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Atmospheric Chemistry and Physics Discussions

Interactive comment on "The spectral signature of cloud spatial structure in shortwave irradiance" *by* S. Song et al.

Anonymous Referee #1

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Overview: This paper shows a robust relationship between net horizontal transport (H) and slope of horizontal transport spectrum ($\partial H\lambda/\partial\lambda$). This relation holds regardless of spatial scales. The authors try to parameterize horizontal net transport as a function of the slope in the spectrum. The authors fully describe radiative terms and equations so that readers are easy to follow them. The figures and tables in this paper clearly show what the authors want to discuss. The reviewer thinks that this manuscript is acceptable to ACP after minor revisions.

General Points #1 Even though this paper contains plentiful new findings and scientific discussions, I feel that the manuscript lacks coherence. I believe that the manuscript can be significantly improved if the authors rearrange paragraphs and shorten unnecessary explanations in Introduction and Discussions.

#2 This manuscript clearly showed a reliable relationship between horizontal net transport and spectral dependency, built a parameterization function, and solved coefficients of the function, such as ε. This is an excellent work indeed. However, it is also important to give a specific direction how the users can apply the parameterization method for inferring 3D effects. I think this is briefly discussed in Section 9 (page 23, line 4-23), so the authors can simply add more detailed explanation/justification of the parameterization in Sections 6 or 9.

#3 As also commented in the manuscript, the relationship between H and S was inferred in Schmidt et al. (2010). In my understanding, the paper definitely shows new findings, such as a strong linear relationship on a pixel-basis, confirmation of molecular effects from the sensitivity study, and parameterization for the future applications. If this paper highlights new findings in Abstract and Introduction clearly, the readers would catch them more easily.

Specific points #1 In Abstract, it might be necessary to comment significance of 3D effects, but the authors can simply mention it here and discuss in more detail in later sections. It seems this long discussion hinders main points of this paper (the strong linear relationship that authors found and devise a parameterization method).

#2 Line 1, Page 2: It is not clear what spectral radiance perturbation means. Please explain spectral radiance perturbation, or remove the last sentence of Abstract.

#3 Line 5-10, Page 3: "The spectral dependence" and the following sentence, I am not sure why the fact - |H| at visible band is similar to |A| at near-infrared - is related to significance of H in broadband A. These two sentences do not seem cause and effect. Please revise them.

#4 The authors often used footnotes. However, ACP does not recommended footnotes because they disrupt the flow of text. Please consider removing footnotes and includes them in the main text. Please refer to http://www.atmospheric-chemistry-and-physics.net/for_authors/manuscript_preparation.html .

#5 Line 6-9, Page 4:"In an accompanying paper. . ." In my understanding, we will need results of Song et al. (2015) to infer dH/dλ from satellite radiance measurements. Once we get dH/dλ from the satellite measurements (or slope), we can estimate H from the parameterization equation in this manuscript. I think this discussion is more relevant when authors explain possible application, e.g. Section 9. It does not carry practical knowledge to readers in Introduction stage.

#6 Line 8, Page 8: "The spectral dependence of ..the full shortwave range" I think the authors cited Song et al. (2016) since this manuscript considered part of shortwave (< 1000 nm). Please state the wavelength range that this study covers.

#7 Line 1, Page 10: "we chose the earlier one because it was more consistent with the MAS retrieval" The 1515 UTC is more consistent with MAS in terms of cloud optical depth? Or perhaps 1515 UTC is closer to MAS observation time? Please clarify this.

#8 Figure 2: From Figure 2, it seems that MAS domain is located boundary of cloud system, according to GOES retrieval. Figure 1 still shows large optical depth up to 80. How consistent MAS and GOES optical depths?

#9 Line 16, Page 11: It would be helpful if the authors provide # of photons per pixel and corresponding accuracy (e.g. 1/sqrt(N)).

#10 Line 3, Page 12: Is it true that H0 cannot exceed 100%? H0 is divergence of horizontal photon transport (e.g. Eq. A7 in Marshak et al. (1998). Therefore, it should be rare, but isn't it theoretically possible that H0 > 100%?

Marshak et al. (1998) Biases in Shortwave Column Absorption in the Presence of Fractal Clouds, J CLI, 11, 431-446.

#11 Line 3-4 page 13: molecular scattering as the underlying cause for this spectral dependence. This is a bit different from conclusion in Schmidt et al. (2010) (paragraph [33]). Could the authors explain the difference?

#12 Line 14-18, Page 17: "In this context, it is. . ..above a cloud field." It is hard to

understand this paragraph. Could the authors consider revise this paragraph? Also radiance in this paragraph means spectral radiance and irradiance is angle-integrated spectral radiance?

#13 Line 1, page 18: CERES algorithm converts broadband radiance into irradiance without taking into account 3D effects, even though the ADM is based on observation. For example, if the CERES observes radiance in illumination side, radiance for that angle is higher than other angles, but ADM does not consider this. Therefore, I guess the derived irradiance is not completely free from 3D errors. Of course these errors are negligible if we get enough samples and take average spatially and temporally.

#14 Line 19-20, Page 20 I wonder why two equations in line 19-20 do not absorption terms. TIPA + RIPA + AIPA = 1 T3D + R3D+A3D+H = 1 Then Eq. (14) is H = ΔT +ΔR + ΔA

#15 From Eq. (14), horizontal transport term H is partitioned into 3D effects on reflection, absorptance, and transmittance (ΔT, ΔR, and ΔA). I think ΔT is strongly correlated with H since absolute magnitude of ΔT is the largest among ΔT, ΔR, and ΔA. Note that cloud albedo is 30%, atmosphere transmittance is 50%, and atmosphere absorption is 20%.

#16 The authors noted that 3D effects are significant even for large scale. However, previous studies already showed that instantaneous 3D effects might be large, but domain-averaged 3D effects are small. I think the authors need to use 'instantaneous' term if necessary, to differentiate from domain-averaged 3D effects.

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