Response to comments of reviewer 2

General comment	***Response***
This paper describes a novel technique to retrieve optical depth from the solar back-ground measured by lidars. The authors show the technique to be valid for stratiform clouds and then go on to explore relationships between retrieved cloud properties. The focus is on comparing drizzling versus non-drizzling stratiform clouds. This paper may be suitable for publication after the authors address the following issues.	• Thank you.

Major comment	***Response***
1. The comparison of cloud properties includes the use of liquid water path (LWP) from a microwave radiometer (MWR). However, LWP is not valid when the MWR window is wet. The authors mention this on page 8970 lines 21-23, stating that these wet window cases are removed. Therefore, the results of drizzling cloud properties in this paper could be biased since they cannot include any observations where drizzle has reached the surface or those observations just after such times when the window will remain wet. Some discussion is needed on how many profiles are excluded because of this and, if this number is significant, the authors need to address the impact on their results.	• For stratiform warm clouds selected in this paper, the fraction of MWR with wet window flags is about 4%. • Additionally, we have also realised that the physically-based approach used in MWRRET products did not use the wet window flag in the retrieval method, because the flag is not necessarily triggered by precipitation. We have therefore removed the statement about excluding observations when the window is wet (i.e., the wet window flag is on). • We found that the time periods with the wet window flag still heavily overlap with the time periods that MWRRET retrieval is unavailable, although occasionally they don't overlap with each other. The fraction of no MWRRET retrieval is ~1% in the time periods used in the paper.
2. page 8968 lines 12-14: Assuming the solar background light has the same uncertainty as an AERONET (5%) is not appropriate. In lidar studies, the background noise is determined by taking the standard deviation in the high altitude region (i.e. 45-55km for the MPL). In addition, there is an uncertainty due to detector noise that depends on signal strength. I suspect the noise is the lidar observations are likely larger then 5% and therefore the authors should revisit their claim of a 10% overall uncertainty.	• Thank you for pointing this out. To give readers an idea of how the uncertainty in cloud optical depth retrievals varies with the uncertainty in calibrated solar background light, we have added the following text on Page 6, Line 18–20: *Note that with an uncertainty of 10% rather than 5% in calibrated solar background light, the overall retrieval uncertainty in cloud optical depth will increase to 17–25%.*

Response to comments of reviewer 2 (cont.)

Major comment	***Response***
3. Throughout the paper the authors write that the cloud optical depth is retrieved using the "solar background light". This is misleading since a radiance is needed for the look- up tables but the "solar background light" is measured by the MPL as photon counts. It be more correct to say "calibrated solar background light" since the photon counts are converted to a radiance via calibration to AERONET.	• Thank you. We have changed most of "solar background light" to "calibrated solar background light", mainly in sections 2–4 after we introduce calibration against AERONET in the beginning of Sect. 2.
4. Page 8969 lines 6-18: Instead of establishing backscatter thresholds, why not just compare the measured backscatter above cloud to the solar background signal? If the two are similar, then the laser beam is completely attenuated and the cloud is optically thicker, otherwise it is optically thin. This would make the author's method more readily adaptable to other lidars beside the ARM MPL and wouldn't require the lidar backscatter profile to be calibrated which is needed if these thresholds are to be used.	• In the ARM Archive, solar background light and signal return are recorded in photon counts. Using these ***uncorrected, uncalibrated*** signals, one will find that the signal return at moderate-to-high tropospheric altitudes in both clear sky conditions and above cloud is often very similar as it is the solar background noise that dominates the signal, especially for locations with a high solar zenith angle. In other words, this won't be able to help distinguish between optically thin and thick clouds. • In principle, applying the same method described in the manuscript (i.e., with help of external data), one can use ***corrected, uncalibrated*** backscatter signals to find suitable thresholds for distinguishing thin/thick clouds. However, we do not prefer uncalibrated signals, because in this case, suitable thresholds vary over time depending on the level of noise, and then we still need to effectively account for all sources of noises in lidar signals, which is equivalent to calibration. Therefore, it is better to calibrate lidar signals first and then find a constant threshold for thin/thick cloud discrimination.
5. Section 3.1: Since the focus later in the paper is on drizzle and non-drizzling cases it seems warranted that an example of retrieval performance for a drizzling case be included here.	• Good point. We have added drizzling cases in Figures 4 and 5 in Sect. 3.1 (Page 10, Line 5–20).
6. Page 8973 line 19: What percentage of the original 1 hour time periods identified by ARSCL does the 5200 min of data points represent? i.e. what fraction of the stratiform periods during these 2 years are included in your analysis of cloud properties?	• 5200-min long data points represent ~35% of daytime ARSCL cases. We have added this information on Page 11, Line 5: *This exclusion process lead to a final sample size of 5,200-min of data points during 2005–2007 that represents ~35% of daytime stratiform cases.*

Response to comments of reviewer 2 (cont.)

Major comment	*Response*
7. Repeating the validation in Fig 5 with the AERONET observations would be nice to see. Although the sample size would be smaller than the ARM Min observations, if other researchers wanted to extend this lidar optical depth method to other sites a sun photometer may be their only means of validation (since one is required for calibration).	• As suggested, we repeat the same comparison using AERONET observations. An additional figure (new Fig. 7) and the following text has been included on Page 11, Line 24–28: *Similarly, Fig. 7 shows a scatterplot for evaluating retrievals against the AERONET official cloud-mode product. The mean cloud optical depth from lidar measurements is 30, smaller than cloud-mode retrievals by 3 optical depths. The correlation coefficient is 0.95, while the root-mean-squared difference between the two is 8 (24% relative to the mean of cloud-mode retrievals).*
8. Does using the Min observations result in the same relationships between cloud properties (i.e. Fig 6-7 and the power law relationships)? Many readers, including myself, may wonder if the differences between the more established ARM Min product and the authors' new lidar retrieval in Fig 5 has any effect on the resulting relationships between cloud properties.	• We have repeated the same analysis using the ARM Min product. For a better flow of discussions, we focus on results binned by cloud optical depth (i.e., similar to the old Fig. 6) and include them in Section 4.3 (Page 14–15). Results are shown in Fig. 10 in the revised version.
9. Fig 6: There is an extra bin in panel (b) at optical depth = 75 that is not present in panel (c) or (d).	• Thanks for spotting this error. We have removed the point in (b) at optical depth of 75 for drizzling clouds, since the corresponding sample size is smaller than 25. Fig. 6 becomes the new Fig. 8.
10. Fig 5b: increase the limits of x and y axis to 100 so it matches the optical depth histogram in 5a	• Thanks. We have changed the X-range from 100 to 80 in 5a (now Fig. 6a) to be consistent with Fig. 6 (new Fig. 8) and to focus on the optical depth range of 0–80.

Minor comment	*Response*
1. page 8964 line 5: change "signal" to "signals"	• Thank you. It is done. • We have also corrected some other "signal" to "signals" throughout the manuscript.
2. page 8965 lines 2-3: remove "and many others"	• Done.

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Minor comment	*Response*
3. page 8965 line 18: why is the relationship "of particular interest"?	• We have made the following changes on Page 3, Line 25–28: *The relationship between cloud optical depth and droplet size is of particular interest, because their correlation patterns are highly related to the stages of warm cloud developments (Suzuki et al., 2010) and have been used for drizzle delineation (Nauss and Kokhanovsky, 2006; Suzuki et al., 2011).*
4. page 8966 line 14: suggest changing "Campbell et al. 2002" to "e.g. Campbell et al. 2002"	• Done (Page 4, Line 16).
5. page 8967 line 14: suggest changing "between 45 and 55 km" to "between 45 and 55 km where the molecular backscatter is negligible"	• Done (Page 5, Line 13).
6. page 8970 line 15: explain what is meant by "worked better"	• Sorry about this. We have added the following text on Page 8, Line 11–14: *Using simultaneous retrievals of cloud optical depth and effective radius at the ARM Oklahoma site, Chiu et al. (2012) found that the second assumption led to a better agreement with LWP measured by microwave radiometers (MWR) in all sky conditions.*
7. page 8973 line 17: Define what an "unphysical 1 min averaged LWP" is.	• We meant any negative 1-min average LWP values unphysical. Since a negative LWP leads to a negative cloud effective radius and will be excluded in our analysis anyway, this bit "*exclude time periods with unphysical 1 min averaged LWP*" is redundant and we have deleted it.
8. page 8974 lines 8-10: Aren't both flux and lidar retrievals averaged to 1 min for this comparison? Why then does only the flux-based retrievals smear out these variations?	• Because fluxes are collected from a hemispheric FOV and lidar has a very small FOV, even when both retrievals are averaged to 1 min, the temporal variations of the flux-based retrievals will be still much smaller than those of lidar retrievals. To make it clearer, we have revised this sentence on Page 11, Line 20–23: *Therefore, the discrepancy in cloud optical depth for these data points is likely because lidar has a narrow FOV to capture larger variations that tend to be smeared out in irradiance-based retrievals due to a hemispheric FOV of shadowband radiometers.*
9. page 8980 lines 24-26: It would be more accurate to say that: "This new method can be easily adapted to existing lidar networks where sun photometer measurements are available"	• Done (Page 18, Line 22).