Climatic signal in tree ring density records from high elevation sites in Bulgaria

Final report

MedCLIVAR Exchange Grant

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PURPOSE OF THE VISIT

From November 1st until December 24th 2009 (8 weeks in total) I completed an internship at the Dendrosciences unit of the Swiss Federal Research Institute for Forest, Snow, and Landscape (WSL). The aim of this research project was to investigate climate-growth relationships for two tree-line species (*Pinus heldrehii* PIHE and *Pinus peuce* PIPE) from the Pirin Mountains in Bulgaria, using maximum latewood density (MXD) measurements. Regional tree ring width (TRW) chronologies were previously developed for both species (Panayotov and Yurukov 2007, Panayotov et al. (in press)), but correlations between TRW data and various instrumental climate data were generally fairly weak. At high elevation Mediterranean sites, MXD can contain a much stronger climatic signal than TRW (Buentgen et al. 2008) and in this project we want to investigate whether this is the case in Bulgaria.

WORK CARRIED OUT DURING THE VISIT

Albena prepared 15 PIHE and PIPE samples for X-ray densitometry. Cores were glued to a wooden support with the radial surface uppermost and 1.5-mm-tick lath cut out with a small twin-bladed circular saw. Film (double-coated medical X-ray film) was irradiated resting on a stationary stage for 70 min with the source of X-ray 250 cm above the film. The films were developed in an automatic processor with standardized processing. Then she measured density values of these samples using a WALESCH 2003 X-ray densitometer. Brightness variations were transferred into g/cm^3 using a calibration wedge. The series were then cross-dated using COFECHA software and detrended using ARSTAN software. Finally, Albena compared the series with local and regional instrumental temperature, precipitation, and PDSI time series.

From 29 November to 5 December 2009, Albena attended The 9th International Winter School „Wood anatomy of tree rings“ in Klosters, Switzerland. The Winter school was organized by Holger Gartner and Fritz Hans Schweingruber. The aim of the course was to provide basic theoretical information about plant anatomy and especially ecological wood anatomy. The course included learning different anatomical preparation techniques.

RESULTS

Cross-dating was possible for 22 samples from 13 PIHE trees. The oldest series started at 1755 and ended at 2008. The PIHE chronology (min. 5 trees) covers the period 1765-2008. Fig. 1 and Fig. 2 show the raw ring-width and MXD series. The mean curve in ring-width clearly shows a growth trend, which is not visible in the MXD curves. MXD series were detrended using a general negative exponential curve (Fig. 3). The residuals from this detrending were then used in the climate-growth analysis.

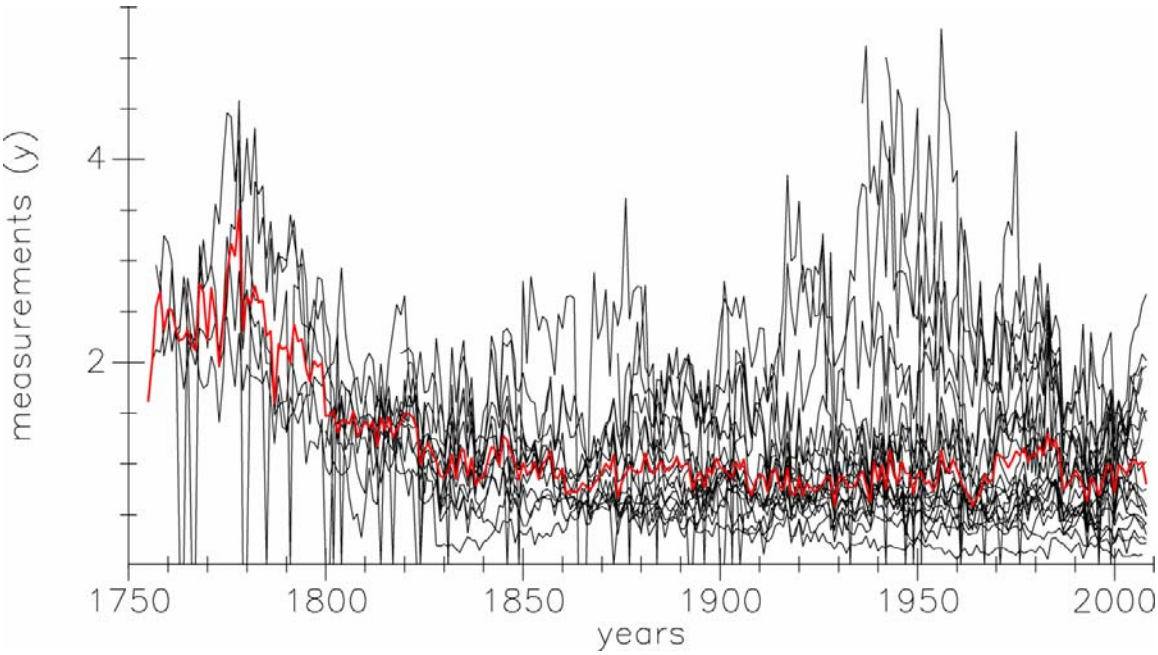

Fig.1: Raw PIHE ring width series and mean curve

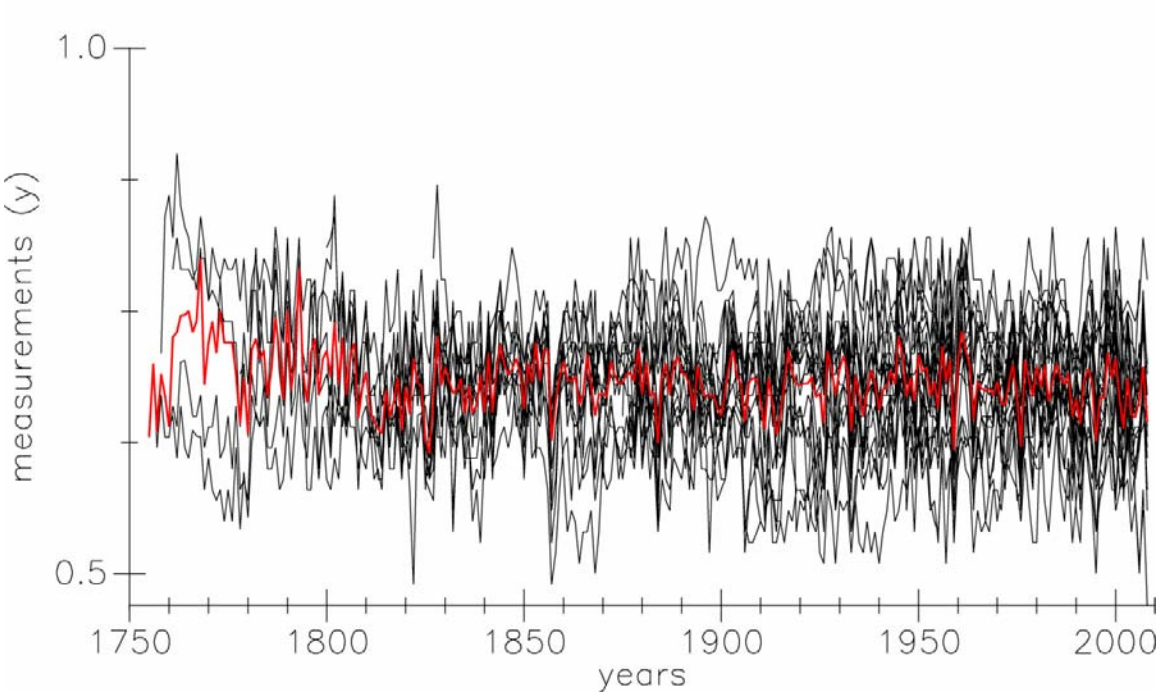

Fig.2: Raw PIHE MXD series and mean curve

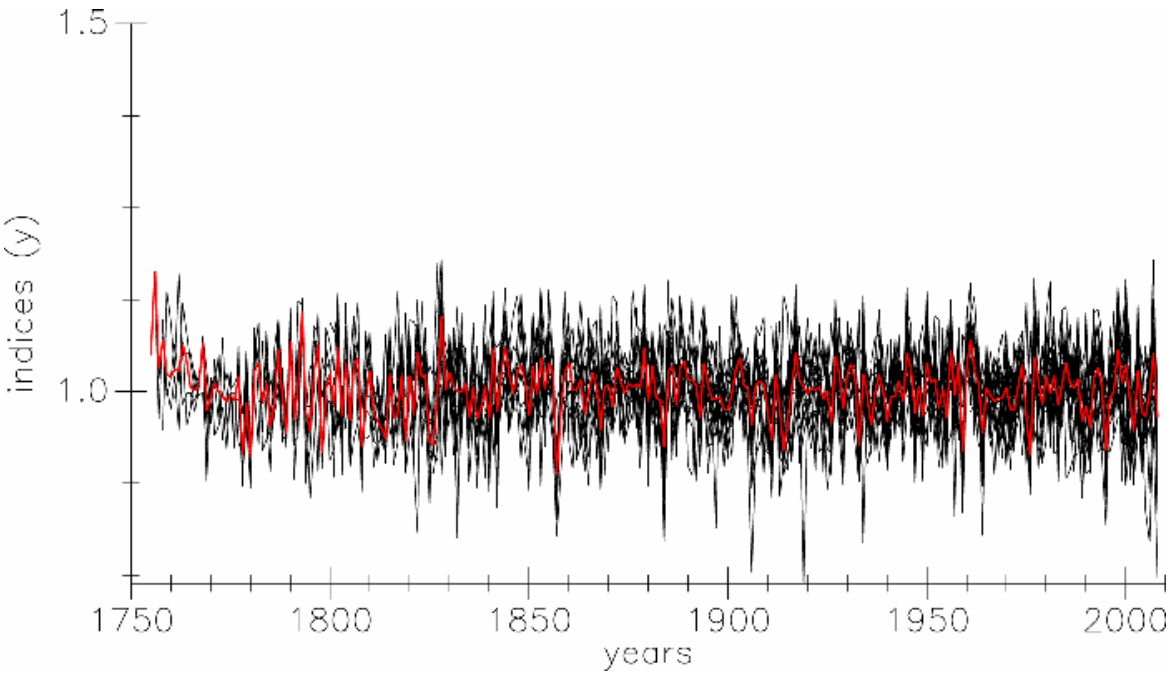

Fig.3: Detrended PIHE MXD series and chronology

Fig. 4 and Fig. 5 show the correlation between the detrended MXD chronology and monthly temperature and precipitation data from a nearby meteorological station in Sofia.

Climatological data were available for the period 1887-2005. Correlation with temperatures is strongest ($p<0.001$) and positive during summer months (Jun-Sep) while precipitations shows significant ($p<0.001$) negative correlations in summer (May-Aug). The strong inverse corelation between temperatures and precipitation is likely the cause of these opposite correlation coefficients. Overall, we found the strongest correlation with average temperature for the months June to September ($r=0.64$, $p<0.001$; Fig. 4).

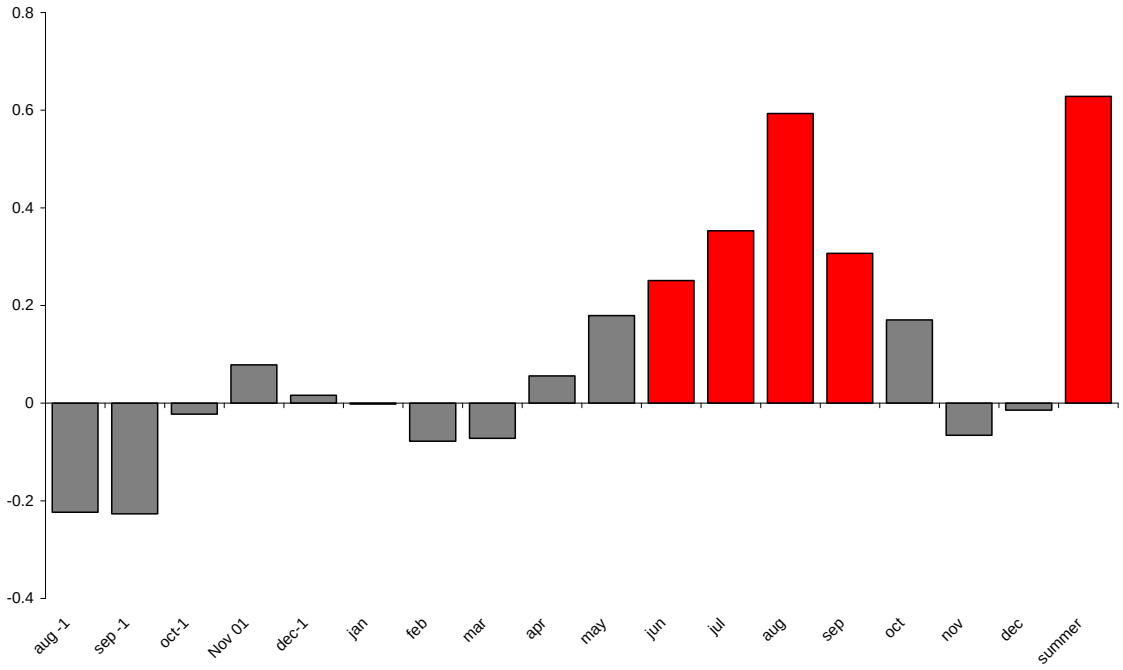

Fig. 4: correlation between detrended MXD chronology and monthly and summer (June-September) temperature from Sofia meteorological station (1887-2005). Correlations were calculated for August of the year previous to the growth year (Aug -1) until December of the growth year (Dec). Significant correlations ($p<0.001$) are marked in red.

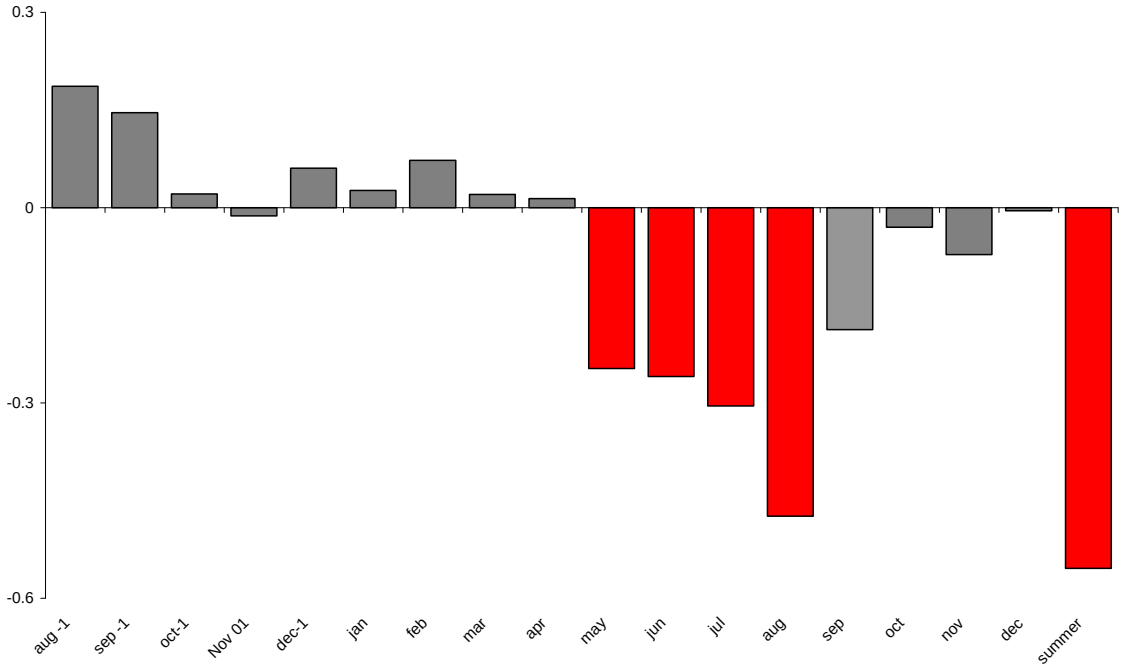

Fig. 5: Correlation between detrended MXD chronology and monthly and summer (June-September) precipitation from Sofia meteorological station (1887-2005). Correlations were calculated for August of the year previous to the growth year (Aug -1) until December of the growth year (Dec). Significant correlations ($p<0.001$) are marked in red.

Due to the complexity of density fluctuations in PIPE, development of a PIPE MXD chronology was unsuccessful until now. Albena succeeded in cross-dating approximately half of the PIPE samples during her visit at the WSL. The remaining samples will be cross-dated by WSL personnel, in order to develop a PIPE chronology.

FUTURE COLLABORATION

The very strong correlation between the PIHE MXD chronology and summer temperature (Fig. 4) is very promising for future work. Three PIHE TRW chronologies have previously been developed for the Pirin mountains (V. Trouet and M. Panayotov, pers. comm.). These chronologies reach back to 1215 CE, but the climatic signal in the TRW data is very weak. The development of an MXD chronology based on these samples, could provide the first summer temperature reconstruction for the Balkan area that reaches back to Medieval times.

Furthermore, the possibility of a joint (WSL - University of Forestry, Sofia) M.Sc. project for Albena has been discussed. A potential topic for her study could be an intra-annual growth analysis of high elevation PIHE trees in Bulgaria. By applying bi-weekly "punching" over the course of the growing season (Moser et al. 2009), the cambial activity in PIHE can be studied and related to climatic conditions. Understanding intra-annual growth dynamics will be pivotal in fully understanding climate-growth relations. The experience in wood anatomical analysis that Albena has acquired during the Wood Anatomical Fieldweek, as well as the expertise in intra-annual growth analysis that is available in the Dendrosciences Unit of the WSL (for instance: http://www.wsl.ch/forschung/forschungsunits/dendro/Loetschental/index_EN?-C=&), guarantee a successful collaboration.

PROJECTED PUBLICATIONS

Trouet, V., Ivanova, A., and Panayotov, M.P., Climatic signal in tree ring width and maximum latewood density data from the Pirin Mountains in Bulgaria (*in preparation for The Holocene)*

REFERENCES

Buntgen, U., et al. (2008), Long-term summer temperature variations in the Pyrenees, *Climate Dynamics*, *31*(6), 615-631.

Moser, L., et al. (2009), Timing and duration of European larch growing season along altitudinal gradients in the Swiss Alps, *Tree Physiology*, doi:10.1093/treephys/tpp108

Panayotov, M. P., and S. Yurukov (2007), Tree ring chronology from *Pinus peuce* in Pirin Mts and the possibilities to use it for climate analysis, *Phytologia Balcanica*, *13*(3), 313-320.

Panayotov, M. P., et al. (in press), Climate signal in tree-ring chronologies of Pinus peuce and Pinus heldreichii from the Pirin Mountains in Bulgaria, *Trees - Structure and Function*.