Rendering Parametrizable Planetary Atmospheres with Multiple Scattering in Real-Time

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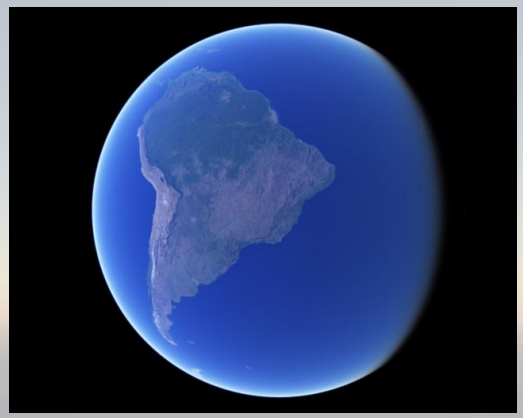
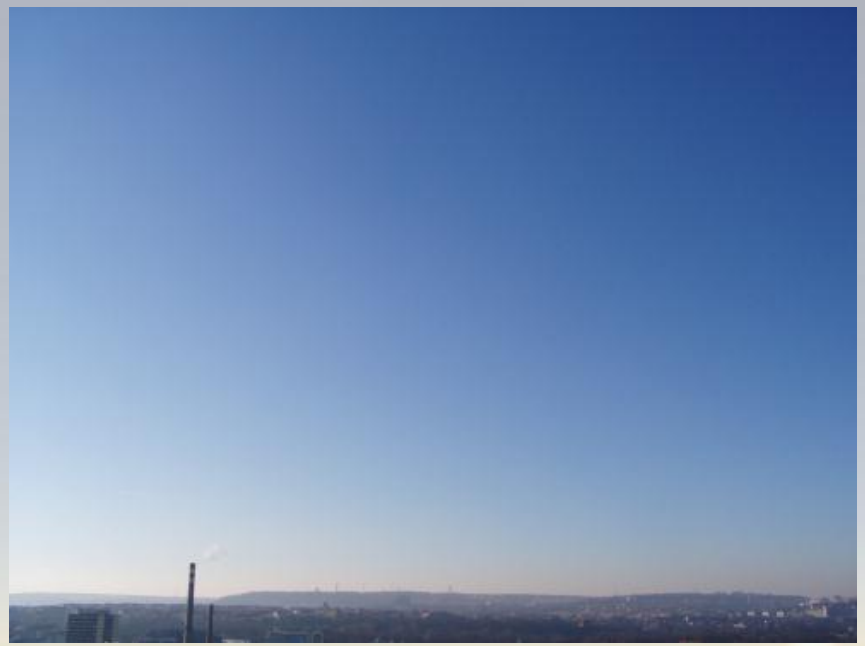
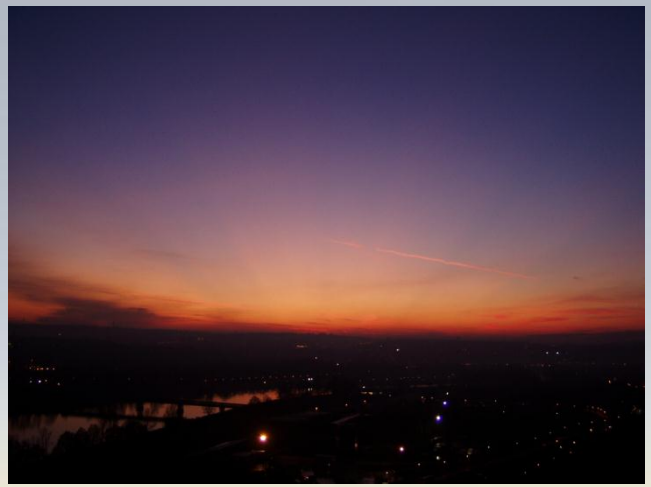
Prague



Motivation

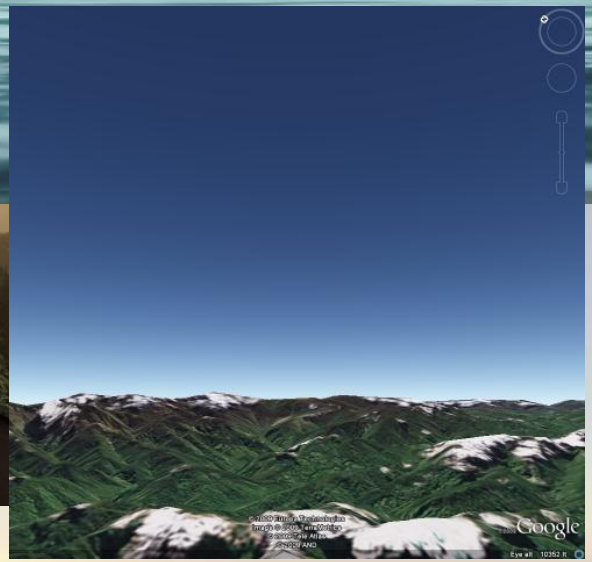
- Why atmosphere?





Motivation

- Why real-time?



Outline

- Introduction
- Related work
- Model and its precomputation
- Rendering
- Results
- Conclusion
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Introduction

- Participating media

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  - Rayleigh / Mie
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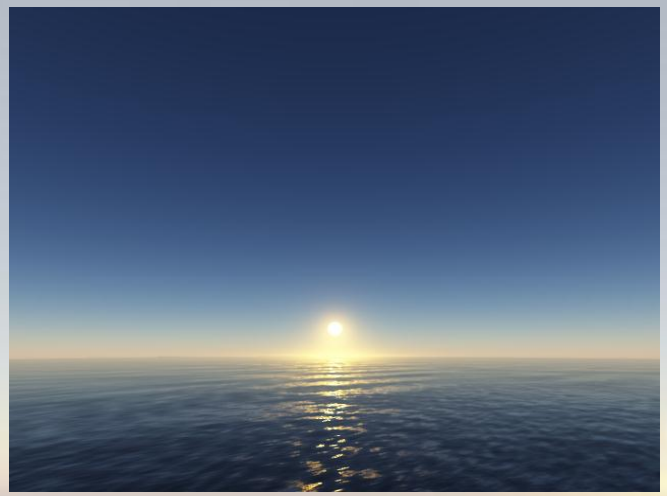
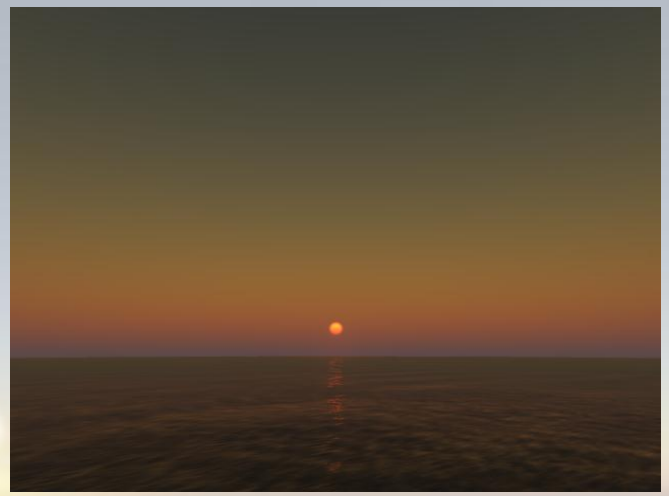
- Parametrizability





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Related work

- Scattering physics
  - Rayleigh (1871)
  - Mie (1908)
- Non-realtime methods
  - Nishita et al. (1993, 1996)
  - Haber et al. (2005)
- Real-time methods
  - Schafhitzel et al. (2007)
  - Bruneton and Neyret (2008)

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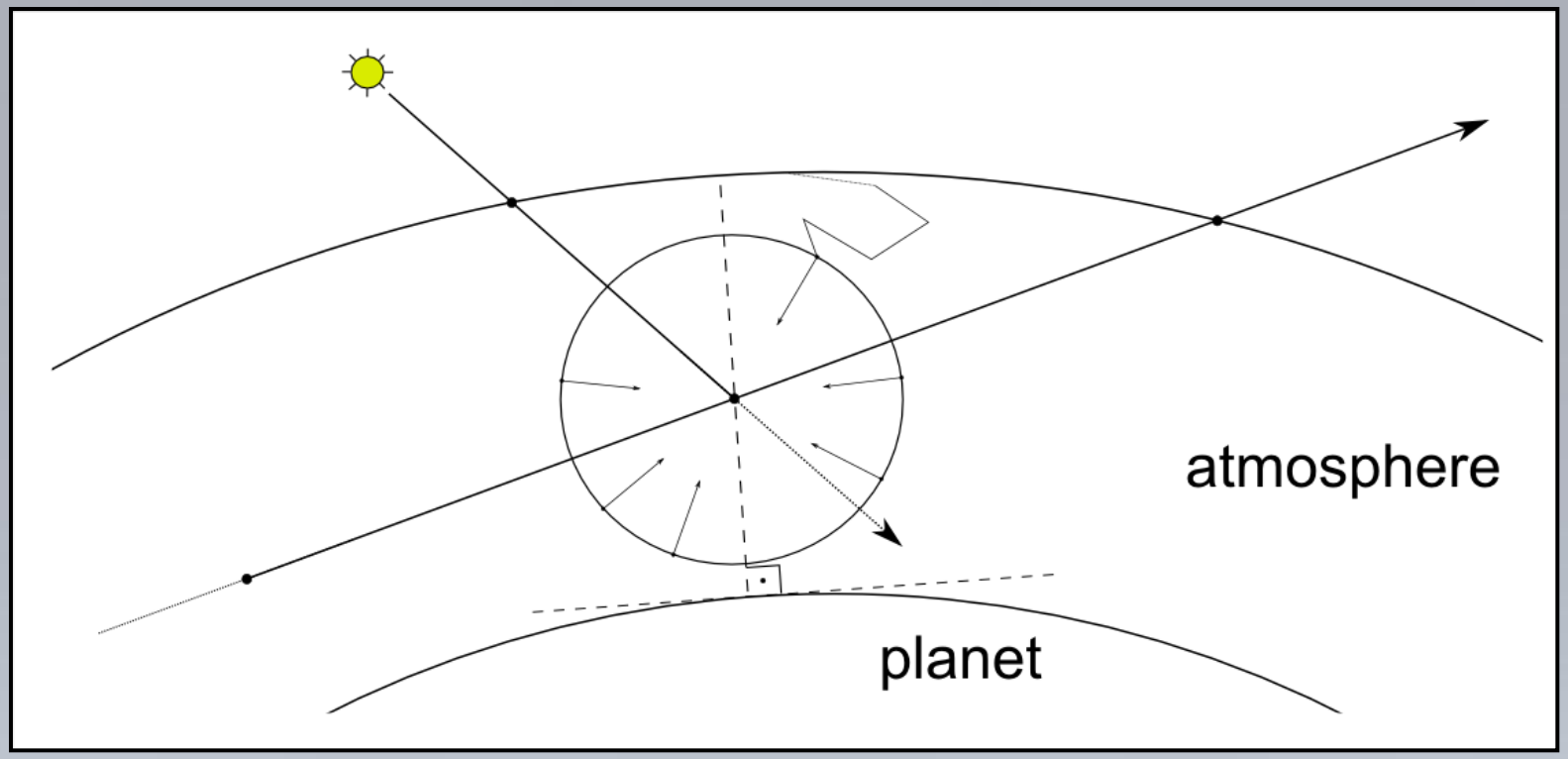
Scattering model



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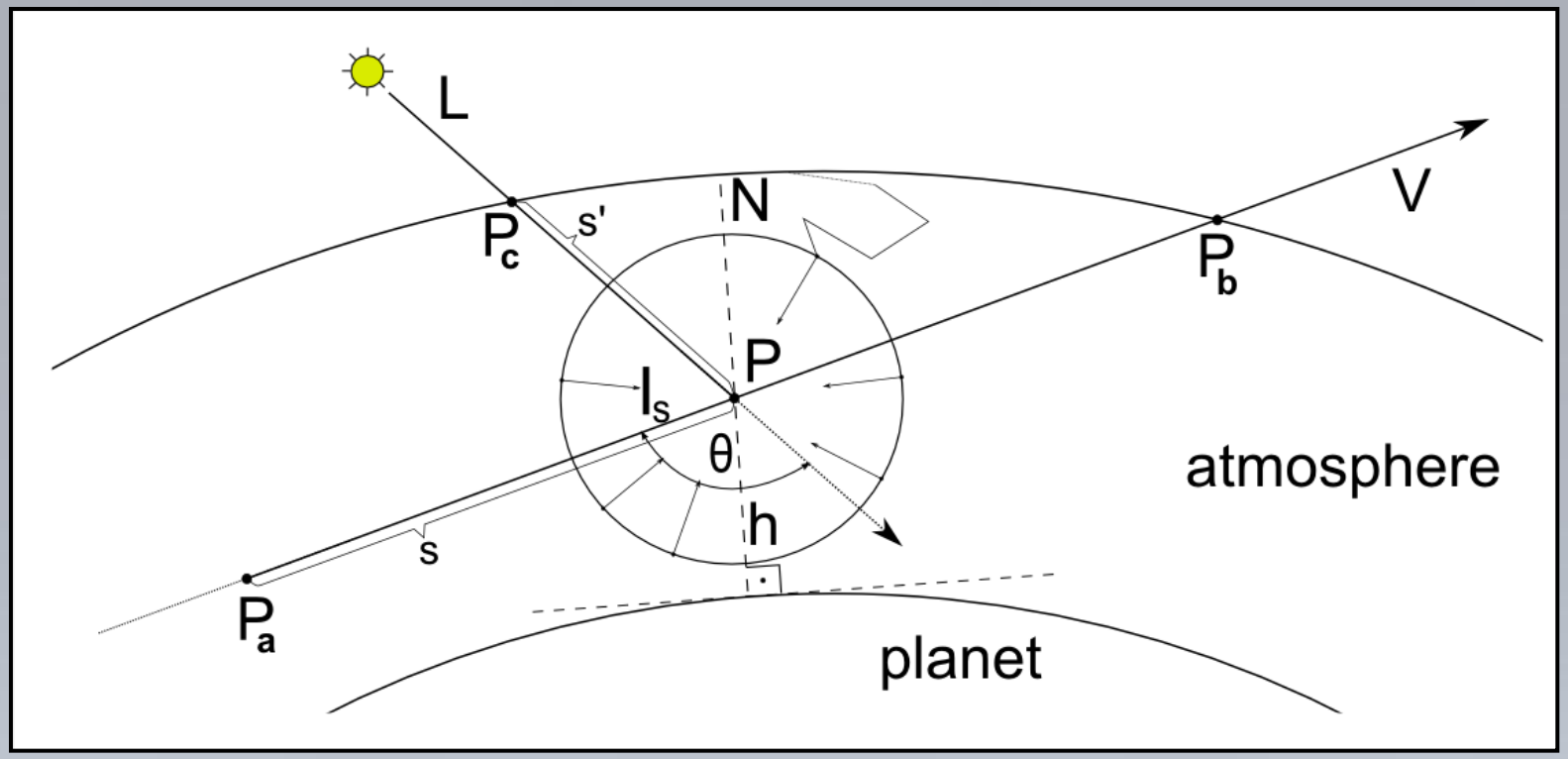

$$I_S(\lambda) = I_I(\lambda) F(\theta) \frac{\beta(\lambda)}{4\pi} \int_{P_a}^{P_b} \rho(h) \exp(-t(PP_c, \lambda) - t(P_a P, \lambda)) ds$$

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- We need scattering for:
  1. Every position
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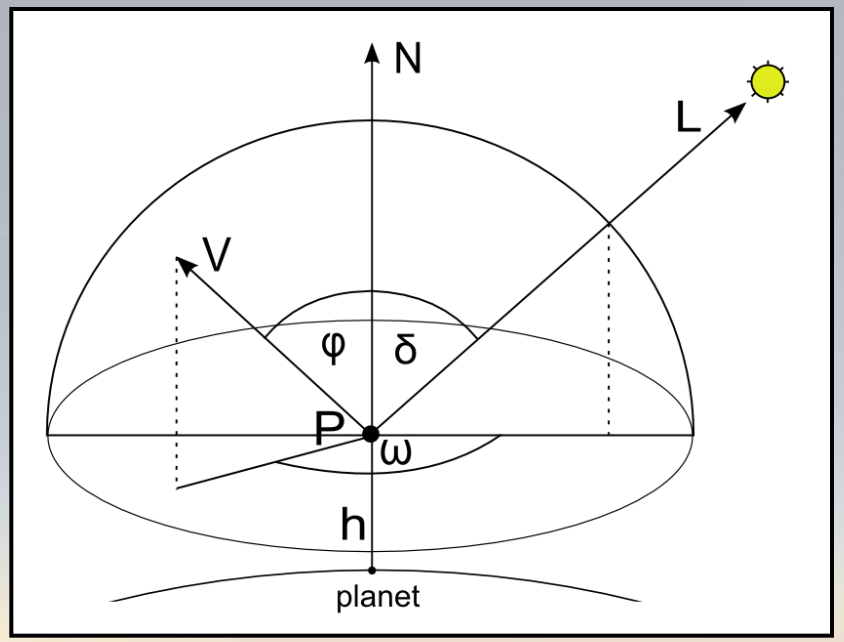

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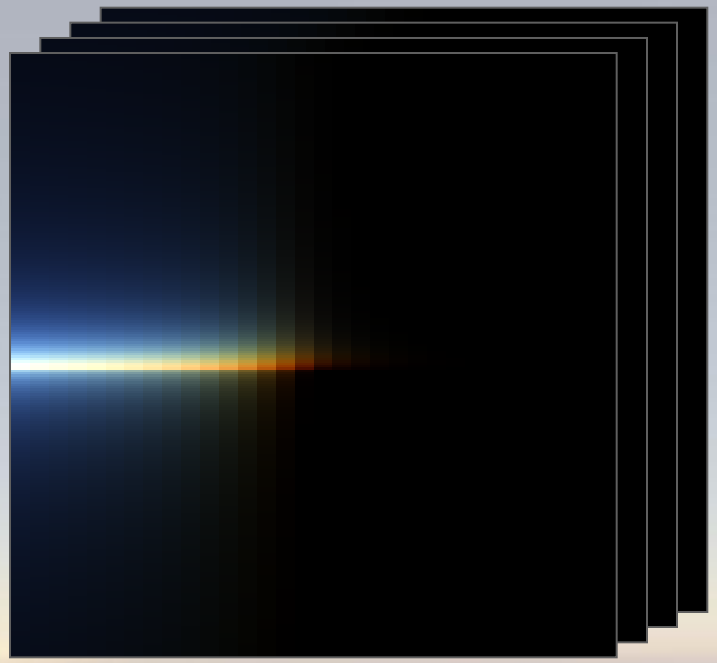
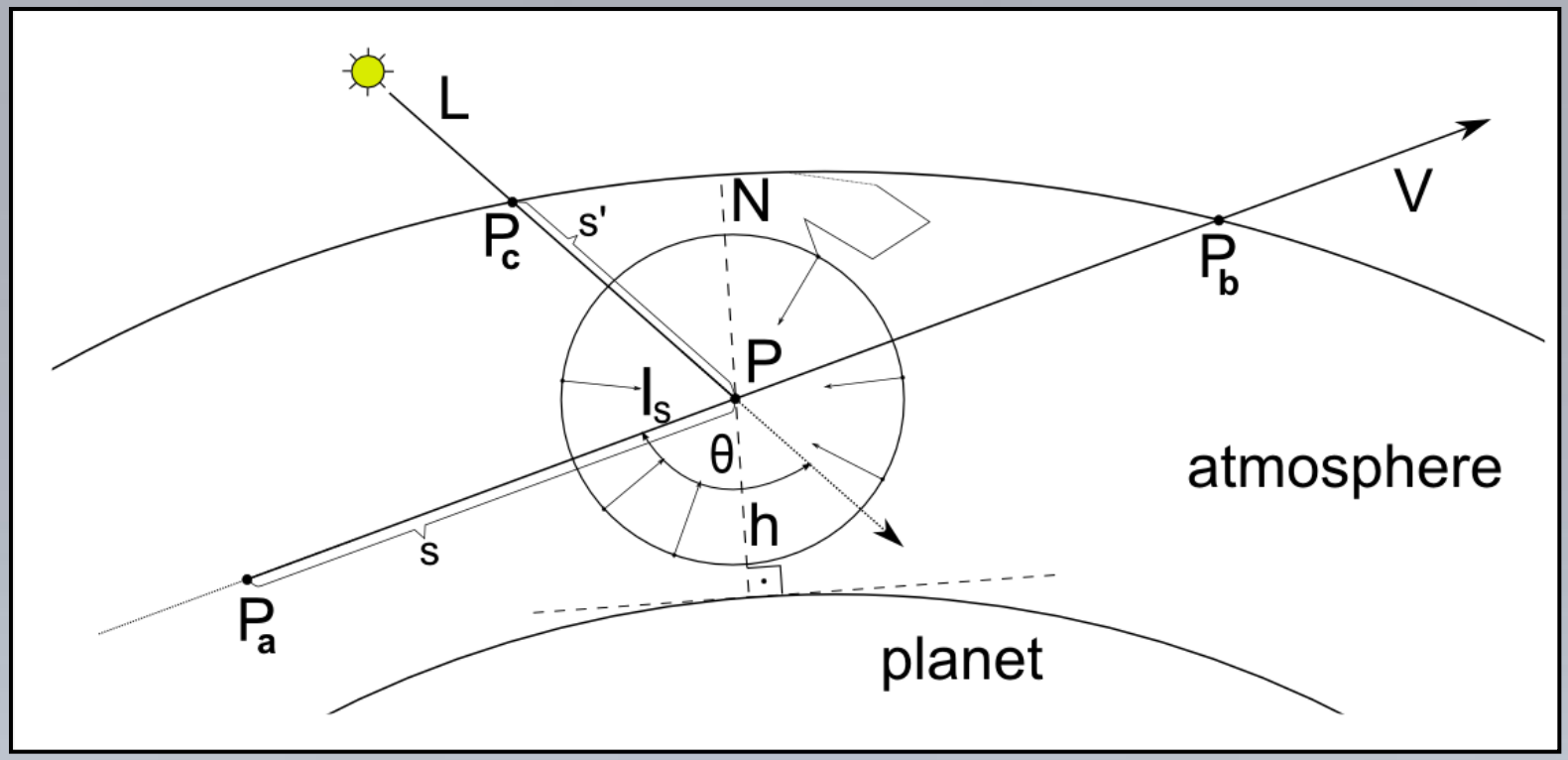


Multiple scattering



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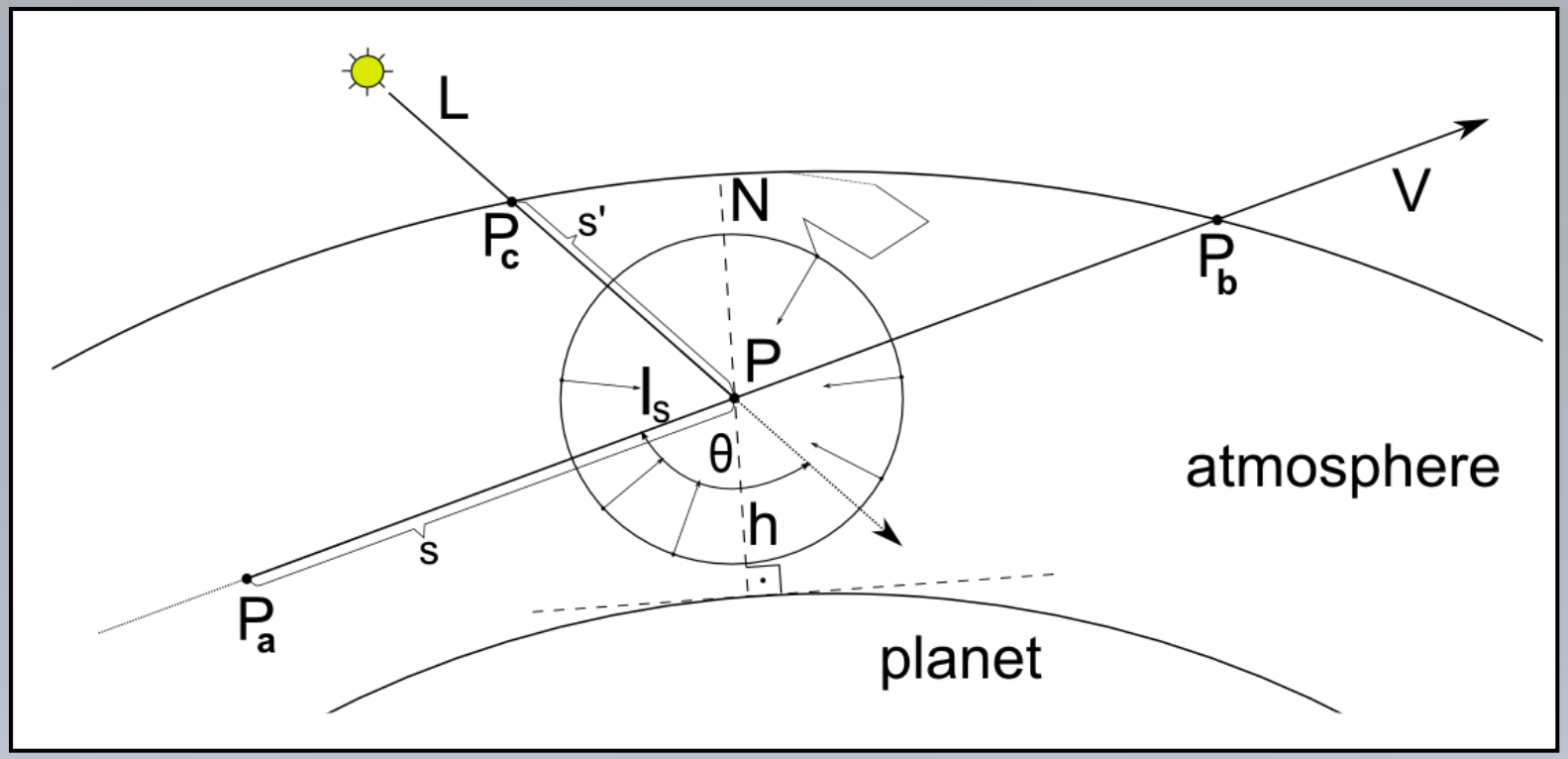

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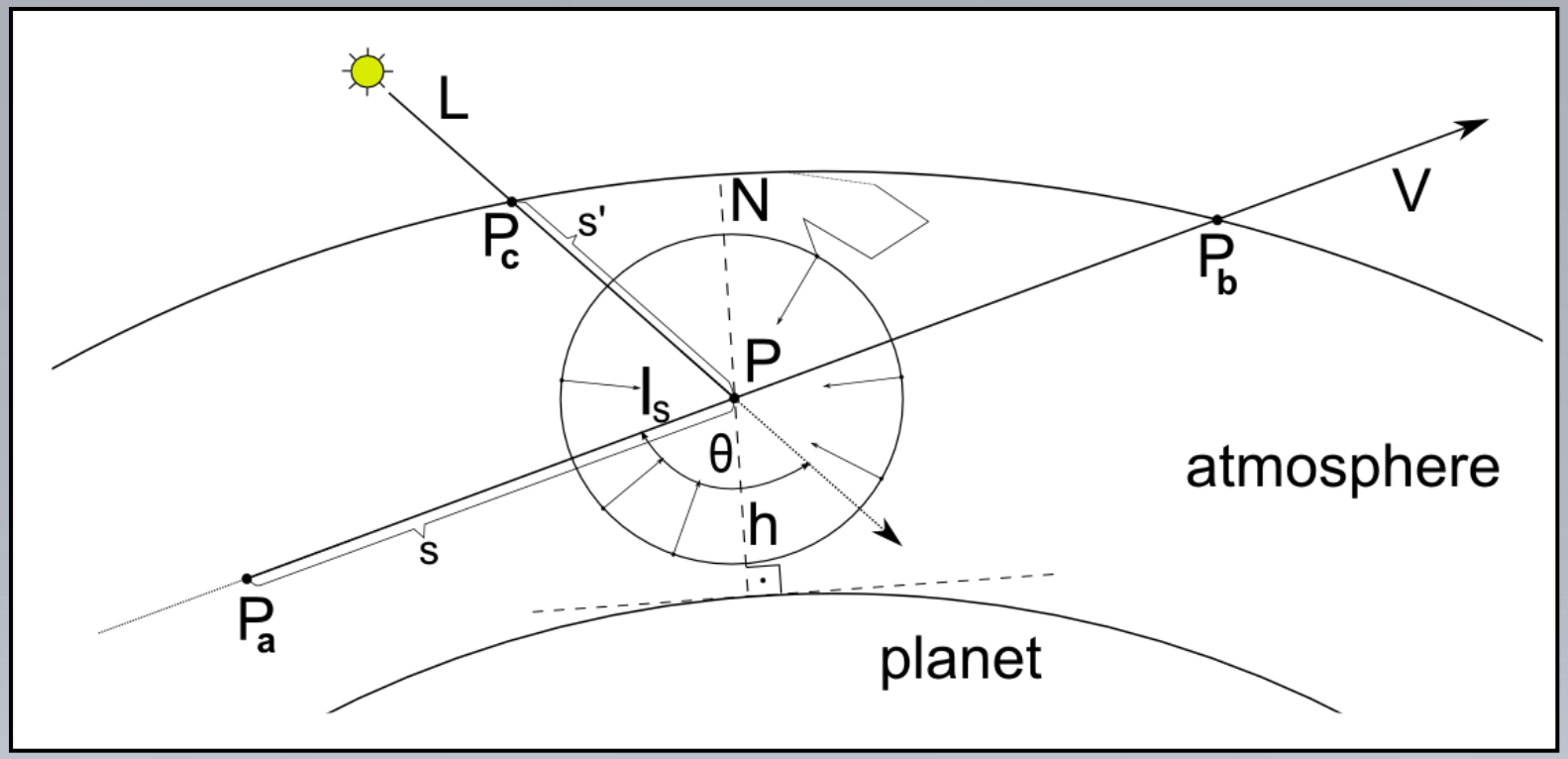
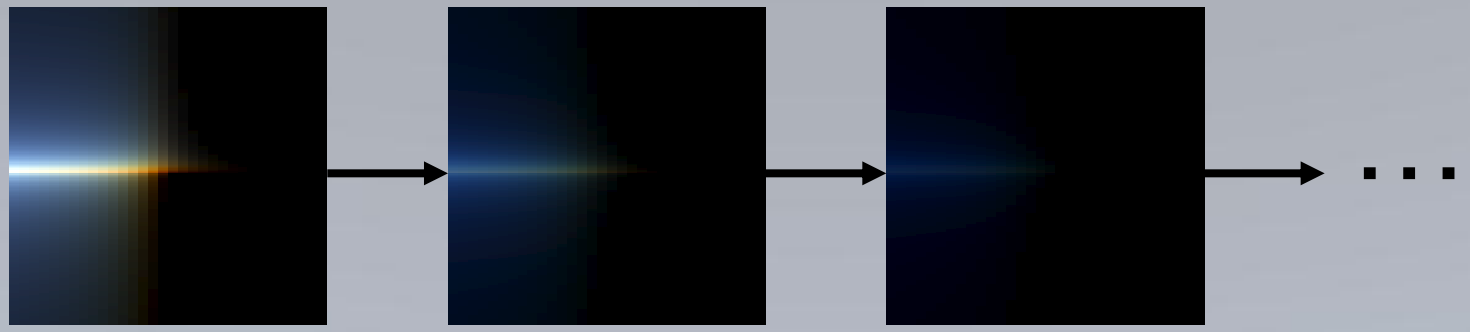


- Computational complexity $C^k*(n^2+n^3)^k$
- Higher scattering orders – similar to I_s for P

Multiple scattering

- Solution – iterative computation
  - Scattering texture contains previous order



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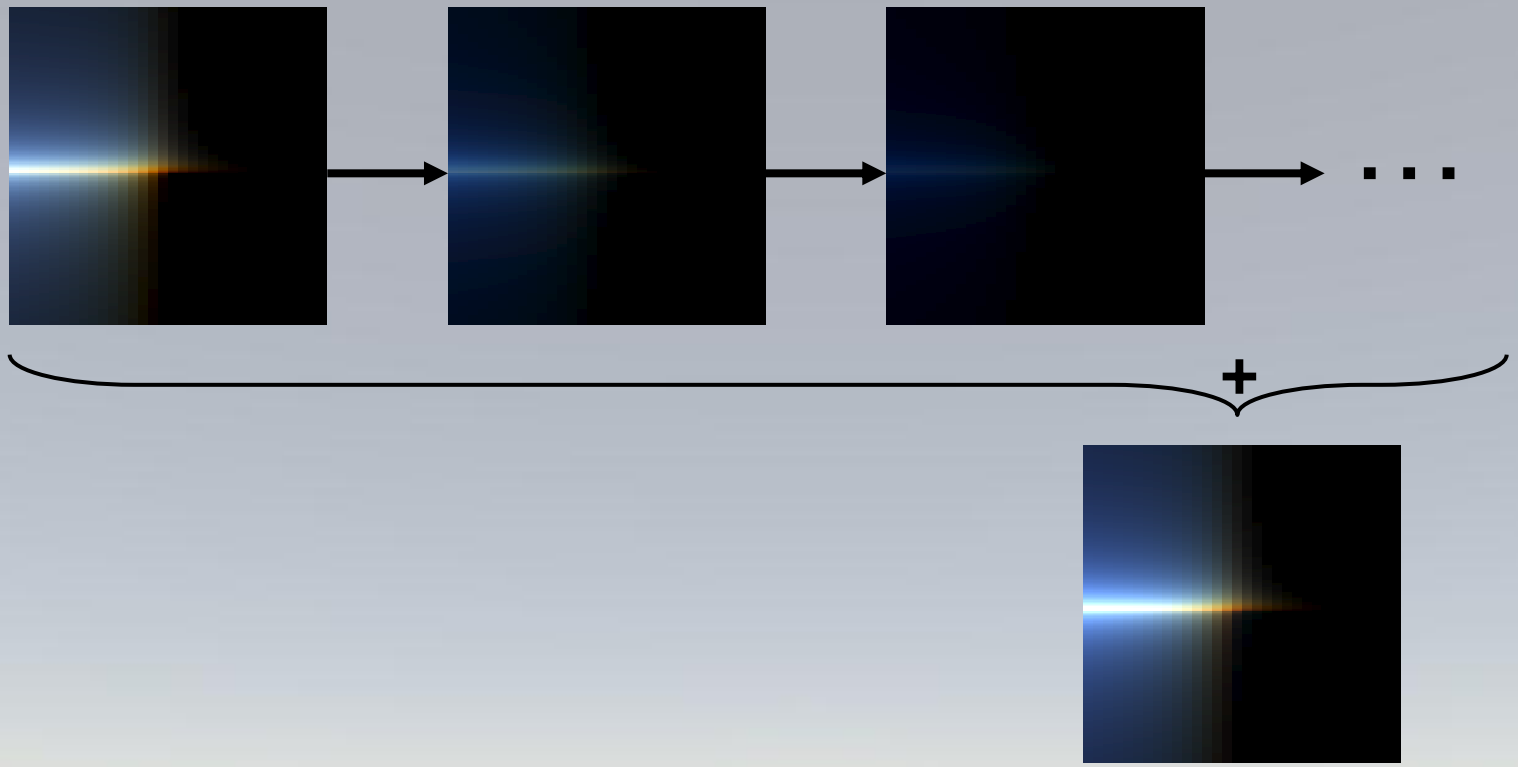

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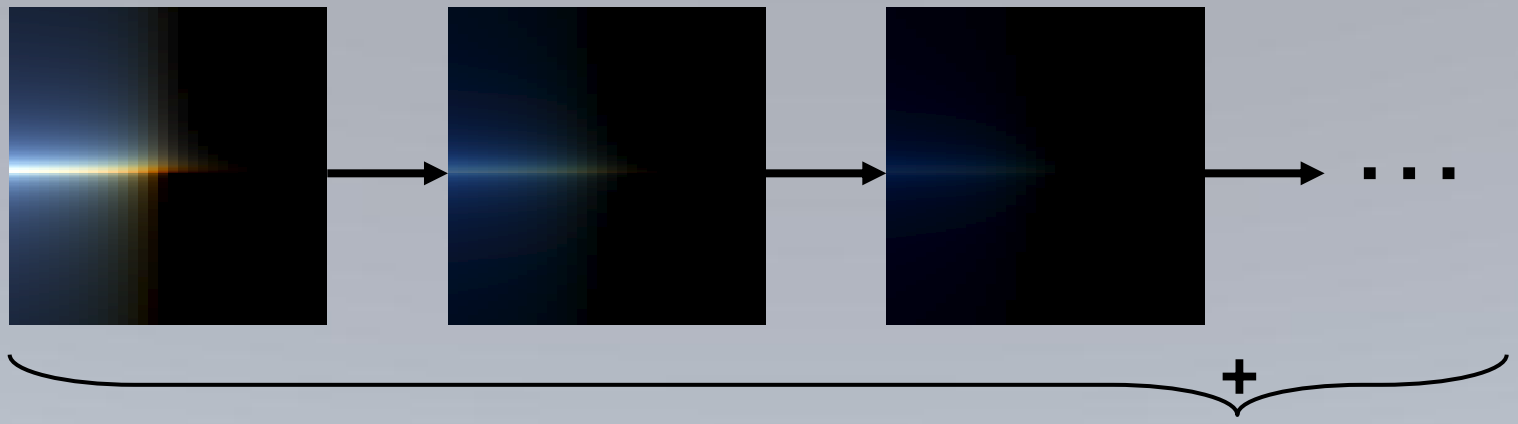
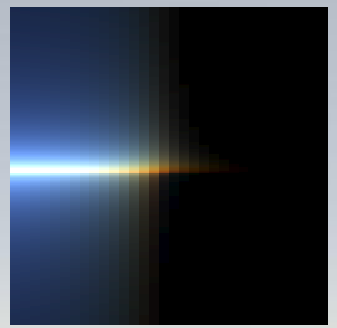


- New complexity

$$C*n^2 + (k-1)*C*(n^2+n^3)$$

  - n^3 term now fast



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- Fragment shader evaluation
- Simple spherical geometry
  - Terrain taken into account in Schafhitzel et al.

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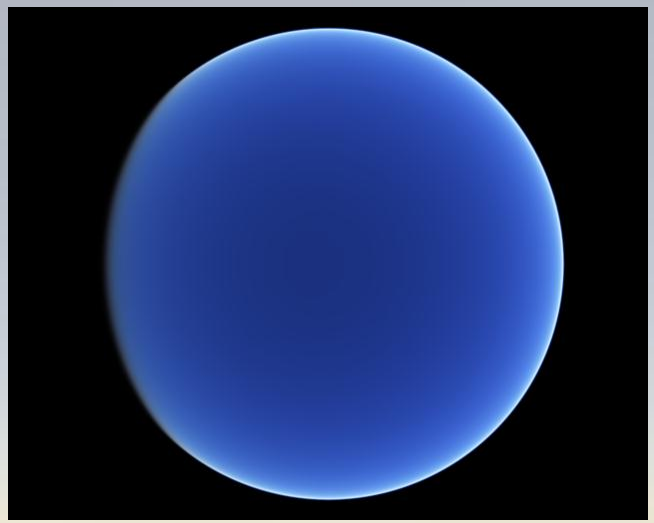

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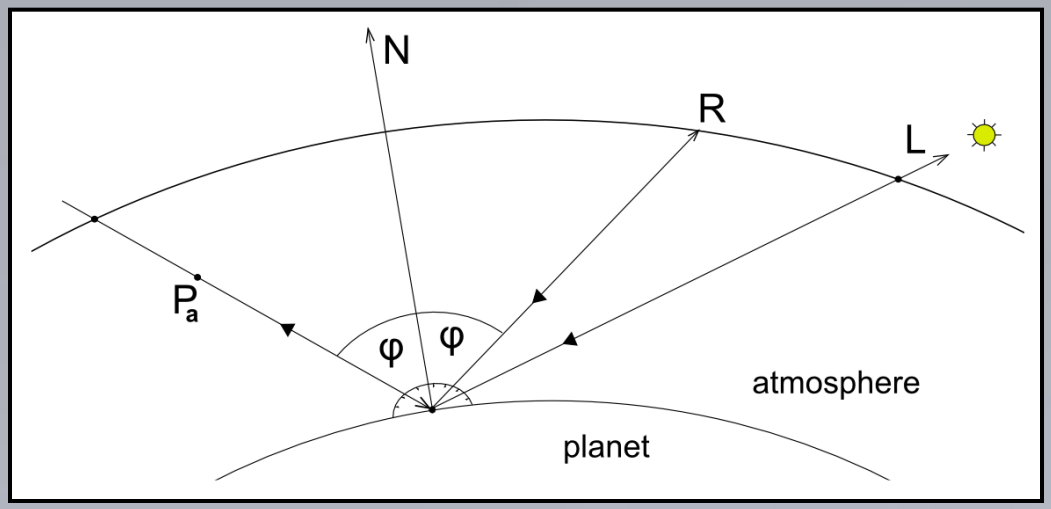
- Planet
  - Scattering
  - Direct illumination
  - Water reflection
  - Ambient light



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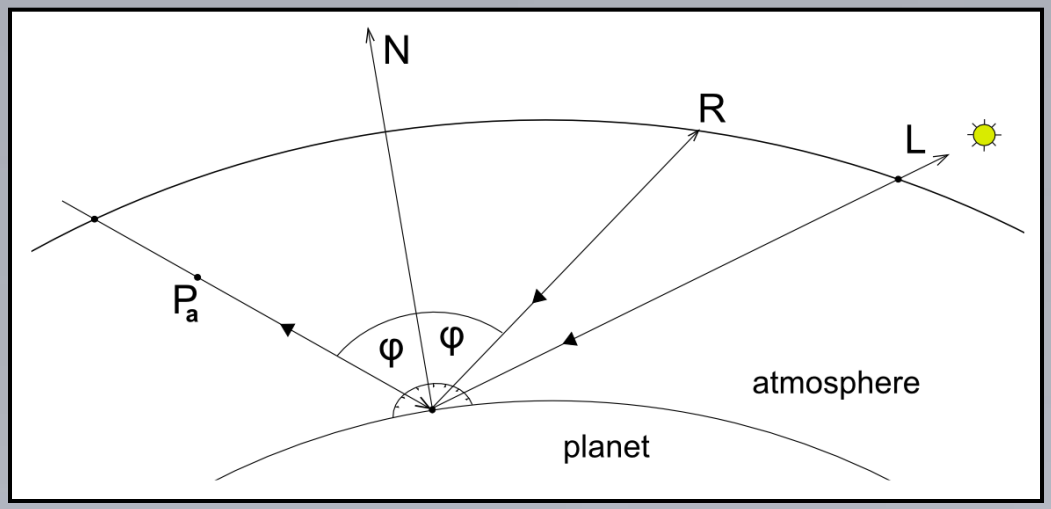

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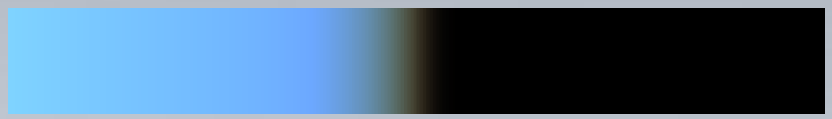

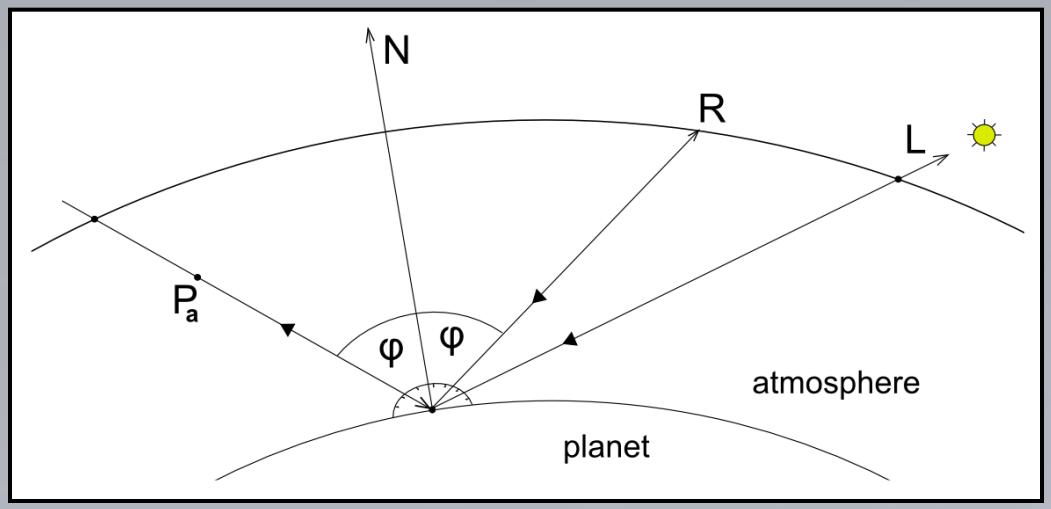

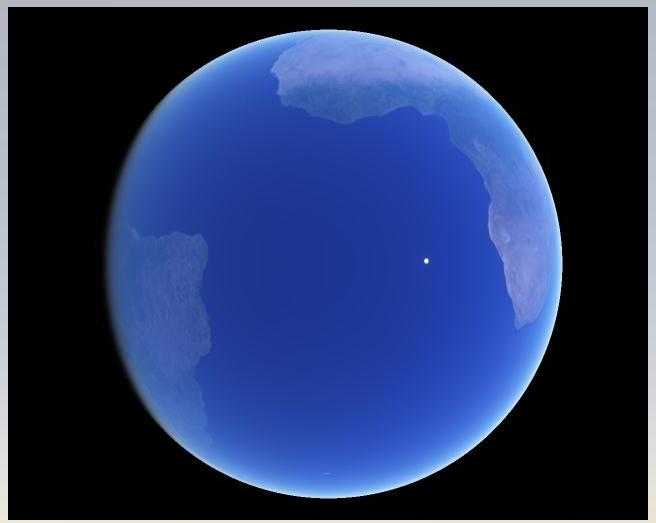

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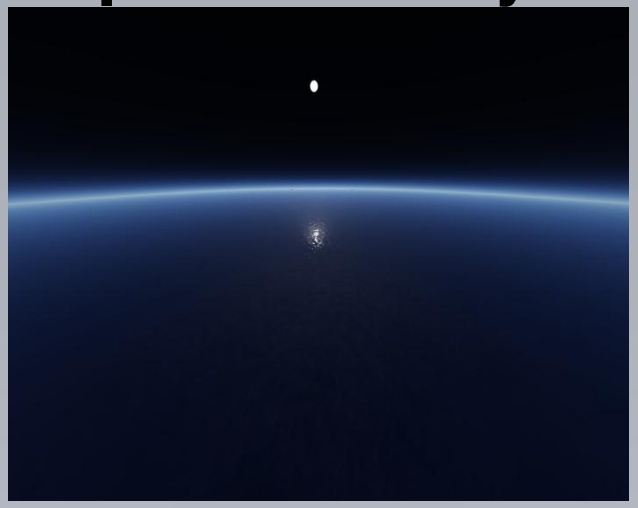
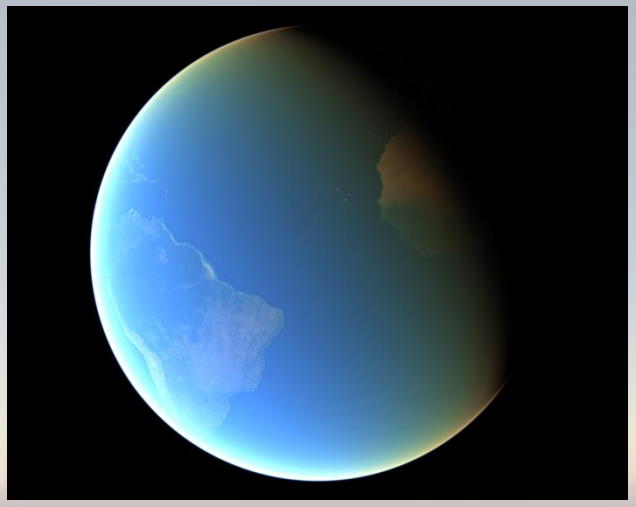
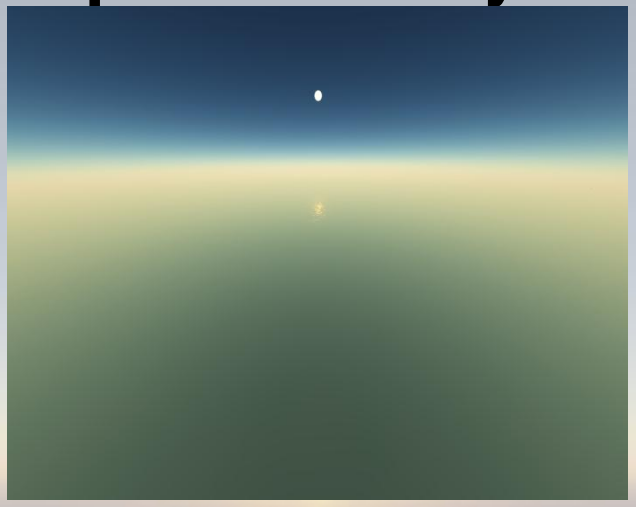
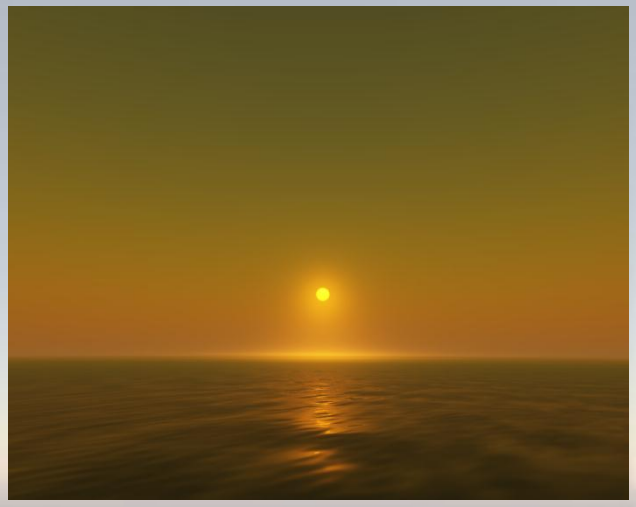
Results

- 0.2x Earth atmosphere density

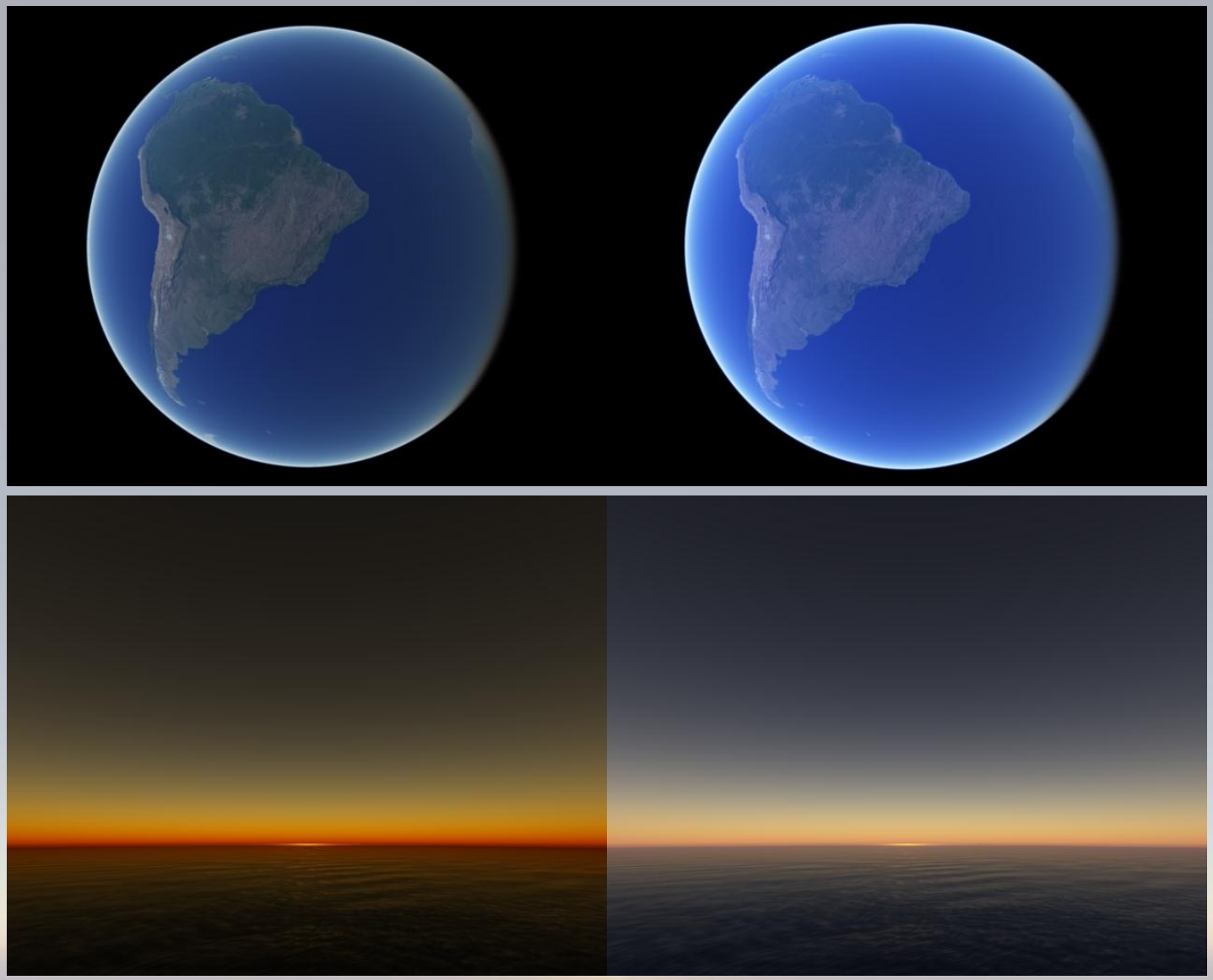




- 5x Earth's atmosphere density

Results

- Single scattering
- Multiple scattering



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Conclusion

- We present:
  - Precomputation scheme for multiple scattering in parametrizable atmosphere
    - 5 MB for whole dataset
  - Real-time rendering algorithm for entire planet
    - 180 FPS @ 1024x768 (GeForce 8800GT)

Demonstration

End

- Thank you for your attention
- Questions?