Rendering the sky

Andreas Agvard
Lund University

Fredrik Lanker
Lund University

1 Introduction

This article is a short summary of our master thesis in computer graphics entitled *Photorealistic rendering of scenes with physically-based sky light* [1]. In this article we are going to present two different methods for computing the appearance of the sky at any time and place.

2 The theory

The color of the sky is due to particles in the atmosphere scattering the light from the Sun. Without these particles the sky would be pitch black even in the middle of the day and the Sun would not appear larger than the Moon. There are two common models used for describing the scattering of the light, these are called Rayleigh and Mie after their originators.

Rayleigh scattering predominates when particles are smaller than the wavelength of light. The amount of scattering due to these particles is highly dependant on the wavelength (proportional to $1/\lambda^4$ – where λ is the wavelength). Rayleigh scattering is the main contributor to the color of the sky and it is due to its high wavelength dependency that the sky is blue. The distribution function for Rayleigh scattering can be seen in figure 1.

Mie scattering predominates when particles are larger than the wavelength of light. It is not as wavelength dependent as Rayleigh scattering and has a strong forward scattering in a narrow region in contrast to Rayleigh scattering that scatters light in all directions. This scattering is the main reason for the perceived size of the Sun, without this scattering the Sun would not appear larger than the Moon. The distribution function for Mie scattering can be seen in figure 2.

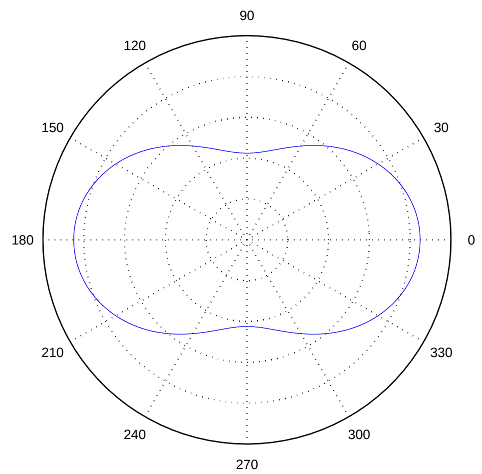

Figure 1: The distribution function for Rayleigh scattering. To fully understand the meaning of this diagram, imagine rays of light from the Sun entering from the left and scattering from the middle of the image. The blue line is the relative amount of sunlight scattering in the specific direction. As can be seen in this image, Rayleigh scattering scatters light in all directions.

3 The models

In our master thesis we use two different methods for computing the color of the sky. One is based on functions fitted to measured values and the other is based on numerical solutions to a physical model of the scattering in the atmosphere.

3.1 Approximative model

The approximative model is based on functions developed by Preetham et al. [2]. The light of the sky has been measured for a number of different Sun positions and turbidities. These values has then been fitted

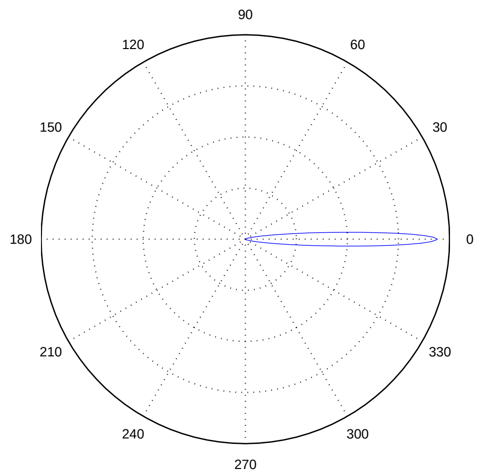

Figure 2: The distribution function for Mie scattering. As can be seen in this image, Mie scattering scatters light mostly forward in a cone shaped area. This scattering makes the Sun look larger than it actually is.

to functions dependant of the turbidity of the sky and the angle between the Sun and zenith. Turbidity is the ratio of the vertical optical thickness of the haze particles and molecules to the vertical optical thickness of the atmosphere with only molecules. Common values for turbidity are in the range 1 to 64, where 1 represents pure air and 64 light fog.

This model has the advantage that it can easily be computed in real time. An example of this model can be seen in figure 3.

3.2 Physical model

The physical model is based on the scattering theory by Rayleigh and Mie. Using a method known as ray marching where incoming light to a point from a specified direction is calculated by stepwise following the incoming ray of light backwards. In every step a segment is created in which all atmospheric properties are considered constant. By doing this the amount of incoming light scattering towards the point can be computed.

This model has the advantage that it gives more accurate results, however, it is much more time consuming than the approximative model. An example of this physical model can be seen in figure 4.

4 Conclusions

In our master thesis we use both models. The approximative model is used for giving real-time feedback of the current appearance of the sky at a given time and place. When one has decided on a suitable time and place, we use the physical model to create a high quality image of the sky. This is not only because of the more appealing appearance of this image but also because this image contains real world brightness dynamics. Because of this property the image can be used as a light source when rendering three dimensional computer generated imagery, a subject discussed more thoroughly in our master thesis.

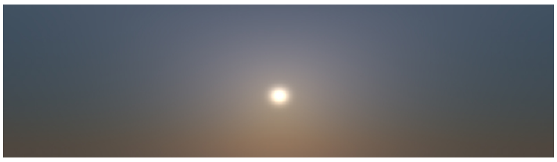

Figure 3: An example of the approximative model.

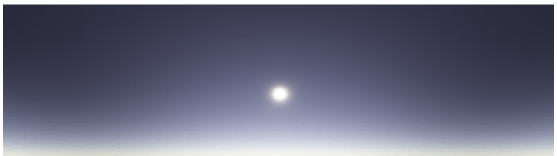

Figure 4: An example of the physical model.

References

[1] AGVARD, A., AND LANKER, F. Photorealistic rendering of scenes with physically-based sky light, 2005.

[2] PREETHAM, A. J., SHIRLEY, P., AND SMITS, B. A practical analytic model for daylight. In *SIGGRAPH '99: Proceedings of the 26th annual conference on Computer graphics and interactive techniques* (1999), ACM Press/Addison-Wesley Publishing Co., pp. 91–100.