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Atmospheric Measurement Techniques Discussions

Interactive comment on "Retrieval of aerosol microphysical and optical properties above liquid clouds from POLDER/PARASOL polarization measurements" *by* F. Waquet et al.

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Reviewer 2

My first recommendation is to better structure the paper and to better point out what the added value is compared to a previous paper from the first author. My second recommendation is to formulate some clear conclusions on the work, and what implications they have for aerosol remote sensing above clouds. This will require some extra work from the authors.

As previously explained (see responses to reviewer 1), (1) we added a paragraph motivations (section 2, paragraph 2.1) that explains in details why the development of a new algorithm for the treatment of Aerosol Above Clouds scenes with POLDER was required and (2) we clearly explained in the new version of the paper the new adding of this work : we are now able to retrieve the mineral dust particles AOT above clouds using measurements acquired in the polarized cloud bow and (3) we reorganized the paper as wished by the two reviewers (see previous responses to reviewer 1)

My second recommendation is to formulate some clear conclusions on the work, and what implications they have for aerosol remote sensing above clouds.

In the conclusion section of the new version of the paper, we listed the aerosol parameters that can be robustly retrieved by the two algorithms. We also explain why the lack of sensitivity of the POLDER polarized measurements to the aerosol absorption properties is a limitation for climate study.

We added the following paragraph in the section conclusion :

“We developed two different algorithms to analyze the POLDER data for AAC scenes. The first one, the so-called research algorithm, allows a simultaneous retrieval of the aerosol and cloud properties and uses POLDER data aggregated at a coarse resolution to have a sufficient angular sampling. The method retrieves the mean properties of the observed particles under the assumption of spatial homogeneity. For clouds, this method also allows to accurately retrieve the cloud droplet effective variance and the cloud droplets effective radius. Our results tend to confirm that the droplets size distribution is narrow in high latitude ocean regions and that the droplets effective radius retrieved from polarization measurements is generally slightly smaller than the one retrieved by passive sensors that uses total radiance measurements, such as the MODIS instrument (departures smaller than 2 μm). In addition, we show that the aerosol parameters that can be retrieved with the research algorithm are: the AOT, the fine mode particles size and the Ångström exponent. The fraction of spherical particles can be also retrieved for mineral dust AAC scenes. The coarse mode particles size, the relative contribution of the two modes to the total AOT as well as the complex refractive index cannot be estimated with confidence with this method. “An operational algorithm was developed to retrieve the aerosol properties for AAC scenes at a finer spatial resolution and at a large scale. This method retrieves the AOT and the Ångström exponent for the fine mode particles and the AOT for mineral dust particles using a non-spherical particles model.” “Any of the two methods described allow the estimation of the aerosol absorption properties and the aerosol single scattering albedo (SSA). However, it is a key parameter for the estimate of the AAC radiative direct forcing. Some assumptions on the aerosol absorption properties will therefore be considered in order to estimate the AAC direct radiative forcing with the data provided by the operational algorithm. For example, a climatology of the aerosol absorption properties derived from ground-based sun-photometer measurements could be used.”

General comments:

- It seems that the polarization measurements do not contain sufficient information to retrieve all aerosol parameters over clouds. The authors conclude that from the fact that 5 retrieval options fit the data equally good. This should be motivated in more detail. For example by doing retrievals from simulated measurements to see what parameters can and what cannot be retrieved. As the paper is now, it could be possible that there is an option 6 that fits the data much better. On the other hand, it is not convincing that the retrieved parameters are reliable as they are now. A synthetic study would make clear the possibilities and limitations. If a method does not work for synthetic data it will neither work for real data. Especially since the retrievals cannot be really validated, such a synthetic study is even more important.

Following the reviewer’s suggestion, we performed a sensitive study analysis with synthetic data in order to check our conclusions (see below).

- It is stated that 3D effects are important, but what would be the effect on the retrieved aerosol and cloud properties? Maybe the errors only affect the retrieved cloud properties. Also, this can be investigated with a synthetic retrieval.

As suggested by the reviewer, we also evaluated the impacts of the 3D effects using synthetic data. We added the following paragraph in the paper :

“To confirm the conclusion obtained in the previous section, we performed a sensitivity study analysis with synthetic data. The particle models and the optical parameters used for the simulations as well as the parameters retrieved with the research algorithm for two different retrieval options are reported in table 4. We use the viewing geometries associated with the hyper-pixel data shown in figure 1-a. We added some noise and calibration errors to the simulations to perform a realistic sensitivity study. We considered 3 cases. For case (1), we ignored the presence of coarse mode particles within the particles size distribution. We considered an AOT of 0.2 at 0.865 μm. For case (2), we added coarse mode particles in the simulations (coarse mode AOT of 0.05 and fine mode AOT of 0.2 at 0.865 μm). Case (3) is similar to case (2), but we reduced the cloud-bow magnitude in the simulations respectively by 4%, 7% and 7%, at 0.490, 0.670 and 0.865 μm, in order to simulate the 3D cloud effects. These values were estimated using the 3D transfer radiative code described in section 2.2.3-b. When we only consider fine mode particles both in the simulations and in the retrieval method (case 1), the algorithm retrieves aerosol absorption properties (mi of 0.013 +/- 0.004) that agree well with the ones considered in the simulations (mi = 0.015). The retrieved aerosol SSA is also in good agreement with the one used in the simulations. When we include coarse mode particles both in the simulations and in the retrieval method (case 2), the retrieved absorption properties are underestimated (mi of 0.006 +/- 0.004 instead of 0.015) and the SSA is overestimated (0.926 +/- 0.045 instead of 0.874 at 0.865 μm). These results indicate that the presence of the coarse mode particles within the particles size distribution perturbs the retrieval of the aerosol absorption properties performed from polarization measurements. These results confirm that the POLDER polarization measurements do not contain enough information to accurately estimate the entire coarse particles properties. This leads to errors on the retrieval of the aerosol absorption properties and then on the retrieved aerosol SSA as the retrieval of the particles size distribution and complex refractive index are connected. The errors on the coarse mode particles properties also affect the retrieval of the complex refractive index. Finally, the 3D cloud effects also impact the retrieval of the aerosol properties. It mainly impacts the retrieval of the AOT (an overestimation of 20% or 0.05 at 0.865 μm) and also slightly affects the retrieval of the aerosol microphysics (e.g. the real refractive index is underestimated).” “We note also that the fine mode particles size, the Ångström exponent and the cloud microphysical properties are accurately retrieved for the three cases. These results confirm that the retrieval strategy used in the operational algorithm is well adapted for the retrieval of the biomass burning aerosol properties observed above clouds. For the operational algorithm, we recall that we use a constant value for the complex refractive index and that we only try to retrieve the AOT and the Ångström exponent using fine mode particles models and data acquired for scattering angles smaller than 130°, where the 3D cloud effects are negligible. The main benefit of using the research algorithm to analyze the POLDER data acquired for biomass burning AAC scenes is therefore to obtain an accurate estimate of the microphysical properties of the cloud particles located below the aerosol layer.”

-Why are there 2 (or even 3) retrieval methods. This needs some more motivation. Is it only computation time. Or is the 1st retrieval method only for a sensitivity study to design a simpler method with less parameters that can be retrieved?

We added a section called “motivations” in the paper, which explains why the previous algorithm described in Waquet et al., (2009a) was not able to handle mineral dust particles. We use two algorithms for the treatment of AAC scenes with POLDER : the “research algorithm” and the operational algorithm. We added a paragraph that describes the aims of both algorithms and their links (see responses to reviewer 1).

The research algorithm is indeed currently too time consuming and cannot be used for a global treatment. This is the main reason that motivates the development of a less sophisticated algorithm (the operational algorithm).

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Interactive Discussion

Discussion Paper

- The phase function truncation method seems not to be suitable to model polarized radiances. What exact procedure is followed in the phase function truncation? To my knowledge the quoted methods are only designed to work for radiance, not for polarization.

The truncature procedure implemented in the SOS code is described in Potter (1970). This is the delta function approximation.

The PFi,j(Θ) are the elements of the scattering phase matrix, PF11_T is the truncated phase function with the sharp peak removed (not normalized) (see fig 1 in Potter 1970 for instance)

We apply a simple ratio to the other elements of the scattering phase matrix :

PF12_T(Θ)=PF12(Θ)* PF11_T(Θ)/PF11(Θ) PF22_T(Θ)=PF22(Θ)* PF11_T(Θ)/PF11(Θ) PF33_T(Θ)=PF33(Θ)* PF11_T(Θ)/PF11(Θ)

Then, we renormalize PF11_T=> PF11_T* (see eq 7 in Potter 1970)

PF11_T*(Θ)= PF11_T(Θ)/A'

All the elements of the truncated phase matrix are also renormalized using the coefficient A' (PFij_T*(Θ)= PFij_T(Θ)/A'). The optical thickness and the aerosol SSA are also modified using this coefficient (e.g. τscatt*=τscatt×A').

The computation of the multiple scattering terms are performed using the truncated phase matrix whereas the single scattering contribution (for both total and polarized radiances) is computed using the exact phase function (Nakajima and Tanaka, 1998).

Please also note the supplement to this comment:
http://www.atmos-meas-tech-discuss.net/5/C3921/2013/amtd-5-C3921-2013-supplement.pdf

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Interactive comment on Atmos. Meas. Tech. Discuss., 5, 6083, 2012.