論文の内容の要旨

論文題目

The last millennium precipitation in Japan reconstructed using oxygen isotopes from tree-rings

（樹木年輪の酸素同位体を用いた過去 1000 年間の日本の降水量復元に関する研究）

氏名　坂下　渉

The Asian monsoon, characterized by variations of the strength and expansion of the summer rain band, is an important part of the Earth's climate system. The long-term hydrological conditions in East Asia indicate complicated rainfall pattern during the last millennium. Previous works proposed that the El Niño-like and La Niña-like equatorial Pacific conditions had an important role for controlling precipitation in East China and its surroundings. To develop the understanding of physical processes in the western North Pacific, hydrological reconstructions are needed in Japan. However, there are as of now few studies that reconstructed the hydrological variability in this region.

The main research objective of this thesis is the annually resolved reconstructions of past hydroclimate changes in Japan. To reconstruct the long-term hydrological condition, I focus on tree-ring cellulose oxygen isotopes ($\delta^{18}O$) from cedar trees in Japan. In chapter 2, two long cedar tree-ring cellulose $\delta^{18}O$ from central Japan are presented during the past four centuries. These data allow me to consider that cedar trees from Japan are suitable to reconstruct the long-term hydroclimate variability. In chapter 3, I report another cedar $\delta^{18}O$ chronology in Yakushima Island from the

Medieval Climate Anomaly (MCA) and Little Ice Age (LIA). In this chapter, tree-ring growth rate and meteorological conditions are also observed in Yakushima Island. Based on these reconstructions, I discuss about the possible influence of the Pacific Sea Surface Temperature (SST) on the long-term hydrological variations in central Japan (Chapter 4) and Yakushima Island (Chapter 5). These discussions indicate that the equatorial Pacific SST and the Kuroshio Current play important roles in the hydrological conditions in central Japan and Yakushima Island, respectively. In Chapter 6, I investigate relationships between El Niño–Southern Oscillation (ENSO) and tree-ring cellulose $\delta^{18}O$. In the final chapter, I provide the general discussion and future perspectives of this thesis (Chapter 7). This discussion can develop an understanding of the mechanism for the long-term rainfall pattern in eastern part of East Asia. Key findings in each chapter are summarized in the followings.

Tree-ring cellulose oxygen isotopes in central Japan (Chapter 2): Measurements of cellulose $\delta^{18}O$ were performed for two long cedar trees from central Japan. These two chronologies allowed me to consider the age-related trend of Japanese cedars from central Japan. Results indicated that Mie tree-ring cellulose $\delta^{18}O$ significantly correlated with May–June–July (MJJ) relative humidity. Time-domain comparisons using two long chronologies showed that these data were consistent throughout the majority of the past four centuries, except for the end of 18th century. Regression lines for tree-ring $\delta^{18}O$ indicated that there were no significant age-related trends in cedar trees from central Japan, except for the $\delta^{18}O$ values of inner cedar.

Tree-ring cellulose oxygen isotopes in Yakushima Island (Chapter 3): I measured Yakushima tree-ring cellulose $\delta^{18}O$ from the MCA and LIA. Results showed that there were no significant correlations between the tree-ring cellulose $\delta^{18}O$ and relative humidity, suggesting that this proxy was mainly controlled by the source water $\delta^{18}O$ changes. Assuming that the source water $\delta^{18}O$ variations mainly controlled by the amount effect, further correlation analysis was performed for precipitation data. This analysis indicated that Yakushima tree-ring cellulose $\delta^{18}O$ significantly correlated with May–June (MJ) precipitation. Meteorological data and tree-ring growth observations supported this correlation.

Relative humidity reconstruction in central Japan during the Little Ice Age (Chapter 4): Here, I reconstructed the variations of hydrological condition in the

Meiyu/Baiu season from AD 1600–1959 by using tree-ring cellulose $\delta^{18}O$ from central Japan. Data suggested that the wettest period occurred around AD 1790–1860, the final stage of the LIA. Comparisons between this relative humidity reconstruction and global SSTs suggested that SST variability in the equatorial Pacific played an important role in the hydrological conditions of central Japan.

Hydroclimate reconstruction in Yakushima Island over the past millennium (Chapter 5): Here I presented a tree-ring cellulose $\delta^{18}O$ chronology for Yakushima Island from AD 1025 to 1805. Assuming that this data mainly controlled by the amount effect, the results indicated that precipitation decreased during the LIA relative to the MCA. Meteorological precipitation data and tree-ring cellulose $\delta^{18}O$ synchronized with SST variations around the western North Pacific, suggesting that the Kuroshio Current played an important role in this hydroclimate changes.

Relationship between tree-ring cellulose oxygen isotopes in Japan and the El Niño–Southern Oscillation (Chapter 6): The ENSO is known to strongly influence East Asian Summer Monsoon (EASM) rainfall in the present-day climate, but the relatively short instrumental rainfall record hindered the development of a longer-term understanding of this teleconnection. To overcome this issue, here I presented tree-ring cellulose $\delta^{18}O$ from AD 1612 to 1935. Time- and frequency-domain comparison of the tree-ring $\delta^{18}O$ record and recent ENSO reconstructions revealed a common high-frequency (3–8 year) variability that characterized the mid-17th, late 18th and late 19th centuries. Similar analyses of instrumental MJ precipitation and several ENSO indexes during the 20th century indicated that this high-frequency oscillation reappeared from AD 1980. In addition, comparison of ENSO and Pacific Decadal Oscillation (PDO) indexes indicated that the ENSO-EASM teleconnection was strong when ENSO variance was high, and the PDO phase may relate to the ENSO-EASM relationship over the past 400 years.