Climate simulations and pollen data reveal the distribution and connectivity of temperate tree populations in eastern Asia during the Last Glacial Maximum

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Supporting Information

Appendix S1: Monsoon progression in the model compared to observation
and
Appendix S2: Uncertainty **of precipitation analysis**

Appendix S1: Monsoon progression in the model compared to observation

The climatology of Eastern Asia is dominated by the monsoon. In Fig. S1.1 the winds at the 850 hPa level (around 1500 m height) are displayed for May to August as analysed (ERA) and simulated for the present (CTR). Although the wind is not a limiting factor for tree growth, it has to be considered because of the vital impact of the monsoon precipitation on the climate of Eastern Asia and because of medium to long-distance pollen transport. Comparing ERA with CTR, one can judge the quality of the model used to reproduce the monsoon. Both fields have very similar patterns over the continent in direction and speed, though with a bias to slightly higher speeds in CTR in spring. The differences hardly exceed 1 m/s, except in August over the sea. Because of the good reproduction of the monsoon wind by the model, it is to be expected also that the monsoon for the LGM has been reasonably simulated.

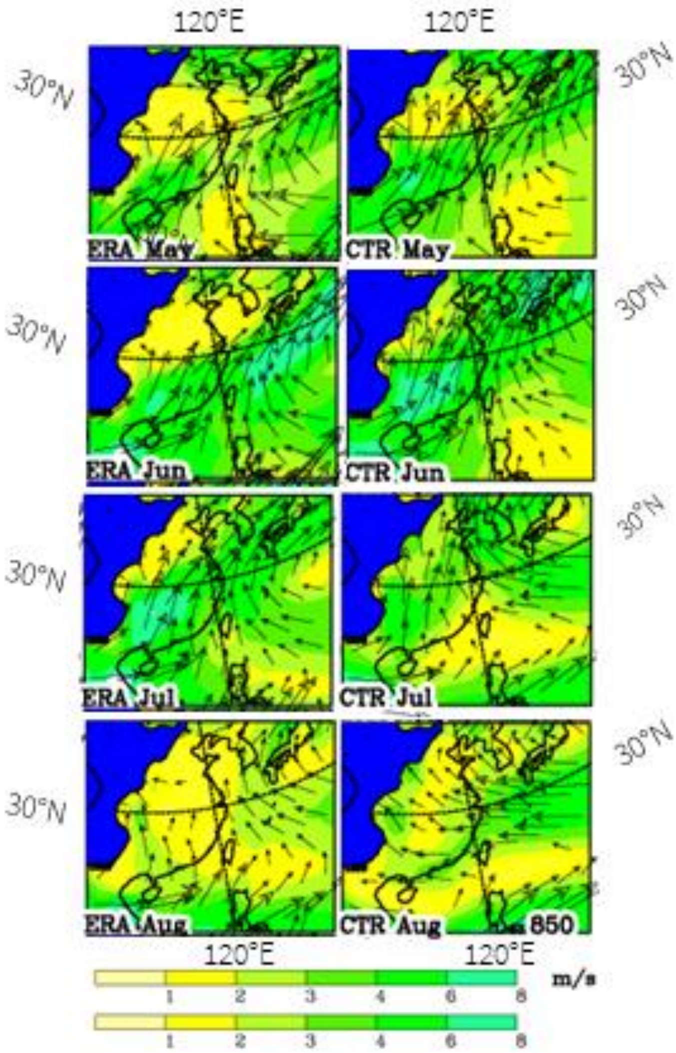

Fig. S1.1: Wind vectors at 850 hPa over Eastern Asia as analyzed by ERA and as simulated for the present (CTR) for May to August. Arrows give direction and amplitude of the mean wind and contours provide the amplitude of the wind vectors. Areas where the 850hPa level lies below ground are masked.

The time change of the monsoon wind through spring and summer is further investigated by comparing the monthly changes of meridional profiles of precipitation and 850hPa meridional wind averaged between 115 and 119 °E for ERA, CTR and LGM (Fig. S1.2). During spring up to May the southerly wind in ERA is confined to south of the Qin mountains (32°N), increasing its speed towards summer and creating there strong precipitation. Then in July the southerlies move northward to 36°N, another mountain range, spreading the precipitation to there. The 32 °N line is marked for its importance between the northern and southern China climate which is crossed after June by the monsoon front. In August, the profiles change completely with stronger southerlies and precipitation mainly in the northern part.

In the CTR simulation, one finds a similar sequence except that the northward propagation of the monsoon front starts already in June and that a maximum summer precipitation belt occurs on the southern slope of the mountain range north of 42 °N which can be seen as well in Fig. 4 where this larger precipitation is shown to be an overestimate compared to all climate estimates of the present precipitation.

Comparing CTR and LGM, one finds a general agreement of the monsoon front progression between the LGM and the CTR simulation, except that for the LGM the monsoon front, also measured by precipitation, is already moving northward in June while this earlier progression of the front for CTR is evident only in the wind field. During the LGM this enhanced movement is also connected with a general decrease of precipitation especially in June and less strong in July. This leads to a belt of reduced precipitation in summer at 30 to 35 °N for the LGM (Fig. 5).

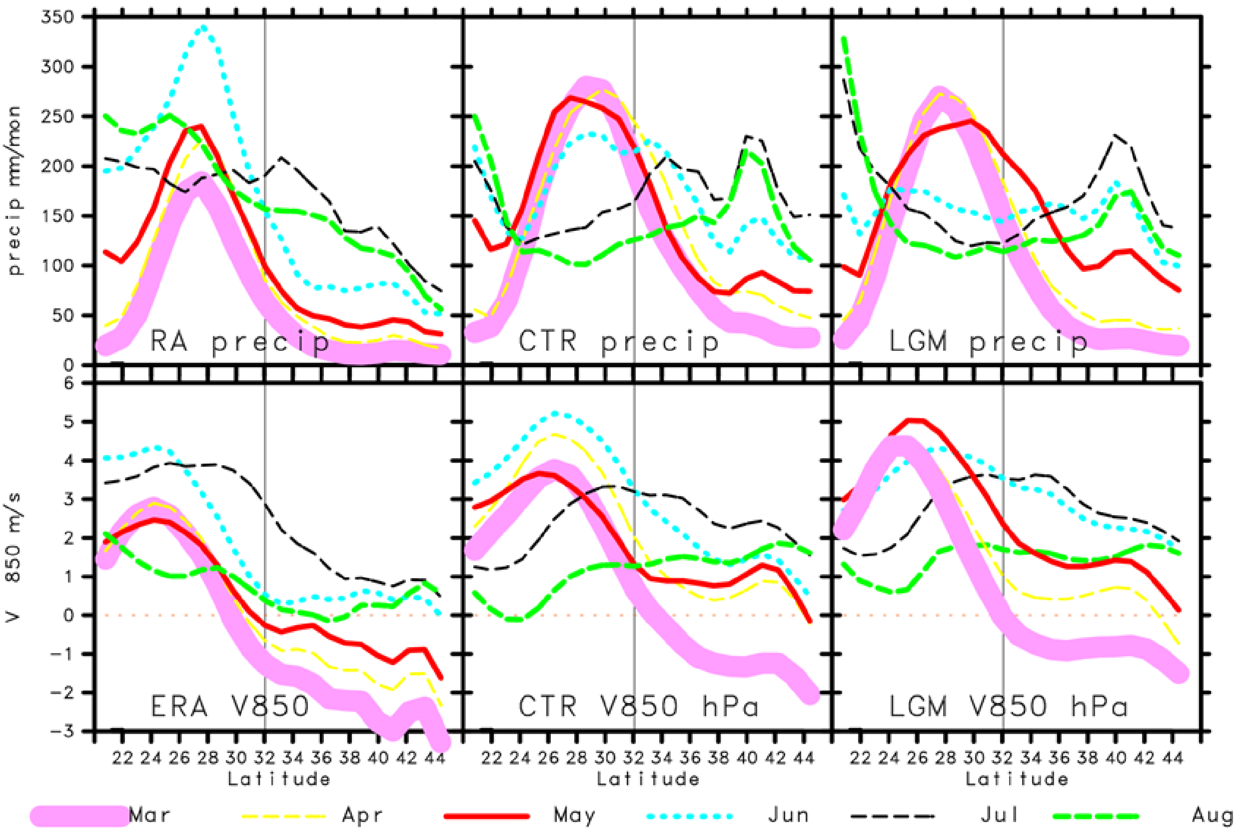

Fig. S1.2: Meridional profiles of precipitation and 850hPa meridional wind averaged between 115 and 119°E from 20 to 50°N for ERA, CTR and LGM for March to August. The 32°N line is marked because of its importance between northern and southern China climate.

Appendix S2: Uncertainty of precipitation analysis

In Fig. 4 large differences of precipitation in different climatologies are shown. They are especially large over the Tibetan Highland. One reason is the low density of observations there (Fig. S2.3). There are hardly any sites in a large area 30 to 35°N and 80 to 90E° for which all suggest high precipitation amounts though with considerable differences (Fig. 4). For this study these differences are not important but further north (indicated by an oval in Fig. S2.3) differences are important for the estimate of possible tree growth (Fig. 6 upper panel indicated by ovals).

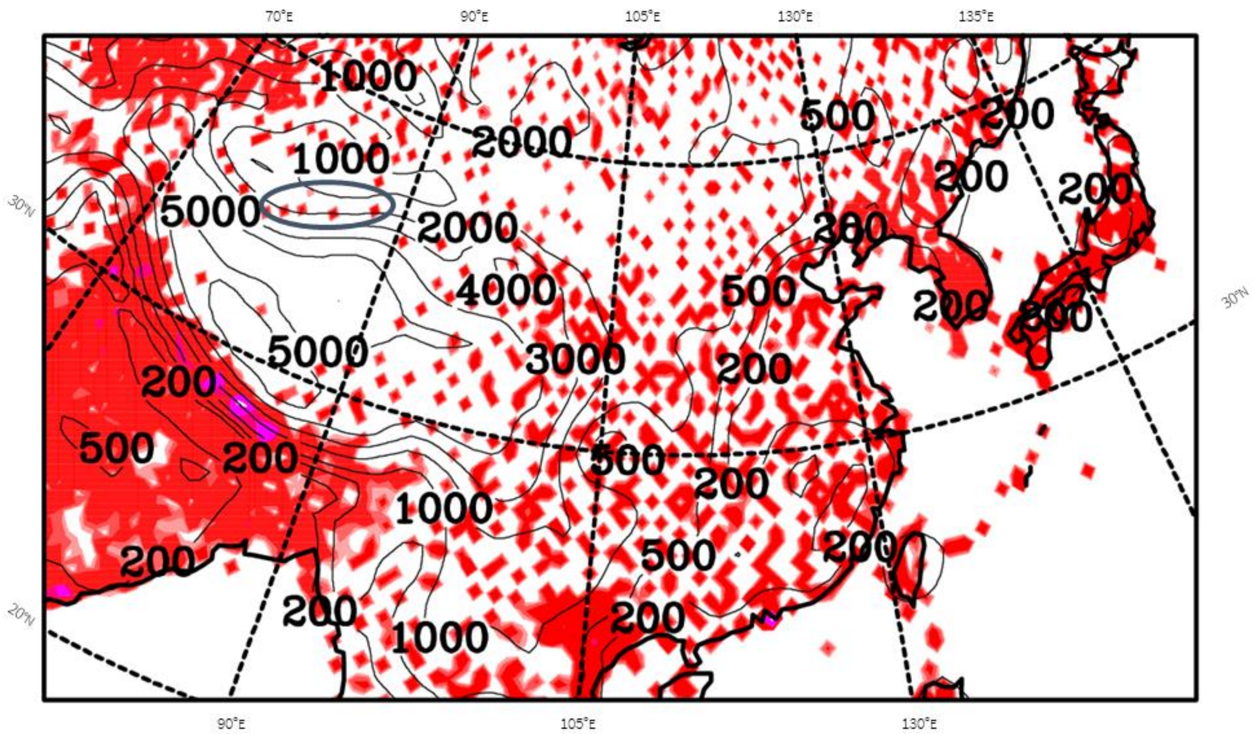

Fig. S2.3: Station density in the GPCC analysis for the season JJA. Dots indicate least one monthly means precipitation observation on average was available each month in a 0.5º grid (blue: more than 3). Black contours give the topography at levels 200, 500, 1000, 2000, 3000, 4000 and 5000 m. The oval in the NE of China indicates where important differences of precipitation from different sources are found.

These areas are on the northern slope of the Tibetan Plateau (Fig. S2.4). The distribution of precipitation in the area is very strongly correlated with the topography, low precipitation at lower levels and high precipitation at higher levels along the mountain slopes. All estimates agree in this respect and in the desert valley with topography lower than 2000 m the summer precipitation amounts are below 50 mm/season. Only in the Leemans, R. and Cramer (1991) (C&L) climatology, the contours of precipitation do not follow the contours of the topography on the northern slopes of the Tibetan plateau, the precipitation and topographic contours are almost out of phase in the east-west direction and this results in two erroneous areas of possible tree growth (Fig. 6). Because of the low station density in this area (Fig. S2.3), wrong coordinate of a single station can cause large errors. Moreover, the strong orographic structure should be associated with strong spatial variations in precipitation, especially in the north-south direction with a steep slope towards the Tibetan highland, thus strongly reducing the representability of individual station data for a larger domain. Further south (30 °N) of this area one finds another strong deviation of the C&L precipitation climatology from the other ones which is however not important for the present study and not further investigated. Similar climatologies from the Climate Research Unit in East Anglia (CRU, 2016) have a distribution similar to that of GPCC (not shown). We regard these areas of possible tree growth as erroneous. Nevertheless we still regard the C&L climatology very suitable for our purpose.

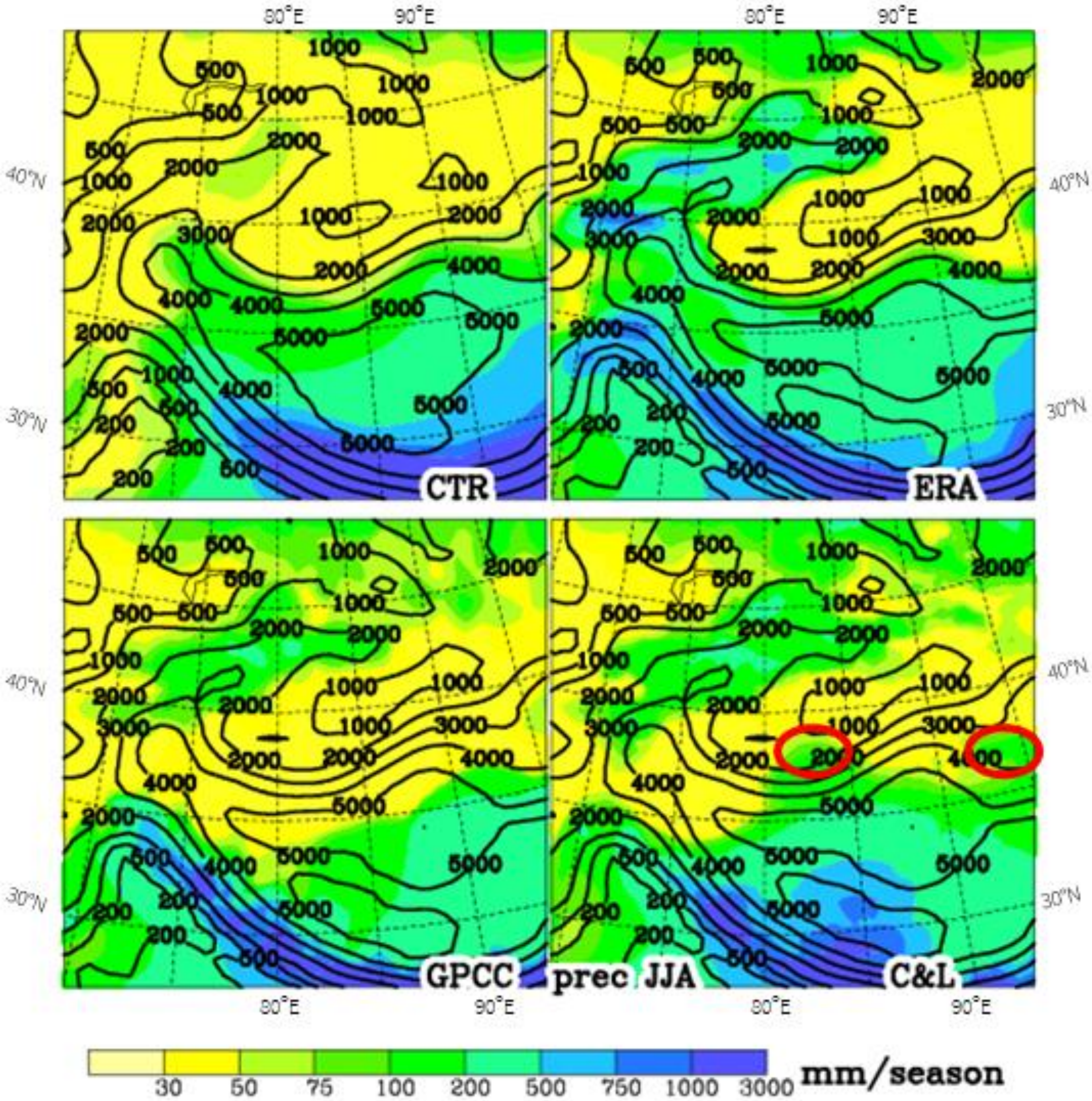

Fig. S2.4: In colour the climatological precipitation distribution by different data sets and as solid lines the contours of the topography. The circles mark the area where in Fig. 6 possible tree growth was indicated.

When using the ERA data instead of C&L for creating a plot like Fig. 6 (not shown), the unrealistic areas for possible tree growth disappear**.** This might partly also be due to strong small-scale topographic structures of which the impact from local climates might not be represented by the climatological estimate on a 0.5° grid used here. For Europe this was found at south facing slopes of mountain ranges with respect to the temperature.