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1 A method to account for surface albedo heterogeneity and its application in the retrieval of cloud optical depth from ground-based measurements of irradiance

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A simple method to derive the broadband effective albedo over highly reflecting surfaces under overcast conditions is presented. High spatial variability in the surface albedo affects the downwelling irradiance on neighbouring regions via the multiple reflections of light between the surface and the cloud base. The effective albedo corresponds to the albedo that would be measured in a single point, if the surface around it was perfectly homogeneous, and the downwelling irradiance was the same as the observed one. The method proposed here results from the combination and development of two existing procedures, and it is illustrated through its application to four idealised surfaces. The method can be used for example in Polar coastal regions, in the marginal sea ice zones, or in patchy terrain with forests and snow-covered fields. The method can be implemented into one-dimensional radiative transfer models or used to interpret broadband irradiance measurements. Here the method is applied to the ground-based retrieval of cloud optical depth. After comparing the available parameterizations of cloud optical depth that take into account the multiple reflection between the surface and the cloud base, the one that resulted in best agreement with the theory was chosen. This parameterization was then applied to the four idealised case studies, to demonstrate the errors caused by not taking into account the non-local

albedo effect when high albedo contrasts are present. The errors found are very large, and comparable to those obtained performing the same error analysis with sophisticated three-dimensional radiative transfer models.