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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Simultaneous retrieval of aerosol and cloud properties during the MILAGRO field campaign" *by* K. Knobelspiesse et al.

Anonymous Referee #1

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General comments

The paper presents a method to retrieve aerosol properties above clouds. The method is applied to a scene observed during the MILAGRO field campaign, where the Research Scanning Polarimeter (RSP) overflew an aerosol layer lofted above a low altitude cumulus cloud. The retrieval approach works as follows: First guess cloud size distribution parameters are determined using features in the angular polarized reflectance, in particular the cloud bow. In the next step aerosol optical properties and cloud properties are varied in a multiple scattering radiative transfer model. Using an optimal estimation approach the parameters which best match the measurements are found. The method requires assumptions about the aerosol vertical distribution (obtained from other instruments on the aircraft) and the optical properties of the coarse

mode aerosol (climatological data). Using this method it was possible to retrieve various parameters with high accuracy: aerosol optical thickness, fine mode aerosol size distribution, and the cloud size distribution. The real part of the refractive index and the single scattering albedo can only be retrieved accurately for higher aerosol optical thickness. The presented study is a test of the capabilities of scanning polarimeters to retrieve aerosols above clouds. It was found that the retrieval works well in particular when additional information about the vertical distribution of the aerosol is available. Therefore the method could have been applied to measurements of the Aerosol Polarimetry Sensor (APS) if the GLORY satellite would have been successfully launched and be part of the A-Train, where simultaneous CALIPSO measurements would be available. Multi-angle polarized radiance measurements certainly yield much more accurate information about aerosol properties compared to non-polarized measurements.

The paper is well organized and well written. I recommend to publish the paper after minor revisions.

Specific comments

- The initial values of the cloud distribution are determined by using a lookup table (LUT). Using the single scattering approximation, the polarized reflectance Q is directly obtained from the single scattering properties. The measured Q is then matched to the LUT in order to find initial cloud size distribution parameters. The authors claim that the polarized cloud reflectance is insensitive to multiple scattering as a justification for this procedure. This is not true, polarized reflectance is less sensitive to multiple scattering than total intensity (as it is also stated in Goloub et al. 2000), but still multiple scattering can not be neglected for clouds. Why is the single scattering approximation used to generate the LUT? I guess it would not take much effort to use the multiple scattering doubling and adding code to generate it and this would yield more accurate initial values.
- On p. 6382 the authors state that the modelled Q is generally lower than the

measured Q. Is Q modelled here using multiple scattering? If the single scattering approximation is used, this could explain the deviation.

- How are the cloud scattering phase matrices treated in the doubling-and-adding radiative transfer code? The phase matrix needs to be expanded in a Legendre series with thousands of terms to accurately represent the forward scattering peak and features like the cloud bow. Accurate calculations would be computationally too expensive to be used in an optimal estimation type retrieval. The authors should clearly state which approximations are made in the radiative transfer calculations.
- size distributions should be specified more precisely (e.g. radius grid resolution and cutoff-values used for Mie calculations)

Technical corrections:

- p. 6364 l. 14: "size distribution" -> "size distribution parameters", not the full size distributions are retrieved but parameters of assumed gamma and log-normal distributions
- p. 6347, l. 9: "effective radius" -> "effective variance"
- p. 6386, l. 2: "t o" -> "to"

Interactive comment on Atmos. Chem. Phys. Discuss., 11, 6363, 2011.