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Updating the Probabilistic Seismic Hazard Values of Northern Algeria with the 21 May 2003 *M* 6.8 Algiers Earthquake Included

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Abstract—The occurrence of the Algiers earthquake (*M* 6.8) of May 21, 2003, has motivated the necessity to reassess the probabilistic seismic hazard of northern Algeria. The fact that this destructive earthquake took place in an area where there was no evidence of previous significant earthquakes, neither instrumental nor historical, strongly encourages us to review the seismic hazard map of this region.Recently, the probabilistic seismic hazard of northern Algeria was computed using the spatially smoothed seismicity methodology. The catalog used in the previous computation was updated for this review, and not only includes information until June 2003, but also considers a recent re-evaluation of several historical earthquakes. In this paper, the same methodology and seismicity models are utilized in an effort to compare this methodology against an improved and updated seismic catalog.The largest mean peak ground acceleration (PGA) values are obtained in northernmost Algeria, specifically in the central area of the Tell Atlas. These values are of the order of 0.48g for a return period of 475 years. In the City of Algiers, the capital of Algeria, and approximately 50 km from the reported epicenter of this latest destructive earthquake, a new mean PGA value of 0.23 g is obtained for the same return period. This value is 0.07g greater than that obtained in the previous computation. In general, we receive greater seismic hazard results in the surrounding area of Algiers, especially to the southwest. The main reason is not this recent earthquake by itself, but the significant increase in the $m_{\max}$ magnitude in the seismic source where the city and the epicenter are included.

Key words: Seismic hazard, spatially smoothed seismicity, Northern Algeria.

Introduction

Recently, a new probabilistic seismic hazard map for northern Algeria (Hamdache *et al.*, 2002; Peláez *et al.*, 2003), using the spatially smoothed seismicity methodology (Frankel, 1995; Frankel *et al.*, 2000), was presented.

Firstly, an earthquake catalog of the region updated to March 2002 was compiled. To compile the catalog, data from several agencies, mainly the Spanish

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Instituto Geográfico Nacional (IGN) (MEZCUA and MARTÍNEZ SOLARES, 1983) and the Algerian Centre de Recherche en Astronomie, Astrophysique et Géophysique (CRAAG) (CRAAG, 1994) were collected. Also, M_S data taken from the US Geological Survey (USGS) and the European-Mediterranean Seismological Centre (EMSC) were incorporated into the catalog. All the non-Poissonian events, identified by EPRI procedure (EPRI, 1986), were removed.

A delineation of the region into seismic sources was performed: 10 seismogenic sources, covering entire northern Algeria, and 4 seismicity sources, including the nearby seismicity in Morocco and Tunisia. For each of them, the b and $m_{\max}$ values were estimated using the procedures developed by WEICHERT (1980) and PISARENKO *et al.* (1996), respectively. In fact, taking into account the scarce seismicity in certain areas in our region, mean b-values had to be used in several seismic sources.

Next, four complete and Poissonian seismic models were established considering the seismic characteristics of the catalog used: those with a seismicity of (1) $M \geq M_S$ 2.5 after 1960; (2) $M \geq M_S$ 3.5 after 1920; (3) $M \geq M_S$ 5.5 after 1850; and (4) $M \geq M_S$ 6.5 after 1700. The final result was obtained by weighing the partial results derived from each of the models.

Finally, to assess the total probability theorem, the attenuation relationship by AMBRASEYS *et al.* (1996) was used. At this moment, this relation is considered the most reliable one for this region, since these authors have considered acceleration data from several earthquakes recorded in northern Algeria.

After this seismic hazard assessment (PELÁEZ *et al.*, 2003), two events necessitated revision of this appraisal without delay. First, the occurrence of the Algiers earthquake (M 6.8) of May 21, 2003, located in an area where there is no evidence of previous destructive earthquakes (HAMDACHE *et al.*, 2004). Second, the reappraisal of significant earthquakes which occurred in the 19th century in northeastern Algeria (HARBI *et al.*, 2003), including the revision of their locations and maximum intensities. We think that this is a clear example of the well-known sentence that "no seismic hazard assessment is definitive" (BRILLINGER, 1982).

The Algiers Earthquake of May 21, 2003

This destructive earthquake (M 6.8, M_S 6.9) is the most significant one in northern Algeria after the El Asnam (M 7.3) earthquake of October 10, 1980. It occurred at 18:44:20 (UTC), and took place in an offshore location (3°34.1 E, 36°54.2 N, h = 12 km; CRAAG data), about 50 km northeast of the city of Algiers (Fig. 1). A preliminary report of the Algerian CRAAG (YELLES *et al.*, 2003) shows a maximum intensity of X in two small cities near the epicenter, Boumerdès and Zemmouri, and an intensity of VII–VIII in the City of Algiers. Effects are in most cases due to the local geology (liquefaction and site effects), the building quality, and the directivity effect of the rupture (BEZZEGHOUD *et al.*, 2004). In the following two months, more than 250 aftershocks above m_b 4.0 were located.

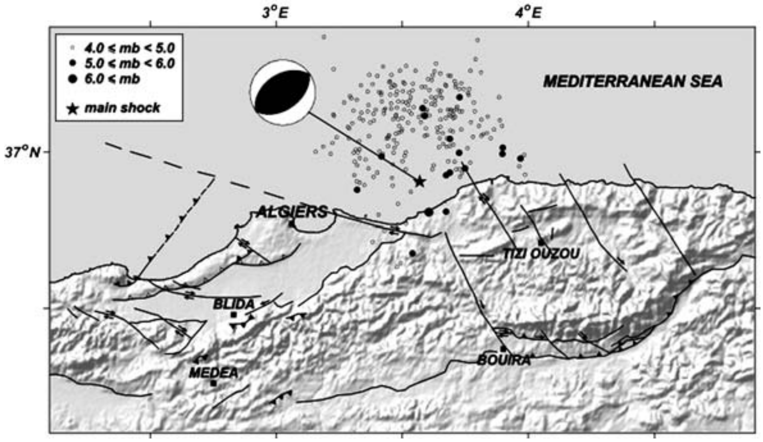

Figure 1
Location and focal mechanism of the Algiers main shock, main aftershocks registered in the following two months (data provided by CRAAG and IGN), and tectonic sketch of the area (simplified from MEGHRAOUI, 1988).

The main earthquake showed a typical reverse or thrust faulting, where the focal mechanism is consistent with the stress field in this region (e.g., HENARES *et al.*, 2003); the direction of compression is NNW-SSE.

The main interest from the seismic hazard point of view is that there is no evidence that significant earthquakes had taken place in the same location. This must be a very good reason to investigate and reconsider the doubtful location of some historical earthquakes around Algiers, especially those of January 3, 1365 and February 3, 1716, both with assigned maximum intensity of X.

No destructive earthquake had struck the region surrounding Algiers since those previously cited in 1365 and 1716. On the contrary, an area to the southwest of Algiers, which is included in the same seismic source, stands out, in which we can observe several significant earthquakes: the 1858 and 1903 Blida earthquakes (I_o = IX and VII, respectively), the 1988 El Afroun earthquake (M_S 5.6, m_{bLg} 6.3, I_o = VII) and the 1989 NE Tipaza earthquake (M_S 5.9, m_{bLg} 6.9, I_o = VIII).

In a new assessment of the probabilistic seismic hazard, we should expect an increase in the computed values for this region due to this recent event, the 2003 Algiers earthquake.

Revision of Several Historical Earthquakes

Recently, in a comprehensive and detailed study, HARBI *et al.* (2003) investigated the seismicity of the pre-1900 period in northeastern Algeria. The most important results, again from the seismic hazard point of view, derive from the revision and reevaluation of maximum intensities and locations of reported significant earthquakes.

We note as more significant for our computation, the next three changes. The Zamora-El Guenzet earthquake of February 9, 1850, which has been revised from maximum intensity IX to VII, and relocated to 85 km east-southeast of the previous location. The Djidjelli earthquake of August 22, 1856, which has been revised from maximum intensity X to VIII. Finally, the Biskra earthquake of November 16, 1869, was revised from maximum intensity IX to VIII. Other less important changes have been taken into account in the new catalog, considering the results by HARBI *et al.* (2003).

In a new assessment of the probabilistic seismic hazard, we should expect a decrease in the computed values for the region where these re-evaluated earthquakes took place.

Seismotectonic Background

Northern Algeria is probably the most active seismogenic area in the western Mediterranean region, located in the Africa-Eurasia plate boundary. From north to south, northern Algeria is divided into four main structural domains. These domains acquired their present geological configuration during Mesozoic and Cenozoic extensional and compressional tectonic events which were related to the openings and closings of the Mediterranean Sea. These geological features, related to interplate processes, are: the Tell Atlas or Tell-Rift system, the High Plateaus, the Sahara Atlas or Atlas Mountains system, and the Sahara Platform (Fig. 2). Several authors simplified the tectonic area by including the High Plateaus within the Atlas Mountains system (e.g., FRIZON DE LAMOTTE *et al.*, 2000).

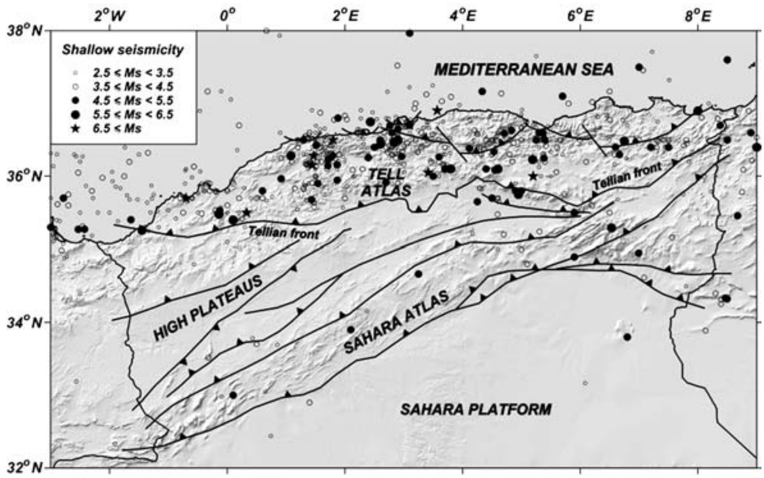

Figure 2
Shallow declustered seismicity of the region since 1700, and regional tectonic setting (simplified from BRACENE *et al.*, 2003).

The distribution of epicenters leads to the conclusion that earthquakes occur mostly in the Tell Atlas and only a few earthquakes appear in the Sahara Atlas. We must bear in mind that the Tell Atlas absorbs 4 to 6 mm/year (ARGUS *et al.*, 1989) of crustal shortening, with predominant dextral shearing. Since the early Cenozoic, this structural domain is under a compressional regime. The direction of compression is NNW-SSE (HENARES *et al.*, 2003). In northern Algeria, unlike their western limit, the contact between the African and Eurasian plates is quite clear and mainly linear. A belt of about 150-km wide, formed by folds distributed *en echelon*, i.e., folds oblique to the overall structural trend, is observed in the Tell Atlas. This is due to neotectonic processes, and lies NNE-SSW (NEGREDO *et al.*, 2002).

Focal mechanisms of earthquakes in northern Algeria indicate that earthquakes in this region occur on reverse faults with NW-SE oriented horizontal pressure axis. Especially the main faults, with strike NE-SW, correspond to thrust faults dipping to NW often organized *en echelon* systems (AOUDIA and MEGHRAOUI, 1995; BEZZEGHOUD and BUFORN, 1999; AOUDIA *et al.*, 2000).

There is scarce paleoseismic information in this region to be included in seismic hazard analyses. We can only quote the works by MEGHRAOUI *et al.* (1988a,b) and MEGHRAOUI and DOUMAZ (1996) on the paleoseismicity of the El Asnam fault. In short, they found three paleoearthquakes with magnitudes above M_S 7.0 in the last 1000 years generated by this fault: the 1980 El Asnam earthquake, and two previous earthquakes in the intervals 1329–1409 and 780–1230. This agrees, on average, with our catalog and assessment. Using seismicity data alone, we include one large earthquake through our catalog (the 1980 El Asnam earthquake) in the El Asnam fault/location every 300 years. As we previously quoted, we have considered a seismic model including earthquakes with magnitudes above M_S 6.5 after 1700.

The most important earthquakes in northern Algeria, including the destructive ones, have taken place in the Tell Atlas, to the north of the Tellian front (Fig. 2). In the last three centuries the following ones stand out. In the western area, the 1790 Oran earthquake and the 1887 El Bordj earthquake, both with assigned maximum intensities of IX-X. In the central area, the most dangerous, the 1716 Algiers earthquake and the 1891 Dupleix earthquake, both with assigned maximum intensities of X. Besides, the 1910 Masqueray earthquake (I_o = X, m_b 6.4), the 1954 and 1980 El Asnam earthquakes (I_o = X-XI, m_b 6.7 and I_o = IX, m_b 6.5, M 7.3, respectively), and the 2003 Algiers earthquake (I_o = IX-X, M_S 6.9). Finally, in the eastern area, the 1963 Bir Hadada earthquake (m_b 6.3) and the 1907, 1908 and 1985 Constantine earthquakes, all with assigned maximum intensity of VIII.

The delineation in seismogenic source areas used in this paper (Fig. 3) is the same that was considered in the previous work by PELÁEZ *et al.* (2003). It is based on those proposed by HAMDACHE (1998) and AOUDIA *et al.* (2000). The seismogenic source model is consistent both with the seismicity distribution (Figs. 2 and 3) and the tectonic and geological knowledge of this region (AOUDIA *et al.*, 2000). We attempted that seismic source characteristics, i.e., the parameters that characterize each seismic

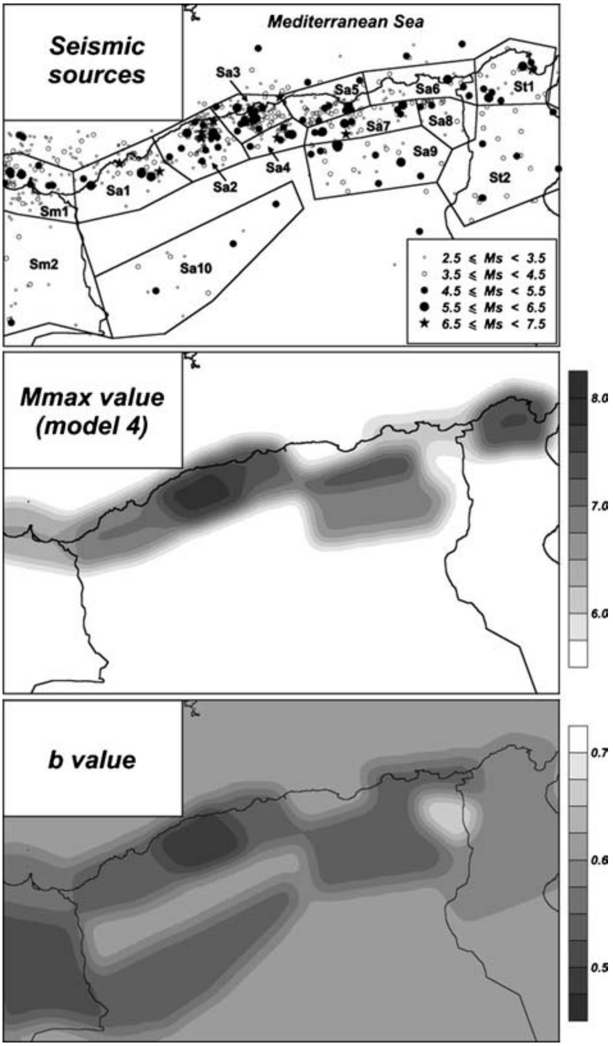

Figure 3
Seismogenic and seismicity sources considered in our study, and smoothed $m_{\max}$ and b values.

source for probabilistic seismic hazard assessment (SSHAC, 1999), were as homogeneous as possible. We must take into account that in northern Algeria, excluding some specific cases (the above mentioned El Asnam fault and the thrust fault responsible for the 2003 Algiers earthquake), no direct relation has been established yet between earthquakes and faults. In general, we work with background seismicity, also called distributed seismicity (STIRLING *et al.*, 2002; LAPAJNE *et al.*, 2003). This is the main reason for using spatially smoothed historic seismicity to assess the seismic hazard. We have insufficienly detailed knowledge of the related seismotectonic data, and cannot include seismotectonic sources, that is, fault sources. The methodology proposed by FRANKEL (1995) is well adapted to model the seismicity that cannot be assigned to specific geological structures. It allows us to combine both parametric and nonparametric (non-zoning) probabilistic methods.

Data and Methodology

With the exceptions previously quoted, we have used basically the same data set (catalog) in our reassessment of the seismic hazard as in our previous appraisal.

The catalog has been updated to June 2003 and includes the 2003 Algiers earthquake and the reappraisal of significant earthquakes carried out by HARBI *et al.* (2003). Using the same delineation in seismogenic source areas, we have reestimated b and $m_{\max}$ values (see Table 1) of the truncated Gutenberg-Richter exponential frequency-magnitude relationship (COSENTINO *et al.*, 1977). To do so, the procedures by WEICHERT (1980) and PISARENKO *et al.* (1996) were used. Also, b and $m_{\max}$ values have been spatially smoothed (Fig. 3), as proposed by BENDER (1986).

The changes in b values are barely noticeable. The computed b values are totally in agreement with those previously obtained by several authors (e.g., LÓPEZ CASADO *et al.*, 1995; HAMDACHE *et al.*, 1998; AOUDIA *et al.*, 2000). The changes in $m_{\max}$ values are only evident in seismic sources *Sa3* and *Sa5* (Fig. 3). The change in the *Sa3* source (including, for example, the cities of Algiers, Blida and Medea) is entirely due to the

Table 1
b and $M_{S\max}$ values for the considered seismic sources.

Seismic source	b, σ	$M_{S\max}$, σ			
		Model 1	Model 2	Model 3	Model 4
Sa1	0.53, 0.06	6.5, 0.3	6.5, 0.3	7.0, 0.7	7.0, 0.7
Sa2	0.48, 0.08	7.8, 0.3	7.8, 0.3	7.8, 0.3	7.8, 0.3
Sa3	0.53, 0.08	7.4, 0.3	7.4, 0.3	7.4, 0.3	7.5, 0.7
Sa4	0.54[a], 0.03	6.0, 0.5	6.0, 0.5	7.1, 0.7	7.1, 0.7
Sa5	0.62, 0.17	5.6, 0.3	5.6, 0.3	5.6, 0.3	5.6, 0.3
Sa6	0.54[a], 0.03	6.1, 0.5	6.1, 0.5	6.1, 0.5	6.1, 0.5
Sa7	0.54[a], 0.03	7.5, 0.5	7.5, 0.5	7.5, 0.5	7.5, 0.5
Sa8	0.67, 0.32	4.7, 0.3	5.7, 0.5	5.7, 0.5	5.7, 0.5
Sa9	0.54[a], 0.03	6.8, 0.3	6.8, 0.3	6.8, 0.3	6.8, 0.3
Sa10	0.54[a], 0.03	4.6, 0.5	5.5, 0.5	5.5, 0.5	5.5, 0.5
Sm1	0.56, 0.05	6.3, 0.3	6.5, 0.5	6.5, 0.5	6.5, 0.5
Sm2	0.52, 0.11	4.8, 0.3	5.5, 0.5	5.5, 0.5	5.5, 0.5
St1	0.58[b], 0.08	6.0, 0.5	6.1, 0.5	6.1, 0.5	7.5, 0.7
St2	0.58[b], 0.08	5.5, 0.3	5.5, 0.5	5.5, 0.5	5.5, 0.5

[a]Mean value obtained using all the Algerian sources.
[b]Mean value obtained using all the Tunisian sources.

Algiers earthquake of 21 May, 2003. An increase in the $m_{\max}$ magnitude by 1.2, 1.2 and 0.9 units for the seismic models 1, 2, and 3, respectively, can be observed. In contrast, changes in the *Sa5* seismic source (including, for example, the cities of Bejaia and Jijel) are due to the revision of historical earthquakes by Harbi *et al.* (2003). In this case, the $m_{\max}$ values decrease by 1.9 units for seismic models 3 and 4.

The attenuation relationship and the considered seismic models remain unchanged. Concerning the seismic models, the changes introduced in the catalog have been insufficient to generate significant changes in their completeness or Poissonian character (Peláez *et al.*, 2003). Again, the model spanning the most time that can be used includes earthquakes above M_S 6.5 in the last 300 years. Only a more complete catalog, including earlier historical earthquakes and paleoseismic events, will eventually allow us in the future to compute seismic hazard for this region with return periods above those computed in this work.

Details on the method of computation can be found in the previous assessment (Peláez *et al.*, 2003), or in other works on seismic hazard computation and deaggregation in the Iberian Peninsula (Peláez and López Casado, 2002; Peláez *et al.*, 2002), in the Ibero-Maghrebian region as well. Next we quote some of them. 1) The region is divided into square cells of size 10×10 km. 2) Values for the *c* parameter in the Gaussian function (Frankel, 1995), are adopted, taking into account uncertainty in earthquake locations, *i.e.* 10, 15, 20 and 20 km, for models 1 to 4, respectively. 3) The assumed threshold magnitude was M_S 2.5, therefore models 2 to 4 were complete starting from this value. 4) Models 1, 3 and 4 were normalized, i.e., constrained to model 2, which has the highest annual earthquake occurrence rate. This is due to both a certain amount of incompleteness of our catalog and to the fact that the seismic cycle embraces, evidently, a longer time span than covered by any of our models. To normalize the models, the rate of occurrence of M_S 2.5 and large magnitudes has been multiplied by a certain factor, different for each model being considered (1, 3 and 4). 5) The $m_{\max}$ value is a function of the seismic model (Table 1), that is, of the time span of the model. 6) Also, weights contributed by each model were taken as a function of the return period; models covering a time interval more similar to the return period provide a higher contribution to the hazard calculation. The weights used for a 475-year return period are 0.2, 0.2, 0.3 and 0.3 for models 1 to 4, respectively. All of these assumptions were justified in our previous work (Peláez *et al.*, 2003).

Results

Figure 4 shows the main results of this study. It depictes a new *PGA* map with 10% probability of exceedance in 50 years, i.e., for a return period of 475 years. The greatest values of the seismic hazard appear in the central area of the Tell Atlas. In particular, in the province of Chlef, including the El Asnam City, and the western part of the provinces of Tipaza and Ain Defla, the mean *PGA* is above 0.24 g, and

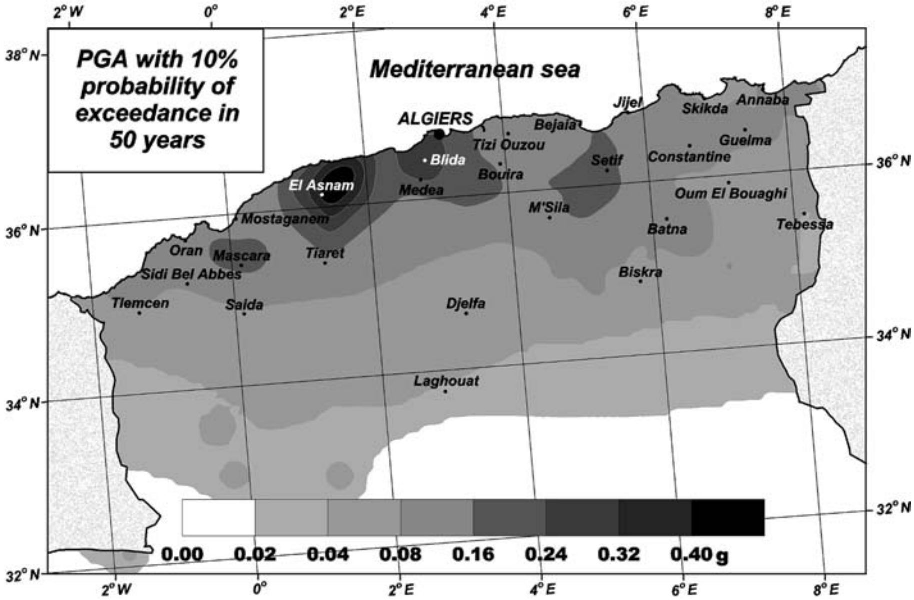

Figure 4
Mean *PGA* (g-units) with 10% probability of exceedance in 50 years, i.e., for a return period of 475 years.

reaches 0.48 g in the meizoseismal areas of the 1954 and 1980 El Asnam earthquakes. We can observe another lobe, with a lower value, around 125 km to the east of the previous one. It includes the provinces of Blida and mostly Algiers, including the city of Algiers. Values above 0.24 g are also reached in this area. The overall tendency shows a clear decay of the seismic hazard values to the south, attaining values, in broad outline, above 0.08 g in the Tell Atlas, between 0.04 g and 0.08 g in the High Plateaus, between 0.02 g and 0.04 g in the Sahara Atlas, and below 0.02 g in the Sahara Platform. With the exception of the Tell Atlas region, all northern Algeria can be considered as a low seismic hazard region.

Table 2 gives specific seismic hazard values for twelve selected cities among the most populated and industrial areas in northern Algeria, and compares them with those obtained by PELÁEZ *et al.* (2003). As we can see, El Asnam City stands out, where higher values are expected (0.42 g). In Algiers, we expect a mean *PGA* value for a return period of 475 years of about 0.23 g. Also, in Figure 5, we display the seismic hazard curves for the four cities that have higher seismic hazard values as indicated in Table 2.

Next we emphasize the differences between these and our previous (PELÁEZ *et al.*, 2003) probabilistic results. Some of them are evident directly through the comparisons displayed in Table 2 and Figure 5. Throughout northern Algeria, with

Table 2
PGA values for a return period of 475 years for twelve selected cities.

City	PGA *(g)*	
	PELÁEZ *et al.* (2003)	This work
El Asnam	0.393	0.418
Blida	0.219	0.315
Medea	0.175	0.240
Algiers	0.164	0.229
Setif	0.223	0.206
Mascara	0.159	0.184
M'Sila	0.157	0.157
Oran	0.138	0.148
Bouira	0.131	0.139
Mostaganem	0.123	0.132
Constantine	0.137	0.129
Tiaret	0.118	0.124

the exceptions quoted below, there are no noticeable differences (at most, to the order of 5%), even in the El Asnam area, where higher seismic hazard values are reached.

Nevertheless, we point out an important increase of the seismic hazard values in the area that embraces the cities of Algiers, Blida and Medea (see Fig. 4). This increase ranged between 37% at Medea and 44% at Blida, as shown in Table 2. Graphically, Figure 5 illustrates this clearly. As mentioned in the introduction, this is what we should expect taking into account the 2003 Algiers earthquake. We obtain seismic hazard values 40% higher on average than previously reported for this area.

On the other hand, we observe lower seismic hazard values in the northeastern region, specifically in the area that includes the cities of Bejaia, Biskra, Tebessa,

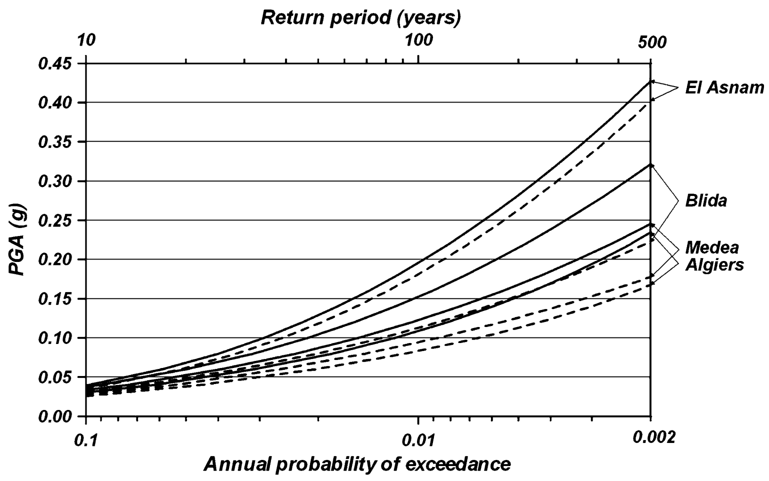

Figure 5
Hazard curves for the four cities showing bigger seismic hazard in Table 2. Continous line: Present study. Dashed line: Previous study (PELÁEZ *et al.*, 2003).

Guelma and Jijel (see Fig. 4). Decreases between 5% and 32% are observed, the latter value in the City of Biskra (from 0.088 g to 0.059 g), the one most affected by the reappraisal of seismicity by HARBI *et al.* (2003).

Finally, we wish to comment about the increase observed in the seismic hazard values in the Algiers area in more depth. For a better explanation we have plotted the number of earthquakes per cell in this area for the four considered seismic models (Fig. 6). For all seismic models, a larger and closer number of earthquakes can be observed south and southwest of Algiers than in the northeast, where the 2003 Algiers earthquake has been located. This nucleus of seismicity has obviously made a bigger contribution to the seismic hazard in Algiers, especially before the occurrence of this latest earthquake.

We continue our discussion of the changes in the computation parameters introduced by this earthquake, that is, how this earthquake affected the value of m_{max}. As previously stated in the source including Algiers and the above-mentioned seismicity nucleus (*Sa3* in Fig. 3), an important increase in the m_{max} value occurs due to the 2003 Algiers earthquake. The exception is the seismic model 4, in which the 1716 Algiers

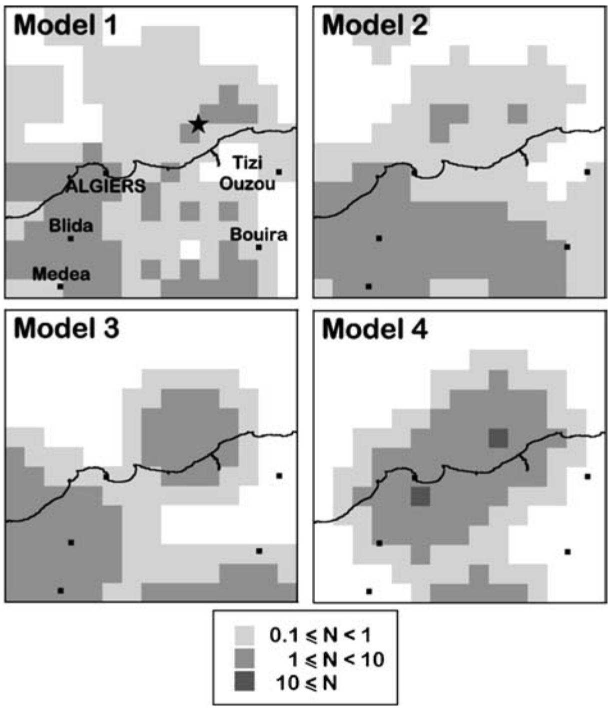

Figure 6
Smoothed number of earthquakes in the area of Algiers. The maps show the number of earthquakes above M_S 2.5 in a 10-km square-grid cell for 100 years and normalized to the second seismic model. Star represent the epicentral location of the 21 May, 2003 Algiers earthquake.

earthquake was included. This increase in the m_{max} value in models 1 to 3, together with a greater number of earthquakes to the south and southwestern Algiers, clearly explains why the contribution of this seismicity nucleus is, paradoxically, more important than the 2003 Algiers earthquake. This is as far as the seismic hazard increase in the region of Algiers is concerned.

Summary and Final Discussion

In this work, using spatially smoothed historic seismicity, a reassessment of the probabilistic seismic hazard in northern Algeria has been conducted. The motivation has been both the ocurrence of a recent destructive event and a reappraisal of several historical earthquakes. The results obtained are presented as a new probabilistic seismic hazard map depicting mean *PGA* with 10% probability of exceedance in 50 years, that is, for a return period of 475 years. The main feature in this map is a higher seismic hazard zone in the central area of the Tell Atlas, where mean *PGA* values of the order of 0.5 g are reached and a continuous decay of the seismic hazard to the south.

The main differences between these results and those previously reported are as follows. First, an increment of the seismic hazard in the region near Algiers, which increases by about 40% on average. This is completely due to the recent 2003 Algiers earthquake. We can also observe lower values of the seismic hazard in entire northeastern Algeria, completely attributed to the recent reappraisal of the intensity and location of several historical earthquakes.

The main reason for this increase in the seismic hazard values is not the 2003 Algiers earthquake by itself, but the combined effect of the change in the m_{max} value in the considered seismic source, the distribution of seismicity surrounding Algiers and the seismic models considered in our assessment.

Finally, we want to stress the performance of the employed approach. The improvement that it provides, as compared to the typical parametric approach, has been pointed out by several authors who used this procedure (FRANKEL, 1995; LAPAJNE *et al*., 1997; PELÁEZ and LÓPEZ CASADO, 2002; STIRLING *et al*. 2002; PELÁEZ *et al*., 2003). For example, among other properties, it considers where earthquakes took place, it does not spread the seismicity homogeneously into the seismic source, it spatially smooths the historic seismicity taking into account the uncertainty in their location, it attempts to combine the advantages of the parametric and non parametric models, and it takes into account the fractal characteristics of the seismicity (WOO, 1996). Additionally, the performance of the methodology when a new significant earthquake occurs is proven with the results shown in this paper. We discuss this statement below.

What changes should we expect in the probabilistic seismic hazard values of a region when a new destructive earthquake occurs?. The answer seems obvious. We should expect an increase in the seismic hazard, unless this new earthquake is in agreement with the assumed magnitude recurrence relationship for the location. In this case, the seismic hazard should remain unchanged. This is more evident when considering that we are assessing a long-term average rate of occurrence (AKI, 1989), i.e., a long-term average prediction. In this work we dealt with the influence in the seismic hazard of the 2003 Algiers earthquake; an event that took place in an area where no destructive earthquakes had occurred. Obviously, we expected an increase in the seismic hazard values and this is what finally occurs.

In a typical parametric procedure, a new earthquake located in a seismic source where significant earthquakes occurred does not produce noticeable changes in the seismic hazard values. This is because an earthquake alone does not produce significant changes in the b or a values of the Gutenberg-Richter relationship in the seismic source. The $m_{\max}$ value should not be affected either if more energetic earthquakes were located in the past in the same seismic source. We think that this is a very clear weakness of the parametric method.

In our assessment, using the spatially smoothed historic seismicity procedure, and with the b value remaining constant in the seismic source when including the 2003 Algiers earthquake, we obtain an increase in the seismic hazard. This is mainly related to an increase in the $m_{\max}$ values in three of the four seismic models considered. Even if an important earthquake had occurred in recent years in the same seismic source, although in another location, which could cause that $m_{\max}$ values to remain unchanged, we would continue to obtain an increase in the seismic hazard values. In this case the reason is the increase of the N value (number of earthquakes per cell in the epicentral surrounding area) in the four considered seismic models. Therefore, not spreading earthquakes into the seismic source, but considering them where they took place, as the spatially-smoothed seismicity procedure does, has its advantages.

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