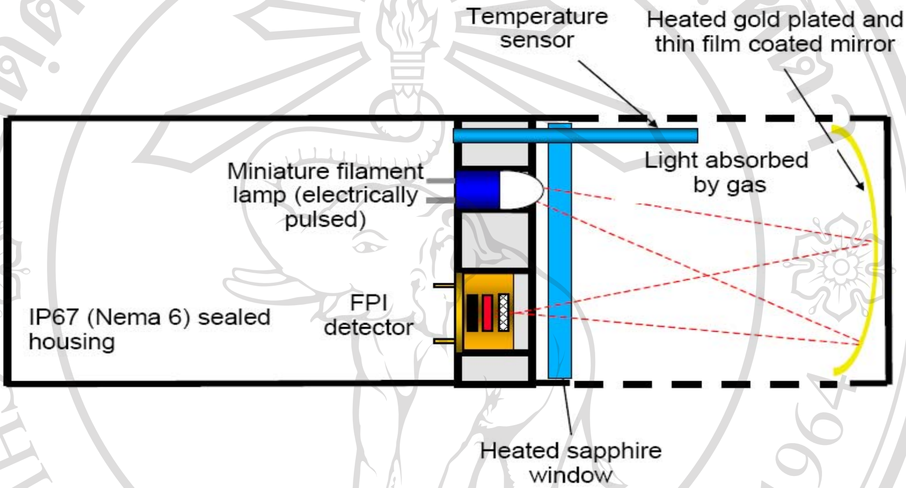
APPENDICES

APPENDIX A Vaisala CARBOCAP® Carbon Dioxide Probe GMP343

A new generation of commercially available sensors enables simple and reliable *in situ* measurements of CO_2 concentration. Vaisala CARBOCAP® Carbon Dioxide Probe GMP343 (Vaisala Corp., Vantaa, Finland) is designed for high accuracy CO_2 measurements. The measurement is based on the advanced CARBOCAP® Single-Beam Dual Wavelength non-dispersive infra-red (NDIR) technology. Here the pulsed light from the miniature filament lamp is reflected and re-focused back to a Infra-Red (IR) detector, which is in front of silicon-based Fabry-Perot Interferometer (FPI). This tiny FPI is tuned electrically so that its measurement wavelength is changed between the absorption band of the CO_2 gas and a reference band. Because of this a true reference measurement, and, therefore, a stable CO_2 measurement can be obtained. When the passband of the FBI coincides with the absorption wavelength of the CO_2 gas, the IR detector sees a decrease in the light transmission. The measurement wavelength of the FPI is then changed to the reference band (that has no absorption lines) and the IR detector sees a full light transmission. The ratio of these two signals indicates the degree of light absorption in the gas and is proportional to the gas concentration. Only a single IR detector is used for measuring both the absorption and the reference bandwidths, which eliminates the errors commonly present in NDIR sensors with two IR detectors. The true reference measurement enables good stability of the sensor both in terms of time, and temperature. It is worth emphasizing that the temperature stability results also in good stability with flow, which is an important feature, especially in diffusion based sensors.

Although the basis of the measurement technology of GMP343 is the familiar Vaisala CARBOCAP® sensor, the NDIR bench in GMP343 is more advance resulting in improved performance and durability.



Appendix Figure 1 The structure of the GMP343.

The structure of the Vaisala CARBOCAP® Carbon Dioxide Probe GMP343 is presented in Fig. 1. It differs from Vaisala CARBOCAP® carbon dioxide sensors in the following ways:

- the sample cell is open in order for the gas to move freely through the sensor by means of diffusion;
- the light source and the FPI/ detector are both located at the same end of the sample cell, in the same space with the electronics behind a heated sapphire window, inside an IP67/ Nema 6 housing;

- on the opposite side of the sample cell there is a gold plated, specially coated focusing mirror, the mirror can also be heated, and;
- a sensor measuring the gas temperature is located in the sample cell.

Compare with conventional analyzer type of carbon dioxide instruments. The Vaisala CARBOCAP® Carbon Dioxide Probe GMP343 has the following advantages:

- cost efficient;
- diffusion based sampling;
- low power consumption;
- can be used in harsh environments;
- good long term stability;
- small size and weight;
- excellent possibilities for performance optimization, as well as
- no additional power supply is need when used with an optional portable indicator/ datalogger.

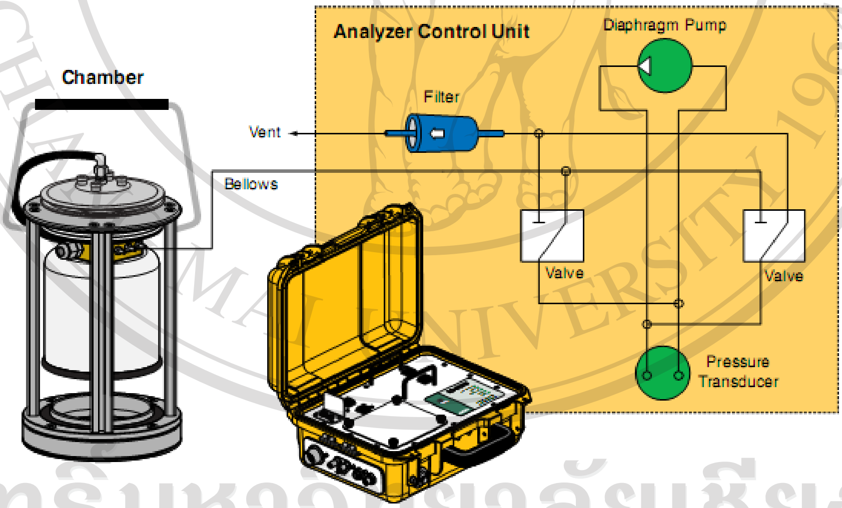
The diffusion based sampling is a welcome alternative in many ecological applications, especially in cases where the pump sampling can create problems or even errors in the measurement. For instance, in soil chambers, the pump sampling can sometimes generate under-pressures that accidentally increase the CO_2 flux from the soil. The main advantage of a diffusion-based sensor is however that it is less complex, less power consuming and requires less maintenance.

The low power structure of this sensor has also its down sides. The peak-to-peak noise of GMP343 is rather large, mainly because of the low power light source and the thermopile detector used in the system. However, if the response time is not critical, output noise can be reduced with the built-in filtering algorithms.

Although the GMP343 probe has advanced built-in pressure and humidity compensation algorithms, the probe dose not to contain a pressure or humidity sensor. However, not all measurement applications need active pressure and humidity compensations since the pressures and humidity remain reasonably constant throughout the measurement. And in cases where active compensation is required, pressure or humidity data is many times already available, and if so, this data can easily be linked to the compensation algorithms available in the GMP343 (http://www.vaisala.com).

APENDIX B Li-8100 System Automated Soil CO_2 Flux Measurements

The LI-8100 is a fully automated system dedicated to making measurements of flux. The analyzer in the Li-8100 is an absolute, non-dispersive infrared (NDIR) gas analyzer with a single path, dual wavelength detection system. The optical bench provides a CO_2 measurement range of 0-3000 µmol/mol and an H_2O measurement range of 0-80 mmol/mol. Pressure compensation and temperature regulation of the optical bench minimize zero and span drift. The optical path can be removed and cleaned by the user if necessary, without requiring factory recalibration.



Appendix Figure 2 Schematic showing path of air flow between chamber and console.

The system is designed for continuous and unattended long-term measurements to obtain the high temporal resolution of soil CO_2 efflux when used with a 20-cm long-term chamber. The long-term chamber moves completely away from the soil measurement area when a measurement is not in progress to ensure that the moisture and temperature of the soil within the measurements collar are similar to the surrounding soil. Li-8100 also support rapid survey measurements when used either with a 10-cm or with a 20-cm survey chamber. The Li-8100 survey chamber designed to minimize environmental perturbations by operating with a unique pneumatic system that contact and expand a bellows to rise and lower the chamber over the soil.

The Li-8100 is a non-steady state, transient system (i.e., closed dynamic system). The flux is estimated by calculating the initial slope of a fitted exponential curve at the ambient CO_2 concentration. This is done to minimize the effect resulting from the altered CO_2 concentration gradient across the soil surface after the chamber is closed. The Li-8100 has a novel feature to prevent pressure differences between the inside and outside of the chamber. Major features include:

- continuous, unattended long-term measurements;
- both survey and long-term chambers close automatically, eliminating variations caused by manual chamber placement;
- new patent-pending pressure vent design minimizes pressure pulses at chamber closing, and allows chamber pressure to track the ambient pressure under calm and windy conditions;
- CO_2 flux rate is calculated at the CO_2 concentration of the surrounding ambient air. This minimizes effects resulting from the necessary increase in chamber CO_2 concentration during a measurement;
- a bowl-shaped chamber provides good mixing without using fans, thus eliminating potential for chamber pressure perturbation;
- air flow is generated by a rotary pump that provides a steady, consistent air flow with much lower pulsations than ordinary diaphragm pumps;

- temperature artifacts are minimized by careful consideration of materials and coatings;
- the perforated baseplates of the Long-Term Chambers minimize perturbations to the soil environment around the chamber, including the prevention of a concentration gradient-induced impedance of soil CO_2 efflux (http://www.licor.com).

CURRICULUM VITAE

Name: Natchaya Pingintha

Birth: 26 June 1980, Chiang Mai, Thailand

Academic records:

Qualification	Area of Concentration	Year	Institution
Ph. D. candidate	Agronomy†	2002-present‡	Chiang Mai University
B.S. (Agriculture)	Horticulture	1998-2001	Chiang Mai University
First Class Honors			
High School		1995-1997	Dara Academy

† Thesis title "Effect of Drought on Carbon Dioxide Exchange in Peanut Field"

‡Examination expected September 2009

Other training:

2005-2009 Conducted the research at Laboratory for Environmental Physics, Crop and Soil Science Department, The University of Georgia, Griffin Campus, Georgia, USA.

2008 Short course on Scintillometry at Scintec Corporation, Alpharetta, Georgia, USA. (November 6)

Scholarship and awards:

2009	Received the supporting fund from National Peanut Board, Georgia, USA. (January 1-December 31)
2008	Received the 2008 American Meteorological Society Award for Best Student Paper, 2nd place at the 28th Conference of Agricultural and Forest Meteorology Conference in Orlando, Florida, USA. April 28-May 2
2007	Received the supporting fund from Georgia Peanut Commission, Georgia, USA. (January 1-December 31)
2007	Received the supporting fund from National Peanut Board, Georgia, USA. (January 1-December 31)
2005-2009	Received the supporting fund from Prof. Monique Leclerc, Laboratory for Environmental Physics, Crop and Soil Science Department, The University of Georgia, Griffin Campus, Georgia, USA.
2003-2009	The Royal Golden Jubilee-Ph. D. Research Scholarship (RGJ) of The Thailand Research Fund, Thailand
2002	Received the Silver Medal Prize for Academic Achievement from Chiang Mai University
2001	Received the Bronze Medals for Academic Achievement from Chiang Mai University
2000	Received the Annual Bronze Medals for Academic Achievement from Chiang Mai University
1999	Received the Annual Bronze Medals for Academic Achievement from Chiang Mai University

Work experiences:

2007-2009 Field Supervisor of undergraduate students and Ph. D. student. Field Coordinator in the Lab for Environmental Physics, Crop and Soil Science Department, The University of Georgia, Griffin, USA

2005-2009 Research Assistant in the Lab for Environmental Physics, Crop and Soil Science Department, The University of Georgia, Griffin, USA

2003-2004 Teaching Assistant in the department of Agronomy, Faculty of Agriculture, Chiang Mai University, Chiang Mai, Thailand

Publications and paper:

Leclerc, M.Y., Holland, B., Foken, T., Pingintha. N. (2009) Sustainability of Gaia: A Question of Balance: Climate Change and Sustainable Growth. Oxford Press, in press.

Pingintha, N., Leclerc, M.Y., Beasley, J.P., Zhang, G., Senthong, C. Assessment of the soil CO_2 gradient method for soil CO_2 efflux measurements: comparison of six models in the calculation of the relative gas diffusion coefficient (accepted for published in Tellus Series B-Chemical and Physical Meteorology).

Pingintha, N., Leclerc, M.Y., Beasley, J.P., Zhang, G., Senthong, C. Hysteresis Response of Daytime Net Ecosystem CO_2 Exchange during a Drought (submitted to Bigeosciences).

Pingintha, N., Leclerc, M.Y., Beasley, J.P., Zhang, G., Senthong, C. (2009) The influence of drought on net ecosystem CO_2 exchange in the southeastern US.

A paper presented at AGU Fall Meeting, December 14-18, 2009, San Francisco, California, USA.

Pingintha, N., Leclerc, M.Y., Beasley, J.P., Zhang, G., Senthong, C. (2009) Assessment of the soil CO_2 gradient method for soil CO_2 efflux measurements. A paper presented at the 2009 ASA-CSSA-SSSA Annual Meetings, November 1-5, 2009, Pittsburgh, Pennsylvania, USA.

Pingintha, N., Leclerc, M.Y., Beasley, J.P., Zhang, G., Senthong, C. (2009) Hysteresis Response of Daytime Net Ecosystem CO_2 Exchange during a Drought. A paper presented at the Ameriflux Principal Investigator Workshop, September 20-23, 2009, Washington, D.C., USA.

Pingintha, N., Leclerc, M.Y., Zhang, G., Beasley J.P., Senthong, C. (2008) Assessment of the soil CO_2 gradient method to measure soil CO_2 efflux in an agricultural ecosystem. A paper presented at AGU Fall Meeting, December 15-19, 2008, San Francisco, California, USA.

Pingintha, N., Leclerc, M.Y., Zhang, G., Beasley J.P., Senthong, C. (2008) Assessment of the soil CO_2 gradient method to measure soil CO_2 efflux. A paper presented at Ameriflux Annual Meeting, October 15-17, 2008, Boulderado Hotel, Boulder, Colorado, USA.

Pingintha, N., Leclerc, M.Y., Beasley, J. P., Hong, J., Zhang, G., Dias, N.L., Senthong, C. (2008) Environmental Controls on the CO_2 Exchange in a Peanut Field. A paper presented at 28^{th} Conference on Agricultural and Forest Meteorology, April 28- May 2, 2008, Orlando, Florida, USA.

Pingintha, N., Leclerc, M.Y., Zhang, G., Hong, J., Karipot, A., Beasley, J. P., Rowland, D., Senthong, C. (2008) Measurement of CO_2 Exchange in a Peanut

Field: Response to Temperature and Soil Moisture. A paper presented at the Southern Branch Annual Meeting, February 2-5, 2008, Dallas, Texas, USA.

Pingintha, N., Chayawat, C., Hong, J., Leclerc, M.Y. (2007) Soil Respiration and Environment by Luo, Y. and Zhou, X., Book Review, Agricultural and Forest Meteorology 144:243-244.

Xiaofeng, G., Chayawat, C., Pingintha, N., Zhang, G., Leclerc., M.Y. (2007) Flux-variance method to estimate the heat, water and carbon exchange under convective conditions. A paper presented at Ameriflux Annual Meeting, October 17-19, 2007, Boulderado Hotel, Boulder, Colorado , USA.

Pingintha, N., Chayawat, C., Hong, J, Leclerc. M.Y. (2006) Measurement of CO_2 nocturnal respiration as an indicator of stress responses in peanut. A paper presented at the Academy of the Environment. 23-24 October 2006, The Georgia Center of Continuing Education , University of Georgia, Athens, Georgia, USA.