

Cyclic change in teleconnection between Baiu and ENSO during last three centuries: Evidence from $\delta^{18}O$ of tree-ring cellulose

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[Introduction] Baiu/Meiyu is one of the most predominant features of East Asian Summer Monsoon and it has been providing Chinese, Korean and Japanese people with many benefits and disasters. Climatological analyses have revealed that Baiu is tightly related to ENSO index in the previous winter, but it is also noticed that the teleconnection is variable in multi-decadal time scales. In order to improve predictability of Baiu, it must be very useful to clarify the historical change in Baiu-ENSO teleconnection during pre-instrumental periods. In this study, we measured the oxygen isotopic ratios ($\delta^{18}O$) of tree-ring cellulose, which can directly indicate past summer hydroclimate, in northern (Hokkaido), central (Nagano) and southern (Kagoshima) Japan during last three centuries to investigate spatial and temporal variations in teleconnection pattern between Japanese summer monsoon (Baiu) and ENSO.

[Materials and Methods] Two oak and cypress tree-ring disks, whose ages were more than 200 years, were collected in spring of 2003 and fall of 2005 at northern Hokkaido and southern Nagano prefecture, respectively. Tree-ring cores were also obtained from about 30 cedar trees, whose ages were more than 500 years, in Yakushima island of Kagoshima prefecture in spring of 2003. Each year ring was cut out from two oak and cypress disks, and separately applied for extraction of alfa-cellulose by sequential chemical treatments. Because tree-ring widths of the cedar (Yakusugi) were too narrow to analyze each year ring of individual tree separately, cross-dated year ring samples from about 10 cores were pooled together and applied for cellulose extraction. The $\delta^{18}O$ of cellulose from each year during last 200-300 years was analyzed by pyrolysis type of elemental analyzer combined to isotope ratio mass spectrometer (TCEA-IRMS, Delta-Plus XL). Reproducibility of the measurement was about 0.2 permil (1 standard deviation).

[Results and Discussions] Historical variations of $\delta^{18}O$ in cellulose extracted from two disks are very similar to each other, in both of oak and cypress trees at Hokkaido and Nagano prefecture, respectively, indicating that $\delta^{18}O$ of tree-ring cellulose are governed by common local climatic factors. Regression analyses between the $\delta^{18}O$ and monthly meteorological parameters at the closest observatories of three sites show that the tree-ring $\delta^{18}O$ have the highest (negative) correlations with summer relative humidity all over Japan. Tree-ring $\delta^{18}O$ at Nagano prefecture was highly correlated with June relative humidity, not only at the near observatories, but also at very wide area extending zonally along central Japan, indicating that the tree-ring $\delta^{18}O$ can be a proxy of Baiu front activity at the studied latitude. In order to investigate the possible long-term changes in Baiu-ENSO teleconnection, we conducted slide correlation analyses between variations in ENSO indices (reconstructed Southern Oscillation Index [Stahle et al., 1998] and recently observed NINO-3 SST) and the tree-ring $\delta^{18}O$ of this study. During last three centuries, the correlations between $\delta^{18}O$ and ENSO have been reversed cyclically at about 40 year intervals at all of three sites. The latest reversal corresponds to the regime shift occurred in 1970's, indicating that the instrumentally observed non-stationariness is part of a longer-term climatic phenomenon. Interestingly, the cyclic changes in the $\delta^{18}O$ -ENSO correlation at all of three sites are coincident with the long-term change in observed and reconstructed Pacific Decadal Oscillation [D'Arrigo et al., 2001], but the phase of the cyclic changes are opposite between northern and central-southern areas of Japan, suggesting that multi-decadal shift of latitudinal location of Baiu front occurred in Japan. Those findings clearly indicate that the predictability of Japanese summer monsoon (Baiu) can be improved by considering other indices of atmospheric circulation, such as PDO, together with ENSO.