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Comparing urbanization patterns in Guangzhou of China and Phoenix of the USA: The influences of roads and rivers

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ABSTRACT

Examining the similarities and differences in urbanization pattern between cities in developed and developing countries may enhance our understanding of urbanization processes and mechanisms. Using a buffer analysis approach, we compared the long-term spatiotemporal patterns of urbanization between Guangzhou of China and Phoenix of the United States during the 20th century, with a particular emphasis on the impacts of major roads and rivers. The development of Guangzhou was relatively compact, whereas the development of Phoenix was much more dispersed. The two metropolitan areas were characterized mainly by two types of urban expansion processes. Guangzhou experienced a diffusion–coalescence–diffusion–coalescence process while Phoenix experienced a diffusion–coalescence process. The buffer analysis indicated that the impacts of roads and rivers on the urbanization of Guangzhou and Phoenix were similar in terms of urban area, the number of urban patches, the mean patch size, but different in terms of the complexity of urban patches. The urban area declined with increasing distances to roads, but it increased when the distance was close to the rivers and then declined with the increment of distances to rivers. In general, the impacts of roads are stronger in Phoenix than in Guangzhou, while the impacts of rivers are greater in Guangzhou than in Phoenix. These similarities and differences between the two metropolitan regions are reflective of those in both physical conditions and land use policies in the two countries. By comparing these similarities and differences, we can improve our understanding of the urbanization processes in both developed and developing countries, which is necessary for achieving global urban sustainability.

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1. Introduction

With the continuing increase in the world's urban population, cities have also become centers of environmental concerns. The urban population is expected to account for 70% of the world population by 2050 (United Nations, 2007), which is a sign of improved civilization of our society. The increasing urbanization is also thought to be an important cause of rapid loss of cropland, hydrological disturbance, species extinction, and biotic homogenization etc. (Paul and Meyer, 2001; Grimm et al., 2008a,b; Tian et al., 2002, 2005, 2011a,b). The increasing urban population and the associated land use and cover change will be major cause. Hence, it is crucial to study the patterns of urbanization (Antrop, 2000, 2004; Kaufmann et al., 2008; Seto and Shepherd, 2009).

The U.S. and China are two of the most powerful countries in the world today, and, consequently, many similarities and differences can be seen between these two countries' urbanization processes. Urban agglomeration of developing world is more compact and dense than their counterparts in either Europe or North America (Wu et al., 2014). The urban dynamic pattern of Phoenix and Las Vegas in U.S. has been compared (Wu et al., 2011). The shape, size and growth rates of the four cities of Guangzhou, Dongguan, Zhongshan and Shenzhen in China exhibit common patterns and a convergence toward a standard urban form despite the different economic development and policy histories (Seto and Fragkias, 2005). But systematic comparison of urbanization process between the developed and developing countries has been lacking (Huang et al., 2007). The comprehensive comparison of the urban dynamic pattern is needed to enhance our understanding of urbanization processes and mechanisms.

Quantifying the spatial and temporal patterns of urbanization is an important step to understand the effects of urbanization on

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environmental change and ecological processes in different places (Jenerette and Wu, 2001; Luck and Wu, 2002; Alberti, 2005; Wu et al., 2011; Tian et al., 2011a,b). The gradient analysis provides an effective way of understanding the structural and functional differences of cities in the temporal and spatial contexts. The combination of landscape metrics with the gradient approach has been considered a useful tool to study the spatiotemporal dynamics of urbanization (Wu et al., 2000; Luck and Wu, 2002; Xie et al., 2006; Zhu et al., 2006; Xu et al., 2007; Yu and Ng, 2007; McDonnell and Hahs, 2008).

Urbanization exhibits expanding patterns across time and space (Winsborough, 1962; Dietzel et al., 2005; Wu et al., 2011). Dietzel hypothesized that urban growth could be characterized as two distinct processes of diffusion and coalescence, integrating the development waves and growth phases (Dietzel et al., 2005). Diffusion that spreads urban growth from existing centers to new development areas and coalescence that is characterized by outward expansion and gap infilling of existing urban areas (Dietzel et al., 2005). The landscape metrics and gradient analysis can help to identify the distinct processes. Generally, three basic types of urban growth are commonly found in many cities: infilling, edge expansion and spontaneous growth (Berling-Wolff and Wu, 2004; Xu et al., 2007). The infilling and edge expansion can be identified as the coalescence process while the spontaneous growth can be identified as the diffusion process.

The spatial pattern of an urban area and growth typology are a consequence of the interaction of physical and socioeconomic factors (Bürgi et al., 2004). Roads and rivers are the important corridors for urban expansion too. The road influenced urban growth has been identified as linear development or branching (Clarke et al., 1997; Camagni et al., 2002; Wilson et al., 2003). In particular, roads are an important part of the bone structure of the city and often play a key role in the development of the urban landscape since they serve as conduits for flows of goods and services. Before the invention of automobiles, cities developed along rivers and coastlines because waterborne transportation was so important. Rivers are important natural corridors. Our study areas are the Guangzhou metropolitan area of China and the Phoenix metropolitan area of the US. Guangzhou and Phoenix are both located in the South of their countries and have become the fastest growing major cities. The similar latitudinal of Guangzhou and Phoenix will make the comparison more convincing. Their rapid urban expansion has substantially altered the composition and spatial structure of the landscape (Wu et al., 2000, 2002; Luck and Wu, 2002). Therefore, we chose those two cities to compare the urbanization process. The primary objectives of this study are to compare the spatiotemporal patterns of two fast growing cities in China and the US, and to examine the influences of major roads and rivers on the urbanization pattern of the two cities.

2. Study areas, data source and methods

2.1. Study areas

Guangzhou is located between 22°26′ N–23°56′ N and 112°57′ E–114°3′ E, with an area of 7434.4 km^2; it is located in the central Guangdong Province, north of the Pearl River Delta (Fig. 1). The city also lies close to the South China Sea, Hong Kong and Macao. As the capital of Guangdong Province, Guangzhou is the center of its politics, economy and science. It has ten administrative districts and two county-level cities. The ten districts are Yuexiu, Liwan, Haizhu, Tianhe, Baiyun, Huangpu, Huadu, Panyu, Nansha, Luogang, while the two county-level cities are Zengcheng and Conghua (Fig. 1). Guangzhou is also the key transportation hub of the southern China. There are three highways passing

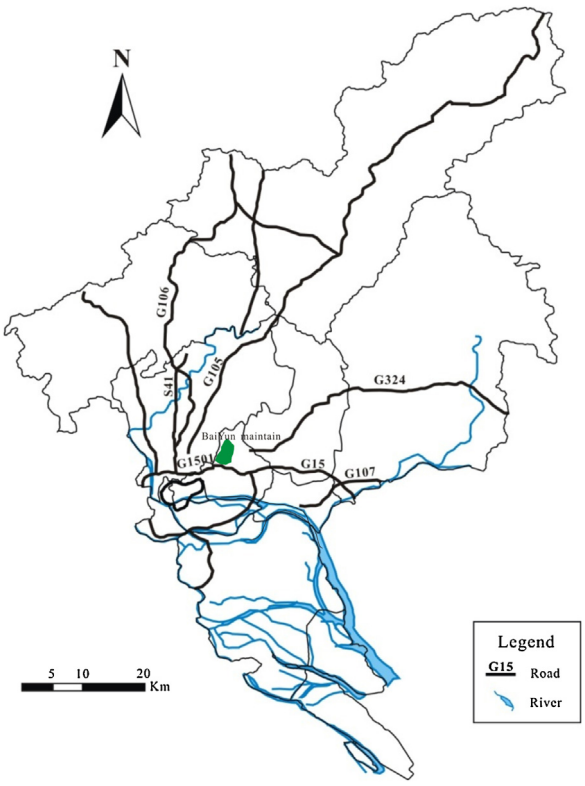

Fig. 1. The administrative districts and counties of Guangzhou metropolitan area.

the whole city, Guangzhou-Cong highway, Guang-Hui highway and Guang-Shen highway (Fig. 1). The Pearl River is the third largest river in China. Spanning eight provinces, the Pearl River is composed of four river systems including the West River, North River, East River and Liuxi River (Fig. 1). The four river systems converge in Guangzhou and flow into the South China Sea.

Phoenix is located at 33°27′ N, 112°4′ W in the southwestern U.S. It is located in the Salt River Valley, or "Valley of the Sun" in central Arizona (Fig. 2). It is the capital and the largest city of Arizona State, as well as the sixth largest most populated city in U.S. It lies at a mean elevation of 340 m, in the northern reaches of the Sonoran Desert. This region is characterized by a hot and dry climate. The average summer temperature is 30.8 °C, the average winter temperature is 11.3 °C, and the annual precipitation is about 180 mm. The freeway and expressway are the arterial roads of Phoenix metropolitan area (Fig. 2). The Salt River runs westward through the Phoenix metropolitan area (Fig. 2). The riverbed is often dry or a trickle due to upstream dams.

Guangzhou and Phoenix metropolitan areas had 6.93 million (Guangzhou Statistics Bureau, 2008) and 3.07 million population respectively in 2000. Although Guangzhou had 2.255 times of population of Phoenix, its urban land was only 18.79% of Phoenix. Hence, the urban land of Phoenix per capita was twelve times of that of Guangzhou metropolitan area. The difference of economic development between Guangzhou and Phoenix was dramatic. The per capita income of Guangzhou was 12,018 Chinese Yuan (equally 1455 US dollars) (Guangzhou Statistics Bureau, 2008). The per capita income of Phoenix was 28,663 US dollars. The per capita income of Phoenix was 19.7 times of that of Guangzhou. In Guangzhou, the service industry made the largest contribution to GDP (Gross Domestic Product) for 59.02% and also provided the largest number of employment. It became the backbone of the economic development. In Phoenix metropolitan area, the third industry of Phoenix was 89.9% of GDP while that of Guangzhou was only 52.35% (Guangzhou Statistics Bureau, 2011). Therefore,

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