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The Paleochrono probabilistic model to derive a consistent chronology for several paleoclimatic sites

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Past climatic and environmental changes can be reconstructed thanks to paleoclimatic archives such as ice cores, marine sediment cores, lake sediment cores, speleothems, tree rings, corals, etc. The dating of these natural archives is crucial for deciphering the temporal sequence of events during past climate changes. It is also essential to estimate the absolute and relative errors of such estimated chronologies. This task is, however, complex since it involves the combination of different dating approaches on different paleoclimatic sites and often different types of archives. Here we present Paleochrono, a new probabilistic model to derive a common and probalistically optimal chronology for several paleoclimatic sites with potentially different types of archives. Paleochrono is based on the inversion of an archiving model: a varying deposition rate (also named sedimentation or accumulation rate) and also, for ice cores, a lock-in-depth of air bubbles (since air is not trapped at surface) and a thinning function (since ice undergoes flow). The model integrates several types of chronological information: prior knowledge of the archiving process, independently dated horizons, depth intervals of known duration, undated stratigraphic links between records, and, for ice cores, Δdepth observations (depth differences between synchronous events recorded in the bubbles and ice, respectively). The optimization is formulated as a least-squares problem, assuming that all densities of probabilities are near-Gaussian and that the model is almost linear in the vicinity of the best solution. Paleochrono is the successor of IceChrono, which was dealing only with ice-core records. Paleochrono performs better than IceChrono in terms of computational efficiency, ease of use, and accuracy. We demonstrate the ability of Paleochrono in a new AICC2012-Hulu dating experiment, which combines the AICC2012 dating experiment, based on records from five polar ice cores, with data from two U/Th-dated speleothems from Hulu Cave (China). We analyse the performance of Paleochrono in terms of

computing time and memory usage in various dating experiments. Paleochrono is freely available under the MIT open source license.