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Atmospheric Chemistry and Physics
Discussions

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 Anonymous Referee #2

ˆ 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.

General Comments

ˆThe paper presents MISR data that are used, in combination with the MODIS thermal alerts, to investigate volcanic plumes from Karymsky volcano between 2000 and 2017. MISR retrievals showed 2-4 km high volcanic plumes having different particle types. From their analysis, the authors identified two eruptive cycles, producing plumes mainly composed by sulfate prior to 2010 and plumes with varying fraction of absorption particles after 2011. The analysis of MISR data is well written but, before the publication, the volcanological interpretation should be improved and validated with other data.

***All line references relate to the track changes version of the manuscript.

Specific points

ˆ1. A detail description of volcanic setting and eruptions for the Karymsky volcano is lacking. The authors should cite other papers and go in depth on some works that could improve their understanding on typical volcanic activity (e.g. Johnson et al.,1998; Ozerov et al., 2003). In the 1.1. Karymsky volcano chapter, the authors should add a table which includes the eruptive events with their main features.

***P3L19-P4L26 – Thank you, this section has been updated to include more details about the volcano, its geological setting and eruption characteristics. Additionally, details of eruptions during the MISR observation period (2000-2017) compiled from the GVP have been included in the Supplemental Material.

ˆ2. Volcanological interpretation is not well supported. Authors should improve the eruption description during MISR observations in chapter 4. It is not very clear what is the eruption style that MISR is detecting (e.g. ash emission, Strombolian activity, lava flow emissions). Although MISR is able to distinguish volcanic ash plumes from degassing/water vapor plumes, data shown in the paper are not able to define the eruption style. Furthermore, the classification among Strombolian or Vulcanian eruptions cannot done only on the base of the column height or duration of the eruptive event. Finally, the differences among the eruption periods should be again supported by other data, mainly due to the small coverage of the MISR sensor (about 4%).

***Thank you for your comment. The section discussing Karymsky eruption types (P4L11-26) has been edited to clarify that we are only analyzing the largest (ash explosions/Vulcanian) eruptions. This paper was never intended to imply we could discern eruption type (Strombolian/Vulcanian) from MISR images alone. The information on eruption types was included to acknowledge that we are only dealing with a small subset of the plumes from Karymsky (P4L23-26). The eruptions phases (P15L1-8) were not defined by the MISR plume data but by the MODIS (Terra and Aqua thermal anomaly record; which includes ∼4 observations in Kamchatka per day), in combination with published studies on complementary investigations with AVHRR (van Manen et al., 2012).

ˆ3. Authors state that MISR was able to detect particle fallout, physical aggregation, chemical evolution only qualitatively but they should clarify how they reached this objective point to point. To validate MISR data and their interpretations they could improve the analysis of MODIS data applying well known algorithms as the Brightness Temperature Difference (BTD) technique (Wen and Rose, 1994).

***Thank you for your comment. Details of the expected characteristics of each process are located in section 4.1 at the following line references: particle fallout (P13L8-11), physical aggregation (P13L11-13) and chemical evolution (P13L13-20). The plumes that display each characteristic are also included in this section. References to the Supplemental Data have been added to point to the graphical evidence from our analysis of each process, as these are too large/extensive to include in the main paper. The BTD techniques suggested, use thermal channels for retrievals and therefore track larger particles (>∼ 2 microns) than the ones MISR is most sensitive to; the MISR-observed particles are likely to stay aloft longer, especially if gravitational settling is the main removal mechanism. In respect to plume heights, Flower & Kahn (2017a; JVGR) compared MISR heights and those obtained from BTD techniques. This comparison indicated that BTD heights fell within the observed MISR height range. However, BTD

heights were skewed below the region of highest spatial contrast identified in the MISR height retrievals, suggesting that the BTD heights have a tendency to underestimate actual plume height.

ˆ4. Volcanic plumes are strongly affect by atmospheric fields. The maximum distance reached by volcanic particles, for example, could depend on the wind speed and, mainly for this reason, I suggest to insert a new figure which includes wind profiles for each event retrieved by MISR.

***Supplement – Thank you for your comment. MISR wind field retrievals have been added to the supplemental data sheets for each plume and are referenced in the text.

Technical corrections

ˆReplace the title 'Tracking microphysical variations in emissions from Karymsky volcano using MISR multi-angle imagery, and implications for volcano geologic interpretation' with 'Tracking microphysical variations in emissions from Karymsky volcano using MISR multi-angle imagery, and implications for volcanological interpretation'

***P1L1 – Thank you, this change has been made.

ˆP1L15. Clarify the sentence. What do the authors mean for 'high volcanic surface manifestation'?

***P1L14-17 – This section has been revised for clarity. By 'high volcanic surface manifestation' we mean "periods of time when lava flows and other radiating features are prevalent at the volcano, causing a high number of observations from the incorporated instruments".

ˆP1L16. Add the size.

***P1L18 – Thank you, this change has been made.

ˆP1L22. See specific points about the interpretation in terms of activity cycles.

***See response to Specific Point #2

ˆP3L10. The authors state that MISR has the potential to distinguish the emission from (a) ash explosions, (b) pulsatory degassing, (c) gas jetting, and (d) explosive activity. May the authors identify those emissions for each MISR data shown in this paper?

***Please see response to Specific Point #2

ˆP3L12-13. Delete this sentence. See specific points.

***P4L16-23 – Sentences in this section have been edited and rearranged for clarity.

ˆP3L18-20. This is in general true at the same atmospheric conditions. I suggest to delete this sentence.

***P4L17-26 – Sentences in this section have been rearranged. The referenced sentence forms part of the justification as to why the larger Vulcanian plumes are the primary eruption type that can be observed by MISR.

ˆP4L17. Explain 'derive proxy particles type'.

***P6L12-14 – This section has been revised for clarity.

ˆP5L3. Define SSA.

***P7L9 – Thank you, this change has been made. SSA = Single-scattering albedo.

ˆP5L13. Add the period.

***P7L22 – Thank you, this change has been made.

ˆP5L15. Add how the size, shape and absorption are retrieved by the MISR RA.

***P6L17-23 – These retrievals are derived through the comparison of radiance recorded in the 9 cameras over 4 spectral bands with a 774-mixture look up table. A brief summary is given, and details of this are included in the references in the second paragraph of Section 2.3.

ˆP5L20. Add the size retrieved by MISR for large, medium and small particles.

***P7L4-7 – Thank you. The size distributions are given in Table 2, and we have added a note directing readers to this table.

ˆP8L15-17. Due the very few MISR observation rate (about 4%), this sentence is not well supported.

***P12L7-11 – This section has been revised for clarity. The observation rate is explained by the fact that we can only observe the largest forms of activity displayed by Karymsky; this is now mentioned within the text. We have also added an additional reference to the fact that we would require coincident observations to validate the capability of MISR retrievals.

ˆP9L14. Add the distance from the volcanic vent.

***P13L20 – Thank you, the distance from the vent has been added to the text.

ˆP10. Replace 'geological' with 'volcanological' in the sub-chapter 4.2. P10L10. Improve the description of the eruptive phases.

***P14L20 – Thank you, this change has been made to the title. An improved description of eruption phases has been included at the end of the first paragraph of this section (P15L1-8).

ˆP10L24. I wonder if the shift from effusive to explosive activity is given only by the amount of ash in the atmosphere without taking into account the amount of sulfate/water that could be also high for both activities. May the authors add some references?

***P15L22-P16L6 – Suggested shifts in activity were defined through interpretation of both the MISR plume characteristics and the MODIS thermal output. We plan to provide additional eruptive style constraints in future through the incorporation of UV satellite data, sensitive to SO_2 emissions.

ˆP11L2-5. Clarify this sentence. P11L11. Fig. 4c is lacking.

***P16L14-19 – Thank you, we have clarified this sentence. The figure reference has been updated to the correct figure.

ˆP11L18. The hypothesis of pyroclastic flows should be justified by published papers or news from web-sites.

***P17L4-9 – Thank you, references have been added to justify: plume dispersion characteristics; thermal anomaly generation following pyroclastic flows; and the low intensity thermal alert report.

ˆP11L26. Is MISR able to distinguish among sulfate or water vapor plumes? P12L16-17. Clarify.

***P17L13 – The similarity of sulfate and water vapor particles (MISR small class) and radiative properties (spherical, non-absorbing) limit our ability to distinguish these components (see Scollo et al., 2012). This was not something that affected analysis in this case, as the plumes we observed were predominantly ash rich.

ˆP12L21-22. Clarify.

***P19L1-4 – This sentence introduces the concluding remarks and therefore the rest of the concluding section clarifies the statement.

ˆP12L25. What is 'volcano's geologic evolution' for?

***P19L7 – This section has been reworded to address the confusion of this statement.

ˆP12L28. The eruption style cannot be derived from MISR data analysis. See specific points.

***Please see response to specific point #2

ˆP12L32. Add the classes.

***P19L15-19 – Thank you, this change has been made.

ˆP13L10-11. I wonder if this analysis is affected by the small percentage of MISR data respect to the eruptions happened in the same period.

***It is likely that information on any smaller/unobserved plumes would improve the interpretation of the internal dynamics of the volcano. Unfortunately, without available data we are unable to posit these variations. Ongoing work with this data will incorporate analyses from multiple volcanoes with varying coverage levels to assess the influence of limited observations. We are also extending the synergistic use of satellite data in volcano monitoring to include SO2 quantities, among others. However, this is outside the scope of the single volcano case presented here.

ˆP13L14. See specific comments on eruptive cycles.

***Please see response to specific point #2

ˆP13L18-19. Are MISR data able to discriminate those processes? How? References

***P20L13-18 – This section has been edited to clarify that these processes are being inferred from interpretation of both the MISR plume details and MODIS thermal anomaly record.

ˆJohnson, J.B., Lees, J.M., Gordeev, E.I. (1998), Degassing Explosions at Karymsky Volcano, Kamchatka, Geophysical Research Letters, DOI: 10.1029/1998GL900102. Ozerov, A., Ispolatov, I., Lees, J. (2003), Modeling Strombolian eruptions of Karymsky volcano, Kamchatka, Russia, Journal of Volcanology and Geothermal Research 122, 265-280. Wen, S., and W. I. Rose (1994), Retrieval of sizes and total masses of particles in volcanic clouds using AVHRR bands 4 and 5, J. Geophys. Res., 99, 5421–5431, doi:10.1029/93JD03340.

***P3-4 – Thank you for suggesting these relevant references; they have been added to the paper.

Figures

ˆFigure 1 is not cited in the text.

***P3L19 – Thank you, this has been corrected.

ˆFigure 2, 3 and 4. Add the scale in km.

***P28-30 – Thank you, the scale has been added.

ˆFigure 7. Add the scale at the bottom of figures. In Fig. 7 B, the plume height of 7 km reached far from the volcanic vent is higher than the height above the vent. Why?

***P33 – Thank you, the scale has been added. A reference to the uplift is included (PL) and is the result of a frontal system moving from the east and causing uplift of the plume and surrounding air mass.

ˆTable 1. Improve the eruption description.

***P24 – The table has been edited to indicate that observations are based on the MISR analysis. Unfortunately, the eruption reports reviewed for these plumes are extremely general and no coincident observations were found in the literature. Therefore, extensive information on each specific eruption was not available for inclusion.

ˆI suggest to move the plots from the supplementary material to the paper and, moreover, add the plots 'height versus distance from the volcanic vent' as retrieved by the MINX software. Finally, the column heights reported in the paper should be above sea level.

***Supplement – The height vs. distance and wind speed plots have been added to the Supplemental Data Unfortunately, the large number and size of each plume retrieval makes it impractical to include all of them in the paper itself. We are grateful that the Supplemental data option allows us to include this much ancillary information for those interested in the details.

Please also note the supplement to this comment:

https://www.atmos-chem-phys-discuss.net/acp-2017-868/acp-2017-868-AC2-supplement.pdf

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