

Solid Earth Discuss., author comment AC1  
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## Reply on RC2

Thierry Camelbeeck et al.

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Author comment on "The damaging character of shallow 20th century earthquakes in the Hainaut coal area (Belgium)" by Thierry Camelbeeck et al., Solid Earth Discuss.,  
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Dear Reviewer 2,

Thank you for your remarks on our paper on the damage impact of the Hainaut seismicity. Here below, we give a detailed reply to your comments and how it impacts the modifications of the paper. We hope this discussion meets your expectations.

Kind regards  
Thierry Camelbeeck for the authors

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### Summary

*R2: This paper presents an exhaustive revaluation of 28 small earthquakes in Belgium between 1887 and 1983 in the Hainaut province of SW Belgium. Macroseismic data are presented in detail and used to refine parameters.*

### Comments

*R2: Technically, this paper is of high quality, with only one error, which is to refer to "attenuation laws" for things that are not laws.*

**We sincerely thank the reviewer for the general comment about the quality of our research. We agree with the comment and changed the term *intensity attenuation law* into *intensity attenuation relationship* everywhere in the paper.**

*R2: The problem with this paper is that it calls to mind the apocryphal most boring headline ever – "Small earthquake in Belgium: No-one hurt". This paper is 40 pages long in the preprint version, and it is questionable what interest it has for an international audience such as the readership of Solid Earth. There is no doubting the quality of the research, but one would normally expect it to appear as a published report of the sponsoring institute rather than a paper in an international journal.*

**Following both reviewer's comments (see also our reply to reviewer 1), we reduced the length of the paper by transferring the description of the seismicity (previous section 4) to Appendix B in the paper.**

**The reviewer furthermore questions the interest of our submitted manuscript for an international audience such as the readership of Solid Earth because it we only report small damaging earthquakes in Belgium. The submitted version of our paper was indeed partly concentrated on the regional context of seismicity in**

**Belgium, but it also largely focused on aspects that are of international interest:**

**1. We provide a strict methodological framework concerning the way an historical/early-instrument earthquake catalogue should be composed and improved based on re-evaluation of historical sources. In the electronic supplement, we provided all references to historical sources and the intensity database which allows the reader to re-evaluate the whole work. Coupling the data with the analyses encourages researchers to build their own opinion on the problematic and motivates them to apply the same methodological approach for other areas where similar moderate past seismicity occurred. Moreover, the Solid Earth journal promotes sharing new data in their open repository to make the work reproducible, hence, this justifies providing all the data in the Supplement.**

**2. Even though the shallow earthquakes may have looked small, the findings of our paper (attenuation, depth, etc) have important implications for decision-makers related to subsurface management. The sensitivity of highly populated areas to small, shallow, induced and triggered, potentially damaging seismicity strongly increased during the last years. Therefore it is important to evaluate if past seismicity that was considered as natural could be related to human activities.**

**3. To increase the interest in the work and meet the reviewer's request, we added a comparison of the attenuation intensity and impact between Hainaut and other regions worldwide subjected to induced or triggered seismicity, such as in Groningen, Oklahoma, Völkerhausen, Le Teil, etc. (please see our detailed reply to reviewer 1).**

**Hence, we think enough aspects are present in the paper to be of international interest.**

*R2: The significance is given in the inset to Figure 1, showing the Hainaut area being depicted as of high seismic hazard in the recent SHARE European hazard map. From the authors' work this is clearly incorrect. Most of the earthquakes in this region are too small to be hazard-relevant, and probably all of them are mining-related, in which case they should be deleted from the earthquake catalogue prior to PSHA.*

**Absolutely, this was part of our motivations for conducting this work. Before this study, the origin of the earthquake activity was considered as natural. The activity was never labelled "induced or triggered". In a country where damaging events are rare, this seismicity is significant, and consequently the whole catalogue was integrated in the different PSHA studies. Of course, even though events were small, they were hazardous because the events were recurrent and caused damage (as shown in the discussion). With our work, re-evaluation of PSHA is encouraged but this is a huge task to do and is beyond the scope of this paper.**

Based on the reviewer's comment, we highlighted the aspects above more in the abstract, introduction and conclusions of the paper.

*R2: It is significant that despite the frequency for events in the period under consideration, there is a complete lack of earthquakes prior to 1887, which is a clear sign that there is no natural tectonic seismicity.*

**Recent work on Stable Continental Regions show that seismicity is sporadic and moves in time and space. The absence of seismicity in SCR for a given period of time is not necessarily a clear sign of absence of natural activity.**

*R2: To make this paper of interest, the focus should be shifted away from the detailed data on these earthquakes (all of which can be moved to an ROB report) and to the more general topics of mining seismicity and hazard. There is at present no examination of what was done for Hainaut in the SHARE project – for instance, how were these events depicted*

*in the SHARE earthquake catalogue, compared to the authors' final versions? This seems like an obvious topic to cover. Also, it would be useful to have a history of coal mining in the region to compare to the progress of the Hainaut earthquakes. What is the likely effect on the PGA hazard to be expected from deleting all these non-tectonic events? These are the sorts of questions that ought to be covered in a paper for Solid Earth.*

**In the EMEC catalogue used in SHARE (Grünthal, G. & Wahlström, R., 2012), Mw was evaluated for most events from the Belgian catalogue from Imax. These magnitudes are sometimes not correct for two reasons: first, because the depth and local attenuation were not considered in the magnitude evaluation; second, the re-evaluation of intensity in all available macroseismic sources shows over-estimation of some Imax values in the original ROB catalogue used in EMEC. For example the 1953-09-15 event in Quaregnon (id 557), Imax was originally set to I = VII, while our re-evaluation reduced it to I = V. The comparison of how seismic parameters in our catalogue (ROB) changed with respect to the EMEC catalogue is shown in the table below. Especially for the 19th and early 20th century events, intensity and magnitude values changed considerably after our work and the reasoning why these values changed are explained in detail in the paper.**

E-ID	Date	Time ROB	Time EMEC	Depth ROB	Depth EMEC	Imax ROB	Imax EMEC	Mw ROB	Mw EMEC
431	1887-09-20	06:40:--	6:40	[0.4]		4_5	6	1.7	4.3
434	1887-10-29	21:--:--	21: --	[0.8]		4_5	5	2.3	3.7
438	1904-04-23	16:30:--	16:30	[0.8]		4	5	2.1	3.7
465	1911-06-01	22:51:5	22:51	4.3		6	7	[3.9]	3.9
466	1911-06-03	14:35:5	14:35	[1.4]		7	6	[4.0]	3.8
505	1936-11-05	00:41:4	00:41	[2.2]		4_5	5	3.3	3.7
533	1949-04-03	12:27:3	12:27			7	6	[3.7]	3.6
534	1949-04-03	12:33:4	12:33	2.2		7	7	[4.1]	4.3
539	1949-04-14	05:12:2	05:12	[2.4]		6	2	[3.6]	3.5
547	1952-10-21	21:15:--	21:15	[2.9]		4	6	3.1	4.3
549	1952-10-27	06:11:--	06:11	3.5		5	6	3.5	4.3
557	1953-09-15	23:55:--	23:55			5	7	3.1	5
562	1954-07-10	17:18:2	17:18	3.3		5	6	3.5	4.3
573	1957-01-08	16:12:--	16:12	[0.4]		6	6	2.2	4.3
577	1958-05-30	14:45:--	14:45	[0.6]		6	6	2.6	4.3
582	1965-12-15	12:07:1	12:07	2.7		7	7	4	4.1
588	1966-01-16	06:51:3	6:51	3.3	5	5		3.5	3.5
589	1966-01-16	12:32:5	12:32	2.1		7	7	4	4.1

	-16	0						
595	1966-03	00:08:1	0:08		5		3.5	3.5
	-20	5						
597	1967-03	15:49:2	15:49	3		7	7	4.1
	-28	5						
606	1968-08	16:57:1	16:57	2.3		6	7	3.9
	-13	4						
612	1970-11	08:46:0	8:45	2.3		5	7	3.6
	-03	0						
627	1976-10	20:33:2	20:33	5.5		6	6	[3.9]
	-24	8						

**Our results show that not only the origin of the activity cannot be considered independent from the mining history, but that also the strong attenuation in the Hainaut Coal Area is an important element to take into account in future PSHA computations for SW Belgium and surrounding regions, i.e. Northern France. But as said before, re-computing the hazard is a big task (but is an ongoing research) and is beyond the scope of this paper.**

**Finally we would like to comment that the work to correct and to extend earthquake catalogues, following the rules of historical criticism, is a huge task. It asks the courage to accept that previous works and catalogues may contain errors and may need re-evaluation. One of our objectives was to demonstrate this statement and to provide an updated ground motion attenuation and seismicity background, necessary to improve hazard mapping in the near future.**