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Decoding Nonlinear Growth Rates in Annually Resolved Archives

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Isotopic and elemental tracers preserved in growth bands of accretionary biogenic skeletal material have received considerable attention due to their potential as recorders of seasonal and inter-annual climate variables. Variations in the stable oxygen isotopes of environmental archives have been widely used to estimate annual means and seasonal ranges of temperature. In recent years variations in proxies have been analyzed with a sub-annual resolution. Besides measurement noise, one of the major sources of errors and uncertainties in these studies is the construction of an unbiased time base.

In such data-series, the environmental proxy is not measured directly as function of time, but along a growth or accretion axis. Since we are mostly interested in the time series, this distance profile has to be transformed in to a time profile, which requires knowledge about the growth or accretion rate. In general, it is not possible to estimate the accretion rate and the time profile from the distance grid. So, without extra information or additional assumption, one has to date at least two observations and assume a constant growth rate to construct a time series. An example of such extra information are growth bands, present in some corals, bivalves or trees, which can be used to date the record, employing e.g. the anchor point method. However, even when growth bands are available, they usually only provide information about variations on annual and multi-annual scales and not on a sub-annual scale. If these sub-annual variations are not taken into account, the annual means will be biased towards seasons of maximum growth rate.

We present a method, which can build an accurate time base for annually resolved archives, based on the periodicity of the record. For this, the time base is split in an average constant accretion rate and a distortion term. Exploiting the periodicity of annually resolved archives, this distortion can be identified. The proposed method is compared with the anchor point method in a study of the Mg profile in an *Isognomon ephippium* specimen, sampled in Kenya. Here is illustrated how a precise growth rate profile can be reconstructed, starting form the proxy record. Next, the stable oxygen isotopes measured in three specimens (*Saxidomus giganteus*) are compared, based on this dating algorithm.

To conclude, an accurate construction of the time base facilitates the spectral interpretation of the record, the estimation of stochastic noise and lowers the bias in the construction of transfer functions and/or climate reconstruction.