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Meeting the Challenge of Outdoor Carbon Dioxide Measurements

The recently launched Vaisala CARBOCAP® Carbon Dioxide Probe GMP343 has been especially developed for use in harsh outdoor environments. Thanks to its rugged design, the probe can be used in a number of ecological measurement applications without the need for any additional protection or shelter. Examples of such important applications are soil respiration chambers and outdoor ambient carbon dioxide measurements. For these two main applications the GMP343 offers an exciting, new measurement approach.

Figure 1. The soil respiration chamber and the measurement set up for the trial measurements conducted at the Hyytiala Forestry Field Station in Hyytiala, Finland.

Soil chamber measurements

There are many types of chambers that can measure carbon dioxide flux from soil. A soil chamber is basically a bottomless box, which can be placed tightly over the soil surface. Generally, chambers can be divided into portable and fixed designs. Furthermore, both portable and fixed chambers can be made either of transparent or non-transparent material. The choice depends on whether the chamber will be used for the measurement of pure soil CO_2 respiration or if the effect of photosynthesis is also under study. On a more detailed level, it is also possible to distinguish between several different subtypes of boxes depending on the sampling technique used.

The Department of Forest Ecology at the University of Helsinki has used the Vaisala CARBOCAP® Carbon Dioxide Probe GMP343 in a specially developed cylinder shaped, portable soil respiration chamber made of transparent plastic (Figure 1). The GMP343 carbon dioxide probe and a Vaisala HUMICAP® Humidity and Temperature Probe HMP75 were fitted to the top of the cylindrical chamber so that CO_2 + RH + T data can be logged with a Vaisala Measurement Indicator MI70. A small battery driven computer fan was used to mix the air inside the chamber. A pump aspi-

Figure 2. Daytime net gas exchange of soil with main vegetation of blueberry (Vaccinium myrtillus) using the cylindrical soil chamber at the Hyytiala Forestry Field Station in June 2004. The raw output signal of the GMP343 is logged once per second.

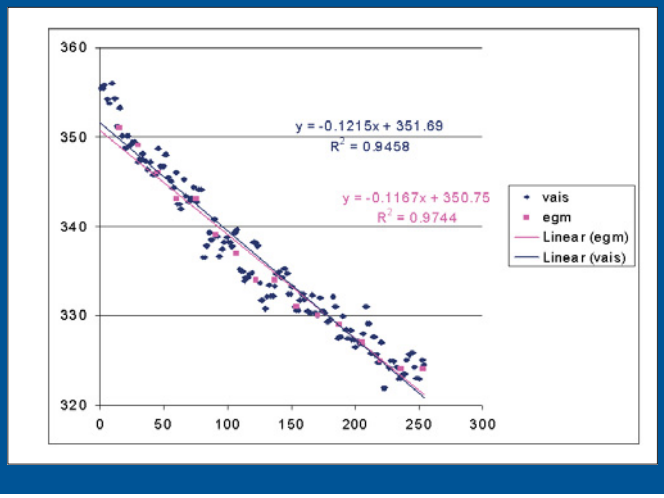
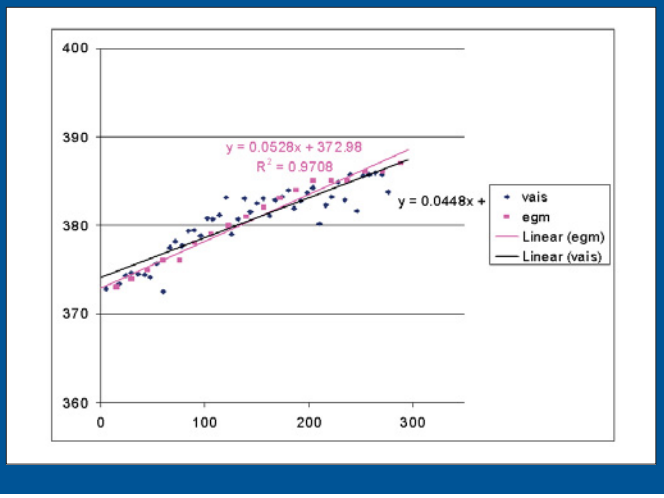


Figure 3. Daytime net gas exchange of soil with main vegetation of lingonberry (Vaccinium vitis-idaea) using the cylindrical soil chamber at the Hyytiala Forestry Field Station in June 2004. Five minutes of logging of the GMP343. The signal is an average of the three last measurements. The logging interval is 5 seconds.



rated EGM-3 Gas Monitor was used as a reference instrument. Solar radiation was not measured in conjunction with the chamber, this information was instead obtained from the test site's fixed radiation sensors. More than one thousand measurements were carried out in order to make as many soil respiration measurements as possible during the short Finnish growing season. An other aim ofthe measurements was to get practical experience in using the new GMP343 with it's accessories.

Figures 2 and 3 illustrate the results of a few of the many soil respiration chamber measurements made at the Hyytiala forestry field station in Finland. More on the soil properties and vegetation type can be found from http://honeybee.helsinki.fi/HYYTIALA/english.htm.

As can be observed from Figures 2 and 3, the GMP343 is suitable for soil chamber measurements, despite the fairly large raw data noise. If desired, this noise can be reduced by using one or several of the three built-in numerical filtering algorithms. According to the researchers of the University of Helsinki the GMP343, HMP75 and MI70 setup has been really user-friendly compared to the reference instrument. In this set up, the batteries in the MI70 indicator provide power to both probes for up to 6 hours of field use.

The RH and T measurement in the soil chamber measurement is used for two purposes:

1. to provide a quality assurance test that the temperature during the chamber measurement will not increase to the level that it would have a considerable impact on the rate of photosynthesis;

2. to link the RH data to the GMP343 so that an active humidity compensation of the CO_2 measurement can be achieved.

Also the water flux can (if desired) be measured with the RH and T probe.

Ground based carbon dioxide background measurements

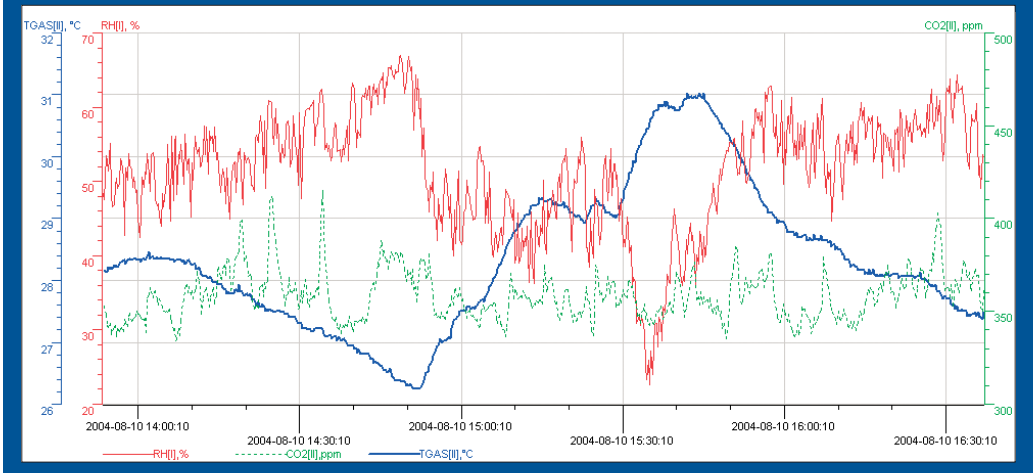
Because of its capabilities to withstand harsh outdoor environments without special protection or shelters around the probe, the Vaisala CARBOCAP® Carbon Dioxide Probe GMP343 is suitable both for long and short term ambient CO_2 measurements. The low power consumption of GMP343 is an advantage particularly for measurements in remote locations. Also, the low power consumption of GMP343 is an advantage. With additional communication equipment, the carbon dioxide probe can easily be powered by a solar panel based 12V battery system.

Good long term stability and good temperature stability are essential in background CO_2 measurements. This is especially important at remotely located measurement sites, where frequent maintenance support is difficult or expensive to organize. Because of the true internal reference measurement, the stability of the GMP343 is better than in many other carbon dioxide instruments on the market. Although expensive laboratory analyzers definitely have better repeatability, the GMP343 can still be used for background measurements, thanks to its good long term stability. By suitable numerical filtration the GMP343 can produce a repeatability at ambient around ±0.7 ppmCO_2.

Although the GMP343 is quite new, the same sensing technology has been successfully used for long in other Vaisala CARBOCAP® products. In addition, the GMP343 has been tested in accordance with a comprehensive qualification testing program. Furthermore, beta units were installed outdoors and run at Vaisala's test yard last winter. This field trial showed that the new instrument works well in the cold and occasionally very humid winter climate of Southern Finland.

Also short-term background measurements have been carried out with the GMP343. This kind of short term measurement are most conveniently done and logged using the Vaisala MI70 Measurement Indicator. Figure 4 represents the results of one such measurement.

Figure 4. Short term outdoor CO_2 + RH + T data logging made with the GMP343, HMP75 and MI70 set up at the Hyytiala Forest Field Station at the side of a grass covered field. Note the large variations in the background CO_2 concentration, which are due to soil respiration and variable wind conditions. In this case the CO_2 concentration varies more than ±50ppm from the current average background concentration.



Other applications

Two main applications for the new Vaisala CARBOCAP® Carbon Dioxide Probe GMP343 have been described and discussed. A large portion of the manufactured units are expected to be used in these two applications.

Several other potential applications exist for the GMP343, both ecological and non-ecological. These will be addressed in future issues of Vaisala News. ●