**INTRODUCTION**

Chronology models aim to reconstruct the sedimentation rate in a core given a limited number of radiocarbon 14 (14C) age estimates and fixed depths. They provide us information on the timing of past environmental change.

We review the background of three recently developed chronology models (Bpeat, OxCal and Bchron), and discuss the results obtained from a large data-driven study of their effects.

**CHRONOLOGY MODEL**

<table>
<thead>
<tr>
<th>°C Age</th>
<th>Error</th>
<th>Depth</th>
<th>Thickness</th>
<th>Cal. Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>1090</td>
<td>95</td>
<td>140</td>
<td>5</td>
<td>?</td>
</tr>
<tr>
<td>2110</td>
<td>55</td>
<td>195</td>
<td>5</td>
<td>?</td>
</tr>
<tr>
<td>10080</td>
<td>160</td>
<td>420</td>
<td>5</td>
<td>?</td>
</tr>
<tr>
<td>10280</td>
<td>210</td>
<td>513.5</td>
<td>5</td>
<td>?</td>
</tr>
</tbody>
</table>

A sample core from Stolpiec (Poland)

The statistical model for a 14C determination is:

\[ y_j - N(\mu(\theta_j), \sigma_j^2 + \epsilon^2(\theta_j)) \]

The posterior density of calibrated calendar dates is computed via the Bayes’s theorem:

\[ P(\theta | y) \propto L(y | \theta)P(\theta) \]

Where \( P(\theta) \) is prior archaeological knowledge (we often use stratigraphical information).

Where 14C data are available only at some depths, chronology models can interpolate dates at all depths. For example, the joint posterior density of calendar dates, depths, and other parameters such as intercept a, slope b and error can be approximated by:

\[ P(\theta(d), a, b, \epsilon | y) \propto \prod_i P(x_i | \theta(d_i), \epsilon) \prod_i P(\theta(d_i) | a, b, \epsilon)P(a)P(b)P(\epsilon) \]

Some preferred properties of a chronology model:

- Use a monotonic stochastic process as a prior distribution
- Provide methods for dealing with outlying dates
- Have variable uncertainty at undated levels

**DATA SURVEY**

The increment probability distribution of age between the depths in the sediment is compounded Poisson-Gamma:

\[ \theta(d_j) - \theta(d_{j+1}) = \sum_{i=1}^{n_j} \delta_i \]

Where \( N(d) - \text{Poisson}(d) \)

\[ r_j - \text{Gamma}(\alpha, \beta) \]

Bchron use two approaches to deal with outliers. The first type is similar to Bpeat. The second type allows for the complete removal of outlying dates:

\[ \delta_j - N(0, \beta^2_j) \]

\[ \phi_j - \text{Bin}(1, 0.001) \]

**RESULTS**

Our summarized statistics include the difference in modes, whether the 95% HDR for the calibrated date is encompassed by the estimated chronology pdf, and the Kulback-Leibler divergence.

**REFERENCES**


**NOTATIONS**

- Calendar date: \( \theta \)
- Radiocarbon determination: \( y \)
- Depth: \( d \)
- Calibration curve’s error: \( \sigma \)
- Calibration curve’s mean: \( \mu \)
- Calibration curve’s variance: \( \epsilon \)

**DISCUSSION**

Bpeat is most useful when there are large numbers of outlying dates, as it tends to enforce simple linearity.

Bchron is most suited when standard outliers and flexible structure are the main objectives of the exercise.

Oxcal seems ideally suited to situations where there is strong prior knowledge about the nature of sedimentation in a core.

Possibilities for expansion of these models:
- Improving the stochastic processes.
- Using physics-based models of sedimentation.
- Tying together dates from multiple correlated cores.

**ACKNOWLEDGEMENTS**

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