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Non-linearity's in proxy space: Three methods to deal with the non-linear behavior of proxies in calcareous marine skeletons

M. Bauwens (1,2), H. Ohlsson (3), V. Beelaerts (2), K. Barbé (2), F. Dehairs (), and J. Schoukens ()

(1) Free University Brussels, ANCH, Brussels, Belgium (msbauwen@vub.ac.be), (2) Free University Brussels, ELEC, Brussels, Belgium (msbauwen@vub.ac.be), (3) Linköping University, Division of Automatic Control, Department of Electrical Engineering,

The reconstruction of seasonal variations in the paleo-environement is possible thanks to the bivalve shells that are commonly found back in archeological sites and that are sensitive environmental recorders. To do these reconstructions we look to the chemical composition of a shell along his growth axis. When a certain element or isotope can be related to an environmental parameter it is called a proxy for that parameter.
Many elemental and isotopic have been proposed as potential temperature proxy. But the same problem is showing up over and over again: a certain elemental shows a good linear correlation with temperature, but at the moment that the intrinsic variation has to be explained, the incorporation of the proxy seems to be much more complex than assumed in the first instance.

Two observations gave us the idea to use a new type of models to reconstruct temperature. In first instance we observed that all proxy incorporations were always influenced by more than one environmental parameter, which automatically implicate that the reconstruction of an environmental parameter should be done with more than one proxy input. A second observation is that some proxy-environment relations seemed to be non-linear. We propose to do climate reconstructions based on Non-linear multi-proxy models. We will present our own intuitive approach to do temperature reconstructions and we will compare our results to two recognized engineering techniques: Manifold learning and Supported vector machines.

These three methods are validated on shell data of Scheldt estuarine environment using high resolution measurements of Mg, Mn, Ba, Sr and Pb on a LA-ICP-MS. The site specificity is tested for all methods using shell-data from 4 different sites along the Scheldt. Time specificity is checked by reconstructing the temperature corresponding to a shell that grew in another year.

The best reconstructions are computed with the manifold learning algorithms, but the simplicity and high precision of the intuitive approach made it a very attractive alternative in the pale-climatology research field. The study shows also that temperature reconstruction are possible with non-linear multi proxy approaches, but with moderate precision since all methods seem to be sensible to site and time specificity.