Study on planning method of urban ventilation corridor a case study in Guiyang, China

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1. Introduction

Guiyang, the capital of Guizhou Province in China, is located in southwest China, having a permanent resident population of 4.4517 million as of late 2012. In Guiyang, east wind and northeast wind prevail in winter, and south wind prevails in summer, as shown in the wind rose diagram in figure 1 b.

We first simulated wind environment in the city to find the areas that need to improve ventilation, based on the analysis on the wind speeds at 10 m in height in summer and winter. Figure 2a shows the wind speeds in Guiyang at around 3 p.m. in winter, Figure 2b shows the wind speed in Guiyang at around 3 p.m. in summer.

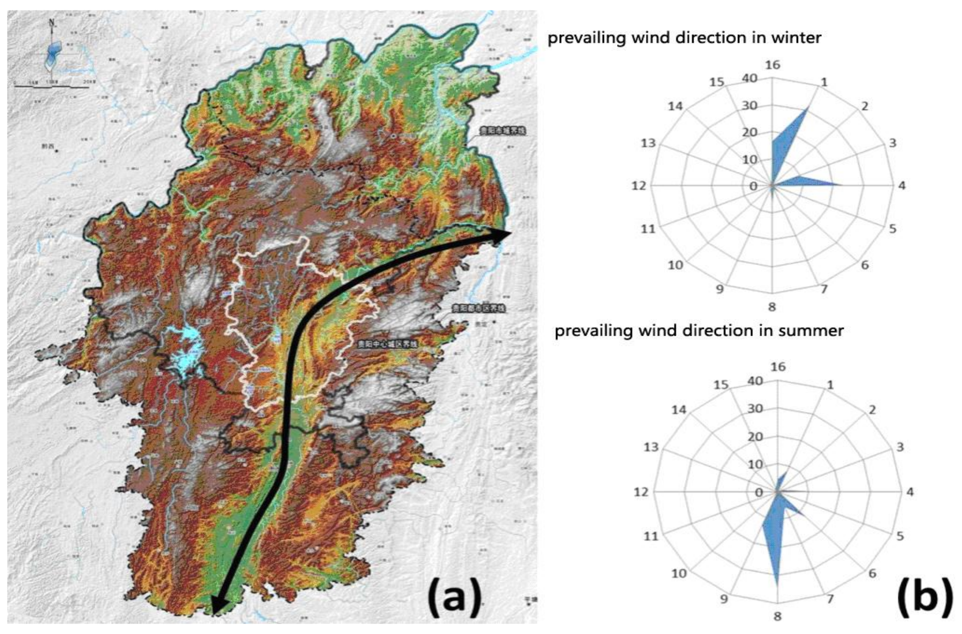

Fig.1 The topographic map (a) and wind rose map (b) of Guiyang

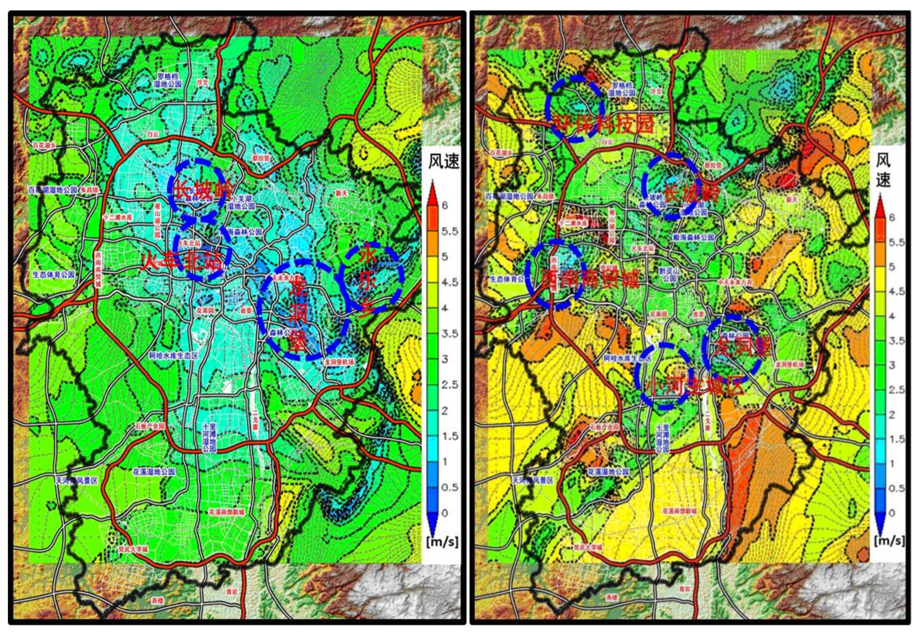

Fig.2 The distribution of wind speeds at 10 m height at 1500 LST of winter (a) and summer (b)

2. Guiyang Ventilation Corridor Planning Design

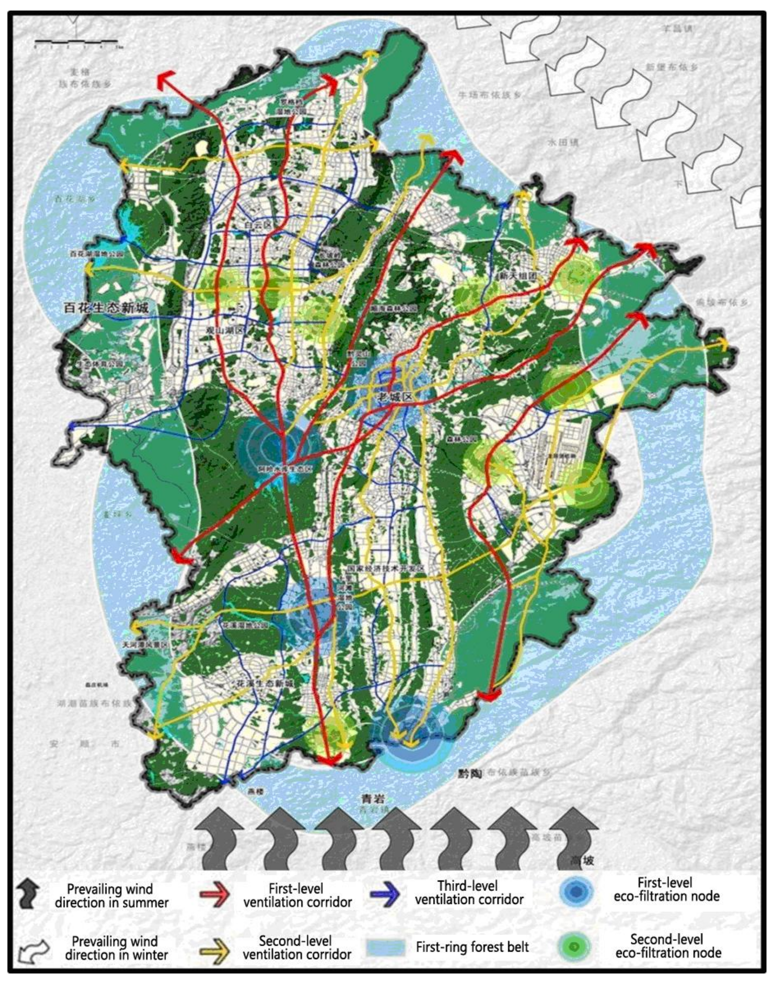

Fig.3 The planning of urban ventilation corridor of Guiyang

In Guiyang urban ventilation duct planning, it needs to (1) o create the urban cold source from point to line and surface by connecting the existing natural green space and water system, to provide fresh and clean air for the city; (2) , make use of green space, water system and road network to plan the corresponding ventilation duct and air change duct for the areas with obvious utilization problem; (3) make the reasonable construction control of potential ventilation area so as to prevent urban ventilation duct from being blocked by too large construction intensity . On the basis of the above ideas and methods, we can mark the green space, water area and road network (as shown in figure 3) in Guiyang, which can be used as ventilation duct, and plan three-level ventilation duct to improve the ventilation in Guiyang.

First-level ventilation corridor goes through the entire central urban area. it is the main part of urban air duct system, with 100 meters to 500 m in width, and 2-4 km in length In order to prevent the block of wind, urban prevailing wind shall be paralleled as far as possible. Because air purification is one of the main functions of the first-level corridor, it is suggested that a public green space shall be set every 3 km, with area of more than 1 hectare, vegetation of more trees, and water area of more than 2000 m^2.

Second-level ventilation corridor assists in the ventilation of first-level corridor, to create a complete network for ventilation system. There are 16 corridors with 50 to 300 m in width, covering the main trunk roads in series , public green space, square and water body.

Third-level ventilation corridor assists in the ventilation of first- and second-level corridor. By combining with the urban roads at all level in central urban area, green space helps to create micro air circulation in urban area. The layout tries to include the road, linear green space and water with 50 to 100 m in height. We shall select the road which is basically at the same prevailing wind direction and the area with smaller building density for the subject of three-level air duct network, to achieve better urban ventilation effect by drawing the airflow from the air duct of the previous level, to the deep inside of urban area.

3. Guiyang Urban Ventilation Duct Simulation Analysis

In order to analyze and illustrate the effect and performance of Guiyang urban ventilation duct planning scheme, we simulated and compared the wind speeds in winter and summer, before and after building the ventilation duct, respectively. The results of the wind speeds are shown in in Figure 4 and 5.

It can be seen from the comparison that the effect of Guiyang urban ventilation duct on improving wind environment is more obvious in the old urban district than in most of the areas of the city. It can be seen from table 1 that the improvement proportion of average wind speed in the old urban district is as high as 12%, higher than the average improvement ratio (8%) of the whole city. Figure 9b shows the change of average wind speed due to the use of ventilation duct in summer. Compared to orderly daily change of wind speed in winter (as shown in figure 6a), change in summer is more disorderly. The obvious effect of building ventilation duct on improving the ventilation only occurs from 10 a.m. to 5 p.m., and the effect of ventilation duct to increase wind speed at nightis not so obvious in summer as in winter. Therefore, urban ventilation duct may not be able to give full play of its role to eliminate pollutants and clean air at night in summer. However, in the daytime, ventilation duct plays a more active role in cooling the city by obviously increasing wind speed.

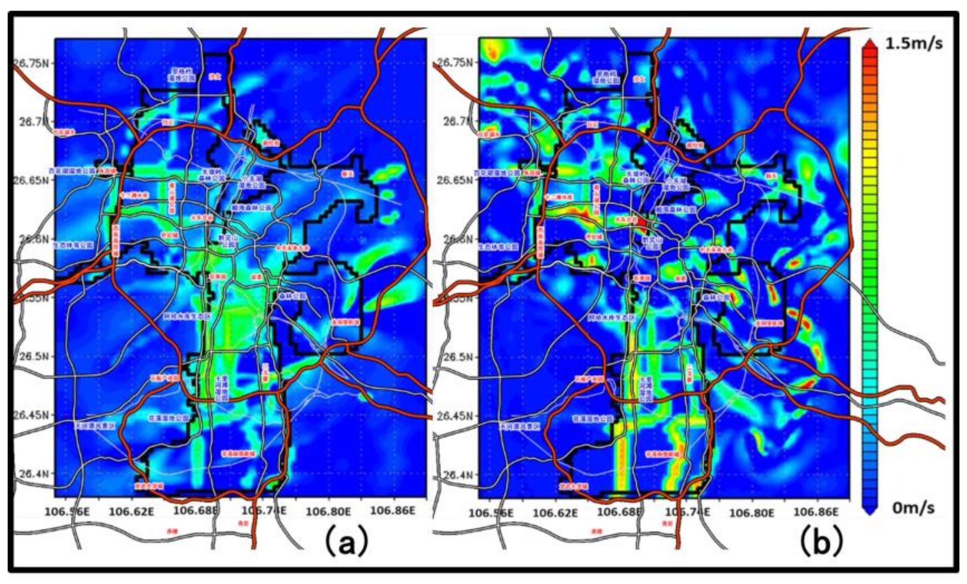

Fig.4 Distribution of the differences in wind speed at 10-m (WS), winter 0200 LST (a), winter 1500 LST (b)

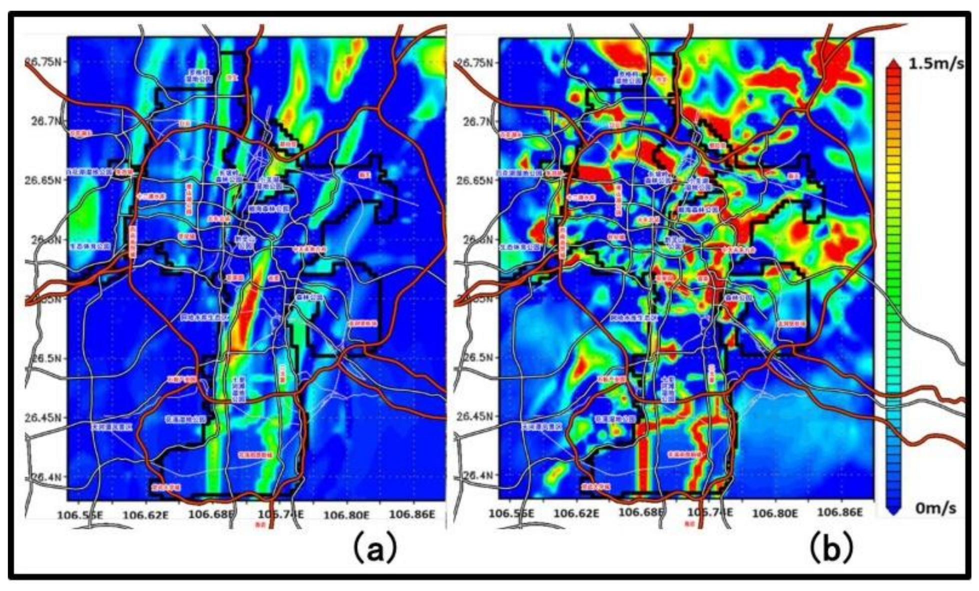

Fig.5 Distribution of the differences in wind speed at 10-m (WS), summer 0200 LST (a), summer 1500 LST (b)

Table 1 Wind Speed at 10 meter height of Guiyang

Improvement of wind speed (m/s)		Maximum wind speed difference (m/s)	Minimum wind speed difference (m/s)	Average wind speed difference (m/s)	Improvement percentage of wind speed (%)
Winter	Average of whole city	0.30	0.001	0.16	8
	Old urban district	0.43	0.003	0.12	12
Summer	Average of whole city	0.44	0.0007	0.18	6
	Old urban district	0.87	0.0009	0.26	9

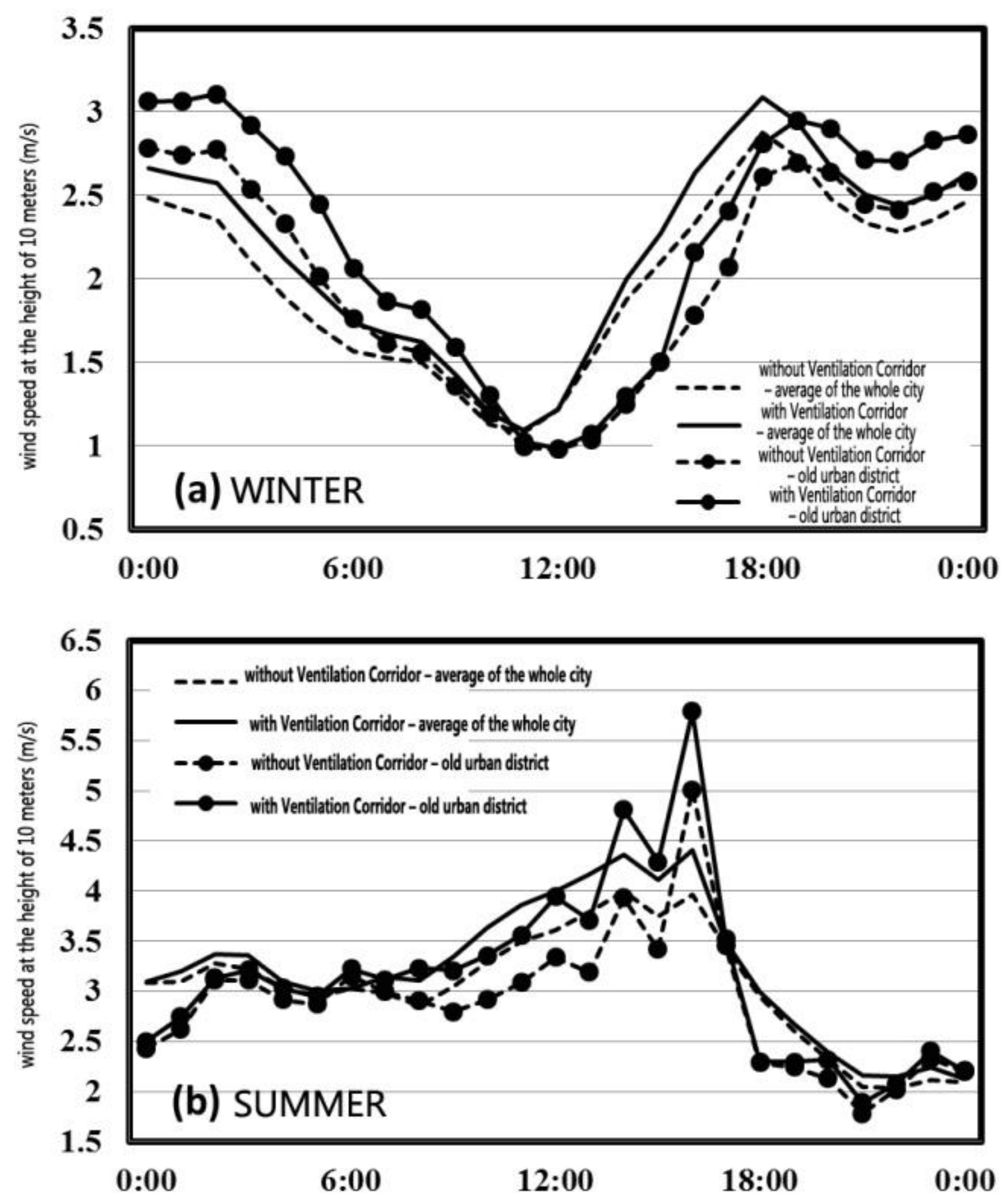

Fig.6 Diurnal wind speed at 10-m (WS) for winter (a) and summer (b)

4. Conclusion

This research simulated f the wind environment in Guiyang with mesoscale meteorological model, and identified the areas with poor ventilation that need planningand transformation.We followed the Guiyang ventilation duct planning principles of “protecting the periphery, dredging the duct and controlling the construction” by combining with the landform and construction situation of Guiyang, and planned 6 first-level ventilation ducts, 16 second-level ventilation ducts and 30 third-level ventilation ducts based on the existing green space, water system and road network of Guiyang. The ventilation duct planning hasobvious effect on improving poor urban ventilation and pollutant accumulation due to great roughness in ground surface. According to the simulation results, the ventilation duct planning design scheme can make the urban average wind speed increase by around 8% in the whole city and by around 12% in the old urban district in winter, while, increase by around 6% in the whole city and by around 9% in the old urban district in summer.