

Atmos. Chem. Phys. Discuss., referee comment RC2  
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## Comment on acp-2022-398

Anonymous Referee #2

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Referee comment on "Turbulent structure of the Arctic boundary layer in early summer driven by stability, wind shear and cloud-top radiative cooling: ALOUD airborne observations" by Dmitry G. Chechin et al., Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2022-398-RC2>, 2022

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Overall comments:

In this paper, the authors reported the vertical structure of atmospheric boundary layer thermodynamics and dynamics, and in particular, turbulence quantities derived from measurements by airborne instruments for a few cases with weakly forced liquid clouds. I recommend the publication of this paper if the following issues can be adequately addressed.

I think the paper can be improved with

1. More meaningful interpretation of the results.
2. Highlighting the new knowledge from the uniqueness of this dataset and reducing descriptions/discussions of features that have been very well known.
3. More discussions about (a) the uncertainty of the statistics from the slanted legs, especially near cloud boundaries (e.g., cloud top) where the size of a feature may be small and (b) the uncertainty in high-order moments, which are more difficult to obtain than low-order moments. It is critical to describe both bias and variance in the derived quantities if the motivation of this paper is to provide a benchmark for model evaluation/parameterization development.
4. The addition of a concise summary of the main characteristics of all cases (maybe using a table).

Specific comments:

1. Aren't the markers corresponding to  $12 \text{ W m}^{-2}$  also measured at PS? The authors said the value 'became close to zero for slanted profiles'. Does it mean the mean measured value dropped to close zero or 'mean minus 1 standard deviation' got close to 0?
2. In Figs. 5c and 5f (and similar plots), the profiles at PS and flights are quite different.

Please reconcile them. For Fig. 5f, the near constant TKE only occur in slanted flights, why? Even for the cloud layer, shouldn't there be height-dependence of TKE? The data from PS seem to suggest a very noisy profile. Please explain.

3. In Fig. 5g, if the positive  $S_w$  is associated with some surface-driven turbulences, why don't we see a signature in other panels, e.g., Fig. 5d?

4. In Fig. 7b, please be specific of the features that indicate 'low level jets'. There is no clear peak in wind speed in any profiles. This is different from the profiles (T4 and T5) in Fig. 3b.

5. P. 16 Lines 4 and 7, what is a profile flight? Do you mean slanted flight?

6. In Fig. 9b, why is  $\sigma_w^2$  so large near cloud top? Shouldn't they be limited near cloud top (like in Fig. 5d)?

7. In Fig. 9c, I agree that  $S_w$  for T1 is largely negative, but certainly not for T2. Please explain.

8. Is it possible to add a panel for LW cooling rate profile in Figs. 11 and 14?

9. In Fig. 12, if the conditions for all 3 profiles are so similar, why not use the space to show profiles associated with inhomogeneous surface? It would be interesting to see how different they are from the profiles associated more homogeneous surface.

10. In Fig. 12g, why should  $S_w$  be so positive near cloud top? The surface-driven eddies should not be able to penetrate the inversion on top of the lower cloud layer anyway.

11. The discussion section is pretty poorly written. One would expect a rigorous estimation of uncertainties, connection with other studies, the key insights from the presented research, and so on (although not necessarily all of them) in discussions. Instead, the authors presented a comparison with mixed-layer model calculation without a clear motivation. (Also, I am not sure why only the cloud-top driven case is discussed. The authors said they showed that the cloud top cooling is strongly affecting the turbulence profiles. But most cases they presented were surface driven.)

Technical issue:

Please use consistent line types (e.g., why lines for Figs. 11a-11d but dots for Figs. 11e-11f?), variable names ( $V$  in Fig. 12b,  $U_{hor}$  in Fig. 15b, but 'wind speed' everywhere else?), and scales ( $T_{sh}$  in Fig. 12j but  $1000 T_{sh}$  everywhere else?). Also, if different ranges of axes are used for same variable across different cases, please make sure there are common ticks/grid lines for easier comparison across cases.