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Estimating maximum magnitude in the presence of varying magnitude of completeness: The M9 Tohoku earthquake

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The technique to estimate the maximum magnitude in a time window of length T as introduced by Zöller et al. (BSSA 103, 2013) is extended for earthquake catalogs with varying magnitude of completeness. In particular, we consider the case that two types of catalogs are available: a historic catalog and an instrumental catalog. This leads to competing interests with respect to the estimation of the two parameters from the Gutenberg-Richter law, namely the b-value and the event rate Λ (or the a-value): the b value is estimated most precisely from the frequently occurring small earthquakes; the tendency of small events to cluster in aftershocks, swarms, etc. violates, however, the assumption of a Poisson process that is used for the estimation of Λ. We suggest to address this conflict by replacing the Bayesian estimation of b by a point estimate $\hat{b}$ inferred from instrumental seismicity and use large magnitude events for the remainder of the study. Applying the method to Japan, we find that with a credibility level of 50% the maximum magnitude for a time interval of $T = 50$ years is $M_{\max} = 9.0$. The results indicate that in the light of the available earthquake catalogs, the size of the $M9$ Tohoku earthquake in 2011 is not at all a surprise. Finally, for typical scenarios related to requirements of nuclear safety, the maximum expected magnitude will be even higher.