Surface Description for Urban Climate Studies: A GIS Based Methodology

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Abstract

In order to understand the nature of the urban climate, predict the effects of urbanization, or attempt to ameliorate some of the negative hydroclimatic effects of urbanization, it is necessary to have a good understanding of the role and significance of the urban surface. This paper presents a methodology which uses GIS to represent the characteristics and morphology of the urban surface, which can be used to describe a site objectively, model fluxes, or ensure spatial consistency between measured and modelled data, all of which can vary through time. The methodology is illustrated with respect to Chicago, Illinois. Surface data collected at three spatial scales were used to construct a georeferenced database which was linked to an objective, dynamic accessing system. Spatial variability of surface cover, derived hydroclimatic attributes, and modelled fluxes associated with changes in the urban environment are used to illustrate potential applications of the approach.

Introduction

A large and ever increasing proportion of the world's population live in urban areas. Current estimates indicate 42% of the world's population are urban dwellers (an average of 72% in more developed countries, 34% in less developed countries) (World Population Reference, 1993). This represents an increase from 28% in 1950 and 39% in 1975 (United Nations, 1980). Urbanization brings about significant changes in land-cover. The replacement of natural surface materials significantly alters the aerodynamic, radiative, thermal and moisture properties of the surface. In turn these perturb the pre-urban balances of energy, mass and momentum and lead to the modification of the atmosphere and the generation of the "urban climate", commonly characterised by enhanced temperatures (the urban heat island), poorer air quality, *etc.* Increasingly, attention is being directed to strategies to mitigate some of the inadvertent environmental effects of urbanization. For example, strategically planting trees or lightening building and pavement surface colors have been suggested as ways of reducing the urban heat island and reducing energy use for cooling (Akbari *et al.*, 1992). Most of these strategies involve some alteration of the morphology or material properties of the "urban surface." Emphasis is directed not only to the mid-latitudes, but through projects such as TRUCE (Tropical Urban Climate Experiment), to those areas which are most rapidly urbanizing (Oke *et al.*, 1990/91; Jauregui, 1993).

The active surface of any system is one of its most important climatological determinants as it is the primary site of energy, mass and momentum transfer and transformation (Oke, 1984). Thus surface properties (geometry and materials) affect energy and water exchanges and variations create micro-and local-scale climates. In order to understand the nature of the urban climate, predict the effects of urbanization, or attempt to ameliorate some of the negative hydroclimatic effects of urbanization it is necessary to have a good understanding of the role and significance of the urban surface.

The urban-atmosphere interface is extremely complex, thereby defying simple description. Thus a fundamental methodological problem in urban hydroclimatological research is the definition of the location and characteristics of the urban surface and its representation. Using Geographic Information System (GIS) based techniques our objective in this paper is: first, to present a methodology to represent the characteristics and morphology of the urban surface which can be used to describe a site objectively, model fluxes, or ensure spatial consistency between measured and modelled data; and second, to outline some of the potential applications of such a methodology for site description, determination of model input, and predictive modelling. The methodology is illustrated with respect to Chicago, Illinois the site of the Chicago Urban Forest Climate Project (CUFCP), an interdisciplinary study investigating the effects of vegetation on the urban hydroclimate (McPherson *et al.*, 1992; Nowak and McPherson, 1993).

Issues to be Considered

(i) Properties of the Surface

When characterizing the surface for studies of the hydroclimate a number of issues need to be considered. First, the definition and description of the urban surface utilized depends upon the process(es) studied. Different hydroclimatic fluxes are influenced by different characteristics of the surface. For example, studies of net all-wave radiation require albedo and emissivity to describe the surface; studies of the turbulence characteristics of the urban atmosphere need the roughness length, displacement length or roughness element separation, height of roughness elements, *etc*; and storage heat flux studies require information on the spatial distribution of thermal admittance, percentage of green and built space, *etc*.

A second set of considerations relate to the spatial and temporal scale of interest. The scale at which the study is conducted determines the area of interest and which attributes are regarded as homogeneous and which heterogeneous. In this paper the methodology will focus on the determination of hydroclimatic fluxes at the local scale, length scale 10^2 - 10^3 m (as defined by Oke, 1984). In urban areas this represents units the size of city blocks to landuse zones i.e. "neighborhoods." However, the methodology is equally applicable to the micro-scale (individual properties) or meso-scale (whole city).

(ii) Delimiting the study area

Once the appropriate parameters and scale for the surface description have been identified, there remains the practical consideration of where to draw the boundaries to delimit the area to be described. Because of sub-scale heterogeneity the choice of boundaries may unknowingly or purposefully change the site description. Conventionally a site has been described in a static sense, with fixed boundaries and areal extent. One description has been used for all periods of measurements or modelling, which does not vary with wind direction or meteorological conditions (e.g. stability). Typically this description is based on a mean parameter for a circle around the measurement site (see for example, Yap, 1973, Kalanda, 1979, Steyn, 1980, Oke *et al.*, 1981, in Vancouver; Ching *et al.*, 1983 in St. Louis; and Yersel and Goble, 1986 in Worcester); although some of the researchers have divided the circle into equal size sectors (e.g. sixteen 22.5° sectors). The choice of radius for the circle is often based on calculated fetch requirements with an extra margin added (of the order of 500 m).

The circle approach assumes either that the surface is spatially homogeneous and/or that over time the variation of wind direction will create spatial averaging. In reality surface properties are spatially heterogeneous and there are preferred wind directions. Consequently, the properties of the surface area contributing to a turbulent flux at any point is constantly changing (see further discussion below). This suggests a dynamic approach, where the surface characteristics and changing meteorological conditions are taken into account, may be a more appropriate way to describe a site when measurements are being conducted, especially if modelled data are to be evaluated against measured data to ensure spatial consistency (Grimmond, 1992).

The surface area contributing to a flux measurement may be termed the "source area" (Schmid and Oke, 1990). The source area is dependent on the process involved, the instrumentation used and the meteorological conditions under which the measurements occurred. The equivalent of the source area for a modelled flux is the "model domain."

For measurements of the radiative fluxes the source area is fixed in time by the field of view of the instruments i.e. by geometry. This source area can be determined using the procedure outlined by Reifsnyder (1967) and Schmid *et al.* (1991). For the turbulent fluxes the source area is not fixed but varies through time. The dimensions of the elliptically shaped source area for the turbulent fluxes can be determined using the Schmid and Oke (1990) Source Area Model (SAM). The SAM output consists of weighted elliptically shaped source areas for each hour with dimensions that are a fairly sensitive function of sensor height, and are further affected by stability and roughness, in that order of importance. Utilizing the meteorologically controlled SAM ellipses with a GIS (see below) it is possible to determine the area influencing the measurements and objectively describe the site, or determine parameters for models which are to be evaluated against the measured data.

Methodology

The GIS based methodology presented here consists of two parts: the development of a georeferenced database and a dynamic, objective means of sampling the database.

(i) Georeferenced database

To develop a surface database for the purposes outlined above it is necessary to take a stratified approach. This allows a large enough areal coverage while maintaining detailed spatial resolution. For within city studies it is proposed that data be collected at three spatial scales, referred to here as "regional" (length scale 10^4 m), "local" (10^2-10^3 m) and "micro" (10^{-1}-10^1m) (shown schematically in Figure 1). At the scale of the region the entire area of interest is delimited (i.e. the city or a large part of the city) and units of similar morphology and surface materials are mapped from aerial photographs. At this stage it is important to consider what aspects of the morphology are significant for the processes of interest, and these are used to define the basic units to be mapped. For example, these may be based on surface roughness, building density, tree cover, *etc.* Many of these properties are strongly related to, but *not* necessarily directly associated with socio-economic activities e.g. commercial, industrial, residential landuse *per se*.

Having delimited the units it is necessary to assign numerical values to surface characteristics. This involves data analysis at the two more detailed scales (local and micro, Figure 1, Table 1). From more detailed

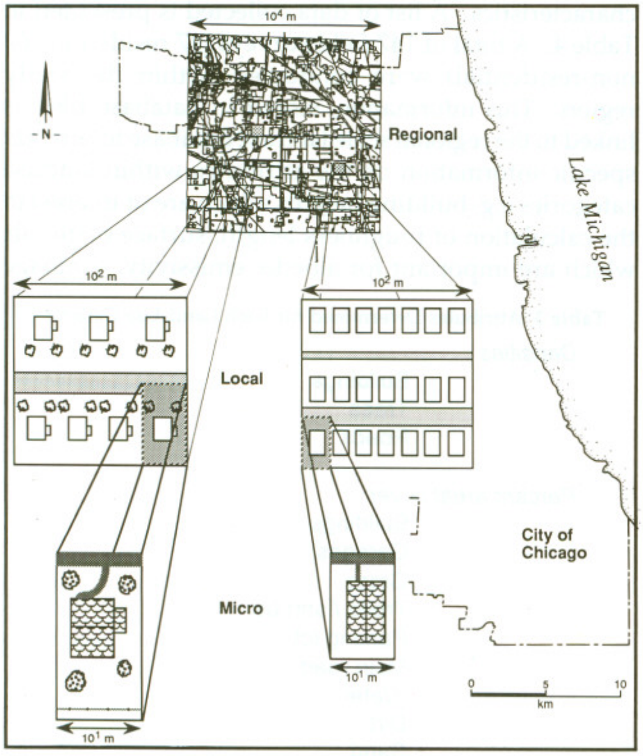

Figure 1 Nested database structure with the location of the Chicago study area shown. The three scales of data collection (regional, local and micro) are shown.

Table 1 Information source at each scale

Scale	Method	Area covered (for Chicago)	Data analysis software (examples for Chicago)
I. Region	Landuse mapping on air photos	5 km radius around pneumatic tower. Area bounded by Touhy, Chicago, Mannheim, & Pulaski	GIS e.g. ARC/INFO Atlas GIS
II. Local	Detailed photo analysis (200 m x 200 m square)	Randomly located replicates within each landuse category	Spreadsheet e.g. Quattro-Pro
III. Micro	Field surveys	147 randomly located points and immediate surrounding area within region	Database e.g. Paradox Fox-Pro

photographs, representative information on building and tree densities, and percent cover of different surface types can be obtained by randomly sampling within each of the units mapped at the regional scale. For North America, Schmid and Oke (1992) have demonstrated that the average suburban block (length scale 10^2m) contains all the important surface elements to form a characteristic local scale suburban climate. At the most detailed scale, field observations at randomly chosen locations allow for field checks of the density and percent cover data, and for more detailed information on the three-dimensional nature of the urban surface and the material characteristics, both built and vegetative, to be collected. All this information is stored in linked digital form so that subsequent analyses can be conducted and spatial variability studied. A major advantage of a GIS based approach is that attributes can be added after the initial land-use mapping as long as the units mapped are homogeneous with respect to these attributes. Alternatively, new layers can be defined.

(ii) Dynamic, objective sampling of the georeferenced database

One of the major objectives in developing a GIS based scheme is to permit objective site descriptions and parameter assignments which can change with meteorological conditions, season, the modelling scenario under consideration, *etc.* The method used involves one of a series of computer programs which calculate where the boundaries should be placed so the landuse information can be determined. The exact location of the boundaries is based in the theory underpinning the variable of interest. For example, the source area for radiant fluxes is determined from view-factor geometry, that of the turbulent fluxes is based in dispersion theory. The boundaries are then converted into map projection coordinates (for example, Universal Transverse Mercator (UTM) or latitude/longitude) and imported into the GIS software. A split operation is then performed between the area-of-interest and the attribute layer, to create a new layer from which the parameters-of-interest are calculated.

Case Study: Chicago, Illinois

In order to illustrate the approach and some potential applications, the methodology is described with respect to Chicago, Illinois, U.S.A. The study area is centered near the intersection of the city streets: Irving Park, Forest Preserve and Harlem (latitude 41°57′ 9.24" N; longitude 87°48′ 19.62" W) (Figure 1). This was the location at which a pneumatic tower and a fixed-tower were instrumented during the summer of 1992 to collect intensive micro-meteorological flux measurements.

The major landuse categories and criteria for distinguishing between them are listed in Table 2. Given the focus of the study on the effects of vegetation on urban climate, the two primary criteria for distinguishing between landuse were building dimensions/density and tree cover dimensions/density. The spatial distribution of the units were mapped for a square of approximately 13 km x 13 km, centered on the fixed tower site (Figure 1) (this delimits an area bounded by the city streets of Touhy to the north, Chicago to the south, Mannheim to the west, and Pulaski to the east). The dimensions were based on preliminary calculations from the Schmid and Oke (1990) Source Area Model on the size and areal coverage of the source areas for the turbulent fluxes measured from the top of the pneumatic tower at a height of 18 m. The aerial photography used for mapping was at the scale 1:24 000 (supplier Geonex Chicago Aerial Survey (CAS), Des Plaines; Flown March 2, 1992). The map was digitized using ARC/INFO. A total of 53 landuse classes were mapped which produced 2628 polygons (Figure 2).

The specific information collected in the local-scale analysis is outlined in Table 3. This was conducted using randomly located 200 m x 200 m grid squares on a second set of more detailed aerial photos (1:4800, Sidwell Company, West Chicago, Spring 1987; 1:4800, Geonex CAS, March 24, 1990). Based on replicates within each landuse category means and standard deviations of densities and percent plan-area cover for each landuse category were calculated. These data were linked to the regional digital landuse map to allow the areal distribution of attributes to be illustrated. As examples, Figures 3 and 4 illustrate the spatial variability of vegetative cover and built impervious surfaces across the study region. Impervious surfaces are important in defining retention and detention storage capacities which are used in both runoff and evaporation modelling. Vegetative cover is important for defining surface resistances for evaporation and air quality modelling. Comparing these figures with the land-use map (Figure 2), differences in terms of surface properties between the classes become clear. See for example, the differences in surface cover within the residential A classes (A - A4). Note also how, in general, the city becomes more impervious towards the east.

At the micro-scale, field surveys were conducted to provide detailed information on surface cover at the scale of the individual lot in residential neighborhoods or tenth of an acre plot (0.04 ha) in non-residential areas. Using a weighted stratified random sampling method (Nowak in McPherson *et al.*, 1992), sample plots within each landuse category were selected to obtain detailed information on the specific surface characteristics. A list of data collected is presented in Table 4. A total of 147 field surveys (87 residential, 60 non-residential) were conducted within the study region. This information, stored in database files, is linked to the regional scale landuse database to provide specific information on the attributes within landuse categories e.g. building heights which are of interest in the calculation of roughness length; surface materials which are important for albedo, emissivity, drainage

Table 3 Attributes Determined for Each Land-Use Category

Densities	
	Buildings
	Trees
	Roads
Percent areal cover	
	Buildings
	Garages
	Grass
	Trees / shrubs
	Parking lot
	Main road
	Water
	Dirt
	Sand
	Pavement (non-parking lot)
	Scruff

Table 2 General Landuse Categories: Chicago

General Landuse		**Categories and description**
Residential: Single		*Categorized primarily on building density, size and vegetation type and density*
	A	High density housing, categories A1-A4 differentiated on shape of buildings and whether attached or not. Yards small, mainly grass, few trees.
	B	Moderate density housing, small houses with trees
	C	Moderate density housing, small houses, large yards. C1-C3 differentiated based on size of houses. All have many trees/extensive landscaping
	D	Large houses, small grass yards with some trees and shrubs
	E	Large houses, large yards, yards landscaped with shrubs and trees
	EA	Mixture of "A" and "E" type housing
	F	Houses equally spaced, large grass yards, few trees, F1 and F2 differentiated on housing density
	MH	Mobile homes
Apartments:	*Categorized primarily on shape, height and arrangement of parking*	
	AA	5-6 stories, U-shaped, distinguished from AA2 based on arrangement of parking around the building
	AB	Square shaped buildings
	AL	L-shaped buildings, 7 stories tall, no trees
	AL1	Rectangular shaped buildings
	AR1	Duplexes
	AR2	Mixture of AR1 and A type houses
	AR3	Highly mixed
	BB	Low-level apartments (2 stories), rectangular shape, BB1, BB2 and BB3 distinguished on height and size
Commercial/Industrial	CB	Large commercial buildings - less than 6 stories
	CC	Very tall commercial buildings - at least 15 stories
	CS	Small commercial buildings
	I	Industrial - either large low level buildings or many small buildings
Institutional	HS	High school: Large building, few trees, medium size parking lot
	S	Elementary / Junior High school: Much smaller building than HS
	U	University: Large buildings, parking lot, vegetated grounds
Transportation	MRI	Major roads e.g. interstates
	RR	Rail road tracks or side-yards
Vacant/Wild	DI	"Dirt"
Vegetated	VG	Golf course
	VGR	100% grass
	VM	50% grass / 50% tree and shrub
	VPC	Cemetery
	VT	Trees and shrubs
Impervious surfaces	CN	Concrete
	IP	Parking lot (impervious)
	IS	Tennis court
Water	WL	Lake
	WR	River

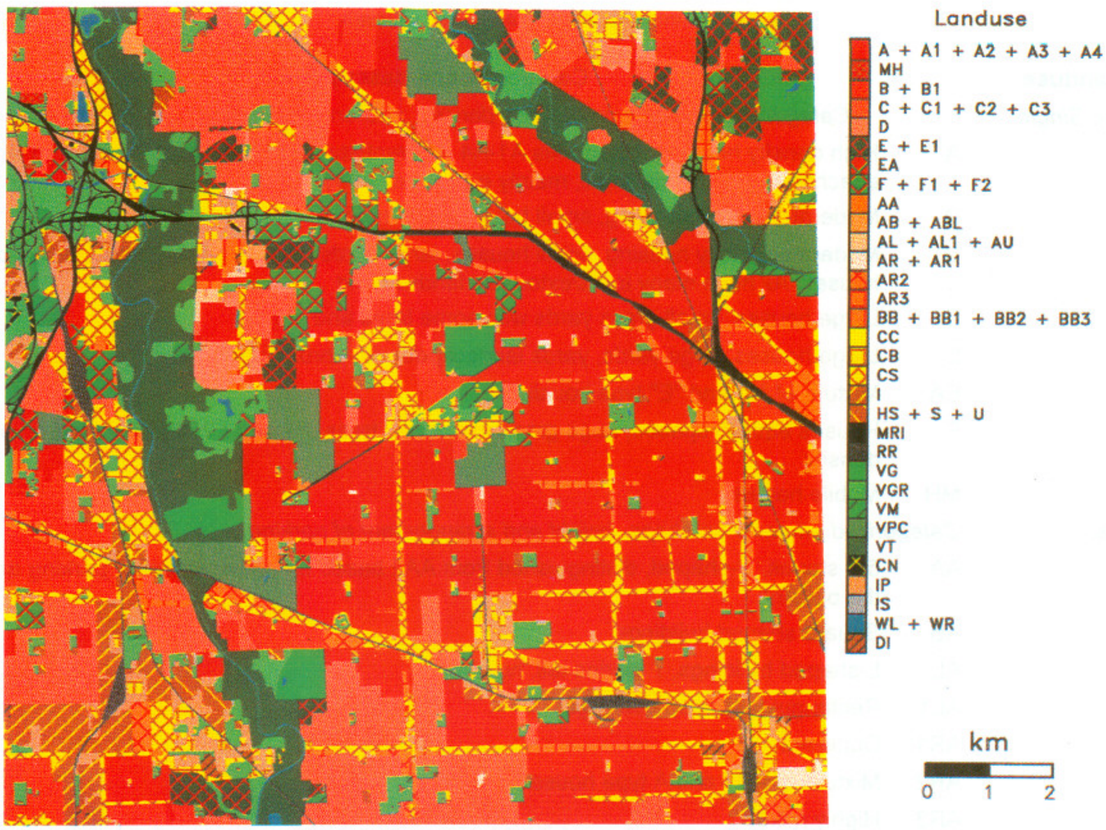

Figure 2 Chicago landuse based on building dimensions/density and vegetation dimensions/density. See Table 2 for description of codes.

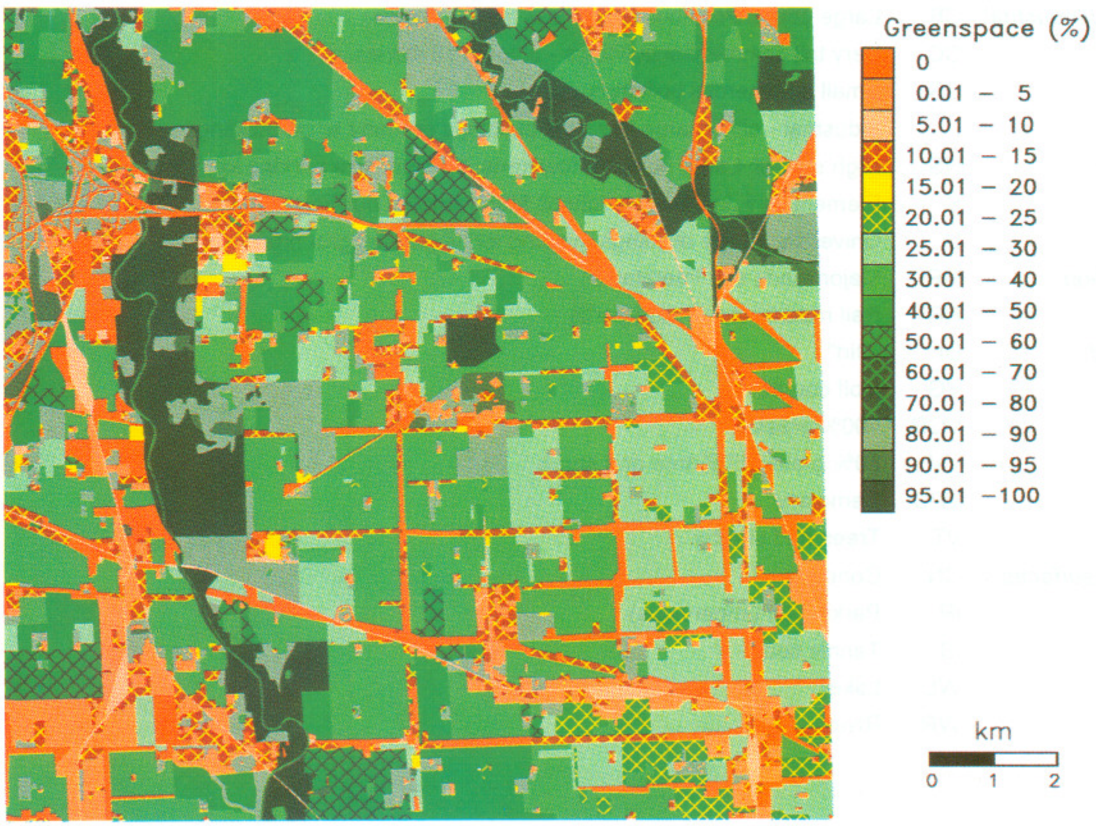

Figure 3 Percent plan area of greenspace (trees, shrubs, grass) across the study region, Chicago, Illinois

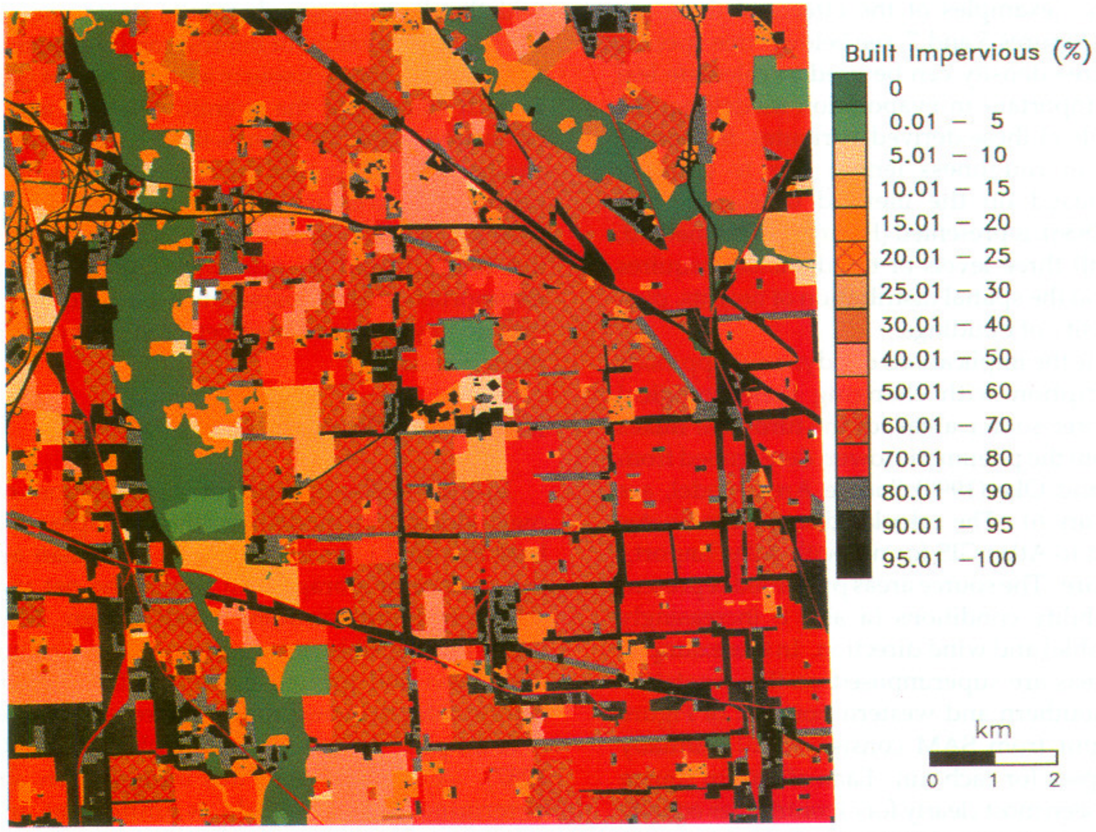

Figure 4 Percent plan area of built impervious materials across the study region, Chicago, Illinois

Table 4 Information collected in the field survey (from Nowak in McPherson *et al.*, 1992)

Non-residential (0.1 acre, 0.04 ha plots)

Landscape:	Managed or unmanaged and conditions
Landuse:	Residential, commercial *etc* and % of plot covered
Ground cover:	% cover by: building, structures, cement, tar, wood, other impervious, soil, rock, duff/mulch, herbaceous/ ivy, grass, wild grass, water, shrubs
Building attributes:	Type, length, width, material, azimuth from front door outward, age, height, number of floors, roof color, wall color, percent wall glass, average distance to nearest building, height of nearest building
Structure shrub & trees:	Full listing of species and size of each tree and shrub, condition of tree, percent beneath canopy of artificial surfaces, dbh, height, height to lower crown, crown width, crown shape, percent of crown volume occupied by leaves, tree condition.

Residential (variable size based on lot size; from mid-street to mid-alley or back of lot)

Road:	Width of road, length of road in front of property, type of road, type of road, width of curb to sidewalk, percent of strip covered by cement
Alley:	Width, length, surface type of alley
Length:	Length of front part of lot, width of front part of lot, presence, type and height of any overhead obstructions
Irrigation:	Percent of vegetation irrigated
Structure:	Length, width, height of structure, percent of plot occupied by structure, type of structure, material, structure of roof
Shrubs:	Species, length and height of shrub mass, percent of shrub volume occupied by leaves, density of leaf mass, number of stems in mass, average diameter of stems in mass
Trees:	Species, number of stems, dbh, tree height, bole height, crown width, crown shape, percent of crown volume occupied by leaves, crown density
Positions:	Sketch and photo of building and tree locations referenced to tree information

properties, *etc* (examples of the effects of these are illustrated in Figures 5 and 7, see below); tree species, which with tree density can be used to calculate leaf area index, important in evaporation modelling, *etc.* As an example of these derived attributes, the spatial distribution of roughness length due to primary buildings, based on the method of Kondo and Yamazawa (1986), is presented (Figure 5). This method, which uses all three levels of the database, requires information on the spatial distribution of heights, plan area and density of buildings.

To illustrate the implications of a dynamic approach to site description with changing meteorological conditions, three source areas for the turbulent fluxes measured from the pneumatic tower, determined from the Schmid and Oke (1990) Source Area Model, are mapped (Figure 6). The calculated map coordinates are converted to Atlas GIS format with Atlas Import/Export software. The source areas presented represent changing stability conditions (a and b increasingly unstable, c stable) and wind direction. In this example, the source areas are superimposed on the vegetative cover map (southern and western portions of Figure 3). The output from SAM consists of 10 mutually exclusive ellipses for each run. Each of the ten source area ellipses (seen most clearly for c) contributes equally to the measurements on the tower. Using the Atlas GIS commands the landuse-layer polygons are split with the ellipse-layer polygons to create a new layer so the parameter values of interest can be determined. In this example, for each source area the area of vegetation in each ellipse and the overall weighted average are calculated (Table 5). Even with this simple example it can be seen clearly that the characteristics of the area contributing to the measurements at this site varied in time i.e. between source areas. Obviously if models are being tested at this site it is important that appropriate surface parameters be used and spatial consistency be maintained between the measured and modelled data.

Modelling Storage Heat Flux

In order to illustrate potential applications of such a methodology in modelling, the example of storage heat flux (ΔQ_S) has been chosen. In urban areas the sub-surface or storage heat flux is the net uptake or release of energy from the urban system. It includes latent and sensible heat changes in the air, buildings, vegetation and ground extending from above roof-level to a depth in the ground where net heat exchange over the period of study is negligible (Oke and Cleugh, 1987). A knowledge of this term and an ability to determine its magnitude is important in many modelling applications and the thermal inertia provided by storage is often regarded as a key term in

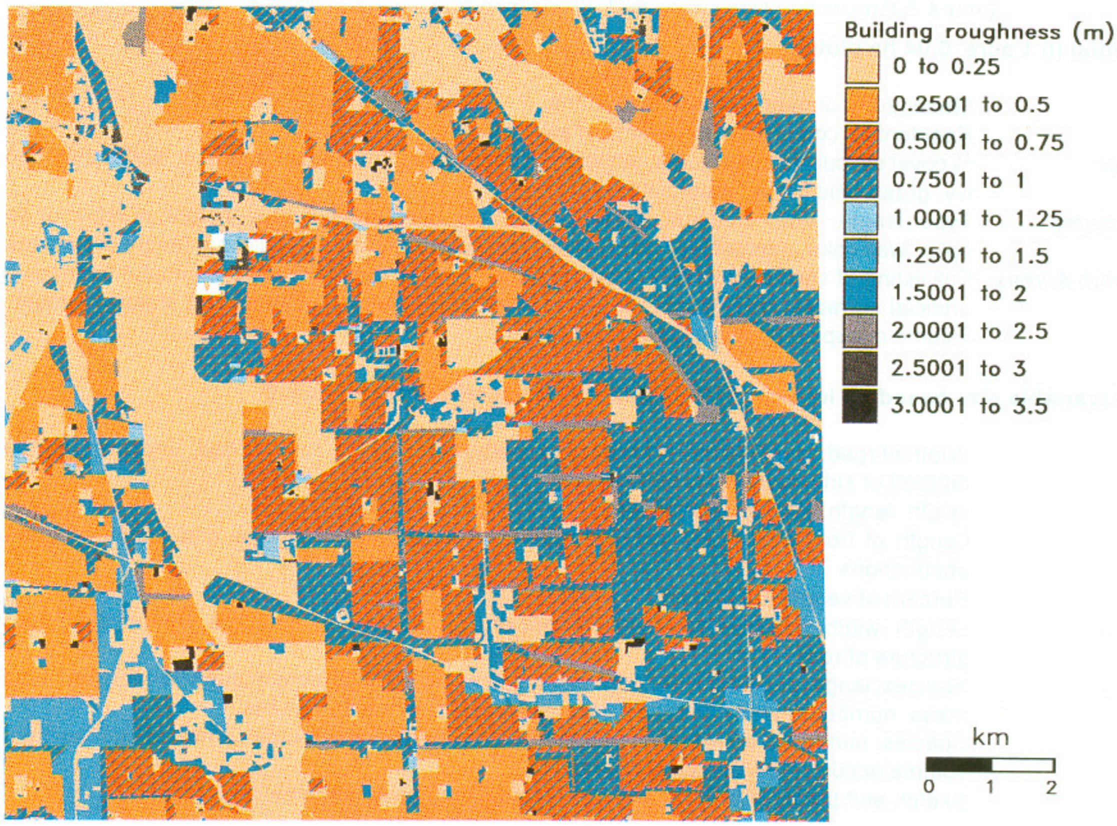

Figure 5 Roughness length due to buildings across the study region, Chicago, Illinois

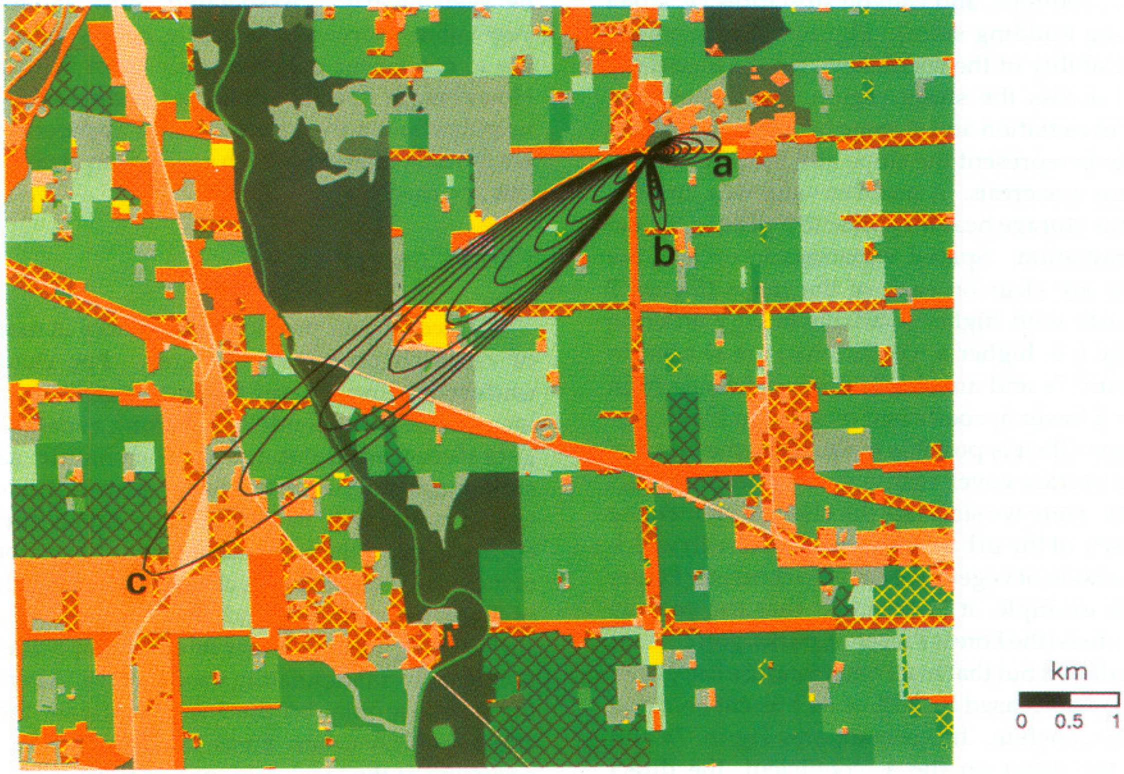

Figure 6 Variability in the turbulent source area of measurements for unstable (a and b) and stable (c) conditions with changing wind direction. The ten weighted ellipses are superimposed on the percent plan area greenspace map (see Figure 3 for legend).

the genesis of the urban heat island (Goward, 1981).

Because of the complexity of the urban environment it is impractical to measure storage heat flux directly and the approach usually adopted is to model the flux. A common method is to parameterize heat storage change in terms of the net-all wave radiation (Q*) which forces the energetics of the system. The model adopted here is the Grimmond *et al.* (1991) objective hysteresis model (OHM). This model requires information on surface properties, building dimensions and the distribution of surface materials. These data are used to weight coefficients for empirical equations which relate the storage heat flux to net radiation for each of the individual surface types in the area of interest. The general form of the objective hysteresis equation is:

$$\Delta Q_S = \sum_{i=1}^{n} [a_{1i}\, Q^* + a_{2i}\ (\partial Q^*/\partial t) + a_{3i}]$$

where, when $\Delta t=1$, $\partial Q^*/\partial t = 0.5[Q^*_{t+1} - Q^*_{t-1}]$. $\partial Q^*/\partial t$ has units of W m^{-2} h^{-1}; and the coefficients a_1, a_2, and a_3 are dimensionless, h and W m^{-2} respectively. The coefficient values (a_1-a_3) are determined from areal weights for each surface type (*i*) within the area of interest (see Grimmond *et al.*, 1991 Table 1 for values of the coefficients that are weighted).

Using the surface database information can be obtained on the appropriate surface types: greenspace/open and built (horizontal, paved areas: concrete,

Table 5 Variation of vegetative cover in source areas illustrated in Figure 6.

Ellipses numbered from 1 closest to the tower, to 10 furthest away.

Ellipse	Vegetative cover (%) a	b	c
1	25.0	37.9	33.1
2	23.5	37.9	35.7
3	22.9	37.9	37.0
4	22.4	37.9	36.3
5	22.1	37.9	37.6
6	21.8	37.0	37.4
7	35.6	37.9	37.1
8	45.8	37.9	47.1
9	51.9	37.9	50.9
10	55.1	37.0	35.4
Average cover in source area (%)	32.6	37.8	38.8
Total area of source area (m^2)	1.7×10^4	7.9×10^3	4.9×10^5

asphalt *etc.*, rooftops, and canyon sturctures i.e. street and flanking building sides). Figure 7 illustrates the spatial variability of the coefficients for the model (a_1, a_2 and a_3) across the study region. In the relation between net radiation and storage heat flux, the a_1 and a_3 coefficients represent the slope and the intercept, a_2 accounts for hysteresis. A positive value of a_2 implies a peak in the storage heat flux prior to a peak in the net all-wave radiation. Spatial variations in each of the coefficients are clear on each of the maps (Figure 7 a,b,c). Areas with higher available energy entering into storage (i.e. higher a_1 coefficients) are shaded in red on Figure 7a and are clearly distinguishable from areas with a lower a_1 coefficient (shaded in blue).

Using the GIS it is possible to illustrate the effect of changes in surface cover within the city on the model coefficients. Here we simulate the effect of an increase in the density of the urban area, associated with which is the conversion of vegetative cover to concrete (Figure 8). In this example, it is assumed that the entirely vegetated areas (the Forest Preserve, parks, golf courses etc) are unaltered but that in all other landuse categories vegetation is decreased by 20% of its present area and replaced by concrete. If one compares Figure 7a and Figure 8, the effect on the a_1 coefficient, the direct proportion of available energy going into storage, can be seen clearly. Associated with a decrease in vegetation/increase in concrete, across the entire area the a_1 coefficient increases only from 0.362 to 0.368. However, in specific areas, for example, residential neighborhoods the effect is more apparent i.e. there are spatial variations which can be seen clearly through this approach.

Final Comments

GIS techniques provide a useful tool in many facets of research on urban climates. For example, in understanding current processes both through measurement and modelling, linking a spatially nested georeferenced database to a dynamic sampling strategy, as outlined in this paper, provides an objective and versatile way to describe the urban surface. In addition, in predictive modelling studies of the impact of increased urbanization, climate change *etc*, the effects of changes in surface boundary conditions, for example, surface roughness or water retention capacities, can be predicted by manipulating the database. Alternatively, the database may be used to investigate the spatial effects within urban areas of atmospheric changes occurring at the local, regional or global scale.

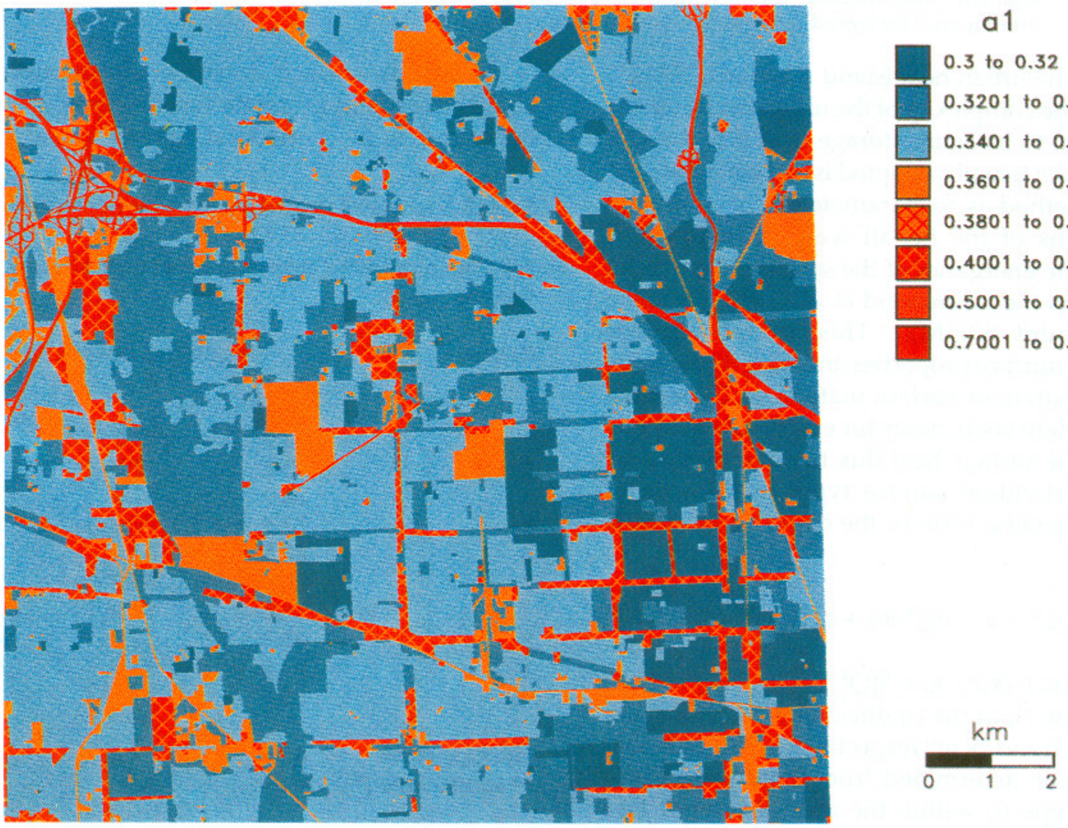

Figure 7 Objective Hysteresis Storage heat flux model coefficients (a) a1, (b) a2 and (c) a3 for present conditions. Units are a1(dimensionless), a2(h) and a3(W m-2) (See text for explanation)

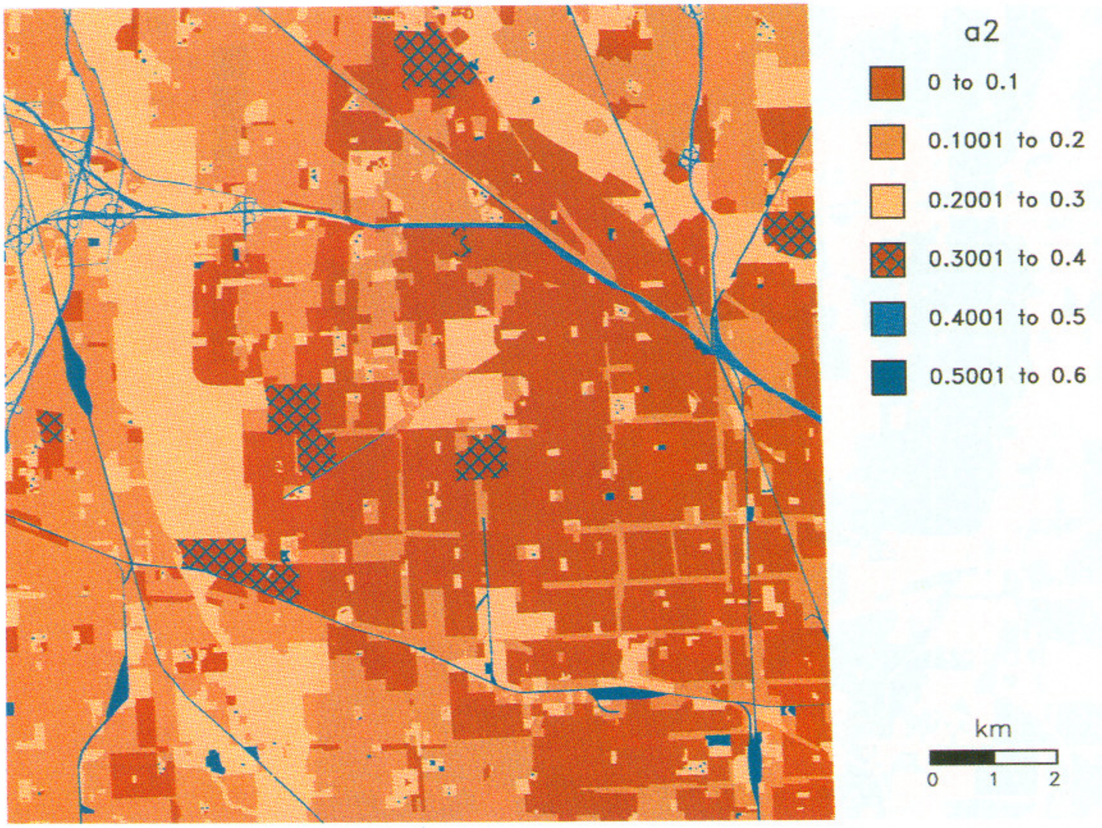

Figure 7 (b)

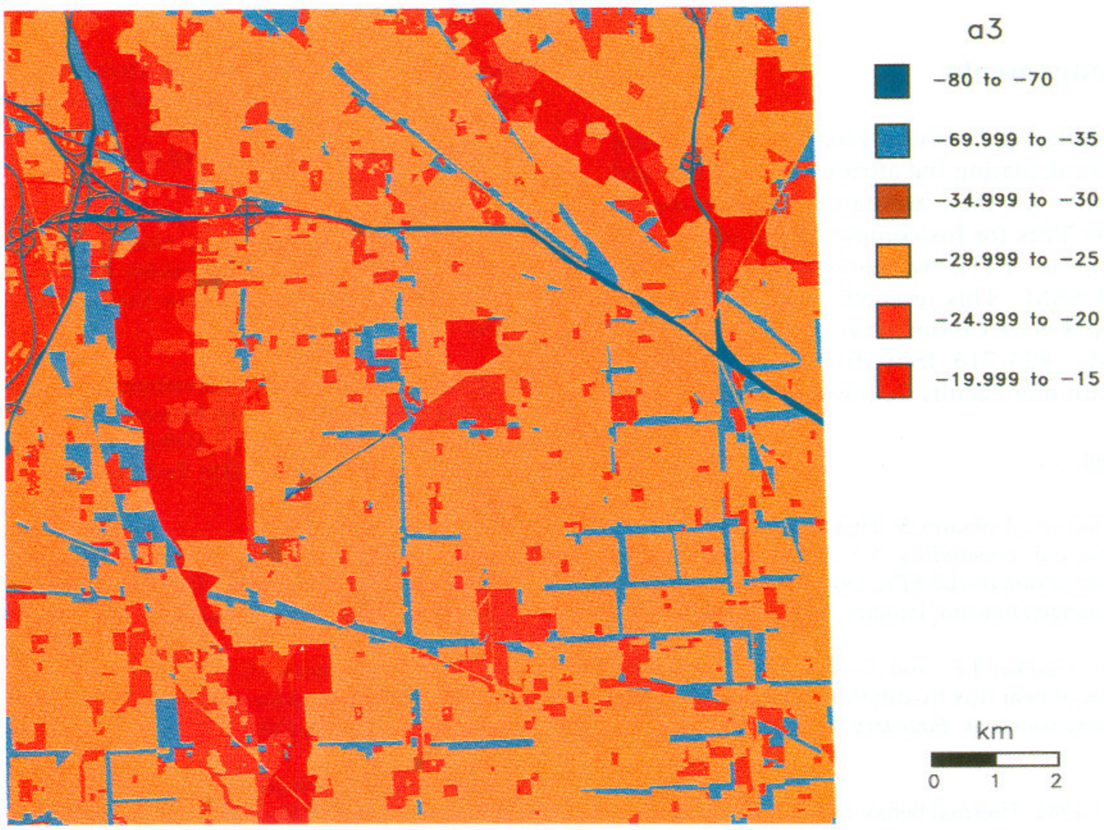

Figure 7 (c)

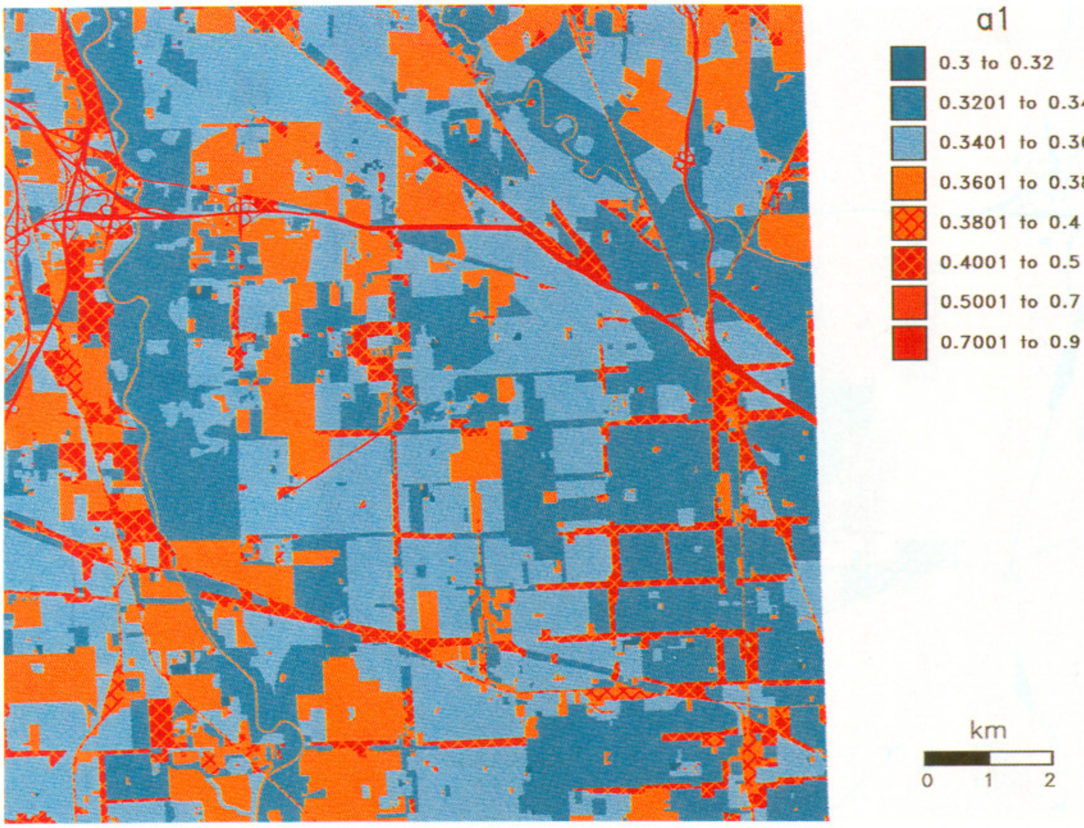

Figure 8 Objective Hysteresis Storage heat flux model coefficient a_1 assuming 20% of a vegetated area is converted to concrete - see text for details (same legend as Figure 7a)

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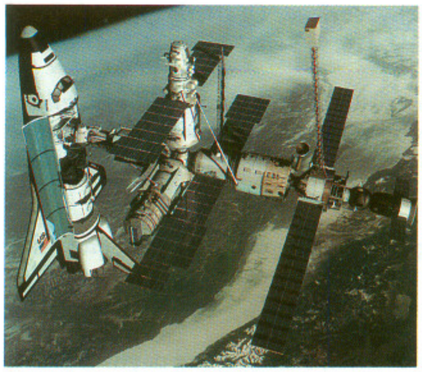

International Earth Observations from Space

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Introduction to this new and expanded section

The time has come to expand our section "Space Shuttle Earth Observations" this year to include the Earth Observations activities from major international space programs. There are many new and exciting developments in the arena of Earth Observations from both the manned and unmanned space platforms. In addition to the NASA's Mission to Planet Earth programs, the International Space Station with joint U.S. and Russian Science objectives is taking shape. There are plans for joint U.S./Russian missions of Space Shuttle and Mir Space Station activities (see our new photo-logo) that will result in unique opportunities for Earth Observation science. Our objectives for the section as enunciated in March 1989 issue of *Geocarto International* remain unchanged (see Lulla and Helfert, 1989). We are expanding the scope of this section to cover the ever growing sensor systems and platforms for Earth Observations. We are positive that you will like this new expanded section. We are eager to hear from you. Your feedback is important to us!

In this issue we are pleased to note that the Jet Propulsion Laboratory scientists (see Way *et al.*) are using Space Shuttle Earth Observations for the Space Radar Laboratory (SRL) Mission. The unique aspect of this project is involvement of the students in developing the tools for Earth Observations for the astronauts on the SRL missions.

In the future issues, we plan to explore the joint U.S./Russian Earth Observation activities, and activities of European Space Agency (ESA) and Canadian agencies. We are developing a network of scientists to bring you the latest developments in International Earth Observation activities.