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Atmospheric Measurement Techniques Discussions
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Interactive Comment

Interactive comment on "High resolution and Monte Carlo additions to the SASKTRAN radiative transfer model" *by* D. J. Zawada et al.

D. J. Zawada et al.

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We would like to thank the referee for their helpful comments and suggestions. Included below are the referee's comments (italics) followed by our reply. We have also attached our proposed changes to the manuscript as a supplement.

Responses to Anonymous Referee 2

General Comments

Description of HR Model:

Please include figures showing the coordinate system for 1D/2D/3D atmospheres. These could may be include the locations of the diffuse profiles which are considered for the simulation of a specific observation point. Also the points s_j, s_{end}, ... could be included

Reply: Two figures have been added. The first defines the viewing geometry and also includes the points s_j, s_{end}. The second figure shows the grids used for the 2D and 3D atmospheres.

How are the angles defined? Are viewing zenith angle and solar zenith angle defined w.r.t. the tangent point. For 3D the definition of the azimuth angle (where is South, East, ...) also matters. These definitions might also be included in the figures.

Reply: See the previous response.

Does the model include surface reflection? If yes, how is it handled? If not, when can it be neglected?

Reply: Currently surface reflection is assumed to be Lambertian. Neglecting to mention this in the text was an oversight and has been corrected.

How is the ray-tracing done in the 3D atmosphere, the equations for intersection points become more complex?

Reply: Yes, while it is possible to calculate intersections with the hull formed from the Delaunay triangulation, it is time consuming. Instead we approximate the triangulation

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with a set of cones and planes. We have added an explanation to the text.

Description of Monte Carlo Code:

Is surface reflection included? If yes, how?

Reply: The planet is treated as a Lambertian sphere – We hope this has been clarified in the text.

Is polarization included? If yes, how?

Reply: Good question. Polarization has been added to both MC and HR since the paper was written. A paper is planned for the near future to explain how this was done, especially for HR, where the memory burden of polarization may be very large. A sentence was added to indicate that polarization will be the subject of future work.

Please include a figure and show r and omega, which are mentioned in the description

Reply: $\vec{r}$ refers to any point (in the atmosphere or its boundary, for our application) and $\hat{\Omega}$ refers to any look direction. We can't think of a figure that would make this more clear, but the sentence that introduces these variables in the Monte Carlo section has been added to for clarification.

Also please include the definition of viewing angles and sun position

Reply: Figure 1 has been added defining the geometry.

Is the Monte Carlo code for 1D, 2D and 3D geometry?

Reply: Yes, MC works for 1D, 2D, and 3D geometries. The code supports any kind of geometry supported by SASKTRAN's ray tracing, optical property table, and optical property integrator (optical depth calculator) classes. We hope this has been clarified near the beginning of the "Implementation" section.

OSIRIS-Simulation:

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If I understood correctly, all simulations are performed for 1D geometry. Is this correct? Please include precise setups for the simulations.

Reply: This is correct. The text has been clarified.

How important is the 3D variability of the atmosphere for O3 retrievals?

Reply: Good question. We are currently looking into tomographic inversion methods in hope of quantifying and correcting this effect.

Specific Comments:

p1., l.10 *Please specify what is retrieved (O3). Also please specify for which settings is the bias of up to 4*

Reply: A sentence was added indicating when the bias is largest.

p.9, Eq. 15 *Derivation of the equation could be included in appendix.*

Reply: We don't feel that the derivation is involved enough to warrant an appendix, however we have added an additional step to the derivation in the text.

p.11, l. 305 *"A target transmission is chosen uniformly between 1 and ..." → should this be "randomly" instead of "uniformly"?*

Reply: Thank you. We have changed this sentence to "... chosen randomly from a uniform distribution..." for clarification.

p.13, l. 365 *"Variance of solar source term" → please explain this, do you only mean the change of solar zenith angle along the line of sight?*

Reply: That's correct. We hope we have cleared this up by changing the sentence to "geometry dependence of the solar source term".

p.14, Tab.1 *Definition of sza in table not clear*

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Reply: Table caption has been modified to indicate that SZA refers to solar zenith angle at the tangent point.

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p.15, l.439 *"Solar zenith angle at the tangent point varies between 60 and 120 degrees ..."* $\rightarrow$ *The largest SZA is 89 degrees, is it possible to simulate SZA* $\geq$ *90 degrees?*

Reply: The solar zenith angle variation of 60 to 120 degrees refers to the Odin-OSIRIS orbit. While both MC and HR are capable of simulating scans with SZA $\geq$ 90 degrees, we don't use these scans in the operational or simulated retrieval. A sentence has been added to clarify this.

Technical Corrections:

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p.13, l. 376 *"for standard deviation 0.2"*

Reply: Corrected.

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p.15, l. 431 *"at 600 km ..."* $\rightarrow$ *"at 600 km altitude"*

Reply: Corrected.

References

Bourassa, A. E., Degenstein, D., and Llewellyn, E.: SASKTRAN: a spherical geometry radiative transfer code for efficient estimation of limb scattered sunlight, J. Quant. Spectrosc. Ra., 109, 52–73, doi:10.1016/j.jqsrt.2007.07.007, 2008.

Wiensz, J. T., Degenstein, D. A., Lloyd, N. D., and Bourassa, A. E.: Retrieval of subvisual cirrus cloud optical thickness from limb-scatter measurements, Atmos. Meas. Tech., 6, 105-119, doi:10.5194/amt-6-105-2013, 2013.

Please also note the supplement to this comment:
http://www.atmos-meas-tech-discuss.net/8/C1258/2015/amtd-8-C1258-2015-supplement.pdf

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Interactive comment on Atmos. Meas. Tech. Discuss., 8, 3357, 2015.

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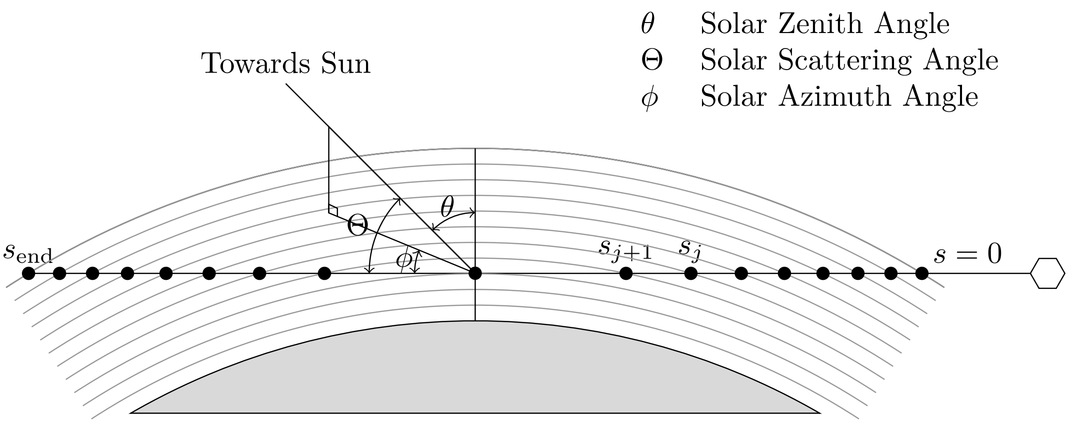

Fig. 1. The limb scatter geometry used in SO, HR, and MC. The solar viewing angles are defined at the tangent point.

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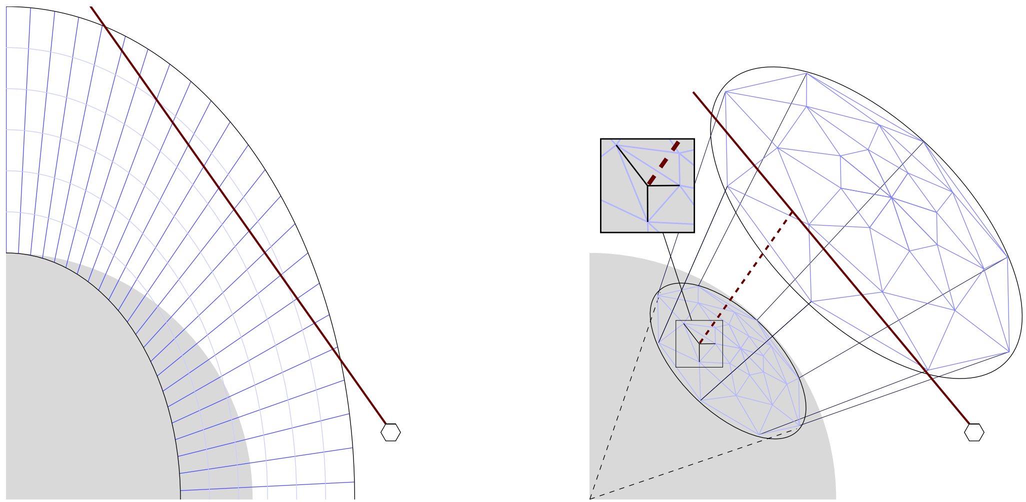

a) Two Dimensional b) Three Dimensional

Fig. 2. The two and three dimensional atmospheric grids used in HR. a) A grid is shown consisting of altitude and angle along the line of sight direction, however, the plane can be placed in any direction

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