Editor Comments (M. King)

Received and published: 14 August 2012

Recommendation: This paper presents a careful analysis of the optical and microphysical properties of volcanic aerosol particles following the eruption of the Eyjafjallajokull volcano in Iceland in Spring 2010, using a research algorithm applied to Terra/MISR multi-angle and multispectral observations. It nicely characterizes the plume evolution, distribution of spherical and non-spherical particles, absorption properties, and size characteristics. The text is quite clear and much improvement in the presentation would be accomplished by attention to improving the figures, scales, and labels. I recommend this paper be accepted for publication with only minor editorial changes, especially with regard to figure quality suitable for publication.

General Comments:

1. This important paper is generally well written and easy to follow, but confusion easily arises when referring to the figures (and tables), that could be improved for publication.

Response: We thank the Editor for these comments, and for many helpful suggestions. We have improved the figures as indicated, and as summarized below.

Major Comments:

1. *Page 14, lines 17-18 – this sentence refers to Figure 1 and 'the sharp edge along the western side of the ash plume for about the first 100 km from the source'. Figure 1 contains no scale at all. In fact, each panel in Figure 1 is a different size, and having scale (and compass direction) on each subpanel, analogous to what is commonly done in the Earth Observatory web site, would be of great value. In addition, the map inserts in Figure 1a, b and c, are incomplete and somewhere misleading. For example, in Figure 1a, the insert shows one block, but the image is not along the block, but appears to be oriented with North vertically in the frame and containing 3 blocks, and showing the edge of the image (in black at the edge)! Figure 1b also consists of 3 blocks, but is not the entire width of the image (and doesn't have the black edge). Figure 1c is in fact one block, but oriented with North at the top, and the west edge of the scan is shown, but not the right edge of the scan. Hence this is likely not the entire ~400 km width (hence the need for a scale). Figure 1d is apparently part of one block, but is not the full 400 km width. Finally, if each figure is labeled above the figure, and a, b, c and d removed from the graphics themselves, this figure might look cleaner.*

Response: We have taken all these suggestions, adding scales to all panels in Figure 1 and insets showing the blocks used for the visible images overlaid onto a cylindrical map project. Panel 1d actually is part of two blocks, as mentioned in the caption (the retrievals are only done for block 50 however). Labels were also added to the panels, as suggested.

2. *Figure 4 – Much improvement could be accomplished in this important figure by doing the following:*
    a. *Delete '250 km' from the figure, as this seems to refer to the distance downwind of the Eyja volcano and is not necessary for this figure (though it could be in the caption).*

b. *Label each sub-frame, such as:*
    i. *General aerosol components*
    ii. *Aerosol component-optical models*
    iii. *Aerosol optical depth (558 nm)*
    iv. *Angstrom exponent (447-867 nm)*
    v. *Shape*
    vi. *Effective radius (um)*
    vii. *Single scattering albedo (558 nm)*
c. *The color bars for each panel should be on the right hand side of the panels. The first one for r doesn't make sense, as I think this is supposed to be the color bar for panel c) and should be in units of optical depth.*
d. *The color bar for effective radius doesn't make sense. Colors for '20.00=1.5' etc. are confusing. I presume the color bar is actually the 20.00 um and the 1.5 represents the % of that effective radius, shown in the pie chart. I don't think it is necessary to show the percentages numerically.*
e. *The color bar in the lower left hand part of the figure no doubt refers to panel b) and again shows the percentages of various aerosol models ('=1.5'). These percentages should be deleted. Finally, the name of the models are computer generated (e.g., 'sph_nonabs_0.57'), please remove these underscores.*

Response: We removed "250 km" from the figure and added it to the caption. Each sub-frame is now labeled. The color bars have been moved to the right hand side, and the one for AOD is now labeled clearly. We added units to the size, and also percentage symbols to the percents. We kept the percentages because they provide important information about the relative abundance of retrieved components to which we refer in the text, and also retained the underscores in the legend, because this matches the entries in Table 2, and replacing them with spaces actually made the legend more difficult to read. Figure quality improved dramatically. Thanks!

Minor Comments

1. *Title Page – Change the affiliation of the authors from 'Laboratory for Atmospheres' to a more appropriate current affiliation (such as Earth Science Division).*

Done.

2. *Page 7, line 7 – Here and in many places, reference is made to the single scattering albedo (SSA), but the wavelength to which the SSA applies is not provided. Since SSA is wavelength dependent, this should be specified here and in the figure captions*

Right. MISR Green Band (558 nm). Now indicated.

3. *Page 10, lines 25-27 – The Last sentence of this paragraph refers to a near-source plume vertical-extent characterization that is presented in more detail in a paper by Garay et al. [2012]. Consider eliminating this reference altogether, or alternatively; provide a complete reference (authors, journal being prepared for, etc.). Since this paper hasn't been submitted, it might be inappropriate to mention it at all here.*

Removed, as suggested.

4. *Page 11, line 19 – This is the first mention of the wavelength for the SSA, and it states 'lower mid-visible SSA'. This should be clarified.*

Done.

5. *Page 12, lines 25-26 – Reference is made to Fig. 3f, h, and j, but there is no Fig. 3j. Please check which sub-panels are being referred to here.*

Fixed.

6. *Page 14, line 25 – The sentence 'Figure 5 provides an overview of the Research Retrievals…' should say 'for a subset of Fig 1b' or some such. These images are not for the entire 3 blocks shown in Fig. 1b.*

Done.

7. *Page 16, line 3 – Change '40 + 100 microns' to '40-100 microns'.*

Fixed.

8. *Page 17, line 2 – Change 'about 0.1 micron and 2.5 micron…' to 'between 0.1 and 2.5 microns'. I presume you are referring to radius, not diameter, of the particles, though this is also not stated.*

Changed to "between," as suggested. Although we tend to follow remote sensing convention and use effective radius for identifying particle types, overall sensitivity in this case refers to PM2.5, that is, particle diameter less than 2.5 microns, because in this section we are comparing with aircraft *in situ* observations, traditionally reported as diameter.

9. *Page 19, line 6 – You should probably state that Cabauw is in the Netherlands. Furthermore, Fig. 6 is a subset of the real estate shown in Fig. 1c, and again a scale would be useful. The red arrow in Fig. 1c is presumably the area you analyzed in Fig. 6, but this arrow is not defined. These figures could be improved without much difficulty.*

All points taken.

10. *Page 20, line 16 – Reference is made to 'considerably more cloud cover of the land (Fig. 6)' but the figure does NOT show the land water boundary, so it is not possible to easily follow what area is being discussed.*

We now identify the cloud boundary as an indication of the coast, because it is difficult to see the coast itself in the images, but over-plotting a coastline would obscure features of the ash plume.

11. *Page 21, line 16 – Change 'non-spherical over the remnant' to 'non-spherical particles over the remnant'.*

Done.

12. *Fig. 3 caption – The figure caption refers to AOD and ANG. Perhaps 'aerosol optical depth (AOD)' and 'Angstrom exponent (ANG)' should be defined.*

These are defined in the text and AOD is also defined in the Abstract. As this caption is quite long already, maybe it is best to keep it a little shorter.

13. *Page 33, Table 3 footnotes – Change '40 + 100 micron' to '40-100 micron'. Also change 'Large (L, > 0.70 micron)' to 'Large (L; > 0.70 micron)'.*

Done.

14. *Figure 3 – for the image of SSA (Fig. 3d), the wavelength should be stated.*

Done.

15. *Figure 5 –Fig. 5d list P1 – P5 and P7, but P7 should probably be P6, which is discussed in text.*

Fixed.

16. *Figure 7 – Since these panels are sub-frames of Fig. 1d, the scale should be included in one of these sub-panels.*

Done.

Anonymous Referee #1

Received and published: 27 August 2012

This manuscript describes the characterization of volcanic ash particles produced by the eruption of the Eyjafjallajökull volcano in the spring of 2010 using a research version of the MISR algorithm. Volcanic ash is a type of primary aerosol whose lifetime varies from a few hours to a few days with gravitational deposition acting the main removal mechanism. Because of the short lifetime of volcanic ash particles and the low frequency of occurrence of explosive eruptions, the role of volcanic ash in climate is considered unimportant.

Detection, monitoring and quantification of plumes of volcanic ash is very important for air safety applications. Volcanic ash ingested by aircraft engines can potentially melt inside jet engines with catastrophic results in both human life and economic losses.

The value of the detection of volcanic ash by satellite observations lies in the ability to accurately determine its location in the atmosphere and determine its mass concentration with the purpose of re-routing and/or rescheduling air traffic. MISR's capability of estimating the height of the ash layer is therefore an important contribution toward these goals. Unfortunately the once-a-day snapshot characteristic of polar orbiting sensors and the limited across-track MISR coverage limit the usefulness of the spaceborne observations to address the actual needs associated with the real importance of volcanic ash plumes.

In view of the foregoing, the special ACP issue on ' Observations and modeling of aerosol and cloud properties for climate studies' is clearly not the adequate forum for the discussion of this work. Thus, based only on the stated narrow scope of this ACP special issue, I recommend rejection of the article unless the authors can establish in the discussion a clear climate connection. The final decision, however, is at the discretion of the editor

The detailed particle type characterization presented in this paper constitutes an excellent research work, and is clearly publishable material. It illustrates the sophistication level of the MISR algorithm that making use of the sensors multi-angle observing capability can provide detailed particle characterization information. I suggest submission to a regular AMT or ACP (or other suitable scientific journal) edition.

Response: We thank the reviewer for these comments, and for the endorsement of our research effort. We agree that the impact of most individual volcanic eruptions on climate is minimal. However, major eruptions that inject sulfur into the stratosphere are exceptions, and more generally, it would be an advantage for climate models to parameterize the numerous, smaller volcanic eruptions accurately. This paper demonstrates capabilities that can be applied to any

eruption in the ~13-year MISR data record, and the Editor has agreed to include this paper in the Special Issue, pending minor revisions requested by reviewers. We have added a sentence to the Introduction providing climate-related context, and will complete our resubmission as indicated.

Anonymous Referee #2

Received and published: 20 August 2012

General Comments:

In this detailed and thorough worked, the authors demonstrate the ability of the MISR Research Aerosol Retrieval algorithm to evaluate the aerosol properties of volcanic plumes. The lack of in situ data for comparison is regrettable, but available sources have been included and qualitative agreement well documented.
This study is well done. I recommend it for publication with only very minor suggestions.

Response: We thank the reviewer for these comments.

Specific Comments:

As this study has been submitted to a special issue related to climate studies, some discussion directly relating these observations to climate studies would be appropriate.

Right. See response to Reviewer #1. We have added this context to the Introduction.

The authors note that their satellite images provide snapshots across both space and time. I would suggest including a measure of distance on the figures and perhaps one of approximate time from emission using local wind speeds.

We have added scale bars to the figures; estimated plume ages are given in the text.

Technical corrections:

Pg. 17946 L20, "we," is repeated twice.

Fixed.

Table 1 – The significance of bolded dates is not given. Table 2 – AOT is not defined.

These are the cases analyzed in the paper, as is now indicated in the table footnotes.

Figure 1d – Inset is absent.

Fixed.