Radial increment of old *Pinus nigra* Arn. forests at newly studied locations in mountain regions of Bulgaria

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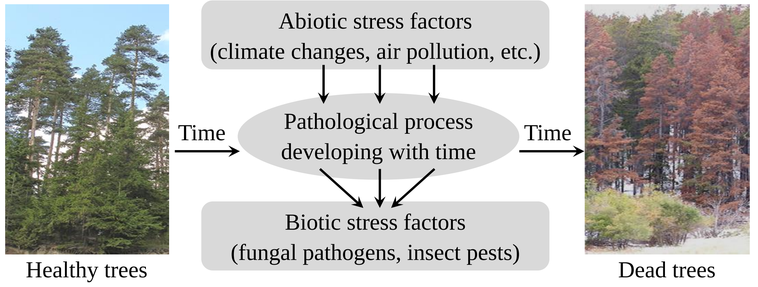
Introduction

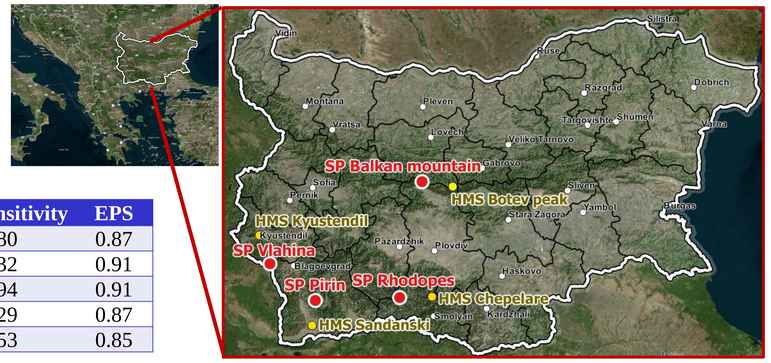
Over the last decades, after prolonged drought periods and heat waves, decreased growth and forest dieback (decline) has occurred in many countries. Studies show that usually they are results of unfavourable climate conditions that are often combined with other stress factors (Manion, 1991; Mirtchev et al, 2000; Zafirov, 2008; Dimitrov et al., 2011). There are several dendrochronological studies of Austrian pine in Bulgaria and Shishkova and Panayotov (2013) analysed and old such forest in the country.

The main **research goal** of this study is to analyse the dynamics of the radial increment of old Austrian pine (*Pinus nigra* Arn.) forest stands in Bulgaria, and to assess the impact of climate conditions on it.



Materials and Methods

Tree-ring samples were taken from 4 natural Austrian pine stands, located in different mountains in Bulgaria. They were processed, measured and analysed by CooRecorder, DendroStat, COFECHA and ARSTAN computer software in the Department of Plant Pathology and Chemistry, University of Forestry, Sofia. Standard dendrochronological methods were used as described by Fritts (1976), Cook and Kairiukstis (1990) and Mirtchev et al. (2000). Climate data from four hydro-meteorological stations in this region are used (HMS Botev peak, Kyustendil, Sandanski and Chepelare).

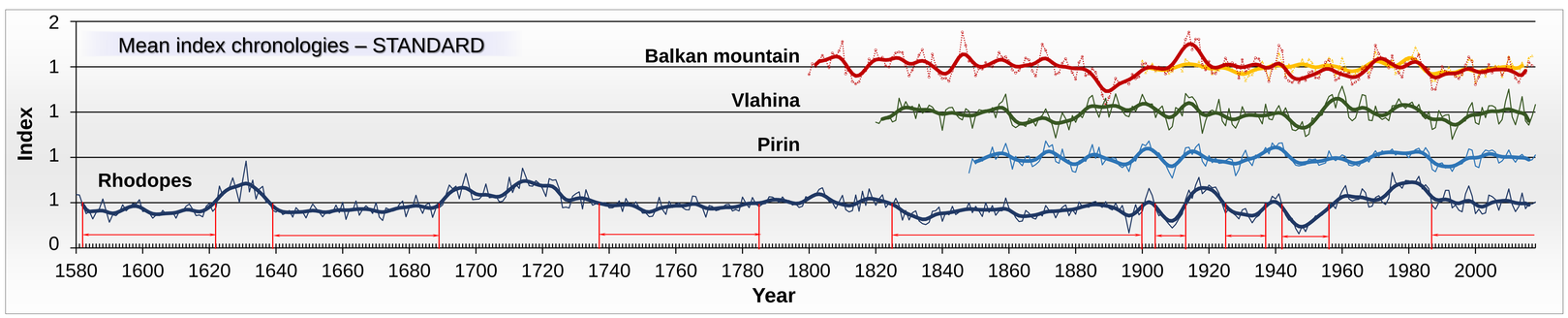


Sample plot (SP)	Altitude, m	Number of samples	Beginning	End	Length	Mean sensitivity	EPS
Balkan 1	1300	15	1800	2017	218	0.180	0.87
Balkan 2	1300	30	1900	2017	118	0.132	0.91
Vlahina	1050	20	1819	2018	200	0.194	0.91
Pirin	1800	15	1848	2018	171	0.129	0.87
Rhodopes	1600	15	1580	2018	439	0.153	0.85

Results and Discussion

Four representative radial increment chronologies for Austrian pine forest stands in Bulgaria were developed, which reflect the dynamics of their growth and health status. Several partially missing rings were found during the cross-dating of the core samples. The time span of the longest increment chronology (Rhodopes mountain) cover the period from 580 until 2018 (439 years).

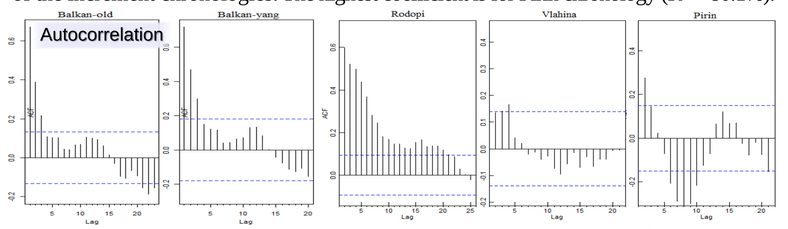
The stress periods (time spans with low increment) during the common period of the three chronologies from Southern Bulgaria (Vlahina, Pirin and Rhodopes) coincide – during: the 1910s; from the mid-1920s until the mid-1930s; from the 1940s until the mid-1950s and from the mid-1980s onwards. The chronology from the Balkan mountain has an additional well expressed stress period 1880–1900. The indices for the radial increment of Austrian pine in the beginning of the current 21st century in all 4 locations remain below 1.



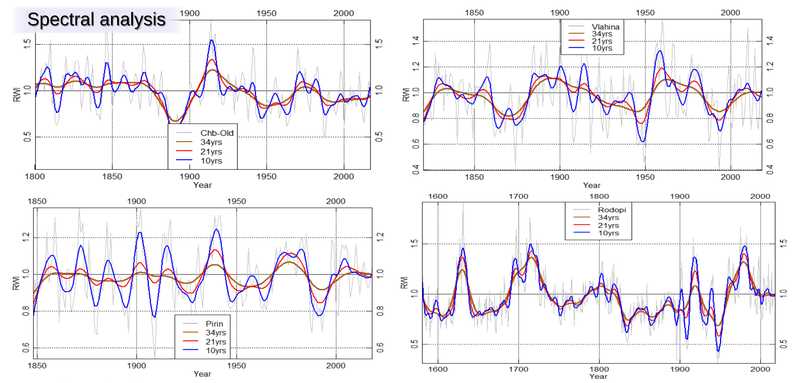
Influence of the temperature-precipitation regimes – Coefficients of determination (R^2) in percent from the multiple regression analysis

Sample plot	R^2, % – air temperature, 15 months, prev. Jul–Sep	R^2, % – precipitation, 15 months, prev. Jul–Sep	R^2, % – combined, 30 factors, prev. Jul–Sep
Balkan 1	55.6	34.9	71.3
Balkan 2	50.5	35.8	67.2
Vlahina	50.2	31.3	73.6
Pirin	42.7	51.0	80.1
Rhodopes	59.9	28.1	71.5

Multiple regression analysis revealed that the impact of air temperature on the radial increment of Austrian pine is stronger than that of precipitation in most sample plots. Only in SP Pirin precipitation has higher influence. The coefficients for determination (R^2) for the influence of both factors are above 67% for all locations, which shows that the temperature-precipitation regime describes most of the dynamics of the increment chronologies. The highest coefficient is for Pirin chronology (R^2 = 80.1%).



The dominant frequencies in the chronologies was determined from a spectral analysis of the time series. First, a linear trend is removed, then the spectral density function is estimated from the best fitting autoregressive model (based on the AIC). We found no large maximums in the spectral density functions, which shows that no dominant frequencies were revealed in the chronologies.



Conclusion

The statistical analyses carried out on the influence of the temperature-precipitation regime on the dynamics of the radial increment of Austrian pine in the studied region prove its significance as major factor for the changes of their growth. There is a tendency for rise of the air temperatures over the last 100 years in this area. This requires a more in-depth analysis of the likely future climate change and its impact on pine ecosystems in this region.

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