 between 1998–2007[9].

Despite these policies, there was unease from media and athletes that they were ineffective or misleading. In October 2007, the IOC was concerned that the addition of 40,000 cars per month in the city would accelerate the air quality problem[10]. There was also speculation that several monitoring stations were moved away from highly pollutive areas in 2006, meaning that subsequent data comparisons were made in reference to the older, "dirtier" stations[11]. In response, the organizing committee disputed the claim of moving monitoring stations[12], and implemented several last minute measures as late as July 2008, which included shutting down pollutive industries for the duration of the Olympics in towns away from Beijing such as Tangshan[13], implementing daily "odd-even" traffic restrictions to remove half of Beijing's 3.3 million cars from its streets[14], and ceasing building construction during windy days[15].

Even so, a persistent haze clouded Beijing as late as 12 days before the opening ceremony[16], and organizers hoped for good weather to clear the city's smog during the games – which did occur as heavy rain fell during the third day of competition (August 10) and cleared the skies[17]. After that day, the Air Pollution Index (API), based on the mean observations of 27 stations situated throughout Beijing, did not exceed 61 for the rest of the Olympics[18], well below the value of 100 that organizers had set prior to the games. The BBC and the Associated Press, however, also measured daily PM_{10} outside the BBC Beijing office[19] and at the "Bird's Nest" stadium[20] respectively. They observed that these point measurements were still well above World Health Organization's (WHO) PM_{10} standard of 150 for developing countries on several occasions during competition. For instance, PM_{10} values at the Bird's Nest stadium on August 13 were 409 over a 2-hour period.

Regional vs. local weather – which is more significant to Beijing's air quality woes?

Another significant question was how much pollution originated away from the city and was transported into Beijing, thereby reducing the impact of local measures within the city? A 2007 report used the Models 3-CMAQ to examine PM and ozone contributions from regional sources ex-Beijing[21]. They concluded that, on average, 34% of $PM_{2.5}$ and 35–60% of ozone during high episodes at the Bird's Nest stadium can be attributed to regional sources.

Attribution of pollution sources also varies with respect to the meteorology in the region. Kenneth Rahn, an atmospheric chemist from the University of Rhode Island, documented that air pollution in Beijing strongly correlates to a regular, fortnightly N-S reversal of summer winds[22], as northerly winds from Mongolia would wash away the city's smog. If there are sustained southerly winds, however, approximately 50–70% of $PM_{2.5}$ and 20–30% of ozone would then originate from industries in neighboring Hebei province[23].

During the Olympics, the change in regional winds from the north was discernable from the API data. In spite of the last minute and wide-scale policies to reduce emissions in Beijing and its environs, Rahn concluded that the drop in API during the Olympics were "more due to Mother Nature than pollution controls,"[24] although a shift to southerly winds prior to the men's marathon did not correspond to a large increase in API over the following days, possibly indicating that the restrictions on regional industrial pollution had a positive effect.

Interestingly, the mass shutdown of industrial and transport pollution for the Olympics during July and August, as well as for the Paralympics held in September, can be viewed as a large-scale lab experiment. Specifically, how would the regional atmosphere respond when a large metropolitan area reduces industrial emissions?

To answer this, the Cheju ABC Plume-Monsoon Experiment (CAPMEX), operating from the South Korean island of Cheju, uses sensors mounted on unmanned aerial vehicles along with ground and satellite observations to track the path of pollution plumes originating from Chinese cities such as Beijing[25]. Part of the project's novelty is that the shutdown of emissions in the region is unlikely to happen again, which thus gives scientists a great opportunity to examine air pollution and cloud interaction impacts. These observations conclude after the end of the Beijing Paralympics on 30 September.

What does the future hold?

Whilst there were no complaints about the air quality during the games from the IOC, it remains to be seen if these strict emissions standards will continue to be implemented post-Olympics. It has been estimated that 3% of GDP was lost after the two-month closure of factories in Beijing and its surrounding areas[26]. With the pressures of maintaining sustained economic growth, it will be interesting to see if business will indeed revert back to normal within a few months, bringing the smog back to Beijing.

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T.R. Oke receives Canada's highest civilian honour

July, 2008

Timothy R. Oke was awarded the "**Order of Canada**" for his contributions to meteorology and urban climatology, as well as for his mentoring of generations of geographers. The Order is the highest civilian honour bestowed by Canada. Tim is a professor emeritus of geography at the University of British Columbia and a Fellow of the Royal Society of Canada. He was a founder of IAUC, its first President and winner of the inaugural Luke Howard Award.

The announcement was made on July 1 by Michaëlle Jean, Governor General of Canada. Awarded for the first time in 1967, during Canada's Centennial Year, the Order of Canada launched the creation of Canada's own system of honours.

Professor Tim Oke, past-president of IAUC and Officer of the Order of Canada.

Recognition of the influence of the urban climate in assessment of large-scale temperature trends

by Kevin Gallo, NOAA/NESDIS and Board Member of IAUC and Robert Hale, Colorado State University

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The editor of the IAUC newsletter, Dr. David Pearlmutter, recently requested that I might initiate discussion in this newsletter on the topic of the influence of urban areas on temperature trends and if these urban influences and related land use effects are being adequately modeled in the assessment of large scale temperature trends. Issue 28 of this newsletter (Gallo, 2008) reported on the increased number of publications related to this general topic, based on a relatively brief review of literature from 1998 through 2007. The intent of this newsletter contribution, as reflected by its title, is to initiate further discussion on the original topic requested by Dr. Pearlmutter. The intent is not an exhaustive review of recent literature on the topic; rather the goal is to stimulate further discussion in future editions of the newsletter.

Survey of Recent Assessments and Data Sets

Recent Urban Assessments

Issue 27 of this newsletter (March 2008) included several features and news items related to this topic. A contribution titled "Impacts of urbanization and land surface changes on climate trends" by Kalnay *et al.* (2008) summarized the results of analyses included in several publications on this topic. These analyses were based on comparisons of observed surface temperatures to those of the NCEP-NCAR Reanalysis (NNR). The NNR data are considered nominally insensitive to the influences of land surface features. Thus, the Observation Minus Reanalysis (OMR) difference in temperatures is considered an indicator of how strongly land cover may be influencing near-surface air temperature in a region. Concerns with some of the datasets used in OMR-based studies have been expressed (e.g., Trenberth, 2004) and responses provided (e.g., Cai and Kalnay, 2004, 2005).

In one of the studies highlighted (Lim *et al.*, 2005), those areas with urban land cover were second only to regions of barren land cover in increased warming observed in the OMR data. While the Lim *et al.* (2005) study focused on correlations between increased or decreased warming and the underlying land cover type, Hale *et al.* (2008) used the OMR method developed by Kalnay and Cai (2003) to examine how *changes* in land cover may affect near-surface air temperature. Observed urbanization was limited to conversion of 1) crop/pastureland to urban use and 2) conversion of forested land to urban use. However, in both cases minimum temperatures were found to be significantly warmer (by 0.38ºC) following urbanization (Figure 1). Maximum temperatures also revealed warmer temperatures following urbanization, though this warming was only statistically significant for conversion of crop/pastureland to urban land use.

Zhou *et al.* (2004) used the OMR methodology to examine land use effects on temperature in the rapidly urbanizing country of China. Focusing on winter temperatures, they found that the diurnal temperature range (DTR) decreased at a rate of 0.195ºC/decade, largely owing to increasing minimum temperatures. Of this observed decrease in DTR, 68% was attributed to land use changes, primarily urbanization. Further, this reduction in the diurnal temperature range was significant and correlated with regional ratios of urban population to total population.

As an alternative to use of the OMR methodology of the previous studies, Stone (2007) compared the temperature trends of climate stations within the 50 most populous cities in the United States with neighboring rural stations and found a 0.05ºC/decade difference in trends for the urban and rural stations.

Urbanization in Climate Datasets

Methods of adjusting for the effects of urbanization in climatic datasets vary, and for analysis of global trends the impacts of urban stations have even been suggested as negligible (e.g., Peterson *et al.*, 1999). When urban adjustments are applied, differences may exist in the methods or metadata related to the urban adjustments, even within a particular dataset.

The Global Historical Climatology Network (GHCN) includes a metadata file (NCDC, 2008a) that identifies

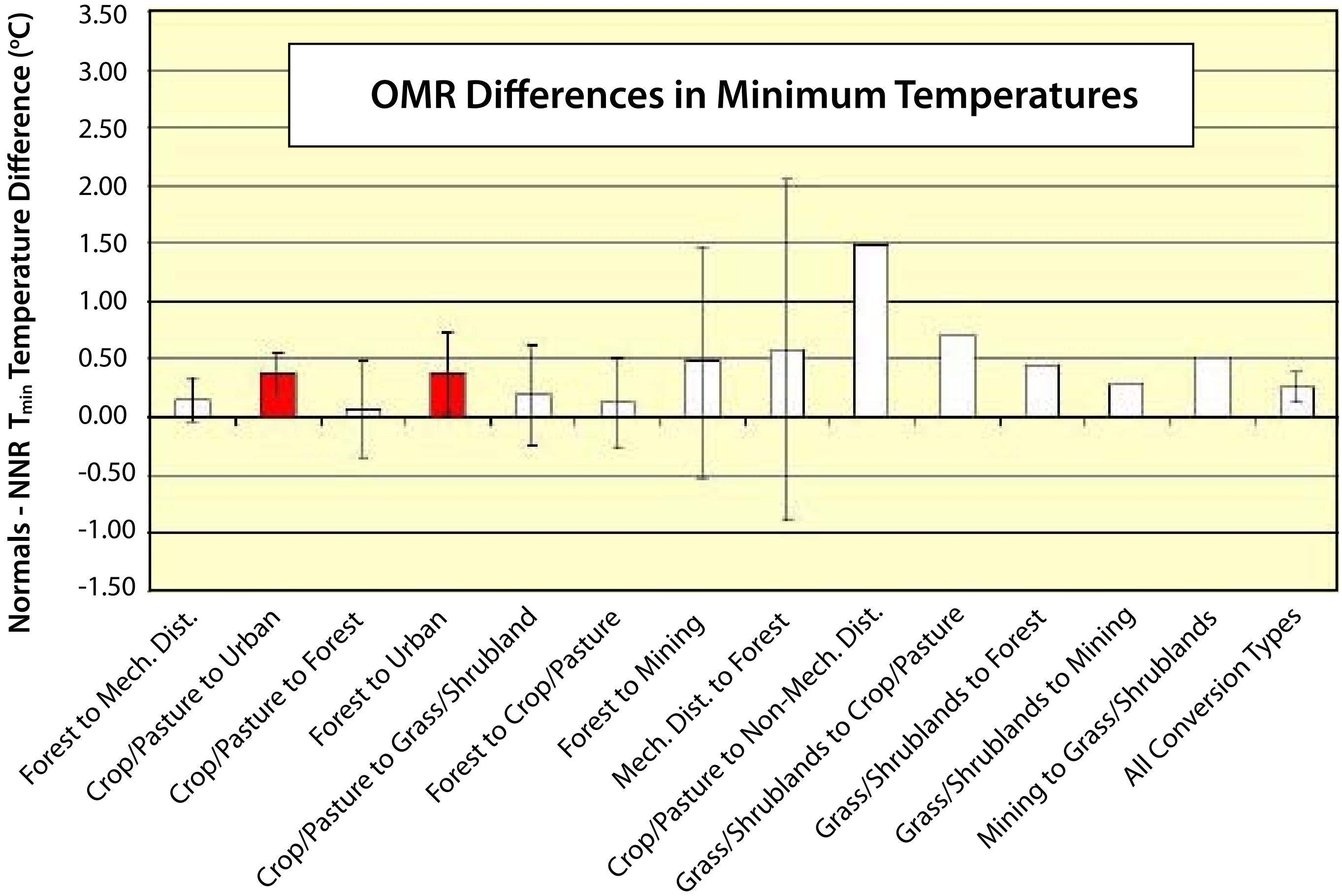

Figure 1. OMR-revealed influence of various land use/land cover changes on minimum temperature. 90% confidence interval error bars demonstrate statistically significant warming for both cases of observed urbanization (red bars). Adapted from Hale *et al*. (2008).

the general population level associated with stations to permit analysis of the data set with or without specific stations based on the GHCN population assessment. The population assessments utilized are from several sources, some with unknown dates of source population information (Peterson and Vose, 1997).

Within the Goddard Institute for Space Studies (GISS) dataset (NASA, 2008), the trends at urban and peri-urban stations "are adjusted so that their long-term trend matches that of the mean of neighboring rural stations." This adjustment resulted in a -0.3°C/100 years adjustment for the urban stations and -0.1°C/100 years for the peri-urban stations within the United States (Hansen *et al*., 2001). However, the distinction between rural and non-rural stations varies geographically. In the contiguous United States "and bordering regions of Canada and Mexico", satellite-derived night-time lights are used to classify stations; elsewhere in the world, population data (from the GHCN dataset) are used for this classification (Hansen *et al*., 2001).

Urban station data in Version 1 of the U.S. Historical Climatology Network (USHCN; NCDC 2008b) were adjusted based on the population of the urban area in which a station is located (Karl *et al*., 1988). That is, the trend at an urban station has a population-based correction factor applied to it, rather than being adjusted to the trends of nearby rural stations.

Version 2 of the USHCN data set includes a homogenization algorithm (NCDC, 2008c) that utilizes differences between a target station and numerous temperature series from neighbor stations to determine "changepoints" in the data series. The change-point algorithm, as described in the online documentation (NCDC, 2008c), "effectively accounts for any 'local' trend at any individual station." Thus, no additional urban adjustment is applied to the Version 2 USHCN data.

The Climate Research Unit (CRU, 2008) data set (HadCRUT3; Brohan *et al*., 2006) includes an estimate for the "urbanization uncertainty" of 0.0055°C/decade starting with data of 1900. This value is used over the "whole land surface."

Summary

While there is evidence that trends in observed temperature within urban areas differ from those observed in rural locations, the overall impact of these differences on estimates of global temperature trends appears to be a topic for continued research and discussion. The world-wide proportion of urban population, compared to total population, is projected to increase to 61% by 2030 (United Nations, 2004). The same report projected that by 2007, the urban population would exceed 50%. Accompanied with this increase in population there will likely be changes in the current landscape associated with urban areas that experience increases in population levels. Thus, the continued monitoring of land surface changes associated with urban areas would seem critical for future temperature trend analyses.

The IAUC Newsletter solicits additional comments on this topic from those that have an interest related to the detection and influence of urban areas (or associated land cover changes) on temperature trends. Please forward contributions to the editor, David Pearlmutter (davidp@bgu.ac.il).

Acknowledgements

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The urban forest in Beijing and its role in air pollution reduction

1. Introduction

Like other metropolitan areas in developing countries, Beijing faces many environmental problems caused by poor urban planning and rapid development. Air pollution is the most outstanding of these. Beijing is among the ten cities of the world with the worst air pollution problems (World Bank, 2000). Severe air pollution causes serious health problems and loss of life. Research indicates that when the air pollution index (AQI) in Beijing rose by 10%, the daily number of deaths caused by respiratory disease increased by 3.52% (Zhang *et al.*, 2003).

Urban forests in Beijing can play an important role in removing air pollutants from the atmosphere. Trees can reduce air pollutants in two ways: (1) by direct reduction from the air, and (2) by indirect reduction by avoiding the emission of air pollutants. In direct reduction, trees absorb gaseous pollutants like SO_2, NO_2, and O_3 through leaf stomata and also can dissolve water soluble pollutants onto moist leaf surfaces (Nowak, 1994). Tree canopies can also intercept particulate matters in the air (Beckett *et al.*, 1998). Indirectly, trees can reduce the air temperature through direct shading and evapotranspiration in the summer, thus reducing the emission of air pollutants from the process of generating energy for cooling purposes. Also, reduced air temperature can lower the activity of chemical reactions, which produce secondary air pollutants in urban areas (Taha, 1996; Nowak *et al.*, 2000).

The study presented here was designed to provide a detailed analysis of the Beijing urban forest and its effect on air pollution. Four objectives were addressed in the study: (1) to describe the current composition and structure of the Beijing urban forest; (2) to quantify the major air pollutants including SO_2, NO2, PM_{10}, and O_3 that are reduced from the atmosphere by urban forest; (3) to quantify the biological volatile organic compounds (BVOC) emission from the urban forest; (4) to calculate the sequestration of CO_2.

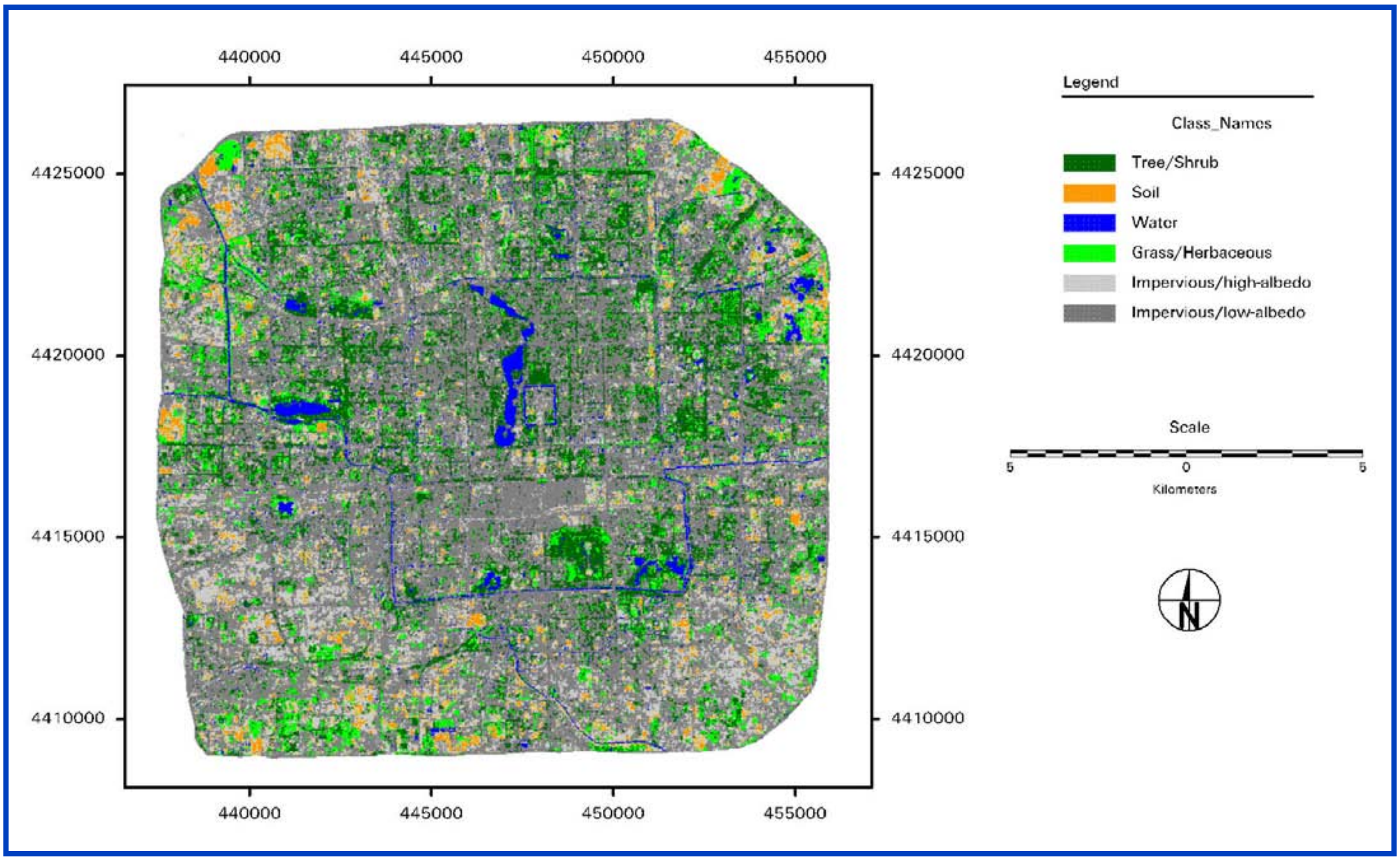

Figure 1. The classification result showing the distribution of various land cover types in the urban part of Beijing in 2002. The map was projected in the UTM coordinate system.

2. Methods

a. Analysis of satellite image

One scene of Landsat ETM+ Level G image taken on 05/22/2002 covering the Beijing region was obtained from EROS Data Center. After preprocessing, the image was analyzed using unsupervised classification procedure to generate the land cover map of urban Beijing.

b. Field survey

Two hundred and fifty sampling plots were located in the urban part of Beijing. The distribution of sampling plots among areas was proportional to the amount of tree/shrub cover in each area determined from the satellite image analysis. The plots were located on the 2.5 m resolution color orthophotos taken in 2000 by randomly picking X and Y coordinates for each sampling point from a coordinate system lay over the photos. The area of each plot was approximately 400 m^2. The land use/land cover information was collected or measured on each plot.

c. Air pollution reduction calculations

Daily, monthly, and yearly removal of NO_2, O_3, PM_{10}, and SO_2 by trees and shrubs in Beijing were calculated using the Urban Forest Effects model (UFORE) developed by the USDA Forest Service, Northeastern Research Station (Nowak and Crane, 2000). Emission of BVOC was also estimated using the model. Daily air pollution data including NO_2, SO_2, O_3, and PM_{10} concentration in the atmosphere of Beijing in 2002 was obtained from the Beijing Environmental Protection Administration. Daily meteorology data for the same year were also acquired. These data were inputs required for running the UFORE model.

3. Results

The classification result (Fig. 1) indicated that the urban part of Beijing in 2002 consisted of impervious surface (68.7%), tree/shrub (16.4%), grass/herbaceous (8.1%), bare soil (4.1%), and water (2.7).

It was estimated that there were 2.4 million trees growing in the urban part of Beijing. The tree density was 79/ha. The urban forest in Beijing was dominated by small-size trees.

The monthly average concentration of the major air pollutants shows that the main air pollutant in Beijing in 2002 was the PM_{10} (Fig. 2). The total annual air pollutant uptake by trees from the atmosphere was around 1261.4 tons (Fig. 3). The standardized pollution removal rate (g/yr per m2 canopy cover) was 27.5, and PM_{10} accounted for 61% of total air pollutants removed. The largest air pollutant removal occurred in April (167.1 tons), and the lowest in November (43.8 tons).

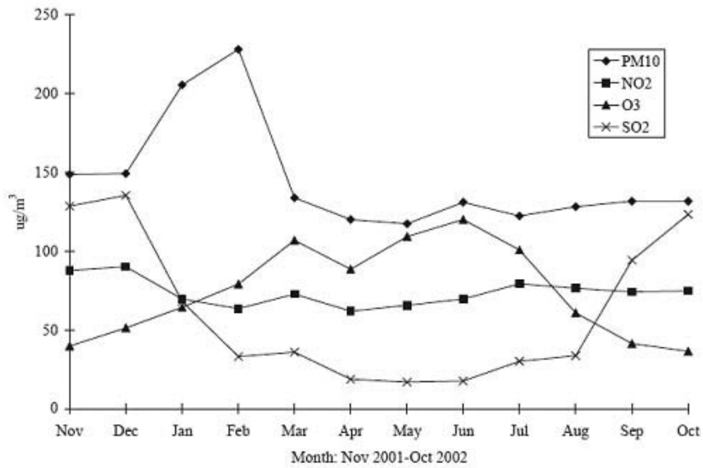

Figure 2. Monthly average concentration of the major air pollutants in Beijing.

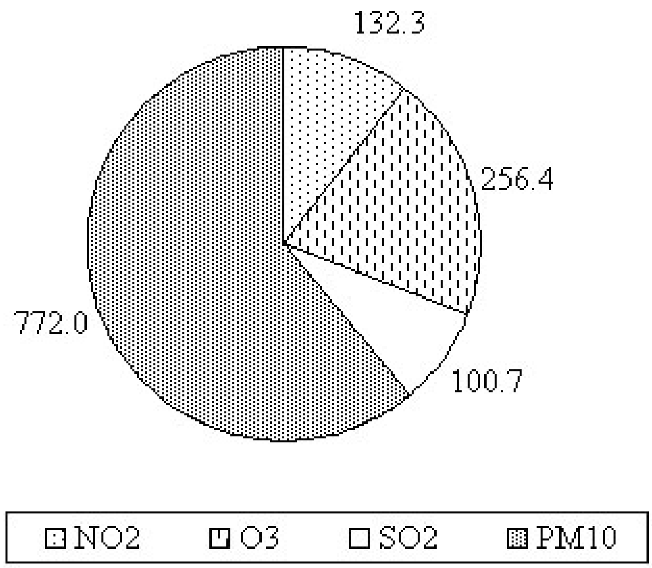

Figure 3. Annual air pollution removal by trees in the total study area in Beijing (unit: metric ton).

The trees in Beijing emitted 201.7 tons of isoprene and 35.5 tons of monoterpene. The total ozone forming potential was 1952.6 tons. This number does not represent the real ozone formed because the urban center is usually thought of as "NO_x limited" and the formation of ozone is small due to a high VOC/NO_x rate (Benjamin and Winer, 1998). The NO_x emission in Beijing is increasing quickly because of the rapid increase in the number of automobiles (Zhu and Jiang, 2002). Combined with the hot summer and the slow air mass movement caused by the topography of Beijing (Liu and Ren, 2003), the BVOC may contribute to the formation of ozone in the future because of its high photochemical reactivity (Chameides *et al*., 1988).

The urban forest in Beijing stored about 224,000 tons of carbon in biomass form.

4. Discussion

The size structure of the urban forest in Beijing was not optimal for air pollution removal. Sixty percent of the trees were still too small to provide considerable air pollution removal. According to Nowak (1994), a large tree with a diameter of 76 cm can remove 70 times more air pollutants from the air in Chicago than a tree with a diameter of 8 cm.

The species composition in Beijing was also not ideal for air pollutant removal and CO_2 sequestration. Populus, Robinia and Salix were among the dominating genera; they have high BVOC emission rates (Benjamin and Winer, 1998) and therefore a high potential for increasing ozone formation. Moreover, these genera are fast growing and have relatively short life spans. The CO_2 fixed wood biomass in these genera will be released back to the atmosphere sooner than it would if trees known for longevity, such as Juniperus. were planted. For future planting in Beijing, species should be chosen based on their suitability for the urban environment and their air pollutant removal ability.

There are three aspects of research on the reduction of air pollution by the Beijing urban forest that merit further study: (1) Uncertainty analysis of the result produced by the current model. (2) Measurement of the air pollutants removal by individual trees. (3) Accurate modeling of the air pollution concentration and its relation to the location of the urban forest to generate better estimation of pollution reduction.

With all these limitations in mind, the result still shows that the urban forest in Beijing has a potential to reduce the air pollutants from the atmosphere. Thus tree planting can be used as an effective way in alleviating the air pollution problem in Beijing. This desired benefit of urban forestry could be further enhanced by adopting our recommendations on careful species selection and better management practice.

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Increased heat stress in Swedish cities due to climate change: the impact of urban geometry on thermal comfort

Introduction

The mean air temperature in Sweden is expected to rise 2 to 5°C by 2100 (IPCC, 2007). Heat waves will become more frequent, intense and longer. As a result, several reports predict dramatic increases in heat-related illnesses and deaths with large economic consequences. For example, the Swedish governmental report "Sweden facing climate change - threats and opportunities" (SOU, 2007) predicts that the number of deaths in the Stockholm area will rise by 5% in summer, if summer mean air temperature rises by 4°C. Furthermore, the increased costs of damage of heat-related deaths due to climate change will be 500-660 million SEK.

Urban centres are particularly vulnerable areas, as a result of the urban heat island and the generally poor air quality. Warmer summer temperatures will increase the demand for cooling. More air conditioners might be installed and their use might increase. This will create an additional demand for electricity, additional release of CO_2 and an additional release of heat to the city itself. Climate-sensitive planning is acknowledged to play an important role in primary prevention of heat stress in cities, but little is known about the effectiveness for human health of different urban planning measures. Thus, more knowledge on the complex interaction between different urban forms and the thermal environment is needed. Furthermore, collaboration between researchers, practitioners and decision makers is essential in order to implement the research. In this respect geographical information systems (GIS) will constitute an important communication tool.

The objective of this project is to simulate today's as well as future heat stress in different urban forms in Göteborg, Sweden. This will allow an insight into the interaction between different urban forms and the thermal environment and the potential increase in heat stress in Swedish cites due to climate change – knowledge that can be used to mitigate thermal stress in urban areas.

Methods

Four urban places – a square, a courtyard and two street canyons oriented in north-south and east-west directions, respectively in the central parts of Göteborg are selected for the case study. The mean radiant temperature (T_{mrt}) for three different cases (climates) is simulated using the SOLWEIG model (Lindberg *et al.*, 2008). The model simulates spatial variations of T_{mrt} in complex urban settings as shown in Fig. 1, using meteorological data (i.e. air temperature, air humidity, direct and diffuse shortwave radiation) and geographical information on topography and buildings. The T_{mrt}, which sums up all short-wave and long-wave radiation fluxes to which the human body is exposed, is one of the most important meteorological parameters governing the human energy balance and the thermal comfort of man. In this project, the thermal comfort (stress) is calculated using the physiological equivalent temperature index (Mayer and Höppe, 1987)

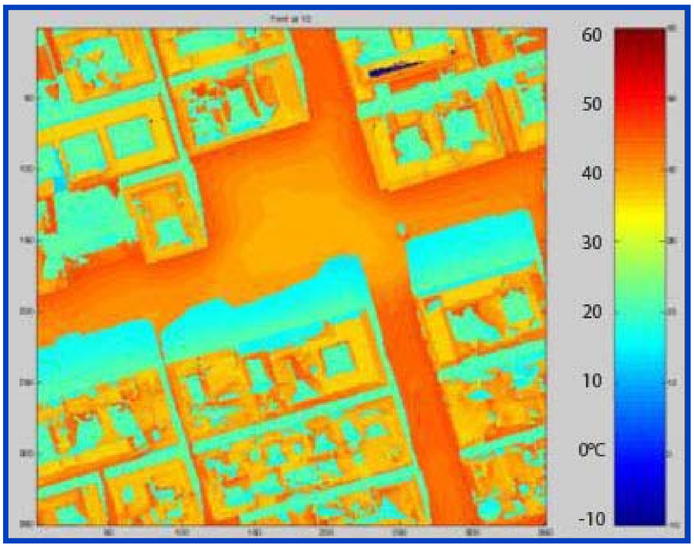

Figure 1. Simulated spatial variations of T_{mrt} at noon on a clear day in October in central Göteborg, Sweden

Data

Today's climate is simulated using hourly meteorological data from 1977. The climate of 1977 is considered to represent the typical climate of Göteborg for the period 1965-1984, exhibiting all the normality and extremes. Future climates are simulated using different climate scenarios, i.e. by adding a potential increase in mean air temperature (2°C and 5 °C) to the air temperature of the typical year. All other meteorological parameters are kept the same.

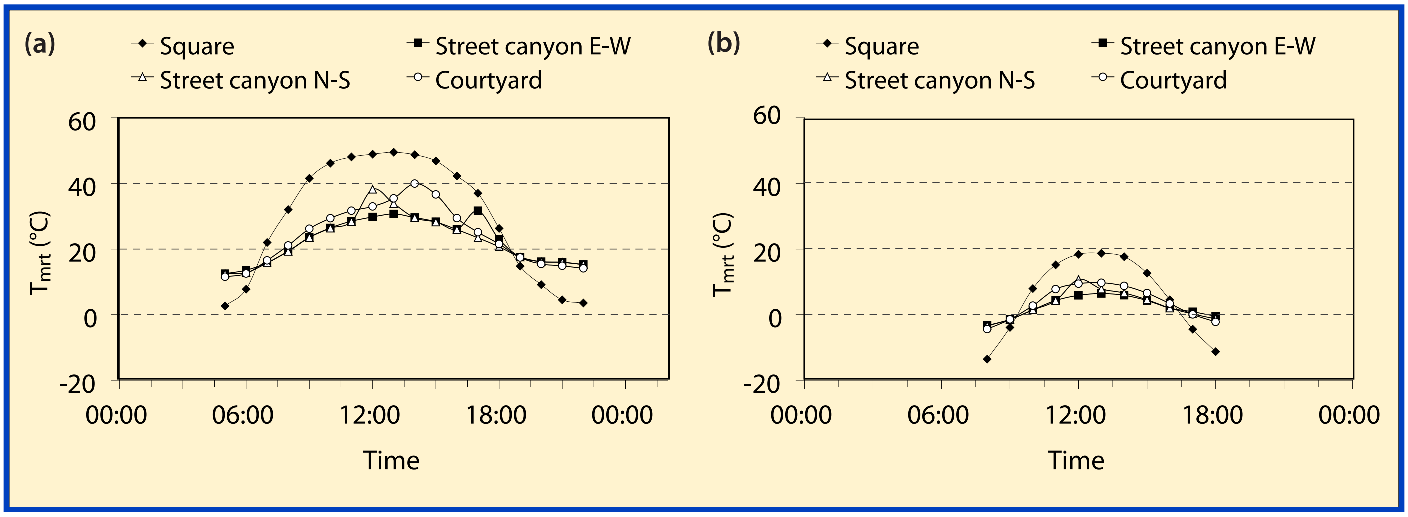

Figure 2. Hourly average daytime T_{mrt} in a) summer (JJA) and b) winter (DJF) at a square, a courtyard and two street canyons oriented in N-S and E-W directions, respectively in Göteborg, Sweden.

Thermal comfort in different urban forms

In cities, large differences in T_{mrt} exist within short distances as shown in Fig. 1. This is mainly due to the urban geometry, e.g. street direction, spacing and width, building height etc. Other important parameters are vegetation and building materials. During daytime, the T_{mrt} is generally considerably higher at open areas compared to narrow street canyons as a result of the higher amount of incoming solar radiation (Fig 2). However, in early mornings and late afternoons narrow street canyons are warmer than open areas due to diminished loss of long-wave radiation through multiple reflections at the canyon surfaces. Although the absolute values are smaller in winter the same thermal pattern exists throughout the year. Today, heat stress occurs 7% of the time in the square, whereas only 1% of the time in the north-south oriented street canyon as shown in Table 1. This implies that the higher building density, the less daytime thermal stress in summer. The opposite applies for night time.

Potential increase in heat stress in Swedish cities due to climate change

In future warmer climates, heat stress is expected to be intensified in northern located cities like Göteborg, with the occurrence of hot extremes (strong and extreme heat stress) increasing by 100 to 300% in summer (Table 1). Today, extreme heat stress occurs on 2-3 days in summer. In the 2°C and 5°C warming scenarios extreme heat stress is expected to occur on 6 and 17 days, respectively. From being a rather rare feature, occasions with extreme heat stress will occur regularly and frequently in summer within the next 100 years. This is expected to have a large impact on both health and demand for cooling. On the other hand the number of cold extremes will decrease considerably in winter, with large positive health, environmental and economic effects.

Future plans

Our aim is to use the SOLWEIG model to quantify and map future increases in heat stress due to climate change in different urban forms and cities (small, medium and large) across Sweden and Europe. Yearly, monthly and daily heat stress maps will be produced and aerial means for different urban areas (open, dense etc.) will be calculated. Based on the results, good and less good examples of urban design will be identified and suggestions on how to mitigate heat stress in urban areas will be presented including preliminary recommendations on design measures such as increased shading.

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Table 1. Thermal stress (in percent) in the square and in the north-south oriented street canyon in the typical year (1977), as well as the change in percent in the 2°C and 5°C warming scenarios.

Thermal stress (PET)	Square			Street canyon (N-S)		
	Typical year (%)	2°C scenario (±%)	5°C scenario (±%)	Typical year (%)	2°C scenario (±%)	5°C scenario (±%)
Extreme cold stress	57	-8	-18	48	-7	-19
Strong cold stress	13	+1	±0	16	-2	±0
Moderate cold stress	11	+2	+6	17	+3	+1
Slight cold stress	6	+2	+5	11	+2	+7
No thermal stress	6	-1	±0	5	+2	+6
Slight heat stress	4	+2	+2	2	+1	+4
Moderate heat stress	2	+1	+3	1	±0	+1
Strong heat stress	1	±0	+2	0	±0	+1
Extreme heat stress	0	±0	+1	0	±0	±0

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Urban Climate Research in Germany

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1. Introduction

Germany has 82 million inhabitants (2008) and an area of about 357,000 km². Approximately 74% of the population live in urban areas, which account for 47% of the total surface area (Bundesamt für Bauwesen und Raumordnung 2006). As a result of the thermal and air hygiene impacts of cities, guidelines and limits for the planning factors of climate and air quality were already embodied in German environmental legislation many years ago. The first German publication dealing with urban climatology from the present point of view and the presentation of air temperature differences probably appeared in Mannheim (Deurer 1784). Systematic work on urban climatology started in 1937. At that time, the Benedictine Father Albert Kratzer, later internationally famous as the "father of urban climatology" published a monograph entitled "The Urban Climate" (Kratzer 1937, 1956; English version: 1956). Surveys of urban climatology with examples from Germany are given in Helbig *et al*. (1999) and Kuttler (2006, 2008). The "Handbook of Urban- and Regional Planning" (Schirmer *et al.* 1993), which appeared several years ago and contains a large number of examples for practical planning, is oriented solely towards climate and air quality applications. Further information on the thermal and air quality aspects of urban climate is given by the German and international urban climate homepage (http://www.stadtklima.de) or (http://www.urbanclimate.net).

2. Urban Climate Research in Germany

The overview of urban climate research in Germany given below builds on the Country Report "Urban Climate in Germany" (Matzarakis 2005) and is mainly based on the evaluation of publications accessible internationally. These were assigned to the areas of climatology, air quality and human biometeorology. In Germany, urban climate research and teaching are mainly established at university institutes with a meteorological or geographic orientation (Table 1). No specialised courses of studies in urban climatology are available. Apart from universities, a large number of other institutions and consulting engineers are concerned with the solution of urban climate problems, mainly with a practical orientation.

3. Climatology related research

Apart from overall analyses of urban climate (e.g. Endlicher and Lanfer, 2003), many studies cover individual aspects. The urban heat island (UHI), one of the best-known features of urban climates, is one of the main focuses of research. Subjects covered by UHI studies include small-scale relationships between surface-specific energy balances (Weber and Kuttler 2005), especially counter-radiation as a function of road geometry and vegetation (Blankenstein and Kuttler 2004), topography (Kuttler *et al*. 1996) and the effects and dynamics of cold air on UHI intensity and air quality at night (Junk *et al*. 2003). The demonstration of the penetration depth of rural cold air into urban areas (Weber and Kuttler 2004; Dütemeyer 2000; Kuttler *et al*. 1998), modelling of cold air dynamics (Sievers 2005) and the occurrence of country breezes (Barlag and Kuttler 1990/91) are relevant for urban planning (see Section 5). The intensity of the UHI is mainly due to the difference of rural and urban land use: although it was possible to establish large-scale relationships, for example with latitude, these were relatively minor, with an explanation of variance of only 6% (Wienert and Kuttler 2005).

In general, the urban boundary layer has lower humidity than the surrounding countryside. However, in low-exchange summer weather situations, these conditions are frequently reversed as the temperature falls below the dew point earlier in the evening and more frequently at night in the surrounding area (Mayer *et al*. 2003). Studies carried out for a year in Krefeld and the surrounding area show that an urban moisture excess (UME; $\Delta e_{u\text{-}r} > 0$ hPa) is established in 36% of cases (Kuttler *et al*. 2007).

Knowledge of the complex turbulence structure with the urban boundary layer, especially in urban canyons, and the height of the mixing layer over the course of the day is essential for statements on heat and pollutant transport (Emeis and Turk 2004; Bohnenstengel *et al*. 2004). Studies of this kind are carried out by vertical sounding (Feigenwinter and Vogt 2005; Rotach *et al*. 2005) and remote sensing (SODAR, RASS, ceilometer; Emeis *et al*. 2007; Emeis and Schäfer 2006; Emeis 2004; Emeis *et al.* 2004; Reitebuch *et al*. 2000). However, numerical model simulations (PALM, Letzel *et al*. 2008),

Table1: German institutions pursuing basic and applied urban climate research

Institution	Focus of Research	Contact
Berlin, Technische ***Universität Berlin***, Fachgebiet Klimatologie, Institut für Ökologie	A research program called "Energy eXchange and Climates of Urban Structures and Environments (EXCUSE)", focuses on experimental and theoretical atmospheric research on quantification of energy as well as associated momentum and mass exchange processes in the urban boundary layer.	dieter.scherer@tu-berlin.de
Berlin, Humboldt-***Universität*** zu ***Berlin,*** Geographisches Institut	Research on urban climate and air quality of large cities, especially Berlin (Germany), Buenos Aires (Argentina) and Dhaka (Bangladesh). Special interests: thermal comfort, particulate matter and human health in the framework of urban ecology.	wilfried.endlicher@geo.hu-berlin.de
Dresden, Meteorologisches Institut, Universität Dresden	The focus of urban climate related research is on (i) downscaling of larger scale climate data to the - typically complex - orographic situation of urban areas, (ii) deriving relationships between urban structures and urban climate by statistical models, and (iii) evaluating the effects of vegetation on the carbon and water budgets of urban areas. The work is done in co-operation with the Leibniz Institute of Ecological Regional Development in Dresden.	christian.bernhofer@tu-dresden.de
Essen, Universität Duisburg-Essen, Abt. Angewandte ***Klimatologie*** und Landschaftsökologie	Research on general and specific problems of urban climate and air pollutant parameters (NO, NO_2, CO, O_3) with emphasis on particulate matter and horizontal CO_2 - distribution and turbulent CO_2 exchange in the urban canopy layer. Investigations of near-surface air exchange between city centres and surrounding green areas during calm weather conditions (cold air dynamics, UHI-circulation). Analysis of the impact of global climate change on urban settlements. Processing of results for use in local planning procedures, e.g. for the characterization of urban land use structures as climatopes.	wilhelm.kuttler@uni-due.de
Freiburg, Albert-Ludwigs-Universität-Freiburg, Meteorologisches Institut	Research focuses on the assessment of the human thermal and air quality comfort, with analysis of the impact of street trees on the thermal condition in street canyons and evolution of the air pollution in urban settlements. Generation of thermal and air quality indices. Epidemiological studies were accomplished and Heat Health Warning Systems developed and implemented. For the thermo-physiologically relevant assessment of the thermal environment a Universal Thermal Climate Index UTCI is under development within COST Action 730. Modeling of radiation fluxes and thermal bioclimate conditions in simple and complex environments. Development of urban climate tools.	meteo@meteo.uni-freiburg.de
Garmisch-Partenkirchen, IMK-IFU Forschungszentrum Karlsruhe	Urban climate research at IMK-IFU is focusing on the interaction between the city and its hinterland, the feedback mechanisms of global climate change on the regional scale, on urban heat islands and on air quality. Within the HGF initiative "Risk-Habitat-Megacity" the research focus is on the sustainable development, risk and governance management in Santiago de Chile and further Latin America mega cites.	stefan.emeis@imk.fzk.de

Table1 (cont.): German institutions pursuing basic and applied urban climate research		
Institution	**Focus of Research**	**Contact**
Hamburg, Universität Hamburg, Meteorologisches Institut	Current research activities of the Environmental Wind Tunnel Laboratory (EWTL) at Hamburg University cover a wide range of problems related to urban air quality modelling and prediction. Major focus of research is shifting from the investigation of mean flow and dispersion in complex urban terrain towards the qualitative and quantitative description of transient flow and dispersion phenomena within urban structures.	michael.schatzmann@zmaw.de
Hannover, Leibniz Universität, Institut für Meteorologie und Klimatologie	The turbulence-resolving parallelized large-eddy simulation (LES) model PALM is used to study integral turbulence statistics street canyons. For the first time in urban LES Kelvin-Helmholtz instabilities atop the street canyon were identified. Neighbourhood scale PALM studies featured Tokyo/Shinjuku and Hong Kong/Kowloon.	letzel@muk.uni-hannover.de
Karlsruhe, Universität Karlsruhe (TH), Institut für Hydromechanik	The Laboratory of Building- and Environmental Aerodynamics of the Institute for Hydromechanics at the University of Karlsruhe is a research unit working in the field of interaction of atmospheric boundary layer flow with technical and natural structures. Research activities are related to urban climate, wind comfort, spreading of pollutants and the determination of wind loads on natural and technical structures. To obtain results in these fields, four atmospheric boundary layer wind tunnels as well as numerical models are applied.	ruck@uka.de
Kassel, Universität Kassel Fachbereich Architektur, Stadtplanung, Landschaftsplanung	The Department of Environmental Meteorology as part of the architectural and planning faculty deals mainly with urban climate and planning, thermal microclimatic analysis and usage of open spaces.	katzschn@uni-kassel.de
Offenbach/M., Deutscher Wetterdienst (DWD)	Analysis of the impact of global climate change on the urban climate by an ensemble of climate projections. The data of those projections are used in impact models of the German Weather Service (DWD), especially for the urban climate model (MUKLIMO_3) and the urban bioclimate model (UBIKLIM) for the assessment of the thermal conditions and heat load.	paul.becker@dwd.de
Stuttgart, Landeshauptstadt, Amt für Umweltschutz	Since 1938 specific aspects of urban climate and air pollutants have been studied by meteorologist in the department of urban climatology in order to provide decision makers with planning related (climate) results.	Juergen.Baumueller@stuttgart.de

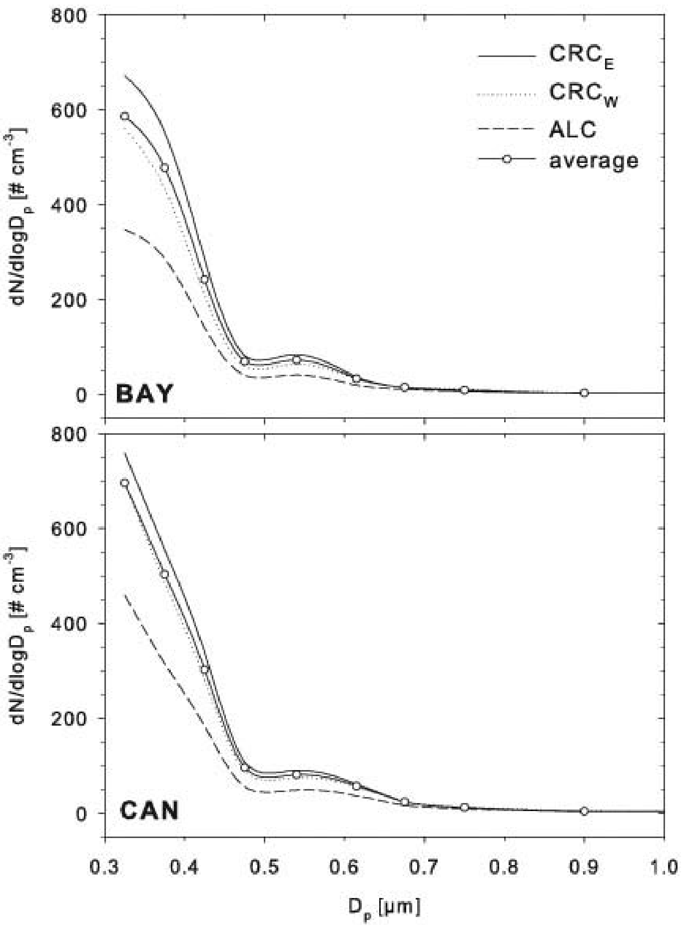

Figure1. Influence of meteorology on particle number concentrations. The plot shows average number concentration of fine particles measured in a street canyon (CAN) and an adjacent backyard (BAY) during different flow regimes within the study area. Flow is perpendicular to street canyon axis either from west (CRC_W) or east (CRC_E) or is blowing along the canyon axis (ALC) (after Weber and Weber 2008).

available to provide information on the thermal effects of urban canyon circulation (MITRAS, Schlünzen *et al.* 2003) and wind tunnel studies (Kastner-Klein *et al.* 2004) are also used. In this context, the validation of the values obtained by numerical model simulation plays an important role (Leitl 2008). It has also been possible to demonstrate large-scale effects of urban settlements on the regional climate. For example, significant changes in total annual precipitation and average air temperatures in connection with the conversion of rural areas into urban areas were quantified using the meso-scale MM5 model (Trusilova *et al.* 2008).

Urban water bodies and green spaces have a favourable effect on climatic and air quality conditions in urban areas. In this context, green spaces not only include parks at ground level, which can have a positive impact on climatic conditions and air quality even if they only have a very small area (Bongardt 2006; Ropertz 2008), but also planted roofs and facades (Köhler 2008). In addition, lakes can also result in an improvement of the climate in and on the margins of urban areas (Kuttler 1991). In the atmospheric boundary layer of a lake located on the edge of an urban area (surface area 3 ha), lower concentrations of the primary pollutants NO and CO were measured but significantly higher concentrations of ozone, as a secondary pollutant, were observed on clear days (Kuttler *et al.* 2002).

4. Air constituents related research

Particle distribution in the urban atmosphere (PM_{10}) is one of the main focuses of current research related to air constituents. The questions to be answered here include: What kind of mechanisms determine the fine particulate concentrations measured in urban canyons (Holst *et al.* 2008; Weber *et al.* 2006), what kind of spatial distribution patterns can be determined as a function of land use (Weber and Weber 2008; Wolf-Benning *et al.* 2005, 2008), what are the effects of the time of day (Vogt *et al.* 2005), what is the contribution of meteorological (Fig. 1) and traffic conditions (Weber and Litschke 2008) and how can fine particulate concentrations be predicted with reference to location and time by a high-resolution weather forecast (Klingner and Sähn 2008)?

Comparative studies of fine particulate concentrations in neighbouring cities (Erfurt and Leipzig) show similar patterns in distribution and diurnal course of particle size (Tuch *et al.* 2003, Tuch *et al.* 2006). However, as expected, there are significant quality and quantity differences between urban areas and the surrounding countryside (Gietl *et al.* 2008). There are also relationships between the particle size distribution and vehicle type (Schneider *et al.* 2008) as well as the source of the air mass concerned (Vester *et al.* 2007).

With respect to air quality improvement, especially near to busy roads, the question arises as to the extent to which planted roadsides and facades can contribute to a reduction in fine particle concentrations (Litschke and Kuttler 2008). To investigate this problem, simulations are conducted with a view to determining the effectiveness of vegetation on the distribution and formation of air pollutant concentration fields (Ries and Eichhorn 2001; Gromke and Ruck 2007) and the basic interaction between plants and the surrounding area with reference to the deposition of dust (Bruse and Fleer 1999).

For theoretical modelling, it is important to determine vehicle emission factors as precisely as possible; however, these factors not only vary as a result of fleet differences but are also determined by the season (Ketzel *et al.* 2007).

A general overview of meteorological factors affecting the propagation of gaseous and particulate pollutants is given by Fisher *et al.* (2005), who indicate ways to improve air quality. Policy aspects of air pollution are discussed by Schatzmann *et al*. (2006).

As regards the secondary pollutant ozone, it was possible to demonstrate a pronounced north-south gradient in maximum summer concentrations in Germany, as in other European countries. Especially in Southern German cities, the EU limits are exceeded, as are the AOT 40 values (**A**ccumulated exposure **O**ver a **T**hreshold of 40 ppb; Klumpp *et al*. 2006), which have a sustained detrimental impact on the growth of urban vegetation.

It is still the case that well-founded data for the establishment of carbon dioxide balances for German cities are not yet available. Apart from the calculation of CO_2 emissions from the relevant sources, information which will be needed in this context also includes precise horizontal distributions in the urban canopy layer and a calculation of CO_2 fluxes for different surfaces (Fig. 2; Kordowski and Kuttler 2008; Schmidt *et al*. 2008). Investigations of horizontal CO_2 distribution in urban areas have been made using mobile and stationary measurements in the city of Essen and indicate significant concentration differences as a function of land use during low-wind conditions (Henninger 2008; Henninger and Kuttler 2007). Investigations of the horizontal distribution of CO_2 as a function of relief energy are currently being carried out in Münster and Lüdenscheid by the Applied Climatology Department of Duisburg-Essen University.

5. Research related to human-biometeorology and planning advice

Human-biometeorological research results can be assigned to the photoactinic, thermal and air quality complexes. In order to determine the actinic conditions in urban areas, for example, the RayMan human biometeorology model may be used (Matzarakis *et al*. 2007). As regards thermal aspects, research focuses on the effects of urban structure elements on radiation and air temperatures (Gulyas *et al*. 2006; Ali-Toudert and Mayer, 2007; Mayer *et al*. 2008a) and the development of thermophysiological indices for assessment (Fig. 3) and health protection (Bruse 2005; Matzarakis *et al*. 1999); a Universal Thermal Climate Index (UTCI) is currently being developed (Jendritzky et al. 2007). Among others, Mayer and Matzarakis (2006) and Ali-Toudert and Mayer (2007) demonstrate the extent to which roadside trees, which provide shade and play an active role in evapotranspiration, may have a mitigating effect on thermal conditions in urban canyons.

In urban climate research, special attention is being paid to the impact of heat waves on the health of city-dwellers, which resulted in a large number of additional deaths in Germany and other countries in the summer of 2003 (Endlicher *et al*. 2008; Kovats and Jendritzky 2006; Schär and Jendritzky 2004).

Work on air quality issues also includes epidemiological studies with a view to analysing the effects of air pollutant concentrations as a function of weather conditions on morbidity and mortality rates among the urban population (Junk *et al*. 2007; Janssen *et al*. 2008).

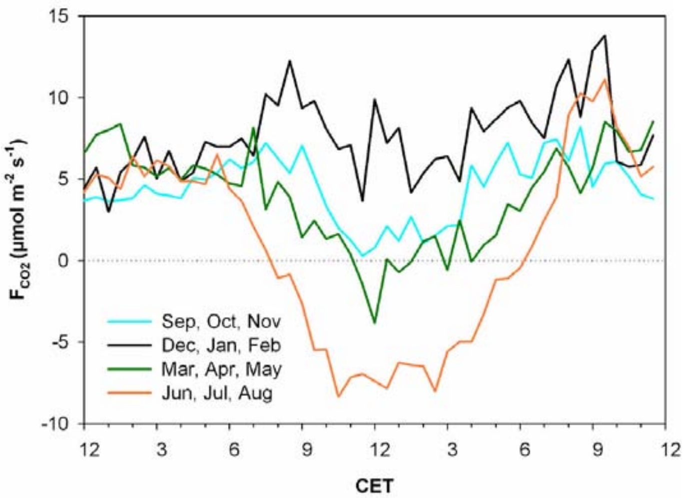

Figure 2. Mean diurnal variation of carbon dioxide flux concentration (FCO_2) at an urban/park tower site in the city of Essen, Germany for different months (1.Sept. 2006 – 31.Oct. 2007) (after Kordowski and Kuttler, 2008).

For the assessment of the air quality component, indices based on various air quality indicators were developed. With the aid of these indices, long and short-term effects on human health can be evaluated. It is possible as well to give statements on spatial distributions and on the development of air pollutants over the course of time (Mayer *et al*. 2008b).

Various VDI guidelines on environmental meteorology (such as VDI 3787, Part 1, 2, 5, 9; Baumüller *et al*. 2008) contain practically oriented notes for the consideration of climate and air quality factors and the presentation of urban climate matters in maps (Scherer *et al*. 1999). Examples concerning the improvement of air and climate quality in cities are mentioned by Barlag (1997). Mayer *et al*. (2008a) indicate further possibilities of improving thermal factors by urban planning measures.

Widely spread synthetic climate function and planning maps of the type developed in Germany are increasingly being used in other countries, such as China (Katzschner and Mülder 2008) and Japan.

Questions concerning the impact of global climate change on urban climate and possibilities to mitigate the effects are discussed for example in Bernhofer *et al*. (2007), Rudel *et al*. (2005) and Kuttler (2001).

6. Presentation of urban climate research results

Forums for the presentation of urban climatology research results include the events organized by the environmental meteorology committee of Deutsche

Meteorologische Gesellschaft (DMG) at three-year intervals (the last event was held at Garmisch-Partenkirchen in 2007; METTOOLS VI) with the possibility of publication in special issues of Meteorologische Zeitschrift and the German-Japanese urban climatology meetings which are also held at three-year intervals (5th meeting, Freiburg, Oct. 2008).

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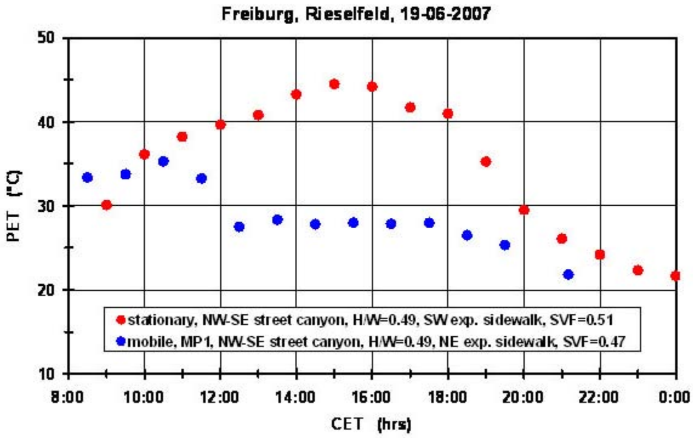

Figure 3. Influence of the exposition of a NW-SE orientated street canyon in Freiburg on the physiological equivalent temperature (PET). Note: Shadowing of solar radiation (NE side) causes low PET-values (after Mayer *et al*. 2008a).

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Thanks to everyone for their contribution in this edition and happy reading after the summer break,

Julia Hidalgo

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Call for Nominations: 2008 Luke Howard Award

The IAUC awards committee is pleased to announce the call for nominations for the prestigious 2008 IAUC Luke Howard Award.

The Luke Howard Award is given annually to an individual who has made outstanding contributions to the field of urban climatology in a combination of research, teaching, and/or service to the internationalcommunity of urban climatologists.

Luke Howard Award Nomination Process

1. Nomination materials should be collected by a nomination coordinator. This is usually the first person to notify the interim Chair of the IAUC Awards Committee (j.salmond@auckland.ac.nz) that a particular person will be nominated. Self nominations are NOT permitted and current Awards Committee members cannot be nominated.
2. The coordinator should collect the following documentation:
   a) a three-page candidate CV
   b) three letters of recommendation from IAUC members from at least two different countries which are two pages in length.
3. Complete packages should reach the interim Chair by November 1st 2008. Please advise the interim Chair of the committee early in the nomination process of the candidate you have selected to avoid duplicated effort.

The IAUC Awards committee will recommend to the IAUC Board the recipient of this award. The IAUC Awards committee can elect not to give an award in a given year.

Previous winners include:

2007 Dr.Sci. Masatoshi Yoshino, University of Tsukuba

2006 Professor Arieh Bitan, Tel Aviv University, Israel

2005 Professor Ernesto Jauregui, UNAM, Mexico

2004 Professor Tim Oke, UBC, Canada

Luke Howard Award Schedule

1 November: Complete nomination packets (single electronic submission) due to Committee chair

15 November: Committee votes and Chair forwards nominee's packet (electronically) to Board

1 December: Board makes decision and announces winner

Jennifer Salmond
Interim Chair, IAUC Awards Committee

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Newsletter Contributions

The next edition will appear in early January. Items to be considered for the next edition should be received by **November 31, 2008**. The following individuals compile submissions in various categories. Contributions should be sent to the relevant editor:

News: Winston Chow (wtchow@asu.edu)
Conferences: Jamie Voogt (javoogt@uwo.ca)
Bibliography: Julia Hidalgo (jhidalgo@labein.es)
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General submissions should be relatively short (1-2 A4 pages of text), written in a manner that is accessible to a wide audience and incorporate figures and photographs where appropriate. In addition we like to receive any images that you think may be of interest to the IAUC community.