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Interactive comment on "Development of a cloud particle sensor for radiosonde sounding" *by* Masatomo Fujiwara et al.

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This contribution presents a new lightweight balloon-borne Cloud Particle Sensor (CPS). It describes the instrumental setup with the constraints imposed by the conditions on operational soundings balloons, and explains how particle concentrations is estimated from the primary count rate. Results from test flights are presented that compare two instrumental setups and provide simultaneous measurements with the Cryogenic Frostpoint Hygrometer (CFH). Various midlatitude and tropical cloud layers are probed illustrating the deployment in a wide range of cloud types. This clearly demonstrates that different cloud types (pure water, mixed phase to cirrus) can be well identified and characterized.

The paper is well organized. The current development state of the new sensor and

the experience gained in various balloon sounding deployments deserve publication in Atmospheric Measurement Techniques. However, limitations and uncertainties need to be addressed more clearly, and a roadmap for future development should be added.

General comments

The term degree of polarization (DOP) is introduced unconventionally including differently adjusted detector sensitivities leading to an observed range from -1 and 1, whereas in common notion it would be expected to range from 0 to 1. To avoid confusion this needs to be stated more explicitly – see specific comments.

The air flow speed in the instrument is essential both to convert the count rate into number density, and to correct for signal overlap caused by multiple particle detection. Substantial flow speed reduction with respect to the ascent rate is reported for the instrument geometry used, rough agreement is found only for larger cross sections tested. Equating the flow speed with the typical sounding balloon ascent rate of 5 m/s – with a resulting reference signal width of 1 ms – is inappropriate when the effects number density conversion and overlap correction are not discussed (see also specific comments). Low number density regions near ground in Figures 5 and 7 with signal widths in excess of 1 ms conflict the undiminished flow assumption. The corrected particle count rate should be clearly addressed as an upper bound estimate, not just as corrected value.

The Meisei radiosonde interface is limited to 25 bytes/s while other radiosonde offer much larger bandwidth as 80 bytes/s for the Intermet Systems iMet or 100 bytes/s for Vaisala RS41. These would allow addressing the above problem by a better characterization of the signal width distribution instead of just transmitting the first six samples. I suggest adding a perspective for future development which could include real-time (on-board) data processing options in conjunction with increased downlink capacity. This could illustrate how the promising potential of this sensor could be exploited further.

Specific comments

Page 1, line 22: before “of the instrument”, replace “volume of the detection area” by “ascent rate together with the detection volume and exposed cross section”.

Page 3, lines 3-13: A very approximate cost might be indicated here.

Page 3, line 12: The situations covered by the four test flights could be mentioned here.

Page 3, lines 16 to 27: The orientation of the rectangular slits should be indicated explicitly in the text or the related Figure 1

Pages 3, line 30: do the “rough-surface particles” cause full depolarization and thus about equal sensitivity for both channels, or is the cross-polarized detector tuned more sensitive due to calibrating with only partially depolarized light?

Page 4, lines 6, 7: replace “gives” by “determines”, and “other factors” by “polarization”.

Page 4, line 15 (compare comment p 3, l 30): To not confuse the reader it should be stated that for equally sensitive detector the DOP should be between 0 and 1. As detector #1 senses the sum of co- and cross-polarized scattered light, negative DOP values can only result from higher sensitivity of detector #2.

Page 4, line 16: mentioning “the uncertainty in the factory calibration”: Is there clear calibration target?

Page 4 line 20: Replace “various” by “nonzero”.

Page 4, lines 26, 27: It should be stated that particle overlap excludes flow rate determination: the two signal-width interpretations are complementary.

Page 5, line 12: Replace “is 1.0 cm longer” by “extends 1.0 cm”.

Page 5, line 19: Other radiosondes offering external instrument interfaces provide higher bandwidth, e. g. 80 bytes/s (Intermet iMet-1RS) or 100 bytes/s (Vaisala RS41). This additional capacity could be used in the future development perspective.

Page 6, line 10: The experimental findings described in this section confirm that the

flow rate through the instrument is reduced, as expected. With the tested larger cross section the flow agrees with the ascent rate, but for the configuration used in what follows it is only about half the balloon ascent rate. It should be stated that assuming the nominal flow speed of 5 m/s implies under-estimating both the count rate and the 1 ms reference signal width.

Page 6, line 27: The signal width factor f enters the count rate correction to the third power. An assessment of the consequences should be provided.

Page 7, line 5: Replace “is close or even greater” by “exceeds”, and delete “highly” in line 6: Ice saturation between 120% and 130% are frequently observed without cloud formation.

Page 8, line 10: Description of future work could be anchored here which allows for an improved signal width characterization rather than just sending the first six samples.

Page 8 line 11: Not calculating the DOP for signals exceeding 7 V contradicts the statement on page 4, lines 17 to 22.

Page 9, line 24: What is the major difference of “the first commercial version” flown 2015 versus the instrument launched 2013? Near ground level signal width of Figure 5 appears to have increased with respect to Figure 3.

Page 10, line 3: Excluding DOP analysis again contradicts page 4, lines 17 to 22.

Page 10, lines 10-11 and 31: The authors set a (debatable) signal width limit of 1 ms as onset for particle overlap correction (see p 6, l 24). This should be reflected using 1 instead of 0 as lower limit in the ranges given for the signal width.

Page 10 line 33: “for some reason” needs further specification: instrumental or telemetry failure?

Page 11, line 15: See signal width range comment for page 10.

Page 11, lines 16-20: Supersaturated layers above cirrus cloud tops are not surprising and have been discussed in detail in Brabec et al. (2012) , including microphysical modeling.

Page 11, line 21: Which of the lidar wavelengths mentioned is used for analysis and displayed in Figure 10?

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