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Inside the Winter issue...

From the IAUC President

Colleagues, welcome to the December 2010 edition of *Urban Climate News*. Again, speaking on behalf of the IAUC, I want to express my gratitude to David Pearlmutter in his role as editor of this Newsletter, which takes a considerable commitment of time and energy.

The recent UN Climate Change conference (http://unfccc.int/2860.php/) in Cancún Mexico (29 November to 10 December) produced a disappointing outcome for many, in terms of firm commitments to extend the Kyoto Agreement. Nevertheless a compromise agreement was reached and a Green Climate Fund was established to help countries with developing economies cut Greenhouse Gas emissions. While there is little in the agreements that refer to cities in particular, there is a growing recognition of the role of cities in climate change issues. This was evidenced in a World Mayors Summit on Climate that was held in Mexico City on November 21 and in a publication by The World Bank on "Cities and Climate Change: An urgent agenda."

The latter (http://wbi.worldbank.org/wbi/documents) outlines the role that cities play in global greenhouse gas (GHG) emissions and presents tables that compare the emissions of cities with those of countries and industries. It states that: *"The world's 50 largest cities, with more than 500 million people, generate about 2.6 billion tCO2e annually, more than all countries, except the United States and China. The top 10 greenhouse gas emitting cities alone, for example, have emissions roughly equal to all of Japan..., the 50 largest cities in the world combined rank third in both population and greenhouse gas emissions, and second in GDP when compared with the largest and wealthiest countries. However, in per-capita emissions large cities are quite efficient. For example, New York City is the city with the world's highest total greenhouse gas emissions, but on a per capita basis, New York City's emissions are much lower than other large cities. For example, they are 40 percent lower than Houston's per capita emissions. Although cities are responsible for high total greenhouse gas emissions, per capita emissions can be comparatively low in cities that are efficient and well planned. Such cities as Hong Kong, Paris, Sao Paulo, Tokyo, Dhaka, and London have the world's lowest energy intensity - about one-quarter of the five highest cities and less than half of the 50-city average."* The report discusses elements of form and of function and suggests that the cities, if well planned can offer energy efficiencies. Not surprisingly then it describes compact, high density cities as more sustainable. It also calls for an agreed means of establishing urban inventories of GHG emissions that are standardized so that effective comparisons can be made.

The Mayors Summit meeting (http://www.wmsc2010.org/the-mexico-city-pact/) should be of considerable interest to the IAUC as it demonstrates the commitment to climate change issues at a municipal level. It is at this city scale that much of urban climate research is relevant and can provide some guidelines on meeting climate-based objectives at all scales. At the summit a ten-point pact was presented that included commitments to the voluntary reduction in GHG emissions and to register "*emission inventories, commitments, climate mitigation and adaptation measures and actions in a measurable, reportable and verifiable (MRV) manner.*" To date, 146 cities have signed the Mexico City Pact (http://citiesclimateregistry.org/).

The recognition of the importance of cities as drivers of global climate change and the role of good urban planning/design in modulating their combined global impact is welcome. What is disappointing from the IAUC's perspective is that there is little mention of the urban climates and its impact on its inhabitants in cities, and none of the research referenced is drawn from the urban climate literature. As a consequence, a number of important opportunities are missed. For example, GHG inventories

(*continued on page 24*)

Satellites Pinpoint Drivers of Urban Heat Islands in the Northeast

December, 2010 — According to NASA scientists who presented new research recently at an American Geophysical Union (AGU) meeting in San Francisco, summer land surface temperature of cities in the Northeast were an average of 7 °C to 9 °C warmer than surrounding rural areas over a three year period.

While researchers have long noticed that the magnitude of heat islands can vary significantly between cities, accurate comparisons have long eluded scientists because ground-based air temperature sensors tend to be unevenly distributed and prone to local bias. The lack of quantifiable definitions for urban versus non-urban areas has also hindered comparisons.

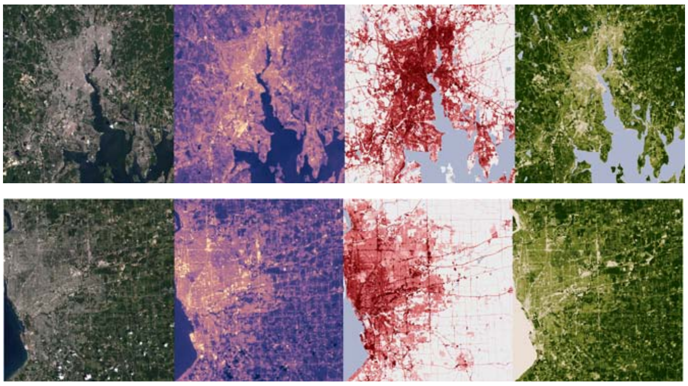
Satellite technology, which offers a more uniform view of heat islands, is in the process of changing this. The group of researchers from NASA's Goddard Space Flight Center in Greenbelt, Md., presented results based on a new method for comparing heat islands at the AGU meeting.

"This, at least to our knowledge, is the first time that anybody has systematically compared the heat islands of a large number of cities at continental and global scales," said Ping Zhang, a scientist at Goddard and the lead author of the research.

The new method for comparing cities, which the team of scientists has honed for about two years, involves the use of maps of impervious surface area produced by a United States Geological Survey-operated Landsat satellite, and land surface temperature data from the Moderate-resolution Imaging Spectroradiometer (MODIS), an instrument aboard NASA's Aqua and Terra satellites.

By analyzing data from thousands of settlements around the world, the Goddard team has pinpointed key characteristics of cities that drive the development of heat islands. The largest cities, their analysis shows, usually have the strongest heat islands. Cities located in forested regions, such as the northeastern United States, also have stronger heat islands than cities situated in grassy or desert environments. Most recently, the Goddard group has shown that a city's development patterns -- whether a city is sprawling or compact -- can also affect the strength of its heat island. By comparing 42 cities in the Northeast, they found that densely-developed cities with compact urban cores are more apt to produce strong urban heat islands than more sprawling, less intensely-developed cities.

The compact city of Providence, R.I., for example, has surface temperatures that are about 12.2 °C warmer than the surrounding countryside, while similarly-sized but spread-out Buffalo, N.Y., produces a heat island of only about 7.2 °C, according to satellite data. Since the background ecosystems and sizes of both cities are about the same, Zhang's analysis suggests development patterns are the critical difference. Cities in desert regions, such as Las Vegas, in contrast, often have weak heat islands or are actually cooler than the surrounding rural area.



Satellite images of Providence, RI (top) and Buffalo, NY (bottom). The images show (from left to right): visible light, surface heat, developed land and vegetation cover. ***Source*****:** NASA

Ratcheting up temperatures can have significant -- and deadly -- consequences for cities. Heat islands not only cause air conditioner and electricity usage to surge, but they also increase the mortality of elderly people and those with pre-existing respiratory and cardiovascular illness.

The U.S. Environmental Protection Agency estimates that, between 1979 and 2003, heat exposure has caused more than the number of mortalities resulting from hurricanes, lightning, tornadoes, floods, and earthquakes combined.

"It is the lack of cooling at nighttime, rather than high daytime temperatures, that poses a health risk," said Benedicte Dousset, a scientist from the University of Hawaii who also presented data about heat islands at the AGU meeting.

Dousset recently analyzed surface temperature images of Paris and showed the spatial distribution of heat-related deaths during a sweltering heat wave in 2003. Some 4,800 premature deaths occurred in Paris during the event, and excess mortality across Europe is thought to be about 70,000.

The risk of death was highest at night in areas where land surface temperatures were highest, she found. Buildings and other infrastructure absorb sensible heat during the day and reradiate it throughout the night, but the cooling effect of evaporation is absent in cities. The lack of relief, particularly among the elderly population, can be deadly, she explained.

Ramped up air conditioning usage may have even exacerbated the problem, other data presented at the meeting suggests. Cecile de Munck, of the French Centre for Meteorological Research of Meteo-France, conducted a series of modeling experiments that show excess heat expelled onto the streets because of increased air conditioner usage during heat waves can elevate outside street temperatures significantly.

"There's no one solution, and it's going to be different for every city," said Dousset. "Heat islands are complex phenomena."

Source: http://www.nasa.gov/topics/earth/features/heat-island-sprawl.html

As host of Cancún climate talks, Mexico shows off its greener capital city

December, 2010 — Twenty years ago, news coverage of Mexico's pollution problem rang apocalyptic.

"Mexico City smog reaching record levels; disaster feared," read a 1992 headline in the Los Angeles Times. "Mexico turning into a gas chamber," the Calgary (Alberta) Herald exclaimed.

Mexico's capital was considered the world's most polluted city in the early '90s. Scientists measured alarming levels of lead, ozone, sulfur dioxide, and carbon monoxide in the air. Respiratory illnesses abounded. Runners donned surgical masks.

But the apocalypse never arrived. Among a host of initiatives, the government reduced road time for older cars, cut gasoline lead levels, and established emissions standards and verification procedures.

"Air quality has improved dramatically over the last decade," says Richard Fuller, president of the Blacksmith Institute in New York, which studies toxic hot spots around the globe. "It used to be one of the worst. Now it is a model."

As Mexico hosts the United Nations climate conference in Cancún through Dec. 10, with leaders from around the globe gathering to talk about a binding treaty to reduce greenhouse-gas emissions, the notoriously dirty capital is touting itself as a green city.

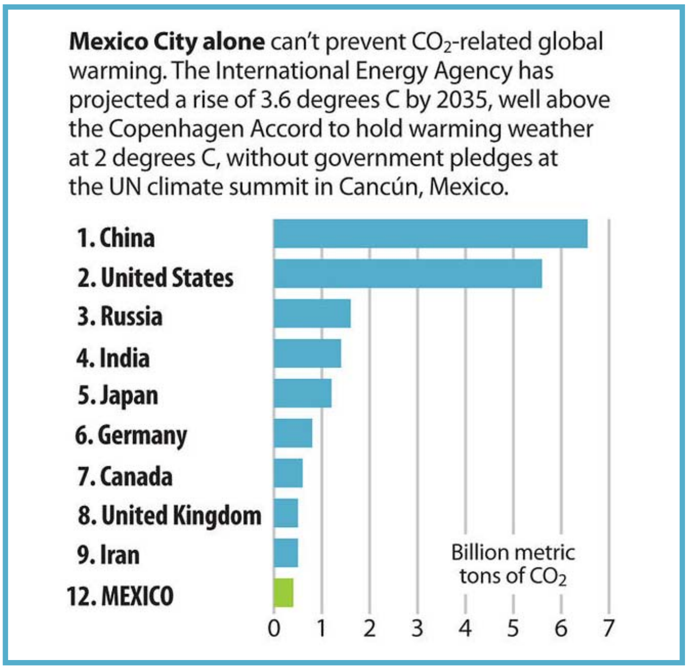
An ambitious 15-year "Plan Verde" promises to reduce vehicle emissions by 7 million metric tons before 2012 by investing in alternative energy, more green zones, and public transport such as electric buses. A bicycle program aims to sign up 24,000 users by February, from 17,000 today, says Martha Delgado, the city's environmental secretary.

"This is very exciting for a city that used to be one of the most polluted in the world," she says.

Mexico City has also signed a voluntary pact – together with 137 other cities present here Nov. 21 at the World Mayors Summit on Climate – to establish a monitoring and verification mechanism to track emissions. The pact is to be introduced at the climate conference in Cancún.

Over the past two decades, Mexico City has shown that it's committed to cleaning up, experts say. In 1991, ozone exceeded safe levels almost every day of the year. Skyscrapers were only visible as silhouettes. Thin air on the 7,300-foot-high plateau, ringed by mountains, was compounded by rapid urbanization as the metropolitan area septupled, from 3 million people in 1950 to 20 million. Chaotic roadways caused interminable commutes.

At the time, Luis Manuel Guerra, who directs the National Autonomous Institute of Ecological Studies, was measuring levels of ozone, particulates, carbon monoxide, and sulfur dioxide atop the roof of the German Embassy. The levels were so high, embassy officials told him, that in Germany they would qualify for an evacuation of staff.



Mexico City alone can't prevent CO_2-related global warming. The International Energy Agency has projected a rise of 3.6 degrees C by 2035, well above the Copenhagen Accord to hold warming weather at 2 degrees C, without government pledges at the UN climate summit in Cancún, Mexico.

CO_2 emissions from different countries. *Sources*: IEA, US department of Energy, European Environment Agency, World Bank

World bodies began sounding alarm bells, stirring the government to action. A new *hoy no circula* (literally, "today it does not circulate") program grounded older cars for one day a week, an initiative replicated around the world. From nearly 350 days of unsafe ozone levels in 1991, that fell to 140 days in 2005, a level at which it has stabilized, says Mr. Guerra.

But skeptics say the real causes of contamination are being overlooked, and some of the most touted programs are failing. Humberto Bravo, an expert in environmental contamination at the National Autonomous University of Mexico (UNAM), says the *hoy no circula* program was never a success because residents bought older, more-polluting vehicles to drive on days their cars were idled. He says corruption has plagued initiatives such as vehicle exhaust verification systems.

Urban planning deserves more attention, says Professor Bravo, such as creating viable roadways that reduce the time that engines are running. Victor Magaña, another scientist at UNAM, says he supports many aspects of "Plan Verde" but worries that talk of emissions and global warming overshadows other causes of environmental destruction, such as mass urbanization.

All agree that the problem is far from solved. Ozone levels here still exceed safety standards. Particulates are also a problem. The city continues to sprawl.

"It achieved very impressive results," says Juan Carlos Belausteguigoitia, lead environmental economist at the World Bank. "The next generation of interventions is going to be more complicated, and will require more coordination."

Source: http://www.csmonitor.com/World/Americas/2010/1201/As-host-of-Cancun-climate-talks-Mexico-shows-off-its-greener-capital-city

Seoul: on course to be one of the world's greenest cities?

November, 2010 — Delegates at the latest G20 (Group of 20 major economies) meeting in Seoul this month reaffirmed their commitment to fighting climate change. Had they taken note of their surroundings, they would have seen what can be achieved with a little political will and some genuine commitment to the environment. By redesigning its road layout and revamping its public transport systems, the South Korean capital is now bidding to become one of the greenest cities in the world.

It's certainly come a long way since the 1960s and 1970s, when South Korea went through an industrial boom that took it from being the second-poorest nation in the UN to one of the richest. The sudden increase in its wealth did not come without consequences, however, and in the early 1980s people began to notice the impact that this economic growth was having on the environment.

Over the past decade South Korea, and particularly the capital city Seoul, has taken drastic steps to try to reduce the amount of pollution it creates and to curb its reliance on fossil fuels. This has involved taking small steps and attempting to re-educate a money-fixated culture. Seeing large roads and old buildings being demolished in the capital, not all South Koreans have agreed with what is happening in Seoul. Its citizens are slowly beginning to reap the benefits, however, as the health and economic benefits of turning their heavily polluted city into a green haven become apparent.

In 2008, Seoul's mayor, Oh Se-Hoon, announced that he was determined to make Seoul one of the world's greenest metropolitan centres and an example to the C40 – formerly the Large Cities Climate Leadership Group – of which Seoul is a member. In an article for the UN's Urban World magazine in 2009, Oh said that he planned to get Seoul to reduce energy use by 20 per cent, reduce carbon emissions by 40 per cent and increase the use of renewable energy by 20 per cent, all by 2030.

Since taking office in July 2006, Oh and the Seoul Metropolitan Government (SMG) have worked hard to tackle one of Seoul's biggest problems: air pollution. Over the past few decades, satellite towns have sprung up around the capital, increasing the use of private cars.

Population growth may have slowed down since the 1980s, but the population of Seoul over the past decade has nevertheless risen from 9.8 million in 2000 to nearly 10.5 million people in 2010. Car-ownership has also increased: in 2003, 215 in every 1,000 South Koreans owned a car; by 2005 that figure had risen to 319. This gives some indication of how numbers will have grown in the past five years, with those of Seoul often higher than the national average.

By greening up its act, Seoul is setting an example.

Despite efforts by the SMG to encourage the use of greener cars, the sheer number of vehicles on the street has cancelled out any effort to reduce air pollution. Until recently the regulations to tackle exhaust fumes were almost non-existent, making cars one of the greatest causes of air pollution in the city. The increase in particulates over the decades led to a rise in respiratory infections, with the life-expectancy in Seoul approximately five years lower than elsewhere in South Korea.

In order to tackle this problem, Oh reduced fares on Seoul's Metro and bus systems to the equivalent of less than £1, and made plans to connect the ever-growing satellite towns to central Seoul by building seven new train lines to be incorporated into the Metro and overground systems. In 2008 Seoul had already converted it's 72,000-strong taxi fleet to run on liquefied petroleum gas instead of petrol, while this year saw Seoul's fleet of buses complete the move from diesel to compressed natural gas. This push to become an example to the C40 cities led to a 10 per cent decrease in airborne particulates in 2008 alone, a drop of more than 90 per cent since records started in 1980.

The SMG also initiated a complete revamp of the bus network, and with help from Korean Air has introduced a limousine bus service between Incheon international airport and various locations in Seoul that rivals the train and taxi services in speed and price. This has helped dramatically reduce the amount of congestion on the roads, as citizens swap their cars for cheap, reliable public transport.

'Our goal is to create a metropolis that can practically be regarded as a city within a park,' wrote Oh in *Urban World*. 'In some parts of the city, large-scale green parks will be created and small spaces in residential areas will be used to create small parks.'

Oh's goal is well on its way to being achieved, with derelict buildings and roads converted into miles of parks or pedestrianised walkways. One such project has been the redevelopment of the flood-control banks on the Han river, which runs through Seoul, and perhaps the biggest change has been the restoration of the old Cheonggyecheon stream, which cuts east to west across the city.

With Seoul leading by example, setting a standard not only for South Korea's other metropolitan centres but also for its Asian neighbours, city councils and regular citizens are beginning to take notice of environmental matters, and making every effort to clean up the mess they made during the mad industrial boom of the late 20th century.

Source: http://www.theecologist.org/green_green_living/out_and_about/687483/seoul_on_course_to_be_one_of_the_worlds_greenest_cities.html

Urban human-biometeorology: Investigations in Freiburg (Germany) on human thermal comfort

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Cities are embedded in atmospheric background conditions on the regional scale, which are also influenced by topography and land use pattern. The atmospheric background conditions can be divided into different components. Two of them, the thermal and the air pollution component, become particularly important for urban planning. Due to different urban structures and processes, cities themselves modify the atmospheric background conditions by a ± Δ, which is not constant. It is rather a function, which depends on weather, time and urban land use. ± Δ is related to meteorological variables like air temperature, vapour pressure or mean radiant temperature as well as air pollutants like NO_2, O_3 or PM_{10} concentration. As a result of ±Δ, local climate zones (Stewart and Oke, 2010) can be identified, which are the spatial basis for many urban planning methods. Local climate zones cause specific human-biometeorological conditions for citizens, which have implications for their efficiency, well-being and health outdoors and indoors.

1. Urban human-biometeorology

The number of people living in urban agglomerations is still increasing (UNFPA, 2010). Therefore, urban climate develops worldwide more and more to a planning factor of continuously rising significance. However, a prerequisite is that results on urban climate meet the demands of urban planning, e.g. their direct reference to citizens. This leads to the fundamental question of urban human-biometeorology: how can processes and phenomena of urban climate be evaluated in a way that is relevant to citizens? For instance, the perception of heat by citizens does not depend only on the near-surface air temperature, but in combination on all meteorological variables, which influence the human energy balance. In addition, citizens are breathing air, which does not consist of only one air pollutant, but of a mixture of different species.

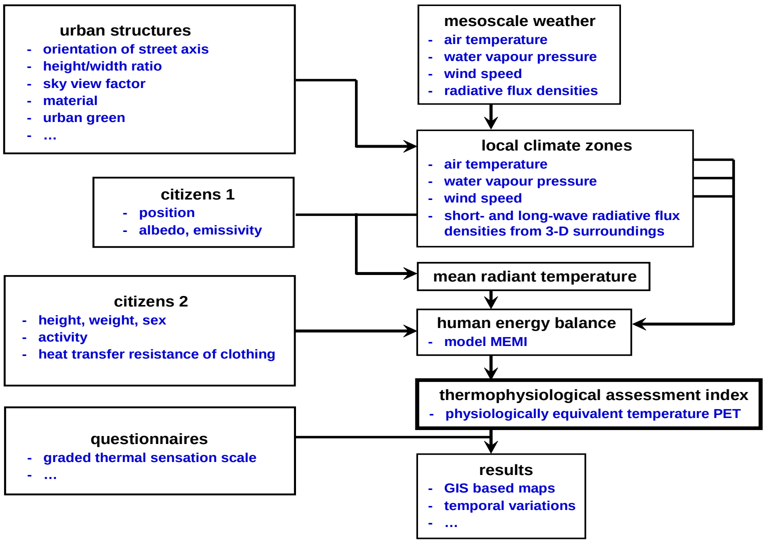

Figure 1. Flowchart for the determination of the physiologically equivalent temperature PET as a human-biometeorological index to assess the perception of heat by citizens (according to Mayer et al., 2008b)

The interdisciplinary field of human-biometeorology has developed assessment methods for both the thermal and the air pollution component of urban climate. They were successfully tested for different urban environments (e.g. Ali-Toudert and Mayer, 2006; 2007a; 2007b; Mayer et al., 2008a; 2008b; Mayer and Kalberlah, 2009). Therefore, they can be applied in investigations on urban climate related to sustainable urban planning.

The physiologically equivalent temperature PET (Mayer and Höppe, 1987) represents a thermo-physiological assessment index, which is used worldwide for analyses of human thermal comfort outdoors. The flowchart in Fig. 1 shows essential characteristics on the method to determine PET and its influencing parameters.

PET is derived from the human energy balance model MEMI (Höppe, 1984, 1993). For the calculation of its energy fluxes, physical characteristics of citizens and meteorological data of local climate zones relevant for the human energy balance are necessary. These meteorological data can be supplied either by specific experimental investigations or suited simulation models at the micro-scale. In urban human-biometeorology, the description of the perception of outdoor heat is usually related to a collective of citizens (Mayer et al., 2008b). In steady state models for the human energy balance, the collective of citizens is represented by a standardised standing person (human-biometeorological reference person).

In order to make numerical results of PET more suitable for application in urban planning, they can be assigned to a graded thermal sensation scale by questionnaires. Most frequent, it is based on the 7-step ASHRAE thermal sensation scale (ASHRAE, 2008). The assignment of PET values to ranges of the thermal sensation scale considers adaptation and acclimatisation of citizens to the regional atmospheric background conditions and, therefore, differs between climate zones.

Worldwide, PET doesn't represent the only thermo-physiological assessment index derived from the human energy balance. The procedure, however, to determine other ones is similar to that for PET.

2. Consequences of regional climate change for urban human-biometeorology

The atmospheric background conditions are governed by characteristics of regional climate change, i.e. trends of climate variables and severe weather events like heat waves. Besides an increase of near-surface air temperature, reliable projections by regional climate models indicate for Central Europe that severe heat waves will be more frequent and intense as well as will last longer, i.e. heat will be a problem of rising significance for Central European cities, as their residents are not adapted to severe heat in a sufficient way.

Due to different dynamic processes, cities themselves strengthen the predefined impairments for citizens by regional climate change. As a result, a pronounced thermal stress arises for citizens from the combined impact of regional climate change and dynamic behaviour of cities. Against the background of the demographic development of residents in Central European cities, sustainable urban planning is challenged to develop and apply methods, which reduce the effects of regional heat on the local urban scale. These should consider targets of environmental control, e.g. avoidance of air conditioning systems. As the methods should be related to citizens, they have to be based on a human-biometeorologically significant assessment of heat in terms of a thermo-physiological assessment index.

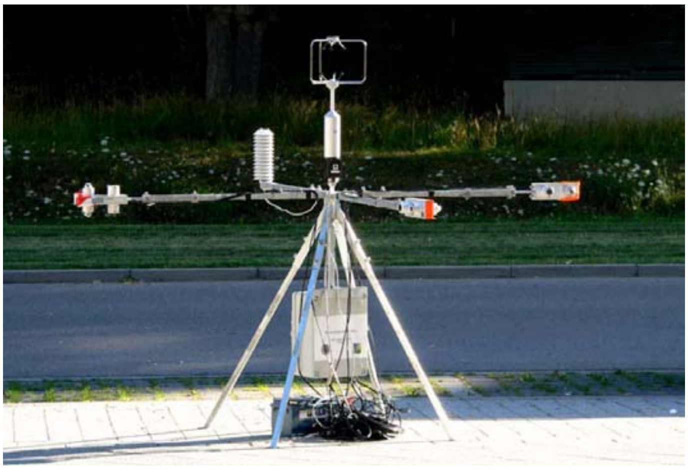

Figure 2. Stationary human-biometeorological station.

In this context, a differentiation between heat impact outdoors and indoors should be made due to different effective methods. Outdoor heat is a phenomenon related to the daytime, while indoor heat mostly affects residents in the night, when they would have a relaxing sleep. In addition, a differentiation between dry heat and humid heat is practical, as effective planning methods exist only for the reduction of impacts of dry heat. During humid heat, residents have the individual perception of sultriness, which is controlled by high water vapour pressure. It represents a regional phenomenon, which can be influenced by local urban planning methods only to a slight extent.

Although Central European cities show existing urban structures with specific patterns of streets, open spaces, buildings and green spaces, there is still a distinct scope for urban planning due to urban redevelopment, urban quarters being up for urban planning and open spaces due to structural change. A slogan for urban planning in Germany is currently "The challenge lies within the stock of buildings".

3. Methods for analyses of human thermal comfort within urban structures

Research in urban human-biometeorology has a relatively long tradition at the Meteorological Institute, Albert-Ludwigs-University of Freiburg. During the last years, the investigations are focused on human thermal comfort outdoors within different local climate zones and urban structure elements. The results obtained meet the demand of urban planning authorities for human-biometeorological information, which represents the basis for the development and application of strategies to mitigate the effects of severe regional heat at the local urban scale.

A co-ordinated design of experiments, questionnaires and numerical simulations was applied to analyse the perception of heat by citizens in a quantitative way. They were mainly carried out in the city of Freiburg during severe heat in summer. Freiburg is a medium sized city (approx. 200,000 inhabitants; 48°00′ N 7°51′ E, 269 m a.s.l.) in southwest Germany and located in the southern NNE-SSW oriented Upper Rhine Plain close to the slopes of the Black Forest. Due to its specific location, Freiburg is well suited for investigations on urban climate effects of regional heat, as it is considered the warmest city in Germany.

In the analyses, PET was used as a thermo-physiological assessment index. For its experimental determination, specific human-biometeorological stations (Figs. 2 and 3) were developed and used in measurement campaigns. Due to their technical design, they enabled measurement of not only air temperature, vapour pressure and wind speed, but also the short- and long-wave radiation flux densities from the three-dimensional surroundings within urban structures - i.e. the calculation of the mean radiant temperature T_{mrt} as a key meteorological variable for human thermal comfort in Central Europe during summer, considering the dependences on the directions in space. In contrast to the use of a globe thermometer, by this method it was possible to investigate the effects of different surface features of walls and soil, which can be modified by urban planning. T_{mrt} was calculated from the measured short- and long-wave radiation flux densities according to the algorithm described by Höppe (1992) and applied by Ali-Toudert and Mayer (2007a), Thorsson et al. (2007) and Mayer et al. (2008b).

Figure 3. Mobile human-biometeorological station.

To describe the local conditions at the investigation sites, the usual characteristics were determined, e.g. ratio of building height *H* to street width *W* (= *H*/*W*), orientation of street canyons, exposition of measurement points and sky view factor SVF, which was derived from circumpolar fish-eye photos. With respect to the short-wave radiation flux densities, SVF was not only calculated for the complete upper hemisphere, but also for its southern part.

4. Exemplary results

Effects of exposition

The experience of citizens that their perception of heat depends on the exposition of the local site is exemplarily quantified in Figs. 4 and 5. They show the results obtained from a 1-day case study conducted

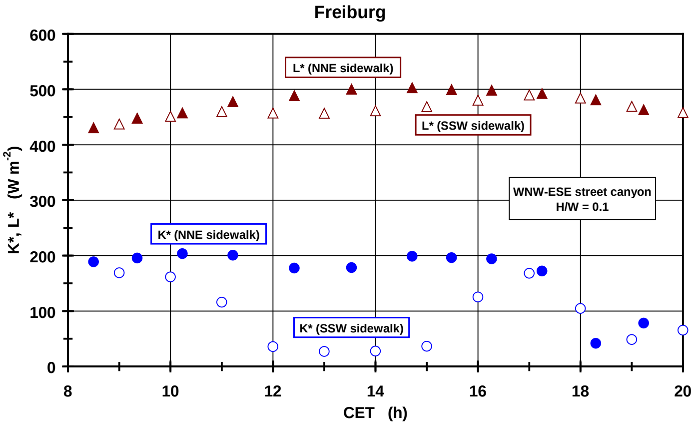

Figure 4. Totals of absorbed short-wave (K*) and long-wave (L*) radiation flux densities from the three-dimensional surroundings at a NNE and SSW sidewalk within a street canyon; Freiburg, Vauban district, typical summer day (July 15, 2007), human-biometeorological measurement height: 1.1 m a.g.l.

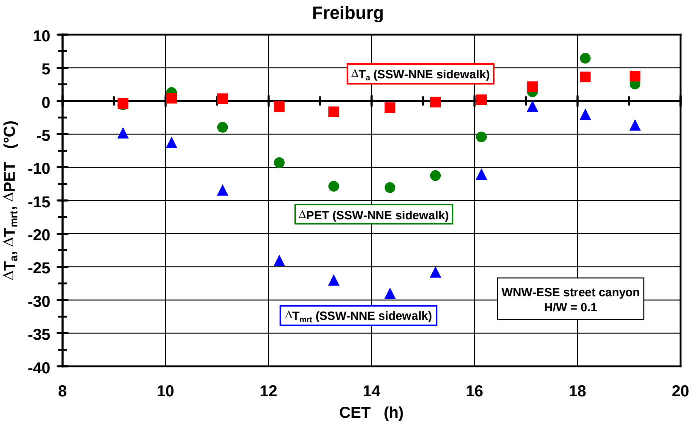

Figure 5. Differences *Δ* of air temperature T_a, mean radiant temperature T_{mrt} and physiologically equivalent temperature PET between a SSW and NNE sidewalk within a street canyon; Freiburg, Vauban district, typical summer day (July 15, 2007), human-biometeorological measurement height: 1.1 m a.g.l.

on a typical summer day in a WNW-ESE oriented street canyon in the Vauban district of Freiburg. The human-biometeorological stations were located at the NNE and the opposite SSW sidewalk.

The values for K* (total of short-wave radiation flux densities from the three-dimensional surroundings absorbed by the human-biometeorological reference person) particularly at the SSW sidewalk point out that this human-biometeorological station was shaded between 11 and 16 CET (Fig. 4), which was caused by a building. For L* (total of long-wave radiation flux densities from the tree-dimensional surroundings absorbed by the human-biometeorological reference person), however, the shading effect was not reflected in a similar intensity. In addition to the different diurnal courses, L* was always distinctly higher than K*. That can be interpreted that the regional heat is indicated by L*, while K* describes its local modification by different urban situations.

According to the temporal course of mainly K*, T_{mrt} and also PET dropped between 11 and 16 CET at the SSW sidewalk, while the temporal course of T_a was only very slightly affected by the shading effect around noon and in the early afternoon (Fig. 5). Averaged over 10-16 CET, mean T_a difference (ΔT_a) between SSW and NNE sidewalk was -0.4 °C, while it was -19.5 °C for ΔT_{mrt} and -7.8 °C for ΔPET. The comparison of the temporal courses between ΔT_a, ΔT_{mrt} and ΔPET confirms findings by Ali-Toudert and Mayer (2007a) as well as Mayer (2008b) that (i) T_a or ΔT_a including urban heat island intensity are unsuited to describe human thermal comfort within cities and (ii) PET is strongly governed by T_{mrt} for typical summer days in Central Europe.

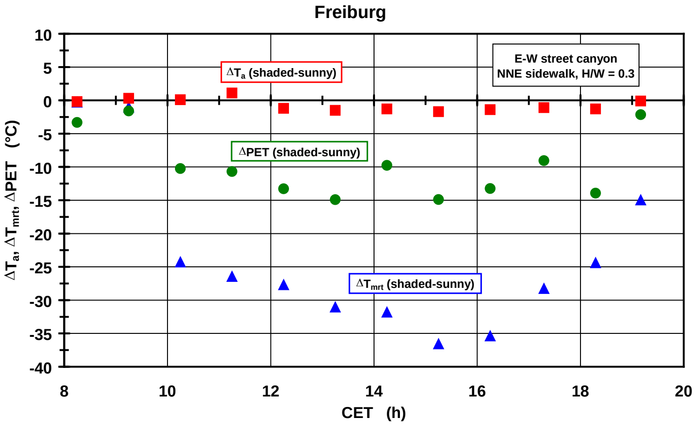

Figure 6. Differences Δ of air temperature T_a, mean radiant temperature T_{mrt} and physiologically equivalent temperature PET between a shaded (by tree canopy) and sunny measurement point within a street canyon in Freiburg, Vauban district, on a typical summer day (July 24, 2008), human-biometeorological measurement height: 1.1 m a.g.l.

Table 1. Differences Δ of characteristics between a shaded (by tree canopy) and sunny measurement point within an E-W street canyon in Freiburg, Vauban district, on a typical summer day (July 24, 2008); $SVF_{1-360°}$: sky view factor from a FE for the complete upper hemisphere, $SVF_{90-270°}$: sky view factor from a FE for the southern part of the upper hemisphere, FE: fish-eye photo, fraction of tree canopy: tree coverage related to FE, T_a: air temperature, T_{mrt}: mean radiant temperature, PET: physiologically equivalent temperature, T_a, T_{mrt} and PET in the human-biometeorological measurement height (1.1 m a.g.l.)

Characteristics	shaded-sunny
$\Delta SVF_{1-360°}$	-37%
$\Delta SVF_{90-270°}$	-64%
Δ(fraction of tree canopy)$_{1-360°}$	39%
Δ(fraction of tree canopy)$_{90-270°}$	68%
mean ΔT_a (10-16 CET)	-0.8 °C
mean ΔT_{mrt} (10-16 CET)	-30.4 °C
mean ΔPET (10-16 CET)	-12.4 °C

Effects of shading

Urban greening, particularly street trees, has been proposed as one approach to mitigate the consequences of severe heat on human thermal comfort (Bowler et al., 2010, Shashua-Bar et al., 2010 a, b). Related to the below-canopy space, the modification of radiation and heat flux densities by the canopy of street trees leads to a drop of T_a in the daytime. However, it is relatively slow, as shown by the results for the case study in Fig. 6, where the maximal T_a drop was -1.7 °C (mean value for 10-16 CET: -0.8 °C). Site characteristics and mean differences for T_a, T_{mrt} and PET between the shaded and sunny measurement point are contained in Table 1.

The shading effect of the canopy of street trees was much more pronounced for T_{mrt} (peak ΔT_{mrt}: -36.6 °C, mean ΔT_{mrt}: -30.4 °C). The corresponding temporal course of PET quantifies in a human-biometeorological way for a typical summer day, why citizens more likely perceive thermal comfort below the canopy of street trees in contrast to the situation on sunny sidewalks (mean ΔPET: -12.4 °C).

Effects of sky view factor

The reduction of SVF represents an effective method during severe regional heat to mitigate human thermal discomfort in the daytime. As the local short-wave radiation flux densities govern modifications of the regional thermal conditions for citizens within urban structures, SVF for only the southern half of a fish-eye photo from the upper hemisphere ($SVF_{90\text{-}270°}$) has a higher significance than SVF related to the complete upper hemisphere. Based on experimental investigations, which were conducted at different sites in Freiburg on typical summer days in summer 2007-2009, a linear relationship was found between mean T_{mrt} (10-16 CET) and $SVF_{90\text{-}270°}$ (Fig. 7).

The reduction of T_{mrt} as a prerequisite to maintaining human thermal comfort for citizens even under regional heat requires a lowering of $SVF_{90\text{-}270°}$. This can be achieved by different ways, e.g. narrow street canyons with optimised orientation, galleries, awnings, sunshades or street trees. Due to additional functions, which are perceived as favourable by citizens, the canopy of street trees is best suited to reduce $SVF_{90\text{-}270°}$.

PET ranges for human thermal sensation

To consider quantitative information on human thermal comfort indicated by PET in urban planning, it is necessary to assign PET values to thermal sensation classes. An appropriate method is the use of the ASHRAE thermal sensation scale (ASHRAE, 2008), as it represents a kind of a standard. Based on experimental investigations including 735 questionnaires of students on two typical summer days in 2010, a graduation of PET ranges for different warm levels of the ASHRAE thermal sensation scale was obtained (Table 2). It considers the acclimatisation and adaptation of citizens to heat for Central European conditions.

Table 2. Ranges of the physiologically equivalent temperature PET for different warm levels of human thermal sensation according to the ASHRAE thermal sensation scale, basis: 735 questionnaires on two typical summer days (July, 8 and 9, 2010) in the botanical garden of Freiburg

ASHRAE thermal sensation scale		PET range (°C)
name	scale	
slightly warm	+1	30 - 34
warm	+2	35 - 40
hot	+3	> 40

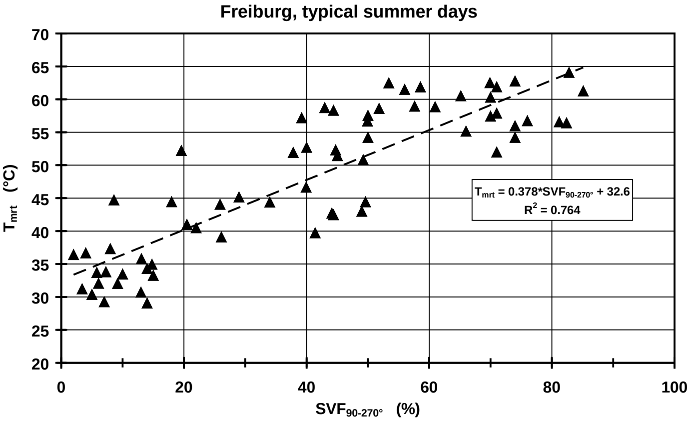

Figure 7. Relationship between mean values (10-16 CET) of mean radiant temperature T_{mrt} and sky view factor $SVF_{90\text{-}270°}$ determined for the southern half of a fish-eye photo from the upper hemisphere, based on measurements at different sites in Freiburg on typical summer days in summer 2007-2009.

5. Conclusions

The experimental investigations in urban human-biometeorology reported here have different objectives. They analyse the conditions at a local urban climate scale, which controls thermal comfort for citizens. They also provide results for the validation of results on human thermal comfort obtained by simulation models. Thus, they can be adjusted to specific site situations and the simulation results reach a higher degree of reliability.

The fundamentals of the human-biometeorological assessment method and the results from the experimental investigations point out that only T_a and also urban heat island intensity identified by T_a differences are unsuited for the description and quantification of outdoor thermal comfort perceived by citizens during severe regional heat. The human-biometeorological assessment method for thermal comfort can be interpreted as a nesting of a smaller volume (human-biometeorological reference person) into a larger volume within urban structures (e.g. air within an urban street canyon). The thermal level within the latter volume can be described by T_a or in terms of human-biometeorology by the long-wave radiation flux densities from the three-dimensional surroundings. As the human energy balance represents the basis for the perception of heat by citizens, additional processes besides those, which are responsible for T_a, have to be taken into account for the smaller volume. They are included in human-biometeorological variables like T_{mrt} and thermo-physiological assessment indices like PET. On typical summer days, outdoor conditions in urban environments during the daylight hours are characterised by high values of T_{mrt}. They can exceed T_{mrt} by more than 30 °C for Central European conditions.

Acknowledgements

This research was supported by the German Federal Ministry of Education and Research (BMBF), project KLIMES ALUF (FZK: 01LS05020) within the scope of the research initiative "klimazwei", and the German-Israeli Foundation for Scientific Research and Development (GIF) under grant no. 955-36.8/2007.

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Urban microclimate and subjective thermal sensation: An arid region case study

Introduction

In our previous studies of pedestrian comfort in hot-arid settings, we employed the Index of Thermal Stress (ITS) – a metric which was originally developed by Givoni (1963) for indoor physiological stress, and later adapted for outdoor urban spaces (Pearlmutter et al., 2007). The ITS allows for a straightforward characterization of energy exchanges between the human body and the environment, without any conversion to an "equivalent temperature." Metabolic heat production is included as a term in the energy balance along with radiation and convection, and evaporative cooling of the body is determined by the "sweat efficiency," an environmental term governed mainly by humidity.

In contrast to ITS, most comfort indices in common usage are based on a hypothetical environmental temperature which embodies the various energy exchange terms. Such indices may be more intuitive because they are expressed in the familiar form of temperature, but their reliability may be limited in an outdoor environment which is rapidly changing due to the variability of solar exposure and turbulent air flow. One such measure, the Physiologically Equivalent Temperature (PET), has emerged as an especially popular index for urban outdoor comfort studies, and, like similar metrics, it is reliant on a suitably accurate estimation of the Mean Radiant Temperature (T_{mrt}). While this may be a relatively simple descriptor of the radiant field in an enclosed room (i.e. an average of the radiant temperatures of surrounding surfaces, weighted according to their relative area or solid viewing angle), it is potentially problematic in a constantly changing open-air environment.

A convenient method for estimating Tmrt in an actual outdoor setting is to calculate its value based on measurements with a globe thermometer, according to the instantaneous difference between the internal temperature of the globe and the surrounding air temperature. This calculation is not a direct evaluation of radiation exchanges, but rather of the heat exchange by convection between the globe and its surroundings. As such, it is highly sensitive to wind speed at the point of measurement, and in lieu of an accurate measurement of this rapidly changing variable, large errors can accrue in the estimation of convection – and in turn of the mean radiant temperature. This is because T_{mrt} – ostemsibly a measure of the radiant field – is computed under the assumption that the globe is in thermal equilibrium (i.e., the radiant energy input is exactly balanced by convective heat dissipation). Thus a crucial limitation of the method is that the globe thermometer must have a negligible heat storage capacity.

Figure 1. Case study site.showing measurement locations in (a) N-S path, (b) E-W path and (c) open square.

Given the theoretical benefit of evaluating outdoor comfort using a direct energy balance calculation, by way of the ITS, it is therefore important to test the assumption that this index does indeed correlate with the subjective sense of thermal sensation experienced by pedestrians. While such a correlation was found for subjects under the controlled conditions of a climate chamber, it has never been investigated in an actual outdoor environment.

The primary aim of this research was to examine the influence of the outdoor urban environment on both physiological stress and thermal sensation in the arid climate of the Negev, and to refine and/or validate the correlations between existing thermal comfort indices and perceived thermal sensation.

Methods

The location of the study is a student dormitory complex located at the Sde-Boqer campus of Ben-Gurion University's Institutes for Desert Research in southern Israel. The local desert climate is typical of the Negev Highlands region (31°N, 30°E, altitude 475m) with hot dry summer days, cool nights and intense solar radiation. The internal design of the complex, with relatively well-defined pedestrian paths between the two-storey buildings, provided us with experimental sites in which complete energy-balance data could be measured, including surrounding surface temperatures. Three locations in the complex were selected for the measurements and administering of questionnaires (Fig. 1): two pedestrian "street" canyons, one with a north-south axis and one with an east-west axis, and an open square in the middle of the complex. Measured micro-meteorological data from these locations served as input for the calculation of ITS and PET.

The value of ITS, which under warm conditions represents the rate of sweat (in terms of its equivalent latent heat, in watts) required for the body to maintain thermal equilibrium through evaporative cooling, is computed by:

$$ITS = [R_n + C + (M\text{-}W)] / f$$

where R_n and C are the net radiation and convective heat exchanges with the urban environment, $M\text{-}W$ is the body's net metabolic heat production, and f is the cooling efficiency of sweating based on measured air temperature, relative humidity and wind speed. The body's absorption of direct, diffuse and reflected short-wave radiation components were calculated from measured global radiation and sky clearness, accounting for solar and building geometry, view factors and the estimated skin-clothing albedo as well as that of surrounding surfaces, and long-wave absorption was based on measured wall, ground and sky temperatures (using shielded ultrafine thermocouples) together with relevant view factors and emissivity values (see Fig. 2). The body's outward radiant emission was determined assuming a constant skin temperature, which was also used to calculate heat exchange by convection based on measured air temperature and wind speed (see Pearlmutter et al. 2007 for more details).

Measured environmental variables were also used calculate PET values in Rayman v1.2 (Matzarakis et al. 2007). T_{mrt} was calculated according to an equation given by ASHRAE (2001) with empirical coefficients recently adjusted by Thorsson et al. (2007):

$$T_{mrt} = \left[(T_g + 273.15)^4 + \frac{1.335 \, x \, 10^8 \, V_a^{0.71}}{\varepsilon D^{0.4}} \, x \, (T_g - T_a)\right]^{1/4} - 273.15$$

where T_g is globe temperature (°C), T_a is air temperature (°C), V_a is air velocity (ms^{-1}), D is the diameter (mm) of globe thermometer, and ε is the globe emissivity. The globe thermometer used in this study (following de Dear, 1987 and Thorsson et al., 2007), consisted of a 40 mm diameter ping-pong ball coated in flat grey paint (RAL 7001) with one ultrafine thermocouple at its center and another adjacent to the globe for measuring air temperature.

Scores for simultaneous subjective thermal sensation, as expressed in responses to questionnaires administered to pedestreans in the three experimental locations, were regressed on ITS and PET. The surveys took place during three time periods on summer days: morning (8:00-10:00), afternoon (13:00-15:00) and evening (17:00-19:00). Subjective thermal sensation was classified by respondents on a 7-point scale ranging from "very cold" to "very hot," while supplementary questions were used to reveal various types of thermal adaptation and how non-environmental factors might influence people's assessment of the thermal environment. These queries addressed factors such as demographic and personal variables, short- and long-term thermal history, thermal sensitivity, frequency of visitation and general perceptions of current local conditions. These responses and the physical metric of ITS were incorporated in a multivariable regression analysis, with the objective of gauging the extent to which thermal comfort is governed by the physical qualities of the space, and to what extent it is governed by more subjective variables which people bring to the space (Nikolopoulou et al., 2001).

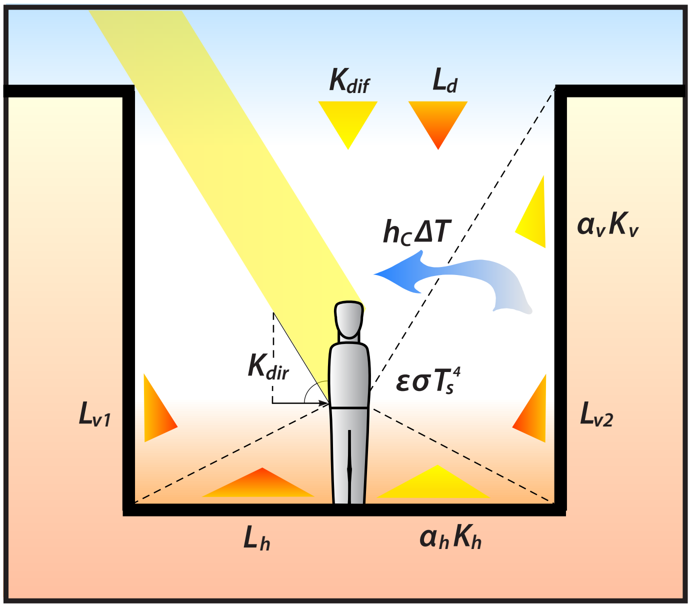

Figure 2. Radiative and convective components of energy exchange between a pedestrian and the urban environment, for the calculation of ITS.

Findings

Figure 3 shows the observed relation between the Index of Thermal Stress (ITS), as calculated from measured data in the built environment, and subjective Thermal Sensation, as compiled from synchronous pedestrian responses. The metabolic heat contribution to ITS for each data point is based on the previous activity of the respondent, with values for sitting/standing, walking and running derived from the multivariate regression analysis. It can be seen firstly that the physical metric ITS does indeed account for a large portion of the variability in subjective thermal sensation, as reflected by the regression R^2 (0.57).

However, it can also be seen that in comparison with the original fit derived by Givoni (1963) under controlled climate chamber conditions (broken line), the new regression line has a considerably shallower slope, which suggests that pedestrians have a larger tolerance to variations in outdoor thermal conditions than in indoor conditions. Thus the thresholds found for 'warm' and 'hot' conditions occur at successive increments of over 300 W each, whereas the original increments between categories were only 120 W. At the same time, it is interesting to observe that that the transition from an acceptable situation ("comfort") to an overheated one ("warm") occurs at a similar ITS value in both cases, in the range of 140-160 W. Thus, the point of departure from comfort is the same, though the rate of departure with increased ITS differs.

Thermal sensation was also correlated with simultaneous PET values, as shown in Figure 4. It can be seen that the linear regression has an R^2 of 0.53, such that just over half of the variance in subjective thermal sensation is explained by PET. Here metabolic heat is estimated according to pedestrians' activities just prior to receiving interviews, based on ISO Standard 8996 (1989). The strength of this relationship is weaker than that found for ITS, though only by a narrow margin – which reinforces the validity of both metrics for representing outdoor thermal sensation.

In a sense the small difference between the two R^2 values is surprising, given that significant inaccuracies were found in the quantification of mean radiant temperature (which serves as a central measure in the calculation of PET) using a globe thermometer. Since it was impractical to measure wind speed in each location, data from a nearby meteorological station were used to estimate wind speed based on previously derived attenuation functions (Pearlmutter et al. 2007), and a sensitivity analysis was performed using short-term measurements of wind speed with high-precision hot-wire anemometers adjacent to the globe thermometers. Due to discrepancies of up to 1 m s^{-1} between these measurements and estimated wind speeds, variations of over 10°C in were found in T_{mrt} values derived by the two methods. On the other hand, ITS values were found to be largely insensitive to inaccuracies in wind speed measurement, with convective heat loss, and in turn overall energy balance, deviating by less than 5 W m^{-2}.

As with the ITS regression, the slope of the regression line in Fig. 4 indicates that pedestrians are tolerant of higher outdoor PET values for a given level of thermal sensation than was found in previously published studies (Matzarakis et al. 1999), though differences in the terminology used for comfort categories in different thermal scales makes a direct comparison difficult. In general terms, the finding that pedestrians have a considerable thermal tolerance in outdoor settings is in agreement with other studies using PET (Nikolopoulou et al. 2001; Thorsson et al. 2004).

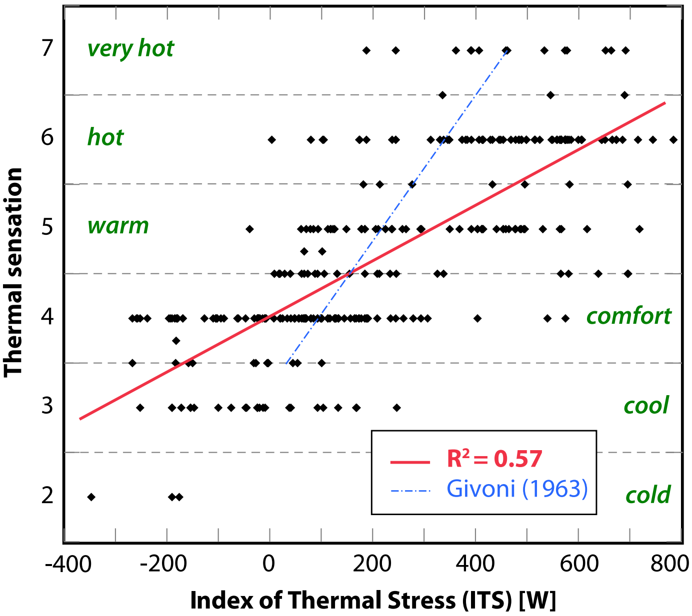

Figure 3. Observed relationship between ITS and reported thermal sensation in urban spaces, compared with original fit line derived from climate chamber data.

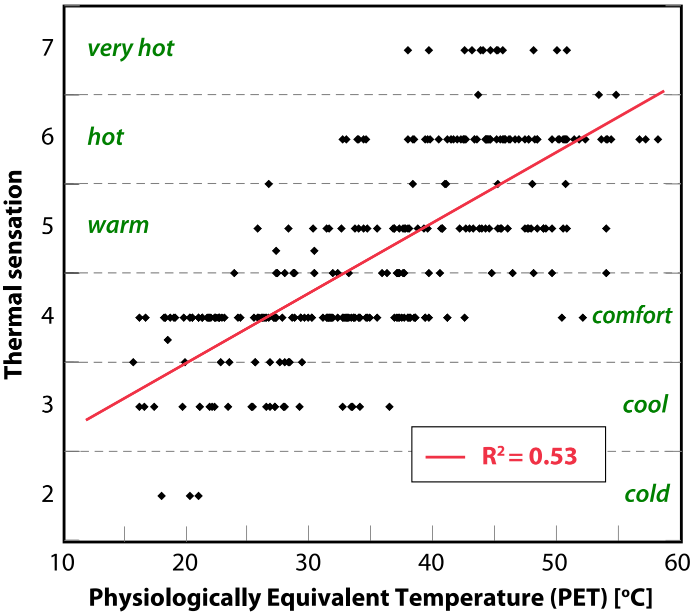

Figure 4. Observed relationship between PET and reported thermal sensation in urban spaces.

A multivariate regression analysis was performed using JMP 8.02 (SAS) to test the relation of subjective thermal sensation not only to physical thermal stress (which in this case is represented by ITS), but to the following additional contributing factors.

- **Previous activity**: Neither the location of the respondent's prior activity (indoors or outdoors) nor the time spent outdoors prior to the response was found to be statistically significant in the multiple regression. However the analysis showed that physical activity does lead to significantly warmer thermal sensation under the same ITS when the latter is based on a fixed metabolism. To reflect these statistical differences, the original ITS values were adjusted by adding 80 W to the original 70 W metabolic heat production at rest for those who had been walking (150 W total), and by adding 180 W for those who had been running (250 W total). The adjusted internal heat production values closely coincide with thresholds for moderate and high activity levels given by ISO Standard 8996 (1989), and the result of this correction is reflected in the overall correlation between ITS and thermal sensation shown in Figure 3.

- **Time of day**: The thermal sensation response for a given level of ITS was found to differ significantly by time of day. When the data are separated into the three periods of the day when interviews were conducted (Fig. 5), the slope of the regression line becomes progressively shallower with time. In the morning period the line is steep, meaning that people are most sensitive to changes in ITS, while in mid-afternoon they are less sensitive and in the evening they are least sensitive. It may be further observed that while the slope of the regression line changes over the course of the day, all three lines cross the thermal sensation level of 4 ("comfortable") at an ITS value very close to 0 W – meaning that in all cases maximum comfort is experienced under conditions of physiological thermal neutrality. In other words, the rate of shift away from perceived comfort differs over the day, but the basic feeling of thermal neutrality is the same regardless of time of day. Based on the different slopes of these regression lines, the shift from category 4 ("comfortable") to category 5 ("warm") requires an addition of only 200W of ITS in the morning, an addition of over 300W in mid-afternoon, and an addition of as much as 500W in the evening. The results suggest that the accumulation of thermal stimuli over the course of the day leads people not only to be progressively less sensitive, but also less homogenous in their sensitivity (as expressed in a decreasing R^2 over time).

- **Location**: A basic distinction in thermal response emerged between the N-S street and the other two locations (E-W street and open square). In the N-S street, which is internally shaded during the morning and afternoon hours (when ITS is highest), thermal sensation is significantly cooler than would be predicted by ITS alone. A possible explanation is that other effects of deep shade (i.e. visual and/or psychological comfort) cause some respondents to perceive this location as even cooler than the thermal conditions would suggest. This difference means that on average a person in the N-S street would feel the same thermal sensation at an ITS of about 100 W higher than someone in the other locations.

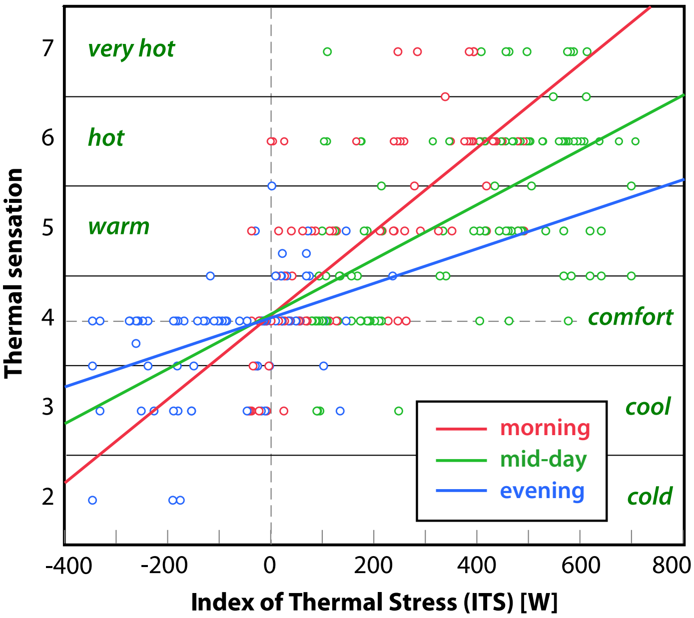

Figure 5. Regressions of thermal sensation on ITS at different time periods on a summer day.

- **Thermal sensitivity**: The multivariate regression showed thermal sensation votes to be significantly higher than average among people who say they usually feel warmer than others, and slightly lower among those who say they are usually cooler than others (with a difference between the two extremes of about 0.3 on the sensation scale). Depending on this self-defined thermal sensitivity, the same level of thermal sensation will be experienced by different people over a range of nearly 100 W in ITS.

- **Non-linearity**: It was found that a non-linear (third-order polynomial) fit explained the variance of thermal sensation with ITS slightly better than the original linear regression. The shape of this «S» curve reinforces the hypothesis that people are less sensitive to incremental changes in thermal conditions at "extreme" values (e.g. under very hot conditions) than they are at values which are closer to the transition from comfort to discomfort. It may also suggest that respondents are hesitant to give responses which fall at the extremes of the sensation scale, based on a preference (conscious or sub-conscious) to conform to the "norm" rather than to "stand out" as being extreme. The phenomenon agrees well with findings from a study by Knez and Thorsson (2008) that examines how people with different cultural backgrounds and environmental attitudes might psychologically evaluate the surrounding environments differently, despite similar thermal conditions.

- **General feeling**: The questionnaire variable relating to pedestrians' "general" sense of the weather in Sede-Boqer (as opposed to their spot feeling of thermal sensation in the specific location) was found to be significant: when the general feeling is warmer, the reported thermal sensation in the particular spot is also warmer, above and beyond what is predicted by ITS alone. The fact that general feeling explains a significant part of the variation in spot feeling apparently reveals a strong role of personal expectation in assessing thermal sensation, which cannot be explained by the physical conditions or by any of the other non-environmental variables. However, this is only the case in the more "exposed" locations of the E-W street and open square, and not in the protected N-S street. What this suggests is that since in the N-S street the person's assessment of general conditions is more speculative (he is not actually experiencing the exposed "general" conditions), and thus exerts less deviating influence on the ITS/sensation relation.

- **Personal variables**: A number of additional personal variables were examined through the questionnaire survey, but were not found to be significant in the multivarirate regression analysis. For example, neither gender, age nor clothing made a statistically significant contribution to explaining variations in thermal sensation. The lack of differences in thermal sensitivity according to these personal variables was somewhat surprising in the case of gender, but expected in terms of the other two variables. Since the study area is located on a university campus, the majority of respondents were students in a relatively narrow range of ages (between approximately 25 and 35), and therefore age distinctions were minor. In addition, almost all pedestrians in the summer survey were observed to be wearing light clothes with low thermal resistance, and any differences in clothing which may have been present did not have a noticeable influence on subjective thermal sensation. The situation in winter might be quite different, of course, as the high thermal resistance of heavy clothing greatly restricts heat loss from the body and can allow pedestrians to feel relatively warm under considerably cold conditions.

Another variable that was found to be non-significant was the reason for visitation, which ran counter to expectations that differences might exist between pedestrians conducting "necessary" activity (i.e. traveling to or from work) and those who are spending time outdoors for leisure or recreation. In addition, neither the country (or region) from which respondents came, nor their characterization of that place as being warmer or cooler than Sede-Boqer, were found to be significant in the overall correlation. This suggests that no "long-term acclimation" was detected in the sample.

A comprehensive regression fit

When all of the significant variables were included in the mutivariate regression analysis, the overall model had an R^2 of 0.71. Thus, when other factors in addition to ITS were taken into account (i.e. corrected for), we can account for over 70% of the variance in thermal sensation. The relation between reported sensation and that predicted by this full model is shown in the scatterplot of Figure 6.

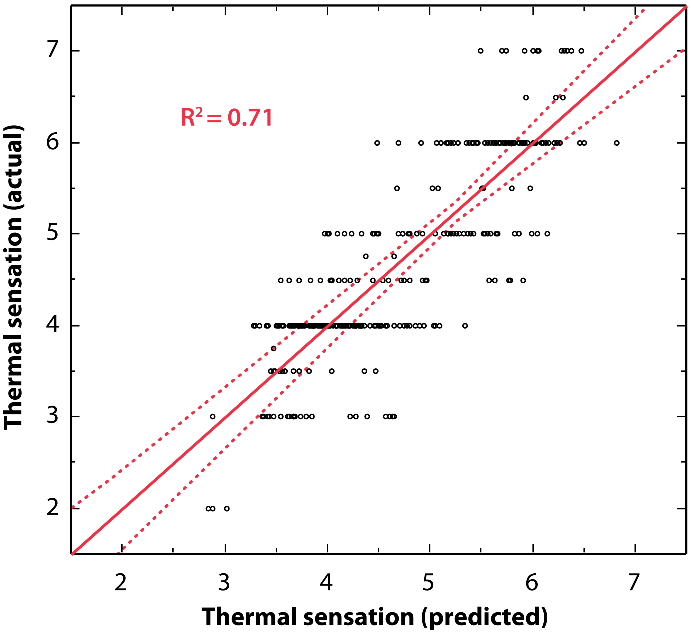

Figure 6. Scatterplot of reported thermal sensation (questionnaire responses) versus that predicted by multiple regression model including ITS and the other significant explanatory variables.

Conclusions

The objective of this study was to examine the influence of urban design features on both physiological stress and thermal sensation in the arid climate of the Negev, and to clarify the relation between outdoor physiological thermal stress and subjective thermal sensation in the context of a desert climate. A number of conclusions may be drawn as follows:

- A regression model of perceived thermal sensation on ITS suggests that this thermal index, which is based on a direct man-environment energy balance, can predict pedestrians' thermal sensation under real conditions to a fairly high degree (R^2=0.57).
- When compared with previous fits of ITS and thermal sensation derived under controlled indoor conditions, the relation observed in this study indicates that pedestrians tend to have a higher tolerance for increasing levels of thermal stress under varying outdoor conditions than they do under stable indoor conditions. At the same time, the level of ITS associated with fundamental thermal "neutrality" was largely corroborated.
- When additional non-environmental (personal) variables are included with ITS in the regression, a larger part of the variance in thermal sensation can be accounted for (total R^2 = 0.71).
- Although PET produced a slightly lower correlation

with perceived thermal stress than did ITS, it still has practical advantages. It uses an intuitive temperature scale, and the estimation of mean radiant temperature with globe thermometers may be a practical alternative in complex urban settings.

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Three years of *Urban Climate News*: Another 18-month review

By David Pearlmutter
Editor

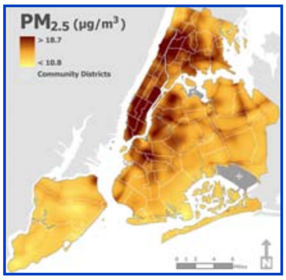
This issue of *Urban Climate News* marks three years since the IAUC newsletter began in its current quarterly format. On the eve of ICUC-7 in Yokohama, I recapped the first year and a half of news, features and other contributions which had been published in these pages – and with the passage of another 18 months since then, it is time once again for a summary.

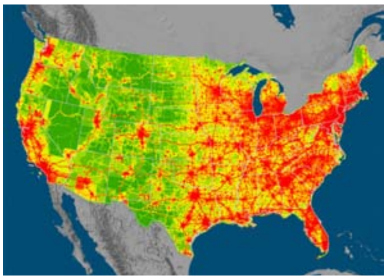
ICUC-7 in Yokohama, Japan

The September 2009 issue was devoted to the IAUC's central international event, the seventh International Conference on Urban Climate. This global gathering was hosted in June by **Manabu Kanda** and the local Japanese organizing committee, and with the support of outgoing IAUC President **Matthias Roth** and many other contributors, the conference was a rousing success – raising the bar for urban climatology as a field, and attracting 350 participants from 36 separate countries around the world. Many of the presentations at the conference, including several plenary talks and a large number of student award-winning papers, were featured in this and subsequent issues.

In the News

Kudos are due in large quantities to News editor **Winston Chow**, who has made sure that each issue offers an enticing selection of timely and interesting news items culled from the international media. This coverage accentuates the importance of urban climate concerns on the world stage, from building energy efficiency to megacity management. Winston even provided a special insight into the climatic aspects of sports stadium design, in honor of the **World Cup** in South Africa. The News section has also highlighted the IAUC's involvement in a number of international events that attracted media attention, such as the World Climate Conference (WCC-3) in Geneva, and the Global Meeting of the International Forum of Meteorological Societies (IFMS) in Atlanta.





Feature Articles

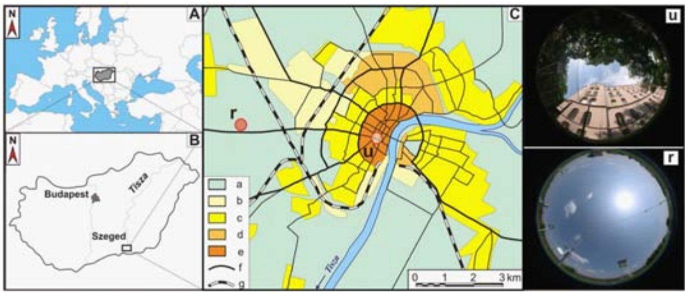
A series of articles focusing on the connections between urbanization and large-scale climate change was initiated as part of the new format and scope of *Urban Climate News*, and has continued in recent issues.

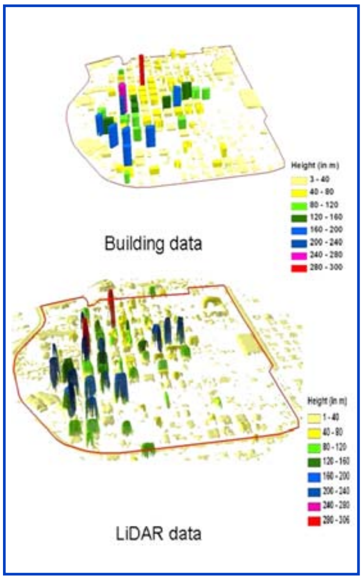
In the first Feature article following ICUC-7 (September 2009), plenary speaker **Fumiaki Fujibe** reported on urban warming in temperature trends in Japan, based on his analysis of data collected over of nearly 30 years in a dense network of meteorological stations throughout the country. Fujibe's study indicated that relative to background warming due to climate change, estimated at 0.3-0.4°C/decade, an anomalous trend of about one third this amount can be found in densely urbanized areas, and a weaker anomaly (representing a bias of about 10%) is detectable even at sites which are more sparsely inhabited.

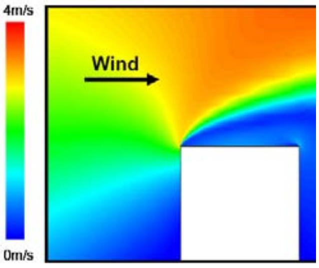
As presented in a Feature by Lowry Award winner **Iain Stewart**, "Local Climate Zones" may be used for classifying urban sites, providing a much more discerning level of description than simple distinctions such as "urban vs. "rural." Developed by Stewart together with Tim Oke, the LCZ system is intended to improve the quality of urban heat island studies and can also be applied to field stations whose data are used in long-term regional or global temperature analyses, helping to removing urban temperature bias from larger scale trends.

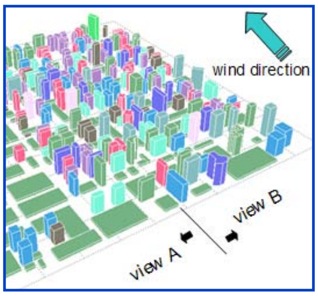
The climatic effects of changes in land-use and land cover were examined in a Feature by **Matei Georgescu**, (March 2010), who used the Regional Atmospheric Modeling System to perform high-resolution numerical experiments over the rapidly expanding Greater Phoenix metropolitan area. Results indicate that while the evolution of the region's modern-day landscape from its pre-sttlement state reflects both warming due to urbanization and cooling due to irrigated agriculture, more recent development of the metropolitan complex since the 1970's has resulted in widespread warming.

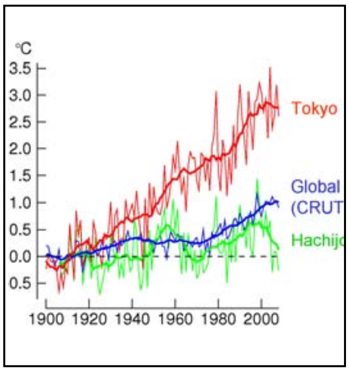
Mark McCarthy of the UK's Met Office Hadley Centre stressed that while global and local climate change operate across very different spatial and temporal scales, they should not be assumed to act independently – and by representing the urban land surface in the Centre's global and regional climate models, he aimed to quantify the cumulative impacts and interactions of radiative forcing from greenhouse gases as well as land use and waste heat in the urban environment (June 2010). He found that urban microclimate is highly sensitive to global change scenarios, and that regions expected to undergo dramatic urbanisation are in many cases also climate zones with a large sensitivity to the effects of such urbanisation.

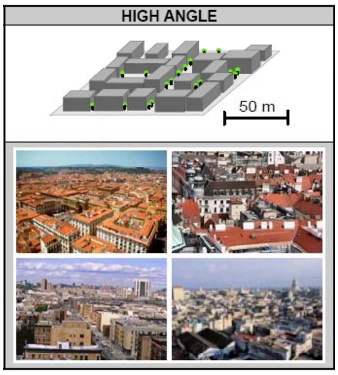


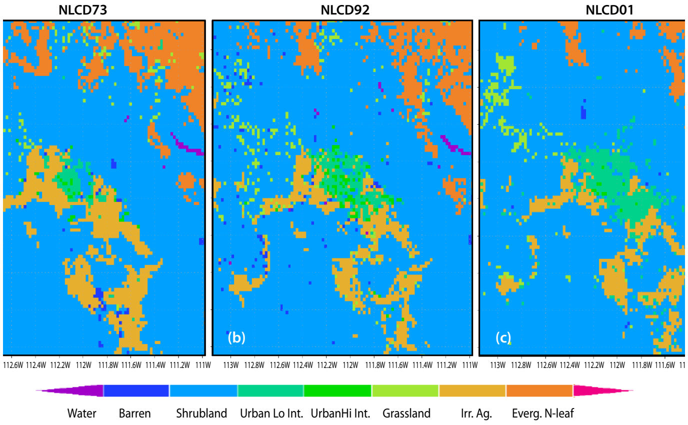


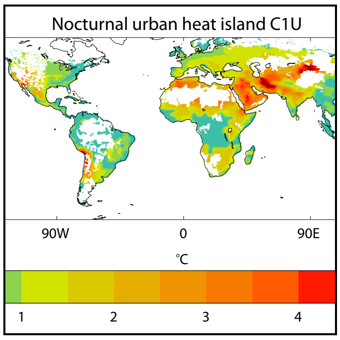












Continuing the theme of urban classification for the analysis of climatic effects, the September 2010 issue featured a novel approach developed by **Aviva Peeters** for the automated recognition of urban objects. Using the capabilities of GIS to recognize contextual relations in remotely sensed data, the model allows for image segmentation, extraction of morphological attributes and supervised classification of the urban form. The GIS database can be analyzed in combination with additional layers of data, such as climate-related variables, to identify relevant trends, patterns and relationships.

In the current issue, the work of **Jutta Holst** and **Helmut Mayer** on human biometeorology is featured with an eye toward urban modifications of climate that are relevant for inhabitants' thermal comfort and well-being. A methodology for evaluating the mean radiant temperature in complex urban settings allows for the quantification of PET as a thermo-physiological assessment index, which is highly sensitive to microscale modifications in urban design.

Urban Projects

The work of Student Award winners at ICUC-7, along with the recipients of ESA and Lowry Awards and the Japan Prize winners, was showcased in the September 2009 and December 2009 issues. Short articles describing these projects are among the Urban Project Reports listed in the Table below, which includes the title and authors of each report over the last 18 months, and a link to the issue of the newsletter in which it appears.

Urban Project Reports: September 2009 - December 2010

Title	**Author(s)**	**Issue**
Coherent structures of a neutrally stratified urban boundary layer using large-eddy simulation	**Marieta Cristina L. Castillo**	September 2009
Computational modelling of convective heat and moisture transfer at exterior building surfaces	**Thijs Defraeye**	September 2009
Long-term and seasonal trend of SPM concentration and its spatial distribution in the Kanto region, Japan	**Sayuri Okubo**	September 2009
Comparison of in situ and remotely sensed radiation and heat fluxes of the megacity of Cairo, Egypt	**Corinne Myrtha Frey**	September 2009
Continuous monitoring of urban air quality with a pulsed DOAS technique	**Yasuaki Kambe**	September 2009
Modeling human radiation exchange in outdoor urban environments	**Sookuk Park, Stanton E. Tuller**	December 2009
Near-ground air temperature calculation model based on heat transfer of vertical turbulent and horizontal air flow	**Qinglin Meng, Lei Zhang**	December 2009
The Effects of Building Parameters on Wind Velocity and Air-Flow Type in the Urban Settlements	**Nuri Serteser, Vildan Ok**	December 2009
PET index applied to wind tunnel erosion technique pictures for the assessment of pedestrian thermal comfort	**Alessandra Shimomura, L.M. Monteiro, A.B. Frota**	December 2009
Benefits and opportunities of the adaptation of geoinformatical software in outdoor human comfort studies	**Noémi Kántor, Ágnes Gulyás, Lilla Égerházi, János Unger**	March 2010
Spatial distribution of environmental noise and total particle number concentrations in urban areas	**Stephan Weber**	March 2010
The *LUCID* project: the local urban climate in London	**Sylvia Bohnenstengel et al.**	June 2010
Development of Urban Canopy Parameter Databases for Advanced Urban Meteorological and Air Quality Models	**Steven Burian, Jason Ching**	June 2010
Analysis of bioclimatic loads inside and outside the city in a long- and extremely hot short-term period (Szeged, Hungary)	**Ágnes Gulyás, János Unger**	September 2010
Urban microclimate and subjective thermal sensation: An arid region case study	**Dixin Jiao, David Pearlmutter, Yaakov Garb**	December 2010

Country and Special Reports

A continuing feature of the newsletter is the Country Report series, which highlights collaboration both within and between institutions in monitoring and modeling the climate of urban areas within the researchers' local region. Recent progress in urban climate research in Nigeria (December 2009) was presented by **Ifeoluwa A. Balogun**, recipient of the William P. Lowry African Student Travel Award, together with **Ahmed A. Balogun**, **Abdulhamid A. Ibrahim** and **Jimmy O. Adegoke**. Recent work in New Zealand was the focus of an update by **Jennifer Salmond** (March 2010).

Reports from countries, regions or urban areas which have not been represented recently in the newsletter are welcome, and I encourage readers who are interested in documenting the work being done in their own area to contact me at davidp@bgu.ac.il.

In addition, Special Reports have highlighted major urban climate-related events in different locations. **Chandana Mitra** (June 2010) reported on the Association of American Geographers (AAG) annual meeting in Washington DC, emphasizing the importance of urban climate within the diverse field of geography. Recently profiled events include (September 2010) the AMS Urban Environment Symposium in Keystone, Colorado by **Evyatar Erell**, the WMO Training Workshop on Urban Climatology in Pune, India by **Gerald Mills**, and the Commision of Climatology's urban sessions at the IGU regional conference in Tel Aviv, by **David Pearlmutter**.

Bibliographic Section

The sheer volume of growth in the field of urban climatology is nowhere more apparent than in the Bibliography section, which lists dozens of recent urban climate-related publications in each issue. This list is compiled by the IAUC Bibliography Committee headed by **Julia Hidalgo**, which also includes **Gregoire Pigeon**, **János Unger**, **Abel Tablada de la Torre**, **Martina Petralli**, **Amirtham Lilly Rose**, **Evyatar Erell, Rohinton Emmanuel** and **Corinne Frey,** who completes her valuable service on the committee this month. I would like to personally thank Julia and all of the committee members for their consistently prompt, comprehensive and precise work. The Bibliography is drawn periodically from a total of 62 journals, and the list has included an average of over 70 references per edition.

Conference announcements

The number of ongoing international conferences, symposia, workshops and other types of meetings devoted to urban-climate related themes has become truly impressive. While the particular focus of the organizers of these conferences may be meteorology, atmospheric sciences, architecture and urban planning, or a host of specific sustainability issues, urban climatology is becoming more and more prominent in these realms – with special sessions devoted in many cases to the urban heat island and similar issues. With help from conferences editor **James Voogt**, each edition of the newsletter has included a healthy offering of announcements for such gatherings.

IAUC Board

Aside from the ICUC gatherings held every three years, the most prominent IAUC event is the annual selection and presentation of the Luke Howard Award. This award honors a colleague from the urban climate community in recognition of his or her lifetime contribution to the field. Last year's award was recently presented to **Sue Grimmond**, whose honoring was announced in June 2010.

IAUC Secretary **Rohinton Emmanuel** has also provided updates on Board elections, with three new board members elected recently: **Alberto Martilli**, **Aude Lemonsu**, and **Silvana di Sabatino**.

Finally, I would like to thank IAUC President **Gerald Mills** for his support, encouragement and full cooperation in the production of *Urban Climate News*.

Recent publications in Urban Climatology

Akritidis, D.; Zanis, P.; Pytharoulis, I.; Mavrakis, A. & Karacostas, T. (2010), A deep stratospheric intrusion event down to the earths surface of the megacity of Athens, *Meteorology and Atmospheric Physics* **109**, 9-18.

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D. Deniz Genc, C. Y. & Tuncel, G. (2010), Air pollution forecasting in Ankara, Turkey using air pollution index and its relation to assimilative capacity of the atmosphere, *Environmental Monitoring and Assessment* **166**(1-4), 11-27.

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In this edition I would like thank **Corinne Frey** from the Institut für Meteorologie, Klimatologie und Fernerkundung of Basel University, who is leaving the Bibliographic Committee this month. She has been part of the Committee since 2008 and she has contributed a great deal to the project. Thanks Corinne! A new person is thus needed to cover some Journals. Please write us an e-mail if you want to be part of the Committee.

You will find here a compilation of papers published until November 2010. Thanks to everyone for their contribution. All readers are invited to send any peer-reviewed references published since January 1st 2011 for inclusion in the next newsletter and the online database. Please note that my email address has changed: please send your references to julia.hidalgo@ymail.com with a header "IAUC publications" and the following format: Author, Title, Journal, Volume, Pages, Dates, Keywords, Language, URL, and Abstract.

Happy reading,

Julia Hidalgo

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Upcoming Conferences...

“URBAN CLIMATE, URBAN HEAT ISLAND AND URBAN BIOMETEOROLOGY” at EGU General Assembly
Vienna, Austria • April 3-8, 2011
http://meetings.copernicus.org/egu2011/

“WEATHER, GEOGRAPHICAL CONTEXTS AND SPATIAL BEHAVIOUR” at Association of American Geographers (AAG) Annual Meeting
Seattle, WA, USA • April 12-16, 2011
http://www.aag.org/cs/annualmeeting

CITY WEATHERS: METEOROLOGY AND URBAN DESIGN 1950-2010
Manchester, UK • June 23-24, 2011
http://www.chstm.manchester.ac.uk/newsandevents/conferences/cityweathers/CFP-cityweathers.pdf

COHERENT FLOW STRUCTURES IN GEOPHYSICAL FLOWS AT EARTH’S SURFACE
Burnaby, British Columbia • August 3-5, 2011
http://www.sfu.ca/CoherentFlowStructures/

URBAN MORPHOLOGY AND THE POST-CARBON CITY: 18th International Seminar on Urban Form
Montréal, Canada • August 26- 29, 2011
http://www.isuf2011.com/

14TH INTERNATIONAL CONFERENCE ON HARMONISATION WITHIN ATMOSPHERIC DISPERSION MODELLING FOR REGULATORY PURPOSES
Kos Island, Greece • October 2-6, 2011
http://www.harmo.org/

WORLD RENEWABLE ENERGY ASIA REGIONAL CONGRESS AND EXHIBITION
Chongqing, China • October 28-31, 2011
http://www.wrenuk.co.uk/index.html

Professor Sue Grimmond presented with 2009 Luke Howard Award

Professor Sue Grimmond is presented with the 2009 Luke Howard Award by her PhD student Simone Kotthaus in the Dept. of Geography at King's College London (KCL) on December 10, 2010. The Strand Campus of KCL is adjacent to Somerset House on the banks of the River Thames. It was here that the Royal Society maintained temperature records that Luke Howard used to compare with his personal observations and allowed him to detect an urban effect on air temperature.

From the IAUC President

(*continued from page 1*)

need to be verified through observations, yet there is no mention of the measurement programmes that already exist in many cities (Urban Flux Network) and the need for long-term measurements to demonstrate the value of mitigation strategies. Nevertheless, it is clear that urban issues and actions are becoming central to the formal debate on climate change. The work of urban climatologists would suggest that different strategies are needed in different climates and that care must be taken in applying strategies that are focused on achieving results at one scale or in one arena, to the exclusion of a more comprehensive approach. These developments should spur the IAUC, and its members, to take a more active role in the global climate debate and to ensure that the urban scale responses to global climate change issues are compatible with desirable urban scale climates.

Gerald Mills
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Board Members & Terms

- Toshiaki Ichinose (National Institute for Environmental Studies, Japan): 2007-2011
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- Petra Klein (University of Oklahoma, USA): 2007-2011
- Sue Grimmond (King's College London, UK): 2000-2003; President, 2003-2007; Past President, 2007-2009*
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- Alberto Martilli (CIEMAT, Spain), 2010-2014
- Aude Lemonsu (CNRS/Meteo France), 2010-2014
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* appointed members

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Newsletter Contributions

The next edition of ***Urban Climate News*** will appear in late March. Items to be considered for the upcoming issue should be received by **February 28, 2011** and may be sent to editor David Pearlmutter (davidp@bgu.ac.il) or to the relevant section editor:

News: Winston Chow (wtchow@asu.edu)
Conferences: Jamie Voogt (javoogt@uwo.ca)
Bibliography: Julia Hidalgo (julia.hidalgo@ymail.com)
Projects: Sue Grimmond (Sue.Grimmond@kcl.ac.uk)

General submissions should be short (1-2 A4 pages of text), written in a manner that is accessible to a wide audience, and incorporate figures and photographs. Images you think would be of interest to the IAUC community are welcome.