Assessments of Cloud Heterogeneity Effects on the POLDER3/PARASOL retrieved cloud parameters

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As recognized in the last IPCC report, clouds are of major importance in the climate budget and in its evolution. Their global and accurate observations are therefore essential. Since 2005 and during 9 years, POLDER3/PARASOL has measured total and polarized multi-angular reflectances of the atmosphere at three wavelengths. In a near future, the Multi-viewing, Multi-channel, Multi-polarisation Imager (3MI) will achieve the same kind of measurements with an extension to the shortwave infrared wavelengths.
These measurements allows to retrieve, among others, cloud optical thickness, cloud albedo, effective radius and variance of the size distribution and aerosol above cloud optical thickness. In the operational algorithm, clouds are still assumed, at the observation scale, flat, homogeneous and horizontally infinite. The consequence of this assumption needs to be evaluated.
Using three-dimensional (3D) synthetic cloud and 3D radiative transfer, we simulate realistic POLDER measurements. For bumpy and fractional clouds, we show that both total and polarized radiances are affected by the cloud heterogeneities. For example, the well-known illumination effects for titled solar incidence, lead to larger polarized radiances at small scale (50m). Consequently, the angular signature at POLDER scale (6x7km) used to retrieve some cloud parameters is modified by these illumination but also shadowing effects, that has to be added to the well-known plane-parallel bias due to the subpixel variability.
To assess cloud heterogeneity effects on operational product, we applied the POLDER operational algorithm on the simulated reflectances. The retrieval of cloud optical thickness is greatly affected by cloud heterogeneities. For solar incidence of 60°, the cloud optical thickness can be underestimated up to -70% in backward viewing direction and overestimated up to +40% in the forward direction. Concerning the cloud albedo, the errors are weaker, between -5% for low solar incidence angles and up to about 8% for large incidence angles. The cloud size distribution parameters retrieval that used multi-angular polarized reflectances, is almost not affected by the cloud heterogeneity. That proved to be a great advantage of polarization measurements. The cloud top pressure determining from molecular scattering in the forward direction can be biased up to 120hPa. Concerning the aerosol optical thickness above cloud the results show different pictures depending on the available angular information. When the scattering angle of the available directions range is between 60° and 180°, the retrieved AOT is almost not affected by the cloud heterogeneity. However, with only scattering angles above 120°, the algorithm retrieved significant amount of fictive aerosol.

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