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樹木年輪セルロースの水素・酸素同位体比によるキルギスの古気候復元
Climate reconstruction using hydrogen and oxygen isotope ratios of tree-ring cellulose in Kyrgyz

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Hydrogen and oxygen isotope chronologies of tree-ring cellulose were established to understand past climate variations in southwestern Kyrgyz. A total of three core samples collected in 1998 from three individual junipers growing in an arid region were subjected to hydrogen and oxygen isotopic analysis. One core sample was analyzed over the last 485 years at pentad (5-year) resolution by simply mixing 5 adjacent rings, while the remaining two cores were individually examined for the last 50 years at annual resolution.

Correlation coefficients between the two trees for the inter-annual variations during the 1948-97 period are 0.60 ($p<0.001$) and 0.30 ($p<0.05$), respectively, for hydrogen and oxygen isotopes, suggesting that isotopic ratios are at least partly controlled by common climatic factors. Response analysis with ambient climatic records revealed, however, that the hydrogen and oxygen chronologies did not show significant correlations with monthly temperatures and precipitation at annual resolution. On the other hand, the pentad isotope records compared with the corresponding instrumental data showed significant positive correlations with March-April and March-August temperatures, respectively, for hydrogen and oxygen isotope chronologies. These results indicate that the pentad-based measurements result in the smoothing of short-term and micro-scale environmental noises, such as heterogeneous spatial and temporal distributions of soil waters in the arid land, recorded in annually resolved chronologies.

The 485-year hydrogen isotope chronology, which reflects spring temperatures, shows multidecadal to century-scale fluctuations, with a notable warm period of ca. 1710-1730 and a warming trend over the 20th century. Interestingly, the warm anomalies of the early 1700s, which can be recognized at many other places in the world, correspond to the end of the Maunder Minimum (1645-1715), thus may indicate some causal relationship between them. The oxygen isotope data, which reflect temperatures in spring and summer seasons, show rough similarity in the high-frequency domain with the hydrogen isotope chronology, since oxygen and hydrogen isotopes of precipitation are highly correlated with each other. However, the long-term variations substantially differ from each other, indicating that different factors control isotopic ratios in the low-frequency domain. One important factor is relative humidity, to which oxygen isotopes are known to be sensitive rather than hydrogen isotopes. Though we were not able to compare the isotope records with relative humidity due to the lack of instrumental data, if we consider the effect of relative humidity, it is possible to explain the reason why oxygen isotopes showed the significant correlation with summer temperatures, which were not correlated with hydrogen isotopes, as follows. In the studied region, summer precipitation is much less than spring one, through which only spring temperatures can be recorded in tree-ring hydrogen isotopes. On the other hand, leaf water oxygen isotope enrichment occurs during photosynthesis in summer, controlled by the summer temperature through summer relative humidity. We therefore interpreted that the oxygen isotope chronology capture both of relative humidity in summer and temperatures in spring, and the divergence of long-term variations between the oxygen and hydrogen isotope chronologies originates from relative humidity. When the 485-year oxygen isotope chronology is assumed to be a proxy of relative humidity, it shows an arid condition during the 1750-1900 period, followed by a humid trend continuing up to present.