Toheli - automatic chamber for soil CO_2 flux measurements

'Toheli' chambers were in use at SMEAR II in 2007-2020 for measuring soil CO_2 efflux and ground vegetation CO_2 uptake.

Technical information

The chambers were planned and constructed by Toivo Pohja, Juupajoki, Finland. The chamber cover is made of transparent PMMA (acryl). The thickness of the sides and UV-permeable cover plate is 6 mm and 3mm, respectively. The chamber is 250 mm in height of which 70 mm is aluminium collar. The ground area of the collar is 250 mm x 200 mm. There is sponge rubber seal between the cover and the collar.

Operation of each chamber is controlled with microcontroller box planned and constructed by Heikki Laakso. The chamber is opened and closed by a gear motor (Micromotors E192.24.625) or by compressed air (from 2009 on). Usually, the chamber was programmed to be open for 30 minutes and closed thereafter for 3 minutes. The data was collected with Nokeval serial transmitter. The system uses 12 V DC and consumes about 300 mA during opening and closing and 20 mA for the rest of the time.

In the chambers, there is a fan with a diameter of 25 mm and air temperature measurements. Vaisala CARBOCAP® Carbon Dioxide Probe GMP343 (Vaisala Oyj, Vantaa, Finland) enters the chamber through a hole on one side. The measurement signal is automatically corrected for temperature, but the oxygen, pressure and moisture corrections must be done afterwards (pressure affects the oxygen correction) according to Vaisala equations. The probes were calibrated monthly. In 2008 there were some technical difficulties, and all the sensors were sent for maintenance during which all the versions were updated from v4 to v7. New versions have been in use from early 2009. Note that the CO_2 correction equations for the different versions are slightly different. Depending on year and chamber, there was a varying set of other measurements too. Usually, they have an air humidity measurement (xx) and radiation sensors (Li-Cor 190SZ or photodiodes).

Locations and additional information

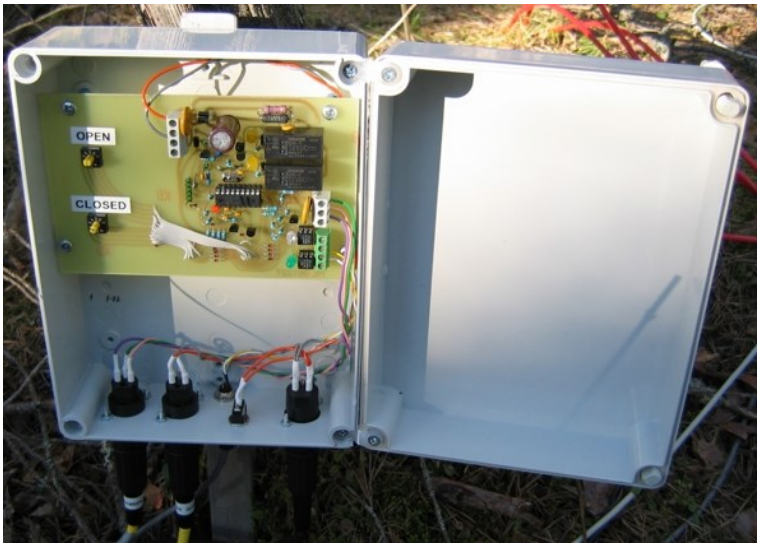
In 2008 and from 2010-05-18 on (chamber 2) or 2013-05-13 (all chambers), the chambers were fully darkened with aluminium cover. In 2007 and 2009 they were uncovered except for the time of manual CO_2 measurements every second week when the chambers were darkened for couple of hours.

In 2007 and 2008, there were two chambers. One of them (1; *.vsl, *.vch, *.lis, *.li1) was located on the top of the water catchment near the pit 100 and the light pole (valoharava). The other one (3; *.v2k, *.li3) was located near the dam of the big catchment near the pit 80 and next to the soil CO2 profile measurements. There were only mosses and sparse population of *Linnaea borealis* in the chamber1. In the chamber3, there was a dense population of lingonberry and some blueberry accompanied by *Polytrichum* moss.

In 2009, there were three chambers. The additional one (2) was located near pit 100. The data exists in the same file with the chamber 1 (*.li1). Wavy hair grass dominated the vegetation in the chamber.

In 2010, there were three chambers. They were located at the catchment area (near pit80 and pit100) exactly as they were in 2009. Toheli 2 was opaque, others were transparent. All of the chambers contained measurements of PAR, air and soil temperature, relative humidity, and CO2 concentration (RH missing from 2 and some problems with 3 have occurred).

The height of the chambers 1/2/3 were 0.20 cm + 0.030/-/0.020 cm; 0.030/-/0.020; 0.022/0.012/0.024cm and 0.0373/0.0419/0.0397 cm in the summers 2007-2010, respectively.



Specifications of photodiodes

Manufacturer: EG & G VACTEC, product no VTB8440BH

* PHOTODIODE, IR FILTERED

* Typ Wavelength: 580nm
* Half Angle: 50°
* Dark Current: 2nA
* Diode Case Style: Top View
* No. of Pins: 2
* Operating Temperature Range: -20°C to +75°C
* Breakdown Voltage: 40V
* External Depth: 1.8mm
* External Length / Height: 6mm
* External Width: 8mm
* Max Voltage Vr: 40V
* Peak Wavelength: 580.00nm
* Active Area: 5.16mm²
* Case Style: Flat Top
* Diode Type: Photodiode
* Max Spectral Range: 720nm
* Min Spectral Range: 330nm

http://fi.farnell.com/eg-g-vactec/vtb8440bh/photodiode-ir-filtered/dp/1182340

Specifications of RH sensors

Manufacturer: HONEYWELL S&C, product no HIH-4000

* SENSOR, HUMIDITY, 1.27MM, SIP
* Sensing Accuracy: 3.5%
* Humidity Range: 0% to 100%
* Output: Analog Voltage
* Sensor Terminals: Pin
* Response Time: 15s
* Supply Voltage Range: 4V to 5.8V
* Operating Temperature Range: -40 °C to +85°C
* Accuracy: 3.5
* Measuring Range: 0 to 100%
* Supply Current: 500µA
* Supply Voltage: 5.8V dc
* Contact Configuration: 1.27mm (0.050 in) Lead Pitch
* External Depth: 2.03mm
* External Length / Height: 22.17mm
* External Width: 4.27mm
* Humidity Measuring Ranges: 0 to 100%
* Hysteresis: 3%
* Lead Spacing:1.27mm
* Max Operating Temperature:85°C
* Max Supply Voltage:5.8V dc
* Min Supply Voltage:4.0V dc
* Min Temperature Operating:-40°C

* No. of Pins:3
* Percentage Accuracy:3.5%
* Repeatability:0.5%
* Series:HIH4000

http://fi.farnell.com/honeywell-s-c/hih-4000-002/sensor-humidity-1-27mm-sip/dp/1187548

Raw data files

*.li1 files

1 Timestamp yyyymmddHHMMSS
2 Chamber1 CO2 ppm (korjaukset puuttuu)
3 Chamber1 open/closed auki ~ 270, kiinni ~ 4.8 mV
4 Chamber1 T air °C
5 Chamber1 T ground °C
6 Chamber1 PAR 1 mV
7 Chamber1 PAR 2 mV
8 Chamber1 RH mV
9 Chamber1 T (RH-sensorin lämpötila, ei toimi)
10 Chamber2 CO2 ppm (korjaukset puuttuu)
11 Chamber2 open/closed auki ~ 1222, kiinni ~ 5 mV
12 Chamber2 T air °C
13 Chamber2 T ground °C
14 Chamber2 PAR 1 mV
15 Chamber2 PAR 2 mV
16 Chamber2 RH mV (ei ole toiminut)
17 Chamber2 T (RH) (ei ole toiminut)

*.li3 tiedoston sarakkeet
1 Aika yyyymmddhhmmss
2 Chamber3 CO2 ppm (korjaukset puuttuu, signaalihäiriöitä)
3 Chamber3 open/closed auki ~ 272, kiinni ~ 5.9 mV
4 Chamber3 T air °C
5 Chamber3 T ground °C
6 Chamber3 PAR 1 mV
7 Chamber3 PAR 2 mV
8 Chamber3 RH mV
9 Chamber3 T (RH-sensorin lämpötila, ei toimi)

PARit saa mikromol m-2 s-1, kun kertoo satasella. Nämä on mitattu sellaisilla halpisdiodeilla, eli kovin suurta absoluuttista tarkkuutta ei voi odottaa. PAR-anturissa nollataso ei aina ole kohdallaan.. Näkee kyllä datasta, kun öisin on "negatiivista säteilyä".

RH mittaa alueella 7-45 mV (0-100%). Tämäkään ei ole markkinoiden hienoin anturi, öisin mennään usein pari prosenttia yli sadankin yms.

Hiilidioksidi on paine-, RH- ja happikorjaamatonta.