

PINUS CEMBRA L. MAXIMUM WOOD DENSITY RECORDS LATE SUMMER MAXIMUM TEMPERATURES IN THE ORTLES-CEVEDALE GROUP (RHAETIAN ALPS, ITALY)

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INTRODUCTION

Increasing temperatures over the last decades are well established [1]. To place the ongoing climate change in a long-term context, climate information extending beyond the industrial era is needed. Many regional climate reconstructions have facilitated our understanding of past climate dynamics [2,3]. Furthermore, local reconstructions are essential to enhance regional climate models by improving the spatiotemporal data coverage back in time [4]. The Alpine region is a key area in terms of impacts of climate change, which is especially evident in the reduction of glacier extents [5]. The use of maximum latewood density (MXD) chronologies can provide a better temperature information than the tree-ring width, nevertheless MXD series in this area are still characterized by a considerably lacking especially in *Pinus cembra* L.

STUDY AREA

The area is the most glacierized of the Italian Alps, where 134 glacial bodies (Fig.1)[5]. Sampling stand was located in the Ortles-Cevedale Group between 2075 m and 2350 m a.s.l. Here, *P. cembra* L. individuals are scattered in an environment dominated by ericaceous species (*Rhododendron ferrugineum* L., *Vaccinium spp.*) on immature and thin podzols, histosols and umbrisols.

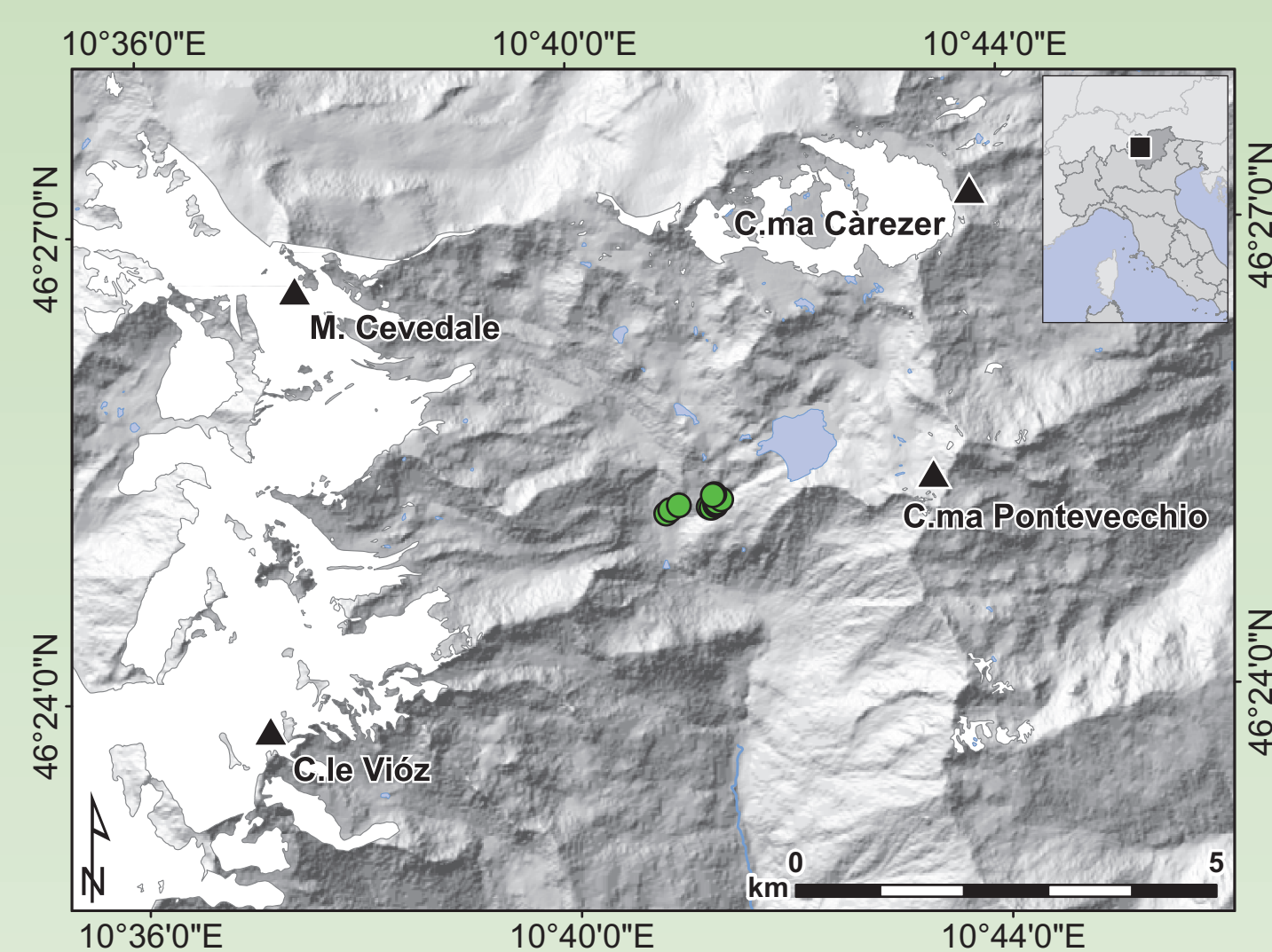


Fig. 1 - Location map of the study area. Green dots represent individuals.

MATERIALS & METHODS

24 cores were collected from 12 trees, polished with progressively finer sand paper and the TRW for each core was measured and cross-dated with a reference chronology of the same species.

A 1.20 mm thin lath was extracted from each core using a DendroCut 2003 twin-blade circular saw.

Resin and other impurities were extracted from the laths washing them in a Soxhlet apparatus with ethanol for 24 h.

Wood density was measured with ITRAX Cox Analytical System tuned at 30 kV and 50 mA with 75 ms time step.

MXD chronologies were measured with the software WinDENDRO and crossdated using TRW chronologies as reference.

Both TRW and MXD chronologies were standardized using Arstan_SigFree v. 0.45 and CRUST applying Huguershoff or Age Adaptive curves. Indexes were created as a ratio in the former and as a difference in latter chronology.

RESULTS

Novel TRW and MXD chronologies were developed. The shortest period covered by more than 5 samples spanned from 1885 to 2015 (Fig. 2). Low frequency patterns were in perfect concordance with previous results [6].

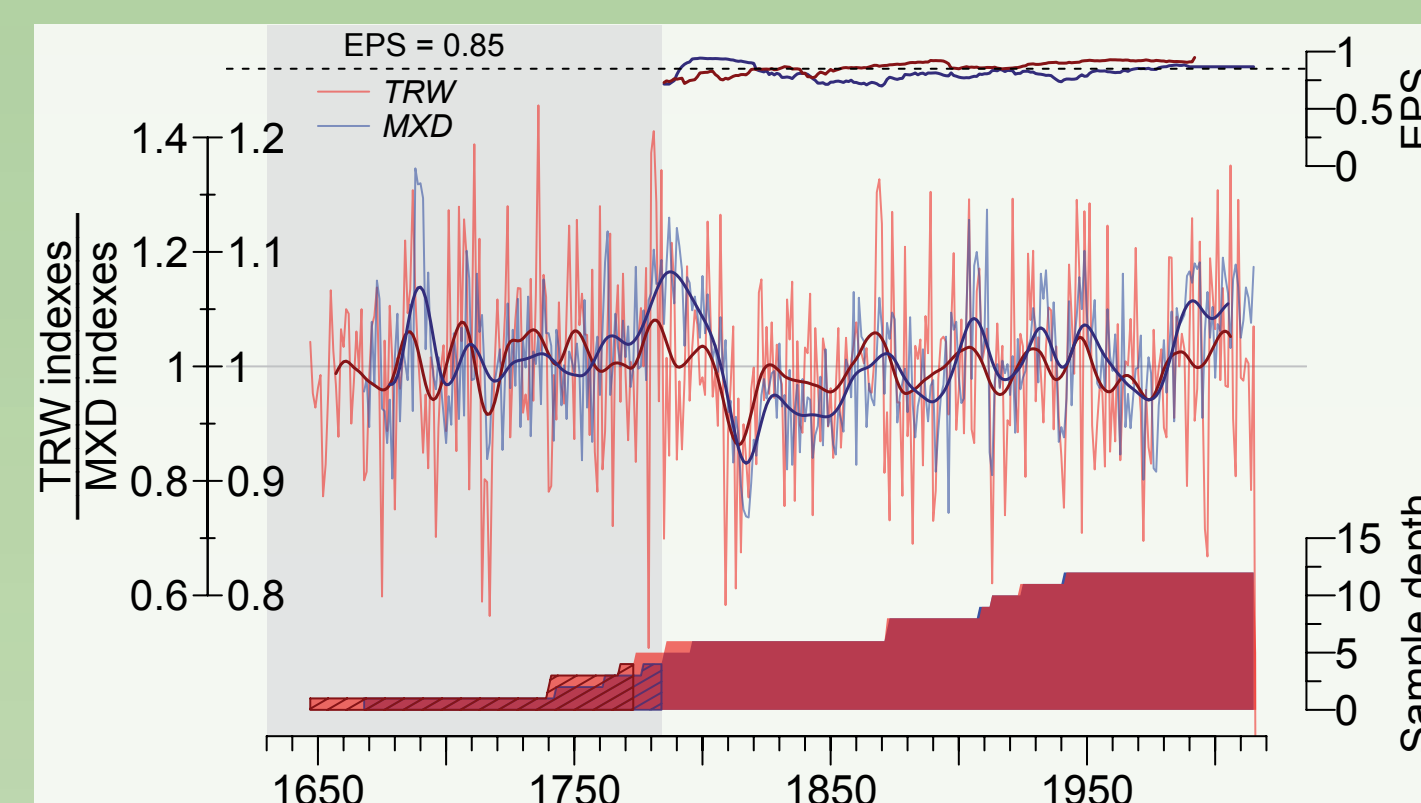


Fig. 2 - TRW and MXD chronologies, EPS (panel above) and Sample depth (panel below). Tick line show the 21 years hanning filtered chronologies.

Correlation results with CRU TS 3.24.01 temperature data showed that *P. cembra* maximum wood density was influenced by the summer average of the maximum temperatures, more than by the average or minimum in both low and high frequencies.

In the low frequency domain, a correlation with the temperatures of August of the previous year persists, highlighting an influence of the trends on correlation values (Fig. 3).

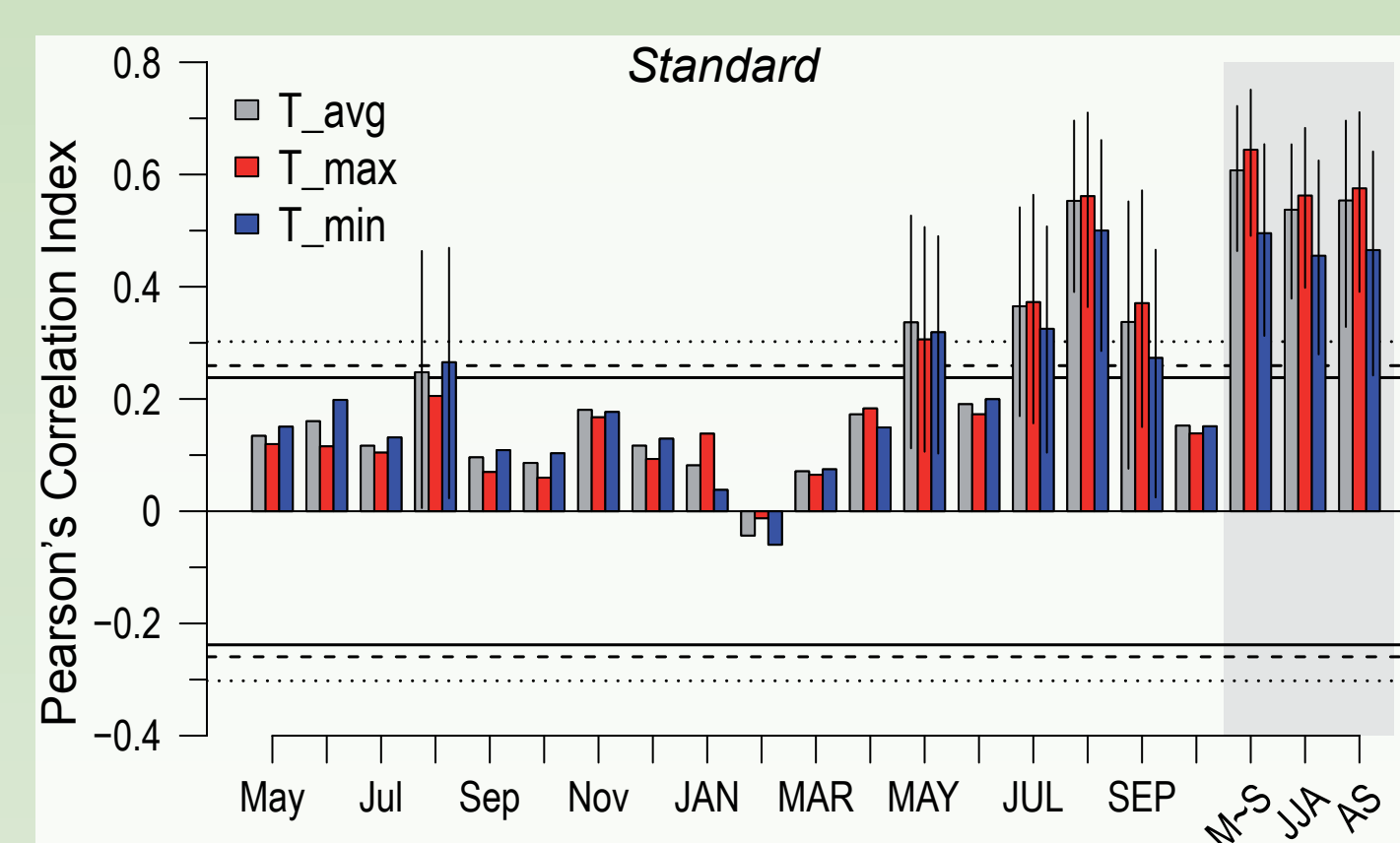


Fig. 3 - Pearson's correlation Index between Standard MXD chronology and Temperatures. M-S: aggregated values from May to September, JJA - June, July, August; AS - August and September.

In the high frequency domain, every correlation with temperatures of the previous year becomes not significant, but values of association with late summer temperatures are enhanced, reaching values near $r \approx 0.65$ with an explained variance of $r^2 \approx 0.42$. As in *Pinus sylvestica* L., also in *P. cembra* the correlation with temperatures showed a bi-modal pattern with significant values in early and late summer (Fig. 4).

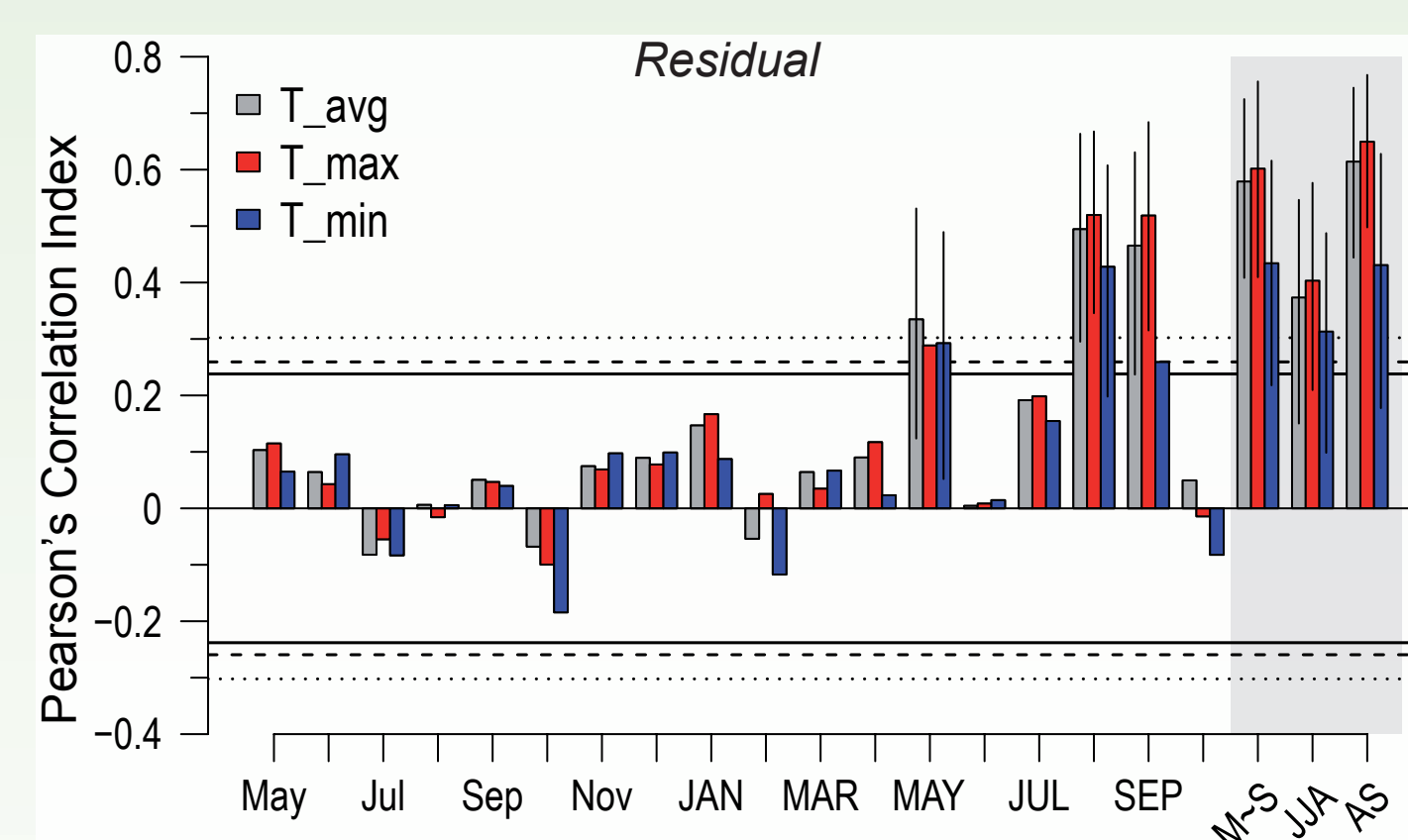


Fig. 4 - Pearson's correlation Index between Residual MXD chronology and Temperatures. M-S: aggregated values from May to September, JJA - June, July, August; AS - August and September.

Spatial correlation analysis showed a high degree of accordance between MXD residual chronology and late summer aggregated temperatures (August and September) over most of southern and central Europe with values higher than 0.6 (Fig. 5).



Fig. 5 - Spatial Pearson's correlation index between residual MXD chronology and detrended Maximum Temperature CRU TS 3.24.01

CONCLUSIONS

A common thought was that *P. cembra* was not able to record climatic signal in the Alps. Because of that, very few MXD analyses were performed on this species. Here we present proof that *P. cembra* could be used in climatic reconstruction as well as others species in high altitude environments. Static correlation analysis showed that *P. cembra* preserves high frequency temperatures variability as well as long-term variability in its wood density. Furthermore, spatial association results showed how density patterns could represent temperature variability for most of the European continent, opening up the possibility of utilizing this specie's MXD data for climatic reconstruction, particularly for the mean maximum temperatures, as well as *Larix decidua* Mill. and *Picea abies* H.Karst. A longer association window than the one usually inferred from other species (JJA) could add important data for temperature reconstruction models.

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