Regional maps of rate of change of pollen percentage as a tool for climate change visualization

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Isoline maps of percentage of pollen, obtained for different time horizons through the Holocene, are a typical tool for palaeobotanical studies. In connection with the West Carpathian project the authors have developed the idea of graphically presenting on the map a rate of change of the pollen percentage. Such a map is based on the data from two time horizons. The precision of such a type of map, which shows the%/change/100 yrs, and in which the value can be negative as well as positive, is lower that of a typical isopollen map. However, this type of map gives a direct insight into changes in the plant cover, which are related to climate change.

Key words: isopollen maps, rate-of-change map.

INTRODUCTION

Palaeobotany, especially palynology, serves as a palaeoclimatic proxy data source, since the taxonomic assemblages indicate many weather parameters with relative accuracy, such as average or extreme temperatures or precipitation. Regional isopollen maps (Szafer, 1935), produced for time horizons from the Holocene and Late Glacial (e.g., Ralska-Jasiewiczowa et al., 2004), are an almost unique source of geographical insight into the plant cover of the past. Since palynological data consists, as a rule, of full profiles frequently covering a geological epoch, it is typical to have isopollen maps not only for one time horizon (Huntley and Birks, 1983; Hoek, 1997a, b), but also for a series of horizons. It is therefore natural to analyse not only one given map, but two neighbouring maps, in search of some pattern of change of plant cover.

The primary result of such an analysis is information regarding in which areas the amount of pollen percentage of a given taxon rises or falls. The question how well the pollen percentage does in fact represent the vegetation is another matter. That problem will not be discussed here, since many papers considering the subject of isopollen maps have already covered this (e.g., Szafer, 1935; Huntley and Birks, 1983; Ralska-Jasiewiczowa et al., 2004), as have more recent publications (Gaillard et al., 2008).

THE IDEA OF THE RATE OF CHANGE MAPS

For each selected point on the map, it is simple to calculate the difference in pollen percentage. Let us denote difference as ΔP (the older P is subtracted from the younger value). The time span ΔT for the two given maps would be of the order of hundreds of years up to 1000 years. The ratio R = ΔP/ΔT is simply the rate of change of pollen percentage for a given geographical position.

Pollen percentage values are plotted on the maps, as a rule, making use of the isoline idea, which makes the map more readable. The natural, continuous values of the estimated pollen percentage are categorised into a set of bands; for example 0–0.1%, 0.1–0.2%, 0.2–0.5%, and so on. It is clear that the R (rate of change) should be calculated prior to this categorization. The map of R values runs the same way as do the P-maps and they will also finally be categorised by isolines. The only significant difference, however, is that twice the volume of data is necessary here; namely the P values, for all the sites available, for two time horizons. A necessary, additional data item is the ΔT. This seems to be trivial, being simply ΔT = 500 years, for example; in practice, though, the question of the precision of ΔT is far from simple.

THE MAP CONSTRUCTION

The palynological profiles are radiocarbon dated as well as dated by comparison with other, neighbouring profiles. The second method does not necessarily make the argument circular, since the data are multivariate. Correlation by one taxon imposes the same correlation for all other taxa. However, even the most precise elements of the dating process, namely the radiocarbon dates, are not free of uncertainty. The only solid fact is that the 14C ages have a well defined confidence band (as long as there is no gross error, for example of the type of sam-
Fig. 1. Two typical isopollen maps (A, B) of the percentage of an example taxon, obtained for time horizons 4000 $^14$C BP (A), and 4500 $^14$C BP (B); the third map (C) comprises the information from both the above time horizons showing differences in percentages recalculated to the time unit (100 yrs)

The value range of (A), and (B) is roughly from 1 to 10%, while for (C) it is from $-0.4$ to $+1.0\%$/100 yrs
Fig. 2. The examples of different data presentation accuracy

The median (B) map is probably a good trade-off between the loss of valuable information and artificially creating information.
features connected with the evolution of the taxon cover. In the middle of the given area, there is an evident increase of pollen. That feature can be discovered when inspecting both the (Fig. 1A) and (Fig. 1B) maps in parallel. Similarly, the fall in pollen percentage visible on (Fig. 1C) on the right can be recognized from (Fig. 1A) and (Fig. 1B); however, on (Fig. 1C), it is simply and directly indicated, with its numerical value (between -0.4 and -0.2 °%/100 yrs).

Selection of the value of \( \Delta T \) is a trade-off between the high number of maps obtained for the given database, and of that particular map accuracy (reliability). The second value is very different since it is measured (while the first one is simply a number). On Figure 2 are shown maps with different smoothing (averaging) degrees. The extremes would be: the representation of each site included with its own value; or, on the other hand, one value used right across the map. Such extremes are not presented below. However, the map (Fig. 2A) is probably slightly too precise, in terms of the reliability of the visible features. Map (Fig. 2C), however, seems to be too poor in terms of sufficient detail. The intermediate one (Fig. 2B) is probably a good option.

Appreciation of the quality offered by maps is possible with the application of the bootstrapping method (Walanus and Nalepka, 2009), or by visual inspection of a series of maps by an experienced scientist. The proposed maps of rate of change of the percentage pollen (Fig. 2) are very sensitive to overestimation in terms of the amount of information they convey. This is connected with the fact that twice as much data has been used in their creation than for typical isopollen maps. However, the potential map reader has to bear in mind that in the case of differentiation, data improvement should be treated as a cross road @ GI next. While the data values themselves may easily be close to zero after subtraction. If used with a due amount of care, the rate-of-change maps could be seen, however, as a good tool for determining plant cover change indicators.

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