P2.1 BUILDING HEIGHT CHARACTERISTICS IN THREE U.S. CITIES

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1. INTRODUCTION

Urban canopy parameterizations have been used to represent urban effects in numerical models of mesoscale meteorology, the surface energy budget, and pollutant dispersion. The urban canopy parameterization accounts for the drag exerted by urban roughness elements, the enhancement of turbulent kinetic energy, and the alteration of the surface energy budget (Brown 2000). Accurate representation of urban effects in numerical simulations requires the determination of urban morphological parameters, including building height statistics. Computer analysis of 3-D building digital datasets can provide details of the urban environment in an efficient manner. Ratti et al. (2001) describe a method for obtaining urban canopy parameters from digital imagery using image processing techniques. Burian et al. (2002) present an alternative analysis approach using a geographic information system (GIS). In this paper, building height statistics computed for three U.S. cities following the GIS approach are presented.

2. BUILDING AND LAND USE DATABASES

3-D building datasets were obtained from commercial vendors for downtown areas of Los Angeles, Phoenix, and Salt Lake City. Table 1 shows several characteristics of the three databases. The GIS databases are in vector format with polygons representing building footprints and rooftop elevation as an attribute. The Salt Lake City building database contains additional information about rooftop color and pitch. Rooftop structures (e.g., elevator shafts and air conditioning units) were not included in the GIS databases. The Salt Lake City database, however, was accompanied by a detailed AutoCAD drawing that did include representations of the rooftop structures.

We obtained land use datasets for Los Angeles, Phoenix, and Salt Lake City from the Southern California Association of Governments (SCAG), the Maricopa Association of Governments (MAG), and the U.S. Geological Survey (USGS), respectively. The USGS dataset for Salt Lake City was updated using a high-resolution (~6-inch pixel size) digital orthophoto. Information about the base land use datasets are contained in Table 1. Burian et al. (2002) give a detailed description of the land use categories for the Los Angeles land use dataset. Similar reports for Phoenix and Salt Lake City are currently being compiled.

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Table 1. 3-D building and land use datasets.

	Los Angeles	Phoenix	Salt Lake City
Area (km^2)	12	16	6
# of Buildings	3,353	7,997	2,891
# of bldgs/ha*	2.8	5.0	4.8
Number of urban land use types in original dataset	>100	>20	>10
Horizontal resolution of land use dataset	¼ ha	½ ha	1 ha

* 1 ha = 10,000 m^2

3. BUILDING HEIGHT ANALYSIS

3.1 *Methods*

The first stage of the project was to analyze the raw building height data to derive building height statistics and create histograms showing the distribution of building height in the downtown areas. The second stage involved intersecting the building polygons with the underlying land use datasets to determine the building height characteristics and histograms as a function of land use type. ArcView scripts were written to automate the analyses. The original urban land use categories were aggregated into a consistent two-tiered classification. The first tier contains seven urban land use categories corresponding directly to the seven Anderson Level II urban land use types used in the USGS LULC dataset (see Table 3). The second tier subdivides the residential, commercial and services, and the other urban or built-up tier I categories into several sub-categories based on building density or height. Only results from the analysis of tier I land use categories are reported in this paper.

3.2 *Results*

Table 2 shows a summary of the building height characteristics for the downtown and surrounding areas for our Los Angeles, Phoenix, and Salt Lake City datasets. The results indicate that the Phoenix area contains much shorter buildings on average than Los Angeles and Salt Lake City. Los Angeles contains the tallest buildings and has the highest variability in building height. The plan area-weighted average building height for Salt Lake City is greater than Los Angeles and Phoenix. This suggests that the tall buildings in Salt Lake City have greater plan areas on average than those in Los Angeles and Phoenix.

Table 3 lists the average building heights for each tier I land use category in the three cities, as well as the land use area fraction for each dataset. In addition to the seven tier I land uses, we defined a Downtown Core

Area using a digital orthophoto. The Downtown Core Area can contain multiple tier I land use types. Dashed lines in Table 3 indicate that either the land use type was not present within the boundaries of our study areas or there were no buildings within the land use. The results suggest that the commercial and services land use contains the taller office buildings, while the residential and industrial land use is comprised of predominantly one to three story structures. The Los Angeles Downtown Core Area contains much taller buildings than the core areas of Phoenix and Salt Lake City.

Figure 1 shows the building height histograms for the commercial and services land use category in Los Angeles, Phoenix, and Salt Lake City and illustrates the variability of building heights within the downtown area and from one city to another. Morphological analysis reports for each city, available from the authors, contain histograms for each land use type.

Table 2. Building height characteristics.

	Los Angeles	Phoenix	Salt Lake City
Avg. height (m)	12.0	5.6	12.0
Std. dev. (m)	22.7	7.6	10.2
Max. height (m)	331.0	137.0	128.2
Plan area-wtd. avg. ht. (m)	17.0	9.2	25.5

Table 3. Average building height (m) for each tier I land use type. Percent of land use type within study area shown in parentheses.

Land Use	Los Angeles	Phoenix	Salt Lake City
Residential (%)	6.4 (7)	3.8 (31)	9.6 (26)
Commercial and Services (%)	24.5 (43)	8.5 (37)	17.9 (55)
Industrial (%)	6.3 (31)	5.1 (21)	10.8 (8)
Mixed Ind. And Commercial (%)	7.4 (4)	--- (0)	--- (0)
Transportation (%)	7.9 (8)	--- (3)	--- (0)
Mixed Urban or Built-up (%)	12.0 (5)	--- (0)	11.2 (7)
Other Urban or Built-up (%)	7.4 (2)	--- (8)	13.8 (4)
Downtown Core Area (%)	45.0 (21)	17.2 (10)	23.6 (27)

4. REFERENCES

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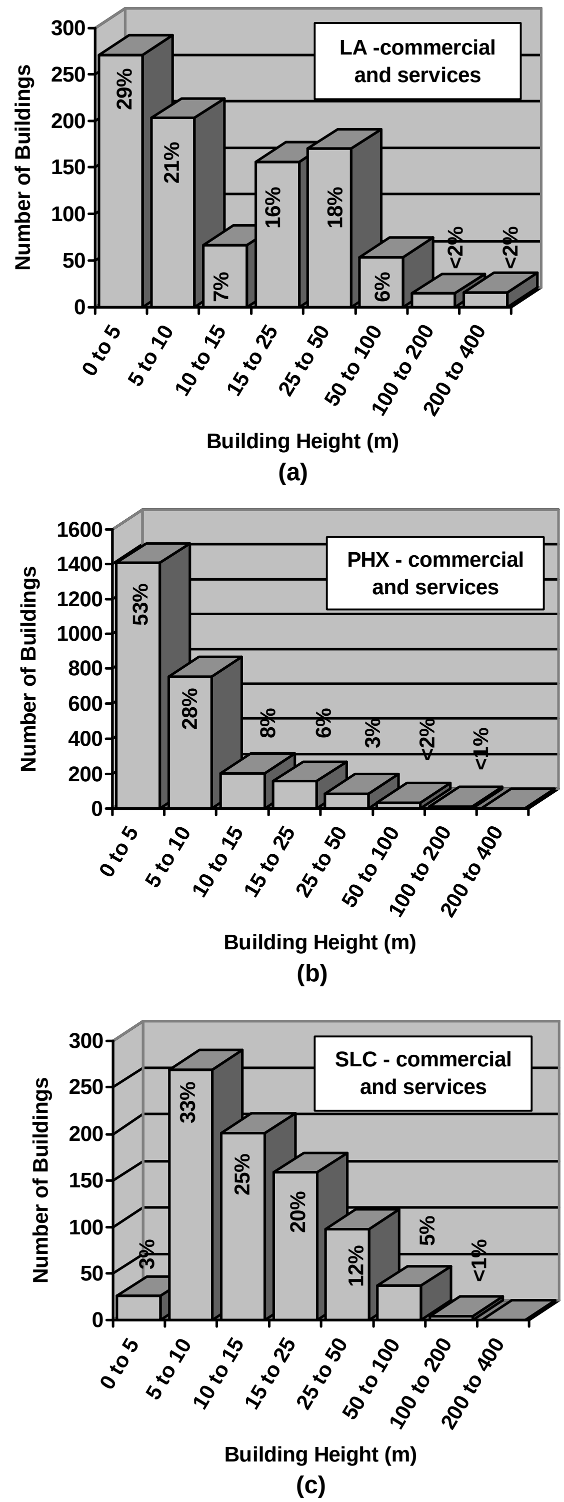

Figure 1. Building height histograms for the Commercial and Services land use category in downtown (a) Los Angeles, (b) Phoenix, and (c) Salt Lake City.