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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Study of cloud droplet number concentration using the A-Train satellites" *by* S. Zeng et al.

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Comments on "Study of cloud droplet number concentration using the A-Train satellites" by Zeng et al.

General comments: This paper presents a comparison of the CDNC retrievals based on two methods, one using MODIS observation and the other using CALIOP observation. This is an interesting topic and of great importance for understanding aerosol-cloud-precipitation interactions. Although there have been several algorithms developed for satellite-based CDNC retrieval, as far as I know this is the first systematic comparison of two independent retrievals on global scale. As such, it is a significant contribution to the literature.

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Interactive Discussion

Discussion Paper

However, as pointed out by other reviewers, there is quite some space for improvement. Please see my comments/suggestion below. I hope after a major revision this paper could become a classic reference for satellite-based CDNC retrievals.

Major comments: 1) Other than some equations, there is very little introduction or explanation of the retrieval methods. I understand that both methods have been introduced in previous studies, but it is necessary to give the readers some background about the retrieval methods, e.g. their theoretical basis, advantages and limitation, to help the readers understand the results presented later. It is also necessary to give more details about the retrieval algorithms. In particular, it is important to describe the quality control process used to filter the data and the parameters used in the algorithm. Here are some information information I think should be given to the readers:

What is the retrieval resolution? MODIS cloud effective radius and liquid water path are made at 1km resolution. CALIOP has a 333m footprint but does horizontal averaging up to 80km to get better signal, POLDER foot print is about 6km but does cloud effective radius retrieval at 200km. Given the dramatic difference of instrument resolution, it is important to tell the reader at which resolution is the retrieval made. How does the resolution affect the CDNC retrieval? How was the liquid water content (LWC) lapse rate computed for the MODIS method? the LWC lapse rate is dependent primarily on temperature and also weakly on pressure. Which temperature is used in the computation? Cloud top temperature? The temperature at cloud base/lifted condensation level?

Which cloud mask and thermodynamic phase products are used to screen out the ice clouds and multiple layer clouds?

Doesn't the CALIOP retrieval algorithm require the cloud to be opaque? Does MODIS have similar requirement? Have the thin clouds been screened out from the comparison?

2) What really confuses me is that the authors emphasized several times in different

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places that clouds are usually sub-adiabatic, i.e. F_ad<1 (for example in line 14 on page 29040 it is mentioned “The MODIS CDNC values (derived with fad = 0.8) are quite close to in-situ observations for stratocumulus over the Chile–Peru coast”). However, F_ad is still assumed to be 1 in the retrieval. Why? It is even more confusing to see that later in the discussion the authors attribute some the difference between MODIS and CALIOP based retrievals to the fact that entrainment leads to sub-adiabatic clouds. If so, why not use some more realistic value, say 0.6 or 0.8 for F_ad in the first place? Some explanation is necessary.

3) The paper claims that it is a comparison on global scale, but the fact is the comparison is only made over oceans. Is there any particular reason that limits the algorithms to be only applicable to maritime clouds? if so, please explain it to the readers. If not, I’d suggest the authors to add comparison over land.

Specific comments: 4) Line 8 page 29037: Twomey effect requires the total cloud water to be same.

5) Line 13 page 2903: The CLAW hypothesis has been challenged/criticized by many papers. I think it is a good idea to give a couple of references of the other side of the story. See the paper below.

Ayers, G. P. & Cainey, J. M. The CLAW hypothesis: a review of the major developments. Environmental Chemistry 4, 366–374 (2007).

6) If my understanding is correct, the CDNC based on Eq. (1) is the so-called “effective CDNC” which is the product of CDNC and a constant that is related to the effective variance of the cloud droplet size distribution. If so, this needs to be clarified. same thins for Eq. (2)

7) where does the parameter “k” at line 21 of page 29039 come from? Clarification is needed

8) I think k=(1-v)*(1-2v)

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9) At line 4 on page 29040 about MODIS effective radius retrieval: Zhang and Platnick, 2011 actually showed that MODIS effective radius bias is dependent on many different factors. Heterogeneity effect is just one of the them. it is not correct to say “Droplet effective radius derived from MODIS tends to be larger than the true value, mostly because of neglecting horizontal photon transport”

10) In section 3.2, it is difficult to say whether Figure 2 reflects the truly seasonal cycle of CDNC because only one year of data were used in the analysis. If the authors want to study the seasonal cycle, more data should be included. Or, it should be pointed out in the text and in the caption that this is only for the year 2007∼2008.

11) In figure 3, it seems MODIS CDNC retrieval overestimates CALIOP retrieval. This goes back to my question above. If a smaller F_Ad, say F_ad=0.8 is used in MODIS retrieval (which seems more reasonable to me), MODIS and CALIOP results would be in good agreement. So the assumption about why F_ad=1 is used in the MODIS retrieval really needs to calcified and justified.

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