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Interactive Comment

# *Interactive comment on* "Incidence of rough and irregular atmospheric ice particles from Small Ice Detector 3 measurements" *by* Z. Ulanowski et al.

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**Response to Anonymous Referee #2**

We thank Referee 2 for encouraging remarks, insightful comments, and suggestions on how to improve the article. Below we respond to individual comments.



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## General Comments

**(i)** We are against the suggestion to move substantial parts of the discussion to the Results section. In our view, the purpose of the Results section is, and should be, to present the data in an impartial manner, unbiased by interpretation, so that readers can draw their own conclusions. Having said that, we have expanded the Results, for example by adding more details of the laboratory and in situ data and the outcomes of statistical analysis.

**(ii)** As already stated in the discussion paper (p. 24985), we examined the data for correlations between variables, including size and temperature, and did not find statistical relationships other than the ones shown in the paper. Concerning sizing by speckle, this subject is too extensive to be dealt with in this publication, and results from in situ measurements will be treated in detail in later work that is currently under preparation. We have used it only to check for possible correlation with the roughness measures, with negative outcome, as already stated. We see no reason to include extensive graphical data that serves no useful purpose beyond reinforcing clear statements already made in the text. We illustrate this point in Fig. 1 included in the interactive response to Referee 1, which shows the (lack of) correlation between particle size and roughness.

**(iii)** The Referee has raised a very important question. We have not attempted to retrieve the detail of particle roughness in this study. Indeed, we already discuss extensively our results indicating that small-scale, fine surface roughness and large-scale crystal complexity can produce similar roughness measures, and how this might affect the scattering properties (p. 24987). However, we anticipate that it may be possible to recover the detail as well as the magnitude (see Ulanowski et al., 2012). Further research is required to establish the links necessary for implementing roughness in scattering models, by connecting the roughness measures either to details of surface properties or directly to relevant scattering properties, such as phase functions and/or



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asymmetry parameter. This is the subject of an ongoing laboratory and modelling study.

**(iv)** We are not entirely sure what the Referee means, but we are including in the revised text several statistical tests for the data shown in the histograms - see response to Referee 1: "Main Comments" point 8.

**Specific Comments**

Abstract

We strongly dispute that there is no (negative) correlation between the halo ratio and roughness, the correlation is statistically significant at the 0.1% level – see also the response to Referee 1 ("Main Comments", point 7), especially concerning the significance of single particle measurement. To prove our assertion further, we have added to Fig. 9 a plot of the mean halo ratio calculated for discrete roughness intervals. It shows clearly that the halo ratio decreases almost monotonically with roughness.

Introduction

*P24977 Line 1*: References to Baran (2012) and Guignard et al. (2012) have been added.

*Line 4–5*: Done.

*Line 16*: We mean that the evidence does not come from in situ imaging of ice particle shape: in the same paragraph we discuss some specific examples. In the revised text we have inserted an additional example (Garrett et al., 2001).

*P 24978 line 24978*: The statement on p. 24978 of the Introduction is a general one: it



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is indeed possible to obtain the size and orientation, at least in some cases. But, firstly, both are beyond the scope of this study – see point (ii) above. Secondly, concerning orientation, it was shown in Kaye et al. (2008) that orientation can be recovered for regular crystals with smooth surfaces. However, once roughness emerges, the features in scattering patterns that would allow such recovery become obscured by speckle. We do not yet know if some orientation information is preserved in such cases.

Section 2: Methods

It is our intention to make this section technical, so that interested readers can extract from it information needed to reproduce the study or to apply the methods elsewhere. We do admit that it is somewhat dry, but this was done for the sake of brevity.

*Line 21*: See response to Referee 1, "Main Comments" point 4.

*P24983 line 7*: We described in the following paragraph how the combined roughness measure was defined: its components were weighted so that they contributed approximately equally and to give approximate bounds of 0 and 1 for the whole expression. It has no relation to detailed surface structure – see response (iii) above.

*P24984 line 1–6*: We did do size retrievals, to establish if there was correlation between ice crystal size and roughness, as stated on p. 24985. This is clarified in point (ii) above.

Section 3: Results

Concerning the structure of the Results and Discussion sections, see "General Comments" point (i) above.

*P24984 line 20*: We agree with the Referee that Fig. 6 is important, indeed it could be considered the main result. Fig. 7 is shown later because it concerns our attempts to



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interpret the results from Fig. 6.

*P24985 line 5–20*: See section “Abstract” above, which deals with the existence of correlation. Concerning “hexagonal crystals”, the halo ratio is a measure of ice crystal “regularity”, in other words how “hexagonal” they are – this was already discussed on pp. 24986–24987. Therefore, selecting hexagonal crystals and then testing the halo ratio for only those crystals is unlikely to reveal anything interesting. To further clarify this point, we have added in the Introduction the phrase “As such, [the halo ratio] is sensitive to the presence in ice crystals of the 60° prism angle and to the smoothness of the prismatic facets”.

Section 4: Discussion

See response to “General Comments” point (i) above.

## References


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