Report

Project title: Temporal FLUCtuation in the responses to climatic variability in old TREE populations (FLUCTREE)

Co-authors: Jaime Madrigal-González & Markus Stoffel

Climatic extremes from summertime heat waves and drought to winter storms and extreme rain can exponentially boost instability in the provisioning of forests functions and services through synchronization of individual tree growth within populations (Tejedor et al 2020). Interestingly, a large proportion of climatic extreme events are tied to fluctuations of the global atmospheric and oceanic circulation patterns, which are somehow predictable on the basis of patterns that are recurrent in time lags from years to decades. In this study we aimed at unveiling whether growth synchronization of individual trees in the Swiss National Park are linked to climatic fluctuations of a global pattern associated with the oceanic circulation in the northern Atlantic (The Atlantic Multidecadal Oscillation, AMO). This global climate mode has been associated with low-frequency fluctuations of weather regimes in the European continent (Zampieri et al 2017).

Figure 1. Landscape view of mountains in the God Margunet forest (Swiss National Park).

We defined a sampling design along a short elevation gradient in the God Margunet forest (Figure 1). There, we established three elevation bands (1980-2100-2300) and within each band we randomly chose and cored 20 individual trees (two samples per tree) of the species *Pinus montana*. Additionally, we measured diameter at breast heigh of every cored tree and obtained geographical coordinates with a Global Positioning System (GPS). Cores were carried to the lab, glued to wood sticks and sanded with different grained sand papers. Finally, samples were measured using Lintab. Tree ring-width measurements were cross-dated using COFECHA and paired samples per tree averaged.

Figure 2. Fieldwork team in the upper elevation band

We transformed tree ring-widths measurements to Basal Area Increments (BAI) since this metric is a little bit less sensitive to age than ring-widths. With this data, we created networks in which nodes are the cored trees and links represent significant positive correlations (p-value < 0.05). Networks were computed for 20-years time windows since 1900. We created a moving window scheme in which such 20-years' time lags moves onwards one year at a time. We calculated a network for every 20-years' time window. After that, we computed connectivity in every network as the number of actual positive links relative to the maximum number of links possible. This index can be interpreted as a metric of tree growth synchrony in space (elevation bands) and time (from 1900 to 2020 at 20-years time intervals with 19 years overlap). We finally fitted mixed effects model to evaluate the relationship between growth synchrony and the AMO.

Results supported the influence of AMO on tree growth synchrony in this area. However, this relationship shifted along the elevation gradient considered. At the highest elevations, AMO negatively drives synchrony: e.g. tree growth synchronizes during negative AMO phases, which are significantly related to cold extreme waves in Europe.

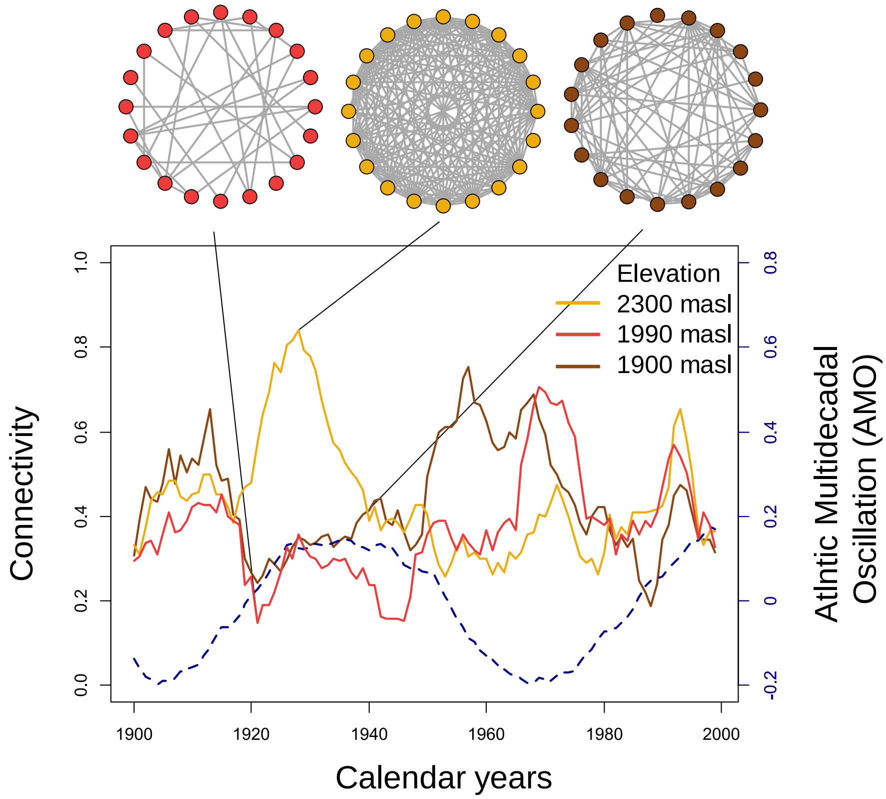

Figure 2. Connectivity values since 1900 at three different elevations (colours). The dashed line represents the smoothed index of AMO averaged for the 20-years time windows. Calendar years represent the initial year of each of the 20-years' time window in which the connectivity values are computed. On the top of the figure an example of three networks with contrasted connectivity values are shown to exemplify what is meant by connectivity graphically.

On the contrary, tree growth synchronizes during positive AMO phases in the lowest elevations (1980 measl), which means that in this elevation, trees tend to respond similarly in response to climatic extreme events such as heat waves and drought (Figure 2).

Literature cited.

Tejedor, E., Serrano-Notivoli, R., de Luis, M., Saz, M. A., Hartl, C., St. George, S., ... & Esper, J. (2020). A global perspective on the climate-driven growth synchrony of neighbouring trees. Global Ecology and Biogeography, 29(7), 1114-1125.

Zampieri, M., Toreti, A., Schindler, A., Scoccimarro, E., & Gualdi, S. (2017). Atlantic multi-decadal oscillation influence on weather regimes over Europe and the Mediterranean in spring and summer. Global and Planetary Change, 151, 92-100.