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Analysis on China Climate Distribution----A Case Study of Key Cities

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Abstract – **China has vast territory, with big difference in north and south across latitude, distances from the sea, coupled with the uneven topography, geographical types and mountain trends, precipitation, sunshine, temperature and other meteorological factors, which leads a variety of local climate in China. China has a typical monsoon climate characteristics, with high temperature and rainfall in summer, low temperature and less rain in winter. This paper intends to analyze the different climatic characteristics of China, and to divide China key cities into several clusters according to the climatic factors such as sunshine, rainfall, relative humidity, temperature and so on.**

Keywords – **Climate, Factor Analysis and Hierarchical Clustering.**

I. Introduction

China has vast territory, with big difference in north and south across latitude, distances from the sea, coupled with the uneven topography, geographical types and mountain trends, precipitation, sunshine, temperature and other meteorological factors, which leads a variety of local climate in China. For example, it can be divided into monsoon climate in the east, continental climate in the northwest and alpine climate in the Qinghai-Tibet Plateau. If divided by temperature zone, it can be divided into tropical, subtropical, warm temperate, moderate temperate, cold temperate and special Tibetan Plateau. From the dry and humid areas, there are arid areas, semi-arid areas, semi-humid areas, humid areas. In the same temperature zone, there are also differences between dry and wet, and the same type of dry wetland may be distributed in different temperature zones. Therefore, even in the same climate type, heat and dry wet degree are different. Because of the complexity and diversity of terrain, the climate types are even more numerous. It also enables the vast majority of crops, animals and plants in the world to find suitable environment for survival in China. This makes our country's choice of crop resources abundant.

China has a typical monsoon climate characteristics, with high temperature and rainfall in summer, low temperature and less rain in winter and rainy period and high temperature period basically the same characteristics. This makes the development of agriculture and planting in China have natural help, because of the high summer temperature, excellent heat conditions, so that the same latitude can be planted with higher heat conditions of crops, which undoubtedly makes China have more crop acreage than other countries located in the same latitude. The natural conditions of summer high temperature period and rainy period are relatively consistent, which is conducive to the growth of plants, and useful to the status of China's agricultural power.

Based on the descriptive analysis of climatic basis of key cities in China, this paper analyzes the climatic differences among key cities in China and carries out clustering to summarize the trend of climatic distribution in China. The climate data of key cities are downloaded from the China National Bureau of Statistics. The results of this paper might be useful for the government to develop and reform the tourism and agriculture in China.

II. Hierarchical Clustering

Hierarchical clustering essentially consists of progressi--vely organizing all of the candidate objects into clusters comprising mutually similar objects as determined by some measure of inter-object and inter-cluster similarity, proceeding in succession from the formation of small clusters containing just two objects to large clusters containing many objects. It is characteristic of this procedure that the clusters formed in each step can be graphically displayed in tree diagrams referred to as dendrograms. Hierarchical clustering is widely used as its visuality, but it is less efficient for large observations. In this paper, the dataset only has 29 observations and 5 columns, and it is suitable for hierarchical clustering method. Each observation indicates each key city, and each column stand for a climate variable. The segmentation is based on these 5 columns and data are transformed by z-score standardized before clustering. By clustering, the 29 areas are grouped into several clusters, and the analysis about these cluster is then performed.

III. Descriptive Study

Figure 1 displays the spatial distribution of yearly average temperature in China key cities. It can be found that the annual mean temperature in China is high in the southeast coastal area and low in the northwest inland area. The overall trend is increasing from northwest to Southeast. The average annual temperature in the southeastern coastal cities of Guangdong, Nanning, Guizhou and Haikou are all more than 20 ℃. Harbin, located in the northeastern part of the motherland, has an average annual temperature of only 5.6 ℃, only one fifth of the average temperature in Haikou. From this we can see that the southeastern coastal cities are more warm and humid, and the northwest inland area is more dry and cold. Meanwhile, the annual average temperature in Chengdu, Chongqing and other areas has not been found to be significantly different from the surrounding cities.

The annual temperature range in China is lower in the southeast coastal area and higher in the northwest inland area as shown in Figure 2. The overall trend is decreasing

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from northwest inland to coastal area. The trend is also contrary to the trend of annual mean temperature distribution. In relatively high latitude cities such as Harbin and Urumqi, the annual temperature span is more than 60 ℃, and in Harbin it is 64.9 ℃, twice as high as the Haikou where the annual temperature range is only 27.7 ℃. In the southeastern coastal area, the latitude is lower, closer to the equator, and the annual sunshine time varies less, so the annual temperature range is very low. The southeast region is closer to the Pacific Ocean and has more rainfall, making the region more water. It is known that water has a higher specific heat capacity than sand and stone, and water has the role of heat preservation in the region, resulting in more concentrated temperature in the southeast coastal areas.

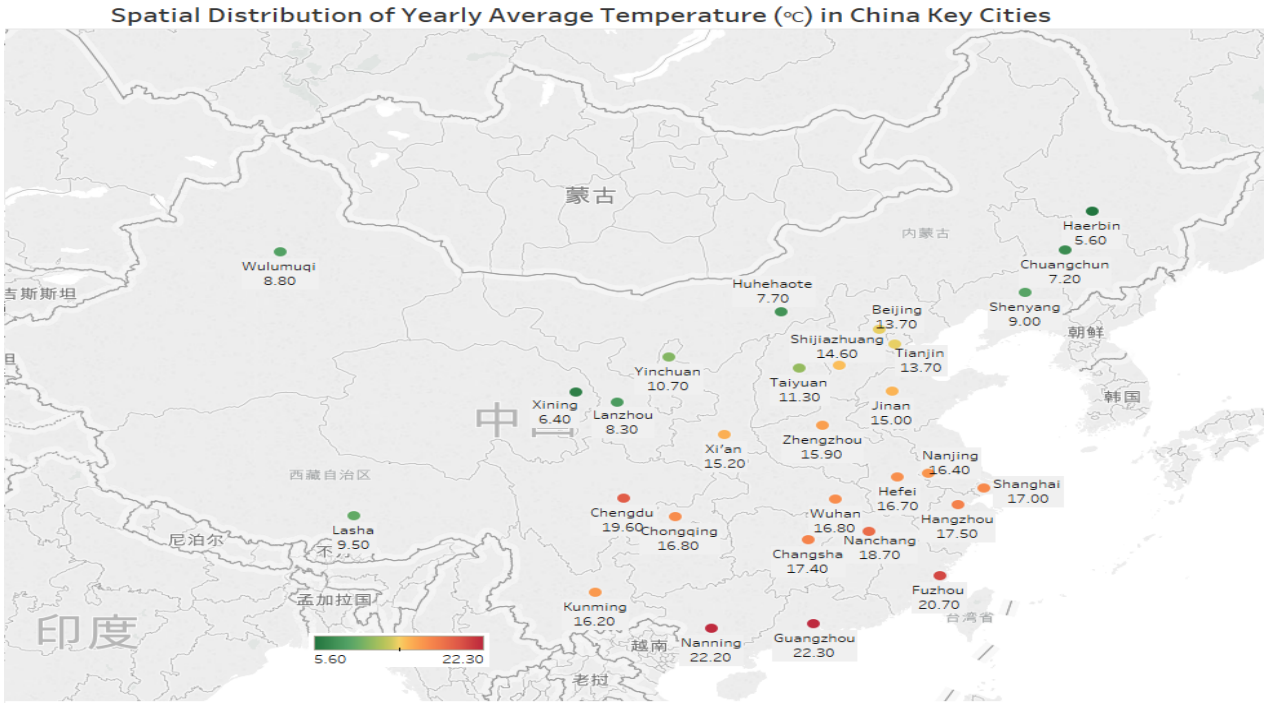

Fig. 1. The spatial distribution of yearly average temperature in China key cities. The color of each city is proportional to its average temperature.

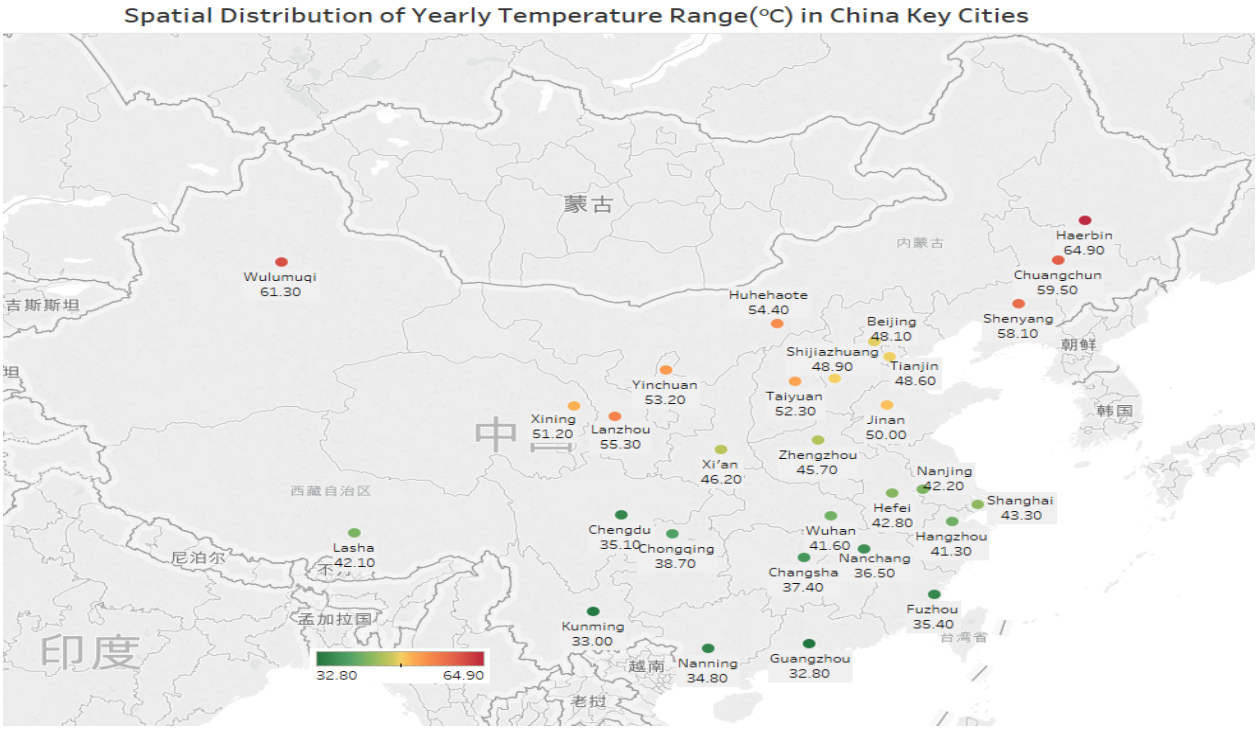

Fig. 2. The spatial distribution of yearly temperature range in China key cities. The color of each city is proportional to its temperature range.

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The sunshine hours in China are generally long in the northwest and short in the southeast, as shown in Figure 3. In Lhasa, Yinchuan, Urumqi and other cities in Northwest China, the longest annual sunshine duration is 3112 hours, three times longer than the shortest sunshine duration of Guiyang 942 hours. Moreover, the topography of China shows a trapezoid distribution: the northwest is high, the southeast is low, and the elevation difference is obvious. The distribution of topography trend is roughly in line with the declining trend of sunshine, and Lhasa, with the longest annual sunshine, is situated above the world's highest ridge. However, sunshine hours in Chengdu, Chongqing and Guiyang are obviously not in line with the trend, which is seriously less than those in the surrounding cities. Therefore, the reason might be related to the local topography or other climate such as local rainfall and temperature.

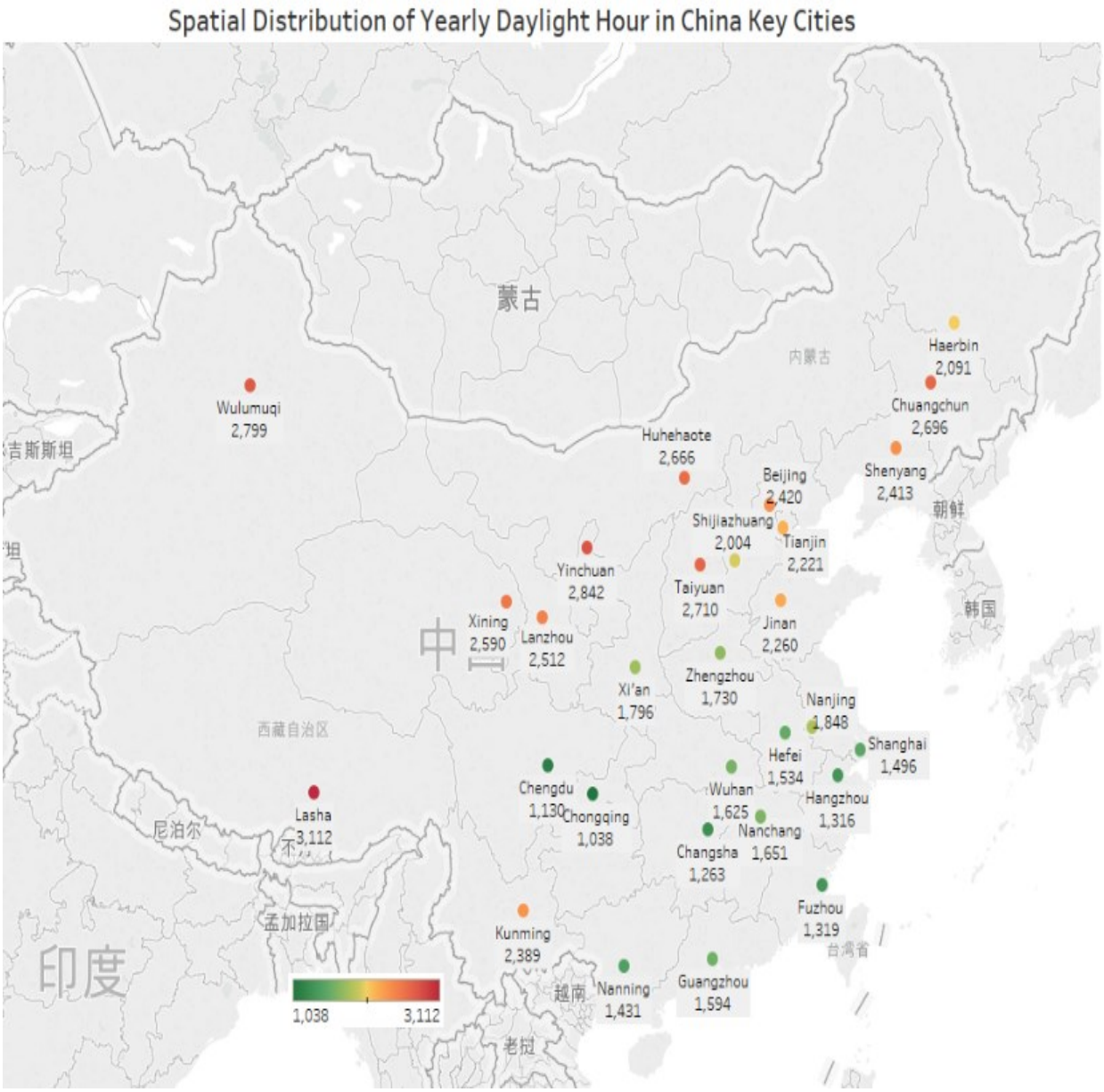

Fig. 3. The spatial distribution of yearly daylight hour in China key cities. The color of each city is proportional to its daylight hour.

As shown in Figure 4, the rainfall is geographically present in China, with abundant rainfall in Southeast China and lack of rainfall in Northwest China. The trend is increasing from northwest to southeast coast. The annual rainfall of Guangzhou is up to 2472 mm, and Nanchang, Hangzhou and other places is more than 2000 mm. However, Lanzhou, Yinchuan, Xining, Lhasa, Hohhot and other central and western cities rainfall less than 400 mm, as these cities are located in arid and semi-arid areas. Lanzhou is only 191 mm, 13 times less than that of Guangzhou. It is concluded that the sunshine hours are inversely correlated with the rainfall in China. It might be because that thicker rainfall layers fly in rainy areas, which leads to a lower penetration rate of sunlight passing through clouds and shorter sunshine time than in rainless areas in Northwest China.

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Fig. 4. The spatial distribution of yearly rainfall in China key cities. The color of each city is proportional to its yearly rainfall.

Figure 5 shows the spatial distribution of yearly average humidity in China key cities. Relative humidity is geographically high in Southeast China and low in Northwest China. The trend is decreasing from southeast to northwest. The relative humidity of Changsha, Wuhan, Chongqing and other cities is more than 80, and the relative humidity of Guiyang is higher than 84, which is 2.5 times more than that of the western city Lhasa, 34. The results show that the relative humidity is positively correlated with rainfall and inversely correlated with sunshine time. Adequate rainfall and relatively little sunshine make the southeast more humid than the northwest, so the southeast coastal region is more humid. The relative humidity in Chengdu, Chongqing, Guiyang and other areas are not significantly different from the surrounding cities.

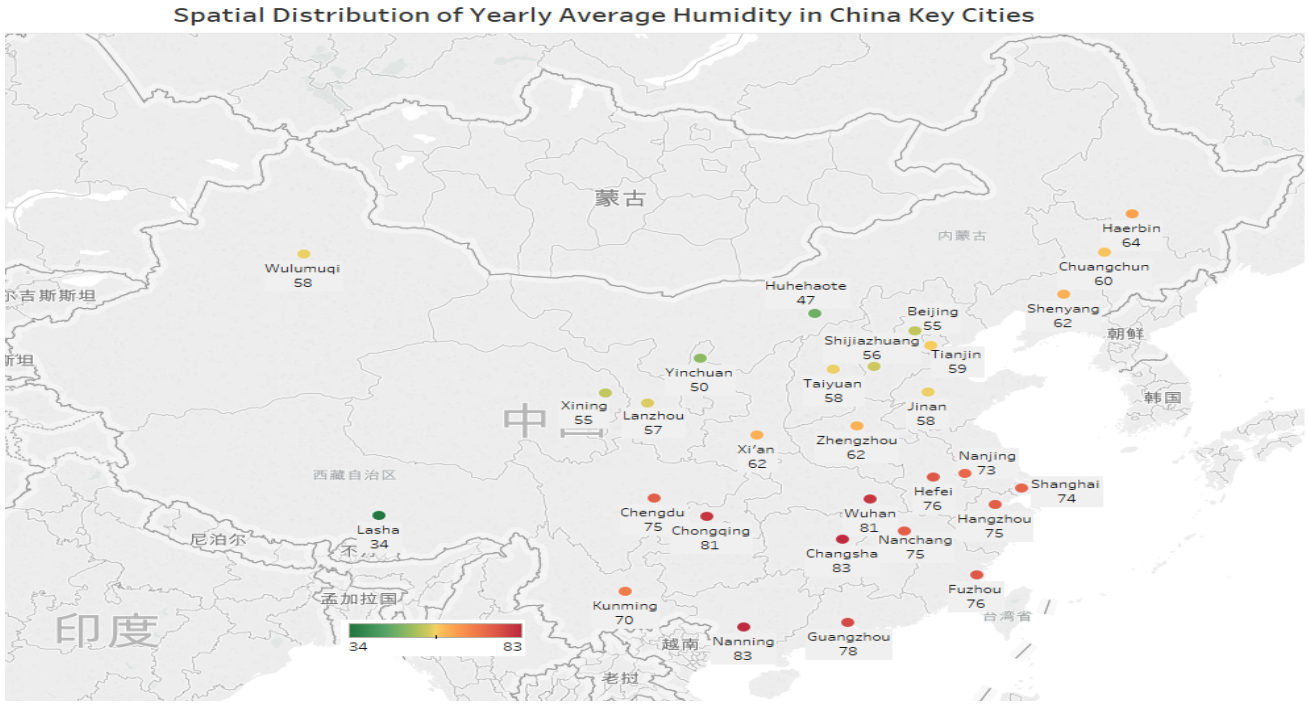

Fig. 5. The spatial distribution of yearly average humidity in China key cities. The color of each city is proportional to its average humidity.

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IV. Clustering Result

After the Hierarchical Clustering, 29 key cities are grouped in 5 clusters, and the spatial distribution of these cities are shown in Figure 6. It can be found that cites in the same cluster also show spatial associations, and they are close to each other comparing with the cities in other clusters. The cluster result of 29 key cities, and the average values of each climate variable are listed in Table 1. Based on the results of Figure 6 and Table 1, the 5 clusters can be named as: Cluster 1, "North of the Yangtze River"; Cluster 2, "South of the Yangtze River"; Cluster 3, "China Northeast"; Cluster 4, "China Southwest"; Cluster 5, "Qinghai Tibet Plateau in Western China". It can be concluded that the climate difference among the cities are mainly caused by their geographical factors.

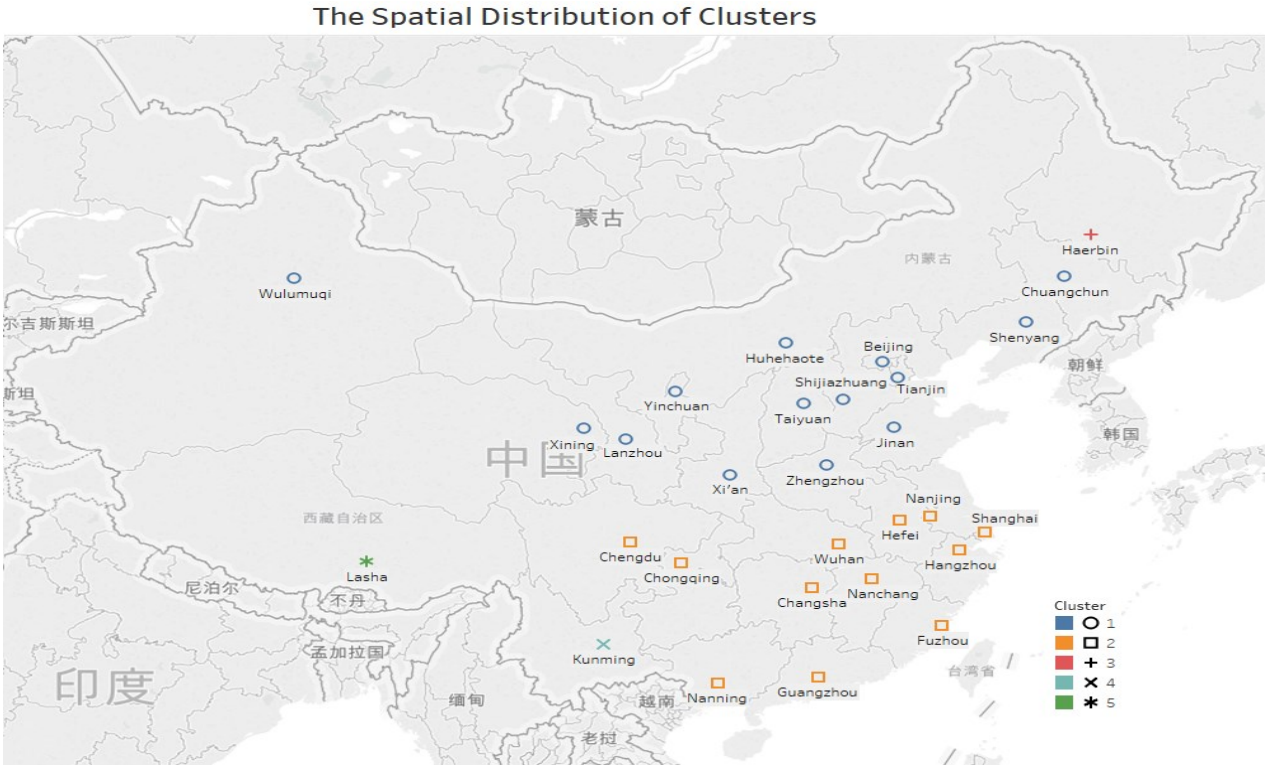

Fig. 6. The spatial distribution of clusters of China key cities. The color and shape of each cluster are labeled in the figure.

Table 1. The cluster result of 29 key cities, and the average values of each climate variable are listed.

Clu	Areas	Daylight	Rainfall	Humidity	Average Temp	Temp Range
1	Beijing, Tianjin, Shijiazhuang, Taiyuan, Huhehaote, Shenyang, Chuangchun, Jinan, Zhengzhou, Xi'an, Lanzhou, Xining, Yinchuan, Wulumuqi	2404.2	466	57	11.3	52.3
2	Shanghai, Nanjing, Hangzhou, Hefei, Fuzhou, Nanchang, Wuhan, Changsha, Guangzhou, Nanning, Chongqing, Chengdu	1399	1631.7	78	18.3	38.3
3	Haerbin	2090.7	420.1	64	5.6	64.9
4	Kunming	2388.9	1190.7	70	16.2	33
5	Lasha	3112.4	340	34	9.5	42.1

V. Conclusions

This paper does a descriptive study of China climate distribution in 29 key cities. China has vast territory, with big difference in north and south across latitude, distances from the sea, coupled with the uneven topography, geographical types and mountain trends, precipitation, sunshine, temperature and other meteorological factors, which leads a variety of local climate in China. This paper firstly demonstrate the spatial distribution of yearly average temperature, yearly temperature range, yearly daylight hour, yearly rainfall, and yearly average humidity in 29 China key cities. The cluster results display that the climate difference among the cities are mainly caused by their geographical factors. The distribution of climatic characteristics in China has a relatively obvious tendency, showing the characteristics of long sunshine in Northwest China, lack of rainfall, low relative humidity, low annual average temperature and large temperature span; while the southeastern coastal areas have a short sunshine time, abundant rainfall, high relative humidity, high annual average temperature and annual temperature.

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