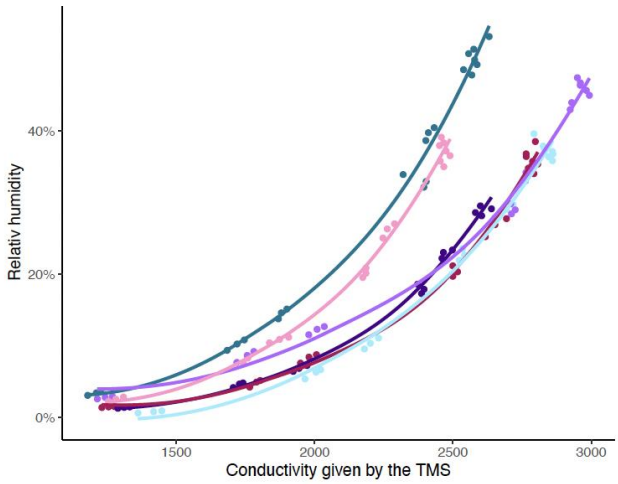

Master's thesis opportunity

Title: ***Calibration challenges and potentials of low-cost microclimate sensors: a case study using the TOMST TMS-4 logger***

BACKGROUND

Microclimate plays a crucial role in shaping ecological and environmental processes. High-resolution spatio-temporal measurements of variables such as temperature and soil moisture are essential for understanding patterns in biodiversity, plant performance, ecosystem fluxes, and species distributions, particularly under changing climate conditions.

Low-cost sensors like the TMS-4 logger from TOMST, which records air and soil temperature as well as soil moisture (via electrical conductivity), are widely used in ecological research. However, their soil moisture raw data requires careful calibration for reliable and comparable measurements.

Accurate prediction of soil electrical conductivity patterns requires calibration measurements that account for multiple soil properties, including total organic carbon (TOC), soil pH, and soil texture (clay, silt, and sand). Integrating these variables into calibration datasets can substantially improve the interpretation of conductivity measurements and enhance the use of sensor-derived soil moisture data. At present, only a limited number of calibration datasets are available, and these generally lack comprehensive soil property measurements. In addition, challenges such as device-specific variability and temperature-dependent effects on conductivity remain insufficiently quantified. Addressing these limitations is essential to fully exploit the potential of low-cost sensors in real-world field conditions.

PROJECT OBJECTIVES

The student will:

- Measure TOC, soil pH, and soil texture (clay, silt, sand) for different soils and link these data to existing calibration datasets
- Sample intact soil cores in the vicinity of Leipzig and develop calibration curves by manipulating soil water content under controlled conditions
- Investigate different calibration approaches and assess the limitations of available datasets
- Analyze logger-specific differences and environmental factors influencing sensor output
- Evaluate the reliability and applicability of low-cost loggers for microclimate studies
- Apply statistical methods to identify key sources of error and variability
- Contribute to improved calibration workflows and methodological recommendations

CANDIDATE PROFILE

We are looking for a motivated Master's student who:

- Is enrolled in a relevant program (e.g. Environmental Sciences, Data Science, Physics, Ecology, Forest Sciences, or related fields)
- Is interested in fieldwork and learning soil laboratory methods
- Is confident in independently learning and applying the soil texture method (https://www.youtube.com/watch?v=XcwcYaoh7f4)
- Has a solid background in mathematics or statistics
- Has experience working with large datasets
- Is familiar with or willing to learn the R programming language
- Is fluent in English and willing to write the Master’s thesis in English, due to the international supervision team
- Has an interest in the physical principles underlying sensor measurements (e.g., heat transfer and electrical conductivity)

WE OFFER

- Supervision by an interdisciplinary and international team of researchers involved in many scientific platforms with unique opportunities
- Access to unique calibration datasets, ecological data, and laboratory facilities
- Insight into real-world applications of environmental sensing and data analysis

Further details

Supervisors: Dr. Rémy Beugnon (University of Utrecht and Montpellier) and Dr. Simone Cesarz (iDiv, Leipzig University)

Your working place: Laboratory work will be conducted at iDiv in Leipzig and is expected to comprise approximately 50% of the project. Remote work will be possible thereafter.

Application

Please send a brief motivation letter and your questions to remy.beugnon@idiv.de and simone.cesarz@idiv.de
The start of the thesis is flexible, but the earliest starting date is **February 2026**.

Duration: approx. 6 months

First read:

Schnabel et al. 2025. Tree Diversity Increases Forest Temperature Buffering via Enhancing Canopy Density and Structural Diversity. *Ecology Letters*: 28, e70096 https://onlinelibrary.wiley.com/doi/10.1111/ele.70096

De Frenne et al. 2024. Ten practical guidelines for microclimate research in terrestrial ecosystems. *Method in Ecology and Evolution* 16: 269-294 https://besjournals.onlinelibrary.wiley.com/doi/10.1111/2041-210X.14476

Huang Y et al. 2023. Enhanced stability of grassland soil temperature by plant diversity. Nature Geoscience. https://doi.org/10.1038/s41561-023-01338-5

De Frenne et al. 2021. Forest microclimates and climate change: Importance, drivers and future research agenda. Global Change Biology 27: 2279–2297. https://doi.org/10.1111/gcb.15569