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Inverse modelling of systematic and random uncertainty of luminescence data: Applying Bayesian statistics on luminescence data

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Bayesian statistics for higher precision luminescence ages requires separation of uncertainty into random and systematic parts. Here we introduce an inverse modelling approach to estimate a probability density function of the two uncertainty parts, based on published datasets. Each input dataset is tested for their random and systematic uncertainty, which explains reported ages and their number of inversions best. Each set of dates comprises a particular number of age inversions, which are assumed to be the result of a combination of random and systematic uncertainties. All combinations of random and systematic uncertainties were tested in steps of 1% using a Monte Carlo simulation approach. An exemplary probability density function of the systematic and random uncertainty parts (based on a specific set of input data) is presented accordingly.
Dividing the overall uncertainty into systematic and random parts directly allows for higher precision in terms of relative time spans compared to the original data. Because systematic uncertainty has an equal effect on all dates, it can be disregarded when investigating time spans between individual dates. This allows a more meaningful interpretation of chronologies. Additionally, obtaining a measure for the random part of uncertainty enables the application of Bayesian methods similar to the ones used for improving the precision of 14C data.
Using example data it is demonstrated that combining the probability density function of the systematic and random parts of uncertainty with a Bayesian age modelling approach result in more precise ages from chronologies obtained using luminescence dating.