

## ***Interactive comment on “Shortwave direct radiative effects of above cloud aerosols over global oceans derived from eight years of CALIOP and MODIS observations” by Z. Zhang et al.***

**Anonymous Referee #1**

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The manuscript discusses the use of CALIPSO and MODIS data for the retrieval of aerosol DRE over clouds at a global scale for 8 years. The presented work is new, of good quality and valuable. The main contribution of the manuscript is the new observations of aerosols over clouds at all parts of the world, for an extensive period, which was hitherto missing in the literature. It will be very helpful to have more observations than only case studies which were so far presented. The combined use of CALIPSO and MODIS is logical and useful, and has the benefit that both scattering and absorbing aerosols can be identified above clouds. This has so far only been achieved with active or polarised measurements, whereas MODIS alone (and other spectrometers)

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only distinguished aerosol absorption from cloud scattering. The manuscript is clear and well-written and presents interesting results, and therefore warrants publication.

However, my main criticism on the manuscript is that the authors present diurnally averaged aerosol DRE based on instantaneous measurements only, and argue that this is better than previous studies that presented instantaneous DRE, with the argument that diurnally averaged values are easier to compare. However, the assumptions made by the authors in order to derive diurnally averaged aerosol DRE, introduce large uncertainties in the presented results which are not evaluated. Instead of a diurnally averaged DRE, the authors in fact derive an instantaneous DRE, convolved with the diurnally varying solar radiation. In the error analysis, all or most uncertainties in the retrieval are evaluated, but the uncertainties of keeping the AOD, COD and cloud fraction constant over the day are not, which will have a much larger effects on the diurnally averaged aerosol DRE than aerosol microphysical property assumption or retrieval uncertainties. Therefore, the manuscript should clearly state that the retrieved parameter is in fact instantaneous ACA DRE for cloud scenes only, while the presented results are an estimation of the global, diurnally averaged, ACA DRE using the very simple assumption that all cloud and aerosol parameters are kept constant throughout the day. The argument that it makes the quantity more easily comparable is not convincing, since an instantaneous DRE multiplied by cloud fraction and diurnally averaged solar irradiance will give similar results, at least with the same large uncertainties.

My main concerns are with section 4.1:

eq 1: the  $1/24$  normalisation factor seems strange. It is probably based on some integration over time in steps of one hour, but this is nowhere explained. Furthermore, only integration over solar irradiance remain, which is likely available in higher resolution than once per hour.

Going from eq2. to eq3. the authors remove cloud fraction from the integral, keeping it constant over the day. This step is understandable, but introduces such large un-

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certainties that one cannot suggest the quantity is still a diurnally averaged DRE, as argued above. Even the authors themselves in section 3.1 remark that clouds have a strong diurnal cycle. Not only the frequency of occurrence of ACA is strongly affected by this, but more importantly the aerosol DRE itself, since it so strongly depends on the brightness of the background.

Eq. 5: the first term can be removed. It makes no sense to denote terms of zero. Describing what has not been considered is enough.

Section 6 Also, it should be mentioned that the presented uncertainties are only valid for the instantaneous DRE, not the presented numbers of diurnally averaged aerosol DRE. If the latter is presented, the uncertainty should include an estimate of the diurnal variation of cloud fraction, COT and AOT at a global scale, and its impact on the diurnally averaged DRE. This is currently missing.

Textual issues: In the abstract a mention of which eight years are presented might be helpful

Page 26370. It seems that four primary ACA regions should be defined in Fig 1, but these are missing.

Section 4.3 "observed" cloud reflectances are not inferred, but 'reflectances (from a contaminated cloud scene) are observed', from which biased COT are retrieved.

"the above COT correction process is dependent on the radiative properties of the ACA." -> The bias is dependent on the radiative properties of the ACA, and the correction process is dependent on the assumed aerosol model.

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