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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "Brief communication: Accuracy of the fallen blocks volume-frequency law" *by* Valerio De Biagi

V. De Biagi

valerio.debiagi@polito.it

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Thank you for your insightful comments that help me to improve the quality of manuscript.

[Dr Hantz's comment] The epistemic error due to missed recorded events is analyzed, but THE ALEATORIC ERROR DUE TO THE STOCHASTIC NATURE OF THE POISSON PROCESS IS IGNORED although it may be bigger than the epistemic one. For example . . . So a confidence interval should be determined for the Poisson parameter. In conclusion, the paper should be completed with a section analyzing the aleatoric error due to the stochastic nature of the Poisson process.

[Author's response] The observation is perfectly true. Discussing the reliability of the

volume-frequency law, in particular to the Section 3.1 related to 'Missed recorded events', the effects of the epistemic error on the value of the computed volume are considered. The aleatoric error due to the stochastic nature of the Poisson process is not taken into account.

$P_{n,t}(\lambda)$ is the probability that, given an average frequency equal to λ, n events are observed during the period t. Mathematically, $P_{n,t}(\lambda)$ can be expressed as

$$P_{n,t}(\lambda) = \frac{(\lambda t)^n}{n!} e^{-\lambda t}.$$

Fixing the number of observed falling blocks and the length of the observation period, say, for example, $n = 5$ blocks and $t = 25$ years, the probability of observing 5 events in 25 years, i.e., $P_{5,25}$, varies as much as the annual frequency changes. The maximum probability, as reported in the manuscript and in parent paper (De Biagi et al., 2017) is obtained at $\hat{\lambda} = n/t$. In Figure 1(a) the values of $P_{n,t}$ against λ are reported for various pairs $(n,\ t)$, all having a ratio equal to 0.2, i.e., $\hat{\lambda} = 0.2$. As supposed, it is observed that the curves get narrow as soon as the number of observations increases (by consequence, the length of the observation period increases proportionally). The area underlined by each curve is equal to

$$\int_0^\infty \frac{(\lambda t)^n}{n!} e^{-\lambda t} d\lambda = \frac{\Gamma(n+1) - \lim_{\lambda\to\infty} \Gamma(n+1, \lambda t)}{t\, n!} = \frac{1}{t}.$$

The curves can be normalized in order to have unitary underlying area, i.e.,

$$Q_{n,t}(\lambda) = \frac{P_{n,t}(\lambda)}{1/t} =$$

Figure 1(b) shows the normalized curves. As suggested by Dr Hantz, a confidence interval should be proposed for accounting for the aleatoric uncertainty of the estimate of parameter $\hat{\lambda}$. Instead of a confidence interval, given n and t, the value of $\lambda = \lambda_i$, corresponding to a given i-percentile can be used. For example, considering the 90-percentile, the value of λ_{90} to be considered is the one for which the following equalities chain subsists

$$\int_0^{\lambda_{90}} Q_{n,t}(\lambda)\, d\lambda = \frac{\Gamma(n+1) - \Gamma(n+1, \lambda_{90} t)}{n!} = 0.90$$

Physically speaking, if n falling block events are observed during the period t, there is the 90% probability that the true frequency parameter is lower that λ_{90}. Figure 2 shows the normalized curves and the shaded areas corresponding to 90-percentile. It can be seen that as much as the number of recorded events increases, the λ_{90} reduces.

Accounting the effects of the variability of the estimate of the frequency parameter has direct consequences on the value of the computed volume, cfr. Eqn. (5) of the discussion manuscript. As done for other types of uncertainty, the effects on the expected volume can be computed in terms of ratio between the volume computed using λ_{90} and the one using $\hat{\lambda}$. This ratio, say $\mathcal{D}$, is

$$\mathcal{D} = \frac{V_t \left(\lambda_{90} T\right)^{\frac{1}{\hat{\alpha}}}}{V_t \left(\hat{\lambda} T\right)^{\frac{1}{\hat{\alpha}}}} = \left(\frac{\lambda_{90}}{\hat{\lambda}}\right)^{\frac{1}{\hat{\alpha}}}.$$

As suggested by Dr Hantz, the previous considerations will be inserted in an appropriate section of the manuscript.

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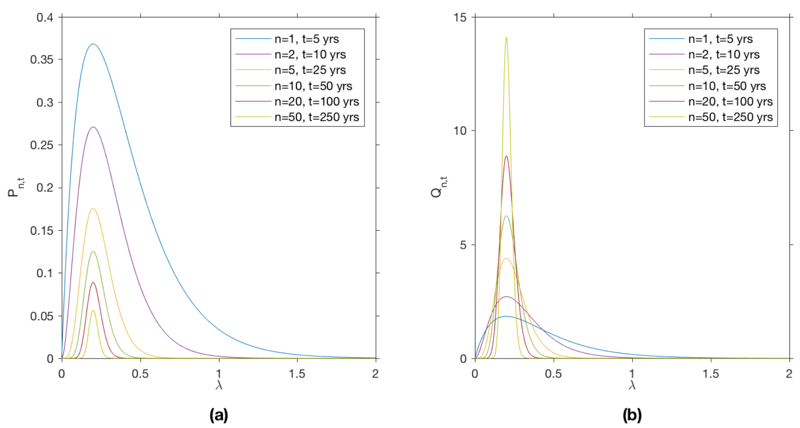

Fig. 1. Plots of the probability of observing a given number of falling blocks in a certain amount of time. The curves in (b) are normalized insomuch that the underlying area is one.

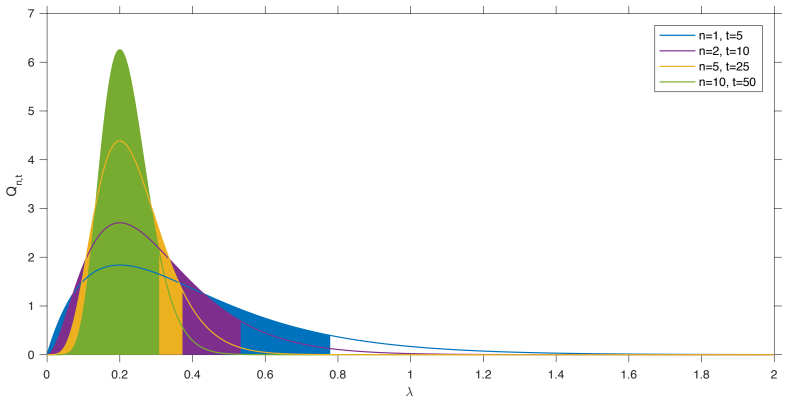

Fig. 2. Normalized distribution curves. The shaded areas corresponding to 90-percentile.