Reply on comments of Prof. Williams

Review of "Lightning and electrical activity during the Shiveluch volcano eruption on 16 November 2014" by B.M. Shetsov, P.P. Firstov, N.V. Cherneva, R.H. Holzworth and R. R. Akbashev

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.

According to Table 1, the time between the onset of the explosive earthquake and the first lightning is 1 min 21 s. The seismic signal traveled from the crater to the BDR seismic station about 5 seconds. In total, we have 1 min 26 s between the onset of the eruption and the first lightning. The first lightning and the next are not the vent lightning.

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.

We said about differentiation and fragmentation of ash cloud and about plume lightnings only.

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.

May be, I have to discuss the finish version of paper with my co-author Prof. R.H. Holzworth.

Summary: Publish after appropriate revision

We are ready to consider the proof of paper.

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.

The number of lightnings which can be recorded is defined not by characteristics of WWLLN, but by the level of radio noise and by the distance between the discharge and WWLLN station. It is impossible to change the level of noise, but it is possible to place the station near a volcano.
On the distance about 500 km, we have 7 lightnings. It is possible to estimate, how many lightnings will be at the distance of 5 km. For that, we have to know the distribution of lightnings on amplitudes. Thus, characteristics of WWLLN are not used.
If we have the optimum placing of WWLLN stations, we can record all lightnings which have the amplitude above the radio noise level. This is the efficiency of WWLLN.
There is the electromagnetic efficiency of volcano. What is the question.
The kind of lightning (cloud-ground, cloud-cloud, into cloud or in ionosphere) is defined by the analysis of radio signal form.
From very far lightnings, the cloud-ground components of signal are recorded as more strong. Detailed information disappear.
The WWLLN is not different from any other lightning system in general. Given that capabilities of WWLLN is used in not full measure, we show how WWLLN may be useful and how WWLLN allows to research electrical efficiency of volcanoes anywhere in the world.

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).

All seven lightning flashes were at 100 km from the electric field detector (fig. 1b) therefore the electric field did not change (fig. 4).

Since VEI estimates are increasingly included of volcanic eruptions that make lightning, 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.

We have not VEI estimates and any visual information on the maximum height of the plume. May be, this is interesting, there is the satellite information that ash cloud was at 9 km of the altitude. We said about it.

VEI is a material characteristic of volcano. We need electricity one.

The electrification of a cat don't depend on its weight, but depends on the condition of its hair.

We are interesting the electromagnetic efficiency of volcano which is depended on the properties of plume.

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.

We included the reference on Williams and McNutt.

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 is now included for the authors to consider.

This reference is included too.

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.

We replied on this suggestion above (in the first comment).

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.

It is made.

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.

It is made.

In Figure 3, and reminder about the consistency between plume displacement and the wind speed and direction aloft would be appropriate.

It is made.

End review

Thank you for discussion and annotated manuscript!

With allowance for comments, the paper will be improved and corrected in English by one of the coauthor Prof. R.H. Holzworth .