General Comment 1 - *The fragmentation of the detached rockfall masse is not included in the proposed* ***methodology although it plays a major role for the number, size and run out of the deposited blocks, and this is critical for the rockfall hazard assessment.***
Page 6 Line 11 - *As also mentioned in the discussion, the fragmentation of the blocks is not taken into consideration in this analysis, however it might have a very important effect on the size and number of blocks reaching the roadway. Please comment on that.*
Page 10 Line 25 -T*he fragmentation plays a major role on the number and size of the deposited fragments, and of course on their run out, but this is not taken into consideration here, which is one of the most important limitations of this methodology.*

This is mentioned in the discussion. The purpose of this paper is to present a methodology which can be applied to combine rockfall information extracted from remote sensing with rockfall simulations to obtain a refined estimate of the hazard. The method can be extended to different types of simulations which take into account fragmentation if possible. However, many industry-standard and off the shelf rockfall simulation and modelling software does not take into account fragmentation and those that do are not doing it effectively. In addition, we do not have sufficient data such as physical tests or high temporal monitoring to calibrate models of rockfall fragmentation on this slope, therefore it has not been incorporated. It is likely that there is a larger number of smaller blocks being deposited rather than larger blocks, which is stated in the discussion. This can be elaborated on Page 10, Line 15 to 17.

General Comment 2 - *The calculated percentages of Table 3 are proposed to be used in order to evaluate the most probable rockfall sources, in an inverse analysis approach. However, this approach does not take into consideration the potential effect of the rockfall source density at each buffer zone, to determine the total expected number and percentage of rock blocks reaching the track trail, ditch etc.*
Page 7 Line 2 *- As far as I understood, the percentages presented in Figure 9 are the percentages of the blocks reaching a certain section (track rail, ditch, past track), out of the number of the trajectory simulations for a given volume, and for all the assumed rockfall sources in a buffer zone. If this is so, in order to obtain the total percentage of the blocks reaching each location, the percentages of Fig 9 should be weighted using the percentage of potential rockfall sources at each buffer zone. As for example, it might be that in the 1st buffer zone 85% of the 10 m3 blocks reach the critical sections, but if the sources are significantly smaller that in the other buffers, the effect will be less. This fact is not taken into consideration in the proposed analysis, with a possible error on the results for the percentages of the blocks reaching the critical sections. In my opinion, the percentages presented in Figure 9, should be calculated over the total amount of simulations results for all the rockfall sources.*
Page 9 Table 3 *- This probabilities correspond to the all events from the sources of these zones, but according to how many potential sources each zone has, this percentage will be different.*
Please comment on how the probabilities that you present in this table should be interpreted.
Page 7 Line 8 *- Following my previous comment, this does not mean that blocks are coming mostly from lower zones, because the number of sources might be higher in the upper zones, results in a higher absolute number of blocks on the critical sections.*
Page 8 Line 13 *- In order to evaluate the hazard in terms of magnitude-frequency of blocks reaching the critical sections, it is better to use the annual rockfall frequency instead of the total number of rockfalls. The number of rockfalls should also correspond to the selected buffer zone and its potential sources. This part needs further clarification.*

The above comments all appear to relate to the same topic. To clarify:

- The location of rockfall sources for the period that laser scanning has taken place can be known from the change detection analysis. The problem we would like to solve is to understand how many of these rockfalls make it to the track level.
- The rockfall simulations are run, taking into account many potential source locations and the results are used to determine the likelihood that a rockfall will be deposited on the tracks or in the ditch, given its source location and block size. The graphs in Figure 9 show the results of the simulations and are not meant to show the total number of blocks ending up in a given area. They are not used

inversely to evaluate the most probable sources, as the sources are already known from the laser scanning.

- Given the results of the simulations, we are able to go back to the database of rockfalls obtained from the change detection and apply the probabilities obtained from the simulations to determine which of the known rock falls are likely to make it to the track, ditch, etc.
- We can then compare the yearly frequency of rock falls that are occurring on the slope, based on laser scanning, to the yearly frequency of rock falls deposited on the track, in the ditch, etc. (Figure 10). This summary can be included in the discussion or conclusions of the paper if necessary.

Page 1 Line 13 *- I think that you make precise here what input us obtained using the propose methodology. In my opinion, this should be made clearer throughout the text, as well.*
Page 2 Line 13 *- As in my previous comment, it is not clear what are the input parameters that you mention here.*

This can be clarified in the manuscript on Page 2, Line 13.

Page 3 Line 5 *- Block higher than 1 m3 that are deposited on the rails can also be of major concern as a train may crush on them. Why do you prioritize the scenario of a wedge under a train over such a crush?*

In the original documentation for the CN Rockfall Hazard Rating System (RHRA), it is stated that blocks between 0.3 and 1 m are of the highest concern for operators because these blocks have the potential to become wedged under a train and derail it. This is referenced in the manuscript. Larger blocks are more likely to set off rockfall warning systems such as trip wire fences, causing trains to run at a slower speed, however the blocks between 0.3 and 1 m may often be too small to trigger any warning. Rocks larger than 1m are still a concern, but the system for this railway states that 0.3 to 1 m blocks are of specific concern. This can be detailed on Page 3, Line 9.

Page 3 Line 29 *- It would be interesting for the reader to provide some technical details, as for example the scanning distance, scanning locations, number of scans, length of slope scanned, density of the point clouds and errors.*
Page 4 Line 6 *- As well, here it would be interesting to mention differences in the resolution of the different point clouds and alignment details and errors.*
Page 4 Line 12 *- As for the TLS and the ALS, more details would be useful here too, on the resolution and errors of the photogrammetry obtained DTM.*

Some additional details can be provided in Section 2.1. There are many details on the technical details of the laser scanning provided in other papers by the authors which have been referenced in the manuscript. The purpose of this paper is to describe a methodology for working with the information obtained from the laser scanning.

Page 4 Line 32 *- There is a very high number of small events indicated by the analysis. The calculated magnitude frequency curve suggests that about 1500 events of 0.01 m3 took place in 2 years. Is this realistic for the study area? Such a high number of events is not indicated by the inventory. Could a part of those events be attributed to alignment or resolution errors of the digital elevation models, which are compared to get the volume differences.*

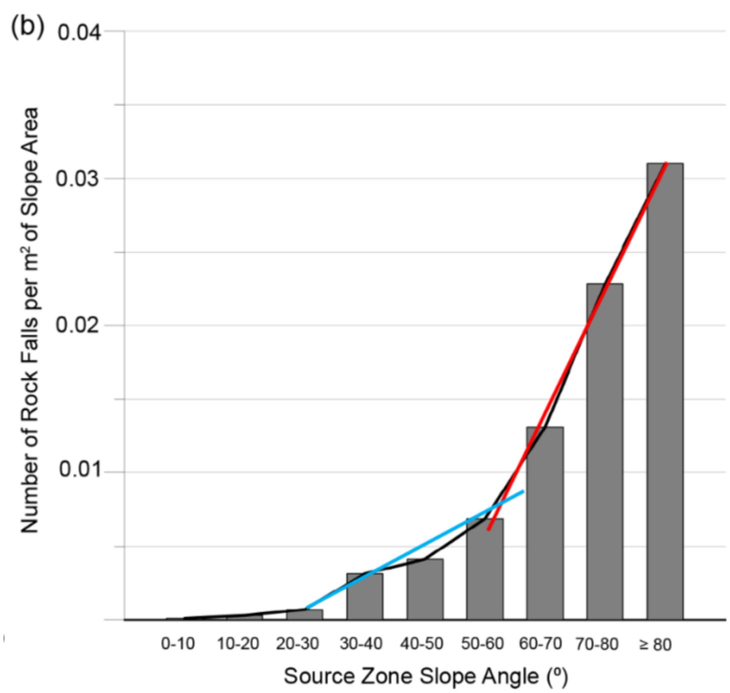
This is described in van Veen et al. (2017) and other papers that have been cited. A Limit of Detection threshold of 0.05 m was applied based on the alignment error between the TLS scans. In addition, other filters were applied to remove noise from the data, as described in the referenced papers. Many of the smaller rock falls have been validated using high-resolution photographs of the slope, therefore the high number of small events is realistic. This can be noted on Page 4, Line 30.

Page 5 Line 3 *- The rockfall occurrence is related to the local geological characteristics in the two opposite banks of the river. Similar discontinuity sets might have lead to rockfall in one back, but not in the other, resulting in different and not comparable magnitude-frequency curves.*

This is the most complete historical dataset available for this area, therefore it is shown as the most comparable example. The two railways cross over and switch sides of the river at various points along the track in addition to changing alignment with respect to geological structures in the region. Further clarification can be added in Section 2.3 suggesting that these datasets cannot be compared directly.

Page 6 Line 4 *- It is not clear from Fig. 5b that the significant increase includes the slope 50-60 degrees. From the data it seems that slope of 60-70 degrees present instead a distinct increase. I think that the selection of the thresholds of 55 degrees needs further justification. Could the dip angle of the existing unfavourable sets could give an insight to that threshold? Additionally, in Figure 7a, you also differentiate in the legend between slope angles of 55-75 degrees and >75 degrees. Why? This distinction in not included in the text.*

Figure 7a can be updated to remove this distinction. By adding lines to figure 5b it is more clear that the change in slope angle occurs between the 50-60 degree bin and the 60-70 degree bin. Given the relatively short sampling period of data for this slope, we must be slightly conservative. Therefore 55 degrees has been used. This can be further justified in the manuscript. See image below.



Page 6 Line 14 *- Why do you use the minimum deposited volume, instead of the maximum one which is a worse scenario?*

The minimum deposited volume is shown, as any block size larger than this will also be deposited in these locations. Therefore, by showing the minimum volume, we can understand the full range of block sizes that could be deposited in each location. This can be specified on Page 6, Line 15.

Page 7 Line 1 *- In Figure 9, why rockfall sources at a distance of 350-500 m from the trail, result in more blocks deposited in the ditch, than the sources of 300-350 distance? In all the other cases, but this, more blocks reach the ditch if the source is closer to the track trail.*

The graphs show a percentage, and not an absolute number of blocks being deposited at the base of the slope, as we are concerned with a probability of a rock reaching the track or the dith. The graphs show that a larger percentage of blocks sourced from 350-400 m are reaching compared to blocks sourced from 300-350 because there are relatively few source zones between 350-400 m, and because of where these source zones are located, a larger proportion of the blocks travel further, compared to the 300-350 distance where there is a larger spatial variation in source zones, so the slope geometry has more of an overall effect. The total number of blocks sourced from 300-350 reaching the base of the slope is larger than 350-400, however the relative proportion is smaller. This can be commented on in the discussion if necessary.

Page 8 Line 12 - How do you define the size the thresholds of the bins?
Page 8, Line 11 and 12 can be reworded/clarified. Instead of specifying that the modelled volume is the central point of each bin, we could state that each of the rock falls was assigned a probability based on being rounded to the closest modelled volume. We also propose to add a diagram to further show the different bins.

Page 10 Line 18 - This is not certain. Rockyfor3D can produce this output.
We state that it is not possible to track the location and energy of a block at any given point in time to determine the specific passage of each block down the slope. In RockyFor3D it is only possible to determine the energy statistics at a given cell in the raster, not for a particular, individual rock fall event. This can be specified on Page 10, Line 18.