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Comment on acp-2021-302

Anonymous Referee #2

Referee comment on "Methodology to determine the coupling of continental clouds with surface and boundary layer height under cloudy conditions from lidar and meteorological data" by Tianning Su et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2021-302-RC2, 2021

Review: "Methodology to determine the coupling of continental clouds with surface from lidar and meteorological data"

The manuscript described a method to determine the coupling of clouds with the surface using lidar measurement at the ARM SGP site. Determining the coupling status of clouds with the surface is important for cloud process-level analyses and understanding. After reading through the manuscript, I feel the study is more focused on method development and therefore a method-focused journal such as Atmospheric Measurement Techniques (AMT) could probably get the work a better exposure to the atmospheric retrieval/measurement community. In this work, the authors first developed a method to determine coupled and decoupled clouds with boundary layer/surface, then they further developed a method to estimate boundary layer height (PBLH) under cloudy conditions on the basis of their previous work published in 2020. The manuscript is well written but not well structured (details are provided in major comments #1 and #3). There are several concerns about the robustness of the methods and uncertainties of the data used. I suggest resubmitting the paper to a more method-focused journal (e.g., AMT) after these major revisions.

Major comments:

- The title is 'to determine the coupling of continental clouds with surface from lidar measurements. However, the manuscript only described the method from lines 277 to 280. More work was presented for estimating PBLH under cloudy conditions. So, I suggest changing the title to include the information of PBLH estimations under cloudy conditions.
- Line 218-231: it is confusing here. Usually, the positive/negative sign of a force reflects the direction of the force, while the magnitude reflects the strength. Figure 4 shows that small magnitude buoyancy forces correspond to strong buoyancy forces. Following Figure 4, 0 buoyancy force is a pretty strong buoyancy force. That does not make sense! I also feel that Figure 4 does not connect to other parts of the manuscript but distracts the discussion.
- To determine coupled clouds, there are two categories: lines 278 and 279-280. Each

category has two constraints. How often does each category occur and under what conditions does each category occur? Which constraint for each category is more critical? Compared with the method listed in Line 317, why can't the lidar-based cloud coupling determination use a single 'criteria' same as that is used with LCL and RS PBLH showed in Figure 6? Do the complicated algorithms with 5 constants and different constraint strategies perform better than just using a single 'criteria'? At least from Figure 6, the RS PBLH method performs well, even just uses a single 'criteria'.

- From line 278-281: cloud coupling status is determined profile by profile. Therefore, in theory, it is possible that a part of the cloud system is coupled while the rest is decoupled. Is such a situation observed in this work? If yes, how often?
- The manuscript did not talk about the uncertainties of LCL estimation and CBH estimation. Ceilometer generally overestimates CBH by 100 m or more (Silber et al., 2018), while the ARM MPL CMASK generally exaggerates cloud boundary estimations (e.g. underestimates CBH, but overestimates the apparent CTH) (Cromwell et a., 2019). What are the impacts of uncertainties in LCL and CBH on cloud coupling determination? In addition, what are the impacts of precipitation (drizzle, rain) on cloud coupling determination?
- Figure 5, similar to comment #3, under coupled cloudy conditions, how often is the PBLH determined using minimum ([CTH and A4*CBH]) or using A5*CBH? Are they correspondent to different PBLH structures? Since PBLH is determined a constant (A4 or A5) * CBH, why can't we just use a single constant * CBH. Do the category-dependent algorithms perform better than just using a single constant?

Minor comments:

- Line 194: what does 'identical cases' mean?
- Line 197: How was the inversion strength calculated? What is the difference between inversion strength and â□□θ (line 202)?
- Line 315 and Figure 6: it is better to state that RS virtual potential temperature method was used as the ground truth for determining the cloud coupling status. In Figure 6, how many RS samples are there? Do the commission and omission errors change with the time of a day and with seasons?
- Line 317: 'some criteria' -> maybe 'â□□h' is better?
- Figure 9 b) and c) mpl backscatters show large signals down to near-surface, why do cloud bases are detected at much higher levels?

References:

Silber, I., J. Verlinde, E. W. Eloranta, C. J. Flynn, and D. M. Flynn (2018), Polar liquid cloud base detection algorithms for high spectral resolution or micropulse lidar data, *J. Geophys. Res.: Atmos.,* doi: 10.1029/2017JD027840.

Cromwell E., and D.M. Flynn. 2019. "Lidar Cloud Detection with Fully Convolutional Networks." In IEEE Winter Conference on Applications of Computer Vision 2019, 619-627. doi:10.1109/WACV.2019.00071