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Research paper

A late Quaternary pollen dataset from eastern continental Asia for vegetation and climate reconstructions: Set up and evaluation

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ABSTRACT

A total of 271 pollen records were selected from a large collection of both raw and digitized pollen spectra from eastern continental Asia (70°—135°E and 18°—55°N). Following pollen percentage recalculations, taxonomic homogenization, and age–depth model revision, the pollen spectra were interpolated at a 500-year resolution and a taxonomically harmonized and temporally standardized fossil pollen dataset established with 226 pollen taxa, covering the last 22 cal ka. Of the 271 pollen records, 85% were published since 1990, with reliable chronologies and high temporal resolutions; of these, 50% have raw data with complete pollen assemblages, ensuring the quality of this dataset. The pollen records available for each 500-year time slice are well distributed over all main vegetation types and climatic zones of the study area, making their pollen spectra suitable for paleovegetation and paleoclimate research. Such a dataset can be used as an example for the development of similar datasets for other regions of the world.

1. Introduction

Global and regional pollen databases are essential if present-day relationships between pollen distributions and climate are to be used for spatial reconstructions of former climates and past biogeographical patterns of the terrestrial biosphere, with a view to interpreting the driving forces (such as climate change and/or human activity) behind any changes in these patterns. They are also important for testing biogeographical and biogeochemical hypotheses, and provide data for use in paleodata-model comparisons (Prentice and Webb, 1998; Prentice et al., 2000; Gajewski, 2008).

Pollen data analyses on regional to continental scales were first introduced for north-eastern North America (Bernabo and Webb, 1977) and Europe (Huntley and Birks, 1983; Huntley, 1990) in order to investigate late Quaternary pollen taxa migrations, broad-scale vegetation changes, and spatial variations in climate. Continental pollen databases from North America, Europe, Africa, and Latin America have subsequently been successfully established, as well as the Global Pollen Database (Gajewski, 2008). Pollen data collections from Eurasia, Japan, China, the Indian sub-continent, and Australasia were not included in the Global Pollen Database, but these data have been used in the global BIOME 6000 project (Prentice et al., 2000; Pickett et al., 2004) and in a pollen-based continental climate reconstruction by Bartlein et al. (2011). Scientists have also used these databases in many multi-disciplinary studies, for instance (1) to localize glacial refugia for different types of trees in order to reconstruct the subsequent migrational pathways to their current distributions and track their genetic variations (Brewer et al., 2002; Magri, 2008), (2) to reconstruct biome or vegetation distributions in space and time (Prentice et al., 1996; Prentice and Webb, 1998; Prentice et al., 2000), (3) to reconstruct paleoclimates (Bartlein et al., 1984; Tarasov et al., 1999a, b), and (4) to reconstruct broad-scale changes in land-use or land-cover (Williams, 2002; Ren, 2007).

The eastern part of continental Asia (mainly China, Mongolia, and southern Siberia) is currently affected by three climate systems: the Indian summer monsoon, the East Asian summer monsoon, and the westerly circulation (Tao and Chen, 1987; Wang et al., 2010). There is a marked precipitation gradient from the rainforest and evergreen forest region of south-eastern China, dominated by the summer monsoon, to the desert areas of north-western China and central Asia, influenced by the westerlies. However, during former global warm periods such as what occurred in the early Holocene, the entire area was dominated by monsoonal circulation (Winkler and Wang,

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1993), and it is therefore assumed to be particularly sensitive to monsoonal evolution and global climate change. It covers the entire vegetation gradient of the eastern part of the Asian continent (from tropical forests to boreal forests, and from tundra to desert and steppe) as well as the alpine vegetation zones on the Tibetan Plateau (Fang et al., 1996; Ni, 2000). Furthermore, the area has a long history of land use, dominated by pastoralism in the western plateaus and land cultivation in the eastern plains and lowlands, with consequent regional effects on vegetation distributions and abundances (Normile, 1997; Gong et al., 2003; Li et al., 2009; Lu et al., 2009). The whole region is therefore particularly suited to studies in historical climatic variations, as well as investigations into past vegetation changes and their climatic and/or anthropogenic drivers.

Researchers in China, Mongolia, and Russia (including the former USSR) have published many modern pollen samples and late Quaternary fossil pollen spectra during recent decades, and paleobiome patterns have been numerically reconstructed for the middle Holocene (MH) and the last glacial maximum (LGM) using these data (Tarasov et al., 1998, 2000; Yu et al., 1998, 2000; Gunin et al., 1999; Ni et al., 2010). A few synthetic studies have attempted to determine pollen taxa migration routes through pollen mapping, focusing on the Holocene (Ren and Zhang, 1998; Ren and Beug, 2002; Zhou and Li, 2012). However, such studies usually focused either on restricted time slices (such as the MH and LGM only), or on specific regions and limited numbers of pollen taxa groups. It is thus both necessary and feasible to compile taxonomically harmonized and temporally standardized pollen records from China and adjacent areas in continental Asia, into a high quality dataset.

We have therefore compiled a fossil pollen dataset from eastern continental Asia, covering the past 22 ka with a 500-year resolution. The quality of pollen data, reliability of chronologies, and representativeness of pollen records to climate systems and vegetation zones in each time slice, are assessed and the potential contributions of this dataset to investigations into vegetation development, climate dynamics, and the relationship between humans and the environment during the period from the LGM to the present, are discussed.

2. Pollen data collection

We initially obtained 419 late Quaternary fossil pollen records from China, Russia, Mongolia, Kyrgyzstan, Kazakhstan, and northern India, from both publications and database sources, including both raw and digitized data. All of the pollen records were screened prior to analysis in order to exclude (1) records older than 22 cal ka BP (18 sites), (2) sites with only one available date or with no dating information (57 sites), (3) sites covering short (<1000 years) time spans (3 sites), (4) repeated sites with less available dates, lower sampling resolutions, and/or shorter time spans (26 sites), (5) sites with a low (>1000 years/sample) sampling resolution (40 sites), and (6) sites from deep ocean floors (4 sites). These remaining 228 fossil pollen records are with reliable chronologies and sufficiently high sampling resolutions, covering all or part the last 22 cal ka. Another 21 pollen records with sampling resolutions >1000 years/sample, 17 records with only one available date, four records with sampling resolutions >1000 years and only one available date, and one record covering <1000 years, were also included to make up for the low density of sites in northern and north-western regions and the shortage of available records covering the LGM. Thus a fossil pollen dataset that includes 271 pollen records was finally established (Fig. 1, Table 1, and Appendix 1).

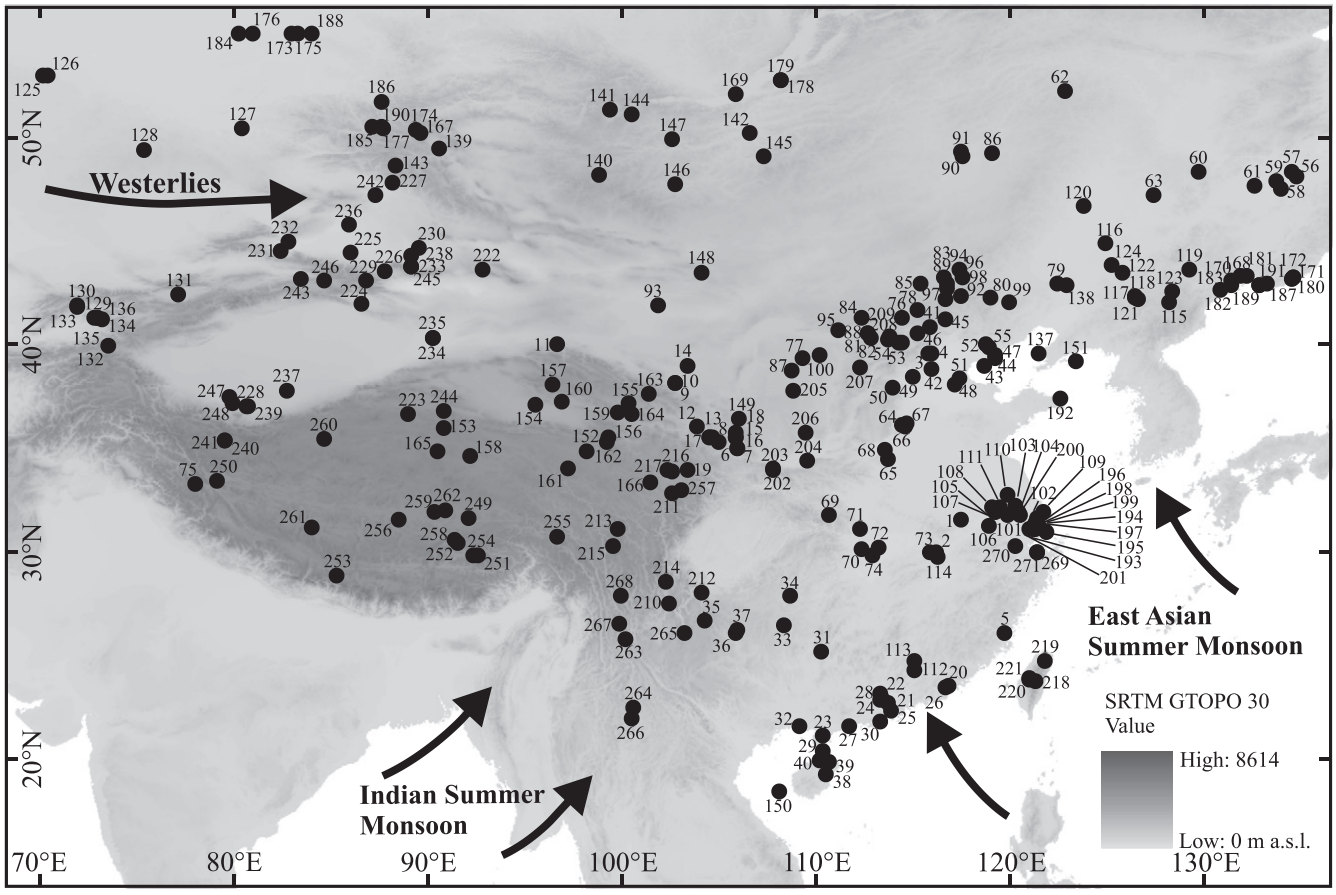

Fig. 1. Spatial distribution of fossil pollen records in the study area. The number of each site is used as its ID in Table 1.