Authors' Response to Anonymous Referee #3 Comments

The authors would like to thank the anonymous Referee for her/his helpful comments. Please find below a detailed point-by-point replies to each comment. Referee's comments are in blue and authors' replies in black.

This paper describes the submicron scale complexity of individual ice crystals derived from airborne measurements and cloud chamber experiments. The authors assess that a new radiation parameterization for global climate models considering the higher roughness of ice crystals reveals a lower SWCRE. I find the paper very well written, logically organized, and the figures and tables are appropriate. I recommend the paper to be published with minor revision.
We thank the anonymous Referee for this very encouraging general comment. Below we address the suggested minor revisions.

Special comments:
1. Page 2, Line 30/31: "In two cases the crystal complexity measurements and the angular light scattering measurements were conducted on the same ice particle population." I did not get where you use this coupled information later. Or is there any advantage at all having the measurements on the same ice particle population?
One of the main conclusions in this manuscript is that the high degree of ice crystal complexity is the reason why a similar angular scattering function is measured at different geographical locations. Two cases, where the two measurements ice crystal complexity and angular light scattering measurements) were performed on the same particle population, helps justify this conclusion.

2. Page 3, Line 22/23: Why is there more shattering in mixed-phase clouds?
Shattering is enhanced by the presence of large ice crystals and ice crystals with certain habits, such as bullet rosettes or large aggregates. In mixed-phase clouds, there tend to be more precipitation-sized ice crystals and rimed (aggregated) ice crystals. Jackson et al. (2014) showed that at temperatures > -8°C more shattering is present than in colder temperatures due to the presence of rimed ice crystals. These observations would explain the higher fraction of shattering in mixed-phase clouds since most of these measurements happened at temperatures warmer than -8°C.

We modified the sentence on page 3, line 22/23 the following: "*In mixed- phase clouds a higher fraction of measured 2-D scattering patterns, between 7.5% and 19%, were excluded from analysis. The higher fraction of shattering in mixed-phase clouds can be explained by the presence of rimed particles (Jackson et al., 2014)".*

3. Page 8, Line 20: Why is the size distribution from the ACRIDICON-CHUVA campaign representive?
The size distribution from the ACRIDICON-CHUVA campaign is measured for the same particles whose angular scattering functions are shown, i.e. the size distribution corresponds to the scattering information. It was also investigated how sensitive the retrieved angular scattering function is to the assumed size distribution and it was found to be insensitive to small changes in the median diameter. This is explained in the text at page 8 lines 22 and 23 (old manuscript version). Therefore, the exact size distribution is not crucial for finding the best fit.

4. Page 10, Line 8: Why are these regional differences in the change of SWCRE? Why is the signal mainly in the tropics?
The regional differences are linked with the cirrus occurrence. The cirrus occurrence is the highest in the tropics which, consequently, leads to the largest change in the SWCRE. We added a sentence in the chapter 4.2 to explain the regional differences: "*The largest effect is found in the tropical regions where also the cirrus occurrence is the highest (e.g. Sassen et al., 2008)."*

5. Page 11, Line 4: Before you could investigate the role in a warmer climate, you need to know if there are changes of the submicron scale complexity in a warmer climate. Do you expect them?
This is a difficult question to answer as long as we do not really understand the origin of submicron scale complexity in ice crystals. The only evidence we have is that abundance of heterogeneous ice nucleating particles (INPs) might decrease the supersaturation needed to nucleate the ice and, therefore, could lead to decrease in ice crystal mesoscopic complexity. However, increase in INPs also changes the cloud optical depth, which leads to another forcing.

With the statement on page 11 line 4 we wanted to motivate studies to investigate how cirrus radiative forcing would change if mesoscopic complexity is included in the projections versus if assuming the standard parameterisation.

Technical corrections:
1. Page 3, Line 3; Page 5, Line 2; Page 7, Line 8: “sub-micron”. Mostly you write “submicron”, hyphenless.
We changed the term “sub-micron complexity” to “mesoscopic complexity” in the entire text. The reason for this was a critique towards presenting a new term to the field whereas the term “mesoscopic complexity” is already established.

References

Jackson, R. C., McFarquhar, G. M., Stith, J., Beals, M., Shaw, R. A., Jensen, J., Fugal, J., and Korolev, A.: An assessment of the impact of antishattering tips and artifact removal techniques on cloud ice size distributions measured by the 2D cloud probe, Journal of Atmospheric and Oceanic Technology, 31, 2567–2590, 2014.