Comparative analysis of climate in East Asia between 13th-14th and 20th-21st centuries

*Ayano Nada[1], Takeshi Nakatsuka[2], Yoshikazu Kato[2], Masaki Sano[2], Minori Kato[2]

1. School of Science, Nagoya University , 2. Graduate School of Environmental Studies, Nagoya University

1.Introduction

PAGES 2k network (2013) elucidated that an extraordinary warming event in Asia comparable to that of the present day occurred in the 1320-30s during which an extraordinary reversal increase in relative humidity occurred along with the increase in temperatures as well as that during the 2010-20s (Nakatsuka, 2022). In 1320-30s, the number of flood disaster documents increased in China as well as those in the present day, but we cannot find significant increases in Japanese flood documents at that time. Given that there are only few medieval documents preserved in Japanese rural areas distant from the old capital city (Kyoto), it might be due to the difference in the nation-wide preservation rate of medieval documents between decentralized Japan and centralized China. On the other hand, recent studies on intra-annual variations in cellulose oxygen isotope ratio ($\delta^{18}O_{cel}$) in the 18th and 19th centuries clarified that during the warm-wet period like the 1320-30s and the 2010-20s, the relative humidity was extremely high only in the late half of the summer (Sho, 2021). Therefore, in this study, we tentatively hypothesize that, during the 1320-30s in Japan, localized heavy rainfall events occurred over wide areas distant from Kyoto only in the late half of the summer, resulting in fewer flood disaster documents and try to confirm it.

2.Method

First, the intra-annual variations in $\delta^{18}O_{cel}$ of the living trees in Toyota City was measured by dividing the annual layer into two parts and compared with the observed data of monthly averaged relative humidity. Next, the annual layers between 1315 and 1335 AD of the excavated wood in Kiyosu City were also divided into two parts, and the temporal changes of relative humidity in summer were reconstructed. Finally, using Chinese disaster records, which contain more abundant documents and reflect disasters in wider areas than those in Japan, we compared seasonal variations in occurrence of flood disasters between the warm-wet period and the cold-wet period.

3.Results and Discussion

The difference in the $\delta_{18}O_{cel}$ between early and late halves of annual layer showed a clear negative correlation with the difference in the average relative humidity between May-June and July-August periods. The large difference in relative humidity between the early and late halves of the summer was also found since the late 2010s to present, which corresponds to the warm-wet period. Similarly, during the warm-wet period around 1330 AD(Figure 1: black arrows), the $\delta^{18}O_{cel}$ in the late half of annual layer was particularly low compared to the early half (i.e., relative humidity was particularly high in the late half of the summer). In China, as well as in Japan, during the 13th and 14th centuries, there were both of the warm-wet period and the cold-wet periods. Although the annual number of flood disasters increased during the both periods, more abundant flood disasters occurred in the late half of the summer in the warm-wet period, while we cannot observe the temporal tendency in the cold-wet period.

These results suggest that, in the 1320-30s, the number of historical flood documents did not increase very much in Japan due to the less medieval documents surviving over a wide area, but localized heavy rainfall events actually increased in the late half of summer as well as in China. The reason why the period of high relative humidity during the warm-wet period is biased toward the late half of the summer must be related to the rise in sea surface temperature. According to Yasunari (2018), rising of sea surface temperature due to the global warming causes active evaporation of sea water. As the result, the amount of water vapor supplied to East Asian land areas by summer monsoon from the ocean increases especially

in the late half of summer, so that the period of high relative humidity is located especially in the late half of summer, and short-term intensive local heavy rainfall events increase.

Keywords: tree ring, oxygen isotope ratio, Paleoclimatology

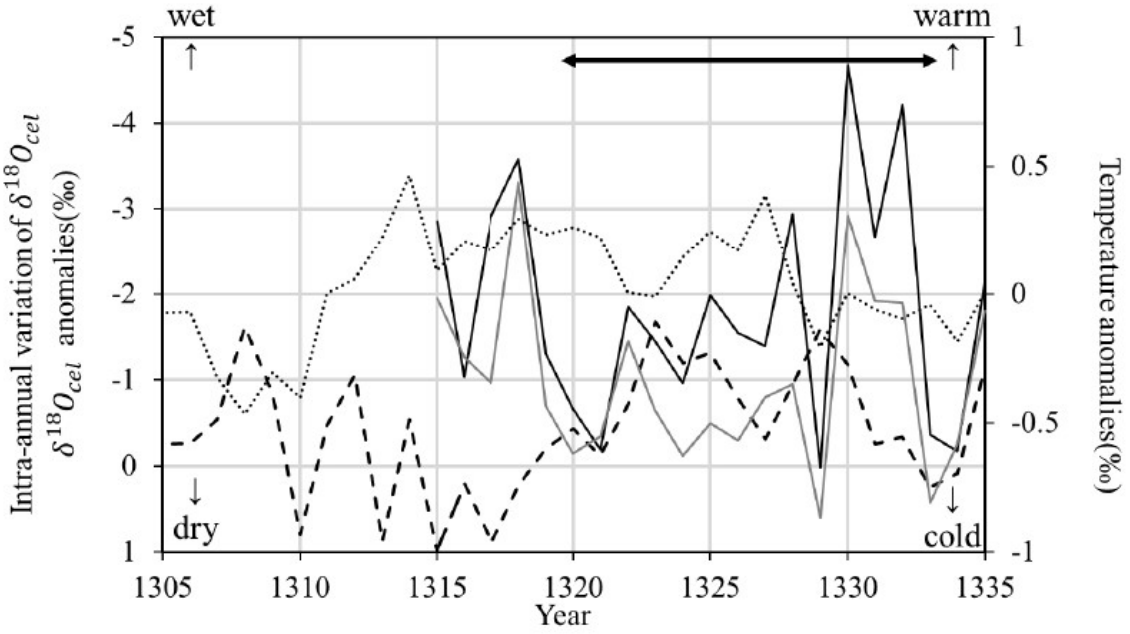

Figure 1 Intra-annual variation in oxygen isotope ratios of tree-ring cellulose ($\delta^{18}O_{cel}$) from 1315 to 1335 (solid line; late half $\delta^{18}O_{cel}$minus early half $\delta^{18}O_{cel}$). Anomalies of annual $\delta^{18}O_{cel}$ (dashed line; Nakatsuka et al., 2020) and summer temperature anomalies (dotted line; Cook et al., 2013) are also shown.

