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Contents

Report on the "1st iLEAPS Science Conference" and the "iLEAPS Special Workshop on Flux Measurements in Difficult Conditions"

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The "1st iLEAPS Science Conference" and a subsequent specialized workshop, "Flux Measurements in Difficult Conditions," were held on 21-26 and 26-28 January 2006, respectively, in Boulder, Colorado, USA. iLEAPS is an acronym for International Geosphere-Biosphere Programme's (IGBP) core project, the "integrated Land Ecosystem-Atmosphere Processes Study."

There were 244 and 43 topics published in proceedings of the iLEAPS Science Conference and flux workshop, respectively, although some of the conference sessions were withdrawn. Results from Asia Flux Network research at Takayama (Japan), Qian Yanzhou (China), and Gwangneung (Korea) were presented.

The session titles follow:

Science Conference Session Titles:

1. Land-atmosphere exchanges of reactive and long-lived compounds: key interactions and feedbacks in the Earth system
2. Feedbacks among land biota, aerosols, and atmospheric components in the climate system
3. Feedbacks and teleconnections in the land surface-vegetation-water-atmosphere system
4. Transfer of material and energy in the soil-canopy-boundary layer system: measurements and modeling
5. Modeling of land-atmosphere interactions: towards the Earth System approach

Workshop Session Titles:

1. The failure of energy balance closure during daytime
2. The failure of monitoring CO_2 respiration flux at night
3. Advective flows caused by topography and/or heterogeneity
4. Stably stratified flows at night
5. Spatial and temporal pulses in exchange processes, including the contribution and origins of low-

Table 1 Relation of corrected NEE to friction velocity and advection

Case	VA	HA	Absolute rate	According to the increase of U_{*cr},	Site
1	+	-	|VA| > |HA|	NEE decrease	Vielsalm (Aubinet, 2003) Tharandt (Feigenwinter, 2004)
2	+	0		NEE constant	Brown River? Prince Albert? (Lee, 1998)
3	+	+		NEE increase	Renon (Macolla, 2005)
4	0	+		NEE varies	Hesse (Aubinet, 2005)
5	-	+	|VA| < |HA|	NEE varies	Niwot Ridge (Tamipseed, 2003)

frequency eddies

6. Synthesis: quantification, modeling, and correction of measurements in difficult conditions

Presentations focused on a wide variety of topics. Many studies focused on the following themes.

1. Fluxes of various compounds.

Numerous studies examined chemical compounds, which ranged from volatile organic matters to NO_x, SO_x, ammonia, methane, and ozone. Topics ranged widely, including flux measurements, modeling of feedbacks between compounds, and estimates of factors that impact climate.

2. Horizontal or vertical advections.

Many studies also examined terrain effects on advection. Complex terrain can be partitioned into two types. One type has slopes with parallel contour lines, e.g., such as at Fujiyoshida or Sapporo (Japan). The other type is hilly terrain with undulating or basin terrain, e.g., Yamashiro (Japan) or Gwangneung (Korea).

2-1. Measurement of horizontal advections on sloping terrain.

Some studies calculated horizontal advection using one-dimensional observations of micro-wind velocity and CO_2 profiler data under the forest canopy. Impressive studies that included data from the Niwot Ridge AmeriFlux measurement site estimated vertical and horizontal advections using 3-D observations of CO_2 concentration and wind profiles within and under the canopy. Other presentations considered such topics as flux observations within the canopy and trace gases monitoring on calm nights. Yi (2005) has described some of these studies in the *Journal of Geophysical Research.*

2-2. Challenges in observing fluxes and advection over hilly or basin terrain.

Challenges inherent in observing fluxes and advections over hilly or basin terrain were examined using data from Italy, the northwestern USA, and Gwangneung, Korea.

3. Correcting flux rates using friction velocity.

A common correction for CO_2 flux in stable conditions uses the relationship between temperature and flux rates in unstable conditions. The corrected net ecosystem exchange (NEE) rate increased at some sites and decreased at others according to the definition of the friction velocity criterion (U_{*cr}) between stable and unstable conditions. Aubinet related this mechanism to the five advection types shown in Table 1; VA and HA indicate vertical and horizontal advection, respectively.

Finnigan showed that eddies in a wind tunnel experiment enter a canopy under radiated conditions and do not enter in non-radiated conditions. Finnigan also presented a theoretical explanation for this phenomenon based on an NEE correction method that uses U_{*cr}.

4. The importance of estimating advection.

Drainage flow was discussed in a three-hour plenary session at the end of the workshop. All presenters agreed that drainage advection occurs. The discussion focused on how to estimate this advection and its effect on the CO_2 budget. According to the workshop presentations, advection estimates should include wind velocity observations to within 0.01 m/s and CO_2 concentration differences to within 10 ppm/100 m. Two reports discussed the difficulty in obtaining such precise observations.

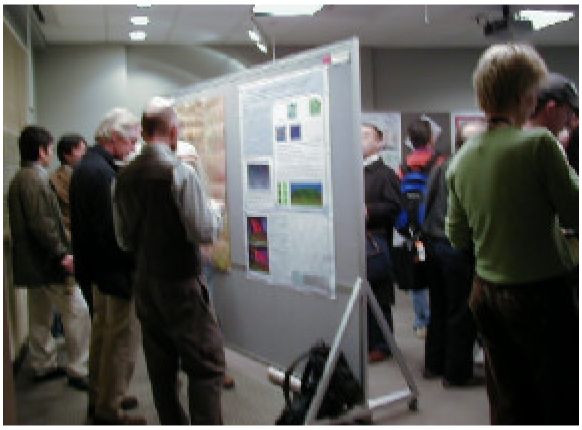
Advection estimates are admittedly challenging. However, we should note advection rates when reporting CO_2 budgets at forested sites, especially in Japan and Korea. All of the experienced scientists at the conference seemed to agree that drainage flow has a major impact on the CO_2 budget in areas of complex terrain steeper than 5°. Many of these scientists are also likely to serve as reviewers of submitted papers.

In addition to the science program, a number of other social functions encouraged communication between young and established scientists. Such events included the dinner for young scientists together with a very experienced scientist, and a basketball game.

The Tellus-B Special Edition of the "1st iLEAPS Science Conference" will be published. The following upcoming iLEAPS events were also announced during the meeting.

a) AS2.05: "Interaction and Feedback between Land Ecosystems and Atmospheric Processes" will be co-sponsored by iLEAPS at the General Assembly of the European Geosciences Union (EGU)on 2-7 April 2006 in Vienna (Wien), Austria.

b) iLEAPS will hold the symposium "Interactions of Changes in Land Cover and Climate", and some sessions at the International Union of Geodesy and Geophysics (IUGG) congress on 2-13 July 2007 in Pelugia, Italy.



A Portable Automated Soil CO_2 Efflux System

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Introduction

Regional networks for measuring carbon sequestration or loss (CO_2 flux) by terrestrial ecosystems on a year round basis have been in operation since the mid-1990s, and there are now over 200 FLUXNET sites sampling tower fluxes over many vegetation types across the globe. Deconvolving the CO_2 flux signal into several components over similar time scales may help us critical understand the controls on ecosystem carbon balance, and it is one of the major goals of the AsiaFlux network. Soil CO_2 efflux - the largest component of ecosystem respiration - is a combination of plant and microbial processes that respond to climatic drivers at a variety of temporal and spatial scales. However, continuous measurements of soil CO_2 efflux have been reported only at a few of the sites. Reasons include the lack of automated systems that are commercially available, and the need for frequent servicing to ensure accurate measurements. Our former works had developed two systems for continuous measurements of soil CO_2 effluxes: a multichannel automated soil chamber system that can be used during snow-free periods (Liang et al., 2003), and a soil CO_2 concentration gradient system that can be used throughout the year - even during snow-cover (Liang et al., 2004). The purpose of this paper is to present a portable system intended to measure the spatial variation of soil CO_2 efflux in a specific ecosystem as well as to make inter-sites comparison over different ecosystems. Furthermore, the system can be used for continuous long-term measurement of soil CO_2 efflux.

System description

The system has a flow-through, non-steady-state design, comprising two automated chambers and a control box (Fig. 1). The cylinder-designed chambers (30 cm in diameter by 30 cm in height) are constructed by 3 mm thick aluminum. The aluminum control box (40 x 30 x 20 cm, L x W x H) includes an infrared gas

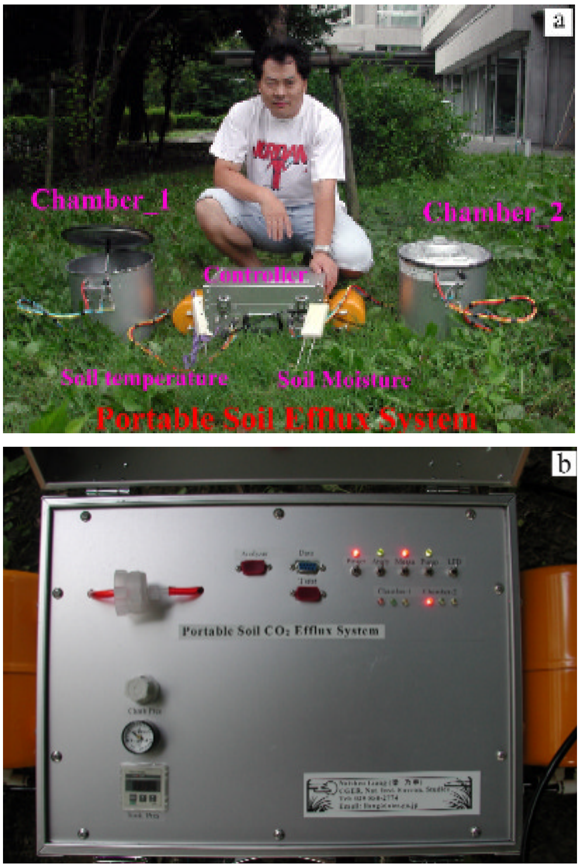

Fig. 1 A portable automated soil CO_2 efflux system (a) and its operation panel (b).

analyzer (IRGA, LI-840, LI-COR, Lincoln, NE, USA), a datalogger (CR1000, Campbell Scientific Inc. (CSI), Logan, UT, USA), a home-made air sampler, a soil temperature sensor (E-type thermocouple, model MHP, Omega Engineering, Inc., Stamford, USA), two air temperature sensors (home-made E-type thermocouples, one in each chamber), a soil moisture sensor (TDR, CS-616, CSI), and a power unit.

Measurement procedure

Between measurements, the lid of the chamber is raised, so as to keep the soil conditions as natural as possible. During the measurement, the chamber is closed and the chamber air is mixed by a micro waterproofed fan that can maintain a turbulence of 0.1 to 0.2 m s^{-1} at 2 cm above the soil surface. The chamber air is circulated through the IRGA by a micro diaphragm pump at a flow rate of 1.5 l min^{-1}, and the increase in CO_2 concentration is measured. The chamber lid is raised and closed by a pneumatic cylinder, which is driven by compressed air from the buffer tanks (yellow in Fig. 1). The sampling tube between the chamber and control box is 3.0 m. The measurement can be made continuously in sequence between the two chambers, and the sampling period for each chamber is programmed by the datalogger. Average power consumption of the whole system is 10.5 W, and the system can be run by an internal battery for about 18 hours. The whole system has a weight of about 17 kg, with 11 kg of the control box and 3 kg each of the chambers.

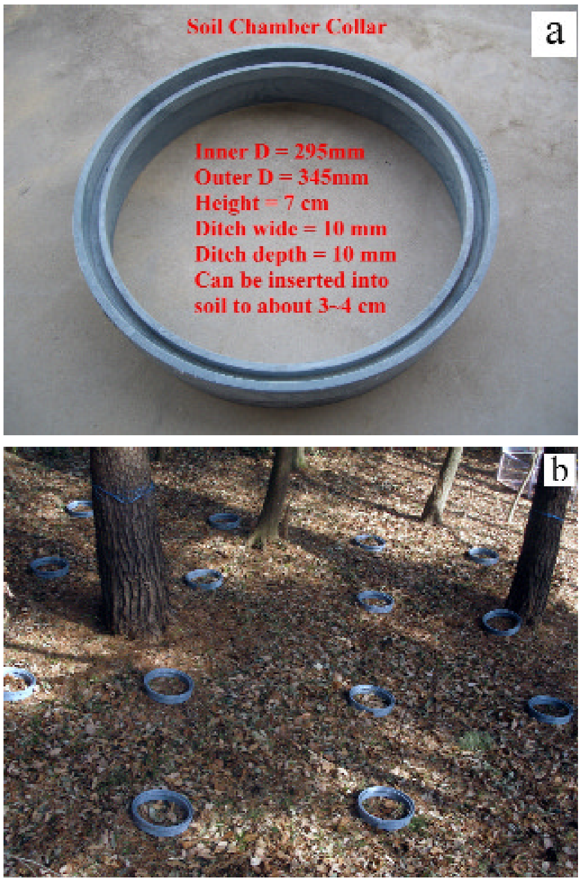

Fig. 2 A collar with ditch can be used for attaching tight to the chamber (a) and collars are installed at the forest floor (b).

System test

We tested the system on the campus of the National Institute for Environmental Studies, Tsukuba. We installed one of the chambers at the forest floor for measuring soil CO_2 efflux, by attaching the chamber to a collar which was inserted into the soil to about 3 to 4 cm (Fig. 2). Another chamber was used as a control chamber, by placed it onto a plastic film to avoid the effluxed CO_2 from the soil diffused into the chamber. In addition, the soil temperature sensor was inserted into the soil to about 5 cm depth, and the TDR sensor was inserted into the soil to 0-20 cm depth. We set the sampling period for each chamber to 130 s. After 30 s followed the chamber was closed, the datalogger acquired output from the IRGA, temperature and soil moisture sensors at 1 s intervals and recorded them every 10 s averaged values. Fig.3 showed that CO_2 concentration increased linearly inside the chamber that was installed directly on the forest floor, but it maintained at a constant value inside the chamber that was installed on the plastic film. Results indicate that the portable automated chamber system is reliable for measuring soil CO_2 efflux.

System application

In October 2005, we used this portable system to measure the soil CO_2 efflux in a 36-year-old dahurian larch (*Larix gmelini*) plantation at Laoshan flux site (lat 45°20'N, long 127°34'E, 370 m a.s.l.) in Mao'er Shan Forest of Northeast Forestry University, China. In 2003, the stand density was 1420 stems ha^{-1}, with canopy height of about 14.5 m and mean DBH (diameter at breast height) of about 17.5 cm. Mean annual precipitation was approximately 724 mm; and mean annual temperature was 2.8°C . The soil was classified as a typical dark brown forest soil. The litter layer (Oie) was 5 cm thick.

Seventy two chamber collars were installed at the forest floor prior to the measurements (Fig. 2b). The collars were placed on a 3 x 3 m mesh that was about 50 m in the north of the flux tower. The system was operated on a continuous sequential measurement mode. We set the sampling period for each point was 3 min; therefore, the measurement over the 72 points took about three and half hours (Fig.4). Soil CO_2 efflux (*Rs*,

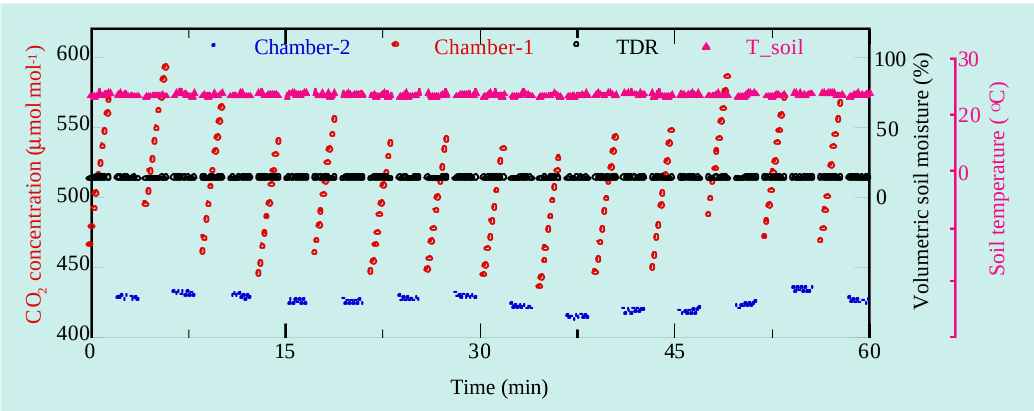

Fig. 3 Test result of the portable soil CO_2 efflux system with CO_2 changing inside the chamber-1 that was installed at the forest floor and chamber-2 that was placed on a plastic film, soil temperature and moisture near the chambers.

Fig. 4 Application of the portable automated chamber system for measuring soil CO_2 efflux in a larch forest in northeast China.

μmol m^{-2}s^{-1}) was calculated using

$$R_s = \frac{VP}{RST}\frac{\partial C}{\partial t} \qquad (1)$$

where V and S is the effective chamber-head volume (0.0212 m^3) and measured soil surface area (0.0706 m^2), P and T is the initial pressure (Pa) and air temperature (K) inside the chamber, $\partial C / \partial t$ is the initial rate of change in CO_2 mole fraction (μmol mol^{-1} s^{-1}), and R is the gas constant (8.314 Pa m^3 K^{-1} mol^{-1}), respectively.

Mean soil CO_2 efflux among the 72 measurement points was 2.1 ± 0.9 μmol m^{-2}s^{-1}. Result showed that this forest had high spatial variation in soil CO_2 efflux, with a mean coefficient of variation (CV) of 45% (Fig. 5).

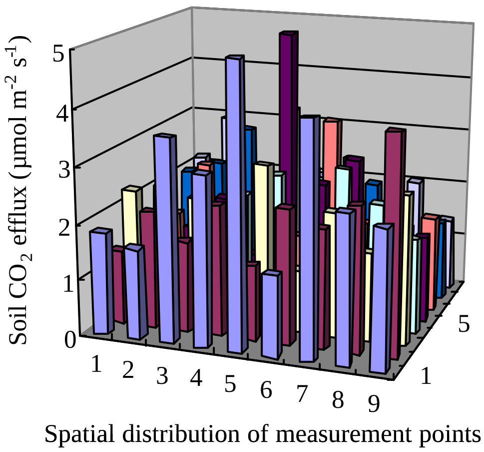

Fig. 5 Spatial variation of soil CO_2 efflux in a 36-year-old larch forest.

After measuring the spatial variation, the two chambers were installed at the forest floor near the flux tower to continuously monitor soil CO_2 efflux for several days until snowing. Distance between the two chambers was about 5 m, with one was placed near a tree stem and another one was relatively far from tree stems. Soil CO_2 efflux showed diurnal and inter-diurnal change patterns that followed the same pattern as the diurnal changes in soil temperature (Fig. 6). However, the coefficient between soil CO_2 efflux and soil temperature was not very significant ($0.4 < r^2 < 0.5$), probably due to the measurement period was too short.

In addition to Laoshan site, several portable automated chamber systems have been prepared to be used as a standard approach for inter-sites comparison of soil CO_2 efflux among Tomakomai, Teshio, Fuji-hokuroku,"Laoshan," Pasoh and other sites within the AsiaFlux network.

Acknowledgements

We thank Professor Wenjie WANG, Mr. Song CUI and Mr. Xiaoguang FENG for their collaborations during the field measurements at Laoshan site. This work is partly funded by the Monitoring Projector of CGER of National Institute for Environmental Studies as well as by the S-1 Projector of Ministry of Environment, Japan.

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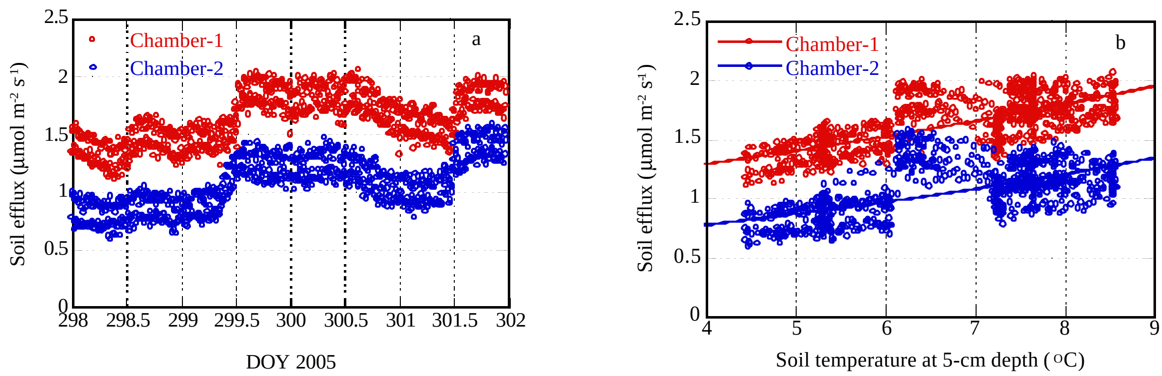

Fig. 6 Diurnal changes in soil CO_2 efflux (a) and its temperature responses (b).

Site Information

Introduction to KoFlux Gwangneung Supersite; Monitoring of Forest Ecosystem Processes on Complex Terrain

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Under changing climate conditions, CO_2/H_2O exchanges in forest ecosystems become increasingly important to evaluate the role of terrestrial forests in regulating atmospheric CO_2. The Gwangneung Supersite is a core flux measurement site of Korea flux network (i.e. KoFlux) where ecological, micrometeorological and hydrological studies are underway to understand carbon/water cycles in a typical montane landscape of the country (Kim *et al*., 2002). Here, we briefly introduce the Gwangneung Supersite as an effort to share our experience and strengthen the collaboration with other research activities in AsiaFlux community.

1. History of the Gwangneung Supersite

Historically, the Gwangneung area has been protected as a royal tomb forest of the Chosun Kingdom since 1468, and most of the area was designated as an Experiment Forest of KFRI (Korea Forest Research Institute) as of 1913, thereby leaving the forest mostly undisturbed. Because the Gwangneung forest functions as an experimental site and also arboretum, most of the lowland area is occupied by plantations and facilities. However, the area near Soribong peak (536.8 m a.s.l.) has been protected specifically as a Natural Reserve Forest since 1929 (Fig. 1).

KFRI launched long-term ecological, hydrological and meteorological studies and started establishing monitoring sites in Gwangneung forest in 1998. The forest was also registered as a participating site of ILTER (international long-term ecological research) network. This was the first comprehensive approach to conduct researches in ecosystem level on Korean forest. Before the project, some individual researcher-based ecological studies (Lee *et al*. 1990, Cho 1992, Lim 1998, You 1994) were carried out such as biodiversity investigations that accumulated long-term records in some research sites. The project covered diverse research areas such as forest stand dynamics, soil

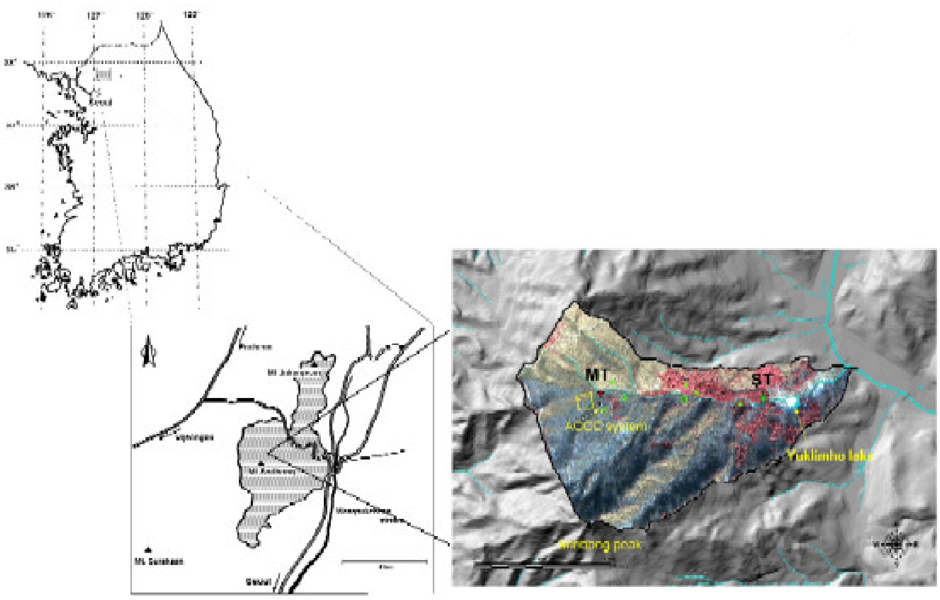

Fig. 1 Location map of the Gwangneung Supersite, plots and facilities (MT; main tower, ST; second tower). Red colors on the right image present conifer plantations and bright white area is a lake.

texture and chemical properties, micro-meteorology, air pollution, NPP, decomposition of leaf litter and coarse woody-debris, data management system with GIS, forest dynamics modeling, and changes of biodiversity including plants, insects, birds and mammals, pathogens and mushrooms, so on. At the site, KFRI researchers conducted a census for the all the trees and shrubs larger than 2 cm in DBH (diameter at breast height) and made stem and coarse woody-debris maps.

In 1999, KFRI set up an eddy covariance flux tower (the main tower, MT) in this area and started flux measurement with the help of scientists at Yonsei University (Fig. 2). This was a significant progress for the inter-disciplinary study on Gwangneung forest and the first flux measurement study in Korea. However, researchers have confronted a serious problem with the recovery of flux data because of the topographic complexity. Although skepticism was widespread, researchers working on Gwangneung forest were determined to keep the site because the site represents a typical montane terrain in Korea and this kind of complexity would provide a challenge to overcome.

Fig. 2 Original flux tower built in 1999. Nowadays the part above canopy layer was removed and the flux measurement system moved to the main tower in late 2002. The tower is mainly used for various ecophysiological studies.

From 2004, KFRI and Yonsei University team restructured the Gwangneung flux measurement site. This includes the construction of a new flux tower (the second tower, ST) to better capture the heterogeneities of the site (Fig. 3). Researchers with widely varying expertise joined the projects including GIS/Remote Sensing, soil sciences, forest hydrology, forest ecology, stable isotopes, and ecosystem modeling (Fig. 4). This represents the begging of true inter-disciplinary research at Gwangneung forest and therefore the site was designated as a 'Supersite' that became the center of three main research projects; 1) Long-term forest ecosystem studies (KFRI, 1997-present), 2) CarboKorea (an Eco-technopia project funded by Ministry of Environment, 2004-present), 3) HydroKorea (an 21st Century Frontier Research Program funded by Sustainable Water Resources Research Center, 2004-present).

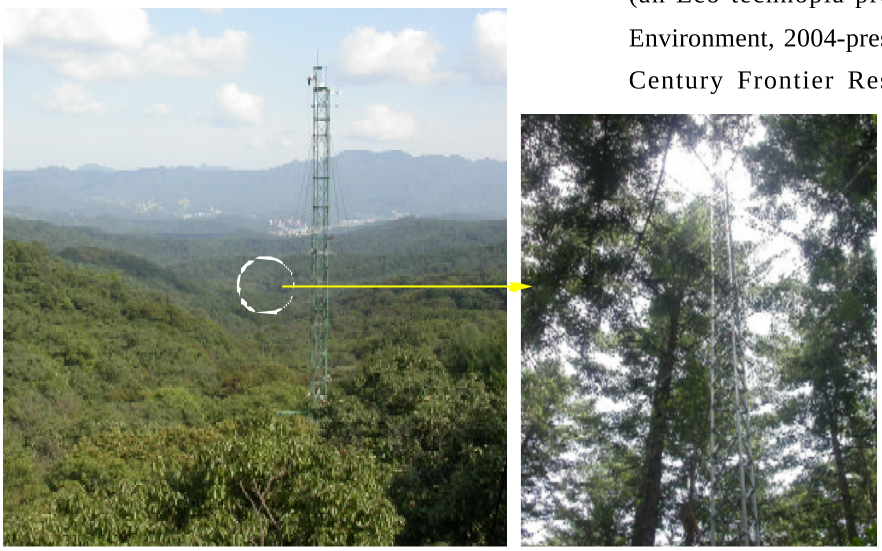

Fig. 3 The landscape of Gwangneung Supersite with two flux towers. The main tower (MT) with 40 m height is on the left photo, and the second tower (ST) in the circle is shown on the right photo. The left photo was taken from the old tower located at 150m west from MT (shown in Fig. 2).

2. Present and Future of the Gwangneung Supersite

Gwangneung Supersite is located at the north of Seoul, Korea and on a valley-like terrain with slope of about 10% to the direction from east to west having longer fetch than other directions (Fig. 1). Major forest type is natural broad-leaved forest in cool-temperate zone. Dominant tree species of canopy layer is *Quercus serrata* with mean canopy height of about 16-22 m. Woody plants lager than 2 cm in DBH in the 1 ha core plot comprised 33 species. *Carpinus laxiflora* is dominant just underneath the canopy crown of *Q. serrata*. *Acer mono*, *Sorbus alnifolia*, *Cornus controversa*, *Celtis jessoensis* and *Prunus mandshurica* var. *glabra* were found at the canopy layer and near the valley. In the middle layer of the forest, *Carpinus cordata is dominant*, and accompanied with *C. laxiflora*, *C. controversa*, *Acer pseudo-sieboldianum* and *Sorbus alnifolia*. *Euonymus oxyphyllus* are the dominant species at the shrub layer and comprises about a third of total number of trees (530 trees/ha) found at the plot, although the biomass is only 3.2 tons/ha. Total stem density is 1,473 trees/ha, basal area is 28 m²/ha, and biomass is 281.2 tons/ha (Lim *et al*. 2004). Major forest types near the ST are plantations of coniferous trees including *Abies nephrolepis, A. koreana* and *Pinus koraiensis*. Even at the broad-leaved deciduous forest, the species composition and biomass amount are spatially heterogeneous mainly due to the topographic position which creates differences in light conditions and soil moisture regimes. Therefore, we made several eco-plots at different forest types, and conduct researches to estimate and model parameters such as the spatial distribution of LAI, biomass, soil moisture gradients, and so on.

At the flux towers, eddy-covariance (EC) systems (CSAT3 and CR5000, Campbell Scientific Inc.; LI-7500, Li-COR) are mounted at 20 and 40 m on the MT and 40 m on the ST. In addition, H_2O/CO_2 concentration profile systems (LI6262, Li-Cor; CR23X-TB, SDM-CD16AC, Campbell Scientific Inc.; vacuum pump, KNF Neuberger) were installed on both towers measuring concentrations at 8 different levels (Fig. 5). Four radiation components above the canopy are being measured at the tops of towers using net radiometers (CNR-1, Kipp & Zonen). To measure photosynthetically active radiation, quantum sensors (LI-190SA, LI-COR Inc.) were installed near radiometer. Soil heat flux was measured at two depths of 0.01 m and 0.1 m at two points with soil heat flux plates (HFT, Campbell Scientific Inc.). Air temperature and relative humidity were measured with a temperature/humidity prove (HMP-45C, Campbell Scientific Inc.) at five levels. Soil temperature proves (TCAV, Campbell Scientific Inc.) and

Fig. 4 Weir (left) and stem flow and through fall measuring systems for hydrological research.

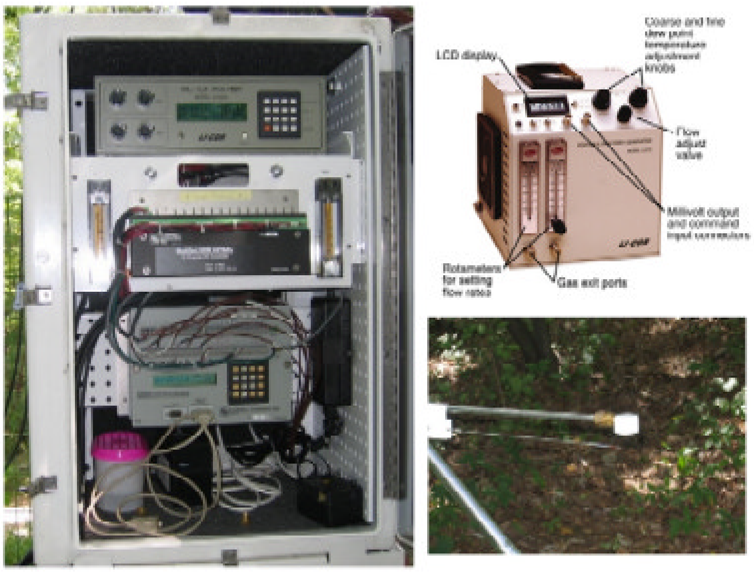

Fig. 5 H_2O/CO_2 concentration profile system.

water content reflectometers (CS-615, Campbell Scientific Inc.) are installed at several depths to measure soil temperature and volumetric soil water content, respectively. Cup anemometers and wind vanes are operational at several heights. These meteorological data are sampled in every thirty minutes. To monitor the soil respiration continuously, our research team developed an automatic opening and closing chamber system (AOCC) based on an open-flow dynamic method (open-flow AOCC, Fig. 6)

Through the integrated researches at the Supersite, we are on the way of constructing base-data sets of the above- and below-ground measurements and boundary-layer flux measurements. Furthermore, many efforts will be given to understand the mechanism and processes in the forest ecosystem and to estimate parameters precisely and to develop models for estimation of CO_2 and H_2O dynamics in a forested complex terrain. And also, spatial and temporal up-scaling of the results is being conducted using various techniques including stable isotopes and GIS/RS-based ecosystem modeling and so on. We are trying to produce data and theories to understand forest dynamics under current and future global changes through synergy effects by focusing research efforts to the Gwangneung Supersite.

Acknowledgement

We would like to thank all the research members at Gwangneung Supersite and Korea National Arboretum. Officially, the site name of "Kwangneung" was changed to "Gwangneung" at ILTER meeting in 2003.

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Fig. 6 Equipments and field arrangement of open-flow AOCC system (Suh et al, in press)

Site Information

Introduction to a Japanese Research Project on "Establishment of Good Practices to Mitigate Greenhouse Gas Emissions from Japanese Grasslands"

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Grassland occupies 40.5% of the total land area in the world (World Resources Institute, 2005), and it is an important ecosystem supporting herbivorous livestock production. Grassland is also an important ecosystem as a reservoir of organic carbon because of perennial plants dominating in grassland vegetation. In Japan, grassland accounts for 13% of the total agricultural land area.

Carbon budget in terrestrial ecosystems which is called a net biome production (NBP) is estimated as the sum of carbon in the net ecosystem production (NEP) and the carbon budget associated with the import of organic matter through manure application and its export through crop harvest, grazing and erosion (Fig.1; IPCC, 2000). The NEP is determined as the value deducted from the net primary production (NPP) to the soil organic matter decomposition. The NBP in an annual crop field is equal to the soil carbon sequestration; because all plant carbon is either harvested or transported into the soil. The result of change in soil organic carbon stocks in the top 15 cm of soils in the UK during the past 25 years showed a loss of soil organic carbon stock with the annual average rate of 0.6%. The higher rate of the loss of soil organic carbon stock was found in the area with high content of soil organic carbon irrespective of cultivation practices (it was more than 2% y^{1} in the soil with organic carbon content exceeding 100g kg^{-1}) (Bellamy et al., 2005). This indicates a serious influence of global warming on the decomposition of soil organic matter.

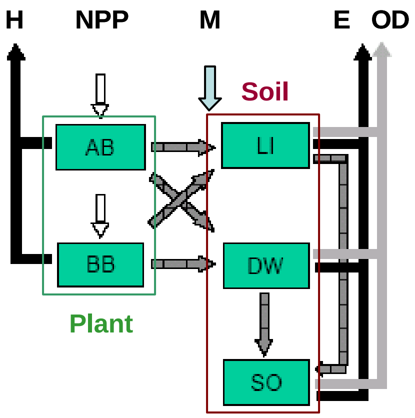

Fig. 1 Carbon cycle of terrestrial ecosystems H, Harvest; NPP, Net primary production; M, Manure; E, Erosion; OD, Organic matter decomposition; AB, Aboveground biomass; BB, Belowground biomass; LI, Litter; DW, Dead wood; SO, Soil organic matter.

We have initiated a three-year project from 2004 to 2006, which is supported by Japan Grassland Agriculture and Forage Seed Association, to clarify the impact of manure application on carbon budget in various types of grassland located from cool temperate region to warm temperate region in Japan. In Japan, the abandonment of livestock excreta together with the insufficient manure application to crop fields due to livestock husbandry supported by enormous imported feed has resulted in the stream and groundwater pollution. In order to address this serious problem, a law on "Promoting Proper Management and Use of Livestock Excreta" was enforced on 11 November 1999, which requires the production and application of high quality manure.

In our project, we try to offer a database of carbon

Fig. 2 Location of monitoring sites.

fluxes through establishing a monitoring system using the eddy covariance method by measuring the exchange of carbon dioxide (CO_2) between the soil-plant ecosystem and the atmosphere in order to estimate the NEP in four monitoring sites: Nakashibetsu (43°32'N, 144°58'E) and Shizunai (42°26'N, 142°29'E) in Hokkaido, Nasushiobara, Tochigi prefecture (36°55'N, 139°58'E) and Kobayashi, Miyazaki prefecture (31°58'N, 130°56'E), which possess major types of grassland in Japan (Photo 1, Fig.2) . The outline of each site has been published in the website (http://www.ghgg-japan.net/index.html).

We established two experimental plots in each monitoring site with an area more than 100 m x 100 m, one for treatment with manure and the other with chemical fertilizer, in the summer of 2004. We also set up the equipments required for applying the eddy covariance method and for carrying out additional environmental measurements, such as photosynthetic photon flux density, soil moisture content and soil temperature. The manure application rate is 40 tFM ha^{-1} for two sites in Hokkaido, 15 tFM ha^{-1} for Nasushiobara and 10 tFM ha^{-1} for Kobayashi. These application rates are reasonable for farmers in the respective region and the difference in the rate of manure application among the sites are on the basis of the adequate amount of potassium application to the fields.

We measure fluxes of methane (CH_4) and nitrous oxide (N_2O) together with CO_2 flux which are major greenhouse gases derived from soil, by using a static chamber method to clarify the influence of manure application on the emission of these gases (Photo 2). The chamber measurements are conducted in six replications in each sampling time. Steel cylinders, about 40 cm in diameter and 30 cm in height, are used for the chamber measurement. The cylinders have blade of 2 cm wide around the top in order to place the white plastic cover on the blade. Thin rubber plate is attached on the blade to minimize leaking air from the chamber. In order to more easily transport the chambers into the field, chambers were constructed in a way that allowed 6 cylinders of slightly differing sizes to fit into the largest of them in the manner of a Russian matryoshka doll. That is, the 6 cylinders each had the same height (30 cm), but were of different diameters (39, 39.5, 40, 40.5, 41, and 41.5 cm). The frequency of measurement is once or twice a week just after the application of chemical fertilizer and manure or after the rainfall events, once a week in snow melting season and once in every three weeks in a regular season of plant growth other than rainfall events. We also take a sample in snow cover season. We expect that the data will contribute in establishing a suitable practice for grassland management especially with respect to manure application with an aim to reduce water pollution and greenhouse gas emissions.

The eddy covariance method is a tool for measuring CO_2 exchange between soil-plant ecosystem and atmosphere associated with the reaction of photosynthesis and respiration in the soil-plant ecosystem. It measures CO_2 concentration, temperature, humidity and wind speed at very high frequency of 10 Hz. Therefore, it is possible to accurately measure the NEP within a short interval of time during a fine weather. However, there are a lot of errors in a long term measurement due to the occurrence of irregular data within a period of inadequate meteorological conditions for measurement such as during the rainfall or quick change of wind direction. The proportion of annual irregular data is reported to be 34% in average in Ameriflux and EUROFLUX in global flux monitoring network (Falge et al., 2000). After adequate

Photo 1 View of the Shizunai monitoring site.

Photo 2 Chamber used.

interpolation of the missing data from the eddy covariance method, we can estimate the amount of photosynthesis and respiration in soil-plant ecosystem separately, because the data indicates the budget of photosynthesis and respiration in the daytime and respiration only in the nighttime. However, the respiration in soil-plant ecosystem consists of plant respiration and microbial respiration derived from soil organic matter decomposition. We need to measure the decomposition of soil organic matter separately to estimate soil carbon sequestration. Furthermore, the eddy covariance method does not provide the NPP. In this project, we will measure soil microbial respiration and NPP as well as NEP by the eddy covariance method. The soil microbial respiration is derived from organic matter and manure decomposition. Therefore, we will measure them by using a chamber method in bare fields with and without application of manure. The below-ground NPP as well as above-ground NPP will also be measured. The carbon budget calculated using these data will be compared with the NEP measured by the eddy covariance method.

In general, the application of chemical nitrogen fertilizer decreases CH_4 uptake by soil (Steudler et al., 1989) and increases N_2O emission from soil (Bouwman, 1996). These are induced from the inhibition of CH_4 oxidation by nitrification and N_2O production through a combination of nitrification and denitrification. However, there is inadequate information on the effect of manure application on CH_4 uptake by soil and N_2O emission from soil. It can be predicted that there is a reduction of CH_4 uptake by soil and an increase of N_2O emission from soil due to mineralization of nitrogen associated with manure decomposition. The emission factors of CH_4 and N_2O can be estimated by measuring both gas fluxes in bare soils without plants, which is an important issue for the precision of global gas inventories.

In order to estimate and compare the contribution of CO_2, CH_4 and N_2O emissions to global warming in the application of manure and chemical fertilizer, the Global Warming Potential (GWP) will be calculated by using a 100-year time horizon recommended by IPCC (2001) from the following equations:.

$$GWP=GWPCO_2+GWPCH_4+GWPN_2O$$

$$GWPCO_2=-NBP(\text{kg C ha}^{-1}\text{ period}^{-1})x44/12$$

$$GWPCH_4=CH_4\text{emission}(\text{kg C ha}^{-1}\text{ period}^{-1})x16/12x23$$

$$GWPN_2O=N_2O\text{emission}(\text{kg N ha}^{-1}\text{ period}^{-1})x44/28x296$$

It is expected that we will be able to identify which greenhouse gas is the major one in promoting global warming, and that what kind of management practice is effective to reduce the greenhouse gas emissions. We are also expecting to be able to take care of trade-offs between the greenhouse gas emissions and production resulted by the manure management practices.

We will report the research findings of 2005 and will propose a monitoring plan to establish a good manure management practice by the end of this project. After the project completion, we will initiate a new project to continue a long term flux measurement to make a more comprehensive manure management practice adjusting various meteorological conditions.

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Site Information

Special Issue on the Long-Term Carbon Exchange at Takayama Forest Site, Japan

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Studies on the carbon cycle at the Takayama forest site started in September 1993 under the collaboration of the National Institute of Advanced Industrial Science and Technology and the Institute for Basin Ecosystem Studies of the Gifu University. The study site, located about 15 km east of Takayama City in the central part of Japan, is classified as a broadleaf deciduous secondary forest dominated by oak and birch.

At the site, tower-based measurements of the forest carbon cycle have been performed throughout the last 12 years. The measurements of meteorological components and the vertical gradient of CO_2 concentration started in 1993 on a tower 27 m in height. The CO_2 flux over the canopy has been estimated by the aerodynamic method (since 1993) and the eddy covariance method (since 1998). Studies on the temporal and spatial variability of the CO_2 flux from soil and snow surfaces, the ecophysiological responses of canopy trees and understory vegetation, and the biometric-based estimation of the net primary production have been conducted together at the site.

To synthesize the results of research done so far, we held a workshop on the decennial anniversary of the observation in October 2003. The main results presented in the workshop were edited as 13 papers into the special issue of *Agricultural and Forest Meteorology* (Volume 134, Issues 1-4, 2005), which contains new findings on the following subjects.

Seasonal and inter-annual variations of NEE and the CO_2 concentration and their relation to meteorological conditions

Saigusa et al. reported the year-to-year change in the annual carbon budget of the forest for nine years and analyzed the relation among the annual carbon uptake, climatic factors, and the growing period length. *Murayama et al*. conducted statistical analyses of inter-annual variations in the vertical profile of atmospheric CO_2 concentration and discussed the long-term trends of the concentration in and above the canopy.

Biometric-based annual NPP

Ohtsuka et al. reported on the annual net production of the forest and on the assessment of the different methods used for estimating the annual NPP.

Photosynthetic and structural characteristics of canopy and shrub tree species and the spatio-temporal variability of net primary production by in-site measurements

Muraoka et al. studied the photosynthetic and structural characteristics of canopy and shrub trees at the site. They conducted leaf-level gas exchange measurements for dominant species at different heights in the canopy and discussed the role of leaf architecture using a mechanistic model. *Sakai et al*. investigated the spatio-temporal variability of NPP of the understory species using multiple measurement techniques. *Kondo et al.* estimated the rate of refixation of respired CO_2 by understory vegetation using stable carbon isotope analyses.

The CO_2 efflux from soil and snow surfaces and implications in forest carbon budget

Uchida et al. reported microbial activity and litter decomposition under a snow covered forest floor. They suggested that microorganisms in the litter layer play an important role in the carbon cycle during the winter. *Mo et al.* measured the seasonal and annual variations in soil respiration for four years and showed the seasonal change in the dependence of the soil respiration on the soil temperature and moisture. *Lee et al.* discussed the importance of root respiration in annual soil carbon fluxes in the forest. Jia and Akiyama proposed a precise method of estimating the carbon storage in forest ecosystems.

Modeling of gross and net carbon dioxide exchange and simulation analysis of net ecosystem exchange

Ito et al. developed a process-based ecosystem model based on Sim-CYCLE to simulate daily photosynthesis and respiration at the site. They mainly analyzed seasonal and inter-annual changes in the carbon budget. Also, they presented the impact of disturbances, such as logging and defoliation by typhoons, on the budget. *Higuchi et al.* presented a modified version of the ecosystem model BEPS (Boreal Ecosystem Productivity Simulator) to reproduce seasonal and inter-annual variations in the gross primary production (GPP) of the site. *Alexandrov et al.* used a recalibrated ecosystem carbon cycle model (TsuBiMo) with eddy-covariance data to project inter-annual and intra-annual changes of the GPP and net ecosystem production at the site.

In order to increase and deepen our understanding of the long-term carbon cycle at the site, we still need to attempt to solve more difficult problems, for example, atmospheric turbulence in non-ideal conditions (stable/unstable, complex terrain, etc.); spatial heterogeneity of stand structure, leaf physiology, and soil characteristics; scaling leaf-level processes up to stand-level, canopy and landscape levels, and so on. We also need to overcome these difficulties in continuing long-term measurements in order to detect the ecosystem's response to climatic variability with timescales longer than a decade. It is obviously important to cooperate with researchers in various backgrounds, such as micrometeorology, soil science, ecophysiology, remote sensing, and mathematical modeling, etc. We expect that the present special issue will stimulate your interest and produce new ideas and a new cooperative relationship to accelerate further studies.

Editor's Note

Our laboratory is now preparing for the moving. I threw out many old paper materials and felt refreshing. On the other hand, old letters and memos reminded me the good old days. It's good to move at times.

The editor of AsiaFlux Newsletter No.17:
Yoshiko KOSUGI
(Kyoto University)

The editor of AsiaFlux Newsletter No.18 will be Sanghyun KIM (Pusan National Univ.).

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