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The impact of Holocene climate changes on Honghe wetland in NE China

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ABSTRACT

Understanding the response of wetlands to climate changes could provide useful insights toward predicting the wetlands future in a warmer world. Here, we present a well-dated peat/mud profile with multiple proxies to reconstruct the historic development of Honghe wetland and discuss its response to the East Asian monsoon variations during the Holocene. The results show that the Honghe wetland developed as a shallow-water lake in the mid-early Holocene during a time of high precipitation from the East Asian monsoon. At 4600 years BP, peat layers appeared with sharp increases in the accumulation rate, grain-size Md and arboreal plants, marking a decline in water levels with the relative dry climate. Moreover, the transition corresponds well to the mid-Holocne monsoon weakening event and we suggest the decrease of the monsoon associated precipitation plays a critical role in driving the lake-peatland transition in Honghe. Facing the intensified summer monsoon in future, we suggest some practical measures should be taken to protect the present wetlands from changing back to lakes.

1. Introduction

Wetlands are among the most important terrestrial ecosystems for their rich biological resources and high C-sinking capacities (Mitsch and Wu, 1995; Bridgham et al., 2006; Kadlec and Wallace, 2008). While under the influence of ongoing global changes, these functions have been impeded by the increasing loss and degeneration of their ecosystems (Raich and Schlesinger, 1992; Moore et al., 1998), and their fate in an approaching warmer world has hence drawn widespread attention (Rustad et al., 2001; Turetsky et al., 2002; Dorrepaal et al., 2009).

Understanding the mechanisms of wetlands response to past climate changes could provide useful insights into projecting the future of these ecosystems, and numerous works have been done on this issue during recent decades (Raich and Schlesinger, 1992; Moore et al., 1998; Freeman et al., 2001; Rustad et al., 2001; Turetsky et al., 2007; Dorrepaal et al., 2009). It was generally accepted that a warmer and wetter condition during the growing season was more favorable for higher primary production and in turn a quicker peat accumulation in wetlands (Moore and Dalva, 1993; Carroll and Crill, 1997; Bridgham et al., 2006). While this conclusion was primarily derived from experimental modeling over a relatively short time period. The response of wetlands to climatic changes in a longer history of >100years has not been well studied (Jones and Yu, 2010; Zhao et al., 2014). Although a few works have tentatively revealed the response of peat accumulation to past climate conditions, the results seem to be inconsistent with modeling results, as a considerable number of peatlands across the world were initiated during the Last Glacial stage, which was a cold and dry interval (Adams et al., 1990; Yu et al., 2010). The mechanisms of climate impact on wetlands may be more complicated than anticipated, and clarification of this issue will require high-quality records from more climatically sensitive locations.

The Sanjiang Plain contains the largest area of wetlands in China (Chen, 1995). It is situated at mid-high latitudes and is at the edge of the influence of the East Asian monsoon. This makes it a particularly sensitive region to variations in the East Asian monsoon (An et al., 2000). Although changes in the East Asian monsoon during the Holocene have been well studied, little is known of its impact on the wetlands of the Sanjiang Plain (Zhang et al., 2014). In this paper, we present a well-dated peat/mud profile with multiple proxies from the Honghe wetland to reconstruct the wetland developing history and discuss its responses to monsoonal variations during the Holocene.

2. Regional setting

The Sanjiang plain (129°11′–135°05′E, 43°49′–48°27′N) is located in the northeast of China (Fig. 1). It is a huge alluvial plain crossed by three major rivers (Heilong River, Wusuli River

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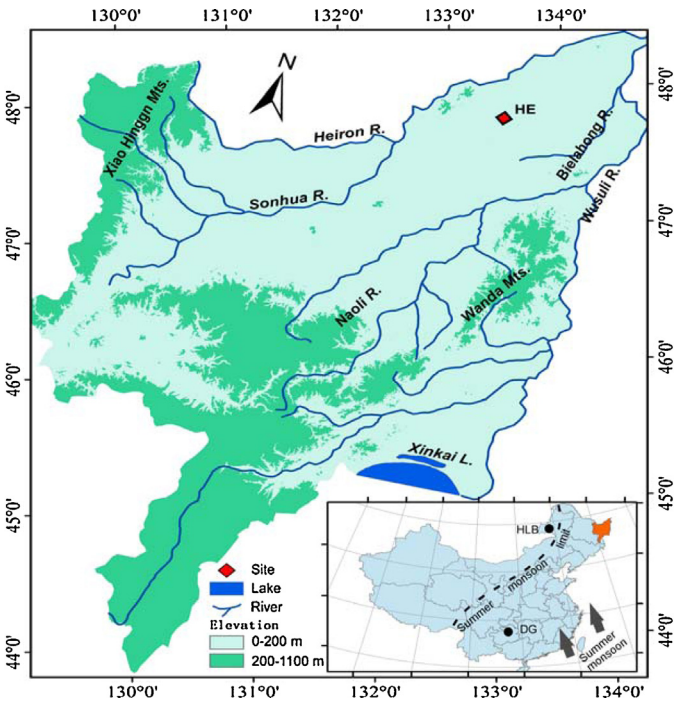

Fig. 1. Digital elevation model of the Sanjiang Plain. The solid diamond in red color indicates the sampling site. In inset figure, the current northern limit (dashed line) of the East Asian Summer monsoon with its direction indicated by the arrows, the locations of the Sanjiang Plain (highlighted in orange area), the locations of Hulun Buir desert (HLB) and Dongge cave (DG) (solid circles) mentioned in the text are shown. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

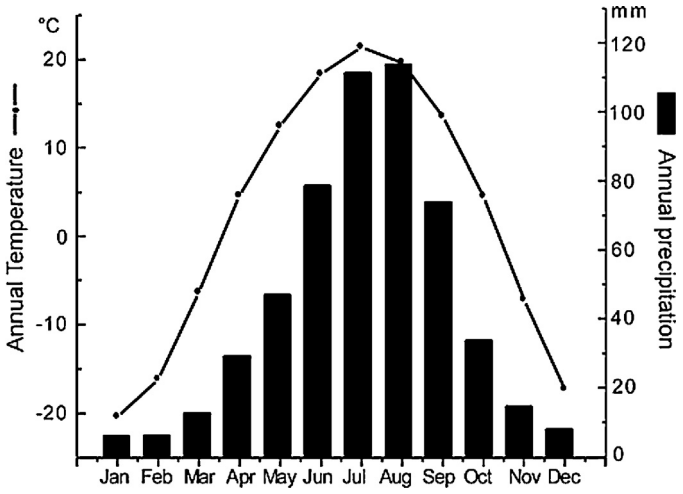

Fig. 2. Climate diagrams showing monthly temperature and precipitation in the Sanjiang Plain. All data were from climate normal for the period 1957–2000 at meteorological stations in the Sanjiang Plain.

and Songhua River). It has a total area of 10.9×10^6 ha, an altitude of <200 m and a slope grade of <1:10,000. The present climate of the plain belongs to the temperate humid or sub-humid continental monsoon climate. The mean annual temperature ranges from 1.4 to 4.3 °C, with average maximum of 22 °C in July and average minimum −18 °C in January. The mean annual precipitation is 500–650 mm and 80% of rainfall occurs between May and September (Fig. 2) (Liu, 1995).

In addition to the high-seasonality climate, such an area of low-relief in the Sanjiang Plain is favorable for the development of wetlands. A recent survey shows that over 70% of the plain has been dominated by fresh-water wetlands, and therefore the plain has been well known for the largest area of the freshwater wetlands in China (Song et al., 2008). Most of these wetlands are situated in low-lying areas, such as alluvial flats, ancient river relics and depressions. While only a part of these wetlands are suitable for peat accumulation, and most of them concentrate in the paleo-pingos related depressions for their stably hydrological conditions (Song and Xia, 1988). During recent decades, over 80% of these wetlands have been converted to farmland, and most of the remaining wetlands are within conservation areas at present day (Song et al., 2008). The Honghe wetland is within the Honghe National Nature Reserve (HNNR; 133°34′38″–133°46′29″E and 47°42′18″–47°52′N with an area of 251 km^2), which is listed in the Ramsar Convention and known as the largest and best-preserved wetland on the Sanjiang Plain.

3. Material and methods

3.1. Sampling and lithology

The studied profile HE (47°35.096′N, 133°30.006′E, 71 m a.s.l.) with a thickness of 148 cm was collected using a Russia Peat Corer from the core zone of the HNNR. The local topography is roughly circular in shape with a diameter of ~2000 m and a mean water depth of 0.5 m in summer. It is dominated by herbaceous vegetation in its low-lying areas and surrounded by deciduous broadleaved forests. According to lithological properties, the profile can be subdivided into two parts: blackish-grey oozy mud sediments with apparent laminar structures in the lower part and the overlying brownish peat layers with a high content of plant residues (Fig. 3). In the laboratory the core was dissected into 1-cm-thick intervals giving a total of 148 samples.

3.2. Chronology

Eight samples were selected at roughly equal intervals across the depth of the HE and dated with an accelerator mass spectrom-