Atmos. Chem. Phys. Discuss.,
doi:10.5194/acp-2016-967-RC2, 2017

Atmospheric Chemistry and Physics Discussions

Interactive comment on "Disk and circumsolar radiances in the presence of ice clouds" *by* Päivi Haapanala et al.

Anonymous Referee #1

Received and published: 1 January 2017

The authors studied the relationship between ice cloud particle properties and circumsolar radiance profiles. This topic is of interest for, amongst others, the cloud remote sensing community and may ultimately lead to a better understanding of ice could micro-physics. The authors built their study around rather precious in-situ measurements of cloud micro-physics and simultaneous ground based measurements of circumsolar radiation. For the simulation of radiance profiles they expanded the MC-UniK Monte Carlo radiative transfer model so it can treat the sun as a realistic disc source instead of a point source. Overall the study is therefore within the scope of ACP.

For the most part the paper is technically well written. The authors put their work in reference to previous studies and it is easy to follow which steps they have undertaken in their study. However, what is lacking is a clear formulation of the study goal. Consequently also the presentation of the findings is somewhat vague. Before publication in

ACP these issues should be addressed.

Basically there are two parts to the study: In the first part the authors investigate in sensitivity test the general influence of ice cloud micro-physics on the circumsolar radiance profile. As basis for their tests they use ice particle size-shape distributions measured in-situ at two different days. The sensitivity test are performed using the radiative transfer model. In the second part they investigate under which assumptions the measured radiance profiles can be replicated best. For this they also use the measured size-shape distributions as input for radiative transfer simulations.

While for the second part of the study it makes sense to use only the size-shape distributions measured at the same dates as the radiance profiles, it is unclear why the authors have limited themselves to also only using the two size distributions as basis in the first part of the study. Unfortunately, little information is provided on how representative these size distributions are or whether it is sufficient to focus only on these two size distributions when deriving general relations between ice cloud micro-physics and circumsolar radiation. The authors discuss differences in simulated radiance profiles caused by the differences in the two measured particle distributions as well as due to impact of the assumed particle roughness. However, it remains unclear why the authors did not explore the parameter space further – e.g. by using more size-shape distributions from the SPARTACUS campaign or idealized single-shape size distributions in different size variations. Although certainly not easy to quantify, at least some comment on how common/representative the measured size-shape distributions are considered by the authors should be provided.

Overall the study explores the sensitivity of the phase function in regard to particle shape and roughness. The finding is that the surface roughness is the dominating parameter. The third parameter, particle size, is largely neglected, however. While radiance profiles for three different concentrations of "small particles" are compared, little information is provided about the size distribution(s) used for this small particle fraction. Modifications to the size distribution of the large fraction are not performed.

Following modifications to the script could help to address the above mentioned issues:

- The authors should leave no doubt in the introduction as to what the study goals are.
- The authors should concisely summarize (if deemed feasible maybe also in tabular form for ease of comprehension) which aspects of the radiance profile are influenced by which of the cloud micro-physics parameters. The authors should also mention which of these aspects were newly identified in this study.
- While the authors found that the small particle fraction (Dmax < 100mu) cannot be neglected, the influence of the overall particle size distribution is not very thoroughly explored. I suggest to expand the study in this regard. Alternatively the authors should comment on why they deem the size distribution not to be as important as the particle shape and roughness.
- While only two dates of the SPARTICUS campaign where usable for a comparison to SAM measurements, the authors should add a paragraph that puts the shape-size distributions measured during those two flights in perspective to what was measured during the rest of the campaign.
- The authors should provide the size distribution for the small particle fraction for flights A and B as well as the optical thickness assigned to this particle fraction. The latter could be added to tables 3 and 4.

Additional minor suggestions:

- In line 24 it is stated that circumsolar radiation is caused by scattering on particles between 1mu and 100mu. However, the study mainly focuses on particles larger 100mu. Please clarify/rephrase.

- Should pictures of the cloud scenes (e.g. webcam) for times of comparison between simulations and SAM measurements be available, I suggest to include those.
- Caption of Figure 5: “Sensitivity of the size and vertically integrated phase functions to the roughness of large ice crystals.”. Potentially remove “the size” from the sentence.

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