Multi-species tree growth response to climate change in southwestern Germany

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1 Introduction

- The extensive dieback of Central European tree species in the 21st century is driven by increasing drought and temperature stress[1,2].
- Southwest (SW) Germany has one of the warmest climates nationwide and was recently identified as a hotspot for future climate extremes[3].
- **However**, tree-ring studies in SW Germany are sparse, limiting the accurate assessment of climate impacts on forest growth and health.

2 Research Questions

1. **Which climate factors primarily control tree growth in SW Germany?**
2. **How has climate sensitivity changed in recent decades?**
3. **How big are differences between predominant tree genera?**

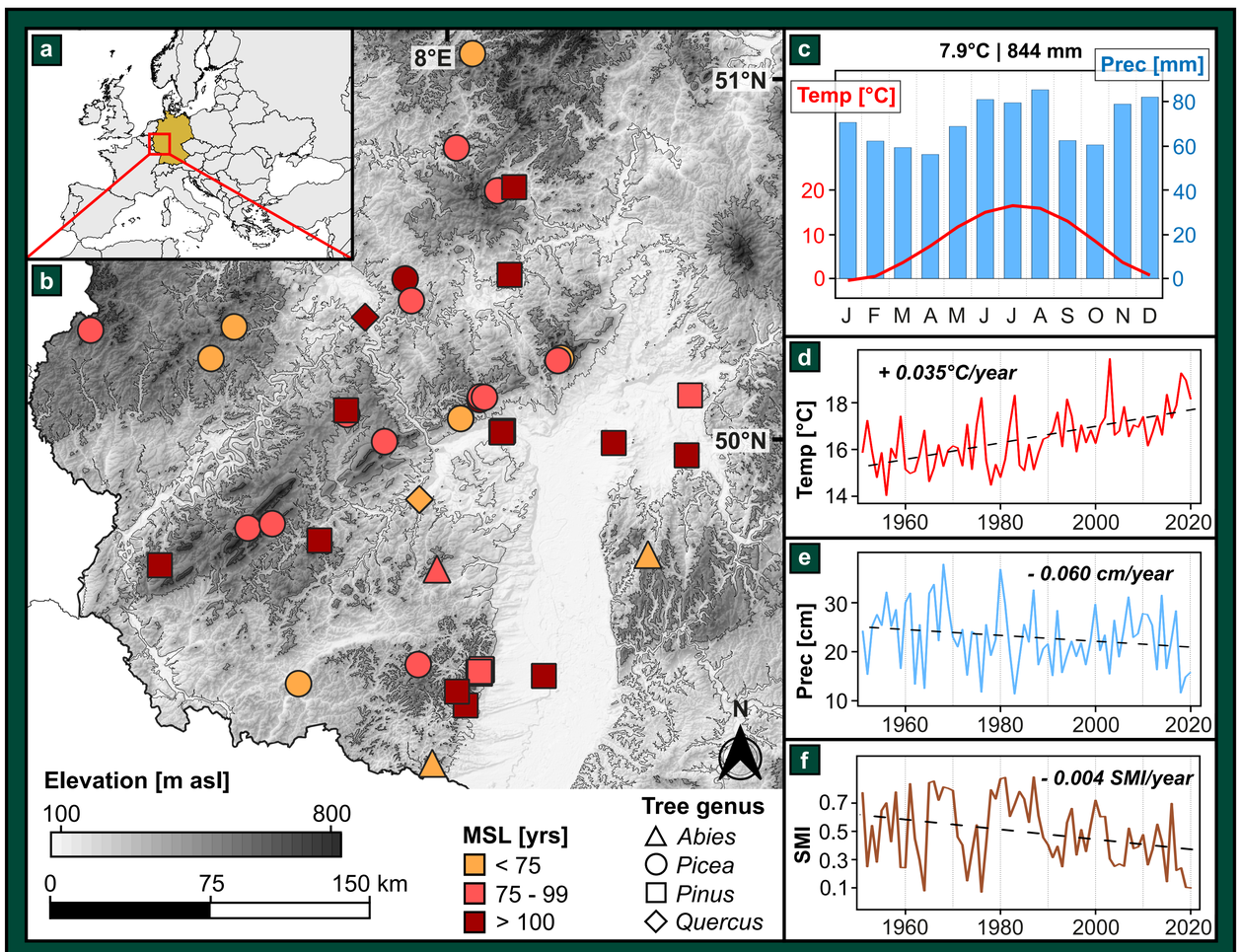

Fig. 1: (a) Location of the study area in Europe and **(b)** of the individual sites in SW Germany. Sites are colored by their mean segment length (MSL). **(c)** Climate diagram for SW Germany (1951-1980 CE) and temporal changes of summer **(d)** temperatures[4], **(e)** precipitation[4] and **(f)** soil moisture index[5] (SMI) for a layer covering the uppermost 180 cm (1951-2020 CE).

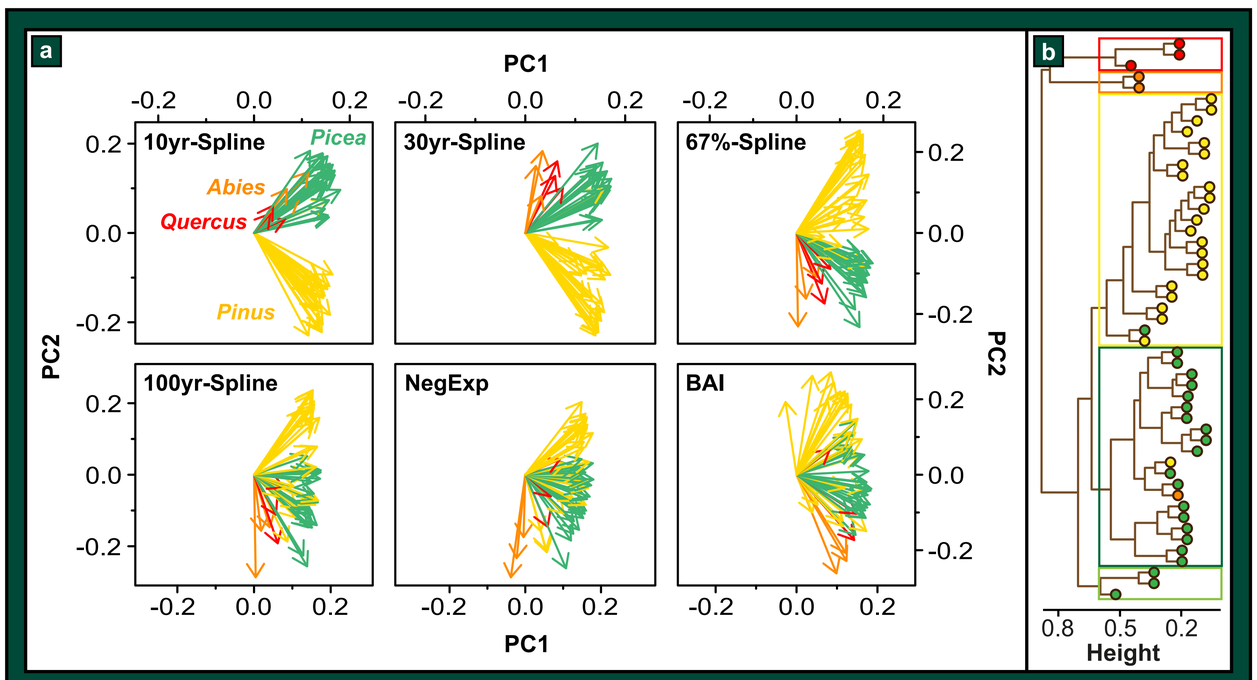

Fig. 2: (a) Principal Component Gradient Analysis (PCGA) and **(b)** Hierarchical Cluster Analysis (HCA) after TRW standardization, both performed over the common period of all chronologies (1951-2009 CE). Each arrow in (a) and point in (b) represents one site chronology colored according to its tree genus. The HCA was applied to the 10-year-Spline detrended data.

3 Material & Methods

- We here introduce a new **multi-species tree-ring width (TRW) network** of 51 low-elevation sites (>2100 trees) in SW Germany (Fig.1a-b), where the summer climate has become noticeably drier in recent decades (Fig.1c-f).
- We investigate the climate sensitivity of four major European tree genera (***Abies***, ***Picea***, ***Pinus***, ***Quercus***) by calculating growth-climate correlations.
- Age-related growth trends were eliminated by standardization (Fig.2a).
- For each site, monthly climate and soil moisture data were extracted from the high-resolution CDC database[4] and from the German Drought Monitor[5].

4 Results

- PCGA reveals that **genus-specific growth patterns** are most distinct in the high-frequency domains (Fig.2a).
- HCA groups the **10yr-Spline detrended chronologies** almost flawlessly into tree genus clusters (Fig.2b).
- Most TRW sites show significant correlations with **summer hydroclimate**, especially the *Quercus* sites (Fig.3).
- Correlations with soil moisture are higher than with climate variables.
- ***Quercus* sites** show highest correlations with current year soil moisture.
- Warmer sites are higher related to current year soil moisture, while **cooler sites** (T_{JJA}<15°C) are more dependent on **previous year conditions**, and this dependence becomes stronger toward the present (Fig.4).

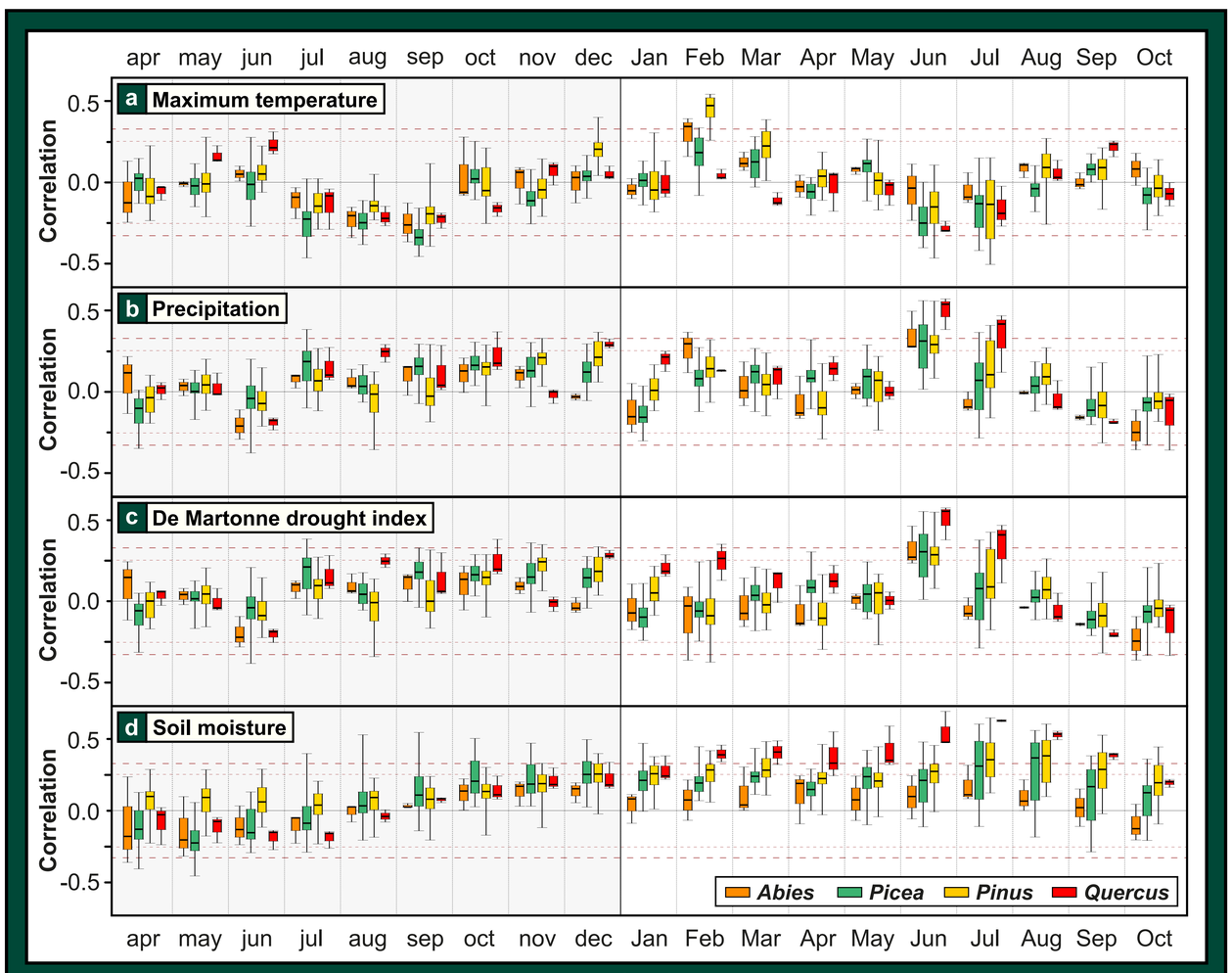

Fig. 3: Pearson correlations between TRW and **(a-c)** climate variables and **(d)** soil moisture of the previous year (left) and current year (right) from 1952-2009 CE. Data were standardized with a 10-year Spline. Dashed red lines represent α = 0.05 (small) and α = 0.01 (large).

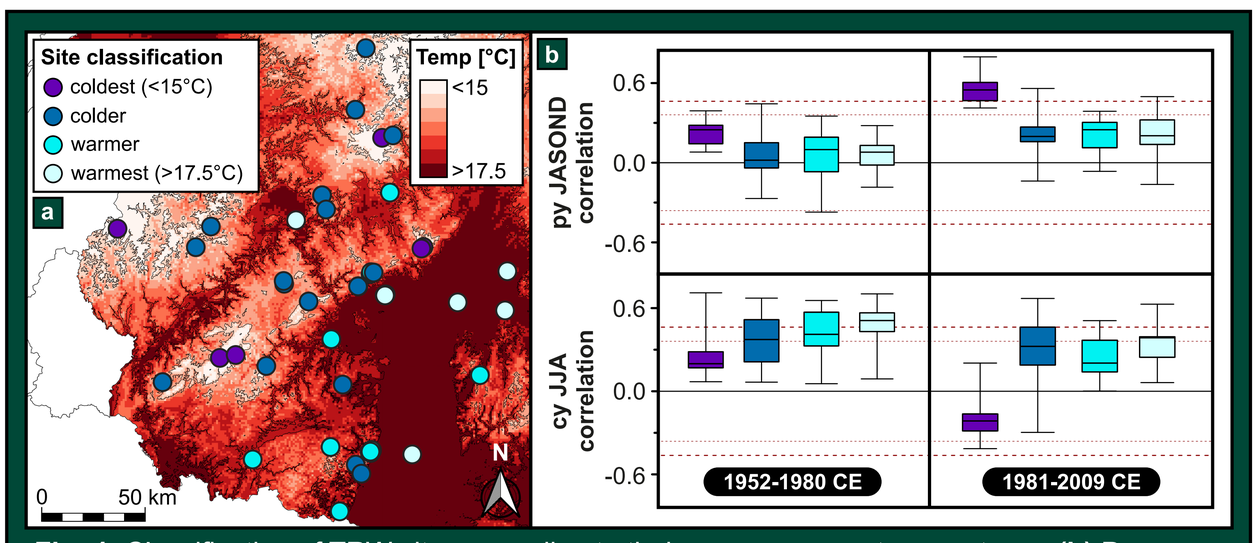

Fig. 4: Classification of TRW sites according to their mean summer temperatures, **(b)** Pearson correlations between TRW and soil moisture of previous July-December (top) and current June-August (bottom) for the periods 1952-1980 CE (left) and 1981-2009 CE (right).

5 Conclusion

- **Climate signals** are limited to the high-frequency domains, likely due to the influence of forest management strategies.
- **Summer hydroclimate and soil moisture** are the main drivers of tree growth, especially for *Quercus*, but not for *Abies*.
- **At colder sites**, previous year soil moisture becomes more important.
- ***Quercus* TRW** shows potential to reconstruct past soil moisture extremes.

6 References

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