

# Study on spatial morphology of cold area settlements based on microclimate parameterized model

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**Abstract.** In the steady development of social economy, the quality of life of urban residents is getting higher and higher, the attention to the spiritual life is getting stronger and stronger, a good urban living environment has gradually become an important factor to evaluate the superiority of the city. Especially for the residential environment in cold areas, the winter is long and cold, accompanied by strong cold wind and snow, in-depth study of the spatial form of residential areas in cold areas, clear the corresponding microclimate conditions, can put forward targeted optimization measures, improve the comfort of outdoor environment, and ensure the quality of life safety of urban residents. Therefore, on the basis of understanding the research status of residential building planning and layout in recent years, this paper takes the spatial form of a region as an example to construct a microclimate parameterized model. The final research results prove that the climate environment of urban residential areas is targeted, different and personalized under the influence of the layout of residential areas. The effective layout means can show its regulating effect and effectively improve the environmental conditions of urban residents.

**Keywords:** microclimate; Parameter delineation model; Cold area residential area; Space form

## 1. Introduction

In the rapid development of our social economy, the urbanization process is faster and faster, and almost every moment the city is rebuilding. To understand the overall urban development status in China, most of the cities are in the stage of construction and development, with the continuous increase of the city construction volume, the coverage of the city is more and more wide, the density of the city building is growing, people's living environment affected by the building degree also improved. With the gradual expansion of the city and the formation of a unique climate environment, a relatively strong urban heat island effect has been generated. Under this influence, the microclimate environment of urban residential areas has been homogenized, making the internal environment of most residential areas very similar. However, the general climate environment in the process of urbanization is not applicable to all residential areas. Under the influence of historical, economic, social, natural and other factors, different residential areas have their own unique patterns and personalities. Nowadays, when studying urban climate environment, scholars from all over the world mainly focus on urban living and explore the close relationship between urban climate environment and architectural layout through various problems. Because the urban environment has a special way of composition, it will lead to the change of urban microclimate environment. At present, academic researchers pay much attention to the relationship between the layout of urban buildings and microclimate, and hope to ensure a more suitable living environment for urban residential areas through the scientific planning and layout of urban residential buildings. Under the influence of the layout, the microclimate environment of urban residential areas forms a specific microclimate environment, which is conducive to better adapt to its own development and construction space. For example, Harbin is located in the cold area of northeast China. Winter climate plays a leading role in the construction of residential areas, while summer climate and environmental factors play a lower leading role than winter factors. Under the background of the gradual improvement of people's living quality, the research on the building layout of related residential areas has become very important. However, there are few studies on building layout based on improving the comprehensive microclimate environment of multi-storey residential areas. Therefore, this paper mainly starts with the influence relationship of building layout on the climate

environment of residential areas, and deeply discusses the overall creation of climate environment under various building layout modes of multi-storey residential areas in a certain region.[1.2.3]

The study of residential building planning and layout has been discussed from many angles by foreign scholars. For example, Howard put forward the pastoral city theory in his research, and Wright put forward the Broad Mu City theory in his research. These studies both started from the perspective of cities and clarified the design principles and future directions of residential area planning. Compared with the residential area planning and building layout of domestic research, foreign scholars' research is more advanced. At present, foreign scholars mainly focus on energy conservation and physical environment of residential areas. For example, in 2005, M.Rohinton Emmanuel proposed a climate design strategy for the local urban planning based on the climatic characteristics of the tropical region. This strategy fully considered the amount of solar radiation and internal natural ventilation of the building at the initial stage of the design, and determined the site location and building orientation according to the above information. The sun shading device and landscape in the outdoor space are fully considered to solve the urban energy consumption problem caused by environmental, traffic, building and other factors. In 2006, Hugh Barton, Geoff Davis, Richard Guise and others implemented the concept of sustainable design in terms of general planning, detailed design and environmental assessment. However, when studying the planning layout of residential area in China, great changes have taken place in both the planning principle and the layout concept. For example, in the 1940s and 1950s, residential planning mainly learned from the Soviet room layout principle, and was greatly influenced by the western neighborhood unit theory; In the 60s and 70s, community planning and architectural layout in our country began to consider how to reduce the input cost, reduce the construction link, ensure the overall construction quality. Nowadays, Chinese scientific researchers pay more attention to energy-saving design and humanization principle when studying building layout and residential area planning. Therefore, this paper mainly discusses the spatial form of cold area residential area based on microclimate parameter model and puts forward corresponding urban planning and management countermeasures.[4.5]

## **2. Method**

### **2.1 Microclimate simulation software**

When conducting numerical simulation analysis based on the influence relationship between building layout and microclimate, appropriate simulation software should be selected to ensure that it can be closer to the real reaction in limited conditions.

First, wind environment simulation software. In this study, the CFD simulation software of wind environment was deeply studied by means of consulting data and other methods, focusing on the analysis of the accuracy and perfection of the simulation software application, and finally obtained the following results as shown in Table 1:[6.7.8]

Table 1 Classification and analysis of wind environment simulation software

The name of the software	The main function	The software features
FLUENT	Conduct outdoor wind environment analysis and indoor ventilation simulation	1. It can be applied to a wide range of numerical models
		2. Fast operation and high efficiency
		3. High precision and good stability
		4. Reasonable network division
AIRPAK	Conduct simulation of air distribution	1. Fast modeling speed
		2. Strong modeling ability
		3. Visualization post-processing
PKPM	Conduct heat island simulation and indoor and outdoor wind environment simulation	1. Easy to operate
		2. For energy saving design
PHONEICS	User HVAC and building environment simulation	1. It is widely used
		2. The operation is not simple enough
VASARI	Simulation of sunshine and wind environment, energy consumption analysis	1. Main user concept design
		2. Simple operation

Combined with the above analysis, it can be seen that in this study, the numerical simulation software FLUENT is mainly selected for comparative analysis, focusing on the mutual influence relationship between various layout changes and wind environment, so as to put forward scientific layout strategy according to the specific situation.

Secondly, temperature and humidity simulation software. Based on the analysis of existing data, it can be seen that the simulation software for outdoor temperature and humidity environment is mainly shown in Table 2 below:

Table 2 Classification and analysis of temperature and humidity environment simulation software

The name of the software	The main function	The software features
ENVI-met	Used to simulate outdoor microclimate, urban heat island effect, etc	1 Rich software modules
		2. Simple operation logic
		3. Micro climate indicators
		4. It cannot be used for microclimate simulation below 0°C
FLUENT	Used of fluids. Simulation of heat transfer and chemical reactions	1. It has a wide range of application and can be solved by a variety of numerical simulations
		2. Fast operation and high efficiency
		4. High precision and good stability
		5. Reasonable network division
		6. The simulation of temperature and humidity environment is complex
ANSYS	Professional commercial software for fluid simulation	1. High precision
		2. Rich physical models
		3. The network is not properly divided
		4. Focus on solid heat transfer and stress and strain analysis
ECOTECT	Perform thermal, optical, and acoustic analyses	1. Simple operation 2. Mainly analyze energy consumption
PHONEICS	Used for HVAC and building environment simulation	1. It is widely used 2. The operation is not simple enough
VASAPI	Simulation of sunshine and wind environment, energy consumption analysis	1. Mainly used in conceptual design
		2. Simple operation

Based on the above research, ENVI-Met software is mainly selected as the residential temperature and humidity simulation software in this paper. In fact, ENVI-Met is a microclimate three-dimensional model software developed in Germany, which is mainly used to simulate the urban space at the block scale as the climate environment. It is widely used in the international scope and has strong verification and accuracy. The corresponding software architecture is shown in Figure 1 below:[9.10]

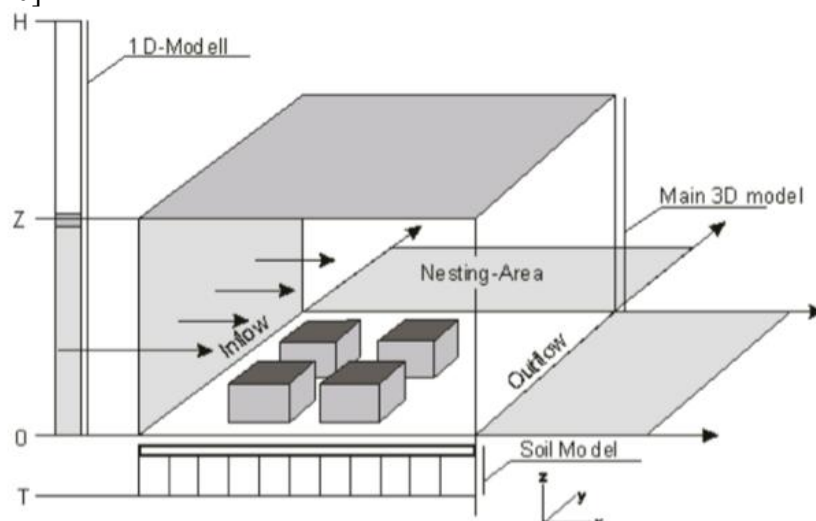


Figure 1 Architecture diagram of the software

Finally, simplify the model. In this study, the southwest wind, the dominant wind direction in summer, winter and the whole year, was used as the simulation wind direction. The designed wind speed was 2.39m/s in summer, and the relative humidity was 75.79% in summer. The average simulated wind speed in winter wind environment reaches 2.37m/s. FLUENT numerical simulation software and pre-processing software GAMBIT were used to set the residence in the model as a simplified model. In the process of simulation, the microclimate data obtained from each numerical point are statistically analyzed by evenly distributing the points in the model. Among them, the distribution principle should comply with the overall uniform distribution characteristics, and the distance between the location of each distribution point and the wall of the residence should reach 5 meters, so as to effectively simulate the real direct distance between pedestrians and buildings in the residential environment. At the same time, it is necessary to ensure that each distribution point has an appropriate position in each model.

## 2.2 Analysis of residential area layout

First, the influencing factors of the wind environment. Under the influence of monsoon, the climate difference between summer and winter is very obvious in northern cold cities. Taking the double-column wind environment in the north as an example, the building layout of residential areas should not only pay attention to the formation of air ducts in summer to strengthen the natural ventilation of the city, but also reduce the penetration of cold air in winter to control the carbon emission sales of the city. From the perspective of building orientation Angle, different incident angles also have different wind field characteristics around the building. According to practical research, the scope of architectural scenic spots can usually reach four to five times of the building height, and the spacing of residences cannot reach such a large distance. In order to further reduce the adverse wind effect between buildings, the wind environment of residential areas can be optimized by changing the wind direction Angle. Taking a single building as an example, the smaller the wind projection Angle, the more favorable the ventilation in the front building room. However, for the wind effect in the scenic spot behind the building and the ventilation of the group building, the smaller the wind projection Angle, the worse the ventilation efficiency of the building. When the wind incident Angle is zero, the scenic area behind the residential building is the largest, and the actual wind speed can also reach the maximum.

Secondly, the influence of different plane combinations on wind environment. The determinant layout is usually divided into two types, one refers to the side by side, the other refers to the dislocation. According to the changes of different directions and angles, the research data of wind environment are made clear. The final results show that in terms of ventilation, the transverse strategy will increase the windward side of the building and facilitate the flow of air between the buildings, and the overall ventilation is better, which is more effective than other layouts. From the perspective of wind protection effect, the vertical staggered type is lower than the parallel type and the horizontal staggered type in the overall wind speed, and the overall wind protection effect is better.

Third, spatial layout. In order to understand the influence of different building height is arranged on the wind environment constitute, to take advantage of the following is shown in figure 2 big data technology platform, the simulation analysis of 40 m in height, the front and rear building height of 40 meters to 60 meters, in front of the building height is 60 meters and rear building height of 40 meters of these three layout.

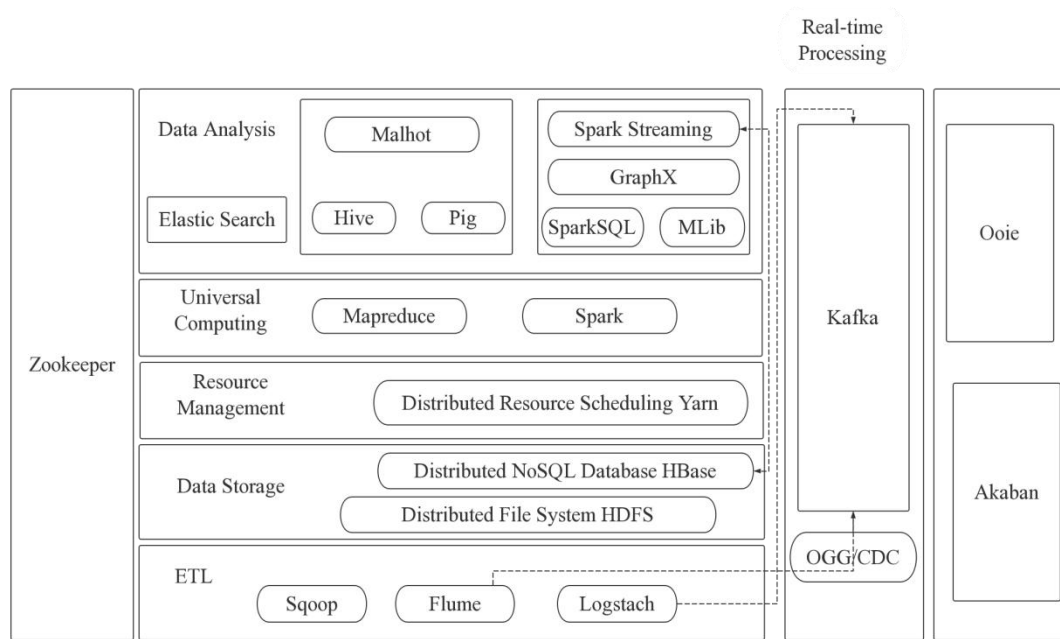
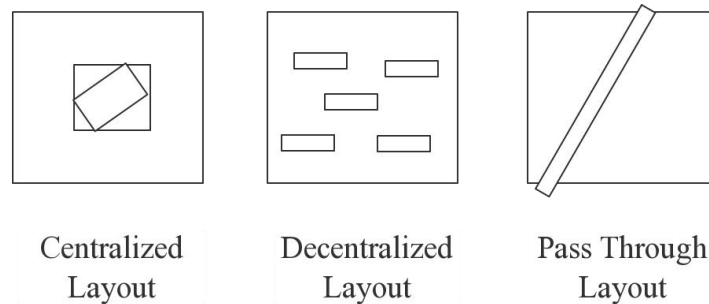


Figure 2 Big Data technology platform

Fourth, water area. According to the practical research, with the continuous increase of water area, the cooling and humidification effect of water body will be stronger and stronger. The final results showed that there was a secondary relationship between water area and cooling quantity and humidity increase. According to the layout and form of water landscape in the residential area, it can be divided into three types as shown in Table 3 below:

Table 3 Layout classification of water landscape



### 3. Result analysis

Combined with the above research and analysis, it is shown that the spatial form design of cold settlements based on the microclimate parameterized model should firstly select the appropriate building orientation, secondly scientifically adjust the group relationship, and finally integrate the previous accumulated planning experience. By analyzing the case study in this paper according to the flow chart of parametric model shown in Figure 3 below, it can be seen that the corresponding planning and design strategy involves the following points: First, reasonable functional layout. According to the schematic analysis of the airflow direction of the building, the residential area is divided into residential area, co-construction area and recreational green area according to its function. Among them, most of the public construction areas and recreational green areas belong to low areas, so the high-rise will be arranged in the northeast side, which can not only facilitate the east in summer, but also use the difference of building height to block the cold air outside the high-rise in winter, and optimize the micro-climate of the living environment. Second, rational use

of green plants. In cold residential space, green plants not only beautify the landscape, but also adjust the climate environment. According to the overall design planning of the residential area, scientific control of green land, green types, green forms, etc., can provide a relatively comfortable microclimate environment for local residents; Third, water body pavement. For cold areas in the north, water landscape can be created in the south of the residential land. In winter, through the reflection of the lake surface, it can be collected into the space area in the north of the water body, so as to raise the environmental temperature in the north of the water body.

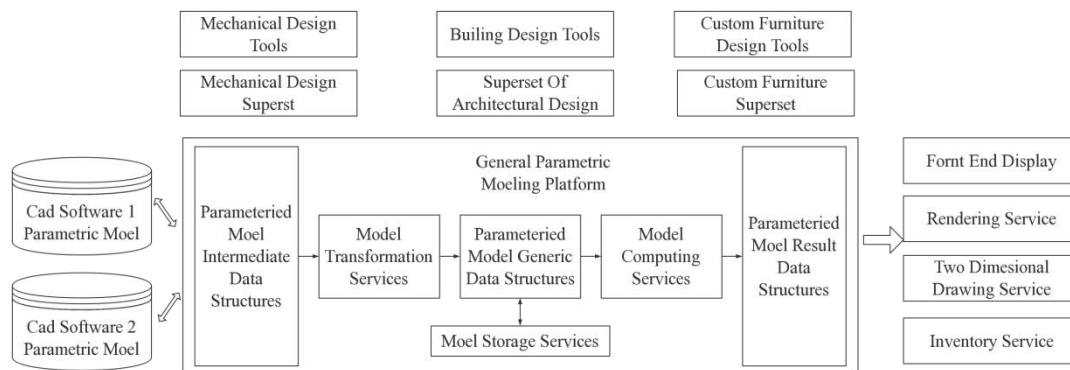


Figure 3 Flowchart of parameterized model

## 4. Conclusion

To sum up, this paper studies the use of microclimate simulation software, thinking from two aspects of summer and winter, to simulate and analyze the climate environment under three building layout modes, focusing on the analysis of the differences in wind environment, temperature environment and humidity environment. At the same time, combined with the analysis results under different layout patterns, the paper puts forward effective countermeasures for the spatial form design of the current cold area residential areas.

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