1 Summary

This manuscript presents the analysis of collocated snowfall sensors collected during two winters in southern Finland. The bulk density of snowflakes is derived from a weighing gauge at 5-min (or more) temporal resolution, and the retrieved values are evaluated by comparison with snow depth measurements. The variability of the density in time is analyzed in comparison with the parameters of Gamma particle size distributions (PSDs) fitted to observations from a Particle Imaging Package (PIP, formerly SVI). The obtained relationship between the density and the median volume diameter is consistent with previous studies. A significant correlation is found between density and $D_0$ and $N_w$, the latter being not expected. The variability of these relationships between the two considered winters is also mentioned.

2 Recommendation

Such studies are necessary to improve our understanding of snowfall microphysics, and the data and analyses presented in this manuscript are of interest to AMT readership. I have some concerns about some aspects of the analysis, as well as a list of specific comments to improve the quality of the manuscript (see below). I hence recommend to send the manuscript back to the authors for moderate revisions.

3 General comments

1. The equi-volume diameter of each individual snowflake/particle is estimated by multiplying the PIP equivalent-area diameter by 0.92. This number has been found by simulating the relationship between the PIP diameter of the 2D projection of a rotated spheroid and its equi-volume diameter (see p.5, l.16-21). This equi-volume diameter is central to the study as the PSD is derived from it, but there is no discussion about the uncertainty of this estimation. Real snowflakes are not rotated spheroids, and I am hence wondering what is the spread of the real equi-volume diameter around the 0.92 estimate, and subsequently the uncertainty in the fitted PSD parameters.

2. The relationship between $D_0$, $N_w$ and the density is quantified using linear correlation. This correlation quantifies the co-fluctuation of two random variables, but does not tell...
anything about causality. I would suggest to investigate the possible link between \( N_w \) and density by using multiple or partial correlation, in order to remove the influence of \( D_0 \) in the co-fluctuation of \( N_w \) and density.

3. It is more a wish than a request: the PIP provides information about the particle type, and it would be very interesting to conditioned the analysis on particle type as well...

4 Specific comments

1. Title: I would change the word “snow” into “snowfall”, to clearly indicate the difference with studies of snow density on the ground.

2. P.2, l.8: Garrett et al. (2012) would be a better reference here I think.

3. P.6, l.9: a reference about the employed method of moments?

4. P.6, l.26: correspondingly.

5. P.6, l.27: How many time steps are filtered here, and how representative is the remaining set?

6. P.7, Eq.8: a \( D_{\text{max}} \) is provided as upper integration limit, while it is implicitly assumed to be \( +\infty \) in Eq.2-3. Please clarify.

7. P.7, l.27: the mean/median values are close to the commonly assumed values, but Fig.2 shows a potentially significant spread around these values. For instance, the mode (most likely value) is around 6-7, and it would be instructive to provide an interquartile range (asymmetric distribution) to quantify this spread.

8. P.8, l.3: “the agreement is rather good”: please provide quantitative descriptors (correlation, RMSE, bias, etc) of this agreement.

9. P.8, l.10-11: fitting a power law in the log-log space using a linear regression does not provide optimum parameter values in the linear space... It should be mentioned.

10. P.8, l.29: I would move “were recorded” in between “rates” and “on average”.

11. P.9, l.5: any comment on the possible explanations of this variability?

12. P.9, Eq.11-13: please provide a quantitative descriptor of the goodness-of-fit of these power laws!

13. P.10, l.3: the term “riming degree” is coming out of the blue here...

14. P.11, l.5: remove “more” before “colder”.

15. P.11, Eq.17-18: please specify what are the integration limits! In Eq.18, shouldn’t it be \( 0.1^{-3} \) rather than \( 0.1^{6}\mu_{-3} \)?

16. Fig.4 and 5: it is not easy to spot the a, b, c markers. They should be made more visible (upper part?).

17. Fig.12: if the minimum integration limit is \( D = 0 \), then \( \mu \) values should be strictly positive (otherwise \( N(D9 \) is not defined). But there are values down to -2 in Fig12...
References