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Controlled environment chamber system for gas exchange measurements: setup and operating principles

Mari Pihlatie (1,2,3), Tatu Polvinen (1,2), Lukas Kohl (1,2), Kaisa Rissanen (2), Toivo Pohja (4), Juho Aalto (2,4), Markku Koskinen (1,2,5)

(1) Environmental Soil Science, Department of Agricultural Sciences, University of Helsinki, Finland (mari.pihlatie@helsinki.fi), (2) Institute for Atmospheric and Earth System Research / Forest Sciences, Finland, (3) Viikki Plant Science Centre, University of Helsinki, Finland, (4) Institute for Atmospheric and Earth System Research / Physics, Hyytiälä forestry field station, Finland, (5) Finnish Meteorological Institute, Helsinki, Finland

Field-scale measurements rarely allow separating parallel processes behind gas exchange of plants or soil. There is an urgent need to construct controlled measurement setups to separate processes and their responses to environmental drivers. Such a setup allows for testing of e.g. dark-light-cycles, drought, freeze-thaw and different temperatures and CO_2 levels.

Important applications for controlled-environment setups include partitioning of emissions to different parts of plants and soil, parameter isolation, tracer tests, improvement of models and tests where easy access to different parts of the test subject is beneficial.

In this presentation we introduce a chamber setup that can be used for trace gas measurements under controlled environmental conditions. The system includes temperature, moisture and CO_2 control in the measurement chambers and PAR, temperature and relative humidity (RH) control of the general environment. The system can operate in either flowed-through or closed-loop setup. CO_2 concentration in the sample chamber is controlled with a mass flow controller and a PID algorithm.

In order to keep the measured objects under controlled conditions, we use a FITOCLIMA D 1200 plant growth chamber. To keep the measurement system safe for VOC-measurements, we use PTFE tubing and stainless steel connectors and valves.

The setup is tested for gas exchange from shoots and root-soil compartment of tree saplings. For shoot measurements, we use a rectangular chamber made of aluminium and transparent polyacrylic with a volume of 1 l. The chamber includes a small fan at one end to enable efficient mixing of air and a peltier cooling element to prevent temperature rise due to the light. The shoot is secured into place by a supporting frame with a fishing line bed. There is an LM-35 temperature sensor inside the shoot chamber. The chamber is hung inside the growth chamber with cords attached to each corner of the chamber so that its placement and stance can be precisely controlled.

We conduct soil gas exchange measurements using a chamber that is large enough to house the pot in which the sapling is placed. The chamber has vents that can be opened and closed using pneumatic actuators to enable ventilation between measurement cycles. Fans inside the chamber keep the air mixed. The chamber is also equipped with a temperature sensor.

Preliminary data from test measurements will be presented to demonstrate the applicability of the system, and to give more insight to the process-level understanding that such a setup can provide for the research community. The design and controlling software will be made freely available to the public.