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Interactive comment on "A Global Analysis of Dust Diurnal Variability Using CATS Observations" *by* Yan Yu et al.

Anonymous Referee #1

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The paper "Global Analysis of Dust Diurnal Variability Using CATS Observations" by Yan Yu et al. investigates the diurnal cycle of dust loading across the global tropics, sub-tropics, and mid-latitudes by analyzing aerosol extinction and typing profiles observed by CATS lidar aboard the ISS. CATS was developed to address three main science objectives; with one of the goals to measure and characterize aerosols/clouds on a global scale and at various local times. The diurnal variability of aerosols consists a significant scientific question partially addressed until recently mainly based on sunphotometers (e.g. Smirnov et al., 2002) and ground-based lidar systems (e.g. EARLINET; Pappalardo et al., 2014), important for a large number of applications / impacts (radiative forcing, aerosol-cloud interaction, public health). Until CATS, the high importance of dust (Kok et al., 2012) was studied on a large scale over the dust sources

based mainly on geostationary satellites (e.g. MSG-SEVIRI; Schepanski et al., 2007). The present study attempts to build on the aerosol diurnal study performed by Lee et al., 2018, focusing on dust aerosols. The idea of the study is of high scientific interest, falls within the scope of ACP, the manuscript is well-written / structured, the presentation clear, the language fluent. However, despite the significance of the scientific idea, the performed approach and methodology are subject to major deficiencies and the results are rather questionable.

Here are some of my main comments which I think will help the authors to improve their manuscript. 1) The authors have established the diurnal variability of dust over main dust source regions based on the concept that there is insignificant difference between CATS daytime and nighttime observations. Some indicative examples are: ". . . there is no significant difference between daytime and nighttime CATS AOD quality" – line 176. "The currently identified insignificant difference between daytime and nighttime CATS data quality is hypothesized to be partly attributed to . . ." – line 181. "Although there is no significant difference between the daytime and nighttime CATS data quality . . ." – line 188. ". . . According to the comparison with ground-based and other satellite observations, CATS aerosol and dust loading observations exhibits reasonable quality and insignificant day-night inconsistency" – Abstract. However this assumptions/hypothesis is not valid. Pauly et al. (2019) extensively addressed the calibration and performance of CATS L1B - ATB based on comparisons with CPL, CALIOP (CCAVE) and PollyNET observations and reported on the significant nighttime and daytime differences. Similarly, Proestakis et al. (2019), implemented a large number of EARLINET stations and collocated ISS-CATS observations and reported on the performance of CATS backscatter coefficient, including on the significant underestimation in CATS daytime observations. The aforementioned studies build on the already reported by Yorks et al., (2016) minimum detection thresholds, with CATS in the case of nighttime to be approximately two orders of magnitude more sensitive than during daytime. Similarly, other studies have reported on the performance of CATS (e.g. Lee et al., 2019; Rajapakshe et al., 2017, Noel et al., 2018). The daytime underestimations compared

to nighttime observations is an issue which is not considered properly, it is ignored as not significant, and not addressed, discussed properly and eventually resulting in questionable conclusions. 2) The authors study the diurnal variability of dust based on CATS aerosol subtype classification. To be more specific, the authors state that: "... DAOD is defined here as the vertical integral of aerosol extinction coefficient over "dust" (Aerosol Type = 3) or "dust mixture" (Aerosol Type = 4) ...". The subtype classification algorithm depends on inputs, one of them the depolarization. 1064nm dust linear depolarization ratio vary strongly between 0.22 and 0.28 to 0.4 (e.g. Freudenthaler et al., 2009; Burton et al., 2015; Haring et al., 2017). On the other hand this has an effect to the non-dust component in "dust" and "polluted-dust" aerosol types considered in the study, always present when the depolarization is lower than 0.22. Although there are methodologies developed to address the decoupling of dust and non-dust components (e.g. Tesche et al., 2009; Mamouri and Ansmann 2014; Amiridis et al., 2013), the authors have performed a more bulk approach, reporting the diurnal variability not only of the dust component but the non-dust component as well, contaminating the results. 3) Although the ISS inclination is confined between (approximately) 51oS and 51oN, there is a clear significantly larger number of ISS overpasses/CATS observations over the Saharan Desert during nighttime that during daytime. The authors should clearly present the available sample of observations per 3-hour over each selected region, and discuss the sample effect. 4) No vertical mean extinction coefficient profiles (including statistical indicators such as SD) have been included, a significant advantage of lidar system compared to passive sensors. In addition, although CALIOP does not provide observations at various local times, since CALIPSO is the longest existing lidar system is space, observations at least during the overpass times should be included.

Considering the above comments, I suggest to ACP journal to reject the paper. The authors should go through the entire manuscript more carefully before resubmitting it.

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