LA-UR- LA-UR- 02-1090

Approved for public release; distribution is unlimited.

c.1

Title: AN OVERVIEW OF BUILDING MOPHOLOGICAL CHARACTERISTICS DERVIVED FROM 3D BUILDING DATABASES

Author(s): M. Brown
S. Burian
S. Linger
S. Velugubantla
C. Ratti

Submitted to: 4th AMS Urban Environment Conference, Norlolk, VA, May 2002

Los Alamos
NATIONAL LABORATORY

4.1 AN OVERVIEW OF BUILDING MORPHOLOGICAL CHARACTERISTICS DERIVED FROM 3D BUILDING DATABASES

Michael J. Brown[1], Steven J. Burian[2], Steve P. Linger[1], Srinivas P. Velugubantla[2], and Carlo Ratti[3]
[1]Los Alamos National Laboratory, [2]University of Arkansas, [3]Cambridge University

1. Introduction

Varying levels of urban canopy parameterizations are frequently employed in atmospheric transport and dispersion codes in order to better account for the urban effect on the meteorology and diffusion. Many of these urban parameterizations need building-related parameters as input. Derivation of these building parameters has often relied on *in situ* "measurements", a time-consuming and expensive process. Recently, 3D building databases have become more common for major cities worldwide and provide the hope of a more efficient route to obtaining building statistics. In this paper, we give an overview of computations we have performed for obtaining building morphological characteristics from 3D building databases for several southwestern US cities, including Los Angeles, Salt Lake City, and Phoenix.

2. Building Databases

Building data is commercially available from a number of vendors in a variety of formats, ranging from raster digital elevation models, shape files, and CAD formats. The data varies in level of fidelity (and cost): at the low end, buildings are described by a single rectangular volume; at the intermediate level a small number of rectangular volumes; and at the high end by a complicated set of polygonal surfaces and volumes. Figure 1 shows a 3D view of the Phoenix building data that are described by polygons using the building footprint with base and rooftop elevation attributes. Figure 2 shows the Salt Lake City CAD data with a much higher level of drawing detail.

3. Methodology

Utilizing shapefile and raster-formatted building data and the ArcView Geographic Information System (GIS), we have developed scripts and Fortran codes for automating the calculations of average building height, standard deviation of building height, height histograms, plan area fraction, plan and roof area density as a function of height, frontal area density for a chosen azimuth, building height-to-width ratio, the complete aspect ratio, roughness length, displacement height, and other aerodynamic parameters. Integrating the building dataset with land use data in the ArcView GIS enables the correlation of building morphological characteristics with underlying urban land use type.

* *Corresponding author address:* Michael J. Brown, LANL, D-4, MS F604, Los Alamos, NM 87545, mbrown@lanl.gov.

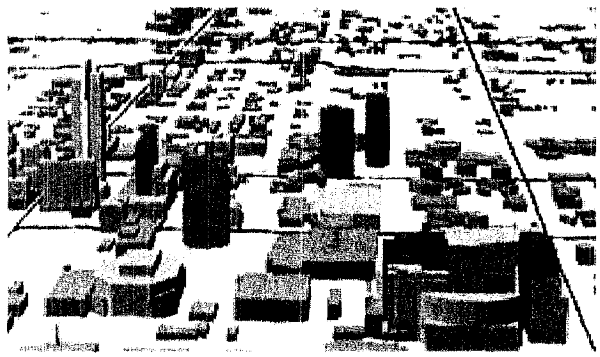

Figure 1. Buildings of downtown Phoenix described by footprint and top-print shape files.

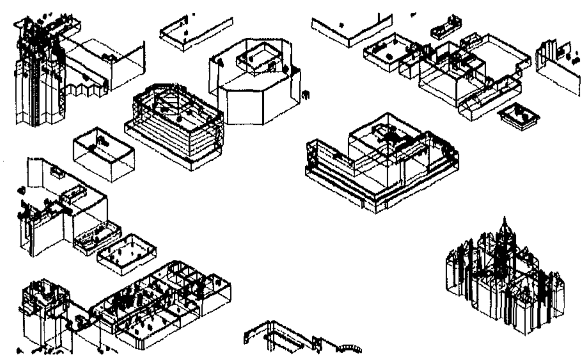

Figure 2. Buildings of Salt Lake City described by lines and polygons in CAD format.

4. Discussion

We present examples for a few of the calculations we have performed. In companion papers, Burian et al. (2002a,b) describe results from building height and roughness length computations. Figure 3 shows a gridded plan area fraction λ_p map obtained from the Los Angeles building database, where λ_p is the building footprint plan area divided by the total plan area. The map shows significant spatial variation, and Table 1 indicates that much of the variability can be correlated to underlying land use type. This type of information can be used to quickly derive urban surface roughness parameters as a function of space (e.g., Grimmond and Oke, 1999).

Figure 4 depicts the plan area density $a_p(z)$ versus height for different urban land use type in Los Angeles. The plan area density, similar to the leaf

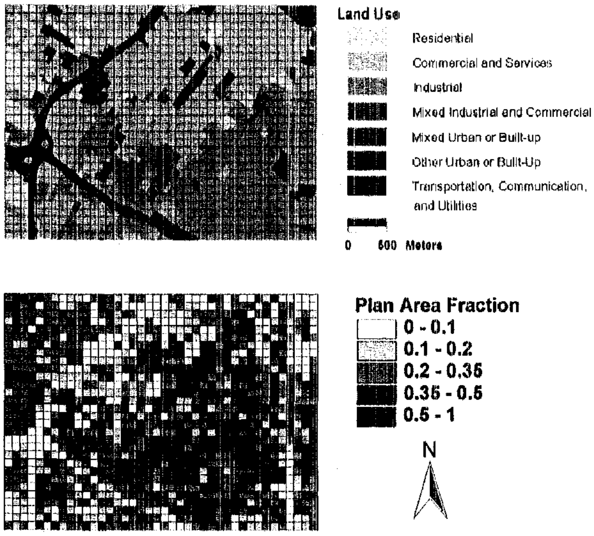

Figure 3. a) Land use and b) plan area fraction computed from the 3D building database for the Los Angeles study area.

area density, is defined as the building plan area within a height increment divided by the increment volume. It is used to parameterize the urban impact on the surface energy budget. The plan area density can also be used to derive roof area density, useful for quantifying shortwave interception and longwave heating and cooling by rooftops.

Computations of the frontal area index λ_f *are shown in* Table 1 as a function of land use type. λ_f is defined as the ratio of the total projected frontal area of buildings (relative to the wind) to the total plan area. It is used in urban canopy parameterizations of drag and turbulence production.

The calculation of height-to-width ratio λ_s can also be automated. Taking linear traverses through the building database, a map of λ_s can be obtained from the building height and street width. Table 1 shows values as a function Los Angeles and Salt Lake City land use. For idealized arrangements of buildings, λ_s

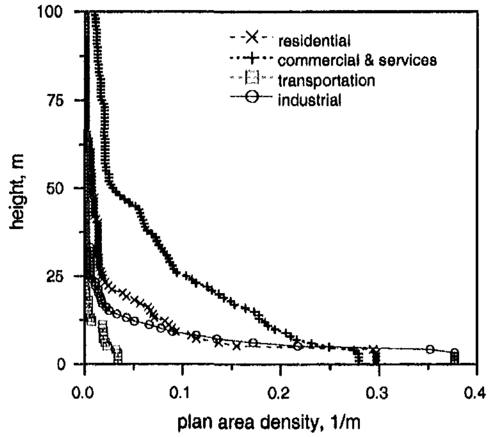

Figure 4. Plan area density computed from the Los Angeles 3D building database.

yields information on the flow regime (Oke, 1987).

Other measurements will be presented at the conference. We hope to prepare a CD with a compilation of reports for each city. There are issues to deal with regarding the use of digital building datasets. For example, building shapes are oversimplified, low buildings are often missing, and trees are generally not accounted for. These limitations in the building data set can lead to errors in the calculation of certain morphological statistics.

5. References

Burian, S., M. Brown, S. Velugubantla, 2002: Roughness length and displacement height derived from building databases, 4th AMS Urban Env. Conf, Norfolk, VA.

Burian, S., M. Brown, S. Velugubantla, 2002: Building height characteristics in three US cities, 4th AMS Urban Env. Conf, Norfolk, VA.

Grimmond, S. and T. Oke, 1999: Aerodynamic properties of urban areas derived from analysis of surface form. J. Appl. Met., 38, 1262-1292.

Oke, T., 1987: Boundary Layer Climates, Routledge, London.

Table 1. Building plan area fraction (λ_p), frontal area index (λ_f)*, and height-to-width ratio (λ_s)

Land Use	λ_p			λ_f			λ_s	
	Los Angeles	Phoenix	Salt Lake City	Los Angeles	Phoenix	Salt Lake City	Los Angeles	Salt Lake City
Residential	0.30	0.13	0.21	0.19	0.04	0.18	0.33	0.37
Commercial & Serv.	0.28	0.20	0.27	0.27	0.09	0.20	0.47	0.37
Industrial	0.38	0.19	0.27	0.10	0.04	0.12	0.20	0.23
Mixed Ind. & Comm.	0.47	---	---	0.14	---	---	0.34	---
Transportation	0.03	0.00	---	0.01	0.00	---	0.08	---
Mixed Urban/Built-up	0.34	---	0.19	0.24	---	0.14	0.43	0.31
Other Urban/ Built-up	0.06	0.04	0.02	0.04	0.01	0.01	0.16	0.06
Downtown Core	0.29	0.32	0.33	0.42	0.20	0.17	0.77	0.54

** values are for a wind azimuth from the north*