**Why are some trees more sensitive to climate than others?**
*A study on the functional linkage of tree hydraulics and their sensitivity to climate*

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Trees are amazing! Over the course of their life, trees transport millions of liters of water from the soil through their vessels and leaves into the atmosphere. They play an important role in the regulation of the earth's climate by affecting the hydrological cycle (Spracklen et al. 2012), cooling the earth (Bonan 2008), and by storing large amounts of carbon (Pan et al. 2011). Understanding the response of trees to a changing climate is therefore important to predict how forests and the earth will look like in the future.

Trees show strong differences in their responses to climate. While some trees succumb even under mild drought others are able to survive and even continue growing under severe droughts (McDowell 2011). These differences are related to the trees' specific properties or traits. One important plant trait explaining differences in trees climate response is that linked to their water transport, and the trade-off between water transport efficiency and safety (Sperry et al. 2008). Trees that are more efficient at water transport due to greater hydraulic conductance are believed to be more sensitive to inter-annual variation in climate. In contrast, trees with more conservative water use strategies and a "safer" hydraulic transport system may maintain a positive water balance throughout drought periods. Recent studies show that forests with more diverse hydraulic traits are more buffered to changing drought conditions (Anderegg et al. 2018). Thus, hydraulic traits play an important role in forest functioning.

At the same time, there is also evidence for an important role of carbohydrate reserves (eg. starch) for tree functioning. Carbohydrate reserves can be used in bad years thus providing resilience to inter-annual variation in climate (Chapin et al. 1990). Thus, besides hydraulics other traits may also play an important role in protecting trees from the impacts of strong year-to-year climate variation. Finally, the climate sensitivity of trees responses may change with increasing tree height and tree age (Ryan and Yoder 1997), which is thus important to consider when evaluating trait-resilience responses of species.

Despite, recent progress in understanding trees' physiological responses to variation in climate, the governing principles to predict trees' resilience to climate remains poorly quantified. In this study, you will provide the first global assessment of trees' climate sensitivity and link these to species' functional traits. To this end, you will use the International Tree Ring DataBase (ITRDB) to assess the inter-annual response of trees to climate, and link those responses to the trees functional characteristics, especially those traits related to hydraulics. In addition to using existing datasets, you will in this PhD also collect new tree ring and trait data on a few tropical and temperate tree species. This will involve fieldwork in the tropics (most likely in the Amazon) and in Europe.

**Objectives**

The aim of this PhD project is to

1. Assess the global linkage between trees' climate sensitivity and their functional traits;
2. Evaluate how functional traits and climate sensitivity change with tree size and age.

3. Provide recommendations for Improving predictions of trees' responses to future climate.

**Material & methods**

You will collate large datasets from across the world to assess the climate sensitivity of tree species to drought and temperature. To this end you will use the International Tree Ring Database (ITRDB) which contains over 100.000 tree ring records from more than 4.000 sites, and 200 species from across the globe (see Fig 1). These data will be complemented with suitable tree ring data from collaborators and published in literature. You will analyse these tree ring data sets to determine the sensitivity of growth responses (ring widths) to inter-annual variation in climate (precipitation and temperature) and use functional trait data (eg. on plant hydraulics, wood characteristics and vessel anatomy) to test whether species with more conservative hydraulic systems are more resistant to variation in climate. Functional trait data will be collated from various functional trait databases that are available.

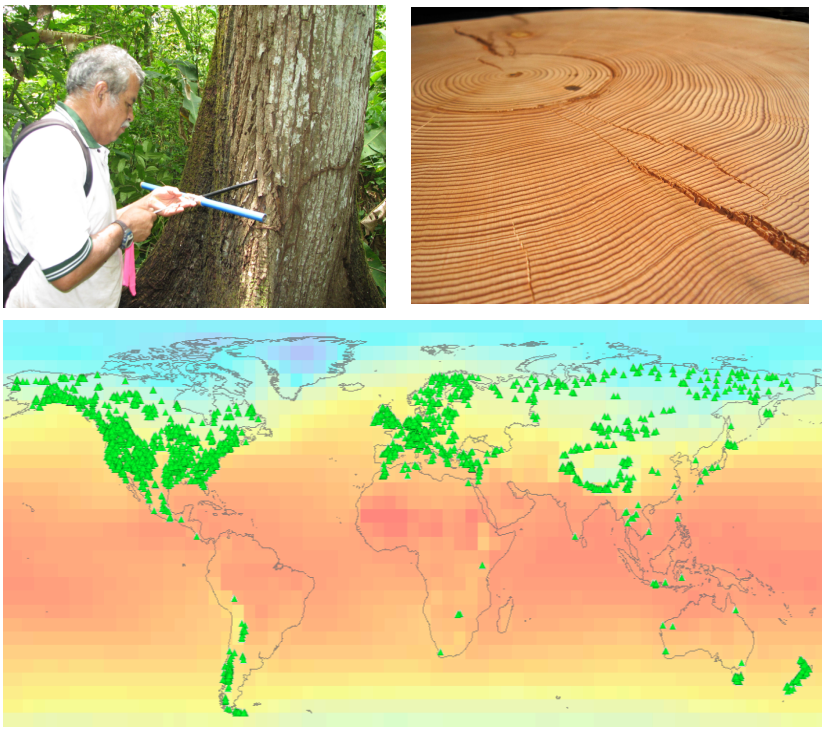

**Fig. 1 Approaches used in this study consist of sampling and analysing tree ring data from new sites and use the extensive dataset of the International Tree Ring DataBase (ITRDB) available online (see** http://www.ncdc.noaa.gov/data-access/paleoclimatology-data/datasets/tree-ring). This dataset contains tree ring data from over 4000 sites, and hundreds of species.

You will also collect new tree ring data from specific regions, probably including the tropics (Amazon basin) and measure new and additional plant traits on a select number of species.

**Potential for high impact outcome**

Despite the large number of studies looking at plant functional traits, only very few studies have linked such traits to plant performance measures. Tree rings are an easy way of obtaining good estimates of plant performance in the form of ring width responses to interannual variation in climate. In addition, for a select number of species tree ring samples from trees that died -in response to climate or other causes- allow assessing the trees survival strategies and assessing differences between species with different functional traits. This study will provide a very new outlook on the significance of species' functional traits by linking trait data to tree ring data. This has not been attempted before and will likely result in important, high impact outcome.

**Training**

You will work under the supervision of a strong team of earth system dynamics experts within the Ecology and Global Change research group of the School of Geography. Direct daily supervision will be done by Dr. Roel Brienen, Prof. Emanuel Gloor and Dr. David Galbraith. You will also benefit from

working within a highly active and multidisciplinary group of scientists in the Leeds Ecosystem, Atmosphere & Forest (LEAF). The school of geography has excellent and state-of-the-art laboratory facilities including a full equipped tree ring lab. You will have access to a broad spectrum of training workshops put on by the Faculty that include an extensive range of training workshops in numerical modelling, through to managing your degree, to preparing for your viva (http://www.emeskillstraining.leeds.ac.uk/).

**Student profile**

You are expected to have strong interests in environmental and earth system science and global change. You also should have some background in disciplines such as mathematics, physics, geography, biology, or environmental science. Strong analytical skills are required.

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