Atmos. Chem. Phys. Discuss., 14, C8810–C8816, 2014
www.atmos-chem-phys-discuss.net/14/C8810/2014/

Atmospheric Chemistry and Physics
Discussions

Interactive comment on "Absorption of aerosols above clouds from POLDER/PARASOL measurements and estimation of their Direct Radiative Effect" *by* F. Peers et al.

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Received and published: 5 November 2014

General Comments:

The submitted manuscript presents a comprehensive inversion method for retrieving above-cloud aerosol optical thickness (ACAOT), single-scattering albedo (SSA), cloud optical thickness (COT) from the multi-angle, polarized, and total radiance measurements made by POLDER instrument onboard PARASOL, of the above-cloud aerosols (ACA) scenes. The present method takes advantage of both kinds of measurements, polarized and total radiance, to first derive the scattering AOT owing to greater sensi-

tivity of polarized radiances to the scattering processes and then after, employs total radiance measured by POLDER along with the information on scattering AOT derived in the first step to estimate SSA and aerosol-corrected COT. The technique is being tested for above-cloud biomass burning and dust cases often found over the south-eastern Atlantic Ocean and the Sea of Okhotsk. Author also develops a procedure to estimate the direct radiative effects of ACA using the aerosol and cloud properties retrieved from POLDER data. The monthly mean DRE of ACA scenes observed over the south-eastern Atlantic Ocean turns out to be 33.5 W/m2. Finally, author simulates the effect of cloud heterogeneity on the aerosol and cloud retrievals for which, it was found that the assumption about the homogeneity of cloud affects the retrieval of cloud retrieval more than that of aerosols.

In the recent years, the topic of aerosols above cloud has received much needed attention from the aerosol as well cloud community. Particularly, the development of satellite-based algorithms that make use of different kinds of measurements, i.e., UV (OMI), visible (MODIS), polarization (POLDER), and active lidar (CALIPSO), have provided unprecedented regional and global maps of ACAOT. The work carried out by the POLDER group including author (this paper) and Waquet et al. (2009, 2012) has been an important contribution in this area. The topic itself is germane to the community and the present manuscript fits quite well within the scope of the ACP.

While the present work brings new information on the character of particles (SSA) of ACA scenes, I find a fundamental limitation of the POLDER approach presented in this paper. First, author retrieves scattering AOT on the basis of retrieved total AOT and assumed SSA using an algorithm developed by Waquet et al. (2008). The retrieved total AOT has been shown to be sensitive to the assumption of real and imaginary part of the refractive index (Table 1 in this manuscript). In the second step, the total radiance measurements and 'retrieved' scattering AOT was used to estimate the imaginary part of the refractive index and aerosol-corrected COT. In this way, the retrieval logic makes a full circle, i.e., starting with an assumption about SSA to retrieve total/scattering AOT and use the scattering AOT again to retrieve back SSA. Estimation of SSA of aerosols above cloud requires independent direct measurements of AOT such as from airborne sunphotometer or High Spectral Resolution Lidar (HSRL)-like extinction retrieval which are free from assumption about aerosol model.

Author highlights in the paper that the uncertainty in scattering AOT can be greater due to wrong assumption of SSA for larger aerosol loading which is frequently observed over the south-eastern Atlantic Ocean. Under these circumstances, the reliability of SSA retrieval and further estimation of DRE is questionable. Additionally, the manuscript is devoid of an uncertainty analysis of SSA retrieval given the realistic bounds of error in the scattering AOT.

Overall, the paper is well-written, structured, and covers important aspects of the present method except the flaws in the retrieval logic explained above. “Specific comments” on this manuscript are listed below for which author is asked to provide a one-to-one response. Given that author defends the retrieval logic adequately, the manuscript can be accepted for publication in ACP.

I look forward receiving the revised version.

Best,

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Specific Comments:

Page 25534, Line 2: While most satellite retrievals of above cloud aerosols...

Page 25534, Line 19: +33.5 W/m2 (warming)

Page 25535, Line 11: Since the DELTA_RHO is a strong function of AOD and SSA of aerosols above cloud, adding the simulation for SSA of 0.9 would highlight the sensitivity of TOA reflectance to the aerosol SSA. What is the value of AOD assumed for this simulation? Since the interest here is to estimate aerosol forcing above cloud, a similar plot as a function of cloud optical depth is desirable.

Page 25535, Line 19: contribution instead of importance

Page 25537, Line 6: Jethva et al. (2014) have carried out a multi-sensor comparison of the above-cloud AOT retrieved from different sensors on board NASA’s A-train satellite.

Page 25537, Line 8: "..results have shown good consistency over the homogeneous cloud fields".

Page 25537, Line 20: While this method is expected to work efficiently for the fine mode aerosols as their interactions at longer wavelengths are minimal or even nil. it may not work for coarse mode dust aerosols due to their radiative interference at longer wavelengths.

Page 25541, Eq 2: Here, I have a fundamental question to the author: First, the POLDER retrieval algorithm retrieves total AOT assuming a model with a fixed value of SSA. What is the sensitivity of the AOT retrieval to the assumed value of SSA? Figure 2 has demonstrated the sensitivity of polarized radiances to the imaginary index around the scattering range angle 140-145 deg.

Page 25541, Line 25: provide an appropriate citation.

Page 25541, Line 27: Do author retrieve ACAOT over sun-glint areas?

Page 25542, Line 15: Where is the UV wavelength in Figure 4? I can see 490 nm (visible) and 865 nm (SWIR) in this figure.

Page 25542, Line 18-19: This is called the 'color ratio' effect. Since aerosol absorption has a spectral signature, it produces stronger absorption effects at shorter wavelengths than at longer ones.

Page 25543, Line 1-5: What is the SSA for the reference case?

Page 25543, Line 13: Author should list the % change in AOT and SSA retrieval in Table 3. It is easier to understand.

Page 25543, Line 20: The climatological value of SSA at 865 for the AERONET station 'Mongu' situated in the central Africa region is about 0.78. The ratio of AOT between 865 and 500 nm for the biomass burning season (July through September) is about 0.35. During active burning period the AOD at 500 nm often exceeds a value of unity. Under these high aerosol loading conditions, the wrong assumptions of both real and imaginary part of the refractive index will lead to significant error in the retrieval of scattering AOD and then in the SSA estimation using the present method. Also, it is desirable to have a simulation in which the real as well as imaginary part of the refractive index go wrong in such a way that it results in the total error in scattering AOT and SSA. This will give an estimation of the bounds of errors. Author should also mention here that though the retrieval of AOT is less sensitive to the assumption of imaginary part of the refractive index, the error is much larger due to wrong assumption of the real part of the refractive index.

Page 25543, Line 24: how the dust retrievals are impacted by assumption of real and imaginary part of the refractive index? A sensitivity analysis, similar to smoke particles, is needed here.

Page 25545, Line 7: What is the range of wavelengths considered as 'shortwave'?

Page 25545, Line 9: It implies that author assumes 'grey aerosols' for the DRE calculation. For smoke particles, it means that the black carbon is assumed to be a sole component of carbonaceous aerosols.

Page 25545, Line 23: "..weakly impacted by the change in cloud top height"?

Page 25546, Line 1: Either rephrase or remove this sentence.

Page 25546, Line 13: It is winds that favor the transport of smoke over ocean and not stratocumulus cover.

Page 25547, Line 2: Did author check the value of SSA (870 nm) retrieved by AERONET at Mongu-an inland station for the Aug 4, 2008 time frame? Page 25547, 2nd paragraph: The absolute difference between two COTs does not tell the full story. A plot of % change in COT (ACCOT minus MODIS MYD06 COT) as a function of retrieved AOT would explain how the absorption is impacting the standard MODIS cloud product.

Page 25548, Line 5: "..significant production of smoke particles".

Page 25548, Lin8: "On 3rd July, aerosols have been..."

Page 25548, Line 15: Did author compare MODIS cloud-free ocean retrieval nearby above-cloud aerosols retrieved by POLDER. Since the smoke plume is lofted well above the surface, both retrievals should provide consistent range of AOT retrievals over ocean.

Page 25550, Line 1: "in the visible (490 nm)"

Page 25550, 1st paragraph: Again, author should check what MODIS retrieves over the clear ocean and what AERONET provides in terms of SSA at stations around the source region. Page 25551, Line 19-20: This is very much consistent with the results of de Graaf et al. (2012)

Page 25552, Line 3-4: Author is appreciated for the honesty of accepting the limitation of the present method.

Page 25552, Line 14: What is the minimum value of COT considered in the estimation of DRE?

Page 25555, section 6: A brief discussion on the uncertainty bounds of the AOT and SSA retrieval, and then after on DRE estimation, is missing in the conclusion section. This discussion should highlight the strength and limitation of the present approach.

Page 25555, Line 20-21: Author needs to be little more cautious here. Before these retrievals are validated against independent direct measurements of AOT above cloud, one cannot arrive at a conclusion about the accuracy of the satellite product.

Interactive comment on Atmos. Chem. Phys. Discuss., 14, 25533, 2014.