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Method of getting transfer functions between geochemical proxies of lacustrine sediments and climatic parameters of palaeoenvironment using artificial neural networks

L.G.Smolyaninova , I.A.Kalugin , A.V.Daryin
Institute of Geology and Mineralogy RAS, Novosibirsk, Russian Federation

Connections between climatic parameters and properties of bottom deposits of contemporary lakes are rather intricate and complicated. Therefore it is difficult to describe them by mathematical functions. As known, all geospheres are ensembles of open nonlinear systems, and methods of nonlinear regression for climate reconstruction by indirect indications is, in our opinion, the most progressive. Now methods of linear regression mostly are used for such tasks. Sometimes it works rather well, but it is great sensitive for completeness and continuity of time data series. It makes additional problems for reconstruction.

In connection with it, method using artificial neural networks (ANN) (Veelenturf, L.P.J., 1995) is offered. ANN consists of simple nonlinear elements (or functions). Elements are connected between themselves, and all information is in connection weights, which may change. ANN can construct multivariate nonlinear models on an experimental data. Models are constructed by training of network with pattern of examples, where both inlet and outlet operation factors are known. As a result, dependence between inlet and outlet data will receive like an uninterrupted multivariate function. The form of function depends on neural network structure. Most nature processes are described by such functions. Neural networks construct models, which reflect processes taking place in concrete locality of the Earth, by training on an experimental data.

The procedure of training, as a matter of fact, is the program of optimization, where functional of training error is minimized, but connection weights between network elements are parameters of optimization. In our case neural networks realize nonlinear multivariate regression with regulating smoothness of the outlet function. One of the versions multivariate views, as Fourier integrals with replacement the integrals on last sums, is used for interpolation. Algorithm “back propagation” was used for optimization (Rumelhart, D.E., Hinton, G.E., Williams, R.J., 1986). The dependence “inlet – outlet” is uninterrupted, as a rule, within the type of examples. That is why neural network will react correctly not only to training pattern, but to all similar cases. Correctness of reaction depends how enough the dependence “inlet – outlet” is constructed by training. Getting function will operate in each place of time scale, where inlet data will be, and problem of sensitivity for completeness of time data series will closed.

ANN method have used in some overlapping fields (p.e. Woodhouse, 1999, Racca, et al., 2001, Belgrano, et al., 2001). But the task to solve has own specific features.

We suggest the method containing following stages:

1. Resulting data series of climatic parameters and geochemical proxies for the same time-scale.
2. Some neural networks with various numbers of net’s elements and values of spectral density should be chose. Each of them should be trained under number of a year to define values of choosing parameters. As a result some variants of initial time series smoothing are received. ANN smoothing is related to polynomial one, since outlet function is superposition of sinusoidal neurons functions.
3. Further, factors of pair correlation between received time series and initial data of climatic parameters at the historical part of time-scale should be found.
4. Series with the maximal correlation coefficient should be used for reconstruction by ANN.
5. Getting trend of initial time series of climatic parameters with the same smoothness.
6. Training ANN to get values of climatic parameters having inlet values of geochemical proxies.

As example, reconstructions on average annual temperature and precipitation were received by geochemical proxies of Siberian lakes Teletskoe and Baikal.

References

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