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Title: The Backscatter Cloud Probe – a compact low-profile autonomous optical spectrometer

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Summary:

This paper present a description of Backscatter cloud probe (BCP), comparison of the probe with other probes on a research flight and data from commercial flights.

General Comments:

Concentration comparison data should be plot for only channels above 5 um. The sampling frequency is not given for the research flight comparison. I expect that the sampling frequency is too large and that in and out of cloud areas are being sampled and confusing the interpretation of the data plots presented. A sampling frequency of 1 second or at most 5 seconds should be used.

The CDP and CAS instrument are taken to be correct; while the BCP is not so a 0.5 factor is used. The paper should present information that the CDP and CAS were working correctly. When were they calibrated. When were bead size performance checks done. Was the same True Air Speed (TAS) used for the concentration of all probes? Does the CDP have an optical mask so that droplet coincidence is not a problem for concentration values? How was the data processed?

The paper represents some really important work. Data from the BCP on a lot of aircraft would be very useful scientific data. The paper illustrates the potential usefulness of the BCP data.

The main scientific question I have is the sampling resolution that presented data is at. The paper doesn't state what the sampling resolution is. I believe that the concentration and amount of clouds is a result of the low sampling frequency. Likewise, comparison presented should be at high sampling frequency. Second major scientific concern is that there is a lack of discussion on the quality and processing of the CDP and CAS measurements.

In addition to not knowing the sampling frequency, the paper leaves out a lot of information about what is being presented. Scientific would need to be repeatable. There is no way this study could be repeated due to the lack of information presented. Likewise, a comparable study is not possible due to lack of details presented. This could be a really good paper; however, major amount of work is still required, see numerous comments below.

Details:

Line 77: Suggest paper or article instead of presentation.

Line 78: Remove first “for”

Line 79: Suggest “clouds” instead of cloud.

Line 82: Suggest “on” instead of “from”

Line 88-90: Suggest “The laser beam is transmitted through a silicate glass window and focused on a small region approximately 4 cm from the fused.” Currently, second part is just stuck onto the first and does not flow.

Line 90: “this region” Be direct and state what this region is. In focused region???

Line 93-94: Suggest breaking up sentence because doesn't flow well. New sentence instead of the and. “The collecting lenses focus light onto an avalanche photodiode (APD).

Line 100: Is there not a minimum transient peak that is needed for the first channel? To be above the

noise level? What about the maximum of transient signal? Hence, does every peak value end up in a channel?

Line 104: “size histogram” is a confusing term to me. Histogram is typically a type of plot. It is really the counts in each of the channels that is transmitted. Should it not be then “channel counts” instead of “size histogram”. No size information is transmitted.

Line 105: For the commercial aircraft measurements, please state the serial sampling rate of the channel counts. 10 Hz, 1 Hz or ???

Line 113: Another example of adding a comma and putting a sentence fragment on the end of another sentence. Construct new sentence for stuff after “, illustrating ...”. Check over rest of paper for this mistake.

Line 118-122: Paragraph only two sentences. Could you add something about if the BCP has to be mounted through a pressurized bulk head? I know on the Citation Research Aircraft, it was within the cable. What about on the other aircraft. Does the pressure and temperature range of the BCP allow it to be mounted in an unpressed location? Also, may want to talk about wiring requirements here, 3 wires for RS232 data, what is required for power, just two wires for A/C?????

Line 125-127: Long sentence with lots of clauses. Suggest ending at “simple indicator for the presence of clouds”. New sentence, “Knowing when the aircraft is flighting through clouds is an important parameter when analyzing IAGOS measurements, i.e. water vapor, ozone, carbon monodixe, etc.

Line 129: “estimate cloud particle sizes” cloud and particles are both nouns in this context and is not correct. “cloud particle” is like saying “car vehicle”. Suggest using “estimate droplet sizes” or “estimate hydrometer sizes”

Line 130: Delete “by the particle”

Line 132: Be direct, what does “its” refer too. The particle, the cloud, ??? Suggest “provide additional information about cloud micro-physical properties such as the droplet number concentration.

Line 133: A well organized paper does not need to state what will be talk about, just talk about it. Delete line 133-138

Line 141-145: A pagagraph is not one sentence, combine with next paragraph.

Line 141: It is not the diode laser that has a Gaussian intensity distribution but the laser beam's cross-section that has a Gaussian intensity distribution. Need to talk about the cross-section here because the laser beam would be two dimensional and where as the cross-section would be one dimensional.

Line 153: Having to state that something will be described later is a clear indication that an article is not ordered correctly. Move lines 141-153 to end of section 2.2 and then remove line 153 since it will not be needed when reordered. Furthermore, Line 141-142 follows from discussion of figure 4 later in section 2.2 and anthoer reason to move this material.

Line 164: Assume 22 um droplets is 22 um diameter droplets. Should state.

Line 164: Why was 22 um droplets used? Accuracy of the map would increase with smaller droplets; however, the intensity would decrease. Would not 10 um droplets provide sufficient intensity? Or even 5 um droplets. Could these small sizes be produced?

Line 165: Should include the length and width values used to come up with this area. Maybe label these values on Figure 4.

Line 186: Poor name for this section, you can not just retrieving data but doing a droplet size

inversion; hence suggest “Droplet Size Inversion”

Line 188: “ambient”???? Ambient means surrouding area or environment. Not very useful word here. To get size distribution information you are using peak intensities from the avalanche photodiode.

Line 191: Suggest “real” instead of “ambient”. If not “real” then “Atmospheric” has the same letter for equations that follow.

Line 192: You do not describe what i and j represent. Suggest “Mathematically, the atmospheric size distribution is represented by the row vector A, with bins (i) of from 1 to n. The measured size distribution is represented by the column vector M, with bins (j) from 1 to m.”

Line 253: Change to “with a real refractive index of 1.33 (liquid water)”.

Line 255: Transformation matrix is not for an individual BCP but for an individual set of samples or time interval. There is not a single T for a BCP but for a set of measurements. Believe this need to be made clear here.

Line 256: Why 5 to 90 um and not 5 µm to 75 µm which is the size interval of the BCP line 229.

Line 256: Why start at 5? Anything smaller doesn't scatter sufficient light to have a peak about the noise level?

Line 260: “particles” Should probably use drops or droplets since you are using refractive index of 1.33 (water). Likewise, further on use droplet if you are making assumption of 1.33 refractive index.

Line 264: Why do the distribution cut off at 12 um for a 40 um particle. Seem that this may be related to a limitation of your software. Should there not be some probability of sizing between 5-12 um? Please explain.

Line 272-274: Delete. No need to tell me what is in the next section, I'll just read it.

Line 307: Why is 100 m conservative. 1 second sampling interval and slow jet would give you 100 m.

Line 334-343: Here you talk about particles with reflective index of 1.33 and should be called droplets and not simply particles.

Line 360: I don't understand about the nose being the best location. Further back on the fuselage the airflow streamlines should be less affected by the aircraft.

Line 366: Where was the detection threshold of 0.1 cm^-3 previously stated? I see online 308 a value of 0.03 cm^-3. Are the units correct here. Doesn't really matter, if the TAS is only know to within a factor of two, then sample value is only this good and so is the concentration and optical depth.

Line 375: 250 ms^1??? Should be 250 m/s or 250 m s^-1.

Line 384: Factors 1 and 2 are labeled but not 3.

Line 386: Should it be “over a range of values”

Line 386-391: Very long sentence that is difficult to understand, please shorten and rephase.

Line 420: Be direct and state what “This” refers to.

Line 445: Need comma after “aircraft”

Line 447: Delete “to measure size distributions” repetitive since you state that you compare with other spectrometers.

Line 447-451: No need to state what is in the next sections. Suggest not having subsections. Just Flight Results or if you want to section, then “Research Flights” and “Commercial Flights”

Line 453-454: Delete/combine with other sentences.

Line 456: “on flights” instead of “in flights”

Line 457: No need for comma before and Check document for correct use of commas

Line 466-467: Even on wing pylons, probes can be affected by the aircraft and hence not in free air? Delete.

Line 467-470: Delete, leave this until the discussion section.

Line 473: “during a four hour flight” Be direct and state what flight (day, flight id).

Line 474: Delete “Also shown with the .. temperature.” This describes the figure and should be in the figure caption.

Line 475-477: Not the way I would think about this. I would calculate the sample volume using the best information and then say that the concentration was multiplied by 0.5 to adjust the concentration to be similar to the other probes.

Line 478-483: Place description about the figure in the caption and provide the interpretation here. Revise.

Line 482-483: What about breakup of water droplets on leading edges. I would not talk about possible fragmentation here. Enough to say that you are sampling a liquid cloud during this period.

Line 487-488: Speculation about measuring accumulation mode aerosols is incorrect. First, there are very few accumulation mode aerosols from 0.5-3 um, second this is an in cloud measurement and all large aerosols would be in cloud droplets. Furthermore, the CAS has is a spectrometer so just plot the concentration from 5-50 um. Likewise for the CDP, just plot concentration above 5 um. If you plot this concentration then there is no need for any speculation.

Line 493-499: Not clear what parameter the author thinks is affecting the airspeed. Yaw angle would not be related to altitude. Typically, the yaw angle doesn't change much. Are you talking about attach angle?

Line 493-502: I don't believe that this speculation is correct. The sampling period is too long and in cloud and out of cloud data are being sampled. Have you looked at high resolution data? I would suggest plotting 1 Hz data for this comparison.

Line 504-511: I see no reason to do a LWC comparison. Do a comparison of the mean diameter and standard deviation of the mean. This is what has been talked about previously.

Line 513-520: 100 seconds is too long of a period. I suggest showing the spectrum every 10 seconds. Put each spectrum in a different color and use different line types for the different probes.

Line 523: Do not use acronym (BCP) in section headers.

Line 525-531: Repeating previous material. Delete, combine figure 13 with Figure 3 and move text there.

Line 533: Be direct and state what “this instrument package is”

Line 542: 20 second at what concentration, is it a 20 second average?

Line 542-547: Delete, this is just describing what is in the figure which should be in the figure caption. Text should present interpretation of the data.

Line 549-553: Delete should be in table caption.

Section 3.2: Delete this section and move material to other section or to captions.

Line 573: State a number for how good. “qutie good” is not scientific.

Line 575: Delete “Expanding ... 2.4,”

Line 577: Boundary layer of what? The atmosphere????

Line 578: Reference, here.

Line 579: “all” have you checked? Best to reference one and go from there.

Line 581: Again reference, why 20 um. Doesn't this depend on air speed?

Line 592: Why 100% and not 50% or 150%? Seems like just pulling a number out of the air.

Line 594: Have you checked with the aircraft manufacturer for air flow information. Lot of commercial aircraft have extensive flow modeling to find thing like static port points.

Line 594-599: Are you sure, the small particles could be following stream lines and large particles have sufficient are sampled because they do not follow the streamlines. High resolution, detailed comparison of the mean volume diameter (MVD) on the research flight should indicate if this is an issue. Do the commercial flights have MVD over all size ranges, similar to the research flights?

Line 663: Define cloud encounter, concentration averaged over what time.

Line 669-670: I don't understand the four layers. Looks like two layers. Again, higher resolution data.

Line 682-683: Present the conclusion of this paper, not other papers.

Line 779: Provide a caption not just a title for the figure. What defines a region? How is cloud encounter define?

Figures:

Figure 1 - Text, items in () are not read as part of the sentence, which would make the caption not make sense. Suggest “The principal optical components of the BCP are shown in the top section and the bottom pictures shows the BCP with dimension and total weight.

Figure 1 – Assume the 500 gm is 500 grams so shouldn't this be 500 g? Also, in Figure 2, the weight of the CDP is given in kg. Use either g or kg but don't switch between them.

Figure 1 – Please add the third dimension in the picture, the height of the probe, looks like 3-4 cm. Also, would be good to give the diameter of the outside plate the is mounted to the fuselage, either in the picture or in the text.

Figure 1 – Can you label the Blue Arrow as “Air Flow”. Also, What is the line or number 1 for next to the laser beam lines and next to “4 cm”. Can these be deleted? Also, should not “skin” and “optics” be capitalized?

Figure 1 – Figure captions should be independent of the text. Hence, all acronyms like BCP need to be defined in the text. Likewise for other figures.

Figure 1 – I don't get what the blue circles are indicating in Fgiure 1A. This can't be the area that droplet are confined to. It can't be the area over which droplets are detected because it is in the beam. I would suggest removing the circle and puting in a blue section of the laser beam to indicate the area over which droplets are detected by the Photo-detector.

Figure 1 – In this figure, the detector is called a photo-detector but in the text it is a “Avalanache photodiode”. Please use the same term in the figure and in the text.

Figure 1-17 – Suggest removing the blue box. The box just adds a lot of white space. Better to just make the figures larger.

Figure 2 – How about labeling the width of the CDP?

Figure 2 – Use either g or kg but not both.

Figure 2 – Figure captions should only describe the figure and interpretation of the figure discussed in the text. The text sentence does not make sense. Suggest “Picture showing the Backscatter Cloud Probe (BCP), the Cloud Droplet Probe (CDP) and the Forward Scattering Spectrometer Probe (FSSP). The size and weight of each probe are given by the labels.

Figure 2 – I would suggest using different cloud fonts for the text of each instrument. Also, if you want, include the year introduced as a label in the figure.

Figure 3b – Description for the Citation (CE-550) could be better. The BCP was not mounted inside the radio compartment, no compartment at this location. The BCP was mounted on one of the hard points that has been added to the Citation for research purposes. Also, might be best to say that the BCP was behind the co-pilot's seat and ahead of emergency exit door.

Figure 4 – Units on the y-axis. Assume the unit is mm.

Figure 4 – The resolution is not 10 um. The spacing of the droplets was 10 um. The droplets themselves were 22 um.

Figure 4 – Why smooth the image? I would like to see an unsmoothed image. If you have to provide a smoothed image, what is the smoothing factor. Can't reproduce image or make a compare one without this informaiton.

Figure 4 – Provide a color bar legend at least in terms of digital number. Is there no way to easily transfer the color to a scattering intensity?

Figure 5 Line 900-902 Text refers to water and assumes 1.33. Also, inversion is only for droplet larger than 5 um. Hence, your red line example should be for water of 5 um or larger. Which does not have nearly the difference in optical diameter as the one you illustrate.

Figure 6 Line 906-910 Use droplet here because you are talking about water and not any particle.

Figure 7: The color lines can't be Atmospheric (ambient) distribution but the BCP measured distributions that need to be inverted. Labeling them as Atmospheric distribution would infer that they have been inverted. Please correct or explain how I am misunderstanding the figure.

Figure 8: Fonts are very small. Should be approximately the same size as the caption text. I don't see why we need three examples. Suggest only showing A and B.

Figure 8: Distribution are not very realistic when compared to real cloud observations. Suggest a peak at 12 or 15 um and not 20 um. Remove figure C you would only have to go up to 40 um. Most real clouds have standard deviations of 2-4 um.

Figure 9: Caption Need space between 10 and um. Figure text needs to define chnls and dbar.

Figure 10b: Use linear scale 0-500 for concentration. Will make the comparison look a lot worst.

Figure 10b: Use temperature scale of 10 to 20 C.

Figure 10b: What is the blue box for?

Figure 10: Provide a description of the figure. Data for what day, for what aircraft, for what location. Define acronyms. Fonts too small. What is the sampling frequency being presented? What is the approximate speed of the aircraft?

Figure 11: Define IWC, MVD in caption. Like figure 10, provide a description of the text. You state

in the caption that plot A is liquid water content but the y-axis label is IWC which I assume is ice water content. Which is it.

Figure 11: I would like to see the standard derivations comparison instead of liquid water content (LWC). If there is really a need of LWC, add a standard deviation plot. Having a standard deviation plot would put would Figures 8 and 9 in the context of real cloud observations.

Figure 11: Describe the data, what day, location/field project.

Figure 12: Use “liquid cloud” or pure liquid cloud instead of all water cloud.

Figure 12: Is the time period the full interval or just what is in the blue box in Figure 10? State in figure caption what seconds the interval is over, even if it is defined in figure 10.

Figure 12: What frequency data was averaged?

Figure 13: Suggest combining this figure with Figure 3 and deleting this figure.

Figure 14: Text in figure is too small. Just label a few key cities and make the text larger.

Figure 14: The x-y ratio of the map has been changed (stretch vertically). Use a standard map project and don't change the x-y ratio.

Figure 14: The yellow diamonds for the arrival/departure airport are confusing. Suggest leaving them off or using a color that is not part of the particle concentration scale. Use black.

Figure 14: What averaging time was used for this data?

Figure 15: Similar comments as on Figure 14.

Figure 17: Delete

Figure 18: I don't understand how there are four layers here, Looks like two layers what a break at 1500 m.

Figure 18: Again what is the sampling frequency? Can you provide higher solution data?

Figure 18: Provide sufficient information (details) so someone else could create this figure. For example what day.