

Reconstruction of past Baiu activity using oxygen isotope ratio of tree rings in central Japan

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The oxygen isotope records presented in natural archives such as tree ring cellulose, speleothems, leaf wax, and ice cores are widely accepted for climate reconstruction. Among other materials, these records are strongly influenced by the isotope value of precipitation as they developed. A better understanding of isotopic variability in precipitation can enable better reconstruction of past environments. For example, in the tropics, various observational and modeling studies have been carried out to provide a greater depth of the interpretation of natural isotopic variability, leading to a common conclusion that isotopic variation in tropical precipitation is related to the large-scale convective activity, rather than precipitation amount. This interpretation proposes that isotope records from the tropical region is used to reconstruct past large-scale convective activity. For Japan, intense observation studies have already done to identify climate drivers controlling isotopic variability. Kurita et al., (2015) showed that north-south displacements of the Baiu front are manifest in the isotopic composition of precipitation in central Japan.

In this study, we reconstructed 100-year long records of oxygen isotopic composition of summer precipitation from tree-ring oxygen isotope records in central Japan. And, we discuss the past location of the Baiu front using reconstructed long-term precipitation isotope data. Since the oxygen isotope ratio of tree rings is not directly influenced by the isotopic composition of precipitation, using mechanistic model predicting the oxygen isotopic ratio of tree-ring, we calculated the isotopic ratio of source water that a tree used during the growing season. The modeled isotopic ratio of source water was exchanged to the oxygen isotopic ratio of summer precipitation using an experimental polynomial function of sunshine duration (SD).

The reconstructed oxygen isotope ratios of summer precipitation during the past 100 years exhibit weak interdecadal variability, with the highest values in the mid-1930s, but inter-annual fluctuations are more considerable. During the period of availability of the reanalysis dataset (1958--2005), the inter-annual and long-term variability in isotopic ratios are closely linked to the Baiu front activity as follows: (1) there is a positive negative correlation ($R=0.37$, $p<0.01$) with the onset days of Baiu rainfall in central Japan, (2) the decreasing trend of the onset days in the later half of the 20th century corresponded to the long-term decreasing trend of the modeled isotopic ratio, (3) the center of Baiu frontal zone is shifted southward, apart from the coast of Japan during the years with low oxygen isotope ratio. These indicate that we can discuss the past Baiu activity beyond the period of availability of the reanalysis dataset using the reconstructed oxygen isotope ratio in precipitation.

Keywords: Tree-ring oxygen isotope ratio, Oxygen isotope ratio in precipitation , Baiu frontal zone