Reply to Review #1 of the manuscript "Determination of circumsolar radiation from Meteosat Second Generation"

We would like to thank the reviewer for the constructive comments. In the following reviewer comments are *italic* and our replies roman.

I would have expected to see some more information on the phase functions used to prepare Fig. 1

The sunshapes depicted in Fig. 1 stem from simulations with cirrus composed of solid-columns from the HEY parameterization with $\tau_{550\,\mathrm{nm}} = 0.5$ and $r_{\mathrm{eff}} = 40\,\mu\mathrm{m}$. The caption of Fig. 1 in the manuscript was amended accordingly. Below Fig. 1 in this document shows the phase functions for HEY solid-columns for effective radii of $5\,\mu\mathrm{m}$, $40\,\mu\mathrm{m}$ and $90\,\mu\mathrm{m}$.

The authors' statement concerning the limited dependence of the corrective factor k on optical depths below 3 may come as a surprise. The authors might consider noting that multiple scattering is the issue and that indeed its effects are much reduced in the case of scattering by particles that are large compared with the wavelength of the light for scattering in the near forward direction

Indeed, we also expected to see a stronger dependence of k on the optical thickness. The MYSTIC Monte Carlo radiative transfer solver allows us to log the scattering events of every photon. Therefore it is possible to break down the contribution of n-times scattered photons and also to derive the mean scattering order of all photons contributing to a result. Figure 2 in this document shows as an example the relative contribution to the irradiance within a circular field of view ($5°$ opening half-angle) for three simulations with cirrus clouds of varying optical thickness τ. For $\tau = 3$ the average scattering order is only 1.7.

In general, the directional photon distribution after two scattering events can be obtained by folding the scattering phase function with itself. One may recall that folding of a Dirac-δ-function with itself yields again a Dirac-δ-function. The forward peak of the considered phase functions certainly deviates from the Dirac-δ-function. However this analogy makes it comprehensible that few scattering events do not alter the directional photon distribution too much.

We added an explaining sentence to the manuscript.

The authors introduce "effective radius" at the end of section 2.3. I understand that this is the measure commonly used to characterize cirrus cloud particle size distributions. I encourage the authors in the future to consider a different measure recently reported in JGRD (doi:10.1002/jgrd.50440). This measure, termed "area diameter", relates directly to diffraction, which is the physical mechanism responsible for the strong forward scattering by ice crystals. The JGR authors noted that the diffraction phase functions for different ice crystals habits with the same area diameter are significantly more similar than those with the same effective radius or a couple of other measures they investigated.

After giving some more thought to my and suggestion of looking into using Methods "area and diameter" in the paragraph starting, "The Data Systems authors introduce 'effective radius' Data at Systems the end of sec- Discussion 2.3", I recommend ignoring this entire paragraph. Area diameter is applicable to individual ice crystals and not, at least as far as I can see, applicable to distributions of crystals of different sizes.

Your comment is not at all far-fetched. Indeed at the beginning of our study we created bulk single scattering properties with equivalent area diameter spacing to homogenize the forward peaks of the phase functions for the different HEY habits. For this the raw data underlying the HEY bulk optical properties created by Hong Gang were used (provided for small size bins). The idea was however refused after examining preliminary results for two reasons: First the homogenization of the phase functions for scattering angles $> 0.1^\circ$ was not satisfying. Second, in the JGRD article by DeVore et al. you mentioned, only the forward part of the scattering phase function is evaluated. Therefore it poses an advantage if this part of the phase function is homogenized, i.e. made independent of the ice particle shape. However for the presented method the backward part is relevant as well, namely for the satellite remote sensing. It is however not possible to homogenize the forward- and the backward part of the phase functions at the same time. Therefore we have to make a distinction of the particle shapes anyway. Because of this we found it more convenient to use the established scattering properties.

I mention a few minor language issues below.

The proposed language corrections have been implemented.

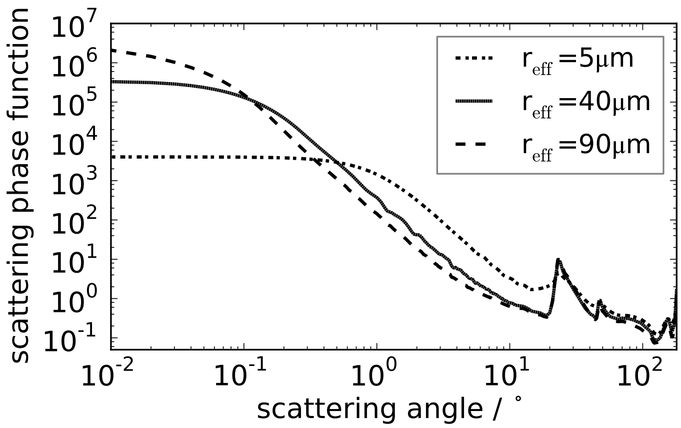

Figure 1: Scattering phase functions for HEY solid-columns (normalized to fulfill $\int_0^\pi P(\mu)\mathrm{d}\mu = 2$, with $\mu = \cos(\theta)$).

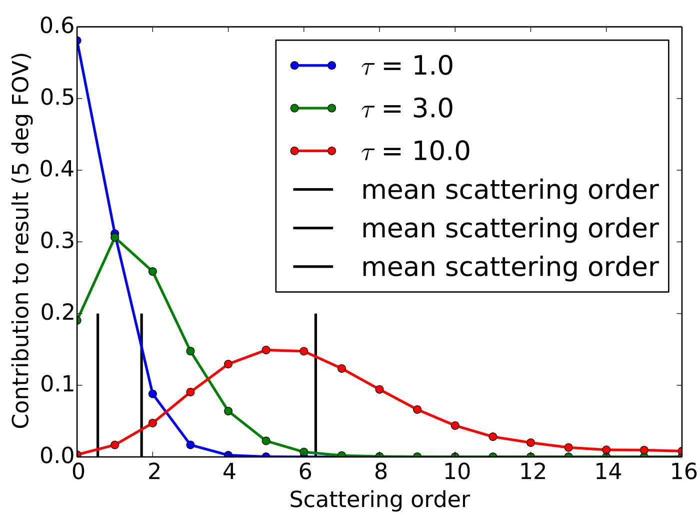

Figure 2: Relative contribution to the irradiance within a circular field of view (5° opening half-angle) broken down by the scattering events. MYSTIC simulation for cirrus clouds composed of HEY solid columns with $r_{\text{eff}} = 40\,\mu\text{m}$ and cloud optical thickness of 1.0, 3.0 or 10.0.