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Atmospheric Chemistry and Physics Discussions

Interactive comment on "A better understanding of cloud optical thickness derived from the passive sensors MODIS/AQUA and POLDER/PARASOL in the A-train constellation" *by* S. Zeng et al.

Anonymous Referee #2

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The manuscript presents a comprehensive comparison of the cloud optical thickness (COT) retrievals from two popular satellite instruments, MODIS and POLDER. It is found that the differences between the two instruments are caused by 1) instrument resolution difference and therefore different degree of sub-pixel inhomogeneity 2) cloud phase difference 3) and different ice particle scattering models used in the retrieval in case of ice clouds.

General comment The COT retrievals from MODIS and POLDER are two most widely used datasets for cloud and aerosol indirect effects studies. Therefore an understand-

ing of the difference between them is of great importance. The topic is appropriate for ACP. The manuscript is well organized and well written. I think it should be accepted for publication with some minor revisions. On the other hand, I think clarifications of the following issues/questions will help further improve the manuscript.

Specific comments 1. What motivated this study and what are main objectives? These questions should be addressed in the Introduction. Since many previous studies have been carried out on COT retrievals, it is necessary to distinguish the present study from them. What are the outstanding issues that haven't been addressed by previous studies? Will they be addressed in the present study? I think clarification of these questions will help readers appreciate the significance of this study.

2. How many and which moths/years of data are used in the comparison? This should be in Section 2. Also, I'd like to see some discussion on the statistics of the compared pixels. For example, what are the fractions of over cast pixels vs. partly cloudy pixels? How often do MODIS and POLDER agree on cloud phase and how often do they differ. These information will give the readers some large pictures about the overall agreement of the two products.

3. A reference is needed to support "but not with ISCCP D product where the land-ocean contrast of COT has been removed primarily because a significant increase in the amount of detected thin cirrus has been found over land with a lower IR threshold".

4. There are several interesting features in Figure 1 that haven't been discussed. Focusing on the Liq.(P)-Liq. (M) comparison, 1) it seems POLDER COT is substantial smaller than MODIS retrieval over the Amazon region and East China. 2) the ITCZ is clearly seen in POLDER retrieval but not seen in MODIS. 3) POLDER retrieval seems to be larger than MODIS retrievals over Southern Oceans although Figure 2a seems to suggest the other way around. It might be inspiring to put some discussion on these features.

5. In the discussion of POLDER and MODIS cloud phase difference, it is mentioned

that “In these cases, angular polarized signal from POLDER is sensible to lower water level however the IR and NIR signals from MODIS give more correct information at the cloud top.” Isn’t polarization also only sensitive to cloud top? If I remember correctly, studies suggest that the polarized radiance is only sensitive to first one of cloud optical depth and becomes saturated after about three optical depths. This penetration depth seems to be even smaller than NIR band. This needs to be clarified.

6. In pixel-to-pixel comparison, Figure 4d seems to suggest that when liquid cloud is thick, MODIS retrieval tends to be smaller than POLDER value. For example, when MODIS retrieves a COT of 60, the POLDER value is typically around 80. What is the reason for this? Is it because the asymmetry factor difference?

7. It is mentioned when discussing Figure 7 that “The good statistical relationship between the liquid COTs of the two sensors in Figure 4d is thus not really improved for the scaled COT in Figure 7d.” I cannot agree. It seems POLDER and MODIS agree better in Figure 7d than in Figure 4d, especially for large COT values. This is really interesting. It seems to suggest that large MODIS COT tends to have smaller effective radius (i.e., larger (1-g)) so that the (1-g)*MODIS_COT adjustment leads to better agreement with (1-g)*POLDER_COT. This behavior of MODIS COT seems worthy of some discussion.

8. Figure 8 and 9 are really creative and interesting plots. But unfortunately I feel they are not very well discussed and some confusing issues are not clarified. First of all, what does the radial direction of the polar plot corresponds to? Viewing zenith angle? In Figure 8 when SZA is between 60$\sim$70 degree, a reddish region is clearly seen over relative azimuth 250$\sim$270, which indicates COT retrieval over this angular range is substantially larger than other direction. Note that this region is also clearly seen in the lower center plot where all SZAs are combined. What causes this reddish region? What is scattering angle corresponding to this azimuth angle between 250$\sim$270? The fact that the reddish region is so regular makes it suspicious. Is it associated with special scattering angles, like rainbow angles, or it might be indicative of artifacts in the

retrieval? Also in Figure 8 when SZA is between 20$\sim$30 degree, the COT is obviously larger in the relatively azimuth direction between 270$\sim$30 degree. Similar feature is also seen when SZA is between 30$\sim$40. What are the reasons for this?

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