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Analysis of 14C age calibration data sets based on tree rings from Japanese wood

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Radiocarbon (14C) dating is widely applied to archeological materials and cultural properties that are sometimes closely related with historical events. In particular, 14C dating is utilized to decide whether the materials are really related with the historical events, and highly accurate dating of the samples is required to judge the real from the false for history-related materials. Accuracy of 14C dating results is determined largely by appropriateness in sample preparation and measurements of 14C abundance of the prepared targets, but it is also related with the procedures to obtain reliable calendar age in calibration of sample conventional 14C age. For 14C age calibration, the IntCal09 data sets are normally used for terrestrial samples whose carbonaceous fractions were synthesized from atmospheric CO2 in the Northern Hemisphere, while the SHCal04 data sets are used for those in the Southern Hemisphere.

The accuracy of calendar age that was obtained by calibration of 14C age with IntCal09 data sets (Reimer et al. 2009) is, however, sometimes questioned because of the possibility that 14C concentration in atmospheric CO2 may vary spatially (Imamura et al. 2007). The calibration data sets IntCal09 are established on the basis of 14C data for tree rings grown in North America and Europe, but do not include those for the tree rings grown in other areas, for example, in Japan, although 14C data for plant residues from the bored cores at Lake Suigetsu, Fukui Prefecture, Japan, will be incorporated in the age range of 11.2-52.8 ka BP in the latest calibration data sets (Bronk Ramsey et al. 2012). The Japanese archipelago is located at the eastern margin of the Asian continent in the middle or a bit lower latitude region, and the 14C concentration in atmospheric CO2 over Japan may be lower than that at inland areas and northern locations as in North America or Europe, as the result of CO2 release to the atmosphere from the near-by ocean surface which has a lower 14C concentration, or air-mass delivery over the Pacific Ocean by East Asian monsoon in summer season when the plants grow quickly.

To investigate the 14C concentration of atmospheric CO2 in the past few millennia over Japan, we measured 14C ages of annual rings on a single year basis from three Japanese trees whose calendar dates range from ca. 2000 years old to present, and compared the tree-ring 14C ages with corresponding 14C ages of IntCal09. It was revealed that 14C ages of annual rings from Japanese trees are not consistent with IntCal09 data sets. Many 14C ages of tree rings are older than those of IntCal09, but younger than those of SHCal04 data sets. The average shifts of Nagoya 14C ages from IntCal09 ones and one-sigma errors were obtained to be +26+/-36, +24+/-30, +16+/-22, +5+/-21 and +14+/-22 14C years, for the intervals of AD72-382, AD589-1072, AD1413-1615, AD1617-1739 and AD1790-1860, respectively. IntCal09 data sets are usually preferred for calibration of 14C ages from Japanese samples, but it is revealed that SHCal04, or maybe a modified intermediate version of IntCal and SHCal, is rather suitable for Japanese samples in some cases. The Japanese archipelago is situated near the boundary of the Inter-tropical Convergence Zone in summer season, and the 14C concentration of atmospheric CO2 over Japan can be influenced by air masses of the Southern Hemisphere with lower 14C concentrations during the period of higher solar activities and magnified East Asian summer monsoon. Our results suggest that the Japanese archipelago is located in the critical zone where it is difficult to calibrate the 14C ages of tree ring samples collected with existing calibration data sets. At the moment, it should be noted that calibration of 14C dates of Japanese samples with IntCal09 may induce additional systematic shifts of calibrated ages toward older ages by about 30 years, from the sample optimum calendar ages.

Keywords: 14C age, calendar date, calibration to calendar date, tree ring, solar activity, Pacific high barometric pressure