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Climate of the late Pleistocene and early Holocene in coastal South China inferred from submerged wood samples

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ABSTRACT

Tree-ring variability of submerged wood specimens in coastal areas provides important clues about sea level change and climate variability of the past. We dated submerged wood samples from coastal Fujian province in China using the radiocarbon methods and investigated their tree-ring variability. The submerged wood samples from the Shenhu Bay that date to the early Holocene (~8000 calibrated years B.P.) may be related to the rise of the sea level after the Last Glacial Maximum (LGM). The submerged wood samples from the Qianhu Bay site dated to the Marine Isotope Stage 3 (MIS 3) (>40,000 calibrated years B.P.). Most of the submerged wood samples are from coniferous trees with frequent branching tree rings. Frequent branching tree rings in this region are mostly found from the currently endangered coniferous species with narrow ecological amplitude at humid sites. Tree rings of the submerged sample show conspicuous interdecadal variability (~20 years) than interannual variations, which differs from modern tree rings of nearby regions which have stronger interannual and multi-decadal variability. Our study highlights the potential to use submerged samples of coastal Southeast China for paleoclimate studies.

1. Introduction

Long-term climate changes are often inferred from proxy-based reconstructions and model-based simulations (Ruddiman, 2014). Proxy-based climate reconstructions can not only provide boundary and forcing conditions for the model but also provide benchmarks to validate paleoclimate simulations. Proxies used to reconstruct paleoclimate since the late Pleistocene (e.g. the Last Glacial Maximum (LGM)) include lake sediments, speleothem, ice core, peatland sediments and marine sediments (Pachauri et al., 2014). However, these long-lasting proxies often have low temporal resolution and do not contain high-frequency signal such as interannual climate variability. Annually resolved proxies, such as tree rings, coral and historical archives, can be used to reconstruct high-frequency climate variations (Hughes et al., 2011). However, such proxy records are often not sufficiently long. In Asia, the longest published tree-ring chronologies are mainly found in northeastern Tibetan Plateau and are no longer than 4000 years (Shao et al., 2010; Yang et al., 2014). As for the humid tropical and subtropical Asia, published tree-ring chronologies are less than a millennium (Cook et al., 2010). This situation can be alleviated by using tree rings from submerged wood samples deposited during the late Pleistocene and early Holocene (Panyushkina et al., 2004).

Submerged woods near coastal areas often lie beneath a sea due to the historical rise of sea level, which caused drowning of the forests (Campbell and Baxter, 1979). Investigations of submerged wood sample can provide not only information on sea level change (Lea et al., 2002) but also climate change. This study dated submerged wood samples from two sites in the western side of Taiwan Strait (Fig. 1) and investigated their climate variability from their tree-ring widths. The study region is currently dominated by the broadleaf forests, which constitutes a “green island” relative to the

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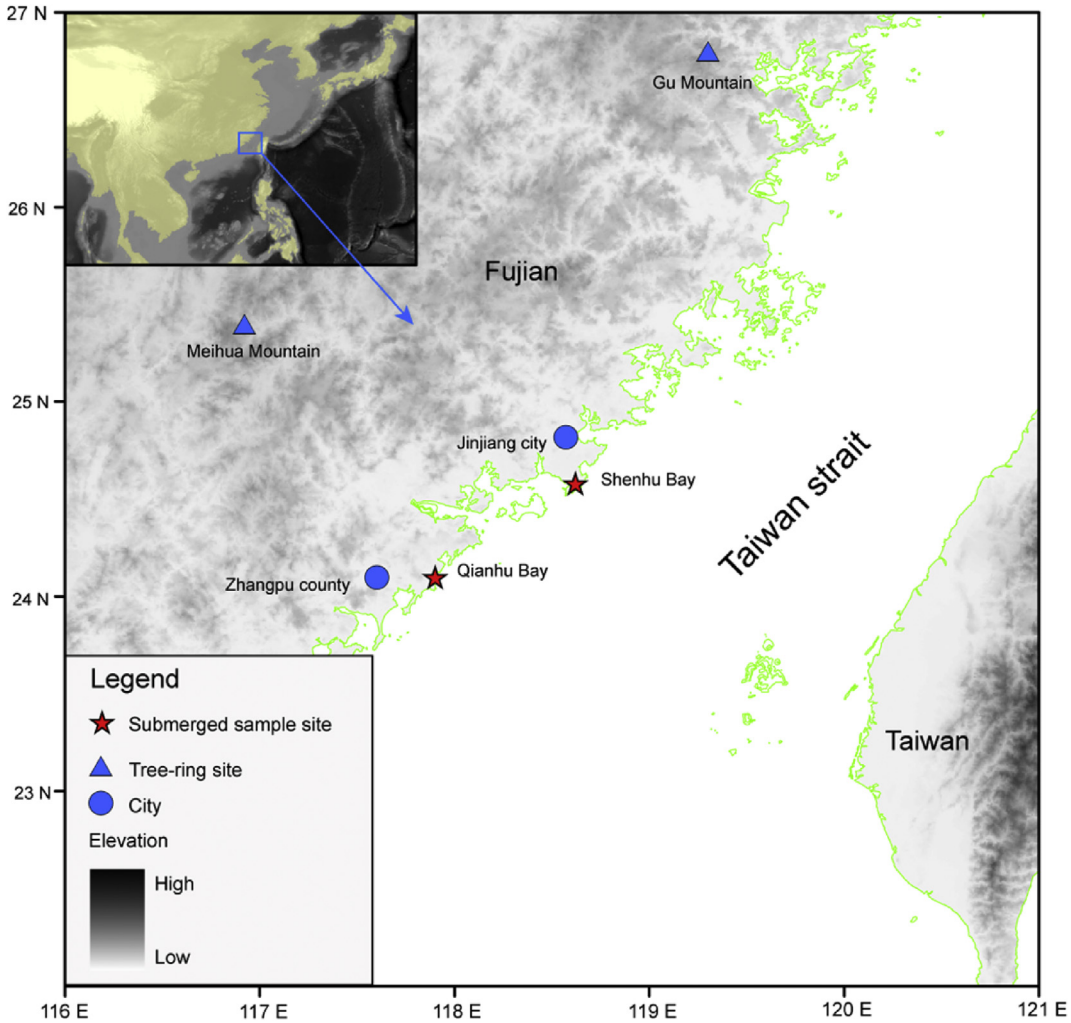

Fig. 1. Locations of the Shenhu Bay and Qianhu Bay sites with submerged samples, the nearby cities and the sites with tree rings from living trees.

other arid or semi-arid subtropics of the world. Previous studies have investigated the environmental and ecological conditions for the deposition of submerged samples from this coastal area (Liu et al., 2003, 2007; Wu, 2004; Yu and Lin, 2009), while none of the study explored their tree-ring variability.

2. Data and methods

2.1. Sampling sites

The submerged wood samples were collected from the coastal areas of Fujian province in South China, western side of the Taiwan Strait (Fig. 1). Currently, the study region is controlled by a humid subtropical climate with annual mean temperature of over 20 °C and annual total precipitation of over 1000 mm. One of the sampling site is at the Shenhu Bay (118.62 °E, 24.58 °N) in Jinjiang city of Quanzhou area, which are well reserved by the National Shenhu Bay Geological Park. The submerged tree stumps remain upright with up to 150 mm above ground, which are below sea surface during the high tide and can show up in the low tide. There are 65 submerged tree stumps, which are mostly composed of *Keteleeria fortunei* trees mixed by a few broadleaf trees such *Gleditsia sinensis* and *Morus alba* according to previous wood anatomy studies (Liu et al., 2003). Most of the submerged trees were weathered and entirely dark, only some samples have tree-ring boundaries distinguishable. The samples have sufficient carbon and are suitable for carbonate dating. Tree stumps at sampling site have diameters of 27–69 cm and are of about 45–100 years old based on previous studies (Liu et al., 2003). Unfortunately, many samples were now destroyed and the remained are strictly protected. We only collected two wood samples from an upright stump with tree rings. These samples can generally represent the this submerged woods since the submerged woods have similar ages and similar number of tree rings as reported previously (Liu et al., 2003). We additionally collected 4 fragmented wood samples from the beach.

The other sampling site is located at an estuary area of Qianhu Bay (117.90 °E, 24.10 °N) in Zhangpu county of Zhangpu area, where the Chihu river meets the ocean (Liu et al., 2007). Previous investigations found 89 submerged stumps of both coniferous and broadleaf species in the intertidal belt with diameters from 30 to 120 cm (Wu, 2004). Unfortunately, this site is not protected and has no submerged stumps left now. We can only find submerged wood pieces under chains of large stones near the beach. We collected 22 submerged wood samples, some of which had tree rings. Unlike the Shenhu Bay site with purely submerged samples of wood, many samples at the Qianhu Bay have tissues of wood embedded in peat deposits (Fig. 2).

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