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Sensitivity of cloud albedo to aerosol concentration and spectral dispersion

of cloud droplet size distribution

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The indirect aerosol radiative effect is still credited with the greatest range of uncertainty, mostly due to the complex issues regarding the link aerosol particles-cloud droplets. Most GCM-based calculations of indirect forcing do not consider the effect of relative dispersion of cloud droplet size distribution (spectral dispersion). There are only few simulations that made it, all of them being focused on global mean value of indirect forcing. Although their findings are within the range (10-80%) suggested by Liu and Daum (2002), important differences exist in the applied methodology, the used models, parameterizations and input data. In view of the large regional variability of aerosol, it is therefore questionable whether the global mean forcing is sufficient to characterize the radiative impact of aerosols and the regional scale would not be more appropriate. In this respect, present study assesses the variability in cloud albedo that may result from the variability of relative dispersion of cloud droplet spectrum (Iorga and Stefan, 2007).

Trimodal lognormal aerosol size distributions were used to describe two aerosol types, marine and rural, with specified chemical composition. The number of aerosols that activate to droplets was obtained based on Abdul-Razzak and Ghan's (2000) activation parameterization. The cloud albedo taking into account the spectral dispersion using a scaling parameter in the parameterization of droplet effective radius and in the

scattering asymmetry factor has been estimated. Two different scaling factors to account for dispersion were used, β_{LDR} (Liu & Daum, 2002; Rotstayn &Liu, 2003) and β_{PL} (Peng & Lohmann, 2003). For the same liquid water content, the variability in cloud droplet concentration, from 60 (marine) to 319 cm^{-3} (continental), determines variability in albedo of up to 3%. Higher values of effective radius when dispersion is taken into account were obtained, but the inferred absolute differences between calculations with each of the scaling factors are below 0.8 μm, as LWC ranges between 0.1 and 1.0 g m^{-3}. In both types of clouds, the dispersion of cloud droplet spectrum could lead to a relative change in cloud reflectivity for more than 20%. For clouds over rural areas, both β-scaled cloud albedos show better agreement with the estimated cloud albedo from measured effective radii in SCAR-B project than the cloud albedo calculated without scaling. In the case of marine clouds, only β_{PL}-scaled albedo fits satisfactory within the validity range of albedo inferred using an effective radius-liquid water content relationship proposed by Reid et al (1999) from ASTEX project.

Even if our simple estimate of the aerosol effect on cloud reflectivity cannot take all the feedbacks operating in a general or a regional climate model into account, present results show that a diminished cloud albedo due to an enhanced dispersion of cloud droplet spectrum could help to explain the high end of the GCM-simulated aerosol first indirect forcing values.

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