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Changes in The Relationships between Temperature and Silver Fir (*Abies alba* Mill.) Growth during the 20th century in The Tuscan Apennine Alps (Middle Italy)

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Aim of the research

In 2010 Monash University (Australia) began a research program in collaboration with the "Corpo Forestale dello Stato, Uffici per la Tutela della Biodiversità" at Pratovecchio (province of Arezzo, Tuscany) and Vallombrosa (province of Florence, Tuscany). The aim was to investigate the relationships between recent and historical variability of climate and silver fir (*Abies alba* Mill.) growth in the Tuscan Alps. Silver fir is highly responsive to variability in monthly mean temperature and susceptible to damage caused by drought or insufficient moisture availability.

Impacts of changing climate conditions are known to vary with space and time. Our previous research has shown that similarity in trends of both monthly mean temperature (**MMT**) and monthly rainfall (**MR**) is non-stationary amongst sites in the study area (Fig. 1), even at short distance (Tab. 1). Since the importance of silver fir forests in the Apennine Alps and the possibility that alterations in trends of MMT during the 20th century would affect silver fir growth, we analysed the relationships between MMT and tree-ring growth in the study area by focusing on potential changes in months that influence silver fir growth amongst sites and within forests.

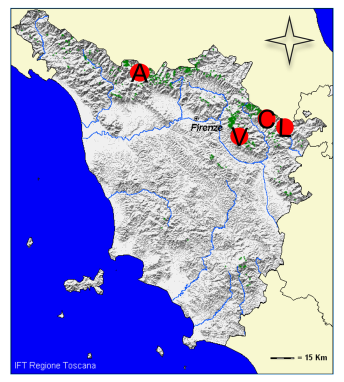

Fig. 1 – Location of the four meteorological stations on tops of the Tuscan Apennine Alps. Abetone is A, Camaldoli is C, La Verna is L, and Vallombrosa is V.

Table 1 – Elevation (m. asl), available period (year) of precipitation (mm) data available, and distance (km) between for the four meteorological stations.

	Elevation	Period	Distance		
			LAV	CAM	VAL
ABE	1340	1931-2000	112.3	100.1	84.6
LAV	1120	1924-2006	-	13.2	30.4
CAM	1111	1885-1996	-	-	22.3
VAL	955	1872-2006	-	-	-

Some information about silver fir in the study area

- In the study area, a threshold for available soil water is ca. 39 mm
- Annual rainfall >1000 mm
- No water stagnation
- Normally, a temperature threshold for silver fir growth is at least 15 days with daily mean temperature >9°C and never <0°C
- Very shade tolerant
- Highly susceptive to climate variations
- 'Anastomosis' may keep trees alive after they are cut
- 'Butt rot' severely affects many silver firs in the Tuscan Apennine Alps (Fig. 2)

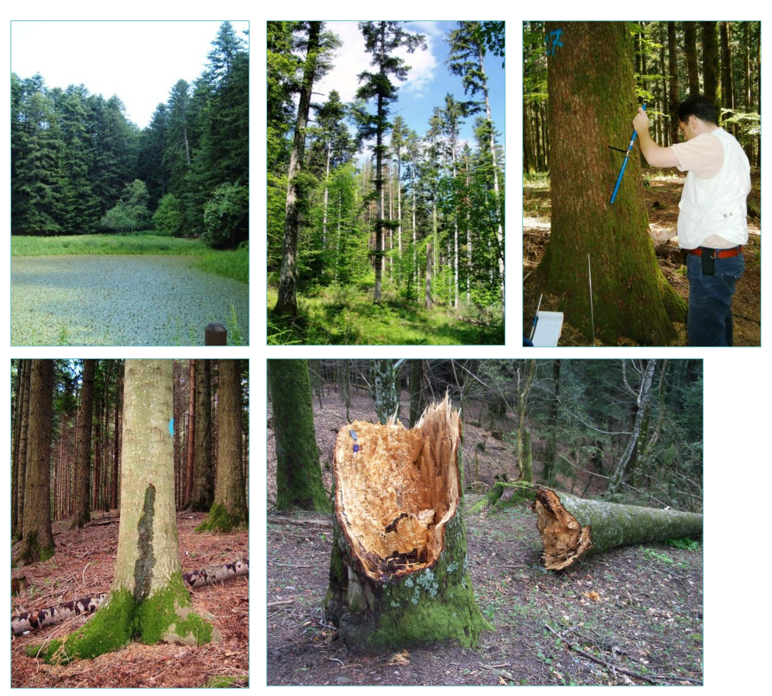

Fig. 2 – Silver fir stands in the study area. Clockwise: healthy firs, with stress symptoms, dendrochronological sampling and health check, anomalous sprouting of liquid, and advanced stage of 'butt rot', a complex fungal disease.

Research Question

How relationships between trends in temperature and silver fir growth vary under changing climate conditions during the 20th century in the Tuscan Apennine Alps (Middle Italy)?

Methods

Dendrochronological methods

• Matrix correlation tests the average level of association in residual tree-ring chronologies (RTRs) within and between forest sites;
• Agglomerative hierarchical clustering (AHC) to verifies how RTRs tend to group amongst sites (Piovesan *et al*., 2005; Leal *et al*., 2007; Oberhuber *et al*., 2007);
• Variability in similarity of RTRs during the 20th century within and amongst study stands is tested by applying the Pearson correlation coefficient to 7-years moving averages between paired series of RTRs.

Analysis of climate/tree-ring growth relationships

• Pearson's *r* correlation between seasonal and monthly mean temperatures and RTRs in both the growth year and year previous growth at all the study stands;
• Regression analysis of seasonal mean temperature versus RTRs in both the growth year and year previous growth at all the study stands;
• Correlation and response functions analyses by using the program DendroClim2002 (Biondi *et* Waikul, 2004) to identify and quantify the differences in climate/growth relationships amongst sets of local MMT series and the RTR chronologies in both the growth year and year previous growth.

Results

Non-stationary similarity in trends of residual tree-ring width chronologies in the study area

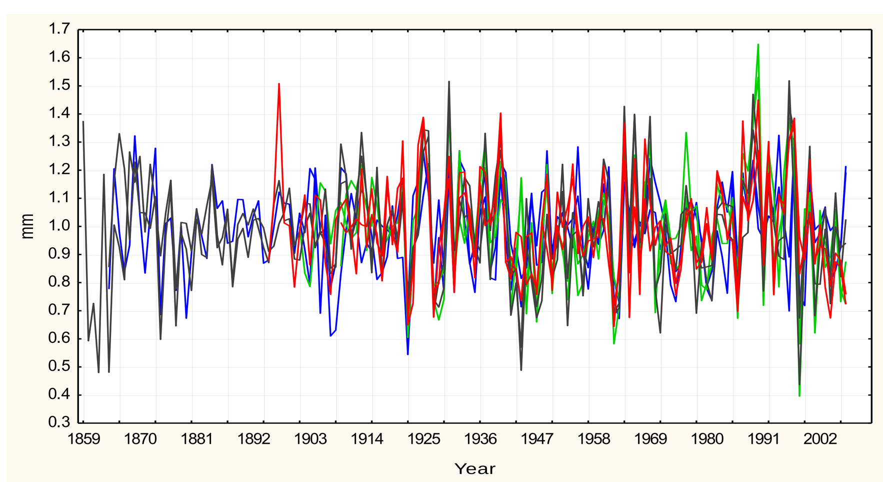

Fig. 3 - Residual tree-ring width chronologies from the late 1850s to the year 2007 at all the silver fir stands in the study area. Upper and lower ABE is blue, upper and lower CAM is green, upper and lower LAV is black and upper and lower VAL is red.

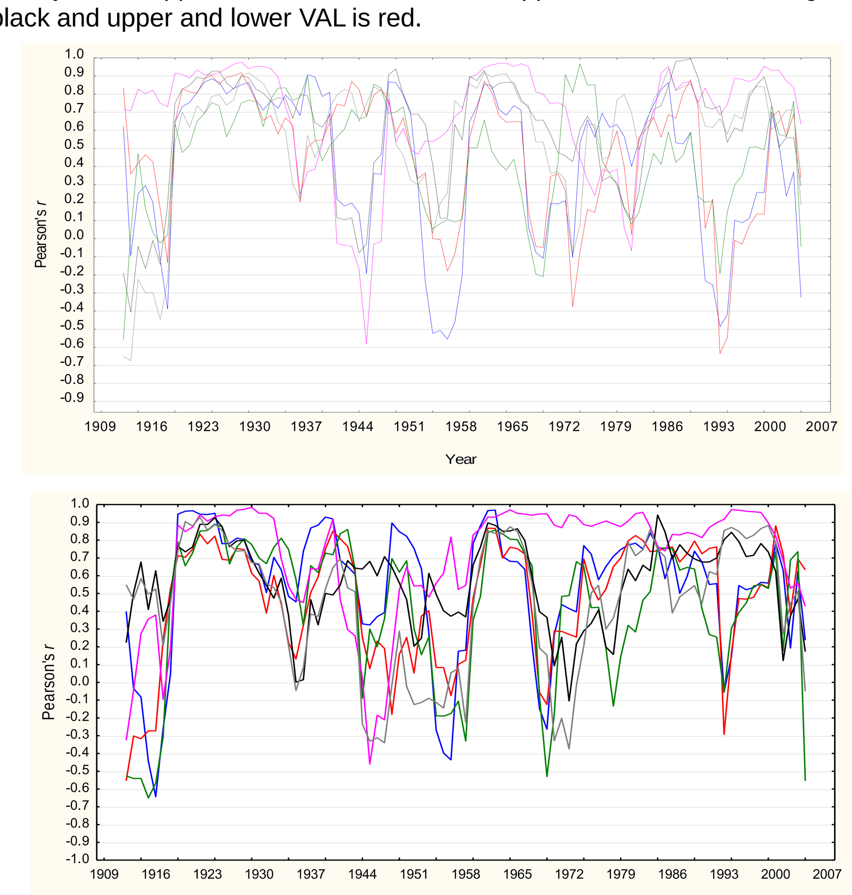

Fig. 4 – Non-stationary correlation of 7-year moving averages between residual tree-ring width chronologies **amongst the upper (above) and lower (below) study stands** of silver fir in the study area; period 1909-2007. ABE-CAM is blue, ABE-LAV is red, ABE-VAL is green, CAM-LAV is magenta, CAM-VAL is dark grey, and LAV-VAL is light grey.

Correlation between MMT and RTR in the study area

Table 2 - Pearson's correlation coefficients between MMT and RTRs in the growth year at the upper and lower silver fir stands in the study area. The study stands are ordered by elevation. Only significant coefficients (*p*-value <0.001) are shown.

	m asl	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
ABE-Upper	1445		0.30										0.35
ABE-Lower	1280												0.30
LAV-Upper	1204		0.49						-0.29				
LAV-Lower	1158		0.65	0.40	0.29				-0.33				
CAM-Upper	1130	0.34	0.27					-0.23	-0.30				
VAL-Upper	1113	0.23	0.29					-0.24	-0.30				
CAM-Lower	1060	0.39	0.33					-0.22	-0.27				
VAL-Lower	903	0.25	0.16				-0.18						

Non-stationary association between seasonal MT and RTRs in the Tuscan Apennine Alps

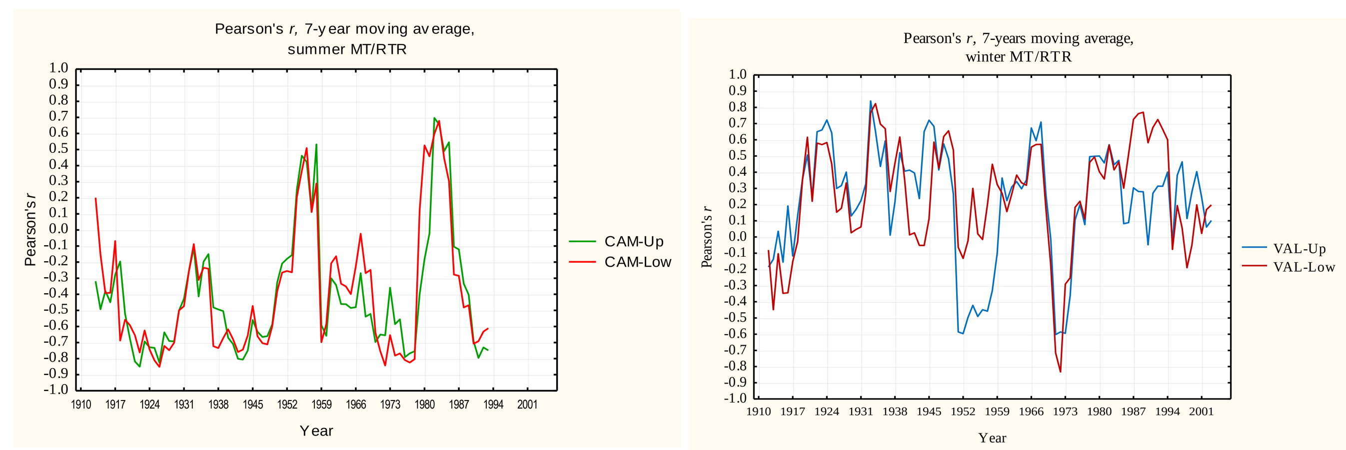

Fig. 5 - Variability of Pearson's coefficient of correlation between 7-years moving averages of winter MT (left) and summer MT (right) with RTRs. High variability as shown in the figures occurs also in spring and summer at all the study sites.

Non-stationary association between MMT and RTRs in the Tuscan Apennine Alps

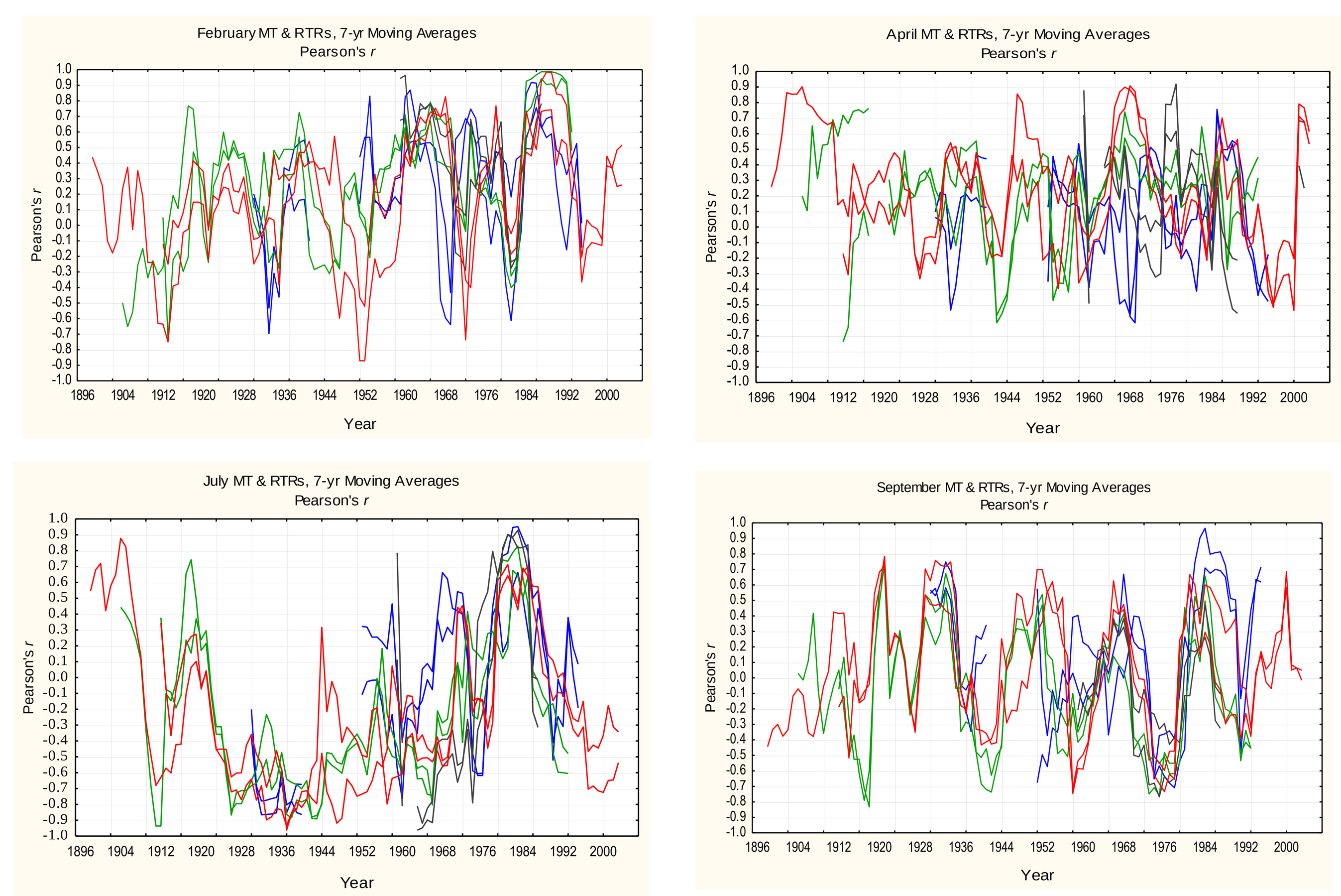

Fig. 6 – Non-stationary association of MMT with RTRs in February, April, July, and September in the growth year. The correlation of MMT appears to change greatly with month and site during the 20th century. High variability - as shown in the figures - occurs in all months in the study area. In the figures, blue is ABE, green is CAM, dark grey is LAV, and red is VAL. Within each color, different trends show upper and lower study stands.

Changing influence of MMT on silver fir growth during the 20th century in the Tuscan Apennine Alps

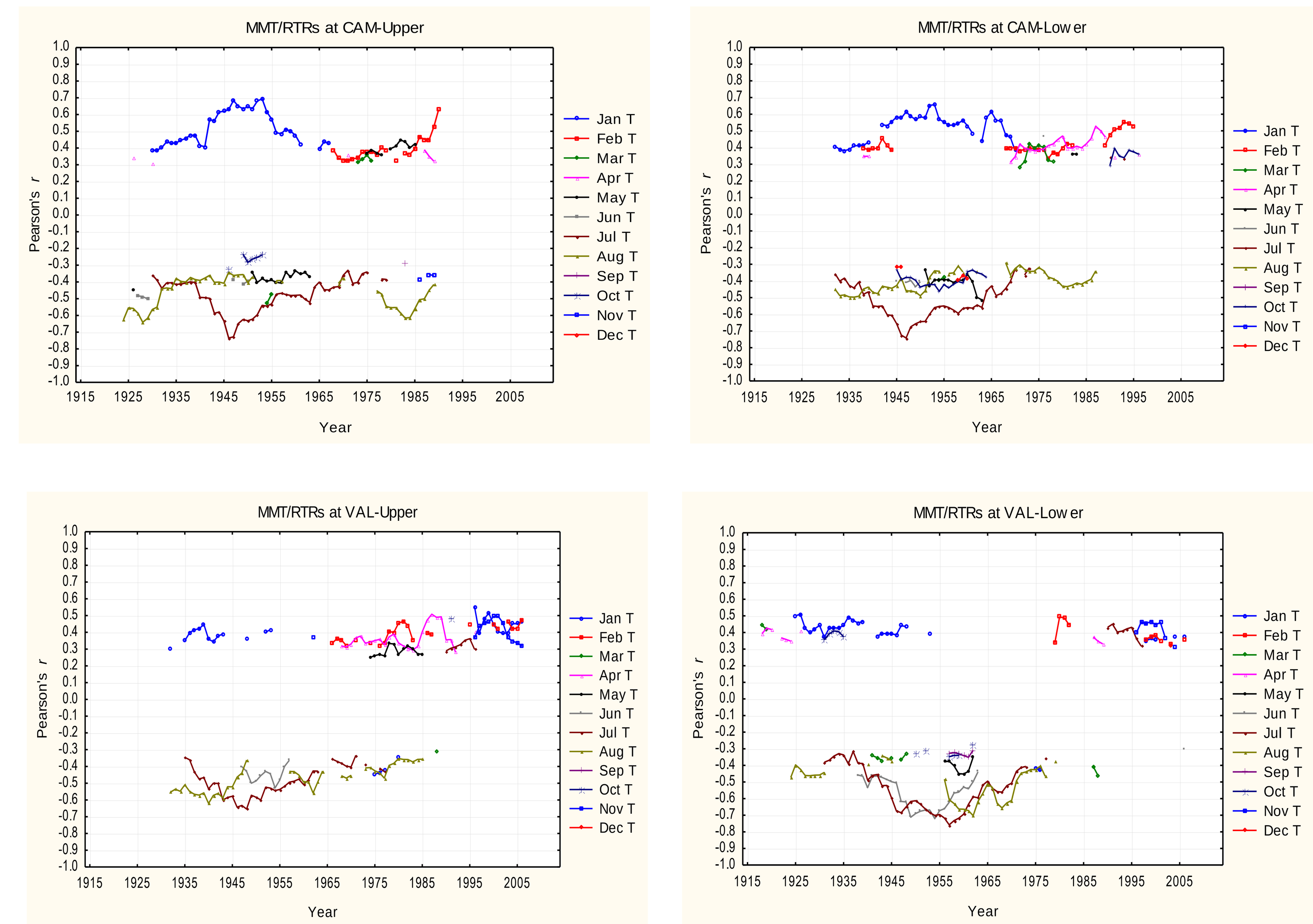

Fig. 7 – Statistically significant levels of correlation between MMT and RTRs at the study stands at CAM and VAL in the Tuscan Apennine Alps. Months of which mean temperature associates to RTRs change during the 20th century and their level of correlation can be highly non-stationary.

Conclusions

In the Tuscan Apennine Alps, recent research has shown that similarity in trends of monthly mean temperature and monthly rainfall is non-stationary amongst sites during the 20th century even between sites that differ little in elevation and at relatively short distance (D'Aprile *et al*., 2010; D'Aprile *et al*., 2011). In addition, the level of correlation between series of monthly climate variables varies irregularly from highly positive to negative – and vice versa – over time. This scenario led to hypothesize that those changing climate conditions could influence differently silver fir growth amongst sites at the local level. Actually, results show that:

➢ Trends in residual tree-ring chronologies vary highly during the 20th century in the study area (Fig. 3). Moreover, they tend to differ within sites and especially amongst sites during the 20th century. However, there are periods when tree-ring growth differs greatly amongst sites (Fig. 4);
➢ Correlation between seasonal mean temperature and tree-ring chronologies varies highly and irregularly in sign and strength during the 20th century in the study area. In particular, trends in correlation are non-stationary amongst sites and can differ highly (Fig. 5);
➢ At the monthly level, the association of mean temperature with tree-ring growth appears highly non-stationary and varies with month and site (Fig. 6); differences in trends can occur also within sites;
➢ Months of which mean temperature is correlated with tree-ring growth change during the 20th century in the study area (Fig. 7); the way they change differs amongst sites. **In other words, the influence of mean temperature on silver growth has changed through different months during the 20th century.**

This research shows that the influence of mean temperature on silver fir growth is highly variable and changes greatly during the 20th century in the study area. In particular, months that might be thought or believed to influence silver fir growth they change over time. Therefore, no prediction about the influence of changing climate conditions on silver fir growth can be done unless climate/growth relationships are based on historical data at the local level. Regional models of climate variable trends may fail to identify the effective periods in which mean temperature influences silver fir growth.
Our results contribute a changing point in forest planning and management in consideration of the need to mitigate the impact of changing climate conditions on silver fir forests, which can be done by adapting management and interventions. Thus, these results introduce climate variability as a key parameter in sustainable forest management for biodiversity conservation, socially responsible uses, and survival of the only conifer tree species today typical of permanent mountain mixed forest in the Apennine Alps.

Bibliography

• Biondi, F. and Waikul, K. (2004). DENDROCLIM2002: A C++ program for statistical calibration of climate signals in tree-ring chronologies. Computers & Geosciences, 30: 303-311. Doi:10.1016/j.cageo.2003.11.004.
• D'Aprile, F., Tapper, N., Baker, P. and Bartolozzi, L. (2010). Variability in trends of monthly mean temperature amongst sites in the Tuscan Apennine Alps. *Geophysical Research Abstracts*. Vol. 12, EGU2010-5681-3. European Geoscience Union , General Assembly 2010, Vienna.
• D'Aprile, F., Nigel Tapper, N., Bartolozzi, L. and Bottacci, A. (2011). Non-stationary similarity in trends of monthly rainfall in the Tuscan Apennine Alps. *Geophysical Research Abstracts*. Vol. 13, EGU2011-1170-1. European Geoscience Union, General Assembly 2011, Vienna.
• Leal, S., Melvin, T.M., Grabner, M., Wimmer, R. And Briffa, K. (2007). Tree-ring growth variability in the Austrian Alps: the influence of site, altitude, tree species and climate. *Boreas*, 36: 426-440. Doi 10.1080/03009480701267063.
• Piovesan, G., Biondi, F., Bernabei, M., Di Filippo, A. and Schirone, B. (2005). Spatial and altitudinal bioclimatic zones of the Italian peninsula identified from a beech (*Fagus sylvatica* L.) tree-ring network. *Acta Oecologica*, 27: 197-210. Doi:10.1016/j.actao.2005.01.001.
• Oberhuber, W., Kofler, W., Pfeifer, K., Seeber, A., Gruber, A. and Wieser, G. (2007*). Long-term changes in tree-ring/climate relationships at Mt. Patscherkofel (Tyrol, Austria) since the mid -1980s*. Trees. Springer-Verlag. Doi 10.1007/s00468-007-0166-7.