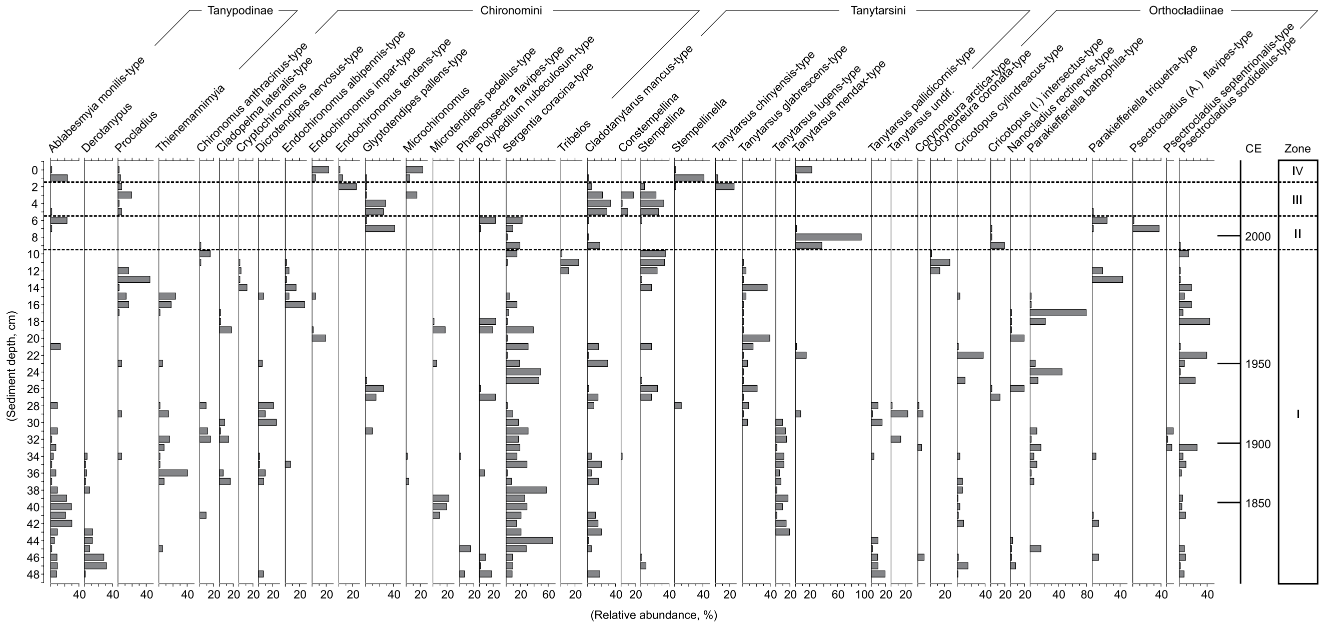

Figure 2. Relative abundance of the most common fossil chironomids in the varved lake sediments of Nurmijärvi.

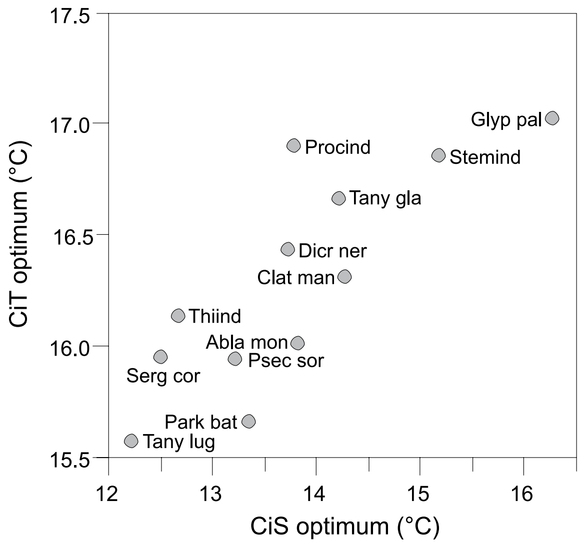

Figure 3. Weighted-averaging temperature optima of the most common chironomids (N2>5) in the Lake Nurmijärvi calibration-in-time (CiT) dataset compared against their optima in the calibration-in-space (CiS) dataset. The taxa codes correspond to the first four letters of the genus name and first three letters of the species name.

zones (Figure 2). Zone I between 48 and 10 cm corresponded to time interval ~1780–1994 CE, zone II between 9 and 6 cm corresponded to years 1996–2004 CE, zone III between 5 and 2 cm corresponded to years 2006–2012 CE, and zone IV between 1 and 0 cm corresponded to years 2014 and 2015 CE.

The temperature optima of the most common chironomids had similar trends in both the CiT and CiS datasets (Figure 3). However, in case of every taxon, the CiT optima were consistently higher (0.7–3.4°C). The largest differences (>3°C) between the datasets occurred in *Thienemannimyia, S. coracina*-type, *T. lugens*-type, and *Procladius*.

The first two PCA axes for chironomids were significant, the first axis (λ = 0.163) explaining 34.9% and the second axis (λ = 0.101) 21.6% of the total community variance. The PCA axis 1 scores varied between −0.54 and 0.78. All the samples dating prior to 1920 CE had negative axis 1 scores, whereas the subsequent samples had mostly positive scores (Figures 4 and 5). A significant correlation was found between the PCA axis 1 scores and the instrumental temperature record (R = 0.47, p = 0.002), suggesting that there is potential to develop a CiT model.

Of tested model types, WA with taxon tolerance weighting and inverse deshrinking regression showed best model statistics and was considered suitable for the nature of the data. This model had an r^2_{jack} of 0.64, an RMSEP of 0.55°C, and a maximum bias of 1.00°C. Compared with the CiS model, the CiT has lower predictive power and higher maximum bias but it outcompetes the CiS model in its prediction error (Table 1).

The chironomid-based reconstruction using the CiS approach varied between 11.7°C and 20.7°C and the reconstruction using the CiT approach between 15.2°C and 18.8°C, both following the trends identified by the chironomid PCA axis 1 scores and the instrumental temperature record (Figure 4). However, the CiS reconstruction showed more intermittent temperature development compared with the smoother CiT reconstruction. A statistically significant relationship was found between the CiS reconstruction and the instrumental record (R = 0.38, corrected p = 0.014) (Table 2). According to the Durbin–Watson test, there was no positive autocorrelation between the series (Durbin–Watson statistic = 1.63, p = 0.114). In addition, the CiT reconstruction was significantly similar to the instrumental record (R = 0.51, corrected p = 0.001) and had no positive autocorrelation either (Durbin–Watson statistic = 1.99, p = 0.483). However, statistically significant lags between Chironomid PCA axis 1 scores and the instrumental temperatures were found for sample intervals 1 and 2, which correspond to minimum of 1 (topmost samples) and maximum of 19 years (lowermost samples of the observational period) in our record. According to the sediment accumulation rate, one sample lag represents ~4-year and two sample lag ~8-year time span on average.

Discussion

Community variance

Since the sediment stratigraphy in Nurmijärvi consisted of annually laminated layers verified by independent dating methods and enough chironomid head capsules were found for quantitative community analysis, we were able to perform temperature reconstructions that were subsequently compared with the meteorological