2 Years Post-Doctoral Position in Applied Physics
Simulating the freeze-thaw cycles within tree stems

INRAE presentation

The French National Research Institute for Agriculture, Food, and the Environment (INRAE) is a public research establishment. It is a community of 12,000 people with more than 200 research units and 42 experimental units located throughout France. The institute is among the world leaders in agricultural and food sciences, in plant and animal sciences, and is 11th in the world in ecology and environment. INRAE's main goal is to be a key player in the transitions necessary to address major global challenges. In the face of the increase in population, climate change, scarcity of resources and decline in biodiversity, the institute develops solutions for multiperformance agriculture, high quality food and sustainable management of resources and ecosystems.

Scientific Context

Freezing stress is the main factor setting plants distribution at high latitude and high elevation. Although species are currently adapted to their highest observed location, climate change is likely to re-shuffle their adaptive strategies facing climatic stress. For instance, earlier snowmelt is likely to increase plant exposure to critically low temperatures, winter drought and number of freeze-thaw (FT) cycles (Charrier et al. 2015). Considering that water balance is among the most critical factor delimiting species distribution at high elevation, we will explore the ability of four contrasted model species to suffer and repair FT induced embolism at high elevation and how it affects their growth ability. In temperate and alpine regions, plants have to withstand freezing

The project "Acoufollow" specifically focuses on embolism repair mechanisms (refilling) in the xylem, both in natura (elevational limit) and in controlled climatic chamber by relying on tools used and developed in the previous "Acoufreeze" ANR-FWF project (ultrasonic emission (UE), infrared thermography, thermocouples and dendrometer analysis). The general aim of this project is to investigate the dynamics and mechanisms of refilling in relation with highly variable environmental factors and the potential feedback on growth processes and frost risks in natural and controlled conditions.

Research Project

We hypothesize that concurring processes (latent heat release, volume increase, solutes upconcentration, cellular dehydration, gas bubble formation) occurring during freezing lead to local increase (pressure) or decrease (tension) in xylem sap water potential. These processes having different magnitudes across species and within the crown, would explain various responses to FT cycles. Furthermore, different refilling mechanisms combined with hysteresis between stress exposure and resilience are likely to explain various patterns across species.

In parallel with experiments, the objective of this project is to simulate the respective influence of the different hypothesized variables and mechanisms within a simple stem architecture. A stem presents a complex mechanical structure that induces different water flux along longitudinal and radial directions. We will simulate the freeze-thaw cycles within a simplified structure, although the underlying structure will be integrated through contrasted resistance to water fluxes with respect to the radial and the longitudinal directions from the estimates of resistances to water fluxes. Simulations will be carried out using the COMSOL multiphysics software, which is a general-purpose simulation software (https://www.comsol.eu). Different physical mechanisms will be handled by using dedicated modules of COMSOL: the heat transfer module that accounts for heat diffusion and phase change, and the structural mechanics module allowing wall expansion due to the water pressure. Based on this geometry and using such modules, we will analyze how putative mechanisms included in our conceptual frameworks could predict the observed xylem sap pressure patterns. He will perform numerical simulations to model the dynamics of local pressure in agreement with the experimental results obtained with the help of ecophysiologists.

Training & Skills

Degree required: Ph.D. in applied physics and modelling. The hired fellow will interact with two other post docs specialized in ecophysiology and dendrochronology and with a PhD student.
The profile sought is a research modeler in physics with skills in multiphase flow and heat transfer with an appetence for environmental science. Previous experience in model coupling would be appreciated. Knowledge the Comsol Multiphysics software is a plus, but is not required.

Location

UMR PIAF INRAE/UCA (https://www6.clermont.inrae.fr/piaf_eng/)

Funds

ANR ACOUFOLLOW project - AAPG2019 (Coll. Innsbruck University - Austria)

Time period

Two years contract starting before May 2021

Salary

Gross salary 2371-2919 €/month depending on experience, travel expenses related to project work will be fully covered.

- 30 days of annual leave + 15 days "Reduction of Working Time" (for a full time);
- parenting support: CESU childcare, leisure services;
- skills development systems: training, career advise;
- social support: advice and listening, social assistance and loans;
- holiday and leisure services: holiday vouchers, accommodation at preferential rates;
- sports and cultural activities;

To apply

Send your application to Marc Saudreau (marc.saudreau@inrae.fr) and Guillaume Charrier (guillaume.charrier@inrae.fr) as a single PDF file containing a single page cover letter describing your motivation to apply, a CV including relevant certificates, a publication list, and contact details of 2 potential referees. Review of applications will begin on February 15th 2021 and will continue until the position is filled.