The Comparison of the method to measure tree-ring width in dendroclimatology using Teak annual rings in Indonesia

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Tree-ring width has been used to establish relationships between tree growth and climate (Fritts 1976). Teak (*Tectona grandis* Linn. f.) has been used for paleoclimate reconstruction in tropical region (e.g., D' Arrigo et al., 1994) because teak is the one of few trees that can make annual tree rings there. The tree ring of teak is, however, not growing in a concentric fashion and the width on the disk might have bias from place to place. Therefore, the discussion of the relationship between tree growth and climate might be influenced by the measurement method of tree-ring width.
In this study, we used three teak disk samples, which were collected in Cepu, East Java, Indonesia. We compared the way of tree-ring width measurement. Three different measuring approaches were developed: "method of back calculation based on area (Method 1)", "method of curve traverse lines (Method 2)", and "method of straight traverse lines (Method 3)". Method 1 is the way as follows: consider two circles, which have the same areas closed in internal and external circumference of a tree ring, and define the difference in the lengths of radius as the tree-ring width. Method 2 is the way of measuring along a pith line (growth line), and Method 3 is the way of measuring along a straight line drown from the center to outside.
First, with Method 1, we calculated tree-ring width, and defined each tree-ring' s age by cross dating. Next, we measured along 16 lines for each teak disk with Method 2, and developed tree-ring width index. Here we made two types tree-ring width index: one is to choose one line for each teak disk and to average them (16^3 patterns in all; below is called "One Line"), and the other is to choose two lines for each teak disk and to average them ($({}_{16}C_2)^3$ patterns in all; below is called "Two Lines"). Method 3 can be described alike. In previous research, Poussart et al. (2004) used one core for each 2 teak disk to measure tree-ring width, so in this study, it corresponds "One Line" in "Method 3". Schollaen et al. (2013) used two cores for each 16, so in this study, it corresponds "Two Lines" in "Method 3".
Tree-ring width set with "Method 1" is calculated by the two-dimensional growth, and with "Method 2" and "Method 3" represent the one-dimensional growth directly, so the former mirrors the amount of teak' s growth more than the latter does. Thus, we analyzed the correlation between each tree-ring width index and climate data, and ascertained how close the consequence of the latter to the former. We also compared the consequences with previous studies (e.g., Schollaen et al. 2013)
This study showed positive correlation ($p<0.001$) between teak' s tree-ring width index and previous year's precipitation in dry season with Method 1, which is consistent with Jacoby and D' Arrigo (1990). With Method 2, the ratio of positive correlation ($p<0.05$) was 96.3% in all cases of "One Line", and 99.9% in all cases of "Two Lines". With Method 3, the ratio of positive correlation ($p<0.05$) was only 44.0% in all cases of "One Line", and 57.8% in all cases of "Two Lines".
Besides, this study ascertained negative correlation ($p<0.01$) between teak' s tree-ring width index and previous year's DMI in dry season with Method 1. With Method 2, the ratio of negative correlation ($p<0.05$) was 84.8% in all cases of "One Line", and 95.5% in all cases of "Two Lines". With Method 3, however, the ratio of negative correlation ($p<0.05$) was merely 13.0% in all cases of "One Line", and 10.2% in all cases of "Two Lines".
As described above, tree-ring width with "One Line" and "Two Lines" in "Method 3" might not have

information enough to reconstruct paleoclimate. In addition, “Method 1” seems to be the most effective to reconstruct paleoclimate of the three, and the information of tree-ring width with “Method 2” seems to be more credible than the one with “Method 3”.

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