

***Interactive comment on “Tracking microphysical variations in emissions from Karymsky volcano using MISR multi-angle imagery, and implications for volcano geologic interpretation” by Verity J. B. Flower and Ralph A. Kahn***

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Response to reviewer 1 - C. Hayer (Referee)

^ Indicates reviewer comment \*\*\* Indicates response from authors. All page (P) and line (L) references relate to the track changes version of the manuscript attached as a supplement.

Specific comments

C1

^P9 Para3 (beginning L18): The authors discuss an eruption observed from ground-based instruments by Lopez et al. (2015) as a way to verify the processes inferred by the satellite-based observations. However, there doesn't appear to have been a MISR observation to compare the Lopez et al. measurements to and so this seems to be mostly speculation on the part of the authors as to what MISR might have been. I acknowledge that ground truthing observations from any satellite instrument is hard and made harder by the narrow swath of the MISR instrument but I'm not sure that this comparison can be drawn. If it is included, I think the authors need to be clearer about this being speculative.

\*\*\*We agree with the reviewer's frustration but unfortunately at Karymsky there were no coincident ground-based or in situ observations with MISR overpasses. The sections mentioned here (P4L12-26) have been updated to better outline that the observations mentioned are included as a general reference and not for direct validation purposes. We feel it is important to present such comparisons, as they represent the best that can be offered in the present situation. Note also that Reviewer 2 actually asked for more discussion of other (necessarily non-coincident) Karymsky observations. We hope to undertake direct comparisons to ground-based and in situ observations as we extend this technique to other volcanoes with more extensive observations (e.g. Iceland).

^Conclusions (P12-13): The authors ascribe the differences in the activity and plume composition from the volcano pre- and post-2010 as the end and beginning of a cycle. I am not convinced, by the data shown, that there is sufficient evidence that this is a long-term cycle rather than a change/evolution of the magmatic regime. I am not ruling out the possibility of this being a long-term cycle, simply that I don't feel the current data is sufficient to determine either way. There does appear to be cyclicity, as the authors say, especially post-2010. The support for this cyclicity I feel is quite strong, with the similar variations in composition shown in Fig. 6h when the measurements are normalized for eruption day. The lack of this shorter-term cyclicity and the change in the plume compositions retrieved pre- and post-2010 could equally suggest a change

C2

in the regime, rather than a different part of a longer-term cycle. Could the authors either present the data that led to their conclusion of a long-term cycle or rewrite this part of the conclusion.

\*\*\*Thank you, for this comment. We have updated the conclusions (beginning P20L1) to better clarify that, although we observe ongoing evolution in the 1996-2016 eruption (2000-2016 observations), there is also an element of cyclicity in the formation eruptive phases at Karymsky.

Technical corrections

^P5 L3: "SSA" not defined

\*\*\*P7L9 – Thank you, we have added the definition. SSA = Single-scattering albedo

^P5 L14: 10 km<sup>2</sup> grids (add square)

\*\*\*P7L23 – Thank you, this change has been made.

^P5 L20-21: Table 2 has two small spherical absorbing flat profiles listed, highly moderately. Do the authors mean the combination of these? Could this be made a little clearer.

\*\*\*P7L8-14 – One of the flat profiles displays strong absorption SSA  $\sim 0.8$  (highly absorbing), the other displays less absorption SSA  $\sim 0.9$  (moderately absorbing). The SSA values are included in the table, and the section in the paper detailing these differences has been clarified.

^P7 L23: The figures displaying variations in the small, medium & large particles are Fig. 6 b, c & d rather than just Fig. 6c as written.

\*\*\*P11L6 – Thank you, this change has been made.

^P12 L25-29: This is all one sentence. Please rewrite to reduce the length/split into more sentences.

C3

\*\*\*P19L7-13 – Thank you, this change has been made.

^P13 L4: The sentence reads as plural but only one Bardarbunga eruption plume was considered.

\*\*\*P17L10-18 – Thank you, this statement and earlier sections has been updated to indicate that although only one plume is shown in Fig 5 & 7, two additional Bardarbunga plumes were analysed and the details are now included in the supplemental table.

^Table 2, title row: What do the "r"s refer to? I am assuming re is effective radius but r1 and r2? Could these be explained in the footnotes.

\*\*\*P26L1 – Thank you, this change has been made.

^Table 2, column 1: s 2 and 9 missing from the table - is this intentional?

\*\*\*P25L1 – Thank you, for you comment. These are intentionally missing as the MISR RA components 2, 9, 11, 12 and 13 were not retrieved in Karymsky plumes and therefore are not relevant here. The header text indicates that only components identified in Karymsky plumes were included.

^Fig. 1: This figure is not referenced in the main text.

\*\*\*P3L19 – Thank you, this change has been made.

^Figs. 2, 3 & 4: Lat-lon markers or a length scale (preferably) should be included in these figures. The authors discuss the variable horizontal extent of the plumes on page 6 (L6-7) but the reader cannot distinguish this for themselves.

\*\*\*P28-30 – Thank you, this change has been made.

^Figs. 2 and 3 b & c: There appears to be an abrupt increase in the plume height retrieved when the plume moves over the water. Is this real or an artifact of the RA? It seems to happen to all of the plumes shown in Fig. 2 and those in Fig. 3b&c (though not Fig. 3 a). There is a significant variation in the plume shown in Fig. 3 d but

C4

there does not seem to be any coastline that may have caused it. The same sudden change is also seen in a number of the plumes in the supplementary material. Could the authors please elaborate on possible causes of these variations?

\*\*\*P28-30 – Thank you, for your comment. The decreasing plume height toward the coast followed by sharp uplift is a function of particles being contained within the lower atmosphere. As air transitions over water the lower atmosphere is subjected to less friction forces causing an increase in wind speed (plots added to supplemental figures) and plume uplift. Additional details and references (particularly Flower & Kahn, GRL 2017b, that discusses this phenomenon in detail) have been added to the manuscript (P9L9-13). In some cases (e.g. P2007b) significant plume uplift is driven by local frontal systems, details have been added to the text (P9L9-13).

^Fig. 6 h: In the text, the authors include the R2 value for 2011 only as well as for all of the 2011-2015 plumes. It may be worth adding the R2 value for just 2011 to the plot as well as the full dataset R2?

\*\*\*P32– Thank you, this change has been made.

^Fig. 7 top: The 3D-effect used on the plot, while aesthetically pleasing, makes distinguishing the saturation of the point much more difficult, especially on the grey data set (LaSpNab).

\*\*\*P33 – Thank you, this change has been made. The shadow has been removed from these figures to improve the variations in color density more easy to discern.

^Fig. 7 legend: In the text (Page 8, L14-15), the authors describe the 2007b plume (panel C) as being dominated by the sulfate proxy (MeSpNab, yellow) and medium grains (MeNspWab). The latter dataset is not denoted on the legend. I'm not certain if the data set is missing or mislabeled – it could be that the brown data set should be this data set – currently labeled MeNspNab. Could it either be included or labeled correctly.

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\*\*\*P33 – Thank you, this change has been made.

^Fig. 7 bottom: Could the wind direction be shown on the plots so that the variation over the plume described in the text can be more easily identified?

\*\*\*Supplemental – Thank you, wind plots have been added to the Supplemental Data along with plume profile plots

Please also note the supplement to this comment:

<https://www.atmos-chem-phys-discuss.net/acp-2017-868/acp-2017-868-AC1-supplement.pdf>

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Interactive comment on Atmos. Chem. Phys. Discuss., <https://doi.org/10.5194/acp-2017-868>, 2017.

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