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Interactive comment on "The Backscatter Cloud Probe – a compact low-profile autonomous optical spectrometer" *by* K. Beswick et al.

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The paper describes a compact instrument (the BCP) that measured cloud particles near the fuselage of a plane and also describes routine measurements with the BCP onboard commercial aircraft. The paper should be published with minor revisions.

Page 7381 "The need for 3-D global data sets is increasing. . . Use of commercial aircraft now allows the collection and transmission of highly relevant observations on a scale and in numbers impossible to achieve using normal research aircraft. . ." This section fails to mention the limitations of using commercial aircraft to map out the cloud statistics. The first, most glaring, limitation is the bias against convective systems (com-

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mercial aircraft typically go out of their way to avoid these). Commercial aircraft also spend most of their time at cruise altitude, and only descend (often into more polluted conditions surrounding airport hubs) during landing. Modelers and other researchers need to keep this type of (biased) pattern in mind when trying to tease out statistical information from, for example, BCP measurements of cloud droplet concentrations as a function of altitude.

——————————————— Page 7383 "The fraction of light that is scattered backward at a solid angle of 144-156-deg is collected by a set of lenses . . ." I suspect these angles were used simply as a practical measure (i.e. to keep the instrument package small). It should be mentioned that the backscattered light is generally greater for ice particles than for liquid cloud droplets of the same size.

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Page 7385 ". . .in which a linear, mono-dispersed droplet stream is producted by a piezoelectric oscillator that breaks up a narrow stream of water into droplets. . ." Was the droplet generator operated in the 'Rayleigh breakup' mode, meaning that a continuous stream of water is streamed under pressure through the orifice while the orifice vibrates (similar in operation to the vibrating orifice aerosol generator)? Or was the droplet generator operated in 'on demand' mode, where a capillary wave is induced within the tip of the droplet generator nozzle? I suspect the former, since the droplet size in this paper is only 22um, whereas my understanding from MicroFab (the droplet generator manufacturer) is that the 'Rayleigh breakup' mode of operation is used for generating much larger droplets. If that is the case, then the description for how droplets are generated is not accurate.

——————————————— Page 7388

"The transformation matrix for an individual BCP is generated by stepping through 85 diameters, in 1 um steps. . ." It is never explained how the droplet size is varied. If drop size is varied in the same manner as used by Lance et al (2010), i.e. changing the

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residence time of the droplets in an evaporation flow tube by moving an impinger connected to the droplet generator device, then it is not clear how perfect 1 um increments in the droplet size could be achieved.

Page 7391 "Thus, droplets 22um and larger will have a sampling area of . . ." This does not follow. With a constant threshold voltage, droplets larger than 22um will have a greater effective sample area than for 22 um droplets. I think some of the confusion behind this statement lies in misunderstanding Fig 4. Figure 4 does not show the laser beam intensity, as stated throughout the text, but rather a combination of beam intensity, particle scattering phase function and efficiency of the collection optics (including the max aperture of the optical system and the sensitive photodetector area). If, for instance, a 50um droplet intercepts the 'edge' of the 22um sample area, the signal will register with amplitude larger than the amplitude of a 22um droplet moving through the same position. Moving just outside of this 'edge', although the 22um droplet will no longer be detected, the scattered light from a 50um droplet will still be sufficient to trigger a counting event. If the authors believe that I am incorrect about this, they should demonstrate that I am wrong by performing another sample area calibration with a much larger droplet (say 50 um). Smaller droplets will have a smaller sample area, as stated in the text. These are a several instances within the text where the laser intensity distribution was indicated as the only reason for the shape of the BCP response map (i.e. Figure 4), e.g.: Page 7388, ln 5 ". . . as a result of the Gaussian intensity distribution of the laser beam"

Page 7390 "The counting efficiency of the BCP is 100% as long as there are no coincident particles in the beam since these would be counted as a single particle. Given the very small sample area of the BCP this is a very low probability event unless concentrations exceed 500 cm-3. . . . with measured sample area of 0.18mmˆ2" First of all, I don't understand how the sample area can only be 0.18 mmˆ2. Looking at the map in Fig. 4 the sample area spans a longitudinal range > 2.5 mm (presumably constrained by the DOF of the collection optics) and the beam width is 0.2mm, which means the sample area must be at least 0.5 mmˆ2, unless most of that plot is below the counting threshold of the electronics. I would also like the authors to provide a calculation of the expected undercounting error due to coincidence at 500 cm-3 droplet concentrations, for whatever the sample area truly is. The beam width parallel to the droplet trajectory should also be stated, since the coincidence error depends on the volume of the sensitive region of the laser beam, not just on the sample area perpendicular to the airflow.

Page 7391 “This accuracy estimate is a good approximation for the case of the 22um droplets that were used to map the area because, even near the edges of the beam where the intensity is only 15% of the maximum intensity, the scattered light will still exceed the minimum detection threshold.” I do not see how the 15% factors in to the question of sample area. For this particular case (22um droplets) the ‘minimum detection threshold’ is set such that it happens to be 15% of the maximum of scattered and collected light. However, the important constraint here is not the 15%, but rather the constant ‘minimum detection threshold’. Thus I do not follow this assertion: “Dividing 0.7x10-8 cmˆ2 by 0.15 results in a scattering cross section of 4.6x10-8 cmˆ2, the scattering cross section through which a particle would have to pass and still scatter sufficient light to be detected.”

Line 25 “. . .the sample area for a 10um particles is 0.12mmˆ2 so the correction factor is 1.5” Is this sample area for 10um particles measured? Or is it calculated by “. . .multiplying by the intensity map of the laser beam” (as described on page 7388, Ln 22)?

Page 7392 “. . .the accuracy in the measurement of the number concentration is dominated by the uncertainty in airspeed” In the Error analysis section, there is no mention of the ‘shadow’ of the aircraft fuselage, which can lead to both depletion or concentration of cloud particles depending on the distance from the airframe, especially when the cloud particles are large or have significant aerodynamic drag (e.g. hexagonal plates) and are therefore not able to follow the streamlines of the airflow perfectly around the curvature of the fuselage. Since the BCP sample volume is only 4 cm away from the outer surface of the airframe, I expect this could have an important effect on the observations.

Interactive comment on Atmos. Meas. Tech. Discuss., 6, 7379, 2013.