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Contents

Report of the “International Conference on Global Change, Forest Adaptation and CO_2, Water and Energy Flux Monitoring”

Po-Neng Chiang[1], Ya-Nan Wang[1,2], Tsong-Huei Wey[1], Yen-Jen Lai[1] and Ming-Jer Tsai[1,2]

[1]The Experimental Forest, National Taiwan University, Taiwan
[2]School of Forestry and Resource Conservation, National Taiwan University, Taiwan

Since Kyoto protocol assessment, Taiwan has made every effort to continuously participate in international conferences about CO_2 issue. Conference on Global Change, Forest Adaptation and CO_2, Water and Energy Flux Monitoring was held on 18 December, 2012 at Experimental Forest, National Taiwan University, Taiwan. This was the third meeting following the first two meetings held in 2008, and 2010. “Conference on Global Change, Forest Adaptation and CO_2, Water and Energy Flux Monitoring” was aimed to gather researchers studying flux and adaptation in the forest, such as CO_2, water, and methane monitoring and modeling. Over 100 scientists and staff from Japan, New Zealand, and Taiwan participated in the conference (Fig.1). We had 8 oral presentations in the conference. The presentation titles are listed below:

FLUXNET-GHG and the current activities of AsiaFlux on non-CO_2 gas flux measurement by Akira Miyata (Japan)

Greenhouse gas emissions resulting from intensive dairy farming by John Hunt (New Zealand)

An automated-chamber network to evaluate carbon budget of Asian terrestrial ecosystems by Nai-Shen Liang (Japan)

Fig. 1. Memorial Photo of the Conference in Xitou, Taiwan

Surface fluxes of a subtropical broadleaf forest at the Lien-Hua-Chih experimental watershed in central Taiwan by Ming-Hsu Li (Taiwan)

Soil respiration dynamic in subtropical old-plantation forest by Po-Neng Chiang (Taiwan)

Preliminary evaluation of the energy balance closure results of the Xitou flux site by Yen-Jen Lai (Taiwan)

Climate Change and Carbon Flow to *Mycorrhizal* Fungi by Teramoto Munemasa (Japan)

Quantifying biosphere- atmosphere interactions at a subtropical estuarial grass marsh ecosystem by Jehn-YihJuang (Taiwan)

In the afternoon, participants visited Xitou Educational Area and Xitou CO_2 flux towers managed by Experimental Forest, National Taiwan University. They look around tower instruments and soil chambers. In the end of the conference, all moderators and presenters had general discussion and summaries. After conference, a field trip to Pingdong flux tower site, which is located on southern Taiwan, was held on 19 December. We introduced the site information and facilities and had well discussion (Fig. 2).

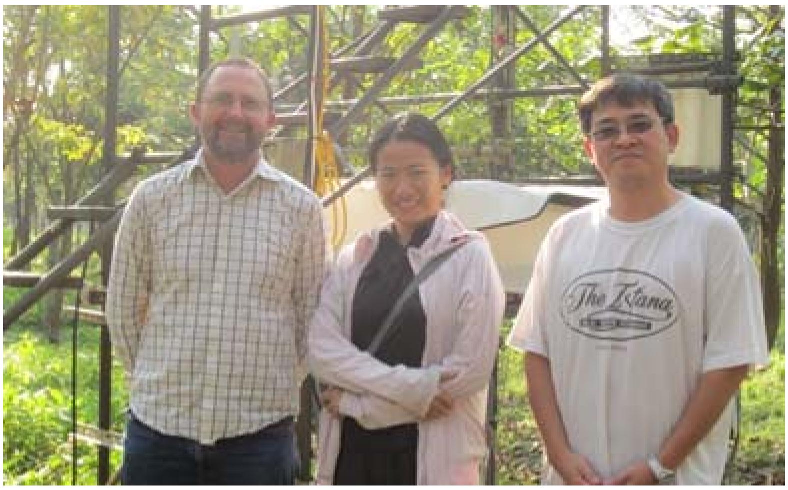

Fig.2. Visiting Pingdong flux tower in southern Taiwan

An Automated-Chamber Network for Evaluation of Carbon Budget of Asian Terrestrial Ecosystems

Naishen Liang[1], Y. Wang[2], Y. Zhang[3], J. He[4], S. Li[5], S. Piao[4], J. Fang[4], T. Hirano[6], K. Takagi[6], C.D. Fletcher[7], M. Teramoto[1], Z-H. Tan[1]

[1] CGER, National Institute for Environmental Studies; [2] National Taiwan University; [3] XTBG, Chinese Academy of Sciences ; [4] Peking University; [5] IGSNRR, Chinese Academy of Sciences; [6] Hokkaido University; [7] FRIM, Malaysia

1. Introduction

The world's soils contain about 1,550 Pg of organic carbon, which is more than twice the amount in the atmosphere (IPCC, 2007). On the other hand, the soil respiration, the second-largest terrestrial carbon flux after gross primary production (GPP), from global terrestrial ecosystems was estimated to be 98 ± 12 Gt C in 2008, of which 13%, 20% and 67% are contributed respectively by boreal, temperate and tropical ecosystems. Moreover, between 1989 and 2008, the global soil respiration increased by 0.1 Gt C yr^{-1}, which is about 10% of global terrestrial carbon sink (Bond-Lamberty and Thomson, 2010; IPCC, 2007). Furthermore, by using a process model (CASA), the annual global heterotrophic respiration was estimated to contribute about 71% of total soil CO_2 efflux (Potter and Klooster, 1998). Therefore, relatively small change in the carbon flow into or out of soils can potentially strongly influence the global cycles of carbon, nitrogen, and water. To date, most of the carbon-climate models employ exponential functions to predict heterotrophic respiration with a Q_{10} of about 2.0. In these models, global heterotrophic respiration increases exponentially with climate warms at an average rate of 6.2% per degree, and resulting in that the current carbon sink of terrestrial ecosystems probably shift to a carbon source after 2050. It has been reported that positive feedback from enhancement of heterotrophic respiration by global warming would raise the CO_2 concentration in the atmosphere by 20-224 ppm by 2100, and that these higher CO_2 levels would lead to an additional temperature increase ranging between 0.1 and 1.5 °C (Friedlingstein et al., 2006; IPCC, 2007). However, modeling prediction is very difficult to validate using measurements because soil respiration is highly spatially and temporally variable.

2. A multichannel automated chamber system

Soil respiration is usually measured with chamber-based techniques. Liang et al. (2003) designed a multichannel automated chamber system (multichannel LAC) that applied a steady-state technique to measure soil respiration throughout four seasons. However, the pressure inside the chamber is 0.22 Pa higher than that outside the chamber, which is likely to lead to underestimation of the actual R_s (Fang and Moncrieff, 1998). Therefore, we modified and improved this system using a flow-through, non-steady-state design (Liang et al., 2010). In brief, the multichannel LAC consists of a control unit that is a field access case, and 12 to 24 automated chambers. The main components of the control unit include a micro infrared gas analyzer (IRGA), a data-logger, two valve manifold (LAC-FL451959, CKD Corp., Komaki, Aichi, Japan). Based on the number of chambers to be equipped, the control unit can be assembled with either a small water-proofed plastic case (53 m long ×43 m wide ×21 cm high; 1550, Pelican Products, Inc., Torrance, CA, USA) for maximum 12 chambers (LAC-12G, National Institute for Environmental Studies (NIES), Tsukuba, Japan), or an aluminum case (60 m long × 40 m wide × 40 m high; SS8800; Daito Co.Ltd., Tokyo, Japan) for maximum 24 chambers (LAC-SW024, NIES) (Fig. 1). Based on the study objective and funding availability, the control unit of LAC can adopt the IRGA such as LI-840 or LI-820 (LI-COR, Lincoln, NE, USA), PGA (ADC BioScientific Ltd., Hoddesdon, England), or a modified (pressure and temperature compensation) micro CO_2 module (K30FR, SenseAir AB, Delsbo, Sweden) (Fig. 2). The standard automated chambers (90 cm long ×90 cm wide × 50 cm tall) are constructed of clear acrylic plastic sheets (1-2 mm thick) glued to an aluminum frame (Fig. 3). Between measurements, the two sections of the chamber lid are raised to allow precipitation and leaf litter to reach the enclosed soil surface, thus keeping the soil conditions as natural as possible. The chamber lids are raised and closed by two pneumatic cylinders (LAC-G90, CKD Corp.,

Fig.1. Control units of the multichannel automated chamber system. a: the unit for equipping maximum twelve chambers; b: the unit for equipping maximum twenty four chambers.

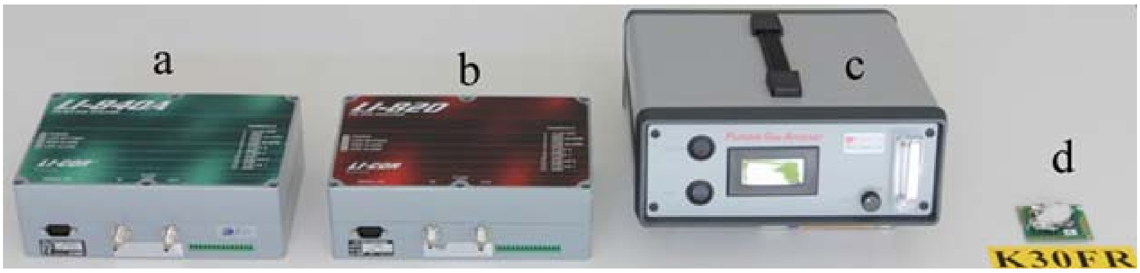

Fig.2. Non-dispersive infrared CO_2 analyzers can be used by LAC. a: LI-840 (Li-Cor); b: LI-820 (Li-Cor); c: PGA (ADC); d: K30FR (SenseAir).

Fig.3. The standard automated chamber of LAC.

Fig.4. Image of solar power for LAC.

Hitachi Industrial Equipment Systems Co.,Ltd., Tokyo, Japan). During the measurement, the chamber is closed and the chamber air is mixed by two micro fans (MF12B, Kyoei Tsushin Ltd., Tokyo, Japan). The chamber air is circulated through the IRGA by a 5 L min-1 diaphragm pump (CM-50, Enomoto Micropump Ltd., Tokyo, Japan), and the change in the CO_2 concentration is measured by the IRGA. Open and close of the chambers are controlled by a home-made relay board that is programmed by the datalogger (CR1000, Campbell Scientific Inc., Logan, UT, USA). The average power consumption of the whole system is about 13 W; thus the system can be continuously driven by three 125-W solar cells coupled with three 120-A·h deep-cycle batteries (Fig. 4).

Fig.5. A portable LAC used in a Malaysian tropical forest (left) and a portable LAC equipped with two transparent automated chambers (right) used in a Malaysian rubber plantation.

3. A portable automated chamber system

Based on the above multichannel LAC, we have been developing a portable automated chamber system (portable LAC), mainly for characterizing the spatial variation of soil respiration (Liang, 2006; Yao et al., 2012). In brief, the portable LAC has a flow-through, non-steady-state design, and comprises a portable control unit and 2 portable automated chambers (Fig. 5). The control unit is assembled with a water-proofed plastic case (53 m long ×43 m wide ×21 cm high; 1550, Pelican Products, Inc.) that comprises with a micro IRGA, a data-logger, and a home-made relay board. For measuring soil respiration, the cylinder-designed chambers (30 cm in diameter by 30 cm in height) are constructed by 3 mm thick aluminum. However, for measuring net ecosystem productivity (NEP) of ecosystems with short vegetation (such as grassland), the transparent chambers with medium size (50 cm long ×50 cm wide × 50 cm tall) are equipped (Fig. 5b). The portable LAC can continuously work for minimum 15 hours with an internal Li-ion battery (GT5, G-Tech Ltd., Tokyo, Japan). The chamber lid is raised and closed by a pneumatic cylinder (LAC-G50, CKD Corp.) at a pressure of about 0.2 MPa from a 5 L aluminum tank that is assembled inside the control unit. The high pressure air is generated by a micro air compressor (LAC-Com10, Maxway Electric Industrial Ltd., Taoyuan, Taiwan) that can be powered either by the internal Li-ion battery or by the cigarette power of car (Fig. 6). In addition, soil temperature and soil moisture are monitored using an E-type thermocouple probe (MHP, Omega Engineering, Stamford, USA) and TDR sensor (SM150, Delta-T Devices Ltd.), respectively.

4. Partitioning of CO_2 budget at forest floor

The multichannel LAC is initially applied for continuous measurement of soil respiration at different forest ecosystems. For example, in the autumn of 2002, we installed a LAC with 24 chambers at the Tomakomai Flux Research Site at a 45-year-old Japanese larch (*Larix kaempferi* Sarg.) plantation. The 24 chambers distributed randomly on the forest floor within a circular area 40 m in diameter (Fig. 7). The 24 chambers were divided into three groups, each with 8 chambers. The first group of chambers was used to measure total soil CO_2 efflux (R_s), in which the understory vegetation was clipped periodically during the growing season. The second group was used to measure heterotrophic respiration (R_h) by installing the chambers in 1 × 1 m root exclusion plots. The third group (chamber size: 90 cm long ×90 cm wide × 100 cm tall) covered the understory vegetation, thus it could directly measure carbon sequestration of the forest floor.

Fig.6. A micro powerful DC air compressor powered by a vehicle cigarette for filling the air tank inside the portable LAC.

Fig.7. Chamber distribution at forest floor of a larch plantation.

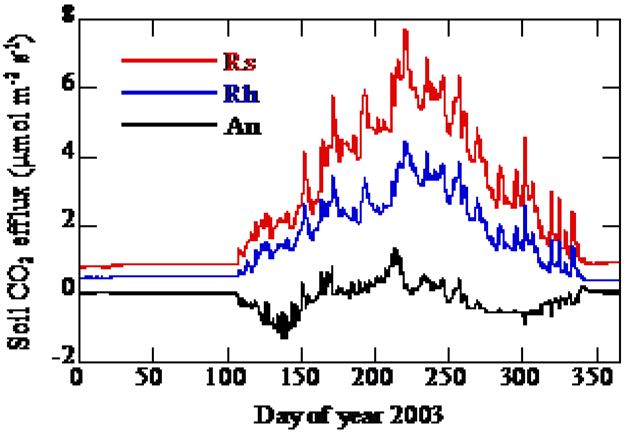

Fig.8. Seasonal changes in total soil respiration (R_s), heterotrophic respiration (R_h) and undergrowth CO_2 sequestration at Tomakomai larch forest.

Over the course of an hour, the 24 chambers were closed sequentially and the sampling period for each chamber was 150 s. Therefore, the chambers were open for 96% of the time. During each 1-h cycle, each chamber was open for 57.5 minutes and closed for 2.5 minutes. Thus, most of rainfall and leaf litter could enter the chambers, and the interior of each chamber had good exposure to any atmospheric turbulence. Air temperature at about 25 cm height inside each chamber was measured with a home-made T-type thermocouple. Soil temperature profile at 5, 10, 20, 30 and 50 cm depths were measured with the home-made E-type thermocouples. In addition, volumetric soil moisture at 10 cm depth was monitored in nine selected chambers (three for each group) with TDR sensors of CS616 (Campbell Scientific). All of the sensors were recorded using a CR1000 data-logger via a home-made 62 differential-channel multiplexers. The data-logger acquired outputs from the IRGA and other sensors at 1-s intervals and recorded the averaged values every 10 s. Soil respiration (R_s, μmol m^{-2} s^{-1}) was calculated using the following equation:

$$R_s = \frac{PV}{RS(T+273)}\left(\frac{\partial C}{\partial t} + \frac{C}{(1000-W)}\frac{\partial W}{\partial t}\right) \quad (1)$$

where V is the effective chamber-head volume (cm^3), S is the measured soil surface area (cm^2), P is the air pressure (hPa), R is the gas constant (8.314 Pa m^3 K^{-1} mol^{-1}), T and W are the air temperature (°C) and water vapor mole fraction (mmol H_2O mol^{-1}) inside the chambers, respectively, $\partial C/\partial t$ and $\partial W/\partial t$ are the rate of change in the CO_2 mole fraction (μmol CO_2 mol^{-1} s^{-1}) and water vapor mole fraction (mmol H_2O mol^{-1} s^{-1}), respectively.

Note that the pressure is the pressure inside the chamber but not the pressure inside the IRGA, because the pressure inside the IRGA is generally several kPa higher or lower than that of atmosphere depending on the installation position of the air sampling pump. However, the W section can be ignored due to it only contributes less than 1% to R_s as well as most of the commercially available IRGA cannot be able to measure water vapor. Therefore, air pressure at 30 cm height around the center of the measurement plots was monitored with a high precision pressure transducer (PX2760, Omega Engineering, Inc., Stamford, CT, USA).Fig. 8 shows the forest floor CO_2 budget for Tomakomai larch forest in 2003. Annual R_s and R_h were measured to be 9.6 and 5.5 t C ha^{-1} yr^{-1}, respectively. Moreover, annual CO_2 sequestration by the understory vegetation was estimated to be about 0.4 t C ha^{-1} yr^{-1} (Liang et al., 2004).

Fig.9. Chamber distribution at the Teshio CC-Lag flux site.

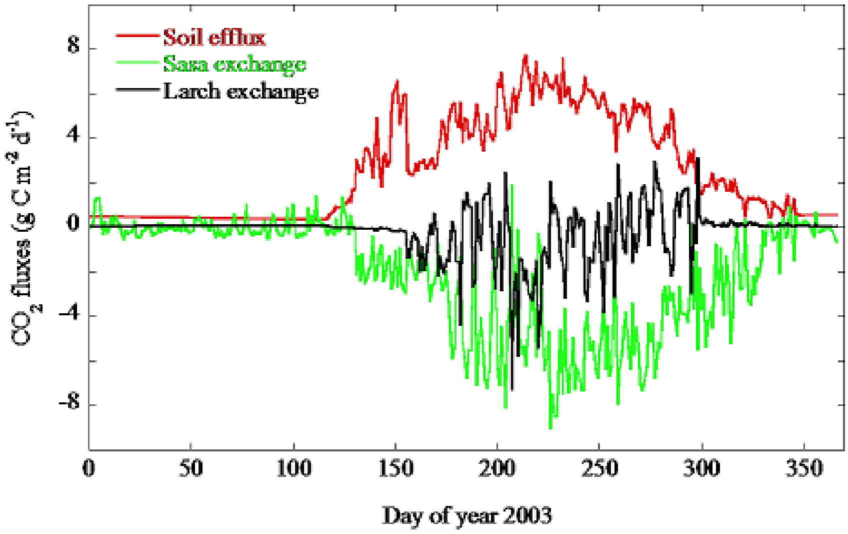

Fig.10. Seasonal changes in soil respiration (efflux) and CO_2 sequestration by dwarf bamboo (Sasa exchange) and larch trees (Larch exchange) at the Teshio CC-Lag flux site.

5. Partitioning of NEP of grassland and wetland

Because of the transparency of the automated chambers, they can be also applied for directly measuring NEP for ecosystems with low vegetation. For example, in the spring of 2004, we installed a LAC with 24 chambers at the Teshio flux site, in the Teshio Experimental Forest of Hokkaido University (45°03'N, 142°06'E, 66 m elevation), northern Hokkaido, Japan. This site is a primary conifer-broadleaf mixed forest with 15% of the trees logged in 1961. A clear-cut harvesting event was conducted during the snow-cover season between January and March 2003. However, the site was planted with hybrid larch (*L. gmelinii* × *L. kaempferi*) seedlings with the density of 2500 stem ha^{-1} in late October, 2003. The 24 chambers were divided into three groups, each with 8 chambers. The first group of chambers was used to measure the total soil respiration (R_s), in which the vegetation was clipped periodically during the growing season. The second group (chamber size: 90 cm long ×90 cm wide × 150 cm tall) covered the dense undergrowth of evergreen dwarf bamboo (*Sasa senanensis*). The third group (chamber size: 90 cm long ×90 cm wide × 200 cm tall) covered the young larch trees (Fig. 9). Thus the multichannel LAC could partition the NEP into soil respiration, carbon sequestrations by larch trees and dwarf bamboo, respectively (Fig. 10) (Takagi et al., 2009). Following the Tomakomai flux site was destroyed by a strong typhoon in September 2004, we installed a multichannel LAC with 18 chambers in 2005 for monitoring the carbon budget with vegetation natural regeneration. We applied 5 chambers for measuring total soil respiration, 5 chambers for measuring heterotrophic respiration, 5 chambers for measuring NEP by covering vegetation, and 3 chambers for measuring decomposition of the stumps (Fig. 11) (Sano et al., 2010). Recently, we have installed multichannel LAC at a wetland on the Tibetan Plateau (Yu et al., 2013) and an arid grassland in Inner-Mongolia for continuous measurements of NEP and heterotrophic respiration (Fig. 12).

Fig.11. Chamber distribution at Tomakomai flux site after typhoon.

Fig.12. A multichannel LAC installed at a Inner-Mongolian arid grassland.

6. Measurement of spatial and temporal variations of soil respiration

Even the above multichannel LAC is generally installed at flux sites for direct inter-comparison with tower-based eddy covariance (EC) measurements and/or calibrating the nighttime ecosystem respiration obtained by EC method, the portable LAC is an effective protocol for comparing the spatial and temporal variations of soil respiration among different ecosystems. Since 2010, we have been using the portable LAC to evaluate the effects of land-use and land-use change on soil degradation of a tropical rainforest in the Pasoh Forest Reserve (2º58'N, 102º18'E), Peninsular Malaysia. We installed 30 soil collars at each ecosystem. The collars were placed on a 5x5 m mesh. The portable LAC was operated on a continuously sequential measurement mode. We set the sampling period for each point as 3 min. Therefore, the measurement over the 30 points took one and half hours (Fig. 13).

Soil respiration among the 30 measurement points was 6.65 ± 1.98, 6.60 ± 2.39, 3.99 ± 1.49, and 3.17 ± 0.94 μmol CO_2 m^{-2} s^{-1} for a primary forest, a logging site that was selectively logged five years ago, a 50-year-old secondary forest, and a 4-year-old rubber plantation, respectively. Result suggests that logging event could enhance soil respiration by increasing the decomposable substitutes, although it had reduced 50-65% of root respiration. Moreover, land-use change would significantly reduce soil respiration through inducing soil degradation.

Fig.13. Measuring spatial variations of soil respiration using portable LAC at a secondary forest (a) and primary forest (b) in Pasoh of Peninsular Malaysia.

7. Potential monitoring no CO_2 GHGs budget

Currently, both multichannel LAC and portable LAC are used only for measuring CO_2/H_2O. The capacity of the sampling air pump is 5 L min^{-1}. It can also provide enough sampling air for an additional analyzer for measuring other no CO_2 GHGs. For example, in 2010, we installed a multichannel LAC with 20 chambers at the Luanhaizi wetland, northeastern the Tibetan Plateau (37°35'N, 101°20'E, 3,200 m a.s.l.). This multichannel LAC was equipped with both a CO_2/H_2O analyzer (LI-840, Li-Cor) and a CO_2/CH_4/H_2O analyzer (G1301; Picarro Inc., Santa Clara, CA, USA). It could simultaneously monitor CO_2/CH_4/H_2O fluxes of the ecosystem (Fig. 14). Moreover, result could be also used for cross-check of NEP that obtained by the two different analyzers (Yu et al., 2013). In 2011, we installed a multichannel LAC with 12 chambers at an arid grassland site in Inner-Mongolia (44°08'N, 116°19'E, 1030 m). This multichannel LAC was equipped with both a CO_2/H_2O analyzer (LI-840, Li-Cor) and an isotopic CO_2 analyzer (G1101; Picarro Inc.) (Fig. 15). Therefore, in addition to NEP, this chamber system could also monitor isotopic CO_2 flux of the grassland ecosystem.

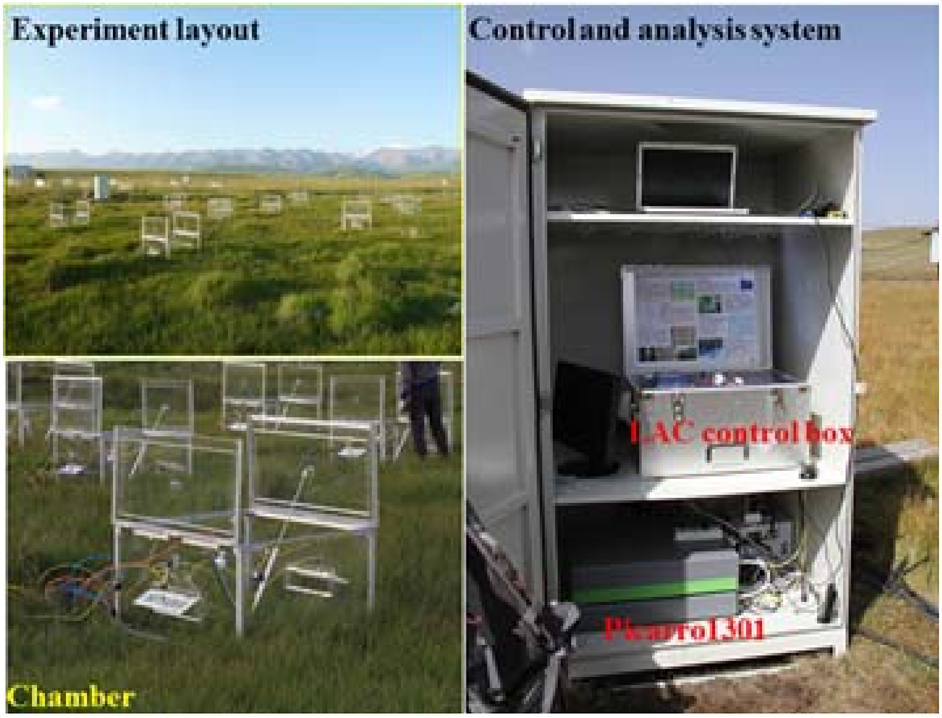

Fig.14. A multichannel LAC coupled with both CO_2 and CH_4 analyzers for measuring CO_2 and CH_4 fluxes at a wetland on Tibet Plateau.

Fig.15. A multichannel LAC coupled with both CO_2 and isotopic CO_2 analyzers for measuring NEP and isotopic CO_2 flux at a Mongolian arid grassland site.

Fig.16. A multichannel LAC applied in a soil warming experiment.

8. Soil warming experiment

Since 2006, we set up seven soil warming experiments at seven typical forest ecosystems, including a 35-year-old cool-temperate mixed forest in northern Hokkaido (Teshio of Hokkaido University Forest), a 70-year-old deciduous oak forest in northeastern Japan (Shirakami maintain range), a natural beech forest (>100-year-old) in Hokuriku region (Mt. Naeba), a 55-year-old Japanese red pine forest in Kantou region (Tsukuba), a 30-year-old ever-green Japanese oak forest in Setonaikai region (Higashi-Hiroshima), a 55-year-old subtropical evergreen forest in Kyusyu (Miyazaki University Forest) of Japan, and a subtropical evergreen forest in Mt. Ailao in Yunnan province, southwestern China (Liang, 2009). We installed multichannel LAC with 15 to 20 chambers (90 cm long ´ 90 cm wide ´ 50 cm tall) at each site with 5 chambers for measuring total soil respiration, 10 chambers for measuring heterotrophic respiration that placed at 100 x 100 cm root exclusion plots (40 cm in depth). The other 5 chambers were used for optional measurements, such as litter decomposition or soil moisture treatment. Half of the trenched plots at each site were used for soil warming experiment, and another half of the trenched plots were used as control plots by keeping them in the ambient environment. For the soil warming plots, an 800 W infrared heater was vertically hanged over the center of the plot at about 170 cm above the soil surface (Fig. 16). Compared to the control plots, the infrared heater could warm the soil for 3.0, 2.5, 2.0, 1.7, and 1.5°C at depths of 0, 5, 10, 20, and 30 cm, respectively (Aguilos et al., 2011).

9. Automated chamber network

Terrestrial ecosystems in Asia cover large land area and represent various biomes including tundra, boreal, temperate and tropical forests, wetlands, grasslands, crop fields, and the world largest rice paddies extending from the arctic circle to equator. Therefore, knowledge of the carbon budget of the terrestrial ecosystems in Asian region is essential to advance our understanding about the global carbon cycle and prediction of the impacts of climate change. Since the mid-1990s, we have been installing the multichannel LAC in a tundra in the West Siberian lowland (56°51'N, 82°50'E), a boreal forest in central Alaska (64°52'N, 147°51'W), cool-temperate and temperate forests in Japan, Korea and China, subtropical forests in Japan, Mainland China (Tan et al., 2013b) and Taiwan, tropical seasonal forests in China and Thailand, tropical rainforests in China and Malaysia (Tan et al., 2013a), and even arid grasslands in Inner-Mongolia and wetlands on the Tibetan Plateau, for continuous measurements of forest floor CO_2 budget as well as NEP (Fig. 18). Among the sites, 7 systems are used for conducting soil warming experiments. Currently, the chamber network is expanding rapidly in the Asian region. Our ultimate objective is to estimate the carbon budget of Asian terrestrial ecosystems as well as its response and feedback to regional climate change.

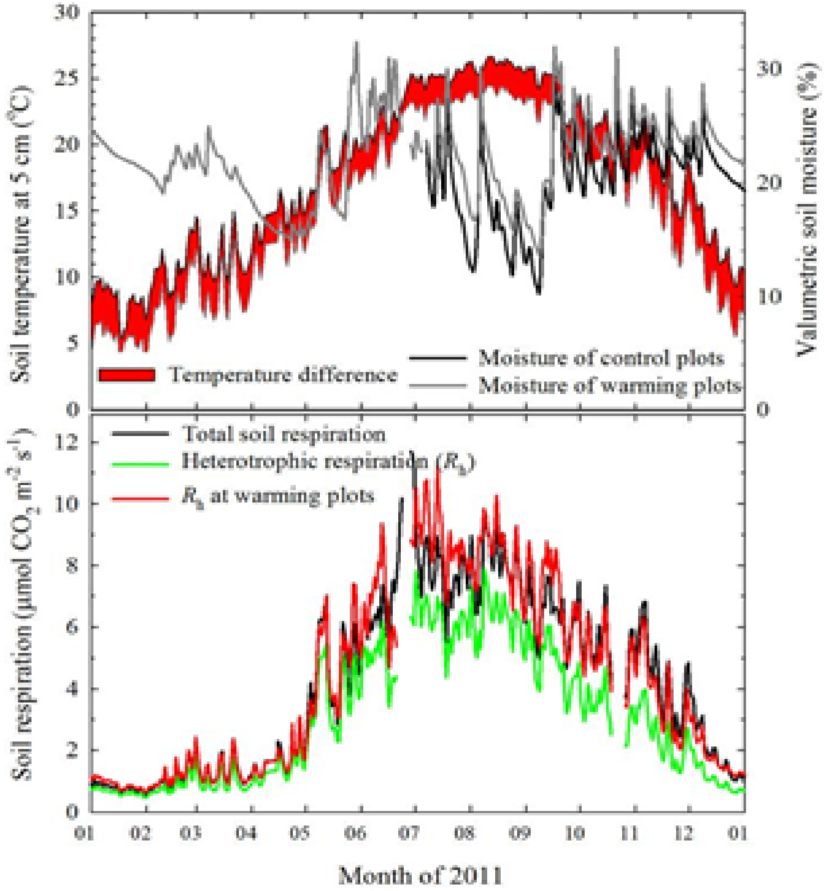

Fig.17. Seasonal changes in soil temperature, volumetric soil moisture and soil respiration at a subtropical forest in Miyazaki, Kyusyu of Japan.

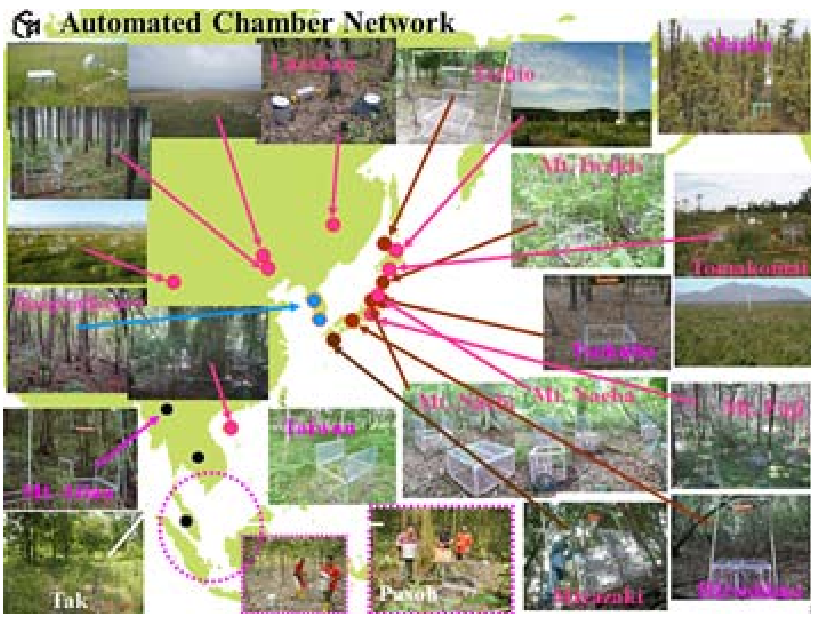

Fig.18. An automated chamber network for evaluating carbon budget of Asian terrestrial ecosystems.

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Spatial patterns and climate drivers of carbon fluxes in terrestrial ecosystems of China——Some New Progresses of ChinaFLUX

Yuling Fu[1, 2], Leiming Zhang[1], Xuefa Wen[1] and Guirui Yu[1]

[1] Key Laboratory of Ecosystem Network Observation and Modeling, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing 100101, China

[2] Shanghai Key Lab for Urban Ecological Processes and Eco-Restoration(SHUES), East China Normal University, Shanghai, China

ChinaFLUX was originally established in 2001 and was co-funded by the Knowledge Innovation Program of the Chinese Academy of Sciences (CAS) and the National Key Basic Research and Development Program of the Ministry of Science and Technology (MOST) of China, aiming at quantifing the spatio-temporal variations of carbon, water and energy fluxes in major terrestrial ecosystems in China and to identify the underlying natural and anthropogenic (grazing, logging, land use change) drivers (Yu et al., 2006). During the last 10 years, ChinaFLUX was well developed and expanded with continuous funding support from CAS, national natural science foundation of China (NSFC), and MOST. Significant progress and scientific achievements in flux observation and carbon cycle research in China have been achieved. By 2010, ChinaFLUX has grown into a regional observation and research network with 17 observation sites (7 forest sites, 7 grassland sites and 3 cropland sites) from the originally 8 ones. With the rapid development and extensive applications of flux measurements, ChinaFLUX has transferred its research focus from terrestrial carbon budget to the mechanisms for the interactions among carbon, nitrogen and water cycles in terrestrial ecosystems and their response and adaptation to global changes.

In 2011, CAS launched a group of “Strategic Priority Research Programs-Climate Change”. The Research period of these programs is 5 years from 2011 to 2015. One of the programs was titled “Carbon Budget and Relevant Issues”, aiming at quantitatively evaluating the current status, mechanism and future potentials of carbon sequestration in major terrestrial ecosystems in China. As a part of this program, ChinaFLUX has been taking the task to quantify the carbon exchange rate in major terrestrial ecosystems in China at different spatial (site- regional-national) and temporal (daily-seasonal-annual-decade) scales. With some funding support from this Strategic Priority Research Program, about 20 flux observation sites joined ChinaFLUX observation network, which greatly increased the ecosystem types and research area of ChinaFLUX and reduced the regional gap of flux observation in China.

Currently, ChinaFLUX has 45 flux observation sites in total, including 12 forest sites, 12 grassland sites, 5 wetland sites, 5 desert sites and 11 cropland sites, covering the major types of terrestrial ecosystems in China (Fig. 1). Among these sites, those original ChinaFLUX sites (such as Changbaishan, Qianyanzhou, Dinghushan, Haibei, Xishuangbanna etc.) already have 10 years observation record while some sites established in recent years have relatively short data record. All these sites will continue the flux observation until 2015, which will guarantee at least 5-year observation data from at each site of ChinaFLUX for future synthesis analysis on regional carbon budget in China.

The flux observation dataset were used to examine variations of carbon and water fluxes at various spatial and temporal scales and underlying driving factors (Fu et al., 2009; Yu et al., 2006, 2008) and to optimize ecological parameters (Ju et al., 2010; Zhang et al., 2011). Recently, Yu et al (2012) examined the spatial pattern and the underlying drivers of carbon fluxes in terrestrial ecosystems in China and primarily quantified the statistic characteristics of carbon budget in typical climate zones and major ecosystems in China based on the long-term flux observation data at 8 original ChinaFLUX sites and published data (GEP, ER and NEP) from other flux sites in China, In this study, only the sites with at least one year continuous flux measurements were selected. Totally, 52 sites were included in their study, covering 18 forest sites, 15 grassland sites, 7 wetland sites and 12 cropland sites (Fig. 2).

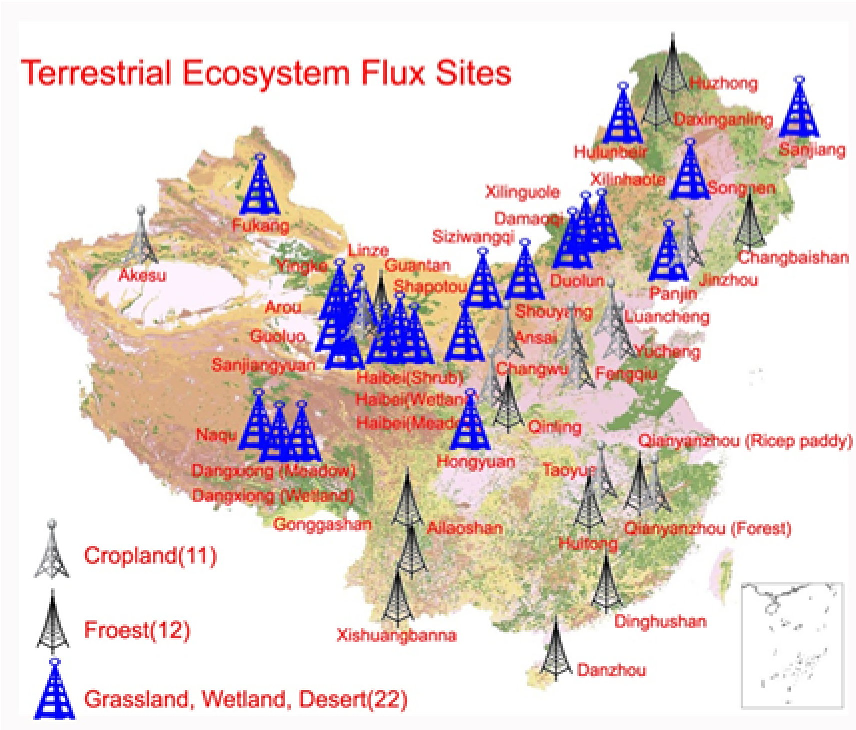

Fig. 1. The spatial distribution of flux observation sites of ChinaFLUX (Updated in October, 2012)

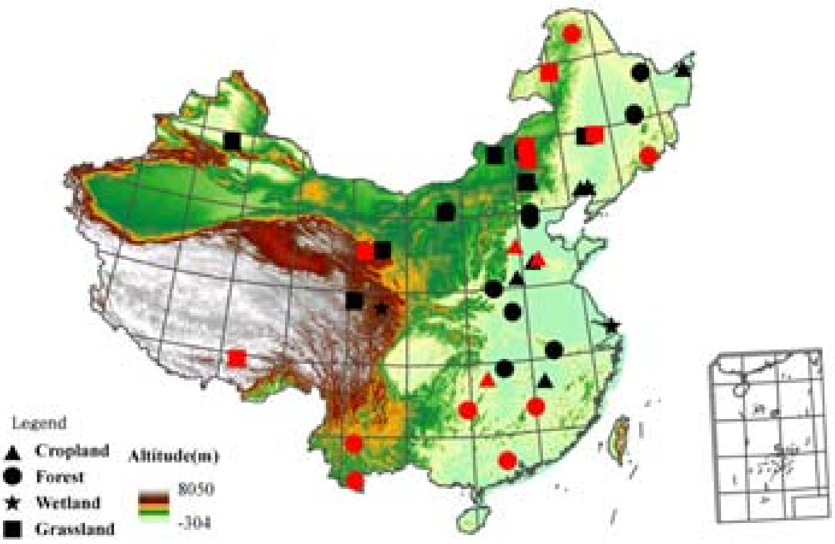

Fig. 2 Distribution of carbon flux observation sites in China in the study of Yu et al., (2012)

They found out that the carbon sink functional areas of terrestrial ecosystems in China were mainly located in the subtropical and temperate forests, coastal wetlands in eastern China, the temperate meadow steppe in the northeastern China, and the alpine meadow in the eastern edge of the Qinghai-Tibetan Plateau. The forest ecosystems had stronger C sequestration capacity than other ecosystems in China. The net ecosystem productivity (NEP) of forest ecosystems in China ranged from 168.8 to 592.4 g C m-^{2} yr^{-1}, with the largest carbon sink in the central sub-tropical forest and the tropical forest (Xishuangbanna site) as a weak carbon sink. Grassland ecosystems had generally weaker carbon sequestration capacity than forest ecosystems, with significant regional differences. The temperate meadow steppe in northeast China and the alpine meadow in the eastern edge of the Qinghai-Tibetan Plateau had relatively larger carbon sequestration capacity than other grasslands in China, with a mean annual NEP up to 112 g C m^{-2} yr^{-1}. However, the semi-arid temperate steppes in Inner Mongolia were characterized as carbon neutral or weak carbon sources due to little precipitation and extensive human activities. Most wetlands in China are acting as carbon sink, with the highest NEP exceeding 400 g C m^{-2} yr^{-1} in coastal wetlands that are located in the deltas of the Liaohe and the Yangtze River. However, the alpine wetlands showed a large difference in NEP, with the Haibei wetland site acting as a carbon source (-79.1 gC m^{-2} yr^{-1}) but the Zoige site as a small carbon sink (63.4 gC m^{-2} yr^{-1}).

The carbon fluxes (GEP, ER and NEP) of major ecosystems in China were compared with other regions in the North Hemisphere (Fig. 3). The average NEP of all ecosystem types in China was 252.9±234.2 g C m^{-2} yr^{-1}. The NEP of forest ecosystems in China was insignificantly higher than in Europe, the United States and Canada ($p>0.05$) (Fig. 3f). The GEP of forest ecosystems were comparable among China, the United States and Europe, but smaller in Canada (Fig. 3d). There was no significant difference in ER for the forest ecosystems among different regions. The difference in NEP of grassland ecosystems was insignificant among different regions (Fig. 3i), while the GEP values of grasslands in Europe and the United States were significantly higher than those in China and Canada (Fig. 3g). The carbon fluxes of wetland and cropland ecosystems were smaller than those of forest ecosystems, but larger than those of grasslands (Fig. 3 j-o) and showed no significant differences among regions.

Then, a quadratic regression analysis was carried out by taking into account the impact of the interaction between MAT and MAP on

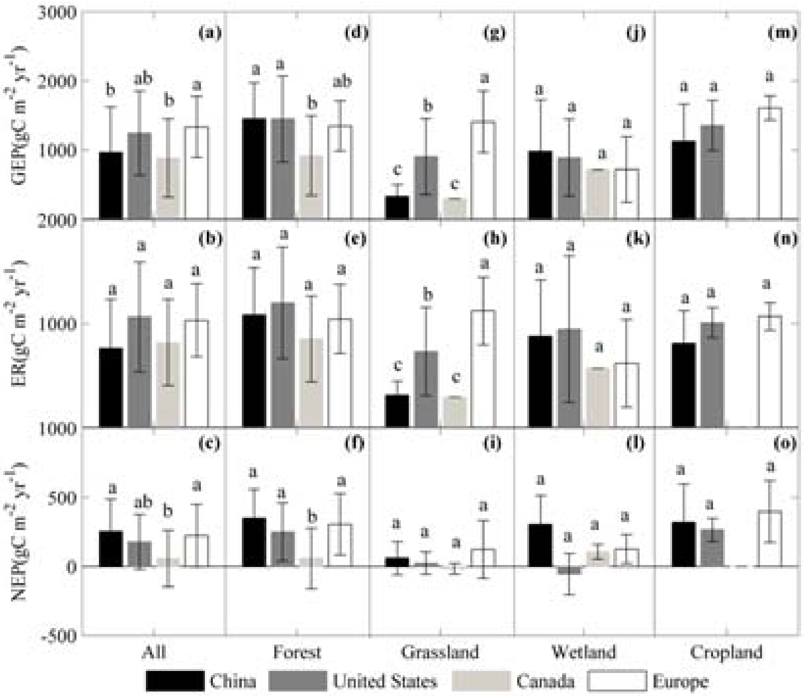

Fig. 3. Statistical characteristics of carbon fluxes in different countries and regions. GEP, ER and NEP are the abbreviation of gross ecosystem productivity, ecosystem respiration and net ecosystem productivity, respectively (Yu et al., 2012)

carbon fluxes. The results showed that the interaction between MAT and MAP had a significant impact on the regional carbon fluxes in China. Based on these analyses, the following quadratic equations were recommended to describe the spatial patterns of GEP, ER and NEP in terrestrial ecosystems in China:

GEP =107.02MAT+2.18MAP-0.10MAT×MAP-544.35, R_2=0.79, n=41, RMSE=313.9 (1)

ER=54.08MAT+1.19MAP-0.05MAT×MAP-103.04, R_2=0.61, n=39, RMSE=308.1 (2)

NEP=48.98MAT+0.79MAP-0.05MAT×MAP-313.85, R_2=0.66, n=52, RMSE=141.6 (3)

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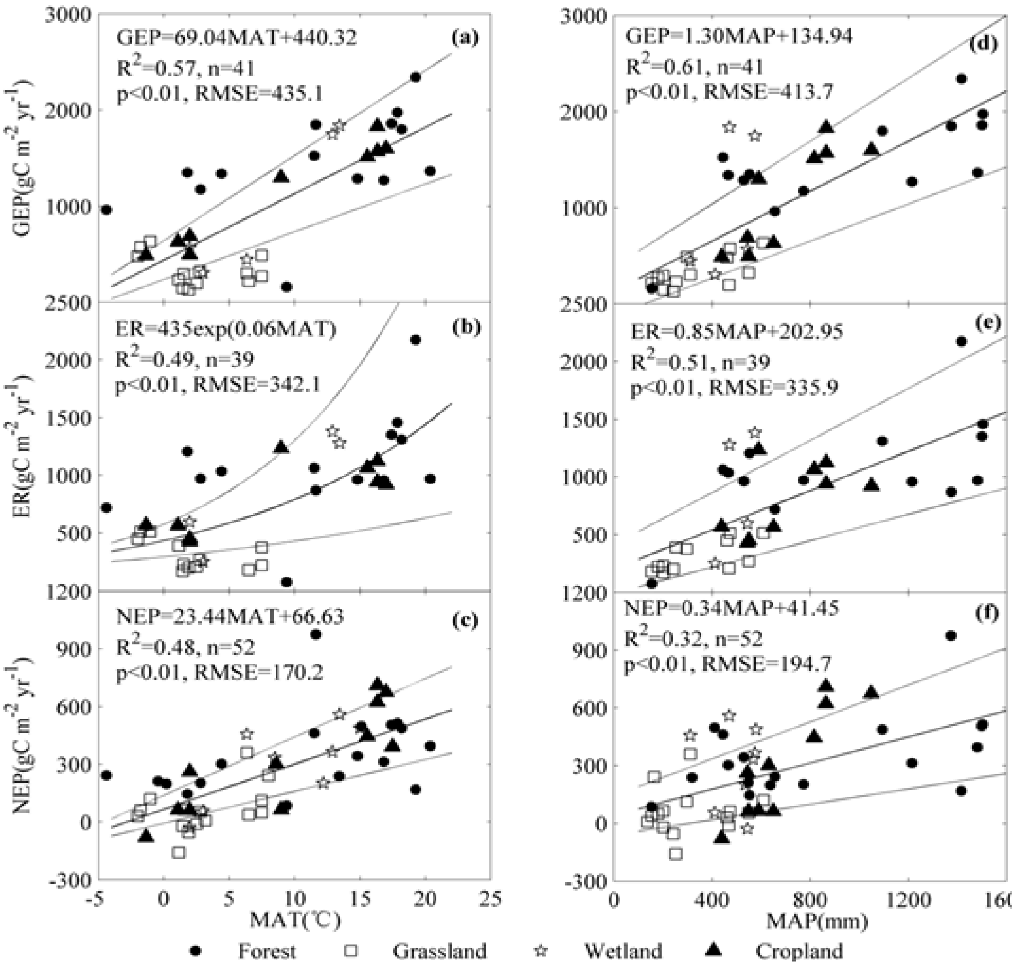


Fig. 4. The relationships between climate variables (MAT and MAP) and GEP, ER and NEP in major ecosystems in China. GEP, ER and NEP are the abbreviation of gross ecosystem productivity, ecosystem respiration and net ecosystem productivity, respectively. MAT and MAP are the mean annual temperature and mean annual precipitation. The thick lines are the regression lines, and the thin lines are the 95% confidence interval.

Flux studies and progress in Malaysia

Ab Latif Ibrahim

Institute of Geospatial Science and Technology (INSTeG)

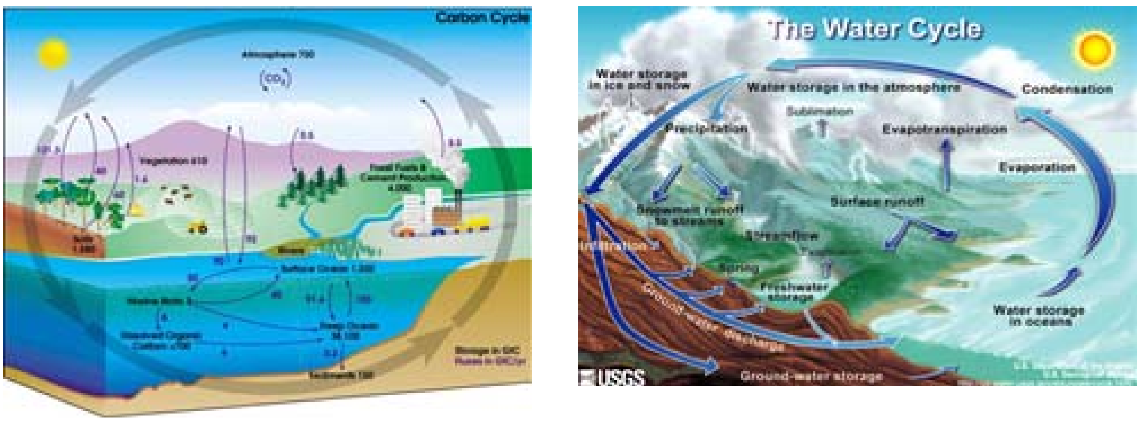
Universiti Teknologi Malaysia, Johor Bahru, Malaysia

The Background

Carbon and water are cycling through the atmosphere, biosphere, geosphere and oceans and strongly influence climate, food supply, and the quality of the environment (Fig. 1a and 1b). Global climate change is driven by increasing concentrations of anthropogenic atmospheric greenhouse gases (GHG) such as carbon dioxide, methane, and nitrous oxides. The increased concentrations of GHG's seen in the atmosphere today are the balance between sources (mainly from fossil fuel burning and land use changes) and net sinks (land and oceans). Increase in the global CO_2 concentration and its potential impact on global climate change have led to an urgent need to find the best way to mitigate CO_2 emissions. Fortunately, photosynthesis from terrestrial vegetation can remove carbon from the atmosphere and provides a significant foundation of CO_2 sink. Current estimates of net land sinks from the IPCC 2007 AR4 are 2.6 Gt C yr^{-1} (Denman et al., 2007) and importantly these sinks are thought to be increasing in tropical regions (Stephens et al., 2007).

In the tropics, the land carbon budgets are uncertain due to a lack of comprehensive datasets that include spatial and inter-annual measurements (Le Page et al., 2008; Stephens et al., 2007). Moreover, the current changes in climate, caused primarily by increasing CO_2 (IPCC, 2007) have affected terrestrial vegetation and its ability to absorb and store carbon (Prentice et al., 2001; Nemani et al., 2003; Fischlin et al., 2007). One of the most pressing questions concerning future climate change is how it will affect the geographical and temporal distributions of the major pools and fluxes of carbon in the global carbon cycle (Global Carbon Project, 2003). These problems are acute in tropical forests because their structure, productivity and carbon balance are vulnerable to variability of, and changes in, major climate change drivers and land use changes. This uncertainty indicates an urgent need to understand the various processes that regulate the uptake and release of CO_2 by tropical forests, elucidate their spatial and temporal variations and analyze their dependence on key environmental drivers.

Understanding the carbon-climate feedback mechanism is critical to: (i) guide better land management, and (ii) inform policy related information to national and global (Kyoto protocol, United Nations Framework Convention of Climate Change and Intergovernmental Panel on Climate Change) efforts to stabilize



(a) (b)

Fig.1: (a) Carbon cycle (Source: Illustration courtesy NASA Earth Science Enterprise), (b) hydrology cycle (Source: U.S. Geology Survey)

atmospheric CO_2 concentration, and (iii) cope with climate change toward sustainability. These specific aims can be achieved by flux study and observation at a particular site in order to investigate the relationship between CO_2 flux and meteorological conditions, and to investigate seasonal and year-to-year variations of the carbon balance. Flux towers use eddy covariance methods to study exchange of CO_2 between the atmosphere and terrestrial ecosystems, heat flux, water vapor flux, air temperature, wind speed and direction, humidity and solar radiation. These measurements are usually used to evaluate ecological variables, including biomass, tree species and height, leaf area index, soil moisture, soil temperature, soil respiration, and decomposition rate of leaves and branches.

Flux Studies in Malaysia

There are more than 500 tower sites from about 30 regional networks across 5 continents are currently operating on a long-term basis. In Malaysia, activities related to flux measurements and observations have been actively carried out since the establishment and operation of the flux tower in the Pasoh Forest Reserve (PSO) located in Simpang Pertang, Negeri Sembilan, Peninsular Malaysia (Table 1 and Fig. 2). There are also flux studies that are carried out in other sites after the establishment of three flux towers in Sarawak, such as Oil Palm station in Sibu, Secondary peat swamp forest station in Betong and Maludam National Park station in Sri Aman Division of Sawarak (Melling and Tang, 2012). CO_2, energy, and water vapor fluxes have been measured at these three sites using eddy covariance systems since January 2011. Apart from this, flux related studies and observation are also carried out to investigate the contribution of oil palm plantation to carbon uptake or carbon emission. This is very important as Malaysia is one of the largest producers and exporters of palm oil in the world, accounting for 38% of the major producers and 46% of major exporters in 2009 (Oil World, 2010). However, studies in this related aspect are still lacking and limited.

Based on the above description, the main focus of flux studies in Malaysia is mainly carried out in Pasoh Forest Reserve. Studies carried out in other observation sites are still at the initial stage. Thus, this article will highlight some of the current flux studies and activities in Pasoh Forest Reserve. For the purpose of better understanding regarding flux study in this area a brief description of PSO is provided in the following section.

Brief Description of Pasoh Forest Reserve

The total area of PSO is about 2,450 ha and about 600 ha is considered as core area. This area is covered with primary lowland mixed dipterocarp forests, which includes various species of Shorea and Dipterocarpus. The canopy of forest area is almost continuous with an approximate height of 35 m. There are also some emergent trees with the height exceeding 45 m. According to FAO classifications, the soil type in PSO, particularly area around the observation tower is categorized as Haplic Acrisol. The A horizon is thin (0–0.05 m; Yamashita et al. 2003), and lateritic gravels are abundant below 0.3 m (Soepadmo 1978; Yamashita et al. 2003). The topography of this area is gently undulating (Takanashi et al., 2010; Kosugi et al., 2008). Analysis of rainfall recorded for the year 2003 - 2009 showed that mean annual rainfall is 1865 mm (Kosugi et al., 2012). This amount is found to be less than the amount of rainfall received in the other regions of Peninsular Malaysia (Noguchi et al., 2003). The maximum amount of rainfall occurred in March to May and from October to December. Most of the rainfall occurs from late afternoon to night.

Recent flux studies in Pasoh Forest Reserve

Many studies have been carried out since the establishment of flux tower in PSO and most of the studies have been published in a numbers of related journals.

The following are some of the recent flux studies in PSO that have been published:

Itoh, M., Kosugi, Y., Takanashi, S., Kanemitsu, S., Hayashi, Y., Osaka, K.,Tani, M., Abdul Rahim N.: Effects of soil water status on the spatial variation of carbon dioxide, methane and nitrous oxide fluxes in tropical rain-forest soils in Peninsular Malaysia, Journal of Tropical Ecology, 28, 557-570, 2012, DOI:10.1017/ S0266467412000569

Kosugi, Y., Takanashi, S., Yokoyama, N., Philip, E., Kamakura, M.: Vertical variation in leaf gas exchange parameters for a Southeast Asian tropical rainforest in Peninsular Malaysia, Journal of Plant Research, 125, 735-748, 2012, DOI:10.1007/s10265-012-0495-5

Makita, N., Kosugi, Y., Dannoura, M., Takanashi, S., Niiyama, K., Abdul Rahman K., Abdul Rahim N.: Patterns of root respiration rates and morphological traits in 13 tree species in a tropical forest, Tree Physiology, 32, 303-312, 2012, DOI:10.1093/treephys/tps008

Kamakura, M., Kosugi, Y., Nakagawa, R.,

Site Name	Pasoh Forest Reserve
AsiaFlux Site Code	PSO
Location	Negeri Sembilan, Peninsula Malaysia, Malaysia
Position	2degree 58' N, 102degree 18' E
	(World Geodetic System 1984, GPS)
Elevation	75-150 m above sea level
	(World Geodetic System 1984, GPS)
Slope	N/A
Terrain Type	gentle hillslope
Area	2450ha (area of the Forest Reserve)
Fetch	3500m (north), 800m (south)
Climate	Tropical rain, Af
Mean annual air temperature	25.3 degreeC (2003-2009)
Mean annual precipitation	1804mm (1983?1997), 1865mm(2003-2009)
Vegetation Type	primary lowland mixed dipterocarp forest (Tropical rain forest)
Dominant Species (Overstory)	Dipterocarpaceae, Leguminosae, Burseraceae
	(814 species exits in the 50ha plot in PFR)
Dominant Species (Understory)	Euphorbiaceae, Annonaceae
Canopy height	continuous canopy height is approximately 35m, emergent trees exceed 45m
Age	Primary forest
LAI	6.52
Soil type	Ultisols and Oxisols (Haplic Acrisol and Xanthic Ferralsol in FAO classification)

Table 1: Pasoh Forest Reserve.
(Source: http://asiaflux.net/network/012PSO_1.html)

Fig. 2: Pasoh Forest Reserve. (Source: Abd Wahid, 2011)

Itoh, M.: Methane flux of leaves in a tropical rainforest and a temperate conifer forest, Journal of Agricultural Meteorology, 68, 25-33, 2012, DOI:10.2480/agrmet.68.1.3

Kosugi, Y., Takanashi, S., Tani, M., Ohkubo, S., Matsuo, N., Itoh, M., Noguchi, S., Abdul Rahim N.: Effect of inter-annual climate variability on evapotranspiration and canopy CO2 exchange of a tropical rainforest in Peninsular Malaysia. Journal of Forest Research, 17, 227-240, 2012, DOI 10.1007/s10310-010-0235-4

Progress of flux study in Malaysia

With respect to the progress of flux study in Malaysia, it can be considered as very slow and only limited to few study sites as compared to the development in other countries, such as Korea, Japan, and China. More observation sites need to be established for the purpose of understanding the contribution of tropical forest ecosystems in water and carbon cycles. As a step to increase activities related to flux study in Malaysia, Universiti Teknologi Malaysia (UTM) have come out with a proposal to establish UTM-MalaysiaFlux. This UTM-MalaysiaFlux based-eddy covariance method will amalgamate the existing flux towers in Malaysia into unity in terms of governance, management and monitoring. Eddy covariance based flux tower observations are important for determining carbon, water and energy budgets at high temporal resolution and at the ecosystem plot scale (~ 1km). This will lead to better understanding regarding carbon, water and energy cycles of an ecosystem particularly in UTM. The establishment of UTM-MalaysiaFlux is also expected to be a centre that can assist in unifying flux community of Malaysia (network with other organizations that also have established flux towers; such as MPOB and FRIM). UTM-MalaysiaFlux tower is very important to enable UTM become the champion in the aspects related to carbon emissions and global warming. This is also in line with UTM new initiative of establishing Ecotourism and sustainable campus. It is also hope that UTM will play an important role to govern, manage, and monitor the activities of existing flux towers in Malaysia. The establishment of UTM-MalaysiaFlux is still in the process of getting an approval and support from UTM.

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Kosugi, Y., Takanashi, S., Yokoyama, N., Philip, E., Kamakura, M., 2012. Vertical variation in leaf gas exchange parameters for a Southeast Asian tropical rainforest in Peninsular Malaysia, Journal of Plant Research, 125, 735-748, DOI:10.1007/s10265-012-0495-5.

Melling, L., and Tang, A., 2012. Tropical Peatland – A Strong Carbon Sink? In AsiaFlux Newsletter. 34, 4-6.

Nemani, R.R., Keeling, C.D., Hashimoto, H., Jolly, W.M., Piper, S.C., Tucker, C.J., Myneni, R.B. and Running, S.W. , 2003. Climate-driven increases in global terrestrial net primary production from 1982 to 1999. Science. 300, 1560–63.

Noguchi, S., Nik, A. R., Tani, M., 2003. Rainfall characteristics of tropical rainforest at Pasoh Forest Reserve, Negeri Sembilan, Peninsular Malaysia. In: Okuda T, Manokaran N, Matsumoto Y, Niiyama K, Thomas SC, Ashton PS (eds) Pasoh: ecology of a lowland rain forest in southeast Asia. Springer, Tokyo, pp 51–58.

Establishment of Eddy-Flux Network in India for NEE Monitoring

C.S.Jha[1], T.R. Kiran Chand[1], R. Suraj Reddy[1], K.V. Raghavendra[1], S.P.S Kushwaha[2], N.R. Patel[2] & V.K. Dadhwal[1]
[1] National Remote Sensing Centre, Hyderabad 500 625, India
[2] Indian Institute of Remote Sensing, Dehraun 288001, India
Corresponding author: C.S.Jha; email: chandra.s.jha@gmail.com

1. **Introduction**

India is a large country with 329 million hectares of geographical area and ranks in the first 5th /6th in terms of total CO_2 energy emissions and also ranks as the second country in terms of population in the world. India is being considered as a major contributor in South Asian Carbon (C) Cycle. Thus, an establishment of multi-purpose flux tower network has been identified as a major priority in understanding the Indian C cycle (Sundareshwar et al., 2007). Indian Space Research Organization, since early 1990s has a very diverse program known as the ISRO Geosphere Biosphere Programme and in the last 5 years, a major initiative to focus on major themes on climate change was undertaken - National Carbon Project was one of them, starting in 2007.

1.1. National Carbon Project, ISRO India – Background

The 'National Carbon Project (NCP) is an Indian Space Research Organization - Geosphere Biosphere Programme's (ISRO-GBP) initiative, which is envisaged to assess the country's total carbon pool and fluxes on an annual basis using ground based measurements and satellite remote sensing data sets. NCP has been launched with the following major objectives:

- To assess carbon pools, fluxes and net carbon balance for terrestrial biomes in India.
- To establish an observational network and create remote sensing-based spatial data-bases for modeling and periodic assessment of net carbon balance in India.
- To provide support to Second National Communication (SNC) activity of Ministry of Environment and Forests, GOI to UNFCCC with respect to carbon balance

Fig. 1: Location Map of the Betul flux tower along with ground photograph

The National Carbon Project is being implemented under three inter-related sub-projects viz., i) Vegetation carbon pools assessment, ii) Soil carbon pools assessment, and iii) Soil and vegetation-atmosphere fluxes.

A network of eddy flux towers for the measurement and modeling of net carbon flux is being established across major ecosystems over Indian region as part of the 'Soil and Vegetation-Atmosphere Fluxes (SVAF) sub project of the NCP. So far 5 towers were established as follows:

1. Haldwani, Dehradun (mixed plantation) – This site was established by a collaborative effort of Indian Institute of Remote Sensing, Indian Council Forest Research and Educationand University of Tuscia, Italy and was based on a closed path IRGA;
2. Meerut, U.P. in the wheat-sugarcane system. This gains importance as the Indian land mass of about 45 % is used as agriculture. Irrigation and fertilizer have strong anthropogenic control (Patel et al., 2009, 2011);
3. Barkot, Dehradun (Shorea robusta forest);
4. Betul, Madhya Pradesh (teak mixed forest);
5. Sundarban Biosphere Reserve, West Bengal (mangrove forests).

Here we present briefly about the two new EC flux towers that have been added in the ISRO NCP network of towers.

2. Eddy Flux Tower, Betul, Madhya Pradesh

An eddy flux tower has been established in teak mixed forests at Sukhwan, Betul, Madhya Pradesh, India with an objective to continuously measure net ecosystem exchange of carbon along with soil and phenological parameters. The tower was erected in October 2011.

2.1. Study Area and Site Description

Fig. 1 shows the location map of the flux tower (210 51' 46.84" N, 770 25' 33.67" E; 507m ASL). Forests of the study area where the current tower is located represent one of the major forest types in central Indian region dominated by teak forests. Age of the forest stand is around 50 years old and average height of the stands is 22 m. The study area has almost a flat terrain with slope less than 5 degrees. Major tree species occurring in the study area are Tectona grandis, Miliusa tomentosa, Diospyros melanoxylon and Terminalia tomentosa. The average winter and summer temperatures of Betul are 20^{o}C and 34^{o}C, respectively. Average annual rainfall of the study area is 791 mm.

2.2 Tower Description, Instrumentation and Measurements

The tower is at a height of 34m. Continuous fast responses of CO_2, H_2O and heat fluxes are measured at 10 Hz frequency (averaged for 30 min) using eddy covariance based open path Infrared Gas Analyzer (IRGA-LICOR 7500) and 3-D Ultrasonic Anemometer (RM Young 81000) from November, 2011. Slow response measurements of meteorological parameters (averaged for every 30 min) viz., wind speed, wind direction, air temperature, relative humidity, incoming solar radiation, soil temperature and moisture are being carried out. Details on the instrumentation and tower infrastructure are available at http://asiaflux.net/network/088BFT_1.html.

Further, Sap Flow Meters (4 number), which work on the Heat Ratio Method (HRM) principle have been installed on 4 dominant species in the study area viz., Tectona grandis, Miliusa tomentosa, Diospyros melanoxylon and Terminalia tomentosa. A high resolution phenocam - digital camera (CC5MPX, Campbell Sci., USA) has been installed on the tower at 24 m (~4 m above the canopy level) and takes hourly pictures in two zoom mode and thus records phenological variability in its foot print. Monthly Leaf Area Index (LAI) measurements are being carried out in the study area using CI-110 (CID Inc., USA) plant canopy imager. Measurement of leaf/plant level photosynthetic responses to environment variables, such as light, CO_2, humidity and temperature are being measured using a portable photosynthesis system LI-6400 (LICOR, USA, figure-4), for dominant species of the study area.

3. Sundarban Flux Tower, Sundarban Biosphere Reserve, West Bengal, India

3.1 Study Area and Site Description

Sundarban is a world heritage site and the largest mangrove biosphere reserve in the world, located in West Bengal, India and Bangladesh (Fig. 2). It covers an area about 9000 km^2 which is estimated about 34% in Indian Territory and 66% in Bangladesh. Sundarban is generally very humid and receives lot of precipitation (annual average of 1800 mm). Sundarban has also been a natural habitat for many endangered species including Royal Bengal Tiger. The average minimum and maximum annual temperatures varies from 20^{0}C to 38^{0}C.

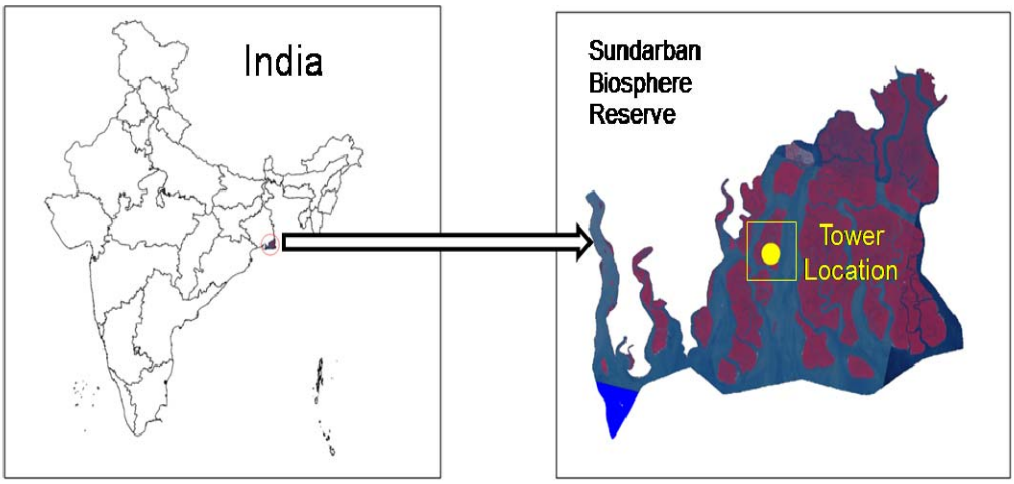

Fig. 2: Location Map Showing Sundarban Biosphere Reserve

Fig. 3: EC Flux tower with surrounding canopy cover and fast response instruments at the Sundarban Biosphere Reservoir site.

3.2 Tower Description, Instrumentation and Measurements

A tower of 15 m (21° 49' N and 88° 37' E) has been established in the mangrove system (mean canopy height of 5 m) in Sundarban Biosphere Reserve, West Bengal (Fig. 3). The eddy flux tower is equipped to study the fast temporal variations of carbon dioxide, water vapor and methane fluxes and underlying driving factors. The slow response and fast response sensors installed on the tower are shown in Tables 1 and 2, respectively. The slow response instruments include those measuring micrometeorological parameters and also radiation components. The fast response measurements include those measuring high frequency wind velocity components (i.e. u, v, w) and air temperature (T) along with the concentrations of carbon dioxide, water vapor and methane at a frequency of 10 Hz respectively and logged every 30 min.

Observation items	Levels / Depth	Instrument
Net Radiation (all components)	11m	CNR 4 ; Kipp&Zonen
Air temperature	8, 4, 2m	HMP45C-l ; Campbell Scientific
Relative Humidity	8, 4, 2m	HMP45C-l ; Campbell Scientific
Soil temperature	4 levels	107-L ; Campbell Scientific
Soil Heat Flux	2 levels	HFT3 ; Campbell Scientific
Wind speed	8, 4, 2m	Wind Monitor 05103 ; RM Young
Wind direction	8, 4, 2m	Wind Monitor 05103 ; RM Young
Barometric pressure	10m	LI 7700 ; LICOR
Precipitation	15m	TB4-L ; Campbell Scientific
photosynthetic photon flux density	4m	LI - 190 ; LICOR
Averaging Time : 10 min		
Data Logger : CR3000 ; Campbell Scientific, USA		
Data Storage : 2GB Data Card		

Table-1: Slow response sensors/measurements at the Sundarban Biosphere Reservoir site

System	Open path System
Wind speed	3 - axis Ultrasonic anemometer (CSAT-3)
Air temperature	3 - axis Ultrasonic anemometer (CSAT-3)
Water vapor	Open path Analysers (IR Hygrometer LI-COR LI 7500A)
Carbon dioxide (CO_2)	Open path Analysers (IR Hygrometer LI-COR LI 7500A)
Methane (CH_4)	Open path Analysers (IR Hygrometer LI-COR LI 7700)
Measurement height	10m
Sampling frequency	10 Hz
Averaging time	30 min
Data logger	On Board Data Logging in LI7700
Data storage	4 GB USB Stick

Table-2: Fast response sensors/measurements at the Sundarban Biosphere Reservoir

4. Analysis

Diurnal and seasonal variations of CO_2, H_2O and CH_4 (Sundarbans only) are being carried out in relation to environmental parameters. Efforts are also in progress to upscale the towers' measurements using concurrent remote sensing data sets. The EC flux data from these towers will be very useful in appropriate validation and understanding of national C budgets (Nayak et al., 2010, 2011).

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The Editor of AsiaFlux
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Weimin Ju
(Nanjing University, China)

AsiaFlux Secretariat in Tsukuba
Center for Global Environmental Research
National Institute for Environmental Studies
16-2 Onogawa, Tsukuba 305-8506, Japan
Ph: +81-29-850-2971
Fax:+81-29-858-2645
E-mail: tsukuba@asiaflux.net

AsiaFlux Newsletter is only available on the AsiaFlux Website: www.asiaflux.net

This newsletter was aimed to report the progress in flux measurements in China, India, and Malaysia, and in the establishment of an automated-chamber network in Asia. It also reports the themes and activities of International Conference on Global Change, Forest Adaptation and CO_2, Water and Energy Flux Monitoring held in December, 2012 at Experimental Forest, National Taiwan University, Taiwan. Significant improvements have been achieved in understanding the spatial and temporal variations of carbon, water, and energy fluxes as well as underlying driving factors in typical ecosystems in Asia. With more flux data available, Asia can play more important role in global terrestrial carbon cycle study. It was my privilege to serve AsiaFlux as the editor of this newsletter. I am sincerely thankful to Dr. Chiang, Dr. Liang, Dr. Fu, Dr. Ibrahim, Dr. Jha, and all coauthors for their contributions to this issue.