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Chironomid-based reconstruction of Lateglacial temperatures and the Holocene thermal optimum in the Altai-Sayan mountain region, southern Siberia

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Chironomids are widely recognized as powerful proxy-indicators for reconstructing past summer temperatures from lake sediment records. However, in central Asia quantitative chironomid-based temperature reconstructions are still lacking. Here we present a chironomid-inferred temperature record from Lake Grusha (50°16'N 89°27'E), a small shallow lake situated at 2413 m a.s.l. in the Tuva Republic (southern Siberia, Russia), just north of Mongolia. Fossil chironomid analysis indicates a number of abrupt shifts in the lake's chironomid assemblages during the past ca. 15,800 years. We applied a chironomid-July air temperature transfer function from the European Alps to quantitatively reconstruct past temperatures based on the Lake Grusha record. This transfer function is based on chironomid assemblages in 101 lakes in the Swiss Alps and covers July air temperatures of 5.0-18.4°C and altitudes of 418-2815 m a.s.l. At the taxonomic resolution of the Lake Grusha record this model featured a leave-one-out cross-validated root mean square error of prediction of 1.44°C and a coefficient of determination (r2) of 0.87. Chironomid-inferred temperatures from Lake Grusha indicate a very similar Lateglacial temperature development as reported from the Greenland ice sheet, with July temperatures of 10-13°C reconstructed before 13,000 calibrated radiocarbon yrs BP (cal. BP) and temperatures of 8.5-10°C inferred

between 13,000-12,000 cal. BP. At the beginning of the Holocene inferred temperatures rise rapidly to reach maximum Holocene values of 14.5-15.0°C between 10,000 and 7000 cal. BP. In the interval 7000-5,500 cal. BP July air temperatures decrease to reach values of 11-12°C during the late Holocene, which is slightly warmer than the modern July air temperature of ca. 8-9°C expected for the altitude of Lake Grusha based on meteorological measurements in the region. The close agreement between the Lake Grusha record and temperature reconstructions from the Greenland ice sheet during the Lateglacial suggest that temperature variations reported from the circum-Atlantic region, such as the Younger Dryas and the Greenland Interstadial events 1d and 1b, may have propagated far into the Eurasian continent and may have affected the climate in the Altai-Sayan mountain system. Furthermore, the high inferred temperatures 10,000-7000 cal. BP suggest that the increased summer insolation during the early and mid-Holocene had a distinct influence on summer temperatures in southern Siberia, leading to inferred July air temperatures 2-3°C warmer than at present.