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Two approaches to timescale modeling for proxy series with chronological errors.

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A substantial part of proxy series used in paleoclimate research has chronological uncertainties. Any constructed timescale is therefore only an estimate of the true, but unknown timescale. An accurate assessment of the timing of events in the paleoproxy series and networks, as well as the use of proxy-based paleoclimate reconstructions in GCM model scoring experiments, requires the effect of these errors to be properly taken into account.
We consider two types of the timescale error models corresponding to the two basic approaches to construction of the (depth-) age scale in a proxy series. Typically, a chronological control of a proxy series stemming from all types of marine and terrestrial sedimentary archives is based on the use of 14C dates, reference horizons or their combination. Depending on the prevalent origin of the available fix points (age markers) the following approaches to timescale modeling are proposed.
1) 14C dates. The algorithm uses Markov-chain Monte Carlo sampling technique to generate the ordered set of perturbed age markers. Proceeding sequentially from the youngest to the oldest fixpoint, the sampler draws random numbers from the age distribution of each individual 14C date. Every following perturbed age marker is generated such that condition of no age reversal is fulfilled. The relevant regression model is then applied to construct a simulated timescale.
2) Reference horizons (f. ex. volcanic or dust layers, T bomb peak) generally provide absolutely dated fixpoints. Due to a natural variability in sedimentation (accumulation) rate, however, the dating uncertainty in the interpolated timescale tends to grow together with a span to the nearest fixpoint. The (accumulation, sedimentation) process associated with formation of a proxy series is modelled using stochastic Levy process. The respective increments for the process are drawn from the log-normal distribution with the mean/variance ratio prescribed as a site(proxy)- dependent external parameter. The number of generated annual increments corresponds to a time interval between the considered reference horizons. The simulated series is then rescaled to match the length of the actual core section being modelled.
Within each method the multitude of timescales is generated creating a number of possible realisations of a proxy series or a proxy based reconstruction in the time domain. This allows consideration of a proxy record in a probabilistic framework. The effect of accounting for uncertainties in chronology on a reconstructed environmental variable is illustrated with the two case studies of marine sediment records.