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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Lightning and electrical activity during the Shiveluch volcano eruption on 16 November 2014" *by* B. M. Shevtsov et al.

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Q: questions

R: reply

Q: This study is a valuable contribution to the literature on volcanic lightning, and deserves to be published after some further attention to other relevant results in the literature, and in particular to published suggestions that two distinct kinds of lightning may occur: vent lightning and plume lightning. This aspect is discussed by McNutt and Williams (2010) but also by Behnke et al. (JGR, 2014) in a more recent publications pertaining to an Iceland eruption. This distinction may also be relevant to distinguishing the lightning flashes listed in Table 1. In the Conclusions, reference is made to "ash

cloud fragmentation process" which seems to this reviewer to be tied with vent lightning rather than plume lightning that in turn might be linked with water substance, and ice in particular. The authors may also wish to consider their characterization (twice in the manuscript) that the WWLLN is an "efficient" detector of lightning. The literature can be consulted for the efficiency of WWLLN as a detector of CG lightning and it is not very high. The efficiency for detection of total lightning is of course even less. As a consequence, it is quite possible that many more lightning flashes were produced by the eruption under study than the seven events listed in Table 1. Somewhere it should be stated that all seven lightning flashes are sufficiently far from the electric field mill to enable a detection of their electrostatic field changes (if this is the case). Summary: Publish after appropriate revision

R: We do not aim at distinguishing vent lightning and plume lightning. At this stage it is impossible without installation of additional WWLLN stations which would surround the volcano within the radius of at least 1000 km. At present there is only one station in Kamchatka. We also installed stations in Magadan and Khabarovk, they are in operation in test regime. Of course, the question is very interesting and seems to be perspective for us for our future investigations in this area. There is no doubt that there were many more lightning flashes than 7. When more stations are installed in the peninsular, we hope to improve the detection of lightning. Thus, we may only state that WWLLN network registers the strongest flashes occurring in the column and the plume during the eruptive process.

Q: English is not the native language of the authors, and so numerous edits on the text have been implemented for the authors to consider in the preparation of their final draft.

R: We'll make the corrections of the English language in the manuscript after all the comments.

Q: Since VEI estimates are increasingly included of volcanic eruptions that make light-

ning, the same information would be welcome here if that is available. Also any visual information on the maximum height of the plume would help to play this eruption in the context of other eruptions that do and do not produce lightning flashes.

R: Unfortunately, we do not have full access to VEI data. We use the data described in the manuscript. According to the data of Kamchatka Branch of Geophysical Service RAS, the height of the eruptive cloud was 12 km which corresponds to the eruption with VEI=3. The description is added to the manuscript. In our manuscript we make the initial analysis with the reference to the paper: The paper [McNutt, Williams, 2010] analyses retrospectively the occurrence of volcanic lightning at 80 world volcanoes for 212 explosive eruptions. The relation of lighting discharges with Volcanic Explosivity Index (VEI) was under investigation. It was distributed as follows: less than 2

Q: Given that this is not the first time that lightning has been detected in eruptions in this particular volcano (see Williams and McNutt), it may be useful to include a short paragraph about earlier findings by other investigators.

R: Please, give the reference to your paper where you describe the event associated with this volcano. For Shiveluch volcano eruption lightning flashes are typical. High lightning activity was observed during the eruptions. As far as I know, for the first time the WWLLN recorded the beginning of this volcano eruption on October 27, 2010.

Q: A better reference for the physical basis that volcano lightning may be linked with ice particle collisions ('the dirty thunderstorm hypothesis') can be found in Williams and McNutt (2005) and that reference is now included for the authors to consider.

R: Within the interval of 25-40 seconds after the onset of the eruption, three discharges were recorded near the eruptive center. They evidently accompanied the rise and formation of the eruptive column. The following three discharges occurred almost simultaneously in 8.5 minutes, supposedly at the front of the eruptive plume carried by wind on the contact with a colder cloud structure according to the theory developed in the paper (Williams, E.R. and S.R. McNutt, 2005). Reference to this paper is made in the

new version of the manuscript.

Q: Other editorial comments on Table and Figures. Table 1 'UT' should be indicated in the 'Time' column. It is quite possible that the initial three lightning flashes are in the "vent lightning" category, and the remaining flashes in the "plume lightning" category. The authors should look into this suggestion (and the literature references pertaining to it) in greater detail. One should also consider deleting "eruption" from the Table caption as it is redundant. The Figure 1 caption would usefully identify all locations shown in the Figure. Also the seismic station Baidarnaya has not been included in the Figure and would be helpful to see. In Figure 2, it is suggested not to use the term stratification, but rather to speak about vertical profiles of temperature of wind direction and speed. In Figure 3, and reminder about the consistency between plume displacement and the wind speed and direction aloft would be appropriate.

R: The corrections were made both in the figures and in the table.

The authors are grateful to Williams, E.R. for the constructive comments. The manuscript was significantly changed according to the remarks. The authors agree with the reviewers that WWLLN method gives the possibility to allocate the strongest lightning discharges in eruptive clouds with the accuracy up to 3 kilometers. Besides the WWLLN network, it is very topical to develop sites for registration of electromagnetic radiation in Kamchatka peninsula. The authors have made the corrections in the manuscript according to the comments of the reviewers and the changed text is attached as a supplement. They hope that Prof. Williams will read the new version of the manuscript.

Please also note the supplement to this comment:
http://www.nat-hazards-earth-syst-sci-discuss.net/3/C2778/2015/nhessd-3-C2778-2015-supplement.pdf

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