Atmos. Meas. Tech. Discuss., 8, C2558–C2561, 2015
www.atmos-meas-tech-discuss.net/8/C2558/2015/

Atmospheric Measurement Techniques
Open Access
Discussions

AMTD
8, C2558–C2561, 2015

Interactive Comment

Interactive comment on "A better understanding of POLDER's cloud droplet size retrieval: impact of cloud horizontal inhomogeneity and directional sampling" *by* H. Shang et al.

B. van Diedenhoven

bastiaan.vandiedenhoven@nasa.gov

Received and published: 13 August 2015

This is a short comment on the manuscript entitled "A better understanding of POLDER's cloud droplet size retrieval: impact of cloud horizontal inhomogeneity and directional sampling" submitted to AMTD by Shang et al. It is not my intent to provide a full review to the manuscript.

The manuscript submitted by Shang et al. presents a study on the effect of horizontal inhomogeneity on retrieval of the effective radius and variance of cloud droplet size distributions using multi-directional polarization data. It is concluded that sub-pixel cloud

Full Screen / Esc
Printer-friendly Version
Interactive Discussion
Discussion Paper

inhomogeneity causes large biases in the retrieved size distribution properties over the larger pixel. However, this conclusion is based on a fundamental misunderstanding of the averaging properties of drop size distributions, as explained below.

In section 3.1, a sensitivity study is performed using simulated measurements of a POLDER-like pixel of which one third is covered by a cloud with a droplet effective radius (CDR) of 10 micron and an effective variance (EV) of 0.01 micron, a third is covered by a cloud with CDR= 15 and EV= 0.01, and the other third is covered by a cloud with CDR= 20 and EV= 0.01. The conclusion is that "the retrieved CDR based on mean reflectance of inhomogeneous pixels tends to be bigger than the mean of the sub-pixel CDRs. Furthermore, the retrieved EV was greater than that at the sub-pixels . . .".

This conclusion is presented as a problem but in fact is entirely expected when the distributions are assumed to be equally mixed. Since polarized reflectances are mostly produced by singly scattered light, it is reasonable to assume that the polarized reflectance of an inhomogeneous pixel can be represented by the polarized reflectance from the mixtures of the particles. However, in the manuscript it is assumed that (1) the mixture of two or more gamma size distributions is another gamma size distribution; and (2) the mixture's size distribution has an effective radius and variance that is simply the average of the effective radii and variances of the sub pixels. Both assumptions are not correct.

As discussed by Alexandrov et al. (2012), the effective radius and variance of any size distribution can be obtained from the second, third and fourth moments of the size distribution. For mixtures of gamma distributions with a constant effective variance, Alexandrov et al. (2012) also give formulas for the effective radius and variance of the combined distributions, which are computed from the average moments of the size distributions and are clearly not simply averages of the effective radii and variances of the gamma distributions that are combined. For the example given by Shang et al. and summarized above, the correct effective radius is 17 micron, while the effective

AMTD
8, C2558–C2561, 2015

Interactive Comment

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

variance is 0.065, which is close to the retrieved values of 16 and 0.1, respectively, especially considering that the selection in variance in the retrieval look-up-table is minimal (i.e., 0.05 and 0.1).

For a visual illustration, the three size distributions of the example given by Shang et al. are plotted in the figure below (black lines). The figure also shows the combined distribution (black-dashed), which is distinctly tri-modal and not shaped as a gamma distribution. The distribution with the average effective radii and variance is simply the middle gamma distribution (CDR=15 and EV=0.01), which is clearly not representative of the combined distribution. Also plotted in the plot is the gamma distribution that has the same moments as the combined distribution as explained above (red-dashed), which is clearly more representable of the combined distribution.

In summary, the assumption that the effective radius and variance of the size distribution in an inhomogeneous pixel is simply the average of the effective radii and variances of the size distributions in the sub pixels is wrong. The correct averaging procedure for size distributions needs to be applied to the analysis in this manuscript and the conclusions need to be adapted accordingly.

Aside I note that a method to retrieve properties of multi-modal size distributions was recently presented by Alexandrov et al. (2012b, see below). I suggest including this reference in the discussion.

Alexandrov, M.D., B. Cairns, and M.I. Mishchenko, 2012b: Rainbow Fourier transform. J. Quant. Spectrosc. Radiat. Transfer, 113, 2521-2535, doi:10.1016/j.jqsrt.2012.03.025.

Interactive comment on Atmos. Meas. Tech. Discuss., 8, 6559, 2015.

AMTD
8, C2558–C2561, 2015

Interactive Comment

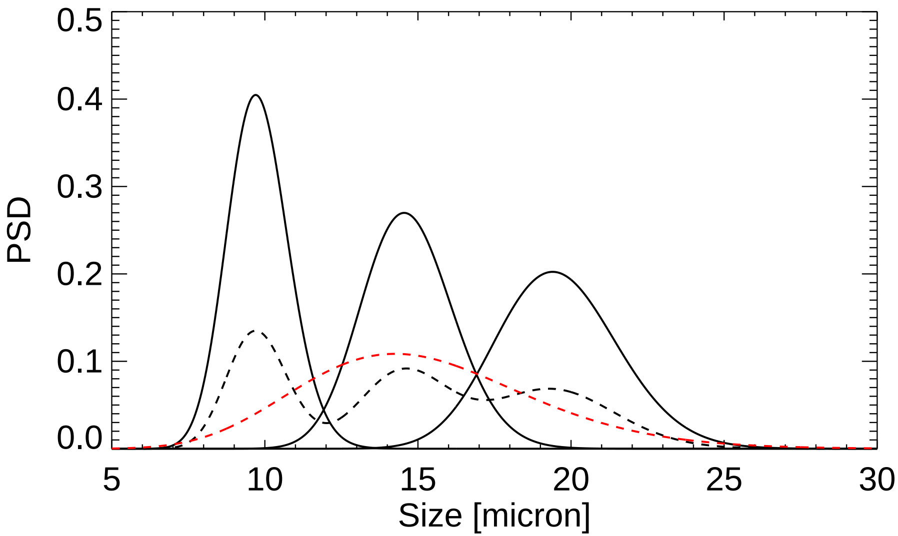

Fig. 1. Size distribution mixing example (see text).

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper