PSHA input model documentation for Northwestern Asia (NWA)

GEM Hazard Team

Version history

Table 1 summarises version history for the NWA input model, named according to the versioning system described here, and indicating which version was used in each of the global maps produced since 2018. Refer to the GEM Products Page for information on which model versions are available for various use cases. The changelog describes the changes between consecutive versions and are additive for all versions with the same model year.

Table 1 – Version history for the NWA input model.

Version	2018.1	2019.1	2022.1	2023.1	Changelog
v2018.0.0	X	X	X		First version of the model.
v2018.1.0				X	Mmin extended to M4 for crustal distributed seismicity. Added GMPEs to the cratonic tectonic region.

The following text describes v2018.1.0.

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1 Summary

The Northwest Asia (NWA) model was developed internally by GEM in collaboration with the Swiss Seismological Service (SED), Swiss Federal Institute of Technology (ETH), Switzerland. The model is based on a distributed seismicity approach. Similar to Northern Africa, we have applied rate redistribution to better represent the spatial variability of seismicity.

2 Tectonic overview

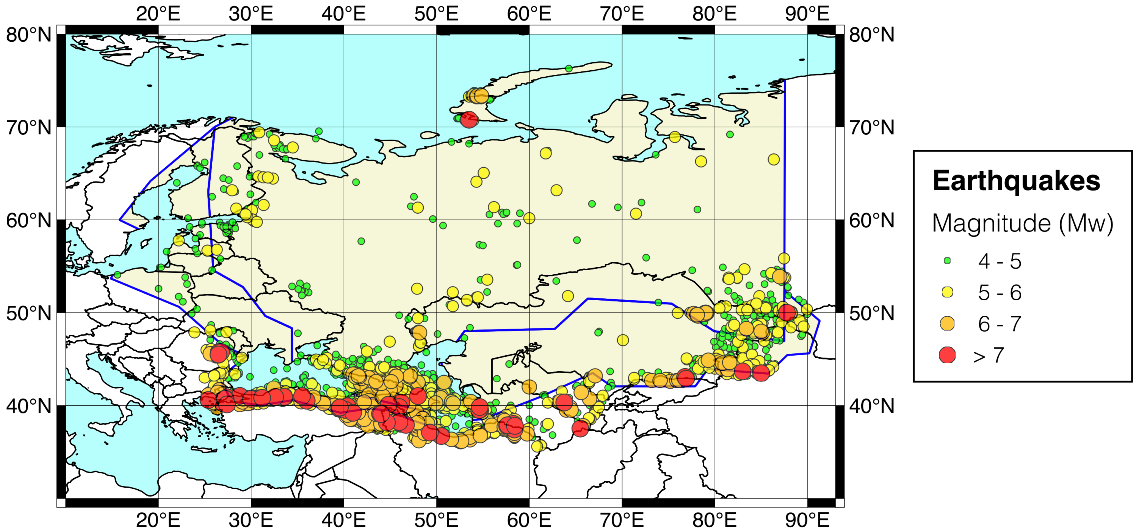
Northwestern Asia is generally tectonically quiescent, though very rare earthquakes may occur throughout the craton. The southern margin of the study area contains the Caucasus Mountains in Georgia, southern Russia, Azerbaijan and Armenia, where the northern deformation front of the Anatolian-Zagros Orogen resulting from the Arabian-Asian convergence zone is located. Major reverse and strike-slip faults in this zone have moderate to high slip rates and pose significant seismic hazard.

3 Basic Datasets

3.1 Earthquake Catalogue

For the purpose of having a unique catalogue valid for NWA, GEM created a new Mw-homogenised earthquake catalogue by assembling globally available sources (ISC review bulleting, GCMT, ISG-GEM, GHEC catalogues) with existing homogenized catalogues from previous projects (SHARE, EMME, EMCA). The GEM implementation of the NWA earthquake catalogue, presently consists of 15106 events with $3.5 \geq M_w \geq 8.2$, covering a period from 10 to 2015 (Figure 1).

Figure 1 – *The Mw-homogenized earthquake catalogue prepared by GEM for NWA.*



4 Hazard Model

4.1 Seismic Source Characterisation

Area Source Zonation The seismic source model for NWA consists of 98 area source zones (Figure 2). The main constrain for the development of the source model came from literature and from a set of geological and seismotectonics considerations, such as style, geometry and distribution of existing faulting systems and their relation to the local stress and deformation regimes. Local and regional source models from previous hazard studies have also been taken into great consideration as starting point for the proposed zonation and to assure compatibility across the borders, particularly with the Europe, Middle East and Central Asia models.

Seismicity analysis Seismicity in each area source is assumed to follow a double truncated Gutenberg-Richter magnitude occurrence relation (or magnitude-frequency distribution, MFD). Lower truncation is arbitrarily assigned to Mw 4.5. Gutenberg-Richter b-values have been calibrated for the whole catalogue and independently for each source group. Conversely, occurrence rates (a-values) have been calculated separately for each source zone by imposing the previously calibrated b-values. A different maximum magnitude (MwMax) estimate is derived independently for each source group as the largest observed event plus an arbitrary - although quite conservative - increment of 0.5 magnitude units. Seismicity parameters are summarised in Table 2.

Id	Name	Region Type	a value	b value	M_{max}
2	GEOAS059	active_shallow	4	1.05	7.1

4	GEOAS066	active_shallow	2.8	1	7
5	GEOAS072	active_shallow	3.7	0.87	7.3
6	GEOAS073	active_shallow	4.4	1.06	7.3
7	GEOAS901	active_shallow	4.51	1.08	6.1
8	GEOAS076	active_shallow	3.7	1	7
9	AZEAS077	active_shallow	4.3	1	7.3
10	AZEAS079	active_shallow	4.3	1	6.8
11	GEOAS080	active_shallow	2.95	0.75	7.3
12	GEOAS081	active_shallow	3.3	0.95	7.1
13	AZEAS082	active_shallow	3.5	1	7.3
14	AZEAS114	active_shallow	3.5	1	7.7
15	AZEAS115	active_shallow	4.32	1.02	7.3
16	ARMAS168	active_shallow	4.57	1.09	7.8
18	AZEAS171	active_shallow	4	1	7.3
19	AZEAS172	active_shallow	4	0.9	7.3
20	GEOAS173	active_shallow	4.18	0.98	7.3
21	TURAS178	active_shallow	4.3	1	7.1
26	AZEAS972	active_shallow	4.63	1	7.3
43	RUAS13	crotonic	1.31	0.99	6.3
44	RUAS12	crotonic	1.18	0.98	6.3
46	UKRAS11	active_shallow	2.37	0.98	6.5
47	UKRAS12	active_shallow	2.38	1	6.5
48	UKRAS13	active_shallow	2.5	1	6.5
49	RUAS02	active_shallow	2.78	0.98	7
50	RUAS03	active_shallow	2.65	0.99	6.5
51	RUAS04	active_shallow	2.86	0.99	7
52	RUAS07	stable_continental	1.35	1	6.1
53	UKRAS14	active_shallow	1.87	1	6.3
54	BSAS00	active_shallow	2.5	1	7.5
55	ARMAS060	active_shallow	3.75	0.9	7.3
56	ARMAS061	active_shallow	4.35	1.05	6.8
57	RUAS05	active_shallow	1.9	1	6.1
58	AZEAS116	active_shallow	3.05	0.99	6.3
59	AZEAS115	active_shallow	4.72	1.02	7.3
61	EMCA51	active_shallow	1.64	1	6.2
63	RUAS06	stable_continental	1.15	1	6.1
64	RUAS01	active_shallow	1.64	0.99	6.3
72	UAAS230	stable_continental	1.94	0.95	6.3
73	BYAS036	stable_continental	2.55	1	6.3
74	LVAS035	crotonic	2.35	1	6.3
75	LVAS024	crotonic	2.5	0.98	6.3
76	FIAS032	crotonic	2.1	1	6.3
77	FIAS026	crotonic	2.65	1	6.3

78	RUAS025	stable_continental	1.8	1	6.3
82	EMCA02	active_shallow	2.3	1	6
83	EMCA05	active_shallow	2.9	1	6
84	EMCA60	active_shallow	2.9	1	6
85	EMCA03	active_shallow	2.3	0.72	6.5
86	EMCA04	active_shallow	2.81	0.74	6.5
89	EMCA38	active_shallow	1.16	0.72	6.5
90	EMCA39	active_shallow	2	0.72	6.5
91	EMCA40	active_shallow	2.46	0.72	6.5
92	EMCA41	active_shallow	2.11	0.72	6.5
93	EMCA42	active_shallow	4.13	1.03	6.5
94	EMCA52	active_shallow	3	1	6
95	EMCA40	active_shallow	2.46	0.72	6.5
96	EMCA41	active_shallow	2.11	0.72	6.5
97	EMCA42	active_shallow	4.13	1.03	6.5
98	EMCA52	active_shallow	3	1	6

Table 2 *– Seismicity parameters used in the NWA model*

Smoothed Seismicity To better represent the spatial variability of seismicity across the study area, the annual occurrence rates previously obtained for the homogenous source zones have been redistributed within each polygon using a procedure that accounts for the irregular spatial pattern of the observed events (Figure 3). The procedure shares some similarity with the popular smoothed seismicity approach (e.g. Frankel, 1995), but is more convenient in that a unique fit of the magnitude-frequency distribution is here required for each zone, while the corresponding total earthquake occurrence is only a-posteriori spatially reorganised as a function of the epicentral distance to all neighbouring events. Moreover, the combined use of zones gives the possibility to account for different modelling parameters (b-value, depth distribution, rupture mechanism) in separate regions.

4.2 Ground Motion Characterisation

To represent the epistemic variability of the ground motion between regions of different attenuation characteristics, we identified three main tectonic groups (active shallow, stable continental and cratonic) for which a set of ground motion prediction equations have been selected. The selection is consistent with what has been used for the Northeast Asia model.

stable_continental	**Weight**
YenierAtkinson2015BSSA	0.34
PezeshkEtAl2011NEHRPBC	0.33
AtkinsonBoore2006Modified2011	0.33
cratonic	**Weight**
SomervilleEtAl2009YilgarnCraton	1.0
active_shallow	**Weight**

AkkarEtAlRjb2014	0.5
ChiouYoungs2014	0.5

Table 3 *– GMPEs used in the NWA model.*

Figure 2 *– The proposed source zonation for NWA. Different colors are used to represent the seismicity level of the region.*

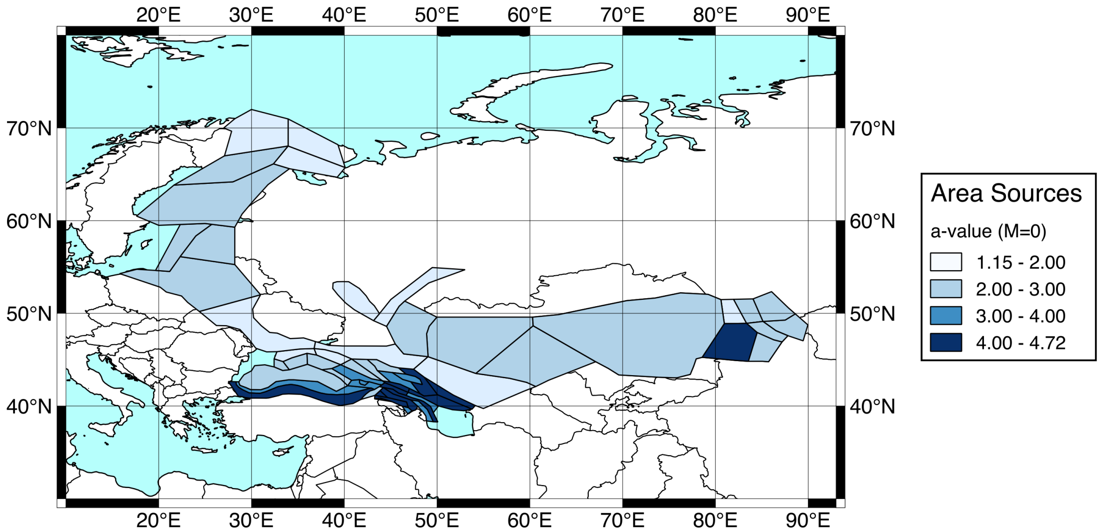
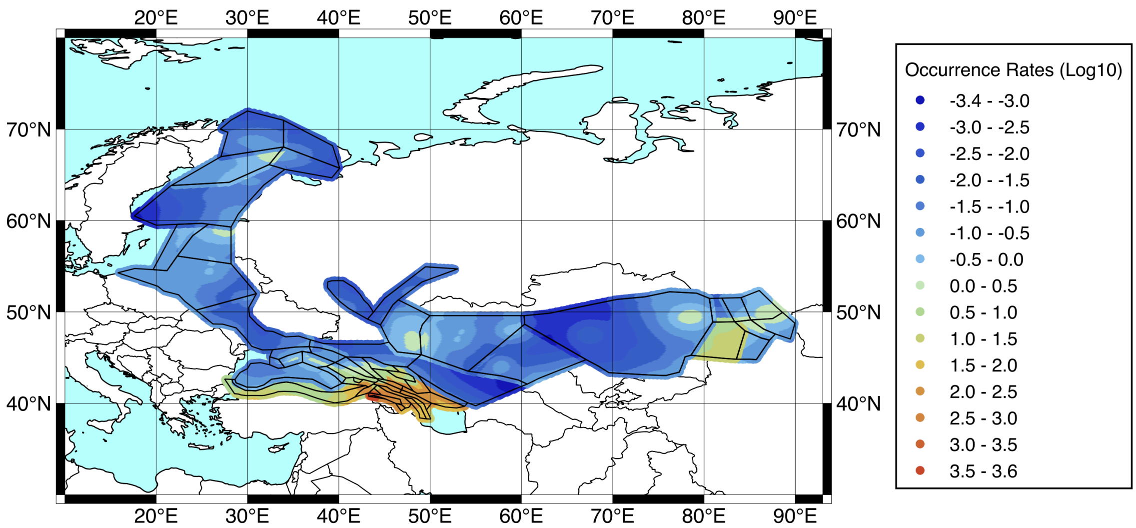


Figure 3 *– Example of spatial redistribution of the cumulative annual rates (M>0) using a decay parameter (λ) of 100. Only shallow crust seismicity is here considered. Rates are intended by unit area of 0.1° (about 11 km²).*



Last processed: `Thursday 8th June, 2023 @ 18:14`

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