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Atmospheric Measurement Techniques Discussions

Interactive comment on "Cloud thermodynamic phase detection with polarimetrically sensitive passive sky radiometers" *by* K. Knobelspiesse et al.

Anonymous Referee #1

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This is an important and well-written paper, which seeks to use the information in the polarized channels of AERONET sunphotomters in zenith-pointing cloud mode for cloud thermodynamic phase retrieval. Due to the nature of polarized RT, it works well for low scattering orders (up to optical thickness of 13), and thus complements other methods that are less sensitive to phase at small optical thickness. This is very desirable and could be emphasized more, as well as the innovative idea of using Q instead of DoLP (essentially proportional to abs(Q) in this case). The manuscript is well structured (progressing from "theoretical basis" to "data exploration" and keeping the uncertainty analysis in the appendix), except that instrument details could be introduced

sooner (which channels are polarized, # of instruments within AERONET, noise/error characteristics, radiometric stability, if available).

In addition to several minor comments below, I only have one major question/comment: When it comes to data exploration, why did the authors choose such a complex scene as first validation case, rather than episodes with homogeneous liquid or ice clouds, and progress to more complicated, mixed scenes later on? In the list of possible explanations for the Q variability ("noise") in Figures 12 & 14 on page 12009, I am missing another, *physical* explanation: Is it possible that the detected radiation has interacted with multiple cloud elements, some liquid and some ice for spatially complex scenes? Can all of the Q variability in Figures 12 & 14 be explained by random noise? Or what fraction of it? Could the data be filtered using a metric for cloud variability and/or number of layers to check whether the spread reduces when limiting data to fairly homogeneous and single-layer episodes?

While many polarimetric applications are not affected much by spatial structure because they are primarily based on single or low-order scattering RT, the situation is different here because the radiation has undergone several scattering events (even if they occurred at some horizontal distance from the detector, say, in a wisp of a Ci before interacting with a low-level Cu directly above the detector) and thus retains information of *all* the cloud particles that it encountered in its course – until it gets "washed out" above COD$\sim$13. It is surprising that this possibility is not discussed at all in the manuscript. At a minimum, it would be nice to see a short statement explaining why spatial structure, and the interaction with both liquid and ice clouds can be ruled out as the reason for the unexpected variability in Q. Finally, are multi-layer clouds with variegated phase a possible explanation, and does the MPL provide information about that? Could lidar curtains be shown, instead of cloud base only? (Of course, this will only work for optically thin cases.)

Sequential comments (both minor content comments & minor language comments):

P11992,L15: "quantity" of polarization is somewhat unspecific. How about "contrast" between liquid/ice for the second element of the Stokes vector

P11992,L24: "comprise" or rather "constitute"? Something seems wrong with this sentence.

P11992,L26/L27: "For this reason, we had no information..." From the abstract alone, one cannot see the logic connection here. The uncertainty aspect is an important part of the manuscript and should be mentioned here, but perhaps a little bit more detail would help.

P11992,L27: "Since this uncertainty. . ." Not enough detail is given here - what uncertainty are we talking about - is this statement needed? If so, a better description of DRAGON and its relevance for this paper is needed.

P11994,L1: ". . .our ability to improve climate models. . ." This is a "broad-brush" statement which should either be made more specific or omitted (the manuscript does not seem to need this kind of motivation).

P11995,L9: "To correspond with AERONET instrument spectral sensitivity. . ." What does the spectral sensitivity have to do with the selection of channels? Also, CIMELs are not spectrometers, so "radiometric response" would be more appropriate than "spectral sensitivity".

Figure 2: Add a line at viewing angle of 0deg?

Figure 2/3: The "crossover" point of Q_liq and Q_ice at about 30deg in Fig 2 is interesting, but not sufficiently explained in the text. Is it related to the crossover shown at $\sim$15deg in Figure 3b?

Figure 4: This is a very nice Figure, almost the "paper at a glance", which explains very nicely why using Q is superior to DoLP (or abs(Q) in this case, since U->0).

P11998,L5: "at left" –> "on the left"

P11998,L17: Fix "The optical depth. . .occurs at. . ." (this sentence does not work, use "value. . ." ". . .at which" instead?)

P11998,L18: "converge to zero for COD>13" is clear, but could be formulated better, perhaps using something like e-folding value of COD or something similar?

P11999,L20: "Since cloud chamber, in situ and remote sensing. . ." please remove comma, otherwise sentence becomes incomprehensible. Alternatively, omit "since" and break up the sentence in two, starting a new one as "Therefore, we have performed. . ."

P12000,L1: "measurementperspective" –> "measurement perspective"

P12000,L5: "totally" –> "completely" (totally sounds too colloquial)

P12001,L12-15: This overview paragraph may be more appropriate earlier on in the manuscript (introduction). Also, I think that the authors are too modest in their assessment that their method is not as powerful as others. Rather, the various different methods complement one another and have their specific advantages/disadvantages.

P12002,L7: Is the 1640nm channel used in this study? It is not shown in Figure 7 and would be interesting to include.

Figure 11 and discussion: I wonder why the authors chose such a complicated scene for initial algorithm tests (see also major comment above).

Figure 11+13 are hard to read, enlarge?

Figure 11: Add Q=0 line horizontal line?

Figure 12: What is the range of dates that was used to generate this figure?

P12004,L27: What kind of noise? And how does the Figure show this? Can the deviations (Q up to +0.2 and -0.2) explained with the uncertainty analysis performed in the appendix, and be traced back to random noise, or do they exceed these values? Is

it possible that there is also another physical explanation for this (see major comment above).

P12005, Figure14. This is good because the negative correlation of cloud base height and Q is what we want to see! Maybe this should be emphasized more because Figure 12 does NOT show it.

Interactive comment on Atmos. Meas. Tech. Discuss., 7, 11991, 2014.