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More reliable physics in seismic hazard assessment (SHA) for disaster risk reduction (DRR)
(More reliable physics in SHA for DRR)

This issue

NDSHA related session in the ASC 15th GA: Abstracts (II)

The 15th General Assembly of the Asian Seismological Commission (ASC) will be held on November 3-7, 2024 (https://www.asc2024.org/). JWG proposed session S15, 'Neo-deterministic seismic hazard assessment (NDSHA): Progress and scientific debate', chaired by Antonella Peresan, Fabio Romanelli, Mohamed ElGabry, Guoxin Wang, and Yan Zhang. The session focuses on a) The theoretical, computational, and application aspects of NDSHA, b) A discussion of related science and a comparison with other approaches, and c) Communication between NDSHA and engineering and emergency management communities for its application.

Here, we attach the second part of the abstracts received for your reference. The presentations are mainly on controlling earthquakes with time-dependent features. The abstract submission deadline is extended to August 15th.

Using M_{design} in the Maximum Credible Earthquake (MCE) Concept for Ground Motion Prediction of the 2023 Al Haouz Earthquake, Morocco

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The M_W6.8 Al Haouz earthquake struck Morocco on September 8, 2023. It was the deadliest since the 1960 Agadir and the 2004 Al Hoceima events and it raised significant questions about ground motion predictability. With this study, we contributed addressing these questions by carrying out a comprehensive analysis of the ground motion predicted for the Al Haouz earthquake, based on the computation of a wide set of plausible scenarios by the Neo-Deterministic Seismic Hazard Assessment (NDSHA) approach. To achieve our goal, we performed a set of experiments, including the use of the Maximum Credible Earthquake (MCE) concept and the application of the maximum design magnitude (M_{design}) definition, consistent with Panza-Rugarli law introduced by Wen and Wang (2024). We started with a reference seismic hazard experiment, based on the input data used in Mourabit et al., (2013) and focusing exclusively on Morocco. We then conducted several experiments, considering the most recent Moroccan earthquake catalog (truncated to 2022), and integrating MCE magnitude based on M_{design} into catalog estimates (Rugarli et al., 2019). We compared the resulting hazard estimates by mapping the ratios between different variants. Applying the MCE concept, where the product of safety factor γ_{EM} and magnitude uncertainty σ_M ($\gamma_{EM}\cdot\sigma_M$ = 0.5-0.7) is added to Moroccan earthquake magnitudes, could have predicted the 2023 Al Haouz earthquake's ground motion. This study highlights the importance of using M_{design} to account for the essential uncertainties on the magnitude of future earthquakes and develops reliable and stable hazard estimates.

Keywords**:** M_{design}, Neo-Deterministic Seismic Hazard Analysis (NDSHA) method, Maximum Credible Earthquake (MCE), Ground Motion Prediction, Al Haouz Earthquake, Morocco

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Seismicity Changes and Numerical Simulation of Coseismic Deformation Following the 2022 M_S6.8 Luding Earthquake in Sichuan, China

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The Xianshuihe fault is a major tectonic boundary between the Sichuan-Yunnan rhombic and Bayanhar blocks in Southwest China. With an average left-lateral strike-slip movement of 10–15 mm/a, it is a fast-moving strike-slip continental fault. On September 5, 2022, the M_S6.8 Luding earthquake occurred along the Moxi segment of the Xianshuihe fault, resulting in a significant number of casualties and severe property damage. This earthquake broke the long-standing seismic quiescence of the Xianshuihe fault, which lasted for more than 40 years, and was followed by a significant number of aftershocks. An outstanding question is how the behavior of the Xianshuihe fault and major earthquakes changed following this mainshock. In this study, we examined the changes in regional seismicity following the Luding earthquake and identified the potential for future strong earthquakes along the Xianshuihe fault. We used a finite element numerical method to simulate the environment of the seismogenic fault and its adjacent areas. In addition, we used the coseismic slip model of the Luding earthquake with the split-node method to calculate how the stress and strain fields in the surrounding area were affected by the 2022 mainshock. Coulomb stress changes were resolved in the main faults, and the seismicity of adjacent faults was analyzed in conjunction with the observed seismic data. The results indicate that variation in the stress field in the epicentral region of the Luding earthquake exceeded 1 MPa. The maximum displacement of the coseismic deformation field was concentrated between Moxi town and Tuanjie village, and the Coulomb stress of the fault zone in this region experienced the largest decrease. However, the b-value of the Gutenberg-Richter magnitude-frequency relationship at the epicenter and the surrounding area exhibited an abnormal pattern of decrease-decrease-increase, indicating that the regional stress may not be fully released. This earthquake increased the Coulomb stress in other segments of the Xianshuihe, Anninghe, and Daliangshan faults, whereas the Coulomb stress in the Longmenshan and Xiaojinhe fault zones decreased. In addition, it triggered a series of normal-fault, moderate-sized earthquakes in nearby areas. In this study, post-earthquake seismicity in the vicinity of the M_S6.8 Luding earthquake was analyzed and predicted by numerical simulation, providing a scientific basis for earthquake prediction and disaster reduction.

The M_{design} approach for engineering oriented Neo-Deterministic Seismic Hazard Assessment (NDSHA): key concepts developed in the recent decade, and retrospective investigations focused on the China Seismic Experimental Site (CSES)

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It has been shown that the Neo-Deterministic Seismic Hazard Analysis-NDSHA can formally define the most credible earthquake, MCE, whose magnitude M_{design} can be tentatively and until proven otherwise set equal to the maximum, historical or instrumental, observed magnitude (M_{max}) plus $\gamma_{EM}\sigma_M$ (Panza and Bela, 2019; Rugarli et al., 2019). The amount σ_M is the central value of magnitude standard deviation (σ_M) at global scale that varies in the range 0.2-0.3 (Båth, 1973; Borman et al. 2007; Kossobokov, 2007). In general, it may be assumed for MCE a magnitude $M_{design} = M_{max} + \gamma_{EM}\sigma_M$ (Rugarli et al., 2019), also called Panza-Rugarli (PR) Law (Wen and Wang, 2024), where γ_{EM} is a tuning factor, that can eventually vary, from region to region. Hutton (1795) established the principle that the geological or physical phenomena that operate now have always acted with the same intensity in the past geological times, and what happened in the past may happen in the present and will happen in the future, with a caveat toward the concept of "return period". In other words, what happened in the past can happen, but from time to time in the present and in the future. The principle of uniformitarianism could be regarded as natural result of the self-organized criticality (SOC, e.g., Bak et al., 1988; Bak and Tang, 1989; Sornette and Sornette, 1989; Ito and Matsuzaki, 1990; Keilis-Borok, 1990; Sornette et al., 1990; Turcotte, 1992). To be conservative and in agreement with Hutton (1795) principle, it is natural to consider $\gamma_{EM}\sigma_M=0.7=3\sigma_M$ truncated to one decimal digit. In such a way, for the MCE, M_{design} could be defined as the sum of M_{max} and 0.7 is formally strictly connected with the upper magnitude bound of the largest observed or estimated (e.g., pattern recognition of morphostructural zonation, Gorshkov et al., 2003) magnitudes in any study area.

Since M_{design} value, supplying the lower bound of the magnitude of MCE, practically envelops the available earthquake catalogue, it will be necessary to update M_{design} only if the magnitude, M, of a large event that occurs, after the M_{design} evaluation is performed, exceeds the value of M_{design} itself significantly. It is worth to mention that M_{design} has a distinct engineering flavour and simultaneous seismological significance for any single event, at regional scale. In this study, summarizing systematically the related concepts which have been developed since the recent decade, using the data of the China Seismic Experimental Site (CSES) collected during the last quarter of a century, a retrospective investigation has been conducted. It turns out that the earthquakes under consideration have not falsified the general validity of the PR relation. Meanwhile, we discuss the rare scenario that a record-breaking event occurs and the M_{design} must be tuned based on such an event, so that an engineering tunable NDSHA is possible. The research offers a response to the aforementioned query, with a showcase example of region-based Popper's falsification and verification. [This work is supported by the National Natural Science Foundation of China (NSFC, grant number U2039207)].

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Towards a joint approach to the development and application of neo-deterministic seismic hazard assessment (NDSHA) for seismic disaster risk reduction (DRR)

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This presentation introduces the progress and prospective of the preparatory Joint Working Group on Neo-

Deterministic Seismic Hazard Assessment (pJWG NDSHA) which belongs to both the Asian Seismological Commission (ASC) and the African Seismological Commission (AfSC). The necessity of the development and application of NDSHA has been proved by recent earthquakes which caused disasters with record-breaking features within other SHA paradigms but well predicted by the NDSHA. Yet regional unbalance in the development and application of NDSHA calls for a joint endeavor with international and interdisciplinary characteristics. The pJWG has been continuously endorsed by the ASC and the AfSC since its launching in mid-2023 associated with the IUGG Assembly in Berlin. Since then several activities were tested and practiced, with limited but prospective results. After the September 9, 2023, Morocco M_S6.8 earthquake a Webinar was organized, with the proposal of the regional unification of the Great-Earthquake-Prone-Areas (GEPAs) for NDSHA as the outcome of the discussion. The pJWG cosponsored the 13th International Statistical Seismology Conference (Statsei-13) in Shenzhen, and joined in the Pre-Statsei workshop in Beijing, with highlight “Statistical Seismology as a platform of dialogue: ACES, CSEP, CSES, NDSHA, and others”, in both of which dialogue between the NDSHA and other SHA approaches was facilitated. In the newly founded African Disaster Mitigation Research Center, the pJWG's scientific and logistic activities are prioritized on the agenda for 2024. In science, the paper of Panza and Bela (2020) was elected as the best paper 2023 by Elsevier, echoing the increased impact of NDSHA. The pJWG members were invited to deliver keynote presentation in the 9th International Conference on Seismology and Earthquake Engineering (SEE 9) symposium in Tehran. Participation in the ASC GA and the AfSC GA has been one of the important activities of the pJWG since 2024, in which the experiences will be beneficial for contributing to the 2025 IASPEI GA, and beyond. The pJWG has now covered experts from over 20 countries or regions in Asia and Africa. The monthly pJWG Newsletter plays an active role in networking the group with opening borders. The pJWG and its activities welcome the joining of seismologists and earthquake engineers not only in Asia and Africa but also from all over the world.

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