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The truncation problem

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Whatever the method used to solve the transfer equation, the calculation of scattered solar radiation in a plane-parallel atmosphere becomes complicated for large particles (coarse aerosol or cloud droplets), for which the strong forward scattering properties (due to the diffraction peak) leads to a very asymmetrical phase function.
To get calculation of a reasonable time, a truncation approximation such as the one developed by Potter (1970) is commonly used : most of the light scattered at small scattering angles is considered to be directly transmitted and the scattered light is calculated for the phase function which is much less asymmetrical thanks to the truncation of the forward peak. This approximation is very efficient to calculate the radiation reflected back into space. Its only flaw is that it overestimates the scope of localized signatures in a narrow angular interval (i.e. cloud glory, primary and secondary bows), which is of importance for applications such as remote sensing of aerosol above clouds and cloud particles properties retrievals from space (Waquet et al., 2013). In the case of ground-level measurements, the truncated calculation must be completed by an appropriate modeling of radiance in the solar aureole region, as it has been eliminated by the truncation procedure.
In this study, we recall the principle of the truncation and present a simple method to correct its flaws. In a first part, we examine the case of ground-level measurements. In order to restore the aureole, we added to truncated calculations an approximate expression of the successive scattering contribution in the truncated forward peak. Then, we, examines the case of satellite measurements. We reduce the biases found for narrow angular signatures simply by changing the expression of the primary scattering. In both cases, the correction is generalized to polarized light. We show, that for aerosol particles (0.1 – 2 microns) and cloud droplets (10 microns), most of the biases observed in narrow angular interval are eliminated for the radiances and polarized radiances simulated for a space sensor. Only minor biases remain for the downwelling radiation and its polarized component. Then, maximal errors do not exceed 0.001 for the degree of linear polarization, which is a sufficient accuracy for most applications based on polarimetric passive measurements.
The analysis of the problem is based on the method of successive orders of scattering (Lenoble et al., 2007), but the suggested corrections are applicable with any resolution method, as they only use the phase matrix of particles and the profile of their optical thickness. Example of retrievals performed with real polarization measurements such as the ones provided by the POLDER sensor onboard the PARASOL CNES platform will be also considered.