

Interactive data production and data analysis on past climate between paleoclimatology, history and archaeology for last 3,000 years in Japan

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Climate has been regarded as a possible driving factor of human history, but simple comparisons between climate and history by paleoclimatologists were often criticized as “climate determinism” by historians. Recently, developments of the high time resolution paleoclimatology are changing the situation, such that historians begin to use precise paleoclimate data in the context of traditional historical researches. However, the relationships between paleoclimatologists and historians are usually unidirectional. Paleoclimatologists create data without interaction with historians and historians don't give any feedbacks to paleoclimatologists. From 2014 to 2018, we conducted an inter-disciplinary research project, “Societal Adaptation to Climate Change: Integrating Palaeoclimatological Data with Historical and Archaeological Evidences” in Research Institute for Humanity and Nature (RIHN), Kyoto, Japan. In this project, we realized full interactive data productions and data analyses based on an innovative paleoclimatological proxy, tree-ring cellulose oxygen isotopic ratio ($\delta^{18}\text{O}$), and made big progresses for all related disciplines as follows.

We have experienced sequentially 5 phases in the interactive data production and data analyses between different disciplines. Phase-1 is the introduction of a new paleoclimate proxy (tree-ring cellulose $\delta^{18}\text{O}$) as a basis of the project. It can be utilized to reconstruct summer hydroclimate critical for rice paddy cultivation, main livelihood of Japanese people for last 3,000 years, and important for historical and archaeological studies. Phase-2 is the collaborative multi-millennial extension of tree-ring $\delta^{18}\text{O}$ chronologies over Japan. Archaeologists provided paleoclimatologists of numerous excavated wood in order to extend the chronology because it can be used to date newly excavated woods reversely. Phase-3 is the development of a method reconstructing long-term climate variations. The tree-ring $\delta^{18}\text{O}$ chronologies are influenced by serious age effects, so that paleoclimatologists must have invented a new method to reconstruct past climate seamlessly from annual to millennial scales corresponding to requests from historians and archaeologists (Nakatsuka et al., 2020; <https://doi.org/10.5194/cp-2020-6>). Phase-4 is the validation and utilization of the paleoclimate data beyond disciplines. The climate data are informative for historians and archaeologists so that they could verify and utilize the data by comparison with numerous evidences in Japanese history. Phase-5 is the discovery of a new climate-history relationship. High correlations between the tree-ring $\delta^{18}\text{O}$ and agricultural productivities enable us to investigate impacts of climate variation to Japanese (Chinese) history at various time scales and we found that intermittent enhancements of multi-decadal climate variability often induced societal upheavals and political regime shifts in East Asian long history.

Interactive data production and data analyses on past climate between paleoclimatology, history and archaeology have brought great progresses to each discipline. However, there were also tiny but significant problems in the collaboration. First, it usually takes a very long time, more than several years, for paleoclimatologists to construct and verify the multi-millennial annually-resolved paleoclimate data in collaboration with historians and archaeologists. Second, historians and archaeologists in Japan usually write papers alone without co-authors even if they use a new paleoclimatological data. Both of the two

problems reduce the motivation of young paleoclimatologists and damage the inter-disciplinary collaboration. In order to mitigate negative influences of these problems, paleoclimatologists, historians and archaeologists should share a common research target such as solution of global environmental issues by intense mutual discussions.

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