

# The analysis of urban Sky View Factor calculation based on geometric form

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**Abstract:** Previous research has shown that there is a clear relationship between the urban morphology on one hand and the local solar irradiance and air temperature on the other hand. In order to describe the urban climatology and its spatial variations the sky view factor (SVF) plays a key role. This fraction of visible sky provides an indication of the street geometry and building density. Adding SVF as an evaluation element in urban planning be used to coordinate the spatial layout of the city, improve the built environment, and reasonably control the height and density of construction projects, which can effectively promote the refinement of urban planning and the construction of green cities.

**Keywords:** Sky View Factor, geometric form, building density

## 1. Introduction

Most of China's urban development has transitioned from the "horizontal development" stage to the "vertical development" stage, which has changed the subjective feeling of every individual, including the openness of the sky, from the urban form to the smallest. Sky View Factor, or SVF, is the actual visible range of the sky when people stand on the ground and look up at the sky. SVF not only affects people's visual experience, but also is an important factor that impacts the urban heat island effect.

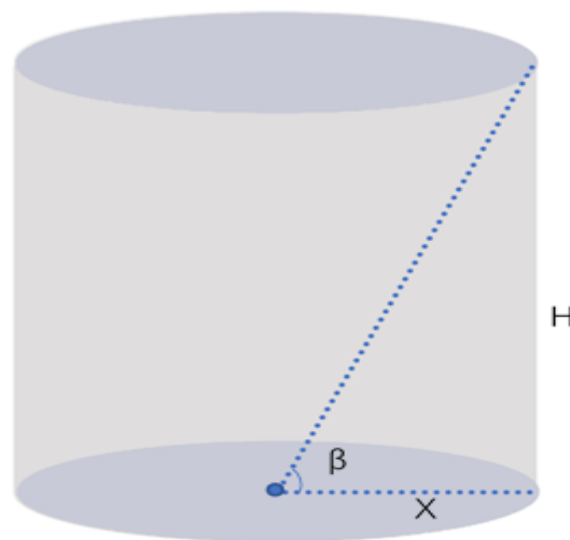


Figure 1 Calculation of the shading degree of a point

Nowadays, the demand for efficient use of energy has prompted the development of green buildings and sustainable urban planning. The research of SVF can provide a solution for the rational control of urban heat island effect and promote the efficient use of urban energy. In addition, with the gradual advancement of urban management into fine management, urban temperature will also serve as important urban information. Taking the city SVF as one of the influencing factors can improve the

prediction accuracy of the temperature at a specific location and time in the city. SVF calculation methods primarily consist of mathematical calculation methods based on simple geometric forms and image segmentation methods based on panoramic images.

The mathematical calculation method based on simple geometric forms was proposed by Oke [6]. The SVF in this method is 1 minus the shading, where shading is defined as the ratio of the portion of radiation emitted from a point on the surface that is blocked by buildings to total radiation. If there is an observation point in the center of a cylindrical basin, the obscuration at this point is calculated as

$$\Psi = \sin^2 \beta$$

In this equation,  $\Psi$  is the shading at the center of the circle,  $H$  is the height of the wall, and  $X$  is the distance from the center of circle to the wall, as shown in Figure 1.

## 2. Calculation method

### 2.1. Determine the observation position

The SVF actually is the result obtained after a person stands at a certain point and observes according to an arbitrary azimuth angle. To facilitate the experiment, a circle of radius  $R$  is made for the specified line-of-sight distance at a certain point and an azimuth step of  $\alpha$  is specified, which means that the observation and calculation of the distance  $R$  is carried out every  $\alpha$  angle. As shown in Figure 2.

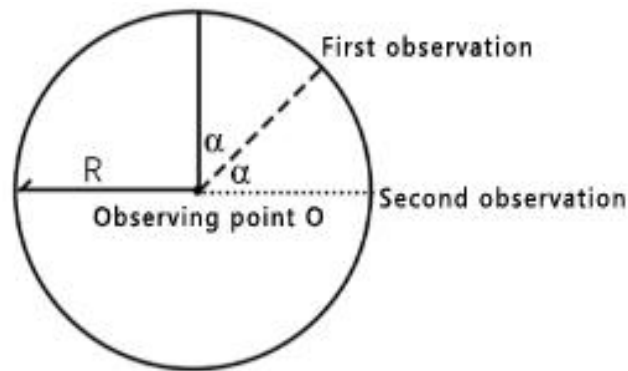


Figure 2 Determination of observation orientation

### 2.2. Determine the shading of a point in a certain direction

$$\Psi_i = \sin^2 \beta$$

$\beta$  is the maximum altitude angle,  $\Psi_i$  is the degree of shading in a certain direction at a certain point.

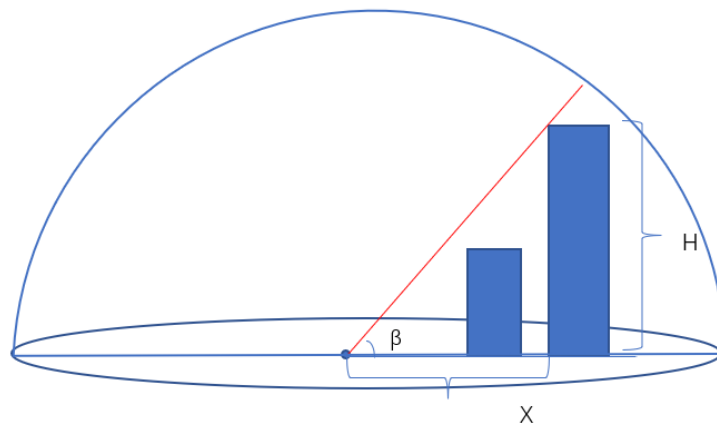


Figure 3 Determination of maximum height angle and shading

Observation is carried out at a defined observation point, observation radius and observation orientation. The angle between the observation point and the line connecting with the highest point of each building in the range and the horizontal ground is an altitude angle. The maximum height angle is not simply determined by the distance  $X$  between the observation point and the observed building and the height  $H$  of the observed building, but comparing the square of the trigonometric function of each height angle determined by both  $X$  and  $H$ , the maximum value can be selected and used as the maximum shading degree of the point in that direction. As shown in Figure 3.

### 2.3. Calculate the SVF at this point.

SVF at this point is 1 minus the average of the shading for the point in all directions, which means

$$\rho_{sky} = 1 - \frac{\alpha}{360} \sum_{i=1}^{360/\alpha} \psi_i$$

### 2.4. Calculation flow chart

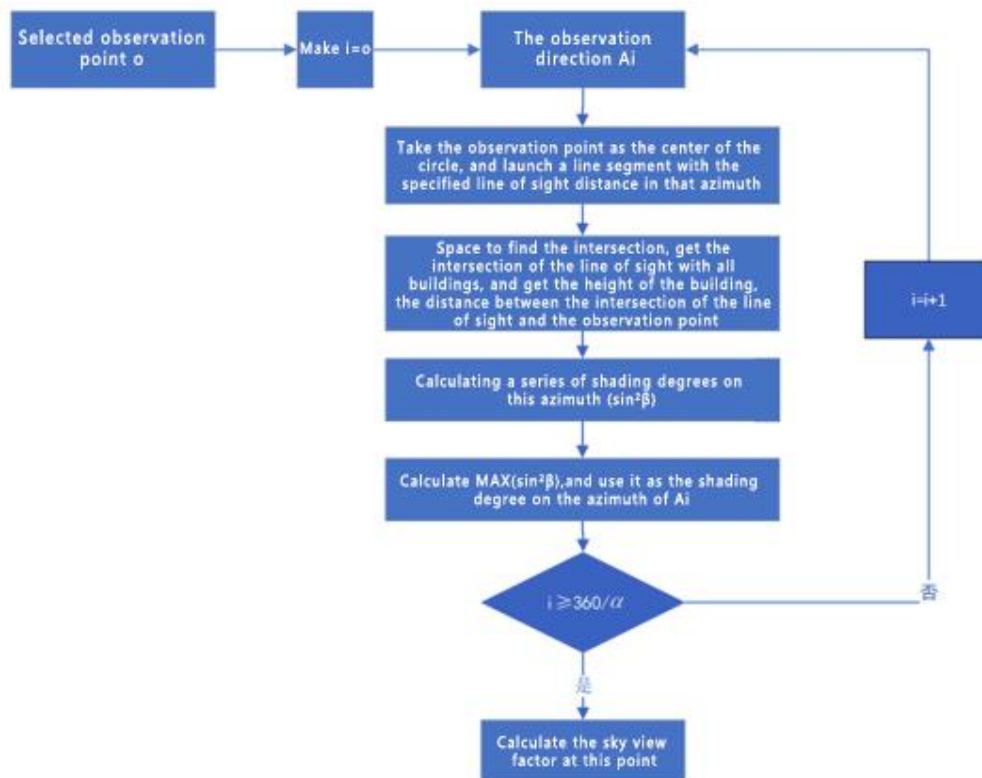


Figure 4 Flow chart of SVF calculation

The flow chart of the calculation for the sky openness of a point is shown in Figure 4.

## 3. Experiment and results

### 3.1. Experimental Zone: Sino-Singapore Tianjin Eco-city

Sino-Singapore Tianjin Eco-city (SSTEC), located in Tianjin, China, is established in the Binhai New Area of Tianjin. The Sino-Singapore Tianjin Eco-city was set up by the Chinese and Singaporean governments as a strategic project to improve the ecological environment and create an environmentally friendly society.

The overall distribution of the Sino-Singapore Tianjin Eco-city is dense in the south and sparse in the north. The spatial distribution includes a large number of concentrated residential neighborhoods

and commercial complexes in the south; central part is the ecological nucleus, including a large amount of green land such as the central park landscape area; the north is an ecological industrial park and industrial park. Each type of space has different urban texture and built environment space, which avoids homogeneous experimental results.

### 3.2. Experimental data

The purpose of this experiment is to carry out the calculation of SVF in the Tianjin Eco-city by using the above-mentioned method and building thematic data, to obtain the spatial distribution pattern of SVF in the area. In this case, the building thematic data is shp format, which contains two parts: first part is the geometry, and second part is the attribute information of the point file, one of the significant attributes is the building height.

In addition, a grid with 10 m cells is generated within the area, and the sky openness is calculated point by point, with the center point of each grid serving as the observation point. A visual radius of 200m and an azimuthal step of 30 ° are among them.

### 3.3. Experimental results

The experimental results are shown in Figure 5.

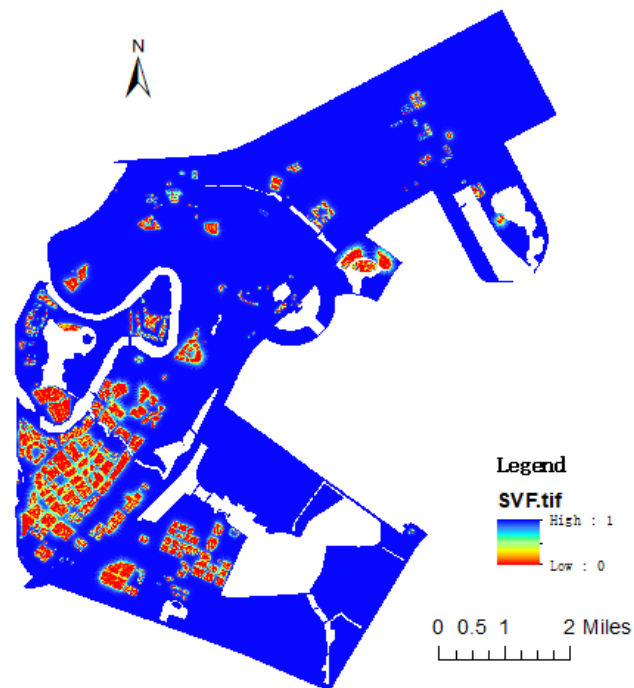


Figure 5 Experimental results

The SVF values are not evenly distributed across the Sino-Singapore Tianjin Eco-city. The bluer the area, the more open the sky is, and the more people can see it from here; the redder the area, the less open the sky is.

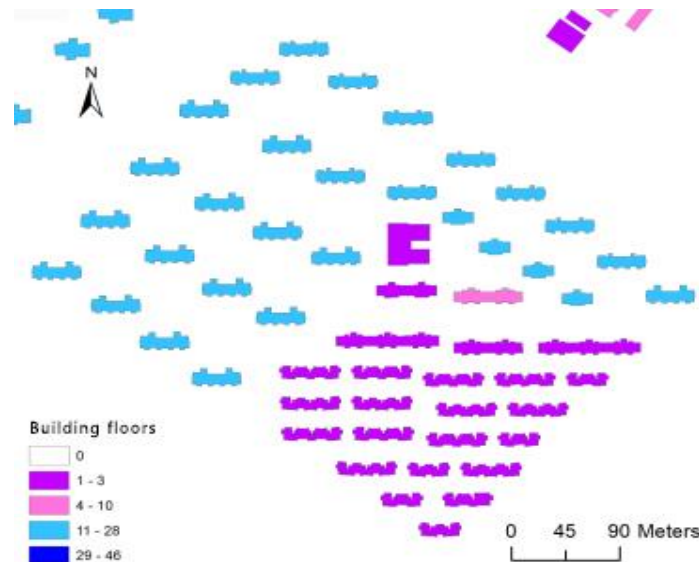


Figure 6. The distribution of the building floors in a residential area

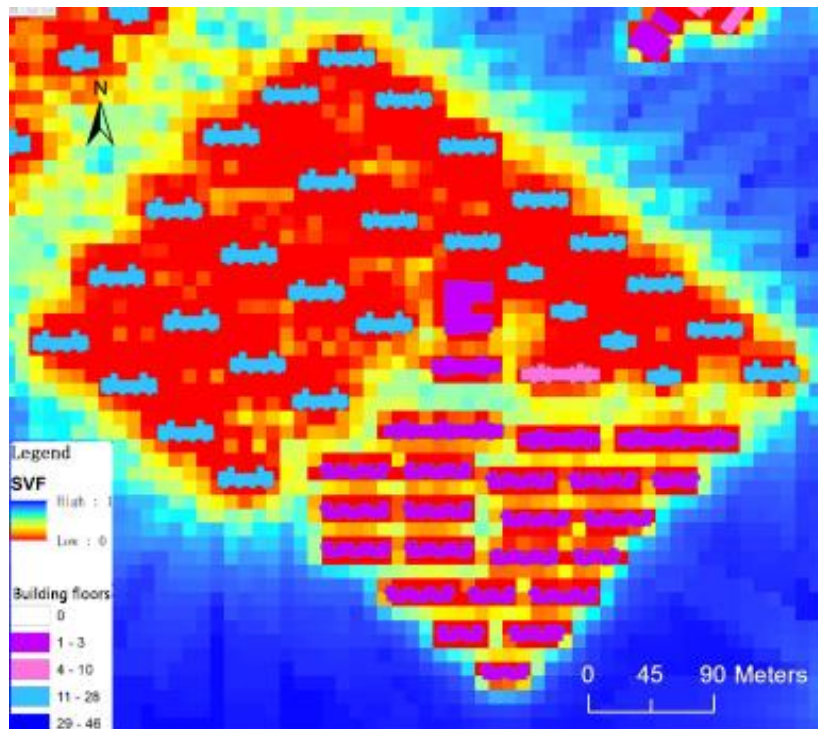


Figure 7. The distribution of SVF in this residential area

As seen in Fig. 6 and Fig. 7, the SVF is lower in areas with more dense buildings. The SVF is higher in areas where buildings are more dispersed and lower in height and distance. The areas with the smallest SVF are concentrated in residential areas, especially in high-rise buildings. Although the row of high-rise residential buildings is sparse, the high building height still significantly reduces the SVF.

#### 4. Conclusion

SVF is closely related to urban heat island, ventilation and other microclimates. The size of SVF is influenced by the spatial distribution of the occluders and their morphological characteristics. Using SVF as an evaluation element in urban planning can start from the urban sky, the "fifth facade" of the city, to coordinate the spatial layout of the city, improve the built environment, reasonably control the height and density of construction projects and other important indicators, and promote the refinement of urban planning and the construction of a green city.

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