

From the IAUC President

Happy New Year and welcome to the December 2011 issue of *Urban Climate News*, which as is always the case, provides a great window onto ongoing urban climate research. There are just a couple of points that I want to draw your attention to.

First, the apparently inexorable transition of the planet's population was marked last month by the announcement that there are now more urban than rural dwellers in China (www.chinadaily.com.cn). While the distinction between urban and rural living is fizzy at best, the increased concentration of population in urbanised areas is occurring at a remarkable speed. The implications of this change were made clear by a speaker at an [ASI workshop on urban climatology](#) hosted by Prof. Edward Ng at the Chinese University of Hong Kong in December. Curt Garrigan, representing UNEP, indicated that when considering urban change between now and 2050, while 80-90% of the cities in the economically developed world are already built, 80-90% of those needed in the rest of the world have yet to be built. In other words, while the former may experience 'climate rehabilitation' (a phrase used by Ariele Bitan), the opportunity to ensure that the newly emerging cities are 'fitted' to their climate is now. Of particular note is that many of these cities will be constructed in climates where we have done relatively little research. This places a great onus on organisations such as the IAUC to take a leading role in extracting useful guidelines from our current knowledge base and extending our research to consider urban climate effects in tropical and sub-tropical climates.

Second, you will see a [report on ICUC8](#) also in this issue. The abstract deadline of December 31, 2011

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has been extended to **January 20th**. The number of abstracts received and their origins is an indication of the health of the field. As is always the case, most abstracts arrived very late in the day and it is only after the deadline that an analysis can be performed. We would ask members to look at the details and actively encourage submissions from those areas where there are fewer abstracts (the urban water budget is a case in point).



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Special Announcement: A new journal 'Urban Climate' is being launched by Elsevier that will be particularly suited to the research conducted by IAUC members.

Urban Climate serves the scientific and decision-making communities with the publication of research on theory, science and applications relevant to understanding urban climatic conditions and change in relation to their geography and to demographic, socioeconomic, institutional, technological and environmental dynamics and global change. Targeted towards both disciplinary and interdisciplinary audiences, this journal publishes original research papers, comprehensive review articles, book reviews, and short communications on topics including Urban Meteorology and Climate, Urban Environmental Pollution, Adaptation to Global Change, Urban Economic and Social Issues, and Urban Policy Planning and Design.

To remain informed about the journal launch (expected within weeks), please send an email to Associate Editor and IAUC member Jan Kleissl at jkleissl@ucsd.edu.

Research workshop examines “Public Open Spaces in the Sustainable City”

December 2011 — An international research workshop focusing on the quantity and quality of Public Open Spaces (POS) in local communities was held in Israel from December 19-22, resulting from a three year research project sponsored by the Israel Science Foundation.

Research and experience on designing public open spaces was discussed from two different perspectives: the human perspective (interactions between individuals or groups and the environment) and the site perspective: (i.e. topography, water and climate). The goal was to examine ways in which these perspectives could be formulated in the form of planning and design guidance, and in addition to bring to Israel top international scholars and practitioners to accelerate learning and innovation.

The themes covered over the four-day event included issues of urbanity, sustainability, livability and social justice; public open space as ecological infrastructure, including considerations of climate change adaptation, water and thermal comfort; and specific issues related to planning in Israel.

Dr. **Yodan Rofé** of Ben-Gurion University of the Negev's Institutes for Desert Research, where the first three days of the workshop were held, organized the gathering and summarized some of the lessons learned over the course of the discussions. Some of these relate to the ways that the design of urban spaces may be affected by user needs. For instance, the success and attractiveness of large public spaces is clearly dependent on an intricate human ecology and the balance between diverse groups, and there appears to be an increasing importance of public spaces – especially streets – which are tied to everyday activities and which are accessible by walking and public transit. In fact the diversity of users was seen not only as an important social consideration, but as a factor with ecological and climatic ramifications as well.



Topography was emphasized as a point of departure for site design of urban parks, and water sensitive development was emphasized as essential for providing a range of benefits including the preservation of biodiversity within cities. The accessibility and visibility of these spaces was shown by **Dee Merriam** to be important for their actual use and health benefits, and the inequality in distribution of heat island effects and the capacity

of urban parks to mitigate them where private resources are lacking was stressed by **Larissa Larsen**.

As pointed out by **Lutz Katschner** and **Sofia Thorsson**, two of the invited international speakers, the importance of climate with respect to human activity, perceptions, and attachment to place within a city means that the design of public open spaces will have special significance in a changing set of local and global scale background conditions. The goals to be emphasized include mitigating heat island effects and reducing cooling loads in buildings, and creating diverse public open spaces that will allow people to spend time outdoors in a warming climate. They stressed the need to model the effects of ventilation corridors and of overall development patterns at the meso-scale, to insure that changes do not exacerbate heat island effects.

To achieve these public goals, there is a growing recognition of the need for regulation and more precise definition of public places. Codes can be specific and context sensitive, rather than taking the form of universal standards or large-scale plans that are overly restrictive. While the workshop certainly allowed for a fruitful cross-disciplinary discussion of these challenges, meeting them will require the discussion to be both broadened and deepened so that the tools for creating better public open spaces become integrated with actual practice.



Using observations of user perception, **Hadas Saaroni**, **David Pearlmutter**, **Tali Hatuka** and **Assaf Frances** looked at thermal stress in a grass-covered urban park located in a water-scarce region – and asked the question: Is this a sustainable model for public open space development?

MED-ways: Urban and Peri-urban Forests in Mediterranean Cities

December 2011 — On December 16-17, 2011, 30 researchers and practitioners in Urban Forestry and Green infrastructure of nine Mediterranean and European countries met in Florence at the seat of the Italian Academy of Forest Sciences. The two-day workshop was co-organized by the Academy, the FAO-UN, the IUFRO, and the Universities of Bari and Florence. The aim of the meeting was to strengthen the exchange of experiences and the networking among the Mediterranean on the strategic themes of Urban and Periurban Forests (UPF). The event was promoted in the frame of the activities of the International Year of Forests. Thirteen presentations on the morning of December 16 drew a rich picture of the ongoing activities in UPF. After the openings remarks, Dr. Konjinendijk, University of Copenhagen, presented a keynote lecture on the "Innovative approaches in European Urban Forestry: perspectives for Mediterranean countries." Michelle Gauthier, responsible for the FAO task force on Urban and Peri-urban Forestry, reported on the FAO actions in the frame of UPF. She focused on SILVA MEDITERRANEA, the subsidiary body of FAO active in networking on forest issues in the Mediterranean area with 26 partner countries, and on the potential constitution of a UPF working group in its context.

A first set of Presentations (Semenzato, Italy; Munzi, Portugal; Verlic, Slovenia), summarized the state of UPF research/actions at national level. Shaler (KKL, Israel) referred to the experience of community forestry in Israel as a nationwide perspective for Urban Forestry. Colletti (CFS, Italy) presented an overview of the activities of control, management and promotion of urban and periurban forests carried out by the Italian Forest Service.

Experiences at city levels were reported for Barcelona (Basnou, Spain), Zagreb (Krajter, Croatia), and Ljubljana (Verlic, Slovenia). Cariñanos (Spain) spoke about the disadvantages of urban forests in term of pollenosis and allergies and how to deal with them. Munzi, Basnou and Semenzato reported case studies on Biodiversity and Urban Forests with particular concern on fragmentation and connectivity in urban and peri-urban environments. Semenzato focused as well on research/actions carried out in Italy on the topics of Urban forest structure and its management, participation and modeling ecosystem services.

At the regional level, Krajter presented the FORCITY project, a collaborative regional research project in Southeast Europe and Verlic quoted the EMoNFUr LIFE Project, aiming to establish a monitoring network on urban forests in Lombardy (Italy) and Slovenia.

Three presentations came from non-Mediterranean countries. Two of them focused on experiences in the Nordic European countries. Nielsen (SLU, Sweden) reported on the governance and management of urban and peri-urban woodlands in Sweden and Annerstedt (SLU, Sweden) presented on the roles of Urban Forestry related to public health. Finally Clive Davies (Newcastle University, UK) proposed a reflection on the priority themes for UPF in the Mediterranean Region and stressed 12 themes that, after the integrative discussion along



Photo: Paloma Cariñanos González

the round table in the afternoon, were adopted as a strategic checklist of priorities for Mediterranean Urban Periurban Forest (MED-UPF). The discussion outlined that MED-UPF refers to a mosaic of viewpoints in societal, geopolitical, environmental/climatic, and economic terms: the risk is to see the Mediterranean only with a single lens, e.g. the south of Europe. There are also many commonalities such as the use of Peri-Urban Forest (and related terms) that is easily perceived as the place for recreation, social activities, nature conservation and sometimes production, while the Urban Forest is still not very familiar to the public and decision makers. Another commonality is that, despite the positive experiences with UPF, the perception that trees and forests in urban areas can be problematic is highly widespread: there is a need to integrate the positive and negative in promoting UPF. Sound indicators are required to bring the ecosystem services and the social values of UPF into the urban planning process: it is crucial to shift from mere quantity to quality indicators, and to accept the challenge to find spatial models able to locate and quantify UPF benefits. Branding and marketing UPF is foreseen as a determinant in promoting sustainable lifestyles as well as highlighting the relationships between public health and UPF. It was pointed out that it is necessary to communicate and build together a message with the politicians. The way forward consists of four lines: a) The need of strengthening MED-ways in the frame of European activities (e.g. EFUF) and in trans-national Mediterranean tasks, as SILVA MEDITERRANEA; b) the design of common projects to strengthen research and actions on UPF; c) the preparation of the State of the Art of the Mediterranean countries on UPF; and d) the preparation of UPF guidelines at a regional level.

The latter was the major subject of the FAO meeting on the morning of December 17 and chaired by Gauthier (FAO). The state of preparation of the Guidelines at a global level was presented, along with the regional guidelines for French speaking Africa (of interest to some Mediterranean countries), and finally it was agreed to start a process of preparation of Mediterranean Guidelines by constituting a core group to advise and support the process. — Fabio Salbitano
MED-ways web site: www.greenspace.it/medways/

Weather Deserves Medal for Clean Air During 2008 Beijing Olympics

December 2011 — New research suggests that China's impressive feat of cutting Beijing's pollution up to 50 percent for the 2008 Summer Olympics had some help from Mother Nature. Rain just at the beginning and wind during the Olympics likely contributed about half of the effort needed to clean up the skies, scientists found. The results also suggest emission controls need to be more widely implemented than in 2008 if pollution levels are to be reduced permanently.

Reporting their findings December 12 in the journal *Atmospheric Chemistry and Physics*, co-author atmospheric chemist Xiaohong Liu at the Department of Energy's Pacific Northwest National laboratory said, "In addition to the emission controls, the weather was very important in reducing pollution. You can see the rain washing pollution out of the sky and wind transporting it away from the area."

Liu and colleague Chun Zhao at PNNL and at the Chinese Academy of Sciences in Beijing took advantage of the emission controls China put into play before and during the August Olympics to study the relative contributions of both planning and nature. Chinese officials restricted driving, temporarily halted pollution-producing manufacturing and power plants, and even relocated heavy polluting industries in preparation for the games.

To find out if the controls worked as well as people hoped, the researchers modeled the pollution and weather conditions in the area before, during and after the Olympics. They compared the model's results with measured amounts of pollution, which matched well.

Adding up the sources of pollution and the sinks that cleared it out, the team found that emission sources dropped up to a half in the week just before and during the Olympics. And while some pollution got washed out by rain or fell out of the sky, most of it got blown away by wind. "They got very lucky. There were strong storms right before the Olympics," said Liu.

In addition to rain, wind also helped. Beijing is bordered on the south by urban areas and on the north by



Beijing scene before a rain storm, showing build up of pollutants and ozone. Every few days pollutants are dispersed by wind or removed by rain. (Credit: US Environmental Protection Agency) Source: [ScienceDaily.com](http://www.sciencedaily.com)

mountains, so wind blowing north would carry more pollution into the city. Examining the direction of the wind, the researchers saw that it generally blew south in the time period covering the Olympic period.

"The area we looked at is about 50 miles south. This suggests that emission controls need to be on a regional scale rather than just a local scale," said Liu. The importance of regional controls meshes well with previous research on 2008 Olympics air quality that focused on nitrogen-based pollutants.

Next, the researchers will be examining the effect of pollution on other weather events and climate change in China. Pollutants are very small particles, and some suspect they might be causing fog to form rather than rain due to numerous pollution particles in China, Liu said.

This work was supported by the U.S. Department of Energy Office of Science, the National Natural Science Foundation of China, and the Ministry of Environmental Protection of China. Source: <http://www.sciencedaily.com/releases/2011/12/111228111727.htm>



2012 Olympic Games: London unveils venues

Olympic Stadium is designed to seat 80,000 people during the upcoming Games, but has managed to score points for sustainability. The stadium is 75% lighter than other stadiums because of its lack of heavy steel, and the concrete used is low-carbon and sourced from industrial waste. After the Games, the stadium will be scaled down to 25,000 seats and will be used for a variety of sports and cultural events for years to come.

Source: <http://www.mnn.com>

How Trees Clean the Air in London

October 2011 — New research by scientists at the University of Southampton has shown how London's trees can improve air quality by filtering out pollution particulates, which are damaging to human health.

A paper published this month in the journal *Landscape and Urban Planning* indicates that the urban trees of the Greater London Authority (GLA) area remove somewhere between 850 and 2000 tonnes of particulate pollution (PM₁₀) from the air every year.

An important development in this research, carried out by Dr. Matthew Tallis, is that the methodology allows the prediction of how much pollution will be removed in the future as the climate and pollution emissions change. This shows the real benefits of the planned increase in the number of street trees in London and throughout England, including the GLA's plan to increase the area of urban trees by 2050 and the current government's 'Big tree plant' initiative.

The research found that the targeting of tree planting in the most polluted areas of the GLA area and particularly the use of a mixture of trees, including evergreens such as pines and evergreen oak, would have the greatest benefit to future air quality in terms of PM₁₀ removal.

One of the paper's authors Professor Gail Taylor explains: "Trees have evolved to remove CO₂ from the atmosphere,

so it's not surprising that they are also good at removing pollutants. Trees which have leaves the whole year are exposed to more pollution and so they take up more. Using a number of different tree species and modelling approaches, the effectiveness of the tree canopy for clean air can be optimised."

This study presents predictions of particulate (PM₁₀) uptake in future climates and for five tree planting scenarios in London. Using seasonal rather than hourly data was shown to have little impact on modelled annual deposition of pollution (PM₁₀) to urban canopies, suggesting that pollution uptake can be estimated in other cities and for the future where hourly data are not available.

Co-author Peter Freer-Smith, Chief Scientist for Forest Research (Forestry Commission) and visiting professor at the University of Southampton, says: "We know that particulates can damage human health, for example exacerbating asthma and this reduction in exposure could have real benefits in some places, such as around the edge of school playgrounds. Urban greenspace and trees give a wide range of benefits and this study confirms that improving air quality is one of them and will also help us to get the most out of this benefit in future."

This work is part of the wider EU BRIDGE (sustainable urban planning Decision support accountinG for urban metabolism) project on planning sustainable cities. *Source:* www.sciencedaily.com/releases/2011/10/111005110800.htm

Beyond mere hot air

Julian Hunt, a former director general of the UK Meteorological Office, made the following observations prior to last month's UN climate summit at Durban.

December 2011 — The main aim of the UN climate summit at Durban, which began on November 28, is to produce an agreement about targets for emissions by developed countries, and longer-term targets for developing countries. But with sudden switches in energy policies, environmental regulations and accidents such as Fukushima, plus increasing financial fragility, national governments are increasingly aware how policy in these areas impacts lives as well as the economy.

Decision-makers also have the difficult task of pursuing long-term objectives about climate change. The key question centres around the best way to do this. Governments have become more cautious about signing up to new long-term and tightly-defined transnational agreements that might affect their flexibility to respond to changing circumstances. A global deal on climate change may be less effective than regional, national and city-level initiatives as the former is perceived to be insensitive to the technologies and time-scales for emission reduction in varying countries.

Governments with rapidly growing populations and developing technology, such as many of those in Asia and Africa, will also take longer to get a grip on their emissions than

those with falling populations and advanced technology such as those in Europe. So in Durban, would it be wiser to find a more collaborative way to respond to climate change than concentrate on what may be unproductive negotiations for a global agreement?

Durban is more likely to be successful if it focuses on engaging and enabling the diverse array of regional, national and city-level climate change mitigation and adaptation measures already in place — such as the European carbon trading system. The latter, despite its mixed record due to early design flaws, is already proving of significant interest for countries looking to introduce their own carbon trading systems like South Korea and China.

Given the particular challenge for urban areas, cities are also leading the charge to action. Municipal governments are adopting some of the most innovative ways of adapting to worsening climate hazards — such as putting wind turbines on dykes as in Rotterdam. Giving more responsibility to city governments to tackle climate change would help expedite national solutions.

A productive outcome at Durban would also include better enabling of private sector innovation to reduce emissions. Unlike other recent UN meetings like Copenhagen, scientists should be present to explain how the most effective local actions should be related to mitigating local climate change. Negotiations and promises on paper do not reduce emissions — only action on the ground can achieve that. *Source:* <http://www.hindustantimes.com>

“Ice Shield” Experiment Aims to Cool Mongolian City

December 2011 — Mongolia hopes to beat global warming by growing an “ice shield” that would cool its capital city, Ulaanbaatar. (Read about [cities as solutions](#) in the latest issue of *National Geographic* magazine).

The shield would be an enhanced version of thick ice sheets that naturally form over rivers during winter. These sheets, which can grow up to 23 feet (7 meters) thick, are known in Mongolia and Russia as *naleds*, and in Alaska and Scandinavia as *aufeis*—German for “ice on top.”

The ice sheets form under certain conditions—very cold temperatures and fast-flowing rivers—when water under the existing ice cover bursts through the cracks and freezes at the surface.

Layer after layer of the ice builds up to form a sheet that typically melts away each summer—though, if it’s thick enough, the sheet will sometimes last through the summer.

Many of Mongolia’s nomadic herders are moving off the steppe and into cities, especially as warmer temperatures are drying up grasslands, which provide food for the country’s livestock.

In the past 60 years, Mongolia has warmed about 3.4 degrees Fahrenheit (1.9 degrees Celsius)—about three times faster than Earth has warmed on average.

To help Ulaanbaatar’s growing population keep cool, a British-Mongolian venture called the EMI-ECOS Consortium will soon launch a one-billion tugrik (U.S. \$750,000) experiment to grow larger *naleds* on the Tuul River, the *Guardian* newspaper reported in November.

For the proposed plan, engineers would grow thicker *naleds* by drilling holes in the ice and pumping water to the surface of the ice sheet, where the water would freeze and form thicker, longer lasting ice. The hope is that this ice could cool the nearby capital, partially countering the effect of global warming as well as the urban heat island effect. Such artificial *naleds* could “create cool parks to combat urban heat islands,” EMI-ECOS Consortium’s lead researcher geologist Robin Grayson wrote in 2010 in Mongolia’s *World Placer Journal*.

By tweaking local temperatures, this sort of microclimate engineering is reminiscent of geoengineering proposals that would purportedly change the temperature of the whole planet.

But some experts are skeptical the *naleds* would chill the air enough to make a difference throughout the city. Though the air is definitely cooler above these ice sheets, the cooling effect tends to be more localized.

Large ice sheets such as glaciers can create chilly winds that cool the surrounding area—but only up to about a third of a mile (half a kilometer) away, noted Marc Olefs, a meteorologist and glaciologist at Austria’s Central Institute for Meteorology and Geodynamics.

To cool Ulaanbaatar, the *naleds* would have to be in



Source: nationalgeographic.com

the right spot for winds to blow across the ice before reaching the city.

Aufeis expert Douglas Kane, of the University of Alaska in Fairbanks, has also seen caribou stand on *aufeis* in the middle of a river as a way of escaping mosquitoes, which dislike cooler temperatures.

To get such an air-conditioning effect, “you could go sit on the *aufeis*,” Kane said, “but that’s probably not what the [ice-shield planners] had in mind.”

In addition this method of growing *naleds* seems to be untested so far, meteorologist Olefs added. He has studied efforts to preserve glaciers by covering them with special blankets and is familiar with efforts to grow snow on glaciers for ski slopes in Germany’s Black Forest.

But “I haven’t heard of any idea relating river-ice manipulation to climate change issues before,” Olefs said.

To cool Ulaanbaatar, another option might be to collect cool water from the melting *naleds* and pipe it through the city—something Sweden is already doing with stored up snow. But “the investment is much bigger,” Olefs admitted, and would likely be a hurdle for a poor country such as Mongolia.

The ice-shield proposal sounds similar to other ideas for geoengineering, noted Hashem Akbari, an expert on urban heat islands at Concordia University in Quebec, Canada. But many of these climate-manipulation plans could have negative side effects, Akbari said. Growing thicker, longer lasting *naleds*, for example, could affect life in the rivers or water supplies downstream, experts say.

But there are other ways of cooling a city that’d be relatively cheap and free from unintended effects, Akbari added. In particular, painting roofs white and using light-colored pavement can cool cities and lower the need for air conditioning—a time-honored way of staying cool that could be used more widely. “The world has thousands of years of experience with this—with no negative side effects.” Source: <http://news.nationalgeographic.com/>

Surface temperature variability and mortality impact in the Paris region during the August 2003 heat wave



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In August 2003, the Paris metropolitan area experienced an extreme heat wave that caused an estimated 4,867 deaths. A satellite time series of 61 thermal images and one multi-spectral high resolution image were used to 1) analyze the spatial variations of land surface temperature (LST) over the diurnal cycle, 2) evaluate indicators of elderly people's exposure to heat, and 3) identify areas with a higher risk of death. The thermal images showed contrasting night time and daytime heat island patterns related to surface characteristics and land uses, and significant cooling effects of urban parks despite a prior warm and dry spring that lowered moisture availability. As compared to normal summers, night time temperature was a predominant factor for heat wave intensity and health risk. The spatial distribution of the highest night-time LST matched that of the highest mortality ratios. LSTs were sampled at the addresses of 482 elderly people (cases and controls) to produce minimal, maximal, and mean thermal indicators with different lags between heat exposure and death. Results from a regression model, adjusted for other parameters, revealed that night time temperatures averaged over 7 days or over the whole heat wave period were significantly linked to mortality, with the risk doubling with a $\sim 0.5^{\circ}\text{C}$ LST increase. This study improves our understanding of urban surface processes and human vulnerabilities to heat waves, and further demonstrates the relevance of satellite monitoring in documenting and managing the health risks associated with summer warming trends.

1. Introduction

Observations and reconstructions of global temperature evolution indicate a pronounced warming during the last 150 years, with an increase in the occurrence of heat waves (Schär *et al.*, 2004). Climate models for the 21st century also suggest that the year-to-year variability of summer temperatures might lead to a significant increase in the frequency, intensity and duration of heat waves (Meelth and Tebaldi, 2004; Tebaldi *et al.*, 2006; Beniston *et al.*, 2007). Given current emissions trends, those predictions are confirmed in the recent IPCC report on managing the risks of extreme events (Intergovernmental Panel on Climate Change, 2011).

In the last decade, numerous heat waves occurred in Western and Central Europe and in the Mediterranean regions (2003, 2006, 2007, 2009, and 2010). In 2003 a persistent anticyclone over Western Europe generated a heat wave of exceptional strength and duration. The average summer temperatures exceeded the 1961–1990 mean by 3°C , up to 5 standard deviations (Schär and Jendritzky, 2004) (Fig. 1) and caused an estimated death toll of $\sim 70,000$ (Robine *et al.*, 2008). This heat wave “was made four to six times more likely by climate change,”

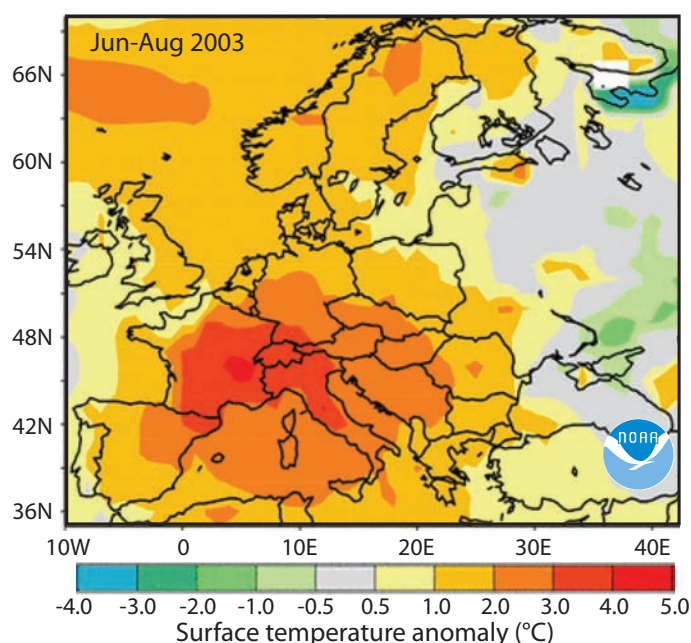


Figure 1. June-August 2003 surface temperature anomalies as compared to the 1988-2003 climatological base period. Values are a blend of in-situ and satellite observations (source: NOAA 2003).

and could recur several times per decade by the middle of the century (Stott *et al.*, 2004).

The converging effects of climate change, urbanization, and aging population have important implications for public health (Kalkstein and Green, 1997). For example, heat waves have led to an estimated excess mortality of 750 over five days in Chicago in 1995, 600 and 4,867 over 10 days in London and Paris, respectively, in 2003 (Fig. 2), and ~15,000 in Moscow in 2010. Health risks proceed from combined heat intensity, relative humidity, time exposure, and night time temperature. In addition, air pollution, which is enhanced by heat, exacerbates adverse health effects by stressing the respiratory and circulatory human systems (Basu and Samet, 2002). The elderly, infants, young children, and people with chronic health problems are more vulnerable.

The work summarized below was published in Dousset *et al.* (2011) and Laaidi *et al.* (2011). It documents the satellite monitoring of the August 2003 heat wave over the Paris metropolitan area and the associated epidemiological risk and time lag of death for elderly people at given locations. Using a synergy of climate and health data, the main objectives of the research were: 1) to analyze the urban surface temperature variation over the diurnal cycle; 2) to evaluate new indicators of elderly people's exposure to heat, from a public health prevention perspective; and 3) to demonstrate the use of satellite sensors to monitor urban heat waves and identify areas with a higher risk of death. Figure 3 presents a diagram of the method applied to assess the exposure, vulnerability and health risks, in the context of climate change and its relevance to risk management.

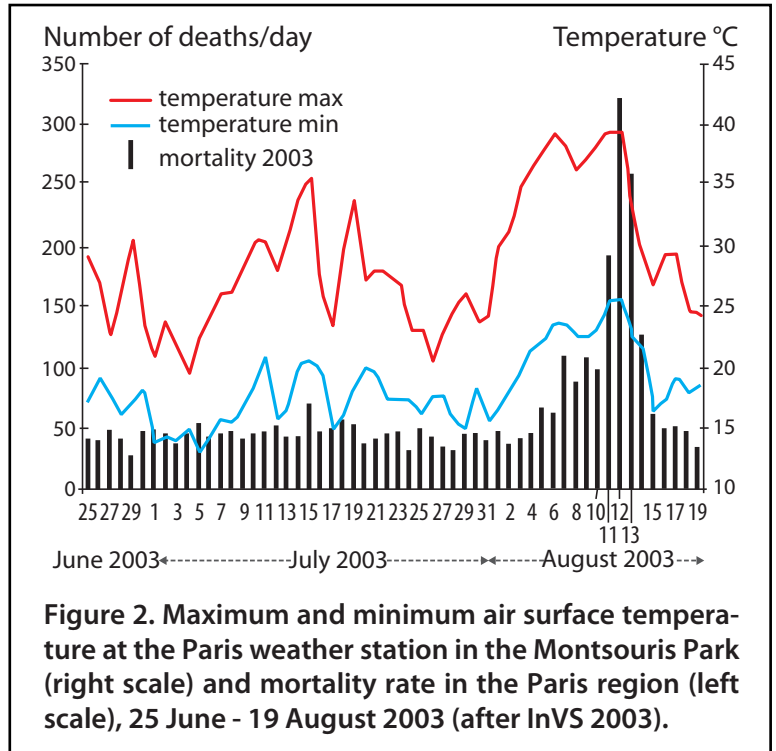


Figure 2. Maximum and minimum air surface temperature at the Paris weather station in the Montsouris Park (right scale) and mortality rate in the Paris region (left scale), 25 June - 19 August 2003 (after InVS 2003).

2. Data acquisition and methods

Paris (2°20 E, 48°50 N) is located in a sedimentary basin on the Seine River. The regional climate is moderated by the oceanic influence of the mid-latitude Westerlies. The area is characterized by compact urbanization, a population of nearly 12 million and a high density of ~20,000 inhabitants/km² within the city.

In August 2003, the Paris region experienced 9 consecutive days with maximum air temperatures (Montsouris Park) higher than 35°C that reached 39°C at the peak of the heat wave on August 12, and minimum temperatures steadily increasing from 20°C to 25.7°C. The atmosphere was very stable, with a wind speed of 1 to

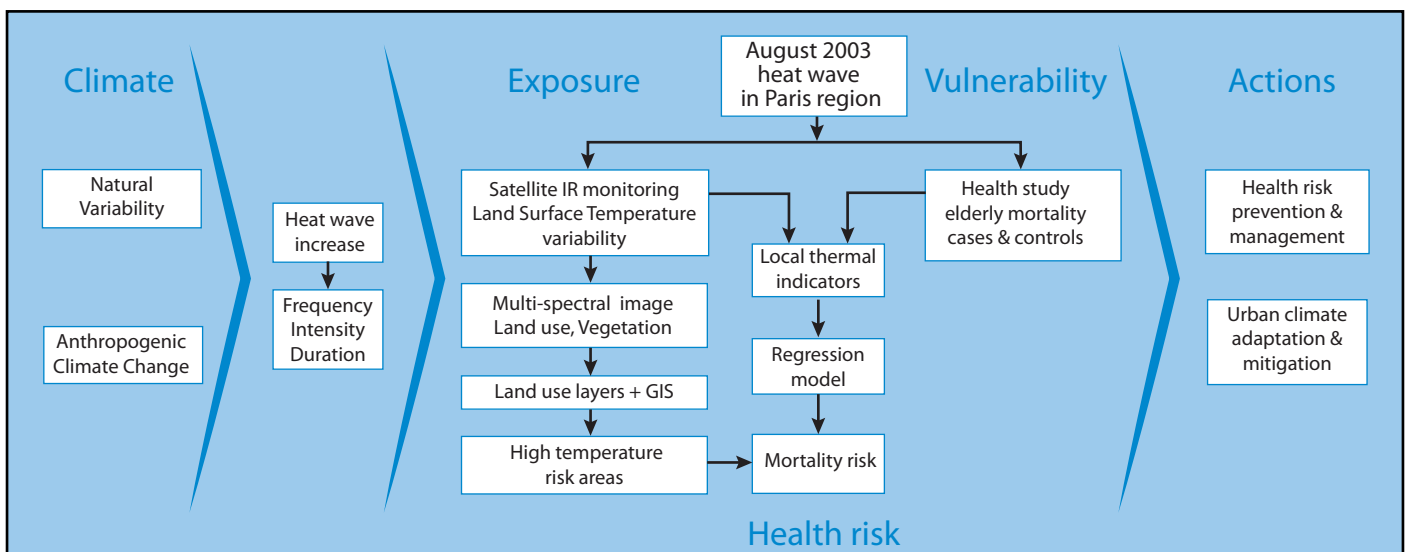


Figure 3. Flow diagram of the method applied to assess the exposure, vulnerability and health risks in the Paris region, in the context of climate change and its relevance to risk management.

4 m/s and relative humidity below and potential evapotranspiration above those of normal summers. In Paris the levels of humidity or of ozone had little influence on the excess mortality, which was mainly attributable to temperature (Filleul *et al.*, 2006).

Climate data – Urban climate monitoring is difficult to achieve using weather stations that, for synoptic purposes, are situated in parks and airports away from the built environment. Furthermore, the station network is too sparse to estimate horizontal temperature gradients and the associated risk of exposure. Those are best resolved using sun-synchronous polar orbiting satellites. A time series of 76 images sensed from July 21 to August 21 by the advanced very high-resolution radiometer (AVHRR) on board NOAA satellites 12, 16 and 17 were acquired at the receiving station of Trieste (Italy). The images were selected according to quality, clear sky and small satellite-zenith viewing angle to ensure ground resolution close to 1.1 km and minimize atmospheric attenuation and anisotropic effects. The images were orthorectified and interactively registered to a common projection. The LST, albedo, cloud cover and vegetation index (NDVI) were retrieved according to Dousset *et al.* (2011). A time series of 50 images was used to analyze the spatial variability of Land Surface Temperature (LST) over the diurnal cycle, for the heat wave episode (August 4–13). Median LST images were constructed over 6 time intervals of satellites passes (Dousset *et al.*, 2007).

A SPOT-HRV multi-spectral image at 20 m resolution recorded on 13 July 2003 was used to extract further surface characteristics and properties through a land classification that includes water, densely built urban areas, suburban residential areas, light bare soils, forest, and lawns and fields. Fractional images were created that merged the 20-m land-use and 1-km thermal pixels. In addition, local ancillary data on administrative delineations, parks, rivers and industrial areas were integrated into the database.

In situ meteorological data, recorded hourly at the Paris weather station in Montsouris Park, include surface air temperature (T_{air}), ground temperature, dew point, wind speed and direction, relative humidity, water vapor, insolation and net radiation. While maximum LSTs occurred at the time of maximum solar irradiance, maximum T_{air} lagged typically by ~ 3 h. Co-located LST and T_{air} were analyzed taking into account the different natures of the measurements. Those are considered complementary because the sensible heat flux is determined by the temperature difference between the surface and the air immediately above it.

Health data – Health data came from a case-control study including 241 people aged 65 years and over who died in the city of Paris and the nearby Val-de-Marne

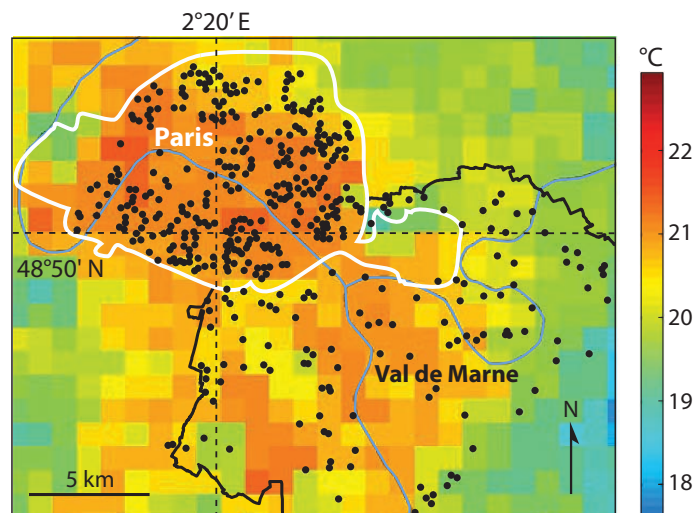


Figure 4. Spatial distribution of the geocoded addresses of cases and control in Paris and Val-de-Marne (black dots) over the NOAA-AVHRR thermal image of 7 August 2003 at 04:50 UTC, (from Dousset *et al.*, 2011).

suburb during the heat wave, and 241 controls above 65 and living in the same areas, that were matched to cases according to age, sex and residential zone (Vandentorren *et al.*, 2006). A time series of 61 images was used to produce $\sim 29,000$ individual thermal indicators with different lags between the sensing time and the health impact, from August 1 to 13. The address of each case and control was geocoded and the temperature of the corresponding pixel was considered as a thermal indicator for the person at the sensing time (Fig. 4). For each person, the thermal indicators were integrated into a conditional logistic regression model, including other risk factors such as prior pathologies, drug intake, profession, housing conditions, behavior related to heat, etc. Indicators of temperature exposure were constructed according to the daily minimum, maximum and mean LST and to its diurnal amplitude. Different lags between temperature and death (1, 3, and 6 days), daily temperatures, and temperatures averaged over 1, 7 and 13 days were considered according to Laaidi *et al.* (2011).

3. Results and discussion

Surface temperature variability over the diurnal cycle – Figures 5a and 5b are composite images of median LST over the Paris metropolitan area. They were constructed from 9 and 10 images, respectively, recorded from August 4 to 13, in the time intervals from 01 to 03 UTC and 12 to 15 UTC. The figures reveal contrasting daytime and night time heat island patterns, reflecting the different day and night rates of heating and cooling between urban and suburban areas, enhanced by the stable atmosphere that characterized the heat wave episode.

The night time image (Fig. 5a) shows a strong heat island of $\sim 8^\circ\text{C}$. The LST distribution was well correlated

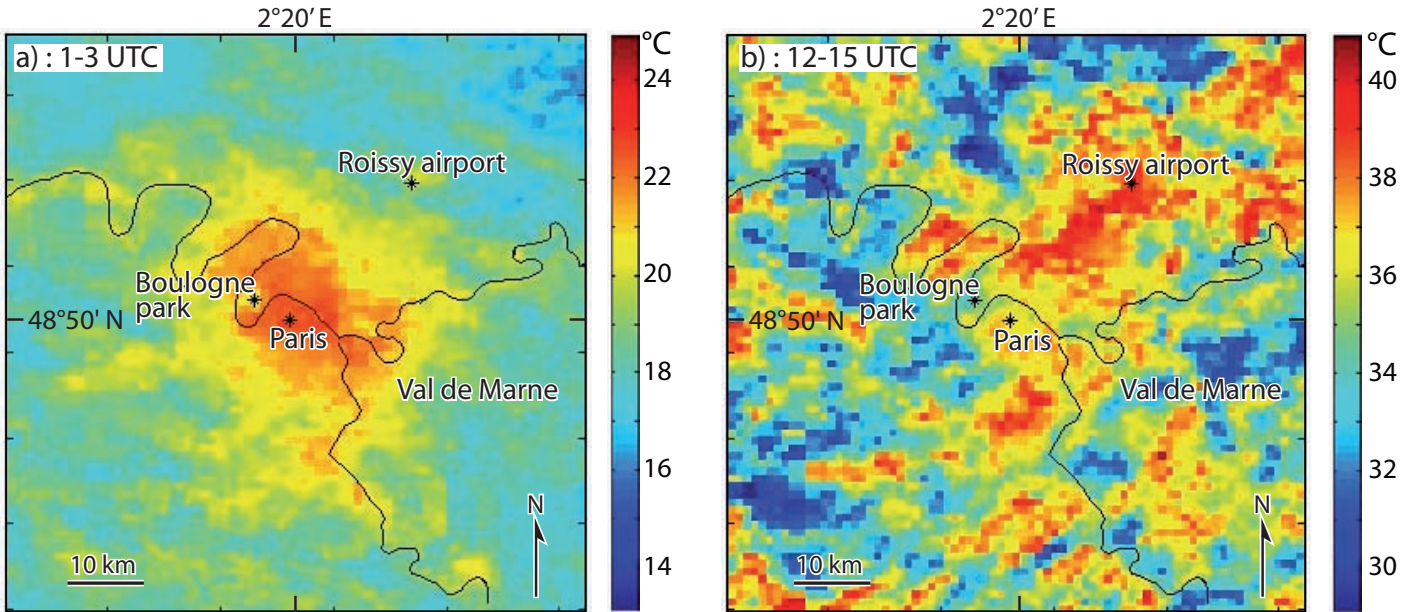


Figure 5. Averaged NOAA-AVHRR infrared images from 4 to 13 August 2003, at the time intervals of: a) 01-03 UTC (composite of 9 images); b) 12-15 UTC (composite of 10 images). The color scale (in degrees Celsius) is optimally enhanced separately for each image (from Dousset *et al.*, 2011).

with built density. At the peak of the heat wave, in the evenings, low relative humidity in the Montsouris Park suggests that vegetated areas in residential suburbs and rural areas may have been conducive to evaporative and radiative cooling. In downtown Paris, temperatures decreased slowly as the heat stored in buildings and trapped in urban canyons was progressively released and anthropogenic heat was continually produced.

The daytime image (Fig. 5b) shows multiple temperature anomalies scattered in the densely built and industrial suburbs, conveying mostly variations of the surface heat balance between dry and comparatively moist surfaces. Heat islands up to 11°C are observed between the industrial suburbs and the forests. The highest LSTs of

38–42°C occur in the industrial suburbs.

The diurnal cycles of temperature in downtown, an industrial zone, and a park (Fig. 6) indicate a mean near-constant difference of ~2°C between downtown and the park, but differences of ~3°C at night, and ~-3.5°C at noon between downtown and the industrial area, and ~4.5°C at noon between the industrial area and the park. The industrial surfaces, which have lower thermal inertia and unobstructed sky view, are consistently warmer in daytime and cooler at night than the downtown and park surfaces.

Night time temperature – Figure 7 represents the median LST cycles of Paris for August 1-13, 2003, and August 5-11, 1998, previously analyzed by Dousset and Gour-

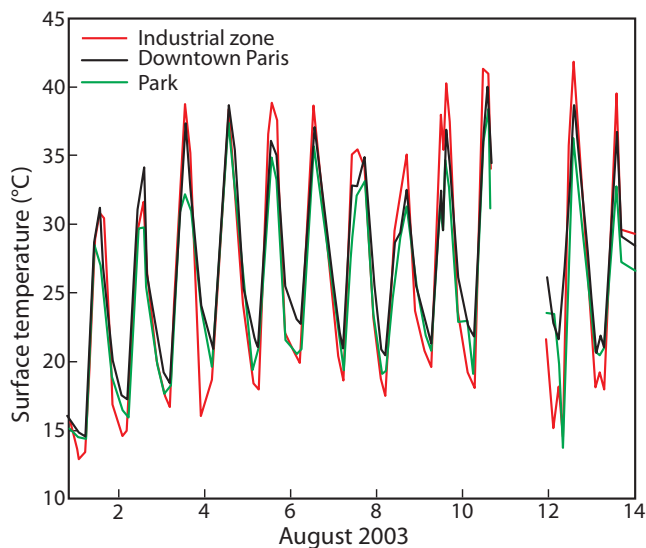


Figure 6. LST diurnal cycles at an industrial site, in downtown Paris, and in an urban park, constructed from 50 NOAA-AVHRR thermal images, from 4 to 13 August 2003.

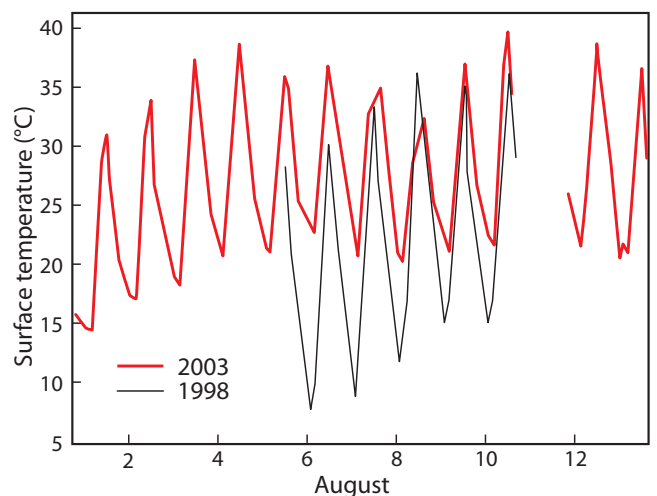


Figure 7. Median LST diurnal cycles over the Paris metropolitan area, 5-11 August 1998 and 1-13 August 2003. Mid-day LSTs that appear lower in 7–9 August 2003 than 1998 are due to a lack of data (from Dousset *et al.*, 2011).

melon (2003). Note that at mid-day, LSTs are lower on August 7-9, 2003 than 1998 due to a lack of data. The 5-11 August, 1998 period was hot and dry with maximum LSTs ranging between 28°C and 36°C, including four consecutive days over 35°C. However night time LSTs never exceeded 15°C, thus averting the occurrence of a heat wave and allowing a night rest. In August 2003, the diurnal amplitude was 5°C lower than in 1998 and the night time LST was 8°C higher, confirming the impact of night time temperature on the heat wave process. Stable meteorological conditions and low winds prevented convective mixing. For example, before sunrise on the 11th LSTs were still 25–26°C in downtown Paris, causing sleep deprivation. Such conditions over nine days eventually led to an estimated 4,867 excess mortality in the Paris metropolitan area.

The state of vegetation – Soil moisture anomalies are important in understanding the predictability of heat waves. In spring 2003, strong incident radiation and a large precipitation deficit forced an early spring green-up and progressively reduced the soil moisture. Consequently, the vegetation index of August 2003 was lower than normal summers and evidences a significantly increased drought and reduced primary productivity (Ciais *et al.*, 2005; Zaitchik *et al.*, 2006; Fischer *et al.*, 2007).

Paris comprises a dozen small parks, two large ones at its west and east edges, and is bounded by fields and forests. Figure 8 represents the bivariate histogram distribution of the composite afternoon LST (12–15 UTC) versus the mean NDVI for 4-13 August 2003. The figure indicates a significant negative correlation with a slope of $\sim -0.2^\circ\text{C}/\% \text{NDVI}$ that illustrates the importance of vegetation in the partitioning between latent and sensible surface heat fluxes. Analysis and manual sampling of individual images indicate that the LST is 2–3°C lower in small parks than in their built surroundings and 4–5°C lower in large ones.

Risk factors areas – The LST variability was analyzed as a function of urban surface characteristics and land cover/uses. Multilayer maps were generated over the six composite thermal images to identify risk factor areas. Standard layers included surface albedo, percentage of built and vegetated surfaces, hydrology, population density, industrial areas and transportation.

Figures 9a and 9b represent a zoom of the composite LST images from 01 to 03 UTC and from 12 to 15 UTC, respectively, with land use overlays. Those reveal the high sensitivity of thermal images, such as a 1.5°C decrease attributable to a small park or a 1.5°C increase attributable to a light soil in a plaza. At night, the spatial distribution of the highest LSTs of 24°C–26°C in the districts south and northeast of the Seine River (Fig. 9a) matched that of the highest mortality ratios (Cadot and Spira, 2006).

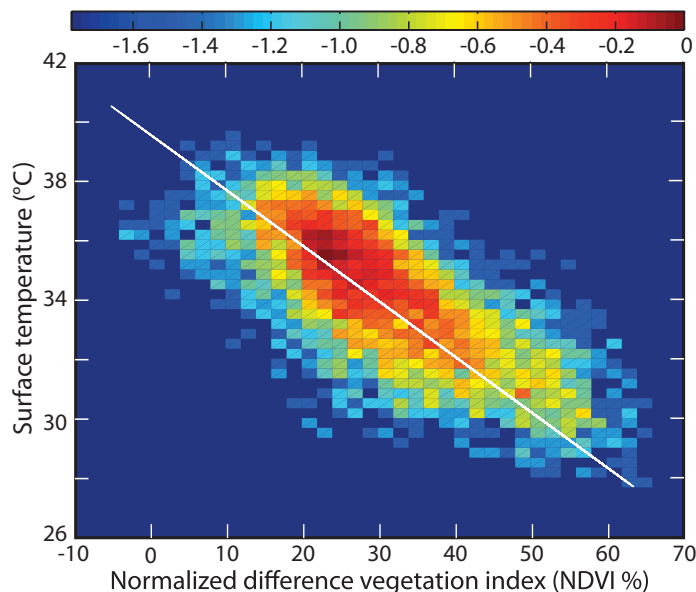
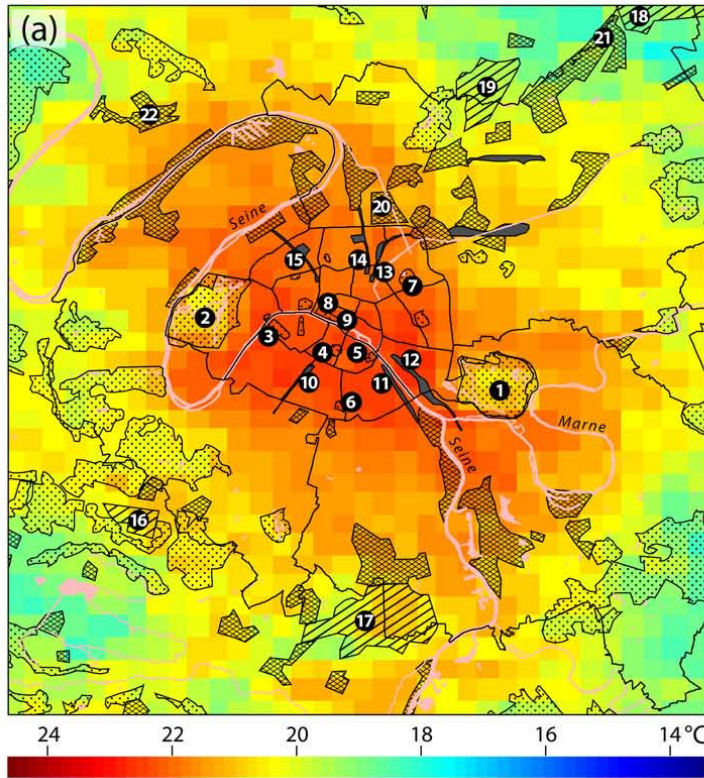


Figure 8. Bivariate histogram of LST-averaged 12–15 UTC (4–13 August 2003) versus the averaged NDVI. The color bar shows the log 10 of the bivariate distribution normalized by the largest value. The principal mode of variance has a slope of $-0.186^\circ\text{C}/\% \text{NDVI}$ (from Dousset *et al.*, 2011).

These maps are useful to take preventive actions such as reducing strenuous activities in industrial areas north of Paris where LST reached 40°C in the afternoon, and assisting elderly people living in the southern districts where LST attained 25°C at night.

Heat related mortality – From August 1 to 13, the LSTs at the addresses of the cases and controls ranged from 12.2°C to 45.4°C, with a median of 21.4°C at night and 34.2°C during the daytime. Table 1 lists the results from the conditional logistic regression model for the thermal indicators derived from NOAA-AVHRR satellite data. The Odds Ratio (OR) indicators were computed comparing the 90th and 50th percentiles of the LST differences between cases and controls. The OR is a relative measure of risk, positive above 1 and negative under it.

The results demonstrate that during a heat wave, exposure to high night time temperature increases the probability of death, whereas exposure to high daytime temperature is not significant. For example, the risk of mortality more than doubles with a mean night time temperature difference between cases and controls of 0.41°C from August 1 to 13, and 0.51°C from the day of death and six preceding days. Consecutive hot days and nights, with no night time rest to recover from daytime heat-stress, eventually leads to the death of vulnerable people. Some bias may have influenced the results; those linked to the health data are described in Vandentorren *et al.* (2006) and those related to the spatial resolution of the images are discussed in Laaidi *et al.* (2011).



- Parks :
- 1 - Bois de Vincennes
 - 2 - Bois de Boulogne
 - 3 - Champs de Mars
 - 4 - Jardin du Luxembourg
 - 5 - Jardin des Plantes
 - 6 - Parc Montsouris
 - 7 - Buttes Chaumont
 - 8 - Jardin des Tuileries
- Courtyard :
- 9 - Palais du Louvre
- Railway stations :
- 10 - Montparnasse
 - 11 - Austerlitz
 - 12 - Lyon
 - 13 - Est
 - 14 - Nord
 - 15 - St Lazare
- Airports :
- 16 - Vélizy
 - 17 - Orly
 - 18 - Roissy
 - 19 - Le Bourget
- Industrial areas :
- 20 - La Plaine St Denis
 - 21 - Paris Nord
 - 22 - Val d'Argenteuil



2 Bois de Boulogne



3 Paris : Champ de Mars



11 Austerlitz railway station



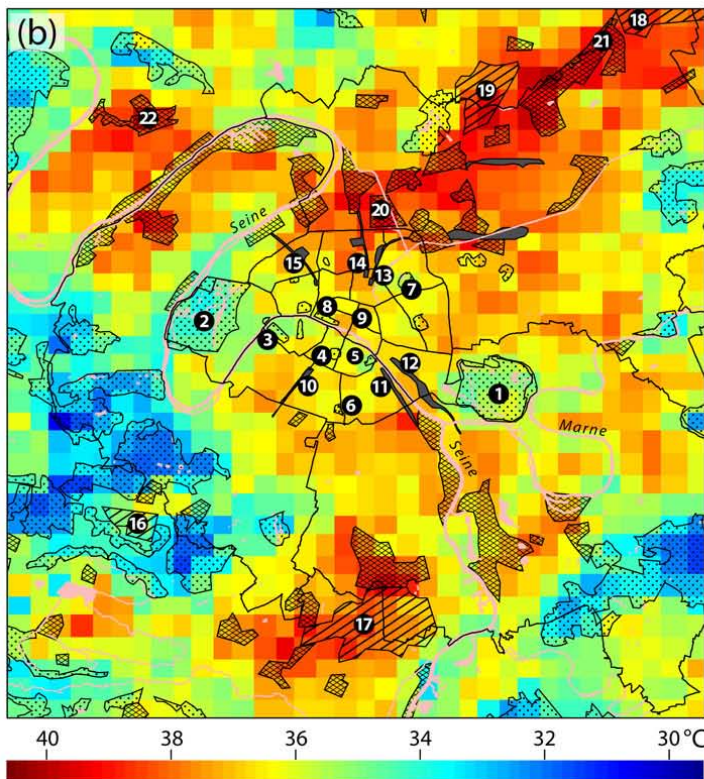
9 Paris : Palais du Louvre



15 Paris : Place de l'Etoile



20 St Denis industrial area



- park, forest, wood
- industrial area
- airport
- railway
- river, lake
- administrative apportionment

0 3 6 km

Figure 9. Averaged NOAA-AVHRR infrared images of the Paris region (4 to 13 August 2003) under a land cover/use information layer; a) at night (01–03 UTC), and b) by day (12–15 UTC). The thumbnail pictures display areas cooler and warmer than their surroundings (images from 2010 Aerodata International Survey, Google 2009). The color scale (in degrees Celsius) is optimally enhanced separately for each image (from Dousset *et al.*, 2011).

Table 1. Results from the conditional logistic regression model for Land Surface Temperature indicators derived from NOAA-AVHRR data, from August 1 to 13, 2003 (after Laaidi *et al.*, 2011).

Thermal indicators	Temperature difference (°C) between cases & controls	OR (95% CI)*
<i>From August 1 to 13</i>		
Average Maximum LST	0.97	1.29 (0.61, 2.72)
Average Minimum LST	0.41	2.17 (1.14, 4.16)
Average Mean LST	0.37	1.71 (0.94, 3.11)
<i>From 6 days before death to the day of death</i>		
Average Maximum LST	0.92	0.93 (0.51, 1.69)
Average Minimum LST	0.51	2.24 (1.03, 4.87)
Average Mean LST	0.46	1.34 (0.71, 2.51)
<i>From 2 days before death to the day of death</i>		
Average Maximum LST	1.25	0.91 (0.56, 1.47)
Average Minimum LST	0.68	1.40 (0.67, 2.91)
Average Mean LST	0.67	1.06 (0.60, 1.89)
<i>The day before death</i>		
Maximum LST	1.51	1.05 (0.77, 1.42)
Minimum LST	0.85	1.17 (0.70, 1.96)
<i>The day of death</i>		
Maximum LST	1.62	0.87 (0.63, 1.22)
Minimum LST	0.64	0.88 (0.52, 1.36)
* OR is computed using the 90th-50th percentiles of the temperature differences between cases and controls.		

4. Conclusion

The joint analysis of urban surface temperatures and co-located cases of elderly mortality during a heat wave is a novel work. It shows the contribution of urban heat islands in intensifying the heat wave by absorbing heat during the day and progressively raising minimum nocturnal temperature, which is linked to heat-stress and mortality. The time series imaging of the spatial LST gradient merged with a land use database allowed us to identify the potential health risk at a given location.

The results prove the relevance of high night time temperatures and duration of heat on mortality and local impact of related heat exposure on elderly population. The analysis shows that an increase in LST exposure of ~0.5°C at night can double the risk of elderly mortality. The analysis also indicates that such temperature increase could be prevented by a 2% increase in urban vegetation. Other measures might include, for example, raising the urban surface albedo and permeability.

Given the Europe summer warming trend and ag-

ing population, urban thermal monitoring and public health surveillance are becoming key issues to manage the risks of heat waves and initiate appropriate actions to advance climate change adaptation and mitigation in urban areas.

Acknowledgements

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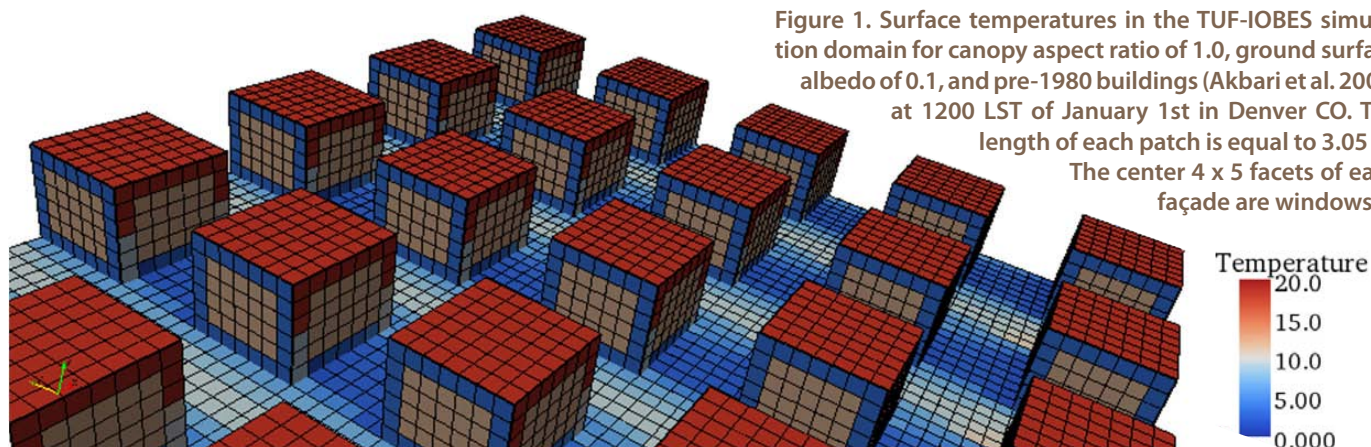
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An Indoor-Outdoor Building Energy Simulator and Application to Study Cool Pavement Impacts on Building Energy Use

Figure 1. Surface temperatures in the TUF-IOBES simulation domain for canopy aspect ratio of 1.0, ground surface albedo of 0.1, and pre-1980 buildings (Akbari et al. 2005) at 1200 LST of January 1st in Denver CO. The length of each patch is equal to 3.05 m. The center 4 x 5 facets of each façade are windows.



While there have been significant advances in energy modeling of individual buildings and the urban canopy, more sophisticated and at the same time more efficient models are needed to understand the thermal interaction between buildings and their surroundings. In particular to evaluate policy alternatives it is of interest how building makeup, canyon geometry, weather conditions, and their combination modify heat transfer in the urban area and affect energy use, human health, comfort, and sustainability. The Temperature of Urban Facets Indoor-Outdoor Building Energy Simulator (TUF-IOBES) is a building-to-canopy model that simulates indoor and outdoor building surface temperatures and heat fluxes in an urban area to estimate cooling/heating loads and energy use in buildings. The indoor and outdoor energy balance processes are dynamically coupled taking into account real weather conditions, indoor heat sources, building and urban material properties, composition of the building envelope (e.g. windows, insulation), and waste heat from air-conditioning. An application of TUF-IOBES to study the impact of different pavements (concrete and asphalt) on building energy use showed that reflective pavements locally increase energy use in adjacent buildings.

Introduction

Urbanization, or replacing natural land cover with buildings and impervious surfaces, is omnipresent due to urban population growth. Thermal and radiative properties of urban materials, building conditions (new versus old buildings), size, type, and location of windows, canyon geometry, anthropogenic heat fluxes and most importantly the combination of these factors in different weather conditions affect urban heat transfer and building energy use. Most existing building energy models emerged from the engineering community, but these models exclude modeling of the outdoor canopy air including heating, ventilating and air-conditioning (HVAC) heat emissions, the ground surface energy balance, and radiative effects of the surrounding buildings. On the other hand, urban surface energy balance models in the meteorological community usually treat the buildings as hollow cubes and exclude dynamic modeling of the indoor building energy balance and anthropogenic heat fluxes released from HVAC systems (see Grimmond *et al.* 2011 for a review).

The last few years have resulted in great progress in modeling the complex interactions in urban environ-

ments (Kikegawa *et al.* 2003, Salamanca *et al.* 2010, Bueno *et al.* 2011). However, there is still a need for computationally efficient 3-dimensional models that employ physical process-based descriptions at fine spatial scales and capture microclimate and building energy effects of urban modifications and heat island mitigation measures.

TUF-IOBES

Our urban energy modeling research builds upon a study with the Temperature of Urban Facets in 3-D (TUF3D, Krayenhoff and Voogt, 2007) model in Yaghoobian *et al.* (2010) and the ASHRAE toolkit, which is a compilation of building energy algorithms (Pedersen *et al.* 2001). As in TUF3D the geometry is composed of arrays of buildings with the ability of rotating the domain (Fig. 1, above). The simple geometry of buildings with opaque walls in TUF3D is modified to accommodate windows. The net shortwave radiation incident on each window patch (SW_{net}) is simulated based on the method used in the ASHRAE Toolkit. TUF-IOBES is capable of simulating multi-pane – up to triple pane – windows. Through the windows transmitted shortwave radiation is passed to the inside heat balance.

Conduction in TUF-IOBES is implemented through the Z-transform method, utilizing Conduction Transfer Functions which is an analytical-based scheme for calculating conduction in solid media (Seem *et al.* 1989). This approach is an order of magnitude more computationally efficient than classical finite difference methods.

Two options for calculating convection exist in TUF-IOBES. Based on TUF3D, Monin–Obukhov similarity theory is used for modeling heat transfer from horizontal surfaces taking into account stability effects. The transfer from vertical surfaces is based on a flat plate forced convection relationship considering patch surface roughness and effective wind speed (Krayenhoff and Voogt, 2007). The other option is the DOE-2 model (LBL, 1994), where the sum of the forced and natural convection components is considered as a function of the orientation of each surface with respect to the wind direction (windward or leeward surfaces) and surface roughness.

A full year of representative weather data, the TMY3 (Typical Meteorological Year 3), is input to force TUF-IOBES using hourly global horizontal, direct normal, and diffuse horizontal irradiances, cloud cover and height, dry bulb and dew point temperatures, pressure, wind speed and wind direction at reference height.

Components of the indoor energy balance model of TUF-IOBES are based on subroutines in the ASHRAE Toolkit indoor model. The inside surface heat balance shows that the heat transfer due to convection, longwave and shortwave radiation is balanced by conduction:

$$q_{LWX} + q_{SW} + q_{LWS} + q_{cond} + q_{sol} + q_{conv} = 0 \quad [1]$$

where q_{LWX} is the net longwave radiant exchange flux between zone surfaces, q_{SW} is the net shortwave radiation flux to the surface from light which is assumed to be distributed over the surfaces in the zone through a user defined fraction of shortwave radiation on each surface, q_{LWS} is the longwave radiation flux from equipment, people and lights in a zone modeled using the traditional model of radiative/convective split of heat from any internal sources in the zone, q_{cond} is conduction flux through the wall simulated using CTF method, q_{sol} is the transmitted solar radiation flux absorbed on indoor surfaces, and q_{conv} is the convective heat flux to zone air based on air and surface temperature differences. Eq. 1 yields the indoor surface temperature.

To obtain cooling or heating loads, convection heat transfer from the zone surfaces, the convective part of internal loads, the sensible load due to infiltration and ventilation, and the heat transfer to/from the HVAC system are considered. TUF-IOBES simulates a single or dual-setpoint (deadband) system with no upper limit on air flow (unlimited capacity) such that the cooling and heating setpoints are immediately satisfied.

In summary, first a real weather data file (TMY3) forces the outdoor energy balance to obtain canopy air and urban surface temperatures. Then through the indoor energy balance surface temperatures, air temperature and cooling/

heating load inside the building are obtained. Finally the waste heat from air-conditioning (AC) systems increases the canopy air temperature. The indoor and outdoor energy balance processes are dynamically coupled. At each timestep the outdoor energy balance model uses the simulated inside building surface temperatures at the previous timestep from the indoor energy model. On the other hand, the indoor energy balance model uses the outside building wall temperature simulated at the current timestep as its boundary condition. Also, the transmitted solar radiation in the interior surface heat balance q_{sol} is based on the radiation in the outdoor energy balance.

In Yaghoobian and Kleissl (2012) transient heat conduction simulation in TUF-IOBES is validated against an analytical solution of interior wall surface temperature response to a step change in outside air temperature. In addition yearly and daily cooling and heating load simulations in TUF-IOBES are validated against other whole building energy simulators.

Effects of surface albedo on building energy use

The effect of urban materials on urban building energy use has received much attention (e.g. Rosenfeld *et al.* 1995; Bretz *et al.* 1998; Akbari *et al.* 2001; Doulos *et al.* 2004). Especially reflective or 'cool' roofs have been a great success story for building engineering and urban meteorology. Policy-makers have taken notice and cool-roof building codes and incentive programs are sprouting around the country (e.g. Cardin 2011). Cool roofs reduce building cooling load, the urban heat island effect, global warming, and prolong roof life. Cool roofs have been shown to be more effective at urban cooling than parks and green roofs, and that at a much lower cost (Mackey *et al.* 2012, Scherba *et al.* 2012). Cool roofs are the only significant urban heat island mitigation measure that makes macro-economic sense and has the potential to become mainstream.

Recent Heat Island mitigation policy measures extend the cool roof idea to require cool pavements. The Heat Island and Smog Reduction Act of 2011 (Bill H.R.51, Connolly 2011) requires "high solar reflectivity (cool roofs), vegetated roofs, and paving materials with higher solar reflectivity". Assembly Bill 296 in California (Skinner 2011) is specifically designed to advance cool pavement practices in the state and requires compilation of a Cool Pavement Handbook.

The main objective of this initial study is to holistically evaluate local thermal and radiative effects of asphalt (a low albedo material) and concrete (a reflective material) ground surfaces on building thermal loads. For this simulation a 5 × 5 identical building array is resolved by 99 × 99 identical patches of 3.05 m length. Buildings have a square footprint of 21.3 m on each side and a height of 18.3 m. The buildings in the domain are separated by 16 patches in both x and y directions (canyon aspect ratio of 0.38). The outputs are computed over the central building in the domain while the surrounding buildings provide appropriate radiative boundary conditions.

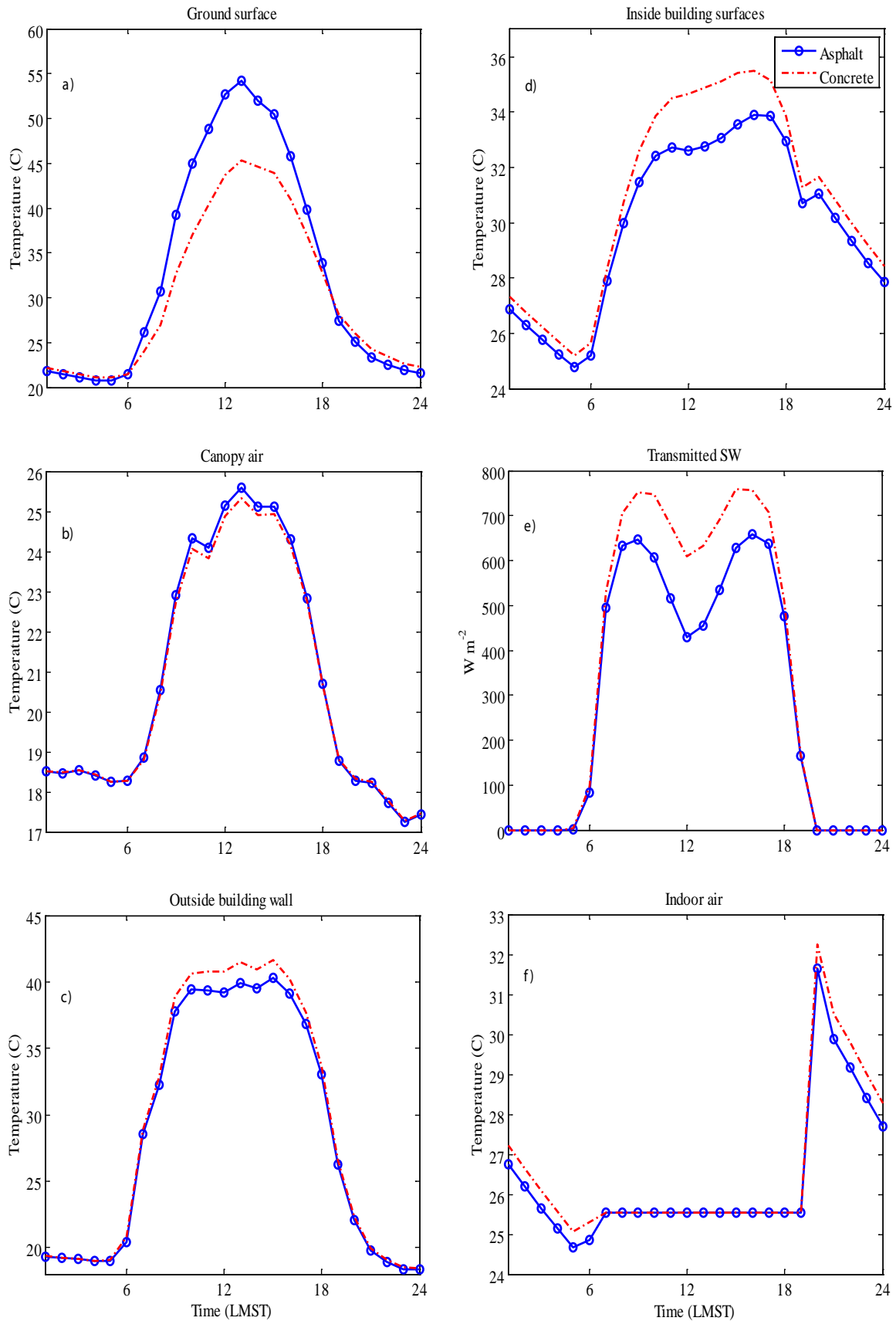


Figure 2. Comparison of a) ground surface, b) canopy air, c) outside building wall, d) inside building surface temperatures and e) transmitted shortwave radiation into the building and f) indoor air temperature for asphalt and concrete ground surface material for a summer day (July 10th) in San Diego, California. Outside building wall temperature is averaged over all four outside walls excluding windows. Inside building surface temperature is the average temperature of all surface temperatures inside the building excluding windows.

Building and system characteristics and the amounts of internal loads are chosen similar to the characteristics of prototypical post-1980 office buildings provided in Akbari *et al.* (2005). Each wall of the building has a double glazing window with dimensions 12.2 m height \times 15.2 m width resulting in a window fraction of 0.47. Every day from 0600 to 1900 LST the building is occupied by 25 persons and internal load from lighting is 15.07 W m^{-2} and from equipment is 16.14 W m^{-2} of building area. Coefficient of performance (COP) of the HVAC system is 2.9 with cooling setpoint of 25.6°C and heating setpoint of 21.1°C . The HVAC system operates between 0600 to 1900 LST and infiltration is neglected. TMY3 weather data file for Miramar station (KNKX at 32.87° north latitude, 117.13° west longitude and 140 m altitude) in San Diego, California is used as forcing data at reference height.

Fig. 2 shows a comparison of ground surface, canopy air, outside building wall, inside building surface and indoor air temperatures with the transmitted shortwave radiation into the building for July 10th (a clear day with average wind speed of 3 m s^{-1}) between the simulations using asphalt and concrete ground surfaces.

The difference in albedo and (less so) other material thermal properties causes a higher ground surface temperature on asphalt than concrete with the maximum difference of 9.1°C . As a result the air temperature above asphalt is up to 0.27°C higher than that over concrete surface. Ground surface materials affect building surfaces directly (through radiation) and indirectly (through convection). Fig. 2c shows that despite the higher ground surface temperature and canopy air temperature over asphalt, building walls are cooler (with maximum difference of 1.56°C) than over concrete. Consequently, the larger building wall temperature over concrete is directly related to the higher albedo of concrete (0.35) than asphalt (0.18). Higher reflection from concrete also results in a 19.8% increase in total transmitted shortwave radiation into the building (Fig. 2e). Together, the larger transmitted shortwave radiation and larger heat conduction through the building envelope result in larger inside building wall (Fig. 2d) and indoor air (Fig. 2f) temperatures. The contribution of transmitted shortwave radiation through windows on indoor temperatures is larger than the effects of conductive heat transfer through the building envelope (Fig. 2c, 2e). Consequently, the daily AC energy use to keep the indoor air temperature at the cooling setpoint increases 16.4% for the concrete ground surface (Fig. 3).

During the winter the same processes cause a reduction in heating load over concrete. The total yearly cooling energy use for concrete is 13.6% (10.7 MWh) larger and total yearly heating energy use is 15.4% (2.2 MWh) smaller than over an asphalt surface. While the relative increases are similar the absolute magnitude of cooling energy use increase trumps the heating load savings resulting in an overall increase in building energy use for more reflective ground materials.

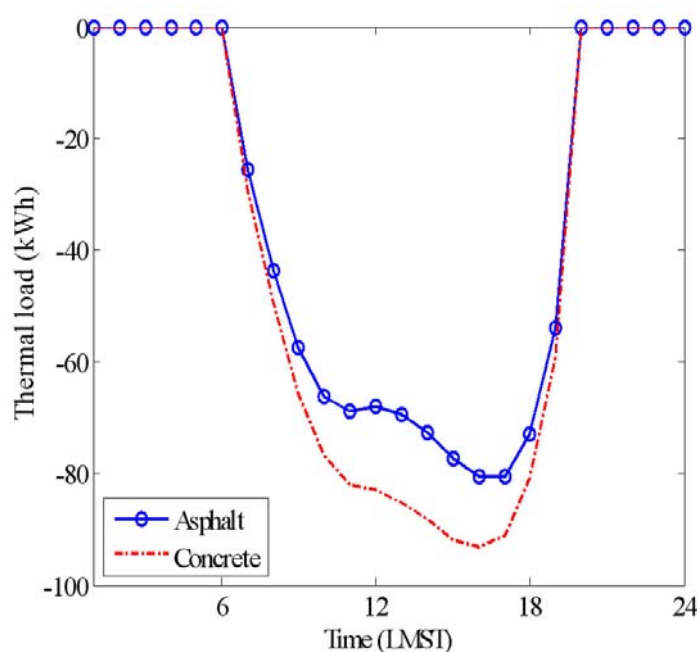


Figure 3. Comparison of sensible cooling load between two simulations with asphalt and concrete ground surface materials for a summer day (July 10th) in San Diego, California.

Conclusion

The Temperature of Urban Facets Indoor-Outdoor Building Energy Simulator (TUF-IOBES, Yaghoobian and Kleissl, 2012) is a building-to-canopy model that simulates indoor and outdoor building surface temperatures and associated heat fluxes in a high resolution 3-dimensional urban domain to estimate cooling/heating loads and energy use in buildings. The indoor and outdoor energy balance processes are dynamically coupled online taking into account real weather conditions, indoor heat sources, infiltration, building and urban material properties and composition of the building envelope (e.g. windows, insulation), and HVAC equipment. TUF-IOBES also simulates the effect of waste heat emissions from HVAC systems on urban canopy air temperature and in consequence on urban and building heat transfer.

The Temperature of Urban Facets Indoor-Outdoor Building Energy Simulator (TUF-IOBES) provides scientific and engineering results with policy relevance, for example by studying the holistic impact of heat island mitigation measures. Simulations of annual thermal loads on a single processor with a reasonable computational speed are possible in this two-way coupled model. The effect of a large number of parameters such as building conditions (e.g. infiltration rate, construction materials, window size and type), canopy aspect ratio, and weather type (very hot and cold cities) on building thermal loads can be investigated.

TUF-IOBES goes beyond previously available models; it is the first three-dimensional fully-coupled indoor-outdoor building energy simulator. Given the complexity of solar irradiance fields in the urban canopy the surface temper-

ature fields and energy use can be simulated more faithfully. TUF-IOBES provides unprecedented insight on urban canopy and building energy heat transfer processes. It can improve our understanding of how urban geometry and material modifications and the interaction between buildings and their surroundings and dynamic combination of all of these effects in 3 dimensions modify the urban energy use. Future work includes more flexible model geometry to accommodate any possible building and canyon shape, more sophisticated HVAC and vegetation including water balance models. The feedback of changes in the urban canopy and anthropogenic heat release onto the surface layer cannot be simulated, since the boundary conditions are imposed in the surface layer. In this case models that can simulate the full boundary layer and mesoscale effects are more applicable (e.g. WRF-Urban (Chen *et al.* 2011); Krayenhoff and Voogt, 2010).

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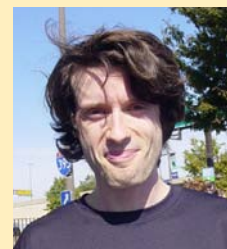
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Urban Heat Islands and Urban Thermography – The UHI Project

Project synthesis

The project “Urban Heat Islands and Urban Thermography” aims at developing a set of satellite/airborne-based services to help municipalities to understand and predict Urban Heat Islands. This would contribute to a better prevention of UHI impacts during summer heat waves, a reduction of the heat wave risk in metropolitan areas and a better implementation of energy efficiency measures. The project started on November 1st 2008 and closed in September 2011.

Municipalities and national administrations from 10 cities/countries were the direct beneficiaries of the project outcomes (products, information system, training). Strong involvement of the users was ensured along the project to refine user requirements, to explain UHI products and to evaluate their utility according to the typology of users. The seventeen (17) public organizations involved in the project have different institutional roles and tasks:

- Ecology and Environment institutes/ agencies: Athens, Brussels, Budapest, Paris and Seville
- Planning authority: London
- Civil Protection departments: Bari, Athens, Thessaloniki, and Lisbon
- Meteorological services and broadcasting channels: Athens and Thessaloniki.
- Urban engineering and GIS/cartography departments or agencies: Lisbon and Madrid
- Health : Lisbon

The project analyzes the UHI trends over the 10 European cities over the last 10 years, using a multi-sensor approach in order to make the best use of all satellite missions that embark TIR sensors (SEVIRI, AVHRR, AATSR, MODIS, LANDSAT, ASTER), and to contribute to the study of the spatial variability of the Urban Heat Islands in the metropolitan areas. Thermography mapping using airborne data was performed for two cities (Brussels and Madrid).

This requires:

- monitoring Land Surface Temperature (LST) and Air Temperature at 1.5 to 2m height (AT) variability with different temporal and spatial resolutions. LST retrievals – derived from remote sensing observations – were assimilated into urban climate models to produce AT. Long time series of data were acquired to study the historical trends of surface and air temperatures in the metropolitan and surrounding rural areas of the cities.

- analysing and interpreting the observed LST and AT as a function of land use/land cover, surface albedo, surface emissivity, surface roughness.

- producing bio-climatic indicators (e.g. thermal stress indices) to be exploited for estimating the well-being of

Table 1. Algorithms and methodologies selected to process UHI products

Products	Sensor/model/algorithms
LST and Emissivity (3-5 km)	Seviri (GSW Freitas et al. 2010, Trigo et al., 2008a and 2008b)
AT (3-5 km)	LST (3-5km) + Surface energy balance + objective hysteresis model
LST and Emissivity (1 km)	AVHRR, ASTRR, MODIS (SWT Jiménez-Muñoz and Sobrino 2008)
AT (1 km)	LST (1km) + Surface energy balance + objective hysteresis model
LST and Emissivity (~100 m)	ASTER (TES Gillespie et al. 1998; Dash et al. 2002) / Landsat (Single channel Jiménez-Muñoz and Sobrino 2003 , Jiménez-Muñoz et al., 2009)
AT (~100 m)	LST + Aerodynamic resistance model (test phase)
LST and Emissivity (5-30 m)	Airborne sensor (AHS) (Hybrid method Peres et al., 2008; SWT Jiménez-Muñoz et al. (2006), Single Channel; Sobrino et al. (2008)
AT (5-30 m)	LST (5-30m) + Aerodynamic resistance model (test phase)
NRT and forecast of AT (1km)	HRES-SEB algorithm (NRT) (Homscheidt, 2008) / Forecasting Model (WRF) (LST assimilation is in development)
NRT and forecast of discomfort indices	Discomfort Index (DI); Thermal Stress Index (TSI); Predicted Mean Vote (PMV); Predicted Percentage of Dissatisfied (PPD); Universal Thermal Climate Index (UTCI)
Heat wave hazard and risk. NRT, forecasting and monthly	Evaluation of vulnerability from census data. Evaluation of hazard using Discomfort Index (NRT) and fuzzy logic (monthly)
Thermographic mapping above 5m	Surface energy budget estimation by flux modelling approach from Grimmond and Oke (1999)
Thermographic mapping airborne	Based on the TES algorithm as per product LST at 100 m
Surface roughness	Use of a LUT table which retrieves surface roughness from the CLC classes of Wieringa, J. (1993)
Surface albedo	Seviri (LandSAF AL product) / MODIS L3 product (500m)

the population in relation to the current meteorological conditions.

- identifying in Near Real Time and forecast the location and magnitude of urban heat islands in particular during heat waves. That entails integrating LST retrievals derived from remote sensing observations into Numerical Weather Prediction (NWP) models.

- producing thermographic maps at high and very high resolution to understand the energy efficiency of city surfaces and to monitor the impact of energy efficiency policies.

Methodology and Approach

An accurate analysis of the advantages and disadvantages of algorithms and climatology proposed in the literature was performed. A trade-off analysis was carried out to select the most appropriate algorithms and methodology for satellite/airborne image processing for each UHI product. Criteria such as: 1) ancillary data needed in terms of quantity and characteristics; and 2) algorithms that are easy to translate into an operational implementation chain were also taken into account.

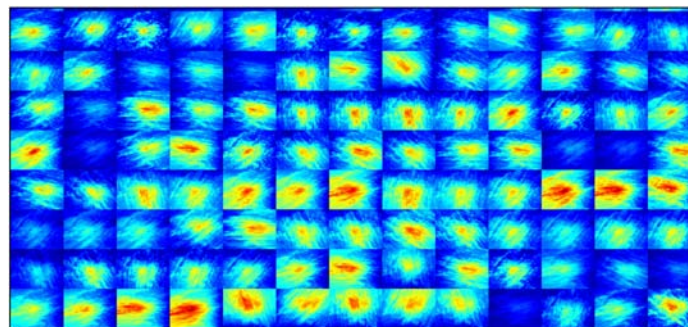
Particular efforts were spent in developing an innovative approach and setting up advanced technical solutions to implement efficient processing chains. Outcomes are summarised in Table 1.

Innovation: Modelling Air Temperature

A new approach was devised to produce historic air temperature maps, based upon satellite-derived LST data for multiple years, which on the one hand tries to capture the essential physics behind the urban heat island phenomenon and on the other hand does not require the computing time a full mesoscale meteorological model would need.

The model realised to generate AT at 3-5 km and 1 km (spatial resolution) is split up into two parts. First a surface model which contains a data assimilation scheme for satellite-observed land surface temperature produces the sensible and latent heat fluxes. Those fluxes are subsequently used as boundary conditions at the surface for an atmospheric heat advection / diffusion model which takes into account the advection and diffusion of heat, enabling the simulation of heat transport downwind of urban agglomerations. This model is very fast, which allows LST assimilation and provides background air temperature but not street canyon temperature. Hourly maps of 2 m AT at 3-5 km and 1 km from May to September 2007–2010 were produced for the 10 cities.

Another methodology was followed to generate AT at 100 m using ASTER or Landsat data. The approach was based on the aerodynamic formulation of the surface sensible heat flux, involving the surface-air temperature difference and a drag coefficient, together with a simple



Paris: Mosaic of simulated daily 22:00 UTC UHI intensity for the summer of 2003. Each panel corresponds to a different day defined as the temperature minus the minimum temperature occurring in each panel. The dark blue colour corresponds to 0°C, the darkest red to 9.6°C. Interesting to note the high variation of the UHI effect that almost disappears on some days, while on other days it rises to almost 10°C.

atmospheric heat dispersion model. The major challenge was to find a suitable parameterization for the thermal roughness length, as a function of land cover characteristics and terrain heterogeneity. The model is very fast and allows LST data assimilation, but does not yield urban-canopy detail. Maps of 2 m AT at 100 m resolution were produced using ASTER or Landsat data acquired from May to September 2007–2010 for 10 cities.

Technological Advancements

- **Forecasting Air Temperature:** The core of the retrieval of the AT for the UHI Forecasting Service (UHI-FS) is the prognostic meteorological model WRF (Weather Research and Forecasting) designed to serve both operational forecasting and atmospheric research needs. Several modifications were applied to the modelling system of WRF in order to improve its performance, concerning the simulation of the urban heat island effect. The model's accuracy was significantly improved by means of: 1) ingesting the CORINE-2000 land use data (three different "urban" land use categories) instead of the default USGS dataset (one "urban" land use category); 2) exploiting satellite-derived data for defining surface characteristics of urban areas (e.g. albedo); and 3) developing a statistical, non-linear mask for downscaling the forecasts' spatial resolution from 2 km to 250 m. In addition, specific efforts were devoted to identify the methodology for assimilating satellite-derived land surface temperature into the WRF model.

- **Monthly hazard and risk:** Heat wave hazard was estimated from the analysis of hourly modeled air temperatures distributed on a 1-km grid over a city by identifying the areas (municipalities) that are more likely to suffer higher temperatures in the case of a heat wave event. The heat waves were identified and extracted and several features were calculated such as duration, intensity and timing. Then artificial intelligence fuzzy logic was

used to classify the heat waves from mild to extreme. Finally, the monthly heat wave risk map provides the spatial distribution of the risk of the population subject to heat waves within a specific month.

- **UHI Information System:** An Informative System (IS) was designed to host all the products with a WebGIS interface for consultation, query and downloading, OGC and ISO 19115-2 compliant (www.urbanheatisland.info).

Products Validation/Verification

The validation/verification of all the products with respect to their usefulness for understanding UHI phenomena and to support users' institutional tasks was one of the central activities of the project. A verification protocol was established describing quantitative and qualitative procedures to be applied for each UHI product.

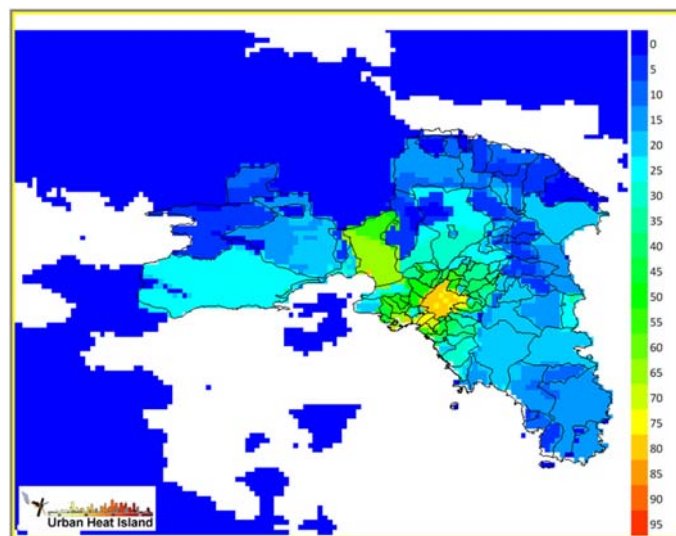
The major issue was to find suitable ground truth data to be compared with. This aspect is critical for LST and to overcome such difficulty, the comparison was performed using official level 2 products from the same sensors: e.g. the LST product at 1 km from MODIS is compared with the MODIS L2 LST product from NASA.

For the verification of the AT products, ground data measurements from two field campaigns - financed by ESA - DESIREX (summer 2008 over Madrid) and THERMOPOLIS (summer 2009 over Athens) - were used. Additional meteorological in situ data were provided directly by the users or acquired by the project.

For the qualitative verification, various techniques have been adopted: time series analysis, spatial pattern recognition of temperature, multi-resolutions and multi-sensor characterisations of UHI or heat wave events and feedbacks from the users.

Data interpretation was carried out taking into account geographical peculiarities of each city (size, sea influence, topographic and climatic characteristics, heat waves events, etc). Qualitative interpretation was also verified with the users of the 10 cities to rely on their knowledge about the "UHI behaviour" of their city.

In the end, all the UHI products have been successfully validated with the exception of the NRT AT product which still requires some algorithmic improvement. In other words, the algorithms selected and models implemented have provided data able to contribute adequately to the monitoring and forecast of UHI phenomena in the urban environment and relevant impacts on the population at mesoscale (1 km). Products at larger scale (100 m) are mainly useful for urban planning purposes. Thermography (winter and summer) products derived from airborne data are highly appreciated by the users while thermography products derived from satellite data at 100 m spatial resolution are too coarse for energy efficiency study.



Athens: monthly risk maps of UHI for June 2007. Scale: 0 (blue) =no risk; 100 (red)=extreme risk. In June 2007 Athens was affected by the most intensive heat wave events in recent history. A hazard map of heat waves for June 2007 was calculated on the basis of the number of heat waves, their intensity, duration and times of occurrence within the month. The risk map was elaborated considering also the population vulnerability (elaborated from 2001 census data). The convolution of population vulnerability and monthly hazard distribution provides the monthly heat wave risk. The increased risk calculated for the City of Athens (city centre) is associated with the increased hazard in the area and high population vulnerability (dense population and large number of elderly and children in absolute terms). The municipality of Aspropyrgos also presents high risk mainly due to large number of non-proper houses.

Final Outcomes

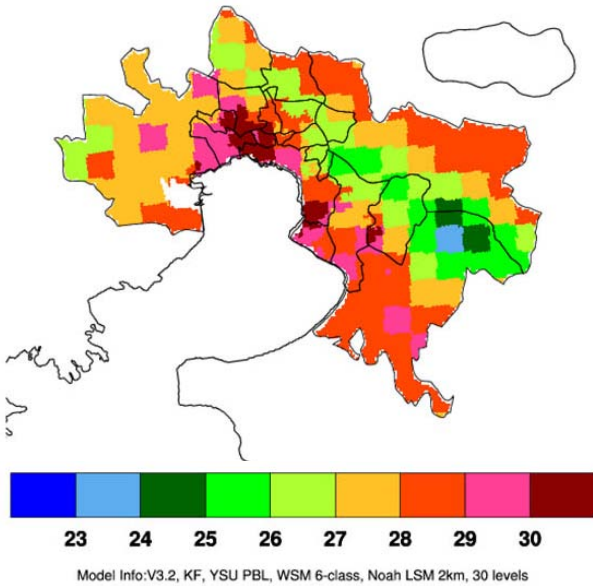
The project was conceived with a strong innovative drive, in particular for the use of the current TIR sensors and the development of models and setting up of adequate methodologies. The project as such contributes to advanced research fields such as the retrieval of air temperature from observed land surface temperature (LST) imagery and assimilation of LST into numerical models. This allows 1) to set up a standard methodology applicable to different European regions to exploit in a pre-operational way current EO sensors and 2) to understand their limits of applications, identifying fields where research efforts should be strengthened.

Outcome 1: Set up of a user-tailored information system (based on a WebGIS) containing products that exploit EO technology using standard and validated methodologies tested in different European regions and 10 cities.

- **Coarse spatial resolution products:**
 - Historical set LST and AT (3-5 km) covering 2007-2009 (May to September) over the 10 cities (every 15').
- **Medium spatial resolution products:**
 - Historical set of LST products (1 km) covering 2001-

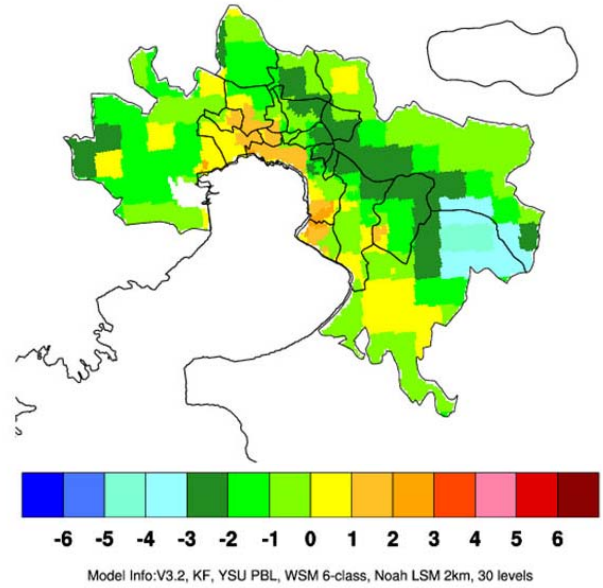
250-m Downscaled ARW-WRF Forecast (GFS Init.) Init: 2010-08-14 12:00:00
 LAP-AUTH, UHI Project Valid: Sunday 15 Aug 2010 at 21-UTC

2-m Air Temperature (°C)

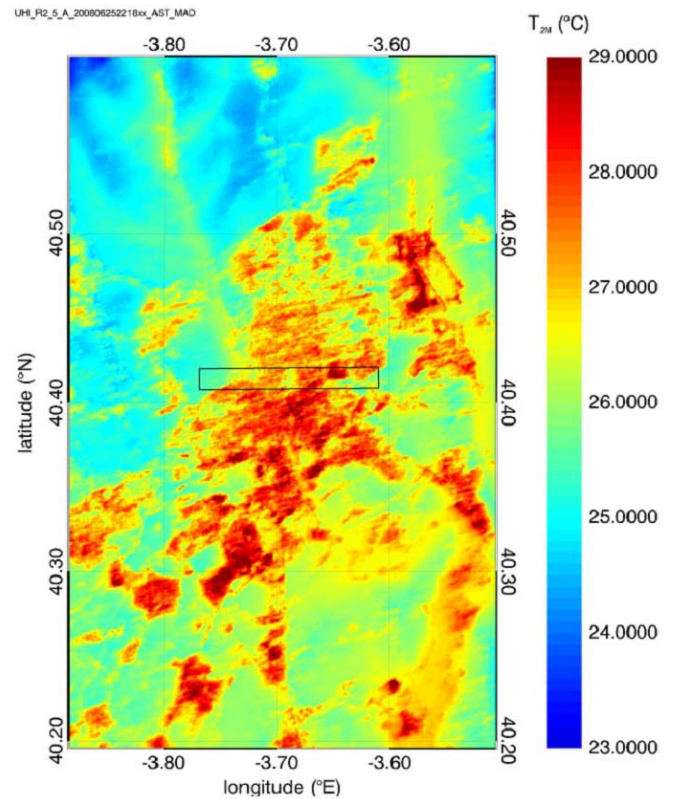
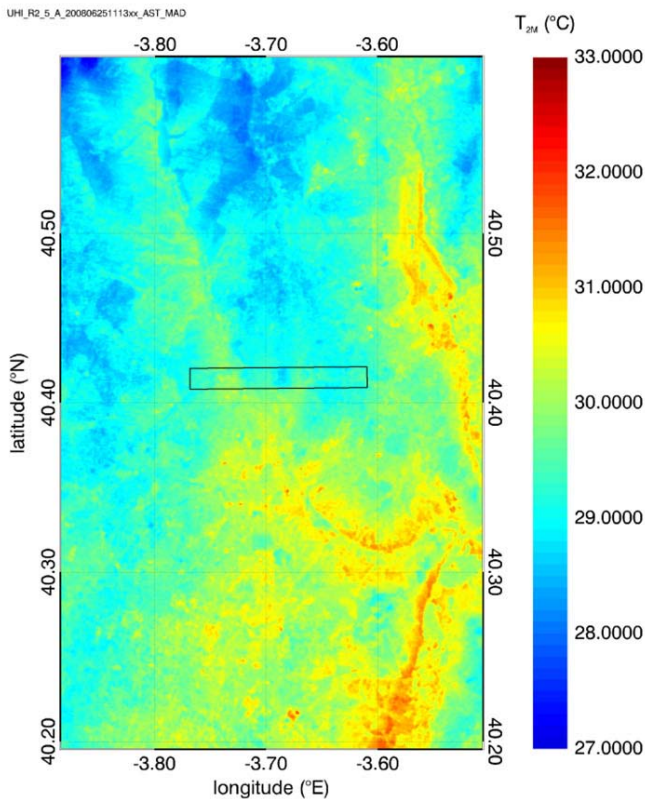


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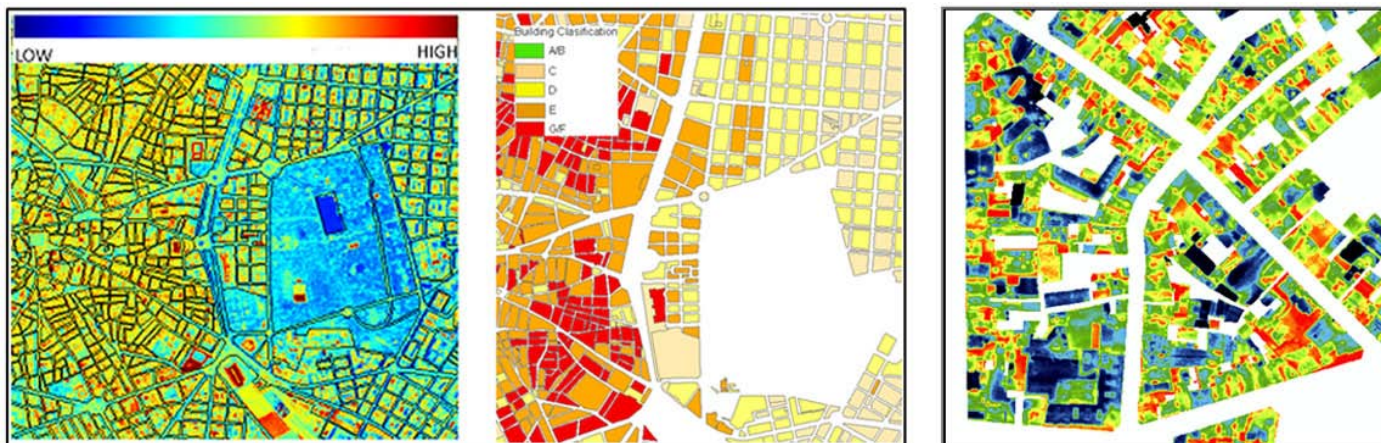
Urban Heat Island Intensity (°C)



Thessaloniki: AT and UHII forecast for 16/08/2010 at mid-night local time. August 2010 was the second warmest August of the past decade in Greece. (+3.9 °C above the climatic mean). During this period, the recorded air temperature in the city of Thessaloniki reached ~38-39 °C with high air temperatures persisting throughout night-time hours in the city's most densely built-up and populated areas. The forecasts appeared to be successful in simulating the complex urban structures of the city, forecasting lower temperatures and risk levels for open space and vegetated areas.



Madrid: 2-metre air temperature for Madrid on 25 June 2008 at 11:13 UTC and 22:18 UTC. The centre of the rectangle features the large Retiro park inside Madrid. The urban-rural air temperature differences are higher at night than during the day. Also, it emerges from the daytime image on that the city can hardly be discerned, in fact the warm areas are found over (semi-) natural features of the terrain rather than over the urban surfaces. During the night the situation is drastically different, as now the city can be identified in the air temperature patterns much better. It is also apparent that the Retiro Park centre of the black rectangle, exhibits lower air temperatures than the built-up areas surrounding it, in particular during night.



Madrid (left & center): The day-night temperature difference index (airborne measurement, DESIREX campaign, summer 2008) was transformed in a user-friendly map based on a standardized building energy efficiency classification (‘A’/B can be considered as a Very Efficient building and ‘G’/F Less Efficient). **Brussels (right):** An airborne “thermo-campaign” was conducted to highlight the abundant heat losses of buildings during winter (December 2008). Coloured thermal images of roof (blue: good roof isolation; red: bad roof isolation) were produced. Information was delivered on the internet to make the inhabitants aware of their own roof losses and stimulate a general energy-reflex during the management and renovation of buildings. Buildings are responsible for 70% of the total energy consumption of the Region (40% residential and 30% services).

2009/2010 (May to September) period over the 10 cities (day & night).

- Historical set of AT products (1 km) covering 2007-2009 (May to September) period over the ten cities (1 / hour).
- Historical monthly risk of UHI waves (1 km) (2007-2009 period) based on historical AT products and population vulnerability for two cities (Athens, Madrid). Population vulnerability was estimated considering population density, population age and percentage of the population living in non-proper houses.
- Forecasted AT, thermal indices and UHI intensity and risk maps (250 m) covering summer 2010 (July or August) over 6 cities: Athens, Bari, Lisbon, Madrid, Seville, Thessaloniki.

• *High resolution products:*

- Historical LST and AT (90/120 m) distributed in the summer period for 2003 & 2006 to 2010 over the ten cities, according to ASTER and Landsat image availability.

• *Airborne thermographic products:*

- Generated for Madrid and Brussels from specific campaigns, to produce “efficiency maps” during the summer period (Madrid) and winter period (Brussels).

Outcome 2: Increase of user awareness on EO applications for thermal monitoring, on their advantages and benefits to support institutional and technical tasks as well as policy obligations.

Outcome 3: Definition of high level mission requirements for UHI monitoring and of a set of observation scenarios as a contribution to the design of a dedicated high spatial resolution TIR sensor (re-orientation of the EW Fuegosat Mission).

Project website

<http://www.urbanheatisland.info/>

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Urban climate issues aired at International Congress of Biometeorology



The city of Auckland, New Zealand provided the backdrop for ICB2011.

By David Pearlmutter

Biometeorology can be seen as the study of interactions between atmospheric processes and living organisms, including plants, animals and humans. Because these interactions are so fundamental to people's well-being and social sustainability, researchers in this field are increasingly occupied with the links between *climate* and *society* – processes which more than ever before play out in urban areas. And indeed, issues and concerns related to the climate of cities were on prominent display at the **19th International Congress of Biometeorology**, held at the University of Auckland, New Zealand on December 5-9, 2011.

Some of these issues arose in a series of plenary lectures, delivered by a diverse group of speakers from different realms of climatology. The first of these was **Tony McMichael**, who stressed that the challenge of climate change does not allow any discipline to operate on its own. This is because fields of study like bio-geography, epidemiology and bio-climatology, which are engaged with phenomena at different temporal and spatial or demographic scales, do in fact overlap – with the intersections occurring mainly at the community or local level. He identified an overarching realm of "cultural climatology," which seems to closely parallel the domain of urban

climatology and which set the stage for the conference theme of "**Climate and Society**."

In keeping with this theme, conference organizer **Glenn McGregor** emphasized in his plenary address that urbanization is a *social process* which leads to dramatic modifications of land use and land cover – and these modifications in turn cause changes in temperature and transfers of heat and moisture at local and sub-regional scales. He pointed out that while human activities, such as building in flood plains, can make societies more vulnerable to climatic stress, proactive urban planning decisions can make them more resilient. In this context, adaptation to global climate change is a problem which requires behavioral changes at a societal scale, and such changes are liable to strain the resources of many countries.

Illustrating the extent to which vulnerability to climate change, and particularly to extreme events, varies between societal groups, Prof. McGregor presented data from London heat waves in which nocturnal UHI intensities were as high as 7-8°C and excess mortality over a two-week heat wave period reached 60% in the 75+ age group. It was clear that heat vulnerability is based not only on exposure, but on sensitivity – which involves the social amplification of risk beyond the event itself, due to factors of age, income, health, ethnic background and housing type.

In another plenary lecture, **Lewis Ziska** addressed the multi-varied implications of climate change, including the response of plants to rising greenhouse gas concentrations. Here the climate of the city was used as a laboratory, with urbanization serving as a surrogate for a future scenario of increased temperatures and atmospheric CO₂. His findings suggest that allergen-producing plants such as ragweed may be expected to proliferate with a changing atmosphere, given that pollen counts were found to be elevated in an urban locale which had a longer growing season (milder winter), warmer temperatures and more carbon dioxide than the surrounding countryside.



gies for urban heat island mitigation. The past and future heat island of London was the focus of a study presented by **Jennifer Salmund**, in which numerical mesoscale modeling coupled with a sophisticated urban canopy scheme was used to simulate the climatic impact of changes in urban land cover between 1800 and 2050. She emphasized the study's conclusion that the densification of urban construction, with its attendant substitution of vegetated terrain with buildings and paved surfaces, has a more pronounced effect on near-surface temperatures than does the geographical expansion of the urbanized area. Results also indicated that ongoing urban development can be expected to further elevate temperatures in the future, in both daytime and night time hours.

The spatio-temporal variability of urban heat islands was also addressed by **Ahmed Balugun** in a study of Akure, Nigeria. The peak UHI magnitude was found during evening hours, generally increasing in the dry season, and temperatures were highest in the city's Central Business District with a clear linear relationship between UHI intensity and sky view factor. Intra-urban variations were also identified with respect to other site factors, such as vegetation type in green spaces. The subject of tree-planting provided fertile ground for another talk by Balugun, on efforts to adapt the local university campus in Akure to the warming effects of climate change – with a proposal for the addition 2500 new roadside trees along pedestrian routes. He also presented findings of a study on carbon monoxide in the city center, showing that average



Four full sessions of the conference were devoted to the built environment, and among the presenters were a number of familiar faces from IAUC. **Andres Christen** showed results of a bottom-up modeling study of urban anthropogenic heat fluxes, associated with buildings, transport and metabolism. Assuming that net storage heat fluxes are negligible over a yearly cycle, and thus the residual in the energy balance could be attributed solely to anthropogenic heat, he found a good correspondence between model results and three years' worth of energy-balance measurements in Vancouver which were used to validate the modeling approach.

Matthias Roth also presented research findings on anthropogenic heat, in this case for the heavily air-conditioned tropical city of Singapore. He stressed that while heat fluxes from vehicles, buildings and people are sometimes seen to make a small relative contribution to the urban energy balance, anthropogenic heat in densely-populated city centers can in fact be a major component (reaching as high as 1,500 W/m² in a single grid cell in Tokyo). His findings in Singapore indicated that 80% of all anthropogenic heat in the commercial district was attributable to buildings, and even in residential districts this proportion was a formidable 50% – in both cases, mainly due to space cooling.

The positive feedback between the growing use of air-conditioning, with its considerable production of waste heat, and the growing need for air-conditioning in urban areas that are undergoing warming trends, is thus being recognized as an important process to consider when formulating strate-



concentrations exceed recommended levels every day of the week except Sunday, when urban activity is restrained.

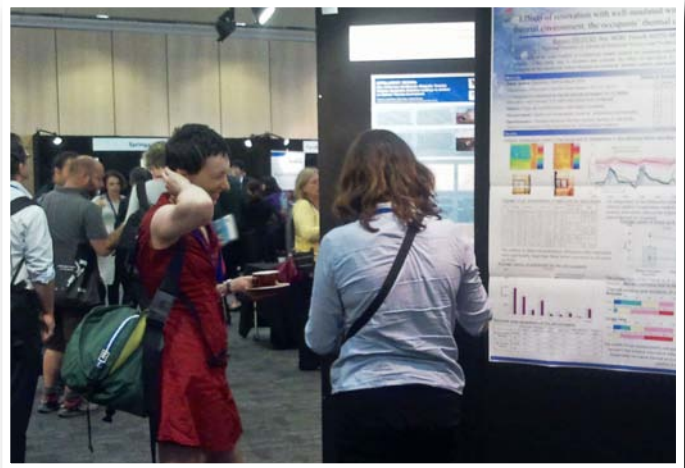
Strategies for urban cooling based on vegetation were also examined in Australia, as reported by **Andrew Coutts**. He described Water Sensitive Urban Design (WSUD) approaches which are being tested at a variety of scales, ranging from succulent-covered green roofs to street trees and public landscape irrigation based on the reintegration of stormwater. The effectiveness of these micro- to local-scale urban treatments is being evaluated by assessing their energy balance, with indications that even drought-resistant vegetation can significantly reduce roof cavity temperatures (at the household scale) and mean radiant temperatures (at the neighborhood scale). Stormwater integration and its climatic benefits was also the topic of a study presented by **Ashley Broadbent** on the Mawson Lakes project in Australia.

Various aspects of the UHI and potential for its mitigation were addressed by a variety of additional speakers, including **Atsumasa Yoshida** (on the use of wood-based cladding) and **Futoshi Matsumoto** (on the effects of wind and heat capacity on urban-rural temperature differences), and the



climatology of individual buildings was discussed by **Masatoshi Tanaka** (on the winter thermal performance of houses in Fukushima, Japan), **Luca Quaglia** (on air-tightness trends in New Zealand homes) and **Sankar Sambandam** (on the use of biomass cook stoves in rural households of southern India). Health threats related to building design were addressed in a different context by **Wendy Marie Thomas** in a study on the susceptibility of hospitals to climatic disasters, and policy for climatic responsiveness was also the underlying theme of a talk by **Melissa Hart** on the development of TMY data for building energy simulation under current and future climate scenarios.

Beyond the sessions that were specifically devoted to the built environment, a number of themes were covered that also bear heavily on urban climate. **Donna Hartz**, for example, looked at the hazards of urban heat stress, and found dramatic differences in adaptation between residents in the cities of Phoenix and Chicago. The discussion of indices for gauging thermal stress, which is central to biometeorology, was a recurring theme throughout the conference. Measures such as the WBGT and UTCI, and particularly their calculation from weather station data, were considered in a series of sessions on heat exposure and "Climate impacts on working people in hot climates." **Jennifer Vanos** used the COMFA outdoor energy budget model to test predicted sweat rates and



core temperatures of athletes under extreme heat stress, and found the accuracy of predictions to be highly sensitive to variations in wind speed. Finally, the Index of Thermal Stress (ITS) was compared by **yours truly** with the more familiar PET and shown to be an effective predictor of pedestrian thermal sensation in hot-arid cities.

The latter was part of a session on "Bioclimatic assessment," which also featured two presentations related to the local climate of Auckland. **Nick Talbot** presented an investigation of "brown haze" events, which provide a visual cue that even a land as unspoiled as New Zealand suffers from urban air pollution (and increasingly so under cool, humid and calm conditions). Auckland's air quality concerns were underscored by **Kim Dirks**, who examined NO₂ levels in geographically diverse parts of the city and their relation to climate and air flow. In her talk she made it clear that the source of these pollutants is no secret: with nearly 600 vehicles for every 1,000 residents, Aucklanders have the dubious distinction of owning more cars per capita than any other urbanites on the planet.

The Auckland City Council appears to have resolved, albeit belatedly, to reverse this trend by investing in public transit. One can only hope that this, and other signs of awareness to the environmental threats facing New Zealand, will help preserve the unique natural qualities of this island nation 'at the end of the world' – leaving future visitors with an impression as indelible as the one left on me.



The Croucher Advanced Study Institute on Urban Climatology in Tropical and Sub-tropical Regions – Hong Kong, December 5-10, 2011



By Evyatar Erell and Chao Ren

The Croucher Advanced Study Institute (ASI) 2011-2012 on Urban Climatology for Tropical and Sub-Tropical Regions took place at the School of Architecture of The Chinese University of Hong Kong on December 5-10, 2011. Organized by a committee led by **Prof. Edward Ng**, it sought to bring together climatologists, meteorologists, environmental scientists, geo-scientists, wind engineers, architects, urban planners, design professionals and advanced postgraduates to review recent advances in climatology and its application in urban design and planning; to explore new concepts and techniques for modelling and analyzing biometeorology, focusing on the impact of urban climate on human comfort and public health; and to address the issues of climate change and air pollution. Given the interdisciplinary nature of the urban climate issue and with an aim of bridging scientific research and application for planning practice, three linked programmes of ASI brought together over 150 participants from diverse academic disciplines.

The well-organized lectures and discussions covered a broad range of topics from many scientific disciplines, some of which have very little in common in terms of methodology or subject matter, so it is tempting to say that they were 'like trains passing in the dark'. Yet the ASI programme organizers evidently believed that in spite of their different backgrounds and interests, each of the lecturers could inform the discussion on urban climatology in a meaningful way and contribute to our under-

standing of climate-related aspects of urban planning and urban design.

There is perhaps one unifying theme to all of these diverse lectures, and one that makes it all the more important to try and seek some common ground among them, and that is *complexity*. Not just complexity in the sense that the term is often used to describe scientific problems that require many factors to be resolved, which may be inter-related and which have multiple interactions. Such problems, though difficult to solve, are framed within one 'grand scheme of things'. They lend themselves to solution by conventional scientific methods if only enough time, effort and the necessary tools are applied.

Planners, unlike the research community, are often required to digest information from several 'universes', which though not parallel – they may intersect and have effects upon others – are impossible to resolve systematically into one coherent structure. They often have to deal with so-called 'wicked problems' (problems that are difficult or impossible to solve because of incomplete, contradictory and changing requirements that are often difficult to recognize), and choose a design that balances environmental, social and economic needs. Climate considerations are easily neglected. So, while many of the speakers at the symposium are not likely to have gained significant insights likely to further their own specialized research, it is hoped that they gained a better understanding of its impacts in other fields, particularly its possible application in urban planning.

The following review will attempt to address this inherent complexity, relating to issues raised by the speakers as they described their own fields, as well as to potential interactions among them. It is divided into two sections – research and application. The classification of talks under these headings is to a certain extent arbitrary – all of them described research. However, some – as a reflection of the physical scale, methodology or intent – demonstrated a greater potential for application in urban planning than others.

Climate Research

Most of the talks described models - as tools for understanding and describing physical phenomena and for predicting the behaviour of the relevant systems in given conditions. As the week progressed, it became clear that even though most of the models dealt with the atmosphere, there were significant differences among them, relating to primarily to discipline but also to spatial scale, temporal scale, processes described and complexity.

Complexity of models

Several speakers focused on the benefits of modeling complex processes involving different mechanisms in combination, at different scales. **Prof. Grimmond's** talk on "Lessons learnt from Urban Energy Balance Models Evaluations" showed that various models of the urban surface differed from one another in their ability to reproduce accurately different fluxes such as net radiation, sensible heat and latent. Although some models were clearly better than others, none of the models in her study were superior in all aspects, and many showed a strong inverse relationship between the quality of predictions of different fluxes. It was noted that although the models differed in the amount of detail required to operate them, introducing more detail to some of them did not necessarily result in better performance. It was emphasized, however, that ultimately models must be able to reproduce correctly all of the fluxes. In particular, the importance of describing the surface hydrological balance was highlighted.

Prof. Pleim's talk on "Two-way Coupled WRF-CMAQ Modeling for Hemispheric to Mesoscale to Urban Scale Air Quality Modeling" demonstrated the importance of carrying out a combined analysis of air quality and weather conditions in the study of air pollution episodes. The advantages of two-way coupled modeling over traditional sequential meteorology and air quality model systems include: more efficient frequent data exchange for high resolution (down to 1 km grid cell size) simulations that are needed for urban-scale modeling studies; it includes feedback of gases and aerosols from CMAQ to WRF where they can affect radiation and microphysics processes; and it allows for more integrated treatment of chemical and physical processes.



Spatial scale of models

Current modelling of climate typically focuses on distinct scales, mostly limited by the computing resources available to the modellers, but also by the availability of data at the level of detail required to drive the models. Although both limitations are gradually being overcome, there is still much to be gained from analysis of the results generated by one type of model by means of models at finer scales. **Dr. Ching's** talk on "Fine scale meteorology and air quality models as urban forecasting, planning and assessment tools" emphasized the importance of selecting a model best suited to the problem at hand, especially with respect to the spatial scale of the investigation. The talk reviewed current understanding of grid size dependent model issues, emerging new urban canopy physics parameterizations and the specialized data inputs for fine grid mesh meso-scale and urban scale simulations.

The benefits of examining results of global models on a regional scale were illustrated in **Prof. Bornstein's** first talk on "Tropical and Subtropical Urban Boundary layers in a Changing Climate," which dealt with observational studies. He showed that although global climate change models predict widespread warming, some locations will actually experience net cooling. Thus, analyzing changes to the patterns of sea breezes in the Los Angeles Basin is critical if we are to understand trends in air temperature recorded at various locations in the region.

Another example of the necessity to integrate models at different scales was shown by **Prof. Fung** in his talk on "Air Pollution and Wind in the Urban Environment." Several modelling studies showed that recent trends in Hong Kong could only be understood in the context of the urbanization of the neighbouring Pearl River Delta of China.

Similarly, meso-scale models are incapable of resolving micro-scale intra-urban variations that are observed over distances as small as several hundred meters – even as urbanized versions of WRF, employing methods such as Martilli's scheme, attempt to introduce ever finer lev-

els of detail to the vertical transfer processes. Thus, there remains a need to nest models of specific urban features, such as street canyons or even individual buildings, into atmospheric models of ever-increasing spatial scale.

Temporal scale of models

Most of the models presented during the workshop were designed to allow detailed study of weather episodes of limited duration, such as intense thunderstorm activity or release of pollutants from a point source into the urban atmosphere. As Prof. Bornstein illustrated in the second part of his talk on "Tropical and Subtropical Urban Boundary layers in a Changing Climate," such models, once calibrated, may provide better understanding of the effect of cities on airflow, taking into account the often opposing effects of increased drag and thermal gradients.

Unlike academic research, where much may be learned from focused study on individual, short-lived episodes of interest, planning applications usually refer to 'design day' conditions and to 'typical meteorological years'. Whereas the former term refers to extreme conditions of, e.g. precipitation, occurring at return periods of 30 years or more, the latter term refers to single-year files that do not represent a specific year of contiguous measured data but rather are composite years comprising months of measured data from different years, selected using statistical criteria to represent typical average weather data and not long-term extremes.

To allow adaptation to changing environments throughout the expected service life of buildings or urban infrastructure, local-scale data of both types need to reflect the combined effect of predicted global climate change and urbanization. During the discussions, it became apparent that the typical approach so far has been to aggregate the effects, without sufficient regard for either spatial variations within the global models (which suffer from even greater uncertainty than global estimates); or for the temporal characteristics of extreme weather events such as heat waves – which may or may not be in sync with urban scale effects such as the urban heat island.

The World Meteorological Organization has recognized this problem, and, as **Dr. Kollu** noted in his talk, it has decided to establish a new *Global Framework for Climate Services (GFCS)* with the goal to: "Enable better management of the risks of climate variability and change and adaptation to climate change at all levels, through development and incorporation of science-based climate information and prediction into planning, policy and practice". The GFCS is expected to help the global community better adapt to the challenges of climate variability and change and bridge the gap between the climate information being developed by climate scientists and service providers on one hand and



the practical needs of information users in many climate sensitive sectors of society on the other.

Application of climate research in planning

As noted in the introduction to this review, our ability to describe, model and understand the urban atmosphere is not, by itself, sufficient to guide the planning of cities so as to ensure effective response to climate.

The planning process

Establishing a scientific basis for climate-based planning and design will require that we know a great deal more on the places where most people live than is currently the case. **Prof. Mills'** talk on "Climate Change and the Geography of Cities" noted that although both the form and the function of cities show considerable variation in space and time, within and among cities, when the contributions of all the cities globally are taken into account, the urban effect is global. It is thus important that policies based upon global-scale considerations take into account the urban-scale context where those policies are enacted.

Of particular importance in this context is the fact that much of the urban growth observed world wide in recent years has been in tropical cities, a trend likely to be reinforced as South Asia and Africa undergo extensive urbanization. A growing number of the world's largest cities are now located tropical and sub-tropical regions – yet we know even less about them than we know about mid-latitude cities. **Prof. Roth's** presentation on "Urban Climate and the (Sub)Tropical City" gave a brief overview of the current understanding of climates in low-latitude cities, comparing their energy balance, heat island and carbon with data from temperate climate cities. Although the lack of sufficient data from tropical cities was noted almost 30 years ago, and led to the initiation of the Tropical Urban Climate Experiment (TRUCE) in 1989, much of the work until recently has been of a descriptive nature, with insufficient emphasis on the underlying physical

processes typical of these climates. This gap is now being bridged by some pioneering and comprehensive studies, especially in Singapore and Hong Kong.

Cities are in fact extremely varied environments. As **Dr. Stewart** noted, they typically comprise numerous different types of land use, whose physical characteristics may change with time. Our understanding of the urban atmosphere may be improved by systematic investigation and classification of this diversity, but there remains a need for an effective means of communication between climatologists and planners to assist in formulating planning policies. **Prof. Kätzner's** talk on "Urban Climate under the Perspective of Global Warming" presented such a tool: a system for mapping and analysis of microclimates and application of the results in the planning process. A primary objective of this tool is to provide very detailed spatial analysis of multiple parameters that cannot be generated by meso-scale descriptions of the same urban regions, by means of maps and graphical means of communication. Since most current climate change studies focus on the global scale, it is often difficult to generate appropriate strategies for adaptation and mitigation at the urban level. Downscaling is required to provide urban planners with the tools they need to make informed decisions at this scale.

Progressing from the urban or 'planning' scale, city development also needs tools suitable for analysis of the environment at the scale of individual buildings, or even of pedestrians. The application of such models, separately and in combination, was demonstrated in **Prof. Erell's** talk on "Implementing Urban Climatology in the 'Real World' - Theory and Practice." The talk showed the effect of using site-specific weather data to estimate building energy performance, taking into account the complex inter-actions among buildings at different urban densities. It also investigated the effect of strategies for modifying existing urban climates, such as application of high-albedo materials and increased vegetation, and argued that although both strategies may be beneficial, their main effect in warm climates is to modify the radiant field rather than air temperature.

As architects and designers are well-aware, description of the existing environment and identification of problems are essential stages in the planning process – but they do not of themselves indicate what the desired outcomes should be. Is there an 'ideal' or 'optimum' outdoor space, for example, and how might it be defined? **Prof. Steemers'** talk on "Outdoor Comfort in the Urban Environment" sought to describe the parameters that influence user comfort and to propose design strategies that provide an acceptable level of comfort for outdoor spaces that take on a more natural, human scale and environmentally sustainable form. He suggested that the most successful urban spaces are those that encompass



the greatest variety and diversity of environmental conditions. Such diversity – in the exposure to sky, sun and wind - allows flexible use of urban open spaces throughout the year, and may provide comfortable conditions to individuals with very different thermal preferences.

Although the workshop focused primarily on the outdoor climate at various scales, it was also recognized that since outdoor conditions are modified through interaction with buildings, some attention must be paid to their properties as well. **Mr. Carrigan's** talk on "Sustainable Buildings: Developing Policies, Tools and Strategies" described the efforts of the United Nations Environment Program (UNEP) to reduce the negative impact of buildings on the environment. The Sustainable Buildings and Climate Initiative (UNEP-SBCI) has addressed this issue through the innovation of a global Common Carbon Metric (CCM), developed together with stakeholders in the building sector, which measures energy consumption and GHG emissions from building operations. The talk discussed the CCM and the other work of UNEP-SBCI to promote sustainable building policies and practices worldwide.

Thermal comfort in outdoor spaces

One of the outcomes of improved understanding of urban climate may be better-planned public open space that responds to the environmental conditions in a way that promotes human thermal comfort.

However, the notion of thermal comfort is, in reality, quite complex. As **Prof. de Dear** noted in his talk on "Thermal Comfort in the Urban Climatic Environment," it is not merely a question of specifying (arbitrary) limits on certain physical parameters, most obviously air temperature: there is no optimum condition that is suitable for all people, at all times. The talk, which gave an overview of human thermal comfort in general and of the challenges in applying such understanding in the context of outdoor space, dealt with a variety of questions, such as the physics and physiological underpinnings of thermal comfort in the indoor context; the psychological construct of comfort related to the physiologically regulated

heat balance of the human body; the formulation of this knowledge into numerical models of thermal physiology and comfort; and the expression of such models in thermal comfort standards. He also introduced the concept of alliesthesia, which pertains to the psychological aspects of our response to external stimuli from the environment.

Our understanding of human thermal comfort is based primarily on studies carried out indoors. However, building interiors differ from outdoor spaces not only in our ability to control the environment, but also in our ability to characterize it and describe it accurately. In particular, air speed varies over a much larger range, and the radiant field is far more complex and dynamic outdoors than indoors. **Prof. Mayer's** talk on "Lessons Learnt from Urban Human-Biometeorology of Urban Areas in Central Europe" provided an overview of the state-of-the-art urban human-biometeorology in outdoor environments. It described key questions to be asked, different investigation methods, presentation of results and application of such results in urban planning.

An important tool in the study of thermal comfort outdoors may be computational fluid dynamics (CFD). Uniquely among the available computer modeling tools, it may have the ability to describe with sufficient detail and accuracy all of the environmental factors that affect a person's comfort, inside buildings but also outdoors. **Prof. Mochida's** talk on "Analysis of Microclimate and Human Thermal Comfort in Urban Areas" demonstrated the application of CFD simulation to predict human thermal comfort outdoors, taking into account the various elements of complex urban locations such as buildings, vegetation and bodies of water. The simulation includes analysis of the three-dimensional turbulent airflow and heat transports around buildings, the effects of multiple reflections of short-wave and long-wave radiation and the contribution of evaporation.

Urban air quality

The processes that control dispersion in urban areas were reviewed in **Prof. Belcher's** talk on "Dispersion in Urban Areas." It showed how the main features of the dispersion can be captured using a simplified 'network model', in which the dispersion is treated as moving through the network of streets whilst being exchanged with the atmospheric boundary layer above.

The need for relatively simple, localized models was also highlighted in **Dr. Carruther's** talk on "Modelling Urban Air Quality using the Street Scale Resolution Atmospheric Dispersion Model ADMS-Urban." The talk showed that it was both necessary and possible to model air quality at extremely small scales, such as the vicinity of a busy highway, taking into account the effects of physical obstacles such as acoustic walls in models that are also nested in larger-scale frameworks.

Prof. Li's talk on "City Ventilation, Thermal Environment and Hong Kong" highlighted the difficulty of ensuring



sufficient ventilation in a compact high-rise city such as Hong Kong. The difficulty of the problem derives from the inter-related effects of mechanical and thermal effects, complicated by the complex structure of the city – both natural (topography) and man-made. Effective ventilation in such circumstances would require a better understanding of buoyancy ventilation at the urban scale than is currently available to planners. The talk also noted that as observed in other cities around the world, urbanization has resulted in a temperature increase in Hong Kong that is greater than the background global warming trend for the same period.

The need for more urban climate studies in high density cities, especially in the developing regions of Asia, Africa, and Latin America, was also highlighted in **Prof. Fung's** talk on "Air Pollution and Wind in Urban Environment." He showed his recent uMM5 CFD study results on the analysis of local thermal circulation of Pearl River Delta region, illustrating the impact of intensive urbanization and land use change on the development of the urban heat island, air pollution dispersion and the wind environment.

Cities and global climate change

Although none of the talks described directly the application of global circulation models to predict climate change – this was beyond the scope of the meeting – the effects of global heating on cities were alluded to in a number of presentations.

Prof. Kuttler's talk on the "Impact of Global Climate Change on Urban Air Constituents" provided an overview of the influence of increasing global temperature on the distribution and concentration of both gaseous and solid constituents of air at the urban scale (such as ozone and pollen), which harm human health directly or indirectly. Comparison of urban and rural data from Europe show that while ozone and pollen concentrations increase in a warmer CO₂ enriched urban climate, there is no clear relationship between higher temperatures and nitrogen dioxide and particulate matter concentrations. While trees are responsible for emission of some pollutants into the urban

atmosphere, negative effects may be minimized through selection of trees that emit fewer VOCs and release less pollen: A list of suitable species native to Central Europe has been produced, but it must be extended to include trees in other locations.

Prof. Rosenthal's talk on "Creating Climate Resilient and Healthy Communities" presented findings on increased rates of mortality and morbidity due to summertime heat, which are a significant problem for many cities around the world and are expected to increase with a warming climate. The talk highlighted the fact that although all populations may be at increased risk because of greater heat exposure (for example, due to the urban heat island) – data show that in fact specific communities are at a far greater risk than others, as a result of demographic, social or medical factors.

Since a growing proportion of humanity now lives in cities, adaptation to global climate change will have to encompass strategies that affect the urban environment. **Prof. Akbari's** talk on "Cool Buildings and Cool Pavements, Cool Cities, and Cool Globe" explored the benefits of high-albedo materials, not only in reducing building energy consumption but as a means of reducing urban air temperature and, ultimately, even global heating. The presentation showed examples of recent progress in the development of wavelength-selective paints for pitched roofs, and described methodologies for estimating the potential effect of widespread application of such materials on the urban energy balance.

Conclusion

Researchers are developing a better understanding of urban climate phenomena. However, although results are becoming increasingly accurate and detailed, we are still lagging in our ability to integrate and display this knowledge in ways that are meaningful to planners and policy makers: Information must be provided at the appropriate scale and should be simple enough to guide their decisions, yet comprehensive and capable of dealing with the inherent complexity of real life, as experienced in their professional practice.

It is nevertheless satisfying to note that several cities

have already incorporated climate analysis into their planning framework. A recent example from Hong Kong, as shown to participants of the workshop at the Hong Kong Planning and Infrastructure Exhibition Gallery, is particularly inspiring: Plans for redevelopment of the now vacant site of the city's old airport, at Kai Tak, were modified extensively to allow better penetration of the sea breeze to improve ventilation not only within the project, but also in adjacent areas that will be affected by the proposed construction. The changes, which include a very substantial reduction in the number of buildings planned and in their massing and alignment with respect to prevailing winds, were made in response to Air Ventilation Assessment (AVA) studies carried out by a team of urban climatologists led by the host of the workshop, **Prof. Edward Ng**. Hong Kong has also carried out a systematic study of the microclimate in the city as a whole. Results of the "Urban Climatic Map and Standards for Wind Environment – Feasibility Study" are applied to inform the decision making process at the local planning level, with the aim of improving the thermal quality of outdoor spaces and of reducing heat stress.

In the closing discussion, participants also noted that there is a great need of urban climatic education, especially for the postgraduate students with architecture and urban planning background. With growing public concerns on the effects of climate change and global warming, discussion and exchanges among different parties should be encouraged.

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In this edition a list of publications that have come out until November 2011 are presented. As usual, papers published since February 2012 are welcome for inclusion in the next newsletter and IAUC online database. 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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ICUC8 Status: A first look at the submission of abstracts

Notice: The final deadline for abstracts has been extended to January 20, 2012

The December 31, 2011 closing date for the receipt of abstracts has passed and this is a short report on the status of the conference. Altogether there are 438 completed abstracts and 49 abstracts that are incomplete - some of the latter may be in error as there are some duplicates. Fifty-one countries are represented and the following table lists these in terms of unique users. The top five countries represented are Japan, Germany, UK, USA and France ([Table 1](#) – see page 39). These numbers are very good and will ensure a vibrant event in Dublin during August 2012.

[Table 2](#) (p. 39) presents the unique abstracts categorised according to the dominant theme or methodology by the primary author. You will see that the

overall breakdown is 3.5:1 in terms of preference for an oral over a poster presentation. The concentration of papers in certain areas is evident, most notably: Urban Heat Islands (50), urban design & planning (46), thermal comfort and stress (30) and climate change (30). Obviously many of these categories overlap with one another, but the purpose of the ICUC events that incorporates both the science of the urban climate effect and its application to the better design of urban places is plainly covered.

The organizing committee has decided to extend the abstract deadline to **January 20th** to allow the opportunity to address any gaps in the overall programme. We are currently in the process of establishing a scientific review committee to assess the abstracts received for acceptance at ICUC8. Once accepted the authors will be asked to register for the event and to complete a paper for the conference proceedings.

I would like to thank all those that submitted an abstract for ICUC8.

– Gerald Mills, ICUC8 Chair

Upcoming Conferences...

SOUTH ASIAN CITIES – COPING WITH FUTURE ENVIRONMENTAL CHANGES, session at AAG 2012

New York, NY • February 24-28, 2012

<http://www.aag.org/annualmeeting>

URBAN AREAS: IMPACT OF EXTREME WEATHER EVENTS, session at AAG 2012

New York, NY • February 24-28, 2012

<http://www.aag.org/annualmeeting>

8TH INTERNATIONAL CONFERENCE ON AIR QUALITY – SCIENCE AND APPLICATION

Athens, Greece • March 19-23, 2012

<http://www.airqualityconference.org>

MEDIATING CLIMATE CHANGE IN THE CITY: EXPERIMENTING WITH URBAN RESPONSES

Durham University • March 19-23, 2012

<http://www.ugec.org>

Recent publications from previous conferences...

PAPER PROCEEDINGS FROM THE CITY WEATHERS WORKSHOP IN MANCHESTER, JUNE 2011

<http://www.sed.manchester.ac.uk/architecture/research/csud/workshop/proceedings.htm>

FIRST INTERNATIONAL CONFERENCE ON BUILDING SUSTAINABILITY ASSESSMENT

Porto, Portugal • May 23-25, 2012

<http://www.bsa2012.org>

THE 2ND URBAN ENVIRONMENTAL POLLUTION CONFERENCE (UEP)

Amsterdam, The Netherlands • June 17-20, 2012

<http://www.uepconference.com/>

THE 8TH INTERNATIONAL CONFERENCE ON URBAN CLIMATE (ICUC8)

Dublin, Ireland • August 6-10, 2012

<http://www.icuc8.org>

ENGINEERING LIFE QUALITY FOR THE FUTURE: Demographic and Climate Challenges in the City

Aachen University, Germany • April 18-20, 2012

<http://www.humtec.rwth-aachen.de/city2020>

LOW CARBON CITIES (45TH ISOCARP WORLD CONGRESS IN PORTO, OCTOBER 2009)

<http://www.sciencedirect.com/science/issue/271784-1-s2.0-S0264275111X00069>

IAUC Board Elections 2011: Meet the new members

The election to select two new IAUC Board members was recently concluded. The following were elected to the Board of the IAUC for a 4-year period starting with effect from October 2011:

Hiroyuki Kusaka (University of Tsukuba, Japan)

David Sailor (Portland State University, USA)

Hiroyuki and David will replace Toshiaki Ichinose (National Institute for Environmental Studies, Japan)

and Petra Klein (University of Oklahoma, USA) whose terms have come to an end. The Board would like to take this opportunity to thank Toshiaki and Petra for their many contributions to the IAUC. The Board would also like to thank all the other candidates who generously agreed to stand for this position. Pen portraits of new Board members follow.

– Rohinton Emmanuel, IAUC Secretary

Hiroyuki Kusaka is as an associate professor at the University of Tsukuba, Japan. Prior to coming to this University, he served as a research scientist at the Central Research Institute of Electric Power Industry in Japan. His research interests include urban climatology and numerical modeling, as well as local-scale processes such as thermal convection and fog formation. One of his major works is the development of an urban canopy model (UCM). The UCM has been integrated into the Weather Research and Forecasting Models, and has contributed to a greater understanding of urban landscape impacts on local weather and climate systems. More recently, his interest expanded to climate change assessment for urban areas and the development of LES models for urban meteorology, and he has won a number of competitive research grants in these areas. He has an extensive publication record in these research areas, including contributions to five textbooks. Professor Kusaka currently supervises 15 graduate students and four undergraduate students, and remains passionate in educating young scientists.



David Sailor received his Ph.D. in 1993 from the University of California at Berkeley. While there he conducted research as part of the Energy and Environment Division at Lawrence Berkeley National Laboratory. His early research focused on mesoscale atmospheric modeling of urban areas with an emphasis on heat island mitigation strategies. After 10 years on the Engineering faculty at Tulane University he moved to Portland State University, where he became founding director of the Green Building Research Laboratory (GBRL). The GBRL research portfolio focuses on sustainability solutions in the built environment with an emphasis on building energy efficiency and energy and urban climate interactions. Dr. Sailor's personal research is in the general field of "energy and the urban environment," with applications in air quality, human health, and energy supply and demand. This research encompasses scales ranging from energy analysis of individual buildings to measurements and modeling of the urban climate system.

ICUC8 Status (continued from page 37)

Table 1: Delegates and the country of origin

Country	Number	Country	Number
Japan	55	Iran	9
Germany	32	Russia	9
UK	27	Sweden	9
USA	27	Korea	8
France	24	Portugal	8
China	21	Finland	7
Hong Kong	18	Singapore	7
Brazil	14	Switzerland	7
Australia	13	Hungary	6
Canada	12	India	6
Canada	12	Malaysia	6
Nigeria	12	The	
Poland	11	Netherlands	6
Spain	11	Italy	5

Table 2: Abstracts by Topic/Method

Topic/Method	Oral	Poster
Air quality	14	8
Biometeorology	6	6
Building climates	9	9
Climate change	30	7
Energy fluxes	12	2
Forecasting urban weather	6	11
Instrumental observations	16	1
Landscaping	10	6
Numerical modelling	35	8
Other	19	6
Physical modelling	6	1
Precipitation, humidity, dew, etc.	5	2
Remote Sensing	12	8
Thermal comfort & stress	30	6
Topoclimatology	2	0
Urban design & planning	46	5
Urban effect	24	9
Urban Heat Island	50	13
Water budget	2	0
Total	350	103

Board Members & Terms

- Tim Oke (University of British Columbia, Canada): President, 2000-2003; Past President, 2003-2006; Emeritus President 2007-2009*
 - Sue Grimmond (King's College London, UK): 2000-2003; President, 2003-2007; Past President, 2007-2009*
 - Matthias Roth (National University of Singapore, Singapore): 2000-2003; Secretary, 2003-2007; Acting-Treasurer 2006; President, 2007-2009; Past-President 2009-2011*
 - Gerald Mills (UCD, Dublin, Ireland): 2007-2011; President, 2009-2011
 - Jennifer Salmond (University of Birmingham, UK): 2005-2009; Secretary, 2007-2009
 - James Voogt (University of Western Ontario, Canada), 2000-2006; Webmaster 2007-2009; 2009-2013
 - Manabu Kanda (Tokyo Institute of Technology, Japan): 2005-2009, ICUC-7 Local Organizer, 2007-2009.*
 - Sofia Thorsson (University of Gothenburg, Sweden): 2008-2012
 - Rohinton Emmanuel (Glasgow Caledonian University, UK): 2006-2010; Secretary, 2009-2011
 - Jason Ching (EPA Atmospheric Modelling & Analysis Division, USA): 2009-2013
 - David Pearlmutter (Ben-Gurion University of the Negev, Israel): Newsletter Editor, 2009-*
 - Alberto Martilli (CIEMAT, Spain), 2010-2014
 - Aude Lemonsu (CNRS/Meteo France), 2010-2014
 - Silvana di Sabatino (Univ. of Salento, Italy), 2010-2014
 - Hiroyuki Kusaka (University of Tsukuba, Japan): 2011-2015
 - David Sailor (Portland State University, USA): 2011-2015
- * appointed members

IAUC Committee Chairs

Editor, IAUC Newsletter: David Pearlmutter
 Bibliography Committee: Julia Hidalgo
 Nominating Committee: Tim Oke
 Chair Teaching Resources: Gerald Mills
 Interim-Chair Awards Committee: Jennifer Salmond
 WebMaster: James Voogt

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 (wchow@asu.edu)

Conferences: Jamie Voogt (javoogt@uwo.ca)

Bibliography: Julia Hidalgo (julia.hidalgo@ymail.com)

Projects: Sue Grimmond (Sue.Grimmond@kcl.ac.uk)

Submissions should be concise, written in a manner that is accessible to a wide audience, and incorporate figures and photographs. The articles in this Newsletter are unrefereed, and their appearance does not constitute formal publication; they should not be used or cited otherwise.