The fluctuation of oxygen isotope ratios of tree ring cellulose during the Little Ice Age and relationship with solar activity

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[Introduction]

The Little Ice Age (LIA) is known to be a period of cooling during 15-19th century. However, the causes of LIA and the detail of climate change during LIA are not well understood. In this study, we reconstructed climate (humidity) in central Japan during mid-LIA (AD1612-1756) with annual and seasonal time resolution, using oxygen isotope ratios (d18O) of tree ring cellulose in a 387-year-old Japanese cedar.

[Materials and Methods]

The tree ring d18O are correlated both negatively and positively with relative humidity (RH) and d18O in precipitation, respectively. Because the latter is negatively correlated with the amount of precipitation in the monsoon area, the tree-ring d18O can be a reliable proxy for past RH and/or the amount of precipitation in the area of the interest. A tree ring disk of a 387-year-old Japanese cedar was collected at the Murou-Temple in Nara, central Japan (34.32'N, 136.02'E, altitude 405m). Cellulose of annual rings was extracted by chemical treatments and its d18O was determined by a pyrolysis-type elemental analyzer and an isotope ratio mass spectrometer (TCEA-IRMS).

[Results and Discussion]

(1) The tree ring d18O record correlates significantly with the mean RH in central Japan in June during AD1938-1998. Therefore this can be a proxy for the activity of the Baiu-front in central Japan.

(2) The annual record of the d18O during AD1612-1756 shows many distinct negative peaks (i.e. higher RH) with approximately 14-year quasiperiodicity. We compared the record with atmospheric carbon 14 record, as is a proxy for solar activity. All solar minimums coincide with d18O peaks and 8 among 10 solar minimums coincide within 1-year during AD1640-1760. It is difficult to attribute the exact cause of these d18O peaks to only internal changes in the climate system, because d18O and solar activity show synchronized fluctuations with approximately 14-year periodicity. Volcanic activities are often produce climate perturbations, yet there is only 1 volcanic event is recorded that coincides with d18O peaks and solar minimum. Therefore weakening of solar activity was the prime candidate to produce d18O peaks.

(3) The seasonally resolved d18O record during AD1687, 1693-1701 suggests that the climate in central Japan during solar minimum was very wet all through spring and summer, not only in June as other years.

(4) We also compared the tree ring d18O record with a temperature reconstruction in Greenland during the same period to investigate the spatial distribution of these climate changes. There were rapid cooling events in Greenland, synchronizing with the humidity peaks in Japan. This fact suggests that the quasiperiodic climate changes during this period were synchronous in at least hemispheric-scale.