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Discussions

Interactive comment on "Quantifying and correcting the effect of vertical penetration assumptions on droplet concentration retrievals from passive satellite instruments" *by* Daniel P. Grosvenor et al.

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Review on "Quantifying and correcting the effect of vertical penetration assumptions on droplet concentration retrievals from passive satellite instruments" by Grosvenor et al.

Summary: This paper assesses a particular type of error in the satellite-based retrieval of cloud droplet number concentration (Nd) retrieval from passive sensors such as MODIS. The error stems from the fact the shortwave infrared band used in MODIS

cloud droplet size retrieval (i.e., cloud droplet effective radius CER) does not correspond to the CER at the exact cloud top, but somewhere below the cloud top due to the penetration of the light into the cloud (termed as the "penetration depth bias" in this study), which leads to underestimation of CER and overestimation of Nd. This study investigates the size of this bias under different conditions and also provide a simple parameterization scheme to correct this bias in the observation.

The topic of this paper is suitable for AMT. The paper is well-written, concise and easy to follow for the readers with the right background (but perhaps too technical for general readers). Overall, I recommend publication after some revision.

Comments/Suggestions:

My biggest concern/criticism for this study and many other studies on Nd retrieval is that most of them are based on highly idealized cloud model, namely, the perfect, 1D, plane-parallel, adiabatic cloud with linear LWC lapse rate and constant Nd. It seems to me that, the meaningfulness of this study depends pretty much on the validity of this ideal cloud model. In particular, it is well known that the entrainment process can significantly affect the cloud microphysics at cloud top and thereby deviates the cloud vertical structure from the classic model assumed in Nd retrieval. How may the cloud top entrainment process influence those equations in section 2? What is the typical vertical scale of cloud top entrainment in comparison with the penetration depth of the SWIR band? Do homogenous mixing and inhomogeneous mixing as a result of cloud top entrainment have a different or similar impact on cloud top CER structure and Nd retrieval? At least, these questions should be mentioned, discussed with some references.

What is the COT (τ) used in the Nd retrieval? Note that in MODIS operational retrieval, clouds are assumed to be vertically homogeneous. Because of the "penetration depth bias", the retrieve CER is different from the CER at the cloud top. Another possible bias is that the retrieved COT is different from the true COT. This might be small but

should be quantified.

In this study, only the solar reflective part of the 3.7 μm band is considered. In reality, the radiance in this band is contributed by two parts during the daytime, the solar reflection and thermal emission. The emission part is "corrected" based on the 11 μm band radiance in the MODIS retrieval. This should be pointed out and if the correction process could somehow confound the results then some discussion is needed. This is especially important as the paper claims that 3.7 μm band is better for Nd retrieval (which I agree) than the 2.1 μm band.

For 3.7 μm band, its weighting function is close to two-way transmittance. I'd like to encourage the author to try to come up with an analytical solution of CER* if the weighting function follows the two-way transmittance. A paper that might be helpful Zhang et al. 2017 JGR (http://onlinelibrary.wiley.com/doi/10.1002/2016JD025763/full) (Equation 4)

Why is land always masked in Nd retrievals? Why or why not can the same method be applied to land?

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