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The secret assumption of transfer functions

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The design and evaluation of transfer functions, used for quantitative reconstructions of palaeoenvironmental conditions, has hitherto ignored the spatial autocorrelation in the modern training set. Model performance has been evaluated using the correlation between the measured and predicted values of the environmental variable in the modern training set: large correlation coefficients are taken as an indication that the variable can be reconstructed. However, as spatially close sites in the training set have similar environmental values, the observations are not independent, therefore the assumptions of Classical significance tests are violated. We show that simulated environmental fields with large scale autocorrelation can apparently be successfully reconstructed with a N. Atlantic foraminifera training set (Pflaumann et al. 2003), as high r^2 are generated. This implies that any spatially smooth environmental variable can be reconstructed with a high r^2, regardless of its ecological importance, and, potentially, that some published reconstruction are spurious. The significance of a transfer function can be tested by modifying the significance test to incorporate the autocorrelation present in the data. By simulating environmental fields with the same autocorrelation structure as SST, we show that the r^2 of the N. Atlantic foraminifera-SST transfer function (Pflaumann et al. 2003) is significant higher than expected by chance.

An alternative strategy for testing the significance of a transfer function is to test a model developed in one geographic area on observations from a spatially independent area. If the transfer function is robust, the root mean squared error of prediction (RMSEP) calculated by cross-validation and from the spatially independent area should be similar. We test the N. Atlantic foraminifera-SST transfer function on the S. Atlantic. With the modern analogue technique, the spatially independent RMSEP

is more than double cross-validation estimate. In contrast, maximum likelihood estimates of RMSEP are similar for both North and South Atlantic. This shows that the modern analogue technique is especially sensitive to autocorrelation in the training set, which causes its error estimate to be spuriously low, and that the true RMSEP of the N. Atlantic foraminifera-SST transfer-function is approximately double previous estimates.

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