

## From the IAUC President



This edition of the newsletter is published on the eve of the 7th International Conference for Urban Climate (ICUC-7) taking place in Yokohama (Japan). A number of important announcements will be made during the conference which are also featured in the present issue. Firstly, the **Bibliography on Urban and Building Climatology** is now available as a searchable on-line database on the IAUC website (see details on p. 28). The hosting of this website has been made possible with funds from the WMO, which is gratefully acknowledged.

A second exciting initiative is the creation of a new **Urban Flux Network** database. The aim of this database, which is also maintained by IAUC, is to collect and share information about micrometeorological tower sites in cities (see details on p. 31). I would like to take this opportunity to thank Julia Hidalgo (LBEIN-Tecnalia, Spain) and Andreas Christen (University of British Columbia, Canada) for their great effort in establishing the bibliography and urban flux network databases/websites, respectively. I have no doubt that they will become very important and useful resources for the urban climate community. I invite everyone to browse these websites which are accessible through <http://www.urban-climate.org/>.

The feature and urban project reports included in the present issue are a good example of the global geographic reach of our members. The **Feature** article presents original research on the urban climate of tropical Rio de Janeiro (Brazil) and is contributed by Edson P. Marques Filho and colleagues. The **Urban Project** reports introduce the DESIREX campaign which was carried out in the summer of 2008 in Madrid (Spain), describe the use of ENVI-met in the German KLIMES project, and report on flash-floods in the cross-border town of El Paso-Juárez (USA/

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Mexico), respectively. Finally, a **summary report** contributed by newsletter editor David Pearlmutter gives an excellent indication of the breadth of news, features, projects, reports and bibliography listings in this newsletter published over the past 18 months.

I hope that you enjoy reading this newsletter, and would like to take this opportunity to call on all members to consider submitting an article, short research report, urban climate news item, conference report or similar contribution for publication either directly to David (at [davidp@bgu.ac.il](mailto:davidp@bgu.ac.il)) or to the respective sub-editors.

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## Urban centers with most polluted air: Northeast of Barcelona, southeast of Madrid

April, 2009 — During the summer, the region of the Mediterranean basin where Spain is found frequently experiences high levels of chemical pollutants in the air. Catalan researchers have studied the contribution of atmospheric processes during the hottest months of the year and have concluded that the areas leeward of Barcelona and Madrid have the poorest air quality levels.

To determine the most polluted areas of north-east and central Spain in summer, a team of researchers from the Universidad Politécnica de Cataluña (Polytechnic University of Catalonia) (UPC) and the Barcelona Supercomputing Centre (BSC) has quantified with great precision the atmospheric processes that contribute to the concentration of pollutants.

"The worst air quality levels are observed in areas leeward of Barcelona and Madrid, due to the plume of urban contamination that affects the south-south-east region of Madrid and north-north-east of Barcelona," María Gonçalves, principal author of the study and researcher at BSC, explains.

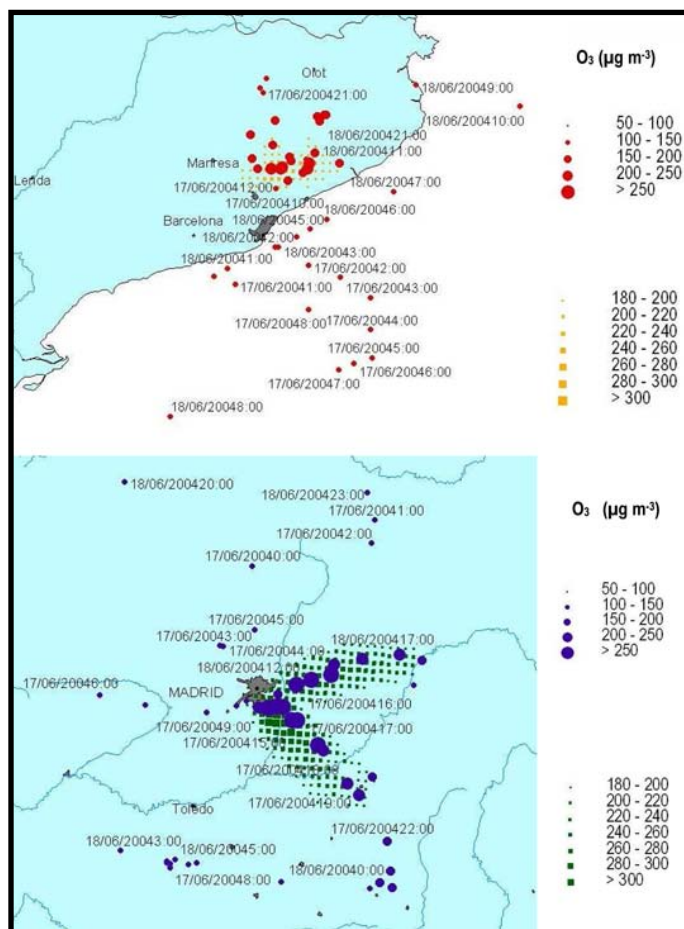
The work, led by José María Baldasano and Pedro Jiménez of BSC and recently published in *Atmospheric Chemistry and Physics*, has been centred around Catalonia and the Autonomous Community of Madrid as they are home to the two most populated cities, Barcelona and Madrid, "where episodes of atmospheric contamination are frequent," the scientist adds.

On June 17-18, 2004, the researchers selected one of the most acute episodes of photochemical contamination in these areas: a meteorological phenomenon "which occurs in 78% of cases in the summer," the researcher emphasizes.

Atmospheric contamination mainly comes from emissions derived from urban activities, particularly traffic, "although industrial emission points or activities carried out at the port, especially in Barcelona, cannot be discounted," Gonçalves stresses.

### How are pollutants dispersed?

In the centre and north east of Spain there are different methods for the dispersion of pollutants. In the coastal area of Barcelona, the nature of the breezes and the complex topography create layers of elevated contamination, which, during the night,



Ozone concentrations in the vicinity of Barcelona (top) and Madrid (bottom). Source: <http://www.alphagalileo.org>

"can act as a reserve of pollutants over the Mediterranean area," the chemical engineer points out.

In the case of Madrid, which is more continental, transport is dominated by "the formation of a convection cell" – a bubble created by the rise and fall of air due to temperature differences – caused by surface heating. The nitrogen oxides emitted in urban areas and by the road network "are transported leeward where they undergo a chemical reaction or are deposited at surface level," states Gonçalves.

During the days observed, the two cities exhibited high concentration levels of dust particles (PM<sub>10</sub>) and nitrogen dioxide (NO<sub>2</sub>) above the urban area. "During the selected episode, higher concentrations of ozone (O<sub>3</sub>) were observed over Madrid and higher levels of NO<sub>2</sub> and PM<sub>10</sub> in Barcelona," the researcher reports.

Source: <http://www.alphagalileo.org/ViewItem.aspx?ItemId=56976&CultureCode=en>

## China vies to be world's leader in electric cars – to reduce urban pollution

April, 2009 — Chinese leaders have adopted a plan aimed at turning the country into one of the leading producers of hybrid and all-electric vehicles within three years, and making it the world leader in electric cars and buses after that.

To some extent, China is making a virtue of a liability. It is behind the United States, Japan and other countries when it comes to making gas-powered vehicles, but by skipping the current technology, China hopes to get a jump on the next.

Japan is the market leader in hybrids today, which run on both electricity and gasoline, with cars like the Toyota Prius and Honda Insight. The United States has been a laggard in alternative vehicles. G.M.'s plug-in hybrid Chevrolet Volt is scheduled to go on sale next year, and will be assembled in Michigan using rechargeable batteries imported from LG in South Korea.

China's intention, in addition to creating a world-leading industry that will produce jobs and exports, is to reduce urban pollution and decrease its dependence on oil, which comes from the Mideast and travels over sea routes controlled by the United States Navy.

But electric vehicles may do little to clear the country's smog-darkened sky or curb its rapidly rising emissions of global warming gases. China gets three-fourths of its electricity from coal, which produces more soot and more greenhouse gases than other fuels.

A report by McKinsey & Company last autumn estimated that replacing a gasoline-powered car with a similar-size electric car in China would reduce greenhouse emissions by only 19 percent. It would reduce urban pollution, however, by shifting the source of smog from car exhaust pipes to power plants, which are often located outside cities.

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Beyond manufacturing, subsidies of up to \$8,800 are being offered to taxi fleets and local government agencies in 13 Chinese cities for each hybrid or all-electric vehicle they purchase. The state electricity grid has been ordered to set up electric car charging stations in Beijing, Shanghai and Tianjin.

Government research subsidies for electric car designs are increasing rapidly. And an interagency panel is planning tax credits for consumers who buy alternative energy vehicles.



China is aiming for an electric vehicle revolution, with an eye toward urban air quality. Source: <http://www.nytimes.com>

China wants to raise its annual production capacity to 500,000 hybrid or all-electric cars and buses by the end of 2011, from 2,100 last year, government officials and Chinese auto executives said. By comparison, CSM Worldwide, a consulting firm that does forecasts for automakers, predicts that Japan and South Korea together will be producing 1.1 million hybrid or all-electric light vehicles by then and North America will be making 267,000.

The United States Department of Energy has its own \$25 billion program to develop electric-powered cars and improve battery technology, and will receive another \$2 billion for battery development as part of the economic stimulus program enacted by Congress.

Electric cars have several practical advantages in China. Intercity driving is rare. Commutes are fairly short and frequently at low speeds because of traffic jams. So the limitations of all-electric cars — the latest models in China have a top speed of 60 miles an hour and a range of 120 miles between charges — are less of a problem. First-time car buyers also make up four-fifths of the Chinese market, and these buyers have not yet grown accustomed to the greater power and range of gasoline-powered cars.

But the electric car industry faces several obstacles here too. Most urban Chinese live in apartments, and cannot install recharging devices in driveways, so more public charging centers need to be set up. The tougher challenge is that lithium-ion batteries are expensive, which will be a hurdle for thrifty Chinese consumers, especially if gas prices stay relatively low compared to their highs last summer. China is tackling the challenges with the same tools that helped it speed industrialization and put on the Olympics: immense amounts of energy, money and people.

Source: [http://www.nytimes.com/2009/04/02/business/global/02electric.html?\\_r=4&em](http://www.nytimes.com/2009/04/02/business/global/02electric.html?_r=4&em)

## Professor Steven Chu: paint the world white to fight global warming

May, 2009 — As a weapon against global warming, it sounds so simple and low-tech that it could not possibly work. But the idea of using millions of buckets of white-wash to avert climate catastrophe has won the backing of one of the world's most influential scientists.

Steven Chu, the Nobel prize-winning physicist appointed by President Obama as Energy Secretary, wants to paint the world white. A global initiative to change the colour of roofs, roads and pavements so that they reflect more sunlight and heat could play a big part in containing global warming, he said yesterday.

Professor Chu said that building regulations should insist that all flat roofs were painted white, and visible tilted roofs could be painted with "cool-coloured" paints that looked normal, but which absorbed much less heat than conventional dark surfaces. Roads could be lightened to a concrete colour so they would not dazzle drivers in bright sunlight. "I think with flat-type roofs you can't even see, yes, I think you should regulate," Professor Chu said.

Pale surfaces reflect up to 80 per cent of the sunlight that falls on them, compared with about 20 per cent for dark ones, which is why roofs and walls in hot countries are often whitewashed. An increase in pale surfaces would help to contain climate change both by reflecting more solar radiation into space and by reducing the amount of energy needed to keep buildings cool by air-conditioning.

Professor Chu said that his thinking had been influenced by Art Rosenfeld, a member of the California Energy Commission, who drove through tough new building rules in the state. Since 2005 California has required all flat roofs on commercial buildings to be white; the measure is being expanded to require cool colours on all residential and pitched roofs.

Dr. Rosenfeld is a physicist at the Lawrence Berkeley National Laboratory, of which Prof. Chu was director. Last year Dr. Rosenfeld and two colleagues from the laboratory, Hashem Akbari and Surabi Menon, calculated that changing surface colours in 100 of the world's largest cities could save the equivalent of 44 billion tonnes of carbon dioxide — about as much as global carbon emissions are expected to rise by over the next decade.

Professor Chu said: "Now, you smile, but he's done a calculation, and if you take all the buildings and make their roofs white and if you make the pavement more of a concrete type of colour rather than a black type of colour, and you do this uniformly . . . it's the equivalent of reducing the carbon emissions due to all the cars on the road for 11 years."

Source: <http://www.timesonline.co.uk/tol/news/environment/article6366639.ece>

### Warming odds: Worse than thought



May, 2009 — The most comprehensive modeling yet carried out on the likelihood of how much hotter the earth's climate will get in this century shows that without rapid and massive action, the problem will be about twice as severe as previously estimated six years ago – and could be even worse than that.

The study uses the MIT Integrated Global Systems Model, a detailed computer simulation of global economic activity and climate processes that has been developed and refined by the Joint Program on the Science and Policy of Global Change since the early 1990s. The new research involved 400 runs of the model with each run using slight variations in input parameters, selected so that each run has about an equal probability of being correct based on present observations and knowledge. Other research groups have estimated the probabilities of various outcomes, based on variations in the physical response of the climate system itself. But the MIT model is the only one that interactively includes detailed treatment of possible changes in human activities as well – such as the degree of economic growth, with its associated energy use, in different countries.

Study co-author Ronald Prinn, the co-director of the Joint Program and director of MIT's Center for Global Change Science, says that, regarding global warming, it is important "to base our opinions and policies on the peer-reviewed science." He says that the MIT model, unlike any other in the peer-reviewed literature, looks in great detail at the effects of economic activity coupled with the effects of atmospheric, oceanic and biological systems. "In that sense, our work is unique," he says.

The new projections, published in the American Meteorological Society's *Journal of Climate*, indicate a median probability of surface warming of 5.2 degrees Celsius by 2100, with a 90% probability range of 3.5 to 7.4 degrees. This can be compared to a median projected increase in the 2003 study of just 2.4 degrees. Source: <http://www.sciencedaily.com/releases/2009/05/090519134843.htm>

## Rio de Janeiro's Tropical Urban Climate

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*There is growing evidence supporting the existence of phase and amplitude departures in the urban heat island (UHI) of tropical cities, in comparison with the corresponding description of the UHI in mid-latitude cities. In this work, qualitative and quantitative results concerning the Metropolitan Area of Rio de Janeiro's UHI are presented and discussed. These results do not agree entirely with published reports to date, and they could be useful in providing a more complete explanation of heat island dynamics and extending the available fragmentary knowledge about tropical urban climates.*

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### Introduction

In a compilation of urban Surface Energy Budget (SEB) studies focusing on dry and clear sky conditions, Roth (2007) has maintained that vegetation is a useful way to reduce heat storage uptake during daytime and hence has the potential to effectively mitigate the nocturnal Urban Heat Island (UHI) of cities in tropical locations.

The Metropolitan Area of Rio de Janeiro (MARJ) is such a city, situated at a tropical latitude ( $\sim 22.8^{\circ}\text{S}$ ,  $43.1^{\circ}\text{W}$ ) over a very complex terrain which is partially covered with rain forest and includes multiple watershed basins feeding the Guanabara Bay. Despite the moderating influence that might be expected from such heavy vegetation, there is growing evidence indicating the presence of a defined daytime UHI in the MARJ. This timing is quite unexpected considering classical descriptions of the UHI for mid-latitude cities (Oke, 1987; Arnfield and Grimmond, 1998; Mills, 2004), which emphasize the nocturnal nature of urban heating.

It is well understood that the processes of interaction between the tropical atmosphere and the surface have a core importance in climatic system regulation. The exchanges of momentum, heat, humidity and other atmospheric components are of particular interest, as their impacts have major consequences for the behavior of the Atmospheric Boundary Layer (ABL) (Garstang and Fitzjarrald, 1999). Few studies, however, have focused on the development of the UHI and its consequences on the local and regional weather in the (sub)tropical regions. One such study, by Jauregui (1997), investigated the climate of Mexico City ( $19^{\circ}26'\text{N}$ ,  $99^{\circ}7'\text{W}$ ) and describes a maximum UHI of  $7.8^{\circ}\text{C}$  during clear-sky and calm wind conditions, mainly in the dry winter months. In that case

study, the researcher reported both nocturnal and diurnal UHI occurrences, but the nocturnal phenomenon is predominant in Mexico City. The diurnal occurrence is during rainy months, and probably it is due to differences in the evaporation rate between the seasons. In the subtropics, Yow and Carbone (2006) investigated the UHI of Orlando, Florida in the USA ( $28^{\circ}33'\text{N}$ ,  $81^{\circ}20'\text{W}$ ). They found that Orlando's UHI is predominantly a nocturnal phenomenon, but with intense heat islands sometimes occurring during warm afternoons. These diurnal events are most likely attributable to isolated thundershowers.

Some questions naturally arise as to: how intense and common are diurnal occurrences of the UHI in (sub)tropical cities, and how strong does the ABL stability need to be to prevent the phase shift toward more intense convective events?

### Urban Surface Dataset

Covering an area of  $5,644\text{ km}^2$ , the Metropolitan Area of Rio de Janeiro is located over the complex eroded terrain of the Brazilian Shield along the Southern Atlantic sea coast, with the Guanabara Bay located close to the center of the study area (Fig. 1). Among all Brazilian metropolitan areas, the 20 administrative districts constituting the MARJ represent the highest urban demographic density, with a population estimated at around 11.6 million (IBGE, 2008).

Due to the particular geographic location, complex topography and surface heterogeneities of the metropolitan area, meteorological conditions are dominated by the tropical climate – with weak wind flow, sea and urban breezes, mesoscale circulations and hazardous levels of air and water pollution (Martins and Arbilla, 2003; Carreira et al., 2004).

During the summer months (December, January and February), Rio de Janeiro's climate is sunny, wet and rainy, with a large diurnal thermal amplitude and the establishment of the South Atlantic Convergence Zone (Liebmann et al., 1999). During the winter, a sequence of weak cold fronts generates small amounts of precipitation. According to Dereczynski et al. (2008) the maximum rainfall occurs over three granite rock outcrops, with values between 1200 and 2000 mm per year – while over the densely populated coastal low terrains to the northwest of Rio's conurbation, rainfall is about 1000 mm per year.

The behavior of the MARJ UHI is scarcely known to date, in spite of its potential impact on weather forecasting and urban climate knowledge.

The observational dataset is applied to describe the time evolution (diurnal and seasonal) of two conservative thermodynamic variables, the potential temperature and the specific humidity, associated with adiabatic and unsaturated processes. The dataset used was obtained from surface weather stations in the MARJ (Fig. 1). For the period of the analysis, from 1999 to 2007, a continuous dataset is no longer available so a statistical treatment was employed. Averages and standard deviations were used to remove spurious information.

**Results and Discussion**

The time evolution of the thermodynamic variables,  $\theta$  and  $q$ , are presented for three weather stations in Figs. 2 and 3. The downtown station is located in a heavily urbanized area with high buildings, over a low terrain sur-

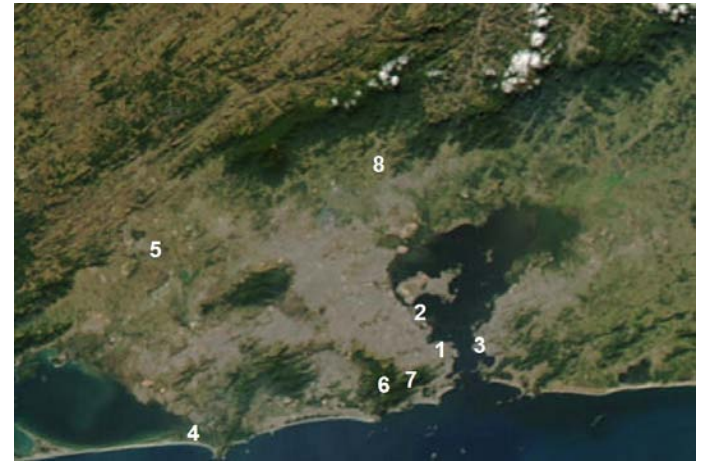
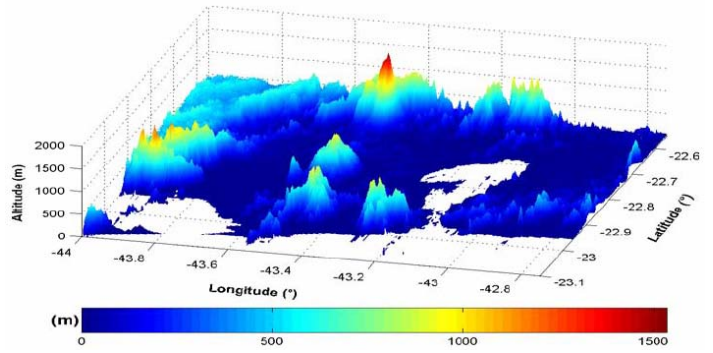


Figure 1. The domain of the MARJ. Top: the corresponding topography with horizontal resolution of 90 m (SRTM, 2000). Bottom: satellite image (EOS, 2008) with the location of the surface weather stations: 1) Downtown; 2) Fundão; 3) Niterói; 4) Marambaia; 5) Agricultural Ecology; 6) Tijuca 1; 7) Tijuca 2; and 8) Xerém.

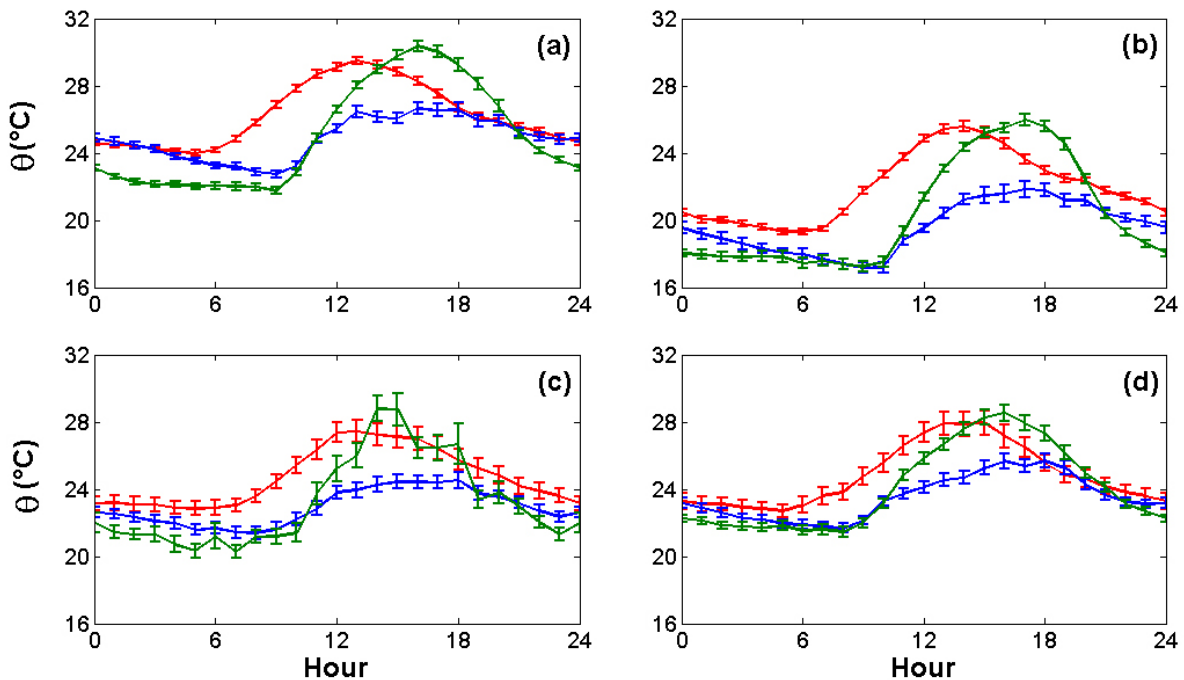


Figure 2. Time evolution of the potential temperature  $\theta$  in the MARJ at the Downtown (red line), Agricultural Ecology (green line) and Niterói (blue line) surface weather stations, for four months: (a) March, (b) June, (c) October and (d) December.

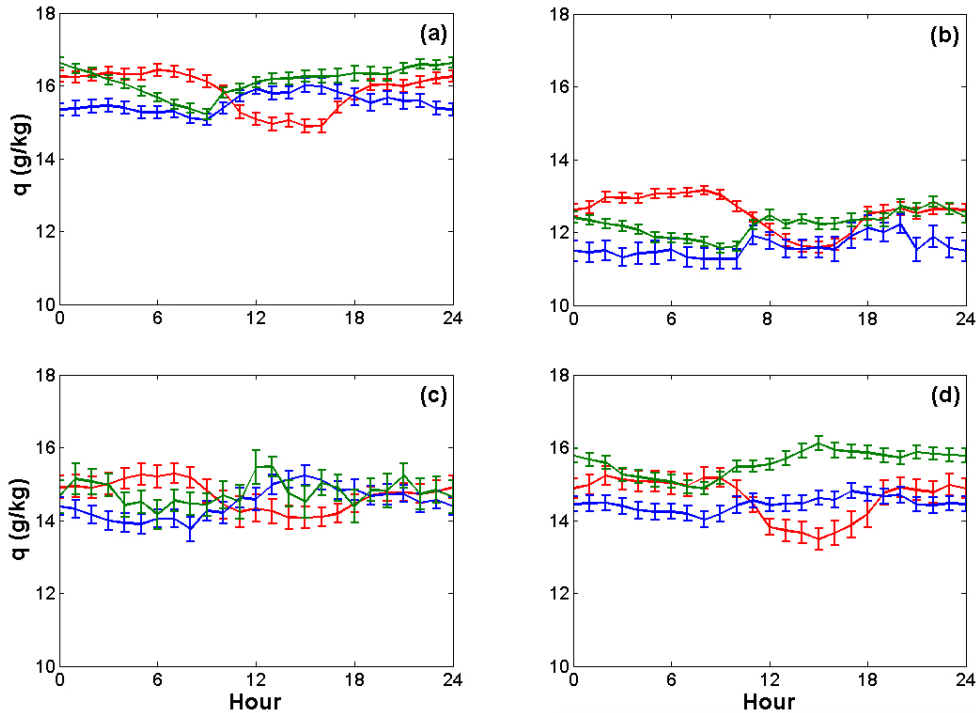


Figure 3. Time evolution of the specific humidity  $q$  in the MARJ at the Downtown (red line), Agricultural Ecology (green line) and Niterói (blue line) surface weather stations, for four months: (a) March, (b) June, (c) October and (d) December.

rounded by three granite rock outcrops (Tijuca Forest, Gericinó and Pedra Branca) and the Guanabara Bay. The Agricultural Ecology is located in the northwest part of the city and represents a zone of mixed land use, with buildings and irrigated crops. On the opposite shore of the Guanabara Bay, the Niterói station is under a strong influence of the penetrating sea breeze without the blocking effect of hills. The location of these surface weather stations is seen as a determinant in the behavior of  $\theta$  and  $q$ , as a response to the diurnal cycle of warming and cooling of the surfaces.

It can be seen that in the rural area (i.e., the Agricultural Ecology station) the value of  $q$  is larger than the corresponding value observed in the urban center (Downtown station) during the period from afternoon to early evening (14:00-20:00 LT). This daytime behavior may be attributed to the great capacity of the vegetation-rich surface for evapotranspiration. In these conditions, the accumulation of water vapor in the Surface Layer (SL) over the vegetated area can be high enough to significantly reduce the loss of thermal infrared irradiation. The Niterói station, meanwhile, shows a consistently small thermal amplitude which is likely due to local circulations, strong sea-breeze influence and more vegetation and water along the Northeastern margin of the Guanabara Bay.

The time evolution of  $\theta$  and  $q$  for all other surface weather stations (not shown) presents similar patterns, either in magnitude or in periodicity. This fact has motivated the computation of linear correlations in order to

identify significant differences and to group the stations with similar thermodynamic behavior.

The correlation analysis (not shown) defined three groups of stations: urban (Downtown and Fundão); maritime (Marambaia and Niterói); and vegetated (Agricultural Ecology, Tijuca 1, Tijuca 2 and Xerém). Certainly,

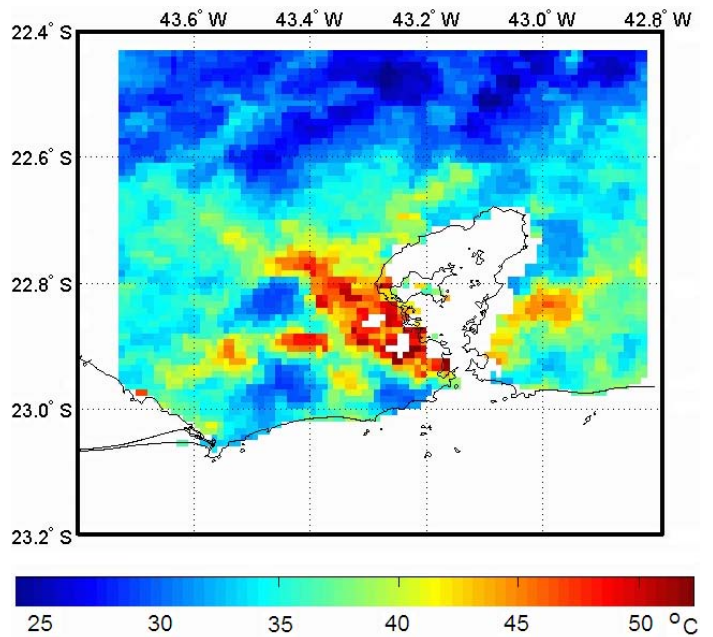


Figure 4. Spatial distribution of surface temperature over the MARJ by remote sensing, from a NOAA satellite image for 03/06/2003, based on NDVI metrics and coefficients determined by atmospheric conditions, as proposed by Coll (2003).

these groups represent only a portion of the microclimates which could be found within this large urban area, and constitute a preliminary analysis of the spatial structure of thermodynamic variables in the MARJ.

The spatial distribution of surface temperature over the MARJ obtained by remote sensing (Fig. 4) is qualitatively consistent with the existence of the three major groups, previously identified by correlation analysis.

Maps of the microclimatological evolution of and throughout the year are shown in Fig. (5). In these maps, there are just two well defined seasons: a relatively warm and dry period from May to September, and a hot, wet and rainy period from October to April.

The MARJ microclimates are characterized by phase-differences in the diurnal cycle of heating and cooling (left column in Fig. 5). In the urban area (a) the maximum occurs around 14:30 LT, which is earlier than the corresponding maxima in the vegetated (b) and maritime (c)

areas – which occur at 15:30 LT and 16:00 LT respectively. This should be considered as an atmospheric thermal response to the surface energy budget due to the heterogeneities. The maritime group presents the smallest thermal amplitude, attributable to the direct effect of sea-breeze advection.

In the afternoon period there is a remarkably low availability of air moisture (right column of Fig. 5) for the urban group (a), in comparison to the vegetated (b) and maritime (c) groups. The increase in specific humidity in vegetated and maritime groups around 10:00 LT is likely associated with the sea-breeze front penetration (right column of Fig. 5; b and c). The specific humidity is in fact not a decisive thermodynamic variable for identification of the sea-breeze front, because of the great amount of moisture in the MARJ – but despite this fact, the sea-breeze front can be easily identified by the shifting of the wind direction, from northwest to southeast (not shown).

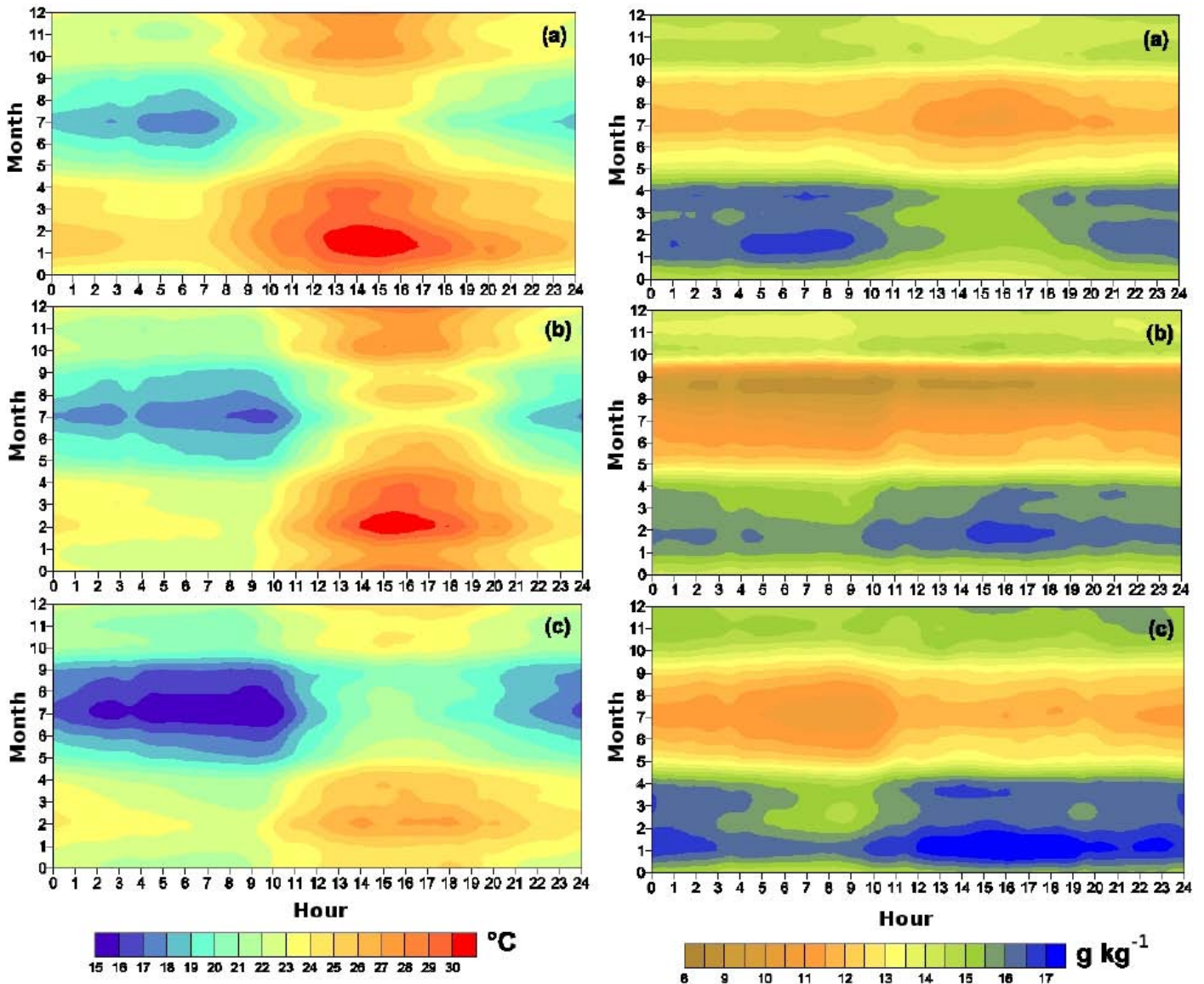
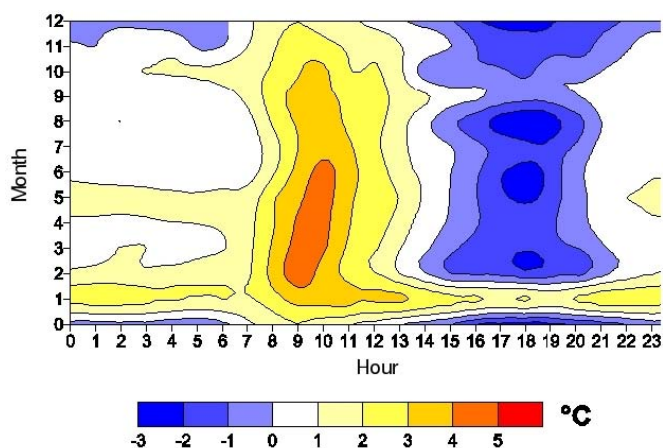


Figure 5. The potential temperature (left column) and the specific humidity (right column) for each microclimatic group found in the MARJ: (a) urban, (b) vegetated and (c) maritime.





**Figure 6.** The time evolution of the UHI in the MARJ. The hours are in the abscissa, and the months are in the ordinate. The color scale indicates the UHI intensity in ( $^{\circ}\text{C}$ ), corresponding to the difference in mean air potential temperature between the 'urban' and the 'vegetated' groups of weather stations in the MARJ.

Considering the different microclimate groupings which have been identified in MARJ, the behavior of the UHI can be determined by the time evolution of the differences between the virtual potential temperature in the urban and vegetated areas (Fig. 6). In this case, allows for the inclusion of the effects of air moisture in the positive buoyancy of the air parcels during the convective period.

The UHI over the MARJ has a diurnal maximum in the morning for all the seasons, and it is more intense in the transition months between rainy summer and dry winter (February to May), with an amplitude of  $4\text{--}5^{\circ}\text{C}$  (as opposed to an amplitude of  $2\text{--}3^{\circ}\text{C}$  in other months). Unlike what happens in the morning, during the late afternoon and early evening the difference is negative, indicating that the vegetated area is warmer than the urban area. The negative minimum value occurs around 18:00 LT. A consequence of this particular phenomenon is the weakness of the wind (urban breeze) over the urban area.

## Conclusion

In this work, we present some preliminary results on the thermodynamics and time evolution of and in the Metropolitan Area of Rio de Janeiro. Three groups of different microclimates have been identified in the MARJ, and the behavior of the tropical UHI was determined throughout the year. In a pattern that is distinctly different from what has been commonly observed in mid-latitude cities, the tropical UHI in the MARJ occurs during the morning and not during the night. This peculiar characteristic found in Rio de Janeiro is a motivation for new studies about the effects of urbanization on the structure of the tropical urban ABL.

## Acknowledgment

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## Flash flooding in the El Paso-Ciudad Juárez (US-Mexico) Border Metroplex: Variable Intensity and Differential Impacts

### Introduction

The *Paso del Norte* metropolitan area (population > 2 million) (Fig. 1) is comprised of two cities (El Paso, Texas, USA and Ciudad Juárez, Chihuahua, Mexico) – a single metropolis in two nations separated by a river (the Rio Grande / *Rio Bravo del Norte*). The cities are built around the Franklin Mountains (which almost completely bisect El Paso) and the *Sierra de Juárez* (which flanks Ciudad Juárez). The two cities experience the same meteorology, but have different socioeconomic status. Located in the Chihuahuan Desert, average annual precipitation is ~22 cm, most of which falls during the North American Monsoon in late summer, often in a short time, making the metropolitan area prone to flash flooding. Flash floods tend to occur at the start of the monsoon: of 48 flash flood events in the (USA) National Weather Service El Paso County Warning Area between 1972 and 2002, 22 occurred between 16 July and 15 August.

The risk for a natural disaster is the combination of a population's exposure to a natural *hazard* and *vulnerability* to that hazard, i.e. the ability to anticipate, respond to, and recover from the hazard. A *natural hazard* becomes a *natural disaster* when it disrupts human socioeconomic activity (Feng and Zhang, 2005). Extreme hydrometeorological events are especially prone to provoke disasters because they cover much larger scales of space and time than other geological hazards (Leroy, 2006).

Geographic factors - both physical and socioeconomic - are illustrated in the *Paso del Norte* with recent cases of catastrophic flash flooding, which have shown a much greater propensity for damage to Ciudad Juárez than to El Paso, even though they are part of the same urban area and experience the same meteorological events. The topographic and socioeconomic complexities of the area create dual and interacting complexities in impacts of, planning for, forecasting, and responding to these flood events.

### Physical Factors

This relationship between hazard and disaster is illustrated in the *Paso del Norte* with the cases of the catastrophic flooding of early August 2006, and to a lesser extent with flash flooding associated with tropical cyclone Dolly's remnants in July 2008.

In what is locally known as "the Storm of 2006" (Figure 2), from 27 July to 4 August, 2006, El Paso International Airport (ELP) received 17.4 cm of rain, or about  $\frac{3}{4}$  of its annual average precipitation in less than eight days: some neighborhoods in the West Side of El Paso received about 25 cm of rain in <8 hr on 1 August (Rogash *et al.*, in press).

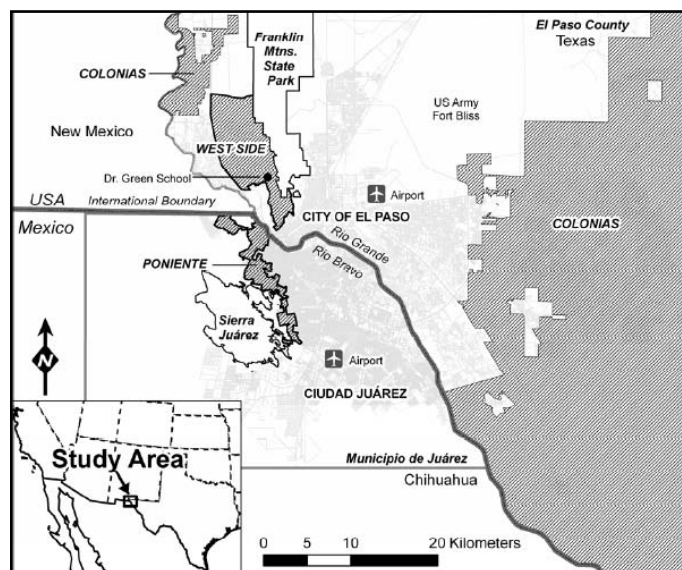


Figure 1. The *Paso del Norte* metropolitan area.

Heavy rains continued through the summer 2006 monsoon: 3 of the top 16 heavy rain events over a 130-year period in El Paso happened within a five-week period in summer 2006, making July-September 2006 the wettest three-month period in El Paso since records began being kept in 1878, and the first time in the period that El Paso has received >7.5 cm of rain in three consecutive months (Gill and Novlan, 2007). Some portions of the area experienced more than a climatological year's worth of rain within a nine day period, and at least one station received almost a climatological year's amount of rain in a single day (Rogash *et al.*, in press). Flash flooding and river flooding occurred numerous times during the period.



Figure 2. Street sign in El Paso documenting area of "Storm 2006" reconstruction.



**Figure 3.** USA National Weather Service NEXRAD image of decaying tropical cyclone Dolly directly over the Paso del Norte, 8:21 AM local time July 26, 2008.

More recently, on the morning of 26 July, 2008, decaying tropical cyclone Dolly passed directly over the *Paso del Norte* (Figure 3), producing 4.8 cm of rain at El Paso International Airport, 11.2 cm on the El Paso West Side, and 11.8 cm at the Ciudad Juárez airport.

In both of these events, much higher rainfall totals in El Paso were reported from (the primarily residential) west slopes of the Franklin Mountains (as much as a 2x precipitation enhancement) due to orographic effects. Similar orographic enhancement of precipitation also likely was experienced in Ciudad Juárez neighborhoods on the slopes of the *Sierra de Juárez*. Large arroyos in western El Paso (at the time, arroyo slopes and/or bottoms were slated for housing development) began running with water for the first time in decades on 1 August, 2006. These flood waters quickly ran downhill to the more urbanized areas below and caused much damage.

During the peak of the 2006 event, the average return intervals (ARIs) for precipitation (as developed by the USA National Weather Service for El Paso based on El Paso International Airport data, and used for planning purposes throughout El Paso) ranged from ~ 1 year on time scales of  $\leq 3$  hr, 5-25 yr on time scales of 6-24 hr, 25-100 yr on time scales of 2-30 days, and ~500 yr on time scales of 45 or 60 days (a "500-year monsoon?") (Gill and Novlan, 2007) (Table I). However, if rainfall data from unofficial gauges on upper slopes of west El Paso (in the first author's neighborhood and deemed credible) were

applied to the ARIs developed from airport data (and used for planning purposes for the entire city), the "apparent" magnitude of the event would have been much higher. Apparent ARIs for the 2006 event based on these data would be ~50 to 200 yr on time scales of  $\leq 2$  hr, and >1000 years on time scales of 3 hr to 60 days (Gill and Novlan, 2007) (Table I).

Short-term ( $\leq 24$  hr) rainfall totals at the "official" airport rain gauge (the only USA National Weather Service first-order station in the metropolitan area) in both the 2006 and 2008 events would correspond to return periods of a few decades (2006) or a few years (2008), but in orographically-enhanced areas of the same city would apparently correspond to return periods of a millennium or more. *Average recurrence interval curves based on airport data are not appropriate for flash flood hazard planning in neighborhoods as little as <10 km away in topographically-complex urban areas.* Orographic effects have not always been properly considered in the development of flood intensity/duration/frequency curves used for urban planning in El Paso and other mountain cities, causing an underassessment of flash flood risk in some neighborhoods and an exacerbation of monetary losses from flooding.

Recurrent heavy rain events (~30 to 40 cm / 9 days) during August and early September 2006 led to river flooding in the *Paso del Norte*: the Rio Grande/ *Rio Bravo del Norte* flooded (Figure 4) five times during a five-week period (the first time since instrumental records started being kept that the river exceeded its banks in the *Paso del Norte* more than once in any single year), after not having flooded at all since 1958 (Gill and Novlan, 2007). Urban development in the floodplain has occurred in both cities in recent decades, putting the very low-lying areas (as well as the highlands) at a higher flood risk.



**Figure 4.** River flooding on the Rio Grande, just upstream of El Paso, August 2006.

**Table I. Estimated maximum annual recurrence intervals for precipitation (based on airport data) for flood events in 2006 monsoon for a West Side rain gauge and El Paso International Airport.**

Period of Precipitation Accumulation during 2006 Monsoon	(Apparent) Maximum Annual Recurrence Interval if based on El Paso International Airport Data	
	El Paso Airport Rain Gauge	Dr. Green School Rain Gauge - West El Paso
1 hr	1 year	50-100 years
2 hr	1-2 years	200-300 years
3 hr	1-2 years	> 1000 years
6 hr	~ 5 years	> 1000 years
12 hr	~ 25 years	> 1000 years
1 d	10-15 years	> 1000 years
2 d	25-50 years	> 1000 years
4 d	50-100 years	> 1000 years
7 d	50-100 years	> 1000 years
10 d	~ 100 years	> 1000 years
20 d	50-100 years	> 1000 years
30 d	50-100 years	> 1000 years
45 d	~ 500 years	> 1000 years
60 d	~ 500 years	> 1000 years

### Socioeconomic Factors

The *Paso del Norte* is one metropolitan area, in two nations (one in the global North, one in the global South) with different capacities to cope with flood hazards. For the same storm, there will be much greater flood risks, impacts, and longer lasting effects in Ciudad Juárez than in El Paso, due to socioeconomic factors (see Table II). During the 2006 floods, no fatalities or serious injuries were reported in El Paso, while there were reports of several persons killed and numerous injuries in Ciudad Juárez.

On the United States side in El Paso, at least 1500 homes, approximately 20 drainage facilities and 100 roadways were impacted by the 2006 floods, with damage estimates of approximately US \$200- \$300 million (Collins, in press; Rogash *et al.*, in press). A federal disaster declaration was made. But on the Mexican side in Ciudad Juárez, approximately 5000 homes were damaged or destroyed, approximately 20,000 residents left homeless, and monetary damage exceeded US\$600 million, which is more than twice the city's annual budget (Paterson, 2006). The higher impacts in Ciudad Juárez appeared to

be due to poorer construction and maintenance of the urban infrastructure. Similarly, during the floods of 2008 associated with Dolly, storm impacts to the infrastructure and economy were much greater in Ciudad Juárez than in El Paso, for the same reasons.

While flood impacts in El Paso County during summer 2006 justified the federal disaster declaration, monetary damage estimates in relation to local economic productivity suggest that the severity of the disaster was an order of magnitude greater in Ciudad Juárez than in El Paso (Collins, in press). Capacities to prepare for, respond to, and recover from flood events are influenced by the resources of government institutions. Federal, state, and local governments with a greater ability to redistribute resources toward flood risk reduction activities can impart a greater degree of security to residents. However, sharp disparities in flood protection capacities exist between and within political jurisdictions in the *Paso del Norte*. El Paso County has greater flood protection capacities than Juárez, and, within El Paso County, municipalities have greater capacities than unincorporated areas (Table II, see statistics for National GDP and Local Governmental Revenue per capita). At the household level, flood recovery is easier for those with higher incomes and it can be compensated by flood insurance; income and flood insurance status vary dramatically within the *Paso del Norte* (Table II).

One can look at the interaction of physical and socioeconomic factors on flood risk in the *Paso del Norte* by considering the differential impacts of residents living on steep slopes experiencing orographically-enhanced precipitation in each city. The neighborhoods built into the "West Side" of the Franklin Mountains are within the most affluent (and thus less socioeconomically-vulnerable) district of El Paso (Figures 1 and 5, Table I). Nearly 95% of West Side residents who experienced flood damage in 2006 maintained flood insurance to compensate for losses (Collins, in press). However, the informal settlements of Ciudad Juárez's "*Poniente*," which are carved into the slopes of the *Sierra de Juárez*, are home to some of the most marginalized (and thus most socioeconomically-vulnerable) residents in the *Paso del Norte* (Figures 1 and 6). Many *Poniente* residents lack legal title to their home sites and few (if any) maintained insurance to compensate for flood losses at the time of the 2006 disaster. Therefore, the residents of some of the most dramatically flood-impacted neighborhoods in Ciudad Juárez had the fewest assets to invest in hazard reduction, mitigation and recovery, and the highest risk of impact from flash floods, while the residents of the portion of El Paso that received the heaviest precipitation and the most monetary damage from the floods suffered a less debilitating impact (Collins, in press). Within El Paso County, the impacts of flooding were most severe and prospects for



Figure 5. West Side neighborhood in El Paso, built into the slopes of the Franklin Mountains.

recovery worst for residents of *colonias* (informal unincorporated settlements), where residents have reduced access to state-sponsored flood protection resources and where few maintained flood insurance at the time of the 2006 disaster (Figure 1, Table II).

### Conclusions and Recommendations

The twin cities of El Paso, Texas, USA and Ciudad Juárez, Chihuahua, Mexico comprise the single *Paso del Norte* metropolitan area, and their differing responses to flash floods illustrate the effects of geography on urban weather and climate. These effects are both physical and socioeconomic.

In regions of complex terrain in western North America – where precipitation often falls as localized convective storms, is influenced by complex topography, and the density of rain gauges is limited – the use of airport rain data may not be appropriate for flood recurrence and intensity planning across a metropolitan area. Areal/temporal averaging and integration of recurrence intervals would be more representative and useful. Reconsideration and updating of recurrence interval planning is underway for El Paso.

There is an insufficient density of rainfall reporting stations in the *Paso del Norte* and likely in other urban areas of the mountainous Western USA, given the spotty nature of convective storms, even within the monsoon. Single-station-based climatologies (and flash flood planning derived from them) are thus likely to be unreliable, causing an underassessment of risk in some neighborhoods and an exacerbation of monetary losses from flooding.



Figure 6. Informal settlement at the base of the Sierra Juárez in the Poniente. (Source: Cruz Roja, Ciudad Juárez).

The urban environmental impacts of floods are more severe in Mexico than in neighboring cities in the USA; the severity of damage in Mexico is amplified by a reduced capacity for social protection. In the *Paso del Norte*, the disaster risk from flash flooding is much greater in Ciudad Juárez, due to the greater socioeconomic vulnerability on the Mexican side of the river.

Floods in the *Paso del Norte* illustrate how both social and physical factors can create highly variable risks for, and capacities to respond to, severe weather hazards within a single metropolitan area. This example supports the development of impact-based, rather than purely hazard-based, severe weather forecasting and planning, which is the envisioned platform of the future for the

Table II. Sociodemographic characteristics and flood insurance status within the *Paso del Norte*.

Sociodemographic Metrics	Geographic Units				
	Ciudad Juárez, Mexico	El Paso County, USA	Poniente	West Side	Colonias
Population (total)	1,204,734	679,622	175,472	69,081	68,164
Housing units (total)	271,536	209,672	37,177	26,262	16,622
Per capita income (US\$)	2,756	21,781	2,302	34,391	17,444
Mean level of education (years)	8.00	11.15	6.35	14.30	9.58
Population not US citizen (%)	*	16.00	*	12.29	24.15
National GDP per capita (US\$)	6,114	37,594	6,114	37,594	37,594
Local governmental revenue per capita (US\$)	116	830	116	928	317
Damaged homes with flood insurance (% in 2006 disaster)	*	57.84	*	93.62	20.00

\* Not applicable. Data in table for year 2000.

USA's National Weather Service. Such a methodology would be especially effective for urban areas with high spatial variabilities in meteorology and/or socioeconomic development. Assessment metrics incorporating GIS and spatially variable risks and impacts, now used to evaluate other natural hazards (tornadoes, earthquakes, winter storms), could be appropriate tools for management and mitigation of urban flooding.

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## The Dual-use European Security IR Experiment (DESIREX 2008)

The DESIREX 2008 campaign took place in Madrid (Spain) from June 23rd to July 6th, 2008. The project was funded by the European Space Agency (ESA), to study the usefulness of a space-borne thermal infrared sensor to help policy makers and town planners to reduce the number of casualties when temperatures soar. The campaign was coordinated by the Global Change Unit (GCU) of the University of Valencia (UVEG), and the scientific team, composed of researchers from 13 different institutes, gathered in Madrid to participate in the two-week field campaign.

DESIREX-2008 was a dedicated campaign for the ESA project called *Urban Heat Islands and Urban Thermography*, funded through the agency's Data User Element (DUE). This project was recently the subject of an open and competitive tender, with the participation of 10 European cities. The objective of DESIREX 2008 was to produce thermal datasets to support the upcoming trade-off studies that will be made by the *Urban Heat Islands and Urban Thermography* project, and to perform a preliminary mission analysis for a dedicated satellite sensor for the provision of temperature observations over European cities.

Both projects belong to a set of activities recently launched by ESA to mitigate the effects of UHIs, within the framework of the proposed activities for the "Reorientation of the Fuegosat Consolidation Phase," which falls under the Earth Watch element of ESA's Living Planet Programme. A high-resolution thermal infrared capability was recognized as necessary for Europe in the medium- to long-term.

### 1. The experimental area

The city of Madrid (Spain) has an estimated population of 3.2 million. It is located in a relatively flat area on the Spanish Central Plateau at a height varying from 700 m to 550 m. The main topographic feature is the Manzanares River, which crosses the city from west to east. Madrid has a Mediterranean climate whose driest seasons are cool winters and hot summers and with most rainfall in autumn and spring. Madrid was chosen for DESIREX 2008 as it is one of the cities in Europe that suffers many heat waves with air temperatures sometimes reaching 40°C.

### 2. The experimental deployment

The DESIREX 2008 campaign combines the collection of quality and coordinated airborne hyper-spectral, spaceborne and in-situ measurements to generate a spectrally, geometrically and radiometrically representative dataset.

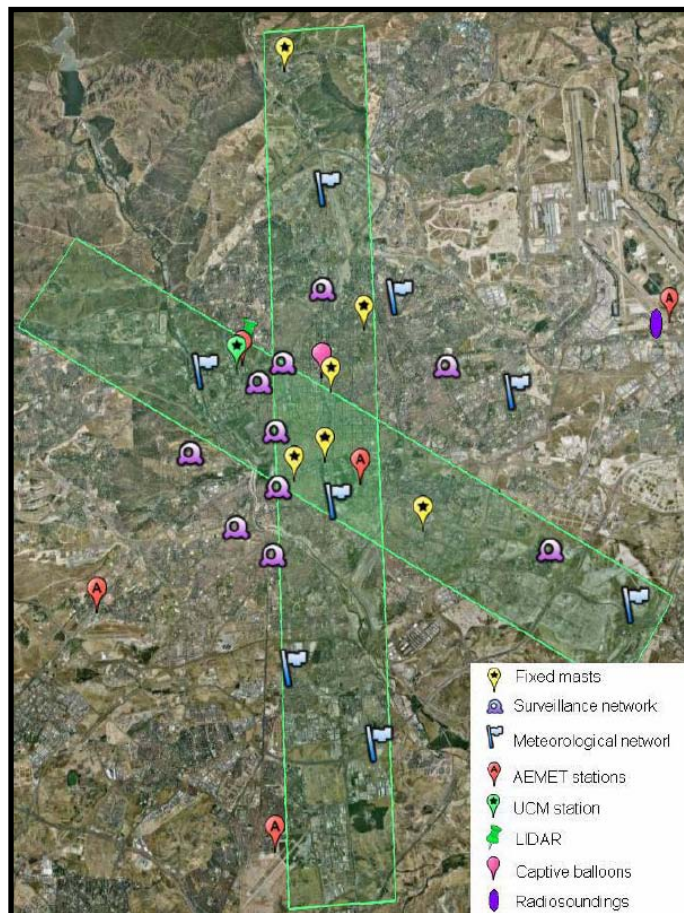


Figure 1. AHS flight lines and location of the atmospheric and ground measurements.

• **Airborne data:** The main instrument used during the campaign was the Airborne Hyperspectral Scanner (AHS), which is an imaging line-scanner radiometer, installed on a CASA-212 200 series aircraft owned by Spain's National Institute for Aerospace Technology (INTA). Thirty acquisition flight lines, in the north-south and west-east direction (Figure 1) were obtained over Madrid with spatial resolutions varying from 2.5 to 6.8 m, in an 11h, 21h and 4h UTC scheme and at 1641 m and 3409 m of altitude. The AHS has 80 spectral channels available in the visible and near infrared (VNIR), short wave infrared (SWIR), mid-infrared (MIR), and thermal infrared (TIR) spectral range (Figure 2).

• **Satellite data:** ASTER/TERRA, AATSR/ENVISAT, MODIS/TERRA and AQUA, TM/Landsat, AVHRR/NOAA and SEVIRI/MSG images were collected due to the real-time antenna station installed in the Imaging Processing Laboratory (IPL) of the UVEG, and also from ESA.

• **In-situ measurements:** Two balloons were launched per day, at noon and at midnight to characterize aerosols and water vapour vertical profiles. For each flight day, four captive balloon soundings were taken at the city



Figure 2. INTA C-212-200 EC-DUQ "Paternina" at Madrid airport (left), with operation and on-board pre-processing consoles (right).

centre (Figure 3). Lidar measurements and meteorological data were acquired to characterize aerosol vertical profiles. The meteorological network stations of Madrid city council provided data of wind direction, wind speed, solar radiation, relative humidity, atmospheric pressure, air temperature and precipitation. Mobile transects with cars to characterize the UHI were defined in four routes, including urban dense and medium dense areas, highly vegetated areas and rural areas (Figures 4 and 5). Geo-referenced data of air temperature and humidity were measured from cars with HMP45AC sondes and ground radiometric temperature with APOGEE IRR-P and OPTRIS

CS. One hour transects were carried out three times per day around 4h, 11h and 22h UTC. Fixed masts were set up for continuous measurements in rural, urban-medium and urban-dense spots in Madrid during the DE-SIREX campaign. Air temperature, relative humidity and ground radiometric temperature were acquired in six masts using Unidata 6501-EU sensors. Wind speed and direction were also available in some of the stations.

• **Calibration of AHS and validation of products:** Mobile and ground radiometric temperature, spectral characterization of urban surfaces, radiation balance and urban thermography were done. Calibration and valida-

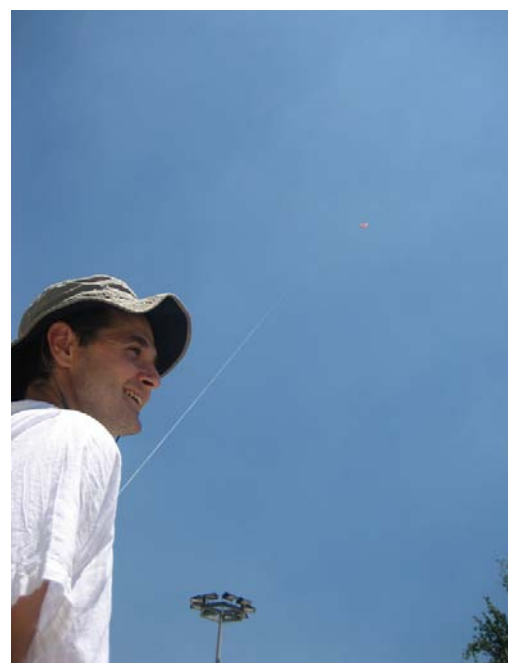


Figure 3. Captive balloon launching at Nuevos Ministerios during the AHS flights.



tion activities were carried out simultaneously with AHS and ASTER. CIMEL, RAYTEK and Heitronics radiometers and the NEC TH9100 thermal camera were used in the thermal domain for measuring downward atmospheric radiance, surface radiometric temperature and emissivity (by GCU and LSIT), and the ASD spectroradiometers were used in the solar range for reflectivity measure-

ments (INTA). The calibration and validation surfaces selected were: green grass in the UAM and water from "El Retiro" park, as cold targets, and bare soil in the UAM and concrete in the Royal Palace, as hot targets. Different natural and artificial surfaces were selected to obtain their spectral reflectance signature (Figure 6) with the aim of making a spectral library of representative urban materi-



Figure 4. AHS channel during 28th June 2008 at 11 UTC. Detail of the regions where transects were developed. Lines in orange (transect 1), white (transect 2), blue (transect 3) and yellow (transect 4).



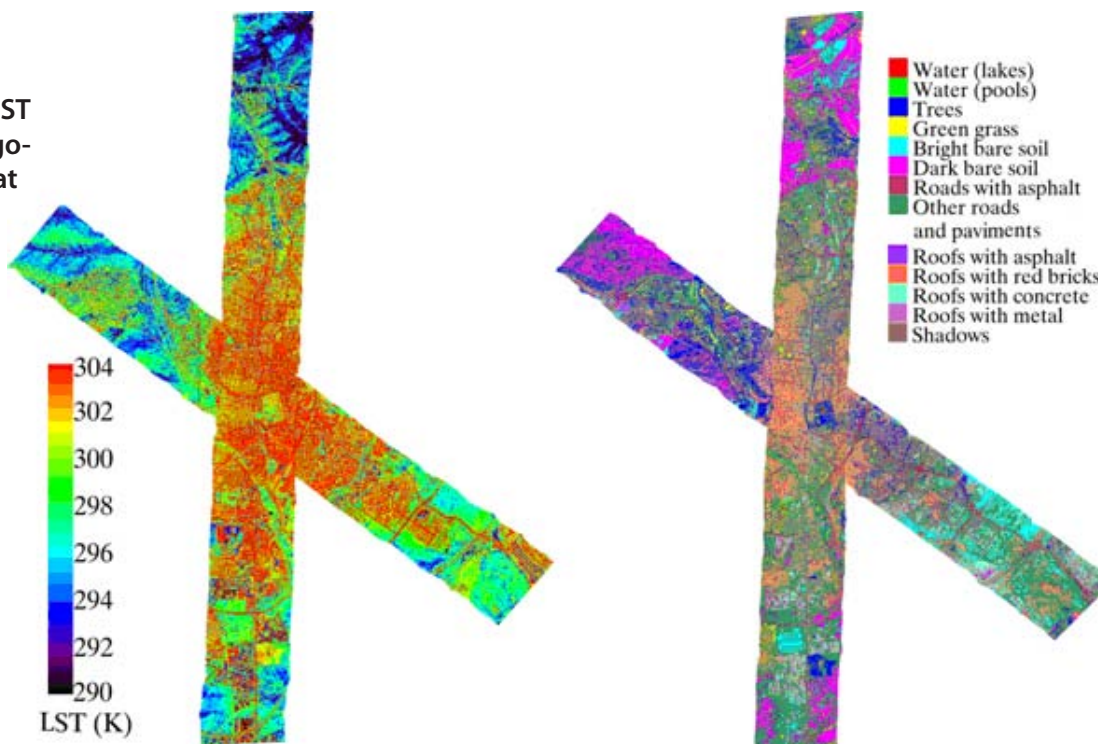
Figure 5. During the DESIREX campaign, four cars carrying instrumentation (GCU and LSIT) drove along the two flight lines three times a day to take meteorological and radiometric measurements.



Figure 6. Calibration/validation targets.

Figure 7. Left: AHS LST image from TES algorithm, June 28th at night time (mosaic of North-South overpass and East-West overpass).

Right: Classification map (July 4th, 11:32 UTC).



als. The emissivity of the different surfaces has been also obtained by means of the Temperature and Emissivity Separation (TES) algorithm. In the thermal infrared domain, multi-band radiometers were used: CIMEL CE312-1 includes eight bands, and the CIMEL CE312-2 detector includes six bands. Single-band radiometers (8-14  $\mu\text{m}$ ) used were Everest 3000.3LC/4ZL, Apogee IRR-P, OPTRIS CS/CT-LT15, Raytek MID, Raytek ST6 and Heitronics KT 19.85. Thermal cameras NEC TH9100, NEC TH7800 and FLIR P640 were also used. In the solar range the spectroradiometers used were ASD FieldSpec3 spectroradiometer and GER 1500.

### 3. The first results and conclusions

An extensive analysis of all the DESIREX-2008 data

collected from spaceborne, airborne and ground observations is now ongoing. The first results, consisting of an analysis of in-situ data and images of LST obtained at different resolutions from AHS images, were prepared for presentation at the ICUC-7 in Yokohama (Figure 7).

The aim of initiatives such as DESIREX 2008 and the THERMOPOLIS 2009 campaign next summer in Athens is to define what would be the best satellite mission for efficient monitoring of European cities during summertime. This will benefit the city council and policymakers, giving detailed information on the spatial and temporal variability of the UHI, and helping to achieve more effective urban planning for heat wave mitigation and to optimise an intelligent use of energy at the level of city districts as well as at the building level.

#### Useful Links:

- <http://www.uv.es/desirex/>
- [http://www.esa.int/esaEO/SEMW3IWIPIF\\_index\\_0.html](http://www.esa.int/esaEO/SEMW3IWIPIF_index_0.html)

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## Simulating climate change in urban structures: the use of ENVI-met within the KLIMES project

### Introduction

As heat waves in central Europe are predicted to occur more often, last longer and become more extreme (Jacob, 2008), human thermal comfort is expected to deteriorate – especially within cities, which often face a significant urban heat island effect. The interdisciplinary joint project “Planning strategies and urbanistic concepts to mitigate the impact of climate extremes on human thermal comfort” (KLIMES), which is funded by the German Federal Ministry for Education and Research (BMBF), is trying to develop a set of guidelines for urban planners on how to mitigate the effect of global warming on cities in central Europe.

Within the KLIMES project, the microclimate simulation ENVI-met is used to quantify the human thermal heat stress that can be expected in future summers, to identify elements of urban planning that intensify or counteract this effect and to evaluate proposed changes in urban planning.

### ENVI-met

ENVI-met is a three-dimensional non-hydrostatic microclimate model including a simple one dimensional soil model, a radiative transfer model and a vegetation model (Bruse, 1998). The software is freely available at [www.envi-met.com](http://www.envi-met.com) and runs on standard x86 personal computers with Windows XP or Vista. ENVI-met uses a uniform grid and the maximum resolution at the moment is about 300x300x35 cells with a typical horizontal resolution of 0.5-10m and the vertical spacing ranging from 1 to 5m. Thus it is not possible to simulate whole cities but only specific quarters in it.

Within the scope of the KLIMES project many new features and modifications have been implemented into ENVI-met and will be available to the public with Version 4 of the software. One of the new features, the possibility to explicitly define a diurnal profile for the atmospheric boundary conditions, is used within the simulations performed for the project.

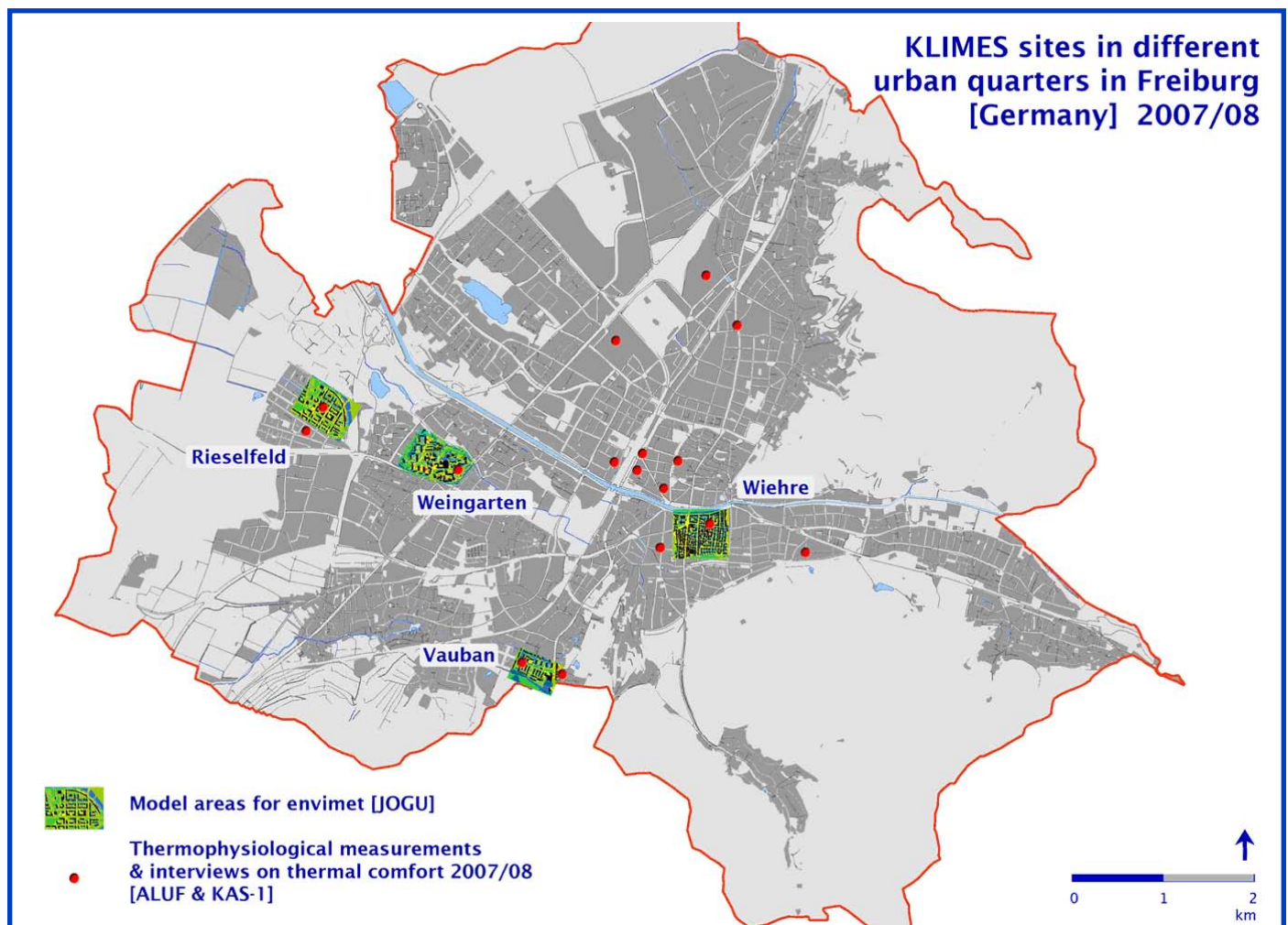


Figure 1. Sites of measurement and model areas of the KLIMES project within Freiburg.

## Methods

For the KLIMES project several quarters within the city of Freiburg in Southwest Germany are investigated. These quarters differ significantly in their date of origin, the ensemble of buildings, the street canyon design and density of vegetation within. During the summers of 2007 and 2008, field measurements within these quarters were conducted by the University of Freiburg (Mayer *et al.*, 2008). At each measurement site, a stationary meteorological station and a mobile human biometeorological station were used. Furthermore interviews with people about their current perception of thermal comfort were conducted by the University of Kassel. Four of these areas were selected as model areas for ENVI-met (see Figure 1).

By using boundary conditions derived from measurements during these field measurement campaigns in Freiburg, a comparison between measurements and the simulations can be made, thus allowing an evaluation of the quality of the results of ENVI-met. Furthermore, these simulations complement the point measurements by providing spatial data and giving an overview of the overall thermal performance of a quarter in present summer conditions.

The Physiologically Equivalent Temperature (PET) (Höppe, 1999) is used as a human thermal comfort index throughout the project. As PET is a static index and does not take into account the thermal history of the individual human, the results do not necessarily concur with the perception of people denoted in the interviews that were made parallel to the measurements. For this purpose the output of ENVI-met is further processed with the multi agent system Botworld, which simulates the thermal comfort of a human while moving through the model area (Bruse, 2007). The results of these simulations will be compared to the results of the interviews conducted by the University of Kassel.

In order to quantify the possible effect of climate change on human thermal comfort in urbanized areas, a worst-case scenario for the boundary conditions of the simulations was created. The maximum air temperatures for this scenario are based on data from the heat wave of 2003 in central Europe. Furthermore, the natural soils are assumed to be very dry (no irrigation), and the wind speed is set to 0.5m/s – an assumption valid for cities that are not situated near the coast or within a mountainous area and are thus not exposed to strong local wind systems. For maximum solar irradiance, the 21st of June is selected as the simulated day.

The evaluation of the efficiency of all urbanistic countermeasures proposed by the urban planners within the project will be based on simulations with this worst case scenario.



Figure 2. Model area "Vauban."

In addition to these large scale models, single components of urban planning, e.g. the effect of wall and surface materials within a street canyon on human thermal comfort, are also being simulated.

## Results

As an example of the simulations performed with ENVI-met within the KLIMES project, the simulated PET values within the Vauban quarter (Fig. 2) are shown for two scenarios in Figure 3. For the simulation of 15.07.2007, a normal cloudless summer day with temperatures of up to 30°C and westerly winds during daytime, the specific boundary conditions of this day in Freiburg were used. The simulation was compared to the measurements of this day and shows a good accordance in all meteorological variables at all measurement points. For the second scenario the worst-case boundary conditions mentioned above were used.

The comparison of the simulated PET for 12CET on the simulated days (Figure 3) reveals that, while all areas that have an elevated PET on normal summer days also show this deteriorating effect on human thermal comfort in the worst case scenario, new problematic areas only emerge under these extreme conditions. While the green spaces have a positive effect on human thermal comfort on normal summer days, they can have an adverse effect at the end of a heat wave when the soils have dried up. In the worst case scenario, also the slipstream of buildings and vegetation is more clearly represented by higher PET.

## Conclusion

The KLIMES project uses the synthesis of results of experimental investigations and numerical simulations in order to develop, in collaboration with urban planners, human-biometeorologically orientated strategies to

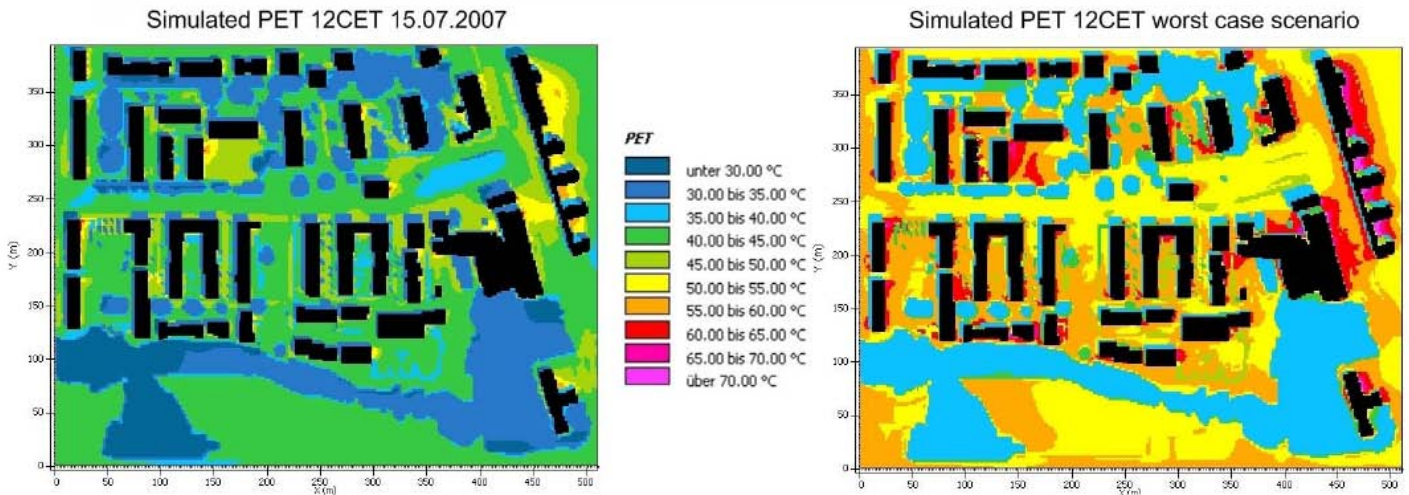


Figure 3. Comparison of simulated PET in the “Vauban” quarter of Freiburg

mitigate heat stress in central European cities. However, while focusing on human thermal comfort in cities in the summer, one must always check if the proposed measures do not have a negative effect during other times of the year, like a lack of solar access in the winter, increased air pollution or wind discomfort.

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## Urban Climate News: The Year (and a half) in Review



By David Pearlmutter  
Editor

In the beginning of 2008, I was asked by IAUC President Matthias Roth to take over as editor of the *IAUC Newsletter*. Thanks to the dedication of Gerald Mills, the editor since its inception, this home-grown publication had become a familiar and valuable conduit for news from the urban climate community – and over the last year and a half, my challenge has been to ensure that the newsletter continues to play this role.

On the eve of ICUC-7 in Yokohama, I would like to summarize here the many contributions, as well as some changes, which have been made to the newsletter over the past 18 months. The first of these changes, as suggested by the IAUC board, was the move to a quarterly format which replaced the previous bi-monthly format and has allowed for a broader spectrum of articles to appear in each edition of the newsletter. Together with this transition came a new design and a new name – *Urban Climate News* – reflecting a further broadening of scope from the activities of the organization to the larger issues and events that are related, in ever-increasing ways, to the field of urban climatology.

### In the News

It is virtually impossible *not* to notice the linkages between urban climate research and many of the most potent issues of the day: global climate change, air pollution and health, energy production and consumption, sustainable design and planning – the list of topics could go on and on. The newsletter's coverage of such issues, by way of articles drawn from the international media, has been expanded with the help of news editor **Winston Chow**. In addition to periodically compiling items for this section, Winston prepared a comprehensive report on urban air quality strategies employed for the Beijing Olympics ([September 2008](#)), and other topical themes that have received expanded coverage include the recent extreme weather events in Australia ([March 2009](#)).

### Feature Articles

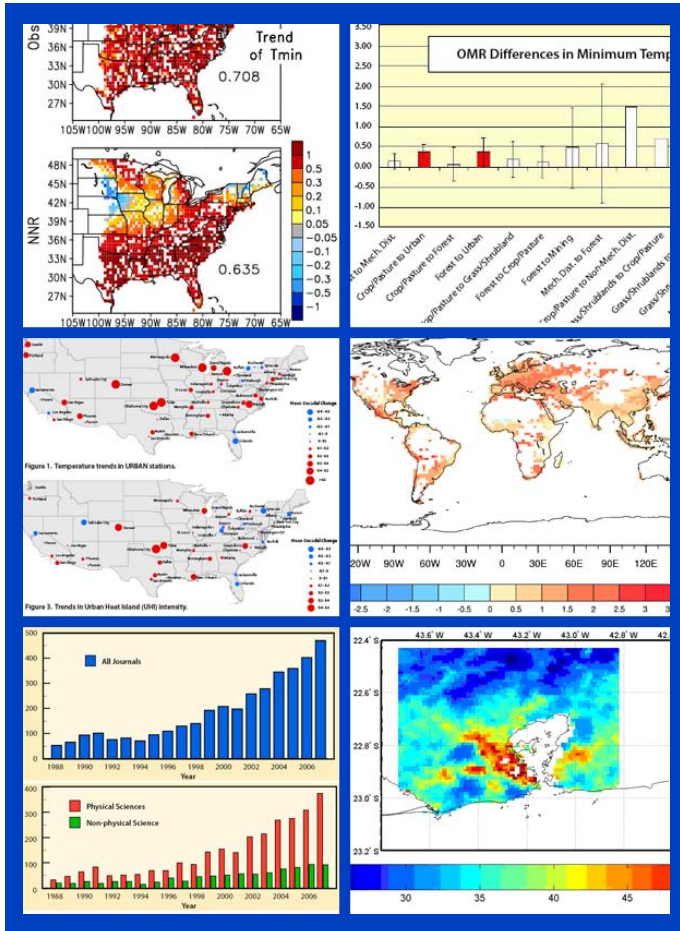
As part of the new format and scope of the *Urban Climate News*, we initiated a series of articles focusing on the role of urbanization in the modeling of large-scale surface temperature trends. The rate of global warming is an issue which has taken center stage in the media and public discourse, but climatologists have had to contend



with urbanization and other land use changes that “contaminate” the global record. A variety of approaches have been developed to account for urban heat islands, and this feature series has highlighted some of these efforts.

The series was kicked off with a report by **Eugenia Kalnay** and her colleagues ([March 2008](#)), who developed an Observation Minus Reanalysis (OMR) method for estimating the impact of land-use effects on regional warming. Application of the method showed that barren and urbanized areas were subject to more of their “fare share” of greenhouse gas warming, and that some 10% of the observed increase in North American minimum temperatures could be attributed to surface land-use effects.

A review by **Kevin Gallo** ([September 2008](#)) described further applications of the OMR methodology, as well as other techniques used in recent assessments of temperature trends and adjustments for the effects of urbanization in climatic datasets. NASA's GISS has used both satellite-derived night lights and population data to classify urban stations, whose temperature trends have been adjusted as a function of trends in neighboring stations. Kevin also contributed a survey of urban climate-related publications ([June 2008](#)), illustrating the impressive growth of the field in recent years.



**Brian Stone** ([December 2008](#)) reported on his analysis of long-term temperature trends from urban and rural stations drawn from the Global Historical Climatology Network (GHCN), and showed that the 1951-2000 warming trend in large U.S. cities (0.20°C per decade) was higher than the trend for rural stations by 0.05°C – indicating a larger heat island intensity than had been found in several previous studies that also included smaller urban areas.

In the [March 2009](#) issue, **Keith Oleson** and colleagues described their parameterization for urban surfaces, which they incorporated into the land surface component of a global climate model (NCAR’s CCSM). Their results have indicated that heating, air conditioning, and waste heat fluxes may be important for simulating realistic heat islands and for determining how heat island characteristics might change in a future warming climate.

In the [current issue](#), a feature article is included which presents original findings on the Urban Heat Island of Rio de Janeiro, Brazil. **Edson P. Marques Filho** and colleagues present their analysis of this tropical metropolitan area, suggesting that the timing and dynamics of the UHI in tropical cities could vary significantly from the familiar patterns observed in mid-latitude cities – with the peak heat island intensity occurring in the morning rather than at night.



## Urban Projects

The breadth and scale of current urban climate research is reflected in the wide variety of Urban Projects that have been featured in the recent issues of the newsletter. These reports are contributed by individuals, small working groups and large collaborative teams, and they cover a wide range of subject matter and geographical location.

In the Table below, a summary is given of the projects which have been featured in the past six issues, including their titles, authors, and links to the issues of the newsletter in which they appear. Special thanks are due to projects editor **Sue Grimmond** for identifying worthy projects, and of course to all those who have been – and continue to be – so forthcoming in the preparation of reports on their work.

Urban Project Reports: March 2008 - June 2009		
Title	Author(s)	Issue
The Oklahoma City Micronet Project	Jeffrey B. Basara	<a href="#">March 2008</a>
Analysis of PM <sub>10</sub> along a Pedestrian Precinct	Sascha Henninger	<a href="#">March 2008</a>
The Environmental Prediction in Canadian Cities (EPiCC) Network	James Voogt	<a href="#">March 2008</a>
Urban Surface Energy Balance Scheme Comparison	Matthew Blackett, Sue Grimmond, Martin Best	<a href="#">March 2008</a>
Energy Balance and Carbon Dioxide Fluxes in Singapore	Matthias Roth, Christer Jansson	<a href="#">June 2008</a>
The Dynamic of Urban Growth in Kolkata, India and Potential Impacts on Pre-Monsoon Precipitation	Chandana Mitra, J. Marshall Shepherd, Thomas R. Jordan	<a href="#">June 2008</a>
The Need for an Urban Climatology Applied Design Model	Mohamad Fahmy, Steve Sharples	<a href="#">June 2008</a>
The Urban Forest in Beijing and its Role in Air Pollution Reduction	Jun Yang	<a href="#">September 2008</a>
Increased Heat Stress in Swedish Cities due to Climate Change: The Impact of Urban Geometry on Thermal Comfort	Sofia Thorsson	<a href="#">September 2008</a>
Urban Climates Spaces – A Multi- and Interdisciplinary Research Project	Sofia Thorsson	<a href="#">December 2008</a>
The Effects of the Variance in Weather Information on Predictions of Buildings' Thermal Performance	Ardeshir Mahdavi, Volker Leinich, Kristina Orehounig	<a href="#">December 2008</a>
Canopy and Aerosol Particle Interactions in the Toulouse Urban Layer: The CAPITOUL Project	Valéry Masson <i>et al.</i>	<a href="#">March 2009</a>
The Helsinki Testbed Mesoscale Observing Network: Experiences 2005–2009	Jani Poutiainen, David M. Schultz	<a href="#">March 2009</a>
Short range Dispersion Experiments in Central London: The DAPPLE-HO Project	Janet Barlow	<a href="#">March 2009</a>
Flash flooding in the El Paso-Ciudad Juárez Border Metroplex: Variable Intensity and Differential Impacts	Thomas E. Gill, Timothy W. Collins, David J. Novlan	<a href="#">June 2009</a>
The Dual-use European Security IR Experiment (DESIREX 2008)	J. A. Sobrino <i>et al.</i>	<a href="#">June 2009</a>
Simulating climate change in urban structures: the use of ENVI-met within the KLIMES project	Michael Bruse, Sebastian Huttner, Paul Dostal	<a href="#">June 2009</a>
Urban Flux Network – A new database for information about micrometeorological sites in urban environments	Andreas Christen, Sue Grimmond, Eric Paryjak, Matthias Roth	<a href="#">June 2009</a>



## Country and Special Reports

A continuing feature of the newsletter is the Country Report series, in which comprehensive accounts are given of urban climate research activity in a particular country. These reports highlight the collaboration both within and between institutions in monitoring and modeling the climate of urban areas within the researchers' local region. Countries recently covered in this series include Denmark ([March 2008](#)), as reported by **Alexander Baklanov**, Hungary ([June 2008](#)), by **János Unger** and **Rita Pongrácz**, and Germany ([September 2008](#)), by **Wilhelm Kuttler**. Reports from countries, regions or urban areas which have not been represented recently in the newsletter are welcome, and I encourage readers who are interested in documenting the work being done in their own area to contact me at [davidp@bgu.ac.il](mailto:davidp@bgu.ac.il).

In addition, Special Reports have been submitted which highlight major urban climate-related events in different locations. These include a report on the Passive & Low-Energy Architecture (PLEA) conference in Dublin, Ireland ([December 2008](#)) by **Gerald Mills**, and a report on the AMS annual meeting in Phoenix, Arizona ([March 2009](#)) by **James Voogt**, **Matthias Roth** and **Scott Krayenhoff**, which included the presentation of the prestigious Landsberg Award to **Sue Grimmond**. In [this issue](#), **Winston Chow** reports from the AAG meeting in Las Vegas.

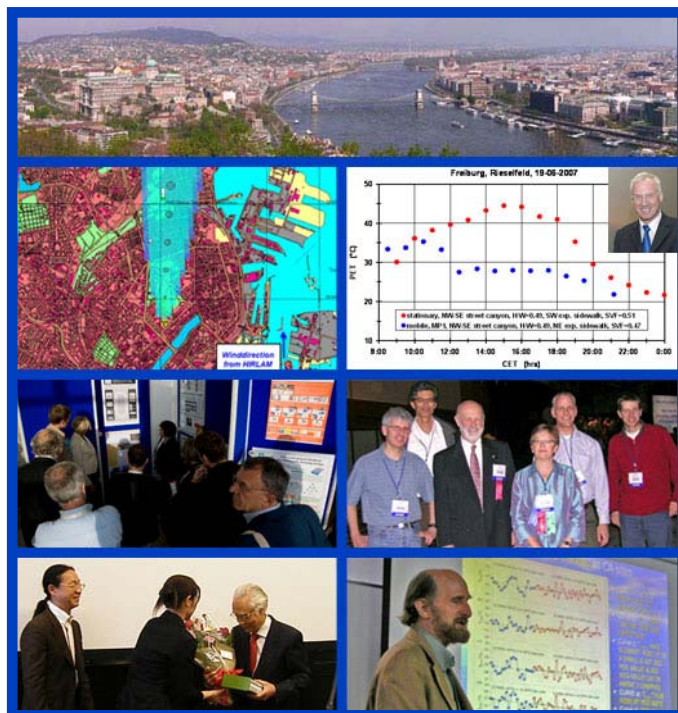
## Bibliographic Section

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

In the bibliographic section of the [current issue](#), you will find the announcement of an exciting new development – the launch of a new online bibliographic database dedicated to urban and building climatology, sponsored by the WMO. This online bibliography will provide access to a multi-year archive of articles, based on the periodic lists published in the newsletter.

## Conference announcements

The number of ongoing international conferences, symposiums, workshops and other types of meetings devoted to urban-climate related themes has become truly



impressive. While the particular focus of the organizers of these conferences may be meteorology, atmospheric sciences, architecture and urban planning, or a host of specific sustainability issues, urban climatology is becoming more and more prominent in these realms – with special sessions devoted in many cases to the urban heat island and similar issues. With help from conferences editor **James Voogt**, each edition of the newsletter has included a healthy offering of announcements for such gatherings – with special interest naturally devoted to the IAUC's own *International Conference on Urban Climate* (ICUC-7), which is now underway in Yokohama, Japan.

## IAUC Board

Aside from the ICUC gatherings held every three years, the most prominent IAUC event is the annual selection and presentation of the Luke Howard Award. This award honors a colleague from the urban climate community in recognition of his or her lifetime contribution to the field. The 2007 award was presented, together with a special IAUC copy of Howard's work *The Climate of London*, to Professor **Masatoshi Yoshino** ([June 2008](#)) in Japan by Awards Committee Chairman **Manabu Kanda**, and the recently-announced recipient of the award for 2008 is Professor **Bob Bornstein** from the U.S. ([March 2009](#)).

IAUC Secretary **Jennifer Salmond** has also provided updates on Board elections, with a new board member, **Sofia Thorsson**, elected last year ([June 2008](#)). Elections have just been held for two new members, and the results will be included in the next issue.

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

## Urban Climates in Sin City: The 2009 AAG Annual Meeting in Las Vegas, March 22-27, 2009



By Winston T.L. Chow  
Arizona State University  
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Arguably the major highlight for many geography departments in the U.S. is the annual meeting of the Association of American Geographers (AAG). This gathering draws together a multitude of academics, professionals, teachers, graduate students, undergraduates, or anyone with a strong interest in the broad and sometimes esoteric subfields within physical and human geography. This year's meeting, which attracted close to 6,500 participants, was held in Las Vegas, Nevada – a notable first in the organization's history, and the location and reputation of the host city was (perhaps) a major factor in attracting close-to-record crowds to the self-proclaimed "Entertainment Capital of the World." Another first was that one in five of this year's registrants was not from the United States, reflecting the growing global influence of the AAG as a scientific and educational organization.

Urban climatologists have historically been well-represented in the yearly AAG meets, largely thanks to the efforts of John Arnfield, Tim Oke and Gerald Mills in organizing paper sessions in years past. These efforts are not restricted to the aforementioned luminaries – humble graduate students like yours truly and Chandana Mitra (U. Georgia) advertised and arranged for well-attended urban climate-themed sessions for the previous two meetings in



San Francisco and Boston. This year, Drs. Joe McFadden (U. Cal.-Santa Barbara) and Jimmy Adegoke (U. Miss.-Kansas City) had the organizational honors, and their session drew in six presenters showcasing their latest research.

A hodgepodge of topics was covered, reflecting the diversity of interests within urban climate. Chandana Mitra presented updates of her work on Kolkata, India, which analyzes precipitation data for past influence of rapid urbanization, as well as modeling precipitation changes resulting from future urban growth. Walker Ashley (Northern Illinois U.) also examined precipitation processes, but focused on UHI-enhanced summer convective thunderstorms in the Atlanta metro area through remote-sensed radar data. Downstream lightning effects were highlighted to illustrate vulnerability of urban populations to this hazard. This theme of urban vulnerability to climate hazards was also demonstrated by Chris Green (U. Miss.-Kansas City), who conducted a ground-level ozone study in Kansas City with respect to temperature and wind field variations. The results pointed to interesting differences in ozone distribution with respect to urban density, land-use and demographics of ethnic minorities.

Climate responses from suburban areas were a focus of the session co-organizers. Jimmy Adegoke compared and evaluated surface temperatures derived from remote-sensed satellite (AVHRR thermal sensor) to tower-mounted infra-red thermometer data for a suburban surface in Kansas City. Joe McFadden looked at three years of CO<sub>2</sub> and water vapor data directly obtained from eddy covariance over a suburban lawn located in Minneapolis-Saint Paul, and examined annual cycles of these fluxes in drought vs. non-drought conditions. Finally, Tim Oke (U. Brit. Columbia) looked at an important scale



The author (right), with fellow Arizona State University researchers Donna Hartz (left) and Chona Sister (center), in the Grande Ballroom of the Riviera Hotel in Las Vegas, Nevada during the AAG annual meeting.

issue in modeling the urban canopy; he questioned if heat fluxes from individual surfaces can be combined as a “bottom-up” approach for estimating a neighborhood-scale flux. He analyzed scintillometer and eddy covariance data from a Basel suburb to illustrate that this was a viable approach in that neighborhood, and also noted the importance of weather differences (for example, dry vs. wet conditions and anabatic vs. katabatic wind flows) in changing sources and source areas of fluxes.

Lastly, it was notable that several presentations directly related to urban climate were not included in an organized themed session. This was rather unfortunate – perhaps the call for paper presentations through the Met-urbclim list was not disseminated widely enough. It can be a “frustrating” experience for presenters slotted in these general sessions (as confided to me by someone wishing to remain anonymous), who desire useful feedback, networking and possible equipment-sharing opportunities that, as Tim pointed out during the session Q & A, researchers need especially in these current economic circumstances. Hopefully, the next gathering, which is held in Washington D.C. during April 2010, will continue having a session (or more) catering for urban climatologists wishing to meet under the aegis of the AAG.

### Upcoming Conferences...

#### WORLD CLIMATE CONFERENCE – 3

Geneva, Switzerland • August 31-September 4, 2009

<http://www.wmo.int/wcc3>

#### INTERNATIONAL CONFERENCE ON MEGACITIES: RISK, VULNERABILITY AND SUSTAINABLE DEVELOPMENT

Leipzig, Germany • September 7-10, 2009

<http://www.megacity-conference2009.ufz.de/>

#### COUNTERMEASURES TO URBAN HEAT ISLAND IN LBL: SECOND INTERNATIONAL CONFERENCE

Berkeley CA, USA • September 21 – 23, 2009

<http://heatisland2009.lbl.gov>

#### LOCAL AIR QUALITY AND ITS INTERACTIONS WITH VEGETATION

Antwerp, Belgium • January 21-22, 2010

<http://www.vito.be/aq-vegetation-workshop>

### ICUC-7 IN YOKOHAMA, JAPAN: PROGRAM AT A GLANCE

	MON June 29		TUE June 30		WED July 1		THUR July 2		FRI July 3	
8:00	Registration		Meas. of airflow 2	Design & planning 1	CFD of air-flow and dispersion 3	Impacts of climate change on cities 1	Models of the urban atmosphere 2	Urban impacts on precipitation 1	Models at all scales 2	Heat Island 1
9:00	Welcome/Awards									
10:00	Plenary (F. Fujibe)		Meas. of airflow 3	Design & planning 2	CFD of air-flow and dispersion 4	Impacts of climate change on cities 2	Models of the urban atmosphere 3	Urban impacts on precipitation 2	Remote sensing 1	Heat Island 2
11:00	Meas. of airflow 1	Building climate								
12:00	Lunch Break		Plenary (G. Carmichael) + Lunch Break		Plenary (D. Sailor) + Lunch Break		Plenary (Y. Ashie) + Lunch Break		Lunch Break	
13:00										
14:00	Exchange processes 1	Impervious surfaces water & green	CFD of air-flow and dispersion 1	Design & Planning 3	Models of the urban atmosphere 1	Low carbon cities 1	Urban pollution met. and modeling	Human biomet. 1	Remote sensing 2	Heat Island mitigation
15:00										
	Coffee / Poster Session 1		Coffee / Poster Session 2		Coffee / Poster Session 3		Coffee / Poster Session 4		Coffee / Poster Session 5	
16:00	Exchange processes 2	Urban parks & plants	CFD of air-flow and dispersion 2	Forecasts for the urban environment	Models at all scales 1	Low carbon cities 2	Aerosols & photo-chemical pollutants	Human biomet. 2	<b>For exact times and updates, check the official conference schedule and web site:</b> <a href="http://www.ide.titech.ac.jp/~icuc7/">http://www.ide.titech.ac.jp/~icuc7/</a>	
17:00										
18:00	Ice Breaker		Bay Cruise		Banquet					
19:00										
20:00										

## Recent publications in Urban Climatology

Bakosi, J., Franzese, P. & Boybeyi, Z. (2009), Joint PDF Modelling of Turbulent Flow and Dispersion in an Urban Street Canyon, *Boundary-Layer Meteorology* **131** (2), 245-261.

Cava, D. & Katul, G. (2009), The Effects of Thermal Stratification on Clustering Properties of Canopy Turbulence, *Boundary-Layer Meteorology* **130** (3), 307-325.

Chen, Y., Zhao, C., Zhang, Q., Deng, Z., Huang, M. & Ma, X. (2009), Aircraft study of Mountain Chimney Effect of Beijing, China, *Journal of Geophysical Research Atmosphere* **114**, D08306.

Christen, A., Rotach, M. W. & Vogt, R. (2009), The Budget of Turbulent Kinetic Energy in the Urban Roughness Sublayer, *Boundary-Layer Meteorology* **131** (2), 193-222.

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Ettouney, R. S., Abdul-Wahab, S. & Elkilani, A. S. (2009), Emissions inventory, ISCST, and neural network modelling of air pollution in Kuwait, *International Journal of Environmental Studies* **66**(2), 181-194.

## Bibliography on Urban and Building Climatology

As announced at ICUC-7, the **Bibliography on Urban and Building Climatology** is now available online from the IAUC web page. This online database, sponsored by the World Meteorological Organization (WMO), was initiated by the CCI



Expert Team on Urban and Building Climatology led by Sue Grimmond, and uses the Aigaion bibliography management software (GPL). As a first step, records from the past year are now available on the site. In the coming weeks, we hope to add all entries for the period 2005-2009. You are invited to review the records at <http://www.urban-climate.org>.

The full database will eventually also include the following three bibliographies:

- *Bibliography of Urban Climate 2000-2004*; 559 articles (prepared by Jennifer Salmond).
- *Bibliography of Urban Climate 1996-1999*; 227 articles (prepared by Jennifer Salmond).
- Jauregui, E (1996) *Bibliography of Urban Climatology for the period 1992 - 1995*, WMO/TD-No. 759, World Meteorological Organization, May 1996.

In this edition of the newsletter, publications are included which have come out by May 2009 – thanks for your numerous contributions.

As usual, papers published in recent months (up to August 2009) are welcome for inclusion in the next newsletter, and now also in our new online database. Please send your references to [jhidalgo@labein.es](mailto:jhidalgo@labein.es) with a header "IAUC publications" and in the usual format (Author/Title/Journal/Volume/Pages/Dates/Keywords/Language/Abstract).

Happy reading,

Julia Hidalgo

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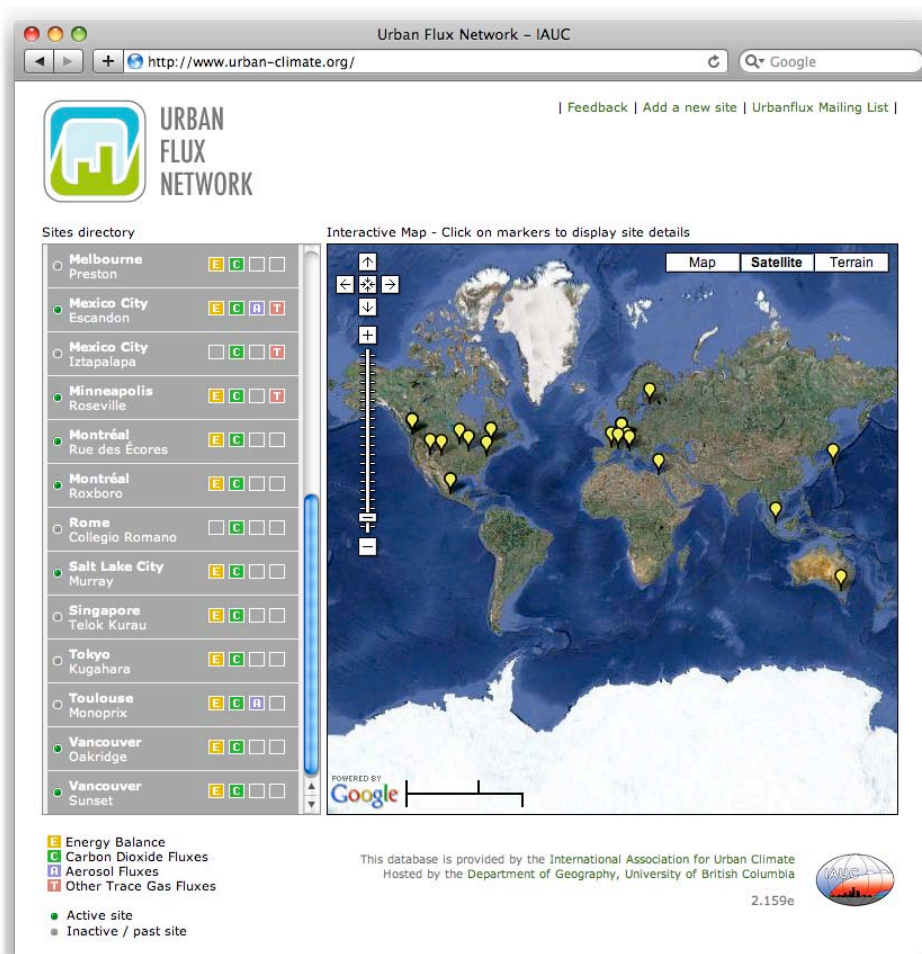
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## The IAUC Urban Flux Network – A new database and mailing list to share information about micrometeorological tower sites in urban environments

Throughout the past decade, numerous research groups in our research community have put significant effort into setting up new infrastructure to directly measure fluxes between urban ecosystems and the atmosphere using micrometeorological methods – mainly eddy covariance of water vapour, carbon dioxide, aerosols and other trace-gases. More and more long-term sites are installed in areas considered ‘typical’ for selected urban developments to quantify the impact of urban form and management, and assist in modeling of urban climates, urban biogeochemical cycling, sustainable urban design, urban water use, urban weather forecasting, urban air pollution, or safety and security in urban areas.

Unlike the research community in forest and agricultural systems, urban micrometeorologists, biologists, and hydrologists do not yet have a platform to share information on historical and ongoing urban measurement sites. A few tall towers and continuous systems are included in the FLUXNET database (<http://www.fluxnet.ornl.gov/>) but most urban sites are not suitable for FLUXNET and virtually no urban sites are focusing on quantifying annual net ecosystem exchange (NEE) of urban vegetation. Urban climate researchers have different needs for specifications and urban surface descriptions, and their research objectives are often different compared to those relevant to forest and agricultural systems (e.g. fossil-fuel emissions, air pollutants, anthropogenic heat fluxes).

The **IAUC Urban Flux Network** intends to fill this gap by providing a simple, web-based database (Fig. 1) with the objective of collecting and sharing information about ongoing and discontinued micrometeorological tower sites located in urban environments. The **IAUC Urban Flux Network** collects and records meta-data (site location, publications, operation periods, urban surface characteristics, photos, contacts, etc.), but is not a data-sharing platform for measurements.



Any site that fulfills certain criteria and is of interest to the IAUC research community can join the **IAUC Urban Flux Network**. To be listed in the **IAUC Urban Flux Network**, a site must be located in an urbanized area and have a proven record of successful flux data acquisition and publications in any of the following categories: energy balance, carbon dioxide, aerosol, or trace-gas flux site. Flux measurements must be representative of the neighborhood scale over a homogeneous area of any city. Both ongoing and historical sites can be added.

The database grew out of discussions during the *Eighth AMS Conference on the Urban Environment* in Phoenix in January 2009 to reactivate the ‘Urban Fluxnet’ list compiled by Grimmond *et al.* (2004), and provide a simple, low-maintenance interface based on Google Maps to navigate through the footprints of towers.

The **IAUC Urban Flux Network** can be accessed via the IAUC Webpage ([www.urban-climate.org/](http://www.urban-climate.org/)) under ‘Urban Climate Resources’. It currently hosts data from approximately 30 sites on five continents. If your site is not yet listed, we highly encourage you to use the ‘Add site’

form and submit your site information and photos.

Further, a new mailing list – **urbanflux** – has been set up along with the web-database to connect researchers and students working on urban-atmosphere exchange. The specific objectives of the **urbanflux** mailing list are to:

- Discuss urban-specific problems such as sensor exposure, urban surface description, data-processing and analysis of urban flux measurements.
- Develop standardized protocols to describe instrument siting and placement, urban surface parameters, and data processing specifically for urban flux measurements.
- Maintain and improve the **IAUC Urban Flux Network** database.
- Disseminate information on planned or recent urban field projects and model developments related to urban-atmosphere exchange.

To join the **urbanflux** mailing list, please follow the instructions given at: <https://mailman.kcl.ac.uk/mailman/listinfo/urbanflux>

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#### Newsletter Contributions

The next edition will appear in late September. Items to be considered for the next edition should be received by **August 31, 2009**. The following individuals compile submissions in various categories. Contributions should be sent to the relevant editor:

**News:** Winston Chow ([wchow@asu.edu](mailto:wchow@asu.edu))

**Conferences:** Jamie Voogt ([javoogt@uwo.ca](mailto:javoogt@uwo.ca))

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General submissions should be relatively short (1-2 A4 pages of text), written in a manner that is accessible to a wide audience and incorporate figures and photographs where appropriate. In addition we like to receive any images that you think may be of interest to the IAUC community.