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Climate-signal changes in a temperature-sensitive dendroclimatic network: the influence of site aspect

Giovanni Leonelli (1,2), Manuela Pelfini (1), Giovanna Battipaglia (3), and Paolo Cherubini (4)

(1) University of Milan, Dept. of Earth Sciences, Milan, Italy (giovanni.leonelli@gmail.com), (2) ARPA Valle d'Aosta, Climate Change Unit, St.Christophe (AO), Italy, (3) ENEA-Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Via Anguillarese 301, I-00123 Rome, Italy, (4) WSL-Swiss Federal Research Institute, Dendro Sciences, Zuercherstrasse 111, Birmensdorf CH-8903, Switzerland

Tree-rings have an important role in defining past climate variability and within the several climatic proxies they are particularly useful because they may provide past information with annual resolution at the century and millennia scale. Many temperature or precipitation reconstructions have been developed by using tree-ring chronologies from climatically-limited environments. Recent findings, however, have demonstrated a divergence between tree-ring data and air-temperature instrumental records for the recent decades.

We analyzed thirteen Pinus cembra ring-width chronologies coming from high-altitude sites comprised in the Ortles-Cevedale Group, an area extending over 30 km in the Central Italian Alps, with several peaks above 3000 m a.s.l. A climatic analysis was performed on the whole period covered by meteorological data (1865-2003) by means of bootstrapped correlation functions. A second climatic analysis was performed by means of a moving correlation approach with the aim to check the stability of the climatic signal over time. Both the analyses were performed using seasonal and monthly climate variables grouping the chronologies from N and SW-facing sites.

The climatic analysis on the whole period revealed both the whole summer (JJA) and July temperatures resulted as the most important climatic variables in modulating tree-ring growth.

The moving correlation analysis revealed that site aspect influences non-stationary growth-climate relationships over time. In particular, chronologies from N-facing sites showed stable relationships over time, whereas a general increasing divergence between ring width and the summer temperature record (JJA) has been observed especially for chronologies from SW-facing slopes.

The monthly analysis of long-term changes in the temperature-growth relationships revealed for all the chronologies significant non-stationary responses especially for late spring (May) and early summer (June) temperature (decreasing correlations especially for S- and W-facing site chronologies). On the other hand, trees from N-facing sites showed an increasing sensitivity to July temperatures, especially since the period 1911–1970.

Our results underline that some climatic factors related to slope aspect (e.g. temperature regime, snow-cover persistence or growing season length) play a key role in limiting P. cembra tree-ring growth at high altitudes, especially in N-facing sites. Moreover, it is evident at all sites that at high altitudes, low temperatures at the beginning of the growing season no longer limit growth as they did in earlier decades. Stronger changes are involving especially the S- and W-facing sites that in the past were more limited by June temperature, whereas trees on N-facing slopes are generally less adapted to warmer conditions at the beginning of the growing season (June) and therefore respond less to an increasing air temperature.

We point out the importance of testing growth-climate relationships over time to detect possible trends in climate sensitivity. In fact, wide variation in climate sensitivity over time could lead to over- or underestimations of past temperatures. Moreover, our findings showed that site ecology can affect dendroclimatic reconstructions.