Verification of methods to measure tree-ring widths in dendroclimatology using Teak annual rings in Indonesia

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Tree-ring has been used to estimate paleoclimate based on its width (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 species of trees that make annual tree-rings. The tree-ring of teak, however, grow with anisotropy and the width data is probably biased by the selection of measurement lines on a disk. Accordingly, the discussion of the relationship between tree growth and climate would be influenced by the measurement method of tree-ring width.

In this study, we used 3 teak disk samples, which were collected in Java, Indonesia, and compared the measurement way of tree-ring width. Three different measuring approaches were applied as follows: “method of back calculation based on area (Method 1)”; “method of curve traverse lines (Method 2)”; and “method of straight traverse lines (Method 3)”. On Method 1, it is assumed two circles, which are drawn by internal or external circumference of a tree-ring, tree-ring width is defined the difference in the radii. Method 2 is the method to measure along a pith line (growth line), and Method 3 is the method to measure along a straight line drawn from the center to outside. In previous researches (e.g. Poussart et al., 2004; Schollaen et al., 2013), one or more cores for each teak were used to measure tree-ring width, that is, it corresponds Method 3 in this study.
First, we calculated tree-ring width using by Method 1 and decided each tree-ring's age by cross dating. We also measured tree-ring width along 16 lines for each teak disk by using Method 2 and Method 3. As the results, the average of tree-ring widths along 16 lines with Method 2 and Method 3 showed the mostly the same value as tree-ring widths of Method 1 on all the samples.

Second, we examined the kinds of standardizing smoothing functions to extract information on tree-growth response to climate. We adopted a cubic smoothing spline as standardizing smoothing functions, and evaluated the appropriate value of frequency rejection filter based on mean correlation coefficients between teak samples. As the results, a cubic smoothing spline with a 50% frequency response cutoff of 90 years was evaluated as appropriate for the standardizing smoothing function.

Third, we calculated tree-ring width index using 90-year smoothing spline on each method, and compared the index of Method with those of Method 2 or Method 3 based on two techniques as follows; mean correlation coefficients between chronologies; the determination coefficient of response function analysis (Fritts et al., 1971). As the result, 2 or 4 lines with Method 2 or Method 3 most likely extract paleoclimate information as similar to Method 1 in the case of the round sample which the center of tree-ring is close to the barycenter. On the other hand, in the case of the sample of which center of tree-ring is far from the barycenter, or of which shape is distorted, 8 or more lines are necessary for paleoclimate reconstruction.

Moreover, we conducted correlation analysis between tree-ring width index and meteorological data (i.e.

precipitation, temperature, relative humidity, cloud cover, PDSI, SOI and DMI). Consequently, there were positive correlations between the average of tree-ring width index and precipitation, relative humidity, cloud cover, PDSI during preceding growing dry season, PDSI during growing rainy season, and the second preceding year's DMI during dry season with Method 1. Also, there were a negative correlation between chronology and the second preceding year's SOI during dry season with Method 1. With Method 2 or Method 3, chronologies which averaged tree-ring width indexes after selecting 4 lines for each teak disk are most likely similar to the result of Method 1.

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