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Atmospheric Measurement Techniques Discussions

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

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A single particle optical spectrometer, the CPS, is described for deployment on radiosondes that will count cloud particles and distinguish water droplets from ice crystals. The design is based on a commercial sensor that measures light scattered from aerosol particles and claims to separate pollen from other types of particles using polarization.

In my opinion, this paper is a long way from publication because it is missing some essential components that would make it a useful contribution: 1) scientific value, 2) Error analysis, 3) calibration details and 4) references to other instruments that measure the polarization state of cloud particles.

1) Scientific value The introduction discusses the importance of clouds and talks about

existing balloon borne cloud sensors but nowhere in the manuscript is there a discussion of either how balloon borne sensors contribute to the science or, in particular, how the sensor described in the paper, the CPS, will provide anything useful to our understanding of clouds. Based on a number of statements made throughout the paper, I don't think that the authors have a very strong knowledge of cloud physics. They refer to "dense clouds" as those with concentrations of 2 particles per centimeters cubed, the limit to their sensor's measurement capability. This is only the case for some cirrus clouds but certainly not for any low to mid-level water or mixed phased clouds.

Hence, the 2 cm3 coincidence threshold really makes this sensor useful only for cirrus clouds and you don't need a polarization detector to tell you that you are in all ice. This makes the CPS just a cloud detector with no useful information on the number concentration until it get high in the atmosphere.

In addition, the assumptions that are made about the difference between the polarization signal from water and ice are wrong. They state that the polarization by water droplets is nearly zero but if they do the calculations, they will discover that only at 180 degrees is this true. Water droplets will change the polarization state at angles less than 180 degrees and as a function of size. Hence, unless this bias is taken into account, the detection system as currently set up will classify some water drops as ice. This bias is clearly shown in Figs. 6a and 9a.

2) Error analysis No paper on measurement technique should be allowed publication without a serious error analysis and error propagation. The number "factor of 2" is given for concentration uncertainty but that is based on a very crude analysis. Given the many factors that affect the flow through the sample tube, the particle velocity can fluctuate much more than that. The suggestion that the transit time can be used to estimate the particle velocity is not valid. A number of things impact the transit time. If the authors would have shown a frequency histogram of transit times, I think it would show values varying by more than factors of three. The reason is that measuring the transit time from threshold to threshold makes the transit time sensitive to particles

size. Secondly, if the laser used has a Gaussian intensity profile, then the transit time will depend on where the particle passes through the beam and how far from the center of focus.

Nothing is said about how particles are constrained to go through the most intense portion of the laser beam. What is the sizing error due to passing through edges or away from the center of focus. Laser beams diverge so the scattering intensity from same sized particles can vary widely.

Is there a polarized filter in front of the laser to insure linear polarized light? If not, polarized laser diodes, particularly inexpensive ones, will have some fraction of the light in a different plane of polarization. This will bias the signal measured by the polarized detector

How is the sample volume defined? What is the uncertainty in the sample volume? Why use a sample volume that is at last 100 times larger than necessary and limits the concentration due to coincidence? Has this sample volume been mapped out?

3) Calibration "Rough particles" are mentioned as calibration for the polarization channel. What are rough particles?

Where are the calibration curves with water for I125? That would clearly show that there is a size dependent polarization signal for water droplets.

Where is the mapping of the sample volume?

4) Polarization references There are now a number of instruments that use measurements of the polarization ratio to differentiate spherical from non-spherical particle yet no mention is made of them. This is a significant oversight. There are a number of IN counters that do this, as well as the CAS-POL and CPSPD that differentiate water droplets from ice crystals looking at backscattered, polarized light.

In summary, unless the authors can better demonstrate that the CPS will provide any useful cloud property data, this paper should not be accepted for AMT.

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