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Review of palaeoclimate records from Northeast India based on pollen proxy data of Late Pleistocene–Holocene

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ABSTRACT

This paper deals with the review of pollen based palaeoclimatic records available from the South-west monsoon dominated northeast part of India. Here, a complete overview of available Late Pleistocene–Holocene records of the past vegetation vis-à-vis climate is structured based on a latitudinal subdivision of the region. The broad spectrum of the past climate in terms of humid/dry, warm/cold inferred by variations of some key pollen or group of pollen taxa is depicted diagrammatically, thereby providing a glimpse of spatio-temporal vegetation vis-à-vis climatic changes. Here, we attempt to create a standard diagrammatic scale with more reliability than using relative terminology to infer past climate records, based on pollen data from sub-surface sediments.

1. Introduction

In India, there are several Palaeoclimatic studies from the high elevation sites of the western Himalaya (Bhattacharyya et al., 2006). These studies have provided climatic records of Late Pleistocene and the Holocene. However, very sparse data for the contemporaneous time span is available from the northeast part of India, the region which experiences maximum rainfall during the monsoon. Thus, there is an urgent need of palaeoclimatic analysis from northeast India to view the climatic changes synoptically in the Indian subcontinent through a spatio-temporal scale. To study palaeoclimate variability in the terrestrial region geological and biological record depends on the reliability of various climate proxies (Bradley, 1999).

In this article, an attempt has been made to review the spatio-temporal climatic changes during the late Pleistocene–Holocene. These records are mainly derived from pollen proxy data from several sites of varying altitudinal and latitudinal regions in northeast India (Fig. 1). The following states of this region are included in this review: Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura. Moreover, to enhance the spatial coverage, the adjoining region of Sikkim and West Bengal are also considered in the present review. This will provide an understanding of long-term linkages between the distribution of precipitation and monsoon dynamics in different spatio-temporal scales.

We focus on the northeastern region of India for various reasons. Firstly, it is one of the regions of the world influenced by high SW monsoon rainfall, influencing the vegetation of the region, along with varied temperature and topography ranging from tropical rainforest to sub-tropical to alpine. Second, the present study will provide valuable insights into understanding the Late Pleistocene–Holocene monsoon history of the region. Lastly, the present comprehensive review of the pollen based palaeoclimate inferences of northeast India would be useful to interpret and understand the variation under the monsoon climate system, and to determine the future direction of detailed analyses of paleo-vegetation in relation to climate changes.

There is no set standard scale or fixed terminology in any of the earlier analyses to assess the palaeovegetation under palaeoclimate scenarios based on pollen proxy data. This review attempts to create a standard scale of representation of climate change inferences based on palynovegetational analysis.

1.1. Present climate of northeast India

Tripura, Mizoram, Manipur and southern Assam have tropical climates, with some of the highest annual rainfalls during the Indian summer monsoon. The high altitude region of the states of Arunachal Pradesh, Sikkim, and West Bengal experiences cold to temperate climate due to the eastern extension of the Himalayas. The temperature in northeast India can be as low as 0 °C in the coldest months and can reach up to 32 °C in the summer months

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(Rao, 2006). Northeast Indian regions are most affected by precipitation of the summer monsoon and its associated cyclonic lows, depressions, and storms. The region has high variability in summer rainfall attributed to orographic influence and variation in location, timing, and intensity of the monsoon (Mani, 1981). There is an average rainfall of 3000 mm–4000 mm, with more than 75% in the monsoon months (June–September). January is the coldest month, and the hottest time of the year is May or early June before the burst of the monsoon. In general, mean maximum and mean minimum temperatures during January are 9.0 °C–9.5 °C and 3.0 °C–3.5 °C respectively, and during peak summer it ranges from 19.2 °C to 19.5 °C and 14.5 °C–14.8 °C respectively. There is commonly heavy fog over the mountain regions throughout the year (Rao, 2006). States such as Arunachal Pradesh receive mean annual rainfall varying from 1400 mm to 6000 mm. Cherrapunji in Meghalaya has an average annual rainfall of more than 11,000 mm (Rao, 2006).

1.2. Monsoon

The monsoon is a dynamic component of the modern climate system of India. Its variability affects the livelihood and culture system of highly populated regions of not only India but all of Southeast Asia. The agrarian populations of the region have faced mega-droughts and extreme flooding events (Cook et al., 2010). The monsoon system in India is affected by two seasonal wind patterns: Southwest monsoon and Northeast monsoon. The Northeast monsoon, commonly known as the winter monsoon, blows from land to sea, whereas the Southwest monsoon known as summer monsoon blows from sea to land after crossing the Indian Ocean, the Arabian Sea, and the Bay of Bengal and brings most of the rainfall. The climate in Northeast India is mostly dominated by Southwest monsoon winds due to its proximity to the Bay of Bengal. When the Southwest monsoon reaches India, it splits into two parts: Arabian Sea branch and Bay of Bengal branch. The Bay of Bengal branch flows over the bay, picking up more moisture and heading towards Northeast Indian states, Sikkim, West Bengal, and Bangladesh. The winds arrive with large amounts of rain at the Eastern Himalayas which extends from east of Nepal to west of Arunachal Pradesh. The Southwest monsoon wind circulation brings inherent seasonality, resulting in a cool and dry winter and warm and wet summer in the northeast Indian states, Sikkim, and West Bengal. The monsoon also plays a vital role in the development of forest types in the region. The representation of taxa growing under different forest types of northeast India has been enumerated from several sites by a large number of workers, and their studies provide detailed information regarding the distribution of taxa in these forests (Hooker, 1906; Hara, 1965; Champion and Seth, 1968; Chauhan, 1996). The forests of this region are markedly different from one place to the other, because of great diversity in physiography, altitude, and climate and also by pressure exerted by anthropogenic factors.

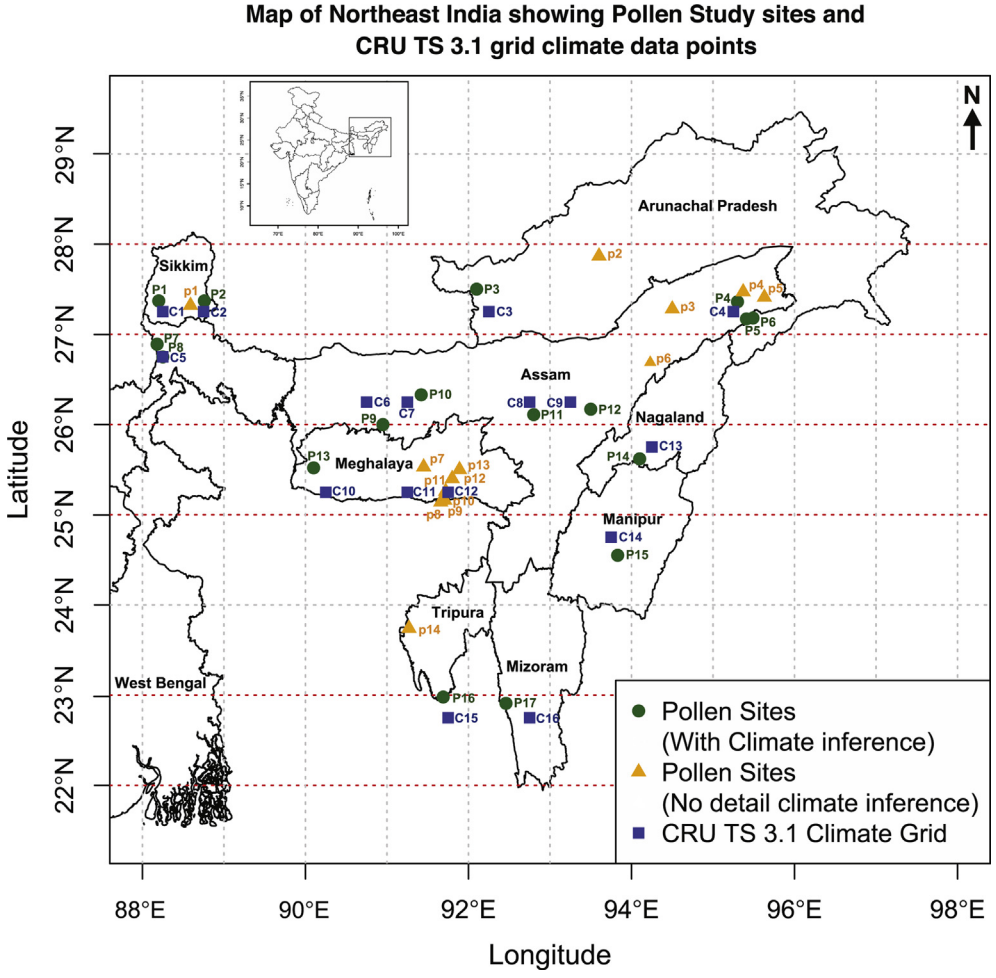

Fig. 1. Map of northeast India showing locations of pollen study sites (sites having climate inferences and sites without climate inferences) and nearest CRU TS 3.1 grid climate data points. Details of the abbreviations P1–P17 and p1–p14 are given in Table 1. C1 to C16 are the nearest CRU TS 3.1 climate grid data points from pollen study sites.