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THE PROBLEM OF CALIBRATION

A possible way to overcome the drawbacks of age models

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1a Radiocarbon (^{14}C) age measurements are few and erroneous.

Using an artificially simulated archive growth, we replicated noisy ^{14}C age measurements with a random error proportional to the age (marked in red).

1b The "calibration" curve relates ^{14}C ages to true ages but results in irregular, multimodal age distributions.

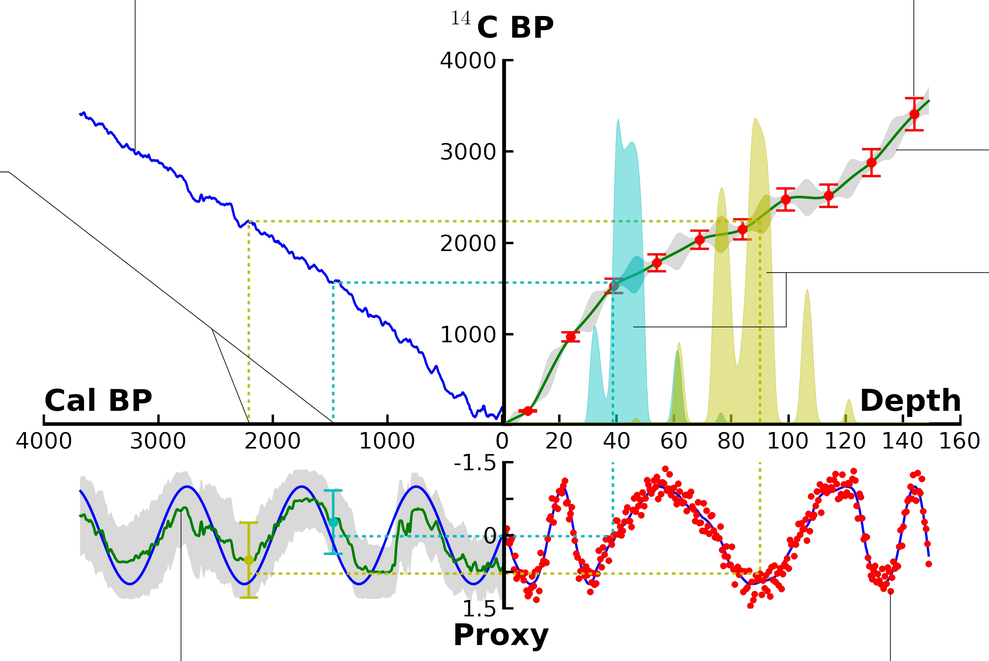
We use the IntCal09 curve here. For U/Th dating, this curve would be a straight line.

2a We apply a nonparametric Bayesian regression [1] on the age-depth observations to get posterior probabilities of ages at those depths where the proxy is measured.

The regression estimate is shown in green.

2b Using Bayes' Theorem, we construct "weight" functions which tell us: Given any calibrated age, which depths are more likely to correspond to that age?

Weight functions can be multimodal with overlapping regions for various calibrated ages.



The final proxy estimate is shown in green.

The artificial proxy we used was a sinusoid in time which is shown in blue here.

From Calibrated Ages to Proxy Values
A Simple How-To-Get-There

PICK AN AGE OF YOUR CHOICE...

... and **FOLLOW THE DASHED LINES** clockwise.
E.g., from the two calibrated ages: 1474 yrs calBP (cyan) and 2211 yrs calBP (yellow), go up to their ^{14}C ages. Turn right. Go straight to the respective weight functions (near their highest peaks).
Go down to the proxy measurements to a value equalling the weighted mean of the proxy observations using the weight function. Turn 90° clockwise and go straight till you are at the age you started with. The height you are at is the expected proxy value for that age (marked with a circle and suitable error bar).

Grey shaded regions in the diagram represent +/- one standard deviation (i.e., 68.3%) confidence bounds of estimate.

2c Given any true age, we estimate the proxy probability density by weighting all proxy observations with the weight function for that particular age.

1c Proxy is measured with higher density than age. *How can we connect a proxy value to its correct calibrated (true) age?*

3 IN SUMMARY, we present a new, analytical method for proxy estimation that circumvents the intermediate step of a proper age model. This overcomes limitations of existing age modelling procedures such as the assumption of Gaussianity of calibrated age distributions. The resulting confidence bounds represent the true amount of uncertainty in the data.

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Research Domain IV: Transdisciplinary Concepts and Methods

References:

[1] J. Heitzig (2012) Moving Taylor Bayesian Regression for nonparametric multidimensional function estimation with possibly correlated errors

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