Rendering Atmospheric Optical Phenomena

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Feb. 27, 2023

1 Checkpoint

I decided to focus on the Rayleigh scattering part of my original proposal. So I will focus on rendering the color of the sky, the Belt of Venus, the aerial and space view of the earth, and potentially alien skys. I plan to do so considering multiple scattering and physically accurate parameters of the sun, the atmosphere and the reflection of earth.

1.1 What I have done so far

In the first stage, I added multiple items on top of our HW2 volumetric rendering code. I first implemented the Rayleigh scattering phase function. Then in order to model the color-changing nature of Rayleigh scattering, I implemented methods mentioned in Nishita's two papers: "Display of the Earth Taking into Account Atmospheric Scattering", and "Display Method of the Sky Color Taking into Account Multiple Scattering". I take into account the height of the current ray, calculate the scattering coefficients based on parameters like the atmosphere's density and the index of refraction, essentially adding a different type of medium on top of the HW2 vol tracer. The size of atmosphere, the earth, the sun and the space in between is all to-scale. The earth is modeled as a Lambertian sphere, the atmosphere is a thin layer of heterogeneous volume, and the sun a spherical area light.

Here are some current results of sunset and sky color: All images are rendered at sea level, with fov 90, and looking directly at the sun

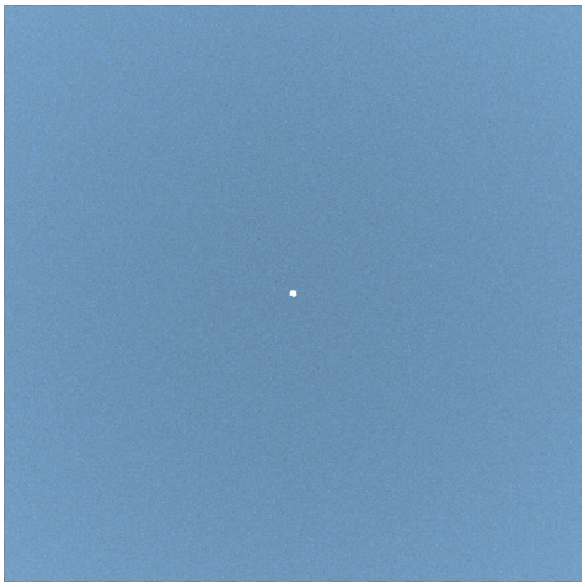

Figure 1: sun directly above our head

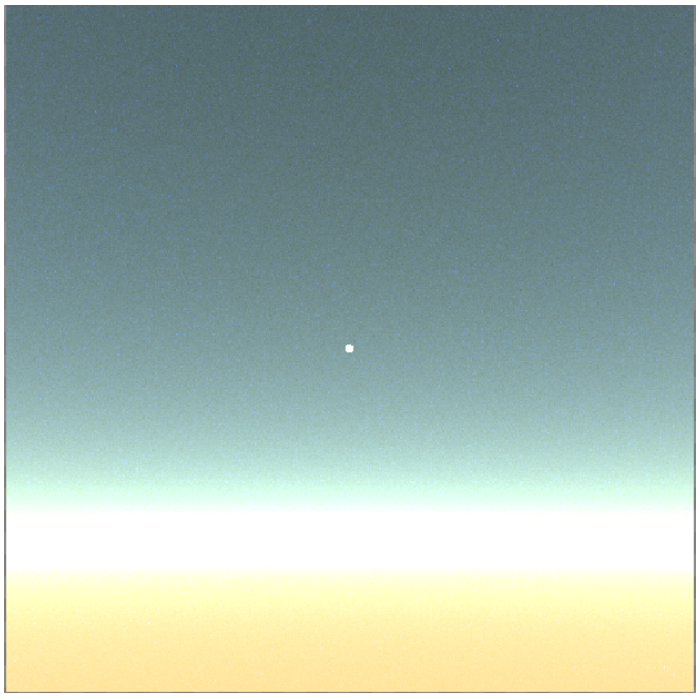

Figure 2: sun 30 degrees above horizon

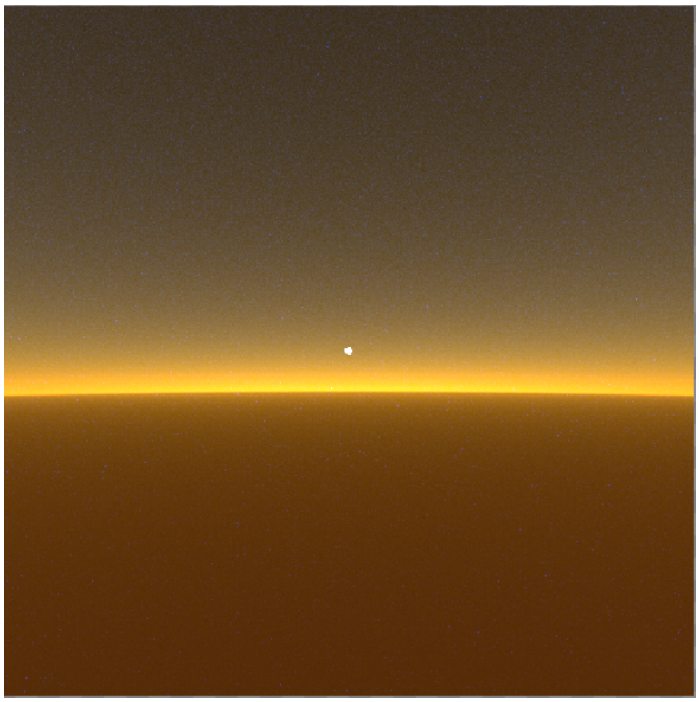

Figure 3: sun 5 degrees above horizon

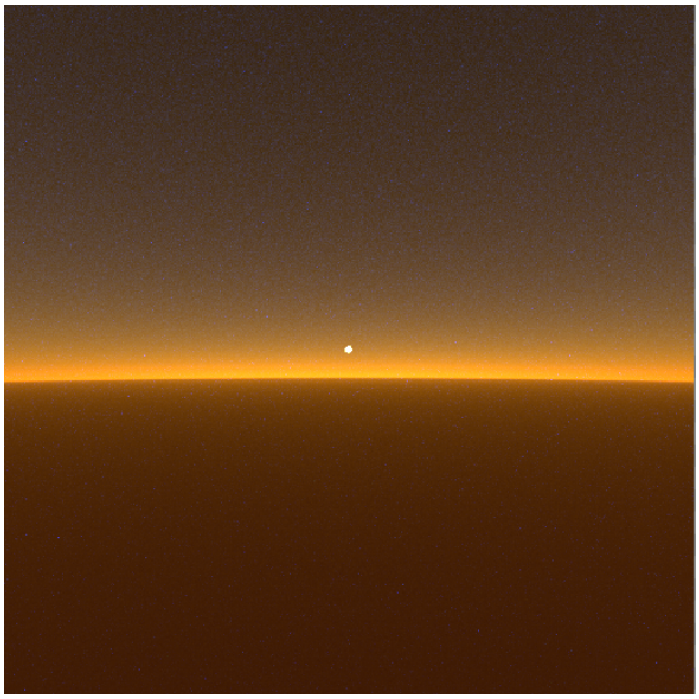

Figure 4: sun 3 degrees above horizon

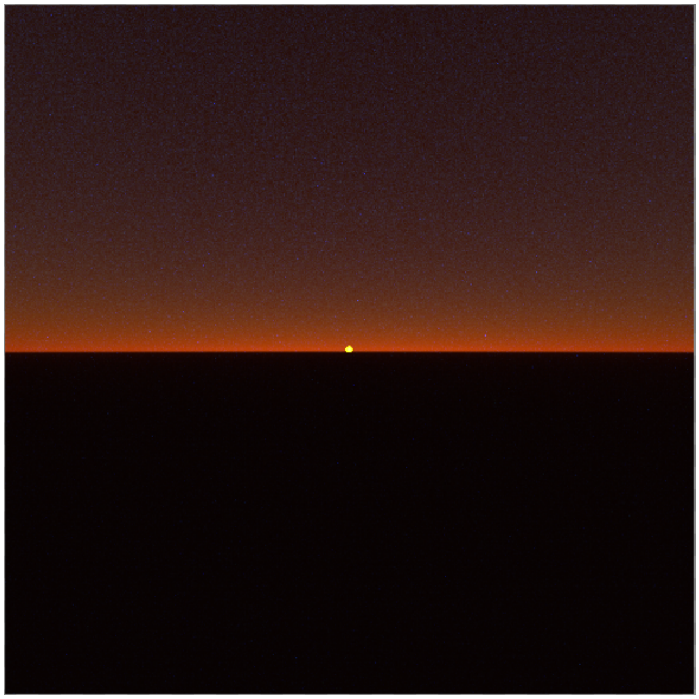

Figure 5: sun at horizon

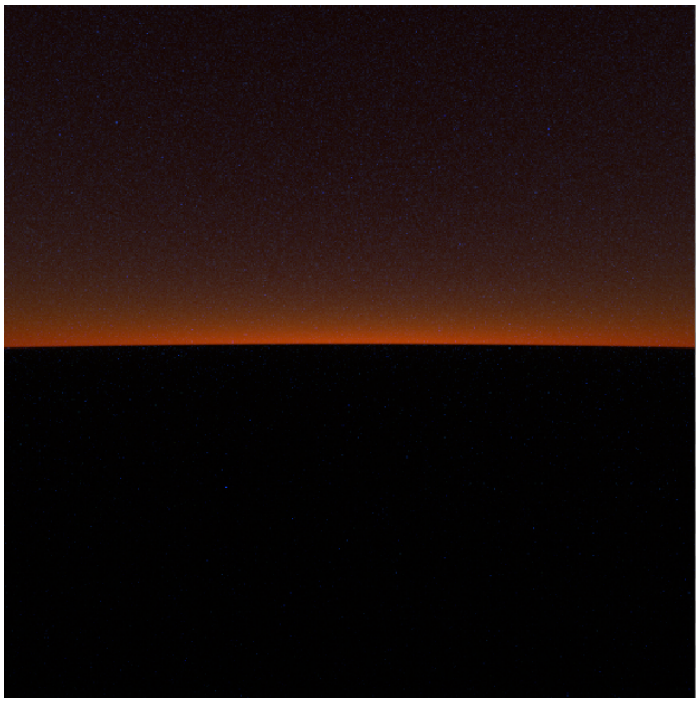

Figure 6: sun 3 degree below horizon

1.2 What I plan to do next

1. Implement importance sampling of the Rayleigh phase function from this paper: "Importance sampling the Rayleigh phase function"

   https://backend.orbit.dtu.dk/ws/portalfiles/portal/6314521/3D9A1d01.pdf.

2. Find a way to use actual physically based parameters, such as the radiance of the sun, and the scale of scattering coefficients. Right now the parameters are sort of a heuristics, and a lot of things are pre-computed.

3. Also implement Mie scattering for a more realistic look. (The earth have aerosol in low altitude, resulting in the "hue" of the sun). But I'm not sure how to combine Rayleigh and Mie.

4. Render a sunset animation.

5. Find out the parameters and render an alien sky. Such as Mars.

6. If have time, implement Zodiac light from Jensen's paper:

   https://graphics.stanford.edu/ henrik/papers/nightsky/nightsky.pdf