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Atmospheric Measurement Techniques Discussions

Interactive comment on "A Fast Visible Wavelength 3-D Radiative Transfer Procedure for NWP Visualization and Forward Modeling" *by* Steven Albers et al.

Anonymous Referee #2

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The manuscript describes an exciting visualization tool that allows comparison between output of numerical weather forecast models and camera or satellite observations. I congratulate the authors to this development! The manuscript is therefore an important contribution within the scope of the journal. However, I have major concerns about the manuscript, which need to be addressed before publication. In particular I am concerned about the frequent reference to data assimilation. For that purpose, the uncertainty of the method needs to be characterized quantitatively which hasn't been done at all. At least it is not obvious from the manuscript. My major points are, in some more detail:

- Description of several methods is missing, most important multiple scattering by clouds and aerosol; I was expecting some more details concerning the methods, in particular how those are applied in 3D geometry. In particular, aerosol and cloud layers observed from above are described, but I didn't find enough information about how the calculation from below and from the side is done.
- A quantitative validation of the method is missing. A number of pictures is provided which show a visual comparison of model results with camera images or satellite observations. One could infer that the model "obviously" works since the comparison looks realistic. But this type of comparison includes uncertainties of the radiation operator and differences between real situation and NWP model output; in particular for data assimilation a more quantitative characterisation of the uncertainty of the operator is required, e.g. by comparison of SWIm with independent model results.
- The manuscript contains a number of unproven claims which need to be proven in the manuscript or a reference needs to be provided; I'll give a number of examples in the specific points below.

Carefully addressing these points is critical in order to reach the scientific quality and presentation quality required for publication in AMT. To consider the second point, it would be possible to phrase the applicability to data assimilation more carefully (and to phrase it less often). Even then, however, at least some comparisons with an accurate 1D radiative transfer model are strongly suggested, which should not be that difficult.

Specific points:

Page 5, line 32: "can be benchmarked" - if so, why hasn't at least some benchmarking been done?

Page 5, line 35: Some more detail and explanation is required: I am not sure how you do this forward-backward calculation. Isn't that like a typical single scattering approach, following the radiation from the source to the detector or the other way round?

Page 7, line 18: "integrated ... weighted by the cosine of the zenith angle"

Page 7, line 21: This is one of the above mentioned unproven claims, "the resulting radiance is nearly proportional to the spectral radiance at 540nm". Please demonstrate or provide reference!

Page 7, line 31: What you propose here is very similar to the relationship between PAR (photosynthetically active radiation) and GHI, and there is a number of references in the literature studying this relationship.

Page 8, line 7: How did you come up with these decisions/numbers?

Page 9, line 4: Please more specific! What kind of two-stream? You are interested in the radiance and thus the angular distribution - how do you handle that with the twostream? How do you apply the twostream in 3D, if you look sideways at a cloud?

Page 9, line 11: With hydrometeor density you mean the density of liquid water or ice?

Page 9, line 18: Bilinear in 3D space?

Page 9, line 24: What kind of "combination"? One in the forward and one in the backward direction, as in Key et al, Parameterization of shortwave ice cloud optical properties for various particle habits, JGR 2002?

Page 9, line 24: Why is the Henyey-Greenstein approximation needed? Couldn't you use the real phase function? Later in the text (page 21), it is stated that "SWIm was tested and can realistically reproduce rainbows, twilight sky colors and other atmospheric phenomena (Albers and Toth, 2018)." which is only possible with the real phase function but certainly not with Heyne-Greenstein.

Page 10, line 27: For an optically thick cloud one would expect (1 + 2 mu)/3 (old literature on asymptotic theory, and easily confirmed with a 1D radiative model). Here it is 1 + 4mu)/3 - how did you come up with this equation?

Page 11, line 15: The backscatter fraction is extremely important in this context - please explain in more detail and give the equations.

Page 12, line 6: Is that true? With increasing polar angle z0 the reflectance should become larger since the path length through the medium becomes longer.

Page 12, line 12: The history is not relevant here

Page 12, line 16: Faster than what?

Page 12, line 27: Equation 10 and 11 show two different expression for the double-Henyey-Greenstein function. My understanding of the DHG was more like equation 11. Which one do you use?

Page 14, line 7: Please explain in more detail what semi-empirical means in that context.

Page 16, line 5: What does that mean? Doesn't the model grid cover the whole atmosphere?

Page 17, line 3: What relatively simple functions?

Page 17, line 6: There is a well-established model of ocean BRDF by Cox and Munk, 1954. Do you use that or do you do something similar / completely different?

Page 17, line 21: I was a bit surprised that you first selected three wavelengths according to the colors RGB. Why not directly use the three wavelengths as input to the matrix? Does it make a noticable difference if the three computational wavelengths were used directly as RGB or if the described interpolation preocedure is applied?

Page 20, line 1: Validation of SWIm itself is missing (see major point above)

Page 20, line 17: As far as I understood, the method is not yet ready and the uncertainty hasn't been quantified.

Page 23, line 32: You don't have an adjoint yet, do you? Is the adjoint easily developed?

Figures are not in ascending order. E.g. Figure 9 is referenced in the text before Figure 6.

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