Water storage on compliant plant leaves

Laboratory: Microfluidics Lab (https://www.microfluidics.uliege.be)
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Context

The interception of rainfall by the forest canopy critically affects the water cycle and, consequently, groundwater recharge, climate, and most ecosystems at the Earth surface. Therefore, it is crucial to determine water fluxes induced by canopy interception and to predict how they would evolve with climate change or modifications of land use. Though the canopy intercepts a large proportion of rainwater, only a fraction of it subsequently reaches the ground (as either splashed droplets, drips or stem flow) while the remainder ultimately evaporates. The storage capacity of a leaf, plant or tree is defined as the maximum amount of water that it can store. We may expect that this capacity depends on the compliance of the leafs: a compliant leaf bends in response to the water weight, and then water drains down and drips more easily. However, the exact relationship between storage capacity and leaf compliance is unknown.

Goal of the project

The goal of this project is to measure and model the relationship between storage capacity and leaf compliance.

Tasks and planning

Before mid-February, 2022, the student will:

1. read the following publications

  - W. Konrad, M. Ebner and A. Roth-Nebelsick, Leaf surface wettability and implications for drop shedding and evaporation from forest canopies, Pure and Applied Geophysics 169(5), 835-845 (2012)
  - Q. Xiao and E. G. McPherson, Surface water storage capacity of twenty tree species in Davis, California. Journal of Environmental Quality 45, 18s8-198 (2016);

2. make a dimensional analysis of the problem, develop a toy model of the leaf compliance, and identify the key design parameters;

3. design and fabricate artificial leaves with variable compliance (and other relevant parameters kept constant);

4. design and build an experimental setup that dispenses water on a leaf (The setup should measure both the weight of stored water and the deflection of the leaf);

5. calibrate the setup, acquire preliminary data, and check the capabilities and the experimental limits of the setup, as well as the reproducibility of results;

6. process the data (signal processing, and extraction/calculation of the relevant information) and evaluate error bars on the calculated quantities;

7. plan the experiments to be performed (list of parameters to be varied and associated range, variables to be measured); and

8. write a research proposal that summarizes the steps above.

Before mid-May, 2022, the student will:

1. improve the setup if needed;

2. acquire and process data according to the plan described in the research proposal;

3. interpret the experimental results, and possibly design a toy model that rationalizes the data;

4. make a poster to summarize the work.

The whole project (incl. proposal and poster) represents approximately 100 hours of work, including 10 full days in the laboratory.

Adaptation of the work plan in case students are not allowed in laboratories

The experiments will be adapted to be carried out from home.

Work environment

The experiments will be done at the Microfluidics Lab. Some instruments need to be booked in advance. The student will be informed of the lab rules on the first day of work.