Study on the influence of different error sources on sky radiance measurements and inversion-derived aerosol products in the frame of AERONET

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The remote sensing of the atmospheric aerosol is a well-established technique that is currently used for routine monitoring of this atmospheric component, both ground-based and from satellite. The AERONET program, initiated in the 90's, is the most extended network and the data provided are currently used by a wide community for aerosol characterization, satellite and model validation and synergetic use with other instrumentation (lidar, in-situ, etc.). However there are still open questions and inconsistencies in the modeling of the aerosol optical properties. For example, there are known limitations in the inversion of sky radiances, especially related to the large uncertainty of the retrieved products from almucantar scans at low solar zenith angles (SZA) or at low aerosol optical thickness conditions. Another topic of especial interest is the analysis of desert dust, which is by far the most problematic aerosol type regarding the adequate modeling of optical properties. Within AERONET, sky radiances are acquired in two geometries: almucantar and principal plane. Principal plane inversions were provided together with the almucantar inversion products at the beginning of the AERONET version 2 direct Sun and inversion algorithm, released in 2006. However the principal plane retrievals were later removed from the AERONET database, keeping only almucantar retrievals considered more stable and reliable, although only at large solar zenith angles. Two problems arise from this situation: first, the monitoring of inversion-derived properties such as size distribution, refractive index and single scattering albedo, which are necessary for the evaluation of the aerosol, cannot be retrieved in the middle of the day. Second, there is a need to find out the reason for the inconsistency between principal plane and almucantar retrievals.

We have investigated to what extent the discrepancies can be a consequence of the measurement procedure. In particular, three systematic errors in the radiance observations were analyzed in order to quantify the effects on the inversion-derived aerosol properties: calibration, pointing accuracy and finite field of view. The aim of this work is to determine how each of the analyzed errors affects the aerosol retrievals in both geometries and try to provide criteria for quality assurance and product error estimations. For this purpose, sky radiances were simulated with the forward module of the Dubovik's algorithm using several aerosol types (desert dust, oceanic, urban and biomass burning), described by the volume size distribution and the complex refractive index. Then the systematic errors were induced and we applied the inversion module to the erroneous radiances in order to compare the retrieved aerosol properties with the original ones.

The results of the analysis show that only the pointing error can cause these discrepancies, since it affects more the principal plane than almucantar (less affected at least from the typical pointing errors considered: 0.2° y 0.4°).

On the other hand, self-consistency test demonstrated that, even for simulated measurements without error, aerosol retrievals at low SZA are distorted due to the lack of information of scattering angles larger than 2·SZA in the almucantar measurements. And what's more, the insertion of the calibration errors presents more influence on the retrievals at low SZA, therefore they can amplify the differences between retrievals at low and large SZA.

Finally we want to remark that most of the investigated errors are more relevant for the desert dust aerosol type: the coarse mode has the worst behaviour in the self-consistency test; the least sensitive to the inversion procedure; and the most affected by calibration errors. These facts, together with the particle non-sphericity, can explain why this aerosol type presents the largest complications in the retrieval of properties from sky radiances.

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