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

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This paper provides a new method of retrieving CDNC (cloud droplet number concentration), an important parameter for water clouds, using a combination of CALIOP, MODIS and POLDER observations. The CDNC retrieved from the new method is globally smaller than the MODIS retrievals, being about 0.64 of the MODIS values. To explain this difference, the authors discussed impacts of cloud entrainment, heterogeneity and effective particle size used. The results are impressing and may be useful for the future study of the cloud-aerosol interaction. Overall I think it is a good paper. I have several technical comments on this paper.

1. The new method is based on Equation (1). However, the paper does not provide how

the equation is derived, and the citation of this equation, "(Hu et al., 2007) ", cannot be found in the references. Therefore I think more information for this equation is needed.

Equation 1 is from Equation 9 in the paper Hu et al. (2007). For readers to better understand the method, we also modified section 2.1 as follows: "CALIOP (Cloud-Aerosol Lidar with Orthogonal Polarization) is an active two-wavelength polarization-sensitive lidar with a horizontal resolution of 333 m and vertical resolution of 30-60 m (Winker et al., 2003). The level 2 official products are derived at horizontal resolution of 5km. CALIOP uses layer integrated depolarization ratio (δ) and droplet effective radius (r_e) to retrieve the CDNC (N, unit: cm^{-3}, see Equation 1, corresponding to Equation 9 in Hu et al., 2007). It is based on the fact that extinction coefficients (β, see Equation 3 in Hu et al., 2007) of water clouds are related to δ (depolarization is related to multiple scatter) and re (droplet size determines the backward proportion of single scatter and absorption). The total extinction (β) is a sum of extinction of each single droplet ($\beta_s = 2\pi r_e^2$)"

2. The concept of effective size of cloud particles is closely related to size distribution. Is Equation (1) derived from a pre-determined size distribution, i.e., modified gamma distribution? Is the CDNC results sensitive to the selection of size distributions? I think this needs to be discussed.

We assumed gamma distribution in our algorithm. CDNC is sensitive to the selection of size distribution. That is why we need both r_e and variance (Hu et al., 2007). The non-Gamma shape of the distribution (e.g., bi-modal distribution) may cause some uncertainty to the CDNC. Like all other published literature, the uncertainty associated with non-Gamma shape is not discussed in this study.

3. CALIOP can only observe the upper surface of a condense water cloud (optical depth<4). Therefore, the CDNC retrieved from CALIOP is for the upper cloud surface only. The CDNC at the upper surface of a cloud may be smaller than the middle-cloud layer. MODIS CDNC retrieval may be a value at a lower part of the cloud layer. This

may also lead to disagreement between MODIS and CALIPSO retrievals.

If clouds are vertical heterogeneous, in particular because of entrainment at cloud top, CDNC at cloud top should be smaller than that in clouds. Correspondingly, CALIOP CDNC is smaller than the MODIS one. We added this information in section 2.4 as follows: "In addition, as CALIOP signal could only detect the most top of clouds with $\tau < 5$ (Winker et al., 2009), the effective radius corresponding to this layer are needed to calculate the CDNC corresponding to this layer. If CDNC is vertically constant, the retrieval can represent the true value for the whole clouds. But in real atmosphere, due to cloud top entrainment, CDNCs at cloud top are smaller than those in clouds. MODIS retrieval suffers from adiabatic assumption and uncertainties to both τ and r_e retrieval, i.e. the 3D biases. As cloud entrainment increases (fad decreases), the positive bias of MODIS retrieval without counting f_{ad} also increases, which is opposite for CALIOP retrieval as mentioned above."

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