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Comment on the paper "Earthquake Hazard Assessment in the Oran Region (Northwest Algeria)" by Youcef Bouhadad and Nasser Laouami

JOSÉ A. PELÁEZ MONTILLA[1*] and MOHAMED HAMDACHE[2]
[1]*Departamento de Física, Escuela Politécnica Superior, Universidad de Jaén. C/ Virgen de la Cabeza, 2. 23071 Jaén, Spain;* [2]*Département Etudes et Surveillance Sismique, Centre de Recherche en Astronomie, Astrophysique et Géophysique. B.P. 63-Bouzaréah, 16340 Algiers, Algeria;* [*]*Author for correspondence (e-mail: japelaez@ujaen.es)*

We would like to make some comments on the recent paper by Bouhadad and Laouami (2002), specially, related to the used methodology, as well as to the source parameters calculation and their use in the logic tree approach to derive seismic hazard.

In our opinion, the authors have merged the deterministic and probabilistic approach to derive the source parameters and the final results. Also, the low unrealistic values of the *b* parameter used by them in the Gutenberg–Richter relationship necessarily lead to a clear overestimate of the seismic hazard in the studied area (the region of Oran, in Algeria).

On the Recurrence Relationship for Fault Sources

It is known that assigning maximum magnitude to a fault using the empirical relationship of Wells and Coppersmith (1994), between the rupture length in the surface or rupture area and the event magnitude, could be either probabilistic or deterministic, depending of how this relationship is used.

For example, if we use data of rupture lengths from paleoseismic events to establish their paleoseismic magnitudes in order to find a magnitude recurrence relationship for the fault being considered, we are clearly within a probabilistic context. The obtained results based on these recurrence relationships could be integrated and combined with others probabilistic results, for example, with the seismic hazard results from fault or area sources near to the fault.

An alternative approach would be to use the total length of the fault, without considering segmentation phenomena, instead of the rupture length in the Wells and Coppersmith (1994) relationship. This approach provides us the maximum magnitude that the fault could generate if it broke in all its length (or area). In this case, the result is purely deterministic. Therefore, such a result would be more related to the fact of estimating the seismic potentiality of the area (an upper limit to the seismic hazard) than to the calculation of the probabilistic seismic hazard. It is then not consistent to merge the previous results and those obtained starting from probabilistic recurrence relationships, such as Bouhadad and Laouami (2002) do in their paper.

Another issue is the fact of assigning earthquakes to faults for estimating their b values.

The process of earthquake occurrence on a given fault is mathematically a chaotic process (Turcott, 1992). Moreover, even considering that the process follows an earthquake characteristic model (Schwartz *et al.*, 1981; Coppersmith and Schwartz, 1983), the small number of earthquakes in the region do not provide any guarantee for the estimation of the b value (Hoffmann, 1996). With three, four or five earthquakes associated with a certain fault (according to Figure 6 in Bouhadad and Laouami, 2002) it is not possible to derive a reliable value for the b parameter. This is specially true considering that the earthquakes do not fit the Gutenberg–Richter recurrence relationship, not even for low nor moderate magnitudes, due specially to the incompleteness of the earthquake data file used.

It is widely accepted that the lowest values for the b parameter ($\sim$0.5) are associated with singular faults (Olsson, 1999). Values in the range between 0.24 and 0.30, used with the greater weight in the branches of the logic tree methodology, have never been previously reported in the scientific literature. A fault as active as the north Anatolian fault, which during the 20th century generated more than 50 earthquakes with magnitude greater than 6.0 M_S (Oncel *et al.*, 1995), never had a b value below 0.5 (Oncel *et al.*, 1995; Oncel and Wilson, 2002). Another example is the calculation of the seismic hazard carried out in the US by Frankel (1995) and Frankel *et al.* (1996). In the recurrence relationships for the faults used in the seismic hazard analysis carried out by these authors, a b value of 0.8 is adopted, with the exception of 0.9 for the California faults and 0.65 for the deep earthquakes ($h > 35$ km) in the western US.

Last but not least, another important question remains. When faults are included using a recurrence relationship, not obtained from paleoseismic data but from seismological data (earthquake catalog), the seismicity associated with the fault cannot be associated again to the source area including it. If we do so, we are duplicating the number of earthquakes, and therefore artificially increasing the seismic hazard.

For example, if the 10/09/1790 Oran earthquake is associated with the Oran fault inside the seismic area source Z1, then which earthquakes remain in Z1 to assign it a 7.0 M_S maximum magnitude? The same remark holds for the 08/18/1994 Beni-Choughrane earthquake. This earthquake is associated with the Beni-Choughrane fault or with the Ghris fault source. Then, which other earthquakes are in the area source Z3, where the Beni-Choughrane and Ghris faults are included, to assign it a 6.5 or 7.0 M_S maximum magnitude? If the Oran and Beni-Choughrane earthquakes are used to justify the seismic activity of their related faults, we face the problem of not having enough important earthquakes to derive such high maximum magnitude values for the area sources.

On the Recurrence Relationship for the Area Sources

We have seen above that the lower *b* values obtained for the fault sources are clearly unrealistic. The same occurs for the area sources, where the authors used comparable low values such as 0.27, 0.43 and 0.47 for the three sources being considered.

Evidently, these results are obtained when working with incomplete data files, and could not be associated with the characteristics of the seismicity in the region. It is well known that the use of an incomplete catalog, specially for the lower magnitudes, provides *b* values lower than expected.

Previous works show that, in the northern Algeria, the *b* value is of the order of 0.8 using the m_b magnitude (López Casado *et al.*, 1995), 0.6 using the M_S magnitude, and considering the whole northern Algeria and Tunisia (López Casado *et al.*, 2000), 0.7 using the M_S magnitude and considering the western Algeria (Hamdache *et al.*, 1998), and 0.9 using the M_S magnitude and considering the northwestern Algeria (Hamdache, 1998).

The studied area in the paper by Bouhadad and Louami (2002) is not so extended, and the catalog used by them is not as complete as would be desirable. This implies that the proposed seismic sources (fault and area sources) have a poor seismicity: 14, 6 and 7 earthquakes in the Z1, Z2 and Z3 area sources, respectively (according to their Figure 6), and only 3 or 5 earthquakes for some of the defined fault sources (according to their Figures 5 and 6).

No probabilistic method for calculating the *b* parameter, including methodologies as complete as the one by Kijko and Sellevoll (1989), can provide realistic values of *b* using so few earthquakes. Standard methods have not been designed for this.

It would seem more appropriate to use a single value of the *b* parameter for all of the seismic sources, which could be a mean computed for this region or a more extensive one, and to establish a difference in the seismic sources only based on the maximum magnitude.

Final Remarks

The maximum value for the seismic hazard obtained by Bouhadad and Laouami (2002), near the Oran city, is such that a mean value of the ground motion of 0.42 g for a exposure time of 500 years is expected. What does this mean?

This mean value of the ground motion is obtained, for example, by replacing the real sequence of earthquakes in this area by a sequence of two earthquakes in 500 years, such that each of them provides us this value of PGA. This is the basis of the methodology proposed in Joyner and Fumal (1985) for seismic hazard determination. An earthquake generating a PGA of 0.42 g should have a macroseismic intensity of IX–X, using the relationship between the PGA and the intensity of Murphy and O'Brien (1977). Well, near the Oran city, along the Oran fault, an earthquake of these characteristics, has taken place only once (1790 Oran earthquake) and not twice.

Finally, it does not seem appropriate to compare as a check the result obtained by Bouhadad and Laouami (2002) with the one by Aoudia *et al.* (2000) using a deterministic approach. The PGA value of 0.42 g for a exposure time of 500 years near the Oran city is mainly due to the unrealistic source parameters used, as explained previously. This value, assumed to be probabilistic by Bouhadad and Laouami (2002) cannot be compared with the deterministic result by Aoudia *et al.* (2000), that is, the design ground acceleration (worst case) calculated for the area.

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