Final author comments on behalf of all co-authors

Response to the reviewer 1

The reviewer's comments have been taken into account as described below.

Reviewer's comments
Line 4, page 125: here, it could be useful to have a picture with the layer sequence.

Authors's response
The required picture has been added in the paper.

Reviewer's comment
Line 14, page 125: Table 1 seems to me worthless, since the main and relevant characteristics of the two beams are already described in the text.

Authors's response
It is not requested by the second reviewer. All the characteristics are not in the text. So I let the editor decide to remove it if the paper should be reduced.

Reviewer's comment
Lines 29, page 129: at line 24 you state that for the Grenoble area Ast = 0.0047 $rockfalls.yr^{-1}.hm^{-2}$. I would expect that this is equivalent to Ast = 0. 47 $rockfalls.century^{-1}.hm^{-2}$ instead of Ast = 0.037 $rockfalls.century^{-1}.hm^{-2}$, as you wrote.

Authors's response
The value of 0.037 doesn't refer to Ast (number of rockfalls larger than 1 m3), but it is the number of rockfalls larger than 100 m^3 , given by the power law.

Reviewer's comment
Figures 2 and 3: I suggest to modify the two figures like in the example below.

Authors's response
The figures have been modified according to the example.

The required grammatical changes have been made.
The authors thank the reviewer for its useful comments and its grammatical and technical corrections.

Response to the reviewer 2

The reviewer's comments have been taken into account as described below.

Reviewer's comments

"I'm not certain of the usefulness of the 'rockfall activity parameter' for the following reasons:

(1) The two datasets used in the discussion to compare the parameter values were collected using different techniques and consequently cover different rockfall volume ranges and are of different resolution and accuracy. Therefore comparing the value or significance of the rockfall activity parameter of the two sites is difficult. Comparing two datasets collected using the same technique would help clarify the usefulness of the parameter.

(2) I'm not sure what the rockfall activity parameter and the ratio of its difference between two sites tells us about the geological, geomorphological and environmental controls of rockfall activity? And I think this is what the authors are saying is the purpose of the parameter value. Perhaps its calculation for a large number of sites may be able to tell us something about these controls."

"Page 124, Line 7: (See comment below for lines 11-16 on page 128: The magnitude-frequency exponent 'a' does not represent only rockfalls larger than 1 m3.) Also in the discussion (line 28 page 129) you use a different description to define the rockfall activity parameter - using it to look at rockfalls >100 m3, not >1 m3 as specified here."

Authors's response

We agree that the parameter A_{st} solely doesn't reflect the rockfall activity, then we don't use this expression no more to refer to A_{st}. We only have compared the power law parameters of the two sites, but not the rockfall activities. Also we have better explained the reason why we have used the frequency of rockfalls larger than 100 m^3. So the corresponding paragraph has been changed as follows (changes in bold):

"Hantz et al. (2003) analyzed the cumulative distribution of rockfall volumes between 10^2 and 10^7 m^3, occurred from the 120 km long limestone cliffs of the Grenoble area, which include the Mont Saint-Eynard cliff. They found that a power law well describes the distribution, with b = 0.55 ± 0.11 and A_{st} = 0.0047 rockfalls per year per hm^2. It appears that both parameters b and A_{st} are significantly different from those obtained for the Mont Saint-Eynard (b = 0.75 ± 0.04 and A_{st} = 0.85 $yr^{-1}.hm^{-2}$). **Note that the two inventories were determined from volumes ranging from 0.05 m^3 to 100 m^3 for the Mont Saint-Eynard, and from 100 m^3 to 10^7 m^3 for the Grenoble area. As the power law obtained from the second inventory may not be valid down to 1 m^3, it is more pertinent to compare the frequencies of rockfalls larger than 100 m^3, which is a limit value for both inventories. These numbers are respectively of 2.7 and 0.037, giving a ratio of 72. It appears that the two power laws don't fit together.** Several reasons can be proposed to explain this strong discrepancy: (a) The rockfalls for the Grenoble area were known from a historical inventory which is probably not exhaustive. (b) Most of the rockfall volumes for the Grenoble area were estimated from historical sources, with more uncertainty than for the Mont Saint-Eynard. (c) The cliffs of the Grenoble area consist of different calcareous rocks of Jurassic and Cretaceous age, including mostly massive limestones (metric to decametric thickness), whereas the cliff studied consists only of thinly bedded limestone of Sequanian stage (thickness of 20-50 cm). **The authors think that the causes (a) and (b) can't explain such a discrepancy and that it is mainly due to the different geological features**."

To better understand the influence of geological conditions, TLS measurements of several mountain cliffs in different conditions have been carried out and will be soon analyzed. A comparison of the rockfall activities in terms of cliff retreat rate will be presented in a next full paper.

Reviewer's comment
"Page 124, Line 19: What do you mean by 'erosion factors'?"

Authors's response
"erosion factors" has been replaced by " intensity and frequency of rockfall causal factors".

Reviewer's comment
"Page 124 line 26 – page 125 line 5: It would be useful to have a figure showing the cliff geology and morphology, including the elevations of the cliff layers so they can be compared to the position of the scanner."

Authors's response
The required figure has been added to the paper (elevations on the photo).

Reviewer's comment
"Page 127, Line 17: What do you mean by a "watertight mesh"?"

Authors's response
"watertight mesh" has been replaced by "closed mesh".

Reviewer's comment
"Page 127, Line 22: States that volumes >0.1 m3 provide a better fit, yet in Figure 2 0.2 m3 is used as a cut-off. Would be better to be consistent in how the data is discussed and presented, as is done for Figure 3."

Authors's response
The error has been corrected : 0.1 m^3 has been replaced by 0.2 m^3.

Reviewer's comment
"Page 127, Line 23 - 27: "According to the accuracy expected" – Do you mean according to the accuracy calculated accounting for the errors caused by a – e that are discussed in the previous section? What is the deviation threshold is between the two scans accounting for errors caused by a – e?"

Authors's response
It has been clarified in the text: "According to the accuracy expected accounting for the errors a – e (previous section), the deviation threshold has been set to 0.1 m."

Reviewer's comment
"Page 128, Lines 11 – 16: The exponent 'a' is actually an indicator of the overall volume of rockfalls during a monitoring period, rather than the number of rockfalls solely > 1m3. Also research by Barlow et al. (2012) suggests that both a and b exponents can be also potentially determined by the spatial and temporal extents of the study, as well as geology and

geomorphology, and there is evidence that variations in environmental forcing also influence the magnitude-frequency distribution exponents, see Barlow et al. (2012)."

Authors's response

Yes, the parameter a does contribute to the overall volume of rockfalls, but also it directly represents the number of rockfalls > $1m^3$. Concerning the influence of the environmental conditions, the discussion section has been modified as follows (changes in bold):

"The distribution of the rockfall volume has been studied by several authors (see reviews in Dussauge-Peisser et al., 2002, and Brunetti et al., 2009). Most of them found that the complementary cumulative distribution function is well fitted by a negative power law:

$$N = aV^{-b} \quad (1)$$

where V is the rockfall volume, N is the number of rockfalls larger than V occurring in a given rock wall during an investigation period, a and b are constants. The constant a represents the number of rockfalls whose volume is greater than 1 m^3 (assuming the law is valid for this volume range). It obviously depends on the size of the cliff, the length of the investigation period and the geological and geomorphological context. **A number of authors have determined the exponent b in different geological and geomorphological contexts (see Brunetti et al., 2009, for a comprehensive review). Some authors have used the complementary cumulative distribution of the rockfall volume; others have used the non cumulative distribution (or probability density function). The probability density function also follows a power law with an exponent which equates (b+1). Using the cumulative distribution, the exponent b has been assigned values ranging from 0.1 to 1. Using monthly inventories, Barlow et al. (2012) have shown that b not only depends on the geological and geomorphological context (as usually thought before), but also on the environmental conditions.**"

Reviewer's comment

"Page 129, Line 13 – 14: Include the equation of the rockfall activity parameter."

Authors's response

The equation has been included.

The required grammatical changes have been made.

The authors thank the reviewer for its useful comments and its grammatical and technical corrections.