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Atmospheric Chemistry and Physics Discussions



# *Interactive comment on* "Observations of rapid aerosol optical depth enhancements in the vicinity of polluted cumulus clouds" *by* T. F. Eck et al.

**MJ Jeong (Referee)**

mjeong@gwnu.ac.kr

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This manuscript reports increased aerosol optical depth (AOD) near cumulus clouds and discusses the factors that cause the AOD enhancement near clouds using Cimel sun-photometers from several AERONET sites, Micropulse Lidar (MPL), High Spectral Resolution Lidar (HSRL), airborne in-situ aerosol measurements during DISCOVER-AQ field experiments (July 2011). The topic covered by this article is closely related with many past findings on the correlations between clouds and aerosols, which bear very important implications about the interactions of aerosols and clouds. For example, several researches have reported (spatial and/or temporal) correlative patterns between cloud fraction and aerosol optical depth (and Angstrom exponent),



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and there have been arguments whether such correlations are the results of real atmospheric processes or artifacts in the measurements. Effects of aerosol humidification (swelling effect), new particle production near clouds, cloud-processed particles (aerosols released from cloud droplets after they evaporate near the boundaries of cumulus clouds), convergence of aerosol particles near cloud-forming fields have been considered as what can actually occur in the real atmosphere. On the other hand, cloud-contamination in the sun-photometric measurements (or satellite measurements), three-dimensional effects of clouds (i.e., enhancement of reflected photons near clouds due to multiple scattering between clouds and atmospheric molecules) are suggested as potential sources of artifact. Given the implications of the enhanced AOD near clouds on the interplay between clouds and aerosols, which contain important clues to narrow down the uncertainty in climate studies, I believe that much more researches like this study should be reported to the related community.

For the analysis on the cases with enhanced (fine-mode) AOD in the vicinity of clouds, are cloud-contaminated measurements (i.e., thin clouds/cloud edge placed in the line of sight between the sun and Cimel) allowed?

Significant parts of this study rely on SDA, but it is not clear how authors could make sure cloud-contaminated portion of radiance contributes only to coarse-mode AODs, leaving fine-mode AOD intact from cloud-contamination. While it was briefly mentioned in the Instrumentation and methodology section, more details would help readers greatly.

Also, when thin parts of clouds interfere the sun-photometric measurements, stronger (than that for aerosols) forward scattering can be expected due to presence of large cloud particles. One would wonder how it can influence the measurements and the analysis in this study. I would like to suggest authors to include discussion about this matter in the text.

In Fig 5, for such circumstances, clouds should have obscured (or interfered) the mea-



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surements of (SDA) AOD for several AERONET sites, but it is not clear when and where it happened. I do not see many of spikes or peaks of coarse mode AOD for many sites. It would be great if authors can mention about this in the manuscript.

Fig. 8c. Does “Range” stand for altitude? Then, it would be better to interpret the figure if the axes of the plot can be switched.

The MPLNet image in Fig. 9c shows very interesting feature – enhanced backscattering within the boundary layer (esp., 0.5 – 1.7 km a.g.l.) several hours before the vigorous cumulus genesis in the late afternoon. The feature may not be associated with cloud-processing as it seems that there was no cloud at that time span. It could be associated with newly generated aerosols or aerosols from transport/convergence. It will be nicer if more discussions about the feature can be provided in the manuscript.

Fig. 12. I wonder if the effect of the enhanced light scattering near bright clouds (so called 3D cloud effects; e.g., Varnai T., and A. Marshak (2009). MODIS observations of enhanced clear sky reflectance near clouds Geophys. Res. Lett., 36(L06807). doi:10.1029/2008GL037089) is considered in MAIAC algorithm. Satellite aerosol retrievals for the pixels near clouds could be positively biased due to this effect. A caution should be exercised for interpreting satellite-based AOD data near clouds.

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